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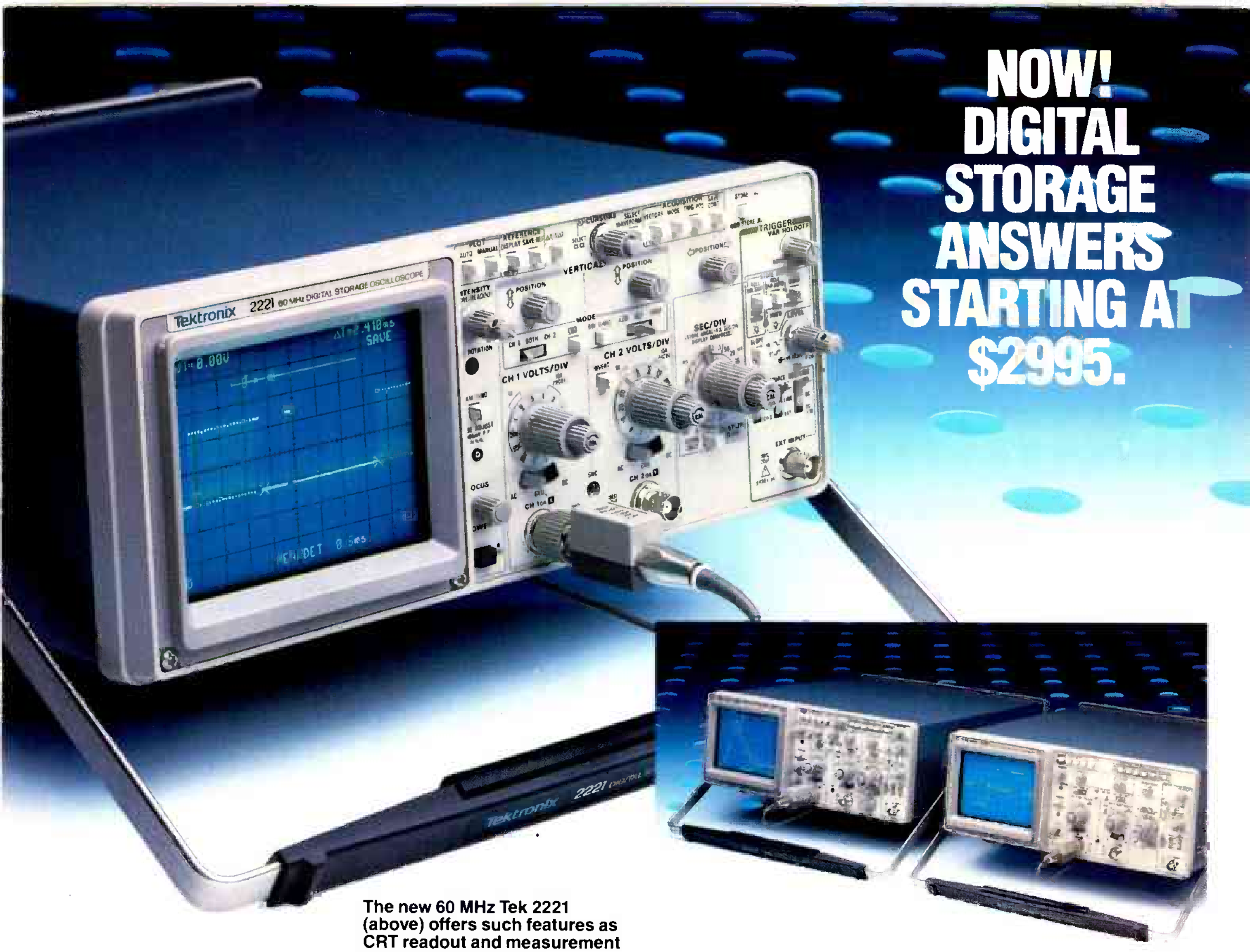


The new 60 MHz Tek 2221 (above) offers such features as CRT readout and measurement cursors for just $3995.

Now you have three low-cost choices in Tek digital storage oscilloscopes. All featuring powerful 20 MS/s *digitizing* along with familiar, full-bandwidth analog operation. It's the best of both worlds in one easy-to-use, portable package.

Discover the potential! With digital storage you can freeze waveforms. Capture events invisible to non-storage scopes. Find signals buried in noise. And build a library of reference waveforms.

CRT readout and cursors distinguish the new 2221. For even higher performance, there's the 100 MHz, dual time base 2230 with optional battery-backed memory for saving up to 26 waveform sets. And if it's economy you want, choose the 60 MHz 2220 with many of the same features at an even lower cost.

With each scope you can automate measurements with interface options. And output direct to a printer or plotter. Tek software is available for systems.

Features	2230	NEW! 2221	2220
Analog/Digital Storage BW	100 MHz	60 MHz	60 MHz
Maximum Sampling Speed	20 MS/s	20 MS/s	20 MS/s
Record Length	4K/1K (selectable)	4K	4K
Peak Detect	100 ns	100 ns	100 ns
Save Reference Memory	One, 4K Three, 1K	One, 4K	One, 4K
Vertical Resolution	8 bits 10 bits (AVG mode) 12 bits (AVG mode over the bus)	8 bits 10 bits (AVG mode)	8 bits
CRT Readout/Cursors	Yes	Yes	No
GPIB/RS-232-C Options	Yes ($750)	Yes ($500)	Yes ($500)
Battery-Backed Memory (save 26 waveform sets)	Yes (inc with GPIB/ RS-232-C)	No	No
Warranty	3 year on labor and parts, including the CRT		
Price	$4995	$3995	$2995

Call Tek direct:

1-800-426-2200

for free video brochure for orders/assistance.

Tektronix
COMMITTED TO EXCELLENCE

CIRCLE 92 ON FREE INFORMATION CARD

January 1988 Radio-Electronics

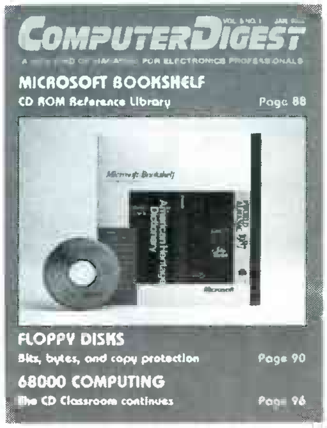
Vol. 59 No. 1

BUILD THIS

TECHNOLOGY

CIRCUITS AND COMPONENTS

DEPARTMENTS



PAGE 87

PAGE 45

AND MORE

ON THE COVER

If you like to stay in touch at all times—while riding a subway in New York, attending a conference in Washington, or relaxing on a beach in California—the nationwide paging system is for you. Cue Paging Corp. has combined satellite communications, SCA FM radio transmissions, *Touch-Tone* dialing, LCD digital displays, and computers to create a paging system that can reach you virtually anywhere in the United States. With six memories, and voice message retrieval you'll never have to worry about missing a message. To learn more about how it works, turn to page 41.

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How to put them to work.

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It's easy to do it yourself—we show you how!

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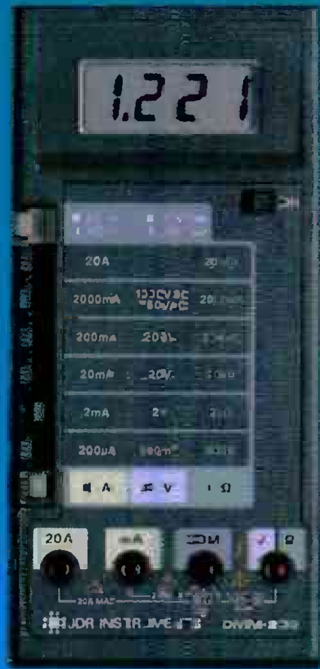
TEST EQUIPMENT THAT MEASURES UP TO YOUR SPECIFICATIONS



DMM-300 $79.95

3.5 DIGIT DMM / MULTITESTER

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

- ★ Basic DC accuracy: plus or minus 0.25%
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High accuracy, 20 amp current capability and many range settings make this model ideal for serious bench or field work. Tilt stand for hands-free operation. 2000 hour battery life with standard 9v cell. Probes and battery included.

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- ★ AC/DC current: 200uA — 20A, 6 ranges
- ★ Fully over-load protected
- ★ Input impedance: 10M ohm
- ★ 180 x 86 x 37mm, weighs 320 grams

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Autorange convenience or fully manual operation. Selectable LO OHM mode permits accurate in-circuit resistance measurements involving semi-conductor junctions. MEM mode for measurements relative to a specific reading. Probes and battery included.

- ★ Basic DC accuracy: plus or minus 0.5%
- ★ DC voltage: 200mv — 1000v, autoranging or 5 manual ranges
- ★ AC voltage: 2v — 750v, autoranging or 4 manual ranges
- ★ Resistance: 200 ohms — 20M ohms, autoranging
- ★ AC/DC current: 20mA — 10A, 2 ranges
- ★ Fully over-load protected
- ★ Audible continuity tester
- ★ Input impedance: 10M ohm
- ★ 150 x 75 x 34mm, weighs 230 grams

DMM-100 $29.95

3.5 DIGIT POCKET SIZE DMM

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

- ★ Basic DC accuracy: plus or minus 0.5%
- ★ DC voltage: 2v — 1000v, 4 ranges
- ★ AC voltage: 200v — 750v, 2 ranges
- ★ Resistance: 2k ohms — 2M ohms, 4 ranges
- ★ DC current: 2mA — 2A, 4 ranges
- ★ Fully over-load protected
- ★ Input impedance: 10M ohm
- ★ 130 x 75 x 28mm, weighs 195 grams

MODEL 2000 $349.95

20 MHz DUAL TRACE OSCILLOSCOPE

Model 2000 combines useful features and exacting quality. Frequency calculation and phase measurement are quick and easy in the X-Y Mode. Service technicians will appreciate the TV Sync circuitry for viewing TV-V and TV-H as well as accurate synchronization of the Video Signal, Blanking Pedestals, VITS and Verticle/Horizontal sync pulses.

- ★ Lab quality compensated 10X probes included
- ★ Built-in component tester
- ★ 110/220 Volt operation
- ★ X-Y operation ★ Bright 5" CRT ★ TV Sync filter

DPM-1000 $54.95

3.5 DIGIT PROBE TYPE DMM

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

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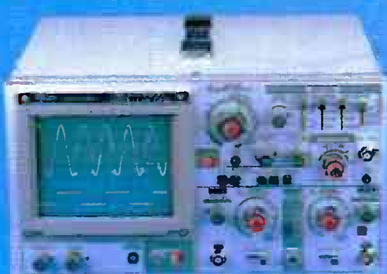
- ★ AC voltage: 2v — 500v, autoranging
- ★ Resistance: 2k ohms — 2M ohms, autoranging
- ★ Fully over-load protected
- ★ Input impedance: 11M ohm
- ★ 162 x 28 x 17mm, weighs 75 grams



MODEL 3500 $499.95

35 MHz DUAL TRACE OSCILLOSCOPE

Wide bandwidth and exceptional 1mV/DIV sensitivity make the Model 3500 a powerful diagnostic tool for engineers or technicians. Delayed triggering allows any portion of a waveform to be isolated and expanded for closer inspection. Variable Holdoff makes possible the stable viewing of complex waveforms.

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CIRCLE 59 ON FREE INFORMATION CARD

EDITORIAL

Some happenings at the FCC

The Federal Communications Commission has proposed opening up the 902 to 928 MHz band to license-free consumer "broadcasting." The band, which would have no bandwidth, use, or modulation restrictions, could be used for everything from wireless speakers to wireless video cameras and VCR's. We think that the proposal (Gen Docket 87-389) is a great idea that will serve both the electronics industry and the electronics consumer.

The electronics industry would benefit tremendously from the new markets opened—just think of all the products that could be developed. We already know that there is a tremendous market for wireless video links for video cameras—even though the FCC has ruled that they are illegal. And although the Commission is doing its best to stop the sale of those devices, they're having trouble keeping up. Based on sales of the *VCR Rabbit* video distribution system, we also know that there would be an even larger market for wireless VCR's.

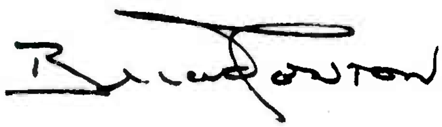
The license-free band could also open up new horizons in home automation. With an RF link, it becomes simple to monitor your front door or backyard pool with a video camera. It also becomes practical to send control-computer data via RF signals. Your stereo speakers could be installed anywhere, without running cables.

Can you imagine having not only a wireless computer keyboard, but a wireless monitor as well? How about a wireless printer? I'm sure you get the idea, and can come up with a dozen applications that you could use the new band for. The possibilities are endless.

Needless to say, there will be many problems to overcome before the band can come into use. Interference from the amateur-radio and government agencies that currently use the band is only one of them. Of course without careful planning of the new regulations—including power and restricted use provisions—the new band could end up being a disaster. We're confident that the FCC and the electronics industry can come up with a workable plan.

But perhaps we have too much confidence in the FCC, which has considered making the NTSC TV standard voluntary. The Commission reasons that relaxing the standard might facilitate the development of high-definition advanced television systems. *We feel that a voluntary NTSC standard would be a serious mistake.*

A non-compatible HDTV system is not in the best interests of either broadcasters or consumers. Giving up on NTSC isn't the answer. Before a compatible color system was developed, many industry experts said that it couldn't be done. And many experts said the same of a high-definition NTSC compatible system. But, fortunately, the people at the David Sarnoff Research Center didn't listen, and you might be watching compatible HDTV in your living room as early as 1993! For an update on HDTV, turn to page 16.



BRIAN C. FENTON
Managing Editor

Information radio is on the air.

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

Breakthrough Technology. Instant Information.

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

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CIRCLE 179 ON FREE INFORMATION CARD

WHAT'S NEWS

Manufacturer "Fights Back" against "scientific test"

Last year, consumer reporter David Horowitz, of the syndicated TV show, *Fight Back*, ran a claimed "scientific comparison" of small batteries, using toy singing birds to make the tests. One of the batteries tested was the Kodak *Supralife* alkaline cell, which in the tests did not show up as well as a competitor's. At the end of the tests, Horowitz challenged any manufacturer "to invite us into its labs and show us how scientifically they do their tests."

Kodak's Martin H. Adams immediately accepted the challenge and invited Horowitz to visit the independent Electrical MET Testing Lab in Baltimore, MD, which tests Kodak batteries. As a result of the trip, which was taped and aired on the *Today Show* this past Sept. 14, Horowitz was persuaded that singing birds can not serve as accurate test instruments.

During the visit, both the independent lab and Kodak's Ultra Technologies division tested battery performance in the toy birds according to international standards, using precision equipment.

"In repeated comparisons, *Supralife* cells performed better overall, though some of the toy birds operated better or worse with continued use," said Adams, "The performance of these toys indeed change, as they are built with inexpensive parts."

"It's a challenge we couldn't pass up. The *Fight Back* supposedly fair test was fraught with inconsistencies. Mr. Horowitz gave us an opportunity to show the public how meaningful battery tests are conducted."

SINGING BIRDS AS TEST INSTRUMENTS have many deficiencies, explains Leonard Frier of Electrical Testing Co. to TV personality David Horowitz (center). Martin H. Adams, marketing VP of Kodak's Ultra Technologies, who initiated the test, is at right.

Fluke and Philips join forces

The John Fluke Manufacturing Co. (Everett, WA) and N.V. Philips (Eindhoven, The Netherlands) have joined forces to create the third largest electronics test- and measurement-equipment company in the world.

Under terms of the agreement, Fluke will sell, support, and service Philips' products in North

GEORGE WINN, President of John Fluke, Inc., and George de Kruiff, Senior Managing Director of N.V. Philips, sign the agreement binding their two companies in a world-wide sales and service alliance.

America, The People's Republic of China, Hong Kong, and Japan. Philips will do the same for Fluke products in the rest of the world. Both companies will continue to develop products independently, but in addition the companies will consider joint ventures to develop product lines in categories in which neither is a significant participant currently.

In commenting on the alliance, Fluke Chairman John Fluke, Jr. said, "Fluke and Philips offer one another non-competing, complementary products which enable each company to greatly expand its product offerings to customers in various test and measurement applications."

According to George de Kruiff, Senior Managing Director of Philips, Philips offers an important and established presence for Fluke products in all of Europe and Fluke offers Philips a strong sales, marketing, and service organization in North America. **R-E**

The Electronic Industries Association/Consumer Electronics Group has recently completed the first in a series of videocassette training tapes.

EIA/CEG ANNOUNCES COMPLETION OF NEW "BASIC CAR AUDIO INSTALLATION" VIDEO TAPE

If you are thinking of "cashing in" on the profits in the ever growing car audio service business, the troubleshooting–service–installation–and removal of car audio products is a large, non-competitive profit center for your service facility. This thirty minute video introduces you to the ever increasing complex world of car stereo installation. It guides the new installer or owner in the correct layout and design of a car stereo installation facility, covering basic as well as specialized tools needed for the installation business.

This informative videotape is also an excellent aid to the electronics technician in that it gives the correct procedure for removing and replacing "any" car radio from the dashboard of any car and shows the installer's, salesperson's and customer's role in the installation and sale of car audio products.

KEY TOPICS COVERED IN THIS VIDEO

- The design and layout of a car stereo installation center.
- Basic and specialized tools needed for car audio installation work.
- Safety in the shop.
- How to treat the customer's car, from pre-installation checkout to demonstrating to the customer the completed job.
- The proper procedure for installing car audio equipment.
- The technical resources available for information about specific types of vehicles, dashboard dismantling, speaker sizes and antenna locations.
- Speaker wiring types found in the automobile. Common and floating ground systems—how to differentiate. Proper wiring procedures used in the car.

The cost of the videocassette is $30.00. Use the order form below to order yours now!

Send to: EIA/CEG, Department PS, P.O. Box 19100, Washington, D.C. 20036

ORDER FORM

Basic Car Audio Installation	Quantity	Amount	Total Enclosed
Videocassette		$30.00 each	
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Only NRI teaches you to service all computers as you build your own fully IBM compatible microcomputer

With computers firmly established in offices—and more and more new applications being developed for every facet of business—the demand for trained computer service technicians surges forward. The Department of Labor estimates that computer service jobs will actually *double* in the next ten years—a faster growth rate than for any other occupation.

Total systems training

No computer stands alone... it's part of a total system. And if you want to learn to service and repair computers, you have to understand computer *systems.* Only NRI includes a powerful computer system as part of your training, centered around the new, fully IBM PC compatible Sanyo 880 Series computer.

As part of your training, you'll build this highly-rated, 16-bit IBM compatible computer system. You'll assemble Sanyo's "intelligent" keyboard, install the power supply and disk drive, and interface the high-resolution monitor. The 880 Computer has two operating speeds: standard IBM speed of 4.77 MHz and a remarkable turbo speed of 8 MHz. It's confidence-building, real-world experience that includes training in programming, circuit design and peripheral maintenance.

No experience necessary—NRI builds it in

Even if you've never had any previous training in electronics, you can succeed with NRI training. You'll start with the basics, then rapidly build on them to master such concepts as digital logic, microprocessor design, and computer memory. You'll build and test advanced electronic circuits using the exclusive NRI Discovery Lab®, professional digital multimeter,

Learn Computer Servicing Skills with NRI's "Hands-On" Training . . .

Using NRI's unique Action Audio Cassette, you are talked through the operation and practical application of your hand-held digital multimeter—the basic, indispensable tool for the computer specialist.

You'll set up and perform electronics experiments and demonstrations using your NRI Discovery Lab. You'll even interface the lab with your computer to "see" keyboard-generated data.

After you build this digital logic probe, you'll explore the operation of the Sanyo detached "intelligent" keyboard and its dedicated microprocessor.

Your NRI total systems training includes all of this: NRI Discovery Lab® to design and modify circuits • Four-function digital multimeter with walk-you-through instruction on audio tape • Digital logic probe for visual examination of computer circuits • Sanyo 880 Series Computer with "intelligent" keyboard and 360K double-density, double-sided disk drive • High resolution monochrome monitor • 8K ROM, 256K RAM • Bundled software including GW BASIC, MS DOS, WordStar, CalcStar • Reference manuals, schematics, and bite-sized lessons.

and logic probe. Like your computer, they're all yours to keep as part of your training. You even get some of the most popular software, including WordStar, CalcStar, GW Basic and MS DOS.

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Send the post-paid reply card today for NRI's 100-page, full-color catalog, with all the facts about at-home computer training. Read detailed descriptions of each lesson, each experiment you perform. See each piece of hands-on equipment you'll work with and keep. And check out NRI training in other high-tech fields such as Robotics, Data Communications, TV/Audio/Video Servicing, and more.

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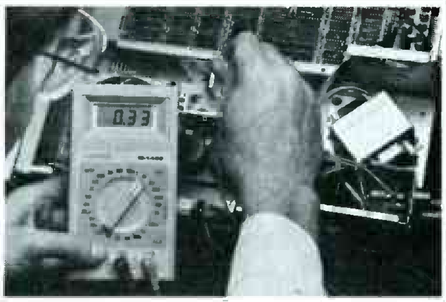


The power supply is assembled in the main unit of the computer. You check out keyboard connections and circuits with the digital multimeter included for training and field use.

Next, you install the disk drive. You learn disk drive operation and adjustment, make a copy of MS-DOS operating disk and begin your exploration of the 8088 CPU.

Using the monitor, you focus on machine language programming, an indispensable troubleshooting tool for the technician. You continue by learning BASIC language programming.

VIDEO NEWS

DAVID LACHENBRUCH,
CONTRIBUTING EDITOR

• **Europe going HDTV.** Last year, sparked by the European broadcasting authorities' distaste for any system based on the 60-Hz field rate (Europe uses 50 Hz), an American-backed proposal for a worldwide high-definition TV production standard based on the Japanese-developed 1,025-line, 60-field widescreen system was rejected by the United Nations' broadcasting body, the International Consultative Radio Committee (better-known as the CCIR). At that time, the Europeans promised to come up with their own HDTV system.

The European system, called "Eureka," was formally unveiled at the *Internationale Funkausstellung* (international TV-radio exposition) in West Berlin in a cooperative effort of virtually all European broadcasting authorities and TV-set and component manufacturers. The major points made by the Europeans—who say they are committed to the system—are "graduality" and "compatibility".

The Eureka project will use the forthcoming direct satellite-broadcasting system as a way-station on the route to HDTV. That system is expected to build on the D2-MAC format, scheduled to be broadcast by both German and French satellites this year. The MAC (*M*ultiple *A*nalog *C*omponent) format separates luminance and chrominance signals for a better picture. MAC will be a decided improvement over the European broadcast-standard PAL systems, increasing the picture resolution to 180,000 pixels from PAL's 120,000.

The second step in the gradual evolution will be the addition of widescreen transmission (16:9 ratio), and the third step will be an increase to 1,250 horizontal lines, bringing the number of pixels to 480,000. Each of those steps, according to the plan, will maintain compatability; viewers with older sets will continue to receive the D2-MAC picture, while those with newer-type sets would get the wide-screen and/or high-definition picture.

Although the basic field rate would be 50 Hz, circuitry in deluxe HDTV receivers would double that to 100-fields per second, thereby eliminating the picture's flicker. The Europeans claim that the transmission bandwidth of the full widescreen HDTV picture would be held to 10 MHz by the use of "...advanced digital-sampling and bandwidth-reduction techniques to eliminate redundant information and compress relevant data for transmission."

An NTSC-compatible HDTV system designed for the United States is expected to be proposed by the Europeans. Because Europe now controls a considerable portion of the TV-receiver market through Thompson (RCA and GE sets) and Philips (Magnavox, Sylvania, and Philco), the gradual approach to HDTV is likely to carry considerable weight here.

• **End of the 3/4-inch road?** The ¾-inch videotape format, the U-matic system that has been the standby for industrial TV and broadcast electronic newsgathering for well over a decade, may be on the way out. Two professional ½-inch formats—Sony's Betacam and Panasonic's MII—threaten it at the broadcast end, and now the Super VHS (SVHS) system may replace it in the industrial arena.

At least, that's Panasonic's view; the company has introduced a completely new line of industrial video equipment using the SVHS system. Panasonic thinks that it will be used for industrial, institutional and educational video, as well as by some cable-TV systems and local TV stations. Although the cost of SVHS equipment is about 30 percent above standard VHS, it's 30 percent below ¾-inch gear and provides longer recording time, better resolution and a better signal-to-noise ratio than U-matic. Panasonic says it stopped developing ¾-inch equipment "several years ago (when) it became evident that ½-inch could produce much better quality with lighter weight and lower cost." Panasonic expects industrial producers to use SVHS for production, standard VHS for distribution. Sony, which has developed a new version of ¾-inch recording using non-compatible metal tape (U-matic SP) may not agree—but Sony has its own super-½-inch system called ED Beta. **R-E**

4TH IN A SERIES

Is Escort Scared or Smart?

Cincinnati Microwave, the maker of Escort and Passport radar detectors, has ignored DAK's **third**, *one-on-one Maxon versus Escort radar challenge. I think they're hiding behind 'independent' magazine reviews and refusing to meet us on the true field of battle. And now, I think I've finally figured out why. I believe they're in a NO WIN SITUATION! Read On.*

By Drew Kaplan

It's time to attack. No more Mr. Nice Guy for me. I've done everything I can to get them out for a conflict.

I've offered $10,000, then $20,000, if they could beat Maxon's lowest price 99^{90} detector (now on sale for just 79^{90}) by more than 10 feet. I've even offered to print the results in my next catalog, win, lose or draw.

In a minute, I'm going to introduce Maxon's revolutionary new Micro-Detector that is CORDLESS and built to **trounce** Escort and Passport, but first let's see what we can do to compare detectors.

IS THIS FAIR? YOU DECIDE

In their recent ads, Cincinnati Microwave quotes what Car and Driver Magazine's April '87 issue says about Passport, "At $295 direct from the factory, it's the most expensive piece of electronic protection in the group, but it's worth every nickel in roadgoing peace of mind."

Well, wouldn't you think that Passport obliterated every other detector by a country mile? And, don't you think everyone is going to go out and find the magazine and read the **WHOLE** review???

Well, look what else Car and Driver said **in the same article** (and not quoted in Passport ad), "As it turned out, the top five brands are so close in their "Overall Sensitivity" scores that a minor juggling of the X/K-band weighting formula would upset the apple cart." Wow, imagine that!

So, Passport didn't beat everyone by a mile. In fact, on the X Band tests, it appears that it came in 3rd in a Dead-Ahead Trap, 3rd in an Over-the-Hill Trap, and 3rd in an Around-the Corner Trap.

But in choosing Passport as best, Car and Driver says, ". . an 'excellent' appraisal of support systems (cords, lights, alarms etc.) is well worth several hundred feet of warning distance..".

Which brings me back to the point I've been trying to make since I first challenged Escort. Today, a good detector can often sniff out police radar as much as 60 seconds ahead.

Traveling at 55 mph, you only cover about 80 feet a second. So, whether there's a 10' or even 100' difference in sensitivity, with today's detectors it just doesn't make much difference.

READ THIS

So, if Passport or Escort lose to the 79^{90} Maxon, it would be catastrophic for their advertising. And, even if they beat Maxon by a second or two, are they worth double or even triple the price?

So, that's why I think they're in a **no win situation**. Without the magazine's loving editorial comments, we'd be down to **who won** and by **how many feet**?

And while they may or may not be scared of losing to Maxon, so far, they sure seem to be smart enough to stay out of a footage contest.

MAGAZINE ROUND UP

Popular Mechanics Magazine in November '86, in their Around A Corner Test said, "The low ranked . . .and Passport had to be rounding the bend and pointing at the radar gun before they'd detect it. Too late then!" (Not quoted by Passport.)

Although in July, after Cincinnati Microwave complained, Popular Mechanics said in an Around A Corner Test, "Consistent with the results of our previous test, Passport was easily the best of the minis." (Quoted in Passport Ads.)

Speaking of 'consistent', the magazines aren't consistent even from issue to issue.

By the way, in July's test they hated Maxon, but at least they said, "No detector in this group had to round the corner before sniffing out Smokey."

Road and Track Magazine (September '86) top rated Passport even though Maxon (a recommended buy) appears to have beaten Passport in Uninterrupted Alert, and Passport beat Maxon in initial alert.

So, when you get right down to which detector protects you, an **on-the-road test** without all the loving editorial 'quotable remarks' seems to be the only way to go.

We need to win or at least tie, to prove to the world that our challenge is for real, and not, as Cincinnati Microwave said, "an advertising gambit". But, speaking of advertising gambits, read this!

PROTECTION FROM RASHID $5? WHOOPEE

Last year, Cincinnati Microwave announced to the world, in virtually every magazine I picked up, that all radar detectors but theirs would be obsolete.

It seemed that a K band collision avoidance system called Rashid VRSS would knock out everyone's detectors.

Well, I said then that the $558 system that recommends cutting a 6½" hole in your grill for installation, wasn't going to take over the highways.

But Cincinnati Microwave kept advertising about Rashid. (My opinion of an advertising gambit). It's been a year and nobody I've talked with has run into a Rashid. I challenged Cincinnati Microwave to prove that there were even 500 on the road in the whole U.S., but they've been silent. (I wonder why???)

Anyway, just to prove that we had the technical expertise, Maxon has developed and implemented an Anti-Rashid circuit in the new Micro-Detector.

It's added about $5 to your cost which **we all think is a waste**, but at least we won't get any more letters saying that the only reason we think it's worthless is because Maxon doesn't have it.

TRUE BREAKTHROUGH NO. FIVE

Unlike the questionable value Anti-Rashid circuit from Cincinnati Microwave, Maxon has now leapt ahead. Now you can have a micro detector that operates from 6 AA rechargeable batteries (included).

Now you can forget plugging your radar detector into your cigarette lighter. A revolutionary circuit design gives you cordless freedom and **improved** protection.

Maxon is using a circuit used in jet fighters and other military applications which replaces the traditional Gunn diode oscillator with a DRO (Di-electrically Resonated Oscillator).

The efficient DRO circuit is much more stable when subjected to temperature extremes and vibration (hence its use in the military, especially aircraft). Its only disadvantage is that it costs more.

The new detector also has incredible "support systems". Its bright LEDs, dim themselves at night. And speaking of dimming, they can be switched off so you can't be spotted from the rear.

And, as for the separate X and K warning tones, not only is the volume adjustable, 'Mute' lets you silence the alarms without adjusting volume. They will automatically reset after the alert passes.

You can plug the Micro into your cigarette lighter, you can run it for about 8 hours on its rechargeable batteries, and it automatically recharges from your cigarette lighter overnight or while you use it plugged in during the day.

OK, now it's time to prove that Maxon is Number One. Cincinnati Microwave, eat our dust!

A $20,000 Challenge To Escort

Let's cut through the Radar Detector Glut. We challenge Escort & Passport to a one-on-one Distance and Falsing 'duel to the death' on the highway of their choice. If they win, the $20,000 check pictured below is theirs.

By Drew Kaplan

We've put up our $20,000. We challenge Escort to take on Maxon's Dual Superheterodyne RD-1 99^{90} detector (right) (Now just 79^{90}), Maxon's new Mini RD25 99^{90} detector (middle) or Maxon's Cordless Micro-Trouncer 149^{90} radar detector (left) on the road of their choice in a one-on-one conflict.

The real question today is: 1) How many feet of sensing difference, if any, is there between Maxon's Detectors and Escort's or Passport's? And 2) Which is more accurate at interpreting real radar versus false signals?

So Escort, you pick the road (continental U.S. please). You pick the equipment to create the false signals. And finally, you pick the radar gun.

Maxon and DAK will come to your highway with engineers and equipment to verify the results.

And, we'll have the $20,000 check (pictured) to hand over if you win!

BOB SAYS MAXON IS BETTER

Here's how it started. Maxon is a mammoth electronics prime manufacturer. They actually make all types of sophisticated electronic products for some of the biggest U.S. Electronics Companies. (No, they don't make Escort's.)

Bob Thetford, the president of Maxon Systems Inc. and a friend of mine, was explaining their anti-falsing Dual Superheterodyne Radar detector to me. I said "You know Bob, I think Escort really has the market locked up." He said, "Our new designs can beat theirs".

. . .Next Page Please

. . .Challenge Continued

So, since I've never been one to be in second place, I said, "Would you bet $20,000 that you can beat Escort?" And, as they say, the rest is history.

By the way, Bob is about 6'9" tall, so if we can't beat Escort, we can sure scare the you know what out of them. But, Bob and his engineers are deadly serious about this 'duel'. And you can bet that our $20,000 is serious.

We only ask the following. 1) The public be invited to watch. 2) Maxon's Engineers as well as Escort's check the radar gun and monitor the test and the results. 3) The same car be used in all tests. 4) We'd like an answer from Escort no later than December 31, 1987, and 60 days notice of the time and place of the conflict to alert the public. And, 5) If Escort can prove that there are even 500 Rashid units in operation, we will present them with a check for $5,000 at the conflict.

HOW'S THIS FOR FAIR?

Cincinnati Microwave will be deemed the winner and given the check if **either** Escort beats Maxon's RD-1 or RD-25 by 10 feet in both uninterrupted and initial alerts or **equals** the Micro-Trouncer, **OR** if Passport beats Maxon's RD-1 or RD-25 by 2 seconds at 55mph in both uninterrupted and initial alerts or **equals** the Micro-Trouncer. So, DAK wins **only** if we beat **both** the $295 Passport and $245 Escort Radar Detectors.

SO,WHAT'S DUAL SUPERHETERODYNE?

OK, so far we've set up the conflict. Now let me tell you about the new dual superheterodyne technology that lets Maxon leap ahead of the pack.

It's a technology that tests each suspected radar signal 4 separate times before it notifies you, and yet it explodes into action in just 1/4 of one second. (1/10th second for the Micro-Trouncer.)

Just imagine the sophistication of devices that can test a signal 4 times in less than a 1/4 of one second. Wow!

But, using Maxon is easy. These long range detectors have all the bells and whistles with **separate** audible sounds for X and K radar signals.

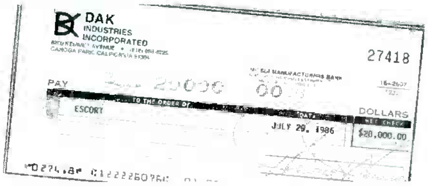
LED Bar Graph Meters accurately **show the radar signal's strength.** And, you won't have to look at a needle in a meter.

Keep your eyes on the road, you'll see these meters with your peripheral vision.

You'll have a very high level of protection. Maxon's Dual Conversion Scanning Superheterodyne circuitry combined with **die-cast aluminum** ridge guide wideband horn internal antennas, really ferret out radar signals.

And the key word is 'radar', not trash. The 4 test check system that operates in 1/4 second gives you protection from signals from other detectors, intrusion systems and garage door openers.

So, when the lights and X or K band sounds explode into action, take care, there's very likely police radar nearby. You'll have full volume control, and a City/Highway button.



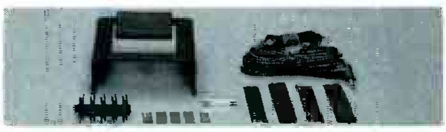
Maxon detectors are backed by Maxon's standard limited warranty.

Note from Drew: 1) Use of radar detectors is illegal in some states.

2) Speeding is dangerous. Use your detector to help keep you safe when you forget, not to get away with speeding.

DON'T WASTE MONEY

As I've said, **good** radar detectors today are very similar. The RD-1 is great. It is much smaller than Escort at just 3½" wide, 4¾" deep and 1½" tall.



If you want an even smaller detector, the RD-25 at just 2⅞" wide, 4½" deep and 1" tall, with its included windshield mount and identical specs is for you.

If you want the very best, or if you want to forget cords and be able to slip a

4½" wide, 3¼" deep, ¾" tall (It mounts sideways to the rest) detector into your shirt pocket, choose the Micro-Trouncer.

I'd love to tell you that the Micro-Trouncer is light years ahead in detection, because its circuitry certainly is.

But, I'd be into advertising gambitland if I claimed that 1 or 2 seconds of improvement over Maxon's other detectors or even over Escort and Passport really make a significant difference.

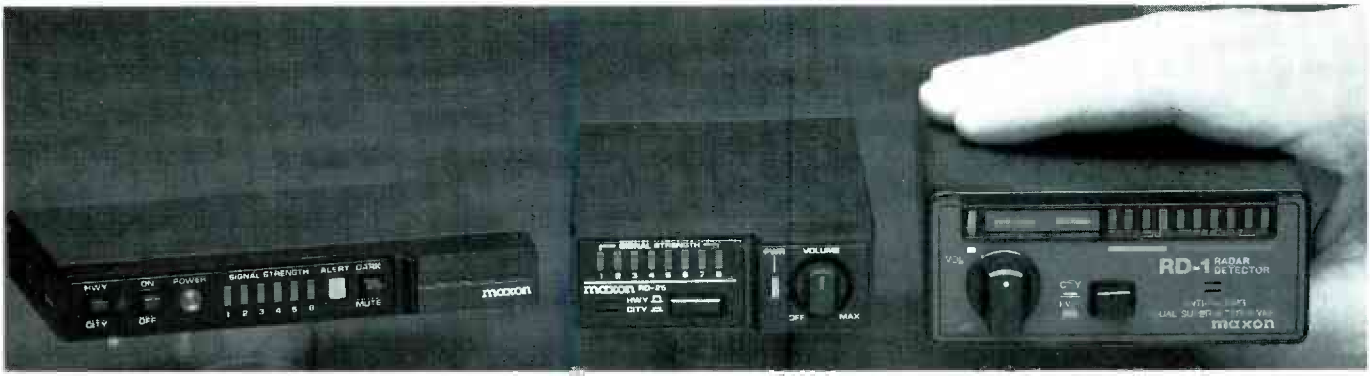
Caution: Cincinnati Microwave is right. There are many cheap imports that aren't very good. My quarrel with them is that except for themselves, I don't know who they think is any good!

CHECK OUT RADAR YOURSELF RISK FREE

Put a detector on your visor, dash or windshield. When it sounds, look around for the police. There's a good chance you'll be saving money in fines and **higher insurance rates.**

If you aren't 100% satisfied, simply return it in its original box within 30 days for a courteous refund.

(RD-1 Pictured to Right.) To get your Maxon, Dual Superheterodyne, Anti-Falsing Radar Detector risk free with your credit card, call toll free or send your



check for DAK's **$79⁹⁰** sale price ($4 P&H). Order No. 6168.

Note: An optional suction cup windshield mount and extra coiled power cord (we can't afford to throw them in for free) is just **$5⁹⁰** ($2 P&H) Or. No. 4800.

(RD-25 Pictured in Middle.) To get your Maxon, Dual Superheterodyne, Anti-Falsing **Mini** Radar Detector complete with 2 Power Cords, Window Suction Cup, Dash and Visor Mounts risk free with your credit card, call toll free or send your check for just **$99⁹⁰** ($4 P&H) Order No. 6169. CA res add tax.

(Micro-Trouncer Pictured to Left.) To order Maxon's Top-Of-The-Line, DRO Circuit Radar Detector with Mute, 4 Second LED Meter Hold, Dark Switch, Cordless Battery Operation (6 AA Ni-Cad Batteries Included) with Windshield, Dash, and Visor mounts and 2 power/charging Cords risk free with your credit card, call toll free or send your check for this revolutionary $249 suggested retail detector at DAK's market breaking price of just **$149⁹⁰** ($6 P&H) Order No. 6170.

OK Escort, it's up to you. We've got $20,000 that says you can't beat Maxon on the road. Your answer, please?

Escort and Passport are registered trademarks of Cincinnati Microwave. Rashid VRSS, and Rashid Radar Safety Brake are registered trademarks of Vehicle Radar Safety Systems, Inc.

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HDTV UPDATE

BRIAN C. FENTON MANAGING EDITOR

HDTV—sooner than you think

ACTV

YOU COULD BE WATCHING HIGH-DEFinition television in your home in as little as five years, thanks to a breakthrough from the David Sarnoff Research Center (formally RCA Labs). They announced—in collaboration with NBC and GE/RCA Consumer Electronics—the development of a new high-definition television system called ACTV or *A*dvanced *C*ompatible *T*ele*V*ision. It's the most exciting thing to happen to TV since color.

ACTV is a single-channel, NTSC-compatible, widescreen, extended-definition television system. It has features that set it apart from any of the other high-definition systems proposed to date, including NHK's MUSE, Philips' HD-MAC, or the Del Rey Group's HD-NTSC. (For background information on those HDTV systems, see the August 1987 issue of **Radio-Electronics**.)

The most important feature of ACTV is that the high-definition picture can be delivered within the existing 6-MHz NTSC broadcast channel. And ACTV is completely compatible with today's TV sets. Of course, a standard NTSC receiver can't display a high-definition picture, but it can display an ACTV picture with the same quality as it can display an NTSC one today.

On the other hand, a high-definition ACTV receiver would display a picture with 1050 lines per frame (that's double the 525 we get today). Its aspect ratio—the ratio of the picture's width to its height—is 5:3, which is close to that of motion pictures, and a far cry from NTSC's 4:3 aspect ratio.

How it works

Figure 1 shows how ACTV delivers what no other system has been able to. The process starts with a high-definition signal, which is separated into four components. The four components are processed and recombined into a single NTSC-compatible signal for both standard and ATSC receivers.

The first component of the high-definition signal is the main NTSC signal, which contains the center panel of the widescreen picture. The low-frequency information of the side panels is also contained in the first

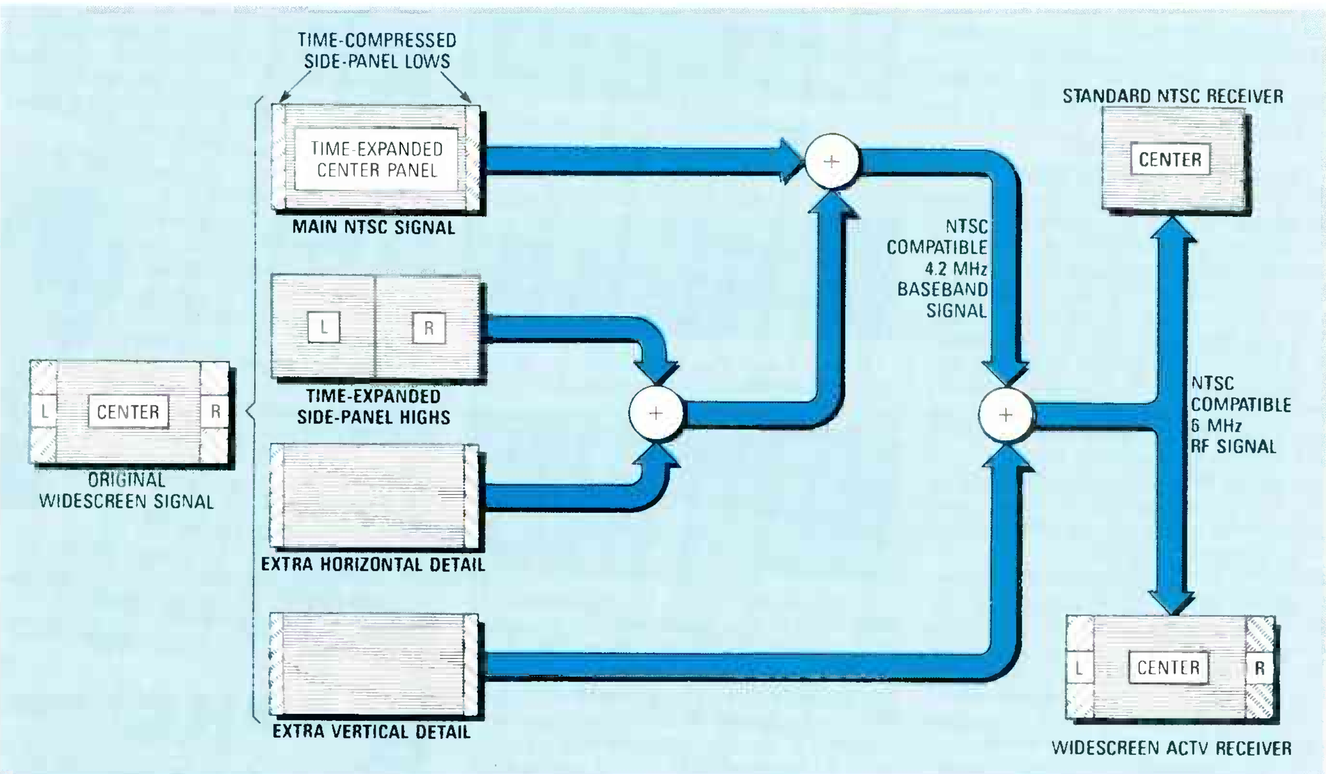

FIG. 1—THE ACTV SIGNAL starts with a widescreen picture that is separated into four components. Those components are digitally processed and combined using quadrature modulation techniques into an NTSC-compatible 6-MHz RF signal.

component, but it is time-compressed and forms a narrow band on each side of the picture (which is hidden by the normal overscan in home receivers.)

The second component of the ACTV signal contains the high-frequency information of the side panels. It is combined with the third component, the extra horizontal detail. Those three are digitally processed and then combined into a single NTSC-compatible baseband signal, which is then combined with the fourth component, the extra vertical detail, on the RF carrier.

NTSC still survives

Today's NTSC standard was developed in the early 1940's by the *N*ational *T*elevision *S*tandards *C*ommittee. Considering that the standard was developed for black-and-white TV, it is truly amazing that the advances in TV technology we've seen since that time—such as color, stereo sound, and teletext—have been developed within its framework.

With the investment in television transmitting and receiving equipment estimated at $100-billion, a compatible system is certainly desirable. But until the Sarnoff/NBC announcement, most had considered that goal to be unachievable.

NTSC compatibility is a tremendous benefit to viewers and broadcasters alike. It gives a consumer the option of keeping his current TV set—with no degradation in picture quality—or of buying a new TV set to receive the improved picture. And each broadcaster can decide when he is ready for the change.

But not all of the players in the HDTV game are concerned with compatibility. The cable-TV industry, for example, does not have the same spectrum-conservation concerns as TV broadcasters. It's possible that they wouldn't mind having an exclusive HDTV system to call their own. In fact, the cable industry is studying a plan to use fiberoptics to distribute programing —perhaps high-definition cable programming. That, in the words of a cable-industry executive, would give cable "enormous advantages over broadcasting."

The Sarnoff research center has

continued on page 66

You've probably seen advertisements from other electronic schools. Maybe you think they're all the same. They're not!

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That's exactly what happens with CIE's Auto-Programmed Lessons. Each lesson uses famous "programmed learning" methods to teach you important principles. You explore them, master them completely, before you start to apply them. You thoroughly understand each step before you go on to the next. You learn at your own pace.

And, beyond theory, some courses come fully equipped with electronics gear (the things you see in technical magazines) to actually let you perform hundreds of "hands-on" experiments.

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AUTOMOBILE BATTERY MONITOR

In Alaska, where I live, it's important to keep a constant watch on the car's battery voltage. My new car's dashboard has digital instrument displays, but it lacks a voltmeter. Obviously, I would prefer to add a digital device. Any suggestions?—F.R., Juneau, Alaska

Figure 1 shows a simple and inexpensive digital monitor system that was published in the December 1976 issue of *Electronic Engineering*. Three colored LED's keep track of the car's electrical system voltage. The circuit uses four switching transistors, a couple of Zener diodes, and red, yellow, and green LED's to indicate four voltage levels.

When the red LED alone is lit, the battery voltage is below 10. That is a serious condition and indicates an electrical-system malfunction. At 11 volts, both the red and the yellow LED's are lit. At 12 volts, the yellow LED alone is lit. The yellow and green LED's both are lit when the voltage reaches 13. Above 14 volts, only the green LED is on.

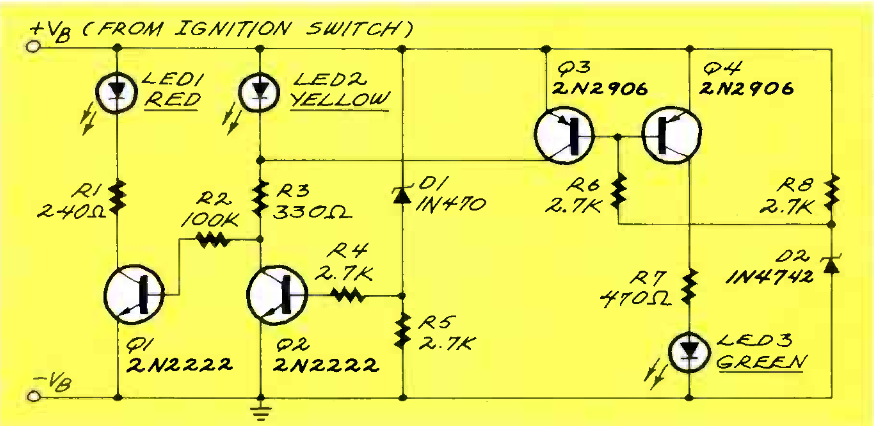

FIG. 1

WHAT'S A CROWBAR?

I've seen the word "crowbar" used in an electronics context. I don't know what it means and I can't find a definition that sound reasonable. A friend says that it amounts to throwing a short-circuit across the output of a power supply. Is that correct?—T.B., Greensboro, NC

A "crowbar" is an electronic circuit that monitors the output voltage of a regulated power supply and immediately throws a short circuit or "crowbar" across the output whenever the voltage rises above a preset level.

Many semiconductor devices are designed to operate from supply voltages that are only a few volts lower than an absolute maximum voltage. For example, the nominal supply voltage (V_{CC}) for all TTL devices is +5 volts with a ±5% (250 mV) tolerance, while their absolute maximum rating is 7 volts. Above that level, a TTL device can be destroyed or its serviceability seriously impaired.

A 5-volt regulated supply is often derived from an unregulated 8-volt or higher DC supply. If the series-voltage regulator fails, the full unregulated voltage is applied to the load, destroying any TTL or other voltage-sensitive devices.

Figure 2 shows a series-voltage regulator with crowbar components (fuse F1, SCR1, D1, and adjustable resistor R1) added. The Zener diode is selected for a voltage rating just below the specified V_{CC}. Resistor R1 is adjusted so that the SCR gate voltage remains just below the conduction voltage as long as the regulated output voltage remains below 5.85.

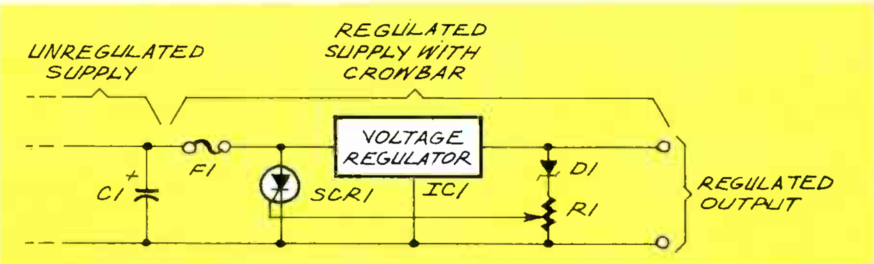

FIG. 2

If the output voltage rises above the preset limit, the SCR fires and short-circuits the unregulated supply's output and, almost instantaneously, removes the voltage from the logic load. The fuse blows and protects the components in the unregulated supply from possible damage caused by the short circuit.

The SCR is used because of its

continued on page 33

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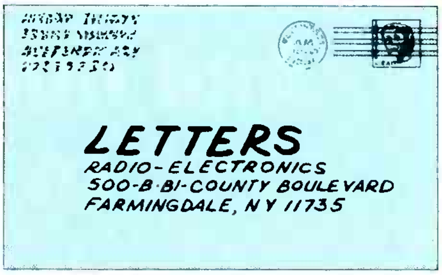


DIGITAL DASHBOARD

I would like to notify builders of the "Digital Tachometer" and "Digital Speedometer" (**Radio-Electronics**, June and July 1987) of a fix for a possible problem that they may have encountered.

After several units were built using IC's from different manufacturers, a problem developed that caused the digital readout to occasionally jump to a reading of "000" during normal operation. That timing problem can be corrected by soldering a .001-µF capacitor across pins 8 and 10 of IC7 on the tachometer; across pins 11 and 13 of IC5 on the speedometer.

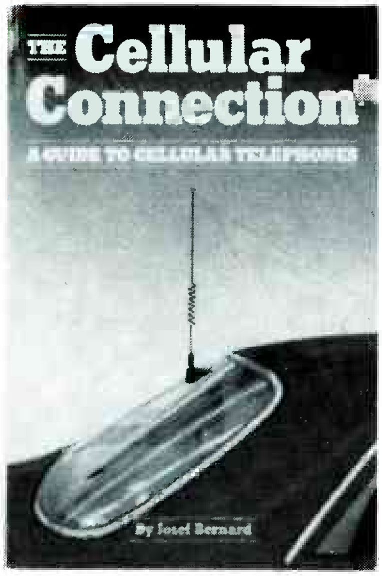
The cause of the problem is that the MC14553 needs a minimum amount of time between the latch and reset pulses. If the CD4001 NOR gate used to build the projects is too fast—has too little propagation delay—the reset pulse will arrive before the internal latches have stabilized and locked in the current reading.

My apologies go out to anyone who has been struggling with that problem.
ROSS ORTMAN
Dakota Digital

CELLULAR PHONES

It was good to see my article, "All About Cellular Telephone," in the September issue of **Radio-Electronics**. You need all the information you can get to keep up with that rapidly expanding sphere of communications.

Readers interested in learning still more about cellular phones, and the cellular system in general, will find what they're looking for in my book, *A Guide to Cellular Telephones*, available at Radio Shack stores. If you can't find it locally, a



basically similar one, *The Cellular Connection*, can be purchased by mail from Quantum Publishing, Inc., Box 310, Mendocino, CA 95460. The cost is $9.95, plus $1.50 for postage and handling.

Keep up the good work in informing the public of what's going on, and what's coming up, in the world of electronics.
JOSEF BERNARD

AUDIO DROPOUTS

Larry Klein's theory as to why there is dropout of audio signal at the beginning of cassette tapes ("Audio Update," **Radio-Electronics**, August 1987) was interesting. Subsonic overload could well be the problem for some—or most—cases. Having suffered that problem myself, I decided to investigate, and I've come up with my own theory about the broken-up audio at the beginning of cassette tapes.

I was using high-quality 90-minute audio-cassette tapes to record source material. When replaying them, the audio would sound uneven and slightly garbled near the beginning of each tape, and would sometimes blank out very briefly. Invariably, the audio dropouts occurred only at the start of the tape, whether or not that corresponded to the start of the record. At the instant the dropout occurred, I stopped and removed the tape to look at it. What I found each time, on approximately a dozen tapes, was that at the instant of the dropout there were little lines, resembling thin ridges or dents, crossing the recording tape in the middle of the cassette shell (where the tape would be above the tape head).

Take out a cassette and examine the first few inches of tape past the leader and you'll see what I'm referring to. I never had a dropout occur where there was no dent. Those dents apparently make the tape briefly lose contact with the head, causing the dropout.

As far as I can determine, the dents are caused by the overlap of the tape when it is being wound onto the hub in layers. It is apparently due to the non-uniform thickness where the leader attaches to the recording tape, because the lines seem to align with the places of thickness-change in the leader/tape junction area. As more layers are wound on, the effect would, of course, decrease. That would explain why the dents and dropouts do not occur in the middle of the tape. Does that sound reasonable?
MARK S. HAYWORTH
Tuscon, AZ

Mr. Hayworth's specific problem—and its cause—are well explained in his letter. I'm surprised that any better-grade cassettes manifest the problem, as most manufacturers take special precautions to avoid bumps where the tape is attached to the leader or hub. Subsonic overload is, nevertheless, the major cause of the dropout symptoms that I described in the August issue.—*Larry Klein, Audio Editor*

BLUE BOXES

Having just read Herb Friedman's article, "The Blue Box and Ma Bell," (**Radio-Electronics**, November 1987) I am convinced that he knows very little about *Automatic Message Accounting* (*AMA*) in particular, and the phone company's use of it in general.

For instance, customer billing through the use of electromechanical meters has been used since the turn of the century. The photographing of the meters started in the early 1920's. AMA came into being in 1948, as a natural adjunct to a new telephone-switching system, namely Number Five Crossbar. (Number One Crossbar used the meters for billing at that time, as did other types of switching systems.) Thus, the introduction of AMA was evolutionary—not a direct result of customer complaints.

The AMA system was not designed to record the details of local calls. It simply recorded the number of message units for message-rate subscribers, exactly as the electromechanical meters did. Flat-rate local calls were by far the most numerous, and they didn't need to be recorded because there was no charge associated with them. (Subscribers served by AMA could have their billing complaints resolved by being connected to a special circuit that forced the AMA to record local-call details.) Knowing that, it seems that Ma Bell was telling the truth when she said there was no detailed record on local calls.

One AMA billing center handled the output of scores of AMA offices on a three-shift basis using electromechanical computers. To imply that sorting through millions of call records to trace criminal or obscene calls was a simple task shows a lack of familiarity with the system. Besides, most obscene calls are of local origin, and no record is generated.

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Finally, the mention of service observing and the reference to Senator Dodd had nothing to do with the Blue-Box story. It was Senator Long of Missouri who conducted the investigation to which the article referred. Ma Bell had many types of switching equipment and a variety of crossbar switching types. I have never seen detailed instructions or even a so-called manual. (Switching offices were described in documents known as "Bell System Practices.")

RICHARD R. PLUM
Bell Communications Research
Red Bank, NJ 07701-7020

The manual shown in Fig. 1 of the article is a Bell manual, and it details the AMA billing procedures—including detailed local calls. The Number Five Crossbar manual had the circuit and recommended monitoring procedure for operators.

In the New York area, at least, the local office had the AMA. It wasn't handled by just one billing center.

Senator Dodd handled the investigation of the Westchester County Fire Department telephone delay, at which subscriber monitoring was first mentioned in the media.—Herb Friedman

FREEDOM OF PRESS

Thank you very much for your October 1987 cover story, "Build This Laser Listener." I strongly disagree with Mr. Mim's criticisms (Letters, November 1987.) The people have a right to know everything. Crooks have access to the information, so nothing is lost—and much is gained—by letting the rest of us know also. We gain the awareness of the existence of those devices, and how they are designed. Design details are critical because they let you know how the device is used, how it looks, and what its capabilities and limitations are.

It's refreshing to know that 200 years after the signing of our Constitution, you can still find freedom of the press alive and well in publications such as **Radio-Electronics**. You also provide an important service by helping to keep electronics a rewarding and fascinating profession and hobby, and by keeping the public informed about new technologies, products, and techniques. With the ever-increasing technological competition world-wide, and the slippage of our educational system, you do a tremendous service to our country.

I also found "The Blue Box and Ma Bell" (**Radio-Electronics**, November 1987) to be well-written and most informative. However, it has one glaring mistake—the Red Box, also described in the article, is the Black Box. The Red Box was used to generate tones that emulated those made by coins deposited in payphones to place free payphone calls. I would have liked to see a little on Captain Crunch and others who "pioneered" boxing; more explanation on the effects of ESS, automatic tone monitoring and computerized billing on boxing; and at least a tabulation of the many other phone color boxes.

JOHN J. WILLIAMS
Alamogordo, NM

SURFACE-MOUNT TECHNOLOGY

The first article in your November 1987 special section on *Surface Mount Technology* (SMT) correctly points out the advantages of working with components that have no wire leads to cut, bend, etc. If SMC's do become the standard in the 1990's, then home experimenters, as well as engineers working in R&D labs, will need a method to quickly evaluate circuits—as we do now with breadboard matrixes designed for "standard size" components (100-mil spacing.) The tremendous savings in time and money that breadboarding provides cannot be overstated.

A possible solution might be a series of rugged, close-tolerance, machined sockets made to fit each SOP, combined with a new breadboard matrix with 50-mil centers to match the new SO devices. Any reluctance to familiarize oneself with SMT would be greatly reduced if a system for evaluating those circuits designed with SMC's could be demonstrated as practical.

DANIEL KATZNELSON
Danielson Electronics
Willingboro, NJ

R-E

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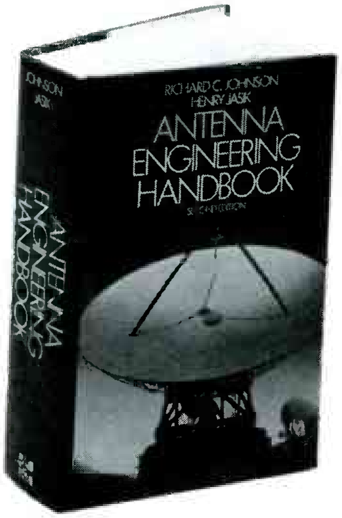

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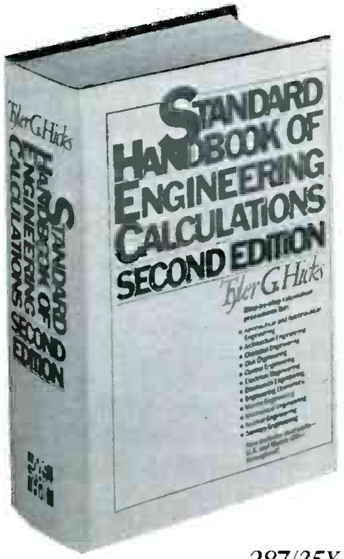

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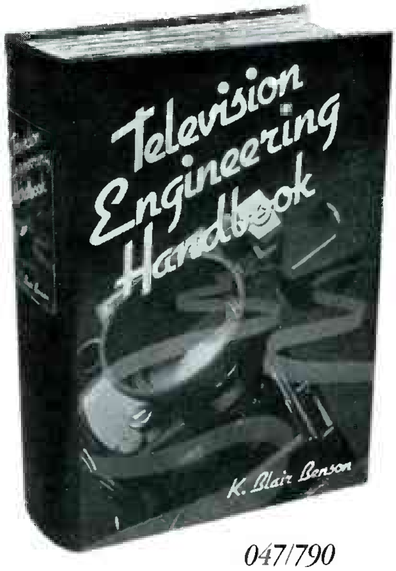

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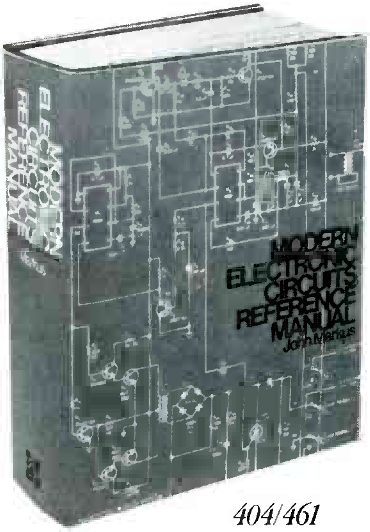

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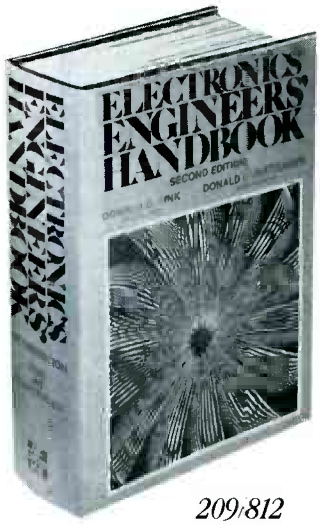

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Heath GR-9009 Portable Color TV

A 9-inch set you can build yourself

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COLOR TV'S USED TO BE AMONG THE most popular types of electronic kits. While they are not as popular as they once were, there are still a few models available. This month, we take a look at the model *GR-9009* 9-inch portable color-TV kit from the Heath Company (Benton Harbor, Michigan 49022).

The *GR-9009* offers a most of the features that you would expect to find on a modern TV, such as a 178-channel tuning capability, quartz-controlled electronic tuning, programmable up/down channel scanning, and an auto-control color system. We'll say more about those features later. First, let's see what it's like to go and build a TV set.

Putting it together

The kit contains six major circuit boards or modules. Despite the fact that five of the six come pre-assembled and factory aligned, there is still plenty of work for the kit builder to do. We guess that it would take the average kit builder about 10 hours to assemble the *GR-9009* from start to finish. We wouldn't recommend the kit to a rank beginner—some of the adjustments require working around high voltages. But if you have some electronics-building experience, a healthy respect for high voltages, and some patience, you should have no trouble building the *GR-9009*.

The assembly work begins with the crosshatch generator board—the only circuit module that must be assembled from scratch. Heath couldn't make building that module any easier. Many of the parts are supplied on taped strips, in the order that they are called for in the assembly instructions. The most difficult task is wiring and assembling a pair of connectors that connect the crosshatch generator to the TV set's main module. Connecting the free ends of the wires to the main module is difficult, because that preassembled module has no provision for the connections. The six wires must be crimped and soldered to component leads on the main module.

That situation is not as strange as you might think. The pre-assembled modules are the same as are used in Zenith factory-built TV sets. Therefore, when you're finished building Heath's kit, you end up with what is essentially a Zenith TV, with the addition of a crosshatch generator that you must use for purity and convergence adjustments.

Most of the rest of the assembly work consists of mounting pre-assembled modules—such as the keyboard/channel-display module, the tuner module, and the power-supply module—to the cabinet chassis. The picture tube must be mounted to the cabinet front, and the video-output module is mounted to the rear of the picture tube.

Once the modules are mounted, they have to be connected to each other. Pre-wired and labeled cable assemblies make what could be a very tedious job pretty easy. More important, pre-wired assemblies greatly reduce the chance of error.

When you complete the inter-module wiring, it's time to turn the TV on and begin the adjustment procedure. Those adjustments call for caution. Many of the heatsinks are electrically hot. And, of course, very high voltages (up to 18,000 volts) are present at several points of the set's circuitry. A respect for high voltages and a knowledge of electrical safety practices are the only essential ingredients that must be supplied by the kit builder.

Once the purity, centering, convergence, and other adjustments are completed, and the final assembly is finished, you're ready to sit back and enjoy some of the features that the *GR-9009* has to offer.

Features of the set

The set's 178-channel tuner accepts signals, through a single 75-ohm connector, from VHF, UHF, MATV, standard CATV cable systems, or HRC (*H*armonically *R*elated Carrier) or IRC (*I*ncremental *C* oherent Carrier) cable systems. The set has a fixed AFC and adds a "search" AFC mode that can be used to electronically tune in frequencies that vary from FCC standards. It's most useful with some video games and cable systems.

All channel, band, and mode se-

continued on page 38

ASK R-E

continued from page 22

ability to carry the short-circuit current and because it can react to the over-voltage condition faster than a fuse.

HUM PROBLEM

I have a Sharp *RT-3388A* stereo cassette deck and two Carver magnetic field-effect amplifiers that I use in a portable disc-jockey system. The setup has to be very compact so the tape deck is only about six inches from each of the amplifiers. The amplifiers induce a hum in the deck that is easily heard over the speakers. The tape head is not shielded and a shielded replacement doesn't seem to be available. How can I eliminate the hum?—P.S., Belle Plaine, MN

We are not familiar with the physical design and placement of the parts in the three components in question. No doubt you tried temporarily reorienting the amplifiers and also moving them away from the tape deck, so that you can be sure that the hum is caused by 60- or 120-Hz voltages induced in the playback head by magnetic fields around the amplifiers.

If you are sure that the hum is induced, and greater separation between deck and amplifiers is not practical, try magnetic shielding. Take a sheet of thin, soft, sheet iron and shape it so that it can be inserted between the parts of the amplifier and the tape head. Try placing it in the different positions between the amplifier's transformers and the tape deck—each time making sure to ground the shield securely to the amplifier chassis.

You want to be sure that the magnetically induced hum is not masking a hum that can develop when two or more sensitive audio components are connected together and to a common power line. First, connect a good electrical ground between the three chassis. Plug the tape deck and one amplifier into the AC line. While monitoring the hum level, try reversing the AC-line plugs, one at a time. Finally, plug in the remaining amplifier, reversing its plug if necessary for minimum hum. **R-E**

NEW PRODUCTS

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INTEGRATED SECURITY SYSTEM. The The Heath-Zenith model *SS-5810* is designed for trouble-free installation and is ready to use "out of the box" as the motion sensor is built into the unit. It uses advanced passive infrared (PIR) technology to monitor movement in a large room or office. If desired, it can be transformed into a complete home-security system by attaching a number of different alarms, which may be hard-wired to the system.

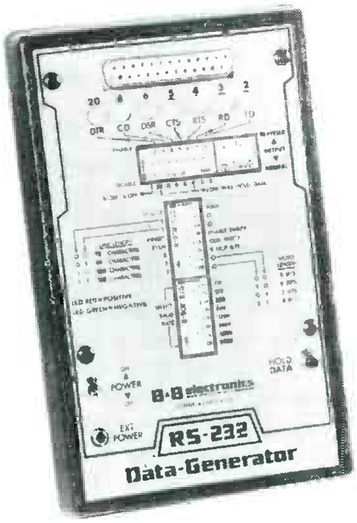
The unit contains features that are usually found in top-line security systems—like the tamper-proof alarm that's activated if the unit's back cover is removed. By adding magnetic contact switches, smoke alarms, and additional infrared motion sensors in other areas of the home or office, the unit is able to monitor virtually all areas of a home, office, apartment, or condominium.

The model *SS-5810* is priced at $149.00.

Three further PIR products are the model *SL-5320* Motion Sensor Light Control; the model *SI-5910* Wireless Motion Sensor Light Control, and the model *SS-5910* Wireless Security System.—**Heath-Zenith**, Hilltop Road, St. Joseph, MI 49085.

DATA GENERATOR. B&B Electronics' model *232DG* outputs ASCII data in various combinations of line length, baud rate, parity, number of stop bits, and word length. The output may be inhibited via Data Terminal Ready (pin 20), or Request to Send (pin 4), or by X-on and X-off. The status of Clear to Send (pin 5), Data Set Ready (pin 6), and Carrier Detect (pin 8) all may be controlled by using the switches.

In the ASCII mode, the model *232DG* produces all of the printable ASCII characters including space: A 2716 PROM is used to store those characters and may be reprogrammed for custom test patterns, or used for sending messages. In the U-U-Mode, the model *232DG* outputs the letter "U" constantly. That is a square wave at one-half the selected baud rate and represents a good "worst case" test. The Output Switch will allow the user to output data on pin 2 or pin 3. The model *232DG* uses a 9-volt battery (not included with the Data Generator). Also, an optional AC power supply is available that can be used to replace the battery.



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The model *232DG* is priced at $199.95. The model *232PS* Optional AC Power Supply costs $14.95.—**B & B Electronics Mfg. Co.,** 1500 Boyce Memorial Drive, P.O. Box 1040, Ottawa, IL 61340.

LIGHTNING-SURGE ARRESTOR. The Spi-Ro model *LA-4* is designed specifically for use on TV's, VCR's and satellite-receiver systems. It uses a gas-filled discharge element that is very sensitive to unwanted transients that may appear

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on the antenna line, incoming cable, etc. The model *LA-4* diverts unwanted surges (such as lightning) away from the equipment and to a safe ground. The unit fits all equipment that uses the standard "F-type" connector. It is priced at $19.95.—**Spi-Ro Manufacturing, Inc.,** P.O. Box 1538, Hendersonville, NC 28793.

CORDLESS MOTO-TOOL. The Dremel *Freewheeler,* is available in tool-only and kit forms. The model *850* includes the *Freewheeler* cordless moto-tool and charger; the model *8500* includes the tool, charger stand, and 30 accessories. A keyless chuck is included with the model *850* as a special introductory offer—a $5.00 retail value—and is standard with the model *8500* kit.


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The suggested retail price for the model *850* is $59.99; the suggested price for the model *8500* is $79.99.—**Dremel,** 4915 Twenty-first Street, Racine, WI 53406.

TACK KIT. Chemtronics' *Micro Bond Tack Kit* includes a 5-ounce no-spill squeeze bottle of Micro Bond #200 cyanoacrylate adhesive, a Teflon applicator needle, and a Micro Bond activator pen. The kit provides fast, reliable wire tacking and component bonding to printed-circuit boards—resulting in a low PCB profile that prevents damage due to sagging wires or loose components.

Each kit contains enough adhesive for approximately 800–1000 drops of "tacks." Other uses for Micro Bond include repairing control knobs, radio and TV parts, cameras and business equipment, as well as bonding other metal, plastic, glass, ceramic, and rubber surfaces. The *Micro Bond Tack Kit* is priced at $9.40.— **Chemtronics, Inc.,** 681 Old Willets Path, Hauppauge, NY 11788.


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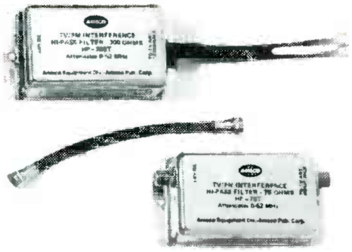
HIGH PASS FILTERS. The Ameco *HP-75T* and the Ameco *HP-300T,* are laboratory-type instruments,



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containing nine sections in five shielded compartments, and are designed to eliminate interference from amateur, CB, and short-wave radio; appliances and industrial equipment; electrical storms and auto ignition; diathermy and X-ray equipment, and police radio and paging systems. They are priced at $12.95 each.—**Ameco Equipment Company,** 220 E. Jericho Turnpike, Mineola, NY 11501.

CRT READOUT OSCILLOSCOPE. The Leader Instruments' model *LBO-2060* allows the user to observe waveforms, setting conditions, and measured values on a single display. It reduces setup time by displaying setting conditions such as CH-1 and CH-2 sensitivity, main and delayed sweep time, and triggering controls.

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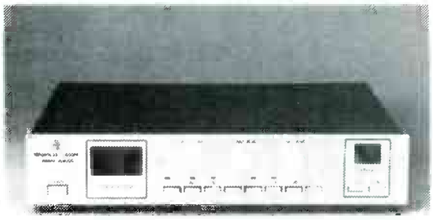
The on-screen cursors provide the user direct reading of measured values, as well as making the unit extremely user-friendly and simple to operate. They provide direct readout of voltage difference in volts and percentage, time difference in seconds and percentage, frequency in Hz, and phase difference in degrees.

The model *LBO-2060* is priced at $1490.00.—**Leader Instruments Corporation,** 380 Oser Avenue, Hauppauge, LI, NY 11788. **R-E**

Radio-Electronics mini-ADS



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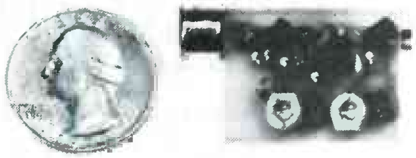

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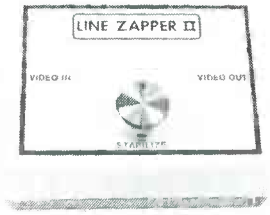

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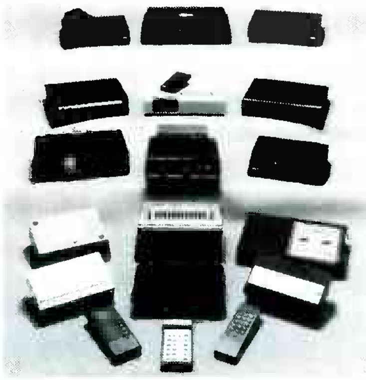

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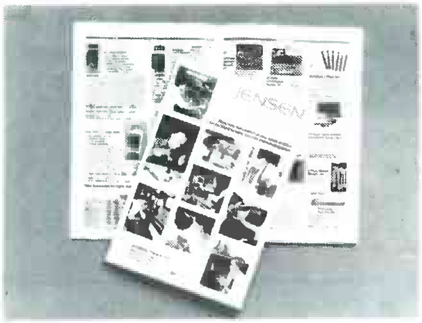

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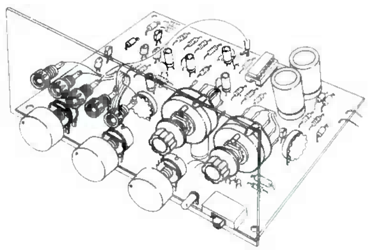

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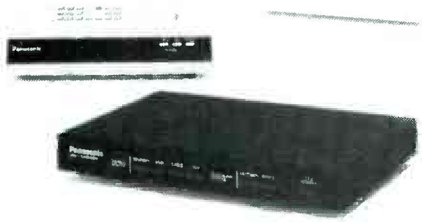

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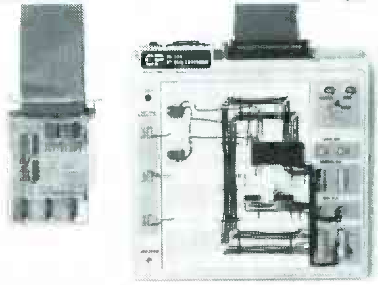

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CIRCLE 193 ON FREE INFORMATION CARD

EQUIPMENT REPORTS

continued from page 32

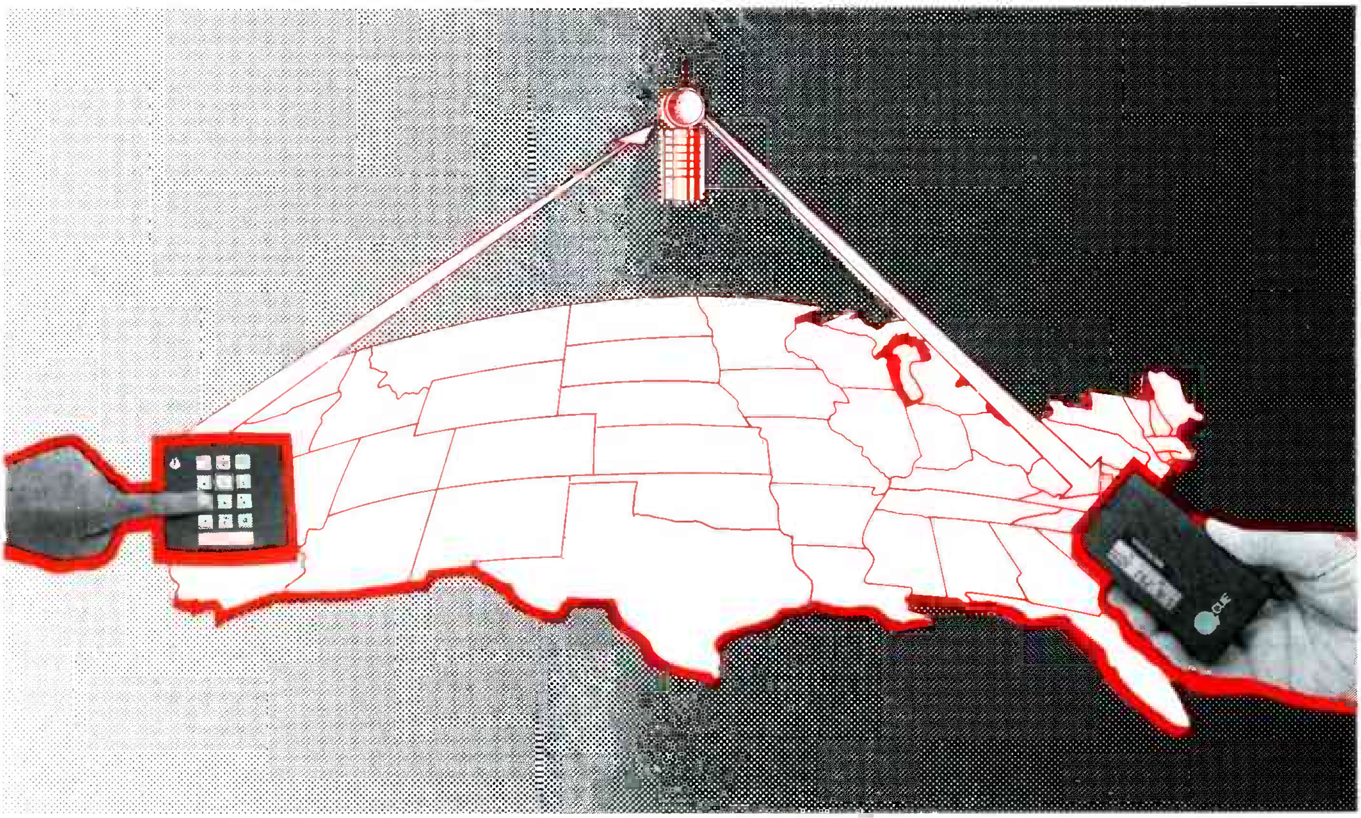
lection is done from the front-panel keyboard. Direct channel entry is possible, as is up-and-down channel scanning. The channel scan can easily be programmed by the user to pass over unused or unwanted channels.

The portable TV can be powered from either 120 volts AC or 12 volts DC, and two power cords are supplied. (The DC cord terminates in a cigarette-lighter plug.) Other accessories include a removable tinted sunscreen, and an earphone for private listening. The picture tube is a *Chromacolor Contrast* type; that type of tube has a black matrix surrounding each phosphor element. Our picture was sharp with high contrast.

The *GR-9009* has a suggested retail price of $249.95. Why would you build a TV kit that when you could buy a preassembled TV for less? If you've asked yourself that question, then you are not a kit builder. Assembling a kit can be a lot of fun. And the advantages are not limited to being able to proudly say "I built it myself."

With the Heathkit manual, you really can learn about the TV's circuitry and how it works. If problems arise in the future, you will feel confident about going in and doing something about it—even if it is just replacing a module with a Zenith equivalent. And if you want to modify your receiver, you'll find the clear schematics and circuit descriptions a great help. But remember that any user modifications will void your warranty, and you will not be able to obtain servicing from Heath.

We know you're all probably wondering if our *GR-9009* worked the first time we powered it up. Well, we were very surprised when it didn't—past experience taught us that if we followed the Heathkit instruction manual, everything would work. At least we had a chance to try out the manual's troubleshooting charts. Using them, we found the problem in less than five minutes. If the problem had turned out to be more perplexing, we could have used the telephone help line. That line is available only to purchasers of Heath kits and is manned by a technician who can quickly track down most problems. **R-E**



A NATIONAL RADIO PAGING SYSTEM

You can run but you can't hide—from satellite paging

HERB FRIEDMAN, COMMUNICATIONS EDITOR

IT WAS A DARK AND STORMY night...somewhere back down the road Snoopy had fallen out of the family's pickup truck, and Charlie Brown had just discovered he was gone. Faster than Clark Kent changing to Superman, Charlie Brown rushed to a roadside telephone booth, punched in an 800 telephone number plus a few more digits, and out in the night Snoopy heard a small brown box on his belt go *beep...beep...beep...beep*, and when he looked down at the box he saw the telephone number of Charlie's phone booth. A quick call and Snoopy was rescued.

Snoopy's rescue worked like this. The 800 number that Charlie called is the free access for the Cue Paging Corp.'s (Box 7789, Newport Beach, CA 92658.) *national* paging system. Cue Paging uplinked the next set of *Touch-Tones* punched in by Charlie Brown—which represented the access code for Snoopy's "brown box" pocket-pager and the telephone number of Charlie's phone booth—to the Westar 4 satellite. Across the U.S., satellite downlinks sent the data signals to more than 100 FM stations, which rebroadcast the data on a 57-kHz SCA subcarrier.

Meanwhile, the pocket-pager on Snoopy's belt, which is a scanning FM receiver with a 12-digit LCD display, was searching for an FM station that was broadcasting a 57-kHz SCA subcarrier modulated with Cue Paging's *attention code*. (The attention code is broadcast so the receiver can distinguish between a Cue Paging subcarrier and all others). The receiver's tuning locked onto the FM station having the strongest Cue Paging subcarrier. When the FM station broadcast Snoopy's access code, the receiver beeped and displayed the data, which was the telephone number of Charlie Brown's phone booth. When Snoopy heard the beep, he simply looked at the receiver's LCD display and saw Charlie's telephone number.

A lot of technology.

As you can gather from our comic-strip scenario, many high-tech disciplines go into nationwide radio-paging. Figure 1, which is a pictorial of the system, gives a better idea of the various technologies used.

Assuming you're the subscriber, the system works this way. Anyone who wants to reach you—even if they have no idea whether you're around the block or on the other side of the continent—uses their *Touch-Tone* phone (1) to dial a toll-free 800 number that accesses Cue Paging's computer (2) in Virginia. Depending on where the telephone is located and the long-distance carrier used by the 800 connection, the telephone signal travels to the computer via ordinary telephone wires, fiber optics, micro-

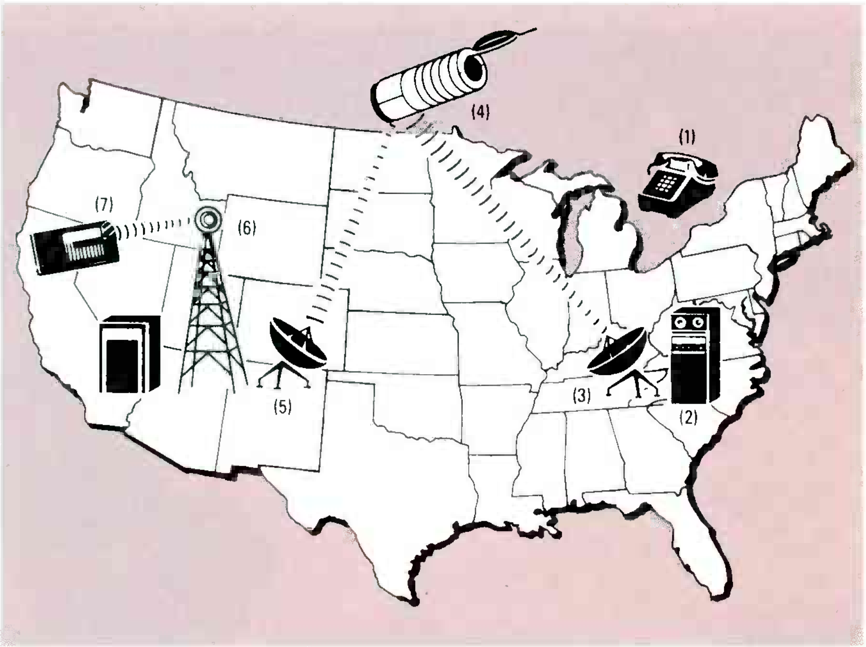


FIG. 1—NATIONAL RADIO PAGING depends on FM stations rebroadcasting the data received from a satellite.

wave, satellite link, or any combination of communication paths. A digitized voice from the computer asks the caller to input the subscriber's access code. A tone beep informs the caller that the computer has recognized the code will accept 12 *Touch-Tone* digits, which can represent a telephone number, or anything else (like a secret code).

The data representing the access code and up to 12 digits is stored in the computer for possible *Voice Message Retrieval* (we'll explain that later) and sent to a Westar 4 satellite uplink (3). The Westar 4 satellite (4) downlinks the signal to local or regional satellite receiving facilities (5), which send the data to one or more local FM stations (6) via telephone, radio relay, or a microwave link.

For example, because of its unusually large metropolitan area and its "canyons" created by many tall buildings, New York City requires several Cue Paging SCA stations for complete coverage (right down into the subway system). The satellite signal is received by WQXR's SRO (*S*atellite *R*eceive *O*nly), which passes the signal along to WCBS by conventional radio line. Another paging station, WNYE, get's its paging data feed from a special receiver that is tuned to the WCBS SCA.

Each FM station is equipped with automatic Cue Paging failure detection, central monitoring station notification, and a satellite-signal bypass via the telephone switched network (dial-up). We will cover that part of the system later.

Six memories

Your pocket pager (7)—called an FM/SCA Cue Unit—receives the message from a participating FM station and stores it in one of six 12-digit memories.

The Cue Unit can be set to either beep or remain silent when it receives new data. Either, way, you can read the data in any of the six memories on an LCD display and save or erase the data as desired. A memory without data cannot be read, therefore no time is wasted stepping through empty memories.

Since every FM station in the sys-

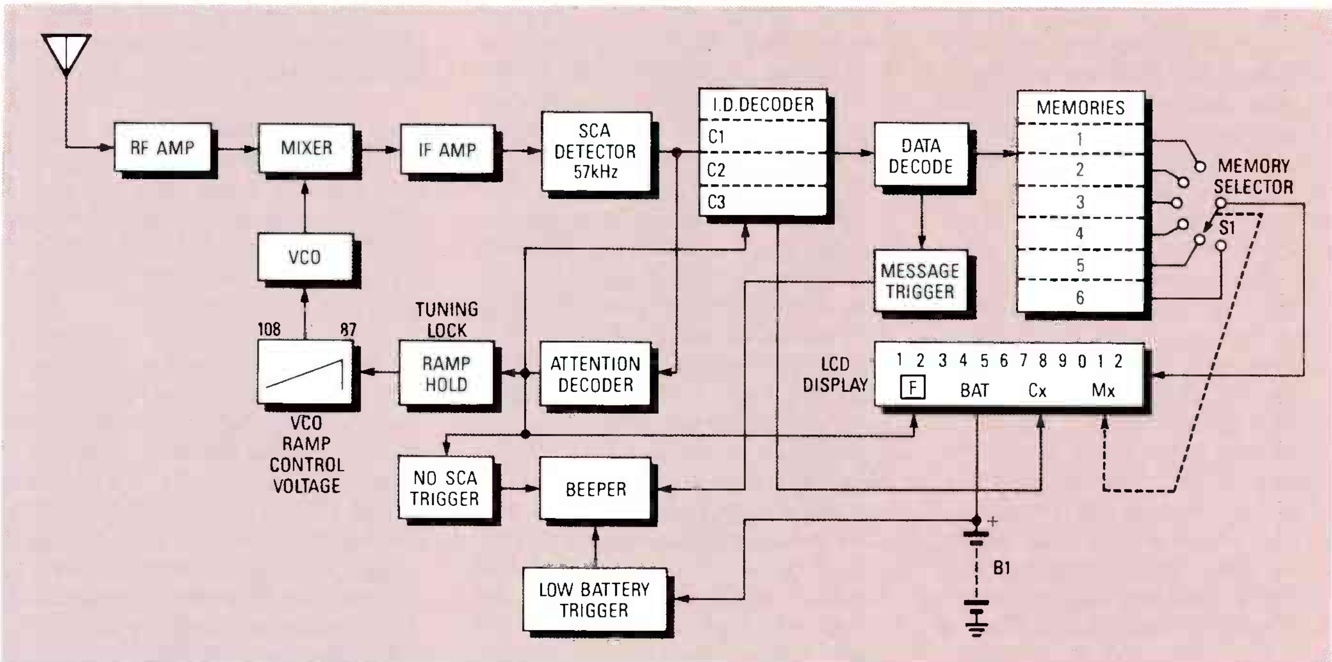


FIG. 2—THE PAGING RECEIVER'S FUNCTIONAL CIRCUIT. The six memories are arranged in a stack so that the most recent message fills the first memory, pushing the other messages down the stack until the one at the bottom, in memory 6, "falls out."

tem receives the data at the same time, you can receive your message anywhere as long as you're within range of an FM station that supplies Cue Paging. Presently, all major metropolitan areas from coast to coast are served by the system, as well as some not-so-major but important industrial areas.

Coverage is not complete, however, and there are some surprising holes in the system. For example, although we can't expect coverage in the wide-open-spaces of Montana, Wyoming, the Dakotas, and Idaho, at the time this article was prepared Cue Paging's service map showed there was no service in Virginia (outside the D.C. area), Oklahoma, and New Mexico. However, Cue Paging plans to expand coverage as FM station access permits.

The individual pieces

The Cue Unit is a special 87–108-MHz scanning receiver that is manufactured in Finland. It is powered by four 100-mAh Ni-Cd batteries that are recharged in 12 to 16 hours by a supplied trickle-charger base. A full battery charge can carry the receiver for about three days. The functional block diagram of the receiver is shown in Fig. 2. (Remember, Fig. 2 is functional for ease of understanding; it does not represent the actual digital/microprocessor circuits.)

An internal antenna feeds the received FM signal into an RF amplifier, then into the mixer and on to the IF amplifier. Tuning is done through a VCO (*V*oltage *C*ontrolled *O*scillator) that automatically sweeps the FM band. The output of the IF amplifier feeds through to a 57-kHz SCA detector, a digital identification decoder, a data decoder, the memory stack, and the LCD digital display. A sampling circuit from the SCA detector's output senses the *attention signal* of a Cue Paging SCA and locks the VCO on frequency. Assorted trigger circuits sound an internal beeper when data is received, the battery is low, or the SCA signal fails (due to low or no SCA signal strength).

ID decoder

The digital identification decoder has two functions. The first sends received data to the data decoder if it receives the "go-ahead" from the attention-signal's decoder. The second function opens the receiver's memory when it senses one of three subscriber access codes. Normally, the receiver responds to a single access code. However, the subscriber user might also want a selected group of receivers to respond to a single code: that would be a second access code. Or, a business might use several receivers having individual access codes but might want a third access code that could simultaneously activate all receivers. Presently, Cue Units can respond to three access codes.

Memory stack

The received data is fed to a 6-memory stack. A user-activated electronic switch selects a memory and feeds its data to an LCD readout. An ERASE switch allows the user to selectively clear a particular memory location.

Since the memories are arranged in a stack, new messages go into the top and push the previous messages down the stack. If all memories are full, a new message will push the message in the No. 6 memory out the bottom of the stack. For example, assume memories 1 to 6 are loaded. If a seventh message is received, it fills the No. 1 memory, causing the message in No. 1 to move into memory No. 2, etc.

FIG. 3—THE LCD DISPLAY LOOKS LIKE THIS when data is received. In addition to the numeric data, the display shows the memory it's in and the access ("C") code being used. The unit is shown in its charger base, which permits simultaneous reception and charging of the NiCd batteries.

The message in No. 6. vanishes. If one or more memories have been cleared by the user, the messages push down until the created space is filled. For example, assume the LCD readout shows all 6 memories are filled, but you clear Nos. 3 and 5. Now you have messages in memories 1, 2, 4, and 6. The next received message fills memory No. 1, which pushes 1 into 2 and 2 into 3. Memory 5 is still empty. If another message is received, everything is bumped down, so No. 4 moves into No. 5 and all the memories become filled. The data in No. 6 is still there because it hasn't been bumped when the two new messages were received. But now that all memories are full, No. 6 gets bumped out of the stack if another new message is received.

Figure 3 shows how a typical readout is displayed. Note that the display shows the memory (1) along with its data—**Radio-Electronics'** phone number—(that's when they tried to reach me while I was in Disneyworld)—and the letters "C1." C1 indicates it's my first access code, meaning the call originated at **Radio-Electronics** because they are the only ones who know my C1 access code. A C2 would have indicated my children were calling because only they have my C2 access code. A C3 would mean that the central station that is dialed by my home's security system in the event of fire, flood, break-in, or other hazard, is trying to reach me because only they have my C3 access code.

In fact, if the display shows a C3 the data doesn't have to be a call-back telephone number because I know the central monitor's phone number. They would send a special code number that represented the hazard so I would know what happened, and therefore, what person—other than the fire or police—to call for immediate action: a neighbor, a plumber, or a friend who can repair the furnace. (Twelve digits can pack a lot of information if they represent special codes rather than a telephone number.)

F for Fail

In addition to the data, memory number, and access group (C1, C2, or C3), the LCD display will also show the letters BAT when the battery power is low, and an F if the received SCA signal strength is too low to receive a reliable paging signal.

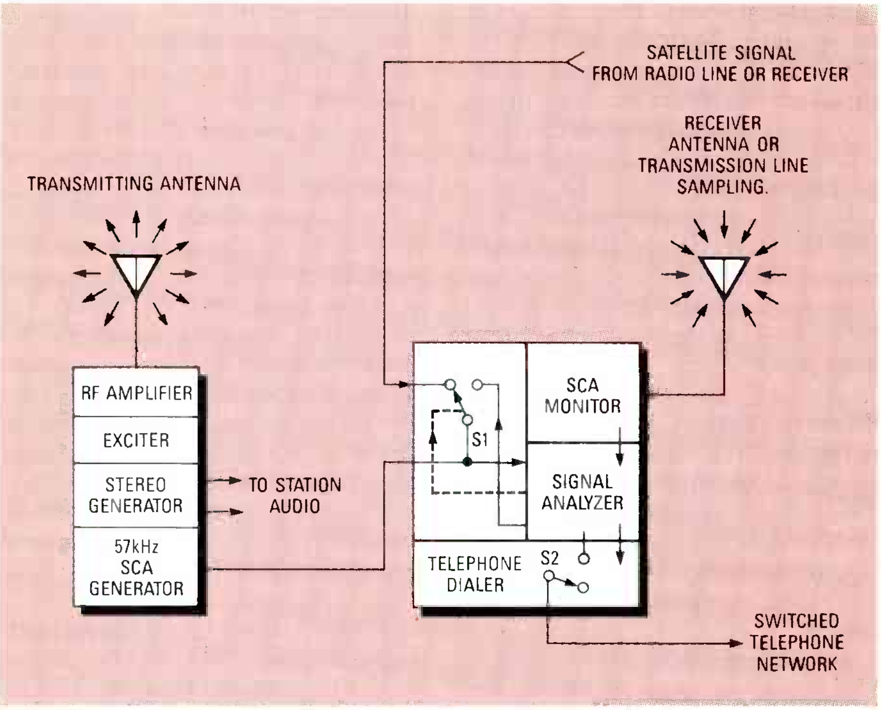


FIG. 4—THE FUNCTIONAL CUE PAGING MONITORING SYSTEM at the FM station. In the event of SCA signal failure, the equipment automatically dials a central monitor, who can instruct the equipment to switch to a dial-up telephone signal feed if necessary.


THE ACTUAL EQUIPMENT installation at WNYE-FM doesn't take up much rack space. Its Cue Page signal originates in a receiver that is tuned to WCBS.

Voice retrieval

Now it's perfectly possible that the user has been paged while his receiver was displaying an F. It is also possible that there was a failure at the local FM station, or anywhere else within the system, that would also turn on the F. Since Cue Paging transmits data only once, it is conceivable that some data wasn't received, and there is no provision to inform the user via radio that a message has been previously transmitted; so a *Voice Message Retrieval System* is provided to handle all situations where the user cannot receive a radio message.

In plain language, voice retrieval means making a toll-free telephone call to Cue Paging's computer to hear a digitized voice repeat *all* the numeric messages that had been transmitted during the previous 12 hours. Even if you had received the data on your receiver, you will hear it again if you call up the computerized Voice Message Retrieval System.

If desired, the user can use the telephone's *Touch-Tones* to selectively or completely erase the voice messages, replay a message, get the time a message was received, or store a message for up to 12 hours.

System failure

Nothing in this world is perfect, so it's possible for the FM station, or anything in the system that delivers the signal to the station, to fail. For example, the satellite receiver might fail, the radio line between the satellite receiver and the FM station can fail, etc. To handle those problems, special off-the-air monitors that analyze the Cue Paging equipment and its signal are installed at each FM station. Figure 4 shows the functional circuit of the monitoring system, which consists of an SCA monitor, a signal analyzer, and a modem/autodialer for the switched-network (dial-up) telephone system. The 57-kHz SCA generator shown as part of the transmitter in the functional diagram is actually part of the Cue Paging equipment package.

If the SCA monitor's signal shows there is some kind of problem, such as intermittent or complete loss of the SCA subcarrier, loss of the attention code, or loss of signal data, the monitoring equipment causes the autodialer to connect to a dial-up telephone line and automatically dials Cue Paging's central-station operator. The monitor also flips S2, connecting the monitoring equipment to the telephone line, and then uploads digital data from the signal analyzer that represents the various conditions at the FM station.

There are several options available to the control operator. He can try to diagnose the problem, alert the FM station's technicians, or even try to correct the condition using digital signalling. If the condition originates with the satellite signal being fed to Cue Paging's SCA modulator, the central monitoring operator can instruct the monitoring equipment to hang up and then dial into a direct-to-computer telephone link for the data until the satellite-originated data link can be re-established. The direct-dial data from the computer is fed to the SCA generator via S1.

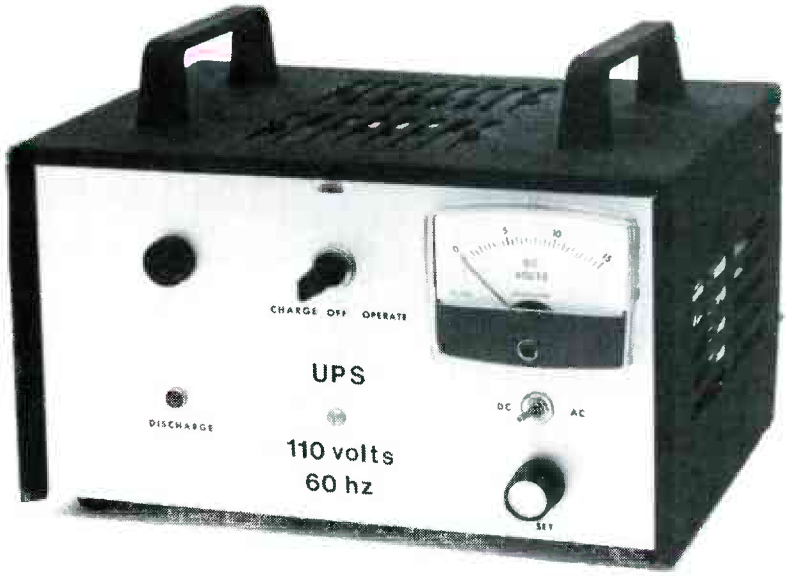
Auto-scan

Meanwhile, back at the receiver, any condition that causes the loss of proper subcarrier reception causes the receiver to display the F and to go into the scan mode. If the receiver is in an area where only one FM station is broadcasting Cue Paging, the F will continue to display and the receiver will beep intermittently to remind the user that he or she must use Voice Message Retrieval. If the receiver is in a multi-station area, it simply scans to the next station having an SCA signal that is strong enough to provide reliable reception. The receiver remains locked to the station as long as reliable reception exists.

Mars and beyond

Practically, there is almost no limit to where you can be paged. Presently, paging is national because the system uses the Westar 4 satellite. Notwithstanding the required international agreements, there's nothing to prevent paging to be done through one of the international communication satellites. Who knows, on your next trip to Lower Slobbovia the boss might decide to page you by radio—at 3 AM your time. **R-E**

UNINTERRUPTABLE POWER SUPPLY



Power failures? Don't worry! This UPS will keep your computer running when the powerline fails.

DUANE M. PERKINS

AN UNINTERRUPTABLE POWER SUPply, usually called a UPS, is one that continues to supply power when the powerline fails, and it does so without even a momentary interruption. The switchover is made so quickly that a computer connected to the UPS wouldn't even know that the powerline had failed.

A UPS's backup power is supplied by a storage battery that switches in only during during a power outage. Naturally, a backup battery isn't going to provide a full day's operation, but it will power the computer for a few minutes; certainly long enough to save whatever data is in the computer, and if necessary, allow enough time to close down in an orderly, non-destructive manner.

Sinewave output

The UPS described here can supply 40 watts continuously at 115 volts with a frequency of 60 Hz. The output is essentially a sinewave that looks to the load like standard household power. A built-in power supply functions as a battery charger. While the UPS can be used for many different purposes, it was designed specifically to power a small personal computer and a critical peripheral, such as a disk drive, so that a power failure will not result in loss of data or interruption of the program that is running at the moment. What constitutes "a small personal computer?" Something like the Radio Shack Color Computer, or a Commodore VIC-20 or C64, although the C64 when used in conjunction with a disk drive draws about 45 watts. The 40-watt UPS will not carry an IBM PC or XT or a clone, which normally run upwards of 60 watts—the actual power depending on the number and type of floppy and hard-disk drives, expansion boards, and the internal modem.

Another advantage in using our UPS is that it supplies "clean" power: defects such as noise, surges, or low voltage on the powerline will not affect the computer's operation.

The load

Before undertaking construction, be sure that the planned load will not exceed the capacity of the UPS. Current ratings for computer peripherals are maximums that may occur only momentarily when a motor starts. The author operates a Radio Shack Color Computer 2 and a disk drive even though the combined current rating is .53 amperes. The momentary overloads do not adversely affect operation. If the load can operate satisfactorily when a 25-ohm, 10-watt resistor is connected in series with one of the leads from the powerline, then it should operate from the UPS.

The power supply

The power supply is unique in that it draws energy from an external 12-volt storage battery as well as from the AC power line because the battery is required for circuit operation. As shown in Fig. 1, when CHARGE-OFF-OPERATE switch S1 is set to either the CHARGE or OPERATE position, relay RY2 is energized and its contacts supply AC power to the primaries of power transformers T1 and T2. The current from the secondaries is rectified by diodes D1, D2, D3, and D4. Chokes L1 and L2 limit the charging current to the battery and also block most of the ripple. The choke coils are available in Radio Shack's *270-030* automotive filter kit. The 220-μF capacitors that come in the kits can be used for C6 and C7. Diode D5 provides "crowbar" overload protection; its job is to protect the other components by causing fuse F1 to blow out if the battery is inadvertently connected with its polarity reversed.

Op-amp IC1 is connected as an inverting voltage comparator whose reference potential can be varied through the range of 11 to 14 volts by potentiometer R3. When the battery voltage drops below the reference, opto-coupler IC2 is triggered, which energizes relay RY1. Current flowing through RY1's contacts will charge the battery if the load is light. When the UPS is operating at or near its full capacity, an external battery charger is required to supply enough current to keep the battery from being discharged. A 10-

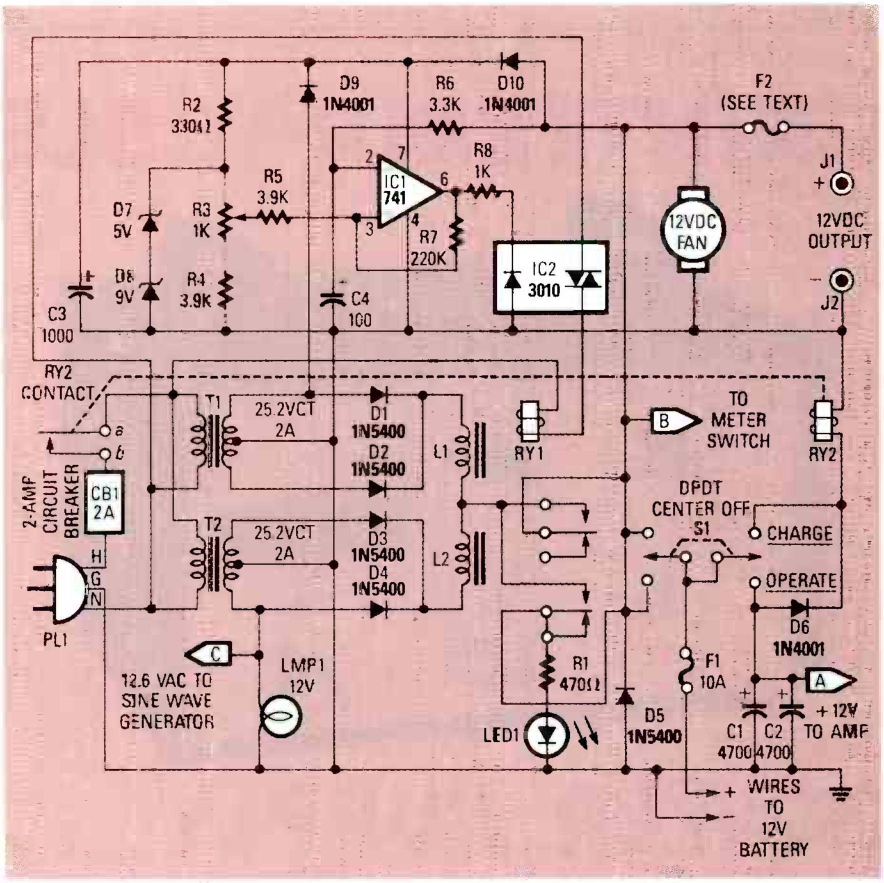


FIG. 1—WHEN THE UPS IS NOT OPERATING, or operating under a light load, this power supply also is used to charge the 12-volt battery. When the UPS is under a heavy load, however, an external 10-amp charger is needed to keep a full charge on the batteries. To prevent overcharging the battery, that charger must be turned off whenever the UPS is not operating.

ampere charger is recommended. Since most battery chargers do not have a filter, a Radio Shack *270-051* 10-amp. filter should be connected between the charger and the battery to reduce ripple. So as not to overcharge the battery, the charger should be turned on only when the UPS is operated under full load.

The 12-volt DC output at jacks J1 and J2 can be used to power a small lamp and possibly a small 12-volt TV receiver for use as an emergency monitor. Fuse F2 should be smaller than 10 amps so that the main fuse, F1, will not blow if the 12-volt output is accidentally shorted.

The amplifier

As shown in Fig. 2, the AC output of the UPS is supplied by a transformer-coupled Class-B amplifier. The four pairs of Darlington-connected transistors (Q4–Q8, Q5–Q9, Q6–Q10 and Q7–Q11) function as emitter-followers to supply voltage to the primaries of power transformers T5 and T6, which are standard power transformers connected in reverse—the secondary windings serve as the primaries and vice versa.

Capacitor C8 filters any high-frequency components that result from

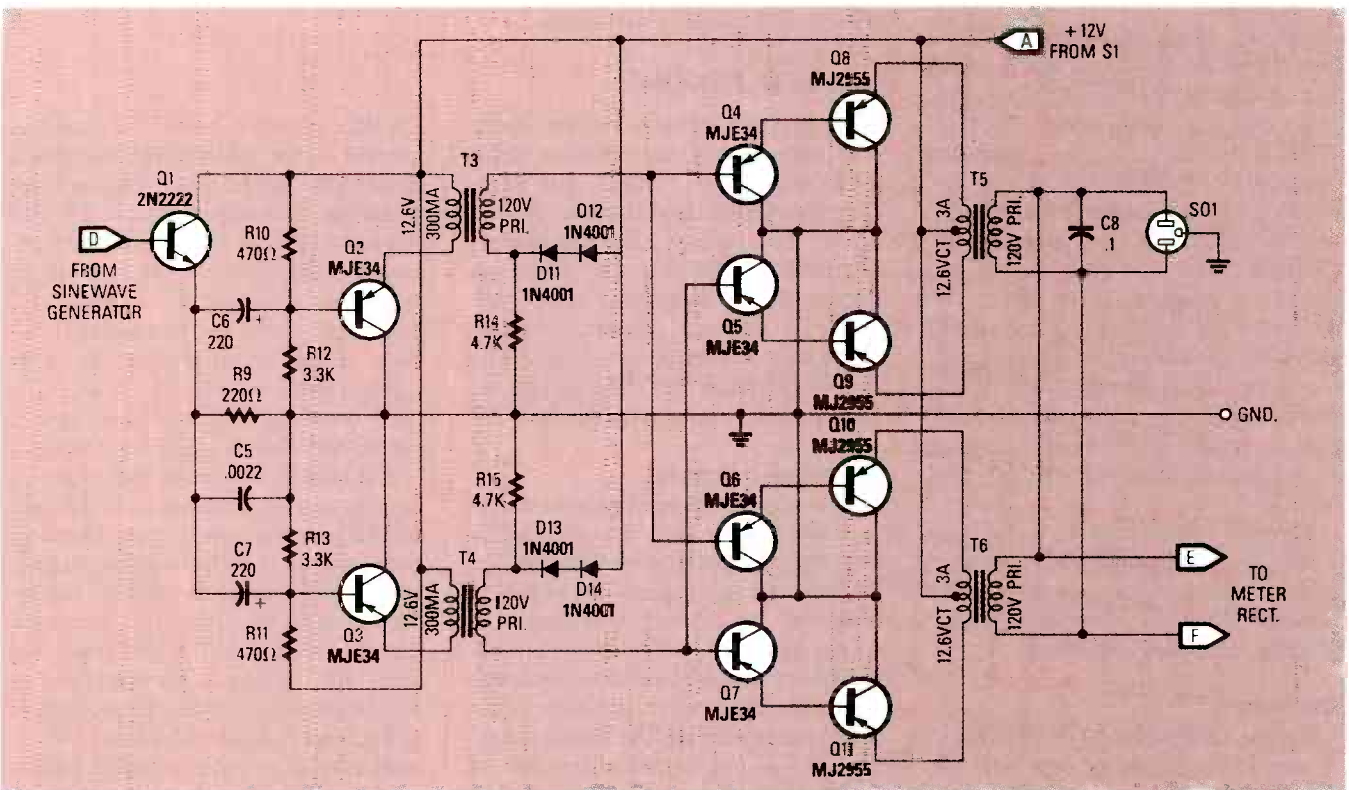


FIG. 2—THE AMPLIFIER STEPS UP the 60-Hz signal from the sinewave generator to nominally 120 volts. To ensure a clean output, C8 is included to remove any high-frequency components caused by crossover distortion or clipping from the output. It also prevents high-frequency self oscillation.

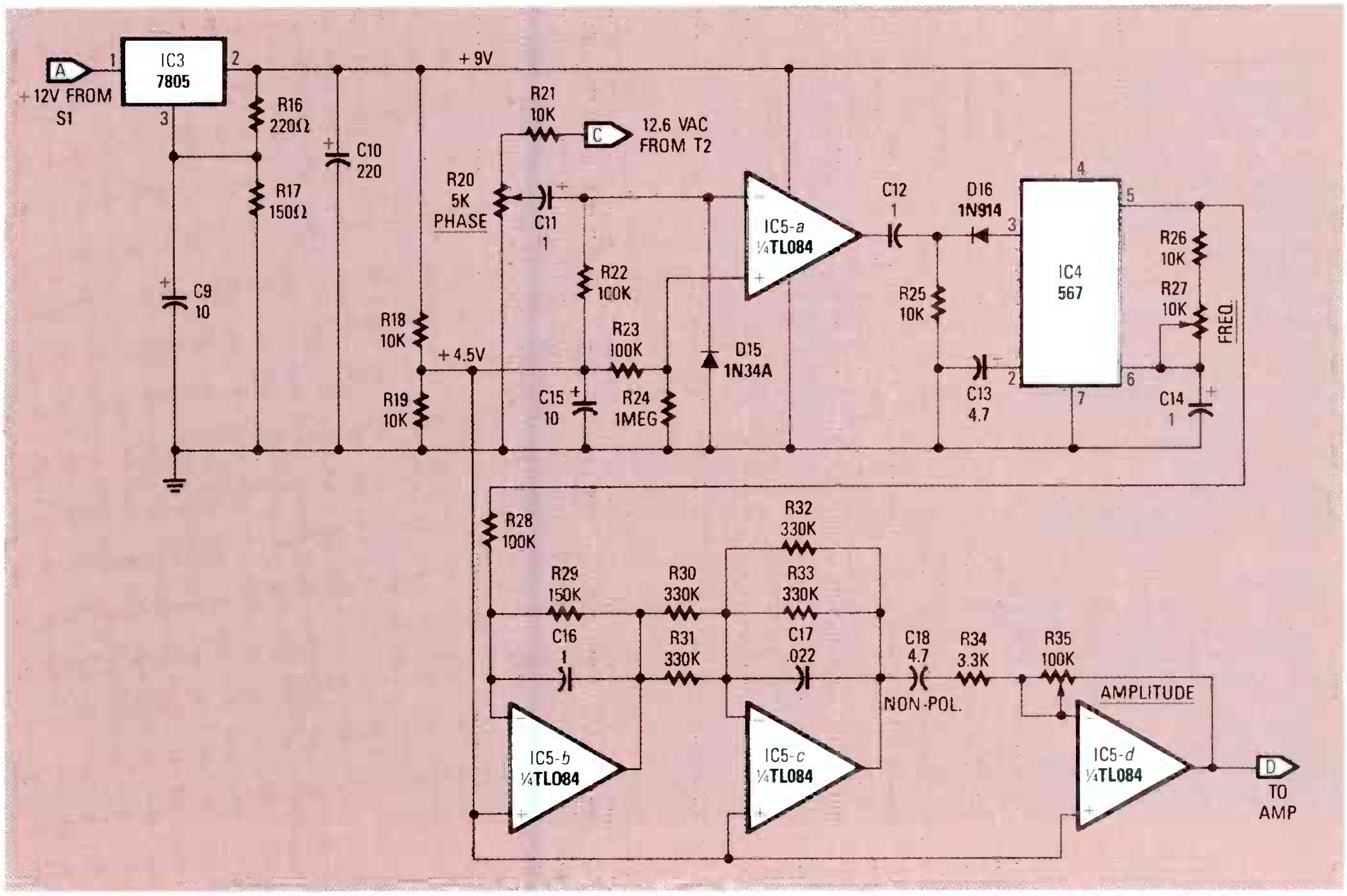


FIG. 3—THE TONE GENERATOR first develops a 60-Hz squarewave. IC5-b and IC5-c then shape the squarewave into a sinewave.

amplifier crossover distortion or clipping, and also prevents high-frequency self-oscillation.

Two of the Darlington pairs are driven in parallel by transformer T3; the other two are driven in parallel by T4. Diodes D11, D12, D13, and D14 provide a fixed DC base voltage that biases the output transistors near cut-off.

The Class-A drivers, transistors Q2 and Q3, also consist entirely of emitter followers. The necessary voltage step-up is provided by T3 and T4, which are also standard power transformers connected in reverse. Transistor Q1 drives Q2 and Q3 in parallel. The base of Q1 is directly coupled to the output of IC5-d (see Fig. 3), which is at 4.5 volts DC. Phase reversal for push-pull drive of the output stage is accomplished with proper connection of the secondaries of T3 and T4.

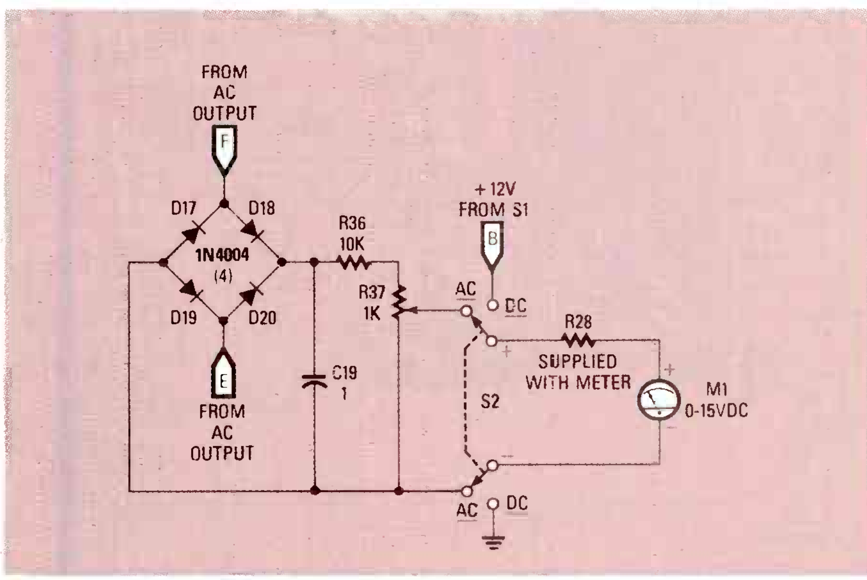


FIG. 4—THE METER CIRCUIT MEASURES both the battery voltage and the UPS output voltage. It is calibrated to the output voltage by potentiometer R37.

The sinewave generator

As shown in Fig. 3, the oscillator is built around IC4, a 567 tone detector. The IC's free-running frequency is controlled by resistors R26 and R27, and capacitor C14, and is set as close to 60 Hz as possible. IC4's squarewave output is converted to a triangle wave by IC5-b, which is in turn converted to a sinewave by IC5-c. Op-amp IC5-d's gain is controlled by potentiometer R35, which is used to set the AC output voltage.

Op-amp IC5-a converts the sinewave from the 12.6-volt output of T2 to a 60-Hz pulse train. D15 protects against damage that could occur if the inverting input were to go negative with respect to ground; the diode is normally reverse biased. The 60-Hz pulses, which are coupled to IC4 through C12 and D16, cause the os-

PARTS LIST

All resistors are ½-watt, 10% unless otherwise noted.
R1, R10, R11—470 ohms
R2—330 ohms
R3, R37—1000 ohm trim pot
R4, R5—3900 ohms
R6, R12, R13, R34—3300 ohms
R7, R9, R16—220 ohms
R8—1000 ohms
R14, R15—4700 ohms
R17—150 ohms
R18, R19, R21, R25, R26, R36—10,000 ohms
R20—5000 ohm trim pot
R22, R23, R28—100,000 ohms
R24—1 megohm
R27—10,000 ohms trimmer potentiometer
R29—150,000 ohms
R30, R31, R32, R33—330,000 ohms
R35—100,000 ohm potentiometer

Capacitors
C1, C2—4700 µf, 35 volts, electrolytic
C3—1000 µf, 35 volts, electrolytic
C4—100 µf, 35 volts, electrolytic
C5—.0022 µF, 250 volts
C6, C7, C10—220 µf, 35 volts, electrolytic
C8—.1 µf, 250 volts
C9, C15—10 µf, 35 volts, electrolytic
C11, C14—1 µF, 10 volts, tantalum
C12—.1 µF, 50-volts
C13—4.7 µF, 35 volt, electrolytic
C16—1 µF, 10 volts, metal film
C17—.022 µF, 10 volts
C18—4.7 µF, 10 volts, nonpolarized electrolytic
C19—1 µF, 250 volts

Semiconductors
IC1—741 op-amp
IC2—MOC3010 opto-triac coupler
IC3—7805 voltage regulator
IC4—567 tone detector
IC5—quad op-amp, TLC274, TL084 or similar
Q1—2N2222, NPN small-signal transistor
Q2–Q7—MJE34 transistor
Q8, Q9, Q10, Q11—MJ2955 transistor
D1–D5—1N5400 silicon rectifier diode
D6, D9–D14—1N4001 silicon rectifier diode
D7—5-volt Zener diode D8—9-volt Zener diode
D15—1N34A small-signal germanium diode
D16—1N914 small-signal silicon diode
D17, D18, D19, D20—1N4004 silicon rectifier diode
LED1—Light-emitting diode

Other components
CB1—2-amp, 120-volt pushbutton circuit breaker
F1—10-amp automotive-type fuse
F2—automotive-type fuse, as required for 12-VDC output
LMP1—12 volt panel lamp
J1, J2—5-way binding posts
L1, L2—choke coil, from Radio-Shack *270-030* filter kit
M1—0-15-VDC voltmeter
PL1—3-wire line cord with grounding plug
RY1—DPDT relay, 120-VAC coil, 10-amp contacts
RY2—SPST or SPDT relay, 12-VDC coil, 3-amp contacts
S1—DPDT toggle switch, center off, 20-amp contacts
S2—DPDT mini toggle switch
SO1—AC outlet, single or duplex
T1, T2—Power transformer: 120 volt primary; 25.2-volt, 2-amp secondary
T3, T4—Power transformer: 120 volt primary; 12.6-volt, 300-Ma secondary
T5—Power transformer: 120 volt primary; 12.6-volt, 3-amp secondary

Miscellaneous: Two automotive-type fuse holders, chassis mounting 12-VDC cooling fan suitable 12-volt battery cable suitable enclosure hardware

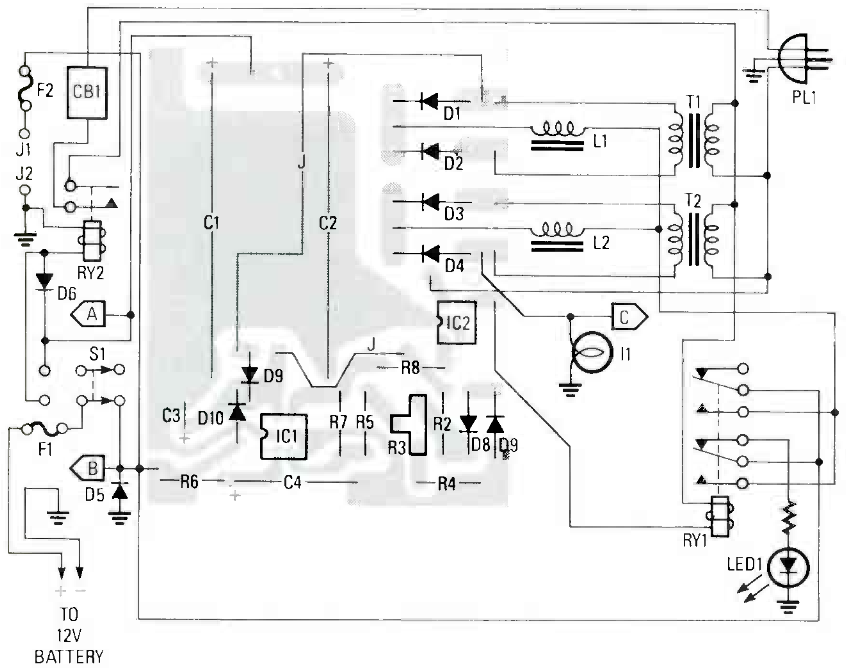


FIG. 5—THE PARTS PLACEMENT diagram for the power supply. Make certain that the parallel-wired connections of T1 and T2 are in-phase. Reversed phase will produce zero output.

cillator to lock to the powerline frequency. Some degree of control over the exact phase relationship is possible by adjusting potentiometer R20. When properly adjusted, the AC output will be in-phase with the powerline, and the unlocking and locking that occurs when the power fails and then returns will be gentle, causing very little disturbance.

The sinewave generator is supplied with clean, ripple-free 9 volt power by IC3, a 7805 5-volt regulator. Pin 3 of the regulator is held at 4 volts above ground by R16 and R17 to obtain 9 volts output.

The meter circuit

Either the battery voltage or the AC output voltage can be monitored with the meter circuit shown in Fig. 4. A bridge rectifier made up of four silicon rectifier diodes converts the AC to DC, which is filtered by C19. A DPDT switch connects a 15-volt DC voltmeter to the 12-volt supply or the voltage divider consisting of R36 and R37.

Construction

There are two important considerations to bear in mind. A considerable amount of heat is generated, particularly by Q8, Q9, Q10, and Q11. A large heatsink is required for those transistors, and a small fan is essential to keep the heatsink at a reasonable operating temperature. The physical placement of the components should allow for free movement of air through the enclosure, with the intake through the sides and the exhaust through the top. The heat-sink should be located near the fan. The power supply's rectifier diode should also be located near the fan and mounted so that the leads hold them about a half inch above the board. To protect them, Q2 and Q3 should each be fitted with a small heatsink.

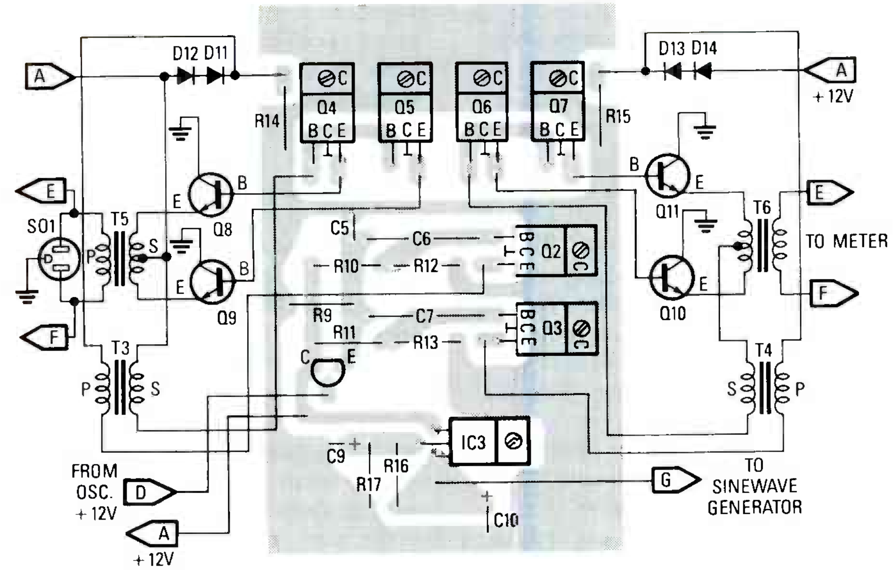


FIG. 6—THE PARTS LAYOUT FOR THE AMPLIFIER. Transistors Q8–Q11 and diodes D11–D14 must be mounted on a heatsink, as indicated by the dashed lines.

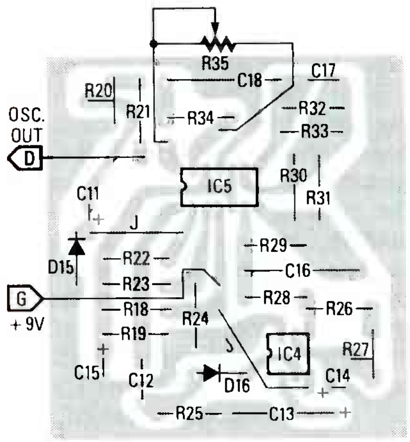


FIG. 7—THE SINEWAVE GENERATOR'S parts layout. Nothing is critical.

The amplifier draws a very high current. A fraction of a volt lost as a result of voltage drop in the power supply leads will result in several volts lost at the output, so use heavy-gauge wire for all leads from the power supply and battery to the center-taps of T5 and T6, and to the chassis ground. (12-gauge wire is recommended.)

A Radio Shack *270-238* aluminum chassis box makes an excellent heatsink. Mount the cover upside down in the bottom of the enclosure. Mount the power transistors on the other section with the leads protruding inward. The transistors' metal cases, which are connected to the collectors, should be grounded to the heatsink. Drill holes for D11, D12, D13, and D14, sized for a tight fit. Position pairs of diodes between the two transistors they affect electrically; i.e., D11 and D12 between Q8 and Q9; D13 and D14 between Q10 and Q11. Use a small amount of heat-sink compound when mounting the transistors and diodes. Insert the diodes in their mounting holes so that the leads from the anode of D11 and the cathode of D12 protrude from the top. Bend and solder the leads together to form a bar between the two diodes. Do the same with D13 and D14. Use soldering terminal strips on the underside of the heatsink for all connections.

Position the heatsink in the other half of the chassis box so that the tops of the transistors will be near the fan, then drill holes for self-tapping screws to hold the two halves together. Transformers T3 and T4, and chokes L1 and L2 will fit nicely in the lower half of the chassis box.

The large power transformers can be mounted in the base of the enclosure to either side of the heatsink. The sides of the enclosure should be vented so that cool air is drawn over them. Depending on the enclosure used, it may be necessary to provide a shelf over each pair of transformers for the associated components.

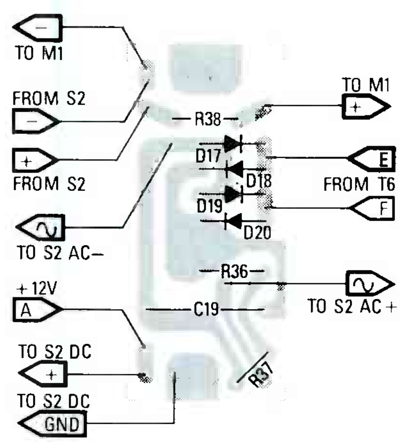


FIG. 8—THE PARTS LAYOUT for the meter board is simple, but there are many connections to other circuits; so take extra care with the interconnections.

Although printed-circuit board construction isn't required, it is recommended, and foil patterns are shown in PC Service for those who wish to use them. The corresponding parts-placement diagrams are shown in Figs. 5–8. The foil patterns can be modified to suit your needs, or the circuits can be built in a similar manner on perforated wiring board. Mounting tabs of Q2, Q3, Q4, Q5, Q6, and Q7 are their collector connections; they must be grounded by machine screws if PC board construction is used.

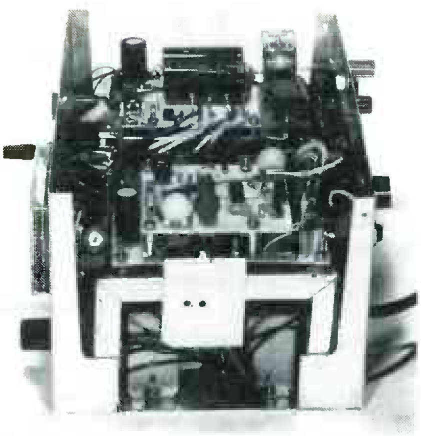
The author used a small section cut from an aluminum chassis box as a heatsink for Q2 and Q3. That heatsink is mounted against the transistor's mounting tabs with machine screws extending through holes drilled in a lip on the heatsink. The heat sink extends down over the edge of the PC board into the flow of air entering the side of the enclosure. The sinewave generator board is piggy-backed over the amplifier board using 6-32 machine screws and spacers.

The fan must operate on 12-volts DC, otherwise cooling would be lost during a power outage. Mount the fan in the top of the enclosure so that it exhausts the air. The vent should be closed except for a circle whose diameter matches that of the fan blades, so that all air must enter the enclosure through the side vents.

Testing the power supply

The power supply should be tested before the amplifier is connected. That can be done before the amplifier is even built. Set R3's wiper at the end that's connected to R4. Do not plug the linecord into an outlet yet. Connect a 12-volt storage battery to the supply and set S1 to either CHARGE or OPERATE. Relay RY2 should energize and LED1 should light. You should measure about 12 volts at pins 2 and 7 of IC1. Pin 6 should be low.

Plug the linecord into an outlet. Lamp LMP1 should light. Relay RY1 should remain deenergized and you should measure about 14 volts at its normally-open contacts. Pin 7 of IC1 should measure about 14 volts and pin 3 should measure about 11 volts. Pin 6 should remain low. Rotate R3 to its



THE UPS IS BUILT LAYER ON LAYER upwards from the base of the cabinet. Stacked mounting nuts, or spacers, at the mounting screws can be used to separate the layers.

opposite end to obtain 14 volts at pin 3; RY1 should now energize and LED1 should be dark.

You should measure about 13 volts across the battery. Rotate R3 just to the point where RY1 deenergizes.

The charger should cycle *off* and *on* as the battery voltage rises and falls. The correct setting of R3 is where, with a fully-charged battery, the charger cycles very infrequently and turns off almost as soon as it turns on. The battery potential should measure 12.5 volts with no charging current. At a lower battery voltage, the charger should cycle unless the battery is so badly discharged that the full current of the charger cannot bring the voltage back up to 12.5.

Testing the sinewave generator

The sinewave generator can be tested independently. If you build it on a PC board without the 9-volt regulator, you can use a 9-volt transistor battery or an external power supply for the test. Set R20's wiper to its ground end. A scope should show a squarewave at pin 5 of IC4. With a 60-hertz sinewave driving the scope's horizontal sweep, set R27 for a frequency of 60 Hz—which will produce a rectangular Lissajous pattern. The frequency need not be exact. A slowly changing pattern is acceptable.

With the scope set for a normal 60-Hz sweep, you should observe a triangle wave at the output of IC5-b and a sinewave at the output of IC5-c. A sinewave should also be present at the output of IC5-d, varying in amplitude as R35 is adjusted. If any of those tests are negative, check for 4.5 volts DC at all input and output pins.

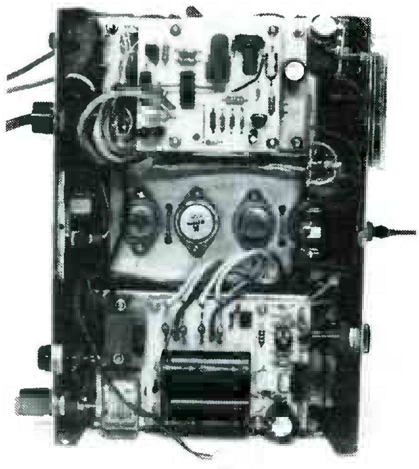
With 12.6-volts AC connected to R21, rotate R20 until the scope shows output pulses from IC5-a: The oscillator should be locked to the line frequency. Set up the scope for a Lissajous display as before and observe the output from IC5-d. It should be an oval that is nearly closed. It should be possible to adjust R20 so that the display is very nearly a sloping straight line, indicating that the output signal is in-phase with the powerline. If the AC signal is removed by unplugging the linecord, the pattern should begin a slow change to an oval that opens and closes. Readjust potentiometer R27 in order to minimize the rate of change. When the AC signal is restored, the display should quickly return to the sloping line pattern.

Testing the meter circuit

The meter circuit can be tested and calibrated by connecting the rectifier to the AC powerline. With S2 in the AC position, adjust R37 for a meter reading one-tenth that of the AC line voltage as measured independently with a calibrated meter. If there is no reading, check for about 130 volts DC across C19 to see if the rectifier is properly connected. A scope will show a large ripple component since C19 has a relatively low capacitance.

Testing the amplifier

Connect the amplifier to the 12-volt power source and the sinewave generator. Set the wiper of R35 to the end connected to the output of IC5-d, which is the setting for a zero output signal. Set S1 to the OPERATE position. Check for 12.5 volts at the emitters of Q2, Q3, Q8, Q9, Q10, and Q11. Those transistors should become slightly warm, but not hot. Check for about 11 volts at the bases of Q4, Q5, Q6, and Q7, and for about 4 volts at the emitter of Q1.



THE AMPLIFIER OUTPUT TRANSISTORS (one is under the function switch) are mounted on the top of a small chassis box that serves as the heatsink. The cooling fan is positioned on the cabinet cover directly over the transistors.

During the following procedures, use the same caution in handling the output as you would with 117-volt household power. Connect one lead of each of the 120-volt windings of T5 and T6 together, leaving the others unconnected. Connect an AC voltmeter across one of the windings and set it to a range higher than 110 volts. Slowly rotate R35 until there is a measurable output voltage. If that fails, make sure that drive to the output stages are opposite in phase. The AC voltage from the base of Q4 or Q6 to the base of Q5 or Q7 should be twice the reading to ground. If it is not, reverse the connections to the windings of either T3 or T4, not both.

Next, check that the 120-volt windings of T5 and T6 are parallel-connected in-phase. Connect the voltmeter to the leads left unconnected. If the voltage is double the previous reading, the windings are connected in series. Reverse the connection of one of the windings. If no voltage is measured, connect the other two leads together. Connect a 15-watt lamp to the output. Adjust R35 for full output. The lamp should reach full brilliance and you should measure about 125 volts.

Using the UPS

In use, S1 should be set to OPERATE before the load is switched *on*. Check the AC output to be sure it is supplying at least 120 volts; the voltage will drop slightly under load. If the voltage is wavering, the oscillator is not locked in synchronization with the power line; readjust R27 and R20 after a short warm-up period. When properly adjusted, lock should occur at turn-on.

Switch the load on and recheck the voltage. It cannot be set high enough to cause harm, but it need not be set to the maximum. Some clipping will occur at the highest setting. A dip to 110 volts during operation of a discontinuous load, such as a disk drive or a printer, is acceptable.

The duration of operation during an outage will depend on the size of the battery. A motorcycle battery should allow 15 minutes of operation. **R-E**

AUDIO SCRAMBLING SYSTEM

PERHAPS THE MOST SERIOUS PROBlem with any kind of radiotelephone transmission is its inherent lack of privacy. Anyone can monitor the signal—using a scanner or a conventional receiver—and eavesdrop on both sides of the conversation.

Although there may be legal considerations either in effect now or under consideration that would limit or prevent the unauthorized reception of some or all radiotelephone signals, the fact remains that there is unauthorized eavesdropping that no amount of laws, rules, or regulations is going to stop.

To thwart both eavesdropping and the unauthorized use of information that might be attained, many communication systems make the signal unintelligible through some kind of scrambling; and only those specially-equipped receivers having matching decoder circuits can unscramble the signal.

One relatively simple but effective technique that's used to scramble voice transmissions is known as "frequency inversion." Briefly, in frequency inversion a fixed-frequency scrambling "carrier" is mixed with the audio signal in such a way that the original audio spectrum is translated into a different spectrum, and the resulting transmitter modulation sounds like duck chatter. As a matter of fact, the scrambled sound is often called "Donald Duck." Even if the scrambled duck chatter is translated back to the vicinity of the original spectrum, *but not necessarily back to the original frequencies*, the audio will still be unintelligible.

Frequency-inversion scrambling is commonly used by the police for radio communications in order to prevent casual listeners from eavesdropping on sensitive messages. Private enterprises also use similar methods to scramble telephonic communications to prevent the interception of proprietary information.

Here's a high-tech version of the old "Captain Midnight" secret decoder ring. Only this time out you scramble and unscramble sound instead of written messages.

KEVIN LINDELL

Your own scrambler

If you have a need to scramble and descramble any kind of radio or telephone voice message, even a cassette tape that is sent through the mail, you'll find you can do the job quickly and cheaply with the combination scrambler/descrambler unit described in this article. The scrambled output, whether by radio, telephone, or tape, sounds similar to the duck chatter that is produced when a single-sideband radio transmission is received by an AM receiver.

The scrambler/descrambler uses a device called a *balanced modulator* to produce frequency-inversion scrambling. A balanced modulator is a special kind of mixer that will produce an output containing sidebands when fed both a carrier frequency and modulation. The upper sideband consists of the *sum* of the carrier frequency and the modulating frequencies while the lower sideband consists of the *difference* frequencies. It is the difference frequencies in the lower sideband that are used for scrambling.

The balanced modulator

The balanced modulator inherently tries to null the two original input frequencies in the process of creating new products at its output.

If the carrier and modulation waves are of the form:

$$A_{PEAK}\ \sin(\omega t) \qquad (1)$$

where, A = Amplitude, $\omega = (2\pi f)$, f = frequency, and t = time, then, multiplying two such waves produces:

$$A_{OUT} = (A_c)\,(A_m)(\sin\,\omega_c t)(\sin\,\omega_m t) \quad (2)$$

where, m = modulation frequency, and c = carrier frequency.

Recalling the trigonometric identity:

$$(\sin A)(\sin B) = \tfrac{1}{2}[\cos(A-B) - \cos(A+B)] \quad (3)$$

substituting equation (3) into (2) produces the following equation, which clearly shows the sidebands;

$$A_{OUT} = \frac{A_c A_m}{2}\left[\cos 2\pi(f_c - f_m)t - \cos 2\pi(f_c + f_m)t\right] \quad (4)$$

where

$$\cos 2\pi(f_c - f_m)t$$

is the lower sideband and

$$\cos 2\pi(f_c + f_m)t$$

is the upper sideband

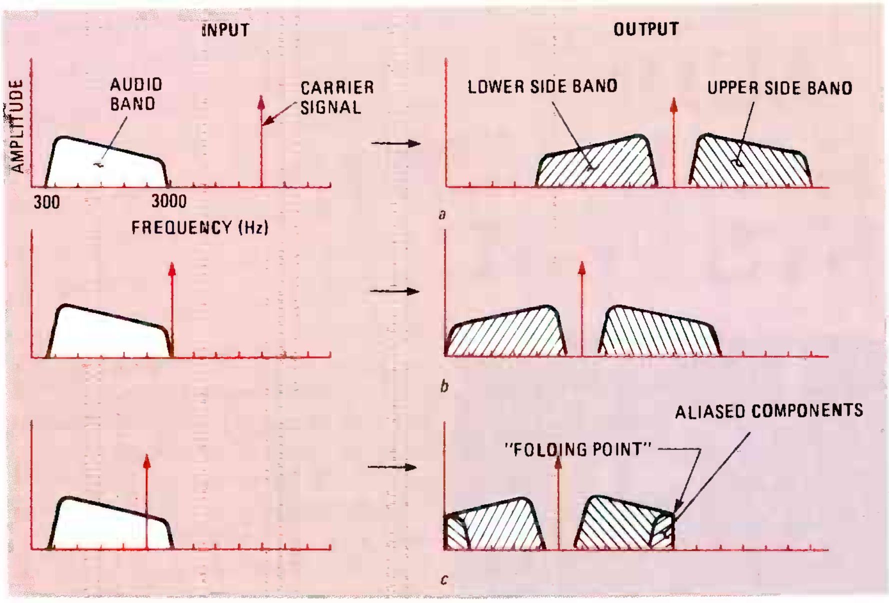


FIG. 1—THE MODULATION WILL FOLD BACK ON ITSELF if the carrier is within the modulation passband. *a* shows how the modulation is inverted and shifted higher in frequency if the carrier signal is displaced from the highest modulating frequency. In *b* the carrier is just above the audio band so the modulation is inverted, but the difference frequencies occupy essentially the original passband. In *c* the carrier is within the audio band, causing some modulating frequencies to fold back within the audio band.

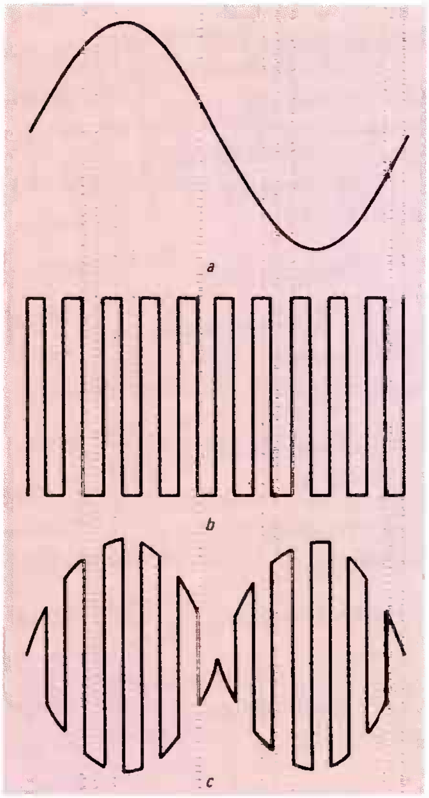


FIG. 2—HOW THE SCRAMBLER'S modulation works. If the audio signal shown in *a* is used to modulate the square-wave carrier in *b*, the resultant output is the signal shown in *c*: the original audio chopped by the carrier.

If the carrier frequency is not higher than the audio range to be inverted, then a distortion that is known as *aliasing* will occur in which the audio frequencies appear to "fold over" on themselves. Figure 1 shows how the aliasing effect might affect a scrambler/descrambler. Figure 1-*a* might be considered normal modulation/carrier positioning. As the carrier frequency moves closer to the audio band (Fig. 1-*b*), the sideband spectrum is shifted lower. When the carrier is within the audio range (Fig. 1-*c*), it causes the output spectrum to produce false, or aliased, products that are "folded" around the carrier frequency.

There are two basic ways to make a balanced modulator. One method uses devices that have non-linear characteristics, such as a diode's voltage/current relationship. That method requires a critical matching of the components to achieve good performance. The second method, which is used in the scrambler/descrambler, uses time-variant devices having two states, either *on* or *off*. The two-state characteristic can be used to pass or not pass a signal through a circuit or a circuit path. If the signal can be toggled through a symmetrical pair of switches whose outputs are summed in a balanced manner (i.e., with equal magnitude and opposite sign), the result will be the signal multiplied in time by the switching rate.

The balanced modulator in our scrambler/descrambler uses a quad FET IC having four closely-matched switches in a single package (which reduces the component-matching problem). The circuit also uses an op-amp to provide the balanced summing operation. The switches are controlled by the clock circuit. Toggling the switches rapidly creates a constant amplitude and frequency square-wave carrier for the balanced modulator.

How it works

Figure 2 shows how the scrambler works in the time-domain. Fig. 2-*a* shows a typical sinewave audio-input signal. Figure 2-*b* shows the square-wave carrier. If the input signal is chopped by the carrier into several smaller pieces at the carrier rate and the phase is reversed at each chopped

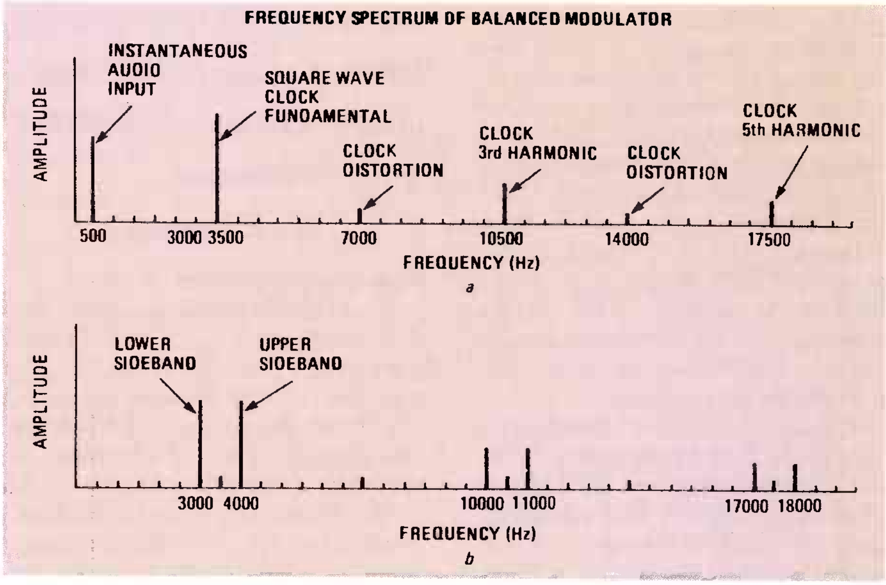


FIG. 3—THE SQUARE-WAVE CARRIER produces unwanted audio products in the form of harmonics and sidebands, shown in *a*. Those products must be filtered out. The resulting frequency spectrum, shown in *b*, has components located at the modulation frequencies both above and below each carrier harmonic.

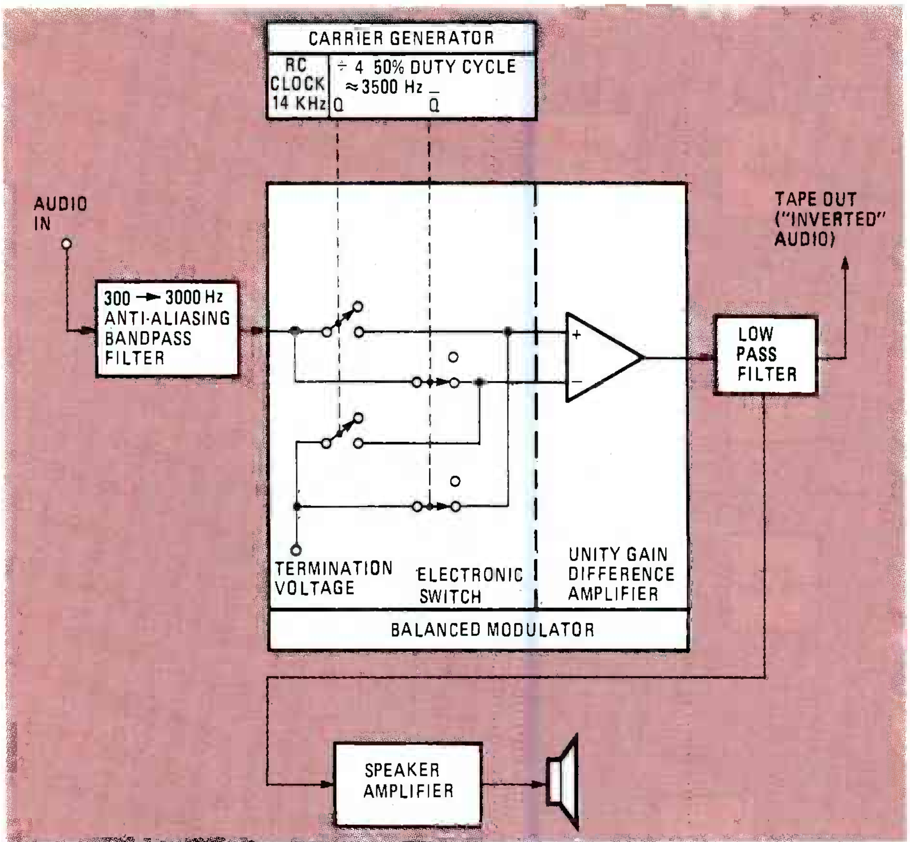


FIG. 4—FUNCTIONAL DIAGRAM OF THE SCRAMBLER. The switching is actually done by a balanced modulator that is driven from the carrier generator.

interval, the resulting output will appear as shown in Figure 3-*c* when viewed on an oscilloscope.

As shown in Fig. 3-*a*, the squarewave carrier also produces unwanted audio products in the form of harmonics and sidebands. Those products add to the distortion and must be filtered out in order to return the audio signal to its original form.

Mixing the squarewave with the audio-input signal results in an output that has sideband components centered around each harmonic of the square wave. As shown in Fig. 3-*b*, the resulting frequency spectrum has components located at the modulation frequencies both above and below each carrier harmonic, but there are no components at the carrier frequency or its harmonics. Filtering out the lower sideband, which is below the fundamental frequency of the squarewave, produces the scrambled audio output.

As long as the carrier switching-rate is maintained slightly above the normal audio range, the scrambled audio will still be audible, but low input tones will produce high output tones, and vice-versa, making the final output sound highly distorted and unintelligible. If an identical method is used to demodulate the distorted speech, the signal will be restored to its original form.

A graphic representation of how the scrambler/descrambler affects the normal audio input is shown in Figure 3-*b*. The carrier, or switch-toggle rate, is set at 3500 Hz. The audio input at the instant shown in this example equals 500 Hz. Note the sidebands that are produced. The upper sideband, also called the sum frequency, is equal to the carrier frequency plus the audio frequency, which, for this example, is 4000 Hz. (3500 Hz plus 500 Hz.) The lower sideband, or difference frequency, is 3000 Hz. (3500 Hz minus 500 Hz). Having selected the lower sideband as the scrambled audio, the 500 Hz tone, which was put into the scrambler, is changed into a 3000 Hz tone. Similarly, a 3000 Hz audio input tone produces a 500 Hz output tone. Carrying that process on for the entire spectrum of input audio frequencies produces the scrambled result. Reversing the process effectively descrambles the audio. The original carrier tone may still be heard when there is no audio modulation present—although at a volume much below that of the scrambled audio level. Carrier leak-through is due to the fact that the carrier frequency is in the audible range and that the balanced modulator is not perfectly balanced.

The major components

Figure 4 is a block diagram of the scrambler's five major sections. The CARRIER GENERATOR is an RC clock and divide-by-four counter that produces the switching signals for the balanced modulator.

The ANTI-ALIASING BANDPASS FILTER conditions the audio-input signal by limiting the frequencies fed into the balanced modulator to the nominal range of 300–to 3000 Hz, thereby reducing the high-frequency components that would cause aliasing distortion. Without the filter the balanced modulator would include erroneous information that would appear in the output signal as distortion.

The BALANCED MODULATOR is the heart of the scrambler/descrambler. Its purpose is to feed the conditioned audio input alternately, at the timing-generator rate, to the inverting input and then the non-inverting input of a differential amplifier. That process mixes the conditioned audio with the timing generator's square-wave signal, thereby creating a composite output signal that contains several sideband and harmonic frequencies.

The LOWPASS FILTER removes all but the first lower-sideband frequencies from the balanced modulator's output. The filter's output is "inverted audio," the scrambled signal.

The SPEAKER AMPLIFIER drives an internal speaker. When the device is used as a scrambler the speaker reproduces the scrambled output from the lowpass filter. When the device is used as a descrambler the speaker reproduces the descrambled sound. Alternately, the sound can be fed through the TAPE OUTPUT connection to an external amplifier, speaker, tape recorder, or whatever.

Circuit description

Figure 5 shows the schematic of the scrambler/descrambler. Integrated circuit IC1 is an astable 7555-timer circuit running at approximately 14 kHz. The timer's frequency is determined by R1, R2, and C2. Small changes to the frequency can be made by adjusting R1, which is an externally-accessible multi-turn trimmer.

The output from IC1 is fed to the clock input of IC2, a dual D-type flip-flop that is used to divide the 14-kHz clock output by a factor of 4 (÷2 +

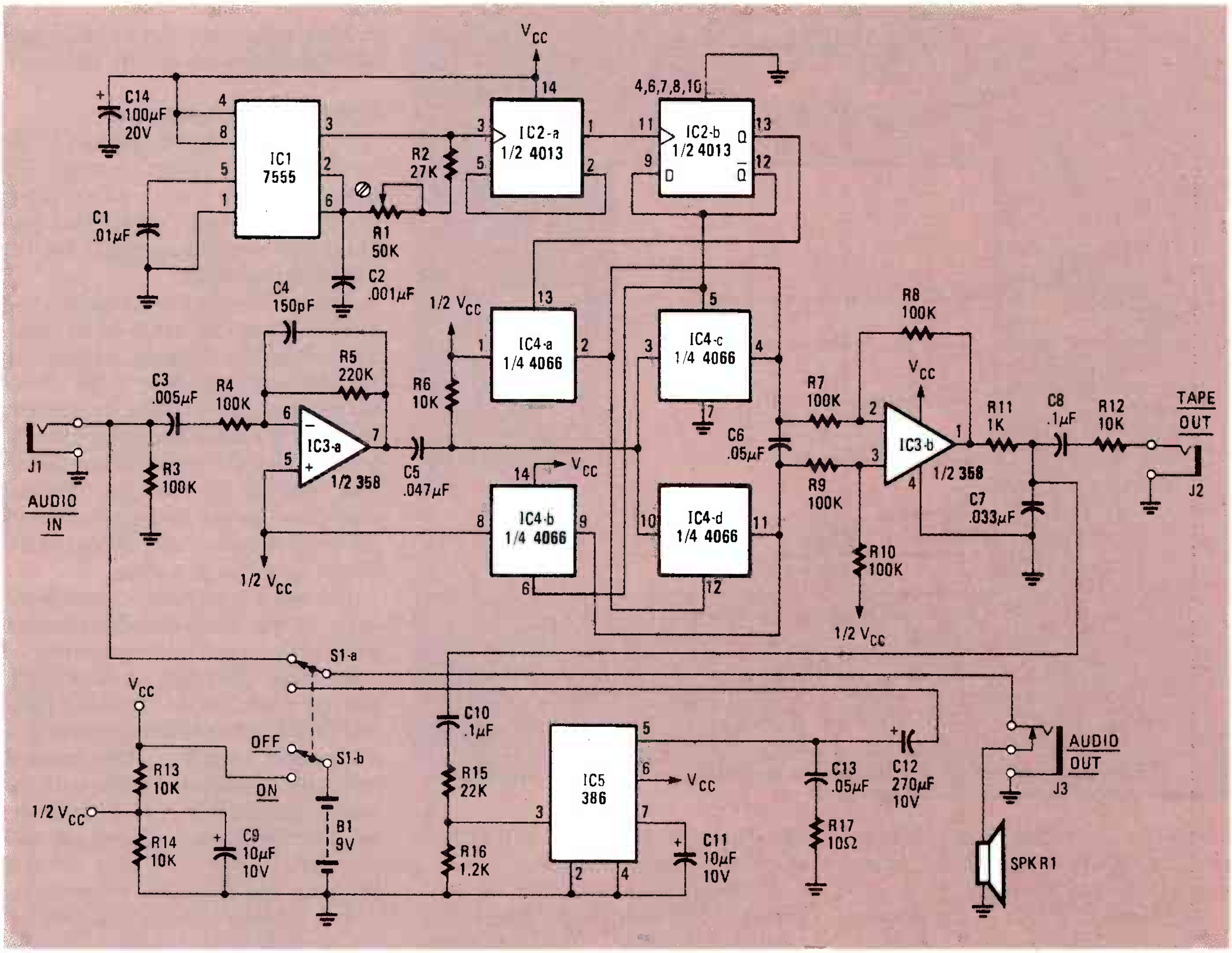


FIG. 5—THE COMBINATION SCRAMBLER/DESCRAMBLER. Switch S1 controls the power through one section and bypasses the scrambler through its other section.

÷ 2). The division creates a 3.5-kHz 50% duty-cycle square wave at IC2 pin 13, and an identical but inverted waveform at pin 12. The two square-wave signals are used as carriers to control IC4, a quad analog switch that functions as the balanced-modulator's switching network.

The other input to the balanced modulator is the audio signal from J1 that is to be scrambled. The input signal should be derived from a low-impedance source such as a tape-player's headphone or speaker-output jack. Using a line-level or AUX signal source is not recommended because the scrambler's speaker is connected directly to the audio input when the scrambler unit is off, and the low impedance of the speaker would load down a high impedance line or AUX signal source. The input signal's frequency range is limited to nominally 300–3000 Hz by bandpass filter IC3-a.

At any given time the squarewave carrier will turn on either switches IC4-a and IC4-d, or IC4-b and IC4-c at the 3.5-kHz rate. When switches IC4-a and IC4-d are on, IC4-d passes the audio input signal to the non-inverting input of differential amplifier IC3-b, and IC4-a terminates the inverting input. Switches IC4-c and IC4-d work similarly on the other half of the squarewave carrier cycle.

Unity-gain differential-amplifier IC3-b multiplies the audio input by a factor of plus or minus one, depending on the state of the IC4 switches. Resistors R7 and R8 set the gain on the inverting input while resistors R9 and R10 set the gain on the non-inverting input.

The balanced-modulator output, IC3 pin 1, is fed through the R11/C7 low-pass filter, which passes only the scrambled audio to TAPE OUT jack J2. The output level from J2 will depend on the input level to the scrambler. A sample of the signal fed to J2 is also fed to audio power amplifier IC5. The output of that device drives SPKR1.

Switch S1 turns the scrambler circuit *on* and *off*. When switch S1 is *off*, section S1-a connects the audio input directly to the speaker, thereby bypassing the audio scrambler circuit so that normal, unscrambled audio, can be monitored.

Construction

A template for the printed-circuit board is shown in PC Service. A predrilled board is available from the source given in the Parts List. Figure 6 shows how the components are installed on the PC board.

Although there is nothing unusual about the assembly, standard CMOS component-handling precautions should be used avoid damage from static discharges. Whether you choose to use a large or a small cabinet, installation of the switch and the jacks is easier if they are pre-wired to the PC board before being mounted on the case.

If you intend to unscramble mes-

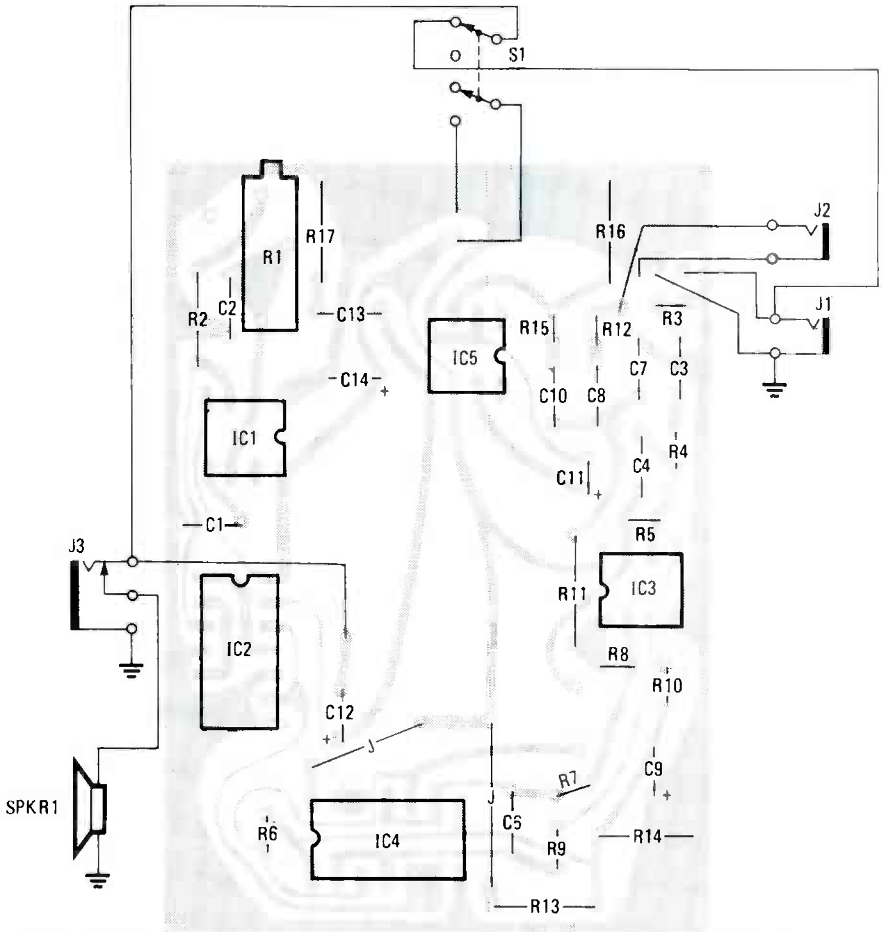


FIG. 6—THE PARTS LAYOUT. Keep the center of the board free so it can fit over the speaker.

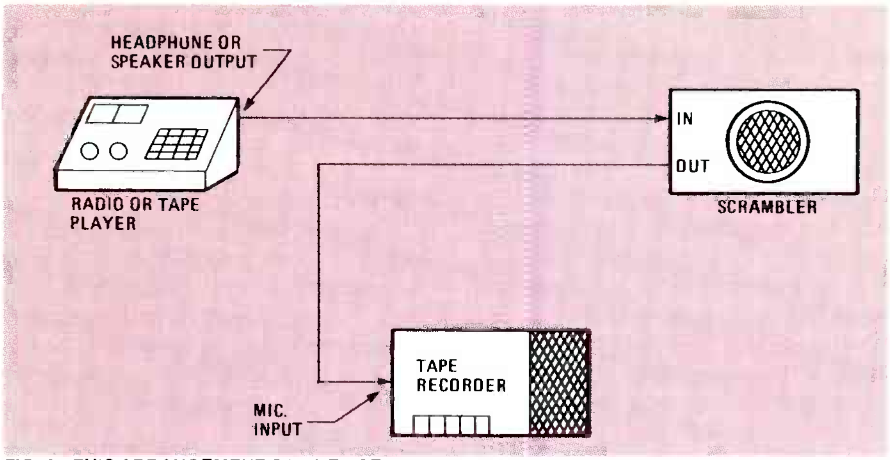


FIG. 7—THIS ARRANGEMENT CAN BE USED for either scrambling or descrambling a signal provided by a radio or tape player.

sages from several sources using different scramblers, it's possible that trimmer potentiometer R1 might have to be re-adjusted for each scrambling source; hence, to minimize headaches later on, R1 should be installed so that it is conveniently accessible from outside the cabinet.

Tuning and adjustment

Trimmer potentiometer R1, which is used to tune the square-wave scrambling/descrambling carrier signal, should initially be set to approximately its center position. If the scrambling device that was used to scramble the audio is also used for descrambling, no further adjustment will probably be required. If different scrambler units are used, as is sure to be the case in a typical two-way communication setup, the receiving unit's R1 will have to be tuned manually until the scrambled audio is successfully descrambled and can be clearly understood.

Applications

The device can be used in many applications, although its use may be restricted by local and/or Federal laws. It should only be connected to the telephone line through an FCC-approved interface, and in conformance with local regulations or procedures of the local telephone company. Be sure to comply with any restrictions before using the device.

Figure 7 shows the scrambler/descrambler connected to a radio, or a tape player. In this application, the device will either scramble the audio coming from the source or descramble an incoming scrambled transmission. The output can be monitored via the built-in speaker and/or passed on to a tape recorder.

The scrambler/descrambler also can be connected between a tape recorder and its source in order to create

continued on page 77

PARTS LIST

All resistors are ¼-watt, 10%, unless otherwise noted.

R1—50,000 ohm, 10-turn trimmer potentiometer
R2—27,000 ohms
R3, R4, R7–R10—100,000 ohms
R5—220,000 ohms
R6, R12–R14—10,000 ohms
R11—1000 ohms
R15—22,000 ohms
R16—1200 ohms
R17—10 ohms

Capacitors

C1—.01 µF, 100 volts, ceramic disc
C2—.001 µF, 100 volts, mica
C3—.005 µF, 100 volts, ceramic disc
C4—150 pF, 100 volts, ceramic disc
C5, C6, C13—.05 µF, 100 volts, ceramic disc
C7—.033 µF, 100 volts, ceramic disc
C8, C10—0.1 µF, 100 volts, ceramic disc
C9, C11—10 µF, 10 volts, electrolytic
C12—220 µF, 10 volts, electrolytic
C14—100 µF, 20 volts, electrolytic

Semiconductors

IC1—7555, CMOS timer
IC2—4013, dual D-type flip-flop
IC3—LM358, dual op-amp
IC4—4066, quad analog switch
IC5—LM386, audio power amplifier

Other components

B1—9-volt battery
J1, J2—Miniature phone jack
J3—Two-circuit miniature phone jack
S1—DPDT toggle switch
SPKR1—2⅛" speaker

Miscellaneous: battery terminals, battery holder, printed-circuit board materials, enclosure, wire, solder, etc.

60-Hz TIMEBASE

Here's a one-IC timebase generator that's both accurate and flexible.

J. DANIEL GIFFORD

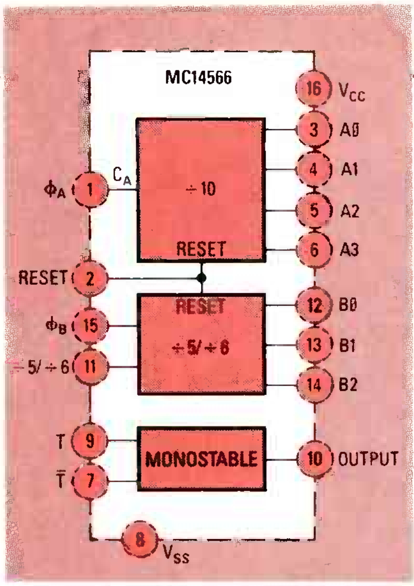


FIG. 1—PINOUT AND BLOCK DIAGRAM of the Motorola MC14566B, or the equivalent 4566, timebase generator.

WHILE A STABLE REFERENCE FREQUENCY is often needed when doing electronics experimentation, generating one can present some problems. Usually, a reference frequency is generated using either a crystal timebase or some form of line-frequency divider. But crystal timebases are fairly expensive and line-frequency dividers usually require two or three IC's to get a usable 1 or 10 Hz frequency from a 60-Hz line. There is, however, a relatively obscure CMOS IC that can do the job inexpensively.

That IC, the Motorola MC14566B (and the equivalent 4566), carries the imposing title of "Industrial Timebase Generator," which is probably a large part of the reason it isn't commonly used. However, the device can be used anywhere an experimenter or hobbyist needs an inexpensive reference frequency: in clocks, frequency meters, period counters, etc.

Being a CMOS device, the MC14566B can operate with any supply between 5 and 15 volts. And, being CMOS, it draws only about 10 mA of supply current across that voltage range.

Inside the MC14566B

As Fig. 1 shows, the MC14566B contains three independent function blocks: a BCD (*B*inary *C*oded *D*ecimal)-output divide-by-10 counter, a BCD-output divide-by-5 or -6 counter, and a monostable multivibrator. The two counters share a common reset, which is tied to ground for normal operation and brought high to reset both counters to zero.

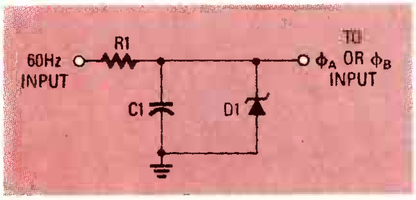


FIG. 2—THIS RESISTOR-CAPACITOR-ZENER network allows the MC14566B to take its clock signal from either end of the transformer that powers the circuit.

Both counters are clocked by the falling or negative edge of the clock pulse, and both have pulse-shaping networks on their clock inputs (ϕ_A and ϕ_B) that allow them to be directly driven by a low-voltage sinewave signal via a resistor-capacitor-Zener network like the one shown in Fig. 2. The source for the sinewave is the transformer that powers the circuit; the input of the network may be connected to either end of the winding that powers the MC14566B circuit. The Zener should be a ½- or 1-in watt unit, and have a voltage rating that's within 10% of the supply voltage. With such a Zener in place, the AC peak-to-peak voltage (V_{PP}) can be from 70–200% of the circuit's DC supply.

Although the counters have standard BCD outputs, we have little need for that format for our application. Therefore, it is more practical to regard them as division-ratio outputs. Table 1 shows the output-division ratios and the accompanying duty cycles for each counter's outputs.

TABLE 1

OUTPUT	DIVISION RATIO	DUTY CYCLE (%)
A0	2	50
A1	4	40*
A2	10	40
A3	10	20
B0	2(2.5)	50(40*)
B1	6(5)	33(40)
B2	6(5)	33(20)

*PULSES IRREGULARLY SPACED
FIGURES IN ( ) FOR ÷5 MODE

Using the IC

Figure 3 shows the most common set-up for using the MC14566B as a frequency standard. With the 60-Hz signal from the transformer applied to ϕ_B, the B2 output will provide a 10-Hz frequency. If that signal is used to drive ϕ_A, the A3 output will provide a 1-Hz signal.

Many other output frequencies can be obtained from the IC. The actual output depends upon which output of the first counter is used to clock the second, and which of the seven outputs is then used. Through various combinations, some 12 different frequencies should be available, with duty cycles of 20, 40, and 50 percent.

The third section of the MC14566B is a simple monostable multivibrator with a fixed pulse-width output, positive- and negative-edge triggering, and a normally-low output. With

continued on page 77

Calibrating VCR Counters

Can't figure tape-timing? Here's an easy way to make a tape counter indicate in hours and minutes.

FRED BLECHMAN

ALL MODERN VIDEOCASSETTE RECORDERS and players, and some tape rewinders, have either mechanical or electronic digital tape counters. With very rare exception—those being the few "pro quality" models with counters that indicate tape timing down to the nearest second—tape counters are "relative reading" devices. That is, they have no correlation to actual timing nor to the length of tape used or remaining. The digits are merely numbers whose rate of change is linked to the design of the mechanism rather than the elapsed time of the recorded program.

The counter is usually powered by a belt that is driven in some way by the take-up reel. Since the tape moves at a constant speed and accumulates to an increasing radius on the takeup reel, as time goes on fewer revolutions of the take-up reel are needed to hold the same length of tape. Therefore, the counter's rate is constantly changing; decreasing because the reel slows down as the tape is wound.

When the rate changes continuously, about the only value that a counter has is to indicate the relative tape position. A given number of counts from the beginning of a tape should bring you to the same point on the tape each time. Although that is a handy way to locate a section of the tape, the counter would be even more useful if its reading were related to the tape's running time. For example, if you go out for the evening and automatically record four hours of TV shows, on returning you can conveniently and quickly cue the tape to the second, or even the fourth program by fast-winding to a known time reading.

Recalibrating a conventional VCR or rewinder counter to be time-indicating is a rather simple task. We'll show you how easily you can do it using two different methods.

Calibrating VCR counters

There are basically two ways to calibrate a VCR's counter. One method takes only paper and pencil, a watch or clock that indicates in seconds, and two hours of your attention. The other method requires a video camera and a specially prepared tape. Either way, the results can be graphed as shown in Fig. 1 through Fig. 4. Once you calibrate your own counter, you'll be able to use the graph and the counter's reading so that you can fast-wind precisely to the desired selection.

The calibration procedures described are for a VHS T-120 (2/4/6) hour tape, which is by far the most popular video-tape size and format. (The procedure would be the same for Beta tapes.) Keep in mind that all tapes do not necessarily have the same takeup-reel hub size, so never assume that a counter reading has the same meaning for various tape lengths. The

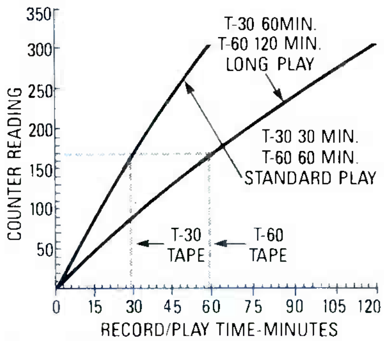


FIG. 1—IT'S ONLY NECESSARY to calibrate the highest speed. The calibrations for a slower speed are simply a linear multiple of the highest speed.

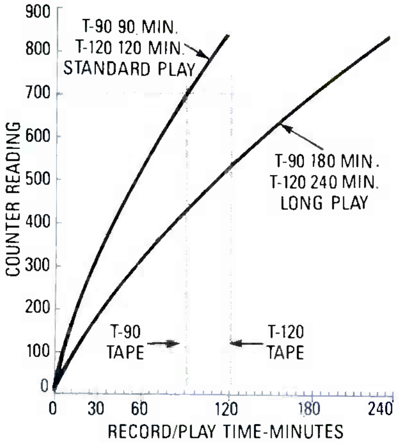


FIG. 2—BECAUSE THE SAME SIZE hubs are used, the curve for a T-90 tape is the same as the first three-fourths of a T-120 tape.

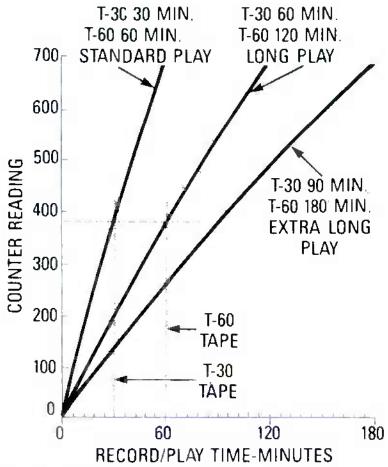


FIG. 3—THIS IS HOW the calibrations for "short" tapes work out for a particular Magnavox 3-speed VCR.

shorter tapes use a larger-diameter hub to create the visual appearance of a "full reel." In the VHF format, the T-90 and T-120 tapes use the same hub, while the T-30 and T-60 tapes use a similar, but larger hub.

Time the tape

Timing a tape is an easy, but time-consuming task. Start by completely rewinding a T-30 or T-60 blank tape. Then set your VCR's counter to zero. Next, set the recorder to the SP (*S*tandard *P*lay) speed, or whatever the *fastest* speed (shortest recording time) is called on your VCR.

Next, using a watch or a clock (a stopwatch is best), wait until the seconds are at zero and then start to record. Every five minutes write down the time and the counter's reading. Do that until the tape ends. That's all there is to it!

Using the data, plot a curve of the kind shown in Fig. 1; which is for a T-60 tape recorded on an RCA model *VBT200*. Once you have drawn the standard-speed curve you can plot a curve for the LP mode (*L*ong *P*lay:

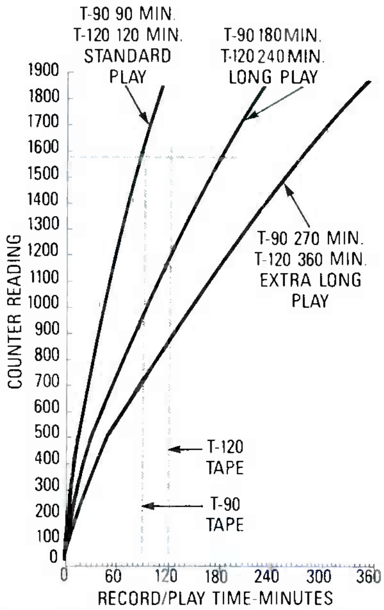


FIG. 4—USING "LONG" TAPES on the Magnavox VCR, we find that the calibrations for the 0–500 reading are exactly the same as those for the shorter tapes.

half-speed, twice-time) by simply doubling the time for each counter setting. Also, since the same hub size is used, the counter readings for a T-30 tape are the first half of each T-60 curve.

Figure 2 shows the the SP and LP curves for a T-120 tape on the same recorder. Notice that the T-90 tape is shown as the first three-fourths of each T-120 curve; that is because the same size hub is being used.

The RCA model *VBT200* recorder is a relative antique; it has only two speeds, 2 and 4 hours, so there are only two curves for each tape. Figures 3 and 4 show what the curves would be like for a typical three-speed VCR; in this instance a Magnavox model *VR8316BK01*.

The curves shown in Figs. 1 through 4 only illustrate the calibration procedure. It is unlikely that your VCR would have the same counter readings.

Using a camera

Although creating a calibration curve is simple, it does take at least two hours of your attention to calibrate a T-120 tape. A faster calibration procedure is possible, but it requires a video camera. However, it is the *only* good method to use when calibrating the counters used on some rewinders.

The first step is to make a T-120 two-hour tape of a clock face. While any kind of clock having a sweep hand or a digital readout for indicating seconds can be used, you'll find the old-fashioned analog clock (meaning it has hands) easiest to photograph. In a pinch you can use a watch if your camera has a macro-focus (close-up) lens.

Make sure your camera lens is aimed straight at the center of the clock. Since the minute hands on most clocks are placed well above the clock face, parallax may make it difficult to tell the exact minute reading if you are too close to the clock, especially if the camera isn't aimed directly at the center of the clock.

Set the clock to Midnight (all hands straight up). Rewind the tape, set the recorder to the fastest speed, and start the clock when you start recording. You will be, in effect, creating a special tape that has the elapsed time displayed on the entire length of tape.

Rewind the tape. Set the VCR counter to zero and prepare your TV for playback of the tape. Fast-forward the tape until the VCR counter reads, say, 25. Stop the tape. Then play the tape at that point and make a record of the clock reading *vs.* the tape counter's reading. Stop the tape, fast-forward to another counter setting, and again read the clock face. Do that as many times as you like, advancing the tape a set amount (25, 50 or 100 counts) between readings. Then plot the curves as described earlier. As shown in Figs. 1 through 4, you only need to make T-120 and T-60 "clock" tapes to cover T-30, T-60, T-90 and T-120 calibrations.

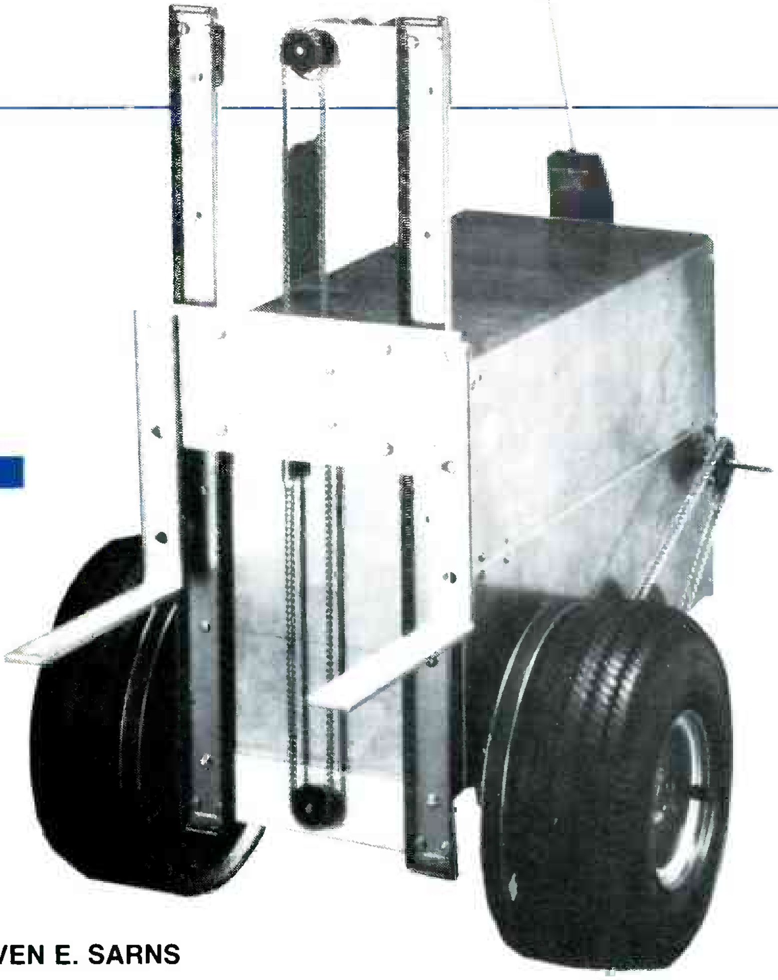
Counter-graph accuracy

Whether you're dealing with a VCR's counter or the one on a rewinder, don't be alarmed if the calibration isn't extremely accurate. Counter belt slippage, inaccuracy in your data, and poor curve plotting all take their toll. However, you'll be surprised, if you use reasonable care in gathering your data and plotting the curves, how close your calibration will be to the actual running time. You should be able to get within a couple of minutes of the desired tape location, and that's certainly better than the hunt-and-guess method you've probably been using. **R-E**

BUILD THIS

R-E ROBOT

Adding some "sense" to the robot.



Part 13 LAST TIME, WE looked at an electronic eye for the robot. However, we had no way to connect the eye to the robot. This month, we'll take care of that by showing you a head unit that serves as an interface for the navigational and sensory circuits, including the eye. The head unit also controls the movement of a small rotating platform that it and its associated sensors are mounted on. The advantage of using a rotating platform is that it allows for more accurate angular movements and measurements than trying to step the robot through ½-degree angles.

The specific functions that the head unit will support are:

- Stepper-motor drive for horizontal scanning.
- Optional stepper drive for vertical scanning.
- Ultrasonic range finder.
- Interface to the light-sensitive eyes that we discussed last time.

Mechanical design

We decided to design the head assembly in such a way that the entire unit, including the motors, etc., is detachable. That means that mounting the motors in the base unit and using a pulley system is out. Instead, a rather simple mechanical design has been used, one that relies on two key components for easy solutions to

STEVEN E. SARNS

tough problems. That design is shown in Figs. 1 and 2.

As shown in Fig. 1, a 78-tooth timing-belt pulley serves as a mounting base for the entire head assembly. The timing-belt pulley is secured to the base unit, but the pulley does not rotate. Instead, the head rotates around it, driven by a motor in the head assembly. A "lazy-susan bearing" attaches the head to the pulley, providing a large diameter access hole in the middle through which all of the control wires can pass. Those bearings are used in barstools and are available at most hardware stores.

The driving motor is mounted on the bottom and inside the head, with the drive belt on the bottom. A 12-tooth timing pulley on the motor results in a 6.5:1 gear-reduction ratio for the assembly. The result is a self contained, detachable, rotating head. The assembly can be mounted either to the top of the robot's chassis or to the top of the arm unit.

The entire head-drive unit is mounted within a 10 × 6.6 × 4.5-inch aluminum case. (The case is available from the supplier mentioned in the Sources Box that is elsewhere in this article.) One .062-inch removable aluminum side is used as the bottom and all of the drive components are mounted to that flat plate. See Fig. 2. Once the unit has been tested, the remainder of the case is slipped back over the plate and re-

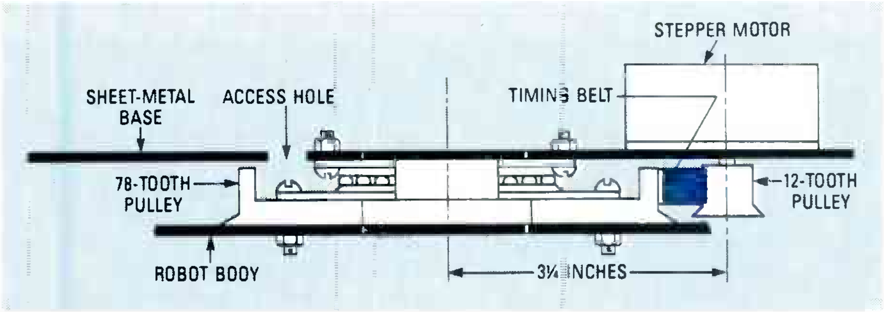


FIG. 1—THE HEAD UNIT mounts on a 78-tooth pulley. The pulley s secured to the base unit and does not rotate; instead the head rotates around it.

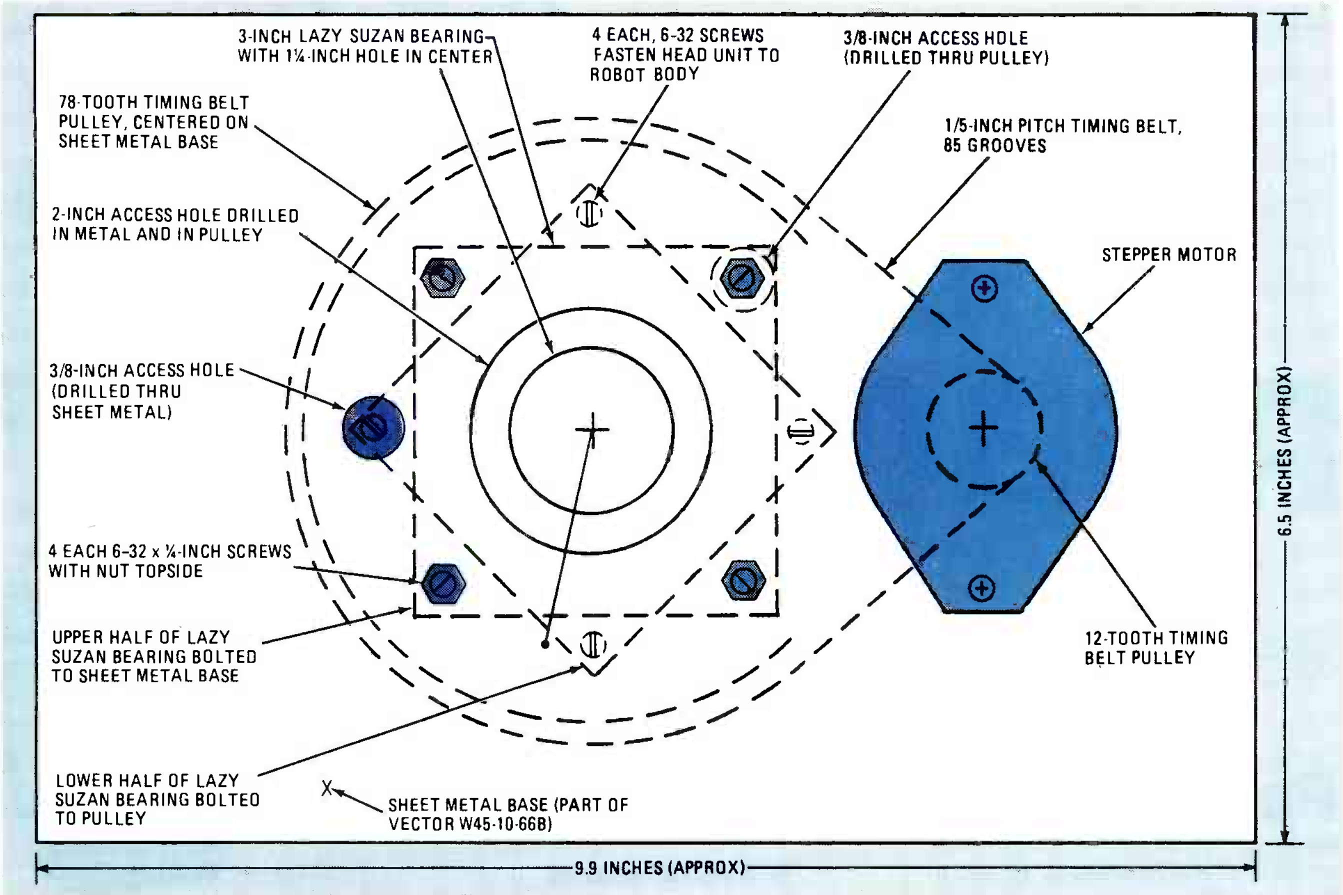


FIG. 2—THE HEAD'S DRIVE-TRAIN is detailed in this top view.

fastened. The case is ample enough to allow a 3.5-inch disk drive to be mounted in the head assembly.

User-bus interface

The schematic of the head-unit electronics is shown in Fig. 3. The head-unit circuit attaches to the bi-directional user bus via PL1. The head unit is mapped at location 0FH and consists of the peripheral functions listed in Table 1.

The peripheral address of 0FH is decoded with a single 74LS138 decoder, IC1. User-bus address lines A0 through A2 are connected to that IC's A0 through A2 inputs (pins 1–3); the fourth address line, A3, is connected to the active-high ENABLE input (pin 6). The output is taken from pin 7, the 07 output. Thus, all inputs must be high for the output to go low. You can use that decoding scheme to map other peripherals on the user bus.

Upon examination, you will notice that the 74LS138 actually decodes the 8 addresses between 08H and 0FH, each one appearing as an active low on its 8 respective outputs. If you connect address line A3 to an active-low enable, you can decode addresses 00H to 07H.

The active-low output of the address decoder is connected to the enable input of a 74LS377 output latch, IC3. The clock input is activated by the $\overline{\text{WRITE}}$ signal on the user bus. Thus we can write a byte of information to the output latch by setting up the data on the 8 data lines, setting up the address on the 4 address lines, and then strobing the $\overline{\text{WRITE}}$ line low to clock the data into the 74LS377 latch.

Inputs are read in a similar fashion. The output of the address decoder is applied to one $\overline{\text{ENABLE}}$ input of a 74LS541 buffer, IC2. The other $\overline{\text{ENABLE}}$ input is activated by the $\overline{\text{READ}}$ signal on the user bus. A byte of data is read from our head peripheral unit by setting the address lines to 0FH, bringing the $\overline{\text{READ}}$ strobe low, reading the byte on the data lines, and then returning the $\overline{\text{READ}}$ strobe high.

TABLE 1

Input	Function	Ouput	Function
DØ	Left eye, high freq	DØ	Horz stepper step
D1	Left eye, low freq	D1	Horz stepper enable
D2	Right eye, high freq	D2	Horz stepper direction
D3	Right eye, low freq	D3	Sonar echo initiate
D4	Sonar echo return signal	D4	Vert stepper step
D5	Limit sensor 0	D5	Vert stepper enable
D6	Limit sensor 1	D6	Vert stepper direction
D7	Limit sensor 2	D7	Sonar blank inhibit

Stepper-motor control

Stepper-motor control can be achieved in a number of ways. One is to use a microprocessor-intensive approach by driving each coil of the stepper with a single-bit output of the microprocessor. That means that each step of the stepper is accomplished by

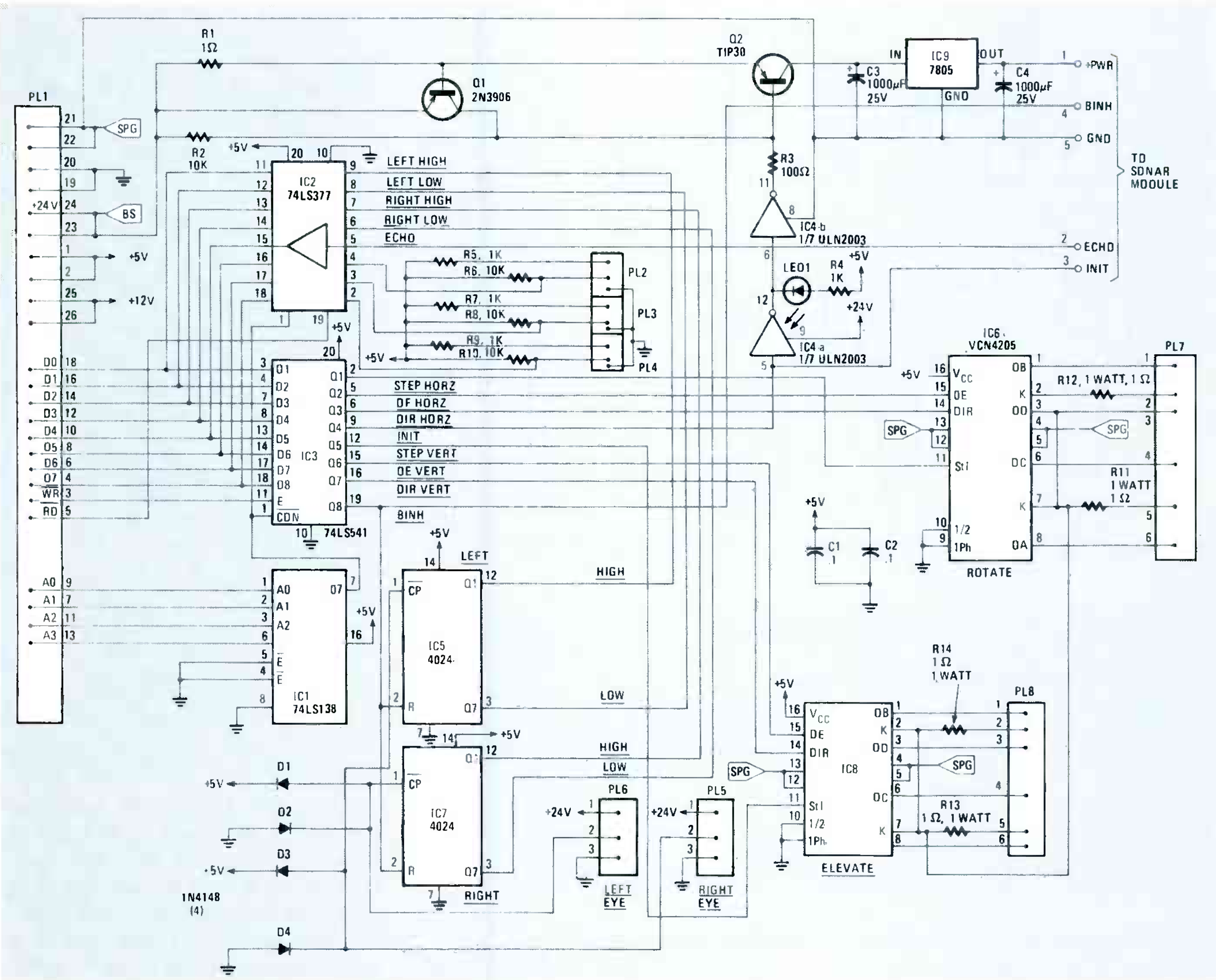


FIG. 3—THE SENSOR INTERFACES and the head's stepper-control electronics.

code look-up tables that contain the state of the phases for each step for both directions. On the other hand, you could use a motion-control IC such as the Hewlett-Packard HCTL-1000. Once the desired final position for the stepper is input to that device, it accelerates the motor, maintains its speed, and decelerates the motor as needed without further instructions from the microprocessor.

The microprocessor-intensive approach is inexpensive, but generating the code required would take quite some time. On the other hand, motion-control IC's are expensive, costing between $40 and $250.

There is another approach that is in-between those two extremes. If we use a stepper-motor control IC and service that IC with the microprocessor, our cost does not rise much and we can greatly cut the time we would need to generate the code.

That approach fits nicely into our requirements for the head unit because the tasks asked of the motor-control circuit are actually pretty simple: step a few times and wait for the sensors to accumulate new data. Step rates and acceleration will not be a major factor.

The Sprague UCN4205B-2 is used as the stepper-motor controller. That IC was chosen for its hefty motor-drive rating of 1.5 amps at up to 30 volts.

During periods of head inactivity, we will de-energize the stepper motor coils, thus conserving power. Drive-sequence selection is accomplished by grounding pin 10 for two-phase drive, or open circuiting pin 10 for half-step drive. Two-phase drive spins the head around faster, but half-step gives smoother operation. Either can be used, depending on your preference or application.

Note that two stepper controllers are included in the circuit. One, IC6,

SOURCES BOX

The following are available from Vesta Technology (7100 W. 44th Ave., Suite 101, Wheatridge, CO 80033, 303-422-8088): Bare head unit PC board; $19; fully assembled and tested head-unit PC board (not including sonar ranging unit), $89; Texas Instrument sonar-ranging module; $29. CO residents must add appropriate sales tax. Other components for the R-E Robot project are also available from Vesta Technology.

Stock Drive Products (55 S. Denton Ave., New Hyde Park, NY 11040, 516-328-0200) can supply the drive-train components for the head unit:Timing Belt, 0.2-inch pitch, 85 grooves (part no. 6G3-85-037); pulley, 12 tooth (part no. 6A3-12H3708); pulley, 78 tooth (part no. 6K3-78SF03712). Contact Stock Drive Products directly for pricing and shipping information.

Stepper motors suitable for the head (12-volt, 36-ohm coil) are available from United Products Corporation (1123 Valley St., Seattle, WA 98109-4425, 206 682-5025) for $6.95 each. Ask for part number Copal SP-57. **R-E**

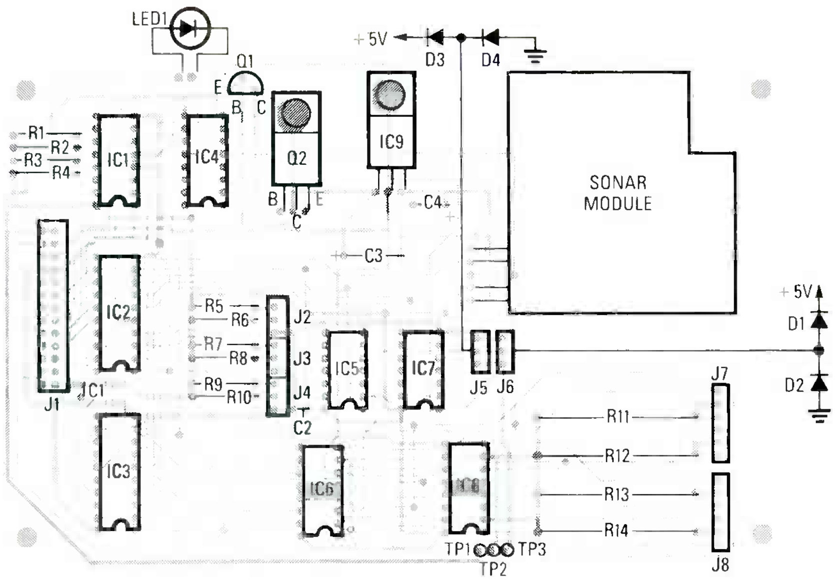


FIG. 4—ALL OF THE HEAD'S ELECTRONICS are mounted on one double-sided PC board.

LISTING 1

```
(HEAD UNT—STEPPER MOTOR TEST)
HEX                                 VARIABLE HEAD-POS
: M+      9 F PCX!                    1 HEAD-POS +!        8 F PCX!
: M–      D F PCX!                  – 1 HEAD-POS +!        C F PCX!
: MØ      A F PCX!
: TEST
    BEGIN
        M+      1Ø DELAY  KEY?
    UNTIL MO ;
```

PARTS LIST

all resistors ¼-watt, 5%, unless otherwise noted
R1—1 ohm
R2, R6, R8, R10—10,000 ohms
R3—100 ohms
R4, R5, R7, R9—1000 ohms
R11–R14—1 ohm, 1 watt
Capacitors
C1, C2—0.1 µF, ceramic disc
C3, C4—1000 µF, 25 volts, electrolytic
Semiconductors
IC1—74LS138 1-of-8 decoder
IC2—74LS541 octal buffer/line driver
IC3—74LS377 octal D flip-flop
IC4—ULN2003 seven-inverter IC
IC5, IC7—4024 7-stage binary ripple counter
IC6, IC8—UCN2005 stepper controller
IC9—7805 5-volt regulator
Q1—2N3906 PNP transistor
Q2—TIP30 NPN transistor
D1–D4—1N4148 diode
LED1—red LED
Other components
PL1—26-pin, dual-row male header
PL2–PL6—3-pin male header
PL7, PL8—6-pin male header
Miscellaneous:PC board, case (Vector W45-10-66B or equivalent), mechanical components (see text), wire, solder, etc.

is used to control the head's rotation. The other, IC8, is used to control the head's elevation. Since vertical scanning is an optional function, the second controller is optional. In any event, both stepper-motor controllers work in an identical manner. For simplicity, we will only discuss the operation of IC6.

The stepper controller is connected directly to the four coils of its associated stepper motor via PL7. The common wires of the two pairs of coils are returned to the power supply through optional resistors R11 and R12. Direct shorts could be used in place of those resistors in most cases. However, in some cases the use of the resistors will allow you to use a higher coil-drive voltage. That drives the stepper in the current mode, enabling a higher step rate due to the reduced effect of coil inductance. Since both 12- and 24-volt supplies are available, steppers with 12- or 24-volt coils can be used. We suggest using steppers with 24-volt coils if possible since the 12-volt regulator on the robot's main board can only supply about 1 amp total.

Motion-control software

Our software must set the direction of rotation and enable the control bits. It then must apply a pulse to the controller's step input, which causes the device to output each of the four phase-drive sequences to the motor. The top speed of our motor will be limited by the ability of the software to output the step commands, but that will not be a problem because the head must stop every few steps to accumulate data. We will not attempt to accelerate the motors, merely step them at a low speed.

As the code in Listing 1 demonstrates, the software required to rotate and test the head unit is very simple. (It is assumed that you have the PCX! and PCX@ words installed. Those were defined in Part 8 of this series, which appeared in July, 1987.)

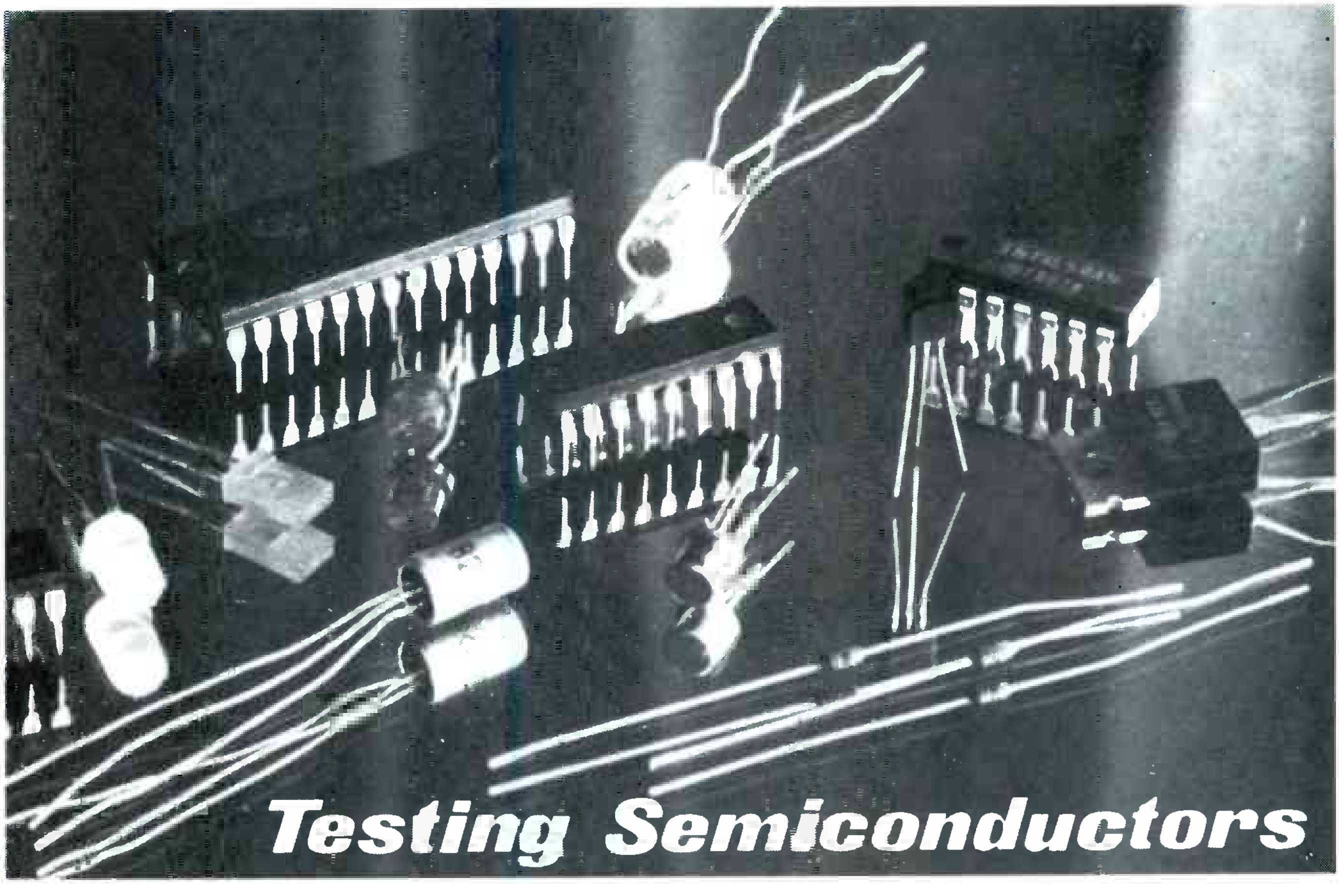
The word M+ rotates the motor one step clockwise and increments the value in the variable HEAD-POS; the word M– rotates the motor counterclockwise. The word M0 turns off the coils. TEST can be rewritten to rotate in the opposite direction by substituting M– for M+. In operation, the 10 DELAY would be replaced by the analog-to-digital conversion process of the optical information from the eye or the sonar information from the sonar module (or both) as well as possibly releasing the Forth-83 multitasker to another task. The following word will rotate the head a given number of steps while maintaining the current relative position in HEAD-POS.

```
: CW   ( STEPS —- )  Ø
   DO
       M+3Ø DELAY
   LOOP MØ ;
```

Sonar interface

Sonar ranging modules are available from Texas Instruments and Polaroid. The TI module is the latest generation and offers improved noise-rejection characteristics. Either module will work in the circuit as will ranging devices that do not use the Polaroid transducer. We have simply designed the circuit board with a mounting area for the module and the control lines ready to wire to the module. See Fig. 4.

That's all for this month. Next time we'll show you how to use the TI module, connect the eye, build the head, and more! **R-E**



Testing Semiconductors

Our back-to-school series continues this month with a discussion of how to test TTL devices, and what the results mean.

TJ BYERS

Part 8 IN 1964, TEXAS INSTRUMENTS introduced a line of digital-logic devices for the military—which they designated as *S*emiconductor *N*etwork series 54 (SN54)—that forever changed the concept of electronic design. That family of TTL (*T*ransistor-*T*ransistor *L*ogic) military integrated circuits quickly evolved into the popular SN74 and 74LS devices now used in nearly every electronic product. In this installment we will explore the static (DC) testing characteristics of TTL devices, and discover facts about their heritage that you may not be aware of.

TTL operation

The internal parts of a typical TTL four-input NAND gate are shown in Fig. 1-*a*; its schematic symbol is shown in Fig. 1-*b*. The device depends on input transistor Q1 having multiple emitters—four, to be exact, labeled INPUT A, INPUT B, INPUT C, and INPUT D. Each emitter represents a logic-gate input. With all four inputs at a high input voltage (representing a logic 1), transistor Q1 is reverse biased, so Q1's base current is channeled through its collector to Q2, thereby causing Q2 to conduct, which in turn causes Q3 to conduct. Since Q3's base-emitter junction is across Q2's emitter resistance (R3), Q2's total emitter impedance is less than the value of R3, which causes a further increase in the current flow through Q2. That decreases Q2's collector voltage, which results in turning off Q4 and Q3 saturating. In that state the output voltage at Q3's collector is theoretically zero volts, representing a logic 0.

If *any* of Q1's emitters is returned to ground via a low input voltage (logic 0), transistor Q1 begins to conduct heavily, thus diverting base current away from transistor Q2 and essentially saturating Q1. With transistor Q1 saturated, transistor Q2 drops out of conduction, forcing Q2's collector voltage high and its emitter voltage low. In that condition, transistor Q4 will conduct while transistor Q3 is cut off, resulting in a high voltage on Q3's collector, representing a logic 1 state.

TTL parameters

In theory, the output levels at Q3's collector should be V_{CC} for logic 1 (Q3 not conducting) and V_{DD} for logic 0 (Q3 saturated). In fact, that is not the case.

Transistors Q3 and Q4 make up what is referred to as a *totem-pole* or *active pull-up* output. Their purpose is to provide a low-impedance current source for capacitive output circuits. Through the use of brute force, subsequent logic gates can be forced to

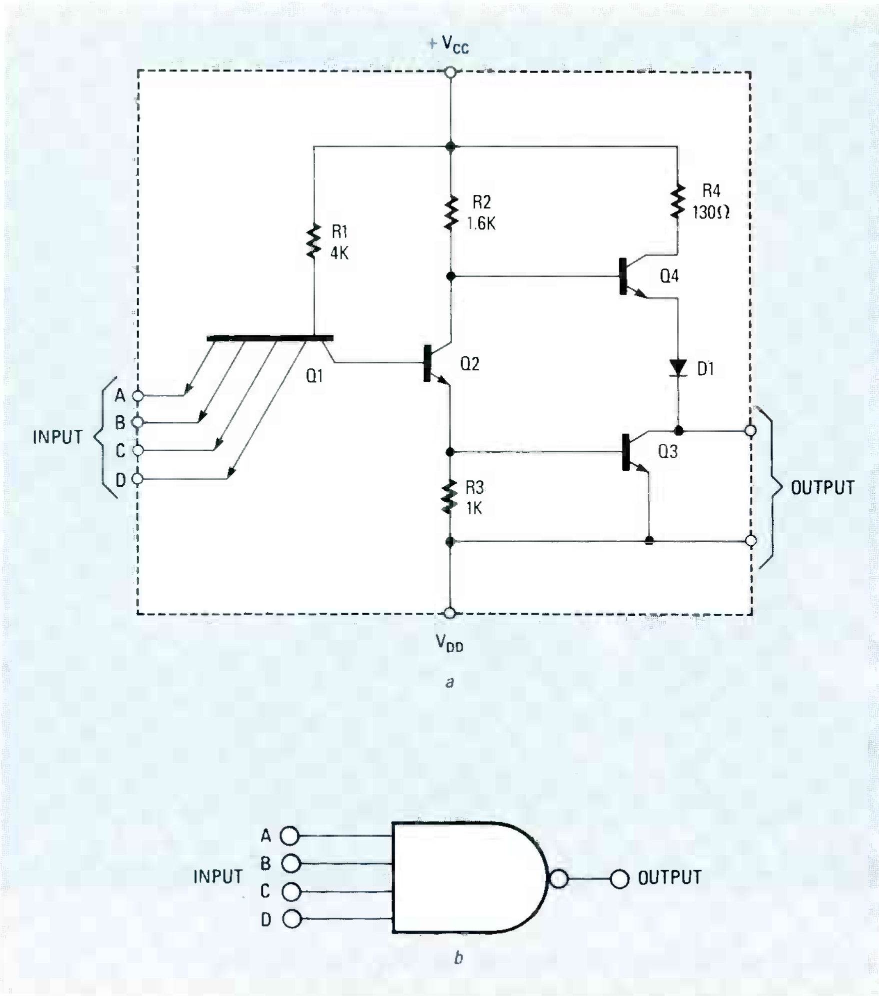


FIG. 1—THE INTERNAL STRUCTURE of a TTL 4-input NAND gate is shown in *a*. The equivalent logic diagram of a 4-input NAND gate is shown in *b*.

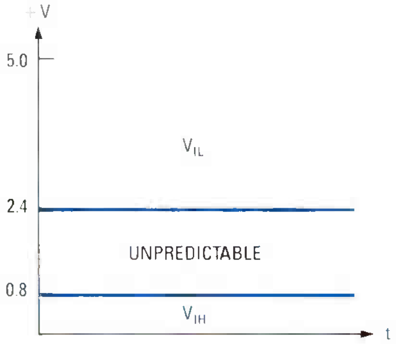


FIG. 2—THE MINIMUM AND MAXIMUM voltage limits of V_{IH} and V_{IL} for TTL negative logic (NAND, NOR). For positive logic (AND, OR) the values are reversed.

switch faster than could be expected from a simple single-transistor driver. With the output in logic 1 state, the output impedance is very low because Q4 appears as an emitter-follower source, driving current into the capacitive load. When in a logic 0 state, Q3 is saturated, resulting in a low shunt impedance to ground that quickly discharges the capacitive load.

Therein lies the problem. Transistor saturation is a relative state of events, and not a simple on/off toggle of a switch. Real transistors have real resistance, as was explained at the beginning of this series. Because transistor saturation voltage—$V_{CE(sat)}$—depends on both base and collector currents, Q3 will go out of saturation either by decreasing its base current (I_B) or else by increasing its collector current (I_C).

Consequently, there is a region in which either the base drive current is too small or the collector current too large to sustain the ideal values of V_{CC} and V_{DD} for logic 1 and logic 0, respectively.

Collector current, I_C, is a function of the output load, which is a function of the resistance between Q3's collector and V_{CC}. As the load resistance from V_{CC} to Q3 decreases, collector current increases, which demands a larger base current to sustain saturation.

Base current to Q3, on the other hand, depends on the h_{FE} of Q1 and V_{CC}. Consequently, limits must be placed on the values of minimum supply voltage (V_{CC}), maximum Q3 collector current (I_{sink}), and maximum Q3-saturation voltage (V_{OL}) before testing of the gate may begin. For reasons that will be discussed later in this installment, TTL-output saturation is defined as 0.4 volt at 16 mA.

The Q1 emitter-input voltage levels at which the output signal at the collector of Q3 switches between logic 0 and logic 1 are referred to as V_{IH} and V_{IL}. V_{IH} is defined as the minimum input voltage required to guarantee a 0-level output, while V_{IL} is the maximum allowed input voltage to guarantee a logic 1 output. See Fig. 2.

Between those two input voltages lies an area that is considered unpredictable. Depending on the transistor's gain and the value of V_{CC}, the output signal may actually come to rest at some voltage midway between logic 0 and logic 1. V_{IH} and V_{IL} are measured to guarantee that it does not happen.

While the following test procedures center around the use of negative logic (the NAND and NOR family of devices), the test parameters are nevertheless valid for all TTL devices. To accommodate positive logic in the described test circuits, such as for AND and OR gates, simply invert the input or output logic voltages to the device (depending on the value to be measured) and proceed accordingly.

Measuring V_{IH}

Before V_{IH} testing can begin, a voltage range must be specified for V_{CC}. Nominal V_{CC} voltage for a TTL device is +5 volts. Fluctuations in power-supply output, however, can

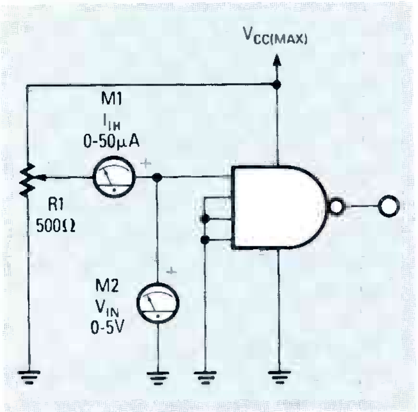


FIG. 3—THE TEST CIRCUIT used for measuring V_{IH}, V_{OL}, and I_{OL}.

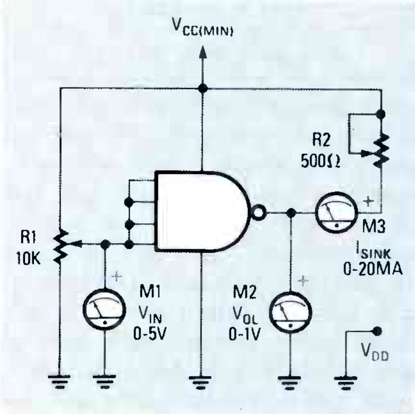


FIG. 4—THE TEST CIRCUIT used for measuring V_{IL}, V_{OH}, and I_{OH}.

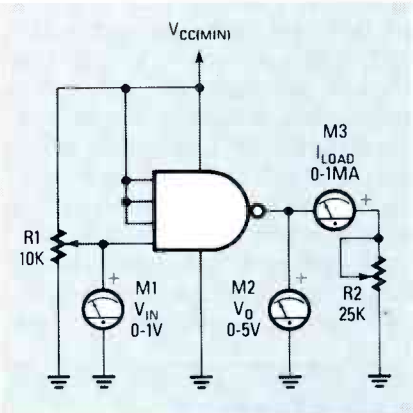


FIG. 5—THIS TEST CIRCUIT is used for measuring I_{IL}.

cause that value to change by as much as 15%. Consequently, a lower limit for V_{CC} must be determined before testing begins.

For 54-series devices, $V_{CC(min)}$ is +4.50 volts; for devices $V_{CC(min)}$ is +4.75 volts. The difference in minimum V_{CC} values between the two families can be explained by the fact that the military part (SN54) must be able to endure more extreme conditions than are normally experienced by commercial equipment.

Now that the test parameters have been defined, V_{IH} can be determined using the test setup shown in Fig. 3. Notice that all four inputs have been tied together and tested as one. That is normal. The test procedure goes as follows.

The value of V_{CC} is first set to the $V_{CC(min)}$ value specified for the device under test. Variable resistor R1 is adjusted so that the input gates (emitters) are essentially connected to V_{CC}. That causes the output to go low (logic 0). Variable resistor R2 is then adjusted so that meter M3 (I_{sink}) measures 16 mA. The test parameters are now set.

V_{IH} is tested by using R1 to decrease the voltage to the input gates while monitoring I_{sink}. As the voltage to the input emitters decrease, V_{OL} increases. When V_{OL} is 0.4 volts, the corresponding V_{in} voltage represents V_{IH}. Typically, V_{IH} is 2.0 volts or greater.

Measuring V_{IL}

V_{IL} is the voltage at which Q3 drops out of saturation and the output signal is at logic. In that state, Q4 is conducting and supplying current to a capacitive or resistive load. Nominal load current is defined as 400 mA.

The test circuit for V_{IL} is shown in Fig. 4. In that test, only one gate at a time is measured. All unused gate inputs are connected to V_{CC}.

The test begins by adjusting the power supply to $V_{CC(min)}$ for the device under test and adjusting R1 so that meter M1 (V_{in}) shows zero volts. Variable resistor R2 is then adjusted so that meter M3 (I_{load}) is 400 μA. Potentiometer R1 is then adjusted while monitoring M2 (V_O). As V_{IL} increases, V_O decreases. When V_O reaches a minimum of 2.4 volts with a load current of 400 μA, the voltage V_{in} is equal to V_{IL}. V_{IL} is typically less than 0.8 volts.

Gate input current

In TTL design, input current is required by the gate emitters before the circuit will function. The maximum input current that flows when the input is at logic 0 is defined as I_{IL}.

Because I_{IL} is a function of V_{CC}, and increases as V_{CC} increases, the worst-case condition exists when the device under test is subjected to $V_{CC(max)}$. Consequently, it is at that voltage that I_{IL} is tested. For the 54 series, $V_{CC(max)}$ is +5.5 volts; for the

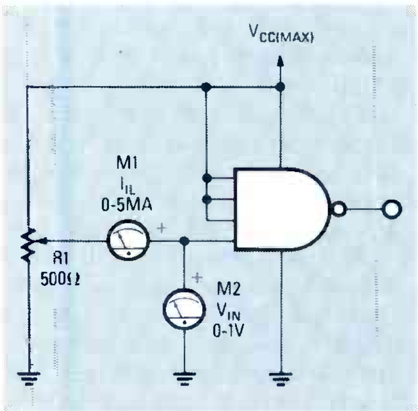


FIG. 6—THIS IS THE TEST CIRCUIT for measuring I_{IH}.

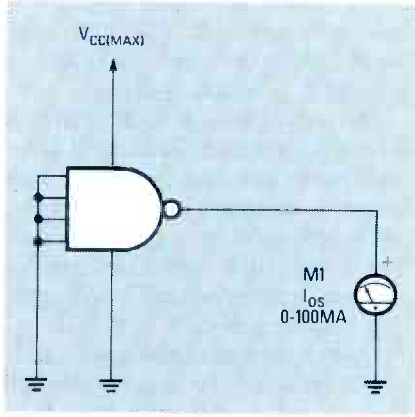


FIG. 7—THE TEST CIRCUIT for measuring I_{OS}.

74 series, $V_{CC(max)}$ is +5.25 volts. Again, the difference in test parameters can be attributed to the more demanding standards imposed by military specifications.

The test setup for I_{IL} is shown in Fig. 5. With the exception of the input under test, all unused inputs are tied to V_{CC} to maximize any contribution the inputs might have on I_{IL}. Should they be grounded instead, one or more of the unused gates could siphon potential leakage current around the input being tested, causing a measurement error. No output loading is required, so the output pin may remain unconnected.

The test is performed by adjusting R1 until meter M2 (V_{in}) indicates 0.4 volt. The current indicated by the series input ammeter, M1, is I_{IL}. Each input is tested and measured separately.

Transistor Q1 (see Fig. 1) is back-biased and a small leakage current flows when the input is logic 1. The input current that flows when the input is at logic 1 is defined as I_{IH}.

The test circuit for I_{IH} is shown in Fig. 6. In that test, the power supply is set to $V_{CC(max)}$, and R1 adjusted until meter M2 (V_{in}) indicates 2.4 volts. The current displayed by series ammeter M1 is I_{IH}. I_{IH} is typically less than 40 μA.

Gate output parameters

As indicated earlier, transistors Q3 and Q4 (see Fig. 1) form an active pull-up output that provides a low-impedance current source for capacitive output circuits. By brute force, an external load can be made to change logic states faster than RC conditions normally allow.

The brute force, of course, is supplied by current: one for the up swing, the other for the down swing. The amount of current a TTL gate is capable of sinking or sourcing is defined as I_{OL} and I_{OH}, respectively.

The output voltage is dependent on the output current. Because it is impossible to maintain Q3 in saturation under all conditions, the output voltage is going to vary as the load varies. The values of the output high and low voltages are represented by V_{OH} and V_{OL}, respectively.

Output current and voltage can be measured using the circuits shown in Figs. 3 and 4. All output measurements are made under the worse-case input conditions; that is, the input logic 1 ls to the gate are adjusted so that they are just within tolerance of TTL specifications for the device under test. In the case of a logic 1 input, the value is 2.4 volts; for a logic 0 input, it is 0.8 volt.

The measurements of I_{OL} and V_{OL} are made using the circuit shown in Fig. 3. Measuring I_{OL} is done by adjusting R1 until meter M1 (V_{in}) indicates 2.4 volts. Variable resistor R2 is then adjusted until meter M2 (V_{OL}) indicates 0.8 volt. Meter M3 (I_{sink}) indicates I_{OL} (16 mA).

V_{OL} is measured by setting R1 for an input of 2.4 volts and adjusting R2 until M3 indicates 16 mA. Meter M2 indicates V_{OL}. Maximum V_{OL} voltage is 0.8 volt.

The measurements of I_{OH} and V_{OH} are done using the circuit shown in Fig. 4. Measuring I_{OH} is done by adjusting R1 until meter M1 (V_{in}) indicates 0.8 volts. Variable resistor R2 is then adjusted until meter M2 (V_O) registers 2.4 volts. Meter M3 (I_{load}) displays the value of I_{OH}. Minimum I_{OH} is 400 μA.

V_{OH} is measured by setting R1 for an input of 0.8 volts and adjusting R2 until M3 indicates 400 μA. The value registered by M2 is equal to V_{OH}. Minimum V_{OH} is 2.4 volts.

Fan out

If you examine the four tests we've gone through, you will notice that a minimum or maximum value is stated for each. The limits are established to guarantee that the output logic levels of a TTL gate are capable of driving 10 other gates.

During the evaluation stage of TTL development, it was determined that the maximum I_{IH} input leakage current of a good TTL gate was never greater than 40 μA., consequently, minimum output-current requirements for I_{OH} were set at 400 μA (40 μA × 10 gates).

It was further determined that I_{IL} did not exceed 1.6 mA per input. The result of that decision yields a minimum I_{OL} current of 16 mA. The upper and lower limits of V_{OL} and V_{OH} were selected on the basis of noise immunity.

In many instances, the values of I_{OL}, I_{OH}, V_{OL}, and V_{OH} are never actually measured. The gate is simply placed in a test configuration where the operator decides between a go or no-go situation.

Short-circuit output current

A puzzling test parameter that appears on the TTL data sheet is I_{OS}; meaning, the output current with the output shorted to ground. Essentially, it describes the amount of current the gate is capable of supplying through a short circuit when the output is at logic 1 (high). The test circuit is shown in Fig. 7. In that test, output voltage is not a factor. V_O may assume any value because output current is the measured value.

While the usefulness of the test may seem obscure, its origin is not. Lore (or mythology) has it that during early development of TTL technology at Texas Instruments, an engineering technician accidentally reversed the gate inputs for the outputs during a routine I_{IL} input-current test. Connected to the devices was, obviously, a current meter for monitoring what was supposed to be input current I_{IL}. Instead, the meter indicated short-circuit output current.

The error became apparenet when a government inspector questioned the wide variations in the recorded I_{IL} readings.

To save face, the technician calmly stated that the test was done intentionally to reveal the true nature of the device's durability under the most adverse of all conditions. The inspector bought the story, and mandated all government devices be subjected to the same test. To this date I_{OS} appears on all TTL data sheets.

And on that note, we will take our leave till next time, when we will continue our examination of integrated digital components as we review the test techniques for *L*ow-power *S*chottley (LS) and *C*omplementary *M*etal *O*xide *S*emiconductor (CMOS) digital devices. **R-E**

HDTV UPDATE

continued from page 17

spent about $45 million over the last decade developing ACTV and expects that another $30 million is needed to complete development. Because everyone involved in the TV industry has so much to gain from a successful, compatible HDTV system, we would expect them to quickly adopt the new system, and to work on solving any of the problems that arise.

Despite the promise of the new system, it's important to realize that no broadcast field tests of ACTV have taken place. However, ACTV signals have been computer-simulated at Sarnoff's Digital Video Facility and stored on videotape. The system was demonstrated publically for the first time at the HDTV Colloquium in Ottawa in early October, and we hope to have a first-hand report and more technical details of the new system in the near future. If the system lives up to its promise, perhaps compatible 3-D TV isn't too far behind! **R-E**

COMING NEXT MONTH

BUILD THE Radio-Electronics ADVANCED CONTROL SYSTEM

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!

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

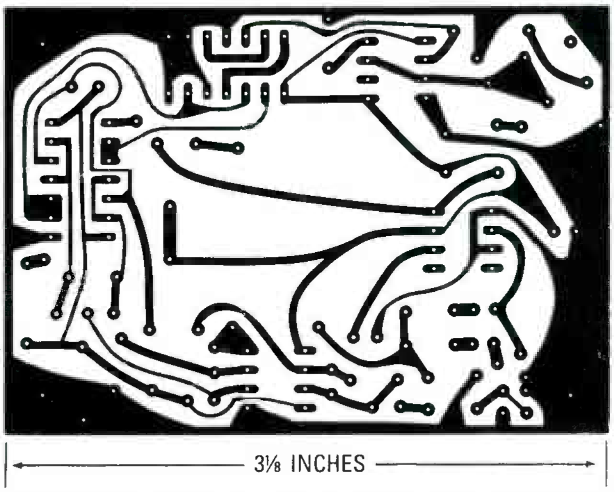
In order to produce a board directly from the magazine page, remove the page and carefully inspect it under a strong light and/or on a light table. Look for breaks in the traces, bridges between traces, and in general, all the kinds of things you look for in the final etched board. You can clean up the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

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

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

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

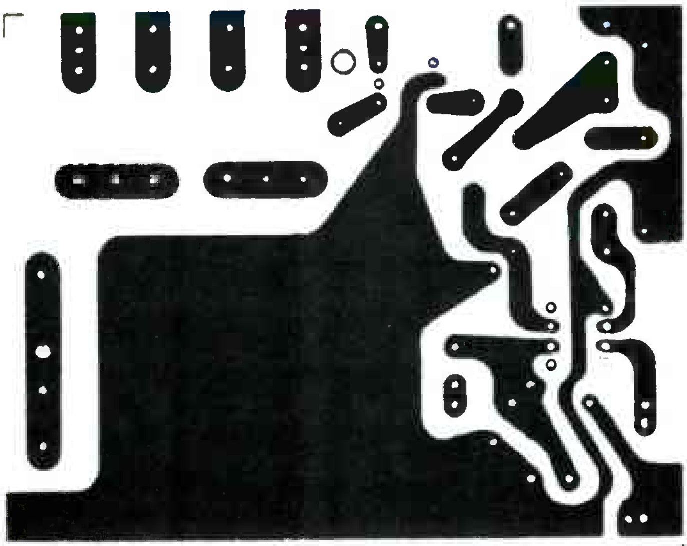
Radio-Electronics
Department PCB
500-B Bi-County Blvd.
Farmingdale, NY 11735



THE AUDIO SCRAMBLER lets you communicate in privacy. The circuit is built on this PC board. The story begins on page 51.

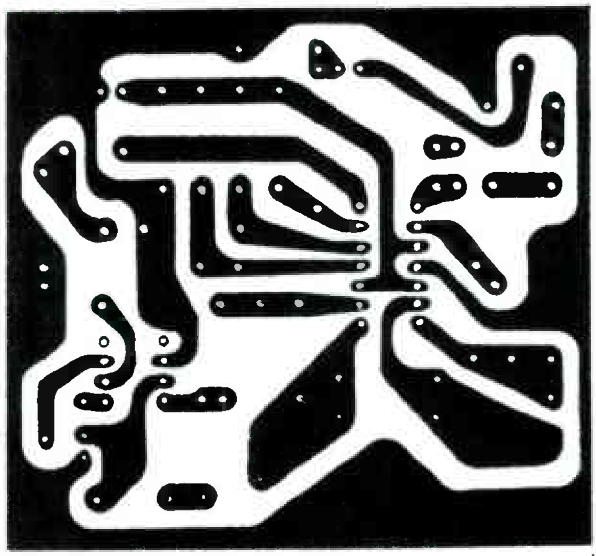
PC SERVICE

PC SERVICE



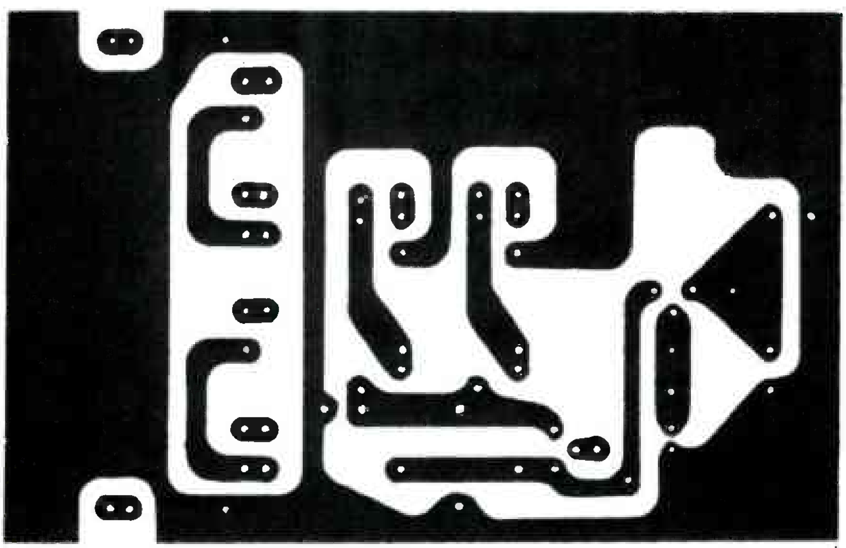
3½ INCHES

THE FOUR BOARDS on this page are used to build the Uninterruptible Power Supply. The board shown here is the power-supply board.



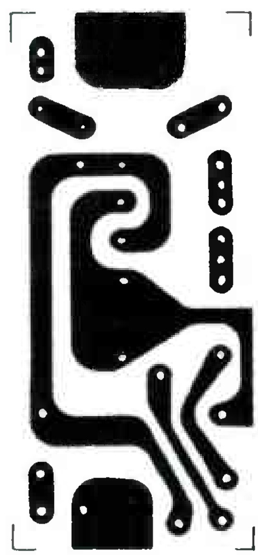
3 INCHES

USE THIS BOARD to build the sine-wave generator circuit.



4⅜ INCHES

BUILD THE AMPLIFIER for the UPS on this board.



2¾ INCHES

THE METER CIRCUIT can be built on this simple board.

PC SERVICE

HARDWARE HACKER

Welcome to a new column

A digital potentiometer
Automotive electronics
Accessing trade journals
New technical literature
The Santa Claus machine

DON LANCASTER

WELCOME TO A NEW **RADIO-ELECtronics** feature column. I'll be doing what I can here to find needed resources, answers, and opportunities for all you readers. While we will center mostly on traditional stand-alone electronics, just about anything at all in the "neat stuff" category can and will come up.

You will find an end box listing a new and no-charge help line that you can call most weekdays 8–5 *mountain standard time* to talk to the guru hisself. A new *resource file* will also appear at the end of each column, containing all the names and numbers that are *very* hard to pin down otherwise.

And, from time to time, we will have a contest or two to close the loop and get you involved. Some of them will be technical and some not. The usual prizes will be a book of mine or an all-expense-paid *tinaja* quest (FOB Thatcher, AZ), with occasional extra cash for an outstanding entry. One hint: your odds of winning one of those are very good!

Let's just jump right in...

What's new in automotive electronics?

There's an outfit called the SAE who used to be known as the *Society for Automotive Engineers* that have a very wide variety of books, technical articles, and other publications on most anything vehicular.

While some of their stuff is rather pricey, there's lots of goodies in the $10 to $30 range. For a complete listing, ask for their current *Publications Catalog.*

Some of the more interesting titles include *Commercial Vehicle Electronics, Some Unusual Engines, Automobile Audio Systems, Recycling of Automotive Catalysts, Understanding Automotive Electronics, Sensors, Audio Systems: Speakers and Receivers,* and *A History of the Internal Combustion Engine.*

They have hundreds more, so be sure and check them out.

Tell me about EEPOT's.

Suppose you took a 100-position selector switch and 99 resistors of, say, 1000 ohms each. You could connect them up to make a 100-position volume control, as was done in older broadcast-quality audio attenuators. Now, what would really be nice is finding some way to *remote-control* the switch setting. That way, you or a computer could change the switch position at will.

The switch would be able to "remember" its correct setting and would still be correct the next time that you applied power.

Well, the folks at *Xicor* have done you one better. They have come up with an 8-pin mini-dip beastie called an *EEPOT* that can be used as a remotely controlled volume control. You can also think of it as an unusual digital-to-analog converter or else as a multiplier that can multiply a digital and an analog value together.

Three of the available devices include the X9103 (10K), the X9503 (50K), and the X9104 (100K). *Xicor* has been known to send out free samples on letterhead requests; otherwise, they cost under $5.

Figure 1 shows you a block diagram of an EEPOT. A pair of leads are used for the +5-volt DC supply and ground. Three leads are used for the two ends and the wiper of the equivalent potentiometer. Finally, three leads, named CHIP SELECT, UP/DOWN, and INCREMENT are used for the digital control.

The position in the resistor string is selected by one of 100 internal field-effect transistors connected as data selectors. The present position is remembered by a seven bit, modulo-100 counter. When the chip is selected, you can raise or lower the position one count at a time, through use of the UP/DOWN and INCREMENT inputs.

To initially set your volume-control position, you bring the CHIP SELECT low. If you want a "louder" output, you make the UP/DOWN input high and then pulse the INCREMENT line by bringing it low and then back high again exactly once. Repeat for each step as needed.

Now for the neat part. The internal position counter is "backed up" by seven non-volatile memory cells. When you deselect by making the CHIP SELECT high, the memory cells "remember" the counter position for you, even after supply

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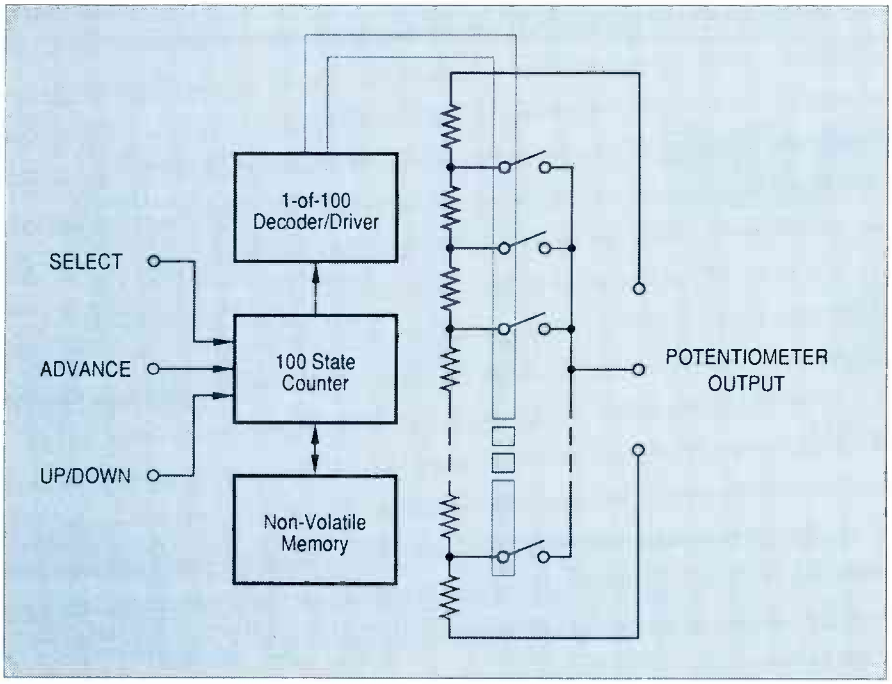

FIG. 1—AN EEPOT CAN SIMULATE an ordinary potentiometer and can be remotely controlled, either manually or by a computer. The wiper position is remembered during any power-down times by an internal non-volatile memory.

power is disconnected. Thus, if you use the beastie to remotely set the volume on your stereo, you will have the same volume setting the next time you apply power.

There are a few "gotchas," though. While a hundred positions are more than enough for most audio uses, it just plain isn't nearly enough resolution for such neat things as remotely setting a floppy-disk drive's speed. While the output distortion is quite low, you are limited to a maximum of + or −5 volts of analog input signal. And you should not try to source or sink more than half a milliampere of output current.

There's one very important use rule: *You absolutely must not disconnect the supply power while the chip is selected.* As is typical with most non-volatile memories, powering down while active can lead to incorrect memory values being stored.

You also have to keep the chip's power applied when you are actually using the output. Thus, while we do have a low-power device, it is not suitable for truly micropower uses.

Figure 2 shows you the pinouts, while Fig. 3 shows you a "bounceless" pushbutton that will let you experiment with the INCREMENT input on your EEPOT without anything fancy in the way of computers or test gear.

A bounceless switch is also shown for the CHIP-SELECT input. Note that debouncing is absolutely essential for those two inputs when you are working with mechanical contacts.

The UP/DOWN input does not need any mechanical contact debouncing, provided that you wait a few milliseconds each time you change it.

In the real world, you are more likely to use the "already clean" and parallel outputs of a personal computer port or the output commands from a remote controller integrated circuit to drive your EEPOT. In those cases, any extra debouncing circuits are not at all needed.

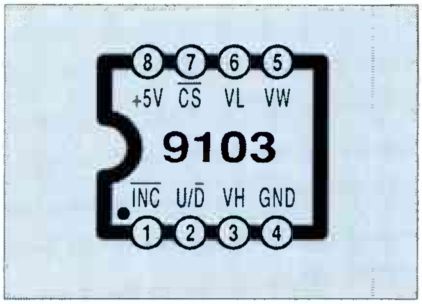

FIG. 2—EEPOT PINOUTS. VL, VW, and VH are the terminals of the output potentiometer. The chip select $\overline{CS}$ is brought low to change position, but is left at +5 otherwise. Position is changed by bringing $\overline{INC}$ low and then high again, with direction set by up/down pin $U/\overline{D}$. A high $U/\overline{D}$ advances the position.

Now, I could sit here and tell you all the marvelous things you can do with a volume control whose setting is remotely and digitally controllable and then later remembered during power down times. Things like variable-gain amplifiers, electronic multipliers, self-calibrating instruments, and stuff like that.

Instead, we'll use the EEPOT for our first contest. Just dream up a good use or two for that IC. Be sure to send your entries directly to me via the address in the box, and *not* to the **Radio-Electronics** editorial offices.

What are trade journals?

Trade journals are far and away the most important resource available to any hardware hacker, yet I still get countless helpline calls from people who have never even heard of them.

Just about any technical field has its own set of special-interest magazines that are intended strictly for "insiders". Those magazines

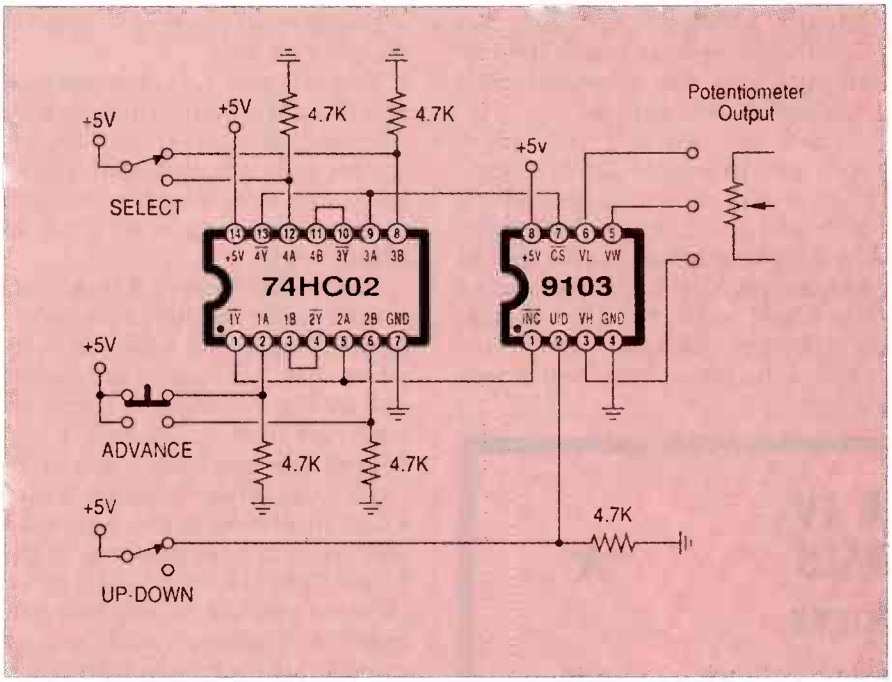

FIG. 3—USE THIS CIRCUIT to test your EEPOT. The debouncing shown is only needed when you are using mechanical contacts.

are often free, but are rarely advertised; they're never seen on newsstands. Inside a trade journal, you will find ads for the latest and the best, technical and survey articles, year-end directories, bingo cards, and various assorted freebies.

There are many thousands of different trade journals being published today. Some important electronic examples include *EDN, Electronic Design, E. E. Times, Electronic News, Powerconversion* and *Electronics*. A few of the great journals on robotics include *Machine Design, Design News*, and *Motion* magazines.

To emphasize the wide variety of stuff that is available, some other trade journals that I have found personally useful include *Signcraft, Textile World, Printing Impressions, Technical Photography, Computer Reselling, Electronic Publishing*, and *Fire Engineering*.

So how can you tap those resources that are absolutely essential for serious hacking? First, go to your local library and check into a most useful reference book called *Uhlricts Periodicals Dictionary*. That, and the similar *International Standard Periodicals Dictionary*, will give you a fairly complete list of what is available from whom.

If you already have your own business letterhead (an *absolute must* for serious hacking, and utterly trivial to do in these days of laser printers), the next step is to write or call the various journals and ask for a reader-qualification card. Chances are you can qualify for a free subscription.

If not, check any large technical library, or see if an engineer at a larger electronics outfit can cop you older issues, or else use the *interlibrary loan service* available at any branch library.

But do not ignore the trade journals. They represent your most valuable resources for serious hardware hacking.

Is there really a Santa-Claus Machine?

Yes, Virginia, there really is a Santa-Claus machine. It exists here and now, and represents enough new hacking opportunities to last you a lifetime.

Most science-fiction authors, including Hugo Gernsback, at one time or another introduced a Santa-Claus machine. This was either a mass teleportation device or an elemental atom smasher and rearranger. All you would have to do is feed it the right set of plans, and out would pop a sports car, an oscilloscope, a roast-beef dinner, or, for that matter, a brand new girlfriend.

As many copies as you like,

even. Might as well print us up some $20 bills while we're at it.

Believe it or not, such a Santa-Claus machine exists today, albeit a very expensive one with very limited capabilities. While you can't yet duplicate the exact function of any object, you can in fact duplicate its exact form, and do so anywhere in the world, given the right set of plans.

The idea is both very simple and astoundingly profound. You take either a tray (2-D) or a tank (3-D) full of an ultraviolet-curing plastic called a *photopolymer* liquid resin. This resin is related to the UV-curing resins already widely used by dentists and printers.

Then you create a very small spot of ultraviolet light, either from a laser or from a special UV bulb and some optics. You move the light spot around as needed to *harden* any desired object out of the liquid resin. For 3-D objects, you place an "elevator" on the surface of the liquid and then slowly lower the elevator so that layers are applied as needed to build up the final object.

You can easily machine the unmachinable with this device. Things like perfect and hollow spheres, blind undercut square holes, or very complex turbine blades with compound curves are utterly trivial.

While the current Santa-Claus machines are limited to a very few plastics, once you have made the prototype, you can easily make any molds, pantagraph copies, or whatever from it, ultimately converting into most any material.

You can also think of Santa-Claus machines as the next giant step beyond laser printing. With a Santa-Claus machine, you could create a replica of any three-dimensional object, while today's printers are pretty much limited to two-dimensional images using very limiting ink or toner.

Think of it. A $500 box beside your personal computer that can create a 3-D model replica of *any* object.

So what does all that have to do with you? Just this: Here is an incredible new opportunity in a brand new field that you can experiment with in a home lab or even on a kitchen table.

The leader in the new field seems to be an outfit called *3-D Systems*, while I think that one source of the UV-curing photopolymeric resins is *Mobay Chemical*. Their current machines sell for $70,000 and $125,000. Those prices, of course, are dirt cheap "must-have" bargains to the automotive people and other large manufacturers who can now make their molds and prototypes in 36 minutes instead of 36 weeks. That is an offer they cannot refuse.

What can we do on a hacker's budget? I don't see any reason why a limited-performance Santa-Claus machine cannot be built up for well under $300.

Figure 4 shows how I would go about it. First, I would initially stick with two-dimensional objects such as letters, nameplates, bezels, or whatever. That third dimension just adds complications at a time when getting the basic process working any way at all should be your foremost goal.

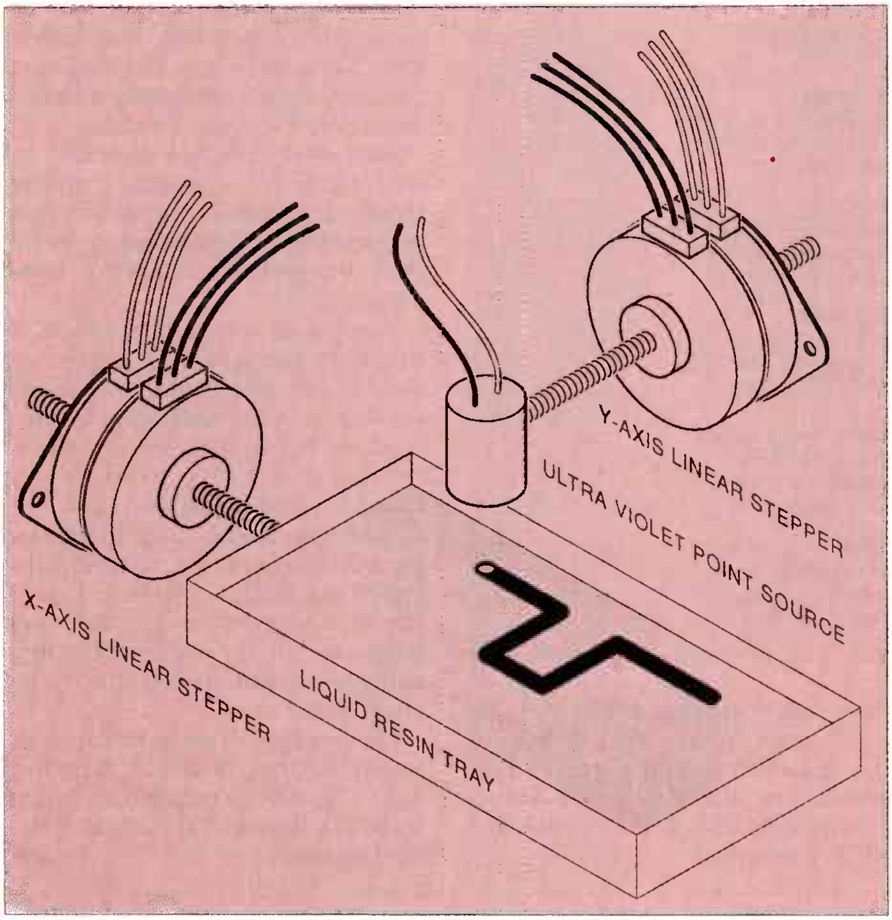

FIG. 4—TWO-DIMENSIONAL SANTA-CLAUS MACHINE can create a replica of virtually any flat object through the selective ultraviolet hardening of a liquid plastic resin.

Second, I would flush the laser and the beam scanning stuff, replacing the laser with a scientific ultraviolet lamp from *EG&G* or whoever, and replacing the beam scanning with two linear steppers such as the *Hurst* type SLS.

And, third, I would not worry about complexity or speed. If it takes a week to machine a simple part, so what? Particularly if you are now three orders of magnitude cheaper than your competition.

There are some very important safety considerations in all that. The resins must be used in a very well ventilated area, and you should avoid breathing any and all fumes. Touching or handling the uncured resin is also probably a very bad idea.

Even worse, intense ultraviolet light can easily cause blindness. That's why all those elaborate interlocks are present on EPROM erasers. Your Santa-Claus machine should be totally enclosed with opaque shields. Experiments on focusing or whatever should be done on a trial and error basis only.

Do **not**, under any circumstances **ever** look at the ultraviolet spot! I would also suggest wearing heavy sunglasses as an additional precaution against an inadvertent powering of the lamp with your shields down.

Needless to say, the editors here at **Radio-Electronics** will pay very well for construction details on the first Santa-Claus machine that can make non-trivial replica models on a hacker's budget.

What's new in the technical literature?

This seems to be a very good month for technical data books. Data books usually contain very detailed specifications on electronic devices, often with accompanying application notes and use hints. The price of a data book varies from free to optional to nominal, depending on the manufacturer, who you are, and how you ask for the book. Once again, you get the best results with your own laser-printed business letterhead.

Data books are a resource sec-

NAMES AND NUMBERS

AMD
901 Thompson Pl.
Sunnyvale, CA 94088
(800) 538-8450

EG&G
35 Congress St.
Salem, MA 01979
(818) 967-9521

Hewlett-Packard
PO Box 10301
Palo Alto, CA 94303
(408) 988-7000

Hurst Manufacturing
Box 326
Princeton, IN 47670
(812) 385-2564

Mobay Chemical
Mobay Road
Pittsburgh, PA 15205
(412) 777-2000

Motorola
PO Box 20912
Phoenix, AZ 85036
(602) 244-6900

SAE
400 Commonwealth Dr.
Warrendale, PA 15096
(415) 776-4970

Sprague
115 NE Cutoff
Worchester, MA 01606
(617) 853-5000

Texas Instruments
PO Box 225012
Dallas, TX 75265
(214) 995-2011

Xicor
851 Buckeye Court
Milpitas, CA 95035
(408) 946-6920

ond only to trade journals in their usefulness to all you hardware hackers. The best rule is—collect them all!

At any rate, there are some real winners this month. Start with the *Texas Instruments Interface Circuits* data book, plus the new *Sprague Integrated Circuits* data book, and the *Advanced Micro Devices* data book on Bipolar and MOS memories.

Hewlett-Packard has a pair of new publications out, one called their *Microwave and RF Designers Catalog*, and the other their *Opto-Electronic Designer's catalog*.

And *Motorola* has checked in with their *Telecommunications Device Data Book*, containing lots of hard-to-find information on all their integrated circuits for telephone use.

Turning to my own products, I do stock autographed copies of most of my own books as a special service to you **Radio-Electronics** readers. For insider secrets on integrated circuits, there's my *CMOS Cookbook* and my *TTL Cookbook*. For the real lowdown on microprocessors, you should check out my pair of *Micro Cookbooks*, Volumes I and II. You may write or call for a complete list, along with some hard-to-find "free stuff" info.

Do feel free to write or call over anything that is worth hacking over. This is your column and your feedback is essential to make it the best possible. **R-E**

60-Hz TIMEBASE

continued from page 56

If desired, any of the counter outputs can be routed to the monostable to get a pulse output with the same frequency and a duty cycle of less

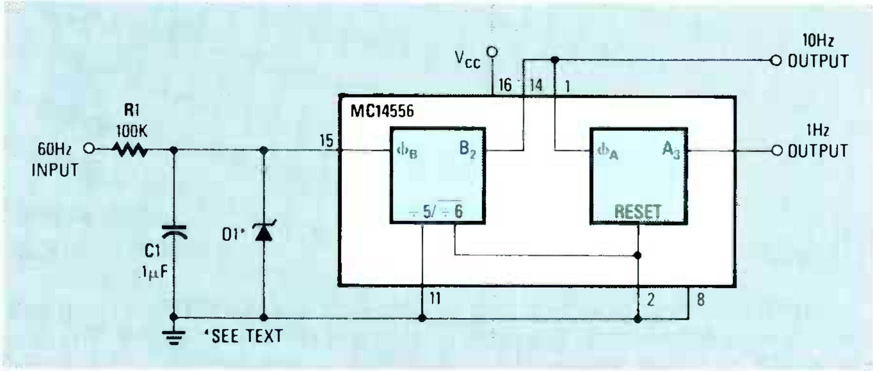

FIG. 3—THIS CONFIGURATION will deliver 1- and 10-Hz signals from either 50- or 60-Hz line frequencies. Note that the outputs do not have 50% duty cycles.

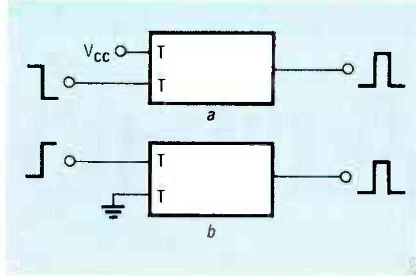

FIG. 4—THE MONOSTABLE can be configured to respond to either a rising or falling edge.

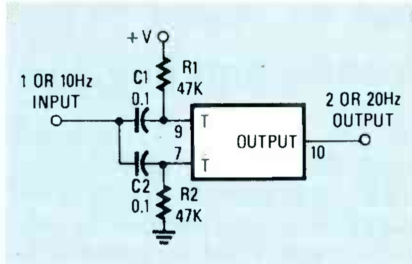

FIG. 5—USING A DUAL RC network, the monostable becomes a frequency doubler with an output duty cycle of less than 1%.

T input tied to the power supply, a falling edge at the $\overline{T}$ input will trigger an output pulse. See Fig. 4-*a*. On the other hand, if the $\overline{T}$ input is tied to ground, a rising edge at the T input will generate a pulse. See Fig. 4-*b*. The output pulse width is short, fixed, and somewhat dependent on the supply voltage.

than 1%. With the dual RC network shown in Fig. 5, the monostable becomes a dual-edge detector or frequency doubler, generating a pulse on each incoming edge, thus synthesizing an output frequency that's twice the input. That doubled frequency (with a sub-1% duty cycle) can be used directly or used to clock the second counter. Note that any unused inputs must be tied to ground.

Finally, pin 11 ($\div 5/\overline{\div 6}$) allows use with 60- or 50-Hz line frequencies. Ground the pin for 60-Hz operation: tie it high for 50-Hz. **R-E**

AUDIO SCRAMBLER

continued from page 55

scrambled tapes, or between a tape recorder and its output to decode them.

The device can also be used to scramble and descramble two-way telephone conversations. For instance, a single scrambler/descrambler unit can be used in a half-duplex mode, which means only one person can speak at a time because the unit must be switched between connections. A mechanical TX/RX switch can be used to do the switching. A much better approach is a full-duplex set-up. Figure 9 shows how two scrambler/descrambler units are connected for full-duplex, meaning that no switching is necessary. (The conventional telephone is full-duplex.) Other than merely eliminating the RX/TX PUSH-TO-TALK switch needed in the half-duplex configuration, the full-duplex application offers a more secure environment. A would-be eavesdropper would have to descramble both sides of the conversation, a difficult task because each transmitting scrambler unit would, of course, be tuned to a slightly different frequency by the users.

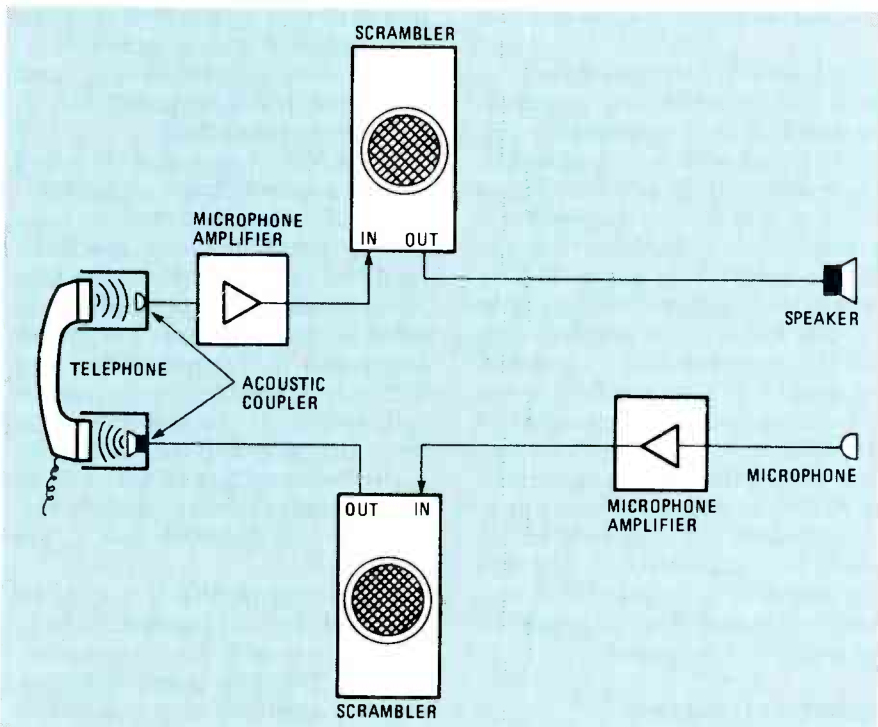

FIG. 8—TWO SEPARATE UNITS are needed in order to provide full-duplex telephone scrambling/descrambling.

The device can also be used to provide computer data transmission security. For that you can connect the full-duplex configuration to a 300-baud computer modem. **R-E**

AUDIO UPDATE

LARRY KLEIN,
AUDIO EDITOR

Positive and negative feedback

NEGATIVE FEEDBACK WAS INVENTED about 50 years ago by Harold S. Black of Bell Laboratories. Because Black's technique seemed to contradict many of the accepted technical concepts of the day, it took almost 10 years for a patent to be granted for his work. However, his work drew international applause once the electronics community realized what Black had accomplished, and for the next 20 years or so hundreds of articles were published in popular and professional engineering journals exploring and extending the ramifications of feedback technology. For example, the servomechanisms of today's sophisticated robotic devices owe much to Black's invention of feedback control circuitry.

Negative feedback is a technique that taps off a portion (sample) of a signal and reintroduces it—180° out of phase—to a point earlier in the circuit. Negative Feedback—usually identified as NF—can be applied from the output to the input of a single stage, or the NF loop can include everything between an amplifier's speaker output and its input-signal jack. A few speaker manufacturers have even extended the amplifier's NF loop to include the speaker itself, usually using some kind of motion-sensing transducer on the speaker's voice coil or cone to supply the feedback signal.

How feedback works

The basic purpose of negative feedback in amplifiers is to reduce nonlinearities. Feedback can correct both individual waveform aberrations (distortions) and frequency-response fluctuations.

To illustrate frequency-response correction, let's assume that we add 20 dB of NF to an amplifier using the R1 path shown in Fig. 1. That means that the amplifier's overall gain is reduced by 20 dB, except—and here's the key to NF—in those areas where frequency-response loss, waveform distortion, or other aberrations have occurred. If, for example, there's an unwanted 6-dB-per-octave drop above 10 kHz in the amplifier's frequency response, the feedback

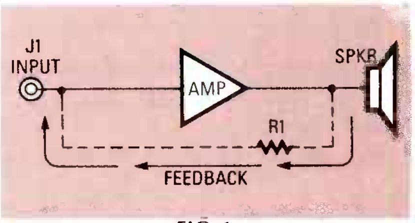

FIG. 1

signal would naturally have the same roll-off. When the rolled-off feedback signal is combined in opposite phase with the input signal, the result is 20 dB of cancellation below 10 kHz (where the feedback is fully in force), that lessens at a 6-dB-per-octave rate above 10 kHz (where the feedback itself starts to roll off). Or to put it another way, the negative feedback modifies the input signal to produce a rise of 6-dB-per-octave starting at 10 kHz relative to the lower frequencies, which have been depressed by 20 dB. In effect, feedback precompensates the input signal for losses (or peaks) that occur later in the amplifier's circuit. If everything works out, the end result is a flat frequency response.

Distortion reduction

The distortion-canceling action of feedback is illustrated in Fig. 2 (exaggerated for clarity). The input signal is shown in Fig. 2-*a*. The distorted waveform (Fig. 2-*b*) is fed back from the output of the amplifier and combined out of phase (Fig. 2-*c*) with the input waveform (Fig. 2-*a*). That results in a signal (*d*) whose distortion "precompensates" for the distortion of the amplifier.

However, if the magnitude of the distortion—or the frequency-response irregularity—exceeds the amount of the feedback available to compensate for it, the amplifier is said to have "run out of feedback," a condition that can cause oscillation, instability, and other unhappy audible effects when clipping occurs. For that reason, it is good engineering practice to design for the best possible performance under "open-loop" (no feedback) conditions, and then apply feedback judiciously as a touch-up procedure.

Is the loss of gain that is caused by negative feedback a problem? Not really—for this reason: Suppose an amplifier before feedback could be driven to full output by a .025-volt input signal. Applying 20 dB of feedback reduces the gain to one-tenth its former value, and 0.25 volt is now required to realize full output. If the feedback has been properly applied, distortion is also reduced by a factor of 10, all at the small expense (these days) of adding 20 dB more gain to the circuit.

Incidentally, the benefits of feedback are not confined just to distortion and frequency response. Properly used, feedback also has a salutary effect on an amplifier's noise and on damping-factor specifications.

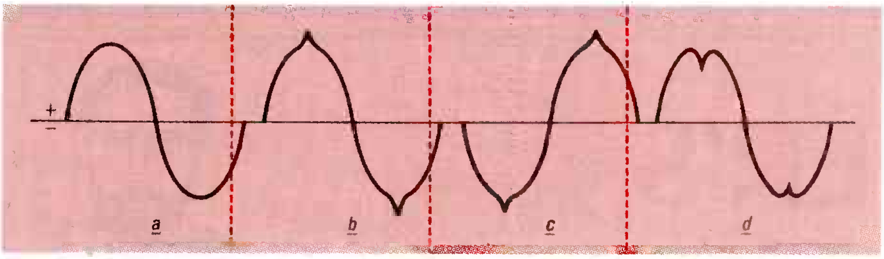

FIG. 2

Positive feedback

What about positive feedback, which is defined as feedback that is in-phase with the signal at the point of its reinsertion into the signal path? Whereas negative feedback works to restore the status quo, so to speak, positive feedback tends to introduce instability. Squealing sound-reinforcement systems and howling turntable setups are both examples of uncontrolled and unwanted *acoustic* positive feedback. However, controlled electrical positive feedback is used in the audio and radio-frequency oscillator circuits found in test instruments and tuners.

As far as I know, the only use of positive feedback in an audio-amplifier was in an old Dynaco tube preamplifier where a positive-feedback loop (enclosed within a negative-feedback loop to ensure stability) was used for increased gain using fewer stages of amplification. Since gain is both cheap and easy to come by in this age of solid-state, I don't expect to see positive feedback in future amplifier circuits. Feed-forward, Black's earlier invention, which has experienced a slight comeback, is sometimes confused with positive feedback, but it's a completely different approach.

Feedback negatives

In the past several years, feedback has fallen into disrepute in some audio quarters. Indeed, some manufacturers have made much of the fact that their new equipment uses little or no negative feedback. A few other manufacturers have taken the purely semantic path to feedback elimination and instead substituted what they call *beta* or *servo* control circuits. In any case, the controversy about feedback dates from the time that Matti Otala, a Finnish researcher/engineer, rediscovered that under certain conditions amplifiers using negative feedback would go into input overload, even though the input signal was theoretically too small to cause such a problem. He dubbed the effect "transient intermodulation distortion" or TIM. I say rediscovered, because several investigators published papers during the early 1950's discussing the TIM effect—although not by that name—and its solution.

In a nutshell, the problem is/was this: A rapidly changing signal—meaning one having high-frequency components—would

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DESIGNER'S NOTEBOOK

ROBERT GROSSBLATT,
CIRCUITS EDITOR

Making sinewave oscillators

ALTHOUGH WE'VE EXAMINED MANY kinds of oscillator circuits, there's one we've left out: the sinewave oscillator. Most of the circuits that we've looked at have been digital squarewave generators of one kind or another. Although I've shown you how you can alter them to get a triangular wave, even with a lot of filtering there's no easy way to get a low-distortion sinewave at the output when you start with a squarewave at the input.

Trying to convert squarewaves into sinewaves can lead to some real design nightmares. Calculating the filter values, dealing with the various kinds of distortion, and, in general, guaranteeing the purity of the output waveform is a lot more difficult than designing a sinewave generator from scratch. If you want a circuit that produces clean sinewaves you have to build one specifically for that purpose; and all it takes is a handful of parts that can be used to produce sinewaves that are much better formed than those you would get from a manipulated squarewave.

Sinewave oscillator

How much more difficult is it to convert a squarewave to a sinewave? Figure 1 will give you a good idea of how simple a sinewave generator can be. The circuit is built around the op-amp's feedback loop in a configuration of resistors and capacitors that is often referred to as a twin-T or twin-tee network. It's mostly used when the designer is interested in one particular frequency.

How well the circuit works is a direct function of: 1) how closely the components are matched; 2) using as low a source impedance as is possible for the tee network; 3) making the tee's output load impedance as high as possible.

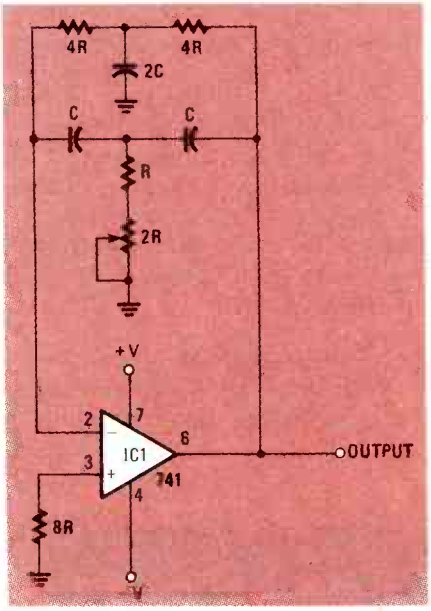

FIG. 1

The center frequency of the network (f) can be easily calculated by plugging numbers into the formula:

$$f = 1/(2\pi RC)$$

and by using components rated 1% or better.

The best way to understand how a twin-T network operates is to look at each half of the tee by itself. The upper half of the circuit is configured as a low-pass filter so it will tend to reject frequencies above a certain value. The lower half is set up as a high-pass filter and tends to reject frequencies below a certain value. Since the twin-T has the two circuits connected in parallel, a frequency-versus-gain plot for the circuit will look like Fig. 2. If both halves of the tee are carefully matched, the filter will reject a particular frequency.

By using a potentiometer (2R) in one tee, we can detune the tee until the phase of the frequency going to the op-amp's non-inverting input is shifted 180°, which is the same as applying positive feedback. That will cause the op-amp to start oscillating, and the output will be a sinewave whose frequency is equal to the center frequency of the twin-T filter.

The other conditions for optimum operation of a twin-T network are satisfied by the op-amp. The tee is being fed by the op-amp's output (pin 6), which is a low impedance, and the tee's output is connected to the op-amp's input, which is a high impedance.

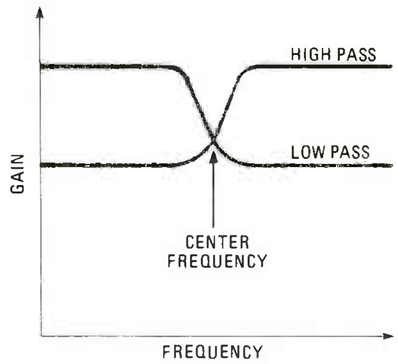

FIG. 2

I haven't given any values for the components because you can use the formula to determine what you need for whatever output frequency you want. Realistic limits are between 1K and 10K for the resistor and .01 μF to 1 μF for the capacitor. I used a 741 op-amp when I put the circuit together, but just about any op-amp will do. The best ones to use are those that have an FET input, such as a TL084, since their input impedance is about as high as you can get. It's also a good idea to build the circuit with a dual op-amp and use the second amplifier as a buffer, since that will help improve the performance of the oscillator when it's connected into an actual working circuit.

The twin-T network is one of the basic building blocks for the design of analog filters. You should experiment with this month's circuit and get familiar with how component values can change the operation of the circuit. By combining the tee configuration with op-amps you can design a wide variety of different filter circuits: high pass, low pass, notch, and bandpass. While working out the component values for those circuits will usually involve a considerable amount of math, don't let that put you off. That's what calculators are for. **R-E**

AUDIO UPDATE

continued from page 79

overdrive an amplifier's input stages, while a signal of the same amplitude, but without the high-frequency components, would cause no such problem. The overload occurred because the input stages were designed to operate with the gain-reduction of negative feedback; but when very fast high-level transients were involved, the feedback signal did not get back to the input stages quickly enough to prevent overload. The basic solution to TIM is to design-in sufficient bandwidth—before feedback—to ensure that high-frequency signals can *slew* (travel) through the amplifier fast enough to avoid problems.

Fortunately, any competent audio designer can easily achieve adequate *slew rate*—and thereby eliminate the possibility of TIM—without really straining his design talents. In my view, those engineers, sales managers, and audiophiles hyperconcerned with TIM problems are essentially chasing a wild goose carrying a straw man up a blind alley. In today's products, TIM is not likely to be the source of any differences you can hear. **R-E**

COMMUNICATIONS CORNER

The phantom hand.

HERB FRIEDMAN,
COMMUNICATIONS EDITOR

ONE OF THE QUESTIONS OFTEN ASKED by hobbyists, technicians, and technical students who got into communications after the development of the transistor is why older equipment didn't use certain high-performance circuits. After all, some of the circuits actually originated back in the stone-age of electronics. The answer to their question is simply one word: *cost*. Using vacuum tubes, or even discreet solid-state devices, just the cost of the extra power-supply capacity and the larger cabinet needed to accommodate certain circuits could easily add $100 or more to the retail price of a receiver, transmitter, or transceiver; and we have not even started to factor in the labor cost for assembling the circuit. But because integrated circuits and automated assembly of high-density circuits sharply reduces overall manufacturing cost, we can now include even the most sophisticated functions in general-purpose communications equipment.

A good example of an old idea made practical by combining the integrated circuit with automated assembly is the *automatic antenna tuner*, such as the Kenwood *AT-250*. (Keep in mind as we discuss the *AT-250* tuner that a similar circuit is included in certain Kenwood transceivers—the whole assembly can actually fit in the palm of a hand.)

An automatic antenna tuner works this way: You select a transmit frequency, set the transmitter's function switch to *tune*, wait a few seconds for the whirring in the tuner to stop (or wait for the SWR indicator built into the transmitter or tuner to drop to about 1.2:1), and then switch to full power. In the few seconds it takes for the SWR to reach minimum, the automatic antenna tuner matches the antenna system to the transmitter. It sure is a lot more convenient than manually rocking a couple of tuning capacitors back and forth until your SWR meter indicates an acceptable value.

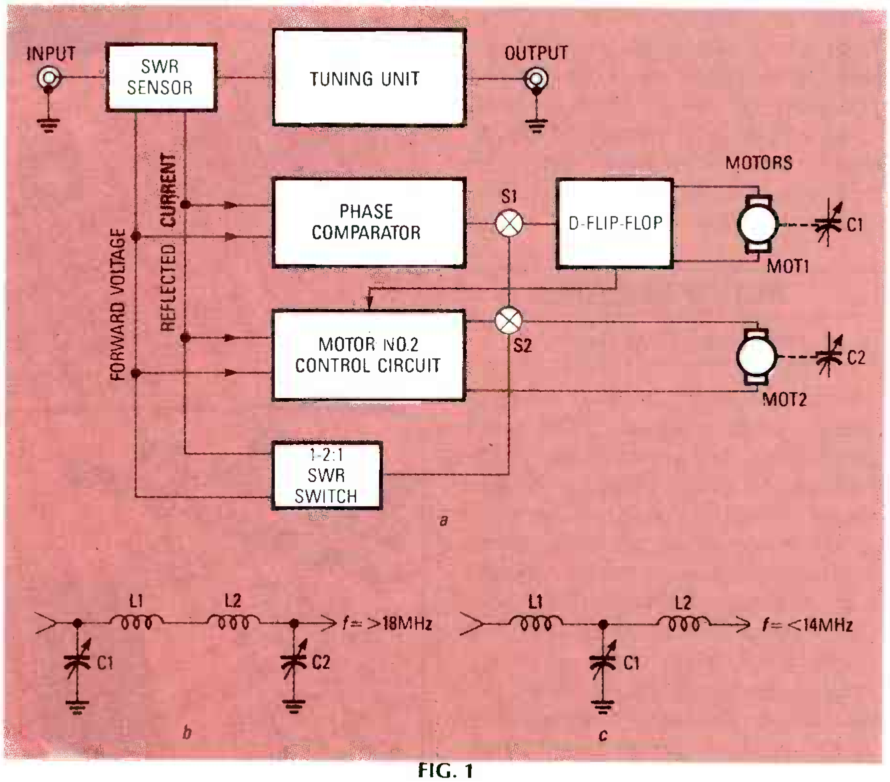

FIG. 1

At first thought, automatic antenna tuning appears to be be very simple. All we need are motor-driven capacitors controlled by some kind of SWR indicator. It should even be possible to build an automatic tuner using vacuum tubes. So how come the "old-time" radio operators didn't use automatic antenna tuning? The answer is the amount of hardware needed, and what the hardware would cost if we built the circuit using discreet components. For example, the circuit used in Kenwood's automatic antenna tuner has 31 transistors, 13 IC's, 2 FET's, and 77 diodes. Want to try doing it with vacuum tubes, or by using all discrete solid-state components?

How it works

Figure 1-*a* shows a simplified block diagram of Kenwood's auto-

matic antenna tuner. The input jack connects to the transmitter's output; the output jack connects to the antenna system's coaxial transmission line. Within the section labeled TUNING UNIT are two tapped coils and two motor-driven variable capacitors. Above 18 MHz, a switching scheme automatically configures the components as a pi network as shown in Fig. 1-*b*. Below 14 MHz, the components are configured as a Tee-network as shown in Fig. 1-*c*. The coil taps are selected by transistor-driven relays. Either a bandswitch on the tuner selects the proper taps, or the taps are automatically selected when the tuner is used with certain transceiver models. Essentially, the coils are set for the band-in-use.

When the transmitter is set to its tune function, a very low RF-output level, about 3 watts, is fed into the antenna tuner. The SWR SENSOR develops an output representing the *forward voltage* and the *reflected current*. Keep in mind that when the SWR is low the two are in-phase; the greater the SWR the greater the phase difference between the forward voltage and the reflected current.

From there, the forward voltage and reflected current are fed to a PHASE COMPARATOR. If there is a difference in phase, the comparator develops an output that passes through electronic switch S1 to a D-type flip-flop switch. The switch "flips" and powers motor MOT1, which drives variable-capacitor C1. When C1 can reduce the SWR no further the flip-flop is turned off, which sends a signal through a feedback line to the MOTOR NO. 2 CONTROL CIRCUIT, which causes motor MOT2 to drive C2.

During the adjustment of C1 and C2, the reduction in SWR is tracked by an SWR SWITCH, that derives the SWR value by comparing the phase of the forward voltage with that of the reverse current. When the SWR SWITCH senses that the SWR has been reduced to 1.2:1 it opens electronic-switches S1 and S2, thereby disabling the tuning motors. The user knows the rig is ready for use because he or she can observe the SWR value on a built-in meter, or see a tuning indicator turn off. **R-E**

ANTIQUE RADIOS

Ancient transformers, tubes, and speakers

RICHARD D. FITCH,
CONTRIBUTING EDITOR

ALTHOUGH THERE'S BEEN TREMENDOUS developments in electronics technology during the past 100 years, fortunately for those of us into antique radios, we don't have to concern ourselves with either the pioneering days or the high-tech '80s. Our interest is primarily the era of the vacuum tube: from the 1920's through the 1940's.

Tube radios have five basic components: 1) Transformers and coils; 2) Resistors; 3) Capacitors (which used to be called "condensers"); 4) Tubes; 5) Speakers. This time out, we'll discuss the different types of transformers, resistors, and speakers, and how they're used.

Transformers and coils are related because they are essentially inductors. Power, IF, and audio-output transformers are the types most commonly used in radios. Components considered to be coils—even though they might actually be transformers—are those in the antenna and RF-amplifier circuits, a speaker field, and the speaker's voice-coil.

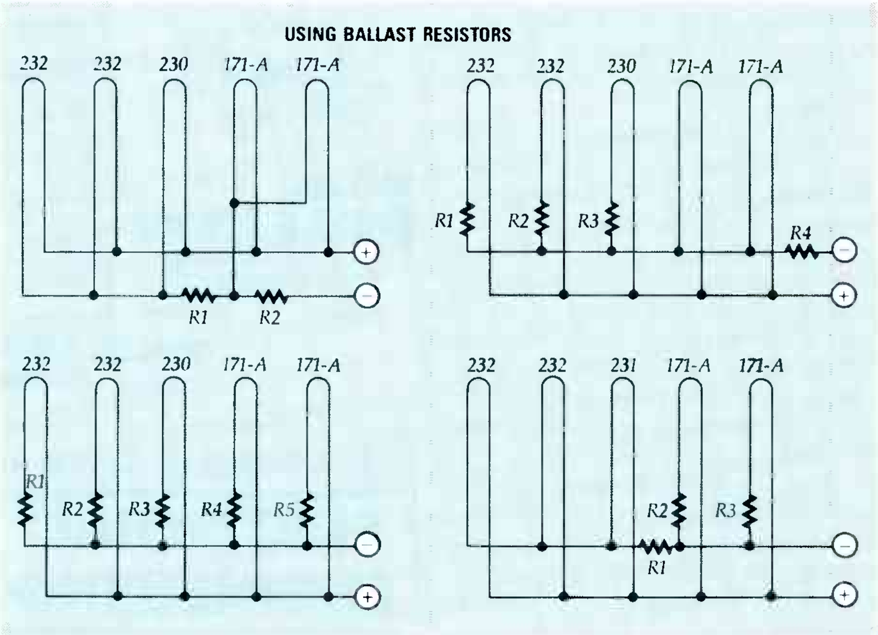

FIG. 2

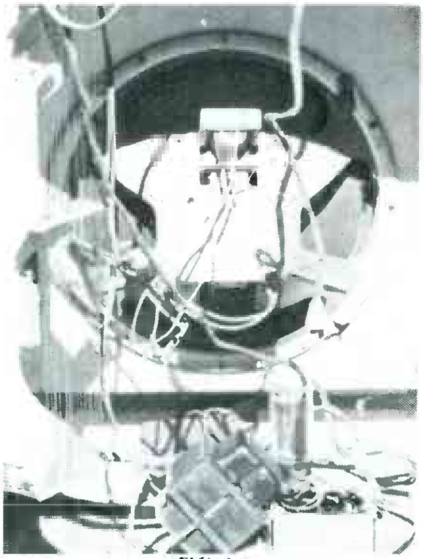

FIG. 1

How is a transformer a coil? Simple! That's what we choose to call it. For example, an antenna input "coil" usually has primary and secondary windings, and that's a transformer in anyone's engineering textbook. Same thing with an RF amplifier's output circuit. While it might use a single inductor (a coil) as a load, more often than not the *plate coil* has primary and secondary windings; and once again, that's a transformer in an engineering textbook. However, in early radio service manuals, and even in modern manuals, both transformer types are usually called coils. It's sort of like calling cycles-per-second Hertz. Hertz is a term created from what alchemists used to call the *ether*—air. Since we all breathe the same air we know what Hertz really is—it just takes a textbook two pages to explain what used to be obvious.

Although many antique radios had more transformers and coils than tubes, it's the tubes that collectors expect to be burned out; few expect transformers and coils to go bad. Unfortunately, power transformers in antique radios have often burned out many years earlier, and it's something you might not be able to check at the time you're purchasing the radio. But it's been my experience that radios with a defective transformer have been worked on at some time or other, so be wary of a set where the transformer's mounting screws are missing or disturbed. Whoever worked on the set shown in Fig. 1 left the power transformer a wreck.

Besides total burn-out, open and shorted windings are also common to old radio transformers. While it's easy to use an ohmmeter to determine whether a winding is open, troubleshooting shorted windings with a conventional instrument is usually impossible.

The nose knows

Antique radio collectors soon learn to recognize the odor of an overheated or burning power transformer. If you fire up an antique radio and the transformer smells or overheats, turn the power off *fast* before a handful of other expensive parts go up in smoke. But keep in mind that a hot power transformer doesn't necessarily mean that the transformer is at fault: make certain that you at least check the rectifier and the filter capacitors before deep-sixing the power transformer.

Removing the rectifier tube or the selenium rectifier (if used instead of a rectifier tube) can help determine if the power transformer is shorted, or if a short in the B+ supply is drawing excessive current. That's because removing the rectifier usually disconnects the transformer from the rest of the circuit. (However, take care that there isn't a second rectifier—perhaps used for grid bias—separately connected to the power transformer.) In all likelihood, the transformer is probably OK if it doesn't overheat when the rectifier is removed.

A superheterodyne radio's IF transformer is another troublesome device. While it can have any of the usual transformer troubles such as shorts, opens, and poorly-soldered terminals, more frequently you'll find that the problem is man-made—or more accurately, tinkerer-made. An old radio that has lain around for many years could have been "repaired" by persons trying to make it play by tightening "the loose screws"—the IF transformer's adjustments.

Moving on to the output transformer, the device that matches the high impedance of the output tubes to the low impedance of the speaker, the most common problem is an open primary winding, which is easily confirmed by using an ohmmeter. Since there are still plenty of universal replacement output transformers available, it shouldn't be too difficult to locate a substitute.

Although it's possible, I don't recall coming across an electrodynamic speaker having an open field coil. As a general rule, a defective antique radio's speaker usually has a damaged or distorted cone that can't be repaired because few technicians have the knowledge, ability, tools, or even the material to re-cone a speaker. So if you must remove what is an otherwise a good speaker from its mounting, be careful not to touch the cone because it's probably so brittle from old-age.

Voice-coil testing

The voice coil is sturdy and rarely opens or shorts; but a problem in early radios known as an

continued on page 108

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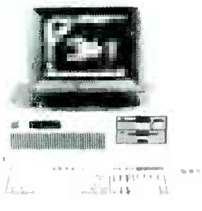

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MICROSOFT BOOKSHELF

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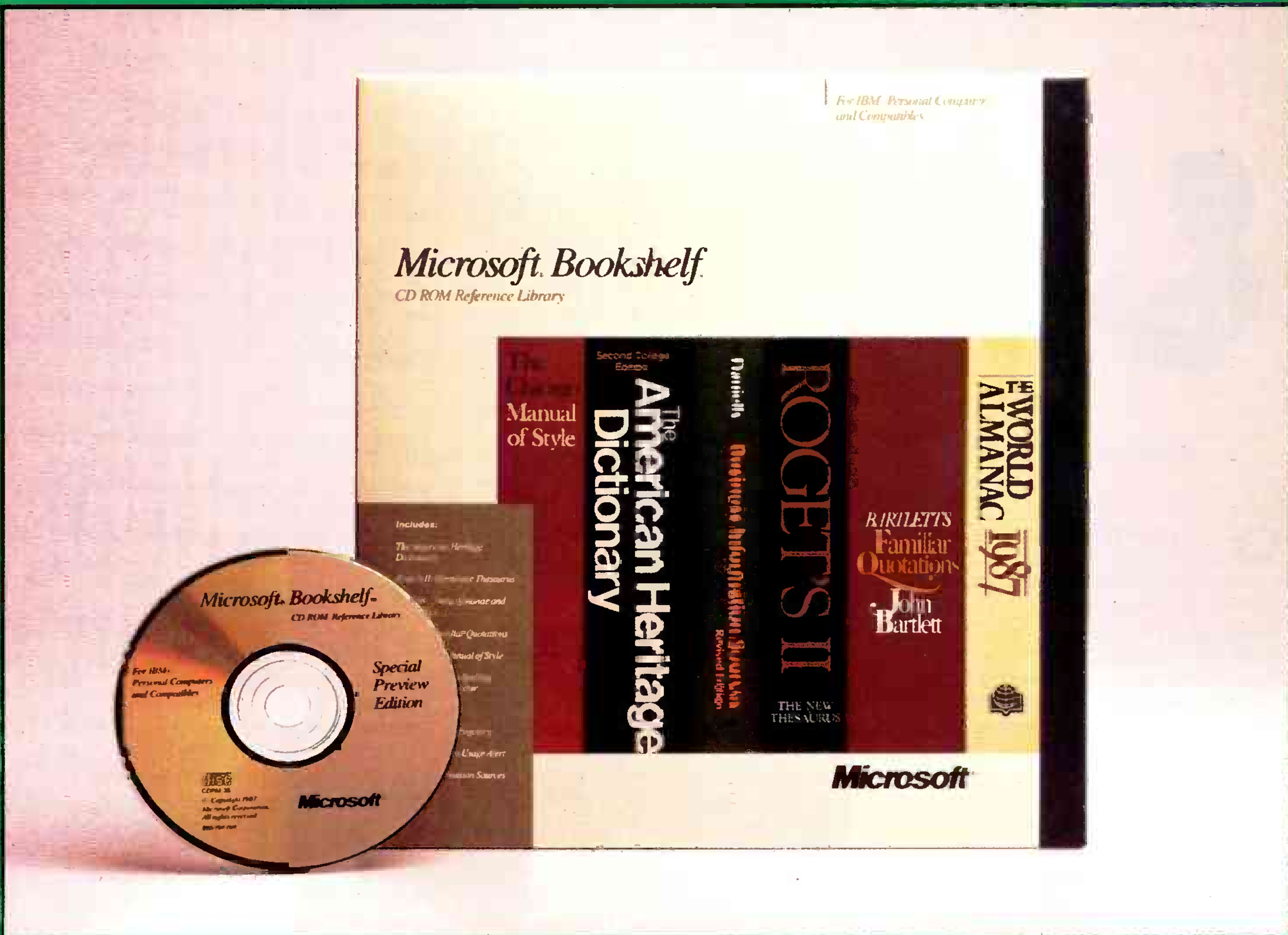

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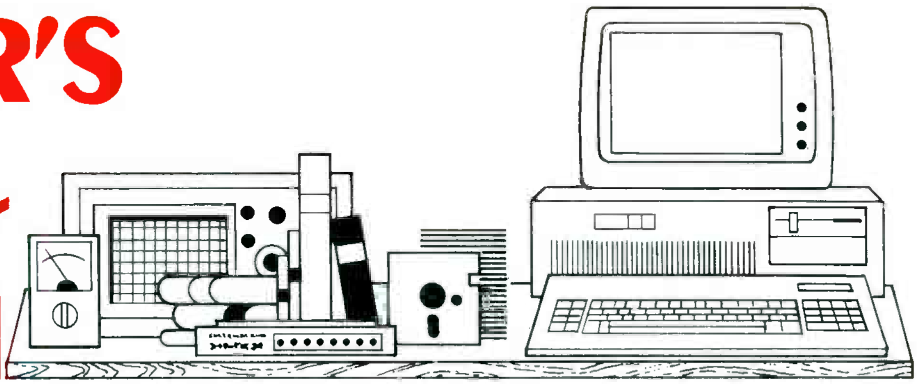
68000 COMPUTING

The CD Classroom continues Page 96

EDITOR'S WORK-BENCH



Microsoft Bookshelf

Optical storage will be at the core of the next evolution in computer technology, some say. Advantages include extremely high information density and very low production costs. To date, however, most commercial products based on optical technology (financial and other specialized databases) have had little mass appeal. The Electronic Encyclopedia published by Grolier on CD-ROM (Compact Disk read-only memory) was the first consumer-oriented optical product; it provides the entire database (text only) of the Grolier Encyclopedia. (See page 90 of the April 1987 issue for a review.)

Microsoft just released the second major CD-ROM product that is likely to have widespread appeal; it is called Bookshelf. Bookshelf consists not of a single database, like the Electronic Encyclopedia, but of ten reference works, including: *The American Heritage Dictionary, Roget's II Thesaurus, The World Almanac and Book of Facts, Bartlett's Familiar Quotations, The Chicago Manual of Style, The U.S. ZIP Code Directory,* a spelling checker, a usage checker, a set of form letters, and a categorized listing of sources of business information.

To run Bookshelf you need a CD-ROM drive, a PC, XT, AT, or clone, DOS 3.0 or higher, and a copy of the MS-DOS CD-ROM extensions (software drivers for the CD-ROM drive, usually supplied by the manufacturer, and which are also available separately). Bookshelf itself costs $295, and the drive will set you back about $1000. In addition, a dual-floppy computer requires 640K of RAM to run Bookshelf; a hard-disk system can squeeze by with only 512K. The program will run on a dual-floppy system. We tested Bookshelf on a standard IBM PC XT with a 20-megabyte hard disk, a 500K RAM disk, and a 500K disk cache.

At those prices, obviously, Bookshelf will not compete with paperback reference works sold at dime stores, but that's not Bookshelf's intended market. The target, rather, is the serious writer—including the serious technical writer.

Setting up

The CD-ROM drive itself interfaces to your PC via a cable that connects to a plug-in expansion card. After installation, which includes modifying your CONFIG.SYS and AUTOEXEC.BAT files, the CD-ROM drive will become your next available drive. On an XT with a single floppy, a hard disk (C:), and a RAM disk (D:), the CD-ROM drive would appear as drive E.

After installing the hardware and system software, you log onto the CD-ROM drive (just as if it were a regular drive, except that you can't write to it), and run a Setup utility. That program copies files to your hard disk and installs the program according to the hardware and software you'll be using Bookshelf with.

Normally you run Bookshelf in a memory-resident mode so that you can call it up from within your word processor while you are writing. (You can also run Bookshelf as a transient application.) Bookshelf requires about 128K of memory (in memory-resident mode), and really works better with a RAM disk, which you'll probably want to locate in the EMS memory.

After booting and loading the program, you can call it up at any time by pressing a user-definable hot-key combination. Bookshelf will work with any word processor or other program that operates in text mode—not graphics mode. It works best, however, with most versions of Microsoft Word, Word Perfect version 4.2, Multimate Advantage version I, IBM Display Write III, Volkswriter 3, XyWrite III and III Plus, and PC Write version 2.71. It's more convenient to use a supported word processor because the thesaurus can replace words automatically, and the spelling checker can check an entire screen at a time. Other functions (the form letters, for example) that feed information into a document work fine, though.

Using it

Press your defined hot keys, and Bookshelf pops up. Figure 1 shows the ZIP Code reference display screen. The top line shows which word processor Bookshelf has recognized (it displays "Unknown" in an unsupported program); the second line presents a twelve-item menu bar which you can navigate using a mouse, the cursor-control keys, or by pressing the first letter of your choice. We found the latter method to be the most convenient.

After selecting the desired reference work, a menu appears, allowing various options for the chosen work. The dictionary's menu, for example, allows to look up a word, biographical information, or geographical information.

Next a dialog box appears, in which you enter additional information. Dialog boxes work differently according to which opus you're working with. The ZIP Code checker, for example, will pick an address off the screen and find the correct ZIP Code. Bookshelf will then feed the ZIP Code back into your word processor just as if you had typed it. Alter-

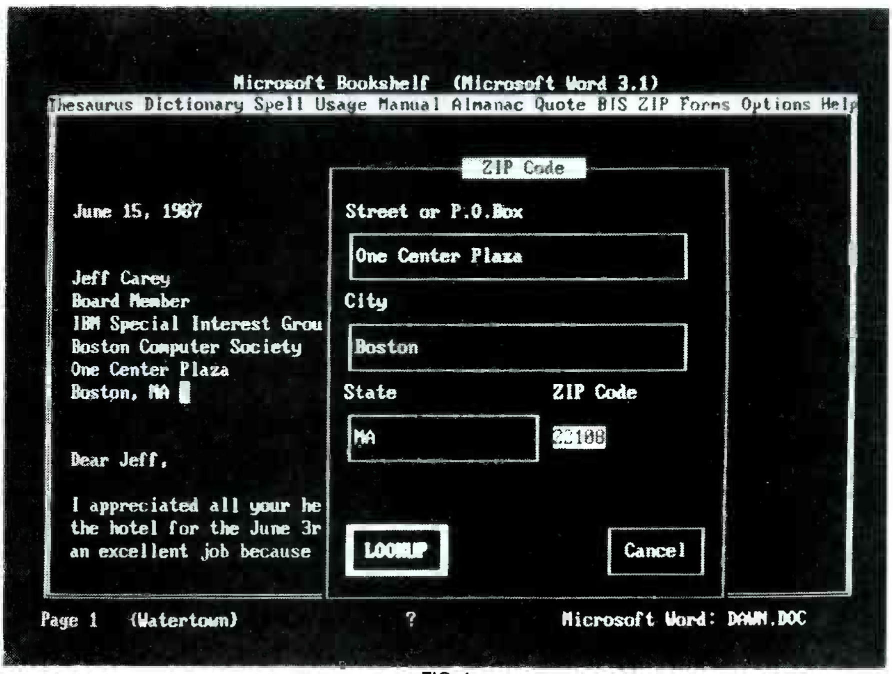


FIG. 1

natively, you can type an address in the dialog box, look up the ZIP Code, and feed the whole thing into your word processor.

The ability to look up ZIP Codes is useful, if unexciting. Bookshelf's real strengths are the dictionary, the thesaurus, the book of quotations, and the almanac. The dictionary is based on the full American Heritage dictionary; it includes complete definitions (not simple "synonyms"), word derivations, and biographical and geographical information. You can look up a word that Bookshelf reads from the screen or you can type one in from a dialog box. In addition, you can do cross-index searches—find all entries in which the word *computer* is used, for example. Unfortunately, you cannot paste definitions into your documents (presumably for copyright reasons). You can scroll through an alphabetized list of entry words only, without displaying definitions, and zoom in on one by pressing a key. In the expanded display, highlighting is used to indicate word entries, syllable breaks, derived forms, the definitions themselves, and derivation. Synonyms and points of usage are discussed at some entries, just as in the "real" (paper) version of the dictionary. For browsing, you can "open" the dictionary at the beginning of any letter—*A* for example.

Accessing the other works functions in a similar manner. However, locating information can be quirky, if not difficult. For example, I wanted to locate financial information in the almanac about the computer industry. After entering the words *computer* and *finance* in the dialog box, I was presented with a list of articles. I selected one, and then read it. I wanted to return to the list of articles to choose another, but was unable to do so without re-entering the search words and waiting for Bookshelf to search its database. In general, depending on the type of search, you may end up doing a lot of thumb twiddling.

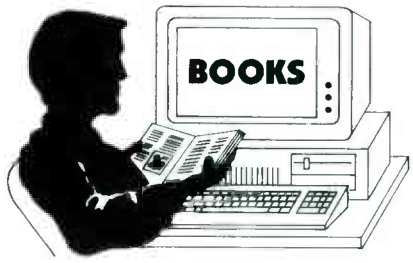
Conclusions

Bookshelf is a wonderful idea, but the implementation leaves something to be desired. In spite of the fact that it uses 128K of RAM and can use a RAM disk for temporary storage, it is slow. Search speed is slow, and display speed, once the information is found, is slow. In fact, text spills across the screen at a rate that is comparable to what a 1200-baud modem provides.

Bookshelf's strong point is the dictionary, which is truly a dictionary, unlike all other products for personal computers. The thesaurus and the quotations reference also work well. The almanac contains a great deal of information, but getting at it is a problem, as described in detail above.

As a professional editor and writer, I want to like Bookshelf, and I want the capabilities it can provide. But the program's slow performance, coupled with the high cost of the product and the hardware necessary to run it, cause me to question whether I couldn't get along without it. Admittedly, Bookshelf can do some things that would be impossible by hand—doing comprehensive searches, for example, or directly importing text into a document—but bread-and-butter searching and browsing can usually be done much more efficiently the old-fashioned way.

Microsoft is to be commended for bringing Bookshelf to market; eventually all personal computers will have comparable capabilities. Let's hope that the company sees fit to upgrade Bookshelf's performance to what it should be, and that CD-ROM drives fall in price to an affordable level.



Borland-Osborne/McGraw-Hill Programming Series

Osborne/McGraw Hill books have for many years provided useful text and reference books for those involved in computers and electronics. Now the book-publishing company has teamed up with Borland International, publisher of many high-quality applications programs and programming languages, including Turbo Pascal, which single-handedly changed the programming language market when it was introduced several years ago. The two companies have launched a new line of books intended to support many Borland products, including the programming languages Turbo Pascal, Turbo C, and Turbo Prolog, and the applications programs Sprint and Reflex, a word processor and a database manager, respectively.

Advanced Turbo Pascal, by Herbert Schildt, for example, contains twelve chapters on advanced programming techniques in that language, including sorting and searching; queues, stacks, linked lists, and trees; dynamic memory allocation; assembly-language and DOS interfacing; etc. An introductory chapter reviews Pascal basics, and an appendix discusses converting programs from other languages. Schildt's style is quite readable, and his coverage appears thorough. The book contains many example programs, which Schildt will provide on disk for the healthy sum of $24.95.

Products Reviewed

- Microsoft Bookshelf, Microsoft Corporation, 16011 NE 36th Way, Box 97017, Redmond, WA 98073-9717, (206) 882-8080.
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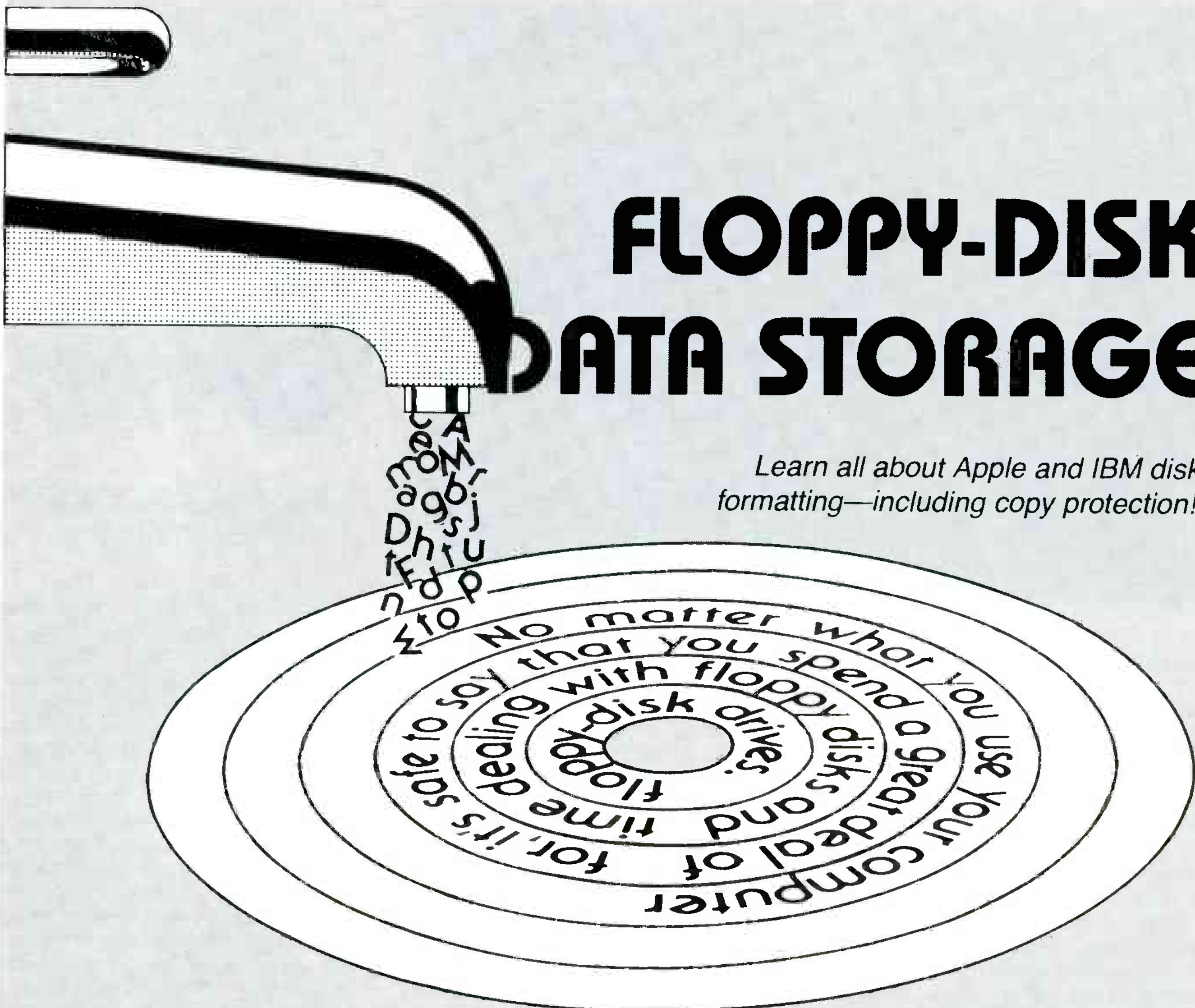
FLOPPY-DISK DATA STORAGE



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

ROBERT GROSSBLATT

Part 2 This month we'll turn our attention more fully to copy protection, highlighting the schemes used to make Apple and IBM software secure.

Oddball formatting and nibble counting

The first two copy-protection schemes form the basis for most others. The basic idea behind oddball formatting is to format most of a disk in the usual manner, but to format one or more sectors in a unique manner. That way, when DOS first starts to read the disk, it assumes one format. When it runs into the odd sector, it thinks a data error has occurred. However, the copy-protected program itself knows where to expect that sector and how to deal with it.

Nibble counting is based on the fact that no two disk drives are exactly the same. In order for disks to be readable on various machines, DOS has a built-in "tolerance" factor that programmers can use to implement copy protection.

The major difference among drives is the speed at which the disk rotates. The standard is 300 rpm (200 milliseconds per revolution), but a drive only has to be within about 1% of that speed to be usable.

As we saw earlier, each sector on a disk has the room to store the requisite data. The remainder of the space is filled with gap bytes that separate one sector's data area from the next sector's ID area. The number of gap bytes written on a track is a direct function of the drive's speed and the rate at which the disk hardware spits out bits. But bit timing is in microseconds and drive timing is in milliseconds, so it's safe to say that the number of gap bytes depends exclusively on drive speed.

The gap bytes in a particular track, called the *signature track*, are counted, and the sum is stored elsewhere on the disk. Then, when you run the program (or boot the disk), the head is moved to the signature track, the bytes are counted and compared to the original number. If they're not the same, the software knows it's not running on the original disk, and that's what makes nibble counting tough to crack.

Track erase, directory move

The earliest forms of Apple copy protection were feeble by today's standards. For example, erasing one disk track would bring the normal copy program to a screeching halt. And if the erased track was near the

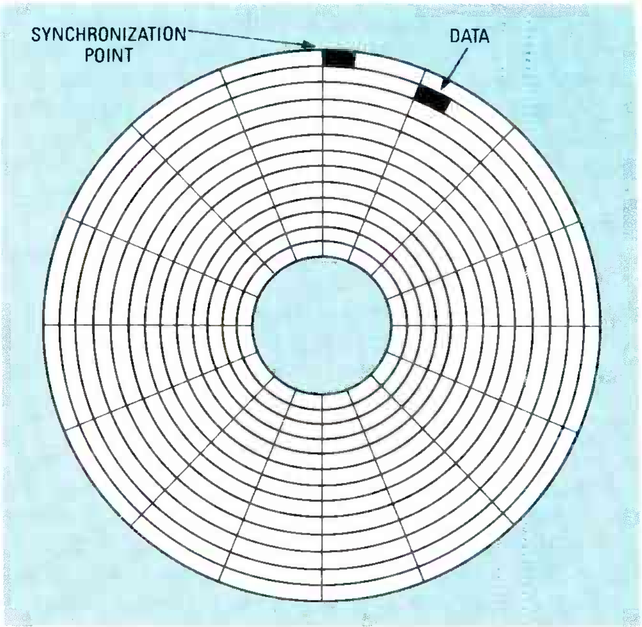


FIG. 5—TRACK SYNCHRONIZATION involves writing data at a particular location, stepping the read/write head, and writing additional data.

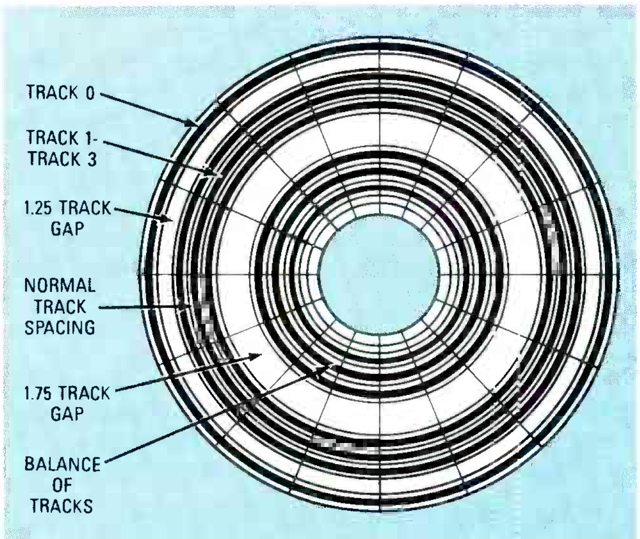


FIG. 6—NON-STANDARD TRACK WIDTH is achieved by stepping the read/write head in ¼-track increments.

outside of the disk (track 3, for example), the rest of the disk would be protected.

Another early method was to move the catalog from track 11, where it was normally found. The files were also made unlistable by changing the standard load locations so you couldn't even look at the files. A reset would wipe out memory and reboot.

Those tricks, and a few others, were attempts to protect programs by altering DOS. They were effective for awhile because no one had taken DOS apart yet, so DOS parameter locations, sector formats, and file structure weren't common knowledge. After those things became known, however, the simple copy-protection schemes were dropped in favor of more-sophisticated ones.

The 36th track

When the copy-protection industry was in its infancy, someone discovered that, although DOS was designed around 35-track hardware, most Apple drives could actually read 36 tracks. That was the first time the disk hardware itself was used as the basis of a copy-protection scheme. Publishers put part of their code on track 36 and checked to make sure it was there whenever the program was run. None of the standard copy programs knew anything about the extra track so the disk was uncopyable—until the method was found out and publicized. Even without the discovery, use of the 36th track was ineffective because not all drives could read that track. So, as soon as consumers started returning software, the method was dropped.

Track syncing

The next type of copy protection can be understood by looking at Fig. 5. When data is either read from or written to a disk, DOS is told to go to a specific track and then look at a particular sector; no special relationship is assumed between adjacent tracks. However, software publishers discovered that it was possible to keep very strict timing relationships when reading the disk. This meant that if you knew where you were on one track at the instant you told the head to step, you knew where you would be when you arrived at the next track.

Building a protection scheme around that fact involves writing a program that reads a track, steps the head when a particular data pattern is found, and then immediately writes some data to the new track. You now have a disk with known data patterns written in a particular order on adjacent tracks. If you change the write to a read and don't find the data pattern you originally wrote there, you know that it's not the original disk.

Playing With Apple DOS

The ways in which you can "customize" DOS are limited only by your imagination. After all, DOS is just another program. Here are a few suggestions on how you can change the internal workings of DOS to provide a measure of copy protection to your own disks.

Normally DOS reads your keyboard commands and tries to execute them. However, by patching in your own routine, you can cause DOS to do just about anything. Location $9FED is a good patch point. In an unmodified DOS, you'll see the following code:

```
9FED    59 A4 A8    EOR    $A884,Y
```

That is the beginning of the code that parses the input line before going into the command table. Here are several ways to patch that code. First, by causing a jump to $C600, any input line will cause the machine to reboot:

```
9FED    4C00 C6     JMP    $C600
```

This line will cause any input line to jump to BASIC:

```
9FED    4C 03 EO    JMP    $E003
```

This line will cause any input line to beep and go into the monitor:

```
9FED    4C 65 FF    JMP    $FF65
```

This line will cause any input line to beep and print "ERR":

```
9FED    4C 2D FF    JMP    $FF2D
```

DOS has both warm and cold boot routines, and it can tell which one is required by looking at the byte stored at location $03F4. If you change the value in DOS, you'll force a cold boot whenever the reset switch is pressed. Normally DOS has the following code:

```
9E36    49 A5       EOR    #$A5
```

By changing the A5 to a 00, you'll be able to initialize a disk with a DOS that will reboot whenever reset is pressed.

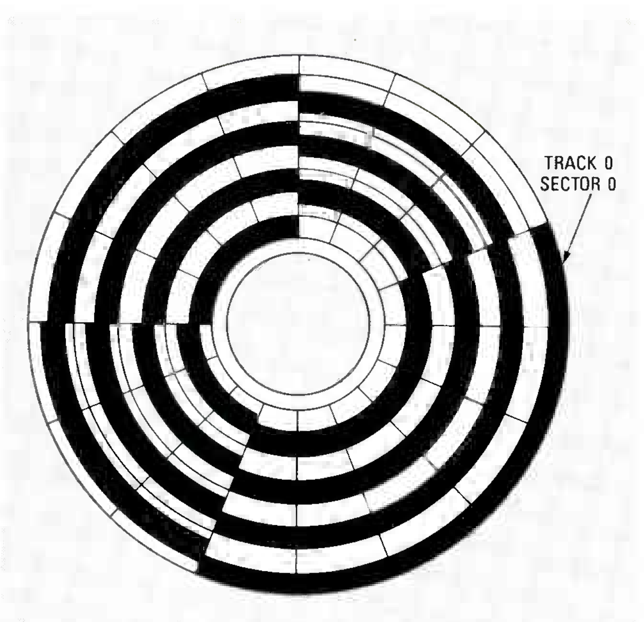


FIG. 7—A "SPIRAL" TRACK organization is achieved by offsetting alternate tracks or groups of tracks.

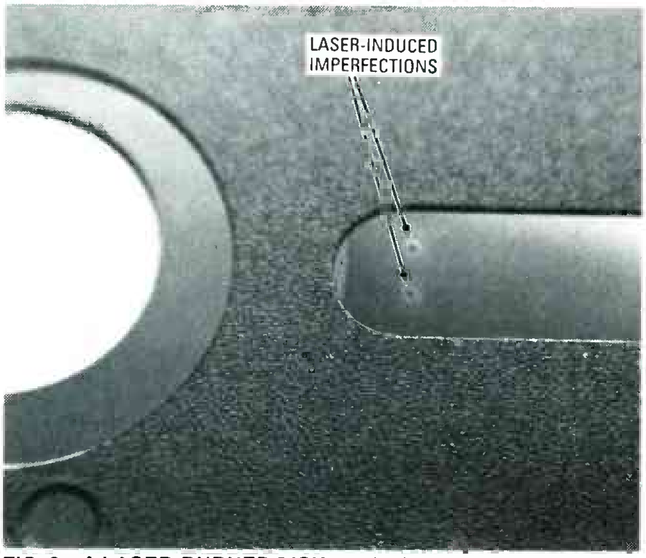


FIG. 8—A LASER-BURNED DISK can be backed up, reformatted, and the copies restored—and the copy-protection is still intact.

Using synchronized tracks became extremely popular. Publishers liked it because it was easy to implement and, at the time, none of the existing copy programs could get around it. Of course, that didn't last long. Most current copy programs can write synchronized copies, so that tracks on the copied disk are arranged in the same order as those on the original disk.

Quarter tracking

All of the copy-protection methods we've discussed so far are techniques that can be implemented from a regular DOS. Apple made their disk system very software intensive, so programmers have much control over the disk hardware. As more and more became known about DOS, programmers found new and sometimes bizarre ways to make their disks unreadable by normal methods.

Some unknown hero in the copy-protection business discovered that Apple DOS didn't actually move the read/write head an entire track at a time, only a quarter of a track at a time. Being able to step between tracks seems useless because data must be at least one track apart for it to be read reliably by the computer. The problem is crosstalk—exactly the same sort of problem that crops up in audio and video tape. If the guard band is too small, or if the recorder's heads are out of alignment, the head can read from two tracks at the same time.

The secret lies in the fact that, although tracks must be separated by at least a whole track, they can also be separated by more than that. A disk using that method is shown in Fig. 6. Track zero is in the correct position, but there's a track and a quarter between it and track one. The next three tracks are one track apart, but then we have a gap that's one and three quarters of a track wide. The remainder of the tracks are separated by one whole track.

It doesn't take much to see that some of the data on the disk is going to be inaccessible to a normal DOS. It will be able to read track zero and the tracks from five to the end of the disk. But when DOS tries to read the odd-spaced tracks, the head won't be positioned over the center of the track, so the signal will be weak. Signal-to-noise problems guarantee that, although some of the data might be read correctly, a good part of it won't. The result is a disk unreadable by any DOS that doesn't know exactly how each track is positioned on the disk.

Writing quarter tracks on a disk requires careful attention to timing details. The stepping rate of the head must be carefully controlled, as does choosing the moment at which data can be read. Many disk drives, particularly older ones with slower stepping rates, have trouble reading a disk with quarter tracks. The problem is more pronounced with tracks that are written near the perimeter of the disk, because the disk turns with a slightly faster linear velocity there.

Spiral tracking

Next, the software industry developed the idea of spiral tracks, which solved the problem of wasted disk space, and made it even more difficult to make copies. Figure 7 is a representation of a disk with spiral tracks. You

LISTING 1

```
10 REM ************************
15 REM * THIS PROGRAM WILL LET *
20 REM * YOU MOVE THE LOCATION *
25 REM * THAT DOS USES FOR THE *
30 REM *     CATALOG TRACK.    *
35 REM ************************
40 :
50 OLDTRACK = PEEK (44033)
90 TEXT : HOME
100 PRINT "THE CATALOG IS NOW ON TRACK ";OLDTRACK
110 PRINT
120 INPUT "WHAT IS THE NEW CATALOG TRACK? ";YOURTRACK
125 VTAB 6: HTAB 1
130 IF YOURTRACK<3 OR YOURTRACK>35 THEN PRINT CHR$(7): GOTO 500
140 :
145 REM PATCH THE FILE MANAGER
150 POKE 44033,YOURTRACK
160 :
165 REM PATCH THE INIT ROUTINE
170 POKE 44703,YOURTRACK: POKE 44764,YOURTRACK
180 :
185 REM PATCH THE CATALOG ROUTINE
190 POKE 46012,YOURTRACK
200 :
210 PRINT "YOU CAN NOW INITIALIZE A DISK THAT HAS"
215 PRINT "FILES UNREADABLE BY A NORMAL DOS."
220 END
500 INVERSE : VTAB 24: HTAB 1
510 PRINT "THE NEW TRACK MUST BE BETWEEN 3 AND 35";: GOTO 125
```

```
                LISTING 2

59E4    CE E7 59    DEC $59E7
59E7    CF          ???
59E8    EA          NOP
59E9    59 EE EA    EOR $EAEE,Y
59EC    59 AD 51    EOR $51AD,Y
59EF    C0 AD       CPY #$AD
59F1    54          ???
59F2    C0 AD       CPY #$AD
59F4    57          ???
59F5    C0 AD       CPY #$AD
59F7    52          ???
59F8    C0 20       CPY #$20
59FA    60          RTS
59FB    5B          ???
59FC    20 C5 5B    JSR $5BC5
59FF    20 4E 5B    JSR $5B4E
5A02    A9 04       LDA #$04
5A04    8D EC B7    STA $B7EC
5A07    A9 00       LDA #$00
5A09    8D EB B7    STA $B7EB
5A0C    A9 00       LDA #$00
5A0E    8D F0 B7    STA $B7F0
5A11    A9 60       LDA #$60
5A13    8D F1 B7    STA $B7F1
5A16    A9 40       LDA #$40
5A18    20 45 5A    JSR $5A45
5A1B    10 01       BPL $5A1E
5A1D    A9 20       LDA #$20
5A1F    91 5A       STA ($5A),Y
5A21    AD 50 C0    LDA $C050
5A24    A9 09       LDA #$09
• • •
```

can see that it meets the track-spacing requirement and that it makes maximum use of disk space. Trying to copy a disk like that can result in major brain damage. Not only do you have to know the track spacing, but you also must have the correct pattern.

There are two reasons why spiral tracks are a real problem for a copy program. The first is simply that it's hard to tell how many sectors have been placed on a particular track. The second more serious problem has to do with the nature of copy programs. We've already seen that there are so many ways to protect a disk that a good copy program can't make any assumptions about what it's going to find when it reads the disk. The more it expects to find, the less it will be able to deal with what's really there.

Let's suppose that you've just bought Acme Copy, the roughest, toughest, smartest, copy program in the world—it's so good it can even copy an unformatted disk—and you use it to make a copy of a spiral-tracked disk. You load the program and turn it loose. Even though track zero is written upside down and backwards, Acme Copy copies it without a hitch. Let's also suppose that the rest of the disk is spiral tracked; only half of the sectors on each track contain real data. Acme Copy doesn't know anything about that—no assumptions, remember?

Acme Copy reads in a track, half of which is data and half of which is garbage—and that's where the problem comes in. There is no way for the program to distinguish garbage from copy-protected data. It reads the track's data, does some sort of analysis, writes out the copy, and steps to the next track. Of course the copy will be worthless. Even if Acme Copy goes through the disk quarter track by quarter track, the act of writing a quarter track will undoubtedly corrupt the previous quarter track. It's sad but true that the only way you can get it to work properly is to tell it what spiral pattern to follow as it goes through the disk.

IBM copy-protection

Most of the Apple protection methods we've looked at have their counterpart in the IBM world. Modifying DOS and messing around with sector information were done early on in PC history—and neither method lasted any longer there than in the Apple world. Most IBM copy programs can deal with those methods without even working up a sweat.

However, some of the more imaginative copy-protection methods found on the Apple simply couldn't be ported over to the IBM because of the basic difference in their disk systems. The PC's designers decided to let most of the disk system be handled by an LSI controller IC. That made it simpler to develop DOS, because the controller has built-in routines to handle disk primitives like moving the head, reading and writing data, formatting, and so on. The ability to do quarter tracking, for example, is impossible because the controller hardware can only step the read/write head in full-track increments. In fact, because of the limited repertoire of commands built into the floppy-disk controller IC, just about the only trick that appeared had to do with the index hole.

Contrary to popular belief, the IBM only uses the index hole when formatting a disk. Every time the head is stepped out to a new track, the PC waits for the index hole to appear and uses that point as the starting point for formatting the track. After a disk has been formatted, particular tracks and sectors are located using the same method as the Apple. The floppy controller reads in the sector address of its current position and then steps in or out to the track DOS wants it to read.

Some protection methods want the track-splice point (the place where start and end points meet) to be exactly at the index mark. As with any protection method, however, this one only baffled copy programs for awhile. After the method was uncovered, it wasn't long before most copy programs could handle it.

Undocumented op-codes

IBM's floppy controller is an NEC PD765, which is really a microprocessor that has been optimized to handle disk drives. Some programmers disassembled the microcode in the IC looking for features and abilities that didn't appear in the documentation.

Several undocumented features were found, the most popular of which was to mix FM (frequency modulation) and MFM (modified frequency modulation) formatting on one track. None of the copy programs were able to handle that mixed formatting, because they didn't know how to make the PD765 do the trick. The result was a nearly unbeatable protection scheme.

However, there are two big problems with undocumented op-codes. The first is that the manufacturers who second-source the IC don't know about them. The second is that, because they aren't part of the 765's published vocabulary, there's no way to guarantee they'll still be there when new versions of the IC are released. And that's what spelled the death of mixed formatting on the IBM. The software ran well on computers that used the same run of 765's, but died on other machines. Needless to say, the scheme was dropped.

Other methods

The search is always on to discover new and wonderful ways to lock up disks. The older, software-only methods such as altering DOS or playing around with sector formatting and address bytes, are still used because they're inexpensive and easy to do. They're usually found on games and other low-priced software. Even though most copy programs know how to deal with them, some are still hard to beat, particularly nibble counting.

The publishers of more expensive software, however, have deep enough pockets to be able to afford more expensive protection schemes. There are two major high-end methods for protecting disks. Both are expensive because it takes more than just changing a few bytes to get them on a disk. The first involves what are called "weak bits," sectors written in such a way that they don't read the same way twice. All that's needed to activate weak-bit protection is to do two successive reads. If they're the same, the software knows it's running on a copy and can take appropriate action. Getting a sector like that on a disk involves the use of special duplicating equipment; it can't be done with a stock PD765.

Just as weak bits make the disk unique from a formatting point of view, laser holes make it unique from a physical point of view. The word *hole* is misleading because the disk isn't actually punctured, but burned, usually in two different places. The photograph in Fig. 8 shows what to look for if you suspect that the disk you're trying to copy has that kind of protection. The marks are usually located on the back side of the disk near the hub. It's easy for the software to check for the laser holes.

Laser-treated disks are probably the most expensive form of copy protection, but they have one big advantage for a publisher. Because the disk is physically unique, the publisher doesn't have to protect the files and can let you back them up on a regular disk. If you develop an error on the original disk, you can reformat it and copy the files from your backup. Remember that reformatting the disk has no effect on the laser holes. However, most copy programs can even get around laser-treated disks.

Because of the ease of overcoming most disk-based schemes, state-of-the-art copy protection these days is the hardware lock. It's a device that plugs into your serial or parallel port and remains totally transparent (in theory, at least) to the normal operation of the port. Software can check whether the device is present at various times during execution, and come to a screeching halt if it doesn't get the proper response.

References

Books (Apple): *Beneath Apple DOS,* Don Worth & Pieter Lechner, Quality Software, Computer Book Division, 21601 Marilla Street, Chatsworth, CA 91311, (818) 709-1721. *Beneath Apple ProDOS,* Don Worth & Pieter Lechner, Quality Software (address above).

Books (IBM): *The Programmer's Guide to the IBM PC,* Peter Norton, Microsoft Press, Dept. RC06, Box 97200, 10700 Northup Way, Bellevue, WA 98009. *Advanced MS-DOS,* Ray Duncan, Microsoft Press (address above).

Hardware (IBM only): The Copy II PC Option Board, Central Point Software, 9700 SW Capitol Highway, Suite 100, Portland, OR 97219, (503) 244-5782.

Software (Apple): *Locksmith 6.0,* Alpha Logic Business Systems, 4119 North Union Road, Woodstock IL, 60098, (815) 568-5166. *Copy II Plus,* Central Point Software, (address above). *Bag of Tricks 2,* Quality Software (address above). *Disk Repair Kit,* Penguin Software, 830 4th Avenue, P.O. Box 311, Geneva, IL 60134, (312) 232-1984.

Software (IBM): *Copy II PC,* Central Point Software (address above). *Master Key,* Sharpe Systems, Corp., 2320 E. Street, La Verne, CA 91750, (714) 596-0070. *CopyWrite,* Quaid Software Limited, 45 Charles Street East, Department 740, Third Floor, Toronto, Ontario M4Y 1S2, (416) 961-8243.

However, hardware locks are very expensive, so it's unlikely you'll see one protecting inexpensive software. Can a hardware lock be beaten? The answer is yes—sort of. The qualifier is there because, no matter what kind of protection scheme is employed, it only protects the disk, not the data. All the fancy tricks that have been used to lock up the software fall away when the program is loaded into the computer.

Your own copy protection

Several of the books mentioned in the References sidebar contain complete discussions and disassemblies of various versions of Apple DOS. By studying that information, you'll see that there are several ways to alter DOS and add simple copy protection to your own disks. DOS commands can be changed (or eliminated altogether), or your own code can be inserted in one of the unused areas of DOS. Then, when your program goes looking for it, if the code is there, the program will run normally. If it's not there—well, the choice is yours. You could be kind and just reboot the system, or you could be nasty and trash a couple of tracks.

If you're interested in playing with a modified disk organization, initialize a spare disk and run the program shown in Listing 1. It will create a diskette with the catalog located in a non-standard location.

To create a custom version of DOS, you can play with the ideas shown in the sidebar entitled Playing With DOS. However, just remember that those are fairly simple schemes, and they'll be no real obstacle to someone whose primary mission in life is to get a look at your code. The kinds of things you can do by messing around with DOS are the things a real "crack-ist" eats for lunch.

continued on page 102

BUILD THE PT-68K

Address decoders, RAM, and ROM.

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PART 4 In last month's installment, we described the 68000 microprocessor and got it running. This time we continue with the address decoders, RAM, and ROM. We'll assume that the jumpers we installed last time are still installed; don't remove those jumpers until you are told to do so. (One jumper connects pins 14 and 22 of IC47, to negate the 68000's $\overline{\text{BERR}}$ line, and one connects pins 1 and 14 of IC66, to assert the 68000's $\overline{\text{DTACK}}$ line.) In addition, the data bus should still be grounded via the two sets of Molex pins installed in the sockets for IC21 and IC27.

Step 8: Address decoding

Before building the address decoder, we need to develop the $\overline{\text{MAP}}$ signal, which provides one input to the decoder. When the 68000 starts operating after power is applied or after a reset, it must know (a) where to place its stack, and (b) where to start executing instruction. It looks for those in the first eight bytes of memory, starting at address $000000.

The problem is that in most 68000 computers address $000000 is in RAM, and that RAM will contain random values after the computer is first turned on. So how and where does the 68000 find the appropriate addresses? The usual solution is to set up the address decoder so that ROM, not RAM, occupies address $000000 and beyond. The trick is that the ROM remains there just long enough for the 68000 to get its two addresses, after which the ROM is switched out of and the RAM is switched into the low-order addresses. A ROM of that type is often called a *phantom ROM* or a *shadow ROM* because it's seemingly there and then gone. The circuit in Fig. 1 implements the ROM-switching function.

IC90 is an eight-stage shift register. When power is first applied to the computer, and each time it is reset, all the flip-flops in IC90 are cleared by the $\overline{\text{RESET}}$ signal. The output of the forth stage (QD), which is jumpered through J25, then provides a low $\overline{\text{MAP}}$ signal that tells the address decoder to put the ROM at address $000000.

When the 68000 starts, it fetches the stack address and the program start address from ROM in four 16-bit reads; each read is accompanied by an address strobe ($\overline{\text{AS}}$). The positive (trailing) edge of each $\overline{\text{AS}}$ then clocks IC90. Since both shift register inputs are tied high, each clock pulse shifts a high further into the register. After the first clock pulse, that high gets to QA; after the second pulse it gets to QB; and so on. After the fourth pulse it gets to QD and negates $\overline{\text{MAP}}$, which tells the address decoder to disconnect the ROM from address $000000 and substitute RAM.

Now that we understand how the circuit actually works, let's build it and verify that it works. First install a socket for IC90 and a three-pin header block at J25. Insert the IC and place a shorting plug over position 1 of J25. (IC66 was installed in a previous step.) Turn on the power and verify that the $\overline{\text{MAP}}$ signal on the center pin of J25 goes low while you short the reset pins (J23), and that it goes high about a second later, at the same time as the HALT LED goes off. (Unless you have a high-quality oscilloscope, it may be difficult to verify that exactly four $\overline{\text{AS}}$ pulses go by before $\overline{\text{MAP}}$ goes high, so you'll have to take it on faith that the circuit is functional.)

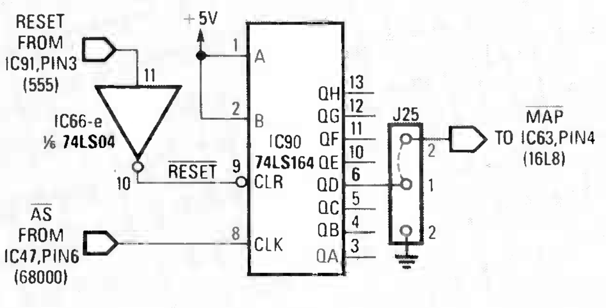

FIG. 1—THIS CIRCUIT GENERATES THE MAP SIGNAL that forces the microprocessor to address ROM rather than RAM at power up and on subsequent resets.

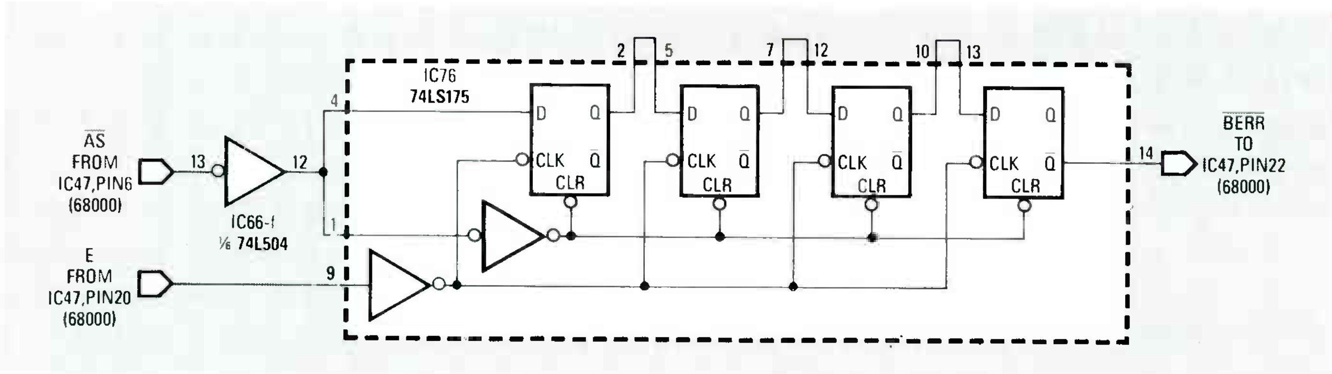

FIG. 2—A BUS ERROR (BERR) IS GENERATED if the address strobe (AS) continues through four E cycles without a data acknowledge (DTACK).

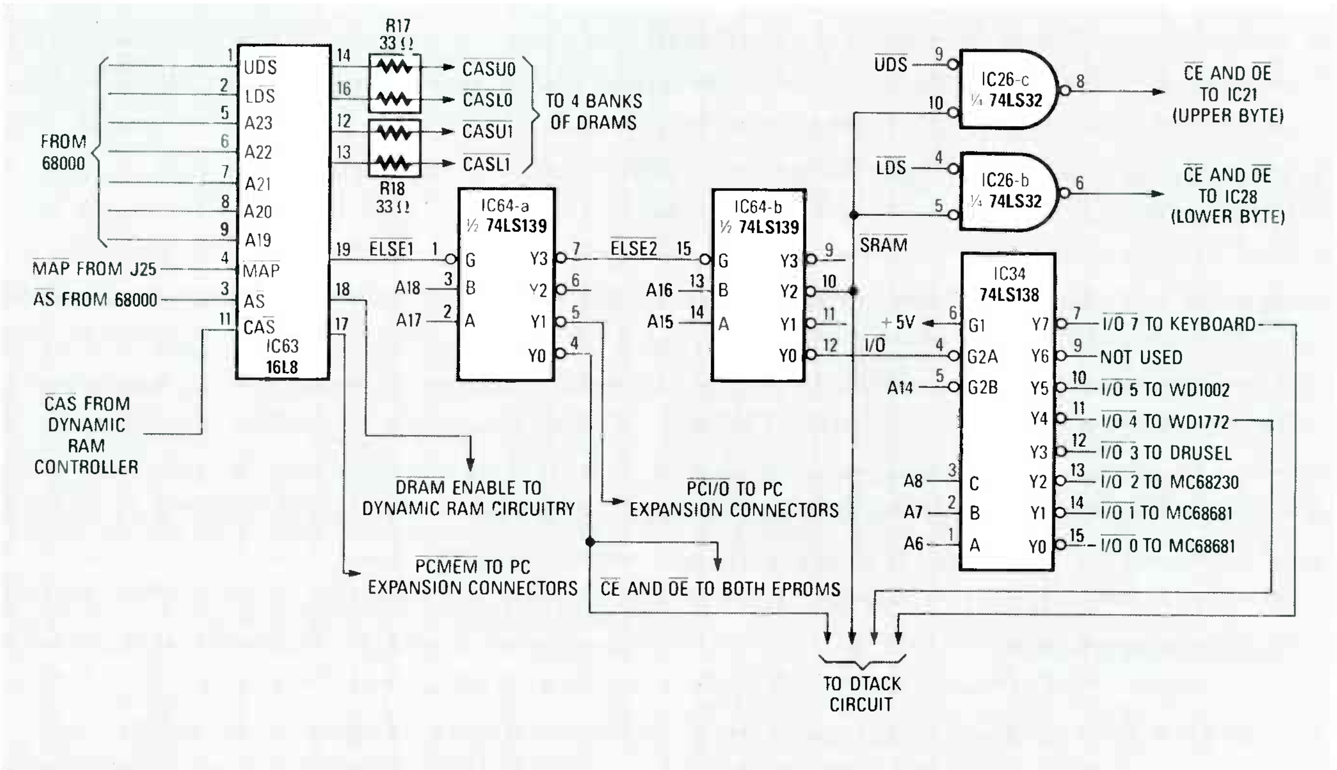

FIG. 3—ALL ADDRESS DECODING is accomplished by three IC's: each IC (or section thereof) further narrows the range of addresses decoded by its predecessor.

Step 9: The bus error circuit

Each time the 68000 wants to access memory or I/O, it sends out an address; LDS, UDS, or both; R/W; and AS. Then it sits back and waits for the memory or I/O to respond. If all goes well, the external circuit should return a low on DTACK (data transfer acknowledge); if something goes wrong, it should return a low on BERR (bus error).

When using slow memory or I/O, DTACK can be used to slow down the 68000; the period of waiting is called a *wait state*. But suppose the 68000 tries—accidentally or otherwise—to access an address at which there is no memory or I/O. What happens then? Since there is nothing to generate DTACK, the 68000 might go into a permanent wait state. That's where the bus-error circuit comes in. Its job is to detect the lack of DTACK after some period of time, and then generate BERR, which forces the 68000 into an error-recovery procedure.

When we first powered the 68000 up last time, we tied DTACK low and BERR high, which allowed the processor to run at maximum speed, and made it think that a bus error never occurred. Since we are still providing a fake DTACK, the 68000 will go full-speed ahead, even though there is no memory in the system yet. However, we may as well install the BERR circuit at this time.

The circuit shown in Fig. 2 looks complex, but actually it consists of just one new part: IC76, a 74LS175 quad D flip-flop. (IC66 was installed in a previous step).

The four flip-flops are configured as a four-stage shift register that is driven by the 68000's E clock. That signal operates at one tenth the speed of MPUCLK, or 800 kHz if the main clock is 8 MHz.

The input data comes from AS, which is also connected to IC76's CLEAR pin. When the 68000 starts a memory or I/O access, it asserts AS, which simultaneously negates IC76's

BUBBLES AND GATES

A given signal in a digital system can be either active high or active low; the signal's name often indicates which. For example, $\overline{\text{DTACK}}$ is active low, and we know it as such because of the bar over the name. FCO, on the other hand, is active high because it has no bar above it.

One way to mark a signal in a schematic diagram is with a *bubble*, which is simply a small circle at the end of a connecting line. Bubbles are a notational convention that, when used properly, can help prevent design errors. The basic idea is that active-high outputs can only go to active-high inputs; likewise with active-low signals. Many engineers and technicians tend to get careless with bubbles, so diagrams can't always be trusted. However, when properly used, bubbles can be very helpful. Look at Fig. 1 for a simple example; the circuit shown there is the Halt indicator discussed in an earlier installment.

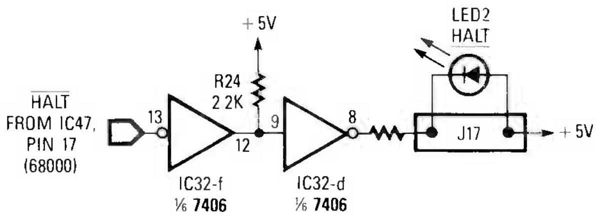

FIG. 1

The $\overline{\text{HALT}}$ signal comes from pin 17 of the 68000 microprocessor; that signal goes low when the 68000 is halted. As stated above, an active-low output must go to an active-low input, so you'll notice a bubble on the input (pin 13) of IC32-f. The output of that inverter is active high, so it goes to an active-high input, IC32-d. The output of that inverter is active low, so we would expect that the LED would light when that output was low, and that is indeed the case.

It's important to understand that IC32d and IC32f are functionally identical—they're both open-collector inverters—even though their symbols are different.

The same principles can be applied to all the basic logic elements, as shown in Fig. 2. Each pair in that diagram is equivalent. For example, the gate on the left in Fig. 2-*a* is normally called an AND gate; described in words, its job is to "make the output high if input A is high *and* input B is high."

There is another way of describing its operation: If either input is low, then the output is low. So we could say "make the output low if A is low *or* B is low." That sounds like an OR gate that works with low-going signals—and that's what the gate on the right in Fig. 2-*a* shows.

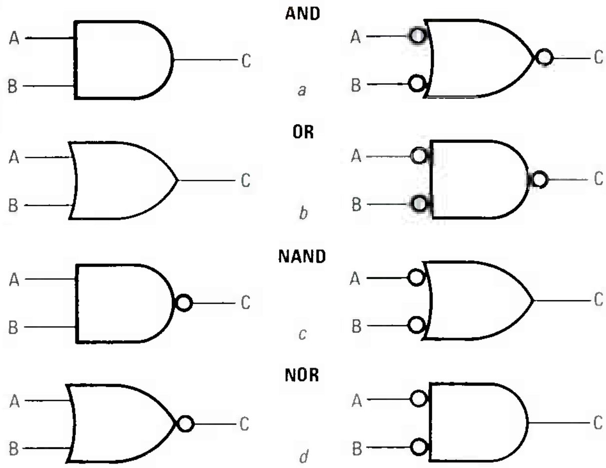

FIG. 2

You can convert from one form to the other by negating all terms on both sides of a logic equation. Highs become lows and vice versa, AND's become OR's and vice versa, and NAND's become NOR's and vice versa. So

A AND B = C

becomes

$\overline{A}$ OR $\overline{B}$ = $\overline{C}$

A designer might use either symbol for the same device, depending on what a particular circuit is supposed to do. Parts manuals, for example, usually describe gates in terms of the "positive logic" function—the symbols on the left in Fig. 2. The 7408, for example, may be described as a "quadruple two-input positive-AND gate." That means the 7408 has four two-input gates, each of which functions as a normal AND gate. However, the 7408 could just as well be called a "quadruple two-input negative-OR gate.

Similarly, Fig. 2-*b* shows a positive-logic OR gate on the left, and a negative-logic AND gate on the right. In reality, both functions could be provided by the same IC (a 7432).

A real-life example is the $\overline{\text{DTACK}}$ generator shown in Fig. 5 of this installment. Note IC36—it's normally described as an eight-input NAND gate, but here it functions as an eight-input NOR gate.

All of that may sound strange, but as we go on, you'll see that the new symbols we've outlined here will help explain how the PT-68K computer works.

CLR input and asserts its D input. Then, each time an E clock signal arrives, that high is shifted one stage to the right. If the $\overline{\text{AS}}$ signal continues through four E cycles (about 4–5 microseconds), the last flip-flop will set, and $\overline{\text{BERR}}$ will go low, informing the 68000 that too much time has passed since the memory or I/O access started. At that point a special interrupt occurs, and a software routine must decide what to do next.

Building the circuit is easy. First remove the jumper that was installed between pins 14 and 22 of IC47. (That jumper forced $\overline{\text{BERR}}$ high.) Next install a socket for IC76, and then the IC (a 74LS175).

Testing is almost as easy. Using the LED probe, look at pins 4 and 9 of IC76. Because $\overline{\text{AS}}$ and E are both square waves, and are on about 50% of the time, the LED should glow at about half brightness. Then look at pin 2, the Q output of the first flip-flop. $\overline{\text{AS}}$ and E are not in any particular phase relationship, so the first flip-flop will trigger once every few $\overline{\text{AS}}$ cycles, but it will never stay on for very long. Therefore, the flip-flop is mostly off, so the LED should be quite dim. The other flip-flops never get a chance to set, so the LED should remain dark when testing any of the other Q outputs. $\overline{\text{BERR}}$, of course, is high all the time, so the LED should be bright when testing pin 14.

Step 10: The address decoder

As described way back in the first part of this series, the address decoder continuously monitors the high order bits of the address bus and signals the RAM, the ROM, and the I/O interfaces whenever an address comes along that is intended for them. The PT-68K's address decoder consists of three IC's, as shown in Fig. 3.

The heart of the decoder is IC63, a 16L8 PLD (programmable logic device). A PLD is like a fast ROM in that it has a number of input and output lines. Each time a combination of ones and zeroes is presented to its input lines, the

PLD outputs a number that is stored in the corresponding location in its internal memory.

By the way, there are significant differences between a ROM and a PLD. The ROM is more complex than the PLD because it can store more information; but, being simpler, the PLD can run faster. In general, the ROM is meant to store numbers, and the PLD is meant to replace logic IC's. In our case, the PLD replaces almost a dozen gates and inverters, thereby saving both space and money.

The PLD functions as follows. It splits the sixteen-megabyte address space of the computer into three areas:

- \$000000–\$0FFFFF, system DRAM
- \$C00000–\$DFFFFF, PC-compatible slots
- \$F80000–\$FFFFFF, everything else

Any other address simply isn't recognized by the address decoder. Now let's examine the details of how the circuit actually works.

1. If $\overline{\text{AS}}$ is negated (high), the PLD does nothing; $\overline{\text{AS}}$ must be low to ensure that a valid address exists.

2. If address lines A20–A23 are low, representing addresses \$000000 through \$0FFFFF (i. e., the first megabyte of memory, where the system DRAM resides), pin 18 ($\overline{\text{DRAM}}$) is asserted. In addition, if $\overline{\text{CAS}}$ is low, indicating that the DRAM refresh circuitry wants to access a column of DRAM, IC63 asserts one or two of the $\overline{\text{CAS}}$ outputs (pins 12, 13, 14, and 16), which in turn activate a group of dynamic RAM IC's. $\overline{\text{LDS}}$ and $\overline{\text{UDS}}$ determine whether to assert one of the lower ($\overline{\text{CASL}}$) outputs, one of the upper ($\overline{\text{CASU}}$) outputs, or both, depending on whether an odd byte, an even byte, or a sixteen-bit word is to be accessed. Meanwhile, the A19 input of IC63 splits the DRAM megabyte into lower and upper 512K groups.

Incidentally, the four resistors, parts of 33-ohm resistor packs R17 and R18, slow the rise and fall times of those signals. Each $\overline{\text{CASL}}$ and $\overline{\text{CASU}}$ signal goes to eight DRAM IC's, and the fast rise and fall times cause sharp signal edges, which contribute to noise in the memory. The resistors reduce that noise and thereby improve reliability.

3. If the three high-order bits of the address bus are 110, representing all addresses beginning with a hex C (1100) or hex D (1101), $\overline{\text{PCMEM}}$ is asserted. That signal goes to the six PC-compatible expansion connectors for accessing memory on plug-in cards.

4. If the five high-order address lines are high, representing all addresses between \$F80000 and \$FFFFFF), $\overline{\text{ELSE1}}$ is asserted; that signal implies that the chosen address contains something besides system RAM or memory in an expansion slot.

5. Operation is different when $\overline{\text{MAP}}$ is low; then the DRAM is disabled and $\overline{\text{ELSE1}}$ signal is asserted instead. That maps the ROM instead of the RAM into address \$000000.

I/O decoding

When $\overline{\text{ELSE1}}$ is low, the address space from \$F80000–\$FFFFFF is divided into three groups by IC64-a, according to the states of A18 and A17. When the $\overline{\text{G}}$ input of IC64 is asserted, one output is asserted according to the binary states of the A and B inputs. For example, the $\overline{\text{Y0}}$ output is asserted when both inputs are low.

1. When A18 and A17 are 00, which occurs for addresses \$F80000–\$F9FFFF, IC64-a asserts the $\overline{\text{CE}}$ and $\overline{\text{OE}}$ signals for both EPROM's, thereby enabling them.

2. When A18 and A17 are 01, which occurs for address \$FA0000–\$FBFFFF, IC64-a asserts $\overline{\text{PCI/O}}$, which goes to the six PC-compatible expansion connectors for accessing port-mapped I/O on plug-in cards.

3. When A18 and A17 are 10, which occurs for address \$FF0000–\$FDFFFF, IC64-a asserts its $\overline{\text{Y2}}$ output, which is unconnected.

4. When A18 and A17 are 11, which occurs for address \$FE0000–\$FFFFFF, IC64-a asserts $\overline{\text{ELSE2}}$, which enables another decoder, IC64-b. So, as you can see, each IC in the address-decoding chain uses the output of its predecessor in the chain to narrow down the range of addresses it recognizes. In this case, IC64-b splits the \$FE0000–\$FFFFFF range into two smaller groups, depending on address lines A16 and A15.

1. If A16 and A15 are 00, which occurs for addresses \$FE0000–\$FE7FFF, IC64-b asserts $\overline{\text{I/O}}$, which drives IC34.

2. If A16 and A15 are 10, which occurs for addresses \$FF0000–\$FF7FFF, IC64-b asserts $\overline{\text{SRAM}}$, which drives the static RAM and the clock/calendar via IC26-b and IC26-c. (The RAM circuit was shown in Fig. 3 in the December installment.) Note that $\overline{\text{LDS}}$ and $\overline{\text{UDS}}$ are combined with $\overline{\text{SRAM}}$ to enable the upper byte (IC21), the lower byte (IC28), or both. For example, when both $\overline{\text{UDS}}$ and $\overline{\text{SRAM}}$ are asserted, the $\overline{\text{CE}}$ and $\overline{\text{OE}}$ pins of IC21 will be asserted, and the IC will be enabled.

WHAT'S IT ALL ABOUT?

The computer described in this series of articles is based on Motorola's 68000 microprocessor, which is also used in a number of personal computers (including the Macintosh, the Atari ST, the Commodore Amiga) engineering workstations, and laser printers. The computer, dubbed the PT-68K, will not run software designed for the IBM PC—at least not yet. But it will accept PC hardware, including keyboard, video display card, monitor, I/O ports, etc.

The PT-68K has a monitor program (HUMBUG) and a version of BASIC, both of which are contained in on-board EPROM. By adding a disk drive and the appropriate control circuitry, the computer will run the SK*DOS operating system, which includes an editor, an assembler, numerous utilities, and a 6809 emulator, which allows you to run much already written 6809 software. In addition, development of a full C compiler and an extended BASIC are nearly complete, and several firms have announced products including a full-screen editor, a disassembler, a communications program, and more. Up-to-date information on software and hardware is available from the SK*DOS BBS (914-241-3307). Technical support is also available there.

The PT-68K motherboard is the same size and shape as an IBM PC XT motherboard, so it may be mounted in an inexpensive clone cabinet. In addition, the PT-68K may be powered by an inexpensive PC clone power supply. Either a serial terminal, or a personal computer running a terminal emulator, or an IBM monochrome adapter card, monitor, and keyboard may be used to communicate with the PT-68K.

Presently we are looking into the possibility of designing or adapting a plug-in card that would contain an Intel microprocessor and would allow you to run PC software on your PT-68K. Right now, it looks very promising, and we'll keep you up to date on our progress.

ERROR CORRECTIONS

- The parts list presented in the October issue listed an incorrect part number for IC28; the correct number is 74S74.
- Several parts were inadvertently omitted from the parts list, including LED1–LED3, SPKR1, and 0.1 µF bypass capacitors C69–C73.
- The parts-placement diagram (Fig. 3 in the November installment) was printed upside down, so references in the text will be rotated 180° from the true position. However, all locations on the board are labeled correctly.

3. The 01 and 11 states of A16 and A15 are not used.

That brings us to IC34, the last IC in the address-decoding chain. IC34's job is to decode addresses of the seven on-board system I/O devices: the two MC68681 DUART (dual UART) serial IC's, the MC68230 parallel port, a drive select latch that controls the floppy-disk drive, the WD1772 floppy-disk controller IC, an optional WD1002 hard-disk controller, and the PC-compatible keyboard. As stated above, IC34 is enabled by the $\overline{I/O}$ signal that is asserted for addresses \$FE0000–\$FE7FFF. In addition, IC34 requires a low (at its $\overline{G2B}$ input) from A14, so it only responds to the 16K of addresses in the range from \$FE0000–\$FE3FFF. Then it decodes address lines A6–A8, asserting one of the $\overline{Y0}$–$\overline{Y7}$ outputs. For example, when A8, A7, and A6 are 000, IC34 asserts the $\overline{I/O0}$ line, which enables the first DUART.

Now comes a difficult question: What is the range of addresses that the DUART responds to? Following the circuit from left to right, we see that, for $\overline{I/O0}$ to be low:

- A23 through A19 must be 11000
- A18 through A14 must be 00000
- A13 through A9 are unknown
- A8 through A6 must be 000
- A5 through A0 are unknown.

It's evident that the address decoder does not really look at all the bits of the address bus—there are eleven bits that are unaccounted for (or ten bits when we realize that A0 doesn't exist.) Let's ignore A0–A5 for the moment; A9–A13 are the problem.

Grouping those bits left to right by fours, they look like this:

1111 1110 00xx xxx0 00yy yyyy

Each of the five unknown bits corresponding to A9–A13 is labeled with an *x*; each of the six unknown bits corresponding to A0–A5 is labeled with a *y*. Each x and y bit could be either a zero or a one; first let's assume that all the *x* bits are zeroes:

1111 1110 0000 0000 00yy yyyy

Converting to hexadecimal, the first four digits are clearly \$F800. If the *y* bits are all zeroes, then the last two digits are \$00; if they are all ones, then the last two digits are \$3F. That tells us that the DUART is addressed from \$F80000–\$F8003F, a total of 64 locations.

But the *x* digits need not all be zeroes; they could just as well be 00001, which would make the complete address look like this:

1111 1110 0000 0010 00yy yyyy

The first four digits here are \$FE02; again assuming that the *y* digits can be anything from all zeroes to all ones, that gives us an address range of \$FE0200 through \$FE023F. In a similar manner, we see that the DUART responds to many addresses:

- \$FE0000–\$FE003F
- \$FE0200–\$FE023F
- \$FE0400–\$FE043F
- \$FE0600–\$FE063F
- \$FE0800–\$FE083F
- ... through ...
- \$FE3E00–\$FE3E3F

The latter addresses are decoded when the *x* bits are all ones.

The preceding is an example of *incomplete address decoding;* it arises because the address decoder does not decode all bits. In fact, the bits that can be either value are usually called *don't cares.* Incomplete address decoding results in using up more addresses than are actually needed, but it allows the circuitry to be simpler and less expensive. When programming an incompletely decoded device, we usually work with the base location—the 64 locations from \$FE0000–\$FE003F in this particular case.

The EPROM's are also incompletely decoded. As stated above, the EPROM is assigned addresses from \$F80000 through \$F9FFFF, a total of 128K bytes. Typically, however, a pair of 27128's would be used, and they provide a total of only 32K, so 96K of address space is wasted. What actually happens is that the 32K of EPROM appears in the 128K space four times. That is, the EPROM *appears* to occupy the entire 128K, but on closer examination we see that there are four copies of the same data in that space. The loss of that many addresses in an 8-bit computer with a total of 64K of addresses would be unthinkable; in a computer with 16 megabytes of addresses, the loss is insignificant.

The same situation occurs with the I/O. Although each I/O device may only require a few bytes of address space, each takes up 32 64-byte chunks of addresses, for a total of 2048 addresses.

Ordering Information

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

Assemble and test the address decoder

Enough theory; it's time to build the address decoder. Install the following components: IC63 (with socket), R17 and R18 (solder directly to the board), IC64 (with socket), IC34 (with socket), and 0.1 μF capacitors at C13, C67, C68, and C70. Place the J25 jumper in position 1, recheck all connections, and then apply power.

Although a thorough test of the address decoder would require sophisticated test equipment, we can perform a simple test with the aid of Fig. 4, which shows the waveforms output by the decoder circuit.

As you recall from last time, while our test circuit is wired up (i. e., the data bus is shorted to ground) the 68000 executes what it thinks are four million OR instructions, looping through the entire 16-megabyte memory space once every four seconds. Figure 4 shows what happens at several key points. During those four seconds the 68000 counts up through 16 megabytes of memory. The left edge of the figure corresponds to memory location \$000000, the right edge (just before the pulses) to location \$FFFFFF. The pulses at the extreme right end of the figure indicate the beginning of the next four-second cycle.

First let's look at the $\overline{DRAM}$ signal. Since dynamic RAM occupies the first megabyte of addresses, the $\overline{DRAM}$ signal

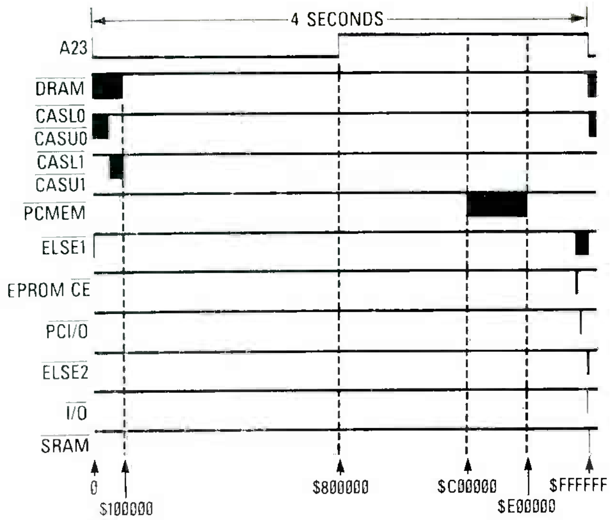

FIG. 4—VARIOUS OUTPUTS OF THE ADDRESS DECODER are shown here; these waveforms will be seen only with the test circuit (shorted data bus, etc.) installed.

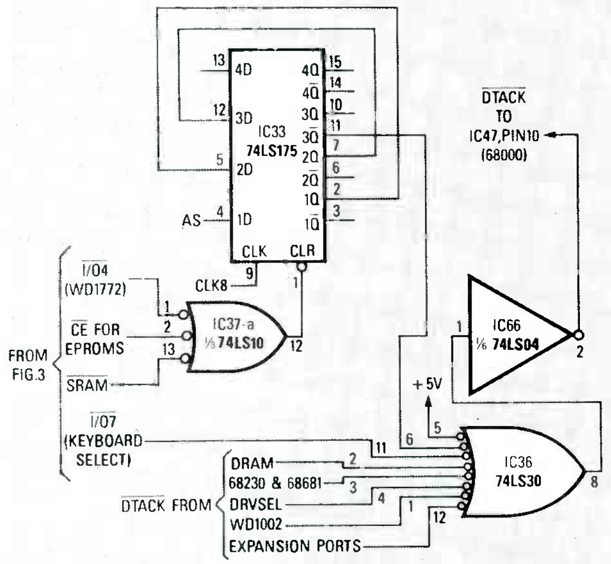

FIG. 5—THE DTACK GENERATOR is similar to the BERR circuit shown in Fig. 2. Here, however, the shift register (IC33) prevents the computer from locking up should a memory or I/O device not supply a data acknowledge.

goes low for the first 1/16th of the four-second cycle, or ¼ second. The DRAM signal does not remain low for the entire ¼ second, however, and that's why it's shown as a solid block in Fig. 4. It doesn't stay low because, like all other signals in the address decoder, DRAM is asserted only when the AS is asserted. Because AS rapidly cycles between high and low, so does DRAM.

You can verify that with a good-quality scope; you should see a continuous high, with a short burst of pulses once every four seconds. Without a scope, you can you connect your LED probe to DRAM (at pin 18 of IC63). The LED should remain on continuously (because the signal is normally high), but once every four seconds, the LED will get slightly dimmer for about a quarter of a second.

Each of the other address-decoder outputs can be checked in the same way, except for the four CAS outputs, which will show a constant high because we have not yet supplied a CAS input to IC63. Some of the other outputs will remain on for a longer period of time—such as PCMEM, which will dim the LED for about ½ second—but most will be much shorter. The I/O and SRAM outputs will be very difficult to see since they last only about ten milliseconds, just barely long enough to flicker the LED if you watch carefully. The outputs of IC34 are too short to be able to see on the LED, although a pulse-catching logic probe or oscilloscope will show a slight flicker once every four seconds.

Step 11: The data acknowledge circuit

Previously we generated an artificial DTACK with a jumper; now it's time to install the real DTACK circuit and see how it works.

Ideally, every device, whether memory or I/O, should generate its own DTACK when it finishes an operation. The 68000 would then know that it was time to continue. That is practical in some circuits (DRAM and some I/O devices, for example), but in others a timer is required; the timer just waits for a period time and then generates DTACK, assuming all is well. However, the PT-68K system uses both approaches.

Fig. 5 shows the DTACK generator circuit. It has eleven inputs, of which two (AS and CLK8) are used for timing.

Four other inputs (I/O4, I/O7, the EPROM CE signal, and SRAM) come directly from the address decoder in Fig. 5. I/O4 goes low whenever the address decoder enables the WD1772 floppy-disk controller; CE goes low when either EPROM is selected; and SRAM goes low when the static RAM is selected.

Whenever I/O4, CE, or SRAM goes low, IC37-a provides a high to the CLR input of IC33, a quad D flip-flop, which is configured like IC76 in Fig. 2. IC33 is clocked by CLK8, the 8-MHz clock signal. The output of IC37-a is usually low, so its four flip-flops are usually in the reset state. Therefore, the 3Q output is usually high.

Now suppose that the floppy-disk controller, the EPROM, or the static RAM is decoded. The output of IC37-a will go high, release IC33's CLR signal, and allow it to start shifting. AS is high at that point, and that high starts shifting through the flip-flops. After three CLK8 pulses, 3Q goes low, which sends the output of IC36 high, and the output of IC66-a low, thereby generating DTACK. In other words, IC33 acts as a delay. Note that it is clocked by CLK8, not MPUCLK. Even if you speed up the computer by using a faster MPUCLK, IC33's delay will not change.

Now let's look at IC36. When any of its inputs goes low, its output goes high. One input (pin 5) is not used, so it is tied high. Of the remaining inputs, one comes from IC33, as we saw above; one comes from the keyboard select line (I/O7); and the other five come from other parts of the computer that we'll discuss (and build) in a later installment of this series.

For now, just understand that each of the other sections generates its own data-acknowledge signal, all of which are combined at IC36. In addition, the keyboard circuit operates very fast, so I/O7, its select signal, immediately generates its own data-acknowledge signal.

To build the DTACK circuit, first remove the jumper between pins 1 and 14 of IC66. Then install IC33 and IC36 (with sockets). IC37 and IC66 were installed previously; J25 should still be in position 1 from the previous step;

and the Molex pins should still be inserted in the EPROM sockets (IC21 and IC27). Now turn on the power and let's see what happens.

Nothing! Well, of course not. The problem is that the 68000 is still trying to execute four million OR instructions. It's still getting them from the Molex pins, but it's not getting $\overline{\text{DTACK}}$. Hence the $\overline{\text{BERR}}$ circuit is timing out and halting everything. You probably noticed that the HALT LED goes on and never even flickers.

Now move the jumper at J25 from position 1 to position 2 and try again; you will see a slight flicker on the HALT LED about a second after you turn on the power (or force a reset by shorting J23), but it still goes on.

The Molex pins in IC21 and IC27 put all zeroes on the data bus, so the address that the 68000 picks up after a reset is also all zeroes. Therefore it starts to execute instructions at address $000000.

With J25 in position 1, low memory is supposed to be dynamic RAM, but because there isn't any, IC36 gets no data acknowledge, so the 68000 quits with a bus error almost immediately after reset. With J25 in position 2, however, the EPROM is supposed to be mapped into low memory. There isn't any EPROM, of course, but the address decoder and the $\overline{\text{DTACK}}$ generator don't know that; hence they generate $\overline{\text{DTACK}}$ as if the EPROM were there. The 68000, therefore, executes the OR program until it passes the highest EPROM address, after which $\overline{\text{DTACK}}$ disappears, and the system halts on a bus error.

Step 12: ROM and RAM

The circuitry for the EPROM and the static RAM was shown in Fig. 3 of the December installment. The 68000's data bus is 16 bits wide, but no one makes EPROM's or RAM's that have 16 data lines. The solution is to use two 8-bit-wide EPROM's and two 8-bit-wide static RAM's.

Three kinds of EPROM's can be used, but both EPROM's of a pair must be the same type. Two 27128's hold 32K bytes; two 27256's hold 64K bytes; and two 27512's holds 128K bytes. 27128's have enough capacity to hold our machine-language monitor (HUMBUG) and BASIC, but the prices on memory IC's are so unstable that kits may contain any of those, depending on current market conditions. Jumpers J19 and J20 are used to select the type of EPROM that is being used.

The static RAM's are pair of 6116's, which provide a total of 4K bytes of memory. But it is possible to replace one—or both—with a Mostek MK48T02, which has the same pinout as a 6116, but which also contains some RAM and two additional features: a clock/calendar (whose registers replace the top eight locations of the RAM), and a lithium battery that powers both the clock and the RAM when the computer is turned off. The battery is rated for at least 31,000 hours of operation, or slightly more than 3½ years. In actual use, it should last longer, because the battery powers the clock only when the computer is off. (Note that the MK48T02, if used, must be inserted into the IC28 socket, because the clock software in SK*DOS expects to find the IC in the lower byte.)

Integrated circuits IC20 and IC21 handle the upper eight bits of the data bus, and IC27 and IC28 handle the lower eight bits. That division may be confusing and hence needs explanation. When the 68000 stores a word (two bytes) from an internal register into memory, the left byte (also called the more significant byte, or the upper byte) goes into memory first, and is always in an even-numbered location. The right byte (also called the least significant byte, or the lower byte) is stored in the next available memory location, an odd number. For example, the number $1234 might be stored as $12 in location $3500 and $34 in location $3501. That arrangement is logical, but it is confusing for two reasons: (1) the upper byte is actually stored in the lower address, and (2) other microprocessors (particularly those in the Intel family) store words in the opposite order. $1234 would be stored in sequential locations as $34 followed by $12.

Further complicating things is the fact that both EPROM's are controlled by the same $\overline{\text{CE}}$ (chip enable) and $\overline{\text{OE}}$ (output enable) signals, whereas there are separate enable signals for each of the static RAM's. Reading both EPROM's simultaneously does no harm; if the 68000 only wants one byte, it simply ignores the other half of the data bus. But writing to the static RAM requires two control lines to make sure that writing to one RAM does not inadvertently store unwanted data in the other.

Note also the difference between $\overline{\text{CE}}$ and $\overline{\text{OE}}$—when RAM or EPROM is read, $\overline{\text{CE}}$ enables the IC and starts the read process, but data does not appear on the bus until $\overline{\text{OE}}$ is asserted. In many systems, $\overline{\text{CE}}$ is used to put the entire chip into a low-power mode when it is not being accessed. In the PT-68K we control both lines together so the IC switches into low-power mode after every access.

Earlier we said that there is no A0 on the address bus; now let's see how the system gets by without it. Consider the static RAM, for example, which starts at $FF0000. Memory locations are located in specific IC's as follows. All the even addresses are stored sequentially in IC21 ($FF0000 is in location 0, $FF0002 is in location 1, $FF0004 is in location 2, etc.), and all the odd addresses are stored sequentially in IC28 ($FF0001 is in location 0, $FF0003 is in location 1, etc.).

The address lines are shifted by one bit because shifting a binary number to the right by one bit divides the number by two. For example, location $FF0008 ends with the bits 1000; physically, that byte would be located in address 0100 (i.e., address 4) of IC21. Location $FF0009, on the other hand, ends with the bits 1001; it would also be in location 0100, but in IC28. So the last bit of an address tells us which IC it is stored in.

Now that we understand how the EPROM and static RAM circuitry works, let's connect it. Remove the Molex pins from the IC21 and IC27 sockets, and install the following components: a socket for IC26 (74LS32), C12 and C66 (0.1 μF), sockets for IC21 and IC28 (EPROM's), and three-pin header strips at J19 and J20.

Then install the EPROM marked *Upper* in IC20 and the EPROM marked *Lower* in IC27, and then the two 6116 static RAM's in IC21 and IC28. Before turning on the power, make sure that the jumpers are positioned correctly, according to the chart shown in Fig. 3 last time. Also, place jumper J18 in position 2 to address the EPROM at location $000000. Now turn on the power.

If all is well, the HALT LED should go off after about a second. If it does, that's a pretty good sign that there are no serious problems, even though the computer is still not fully operational. If it doesn't, recheck all connections and parts installed since last time.

For more confidence, use the LED probe to check a few

continued on page 102

FLOPPY-DISK DATA STORAGE

continued from page 94

Breaking copy protection

Copy protection—both making it and breaking it—is big business. There are two fundamental ways to get around copy protection. The first is to buy a program that knows how to copy protected disks. If you're lucky, it will know how to make sense of the particular protection scheme(s) used on your disk and will be able to copy it with no muss and no fuss. But the price you pay for that kind of mindless copying is that, if the program can't copy the disk, there isn't a thing you can do except try some other copy program.

The second method is to use some disk tools to snoop through the disk and remove the copy protection yourself. As with most things, each method has advantages and disadvantages. The method you choose depends on how good your tools are, how well you can use them, how much you know about your computer, how much time you want to spend, and how badly you want to make the copy.

There's simply not space to go into the details of how to break copy protection; it's an art in itself. Basically, it involves spending endless hours at a totally unnatural act: staring at and trying to decipher page after page of undocumented object code. Unless you've actually done it, there just aren't any words to describe the amount of work involved.

One reason is that the code you'll be looking at probably was written to be confusing. The code in Listing 2 is a perfect example. Go through it and see whether you can understand what's going on. It's real code from a popular Apple game. There are no tricks here, either. It's just that things aren't what they seem to be. The real meaning (and the real code) is hidden. If you figure it out, drop us a note. And if there's enough response, we'll take up the subject of copy breaking in another article.

If you want to learn about the in's and out's of copy protection, you'll have to get familiar with the normal workings of the standard DOS used by your computer. Read the books mentioned in the References sidebar, and follow their tutorials. Those books won't tell you how to break copy protection, but they'll give you the basic tools you need to do so.

If you just want to back up your copy-protected (IBM) software, try the Option Board from Central Point Software. It's the ultimate tool for dealing with disks on a bits-and-bytes level, and it also helps copy "un-copyable" software. All the screen dumps in this article were produced using the Option Board, which also reads disks formatted on just about any computer, including IBM, CP/M, and even the Apple! That's a major accomplishment—especially for a $100 piece of hardware.

You'll also find a list of some good copy programs in the References sidebar; you should have some of them in your library even if you don't need to copy protected disks. Whenever you get a floppy-disk data error, chances are what has happened is that at least one sector was written incorrectly. All it takes is one bad bit in a header and the sector will be unreadable by DOS. If the damage is in the directory, you'll be unable to access any of the data and will be faced with the thankless job of trying to reconstruct your files. The point is that many programs capable of dealing with protected disks can deal with damaged disks as well.

BUILD THE PT-68K

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signals. First, all data-bus lines should have pulses. Likewise, address lines A1–A18 should have lots of pulses, but A19–A23 should not dim the LED at all. If HUMBUG (the EPROM monitor) is running, it is accessing mostly EPROM locations $F80000 and above, and static RAM locations $FF0000 and above. Since the first five bits of both $F8 and $FF are 11111, the LED probe should indicate a high when it is connected to each line.

You can also test the outputs of the address decoder. You should note many pulses on pin 19 of IC63, which decodes all addresses above $F80000. You should also see pulses on IC64, pin 4 (which selects the EPROM), pin 7 (which drives IC64-b), and pin 10 (which selects the static RAM.)

What you can't see on the LED (although you can on a good scope) are very brief pulses on the high-order address lines. The 68000 is trying to access error vectors (pointers to special software routines) because it senses a bus error due to the fact that no DUART (serial port) is installed. Likewise, you can see brief pulses on IC64, pin 5, as HUMBUG is desperately trying to access the expansion slots in the hope that there is a video board there to report the error on.

Step 13: Running at last!

Now we can finally get the computer to do something useful. Install IC10 (MC68681 DUART) and its socket, 10K resistors R9, R10, R12, R13, and IC3 (3.6864 oscillator) on the board. The pointed corner of the oscillator is pin 1. Last, connect a speaker to J18. The small speaker that comes with PC clone cabinets is best; any other inexpensive speaker will do. Just don't connect one of your stereo system's speakers!

Now turn on the power; about a second later, the HALT LED should go off, and another second later you should hear a beep-boop from the speaker. That's a signal from HUMBUG that it is running, and it's the first indication that there are no serious problems—even the slightest problem occurring would prevent HUMBUG from sounding that dual tone.

Now that a real program is running with no errors, the signals in the address decoder will be slightly different. HUMBUG is currently running a loop that continuously checks for the presence of a keyboard; that loop runs entirely in EPROM and calls the first DUART, so you will see pulses on the $\overline{\text{EPROM}}$ chip-select line, IC64-a, pin 4; the $\overline{\text{I/O}}$ line on IC64-b, pin 12; and the $\overline{\text{I/O0}}$ line, IC34, pin 15. You will no longer see pulses on the $\overline{\text{SRAM}}$ chip select line.

Next time we will continue building the I/O section of the PT-68K so we can communicate with it. See you then.

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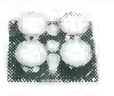

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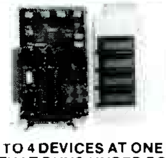

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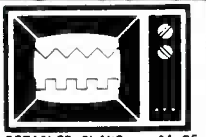

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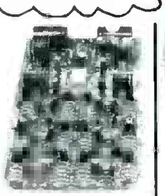

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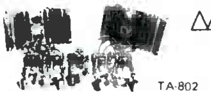

TA-802

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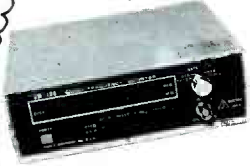

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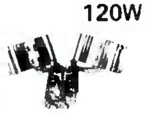

TA-477

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Metal Cabinet/X'Former (Optional) .... $26.00/$19.88

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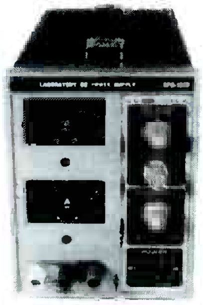
#72-420 Tenma Laboratory Power Supply

1 YEAR LIMITED WARRANTY



This is a lab quality DC power supply with adjustable current limiting.

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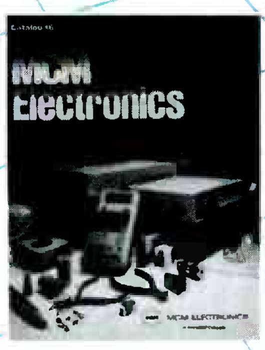

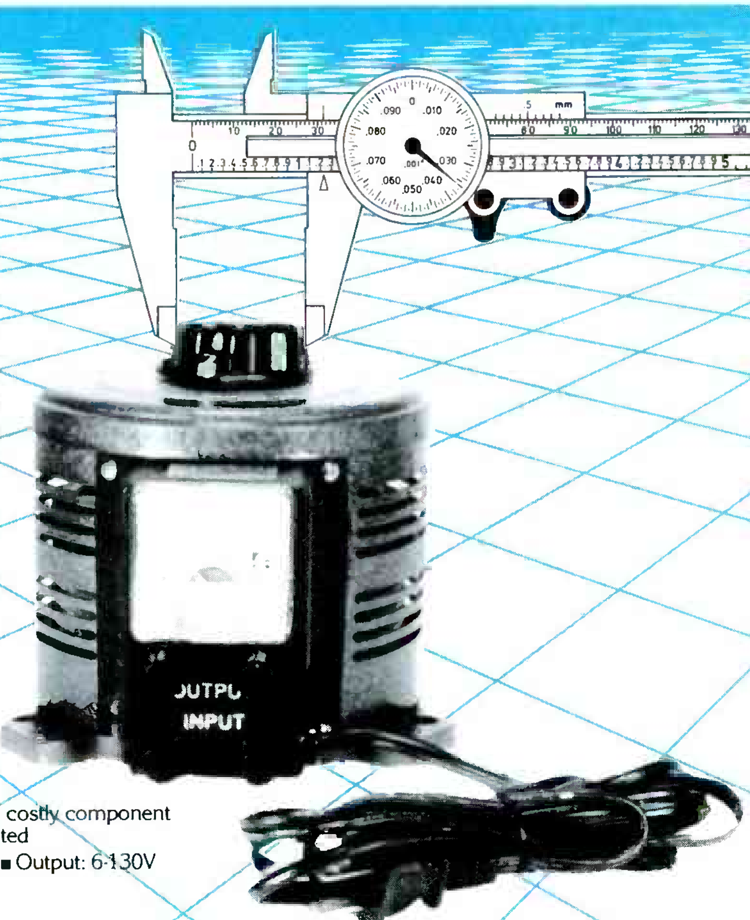

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ANTIQUE RADIO

continued from page 85

"off-center voice coil" can occur. When the voice coil is uncentered it rubs against the speaker's magnet, producing a thin, tinny, distorted sound. Although the speakers used in modern radios make no provisions to recenter the voice coil, many of the speakers used in antique radios had some form of adjustment that allowed a voice coil to be recentered.

The voice-coil test is made with the set off and unplugged. Put the speaker on the workbench with its cone facing up. Lightly touch the cone at various places with the tips of your fingers. If you hear a mechanical scratching noise you know that the voice-coil is off-center because the scratching sound is caused by the voice coil rubbing against its magnet. If you have a steady hand and nerves of steel, you can try whatever steps are necessary to recenter the voice coil. But remember, if the cone is brittle just one "whoops!" can permanently damage the cone.

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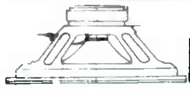

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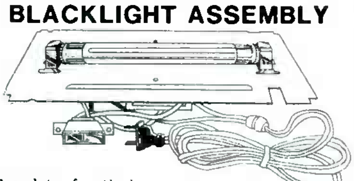

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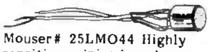

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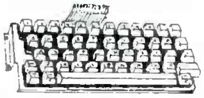

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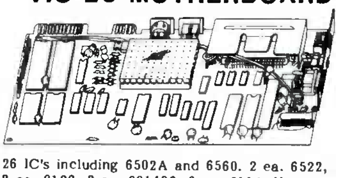

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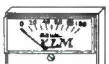

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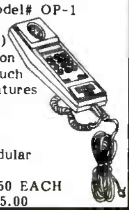

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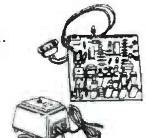

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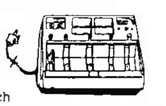

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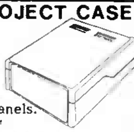
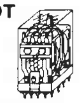


Bopla #BO 718L Vented top and bottom. Black plastic with removable end panels. 9" X 8 1/2" X #"
CAT# MB-718 $12.50 each

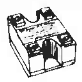
RELAYS

12 VDC-4PDT



P.C. mount
5 amp contacts
150 ohm coil
Size: 1 1/4" X 1 3/4" X 7/8"
CAT# 4PRLY-12PC $3.50
10 for $30.00

10AMP SOLID STATE

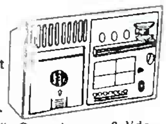


Control: 3-32 Vdc
Load: 10 AMPS, 120 Vac
Size: 2 1/2" X 3/4" X 7/8"
CAT# SSRLY-10A $9.50
10 for $85.00

25 AMP SOLID STATE

OPTO 22# 240D25
TTL compatable.
INPUT: 3-32 VDC
OUTPUT: 25 AMPS @ 240 VAC
SIZE: 2 1/2" X 3/4" X 7/8"
CAT# SSRLY-2524 $15.00 each

LIGHT ACTIVATED MOTION SENSOR



This device contains a photocell which senses sudden change in ambient light. Could be used as a door anunciator or modified to trigger other devices. 5 1/2" X 4" X 1". Operates on 6 Vdc. Requires 4 AA batteries (not included).
CAT# LSMD $5.75 per unit

6-12 VDC MOTOR

Mabuchi # RS-550S
Permanent magnet motor. 1 7/16" dia X 2 1/4" long
2,600 RPM @ 6 Vdc-200 mA
5,300 RPM @ 12 Vdc
CAT# DCM-7 $3.00 each

COMPUTER GRADE CAPACITORS

1,400 MFD 200 VDC
2" dia. X 3" high
CAT# CG-1420 $2.00

7,500 MFD 200 VDC
3" dia. X 4 3/4" h.
CAT# CG-75 $4.00

22,000 MFD 25 VDC
2" dia. X 4 3/4" h.
CAT# CG-22 $2.50

72,000 MFD 15 VDC
2" dia. X 4 3/8" h.
CAT# CG-130 $3.50

TRANSISTORS

2N2222A
3 for $1.00
PN2222A
4 for $1.00
2N2904
3 for $1.00
2N2905
3 for $1.00
2N3055
$1.00 each
PN3569
10 for $1.00

LED'S

Standard Jumbo Diffused
T 1-3/4 Size

RED CAT# LED-1	10 for $1.50 100 for $13.00 1000 for $110.00
GREEN CAT# LED-2	10 for $2.00 100 for $17.00 1000 for $150.00
YELLOW CAT# LED-3	10 for $2.00 100 for $17.00 1000 for $150.00

FLASHING LED

w/ built in flashing circuit operates on 5 Volts...

RED $1.00 each
CAT# LED-4 10 for $9.50
GREEN $1.00 each
CAT# LED-4G 10 for $9.50

BI-POLAR LED

Lights RED one direction, GREEN the other. two leads.
CAT# LED-6 2 for $1.70

LED HOLDERS

Two piece holder.
CAT# HLED 10 for 65c

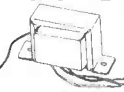
CLIPLITE LED HOLDER

Makes L.E.D. look like a fancy indicator

CLEAR	CAT# HLDCL-C
RED	CAT# HLDCL-R
GREEN	CAT# HLDCL-G
YELLOW	CAT# HLDCL-Y

4 of one color $1.00

TRANSFORMERS



5.6 VOLT- 750ma
CAT# TX-56 $3.00
12 V.c.t.-1amp
CAT# TX-121 $4.00
12 V.c.t.-2amp
CAT# TX-122 $4.85
12 V.c.t.-4amp
CAT# TX-124 $7.00
18 VOLT-650ma
CAT# TX-186 $2.00
10 for $18.00
24 V.c.t.-1amp
CAT# TX-241 $4.85
24 V.c.t.-2amp
CAT# TX-242 $6.75
24 V.c.t.-3amp
CAT# TX-243 $9.50
24 V.c.t.-4amp
CAT# TX-244 $11.00

SWITCHES

MINIATURE TOGGLE SWITCHES rated 5 Amps

S.P.D.T. (ON-ON)

Non threaded brushing P.C. mount.
CAT# MTS-40PC
75c each
10 for $7.00

S.P.D.T. (ON-ON)

Solder lug terminals.
CAT# MTS-4
$1.00 each
10 for $9.00

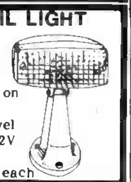
D.P.D.T. (ON-ON)

Solder lug terminals.
CAT# MTS-8
$2.00 each
10 for $19.00

MINI PUSH BUTTON

S.P.S.T. momentary. Push to make 1/4" brushing. Red button.
CAT# MPB-1 35c each
10 for $3.00

THIRD TAIL LIGHT

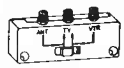


Sleek high-tech lamp assembly. Red lens is 2 3/4" X 5 1/2" mounted on a 4" high pedestal with up-down swivel adjustment. Has 12V replaceable bulb.
CAT# TLB $3.95 each

WALL TRANSFORMER

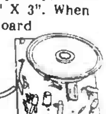
11.5 Vdc
1.95 AMP.
Input: 120 Vac
SIZE: 3 3/4" X 2 7/8" X 2 5/8"
CAT# DCTX-11519
$6.50 each

A/B SWITCH



JVC# PU53593-2
High quality A/B switch.
Measures: 3 3/4" X 1 7/16" X 1".
75 OHMS IN/OUT
CAT# ABS-2 $3.50 each

SOUND EFFECTS BOARD



P.C board with 2 1/4" speaker, 2 LEDs, IC, battery snap, other components 2 3/8" X 3". When switch is pushed board beeps and leds light. Operates on a 9V battery (not included)
CAT# ST-3
$1.25 each

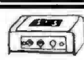
13.8 VDC REGULATED POWER SUPPLY

Solid state, fully regulated 13.8 Vdc power supplies. Both feature 100% solid state construction, fuse protection and LED power indicator. UL listed.

2 AMP CONSTANT, 4 AMP SURGE
CAT# DVP-412 $22.50 each

3 AMP CONSTANT, 5 AMP SURGE
CAT# DVP-512 $30.00 each

POLARITY SWITCH



Designed to control an external coaxial relay on a satellite t.v. system. Ideal for parts. Contains a 5 Vdc relay and many other parts on a P.C. board.
CAT# RPDS $1.75 each 10 for $15.00

XENON FLASH TUBE

3/4" long X 1/8" dia.
CAT# FLT-1 2 for $1.00

STORES:
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905 S. VERMONT AVE.
LOS ANGELES, CA 90006
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VAN NUYS
6228 SEPULVEDA BLVD.
VAN NUYS, CA 91411
(818)997-1806

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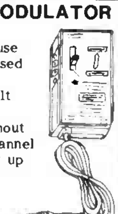
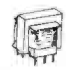
SOUND AND VIDEO MODULATOR



TI# UM1381-1. Designed for use with T.I. computers. Can be used with video cameras, games or other audio/video sources. Built in A/B switch enables user to switch from T.V. antenna without disconnection. Operates on channel 3 or 4. Requires 12 Vdc. Hook up diagram included.
CAT# AVMOD $5.00 each

TELEPHONE COUPLING TRANSFORMER



STANCOR
TTCP-8
600 ohms c.t. to 600 ohms c.t.
P.C. board mount.
3/4" X 5/8" X 3/4"
CAT# TCTXS
$2.50 each

CIRCLE 107 ON FREE INFORMATION CARD

What's New at AMERICAN DESIGN COMPONENTS?

"The Source" of the electro-mechanical components for the hobbyist.

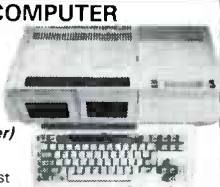
We warehouse 60,000 items at American Design Components – expensive, often hard-to-find components for sale at a fraction of their original cost!

You'll find every part you need – either brand new, or removed from equipment (RFE) in excellent condition. But quantities are limited. Order from this ad, or visit our retail showroom and find exactly what you need from the thousands of items on display.

OPEN MON. – Sat., 9–5

THERE'S NO RISK. With our full 90-day warranty, any purchase can be returned for any reason for full credit or refund.

ADAM COMPUTER



(Less printer)

No wiring necessary (just plugs together). Hook-up diagram included. Includes: Keyboard, 1 cassette digital data drive, 2 game controllers, power supply, & one cassette. Capable of running CP/M, has built-in word processor.

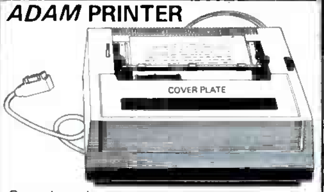
Item #7410 Complete – **$99.00**

ADAM 5¼" DISK DRIVE

Gives your Adam fast, reliable data storage & retrieval. Can hold up to 160K bytes of information. Uses industry-standard SS/DD disks. Connects directly to your Adam memory console. Comes w/disk drive power supply, Disk Manager disk and owner's manual. Mfr – Coleco, model 7817

Item #12830 *Like New* – **$199.00**

ADAM PRINTER



Complete, less top cover plate. Friction feed. Takes standard paper 8½" x 11". (Customer returns; tested – operational.)

Item #8839 **$69.50**

ADAM Accessories . . .

Data Drive – Item #6641 **$19.95**

Printer Power Supply – Item #6642 **$14.95**

ASCII Keyboard – Item #6643 **$19.95**

Controllers – (Set of 4) Item #7013 **$9.95**

Adam Cassettes – (Consisting of Smart Basic, Buck Rogers & blank cassette.) Item #7786 *BAKER'S DOZEN* – **$19.95**

Adam Link Modem – (Software included.) Item #12358 **$29.95**

Auto-Dialer Address Book – Item #12365 **$19.95**

Adam Daisy Print Wheel – Item #13305 **$3.95**

Adam Ribbon Cartridge – Item #13306 **$3.95**

Disk Drive Power Supply – Item #14603 **$14.95**

5¼" FULL HT. 15 Mb HARD DISK DRIVE

(IBM PC/XT Compatible)

Removed from working equipment. Tested & formatted. Mfr – CMI model CM5619

Item #14511 **$199.00**

5¼", HALF HT. 10Mb HARD DISK DRIVE

(IBM® Compat.)

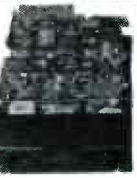
Fits standard 5¼" spacing. Shock mtd. High speed, low power. Mfr – Seagate/Tandon

Item #13250 **$159.00** New

Controller Card for above

Item #10150 **$89.00**

5¼" FULL HT. DISK DRIVES 48 TPI (IBM® Compat.)



Double sided/double density, full height drive. 48 T.P.I., 80 tracks. Mfr – Tandon TM100-2

Item #7928 **$79.00**
2 for **$150.00**

96 TPI, DS/Quad Density
Mfr – CDC #9409T
Item #1893 **$99.00**

5¼" 1/2 HT. DISK DRIVES

48/96 TPI 1.2 Mb. (AT Compat.)

DS/single-double density; 80 track. Mfr – Panasonic #JU-475

Item #10005 **$119.00** New

96 TPI, DS/Quad Density (DOS 3.2 Compatible)
Tandon TM55-4; DS/Quad
Item #1904 **$79.00**
2 for **$150.00**

14" RGB COLOR MONITOR

PC, XT, & AT Compat.

Scanning frequency to 25KHz. Resolution: 720 x 350 max. Input: 110/220V, 50/60Hz. 1.1/.6A., 80W. (Hook-up diagram included.) Mfr. No. 14-GZF2

Item #14864 **$179.00** New

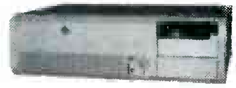
115 CFM MUFFIN® FAN

115 VAC/60 Hz., 21W., .28A., 3100 RPM; 5-blade model, aluminum housing. Can be mounted for blowing or exhaust. Dim.: 4$^{11}/_{16}$"sq. x 1½"deep.

Item #5345 **$5.95** RFE

With Speed Control – Item #5345S **$8.95**

AT-STYLE COMPUTER CABINET



Contains 10 full-length expansion slots (w/guides). With room for an internal 5¼" hard disk drive. Has 3 half-height disk drive slots. Rear on/off switch, notched to hold in power supply (not incl.), and security switch w/key.

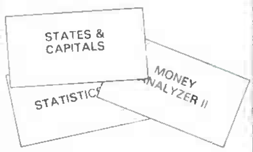
Item #12266 **$49.95** New

EXTERNAL DISK DRIVE CHASSIS

With 60W power supply (fan cooled). Can accommodate: 2 full ht. drives our item #7928; 2 floppy drives #1904; 1 hard drive & 1 floppy #13250. Input: 115/230V, 50/60 Hz. Originally for Burroughs computer. Dim.: 11"W x 8"H x 12" deep

Item #14541 **$59.50**

TIMEX-SINCLAIR 1000 & ZX-81 CASSETTES



Consists of 13 assorted cassettes. May include: *Money Analyzer II, States & Capitals, Casino Craps, Statistics, The Carpooler & others.*

Item #14651 Set of 13 **$19.95** New

12V BATTERY PACK & CHARGER

12V @ 9.5Ah

Consists of: 2 solid gell cell batteries, 6V @ 9.5Ah ea. Connected in series by a fusable harness. Mating battery charger: 12VDC @ 800Ma. Perfect for battery-operated toys, robotics, solar storage, burglar & fire alarms, etc. OA Dim.: 4¼"W x 5½"H x 5½"D

Item #14619 **$29.95** New

5" COMPOSITE VIDEO MONITOR

Power regulated, 12VDC. Mtd. in plastic cabinet, w/brightness control knob. Mfr – Sperry. OA Dim.: 8"W x 8"H x 8¾"deep

Item #14536 **$24.95**

PC 8300 HOME COMPUTER (Advanced version of the Timex 1000)

42-key mech. keybd. 2K RAM. Rev. video, Z80A, 6.5MHz processor, ROM 8K BASIC. Graphics cap./sound–music, TV or monitor. Joystick input. 115 VAC. AC adapt., TV cable, & cass. cables. Runs tapes for Sinclair/Timex 1000-ZX85. Mfr - Power 3000. (In orig. boxes.)

Item #10336 **$29.95** New

★ **16K RAMPACK upgrade** Item #10337 **$9.95** New

Call or Write with Your Requirements

COLECOVISION . . . Accessories . . .

***ColecoVision* to *Adam* Expansion Kit**
Just plugs into your *ColecoVision*.
Item #9918 **$59.50**

Expansion Module #2
Incl. *Turbo* cart.
Item #13146 **$39.95** New

Roller Controller
Incl. *Slither* cart.
Item #13147 **$39.95** New

Super Action Controller Set
Incl. *Baseball* cart.
Item #13148 **$39.95** New

COMMODORE CARTRIDGES

C-64
Consists of 8 asstd. cartridges. Includes: *Number Nabber, Star Post, Radar Rat, Jupiter Land, Viduzzles, Golf, Dragon's Den, & ABC Voice.*
Item #13573
Set of 8 – **$39.95** New

C16 & +4
Consists of 8 asstd. cartridges. Includes: *Calc Plus, Script +, Jack Attack, Pirate Adventures, Atomic Miss, Strange Odyssey, Financial Advisor, & Logo.*
Item #13572
Set of 8 – **$29.95** New

– BATTERIES – FANS – BLOWERS

COMMODORE/AMIGA POWER SUPPLY

DC Output: +5V @ 8 amps. +12V @ 1 amp. –5V @ 250 ma. Input: 110VAC/60 Hz., ±20% Dim.: 12"L x 3¾"H x 5¾"D Encl. in alum. housing. Fan cooled. Mfr – Shindenger Electric #130569SXD

Item #14047 **$24.95** New

COMPUTER GRADE POWER SUPPLY

Other uses–runs CB & car radios. Comes ready to plug in!

DC Output: –5V @ .5 amp. +5V @ 3 amp. +12V @ 6 amp. Input 115V/60Hz. Dim.: 9¼"W x 3¾"H. (Rubber ft. incl.)

Item #9501 **$24.95** New

AMERICAN DESIGN COMPONENTS, 62 JOSEPH STREET, MOONACHIE, N.J. 07074

MINIMUM ORDER $15.

RE-18

YES! Please send me the following items:

Item No.	How Many?	Description	Price	Total

Total

Shipping & handling, we ship UPS unless otherwise specified. Add $3 plus 10% total. Canadian: $3 plus P.O. cost. Charge only.

Sales Tax (N.J. residents only, please add 6% of total)

ORDER TOTAL

FREE Fall Supplement with every order.

☐ My check or money order is enclosed.
☐ Charge my credit card.
☐ Visa ☐ Master Card ☐ Amex

Card No.

Exp. Date

Signature

Telephone: Area Code Number

Name

Address

City

State Zip

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CIRCLE 106 ON FREE INFORMATION CARD

256K STATIC 150ns 32K x 8 $12.95 256K DRAMS 150ns 256K x 1 $2.95

STATIC RAMS

2112	256x4	(450ns)	2.99
2114	1024x4	(450ns)	.99
2114L-2	1024x4	(200ns)(Low Power)	1.49
TMM2016-100	2048x8	(100ns)	1.95
HM6116-4	2048x8	(200ns)(CMOS)	1.79
HM6116-3	2048x8	(150ns)(CMOS)	1.85
HM6116LP-4	2048x8	(200ns)(CMOS)(LP)	1.85
HM6116LP-3	2048x8	(150ns)(CMOS)(LP)	1.90
HM6116LP-2	2048x8	(120ns)(CMOS)(LP)	2.45
HM6264LP-15	8192x8	(150ns)(CMOS)(LP)	3.95
HM6264LP-12	8192x8	(120ns)(CMOS)(LP)	4.49
HM43256LP-15	32768x8	(150ns)(CMOS)(LP)	12.95
HM43256LP-12	32768x8	(120ns)(CMOS)(LP)	14.95
HM43256LP-10	32768x8	(100ns)(CMOS)(LP)	19.95

DYNAMIC RAMS

4116-250	16384x1	(250ns)	.49
4116-200	16384x1	(200ns)	.89
4116-150	16384x1	(150ns)	.99
4116-120	16384x1	(120ns)	1.49
MK4332	32768x1	(200ns)	6.95
4164-150	65536x1	(150ns)	1.29
4164-120	65536x1	(120ns)	1.55
MCM6665	65536x1	(200ns)	1.95
TMS4164	65536x1	(150ns)	1.95
4164-REFRESH	65536x1	(150ns)(PIN 1 REFRESH)	2.95
TMS4416	16384x4	(150ns)	3.75
41128-150	131072x1	(150ns)	5.95
TMS4464-15	65536x4	(150ns)	4.95
41256-150	262144x1	(150ns)	2.95
41256-120	262144x1	(120ns)	3.95
41256-100	262144x1	(100ns)	4.95
HM51258-100	262144x1	(100ns)(CMOS)	6.95
1 MB-120	1048576x1	(120ns)	19.95
1 MB-100	1048576x1	(100ns)	24.95

EPROMS

2708	1024x8	(450ns)	4.95
2716	2048x8	(450ns)(5V)	3.49
2716-1	2048x8	(350ns)(5V)	3.95
TMS2532	4096x8	(450ns)(5V)	5.95
2732	4096x8	(450ns)(5V)	3.95
2732A	4096x8	(250ns)(5V)(21V PGM)	3.95
2732A-2	4096x8	(200ns)(5V)(21V PGM)	4.25
27C64	8192x8	(250ns)(5V)(CMOS)	4.95
2764	8192x8	(450ns)(5V)	3.49
2764-250	8192x8	(250ns)(5V)	3.69
2764-200	8192x8	(200ns)(5V)	4.25
MCM68766	8192x8	(350ns)(5V)(24 PIN)	15.95
27128	16384x8	(250ns)(5V)	4.25
27C256	32768x8	(250ns)(5V)(CMOS)	7.95
27256	32768x8	(250ns)(5V)	5.95
27512	65536x8	(250ns)(5V)	11.95
27C512	65536x8	(250ns)(5V)(CMOS)	12.95

5V=Single 5 Volt Supply 21V PGM=Program at 21 Volts

★★★★ HIGH-TECH ★★★★

HM43256LP-15 $12.95

- ★ 32K x 8 STATIC RAM
- ★ LOW POWER CONSUMPTION
- ★ HIGH SPEED — 100ns AVAILABLE
- ★ LOW STAND-BY CURRENT (2mA MAX.)
- ★ TTL COMPATIBLE INPUT AND OUTPUTS

★★★★ SPOTLIGHT ★★★★

CMOS

4001	.19	4049	.29
4011	.19	4050	.29
4012	.25	4051	.69
4013	.35	4052	.69
4015	.29	4053	.69
4016	.29	4060	.69
4017	.49	4066	.29
4018	.69	4069	.19
4020	.59	4070	.29
4021	.69	4081	.22
4023	.25	4093	.49
4024	.49	14411	9.95
4025	.25	14433	14.95
4027	.39	14497	6.95
4028	.65	4503	.49
4040	.69	4511	.69
4042	.59	4518	.85
4044	.69	4528	.79
4046	.69	4538	.95
4047	.69	4702	12.95

HIGH SPEED CMOS

74HC00		74HCT00	
74HC00	.21	74HCT00	.25
74HC02	.21	74HCT02	.25
74HC04	.25	74HCT04	.27
74HC08	.25	74HCT08	.25
74HC14	.35	74HCT32	.27
74HC32	.35	74HCT74	.45
74HC74	.35	74HCT138	.55
74HC86	.45	74HCT161	.79
74HC138	.45	74HCT240	.89
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74HC245	.85	74HCT393	.99
74HC273	.69	74HCT4017	1.19
74HC373	.69	74HCT4040	.99
74HC374	.69	74HCT4060	1.49

74LS00

74LS00	.16	74LS112	.29	74LS241	.69
74LS01	.18	74LS122	.45	74LS242	.69
74LS02	.17	74LS123	.49	74LS243	.69
74LS03	.18	74LS124	2.75	74LS244	.69
74LS04	.16	74LS125	.39	74LS245	.79
74LS05	.18	74LS126	.39	74LS251	.49
74LS08	.18	74LS132	.39	74LS253	.49
74LS09	.18	74LS133	.49	74LS257	.39
74LS10	.16	74LS136	.39	74LS258	.49
74LS11	.22	74LS138	.39	74LS259	1.29
74LS12	.22	74LS139	.39	74LS260	.49
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74LS22	.22	74LS154	1.49	74LS290	.89
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74LS28	.26	74LS156	.49	74LS299	1.49
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74LS33	.28	74LS160	.29	74LS365	.39
74LS37	.26	74LS161	.39	74LS367	.39
74LS38	.26	74LS162	.49	74LS368	.39
74LS42	.39	74LS163	.39	74LS373	.79
74LS47	.75	74LS164	.49	74LS374	.79
74LS48	.85	74LS165	.65	74LS375	.95
74LS51	.17	74LS166	.95	74LS377	.79
74LS73	.29	74LS169	.95	74LS390	1.19
74LS74	.24	74LS173	.49	74LS393	.79
74LS75	.29	74LS174	.39	74LS541	1.49
74LS76	.29	74LS175	.39	74LS624	1.95
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7438	.29
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7445	.69
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7489	2.15
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7493	.35
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74123	.49
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74F00

74F00	.35
74F02	.35
74F04	.35
74F08	.35
74F10	.35
74F32	.35
74F64	.55
74F74	.39
74F86	.55
74F138	.79
74F139	.79
74F253	.89
74F157	1.69
74F240	3.29

74S00

74S00	.29	74S163	1.29
74S02	.29	74S175	.79
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6.8	15V	.42	1.0	35V	.45
10	15V	.45	2.2	35V	.19
22	15V	.99	4.7	35V	.39
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10pf	50V	.05	680	50V	.05
22	50V	.05	.001µf	50V	.05
27	50V	.05	.0022	50V	.05
33	50V	.05	.005	50V	.05
47	50V	.05	.01	50V	.07
68	50V	.05	.02	50V	.07
100	50V	.05	.05	50V	.07
220	50V	.05	.1	12V	.10
560	50V	.05	.1	50V	.12

MONOLITHIC

.01µf	50V	.14	.1µf	50V	.18
.047µf	50V	.15	.47µf	50V	.25

ELECTROLYTIC

RADIAL			AXIAL		
1µf	25V	.14	1µf	50V	.14
2.2	35V	.11	10	50V	.16
4.7	50V	.11	22	16V	.14
10	50V	.11	47	50V	.19
47	35V	.13	100	35V	.19
100	16V	.15	220	25V	.25
220	35V	.20	470	50V	.29
470	25V	.30	1000	16V	.29
2200	16V	.70	2200	16V	.70
4700	25V	1.45	4700	16V	1.25

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7815T	.49				
7905T	.59	TO-93 CASE			
7908T	.59				
7912T	.59	78L05	.49	79L05	.69
7915T	.59	78L12	.49	79L12	1.49

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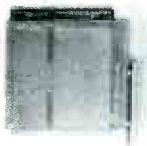

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DPDT	MINI-TOGGLE ON-OFF-ON	1.75
SPST	MINI-PUSHBUTTON N.O.	.39
SPST	MINI-PUSHBUTTON N.C.	.39
BCD OUTPUT 10 POS. 6 PIN DIP		1.95

DIP SWITCHES

4 position	.85	7 position	.95
5 position	.90	8 position	.95
6 position	.90	10 position	1.29

D-SUBMINIATURE CONNECTORS

DESCRIPTION		ORDER BY	CONTACTS 9	15	19	25	37	50
SOLDER CUP	MALE	DBxxP	.45	.59	.69	.69	1.35	1.85
	FEMALE	DBxxS	.49	.69	.75	.75	1.39	2.29
RIGHT ANGLE PC SOLDER	MALE	DBxxPR	.49	.69	---	.79	2.27	---
	FEMALE	DBxxSR	.55	.75	---	.85	2.49	---
WIREWRAP	MALE	DBxxPWW	1.69	2.56	---	3.89	5.60	---
	FEMALE	DBxxSWW	2.76	4.27	---	6.84	9.95	---
IDC RIBBON CABLE	MALE	IDBxxP	1.39	1.99	---	2.25	4.25	---
	FEMALE	IDBxxS	1.45	2.05	---	2.35	4.49	---
HOODS	METAL	MHOODxx	1.05	1.15	1.25	1.25	---	---
	GREY	HOODxx	.39	.39	---	.39	.69	.75

ORDERING INSTRUCTIONS:
INSERT THE NUMBER OF CONTACTS IN THE POSITION MARKED "xx" OF THE "ORDER BY" PART NUMBER LISTED. EXAMPLE: A 15 PIN RIGHT ANGLE MALE PC SOLDER WOULD BE DB15PR.

MOUNTING HARDWARE 59¢

LIGHT EMITTING DIODES

LED DISPLAYS

FND-357(359)	COM CATHODE	.362"	1.25
FND-500(503)	COM CATHODE	.5"	1.49
FND-507(510)	COM ANODE	.5"	1.49
MAN-72	COM ANODE	.3"	.99
MAN-74	COM CATHODE	.3"	.99
TIL-313	COM CATHODE	.3"	.45
TIL-311	4x7 HEX W/LOGIC	.270"	10.95

DIFFUSED LEDs

		1-99	100-UP
JUMBO RED	T1¾	.10	.09
JUMBO GREEN	T1¾	.14	.12
JUMBO YELLOW	T1¾	.14	.12
MOUNTING HDW	T1¾	.10	.09
MINI RED	T1	.10	.09

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

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

25 PIN D-SUB GENDER CHANGERS $7.95

DIP CONNECTORS

DESCRIPTION	ORDER BY	CONTACTS 8	14	16	18	20	22	24	28	40
TOOLED SOLDERTAIL IC SOCKETS	AUGATxxST	.62	.79	.89	1.09	1.29	1.39	1.49	1.69	2.49
TOOLED WIREWRAP IC SOCKETS	AUGATxxWW	1.30	1.80	2.10	2.40	2.50	2.90	3.15	3.70	5.40
COMPONENT CARRIES (DIP HEADERS)	ICCxx	.49	.59	.69	.99	.99	.99	.99	1.09	1.49
RIBBON CABLE DIP PLUGS (IDC)	IDPxx	.95	.49	.59	1.29	1.49	---	.85	1.49	1.59

FOR ORDERING INSTRUCTIONS, SEE D-SUBMINIATURE CONNECTORS, ABOVE

RIBBON CABLE

CONTACTS	SINGLE COLOR 1'	10'	COLOR CODED 1'	10'
10	.18	1.60	.30	2.75
16	.28	2.50	.48	4.40
20	.36	3.20	.60	5.50
25	.45	4.00	.75	6.85
26	.46	4.10	.78	7.15
34	.55	5.40	1.07	9.35
40	.72	6.40	1.20	11.00
50	.89	7.50	1.50	13.25

MUFFIN FANS

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2 conductor 39¢ 3 conductor 99¢
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2 MB OF LOTUS/INTEL/MICROSOFT COMPATIBLE MEMORY FOR XT
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- ALLOWS DATA TO FLOW FREELY FROM XTs TO ATs

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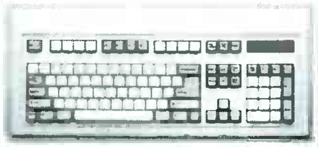

MCT-5339 **79^{95}**
- IBM ENHANCED STYLE LAYOUT
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- LED INDICATORS
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MCT-5060 **59^{95}**
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- SOFTWARE AUTOSENSE FOR XT OR AT COMPATIBLES
- LED INDICATORS
- AUTO REPEAT FEATURE

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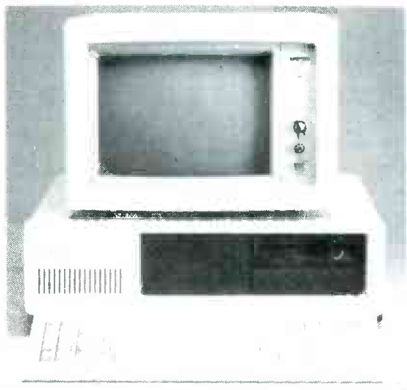
- ★ DRIVE CONTROLLER
- ★ MONOCHROME MONITOR
- ★ GRAPHICS ADAPTOR



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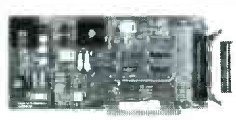
- SOFTWARE FOR HEX AND INTEL HEX FORMATS



MCT-EPROM-4 4 GANG PROGRAMMER 189^{95}
MCT-EPROM-10 10 GANG PROGRAMMER 299^{95}

MCT-PAL PAL PROGRAMMER **269^{95}**

MCT-MP PROCESSOR PROG. **199^{95}**

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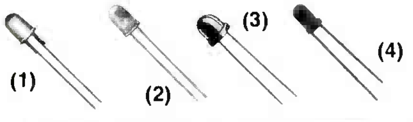
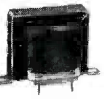


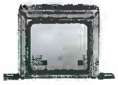
Fig.	Type	Cat. No.	Price
1	T-1 Super Bright Yellow	276-054	Pkg. 2/69
2	Micro-Size Yellow	276-055	Pkg. 2/59
3	T-1 Super Bright Green	276-056	Pkg. 4/89
4	Micro-Size Red	276-057	Pkg. 3/89

Popular Transformers

Mini



Std.

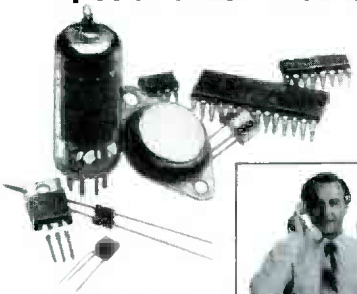


Primaries 120 VAC, 60 Hz. CT = Center Tap.

Transformers are UL listed AC.

Type	Volts	Current	Cat. No.	Each
Miniature	12.6	300 mA	273-1385	3.29
Miniature	12.6 CT	450 mA	273-1365	3.99
Miniature	25.2 CT	450 mA	273-1366	4.59
Standard	12.6 CT	1.2 A	273-1352	5.79

Special-Order Hotline



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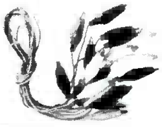
Color-Coded Test Cables



Insulated Clips at Both Ends

Set Of	Length	Clips	Cat. No.	Only
10	14″ Cables	Mini 'Gator	278-1156	3.99
4	30″ Cables	'Gator	278-001	3.49
6	40″, Heavy Duty	Claw-Type	278-002	3.99
8	24″, 4 Colors	Mini 'Gator	278-1157	3.99

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AC Fan. Just right for cooling microcomputers, audio amps, Ham gear. Moves 32 CFM, 11 watts. 120 volts, UL recognized. #273-242 .... **14.95**

Precision DC Voltmeter

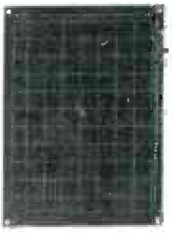
- **Measures 0 to 15 VDC**
- **Zero Adjust**

Panel meter for monitoring the voltage of a car's electrical system or a custom-built power supply. Jeweled movement for accuracy to ±5% of full scale. 2¾ x 2¼ x 1¼″. Requires 1⅞″ round mounting hole. #270-1754 .... **7.95**

Predrilled PC Boards

Accept DIP ICs, Sockets, Headers

Grid Boards. Columns and rows are indexed to identify pin-outs. Solder-ringed holes.



Size	Cat. No.	Ea.
4½ x 6⅝″	276-147	3.49
2¾ x 3¾″	276-158	2.29
1²⁷⁄₃₂ x 2²⁷⁄₃₂″	276-149	.99

Computer Connections

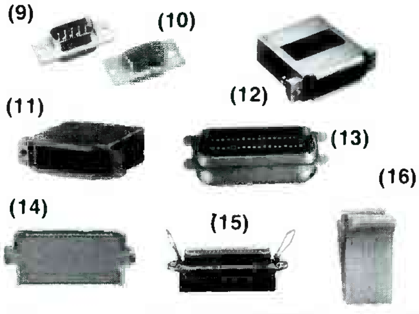
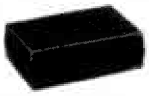


Fig.	Description	Position	Cat. No.	Each
(9)	Solder-Type "D" Submini, Male	9	276-1537	1.49
(10)	Solder-Type "D" Submini, Female	9	276-1538	2.49
(11)	Hood for 9-Position Connectors	—	276-1539	1.99
—	Solder-Type "D" Submini, Male	25	276-1547	1.99
—	Solder-Type "D" Submini, Female	25	276-1548	2.99
—	Hood for 25-Position Connectors	25	276-1549	1.99
(12)	Multipurpose Hood—25 Position	—	276-1520	1.79
(13)	Solder-Type Printer Connector, Male	36	276-1534	4.99
(14)	IDC Printer Connector, Male	36	276-1533	4.99
(15)	IDC Printer Connector, Female	36	276-1523	4.99
(16)	Printer Cable—Color Coded, 6 feet	36	278-774	4.69

Enclosure / PC-Board

(5)



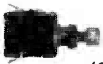
(6)

(5) Black Plastic With 2 x 3⅛″ Board. Accepts DIP ICs. With labels, feet, hardware. 3⁷⁄₁₆ x 2⁵⁄₁₆ x 1³⁄₁₆″. #270-291 .... **3.99**
(6) Gray Plastic With Predrilled PC Boards. Boards are IC-spaced (0.1″ pitch) and etched.
2⅛ x 3⁵⁄₁₆ x 1⅜″. #270-283 .... **3.69**
2¾ x 4³⁄₁₆ x 1¼″. #270-284 .... **4.69**

Relays & Lighted Switch

(7)

Project Bargains

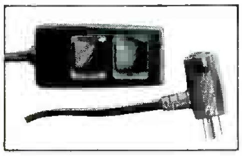


(8)

(7) SPDT 5 VDC, 90 mA, 55-Ohm Coil. Contacts: 1 amp, 125 VAC. #275-240 .... **1.89**
12 VDC, 38 mA, 320-Ohm Coil.
#275-241 .... **1.89**
(8) 120 VAC SPST Push On/Off Lighted Switch. 10 amps. Mounts in ⁷⁄₁₆″ hole.
#275-671 .... **3.49**

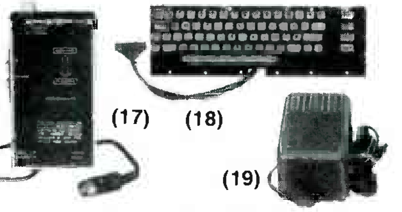
Clamp-On Ammeter And AC Voltmeter

Includes Inductive Pickup/Multiplier



Measures up to 300 amperes AC without direct connection to circuit, and measures up to 600 volts AC with included test leads. Clamp jaws reach into tight places. Lock-switch freezes pointer for easy meter reading.
#22-161 .... **49.95**

Special-Purchase Hot Values



(17) Sound/Color-Video TV RF Modulator. Prewired module with antenna/modulator switch. For 12 VDC. With data.
#277-1015 .... **4.95**
(18) Keyboard. Upgrade your membrane-type keyboard! Sixty three full-stroke keys, three function keys, 18-position connector.
#277-1027 .... **4.95**
(19) Plug-In 9 VDC Adapter. Provides 9 VDC at one amp, up to 13 VDC with a light load. UL listed AC. #277-1026 .... **4.95**

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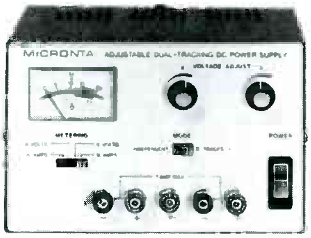

Delivers rock-steady DC that's easy to adjust to the exact voltages you need. Variable split 0-15 VDC or series up to 30 VDC. Offers choice of independent or slave operation; a single knob lets you adjust both voltages simultaneously, or use independent mode to adjust voltages separately. Switchable volt/amp meter for monitoring the voltage or current of either output. Fuse protected. UL listed AC.
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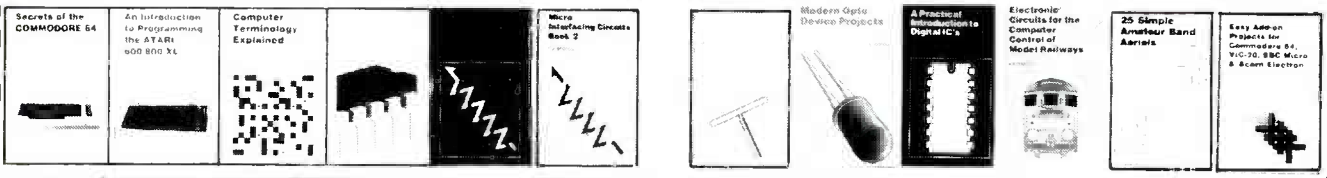

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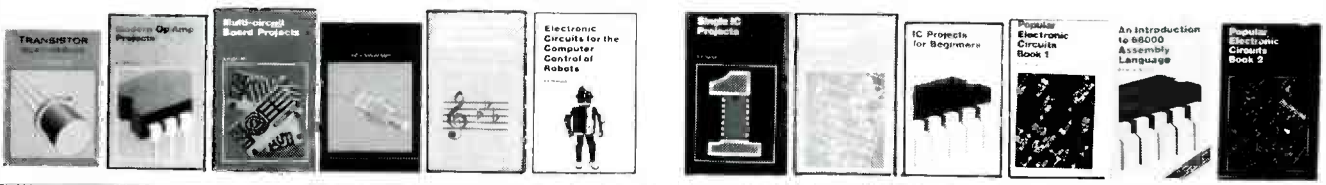

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