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WORLD'S LARGEST-SELLING ELECTRONICS MAGAZINE

NOVEMBER 1978/\$1

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**Auxman R-1120 AM/FM Stereo Receiver
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COBRA RE-INVENTS THE REMOTE CB.

The first remote CBs were nothing more than a CB transceiver that you locked in your trunk and an oversized mike that could barely fit in your hand.

Such was the state of the art when the first remotes were introduced. Which was why Cobra spent till now improving the state of the art.

Introducing the result. The Cobra 62XLR. Small enough to go under the seat or on the firewall as well as in the trunk. Strong enough to take the bounces and jolts those early remotes couldn't. Powerful enough to punch through loud and clear.

The receiver has automatic gain control, switchable noise limiting, plus Dual-Gate Mosfet and Monolithic Crystal Filter to keep interference to a minimum. So the voice you hear always comes through loud and clear.

The streamlined mike puts all the controls at your fingertips. Speaker, channel selector and squelch are built right in. So there's no fiddling around while you're driving around.

And with Cobra's reputation for building them right and our nationwide network of Service Centers making sure they stay that way, you can be pretty sure that nobody's ever going to improve on the 62XLR.

Cobra may not have been the first to make a remote. But we were the first to do it right.



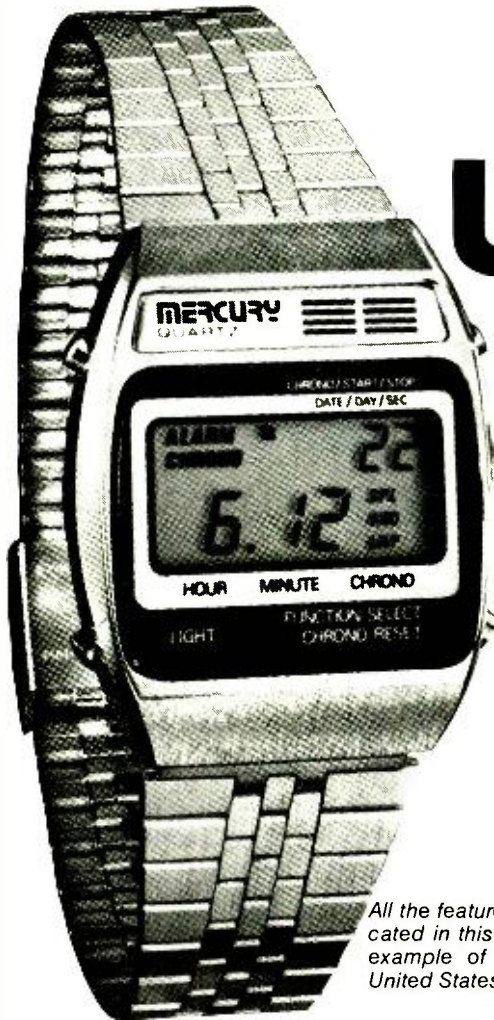
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CIRCLE NO. 10 ON FREE INFORMATION CARD

Unfair Copy

The watch shown here is a copy of the world famous Seiko chronograph alarm. Unfair? You be the judge.



All the features of the Seiko watch are duplicated in this digital watch. It is an excellent example of the fierce competition in the United States.

It's really a shame. The watch shown above is a copy of the Seiko chronograph alarm.

Seiko is one of the world's most respected watchmakers, having literally taken over the quartz watch industry. Their quality is outstanding, and they have produced many great innovations in the digital watch industry.

The Seiko chronograph alarm sells for \$300. The watch costs jewelers \$150. And jewelers love the item, not only because of the excellent reputation of the Seiko brand, but because it's probably America's best-selling new expensive digital watch. And Seiko can't supply enough of them to their dealers.

The Mercury copy shown above looks almost exactly like the Seiko and costs dealers approximately \$50. Most dealers are selling it for \$100, and they're selling them as fast as they get them.

LABOR EXPENSIVE IN JAPAN

Unlike the Seiko watch which is made in Japan, the Mercury is manufactured under special contract in Hong Kong by a prominent American watch manufacturer. The watch uses basically the same components as the Seiko, but the differences lie mainly in the labor. Hong Kong's labor costs are far less than in Japan. An average Japanese watch assembler makes the equivalent of \$75 per day whereas the equivalent employee in Hong Kong makes only a few dollars per day.

The value of the yen has skyrocketed while the Hong Kong dollar has changed little in comparison to the U.S. dollar. So all Seiko products have become even more expensive to export.

BOTH BACKED BY SERVICE

The Seiko is backed by a national network of service centers. The Mercury is backed by a very efficient service-by-mail center. Since the latest crop of space-age digital LC watches require very little service other than battery replacement, which any jeweler can do, service has become less a concern.

Why then would anyone want to buy a copy of the Seiko? For several reasons:

Savings JS&A has obtained sufficient quantities of the Mercury to offer you the item for as low as \$69.95.

Support Mercury is a division of Leisurecraft Industries, a public company that specializes in obtaining the best digital watches and insuring their value with excellent service, support and quality.

Quality You'll be amazed at the excellent quality of the Mercury, especially compared side by side with the Seiko.

Accuracy The Mercury is guaranteed accurate to within 15 seconds per month, although much greater accuracy can be expected.

THE BEST FEATURES

The alarm chronograph has an alarm that really wakes you up. Its chronograph measures time to one hundredth of a second and has three settings: **split** which continues counting the split seconds while you freeze the time for reading, **add** if you want the total time of several periods, and **lap** which starts counting from zero when you press the button.

You have hours, minutes, seconds, day of the week, the month and date. The Mercury

Quartz LC also remembers the days in a month and automatically recycles to the correct first day of the next month.

EXAMINE THE FEATURES

Order the Mercury from JS&A on a trial basis. Compare it feature for feature with the Seiko. Compare its accuracy, its alarm, and its chronograph functions.

If after a truly side-by-side comparison, you aren't convinced that its accuracy, quality, and features make it a truly outstanding value, return it within 30 days for a prompt and courteous refund. We promise to accept the return of your watch with absolutely no questions asked and even refund the \$3.50 postage and handling.

AMERICA'S LARGEST SOURCE

JS&A is America's largest single source of space-age products—further assurance that your modest investment is well protected.

The new crop of digital watches rarely malfunction, but if service is ever required, it is reassuring to know that there is a prompt service-by-mail facility, a one year limited warranty and two substantial companies backing your modest investment.

To order your Mercury Quartz LC, send your check for **\$69.95** for the silver-tone model or **\$79.95** for the gold-tone along with \$3.50 per order for postage and handling (Illinois residents, please add 5% sales tax) to the address shown below or credit card buyers may call our toll-free number below.

Is it unfair to copy a popular expensive watch? America's growth can be traced directly to the principle of open competition. Open competition has not only been the catalyst for innovation, but it is also responsible for bringing better value to a free marketplace. Unfair? Maybe if you were Seiko it would be. But then we're all not that lucky.

Your timing is perfect. Why not order the Mercury LC at no obligation, today.

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Brand New. LCD Alarm Chronograph



You can't wear a more accurate watch ... With the split second precision of the finest Swiss stopwatch ... Plus a 24-hour alarm & personal reminder system.

This spring and summer, our LCD Alarm Chronograph was a runaway best seller. It's sold out in fact. For this reason, we've improved it. Made it even bolder and more exciting, with extra convenience features and for less money!

How? By placing one of the largest watch orders in our history... and passing the quantity savings along to you.

Truly Extraordinary

This new LCD Alarm Chronograph is truly extraordinary. It does more and does it better than any other watch. With an impressive, dramatic appearance that reflects its uncommon ability.

Remarkable Value

The only thing about it that's not extravagant is its price. It's actually over \$200.00 less than the nationally advertised watch that comes close to its usefulness and accuracy.



Correct time is 6:53.44 on Tuesday

Quartz Crystal Time... The LCD Alarm Chronograph gives you accuracy to ± 60 seconds a year. Quartz crystal accuracy that would have been considered sensational per month in earlier micro-electronic watches. And is still not available in models selling for as much as \$500.00 to \$1000.00.

The Electronic Calendar... So you always have exactly the right time on display—the hours, minutes and running seconds, plus the day of the week. Then, at a touch, you can replace the time with the month and date. Of course, the electronic calendar adjusts automatically for the number of days in the month. Then, so you can see when it's dim or you're in the dark, the face lights up.



Correct date is August 8th

24 Hour Alarm

Of all the features available in digital watches today, an alarm system like this is the one that's most wanted. And no wonder. It will wake you; remind you of your appointments, phone calls and meetings (or break one up that's been going on too long). It's really important enough all by itself to warrant your getting a new watch.

You can set this alarm for any minute of any hour. Day or night. In all, 1440 positions are available—easily and instantly. Then, unless you change or deactivate it, the alarm will sound for a full minute at the same time every day. With an insistent, though pleasant, beep. When the alarm is set, an A appears on the face. To check the time it'll go off, just touch the alarm button.



Set to ring at 11:45 P.M.

The Chronograph System

As to the chronograph, or split-second timer, its precision is so fine, it borders on the infinitesimal. Imagine, it enables you to time an event for up to an hour to one-hundredth of a second... and beyond that, for a full 24 hours, to the second! On top of which, you can time an event in memory, keeping the regular time of display until you need the chronograph readout. Then, as you'll see in the explanation to the far right, the chronograph measures or stops time, in an extraordinary variety of ways.

This exceptional versatility makes the LCD Alarm Chronograph with its highly sophisticated micro-computer chip the ideal instrument for doctors, pilots, motion picture directors and photographers, sound and efficiency engineers, sportsmen of course, and every executive who wants the ability to command time to stand still.

Only \$70

Right now, only the Seiko among nationally advertised brands has all these features. And it regularly sells for \$299.95. Well over two hundred dollars more—even though its chronograph is accurate to only a tenth of a second.

This incomparable value (proved after exhaustive quality control tests) is what really impressed us. And we're one of the oldest and largest mail merchandisers in America.

30 Day Trial

What is more, buying by mail, you can prove all this to your own satisfaction without risking one cent. You have thirty days to put the LCD Alarm Chronograph to the test—to confirm it won't gain or lose five seconds a month, prove the convenience of the alarm, satisfy yourself that the LCD Alarm Chronograph is as useful as it is easy to operate. More, to compare it with any watch at any price, and to send it back for a complete refund if the value is not as great as we say, if it doesn't arouse the admiration and fascination of your friends, win your own pleasure and satisfaction.

Silver-tone or gold plated

So order your LCD Alarm Chronograph today. The price, including shipping, handling, insurance and a handsome gift case is just \$70.00 with chrome case and stainless steel bracelet, or \$80.00 in gold plated case and

bracelet. Your watch comes with a full ONE YEAR Limited Warranty. Remember, too, the printed circuitry eliminates all moving parts and normal servicing, and assures you of years of trouble-free performance

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The Multi-Function Chronograph System

No other instrument, at any price, gives you greater precision than the 1/100th of a second accuracy of the new LCD Alarm Chronograph, or greater versatility and flexibility in timing an event from a fraction of a second to 24 hours. Only with the micro-electronic revolution could you have a multi-function chronograph, a chronograph that can be put in memory, in a sleek, thin, superbly styled timepiece like this.



Timed to 54 minutes and 14.85 seconds

#1 Add Time... is the stop watch mode. You'll use it to time everything from a phone call to the length of a meeting. How long your car's been at a parking meter, the time you've been jogging or exercising, even the time it takes a quarterback to set up and throw. With Add Time, you can stop when necessary, like a time out in basketball, and start again when the action begins. Try it the next time you prepare a speech.

#2 Split Time... is the mode you'll use to get the time of each contestant across the finish line, or to get the time for the 1/4 or the 1/2 or any interim. On Split Time the chronograph is actually stopped and running at the same time, so you can use it to figure the time of a pit stop, for example, and still get the over-all time of the race.

#3 Twin Timing... Most extraordinary of all, you can actually combine these functions, using your chronograph as both a stopwatch and split timer. For example, a television producer would start timing a show, he then stops and starts the chronograph to get the time of the commercial, writes down the figure, and starts the chronograph again, which jumps ahead to the total elapsed time. With an ordinary or analog stopwatch, you'd need two sets of hands to do this—and would probably have to pay more for just a stopwatch than for the LCD Alarm Chronograph.

You'll find the chronograph so easy to use, you'll master it in minutes, and in days find innumerable business and personal uses. Take 30 days to prove it to yourself.

Be sure to specify white or gold. You'll have the precise time, absolute control over time, plus ample warning when it's time to do anything. And the pride that comes with wearing a watch that's second to none.

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Coming Next Month

- A COMPUTER-VS-YOU CHESS GAME
- SECURITY PROJECTS: AN IR INTRUSION SYSTEM AN ELECTRONIC INTRUDER ALARM
- POPULAR ELECTRONICS ANNUAL EDITORIAL INDEX
- TEST REPORTS: Lafayette AM/FM Stereo Receiver
Dual 819 Cassette Deck
Crown DL-2 Audio Control Center

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JOSEPH E. MESICS
Publisher

ARTHUR P. SALSBERG
Editorial Director

LESLIE SOLOMON
Technical Director

JOHN R. RIGGS
Managing Editor

IVAN BERGER
Senior Editor

ALEXANDER W. BURAWA
Features Editor

EDWARD I. BUXBAUM
Art Director

JOHN McVEIGH
Assistant Technical Editor

ANDRE DUZANT
Technical Illustrator

CLAUDIA TAFARO
Production Editor

RUTH POLSKY
Editorial Assistant

Contributing Editors
**Hal Chamberlin, Lou Garner, Glenn Hauser
Julian Hirsch, Ralph Hodges, Forrest Mims**

CARMEN VELAZQUEZ
Assistant to the Editor

LINDA BLUM
Advertising Service Manager

KATHERINE REINHARDSEN
Executive Assistant

EDGAR W. HOPPER
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ZIFF-DAVIS PUBLISHING COMPANY
Editorial and Executive Offices
One Park Avenue, New York, New York 10016
212-725-3500
Joseph E. Mesics (725-3568)
John J. Corton (725-3578)
Bonnie B. Kaiser (725-3580)

Midwestern Office
Suite 1400, 180 N. Michigan Ave.
Chicago, IL 60601 (312-346-2600)
Midwest Representative: Buzz Vincent

Western Office
9025 Wilshire Boulevard, Beverly Hills, CA 90211
213-273-8050, BRadshaw 2-1161
Western Advertising Manager: Bud Dean
Western Representative: Norm Schindler
Suite 205, 20121 Ventura Blvd
Woodland Hills, CA 91364 (213-999-1414)
Japan: James Yagi, Oji Palace Aoyama,
6-25, Minami Aoyama, 6 Chome, Minato-Ku
Tokyo 407-1930/6821, 582-2851



Editorial

POPULAR ELECTRONICS AT THE WHITE HOUSE

I spent an interesting day at the White House a few weeks ago, together with a small band of other magazine editors. This included a half-hour session with President Jimmy Carter.

The energy problem is clearly one of the uppermost challenges with which the administration is grappling. At this time, though, it appears that a distinct energy substitute for oil is not at hand. Rather, a host of other energy-resource avenues are being explored, solar being one. But solar energy, though glamorous, is costly: about \$81 per equivalent barrel of oil compared to \$14 for fossil fuel and \$25 for other sources.

Our energy crunch—when oil demand exceeds productive capacity—is expected to be reached sometime between 1982 and 1988. Extending this date by conservation and substituting other fuels such as natural gas and coal is a primary goal, giving the U.S. time to fully develop energy alternatives. One alternative, says Jim Bishop, chief spokesman for the energy department, is restoring to service hydroelectric turbines in disuse since the 30s and 40s, when oil was cheap. Moreover, the U.S. is encouraging use of small dams for electric generation, where there's a potential generating capacity of more than 54,000 megawatts.

Walking onto a balcony at the Executive House with Energy Secretary James Schlesinger, I asked him what he thinks I should do when my 25-year-old oil burner passes on. He suggested the possibility of substituting a heat pump, though hesitating to make a firm recommendation for the refrigerant system that uses a reversing valve to provide both heating and cooling. Seems that the pump is advantageous when proper factors are present, such as having a satisfactory duct system, when electric-resistance heating is available, when it doesn't get terribly cold outside, and where electricity costs are not outrageously high. Solar heating, even for hot water only, is not around the corner for me either since I'm living in the North and solar costs are still quite high. Schlesinger pointed out, though, that there will surely be a solar energy tax break bill passed soon and, besides, it will be retroactive to April 20, 1977. He also noted that nuclear breeder reactors are OK, though fusion types are not.

On another subject of interest, I tried to find out what alternatives the U.S. had in the event the rumored "Third World" attempt to take frequencies away from the amateur radio and CB bands does indeed occur at the upcoming WARC meeting in '79. Rick Neustadt of the Domestic Policy Staff was aware of the rumors, saying that our embassy people in each country are trying to persuade the foreign governments that it would be in their own best long-term interests not to do this. He declined to answer my question about the U.S.'s planned posture should the countries decline to follow the industrial nations' lead, however.

There were many more subjects covered at this meeting in Washington, D.C., but the foregoing are of special interest to PE readers, I know.

Reflecting on the energy problem reminded me of an article reprint I read recently in which the author observed that energy alternatives are needed, determined long-range trends, and analyzed available resources and future possibilities that deserve research efforts to forestall the inevitable. Solar radiation, he concluded, would be the great source of energy for the future. The author's name: Charles P. Steinmetz. The date: June 27, 1918.

The Age of Affordable Personal Computing Has Finally Arrived.

Ohio Scientific has made a major breakthrough in small computer technology which dramatically reduces the cost of personal computers. By use of custom LSI micro circuits, we have managed to put a complete ultra high performance computer and all necessary interfaces, including the keyboard and power supply, on a single printed circuit board. This new computer actually has more features and higher performance than some home or personal computers that are selling today for up to \$2000. It is more powerful than computer systems which cost over \$20,000 in the early 1970's.

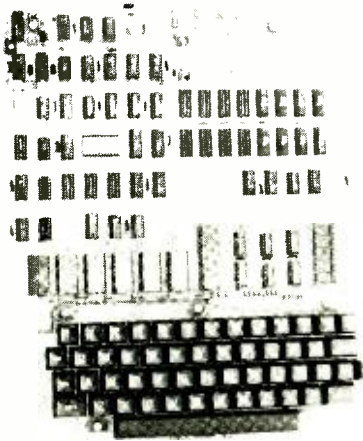
This new machine can entertain your whole family with spectacular video games and cartoons, made possible by its ultra high resolution graphics and super fast BASIC. It can help you with your personal finances and budget planning, made possible by its decimal arithmetic ability and cassette data storage capabilities. It can assist you in school or industry as an ultra powerful scientific calculator, made possible by its advanced scientific

math functions and built-in "immediate" mode which allows complex problem solving without programming! This computer can actually entertain your children while it educates them in topics ranging from naming the Presidents of the United States to tutoring trigonometry all possible by its fast extended BASIC, graphics and data storage ability.

The machine can be economically expanded to assist in your business, remotely control your home, communicate with other computers and perform many other tasks via the broadest line of expansion accessories in the microcomputer industry.

This machine is super easy to use because it communicates naturally in BASIC, an English-like programming language. So you can easily instruct it or program it to do whatever you want, *but you don't have to*. You don't because it comes with a complete software library on cassette including programs for each application stated above. Ohio Scientific also offers you hundreds of inexpensive programs on ready-to-run cassettes. Program it yourself or just enjoy it; the choice is yours.

Ohio Scientific offers you this remarkable new computer two ways.



Challenger 1P \$349

Fully packaged with power supply. Just plug in a video monitor or TV through an RF converter to be up and running.

Superboard II \$279

For electronic buffs. Fully assembled and tested. Requires +5V. at 3 Amps and a video monitor or TV with RF converter to be up and running.



Standard Features

- Uses the ultra powerful 6502 microprocessor
- 8K Microsoft BASIC-in-ROM
Full feature BASIC runs faster than currently available personal computers and all 8080-based business computers.
- 4K static RAM on board expandable to 8K
- Full 53-key keyboard with upper/lower case and user programmability
- Kansas City standard audio cassette interface for high reliability
- Full machine code monitor and I/O utilities in ROM
- Direct access video display has 1K of dedicated memory (besides 4K user memory), features upper case, lower case, graphics and gaming characters for an effective screen resolution of up to 256 by 256 points. Normal TV's with overscan display about 24 rows of 24 characters, without overscan up to 30 X 30 characters.

Extras

- Available expander board features 24K static RAM (additional), dual mini-floppy interface, port adapter for printer and modem and an OSI 48 line expansion interface.
- Assembler/editor and extended machine code monitor available.

ORDER FORM

Order direct or from your local Ohio Scientific dealer.

I'm interested. Send me information on your

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Send me a Superboard II \$279 enclosed

Send me a Challenger 1P \$349 enclosed

Include 4 more K of RAM (8K Total) \$69 more enclosed

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All orders shipped insured UPS unless otherwise requested. FOB Aurora, OH

Interested in a bigger system? Ohio Scientific offers 15 other models of microcomputer systems ranging from single board units to 74 million byte hard disk systems.

NOVEMBER 1978

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5

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Letters

DX BOOSTER

I can't begin to tell you how much I enjoyed reading Harry Helms' articles on DXing. Be-

ing a DXer myself, I find his articles invaluable. Among my favorites are "Ending that Utility Futility" (July 1977) and "DX Catches from Africa" (July 1978). I would certainly enjoy seeing more articles by Mr. Helms. Incidentally, I am also a Glenn Hauser fan. —David Reed, Jr., WDX4DR, Miami, FL.

CAR STEREO NR & CR0₂

Thanks for "How to Get Hi-Fi Sound in Any Auto" (July 1978). After reading this article, however, two questions came to mind. First, will tapes recorded on one deck with Dolby noise reduction (at home, for example) be properly decoded by another Dolby deck

(such as in a car)? Secondly, why don't the cassette players in car radios have provisions for CrO₂ tapes and why do so few of them have Dolby noise-reduction systems?—Rick Whiting, WOTN, Hopkins, MN.

The answer to your first question is "yes." The tracking of Dolby noise-reduction circuits from deck to deck is quite close. The answer to your second question boils down to a matter of marketing. If manufacturers feel that there are enough people out there who want CrO₂ and other tape formulations besides "standard," they'll likely start producing them. Also, improved tape formulations and the noise-reducing benefits of a Dolby system may not always be justified in an automotive environment, where ambient noise might mask tape noise and other advantages enjoyed at home.—Ed.

SWR CLARIFIED

SWR continues to be misunderstood. In "Build a Low-Cost SWR Tester" (June 1978), there was a chart relating SWR to reflection loss and antenna power. The chart gives the impression that, with 4 watts of transmitter output power, antenna power will be 4 watts if the SWR is 1:1. This would mean that it makes no difference whether one uses a short length of low-loss feedline or a long length of lossy feedline as long as the SWR is 1:1. This is not so. The reflection losses due to the SWR must be added to the losses of the line. SWR is only one of the contributing loss factors.—John J. Duda, Erie, PA.

SERVICE BY MAIL

In "Personal Computers for Small-Business Applications" (August 1978), the statement "... service from manufacturers is obviously not a satisfactory route to take" is open to challenge. In my own experience, I have had excellent service from a computer manufacturer, from initial purchase, to help with programming, to repair and debugging my computer—all conducted by mail. Within a week of placing my order, I had my burned-in computer. After that, I never had to wait more than three days for a response to my letters. This is excellent service from a company located more than 600 miles from where I live.—Art Baldwin, Dallas, TX.

Your experience, though not unique, is not commonplace. Even so, computer down-time for as short a time as one day can be very frustrating (not to mention costly for small businesses).—Ed.

Out of Tune

In "The Versatile Keypad" (August 1978) in Fig. 3, the left side of IC11 was incorrectly labelled 3, 4, 5 from top to bottom. The correct sequence should be 3, 5, 4.

POPULAR ELECTRONICS

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NEW PRODUCTS

The Model 10 at \$49.95 represents the most outstanding blood pressure computer value.



Blood Pressure Computers



The Model 11 at \$69.95 is one of the most deluxe blood pressure models available.

More Americans are taking their own blood pressure with today's new electronic marvels. Here's a report on two of the newest and lowest priced quality models.

There's a new way to take your blood pressure. Scientists have developed electronic systems that wrap around your arm, require no stethoscope, and don't even require rolling up your sleeve.

When a doctor reads your blood pressure, he uses his skill and a stethoscope to determine your systolic and diastolic readings. Now a computer can do this in the convenience of your home and on a regular basis.

DOCTORS ENCOURAGE USE

It's a good idea to know your own blood pressure. Doctors estimate that 25 million Americans suffer from hypertension and yet only half know about it.

Hypertension is high blood pressure, and high blood pressure usually goes unnoticed until serious symptoms develop—often too late to correct.

Doctors encourage their patients to regularly monitor their blood pressure, and the new electronic models make monitoring easy enough for everyone to do. Even if your health has been perfect, hypertension or high blood pressure can occur at anytime.

EASY TO USE

Taking your blood pressure is quite simple. Just slip your hand through a self-tightening velcro cuff, slide the cuff up your arm, pull the tab, and attach the tab to the velcro material. The tab will stick automatically without loosening. Then squeeze the rubber bulb to inflate the cuff, and read your blood pressure on the dial.

The two units shown above are two of the most advanced models available. The JS&A Model 10 sells for \$49.95 and the Model 11 shown to the right sells for \$69.95.

Both units use three integrated circuits and a microphone transducer. The microphone picks up pulses in your artery, and the integrated circuits measure the pulses and

relay the information to a meter which visually displays your two blood pressure readings. There is no expensive stethoscope required, no guesswork or complicated steps to follow.

The Model 10 has a separate bulb to inflate whereas the Model 11 has the bulb built into the handle making the process a one-handed procedure. The deluxe Model 11 also has a self-bleeding release valve and a more attractive carrying case.

The units shown above also flash an LED signal and an audible tone at the two blood pressure readings to assist the hard-of-hearing or those with poor eyesight.



Both JS&A blood pressure units were designed to easily slip over your arm and tighten with the self-tightening bar and the velcro material. Just pull the flap and press.

Both models represent outstanding value. If you are looking for the lowest priced electronic monitor available, we recommend the Model 10. If you are looking for a more deluxe unit, we recommend the Model 11. In either case, you will own the finest.

SOLIDLY BACKED

The JS&A units are powered by a readily-available 9-volt battery supplied with each

unit. The units use solid-state electronics so service should never be required. But if service is ever required, JS&A's prompt service-by-mail center is as close as your mailbox. JS&A is America's largest single source of space-age products—further assurance that your modest investment is well protected.

We recommend that you at least try a blood pressure computer without obligation for 30 days. Order one. When you receive it, see how easy it is to slip the cuff on your arm, tighten, and inflate. See how easy it is to read and monitor your blood pressure regularly. If, for any reason, you decide that you would rather return your unit within the 30 day trial period, please feel free to do so, and we will be happy to refund your money and even the \$2.50 postage and handling. There is no risk.

To order your blood pressure computer, simply mail your check for **\$49.95** for Model 10 or **\$69.95** for Model 11 plus \$2.50 per order for postage and handling (Illinois residents add 5% sales tax) to the address shown below. Credit card buyers may call our toll-free number to order.

We will promptly ship you your blood pressure computer, batteries, carrying case, complete instructions, and your 90 day limited warranty.

Space-age technology has made it easy to monitor your own blood pressure. Order a JS&A blood pressure computer at no obligation, today.

JS&A NATIONAL SALES GROUP

Dept PE One JS&A Plaza
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New Products

Additional information on new products covered in this section is available from the manufacturers. Either circle the item's code number on the Free Information Card or write to the manufacturer at the address given.

B.I.C. Two-Speed Cassette Deck

B.I.C./Avnet's Model T-3 cassette deck features two speeds—the standard 1 7/8 ips and a new 3 3/4 ips. The higher tape speed is said to improve frequency response, wow and flutter, and S/N. The three-head

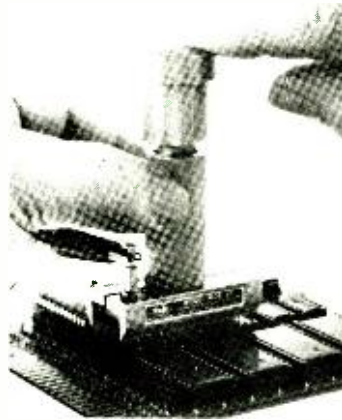


unit is claimed to have frequency responses of 25-19,000 Hz \pm 3 dB at 1 7/8 ips and 25-22,000 Hz \pm 3 dB at 3 3/4 ips. Its transport system has primary and secondary capstans and pinch roller assemblies in a closed-loop system. Four separate Dolby circuits allow simultaneous encode and decode of left- and right-channel signals. Wind or rewind time on a C60 tape is 45 seconds. A BIAS switch provides a selection of HI, NORMAL, AND LO; equalizations of 70 or 120 microseconds can also be chosen. Peak-reading meters have an extended range of 45 dB. \$499.95. Address: B. I. C./Avnet, Westbury, NY 11590.

CIRCLE NO 87 ON FREE INFORMATION CARD

OK IC Insertion Tool

The new Model MOS-40 DIP IC insertion tool from OK Machine and Tool Corp. handles all TTL and MOS ICs in standard 36- and 40-pin packages with 0.6" pin-row spacing. This tool also aligns bent-out IC pins. A twist of the handle compresses the pins to the proper 0.6" spacing and locks the IC into the tool. To insert the IC in its socket or directly on a pc board, the user simply places the tool over the appropriate



location and presses the plunger. The tool features heavy chrome plating throughout and a terminal lug for attaching a grounding strap for reliable static dissipation and safe handling of MOS devices. \$7.95. Address: OK Machine and Tool Corp., 3455 Conner St., Bronx, NY 10475.

CIRCLE NO 88 ON FREE INFORMATION CARD

JVC Portable SW Receiver

JVC's new Model FR-6600JW portable communication receiver features AM, FM, and four shortwave bands, the last spanning a 1.6-to-30-MHz range. The dual-conversion receiver is designed to operate on ac, D cells, or car batteries. The control complement includes: r-f gain, independent bass and treble tone, audio filter for noise reduction on AM and SW, afc switch,



bfo switch, pitch control, and main-tuning and vernier-type SW-tuning controls. A calibration signal produces a beat sound at 250 kHz. The afc switch doubles as a distant/local switch on AM. The bfo frequency can be adjusted over a \pm 3-dB range. Other features include a built-in 5" (12.7-cm) speaker; jacks for earphones, headphones, recording output, and external dc input; and swivel telescoping and ferrite-core antennas. Size is 12.9"W X 8.4"H X 3.9"D (32.7 X 21.3 X 10 cm) and weight is 6.4 lb (2.9 kg). \$149.95. Address: JVC America Co., 4875 Queens Midtown Expwy., Maspeth, NY 11378.

CIRCLE NO 89 ON FREE INFORMATION CARD

Empire Scientific Record Cleaner

Disco Film from Empire Scientific Corp. is a new record cleaner that forms a peel-off film to remove dirt and grime from record grooves. Disco Film is water-soluble and harmless to vinyl. (It should not be used on old shellac records.) It is applied to the record surface with a built-in sponge applicator. When dry, a flexible film is formed that is easily peeled off with adhesive tape. One container of Disco Film will clean up to 70 vinyl LP record sides. \$29.95. Address: Empire Scientific Corp., 1055 Stewart Ave., Garden City, NY 11530.

CIRCLE NO 91 ON FREE INFORMATION CARD

Pace Mobile CB AM Transceiver

Only 5 1/4 inches deep, for tight installation, the new Pace 8016 CB AM transceiver features a digital LED display with manual



dimming, a front-panel microphone level control, and switchable ANL. Specifications include harmonic suppression of -70 dB at 100% modulation. Other features are an edge-mounted S/r-f meter and switchable PA facilities. Dimensions are 7 1/4" W x 2 3/8" H x 5 1/4" D (19 x 6 x 14 cm). \$99.95. Address: Pathcor, Inc., 24049 S. Framp-ton Ave., Harbor City, CA 90710.

CIRCLE NO 92 ON FREE INFORMATION CARD

Microcomputer Light Pen

A new, low-cost light-pen for microcomputers is available from Esmark. Called the "Vidiet-Stik" (for Video Integrated Electronic Tracking), the light pen is touched to a CRT display screen at any desired point to indicate that point to a computer. Typical applications include hand-drawn computer graphics, interactive games, keyboard substitution, program "menu" selection, and educational drills for pre-schoolers. Designed for virtually all mini/micro systems with at least one parallel I/O line, the light-pen is supplied with software for 8080 and Z80 systems. Only three electrical connections are required: +5V, ground, and a single, TTL-level signal line. The

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If you want information on microprocessors, read the Osborne books.

An Introduction to Microcomputers

Volume 0 - The Beginner's Book
 If you're not familiar with computers, but would like to be, then this is the book for you. Computer logic and terminology are introduced in a language the beginner can understand. Computer software, hardware and component parts are described, and simple explanations given for how they work. Text is supplemented with creative illustrations and numerous photographs. 300 pages.

Volume 0 #08-X \$7.95

Volume 1 - Basic Concepts

A must for anyone in the computer field, this best selling text explains hardware and programming concepts common to all microprocessors. Its universal appeal is reflected by its having the greatest yearly sales volume of any computer text. 350 pages.

Volume 1 #02-0 \$8.50

Volume 2 - Some Real Microprocessors
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These two books provide complete descriptions of virtually every microprocessor and most support devices. There are no other books like these; they provide detailed part descriptions from an independent source.

To cope with the rapid evolution of microprocessor products, Volumes 2 and 3 have been printed in loose leaf form; each volume has its own series of six bimonthly updates, allowing you to remain current with all parts as soon as they are really available. Updates sold separately.

These two books replace the 1977 edition of Volume II - Some Real Products.

- Volume 2 with binder #14-4 \$20.00
- Volume 3 with binder #17-9 \$20.00
- Volume 2 update only \$25.00/yr.
- Volume 3 update only \$25.00/yr.
- Volume 2 and 3 updates \$40.00/yr.

Program Books Written in BASIC

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Accounts Payable and Accounts Receivable
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These books feature complete, quality applications software for small-to-medium sized businesses. Each book includes fully documented program listings, sample printed reports, installation instructions and user's manual. Written in an extended Wang BASIC (write to ask us about our CP/M CBASIC version and other conversions). 375 pages each.

- Payroll #09-8 \$15.00
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Some Common BASIC Programs

76 short practical programs, most of which can be used on any microcomputer with any version of BASIC. Complete with program descriptions, listings, remarks and examples. 200 pages.

SCBP #06-3 \$8.50

Assembly Language Programming

8080A/8085 Assembly Language Programming
6800 Assembly Language Programming

These books describe how to program a microcomputer using assembly language. They discuss classical programming techniques, and contain simplified programming examples relevant to today's microcomputer applications. 400 pages each.

- 8080A/8085 #10-1 \$8.50
- 6800 #12-8 \$8.50



Programming for Logic Design

8080 Programming for Logic Design
6800 Programming for Logic Design
Z80 Programming for Logic Design

These books describe the meeting ground of programmers and logic designers; written for both, they provide detailed examples to illustrate effective usage of microprocessors in traditional digital applications. 300 pages each.

- 8080 #04-7 \$8.50
- 6800 #05-5 \$8.50
- Z80 #11-X \$8.50

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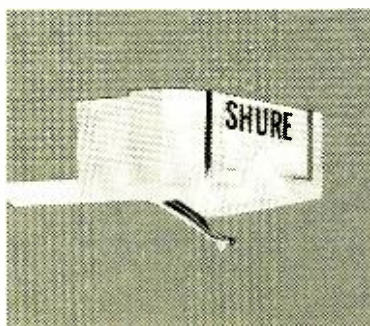
F11



Needle in the hi-fi haystack

Even we were astounded at how difficult it is to find an adequate other-brand replacement stylus for a Shure cartridge. We recently purchased 241 random styli that were not manufactured by Shure, but were being sold as replacements for our cartridges. Only ONE of these 241 styli could pass the same basic production line performance tests that ALL genuine Shure styli must pass. But don't simply accept what we say here. Send for the documented test results we've compiled for you in data booklet # AL548. Insist on a genuine Shure stylus so that your cartridge will retain its original performance capability—and at the same time protect your records.

Shure Brothers Inc.
222 Hartrey Ave., Evanston, IL 60204
In Canada: A.C. Simmonds & Sons Limited



Manufacturers of high fidelity components, microphones, sound systems and related circuitry.
CIRCLE NO. 65 ON FREE INFORMATION CARD

software occupies less than 1K of memory, and is relocatable to any address. \$40, plus \$1.50 postage and handling. Address: Esmark, Inc., 507½ E. McKinley Highway, Mishawaka, IN 46544.

CIRCLE NO. 93 ON FREE INFORMATION CARD

Heath Logic Probe

Heath's new Model IT-7410 (kit)/ST-7410 (wired) logic probe is designed for in-circuit testing of TTL and CMOS integrated circuits. It features switch-selectable thresholds for either TTL or CMOS circuitry and

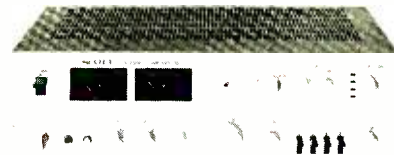


lamps that turn on when the input voltage crosses the appropriate levels. A memory circuit is incorporated to turn on a LED when either threshold is crossed. The probe is designed to detect pulses as short as 10 ns. Upper frequency limits are 100 MHz for TTL and CMOS devices at 5 volts and 80 MHz for CMOS at 15 volts. Power for the probe is obtained from the circuit under test via a pair of insulated alligator clips. A ground lead is provided for high-frequency operation. The probe is protected for up to 50 volts continuous and 175 volts dc for 5 seconds. Price is \$39.95 kit, \$64.95 assembled. Address: Heath Company, Benton Harbor, MI 49022.

CIRCLE NO. 90 ON FREE INFORMATION CARD

H. H. Scott Integrated Amplifier

H.H. Scott's top-of-the-line Model 480A integrated amplifier, rated at 85 watts continuous power/ch at 0.03% THD, has two independent phono preamplifiers with separate input and record capability. This permits the user to record from any one function while simultaneously listening to any other source. The amplifier also features active subsonic and high filters; base, mid-range, and treble tone controls that can be bypassed for flat response; dual logarithmic dBW power meters; dc OCL power



amplifier; and 117/220-volt ac switchable voltage. A switch is provided on the front panel for outboard sound processors. Also provided are impedance and capacitance selectors for cartridge/system compatibility and an electronic protection system to prevent a short circuit from damaging the amplifier or speaker system. \$449.95. Address: H.H. Scott, Inc., 20 Commerce Way, Woburn, MA 01801.

CIRCLE NO. 94 ON FREE INFORMATION CARD

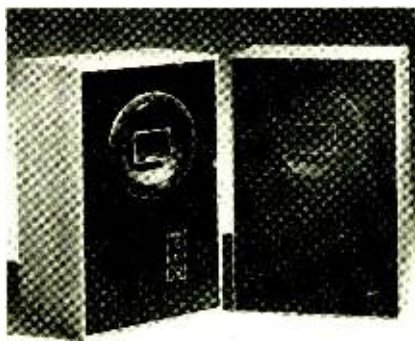
Sylvania Power Microphone

The Sylvania Model SDX-400 power microphone for CB base-station applications has 20-dB gain available and is continuously adjustable via a slide control. The mike's output impedance ranges from 0 to 2500 ohms, and maximum sensitivity is -45 dB. A 9-volt battery powers the mike's transistorized amplifier and an on-the-air LED indicator. There's a built-in compressor circuit in the amplifier for high transmitter modulation levels. The push-to-talk switch has a lock-on position and the mike head can be adjusted for optimum pickup. Address: GTE Sylvania Inc., 1 Stamford Forum, Stamford, CT 06904.

CIRCLE NO. 95 ON FREE INFORMATION CARD

Altec Lansing Model Eighteen Floor-Standing Speaker

Altec Lansing's Model Eighteen, a floor-standing speaker system, utilizes its 604-8H driver combination. The latter con-



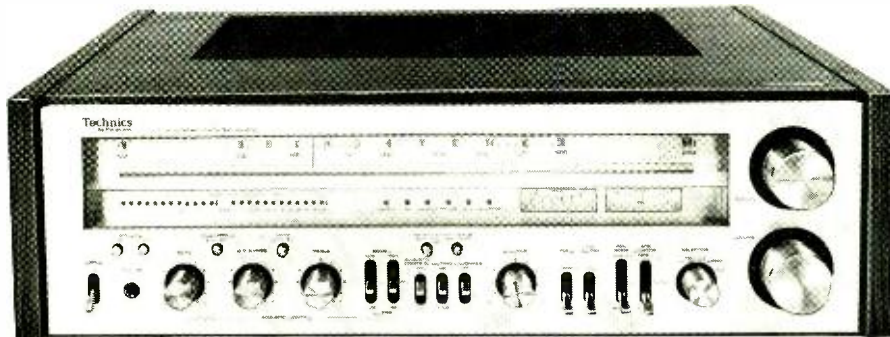
sists of the "Tangerine" phase plug, "Mantaray" horn, and a new dual equalizing network. The phase plug transmits high frequencies beyond 20,000 Hz, while the



**fact:
calling this a “brush”**



is like calling this a “radio”



we call it a Dynamic Stabilizer

...critics call it a major innovation

True, the device on the front of a V15 Type IV cartridge bears a superficial resemblance to a cleaning brush.

In reality, it is a complex, exquisitely engineered subassembly which performs several complex functions that measurably enhance the quality of record reproduction!

Each one of its 10,000 conductive carbon fibers is positively grounded to discharge ever-present static electricity from the surface of your records. This eliminates static clicks and pops, as well as the tracking distortion produced by the varying electrostatic attraction between the record surface and the tone arm.

What's more, the Dynamic Stabilizer incorporates Shure-developed viscous damping that results in a uniquely efficient suspension system which maintains precise cartridge-to-record distance and uniform tracking

force—even on severely warped records. The stabilizer also acts as a shock absorber to cushion the stylus in case you accidentally drop the tone arm onto the record.

Finally, the tiny carbon fibers are so fine that 10 of them can fit *inside* a single groove to sweep free minute dust particles.

This integrated approach to pure sound reproduction extends throughout the design of the V15 Type IV. It sets a new standard of high trackability at ultra-low tracking forces—even on records that are warped, dusty, and charged with static.

If faithful reproduction of *all* your recordings is of paramount importance to you, we invite you to audition the V15 Type IV with the Dynamic Stabilizer. Or, write for the complete story (ask for AL569).



V15 Type IV...the stabilized cartridge



Shure Brothers Inc., 222 Hartrey Ave., Evanston, IL 60204, In Canada: A. C. Simmonds & Sons Limited
Manufacturers of high fidelity components, microphones, sound systems and related circuitry.

horn is said to provide improved horizontal dispersion. The Model Eighteen is a tuned, vented enclosure which reproduces more than 100 dB (SPL) from one watt at one meter. It is available in a hand-rubbed oak cabinet with a black semi-transparent grille fabric. Address: Altec Corp., 1515 S. Manchester, Anaheim, CA 92803.

CIRCLE NO 96 ON FREE INFORMATION CARD

Electro Scientific DMM

Electro Scientific's Calcmeter 4100 is a fully CMOS-microprocessor-controlled 3½-digit DMM that sells for less than \$400. It can automatically and directly scale and offset; sort with high/low limits; average noise away; measure dBV directly; display in percent deviation; and troubleshoot by sound. It can measure and hold a million times on a single 9-volt battery, control and



datalog remotely with an accessory printer, and perform math conversions with 11 special keys. It can also store measurements and/or calculations in five different memory locations; operate with autoranging, autozeroing, and autopolarity; and display in scientific, engineering, and fixed-decimal formats. Its ranges are: 10- μ V sensitivity through 1000 V dc, 750 V ac; 10 μ A sensitivity up to 200 mA (20 A with accessory shunt); 0.1-ohm resolution through 20 megohms. Basic accuracy is 0.25% dc V. Address: Electro Scientific Industries, Inc., 13900 N.W. Science Park Dr., Portland, OR 97229.

CIRCLE NO 97 ON FREE INFORMATION CARD

ADC Turntable

The ADC Professional Products Group of BSR(USA) Ltd. has introduced a new series of turntables with resonance-canceling bases and energy-absorbing resonance-tuned suspension feet. Topping the line is the Model 1700DD quartz direct-drive PLL semiautomatic turntable. An electronic phase comparator monitors speed changes and makes immediate cor-

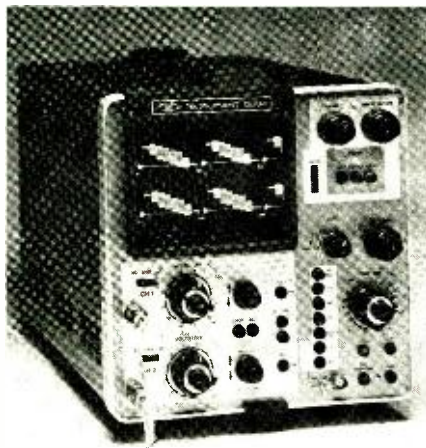


rections. Also featured is an ultra-low-mass professional straight tonearm and a headshell molded of carbon fiber. The tonearm has viscous cueing and facilities for adjusting the antiskating force. Other features include: microswitch electronic controls, electronic speed and pitch controls, die-cast aluminum platter, and a removable hinged dust cover. Address: BSR(USA) Ltd., Rte. 303, Blauvelt, NY 10913.

CIRCLE NO 98 ON FREE INFORMATION CARD

Telequipment Dual-Trace Scope

The Telequipment Model D66A is a 25-MHz dual-trace oscilloscope. Features pushbutton operation for all standard trigger operations, and a TV trigger switch for TV servicing. Calibrated sweep speeds



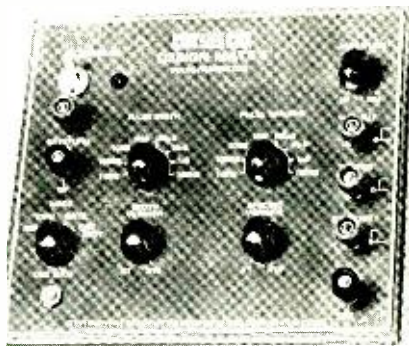
range from 20 ns to 2 s/division; vertical sensitivity ranges from 10 mV to 50 V/division across the 25-MHz bandwidth of the scope. A 1-mV/division sensitivity can be selected, but the bandwidth would then be 15 MHz. Address: Marshall Pryor, 43-000, Tektronix, Inc., P.O. Box 500, Beaverton, OR 97077.

CIRCLE NO 86 ON FREE INFORMATION CARD

Continental Specialties Pulse Generator

The CSC DM-4 Design Mate pulse generator produces a wide range of repeated,

triggered, gated or one-shot pulses. Pulse repetition frequency is continuously variable from 0.5 Hz to 5 MHz, in seven, overlapping decade ranges. Duty cycle, pulse width and pulse spacing are variable over a range of 10⁷:1, from 100 ns on/1 second off to the reverse. Pulse output amplitude is variable from 0.1-10 volts, with sufficient output current for a TTL fanout of 40. Ex-



ternal triggering to 10 MHz is accepted, and a push-button is provided for one-shot use. A separate sync output pulse leads the main pulse output by approximately 20 ns. \$130. Address: Continental Specialties, 70 Fulton Terrace, New Haven, CT 06509.

CIRCLE NO 99 ON FREE INFORMATION CARD

Sonus Phono Cartridges

Sonic Research, Inc., has developed two new series of high-definition phono cartridges to suit a wide range of record-playing needs. The premium Sonus Gold series consists of three models with identical



bodies and stylus assemblies. They differ from each other only in their diamond stylus shapes. The \$140 Blue Label is specially designed for discrete 4-channel playback. The \$125 Red Label is fitted with an elliptical stylus. And the \$110 Green Label has a spherical stylus. All three cartridges are designed to track at from ¾ to 1¼ grams. The Sonus Silver series consists of the Silver P (\$75), which is a modestly priced version of the Blue Label, and the Silver E, which has an elliptical stylus. Both are designed to track at between ¾ to 1½ grams. Address: Sonic Research, Inc, 27 Sugar Hollow Rd., Danbury, CT 06810.

CIRCLE NO 100 ON FREE INFORMATION CARD



The priceless gift of learning now has a price: \$599. And a name: the Radio Shack TRS-80™ Microcomputer. And now, at last, your child has a chance to discover Tomorrow on Christmas morning.

"Tomorrow" is an electronic world, based on computers — and it's already here. In it your child can be a number in a machine. A robot. Because he or she does not understand either the number or the machine. Or your child can be pleurably elevated into this brave new world with a gift that has only become affordable in recent months.

Quotes from Fascinated Customers

The Radio Shack personal computer surely ought to be on the gift list of every concerned parent, despite that \$599 — though less than a moped — is costlier than an electric train. A father writes to tell us "this investment is one of the most significant in value to our family and to the future education of our child that we have ever seen."

A Californian, aged 12, writes to tell us that he's "too young to go to work for Radio Shack . . . but maybe we could work a deal where I could write some programs for you." An educator thanks us for "making possible the tapping of human innovation and creativity on an unprecedented scale."

Advice for Parents Who Care

In your lifetime the possibility of owning or giving a computer — up to now — was unthinkable. A computer? That can teach? Remember? Display on its own screen? Play games? Complete with a standard typewriter keyboard? Unthinkable — up to now.

But now the Tomorrow Machine is not only thinkable but practical, affordable and available at every Radio Shack store and participating dealer. The TRS-80 personal computer system? For the kids? For Christmas? Crazy? Like a fox!

Radio Shack®
The biggest name in little computers™

A Division of Tandy Corporation
Fort Worth, Texas 76102



TRS-80 manual, written by an educator, is 232 pages of instruction for a beginner.



TRS-80 system includes everything in this picture and, of course, the manual.



TRS-80 is expandable and can grow in power and utility. Everyone in the family becomes involved, entertained, informed.



FIND!

When you discover A P Products, you've got it made.

To electronics hobbyists, A P Products are a "find" every time. You'll see.

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New Literature

ITT POMONA TEST ACCESSORY CATALOG

An 86-page test accessory catalog from ITT Pomona Electronics lists products such as molded patch cords, cable assemblies, test socket adaptors, spaced molded accessories, molded test leads, connecting leads and banana and phone plugs. The catalog introduces 23 new products and includes cable and wire description and metric conversion charts. Address: ITT Pomona Electronics, 1500 E. Ninth St., Pomona, CA 91766.

CB INTERFERENCE FLYER

"CB Interference Cures" is a flyer describing common FM, TV, and audio interference problems and cures. Topics covered include ac power lines, stereo speaker leads, phono inputs. For a free copy ask for Flyer CB-1 and enclose a SASE. Address: Electronic Specialists, Box 122, Natick, MA 01760.

WESTINGHOUSE SEMICONDUCTOR MOUNTING DATA

Proper mounting methods of power semiconductors is the topic of new application data from the Westinghouse semiconductor division. The seven-page data sheet gives procedures for applying all types of devices—lead mount stud type, flat base and disc. Thermal resistance considerations, surface requirements, cleaning procedures, optimum mounting pressures, hardware considerations, and heat-sink recommendations are covered. The data sheet, entitled "Mounting Power Semiconductors," includes diagrams and tables. Address: Semiconductor Division, Westinghouse Electric Corporation, Youngwood, PA 15697.

TAB BOOK CATALOG

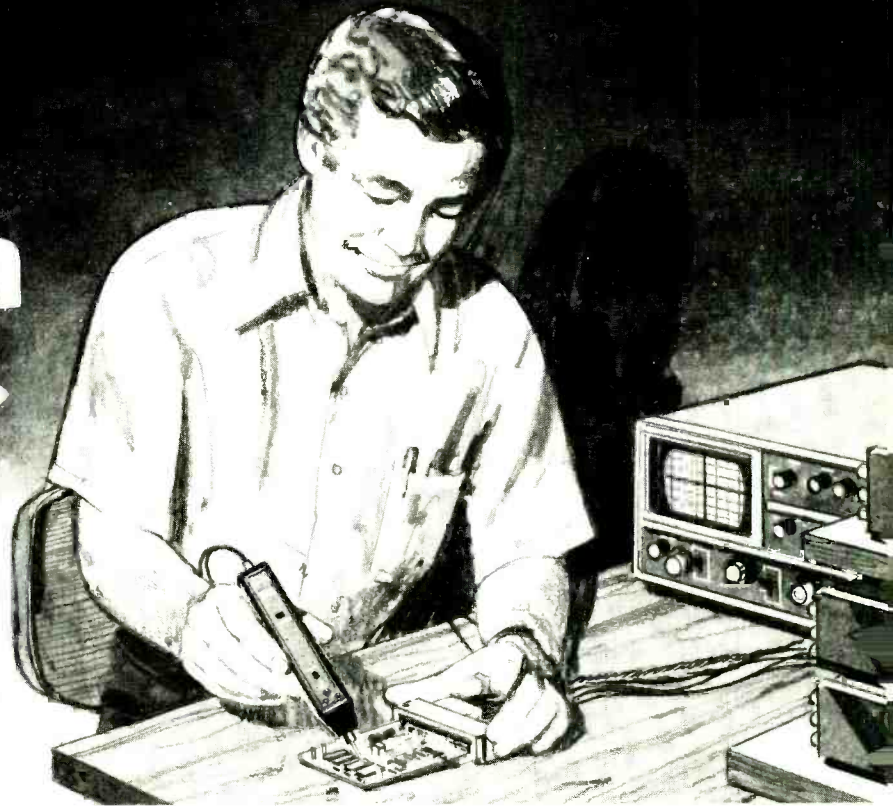
A new 1978 catalog is available from Tab Books. More than 600 current, new, and forthcoming technical and do-it-yourself titles are listed. The 52-page catalog is fully illustrated. Address: Tab Books, Blue Ridge Summit, PA 17214.

TANDY COMPUTER CATALOG

The Tandy Computers 1978 mail-order catalog lists a full line of popular microcomputers and accessories. Kits as well as assembled microcomputers are described, along with software, literature, and parts. The 52-page, four-color catalog can be obtained by calling (toll free) 1-800-433-1679 or writing to the company. Address: Tandy Computers, Dept. R7, Box 2932, Fort Worth, TX 76101.

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offers more than logic.



ACTUAL
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COLOR BAR GENERATOR	NRI designed-for-learning kit. 10 patterns	Elenco SG-200 (kit) 10 patterns	Elenco SG-200 (fully assembled) 10 patterns
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METER	NRI designed-for-learning kit. Transistorized AC/DC volt-ohm meter	Heathkit (part of TV kit) DC only; 1K Ohm/volt	Private label multimeter
AUDIO	NRI designed-for-learning kit. Four-channel high-fidelity AM, FM tuner with speakers	Private label pocket transistor AM radio kit and AM-FM-SW solid-state portable radio kit	
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MISCELLANEOUS EQUIPMENT		EICO Digital Logic Probe	

All data as shown in each school's catalog as of September 1, 1978.



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Stereo Scene

By Ralph Hodges

NEW MAPS OF SOUND

WHATEVER happened to the great tube vs. transistor debate, the TIM (transient intermodulation distortion) uproar, the showdown between moving-magnet and moving-coil phono cartridges, and all the other provocatively controversial issues that were once ready grist for this column's mill? This was the first question to pop into my mind when I recently reviewed a few years' worth of these columns in search of new directions.

Not many years ago, it was widely believed that new conceptual models for nonlinear phenomena—TIM, for example—and new test techniques for studying them would finally explain what it was that so many seemed able to hear but unable to measure. After all, it appeared certain that these phenomena were being heard, not only by audiophiles but by credentialed engineers. Surely the application of enough intense study to things that were perceptually detectable would ferret out their secrets in time, and give us a means of determining why one amplifier seemed to sound good and another not so good.

Well, the march toward the great sonic truths has not been as orderly or inevitable as it was hoped it would be back then. TIM has been defined and redefined, measured this way and measured that. Yet, a clear-cut correlation between what looks good in the laboratory and sounds good in the listening room eludes us. Moving-coil cartridges continue to measure not especially better nor especially worse than moving-magnet designs—at least according to presently applied tests—and no one can be definite about why some ears seem to prefer them. Several of the original true believers in "esoteric" distortions have actually recanted. Many of those who remain dedicated to the cause are either perplexed by the lack of good ear-instrument correlation or have safely tucked themselves away in a world of abstraction in which they envision future tests that will reveal the whole elephant rather than just its trunk, leg, or tail.

The Whole Elephant. The favorite argument (and it's beginning to sound a little bit like an apology) of researchers who cannot find revealing measurements for what they hear is that all our present-day measurements are dimensionally limited. We plot distortion against frequency or against power output but ignore many time- and phase-related considerations in the measurement. In another test—rise time, perhaps—we'll attack some time-related phenomenon directly, but without relating it in a sophisticated way to the frequency and power output domains. It has long been the view of many researchers that a properly chosen test signal such as an appropriate square wave can enable you to make virtually any significant amplifier measurement you choose. These would include frequency response, effective power output, phase shift, rise time, slew rate, general transient and overload behavior, and—by using modern spectrum-analysis techniques—harmonic and intermodulation distortion. But the problem, according to the critics of present-day measurements, is that we continue to look upon all these amplifier characteristics as separate, independent entities.

What is necessary, the critics further suggest, is an agreed-upon system of mathematical transformations by which all these parameters can be plotted or "mapped" against a set of common (if complex) coordinates, so that their vital interrelationships can be observed. For example, slew rate and high-frequency power output tend to be inversely related; as power output goes up, undistort-

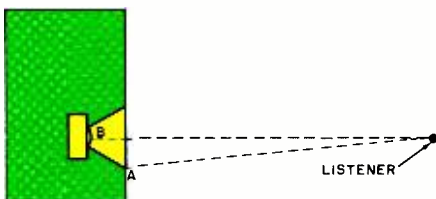


Fig. 1. Due to quick travel through cone, sound from A reaches the listener sooner than from B, where output is supposed to originate.

ed high-frequency response falls off. Something of a trade-off is involved here, and it's presumably important for us to know how much we can balance the requirements of bandwidth and output capability to obtain audible results for most musical material. Present specifications do not even indicate that this critical interrelationship exists. Therefore, we need new "maps," or so the argument goes.

Maps to Where? Speaking before a convention of the Audio Engineering Society in Hamburg, Germany early this year, Henning Møller put forward some practical remarks as to how present specifications for many audio components are deficient. A Dane, but hardly a melancholy one, Møller believes we are now at the point where, with the proper measurements properly interpreted, meaningful correlation between test instruments and ears is just barely possible. Møller (whose connection with Brüel & Kjaer would seem to put him in a position of authority on these matters) proposes six domains of evaluation for an audio system:

(1) 1/3-octave-band steady-state response measurements of the system's acoustical output, taken either in the actual listening environment or in a "standard" room representative of typical environments. Only frequencies from 20 to 2,000 Hz need be considered here.

(2) Free-field (anechoic) evaluations of amplitude and phase performance from 2,000 to 200,000 Hz. This is essentially an examination of the transient behavior of the system, and would reveal aberrations in phase/time coherence.

(3) Amplitude measurements from 200 to 20,000 Hz on varying time bases. "Gating" techniques would be used to examine the system's behavior subsequent to stimulation by a pulse or a tone burst of specific duration. Møller lays particular emphasis on what happens up to 1 millisecond after the cessation of the burst, as well as on spurious "early" reflections that may actually precede the proper output of the system.

(4) Measurements from 2 to 20 Hz, particularly on record players and other program sources involving mechanical operation. This frequency range is the "tonearm resonance, flutter, and rumble domain," and the problems to be expected are time-base fluctuations ("frequency smear") and intermodulation effects extending up into the audio range. Møller is certainly not alone in believing that a turntable flutter measurement is

much more an evaluation of the tone-arm/cartridge combination than an assessment of the platter drive.

(5) Swept two-tone intermodulation measurements from 20 to 20,000 Hz. These are suggested as a more revealing substitute for traditional steady-state THD and IM tests.

(6) Similar swept two-tone tests from 2,000 to 200,000 Hz. These are intended to be revealing of a system's transient performance and its ability to slew with adequate speed.

Rationalizations. It is strongly emphasized that these tests are tentative, awaiting further confirmation of their useful correlation with perceived sound quality. And beyond that will come the business of standardizing procedures, weighting various parameters for their subjective importance and "trade-off" values, and establishing some scheme (if possible) whereby overall "figures of merit" can be awarded. But what, specifically, do these tests have to recommend them?

The first test is a traditional steady-state evaluation of spectrum, with a little more emphasis on interface with the actual listening environment than has been usual. Tests 2 and 3 begin to occupy us seriously with controversial time and phase considerations, which Møller evidently takes quite seriously. For example, he speaks of a situation (Fig. 1) in which the transmission time of an impulse through the material of a speaker cone is so much faster than the speed of sound through air that a spurious "pre-echo" of a transient can actually reach the listener sooner than the signal from the cone's "acoustic center." Compound these effects with (in the case of loudspeakers) the better recognized driver and cabinet resonances as well as diffraction phenomena and we can see that any abrupt impulse a loudspeaker is called upon to reproduce is not likely to be very well defined in time. Møller considers this a very audible fault.

Test 4 gets us into more-or-less steady-state time modulation where we can expect to see distinct spurious frequencies generated as the result of constant infrasonic disturbances in the system. And the remaining two tests look for similar distortion products, this time generated by audible and ultrasonic sig-

nals passing through the system. Møller states that the two-tone swept IM measurements over a 200-kHz bandwidth typically reveal distortion levels of 10 percent in tuners, phono preamplifiers, and tape decks. These distortions frequently consist of difference products that crop up in the audio band, although they are generated by signals well above it in frequency.

One of the arguments that has been repeatedly leveled at wide-band (200-kHz or more) distortion measurements is that there is no reason to believe that frequencies much above 15 kHz ever find their way into an audio system; and if they never get in, there is no point in worrying about just what they might do if present. Lately, however, there has been some evidence to dispute this view. Tuners and tape recorders both make use of ultrasonic signals and, sophisticated filtering notwithstanding, their effects can be clearly heard under the proper conditions (for example, a high-level frequency sweep on a cassette deck can almost always be made to give you a very audible beat with the bias oscillator, descending in frequency as the test signal ascends).

Even record players, traditionally thought to be severely bandwidth-limited, can present some surprising inputs to a phono preamplifier. With a scanning electron microscope, George Alexandrovitch of Pickering/Stanton has measured frequencies higher than 40,000 Hz at levels exceeding 40 centimeters per second on some records! How on earth did such horrendous signals ever get there? It seems unlikely that they have anything directly to do with the music that was being recorded, but they are there nonetheless. Furthermore, since we know that a record player can and often does have a bandwidth exceeding 40,000 Hz (that's what enables CD-4 to work), it is no longer safe to assume that a sound system will merely ignore this sort of recorded information.

Møller presents additional data that persuasively argue for the presence of unexpected levels of ultrasonic energy in phono reproduction. Through the use of a small accelerometer (rather than a test record) B & K has been able to take a closer look at the square-wave responses of various phono cartridges. Figure 2 shows "typical" results for mov-

ing-magnet and moving-coil devices. The rise time for the moving-coil sample is an astonishing 5 microseconds (the moving-magnet achieves a 20-microsecond rating), testifying to an ample bandwidth. The question now arises as to whether the moving-coil cartridge, with its obvious ability to inflict significant amounts of ultrasonic energy upon the phono preamplifier, should really sound better than the moving-magnet device. The question remains to be answered.

Good Enough? Setting aside the interpretive criteria that will have to be applied to this battery of tests, and not even considering how the various results might be brought together into a "multi-dimensional" panorama of overall system performance, we can still ask how well each test seems to meet the requirements others have suggested for good subjective correlation. In this respect, Møller's proposals seem to stack up fairly well. In some respects they may be too stringent. Extending measurements to a bandwidth of 200 kHz (the traditional order of magnitude better than the 20-kHz bandwidth of interest) might just be stretching things a bit for practical power amplifiers. Careful listeners seem satisfied with a usable bandwidth of 80 kHz or so, provided it is free of TIM and related effects. This would make the job of the amplifier designer significantly easier.

Møller's emphasis of time-related performance factors seems to be right on the money. Luckily, now is just the moment for the world to "discover" time-base aberrations in audio equipment because the instrumentation is at last becoming capable of measuring it with real authority. Beyond that, there is one serious practical difficulty that Møller's tests fail to solve: the matter of appropriate performance for individual components, and the problem of interfacing said components. As it stands the program applies itself to the system as a whole, including the listening room. This is undoubtedly the right way to go about the evaluation procedure, but it doesn't suit the marketing realities of high-fidelity equipment in the U.S. very well. It also doesn't address itself directly to the questions that prospective purchasers of audio equipment desperately need answered. Let us hope that someone with resources comparable to Møller's gets excited by these proposals for new test procedures and begins to present the results, tempered by experience, in a form we can truly make use of. ◇

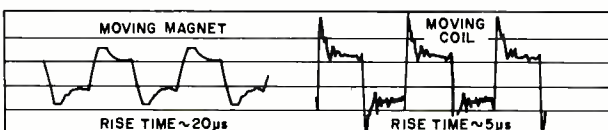


Fig. 2. Responses of moving-magnet (left) and moving-coil cartridges.



Julian Hirsch

Audio Report

Microprocessors in Audio Components

In the few years since it first appeared, the microprocessor—the “computer on a chip”—has made impressive inroads into consumer products. The list of applications grows daily: microwave ovens, automobiles, TV receivers, scanning receivers, video games, CB transceivers, and countless others. High-fidelity components are also a part of that list. Considering the “novelty oriented” nature of many audiophiles, it is surprising that we have not seen even greater use of microprocessors in this popular field.

The range of possible uses for the microprocessor is limited only by one’s imagination. It is as though we have been handed a “universal solution” and merely have to find the problems for it to solve! The first use of a microprocessor in a high-fidelity component was in the ADC Accutrac 4000 turntable. This unit can be programmed to play the various bands of a record in any desired sequence, receiving its inputs from an optical system in the cartridge that counts the blank spaces between recorded bands as the pickup scans the record under motor control. ADC followed up the Accutrac 4000 with the lower priced Accutrac +6, a record changer with many of the same control features. After a considerable delay, it is only now reaching the marketplace. Although the Accutrac players have been available for some time, it is only recently that competitive record-playing products have been announced.

In cassette recorders, the first microprocessor control appeared in the Sharp RT-3388 (and the nearly identical Optonica 6501). Originally, Sharp had a relatively simple feature of counting the quiet spaces between recorded selections on a tape. Thus, it was able to “skip” unwanted selections and go at high speed directly to the desired

program segment. Sharp has now extended this system to include all the tape indexing and counting functions plus real-time tape timing, with its memory rewind and cueing system linked to the digital counter system. Even a quartz-controlled clock is built into the Sharp cassette deck.

The Pioneer CT-F900 cassette deck, tested in this issue, also uses microprocessors, but in a somewhat different way than was used by Sharp. Its capabilities include the various memory indexing and rewind features, but there has been no attempt to include a user-programmable “signal seeking” feature or digital clock. In this regard, it should be noted that even the Sharp decks can only be programmed to scan a tape in one direction (either forward or reverse) looking for a specific selection, but they are not able to be programmed to scan in either direction so as to play sections of a tape in *any* order (as can be done with the Accutrac record players). Pioneer’s most effective use of a microprocessor (so far, unique to its machine) is as an analog-to-digital signal processor for driving the level display tubes.

The Sherwood Micro CPU 100 FM tuner is among the most advanced applications we have seen of a microprocessor in an audio product, with its digitally synthesized tuning and 48 station memory. It also has call letters that appear on the alphanumeric display together with the frequency of each station. In addition, Sherwood’s “on board” computer, by insertion of a special test ROM, can check all its own circuits and those of the tuner section in a matter of seconds. It will identify any incorrectly operating component or semiconductor by circuit symbol number on its alphanumeric display. Considering the complexity of so much of today’s hi-fi equipment, this sort of self-

“It is as though we have been handed a ‘universal solution’ and merely have to find the problems for it to solve!”

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CSC's multi-family Logic Probe 1 with memory.
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LP-1's unique circuitry does the work of a level detector, pulse detector, pulse stretcher and memory. HI LED indicates logic "1," LO LED, logic "0," and all pulse transitions — positive and negative, as narrow as 50 nanoseconds — are stretched to 1/3 second and displayed on the PULSE LED. One-shot, low-rep-rate narrow pulses — nearly impossible to see even with a fast scope, are easily detectable and visible. And you can indefinitely store single-shot as well as low-rep-rate events.

At frequencies above 1 MHz, there is an additional indication with unsymmetrical pulses: duty cycles of less than 30%, light the LG LED; over 70%, the HI LED. In all modes and circuit states, LP-1's high input impedance virtually eliminates loading problems. The unit also features overvoltage and reverse-polarity protection, interchangeable probe tips, cables and other optional accessories.

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Logic Family Switch — TTL/DTL or CMOS matches Logic "1" and "0" levels; CMOS position also compatible with HTL, HINIL and MOS logic.

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36" leads — 36" supplied, with alligator clips. Virtually any length leads may be connected via phono jack.

*Metric rec. resole. Slightly higher outside U.S.

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Specifications

Input impedance: 100,000Ω

Thresholds (switch selectable)

logic "1" thresholds (HI-LED) 2.25V ± 15%

logic "0" thresholds (LO-LED) 0.60V ± 10%

Min. detectable pulse width 50 nsec. guaranteed

Pulse detector (PULSE LED) in PULSE position of PULSE/MEMORY switch, 1/3-sec pulse stretcher makes high-speed bus stream or single events (+ or - transitions) visible in MEMORY position, first transition lights and activates LED

Operating temperature 0-50°C

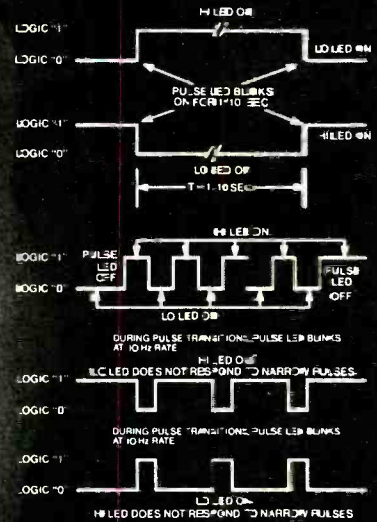
Physical size (l x w x d)

5.8 x 1.0 x 0.7" (147 x 25.4 x 17.8mm)

Weight 0.2 oz. (0.065Kg)

Power leads removable 36" (914mm) with color-coded insulated clips; others available

Input protection overload, ± 500V continuous 117 VAC or less than 15 sec.; reverse polarity, 50V; power leads reverse-voltage protected.



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NEW LP-1!

checking ability would seem to represent a very healthy trend.

In audio amplifiers, the closest we have seen to a microprocessor-controlled device is the Crown DL-2 preamplifier. It differs from others we have mentioned in that it has no built-in microprocessor. Instead, it has been designed to interface with a computer. (The Sherwood Micro CPU 100 has this potential capability, but there are no connections for the interface. The Crown has the connectors as a standard feature and an interface board will shortly be made available by Crown.) Using this option, the DL-2 can be used to control a sound system, including both program selection and level selection,

completely under computer control.

To do this, its basic operations have been converted to a digital basis. In the case of switching, the change has been relatively simple since switching is inherently digital in nature. The volume adjustment is handled by a reed-relay attenuator system. Volume is normally controlled by a voltage adjusted by a human operator, but it is obviously just as adaptable to a direct computer input.

We have no doubt that many other products will be appearing in the future that employ some of these features and (we hope) many more that can only be guessed at. In the products we have seen so

far, we find a curious mix of genuinely useful features and the other kind—the “solution looking for a problem.” Some of these, to be sure, are obtained “free” when one incorporates a microprocessor. If they are available at the touch of a button, they cost essentially nothing and can add to the appeal of a product. Still, most of the products we have tested so far leave us slightly dissatisfied in their control flexibility. They seem to be able to do so much, yet each of them has some obvious and often irksome limitation. If these are also perceived as drawbacks by the general public, they will likely be corrected in future models, or in competitive products.

audio test reports:

automatic rewind is a control function of the built-in microprocessor

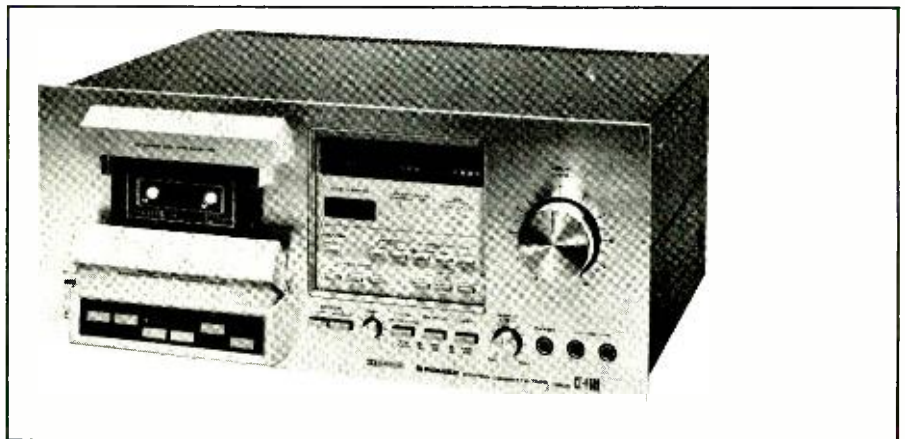


Some interesting new features highlight Pioneer's Model CT-F900 three-head,

two-motor cassette deck. For instance, it has replaced VU meters with fluorescent level indicators; and it has electronic memory controls, a dual-capstan drive system operated through a microprocessor-controlled logic system, and a “double Dolby” system that allows programs to be monitored just as they will sound with noise reduction.

This is a relatively large cassette deck. It measures 16.5”W × 14.5”D × 7.38”H (42 × 36.8 × 18.7 cm) and weighs 24.25 lb (11 kg). An optional rack mounting adapter permits the deck to be installed in a standard 19” (48.3-cm) EIA rack. The suggested retail price of the Pioneer CT-F900 is \$475.

General description. Since the cassette well extends beyond the front panel, the status of the tape on a cassette being played is clearly visible at all



double Dolby, dual-capstan, and fluorescent level indicator in the Pioneer Model CT-F900 stereo cassette deck

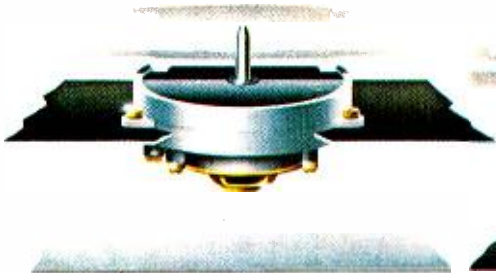
times. When it is first inserted, the machine goes into REWIND for an instant, taking up any slack in the tape so that the portion between the two capstans will be under the proper tension. A hinged cover can be swung up to protect the heads and capstans when no cassette is in place.

The tape transport employs a servo-

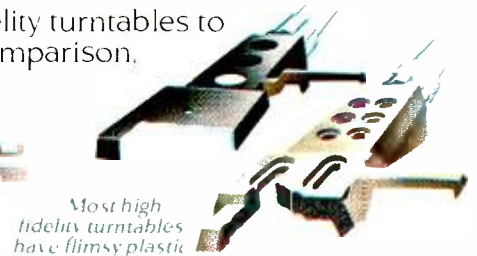
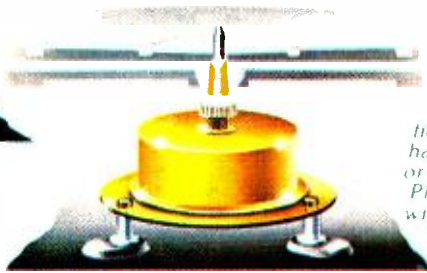
controlled dc motor for the capstan drive and a mechanical governor-controlled dc motor for the hub drive. The transport is controlled by solenoids that are actuated through a logic system by light-touch buttons located on a black panel below the cassette well. Rectangular transport control buttons are grouped functionally.

TO FULLY APPRECIATE PIONEER'S NEW DIRECT-DRIVE TURNTABLE, YOU HAVE TO TAKE APART THE COMPETITION.

When you compare what goes into most \$175* high-fidelity turntables to what goes into Pioneer's new PL-518, you'll find there's no comparison.



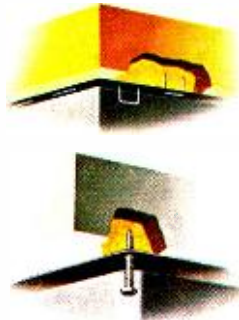
On many turntables, the motor is suspended from the base itself, where the slightest vibration can be picked up by the stylus. The PL-518's direct drive motor is anchored to a metal plate beneath the base, where this is far less likely to happen.



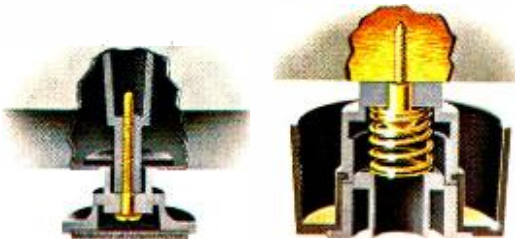
Most high fidelity turntables have flimsy plastic or metal headshells that can distort the music. Pioneer's is made of glass fiber, a substance with far greater mass yet less weight, which is unaffected by resonance.



Many tone arms are mounted on piano wire and cheap plastic casings which vibrate. Instead, ours float on pivot bearings which are immune to vibration.



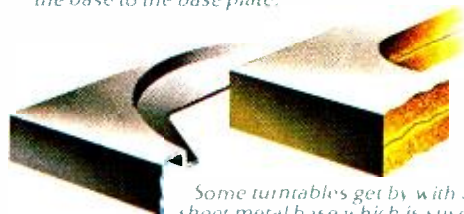
Some turntables are held together by staples, which can work themselves loose. Pioneer uses aluminum screws to seal the base to the base plate.



A lot of turntables have skinny plastic legs that merely support the weight of the turntable. The feet of the PL-518 are spring mounted which helps reduce acoustic feedback. So you can play your music loud enough to rattle the walls without rattling the turntable.



Some rely on 3 ball bearings for stability in the tone arm shaft but Pioneer uses 34.



Some turntables get by with a common plastic or sheet metal base which is susceptible to vibration and can cause acoustic feedback. Not the base of the PL-518. It's made of two solid blocks of compressed wood, which when joined eliminate feedback.

What you see here will tell you a lot about Pioneer's PL-518.

It'll not only tell you what kind of care and engineering went into it, but also the kind of exceptional performance you can expect to get out of it. Performance free of audible distortion, acoustic feedback and rumble.

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John E. Cunningham

**Special Projects Director
Cleveland Institute of Electronics**



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CIRCLE NO. 57 ON FREE INFORMATION CARD

Product Focus

Although the Pioneer Model CT-F900 is not the first cassette deck to employ a microprocessor for certain of its functions, it is the first to our knowledge to use one as a signal processor for operating a digital level display. The instruction manual for the deck does little more than state that the "brain" of the level indicating system is a 4-bit parallel processing chip. The schematic adds a little more information, and shows that the microprocessor is a 28-pin LSI device

The audio levels, as they appear at the LINE outputs of the recorder, are amplified and detected, and the rectified audio is supplied to the LSI chip, where it is apparently sampled at a high rate (an LC tuned oscillator circuit is connected to the IC); digital equivalents of the instantaneous analog levels are generated. The outputs of the LSI chip go to the many terminals of the Digitron level display tube, a 20-segment device whose square fluorescent "dots" are controlled by the digital signals applied to it.

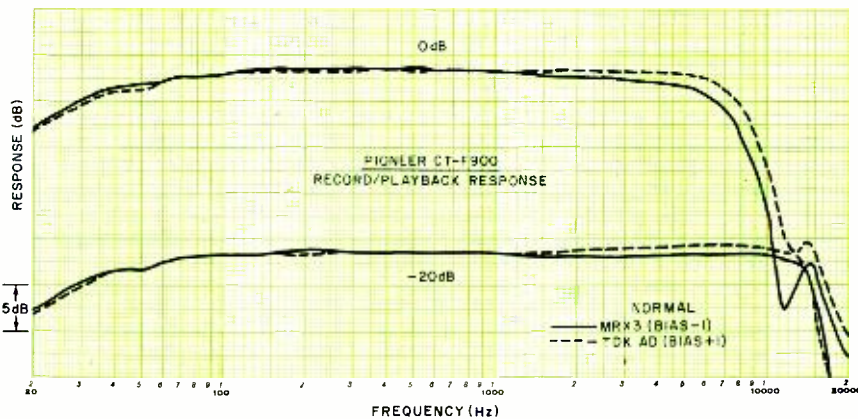
The on/off nature of the display segments removes the ambiguity that detracts from the accuracy and usefulness of most LED peak level indicators. As the level is increased slowly, there comes a point when the next higher segment, even if only 1 dB above the last one to be illuminated, lights abruptly, with no intermediate state of partial brightness. The selection of either PEAK or AVERAGE response is made before the signals go to the microprocessor by changing the signal circuit's time constant.

Although many of the functions of the Pioneer level display can be done with conventional LED systems, we found the very bright, visible, and unambiguous blue Digitron display to be both more useful and more attractive than any of the LED displays we have seen.

Small, colored indicators near the buttons light when the buttons are actuated.

The logic system makes it possible to operate the controls in any sequence without damage to the tape or the deck. Pressing any control while the tape is in motion momentarily stops the deck before executing the change of mode. The transport shuts off and mechanically disengages when the tape stalls at the end of a cassette, or in the event a tape should break.

At the upper right of the panel is a large recording INPUT level control that consists of two concentric knobs coupled by a slip clutch. Below it are two microphone jacks (for dynamic or electret microphones), a stereo headphone jack for low-impedance phones, and a small concentric knob control for adjusting the



Frequency response at two recording levels for two standard tapes.

playback OUTPUT level. In the lower center of the panel are a number of push-button switches. Two are for selecting the program that appears at the LINE outputs (SOURCE or TAPE playback) in the rear. The recording input can be transferred from the rear LINE jacks to the microphone inputs by one of the buttons (the two sources cannot be mixed, however). One button turns on and off

easy-to-read signal level is shown on a fluorescent vacuum-tube display

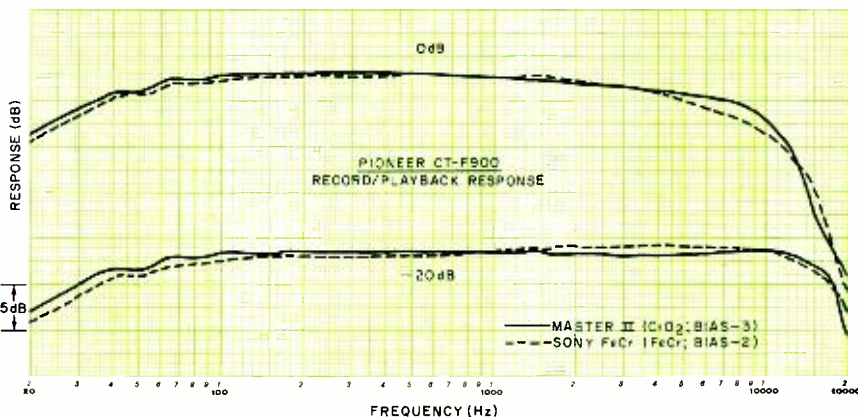
the Dolby system, and another selects the recording bias and record/playback equalization. In the AUTO (out) position of this latter button, the recorder automatically selects the bias and equalization for any ferric (STD) or chromium dioxide (CrO₂ or a "chrome equivalent" tape such as TDK SA, Maxell UD-XL II, etc.) tape. This is done by a sensor

that detects the special notch in the back of a chrome cassette.

When the TAPE button is pushed in, the bias and equalization are set for ferrichrome (FeCr) tape. A small BIAS knob near the TAPE button can be used to trim the bias over a limited range to optimize the recorder for any specific brand of tape within the three basic categories.

Some of the most novel features of the Model CT-F900 are contained in a square indicator and control subpanel in the center of the front. Across its top are two horizontal rows of level indicators from a fluorescent Digitron vacuum tube display that creates a row of blue-lighted squares that moves to the right with increasing signal level. There are separate rows of level indicators for the two channels. Between the rows is a calibrated scale that covers a -20-to-+7-dB range. Below the level-indicator display is a large three-digit TAPE COUNTER display made up of 8-mm high Digitron numerals that can be seen easily from a considerable distance.

Twelve small pushbuttons on the sub-panel control the unique operating features of the CT-F900. The deck has a



Frequency response at two recording levels for "chrome" and FeCr tapes.

Performance Specifications

Specification	Rating	Measured
Frequency Response		
Standard LH tape: (20-17,000 Hz)	30-15,000 Hz ± 3 dB	Within limits
Chromium dioxide tape: (20-19,000 Hz)	30-17,000 Hz ± 3 dB	Within limits
Ferrichrome Tape: (20-19,000 Hz)	30-17,000 Hz ± 3 dB	Within limits
S/N Ratio: Dolby off	Over 54 dB	55 to 63 dB
Dolby on	Over 64 dB	62 to 68 dB
Harmonic distortion	Less than 1.3% (0 dB)	—
Input sensitivity		
MIC:	0.3 mV	0.22 mV
Line:	60 mV	50 mV
Max. Allowable input/imp.		
MIC:	100 mV/30,000 ohms	150 mV
Line:	25 V/100,000 ohms	—
Max. output level	640 mV into 50,000 ohms	—
Fast winding time (C-60)	Under 85 sec weighted	80 sec
Wow and Flutter	0.05% weighted rms max.	0.06% weighted rms

"memory rewind" like that offered on a number of other tape decks, except that it operates entirely electronically through a special purpose LSI microprocessor that can perform four different memory functions. In the MEMORY STOP mode, pressing the rewind button causes the tape to rewind to the point where the indicator reads 000, and stop. MEMORY PLAY is similar, except that it goes into a normal play mode after stopping. REPEAT END operates automatically when the end of the tape is reached, rewinding the tape to its beginning and replaying it. COUNTER REPEAT operates in a similar fashion, except that the tape rewinds to 000 and starts playing from there.

The deck can be operated from an external clock timer for unattended playback or recording of programs. After the machine has been set up for correct recording conditions, it and the program source are plugged into the clock timer and the TIMER START-REC button is pressed. When power is restored by the timer, the recorder automatically goes into the record mode. For playback only, TIMER START-PLAY is pressed.

external clock
timer can be
set for recording

The level meter is more than merely a nonmechanical voltage indicator. It can be set to read AVERAGE levels, roughly corresponding to a VU meter, or to be a PEAK meter that can accurately follow the shortest musical transients. There is also a PEAK HOLD mode, in which the highest peak level attained is held on the display. A button resets the TAPE COUNTER to 000, and colored indicator lights show the status of the MEMORY, DOLBY, and TAPE BIAS systems.

Laboratory Measurements. No information was supplied on specific tapes for which the bias had been set on the tape deck we tested, so we ran frequency-response curves on a dozen or more tapes, adjusting the BIAS control for flat-test response for each tape. Although our BIAS settings usually did not match the recommendations in the manual, the differences were not large, and perfectly satisfactory results should be obtained with almost any good-quality tape. In the absence of built-in oscillators, the best way to make this adjustment is to record interstation FM tuner hiss at a -20 -dB level and switch between the SOURCE and the TAPE monitor signals while adjusting the BIAS control for the closest audible match between the two.

We selected one of each basic tape type for the balance of our tests. (The selection was partly arbitrary, and partly because these tapes seemed to give the

flattest overall frequency response.) Scotch Master II was used for the "chrome" tape. This is a cobalt-treated ferric tape, designed for chrome bias and $70\text{-}\mu\text{s}$ equalization. Sony Ferrichrome was used for the FeCr tape and Memorex MRX3 for the STD tape.

At a -20 -dB recording level, the frequency response was within the manufacturer's limits of ± 3 dB over a range of 30 to 15,000 Hz for STD tape and 30 to 17,000 Hz for the other two tapes. The low-end response dropped off smoothly below about 60 Hz, with almost no sign of the response "ripples" that are typical of most cassette recorders. The response was, in fact, much flatter than the Pioneer specifications would suggest. With Master II tape, it varied less than ± 0.5 dB from 55 to 14,000 Hz, and the other tapes yielded very nearly as good results.

a rare combination
of listening quality
and operating
versatility

The "tracking" of the Dolby circuits was acceptable at a -20 -dB level, where they changed the overall response by about 2 dB over much of the high-frequency range. It was virtually perfect at -40 dB, where there was no detectable change in response until the frequency exceeded 10,000 Hz. The $120\text{-}\mu\text{s}$ (STD) playback equalization was measured with a TDK AC-337 test tape. The response was an excellent ± 0.5 dB from 60 to 12,500 Hz and was up only 1 dB at 40 Hz. At first, it seemed that we would not be able to measure the $70\text{-}\mu\text{s}$ (CrO₂) equalization, since our test tapes do not have the notch that switches the recorder. However, we found that the FeCr switch setting changed the playback equalization to $70\text{-}\mu\text{s}$. With our Teac 116SP tape we found it to be flat within ± 1 dB over the 40-to-10,000-Hz range of the tape.

A line input of 50 mV or a microphone input of 0.22 mV was needed to produce a 0-dB recording level. The microphone inputs overloaded at 150 mV, the highest figure we have measured on a cassette recorder. The playback output from a 0-dB recording varied somewhat with the tape used, from 0.59 volt with Master II to 0.78 volt with MRX3. The third-harmonic playback distortion with a

1000-Hz input signal was measured with each tape as a function of recording level. The reference 3% distortion level was measured at 0 dB with the Master II tape and at -0.5 dB with Sony FeCr. With Memorex MRX3, we measured only 0.5% up to a +3-dB level and had to record at +7.5 dB to measure 3% distortion in the playback mode.

The playback S/N ratio, referred to the signal level that produced 3% distortion, was about 50 dB in an unweighted measurement with Master II and FeCr tapes. It was a very good 57 dB with MRX3. With A weighting, the S/N was 55 to 56 dB with the first two tapes and 63 dB with MRX3. Finally, with CCIR/ARM weighting and using the Dolby system, the S/N was 62 dB with the first two tapes and 68 dB with MRX3. The noise level increased by 18.5 dB through the microphone inputs at maximum gain and by 5 dB when the gain was set to its center position.

Tape speed in our sample machine was about 0.5% fast. In the fast-speed modes a C60 cassette was moved from end to end in about 80 seconds. The flutter, with a weighted rms (JIS) measurement, was a low 0.06%. Even the weighted peak flutter (DIN) was a very good $\pm 0.08\%$. The playback flutter readings were made with a TDK AC-342 test tape. In a combined record/playback measurement, the flutter was 0.07% wrms and $\pm 0.14\%$ weighted peak. The flutter was principally in the 15-to-20-Hz range, with another peak at 55 Hz.

User Comment. When we recorded interstation FM tuner hiss at a -20-dB level and listened to the playback, we

discovered that all three tapes we had chosen were capable of almost perfect response. In each case, there was only a very slight difference in the playback signal that we were unable to eliminate with the BIAS control. Even though the BIAS adjustment appears to lack the convenience of use that we have seen on some other recorders that have built-in test oscillators for making this adjustment, we believe that by using tuner hiss one can actually come closer to an optimally flat response in most cases.

The fluorescent level "meters" worked very well, being accurate and extremely easy to read. In the AVERAGE mode, they indicated about 1 dB low on 0.3-second tone bursts, which is slightly slower than a standard VU meter but still better than most mechanical meters used on consumer cassette recorders. As PEAK indicators, this indicator is one of the best, with virtually instantaneous response and a slow decay that takes a couple of seconds to descend through its full range.

It is worth noting that shutting off the recorder returns the TAPE COUNTER to 000. If one is recording or playing a tape and interrupts it by shutting off the power the electronically controlled index counter reading is lost, unlike the case with mechanical index counters.

Although the manual does not recommend using high-impedance phones with the Model CT-F900, we found that it produced very comfortable listening levels with 200-ohm phones (most recorders cannot). The various special functions of the machine, such as the MEMORY and REPEAT features and TIMER operation, worked perfectly. The automatic tape sensing system excluded older

chromium-dioxide tapes from use. Although the manual does not mention this, these tapes can be played (but not recorded) by pushing the selector button to its FeCr setting.

We can say unequivocally that the Pioneer Model CT-F900 is a first-rate cassette deck. The sound quality of prerecorded tapes and of tapes we made on this machine was uniformly excellent. There is no longer much excuse for distorted recordings due to excessive signal levels. The PEAK HOLD feature lets one know, after one brief practice run, what maximum level to expect from any program. A convenient feature of this deck is its ability to make "flying-start" recordings. This can also be valuable in editing tapes. While listening to a tape, at any point where one wishes to record another program, holding down both the PLAY and REC buttons places the machine in its recording mode.

As we have often found with cassette decks, the greatest dynamic range is usually obtained with a good ferric tape. The chrome and ferrichrome tapes saturate at a lower level, and cannot be recorded as heavily without excessive distortion. However, they have better high-frequency saturation characteristics. So if the program has strong high-frequency content, these tapes will often give the best results, in spite of their slightly reduced midrange.

The Model CT-F900, which stands second from the top in price among Pioneer's six front-load cassette decks, offers a rare combination of listening quality and operating versatility. Combined with a price that is, by today's standards, moderate, it ranks extremely high among other high-quality decks.

CIRCLE NO. 101 ON FREE INFORMATION CARD

solid and conservative design in a premium product: the Luxman Model R-1120 AM/FM stereo receiver

novel afc
circuit is
especially effective



Several AM/FM stereo receivers were added to Luxman's line recently. The most powerful of these is the Model R-1120. It

is rated to deliver up to 120 watts/channel into 8 ohms from 20 to 20,000 Hz at no more than 0.03% THD. The external design of these new receivers is intended to minimize the visual impact of their less frequently used controls and to give the front panel of the receiver an uncluttered appearance without sacrificing any of the operating and control versatility expected of such a deluxe product.

The Model R-1120 is supplied in a rosewood-veneered wooden cabinet. It measures 19¼"W × 16⅝"D × 7⅛"H (49 × 41.5 × 18 cm) and weighs 37.4 lb (17 kg). Its suggested retail price is \$995. An optional Dolby FM decoder module that plugs into the inside of the receiver and



amplifier output is displayed via LED indicators at six levels

is controlled by a front-panel switch is available for \$55.00.

General Description. The front panel and control knobs of the receiver are finished in a pale bronze tone. The contrasting dark-brown dial section is covered by a clear glass window. Behind the window are the long AM and FM scales, separate tuning meters for relative signal strength on AM and center-channel tuning on FM, and a number of LED indicators. One LED, labelled DOLBY FM, is functional only when the Dolby FM decoder module is installed. When the DOLBY FM button is pressed, the FM tuner's deemphasis is changed to 25 μ s, the Dolby decoder is activated, and the LED indicator comes on. If the Dolby module is not installed, pressing the DOLBY FM button silences the tuner's output (the LED remains off).

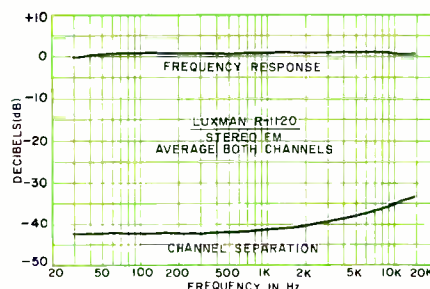
Near the Dolby LED is another LED labelled STEREO FM. This LED comes on only when a stereo-FM signal is being received.

In the lower right of the dial area are two horizontal rows of LED's that make up the peak power indicator. Each of the receiver's two channels is assigned six LED's that indicate 0, -6, -9, -12, -15, and -18 dB, relative to the rated 120-watt output of the amplifier. A pushbutton switch on the front panel can be pressed to increase the sensitivity of the display by 12 dB so that the -18-dB LED comes on when the output is only 120 mW. A switch on the rear apron permits the power display to be defeated if desired.

A large tuning knob bisects the lower edge of the dial cutout and operates a very smooth flywheel tuning mechanism. Above the dial scales is a row of small control knobs and pushbutton switches that are inconspicuous because of their sizes and the fact that their brown color blends with the panel's background. They include pushbuttons for the DOLBY FM system, FM MUTING OFF, tape MONITOR, and tape DECK 1/2 select. The last connects the monitoring inputs to either of two tape decks. A small knob switch is provided for interconnecting the tapes for dubbing from one deck to another. A similar control is used to select the receiver's operating mode, for which there are STEREO, MONO, and REVERSED STEREO.

switch provides dubbing capability for two tape decks

Other pushbutton switches are provided for switching in and out LOUDNESS compensation, a SUBSONIC filter, LOW CUT and HIGH CUT filters; changing the sensitivity of the power display; and switching on and off the POWER. When power is first applied, the speaker outputs are silenced and a red LED near the POWER switch flashes on and off for



Frequency response and crosstalk averaged for both FM channels.

about 7 seconds. After this stabilization period, the speaker outputs are activated and the LED extinguishes. If an overload or short circuit should occur in the output during operation, the speaker outputs are instantly disabled and the LED commences flashing until the fault is corrected.

The remaining control knobs are in a single row across the bottom of the front panel. The INPUT SELECTOR switch has positions for AM, FM, PHONO 1, PHONO 2, and AUX inputs. The smaller bass and treble TONE CONTROL knobs are continuously adjustable and have center detents. Also, pulling out on the knobs changes the turnover frequencies by one octave. (The bass frequencies are 200 and 400 Hz and the treble are 2000 and 4000 Hz.)

The VOLUME CONTROL is concentric with a center-detented BALANCE ring. The SPEAKERS selector switch can be used to connect either, both, or neither

Product Focus

Although in most respects the Luxman Model R-1120 follows conventional receiver design practice, we found, to our surprise, that it has a novel afc system that is not mentioned as such in the instructions or specifications. Our only clue to its existence came from a study of the functional block diagram in the instruction manual, which showed a connection from the detector output, through a "servo amplifier" block, to the FET r-f amplifier stage. This might have been an amplified afc system, except that the afc function was clearly shown as a separate part of the circuit, and a switch on the "servo amplifier" was identified as "FM Tuning Lock" (This is not a physical switch that can be seen on the receiver, however.) We suspected that this was some form of afc, which should have been shown as going to the local oscillator instead of to the r-f amplifier. A little experimenting confirmed this.

Although this afc system is nondefeatable, and as a rule we consider a non-defeatable afc to be highly undesirable, as used in the Model R-1120, it proves to be a strong "plus" feature. It is actually disabled electronically at all times, except when the receiver is tuned very close to the center of a channel (so that the tuning meter's pointer has entered its center segment). At that point, the afc takes over and imperceptibly pulls the tuning all the way to its correct point. This system prevents the afc from interfering with tuning in a weak signal adjacent to a channel occupied by a strong signal, yet it makes mistuning virtually impossible.



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NEW

Computerized Weather Monitor



If you need weather information for ANY purpose, the ID-4001 is the way to get it! This microcomputer-based weather instrument displays — time of day in 12 or 24-hour format; wind direction and magnitude; indoor and outdoor temperature; barometric pressure; even wind chill factor! What's more, the computer's memory stores the highest and lowest data for each function so you can recall it for easy and accurate record keeping. Chart recorder and computer outputs provide even more versatility!

NEW

Rack-Mount Stereo Components



Heath has developed an entire new line of sophisticated audio equipment designed to offer the striking good looks and versatility of rack mounting combined with specifications and performance capabilities that are the equal of the finest components available today! The AA-1600 Stereo Power Amplifier features 125 watts, minimum RMS, per channel into 8 ohms, with less than 0.05% total harmonic distortion from 20-20,000 Hz. The AD-1700 provides a graphic LED display of power output to monitor system performance and help prevent overloads. Other components soon to come will be a versatile, low-distortion stereo preamplifier, and a deluxe digital FM-AM Stereo Tuner.

NEW

Digital Readout Car Clock with Trip Timer



Versatile clock/timer for any vehicle shows time in hours and minutes, has 24-hour timer that reads to nearest second. Bright, easy-to-read display, low-power circuit doesn't drain battery.

NEW

Deluxe Dual-Trace Oscilloscope



Low-priced dual-trace scope ideal for audio and TV servicing. Features outstanding sensitivity, extra-bright traces, selectable triggering, 7-position variable time base, DC to 5 MHz bandwidth.

NEW

Hand-Held 2-Meter Transceiver



Superb features specifications and a great low price make the VF-2031 a terrific buy in a hand-held two-meter transceiver. Features 8-channel simplex with ± 600 kHz offset using one crystal per channel, minimum 2 watts out, and 0.5 μ V sensitivity for 20 dB quieting. Includes built-in antenna, nickel-cadmium batteries and battery charger. An optional tone encoder and other accessories also available.

NO PREVIOUS EXPERIENCE NECESSARY

Thousands of people with no electronics experience whatsoever — people who have never handled a soldering iron before — have proved that you can build any Heathkit product you want — and enjoy every moment of it! Simple step-by-step manuals make it easy as 1-2-3, and every Heathkit product you build will be a source of pride and satisfaction for years to come as you say "I built it myself"!



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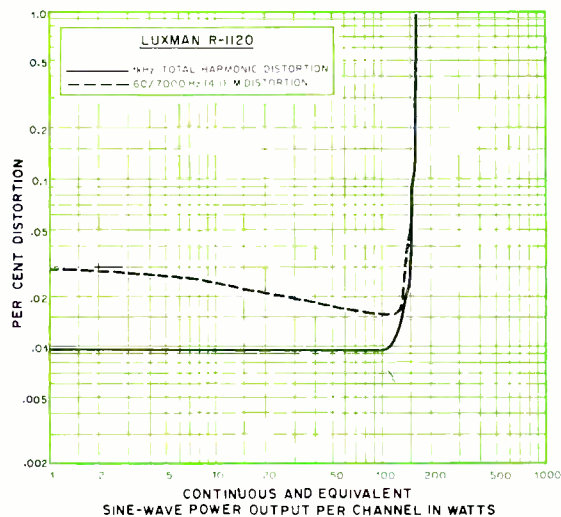
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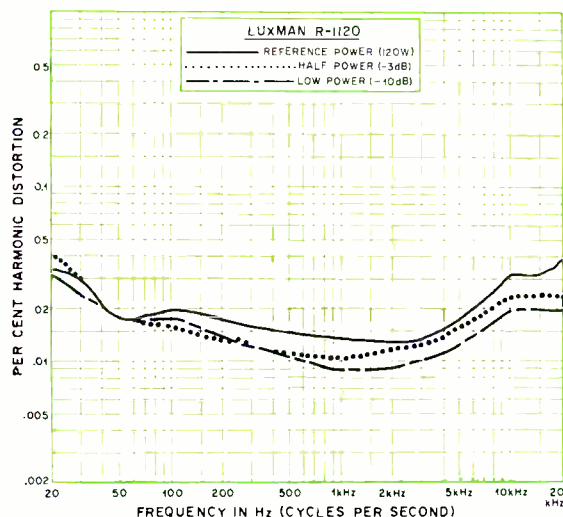
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Total harmonic distortion and 60/7000-Hz distortion.



Harmonic distortion at three power levels.

of two speaker systems to the amplifier's outputs and has an additional position for driving a separate pair of electrostatic speaker systems through their own separate output terminals on the rear apron. The labelling for the front-panel switches is on the dial window above the respective knobs. (The fluted metal knobs do not have clearly visible index lines, which is one of the few sacrifices made in the interest of style in the Model R-1120.)

On the receiver's rear apron are insulated connectors for the speaker outputs, two ac convenience outlets (one switched), and the various input and output jacks, including a DIN socket that duplicates the functions of one set of tape connections. In addition to terminals for external antennas, there is a hinged AM ferrite rod antenna and a switch that attenuates the FM antenna input near powerful stations that might overload the front end of the FM tuner.

1000-Hz THD was only 0.011% at rated 120 watts

Laboratory Measurements. The one-hour preconditioning period at one-third power left the top of the receiver above the output section very hot. However, the receiver was comfortable to the touch elsewhere. It delivered a clipping output of 144 watts/channel at 1000 Hz into 8-ohm loads, with both channels driven. (The IHF Clipping Headroom was 0.8 dB.) Into 4- and 16-ohm loads, the output clipped at 159 and

Performance Specifications

Specification	Rating	Measured
Power output (8 ohms, 20-20,000 Hz)	120 W at 0.03% THD	Confirmed
IM distortion	0.03%	Confirmed
Input sensitivity		
Phono	2.5 mV (120 W)	0.22 mV/1 W
Aux	160 mV	15.5 mV/1 W
Phono overload	160 mV	162 mV
S/N		
Phono	72 dB (re 120 W)	61 dB (re 1 W)
Aux	88 dB	61 dB (re 1 W)
Dynamic headroom (20-ms burst at 1000 Hz)	Not specified	2.13 dB
IHF slew factor		2.21
FM Section		
IHF sensitivity		
Mono (across 300 ohms)	10.3 dBf (1.8 μV)	11.0 dBf (1.9 μV)
Stereo " " "	17.2 dBf (4.0 μV)	15.7 dBf (3.3 μV)
50-dB quieting sensitivity		
Mono (across 300 ohms)	14.1 dBf (2.8 μV)	12.8 dBf (2.4 μV)
Stereo " " "	36.8 dBf (38 μV)	38 dBf (44 μV)
Alternate-channel selectivity	80 dB	69 dB
S/N at 65 dBf		
Mono	74 dB	73 dB
Stereo	70 dB	69.5 dB
Frequency response (stereo)		
50-10,000 Hz	+0.2/-1.5 dB	+0.6/-0.3 dB
20-15,000 Hz	+0.2/-1.5 dB	+0.6/-0.9 dB
1-kHz distortion at 65 dBf		
Mono	0.1%	0.09%
Stereo	0.2%	0.19%
Capture ratio at 65 dBf	1.3 dB	1.7 dB
Image rejection	80 dB	86 dB
AM suppression	55 dB	66 dB
Stereo separation:		
100 Hz	45 dB	42 dB
1 kHz	48 dB	41 dB
6 kHz	42 dB	37.5 dB
Subcarrier product ratio	60 dB	78 dB
AM Section		
Frequency response (-6-dB points)	Not specified	250-4500 Hz

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Now you can forget about price/performance trade-offs when you select a frequency counter. In Sabtronics' Model 8100 you get features you once expected to pay several hundreds of dollars for. But you pay only our low, low price of \$89.95!

Dare to Compare. This frequency counter, using LSI technology, has the performance and input characteristics you demand. Note the specifications: You will see that the frequency range is guaranteed all the way to 100 MHz; and a high or low input impedance allows you to select for high-frequency operation. And you'll see a sensitivity that holds well over the frequency range; convenient selectable gate-time for best resolution; and selectable attenuation; and even an optional pre-scaler. Note the highly accurate time base, and its excellent ageing and temperature characteristics. And a full 8-digit LED display with floating decimal point, leading zero suppression, and overflow indicator.

You would expect to find all these features together only on a much higher-priced instrument. But Sabtronics' advanced digital technology combines with your own skill — you assemble this kit from our easy-to-follow instructions — to make it possible for you to have this fine frequency counter at a fraction of what you would otherwise expect to pay.

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Examine the 8100 Frequency Counter Kit for 10 days. If not completely satisfied, return unassembled for full refund of \$89.95 purchase price.

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Brief Specifications

- Frequency Range: 20 Hz to 100 MHz guaranteed (10 Hz to 120 MHz typical)
- Sensitivity: 25 mV RMS, 20 Hz to 70 MHz (20 mV typical); 45 mV RMS, 70 MHz to 120 MHz (30 mV typical)
- Selectable Impedance: 1 M Ω at 25 pF, or 50 Ω
- Selectable Attenuation: X1, X10, or X100
- Accuracy: \pm 1 Hz plus time-base accuracy
- Ageing rate: \pm 5 ppm/yr
- Temperature stability: \pm 10 ppm, 0 $^{\circ}$ to 50 $^{\circ}$ C
- Selectable Gate-time: 0.1 sec, 1 sec., or 10 sec.
- 8-digit LED display with floating D.P., overflow indication
- Input: 9-15 VDC, 350 mA (550 mA with optional prescaler)
- Input protection: 150 V RMS, 20 Hz to 10 kHz; 30 V RMS to 2 MHz; and 3 V RMS to 100 MHz
- Optional prescaler extends frequency range to 650 MHz. (Available soon)

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PE 11

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 Frequency Counter Kit(s) at \$89.95 each \$ _____
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97.5 watts, respectively. The 1000-Hz THD was less than 0.01% up to 100 watts output, and was only 0.011% at the rated 120 watts and 0.02% at 140 watts. IM distortion was 0.03% at the rated 120 watts and 0.02% at 140 watts. IM distortion was 0.03% at 0.1 watt. It dropped to 0.017% at 100 to 120 watts and was only 0.04% at 150 watts.

The THD at the rated 120-watt/channel output was less than 0.02% from 40 to 6000 Hz. It rose to 0.036% and 0.04%

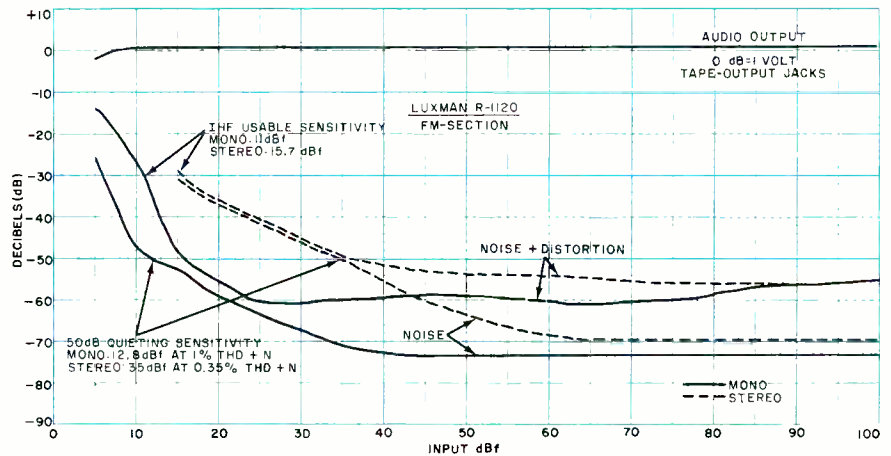
Muting action of FM tuner was ideal

at 20 and 20,000 Hz, respectively. The distortion at reduced output levels was lower, but followed a similar characteristic. To drive the amplifier to a reference output of 1 watt, as called for in the new IHF-A-202 standard, required an AUX input of 15.5 mV or a PHONO input of 0.22 mV. The A-weighted S/N in both cases was 61 dB, referred to 1 watt. The PHONO input overloaded at a safe 162-mV level at 1000 Hz.

The amplifier's dynamic headroom, when driven by a 20-ms toneburst at 1000 Hz, was 2.13 dB, since it could deliver just shy of 200 watts into 8 ohms under this condition. The amplifier was stable with capacitive loads as great as 2 μ F in parallel with 8 ohms through its normal speaker outputs. We made no measurements through the electrostatic speaker outputs, which are driven through an RC network, presumably to improve the amplifier's stability margin. The IHF slew factor was 2.21.

The peak-power indicators proved to be very accurate, and their instantaneous response made them highly effective indicators of the true peak power output in each channel. The R-1120's tone-control curves were conventional when the 400- and 2000-Hz turnover frequencies were used, but were much more useful with the 200- and 4000-Hz frequencies. These allowed the response to be adjusted at the frequency extremes. This is of importance because here's where this correction is most likely to be needed, without affecting the midrange response or the overall sonic balance.

Audio filters had the desirable 12-dB/octave slopes, with -3-dB response frequencies of 45 and 6000 Hz. They were



Noise and sensitivity curves for FM section of tuner.

considerably more effective than most filters in their ability to reduce noise without undue loss of program content. The effect of the subsonic filter was below our measurement range, but it reduced the 20-Hz response by only 1 dB. The loudness control boosted both low and high frequencies by an amount we feel was much too heavy-handed. RIAA phono equalization was accurate within +0/-1 dB from 50 to 20,000 Hz. It was down 3 dB at 20 Hz. There was a very slight interaction with the phono cartridge inductance, which boosted the output by about 0.5 dB in the 5000- to 20,000-Hz range.

FM tuner performance ratings and our measurements are shown in the Specifications table. The AM frequency response, reasonably good at high fre-

RIAA phono equalization was accurate within +0/-1 dB from 50 to 20,000 Hz

quencies, was severely reduced at low frequencies for no apparent reason.

User Comment. As the test data shows, the Luxman Model R-1120 receiver met or exceeded virtually all of its specifications. Some of the apparent discrepancies resulted from differences in test conditions, but none of them

affected the usefulness or actual performance of the receiver.

The receiver had the "feel," smoothness of operation, and overall elegant quality that we found to be characteristic of Luxman products we have used in the

operating smoothness, elegant appearance are evident in overall design

past. This is one of the intangibles that one expects to enjoy in any premium-priced product like this Luxman receiver. The muting action of the FM tuner was ideal, with no trace of noise when tuning through a station and a barely perceptible time delay in the unmuting.

The Model R-1120 does not have separate preamplifier outputs and power amplifier inputs, but this was just about the only significant omission among its features. It is easy to forget how versatile this receiver actually is because so many of the controls that contribute to its versatility are small and are designed to blend with their background.

At first glance, the Luxman Model R-1120's price might seem rather high on a watts-per-dollar basis. But considering its performance and features, its styling and flexibility, and the very solid and conservative design and construction that is in evidence throughout it, the R-1120's cost is not at all excessive. Clearly, it's a premium product.

CIRCLE NO 102 ON FREE INFORMATION CARD

(Continued on page 44)

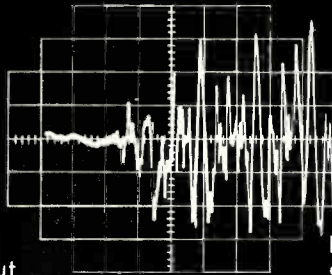
Technics Linear Phase SB-4500A. For people with an ear for waveform fidelity. And an eye for beautiful cabinetry.

If you keep up with the latest in hi-fi successes, you already know about Technics Linear Phase Speaker Systems. The Technics speaker systems with waveform fidelity: The ability to reproduce a musical waveform that's virtually a mirror image of the original. Now you can know Technics Linear Phase Speakers for something else: Beautiful simulated walnut wood cabinetry. Introducing the SB-4500A.

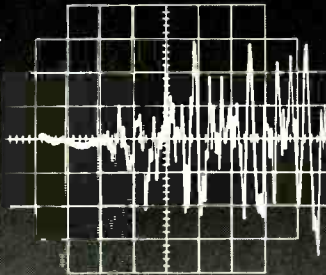
Like our other Linear Phase Speakers, the SB-4500A is capable of achieving not only a wide frequency response, but also flat amplitude and precise linearity.

And if seeing is believing, look at the waveforms. On top is the oscilloscope reading (the fingerprint) of a live piano waveform.

The other, the piano waveform as reproduced by the Technics Linear Phase



Live Piano Waveform.



Piano Waveform reproduced by SB-4500A.

SB-4500A. That's waveform fidelity you can see as well as hear. And that sounds better than good. That sounds live.

How did we do it? First by conducting exhaustive amplitude and phase studies in acoustically perfect chambers. Then by developing a unique new phase-controlled crossover network that not only compensates for the time delays caused by different frequencies, but simultaneously corrects any acoustic differences in the drivers. And finally by staggering each driver unit for the optimum acoustic position.

Technics Linear Phase SB-4500A. Your ears will love the way it sounds. Your eyes will love the way it looks.

Technics

Professional Series

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frequency response is less dependent on load conditions than other cartridges



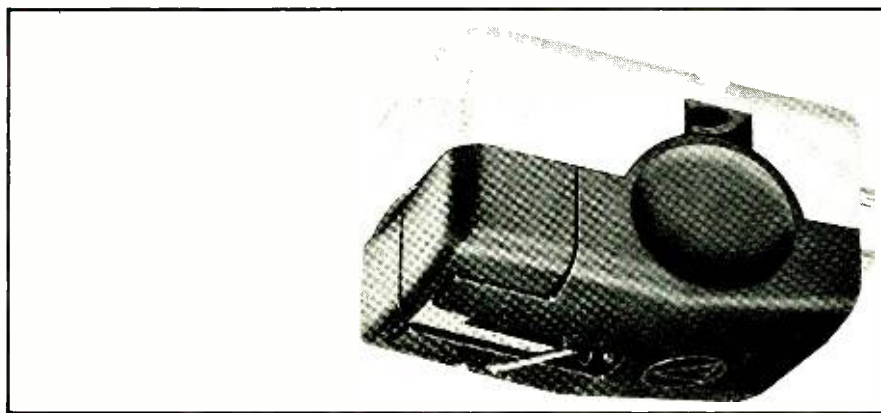
Signet phono cartridges are premium-quality products made by a division of Audio-

Technica. The Signet series employs a dual-magnet transducer design. There are two models for stereo and one for CD-4 quadraphonic reproduction. Both of the stereo versions, one of which is the Model TK7E reviewed here, have a tapered aluminum cantilever with a 0.2- \times -0.7-mil elliptical nude diamond stylus. The Model TK7E has a special "Micro-Mass" cantilever and diamond. Its coil windings have minimal inductance and resistance, making the cartridge's frequency response less dependent on external load conditions.

Suggested retail price for the Model TK7E phono cartridge is \$150.

General Information. The typical moving-magnet cartridge has a single magnet on its cantilever. The flux of this magnet is distributed between the pole pieces for the two channels as the stylus moves in the record groove. This generates a voltage in each winding, proportional to the magnitude of the magnet's excursions between the pole pieces. This Audio-Technica dual-magnet design employs two separate magnets mounted on the cantilever at an angle of 90° to each other. The combined mass of the two magnets is claimed to be less than the mass of the single magnet used in typical cartridges. In addition, the moving magnets are located as close as possible to the cantilever's pivot point to reduce their contribution to the effective moving mass at the stylus tip.

The cantilever tube in the Signet series of cartridges is tapered to achieve optimum combination of low mass and high rigidity. The Signet cartridges are normally supplied with styli that have aluminum cantilevers. However, the wide variety of accessory styli available gives the user considerable latitude in choosing the parameters of his stylus. These styli can be ordered from any Audio-Technica dealer and are the same price as the standard replacement styli.



premium-quality, dual-magnet design in the Signet Model TK7E stereo phono cartridge

The styli can be replaced by a user with ease. The Signet stylus itself is a square-shank nude diamond installed through a square hole in the flattened tip of the cantilever tube. This system accurately positions the stylus surfaces relative to the record groove walls. It has a minimum effective mass, owing to its small size and the fact that it is bonded

three stylus shapes are available for greater versatility

to the cantilever instead of being mounted with a metal holder. In the accessory series, each cantilever material is offered with a choice of three stylus shapes: 0.5-mil spherical, 0.2- \times -0.7-mil elliptical, and Shibata. There is also a low-mass aluminum cantilever with a 0.5-mil spherical tip and a heavier aluminum cantilever with a 2.5-mil spherical tip for playing 78-rpm discs.

Laboratory Measurements. We tested the cartridge in the tonearm of a Dual Model 701 record player. The installation instructions did not list a specific load capacitance for the cartridge, but it did suggest keeping the capacitance to a minimum. We loaded the cartridge with 280 pF across the recommended 47,000-ohm load, since this is a typical circuit capacitance in stereo systems. We did, however, check the effect

of load changes on the frequency response.

With a fixed 47,000-ohm load, changing from 190 to 280 pF had negligible effect on the frequency response. An increase to 420 pF produced a peak at 10,000 ohms, after which a rapid drop-off in output was observed. With a fixed 280-pF load, the flattest response was obtained with 47,000 ohms. An increase to 100,000 ohms caused a rise in output beyond 5000 Hz, to a maximum of +4 dB at 20,000 Hz. All basic performance and listening tests were performed with a tracking force of 1.25 grams.

Using the CBS STR100 test record, the cartridge had a response of 40 to 20,000 Hz \pm 1 dB. The high-frequency and midrange output levels were the same, but there was a broad dip in the range between 3000 and 5000 Hz. Channel separation was about 20 dB in the midrange, 18 dB at 10,000 Hz, and 11 to 12 dB at 20,000 Hz.

styli are easily replaceable by the user

The cartridge's output measured 3.65 mV at a 3.54-cm/s velocity, and the channel levels were matched within 0.2 dB. The vertical stylus angle was 22°. The combined low-frequency tonearm/cartridge resonance was about 7 Hz at an amplitude of 8 dB.

(Continued on page 50)

The last word. We thought we'd said it last year. But it turns out we spoke too soon.

The reason for our premature announcement is the Touch K500. It's not just more to say, it's almost a whole new vocabulary in scanners. With totally new words to describe totally new features. For example.

RAM* Scanning: Program in frequency numbers. Enter them into channels. Then scan the channels to hear a call. Simple concept. Monumental capability. Because the Touch K500 gives you 40 channels to scan any of 15,757 different frequencies. You need never even mention the word "crystals".

ROM* Scanning: There are no words or numbers required. Just choose from the three sets of frequencies: police, fire, or marine and weather. Then tap the symbol that corresponds to the set you've chosen. The red light symbol is for police, the flame means fire and the boat will get you marine, weather and mobile phones. Next, get ready. The Touch K500 will promptly scan through every common frequency in the ROM set. So you can actually scan police calls without ever knowing the frequencies, just remember that the red light symbol calls the cops.



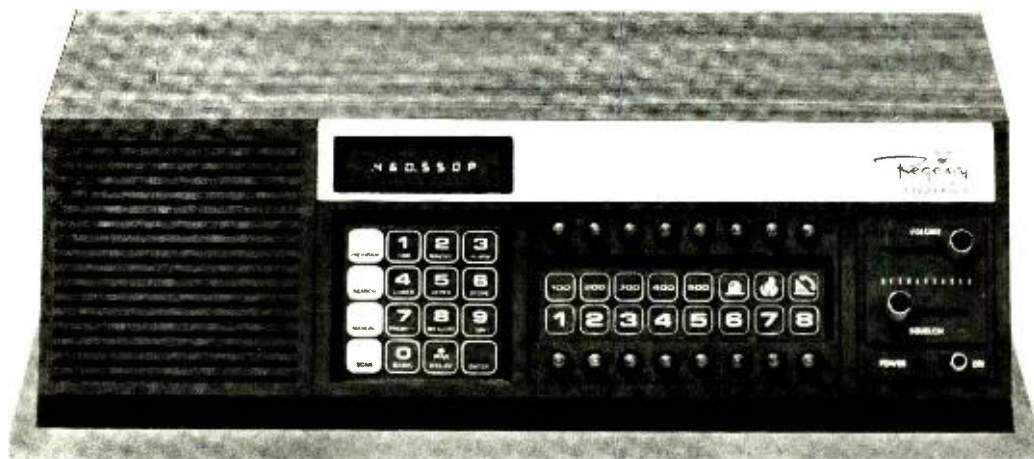
Search and Store: With a conventional radio you turn the tuning dial to seek new signals. With ours you search automatically. Besides being easier, our system has some definite performance advantages. Because the Touch K500 not only covers each frequency individually, it also remembers where it heard a call. You can go on searching and enjoying. Then later, you can ask the radio to go back and recall the frequencies it heard. As always, it will respond instantly to your touch.

Et Cetera: There's a lot more to say about our Touch K500: like priority, programmable scan delay, channel activity count, remote equipment switching, Weather Alert[®], and even digital clock with alarm. But enough of our speech. There's something more important you should hear. That is:

The Good Words: Try it. When you go to your Regency retailer, to see the Touch K500, the best thing he can say is: "Try it". Because after just one touch, you'll know you're listening to the scanner from the company that's said it all: Regency.



Last year we introduced the last word in scanners. This year we've got more to say.



MORE—591 Channels, Search, Store, Time—MORE

Regency Electronics, Inc. • 7707 Records St. Indianapolis, IN 46226

*RAM: Regency Alterable Memory

*ROM: Regency Organized Memory

NOVEMBER 1978

CIRCLE NO. 59 ON FREE INFORMATION CARD

45

ANNOUNCING ... A New CREI Program: Minicomputer & Microprocessor Technology Including A Microprocessor Laboratory

Now you can learn at home
the new technology that is
revolutionizing electronics

The microprocessor has ushered in the age of microtechnology and electronics will never again be the same. The microprocessor has made possible the placing of an entire computer on a silicon chip one quarter inch square. The microprocessor "miracle chip" is in the process of changing the world. Soon all technical personnel in electronics will have to understand and work with the microprocessor. It is invading virtually every area of electronics. And it is profoundly affecting your electronics career.

Brand New Program

CREI has a brand new program to help you learn how to work effectively with this revolutionary electronics development. CREI's new program in Minicomputer and Microprocessor Technology is designed to prepare you for this field by giving you the education and practical experience you need.

The program provides solid preparation in electronics engineering technology with a specialization in minicomputers and microprocessors. In addition, it includes a microprocessor laboratory which features a fully programmable microcomputer which utilizes the Motorola 6802 microprocessor chip. This is an extremely important element of your program.

Programming Essential

As you may well know, you must learn how to *program* the microprocessor in order to design, service or troubleshoot microprocessor electronic systems. There is only one effective way to learn this all-important skill of programming, and that is by actually *doing it*. CREI's new program gives you this opportunity as you work with the exciting microprocessor laboratory.

Programming Is Easy

With CREI's new program, learning the skill of programming is simple. Within a few hours you'll be programming the microprocessor and in a short time you'll learn how to program it in three languages: BASIC, assembly and machine languages. In addition, you will learn how to interface the microprocessor with other systems and to test and debug specialized programs.

Preparation at Home

Wide Choice of Programs

Please note, however, that CREI's new program is only one of 16 state-of-the-art programs in advanced electronic technology offered by CREI. So even if you choose not to specialize in microprocessor technology, CREI has an advanced electronics program to meet your needs.

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- Industrial Electronics
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- Cable Television
- Radar and Sonar
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- Solid State Theory
- Nuclear Engineering

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Tracking tests revealed that the cartridge had outstanding tracking abilities over the full audio range. Using the German Hi Fi Institute record, the 60-micron level of the 300-Hz tones could be played at the cartridge's 0.75-gram minimum rated force. At the 1.25-gram force we used, the 90-micron level could be played without audible mistracking (very few cartridges can do as well). At 1.5 grams, the cartridge could play the rec-

ord's 100-micron maximum level. Our other high-level test records could be played at forces from 0.75 to 0.9 gram.

outstanding tracking abilities over the full audio range

We measured tracking distortion with

the Shure TTR102 and TTR103 records. The TTR102 is a conventional IM test record, with frequencies of 400 and 4000 Hz recorded at velocities ranging from about 7 to 27 cm/s. The measured IM distortion was between 0.8% and 0.9% (which we believe to be the residual of the test record) for velocities up to 15 cm/s. It increased smoothly and gradually to 2% at 23 cm/s and 3.5% at 27 cm/s.

With the high-frequency tracking tests of the TTR103 test record, which has shaped 10,800-Hz tone bursts at a 270-Hz repetition rate, the repetition-rate distortion was very nearly as low as we have ever measured. It varied between 0.7% and 1.1% as the velocity increased from 15 to 30 cm/s. These measurements were made at 1.25 grams and clearly illustrate the Model TK7E's very excellent tracking ability. The square-wave response with a CBS STR112 test record revealed a single cycle of ringing, with a small overshoot at a frequency we estimate to be at about 15,000 to 20,000 Hz.

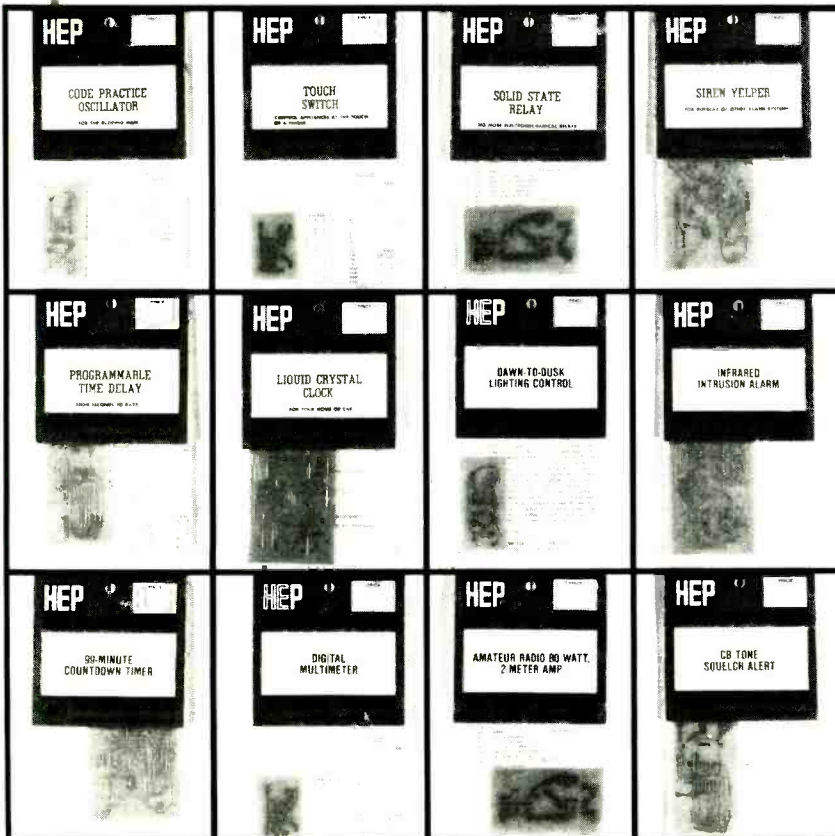
User Comment. Our measurements left little doubt that the Signet Model

Performance Specifications

Specification	Rating	Measured
Frequency response	5-30,000 Hz	40-20,000 Hz \pm 1 dB
Tracking force	0.75-1.75 g	1.25 g
Channel balance	0.75 dB	0.2 dB
Channel separation: 1 kHz	30 dB	20 dB
10 kHz	22 dB	18 dB
Output @ 5 cm/s	2.7 mV	5.1 mV
Stylus tip	0.2 \times 0.7 mil	_____
Vertical tracking angle	20 degrees	22 degrees
Recommended load impedance	47,000 ohms	47,000 ohms/280 pF
Cartridge inductance	370 mH	_____
DC resistance	500 ohms	_____
Cartridge weight	6.8 g	_____

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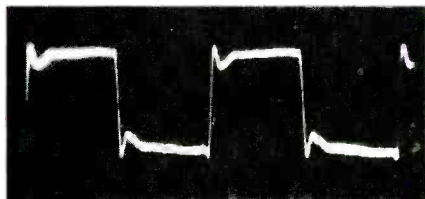
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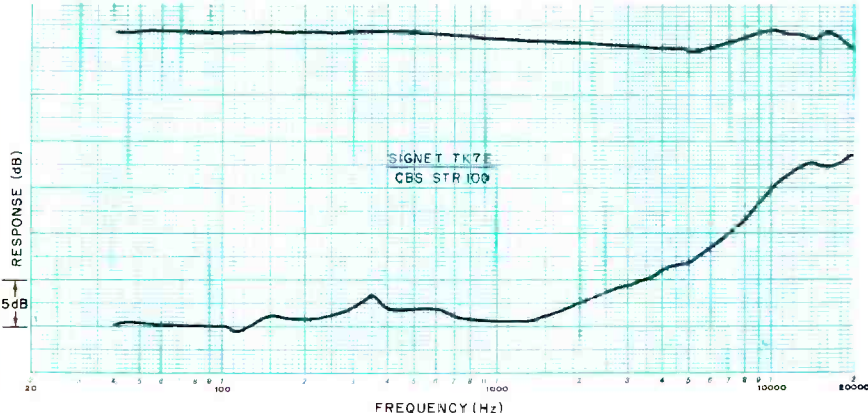
HEP

TK7E was an outstanding stereo phono cartridge. Just how outstanding, however, can be determined only by listening. First, we played the Shure Audio Obstacle Course tracking test records. With the older Era III record in this series of records, only a trace of "sandpaper" quality at the highest level of the sibilance test prevented the cartridge from achieving a perfect score. Even this slight mistracking was corrected by increasing the tracking force to 1.75 grams.

Although we have less experience with the newer Era IV test record, it has revealed that it is a much more severe test for high-frequency tracking than the older record, to say nothing of being far more demanding than almost any commercially pressed music disc. In view of



Square-wave response to STR112.



Composite response and crosstalk using CBS STR100 test record.

this, we were most impressed to discover that the Signet cartridge could track everything on the record without audible signs of distress. After this ordeal, listening to conventional records was almost anticlimactic.

Rarely have we heard a cartridge whose sound had such total ease, smoothness, and lack of coloration. Especially noticeable was the silent background. Record hiss was distinctly lower than we have heard from the same records with most other cartridges. Let one get the impression that this cartridge must be heard under the most demanding conditions to be appreciated, we hasten to report that we

were struck with how unstrained the sound was with every record we played.

It is interesting to observe that, with the possible exception of our tracking distortion measurements, there was nothing in our test data that clearly and unequivocally correlated with this cartridge's sound quality. To be sure, all the test data was first rate, but we have used cartridges that "tested" as well as or better than this one, yet did not have the listening quality of the Model TK7E. Only a few moments of listening to it are enough to place this cartridge in its proper place among the very few "finest" on the market today.

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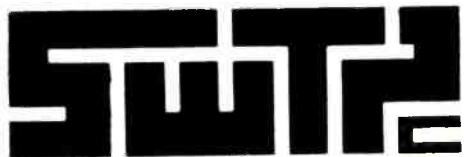
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A Basic Guide to Digital Logic Probes, & Clips, & Pulsers



Hewlett-Packard Model 548A Logic Clip and 546A Logic Pulser.

How to use low-cost digital test equipment

TROUBLESHOOTING digital logic circuits can often be simplified by the use of low-cost testers especially designed for this purpose. These include logic probes, clips and pulsers. Every modern-day electronics experimenter, designer and service technician should know how to work with these important digital testers, as well as have an understanding of the sundry attributes.

Homebrew Testers. The most commonly used logic testers are the probe and pulser. Very basic versions of these, suitable for building in a test lead, ball-point pen, or spark-plug tester, are shown in Fig. 1.

The logic probe (Fig. 1A) is a state checker. It tells whether an input or output pin of an IC is "high" (logic 1) or "low" (logic 0). The clip lead attaches to the positive supply. The LED comes on when the probe is touched to a point at ground potential (low or logic 0) but remains off for a high state. You could also use a voltmeter, bearing in mind that for TTL, high is greater than 2.4 volts and low is less than 0.8 volt; but it is simpler to use a logic probe. It is also safer because it lets you keep your eye on the IC you are probing to avoid shorting adjacent pins and possibly damaging the IC.

It is generally convenient to trigger a logic circuit manually during troubleshooting, using a logic pulser. To use the one shown in Fig. 1B, clip one end of the capacitor to ground and touch the other end (prod) to the positive bus to charge the capacitor to the bus voltage. Then touch the prod to the input of a gate to be tested; the capacitor will discharge, creating a positive pulse. Now monitor the output of the gate with a logic probe.

The homebrew instruments just described are very crude, of course, but they do illustrate some fundamentals of the commercial instruments. For example, the simple LED state checker gives an unambiguous reading for only one state. The probe's LED lights for the low

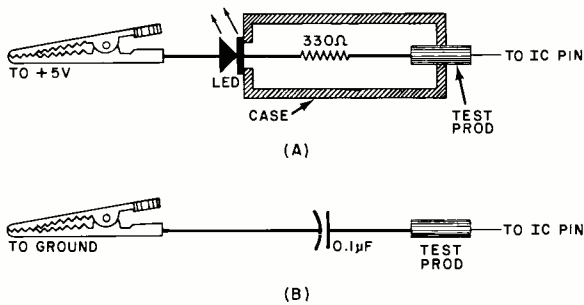


Fig. 1. How to construct your own logic probe (A) and pulser (B).

state and remains off for the high state. Unfortunately, it also remains off in the case of an open in the circuit or IC. A good commercial logic probe, in contrast, gives a positive indication of a low state or high state, as well as detecting bad levels (between high and low), single pulses, and pulse trains.

Logic Probes. A logic probe is much simpler to set up and use than a scope or meter. One simply connects the probe's clip leads to the power supply of the circuit being tested, touches the probe to the circuit point to be tested, and looks for an indication on the probe.

There are a host of different logic probe designs available. Continental Specialties and Kurz-Kasch probes have three indicators (LEDs for CSC and red, white, and blue lamps for Kurz-Kasch) to indicate highs, lows and pulses. AVR probes have two LEDs that indicate highs and lows and flash for pulses. Hewlett-Packard probes have a band of light all around the tip for omnidirectional viewing. The light is at full brilliance for highs, half brilliance for opens or poor levels, and off for lows. Production Devices probes indicate highs and lows with high- and low-frequency audio tones, and a new audio-visual model has LEDs as well.

When the power leads of a logic probe are connected to a circuit's power supply, circuitry inside the probe automatically programs the logic thresholds. For the TTL family, the circuitry sets logic thresholds at about 16% of the supply voltage for lows, and 48% for highs. Hence, a low indication occurs for potentials less than 0.8 volt, and a high indication occurs for potentials greater than 2.4 volts. There's a "no-man's"

land between the thresholds (Fig. 2) where the absence of a light or tone indicates an open circuit or bad level.

Figure 2 shows how the HIGH and Low LEDs indicate negative pulses from a high level or positive pulses from a low level. A probe can also indicate the duty cycle of pulses in a train (percent of time the logic level is high), since this determines the amount of time the LEDs are on (and thus their relative brightness).

Probes sometimes have a PULSE indicator. For continuous trains of pulses within the frequency limits of the probe, the PULSE LED blinks at a steady rate, typically of 3 or 10 Hz. For displaying short single-shot pulses, probes usually have a pulse-stretcher circuit that detects pulses of 200, 50, or even 5 ns, turning the PULSE LED on long enough to make a visible flash.

Probes sometimes even give a rough idea of pulse frequency. For square-wave pulses of 50% duty cycle, the CSC probe, for example, flashes its PULSE LED and turns on both HI and LO state LEDs if the frequency is below 100 kHz, or neither state LED if the frequency is above 100 kHz.

The ability of some probes to detect pulses as short as 5 ns and to handle frequencies of 50 or 100 MHz shames some very expensive oscilloscopes.

Buyer's Guide. In evaluating a probe, consider these capabilities:

Single Pulse. Look for an ability to catch short, intermittent single pulses and detect "glitches" (noise transients). The minimum detectable pulse width of probes varies widely. Some are capable of detecting pulses as narrow as 5 or 10 ns, something that is difficult to do with even a high-performance scope.

Memory. Some probes have a switch-selectable memory mode in which the leading edge of a pulse latches a flip-flop on to keep the PULSE LED lighted. This means you do not miss a short pulse because you blinked or turned your head when the LED flashed. It also means you can clip the probe in place and wait as long as necessary to trap a troublesome glitch. Or you can hang the probe on a backplane, make a change to the circuit under test, and come back to see if anything has happened. Best of all, a probe with memory costs a fraction as much as a memory scope.

Input Impedance. The input impedance of a probe must be high enough not to affect your measurements. For example, a low resistance into a Schottky gate will overload a low-power output in the low state.

Overload Protection. Most probes have input-overload protection that prevents damage even if the probe is plugged into a wall socket for 15 to 30 seconds.

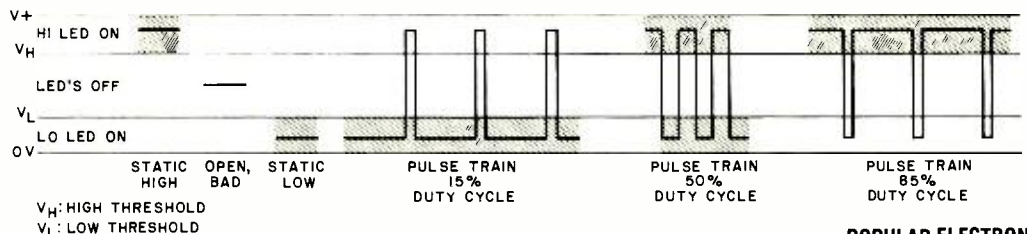
Bad Levels. A probe should be able to detect bad levels between logic high and low. Ideally, it should be able to distinguish between highs, bad levels, and high impedance in three-state logic.

Multifamily Use. Some probes are compatible only with TTL and DTL. Others are compatible with TTL/DTL at one switch setting, and with CMOS and high-threshold families at another setting. Interestingly, the AVR probe requires no switch setting to go from one logic family to another.

When a logic probe is connected to the power supply of a circuit to be tested, circuitry inside the probe automatically sets the thresholds for high and low according to the supply voltage. For TTL, the thresholds for high and low are typically 48% and 16%, respectively, of the supply voltage. For other families they are typically 70% and 30%, although they may be 60% to 70% and 15% to 30%. Figure 3 shows how to connect a probe for various families. Always connect the positive (red) clip to the more positive power-supply terminal and the negative (black) clip to the more negative terminal.

(Continued on page 61)

Fig. 2. Illustration shows the three light-indication possibilities of a logic probe under given circuit conditions.



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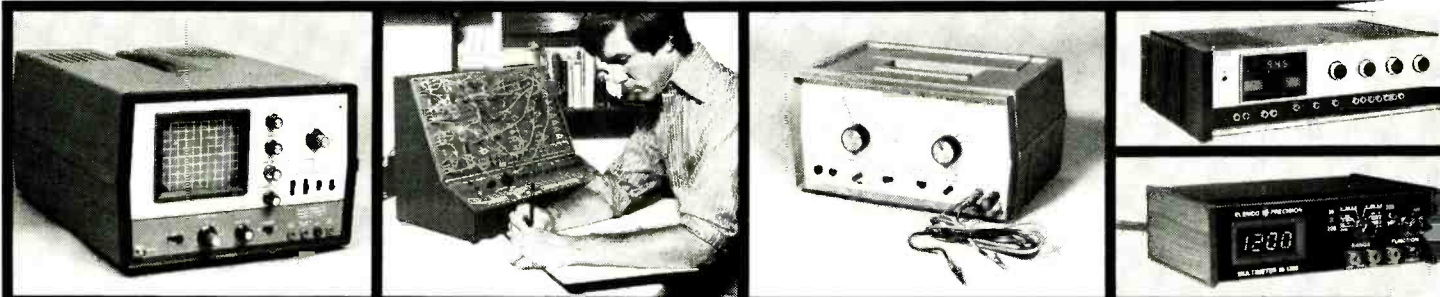
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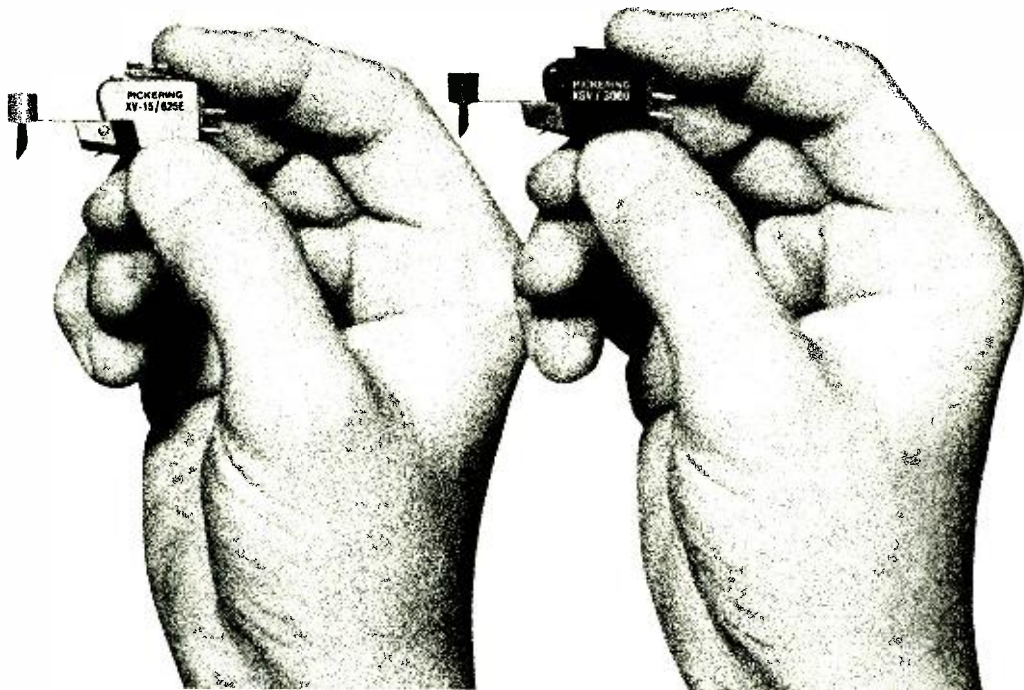
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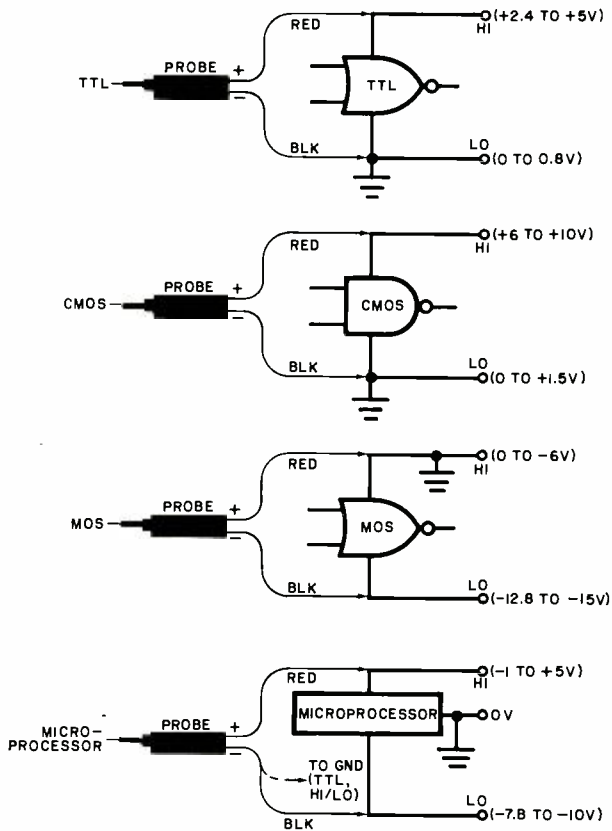
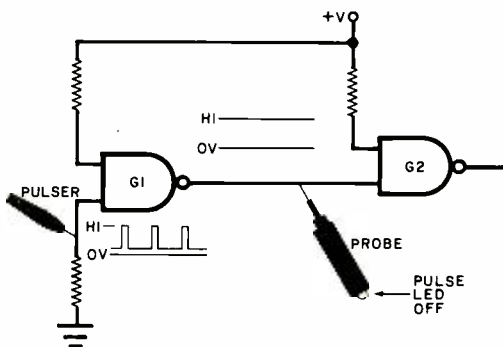
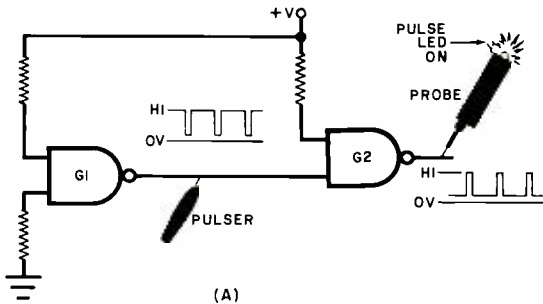


Fig. 3. Probe connections and tester thresholds for various logic families.

Sometimes the thresholds based on the supply voltage of the circuit under test may not be the ones needed. You can redefine the thresholds by connecting the probe's power clips to another power supply whose 70% and 30% points correspond to the desired thresh-



NAND TRUTH TABLE

INPUTS		OUTPUT
0	0	1
0	1	1
1	0	1
1	1	0

(B)

Fig. 4. Using a logic probe and a pulser to test a NAND gate.

olds, connecting the grounds of the two supplies together.

Logic Clip. A logic clip is another easy-to-use digital tester. Unlike the logic probe, it checks a number of points simultaneously. You just clamp it over an IC DIP package and two rows of LEDs instantly indicate the logic states of all pins. There are no controls to set—even even any power leads to connect. The clip's circuitry automatically locates the positive and ground supply pins, whichever way you connect the clip. You cannot connect it incorrectly. In contrast to these advantages, clips do have some relative shortcomings, as follows.

Logic clips cannot test many circuits

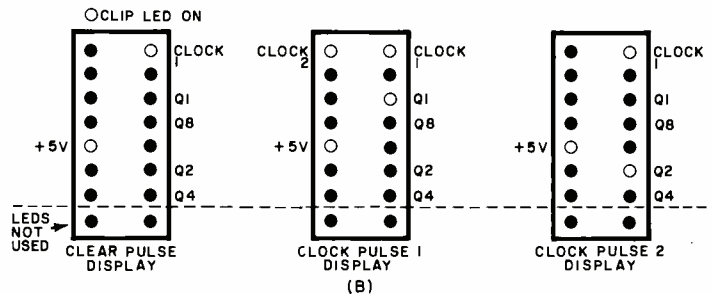
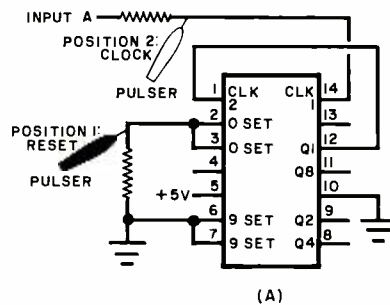


Fig. 5. Checking a 7490 decade counter with a logic clip and pulser. (A) Shows IC pins and pulser signal injection points. (B) Illustrates clip's expected display.

that probes can, though they can give indications faster with static or slow-changing signal conditions (one simply can't monitor many fast-changing LEDs at the same time). Some clips are limited to 7 volts, while others can be used with ICs that have up to 15 or 18 volts between any two pins without suffering damage. Clips operate with positive-voltage logic families (TTL, RTL, DTL, CMOS, etc.), which means that they will not work with some MOS ICs and ICs with three supplies (such as -12 volts, ground, and +5 volts).

A logic clip has a single threshold, for logic high. It does not have a low threshold and, therefore, cannot indicate a bad

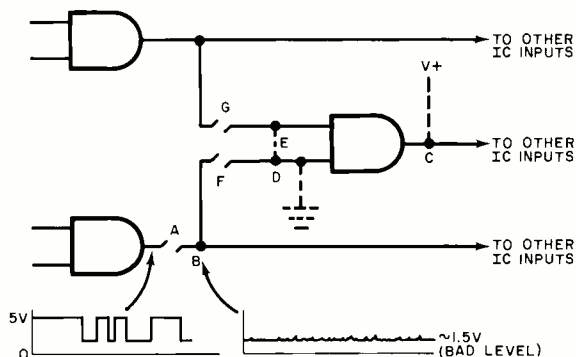


Fig. 6. Five steps to follow in isolating the most common faults in digital logic circuits.

level. The latter shows up as a high state on a clip. A clip also lacks pulse-stretching circuitry, so it cannot indicate narrow single-shot pulses. For viewing these or high-frequency pulses, you *will* need a probe.

Depending on the supply voltage and how many LEDs are on, a logic clip may draw 100 or 200 mA. This can tax some power supplies, especially if the clip is left in continuous operation.

The logic-high threshold of most clips is about 1.5 to 2 volts, which is compatible with TTL and DTL. In comparison, the costlier H-P Model 548A, has a threshold that is 34% to 46% of the supply voltage, and is also compatible with CMOS and other positive-voltage logic families.

A logic clip is usually used with a pulser to check sequential-logic ICs such as flip-flops, latches, counters, shift registers, and adders. A clip is sometimes useful for testing gates, too. For example, if the clip shows that the output pin of a 4-input NAND gate is constantly low and that the NAND gate's inputs are not all high, then as a look at a NAND truth table will reveal, the output must be shorted to ground.

Logic Pulser. A commercial logic pulser is much more than a capacitor in a probe, as in our earlier home brew example. It is (or should be) a high-quality pulse generator with the versatility of a laboratory pulse generator minus the complicated controls. Just clip the pulser's leads to the power supply of the circuit under test, touch the pulser to the point to be stimulated, and press the PULSE button. All circuits connected to that point, outputs as well as inputs, are briefly driven to their opposite state. There is no need to unsolder any pins. Whether the test point is high or low, the pulser drives it to the opposite state each time you press the button. Holding down the button produces a series of pulses. The pulses should be bounceless, safe for the circuit under test, capable of overriding the state of any normal (unshorted) circuit node, and tailored to the logic family being tested.

Usually, the pulser is teamed with a probe for testing logic gates, and either

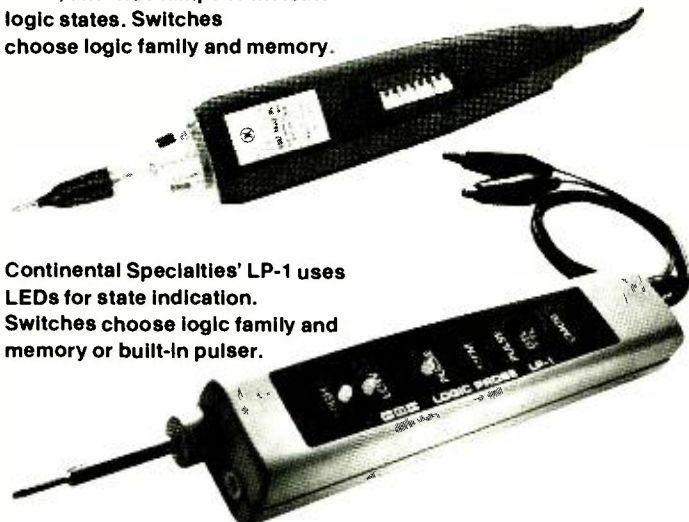
a probe or clip for testing sequential circuits such as flip-flops and counters. To test a gate, the pulser drives the input while a probe monitors its transmitted pulses at the output. (A probe is required because a clip cannot monitor the pulser's narrow output pulses.)

Assume that the output of NAND gate G1 in Fig. 4A is being held high, causing the output of G2 to be low (refer to the NAND truth table). When its button is held down, the pulser overrides the high output state of G1 and places a train of pulses on the input of G2. Accordingly, a train of narrow logic-high pulses appears at the output of G2. The PULSE LED of the probe flashes, indicating pulse activity and the LOW LED glows continuously to indicate a low that is going high. Although the output of G2 is stuck at a low level, the gate is not defective since it does indeed transmit pulses from the pulser.

Next, assume that the probe and pulser are moved to the positions shown in Fig. 4B. The pulser now applies a series of high pulses to the input of G1. Note that the pulser automatically supplies pulses of the proper polarity with no intervention by the operator. If the PULSE LED of the probe does not respond, gate G1 is defective and is the likely source of the stuck level at the output of G2.

Assume now that a 7490 decade counter sequential circuit is to be checked with a logic clip and pulser (Fig. 5). First, attach the 16-pin clip to the 14-pin IC (Fig. 5A) (the top or bottom two LEDs are not connected). Touch the pulser to the reset input and press the PULSE button once to inject a zero pulse into the IC and zero the outputs (Q1, Q2,

The Kurz-Kasch Model 670 probe has red, white, and blue lamps to indicate logic states. Switches choose logic family and memory.



Continental Specialties' LP-1 uses LEDs for state indication. Switches choose logic family and memory or built-in pulser.



In AVR's "Catch -A-Pulse," two LEDs indicate high and low states and flash for pulses.

Q4, Q8). The display should be as shown at the left in Fig. 5B. Next, move the pulser to the clock input and single-step the counter through its decade cycle (0 to 9 decimal, 0000 to 1001 binary). After the first clock pulse, the LED for Q1 lights, indicating a count of 1. After the second clock pulse, the LED for Q2 lights and the LED for Q1 goes out, indicating a count of 2. Continuing this way, you can check the counter over its entire cycle of operation.

A probe is often all you need for testing sequential ICs. The circuit in which the IC is used can provide the pulses. For example, if there is a clock signal on a decade counter and the enabling inputs (usually reset lines) are enabled, the output should be counting. You can check this by monitoring the clock and enable inputs with a probe. If the probe indicates pulse activity on the outputs, you can assume that the IC is operating okay. When ICs fail, they usually do so completely and produce a circuit node stuck at a high, low, or bad level. Usually, it is not necessary to observe the timing relationships of the signals in a circuit under test, which would require an oscilloscope. An indication of pulse activity by a logic probe is normally sufficient evidence of proper operation.

Checking Logic Circuits. The most common defects found in digital circuits are shown in Fig. 6. The following five steps, performed in the sequence shown, will isolate the trouble quickly.

1. Narrow down the area of possible trouble by testing for bad nodes with a probe. A node is simply a circuit junction

point common to two or more gates or other elements. A bad node may be stuck at logic high or low or somewhere in between. Service literature for the equipment under test, or a knowledge of the equipment, will usually suggest points to monitor with a probe.

2. Check for an open bond in the IC driving the failed node. An open output at A in Fig. 6 would cause the node at B to float to a bad level of 1.4 to 1.5 volts. Inputs connected to B would interpret this as a high level, but a logic probe would not be fooled! It would indicate a bad level. The IC driving the node should be replaced.

3. If the node is not at a bad level, then test for a short to V+ (point C) or ground (D). Inject a pulse at the suspect node while monitoring the same node with a probe. The pulser is powerful enough to override even a low-impedance TTL output, but it is not sufficiently powerful to cause a change of state on the V+ or ground bus. Therefore, the absence of a pulse indicates that the node is shorted to V+ if it is high or to ground if it is low.

In case of a short, examine the circuit board for solder bridges, shorted-together pins, etc. If this does not isolate the short, then it is equally likely to be an internal short in any of the ICs attached to the node. Try replacing the IC driving the node and then each of the other ICs until the problem disappears. (Sometimes there may be a shorted capacitor or resistor attached to the node.)

4. Check for a short between two nodes (E in Fig. 6). Pulse one failing node and observe each of the other fail-

ing nodes with a logic probe. If there is a short between the pulsed and probed nodes, the probe will detect the pulse. To verify the short, transpose the probe and pulser and check again. As a further check, you can remove the circuit board from the system and investigate the short with an ohmmeter. The most common short between nodes is a circuit-board short caused by a solder bridge, loose wire, or other visible defect. Only if the two shorted nodes are common to one IC can the failure be inside the IC. If the short is not visible, replace the IC.

5. If you still have not isolated the problem, check for an open input bond (F in Fig. 6), a failure of the internal steering circuitry of the IC, or an open in the circuit outside the IC (G in Fig. 6).

With an open input bond (F), a signal appears at the input pin of the gate, but the gate responds as if a static high were applied. A failure of the steering circuitry will cause the output of an IC to be stuck high or low. In the case of a circuit open, inputs attached to the left side of the break will be driven normally, while inputs to the right will float to a bad level that looks like a static high.

In Conclusion. Logic probes, clips, and pulsers provide a digital answer to digital problems. Many of them cost less than you would pay for a multimeter. There are times, however (especially in complex computer circuitry), when a logic comparator is desirable because it can check out a host of logic levels simultaneously under dynamic conditions. But comparators are costly and require a large inventory of good ICs. ◇

Production Devices' Model 95 Indicates highs and lows with audio tones.



CSC's 16-LED Logic Monitor clip displays states of all IC pins at once.



Micronta three-LED Digital Logic Probe



COMPARING AUDIO "CLICK" AND "POP" SUPPRESSORS



DURING the past year or so, a new type of audio signal processing accessory has made its appearance. Usually called a "click and pop" suppressor, its function is to remove or greatly reduce the audible transient sounds resulting from scratches and blemishes on the surface of a phonograph record. Although nothing can be done to restore to perfect condition a scratched disc, it is possible to greatly reduce the annoyance from the resulting clicks. "Pops" are another form of record noise, which usually result from disc imperfections and the ever-present electrostatic charge (with its attendant crackling sounds) on the disc.

The designer of a noise-reducing accessory must first determine how to recognize noise and to distinguish it from program material. Fortunately, a

record scratch has several unique characteristics that distinguish it from the music: (1) It usually produces a vertical displacement of record material thereby generating an out-of-phase record modulation. (2) It has a very fast attack and decay time. This contrasts with normally slow action of musical sounds (even high-frequency percussive sounds decay slowly, though attack time is fast). (3) The transient will be brief in duration, lasting no more than one or two milliseconds. Musical sounds are always of greater duration. Although commercially available suppressors differ in most of their circuit details, all operate on the same general principles.

Once a transient noise is identified, the next step is to remove it without affecting the program. Though the audio signal can simply be blanked out for the

duration of the noise pulse, this leaves a "hole" in the program that can be just as audible as the "spike" of noise. Hence, each click and pop suppressor has been designed to fill in the holes in the program as unobtrusively as possible. It is necessary, therefore, for each system to pass the program through a time-delay circuit, since a finite time is required for the sensing circuits to determine that a noise pulse is present. Any suppression that occurs must be applied from the beginning of the transient.

The incoming program in suppressors is split into two paths. One path delays the signal for a short time before passing it through a gate or other circuit that is used to remove the transient. The other path passes the signal with no delay to the sensing circuits that control operation of the gate. Each of the competing



The SAE Model 500 impulse noise-reduction system.



Garrard's Model MRM 101



Now you can step up to higher fi with a new breed of record noise-removal audio components

BY JULIAN HIRSCH

suppressors on the market is claimed to use a different method for filling in the hole left by the removal of the noise transient, but the manufacturers are vague about the details of their techniques.

External measurements on a device like a click and pop suppressor (or any dynamic signal processor, for that matter) are at best an incomplete and unsatisfactory method of judging its performance. We chose, therefore, to depend mostly on subjective side-by-side comparisons, using measurements only where they could be truly informative.

Let us take a close look at the presently available click and pop suppressors and compare them on the basis of published specifications (see Table).

SAE Model 5000. The first click and pop suppressor to reach the market was

the SAE Model 5000 impulse noise-reduction system. This compact black box has input and output jacks as well as a second set of tape recorder input and output jacks that duplicate those on the amplifier used for connecting the suppressor into an audio system. INVERT, DEFEAT/NORMAL, and MONITOR switches are at the top of the front panel. The DEFEAT switch bypasses the suppressor circuits entirely, while the MONITOR button has the same function as the monitor button on the amplifier, except that it processes the signals going to the tape recorder through the impulse-noise suppressor circuits to remove transient noises from a disc program being copied onto tape.

The INVERT switch is used with a SENSITIVITY slide control to adjust the operating threshold. When INVERT is en-

gaged, the output from the system consists of only the noise pulses removed. As the SENSITIVITY control is moved up from zero, clicks and pops on the disc will be heard emerging from a silent background. If it is advanced too far, portions of the program will be heard as well. Hence, the correct adjustment point is obtained when only the pops are heard. Then, releasing the INVERT switch allows the program to be heard.

SAE's literature states that portions of program material immediately preceding and following the noise pulse are evaluated and substituted for the chopped-out portions. It also states that since this takes less than a millisecond, the substitution cannot be heard.

Burwen Model TNE 7000. This transient noise eliminator is manufac-



Music Recovery Module.



The Burwen Model TNE 7000 noise eliminator.

CLICKS and POPS

continued

tured by KLH. The design is based on the premise that noise transients last no more than 2 μ s; that they have attack and decay times of 50 to 200 μ s; and that they have high-energy content in the ultrasonic region from 20 to 50 kHz, where there is little or no music.

When the Burwen device senses the presence of impulse noise, using the above criteria, it cuts off the direct program for the duration of the noise pulse. However, instead of a delay of several milliseconds, the Model TNE 7000 has a very short 40- μ s delay in its signal path. It is much faster in operation than the other suppressors and is able to blank the signal for a period as brief as 80 μ s. A smoothing circuit that substitutes a smoothly varying signal for the program is used to fill in the hole instead of the abrupt transition of the noise gate to make the suppression inaudible.

This is a fairly large component. Like the SAE Model 5000, it has no power switch and is meant to be switched on and off by the amplifier's switched convenience outlet or left on continuously (it draws negligible power).

In the center of the front panel are pushbutton DEFEAT and TAPE MONITOR switches. The latter replaces the amplifier's tape monitor switch, since the device connects to the amplifier in the same manner as does the SAE device. The DEFEAT button allows one to bypass the noise-suppression circuit when it is not needed.

A large SENSITIVITY control is at the left of the panel, and next to it is a LED labelled HIGH FREQUENCY CALIBRATION. The control is used to adjust the sensitivity of the suppressor to high-frequency signals (in the vicinity of 30,000 Hz) that are used to actuate the noise-blanking gate. When the control is correctly set with relation to the noise "floor," the LED noticeably dims. At the right of the panel is another control labelled THRESHOLD, accompanied by a LED labelled TRANSIENT NOISE ELIMINATION. As the control is turned clockwise, transient

Test results in Figs. 1-4 are for SAE 5000, Figs. 5-7 are for Burwen 7000. Time base is 1 ms/div., except 1 μ s/div. for Fig. 7. Test signal is 10,000-Hz tone burst on 10,000-Hz sine wave. Fig 1 shows 0.4-ms burst input
(Continued above on following page.)

Fig. 1

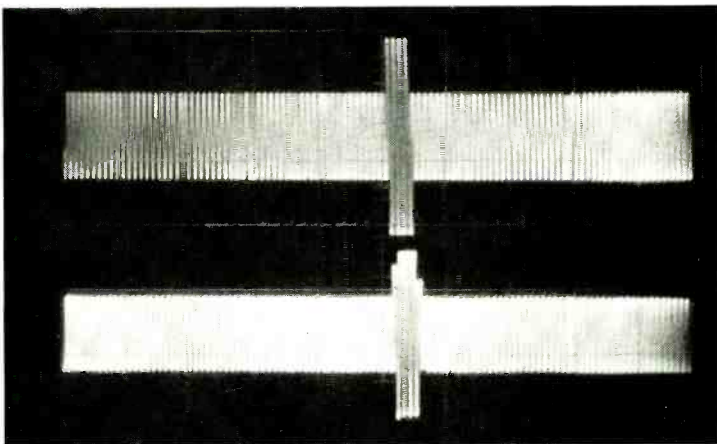


Fig. 2

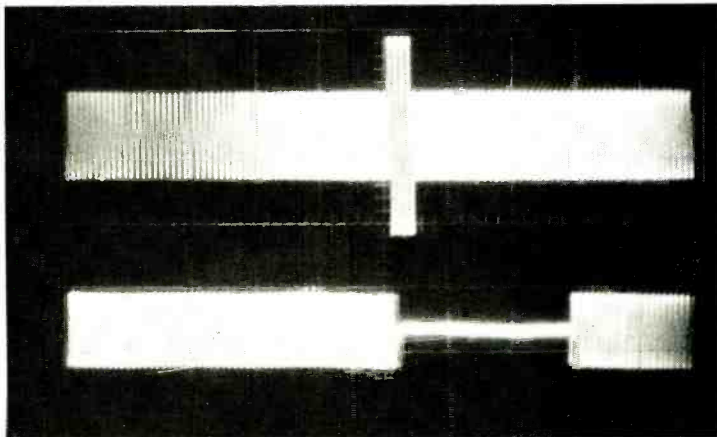


Fig. 3

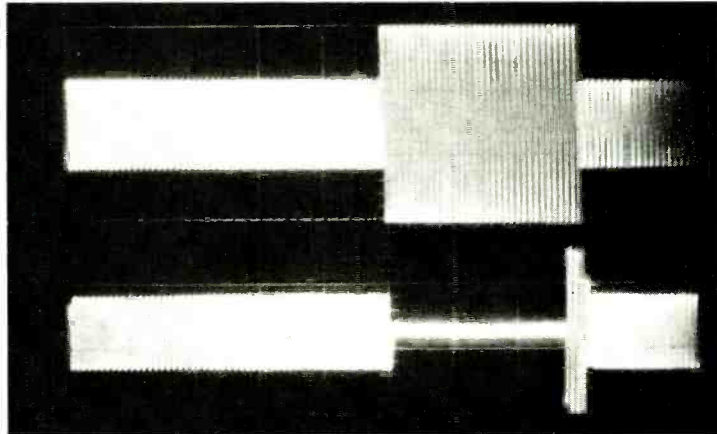
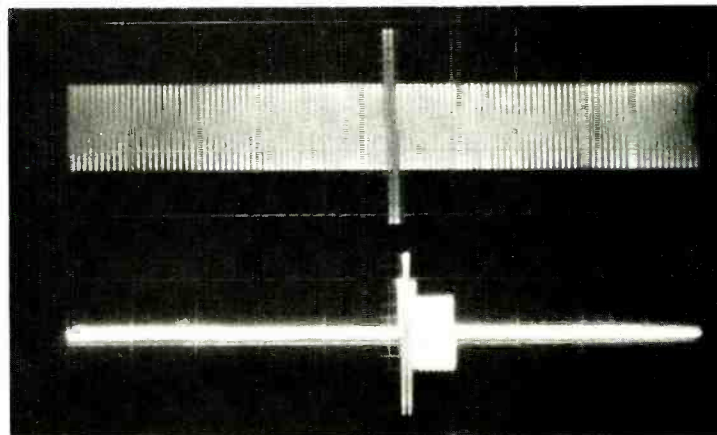


Fig. 4



(Continued from preceding page.)

and output with suppressor defeated. Fig. 2 is same with suppressor in use. In Fig. 3, burst is 3 ms, suppressed for only 2.7 ms. Fig 4 shows output with INVERT switch activated. Figs. 5 and 6 can be compared to Figs. 2 and 3. In Fig. 7, lack of fill-ins is shown when burst is shortened to 100 μ s.

noise causes the LED to flash, which indicates that the noise is being removed from the signal.

Since the Model TNE 7000 uses noise impulse energy in the vicinity of 30,000 Hz to trigger its circuits, it is desirable to use it with a cartridge that has extended high-frequency response. A CD-4 cartridge is ideal, for example, but the system will function properly with any reasonably good cartridge.

Garrard Model MRM 101. Garrard's suppressor is named, somewhat cryptically, a "Music Recovery Module." Unlike the other suppressors, which are designed to connect into an audio system via the amplifier's tape-monitoring loop, where it can be used to remove transient noise impulses from any program source, the Model MRM 101 can be used only on phono sources. It contains its own RIAA-equalized preamplifier, whose output can be connected to a high-level (AUX) input on an amplifier or receiver.

The Model MRM 101 identifies transient noises by using the same criteria employed in the Burwen and SAE systems. The decision time of the Garrard device's logic is 0.4 ms, and a 2.7-ms program delay is used so that the device can suppress a transient from its onset. The program delay is accomplished with a 256-stage "bucket-brigade" IC. Instead of attempting to fill the hole left in the program by the deleted pulse, the pulse is blanked to a depth of 34 dB with a smoothly operating optical attenuator. A LED/photoreistor circuit reduces the gain smoothly and relatively slowly, in contrast to an abrupt cutoff action, while another LED/photoreistor circuit returns the gain to its original level after the transient passes. This cycle of pulse recognition, gain reduction, and gain restoration takes about 2.5 ms and falls within the 2.7-ms program delay period. Because of the smooth change in gain, the action is relatively inaudible.

At the left of the Model MRM 101's front panel is the POWER switch. At the right is the SUPPRESSOR on/off switch; a red LED lights when the suppression circuits are switched in. The remaining control is simply labelled MIN and MAX at its rotation extremes. Near it is a red

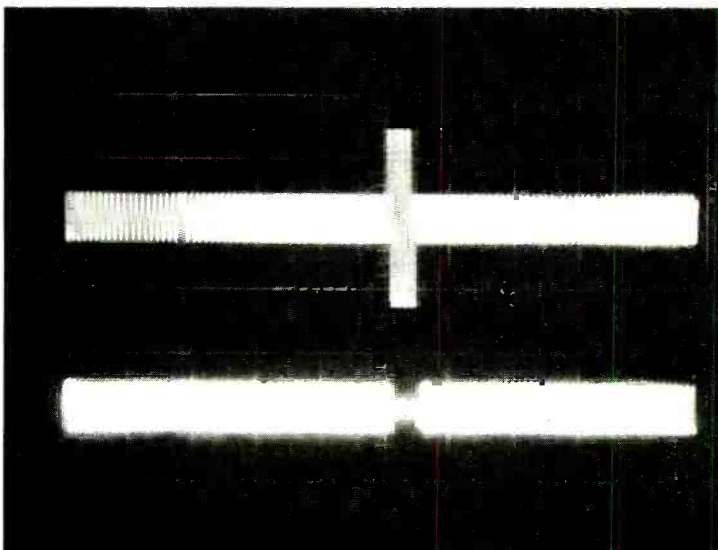


Fig. 5

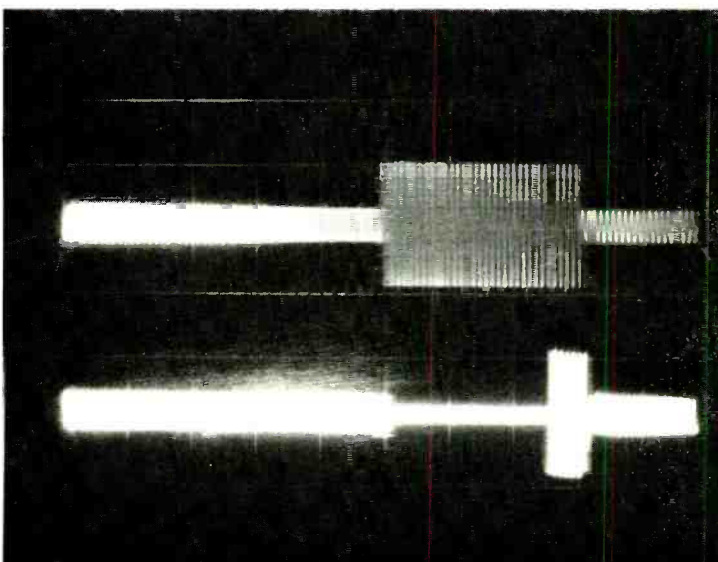


Fig. 6

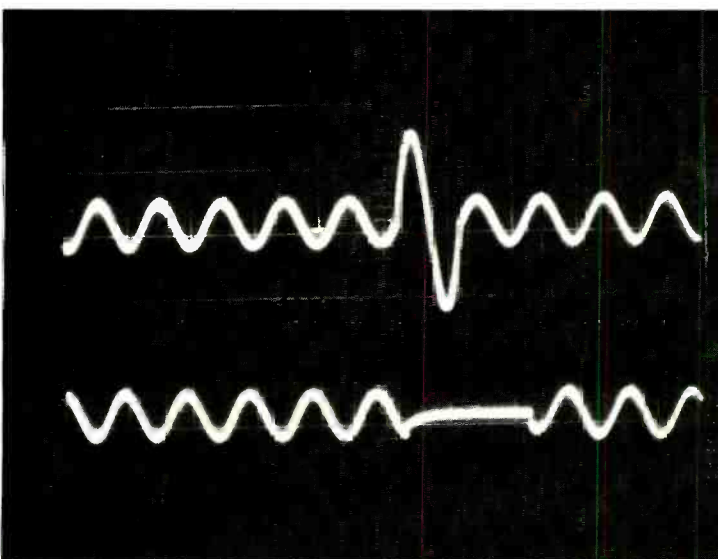


Fig. 7

LED labelled SUPPRESSOR ACTIVITY.

It is not necessary to turn on the suppressor circuits to use the Model MRM 101 solely as a phono preamplifier. If a record has impulse noise, the suppressor circuits can be switched in and the MIN/MAX control advanced clockwise until the SUPPRESSOR ACTIVITY LED begins to flash, indicating that the suppressor is acting on the noise impulses.

Laboratory Tests. Most conventional laboratory performance tests on click and pop suppressors are uninformative. We simply verified the devices' maximum output capabilities, distortion figures, and noise levels. In the case of the Garrard Model MRM 101, we also measured the performance of its phono preamplifier.

The Garrard suppressor's preamplifier was affected considerably by whether or not the noise-elimination circuits were switched in. Without suppression, it overloaded at a safe 135 mV at 1000 Hz and could deliver an 8.8-volt output. With the suppressor switched in, the overload limit was a marginal 47 mV and the maximum output voltage was 2.8 volts. In both cases, a 4.5-mV input was needed to develop the rated 300-mV

output. The unweighted noise level in the output was -66 dB without suppression and -60 dB with suppression, referred to the 300-mV nominal output. Both figures are quite acceptable for a phono preamplifier. (They would be improved by slightly more than 4 dB if referred to the IHF standard output level of 0.5 volt.)

The 1000-Hz THD was very low without the suppressor, measuring only 0.0025% at 1-volt output. It increased to 0.1% when the suppressor was activated. The RIAA phono equalization was accurate to within ± 0.5 dB from 30 to 20,000 Hz without the suppressor, and there was no interaction with cartridge inductance. The suppressor circuit rolled off the response above 10,000 Hz to -6 dB at 20,000 Hz and introduced a rise of about 1.5 dB from 70 to 250 Hz.

It must be remembered that, even if some of the preamplifier specifications deteriorate when the suppressor is used, this condition would exist only when records in substandard condition are being played. There would be no reason to use a transient suppressor when playing a record of high quality.

Aside from the measurements of the phono section of the Model MRM 101,

the only objective tests we made on all three noise suppressors were with simulated transient signals to determine how suppression affected the total signal waveform.

Interpreting Oscilloscope Photos. The oscilloscope photos we took during our tests reveal some significant differences between the Burwen and SAE suppressors. The test signal was a 10,000-Hz sine wave on which was superimposed a 10,000-Hz tone-burst signal of adjustable duration. We adjusted the amplitude of the burst so that it would reliably operate the suppressor circuits. (About 6 dB greater than the steady-state level was a suitable level, although the suppressors could be adjusted to operate over a very wide range of levels.)

On all photos, except that in Fig. 7, the time base is 1 ms/division. In Fig. 1, we see a 0.4-ms burst signal at the top of the photo and below it the same signal at the output of the SAE Model 5000 with the suppressor defeated. Except for the approximately 100 μ s required for the burst to build up and decay, the signal was unmodified by its passage through the SAE system.

In Fig. 2, the suppressor is in use, with the sensitivity adjusted so that the burst is recognized as a "noise." Two things are apparent here: the off time is much longer than the noise pulse by about 2.7 ms and there is no sign of any "fill-in" signal during the off interval. In Fig. 3, the length of the "transient" has been increased to about 3 ms, which is somewhat longer than any real click or pop would last according to the criteria accepted by all three manufacturers. The suppression interval is still only 2.7 ms and about 0.3 ms of the pulse passes through at full amplitude. This suggests that the signal-path time delay in the Model 5000 is about 2.7 ms.

In Fig. 4, we see the output of the Model 5000 with the INVERT switch activated, using a short burst of 200 μ s. As claimed, the signal is suppressed in the output and only the noise pulse is present, which makes it very easy to set the operating threshold. Note, however, that the INVERT output continues after the noise pulse at roughly the steady-state program level for another 0.7 ms. This time remains constant when the duration of the noise pulse is varied over wide limits.

The performance of the Burwen suppressor with the same signals used in Fig. 1 and Fig. 2 for the SAE device is

Performance Specifications—"Click" and "Pop" Suppressors

Specification	SAE 5000	Burwen TNE 7000	Garrard MRM 101
Harmonic distortion (20-20,000 Hz, rated output, unless specified)	0.1%	0.2%	0.01% DIRECT 0.1% SUPPRESSED (1 KHz)
IM Distortion	0.1%	NA	NA
S/N (output V)	90 dB (2.5 V)	96 dB (2.5 V)	100 dB (DIRECT, 8 V) 80 dB (SUPPRESSED, 2.5 V)
Rated output	2.5 V	2.5 V	300 mV
Maximum output	9 V	7 V	8 V (DIRECT) 2.5 V (SUPPRESSED)
Frequency response (20-20,000 Hz)	± 1 dB	± 0.5 dB	± 1.5 dB (from RIAA)
Input impedance	75,000 ohms	40,000 ohms	47,000 ohms
Load impedance	Over 600 ohms	5000 ohms	10,000 ohms
Gain	+0/-1 dB	0.0 dB	NA
Power consumption 120 V	7 W	8 W	7 W
Dimensions (in.) (W x D x H)	10 $\frac{3}{4}$ x 9 $\frac{1}{4}$ x 3	16 $\frac{3}{4}$ x 7 $\frac{5}{8}$ x 2 $\frac{3}{4}$	14 $\frac{7}{8}$ x 11 $\frac{3}{4}$ x 2 $\frac{3}{4}$
Suggested retail price	\$200	\$300	\$200

shown in Fig. 5. In this case, the off time is the same as the duration of the noise pulse. It maintains this relationship until the duration of the pulse exceeds about 2.5 ms, after which the pulse is no longer suppressed (see Fig. 6). To judge how effectively the Burwen device dealt with very short pulses, for which it had supposedly been optimized, we shortened the burst to 100 μ s (one cycle of the 10,000-Hz signal). The result is shown in Fig. 7 on a time scale of 100 μ s/division. It can be seen that the 100- μ s transient causes the program to be suppressed for about 200 μ s. It also appears that, as was the case for the SAE device, it has no visible fill-in action while the signal is interrupted.

We did not test the Garrard Model MRM 101 with this composite signal, because of the manner in which this suppressor is connected to the amplifier.

Listening Comparison. The tone-burst tests are interesting, but they're hardly comprehensive enough to properly evaluate the suppressors. Such tests can be made only by subjective listening comparisons to genuine record clicks and pops. Tone bursts, however, do tell us something about the range of transient durations over which the suppressors can operate, the duration of the signal-blanking interval, and the nature of any "fill-in" signal during the interval. (We found no evidence of a fill-in signal with any of the suppressors.)

Most of our listening evaluation was done with records, since they are the prime source for which these products were designed. Several different phono cartridges were used, including CD-4, low-cost moving-magnet, and some moving-coil cartridges. We found no significant performance differences with different cartridges.

For our listening tests, we made a "demonstration" record by using a razor blade to cut radial "scratches" in a spoke pattern on a record. When we played the record without suppression, the scratches generated a fusillade of loud pops with each revolution. This kind of record makes for a very effective, though potentially misleading, demonstration of a click-and-pop suppressor.

In our judgment, the Garrard and SAE suppressors were very nearly equivalent in their ability to eliminate the audible effects of such "scratches." Depending on the severity of the razor scratches, there might be a complete suppression of the noise, or the "hole" might be heard as a soft low-frequency "thump." Even the

latter was far less objectionable than the original transient in every case.

The Burwen device had almost no effect on the noises from the massive gouges made by the razor blade. At first, we wondered if the system was operating properly, but a telephone call to designer Richard Burwen clarified the matter. The Model TNE 7000 is designed to deal with "real-world" scratches, which are almost invariably much more shallow and produce briefer and less audible transients than the artificially spiked discs. The Burwen circuitry has been designed specifically to suppress these short-duration transients.

We had to ferret out some of our discs with short, sharp ticks to evaluate the Burwen suppressor. Some of these discs produced little more than a crackle in the sound, akin to the sound from dust particles and electrostatic discharges. The SAE suppressor cleaned up the sound fairly well, but tended to leave audible thumps. (This is explainable by the constant duration of its blanking action, which treats all transients alike, regardless of their duration.) The Garrard suppressor removed the ticks fairly well, with little or no trace of residual thump. The Burwen system proved to be by far the most effective of the three suppressors in this situation. The only clue that a transient was present was the flashing of its LED indicator.

We tested the three suppressors with an off-the-air FM program that contained the effects of scratched records. Though the Garrard system cannot do anything about this, the other two systems can, at least potentially. The few times we encountered FM broadcasts of scratched records, we were unable to make any real comparisons between the Burwen and SAE suppressors because the noises did not last long enough and were not under our control. However, we did find that both suppressors could do at least a fair job of removing clicks from FM signals. In addition, the very fast response of the Burwen system made this suppressor surprisingly effective in removing automobile ignition interference to the FM signal.

In Conclusion. The applicability of click-and-pop suppressors for a home music system must be decided on the basis of how many seriously scratched records one has. Of course, one can buy a lot of replacement discs for the \$200 to \$300 cost of a suppressor. If you are engaged in making tape copies of old, scratched discs for which there are no

replacements, a suppressor can certainly be an invaluable accessory.

The Garrard system has the advantage and disadvantage of containing its own phono preamplifier. When its suppressor is in use, its preamplifier is not the equal of those found in moderately priced amplifiers and receivers, and critical listeners might not wish to use it in lieu of an existing preamplifier (although when the suppressor is defeated, the preamplifier in the Garrard system is of very good quality). On the other hand, the Model MRM 101 does provide one with an additional magnetic phono input when it is connected to an amplifier's aux inputs. As we see it, any deficiencies it might have are of little importance when one is faced with the alternatives of listening to a scratched disc "as is" and not playing it at all.

If one decides to keep his present phono preamplifier, the SAE Model 5000 comes close to equalling the performance of the Garrard system in suppressing clicks and pops. Either system will do a very impressive job of suppression with relatively little effect on the program itself. The worse the click, the more effective these systems will be in removing it.

The Burwen Model TNE 7000 is much more refined in its action. If razor gouges are a good approximation of the condition of your discs, this is *not* the system to buy. For dealing with most real, accidentally caused clicks, manufacturing defects, and electrostatic crackles, whether, on your own discs or in FM broadcasts, however, the Burwen system was the most effective of the three we tested.

All three systems were easy to adjust for good suppression without audible distortion, although excessively high settings of the threshold controls on the Burwen and SAE systems could produce an unpleasant "hashy" distortion. Since it is easy to set the controls correctly, this is no cause for concern. We were unable to make the Garrard system produce audible distortion or overload over the entire range of its threshold control.

Keep in mind that none of the devices detailed here will do anything about record hiss, rumble, or any record noise except transient sounds that satisfy their recognition criteria. When used for the intended purpose, they can be effective and useful additions to any music system in which the quality of the records does not match that of the individual playing components. ◇

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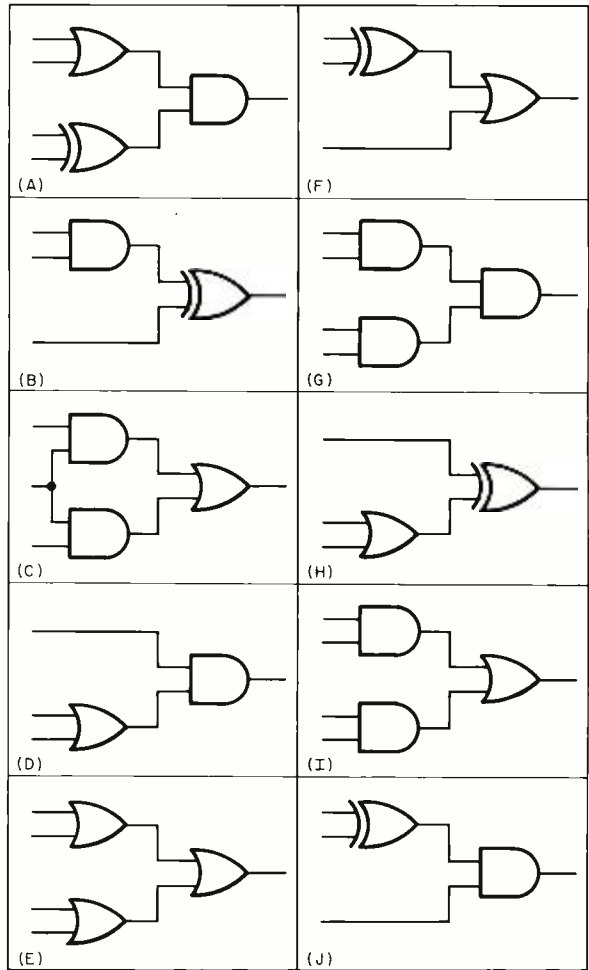
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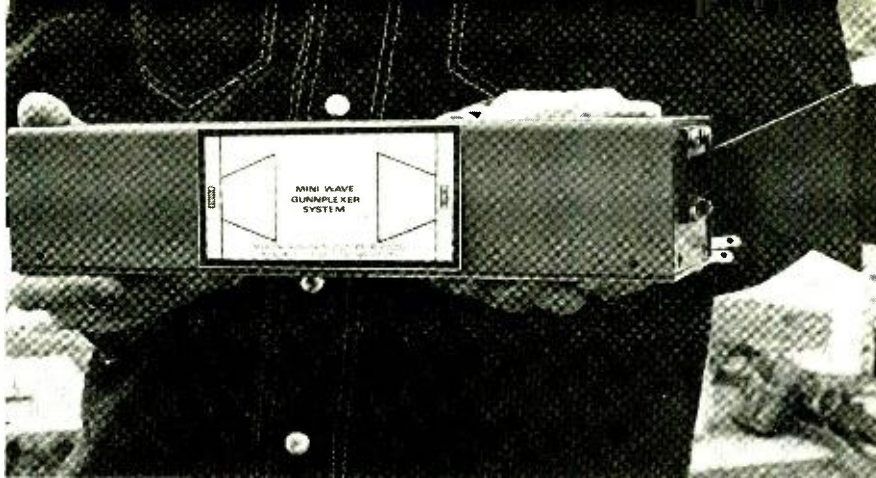
7. To get in, you must have either \$4.00 and a discount card, or come up with another dollar.

8. You must attend at least one morning or afternoon session of either day of the conference.

9. If you take a course in Law or Sociology, or both, you must also take one in either English or History, but not both.

10. You can play doubles at tennis there; but if a player on either team fails to show up, the game is called off.

(Answers on page 119)



BY ROBERT B. COOPER, JR.,
W5KHT,
AND S. K. RICHEY

PART 2

A PERSONAL MICROWAVE COMMUNICATIONS SYSTEM

THE MINI-WAVE

*Construction,
alignment, and
setup details*

HAVING examined the Gunnplexer microwave module and its transmit and receive support circuits in Part 1, last month, this concluding part will focus on assembly and alignment of Mini-Wave communications gear, selection of antennas, and how this choice affects communications range. Other topics to be discussed are licensing your Mini-Wave system and safety considerations in the use of microwave devices.

Construction. The use of printed-circuit construction techniques is recommended. A carefully designed pc board will minimize instability due to parts placement and lead positioning that can occur in a high-gain, high-frequency stage such as the receiver i-f. Suitable etching and drilling and parts placement guides for the receiver, optional audio subcarrier generator/modulator and demodulator boards are shown in Figs. 5, 6, and 7, respectively. (The transmitter without the optional audio subcarrier generator/modulator is so simple that no circuit board is required.)

The receiver contains a number of hand-wound inductors. Air-core coils can be wound on a pencil, a piece of plastic tubing, or a coil form made speci-

fically for that purpose. Several coils are lengths of very fine (No. 30) enamelled copper wire wound on Ferroxcube ferrite shielding beads. The edges of the beads should be smoothed so that the enamel insulation is not inadvertently scraped off when the coils are wound, either by tumbling the beads in a lapidary tumbler or with a fine grade of sandpaper.

When components are mounted on the printed circuit boards, attention should be paid to the polarity of electrolytic capacitors and diodes and pin basing of transistors and IC's. The minimum amount of heat and solder consistent with good connections should be applied to each solder joint. Also, the boards should be scrutinized for unwanted solder bridges between adjacent foils. Interconnections between the boards, Gunnplexer signal ports, and input and output jacks should be made with small-diameter coaxial cable such as RG-174/U. Hook-up wire can be used for other connections.

The author's prototype transmitter is shown in Fig. 8 with the cover of its enclosure removed. Video and audio level and Varactor tuning voltage controls, input jacks, the power switch and fuseholder are mounted on the rear of the

enclosure. Terminal strips and point-to-point wiring are employed in the power supply and non-audio portions of the transmitter. The Gunnplexer is bolted directly to the front of the enclosure. The entire assembly forms a neat, relatively compact unit that can be mounted on a camera tripod or other support. If it is inconvenient to mount the entire transmitter or receiver at the antenna site, the Gunnplexer alone can be installed there with coaxial lines to other circuits.

The enclosures that come with the Mini-Wave kits are not intended for permanent installation outdoors. The major problem is moisture. One very simple solution to this problem is to cover the entire transmitter or receiver package, including a 17-dB gain horn antenna if used, with a large plastic bag equipped with a downward-pointing plastic tube that will allow "breathing" and the escape of condensed moisture. Of course, adequate measures should be taken to keep the 117-volt ac power line isolated from the environment. Alternatively, low-voltage ac derived from a step-down transformer can be applied to a remote Mini-Wave transmitter or receiver by means of a suitable length of multiconductor cable approved for outdoor use.

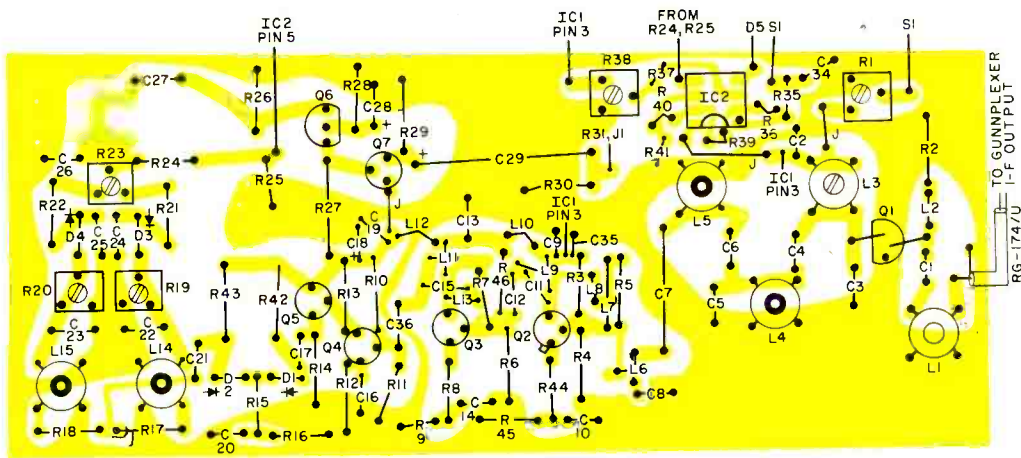
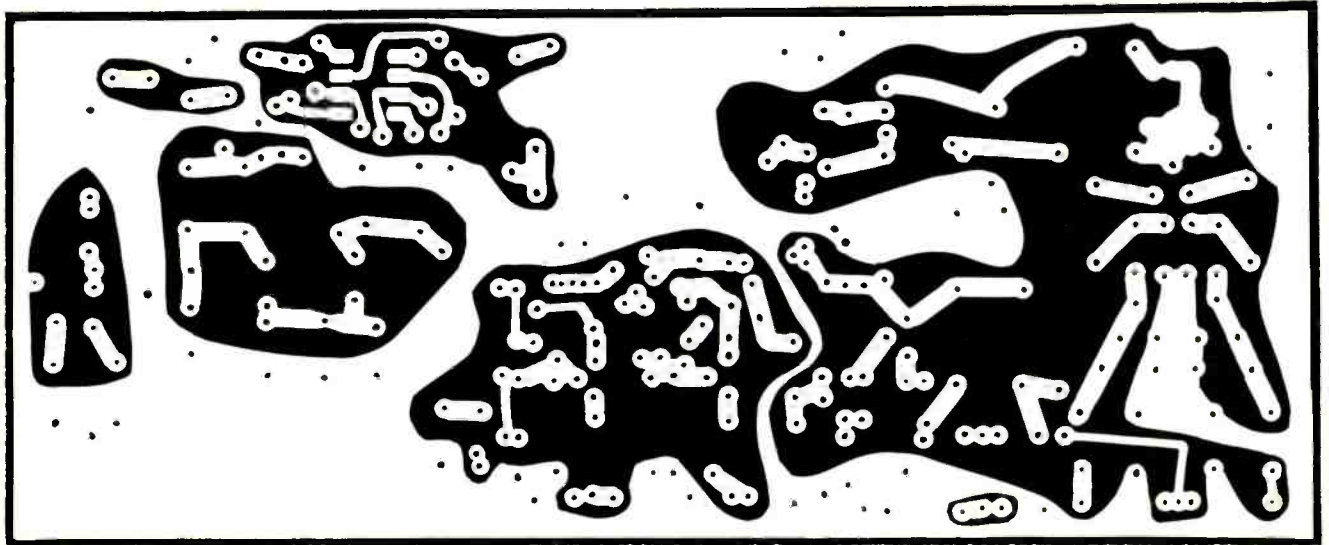


Fig. 5. Etching and drilling guide (below) and parts placement (left) for the receiver board.



Alignment. For best performance, Mini-Wave communications equipment must be properly aligned. This is especially true in the case of the receiver, audio subcarrier generator/modulator and audio subcarrier demodulator. The transmitter, however, requires almost no alignment at all, owing to its simplicity. Instrumentation required includes a voltmeter, an oscilloscope and a frequency-swept signal generator.

Align the receiver in the following manner (see Fig. 9). First, disconnect the coaxial cable running from the Gunnplexer's i-f output to the receiver pc board. This is most easily done by disconnecting the cable from the Gunnplexer rather than from the pc board. Next, couple signals to the coaxial cable from a frequency-swept signal generator via a 100-pF silver mica or disc ceramic capacitor. The generator's controls should be adjusted so that the output signal is at a relatively low level (0 dBm or 1 mV) and sweeps to beyond 60 MHz

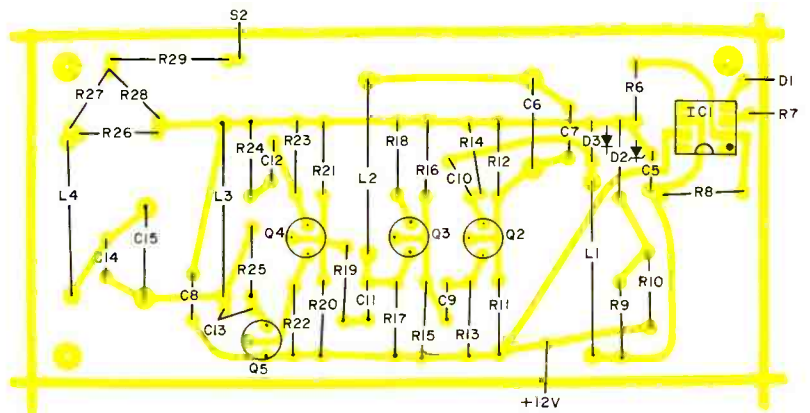
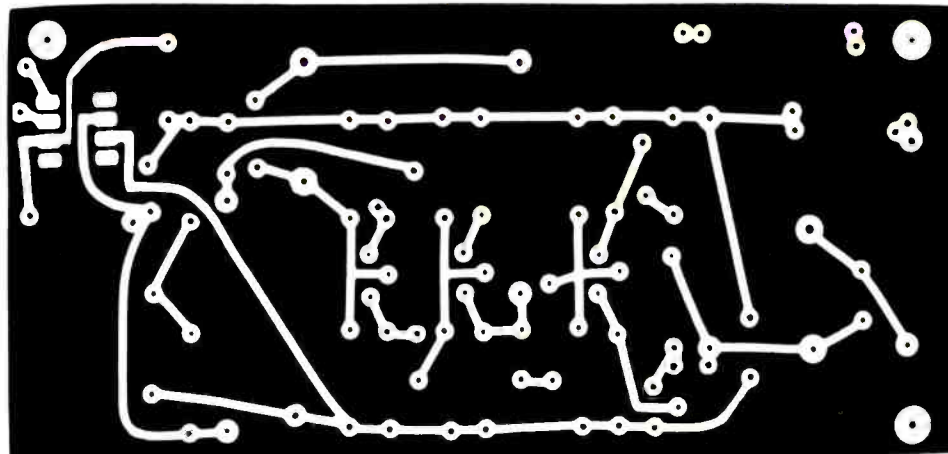


Fig. 6. Etching and drilling and parts placement guides for audio subcarrier generator/modulator.

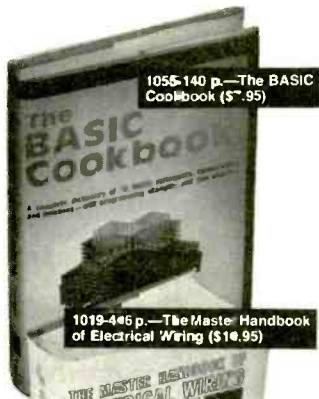


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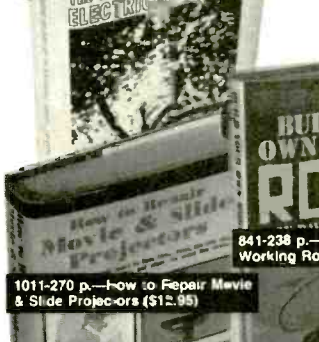
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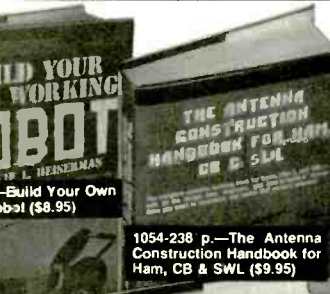
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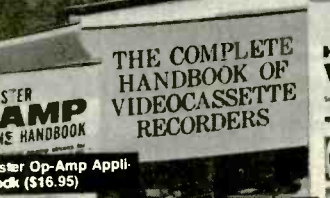
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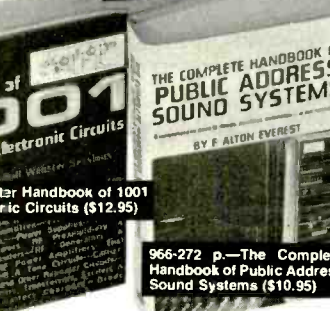
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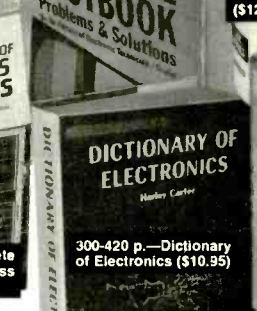
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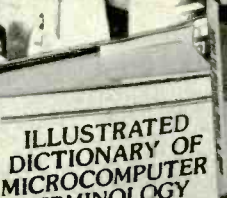
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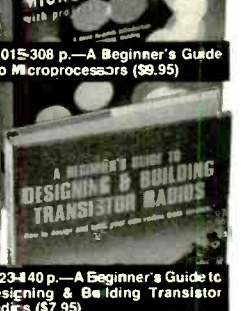
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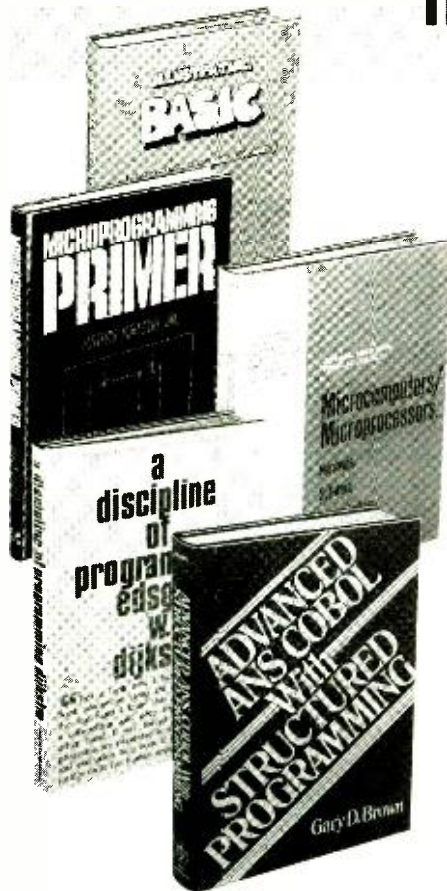
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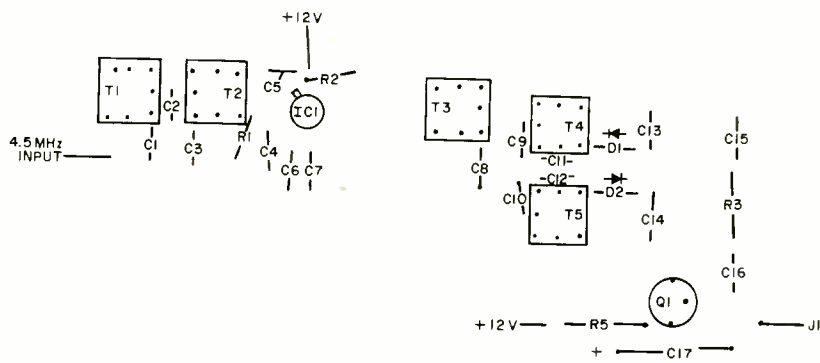
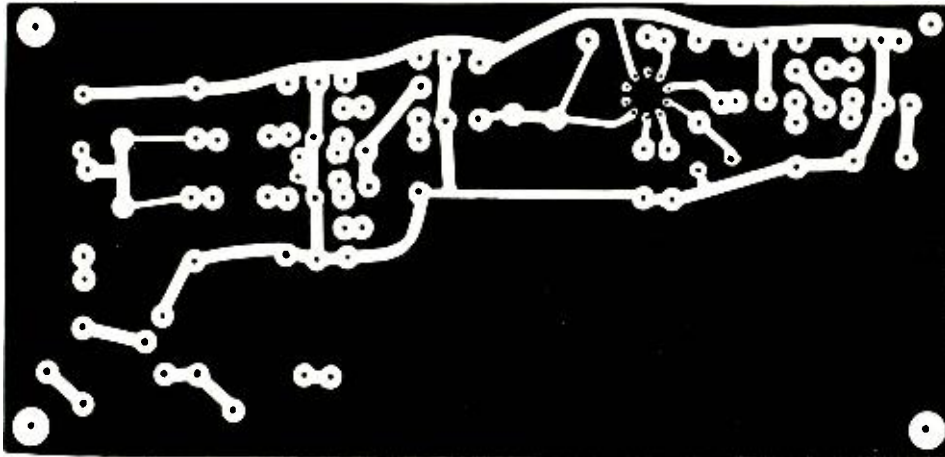


Fig. 7. Etching and drilling and component layout guides for an audio subcarrier demodulator board.



+8 volts dc above ground. Then, place S1 in the AFC OFF position and adjust R1 so that the +4 volts dc appears between the Varactor voltage input of the Gunnplexer and ground. Finally, place S1 in the AFC ON position and adjust R38 so that +4 volts dc appears between the Gunnplexer's Varactor voltage input and ground. This last adjustment should be performed with the transmitter or any other source of 10-GHz microwave radiation turned off.

Only a few adjustments are necessary for transmitter alignment. First, adjust trimmer potentiometer R1 so that +8 volts dc appears between the emitter of Q1 and ground. Then open S2 (if this switch and the audio subcarrier generator/modulator have been included) and adjust R4 for a +4-volt bias between the Gunnplexer's Varactor voltage input and ground. The remaining control, R30, is adjusted while the video source to be used with the transmitter is supplying an input signal to J2. This adjustment can be performed now with the aid of an oscilloscope or "by eye" after the receiver has been aligned. If an oscilloscope is used, monitor the Varactor bias and adjust R30 so that 1 volt peak-to-peak of video rides on the +4-volt dc level. Otherwise, adjust the control after communications between the transmitter and the receiver have been established, varying the setting of R30 for best picture quality.

The audio subcarrier generator/modulator should now be aligned if it has been built into the transmitter. Sample the audio subcarrier at a convenient point (say, the pole of S2) and apply it to a frequency counter. With no audio sig-

with markers at 40, 45 and 50 MHz. Couple signals at the emitter of Q5 to the scope's vertical amplifier input via a 0.001- μ F disc ceramic capacitor and a sweep demodulator probe. The frequency-sweep sawtooth should be applied to the scope's horizontal amplifier input.

Alignment of the receiver i-f involves adjusting L2, L3, L4, L5 and C7 so that a total gain of 50 dB \pm 0.5, \pm 0.5 dB is obtained across the i-f passband. The oscilloscope trace will appear as in Fig. 9B when the i-f section is properly aligned.

Next, the FM detector or discriminator will be aligned. Disconnect the coupling capacitor and oscilloscope probe from the emitter of Q5 and connect the probe to J1, the video output jack, as shown in Fig. 10 A. Inductors L14 and L15 should be slug-tuned to resonate the two legs of the discriminator at 35 and 55 MHz, respectively. Adjust potentiometers R19 and R20 so that an unmodulated carrier at exactly 45 MHz produces a zero-volt output. These adjustments are most easily done with the sweep function of the signal generator disabled.

When the wiper of R23 is at its proper setting, the two legs of the discriminator will cause equal negative- and positive-voltage swings as the carrier is swept from below 35 MHz to above 55 MHz. A

correctly aligned discriminator will generate the S-shape oscilloscope trace shown in Fig. 10B. The 35-MHz marker will be at the bottom of the curve, the 45-MHz marker at the zero-volt center line, and the 55-MHz marker at the top of the curve. Aligning the discriminator for this extended frequency range ensures near-perfect linearity over the actual 40-to-50-MHz i-f passband.

The remaining steps in the alignment of the receiver deal with the bias voltages applied across the Varactor and Gunn diodes in the Gunnplexer. Adjust trimmer R32 so that the emitter of Q8 is

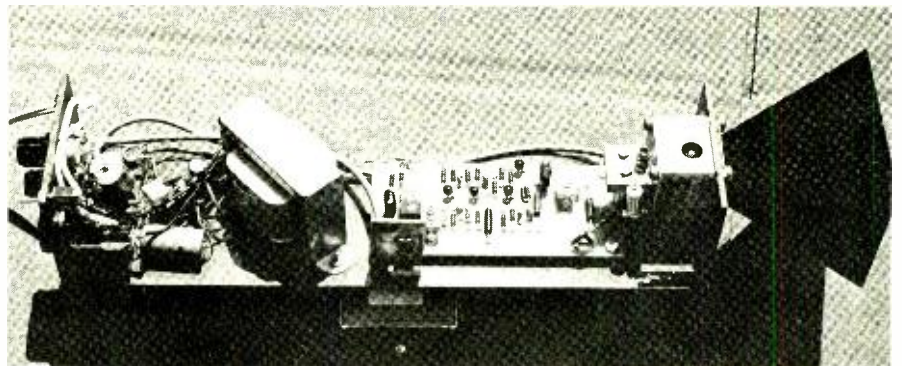


Fig. 8. Photo of Mini-Wave transmitter with case removed. Pc board holds circuit for audio subcarrier generator/modulator.

nal applied to input jack *J1*, adjust trimmer capacitor *C6* so that the subcarrier frequency is exactly 4.500 MHz. Then remove the counter probe, replace it with one from an oscilloscope, and adjust trimmer *C15* for maximum subcarrier amplitude (about 0.1 volt rms).

Level control *R7* should be adjusted so that the audio signal source to be used with the transmitter causes the subcarrier to deviate ± 25 kHz, the optimum amount. This adjustment can be done "by ear." That is, after the audio subcarrier demodulator has been aligned, the audio source can be coupled to the transmitter and level control *R7* adjusted for the best-sounding audio. In practice, an audio source with an output impedance or 10,000 ohms or more and an output level of 50 to 100 millivolts should be used to drive the audio circuit. If your audio source cannot provide that much signal, the gain of audio preamp *IC2* can be increased by replacing feedback resistor *R8* with a higher-value component. As is, this stage has a voltage gain of 10 (20 dB).

Alignment of the audio subcarrier demodulator is similar to that of the receiver. Apply the output of a signal generator operating at 4.5 MHz to the primary of transformer *T1*. Signal level is not critical, but should be approximately 100 millivolts. Couple an oscilloscope probe to the secondary of *T3* and monitor the 4.5-MHz signal. Using an alignment tool, adjust the slug cores of *T1*, *T2* and *T3* for maximum amplitude on the scope.

Next, activate the frequency-sweep function of the signal generator and place markers at 4.450, 4.500 and 4.550 MHz. Remove the oscilloscope probe from the secondary of *T3* and place it at audio output jack *J1*. Adjust the slug of *T4* so that the transformer resonates at 4.450 MHz. Then tune *T5* so that it resonates at 4.550 MHz. The resulting oscilloscope trace will resemble that shown in Fig. 10B when the transformers are properly tuned. The 4.450-MHz marker will appear at the bottom of the S-shaped discriminator characteristic curve, the 4.500-MHz marker will appear at the zero-volt center line, and the 4.550-MHz marker will be at the top of the S-curve. Aligning the audio demodulator for a ± 50 -kHz passband ensures maximum linearity over the actual ± 25 -kHz bandwidth occupied by the frequency-modulated subcarrier.

This completes alignment of the Mini-Wave communications link. There are two screw adjustments built into the Gunnplexer. One varies the characteris-

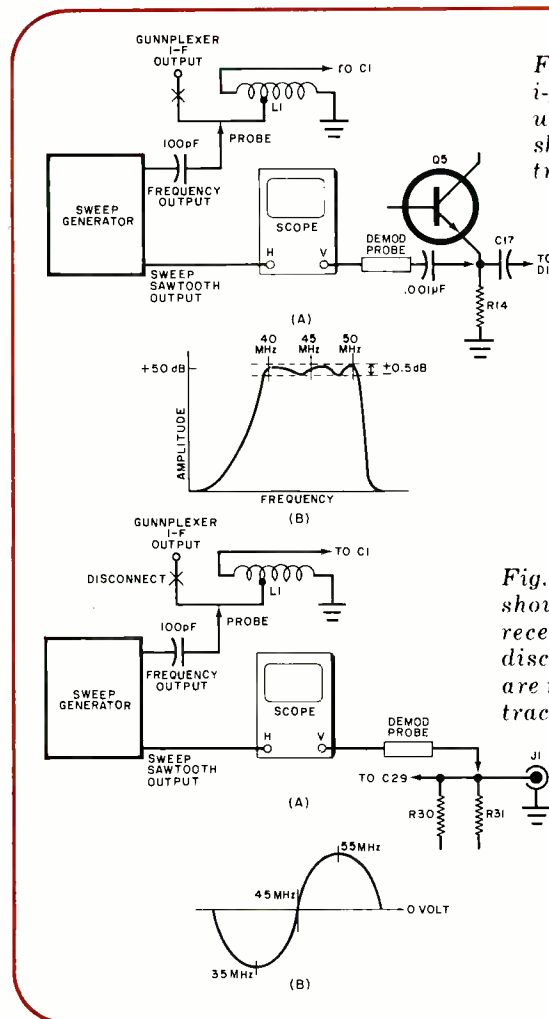


Fig. 9. To align receiver i-f, disconnect input and use sweep and scope as shown at (A) to obtain trace shown at (B).

Fig. 10. Use the circuit shown at (A) to align the receiver FM detector or discriminator. Adjustments are made to obtain trace shown in (B).

tics of the cavity in which the Gunn diode is mounted and thus determines the frequency of oscillation. The other controls the amount of local oscillator output applied to the Schottky mixer diode. This mixer injection control screw is mounted in front of the ferrite circulator and its setting need not be disturbed. If the transmitting and receiving Gunnplexers have been ordered for frequencies establishing the correct 45-MHz offset, the frequency adjust screws should be left at their factory settings.

To communicate with Mini-Wave systems employing Gunnplexers oscillating at other frequencies, either the Varactor bias or the position of the mechanical tuning screw (or both) will have to be changed. Keep in mind, however, the limits of these frequency adjustments (± 100 MHz mechanical, 60 MHz minimum electronic). The Varactor bias should not be varied so much that the composite video signal cannot fully modulate the microwave carrier.

Be sure that you can tune the Gunn oscillator back to the frequency required by your own link before attempting any off-channel operation. Retuning can be

accomplished by one of several means. You can keep one end of your link on-frequency and tune the other off frequency. Then, after communications are complete, adjust the frequency of the off-channel Gunnplexer for best reception at the other end of your link. A frequency counter can also be employed. Couple the two Gunnplexers and sample the i-f output of one, applying it to a frequency counter. The off-channel Gunnplexer can then be retuned to its "home" frequency by monitoring the frequency difference between the two oscillators displayed by the counter. Finally, a locally installed "beacon" Gunnplexer can be used by a number of microwave communicators as a common reference for equipment calibration and frequency setting purposes. \diamond

Editor's Note: In Part 3 of this article, next month, we will conclude with antenna and set-up instructions and information on licenses. In Fig. 2 of Part 1, last month, *D3* should have been shown so that the anode was on the right, the cathode on the left. Also, the shell of *J1* and the junction of *R28*, *R29*, *R30*, and *C28* should have been grounded.

ADD A "TICK-TOCK" TO YOUR DIGITAL CLOCK

Give your modern clock a familiar sound.

BY WILLIAM D. KRAENGEL, JR.

MODERN digital clocks keep very accurate time and make a fine addition to most living rooms. In fact, digital timepieces in the shapes of grandfather clocks are now available. Some of these even have a moving pendulum (made from LED's) to further enhance their appearance. About the only thing missing from these clocks is the familiar "tick-tock" sound.

If your digital clock has a LED pendulum, or a source of 1-Hz logic signals somewhere in its circuit, this project will add a nice touch to its operation.

The inputs to this project are buffered CMOS for negligible circuit loading, and the small amount of power required is easily supplied by the clock's power supply.

The basic circuit, shown in Fig. 1 is for CMOS and TTL approaches.

Circuit Operation. If your clock has a LED pendulum, one LED (usually the leftmost one) is designated the "tick" LED while the one on the right end is the "tock" LED. If the pendulum timing is conventional, these LED's will light alternately at 0.5-second intervals.

The individual tick and tock inputs are buffered by IC1D and IC1E then differentiated by R3C2 and R5C3 to pro-

duce two narrow pulses with the tock pulse a little wider than the tick pulse and lagging by 0.5 second. These alternate pulses are gated into two parallel-connected buffers. IC1A and IC1F, and used to drive transistor Q1. This transistor drives a small loudspeaker. Because of the narrow pulses, the average current through Q1 and the speaker is small. The instantaneous current through Q1 and the speaker is limited by the inductive reactance of the speaker voice coil to fast pulses.

The various alternate positions shown in the schematic, along with IC1B, are used to reverse the polarity of the differentiators and the diodes so that they can respond to either positive- or negative-going input pulses. When IC1C is used with a common 1-Hz input signal, the tick differentiator triggers the high level of the input signal while the tock differentiator triggers the low level.

The resulting output pulses from Q1 sound surprisingly like the familiar tick-tock of an old-fashioned grandfather clock. The volume control (R6) can be used to reduce the level to that of a pocket watch.

Interfacing. The drive signals to the LED's on the electronic pendulum will be

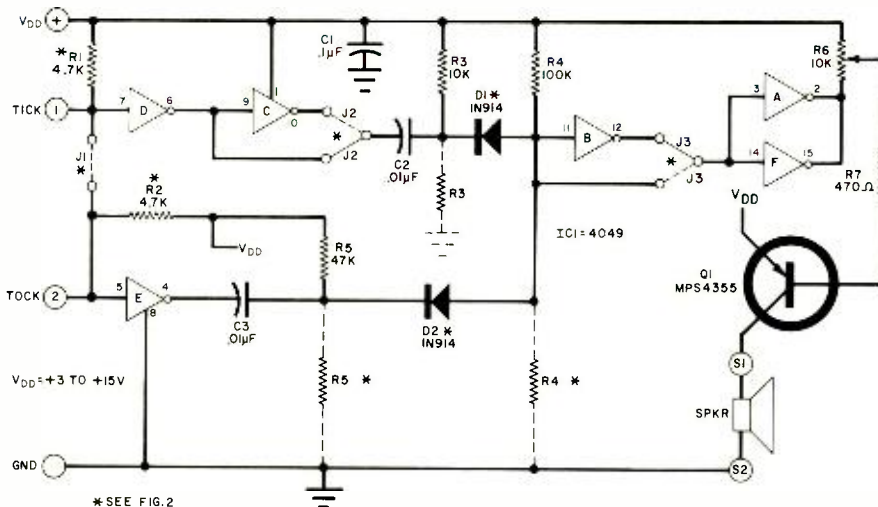
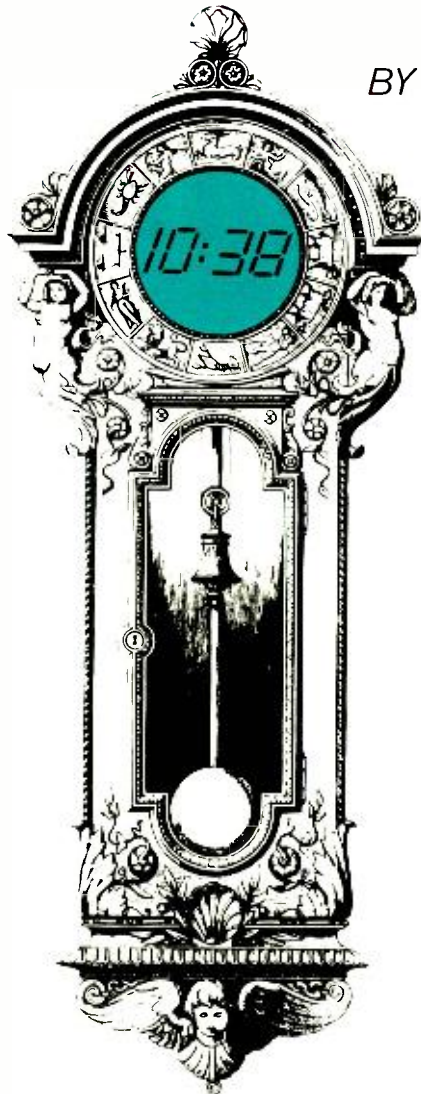


Fig. 1. Schematic of tick-tock circuit also shows alternate connections for different inputs.

PARTS LIST

- C1—0.1- μ F disc ceramic capacitor
- C2, C3—0.01- μ F, disc ceramic capacitor
- D1, D2—1N914
- IC1—4049B hex inverter (CMOS)
- Q1—MPS4355 or similar
- The following are 1/4-watt, 10% resistors unless otherwise noted:
- R1, R2—4700 ohms (see text)
- R3—10,000 ohms
- R4—100,000 ohms
- R5—47,000 ohms
- R6—10,000-ohm trimmer potentiometer (Radio Shack No. 271-218 or similar)
- R7—470 ohms
- SPKR—1 1/2" to 2 1/2" 8-to-10-ohm speaker
- Misc.—Socket (optional), hookup wire, mounting hardware, etc.

Note: The following is available from CM Circuits, 22 Maple Ave., Lakawana, NY 14218; etched and drilled pc board at \$3.00 plus \$0.50 postage and handling. NY state residents, please add sales tax.

Fig. 2. Three approaches to parts usage and wiring for different inputs and clock types.

INPUT WAVEFORMS	FOR TTL CLOCK ONLY	POSITION OF * PARTS
	R1, R2	FIG. 3A
	R1, R2	FIG. 3B
	J1, R2	FIG. 3B + J1

either a 1 or a 0. The tick-tock project will accept either one. If the drive signals are logic 1, use the approach shown in row 1 in Fig. 2. If the signals are logic-0, use approach in row 2 of Fig. 2.

If your clock does not have a pendulum, and you can locate a 1-Hz logic signal in your circuit, use row 3 of Fig. 2.

The input logic signals can vary from +3 to +15 volts as long as the project is powered from the clock supply.

Construction. The actual-size pc board shown in Fig. 3 will accommodate

either of the three variations of construction. Note that jumper *J1* is used only for the approach in row 3, while jumpers *J2* and *J3* are used in accordance with the parts placement guides.

If you have a TTL clock, pull-up resistors *R1* and *R2* are required at the inputs. When *J1* is used with row 3, only *R2* is used. Note the alternate placement of some resistors and diodes and follow Fig. 2 for particular input signals.

If desired, a socket may be used for *IC1*, and any method of construction can be used. ◇

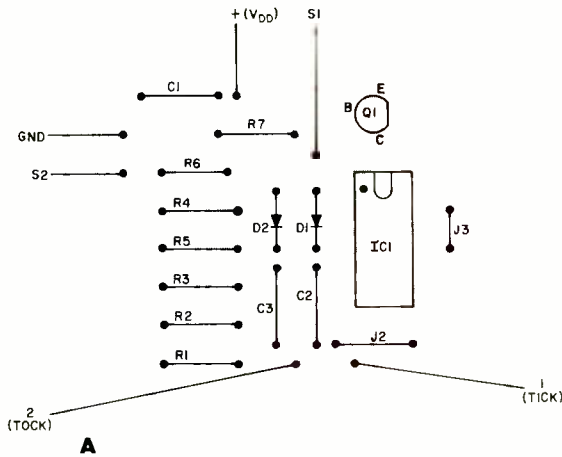
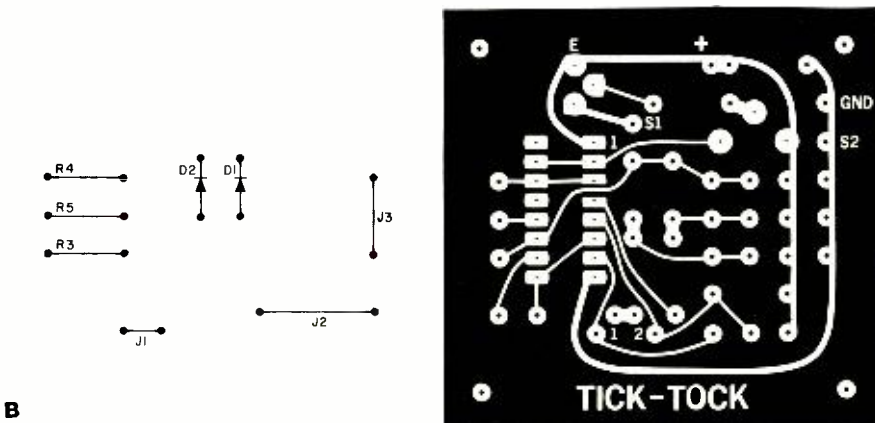


Fig. 3. Etching and drilling guide for pc board is shown below. At (A) is component arrangement for row 1 in Fig. 2. Use (B) for rows 2 and 3 in Fig. 2. Note *J1* is used only for row 3 of Fig. 2.



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IN RECENT YEARS, the cassette tape recorder has been used in a number of nonaudio applications. A good example of such use is as a mass-storage memory medium in a microcomputer system. Using a similar technique, the cassette recorder can be employed in model railroading. In the "Automatic Model-Railroad Engineer" described here, the cassette recorder serves as a storage system for timed "stop and go" commands. The approach is simple and inexpensive.

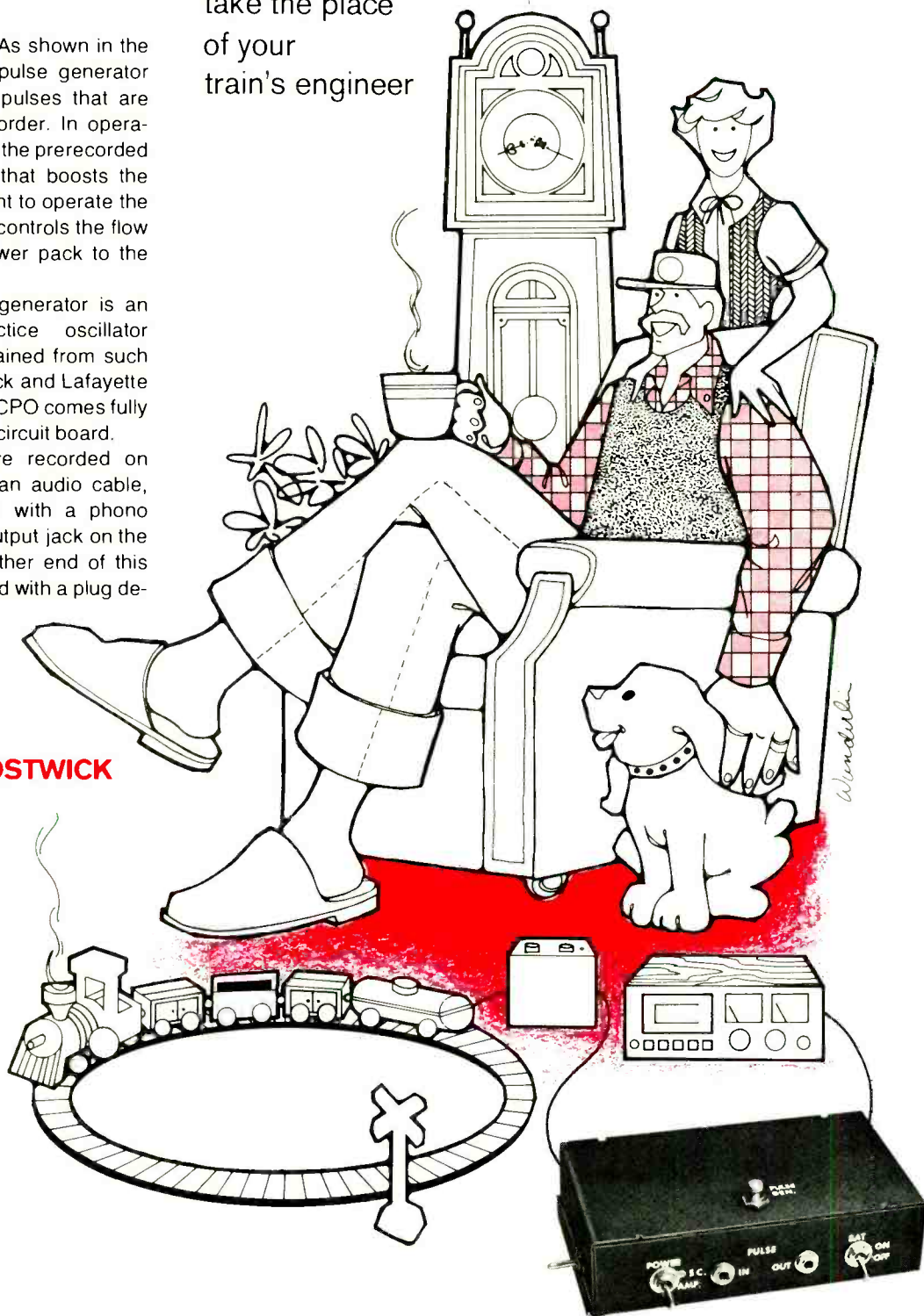
System Operation. As shown in the schematic diagram, a pulse generator initiates the command pulses that are fed into a cassette recorder. In operation, the recorder sends the prerecorded pulses to an amplifier that boosts the signal to a level sufficient to operate the relay. In turn, the relay controls the flow of current from the power pack to the model railroad's track.

The system's pulse generator is an inexpensive code-practice oscillator (CPO) that can be obtained from such suppliers as Radio Shack and Lafayette Radio Electronics. The CPO comes fully assembled on a printed circuit board.

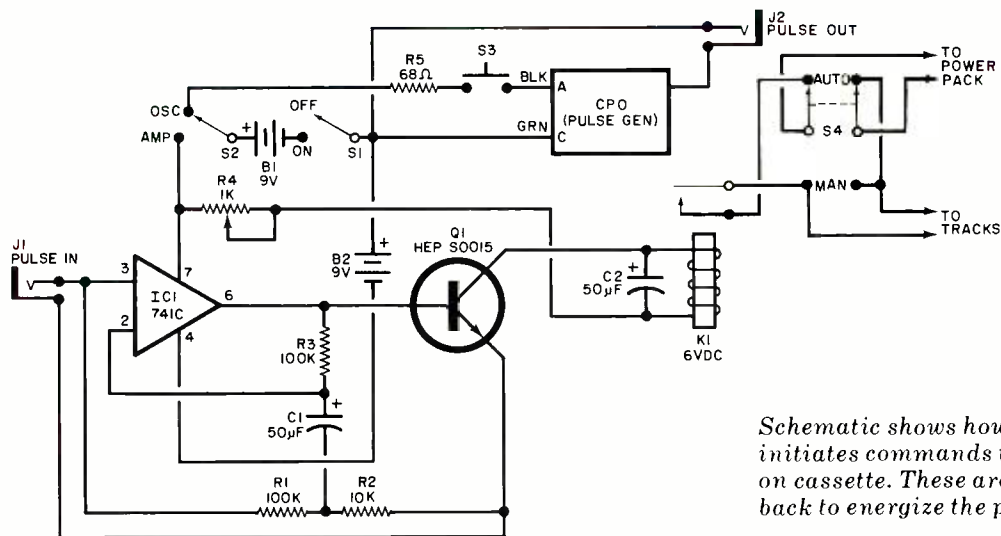
Pulse commands are recorded on tape as follows. First, an audio cable, terminated at one end with a phono plug, connects to the output jack on the pulse generator. The other end of this cable must be terminated with a plug designed to mate with the auxiliary (AUX)

Control Your Model Railroad With Audio Tape

Let signals from a cassette tape take the place of your train's engineer



BY SPENCER BOSTWICK



Schematic shows how pulse generator initiates commands that are recorded on cassette. These are later played back to energize the power relay.

PARTS LIST

B1, B2—9-volt battery
 C1, C2—50 μ F, 15-volt electrolytic
 IC1—741 operational amplifier
 J1, J2—Miniature phone jack
 K1—6-volt dc relay (Potter & Brumfield No. RS5D or similar)
 Q1—HEP S0015 (Motorola) transistor

R1, R3—100,000-ohm, 1/4-watt resistor
 R2—10,000-ohm, 1/4-watt resistor
 R4—1000-ohm flat-mount pc potentiometer
 R5—68-ohm, 1/2-watt resistor
 S1, S2—Spst toggle switch
 S3—Spst, normally open pushbutton switch
 S4—Dpdt switch
 Misc.—Printed circuit board or perforated

board and solder clips for amplifier circuit; battery holders and connectors for B1 and B2 (2); code practice oscillator (Radio Shack No. 20-1155 or similar); suitable enclosure; patch cord; connectors for power pack and track (4); rubber grommets (2); spacers; machine hardware; hookup wire; solder; dry-transfer lettering kit; etc.

input jack on your cassette recorder. Then, with the recorder operating in the record mode, the pulse generator can be keyed on and off for the desired run and stop times.

Once the desired run and stop times are recorded on tape, the tape can be rewound and played back through an amplifier that energizes and deenergizes a relay. The relay's contacts open and close the output circuit from the model railroad's power pack to its track, timed according to the blank spaces and pulse trains recorded on the tape. Pre-recorded programs can be as short or as long as the tape's running time.

The amplifier is built around dual high-gain operational amplifier IC1. The op amp drives conventional transistor amplifier Q1 to develop enough current flow to operate relay K1. Two standard 9-volt batteries, B1 and B2, provide power for IC1. One battery (B2) is also used to power the pulse generator (CPO) and relay K1 through dropping resistor R5 and potentiometer R1, respectively.

Construction. Both the pulse generator (CPO) and amplifier/relay circuits can be housed in a single compact box (see lead photo). Prepare the box by drilling 1/4" (6.4-mm) holes as follows: four evenly spaced across the front of

the box; two through the left side of the box; one through the rear of the box; and one through the top of the box. Locate the hole toward the front on the left side of the box well to the front but where it will not interfere with any other components. Also, locate the hole in the top well toward the front and midway between the front-panel center holes.

Deburr the holes and scrub the box with fine steel wool. When the box is completely dry, spray it with two or more

coats of paint, allowing each coat to dry before applying the next. Allow the final coat to dry for at least eight hours. Then use a dry-transfer lettering kit to label the holes as follows: PULSE GEN. for the hole in the top; TO TRACK for the hole in the rear; MAN/AUTO for the front and POWER PACK for the rear holes in the left side; and POWER OSC/AMP, PULSE IN, PULSE OUT, and BAT ON/OFF for the holes in the front panel from left to right. (Note: Legends with slashes indicate al-

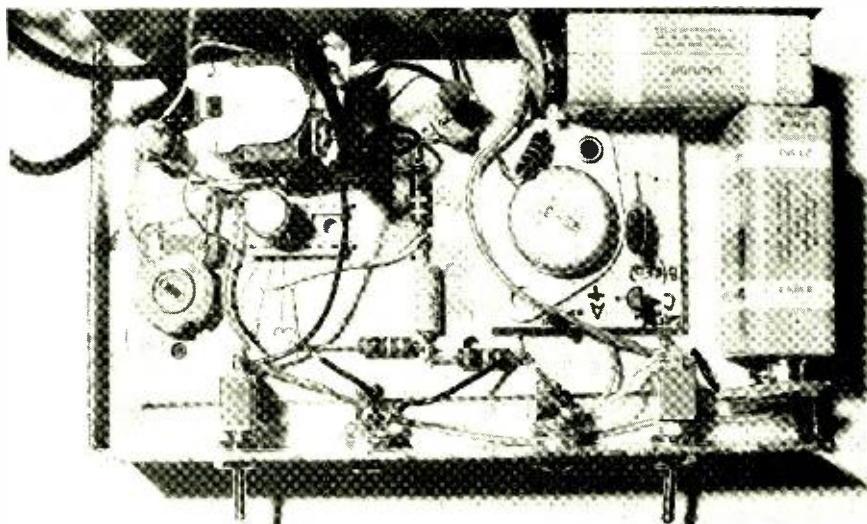


Photo shows layout and wiring of enclosure for the author's prototype Model Railroad Automatic Controller.

EVENT	PLACE	TIME	ELAPSED TIME MIN. SEC.
START OF RUN	SMITH RIVER	00.00	00.00
RUN TO →	REDSTONE LIVESTOCK	00.08	00.08
HOLD	" "	00.10	00.18
RUN TO →	HENRY TOWN WATER TOWER	00.19	00.37
HOLD	" "	00.11	00.48
RUN TO →	ADOBE BRIDGE	00.12	1.00
HOLD	" "	00.11	1.11
RUN TO →	ALICE SPRINGS	00.20	1.31
HOLD	" "	00.10	1.41
RUN TO →	SMITH RIVER	00.20	2.01
END			

Typical timing chart for a train run lasting about two minutes.

ternate positions of the switch. For example: POWER OSC/AMP means that this switch applies power to the CPO in one position and to the amplifier/relay circuit in the other position, but not to both circuits simultaneously.)

Mount the switches and jacks in their respective holes. Line the TO TRACK and POWER PACK holes with rubber grommets to protect the wires that will exit the box through these holes from being cut through by bare metal. Take care to avoid damaging the lettered legends.

Using appropriate machine hardware and spacers, mount the CPO, amplifier/relay circuit, and battery holders in the box. Interconnect the various elements

in the system with hookup wire and solder. Then carefully check your wiring and install the batteries.

Before you can put the Automatic Railroad Engineer into service, potentiometer *R1* must be properly adjusted. To do this, you will have to make a test tape. Connect one end of a patch cord to the PULSE OUT jack and the other end of the cord into the recorder's AUX (auxiliary) input jack. Place the recorder in the RECORD mode and turn up the volume to maximum. Now, press and hold the PULSE GEN switch for 10 seconds, release for another 10 seconds, and press and hold for a final 10 seconds. Rewind the tape to the start of the program.

Plug the patch cord into the remote-speaker output jack on the recorder and the PULSE IN jack on the Automatic Railroad Engineer and play the tape while observing the relay and with the POWER switch set to AMP. As the tape is playing, the relay's contacts should close, open, and then close again, each for a period of 10 seconds. If you do not observe this relay action, rewind the tape and play it again while adjusting *R1* for the proper response.

This completes test and adjustment. Assemble the Model Railroad Engineer's box and connect it into your model railroad system.

All Aboard. As you become familiar with the operation of the Automatic Model-Railroad Engineer, you will find that you can set up just about any combination of stop-and-go programs to suit any run, no matter how complex. Programs can be as long as you wish, up to the maximum length of time possible on a single side of a cassette tape. Now when you want a break, you can play a program cassette and sit back to drink your coffee and watch your model railroad run automatically. ◇

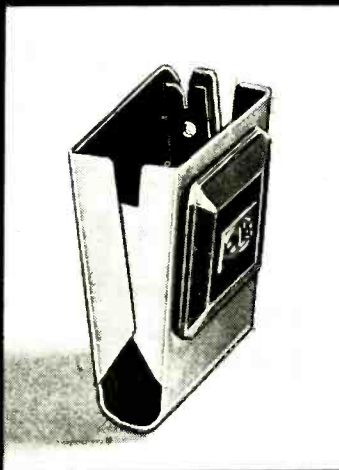
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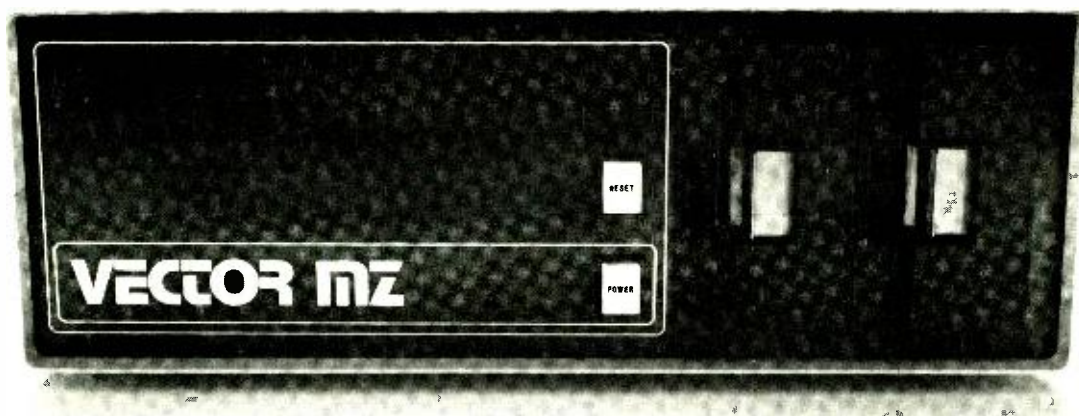
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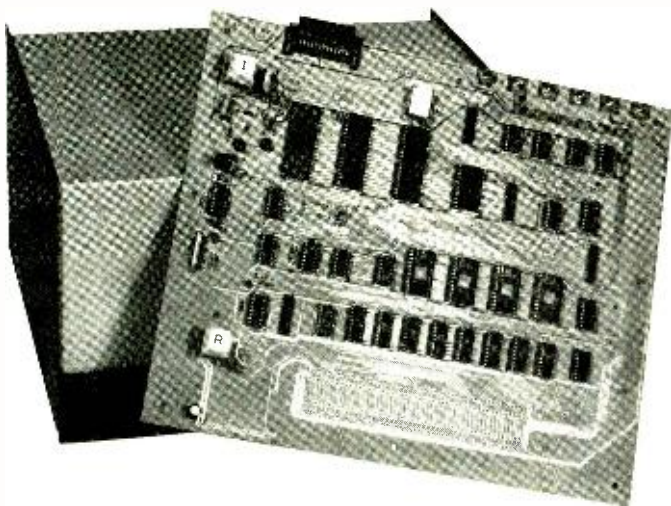
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SPECIAL FOCUS ON

computers

This special editorial section crams into more than 18 pages a host of personal computer articles that illustrate the field's continued vigor. It includes a new low-cost microcomputer project that employs the advanced 8085 CPU, a look at an upcoming peripheral that will put all the colors of the rainbow—and

then some—into the hands of computer users, an auxiliary-device project for the popular TRS-80 to make cassette program retrieval easier, a discussion about the new 16-bit CPUs and how they compare to the presently dominant 8-biters, and how to care for and handle floppy diskettes.



CONSTRUCTION PROJECT

“EXPLORER” 8085-Based Microcomputer

Expandable, single-board \$130 computer uses simplified hardware and is fully compatible with 8080 software

BY MARTIN MEYER

IT IS no secret that hundreds of thousands of programs have been written for 8080-based microcomputers. While the 8080 is an excellent microprocessor, it requires 30 support ICs and has a rather complicated system architecture. Consequently, users generally do not understand how the μ P works and are, therefore, relegated to being “appliance” operators and slaves of packaged software. The new Intel 8085 μ P, which is 100% software-compatible (though not pin-compatible) with the 8080A, simplifies hardware and software matters considerably because it requires only

three support ICs. Without a maze of flip-flops to fight through and with eight fewer connections and bus lines for every chip added, you need no longer be confused about μ P operation with the 8085.

In addition to using “canned” programs, one can learn the rudiments of machine language more easily with the 8085 than its 8080 predecessor. Hence, program debugging is simplified so that exchanged programs that are slightly askew from your BASIC can be corrected and modified. Also, programs published in magazines and other literature

can be made to work with your computer. Once you learn machine language with the 8085, you will no longer be a prisoner of canned software. This means that you will not have to search out software to instruct your computer to do a myriad of simple dedicated tasks. You will be able to program it yourself to, say, turn on and off a light with a specified delay, act as an alarm system or telephone dialer, etc.—all without expensive RAM or ROM or any special expertise.

The minimum-system 8085-based “Explorer” microcomputer presented

here has a host of other welcome attributes, including: built-in ROM monitor; 50% faster speed than the 8080A; S-100 bus compatibility; single 5-volt supply requirement; four *built-in* hardware and seven software interrupts; and multiplexed data/address lines. A basic starter kit with full on-board expansion capabilities (see Minimum System Parts List) allows one to grow at his own pace. System peripherals designed to work directly with the 8085 already include interval timers, DMA and interrupt controls, programmable floppy-disk and CRT controllers.

The Minimum System. The basic Minimum Explorer T-8085 computer system described here is built around just eight ICs, the most important of which is the 8085 μ P. Direct support of the 8085 is provided by an 8355 ROM and an 8155 RAM. The ROM contains a 2K monitor and two programmable 8-bit bidirectional parallel I/O ports (see table for commands contained in the ROM). The RAM contains two programmable 8-bit bidirectional and one programmable 6-bit bidirectional I/O ports and a programmable 14-bit binary counter/timer. The remaining five chips include operational amplifiers, inverters, and gates.

Bear in mind in the following circuit descriptions that all components with 100-series part numbers (C101, R115, U101, etc.) comprise the basic minimum system. Components labelled with 200-series numbers are required for S-100 bus expansion, 300-series components are for on-board RAM and ROM expansion, and 400-series components are for a hex keypad.

The 8085 (U101 in Fig. 1) utilizes a multiplexed address/data bus (pins 12 through 19). The lower eight bits of the address output is followed by eight bits of data or I/O. ALE pin 30 synchronizes the accessory chips in the system, which latch in first the address and then the eight bits of data. This greatly simplifies the system and use of the I/O ports and is largely responsible for its compactness and the saving of up to eight pins per add-on chip. High-order bus pins 21 through 28 contain the high-order address signals.

Transistors Q101, Q102, and Q103 are serial-output buffers and are selectable via S9 and S10 to be either a 20-

mA TTY or an RS232-C interface. (A negative supply is required to drive an RS232-C device.) The collector circuit of Q102 also includes light-emitting diode L100 and an output for a speaker or a headphone. The LED is useful for signalling the end of a program or event. (For example, the last statement in a program could be an instruction to turn on the LED after the program has been successfully executed.) The headphone or speaker is useful for monitoring music and audio programs.

Integrated circuits U104A, U104B, U105, and U106A are address decoders that specify the address of the system's ROM at F800 and RAM at F000. IC's U104C U104D, and U106B are part of the auto-boot that automatically points the system to the monitor on turn-on and when pressing the monitor switch. IC U106C is a memory-ready control that is employed only when using memories that are slower than the speed of the 8085.

Integrated circuit U102 is the 8355 system ROM. System port A at pin 24 is the tape-output port. Pin 25 is the tape-control port. Pin 26 is the cassette-tape output port. The 8155 U103 RAM is used to take data in and pass it out of the computer to a variety of different types of equipment. The 8155 also contains a 14-bit counter/timer.

Cassette tape operation is controlled by U108, Q104, and reed relay K1. (For more details, see Fig. 2.) The tape output is designed to drive a microphone input on a low-cost cassette recorder. Tape phase selectors S11A and S11B in Fig. 2C permit the use of virtually any tape recorder. If your recorder inverts the signal during record, a condition that might cause loading errors, simply install a jumper for S11B.

Reed relay K1 in Fig. 2B closes whenever you write or read a tape program and automatically turns off the tape recorder when the information being written or read is completed. ICs U209 and U210 are bidirectional data bus drivers, while U214 is used for on-board memory acknowledge, which turns off the S-100 data bus when either the on-board RAM/PROM or monitor is in use. Jack J2 is the hex keypad output jack. (The 200-series components mentioned here are *not* part of the basic system.)

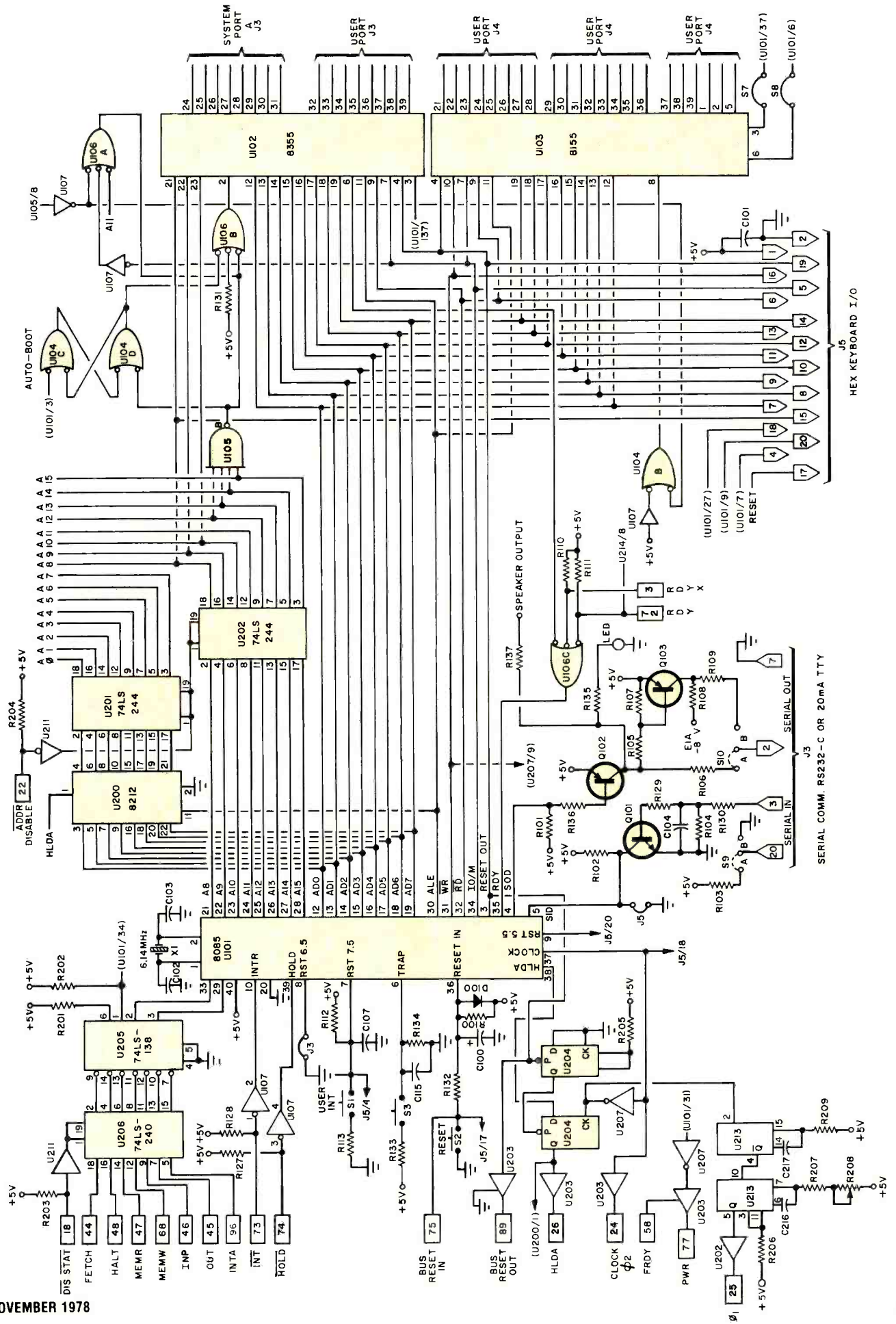
Due to the complexity of the double-sided pc board, which includes expansion provisions, its etching and drilling guide is not given here. Since the basic system actually consists of so few parts, they can be direct-wired on perforated

Fig. 1. Schematic of the basic Minimum Explorer T-8085 computer system is shown on the opposite page. The Parts List is below. The system is built around eight ICs, the most important of which is the 8085.

MINIMUM SYSTEM PARTS LIST

C100—1- μ F, 35-volt tantalum capacitor
 C101—25- μ F, 25-volt upright electrolytic capacitor
 C102, C103—18-pF disc capacitor
 C104, C107, C115—0.1- μ F disc capacitor
 C105—0.0047- μ F Mylar capacitor
 C106—0.47- μ F Mylar capacitor
 C108 through C114—0.01- μ F disc capacitor
 D100, D101—1N4148 switching diode
 K1—Spst reed relay
 LED100—Red light-emitting diode
 Q101, Q104—2N4384 transistor
 Q102, Q103—2N4355 transistor
 The following resistors are 1/4-watt, 5% tolerance:
 R100, R134—47,000 ohms
 R101, R110, R111, R115, R119, R123, R124 through R128, R131—10,000 ohms
 R102—2200 ohms
 R103, R135—390 ohms
 R104, R105, R107, R108, R109, R116, R118, R129, R132—1000 ohms
 R106, R117, R133, R137—100 ohms
 R112—39,000 ohms
 R113—200 ohms
 R114—100,000 ohms
 R120, R121—1 megohm
 R122—22,000 ohms
 R130, R136—3900 ohms
 S1, S2, S3—Spst momentary-action keyswitch
 U101—8085A CPU
 U102—8355 I/O ROM (see test)
 U103—8155 RAM I/O-timer
 U104—74LS00 2-input NAND-gate
 U105—74LS20 4-input NAND-gate
 U106—74LS10 3-input NAND-gate
 U107—74LS04 hex inverter
 U108—LM3900 quad op-amp
 X100—6, 14-MHz crystal
 Misc.—Printed-circuit board; sockets for IC's (three 40-pin, five 14-pin); rubber feet (8); solder; etc.

Note: The following items are available from Netronics R&D Ltd., 333 Litchfield Rd., New Milford, CT 06776: Complete 8085 minimum system Explorer microcomputer kit, including IC sockets (No. 8085EIA for EIA terminals or No. 8085HEX for hex keypad systems) for \$129.95 plus \$3.00 postage and handling. The double-sided, plated-through hole pc board No. 8085PC is also available separately for \$49.95 plus \$2.00 postage and handling. Additional equipment not part of minimum system includes: No. PS5VR 5-volt regulated power supply for \$39.95 plus \$2.00 postage and handling; Explorer case for \$39.95 plus \$3.00 postage and handling; hex keypad kit (see Hex Keypad Parts List) for \$69.95 plus \$2.00 postage and handling; Intel 8085 User's Manual for \$7.50 ppd.



board; but a finished pc board is available to those desiring it from the source given in the Parts List.

General Information. The data bus used in the 8085 is multiplexed. The 16-bit address is divided into the high 8-bit address bus and lower 8-bit address/data bus. The address is sent out during the first part of the cycle. Then the least-significant eight bits of the address are latched into the peripherals by the address latch enable (ALE) signal. During the rest of the machine cycle, the data bus is used for memory or I/O data.

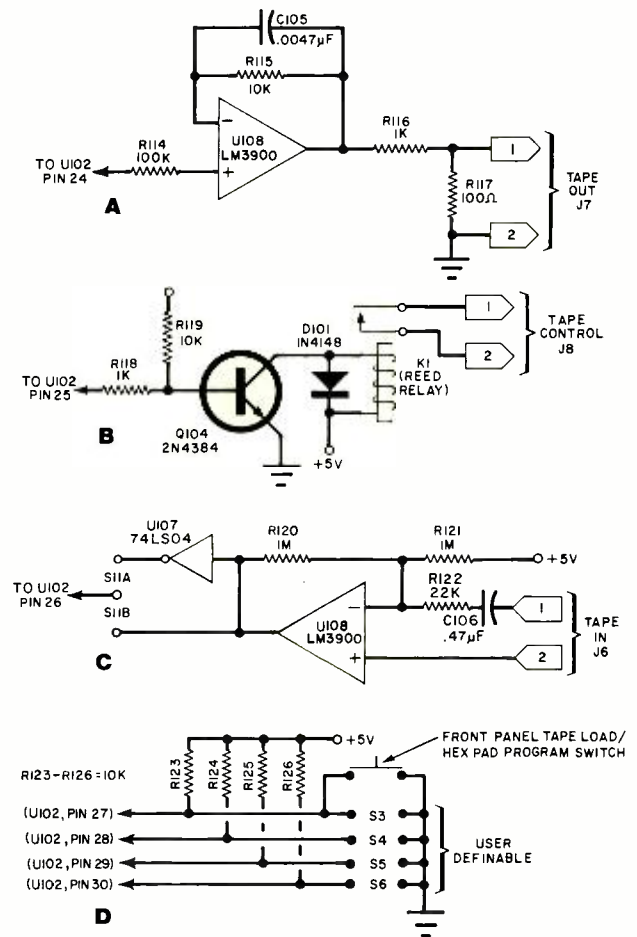
In addition to all of the functions provided by the 8080, the 8085 has on-chip: an internal clock generator; clock output; fully synchronized ready; Schmitt-action RESET IN; RESET OUT pin; RD, WR, and IO/M bus control signals; encoded status information; multiplexed address and data; direct restarts and mask-programmable interrupt; and serial I/O lines. An interrupt acknowledge signal (INTA) is also provided. Hold, ready, and all interrupts are synchronized. The serial input data (SID) and serial output data (SOD) lines are provided for simplified serial interface.

The internal clock requires an external crystal or RC network and oscillates at twice the operating frequency. A 50% duty-cycle, two-phase, nonoverlapping clock is generated from this oscillator. One phase of the clock ($\phi 2$) is available as an external clock.

COMMANDS CONTAINED IN 8355 ROM MONITOR

GETCM		Fetch command (from console).
DCMD	DXXXX,YYYY	Display data contained in memory locations XXXX through YYYY.
GCMD	GXXXX	Run user program beginning at memory location XXXX. If no location is specified, contents of user PC are used.
ICMD	IXXXX	Insert data into memory beginning at location XXXX.
MCMD	MXXXX,YYYY,ZZZZ	Move data in memory locations XXXX through YYYY to memory locations beginning at ZZZZ.
SCMD	SXXXX	Substitute or examine data in memory locations beginning at XXXX.
XCMD	X or X(REG)	Examine contents of all registers or just one register.
WCMD	WXXXX,YYYY,ZZ	Route contents of memory locations XXXX through YYYY to TTY punch or to cassette interface.
LCMD	LXX	Load contents of recorded program into memory. In cassette systems, XXth program can be selected.
FCMD	FXXXX,YYYY,ZZ	Fill contents of RAM locations from XXXX to YYYY with constant ZZ.

Fig. 2. Cassette tape operation is controlled by circuits shown. (A) Amplifies signal for tape deck. (B) Controls tape movement. (C) Amplifies output from deck to microcomputer and choice of normal or inverted signal. (D) Shows hex keypad hookups for tape functions.



The 8085 directly provides the external RDY synchronization previously provided by a 8224 in the 8080 system.

The 8085 has five interrupts: INTR, RST 5.5, RST 6.5, RST 7.5, and TRAP. INTR is identical to INT in the 8080. Each restart (RST) input has a programmable mask. TRAP is also a restart input, but it is nonmaskable. The interrupts are arranged in a fixed priority order that determines the interrupt to be recognized if more than one is pending.

The TRAP interrupt is recognized as if it were any other interrupt, except that it has first priority. It is not recognized by any flag or mask. The TRAP input is both edge and level sensitive. It must go high and remain high to be acknowledged. It is not recognized again until it goes low and then high again. This avoids false triggering due to noise and logic glitches.

The instruction set for the 8085 includes five different types of instructions. The Data Transfer group moves data between registers or between memory and registers. The Arithmetic group adds, subtracts, and increments or decrements data in registers or memory. The Logical group ANDs, ORs, EX-ORs, compares, rotates, or comple-

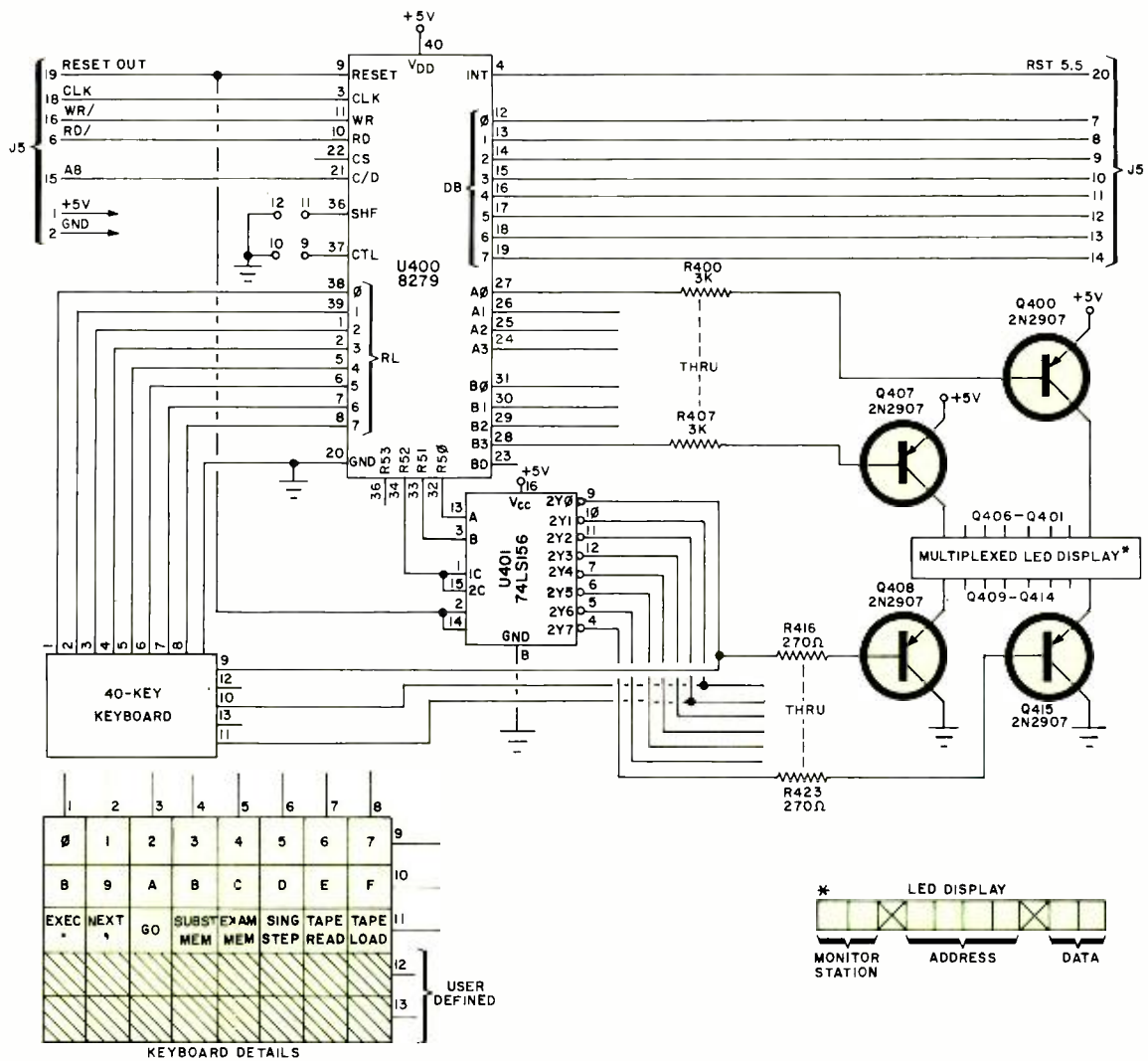


Fig. 3. Hex keypad terminal for use with Explorer computer.

HEX KEYPAD PARTS LIST

- DIS1—Eight-digit multiplexed calculator LED display array
- Q400 through Q415—2N2907 or equivalent transistor
- R400 through R407—3000-ohm, ¼-watt, 5% tolerance resistor
- R408 through R415—24-ohm, ¼-watt, 5% tolerance resistor
- R416 through R423—270-ohm, ¼-watt, 5% tolerance resistor
- U400—8279 keyboard decoder IC
- U401—74LS156 3-to-8 decoder IC

- U401—74LS156 3-to-8 decoder IC
- Misc.—40-key keyboard assembly; 16-conductor cable to mother board; printed circuit board; sockets for ICs (one each 40 pin and 16 pin); solder; etc.

Note: A complete kit of the above parts is available from the source given in the Minimum System Parts List. When a keypad is ordered with a Minimum System the latter will have an 8355 ROM programmed to talk to the keypad.

ments data in registers or memory. The Branch group permits conditional and unconditional jump instructions, and return instructions. The Stack I/O and Machine Control group includes I/O instructions and instructions for maintaining the stack and internal control flags.

Memory for the 8085 is organized into 8-bit bytes, each with a unique 16-bit binary address that corresponds to its sequential position in memory. (The 8085 can directly address up to 65K of memory, including both ROM and RAM.)

Data in the 8085 is stored in 8-bit registers. When a register or data word contains a binary number, the order in which the bits are to be written must be established. In the 8085, bit 0 is the least-significant bit (LSB), while bit 7 is the most-significant bit (MSB). Program instructions can be one, two, or three bytes long. Multiple-byte instructions must be

stored in successive memory locations. The address of the first byte is always used as the address of the instructions. The exact instruction format depends on the particular operation being executed.

The 8085 has four different modes for addressing data stored in memory or its registers. In the Direct mode, bytes two and three of the instruction contain the exact memory address of the data. The low-order bits of the address are in byte two, the high-order bits in byte three. In the Register mode, the instruction specifies the register or register-pair in which the data is located. In the Register Direct

mode, the instruction specifies a register-pair that contains the memory address where the data is located. The high-order bits of the address are in the first register of the pair, while the low-order bits are in the second register. In the Immediate mode, the instruction contains the data itself, which is either an 8- or a 16-bit quantity. The LSB bit goes in first, the MSB last.

Unless directed by an interrupt or branch instruction, the execution of instructions proceeds through consecutively increasing memory locations. A branch instruction can specify the ad-

dress of the next instruction to be executed, either directly or register indirectly. In the Direct mode, the branch instruction contains the address of the next instruction to be executed. Except for the RST instruction, byte two contains the low-order address and byte three contains the high-order address. In the Register Indirect mode, the branch instruction indicates a register-pair that contains the address of the next instruction to be executed. The high-order bits of the address are in the first and the low-order bits are in the second register of the pair.

The RST instruction is a special one-byte call instruction that is usually used during interrupt sequences. RST includes a three-bit field. Program control is transferred to the instruction whose address is eight times the contents of this three-bit field.

There are five condition flags associated with 8085 instruction execution. Each is represented by a 1-bit register in the CPU. A flag is set by forcing the bit to 1 and reset by forcing it to 0.

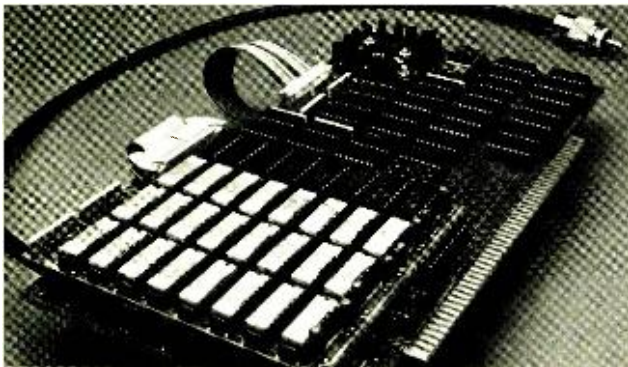
An instruction sets a flag as follows: Zero—if the result of an operation has the value 0; Sign—if the MSB of the result of an operation has the value 1; Parity—if the modulo 2 sum of the bits of the result of an operation is 0 (even parity); Carry—if the instruction results in a carry (from addition) or a borrow (from subtraction or a comparison) out of the high-order bit; Auxiliary Carry—if the instruction causes a carry out of bit three and into bit four of the resulting value. If the above criteria are not met, the individual flags are reset.

The Auxiliary Carry flag is affected by single precision additions, subtractions, increments, decrements, comparisons, and logical operations. However, it is principally used with additions and increments preceding a DAA (decimal adjust accumulator) instruction.

Hex Keypad. Obviously, you must have an input/output terminal to operate a computer. It can be a hex keypad, a TV terminal with an ASCII keyboard, or a Teletype terminal. (Teletype terminals can often be rented for about \$40.00 per month.) The hex keypad shown in Fig. 3 is the least expensive (see Hex Keypad Parts List for Fig. 3). It is adequate for the beginner in computing because machine-language programming is performed in hex code.

The Fig. 3 hex keypad input circuit utilizes an 8279 keyboard decoder chip (U400) and a 10-digit multiplexed calculator LED display (DIS400) output. In addition to the normal hex input, switches are provided for reset, vector-interrupt, single-step go-to, subst (substitute) memory, examine-registers, execute, next, tape-read, tape-load, plus any additional user-definable functions that may be needed.

This keypad is very simple to use. You simply plug it into the computer and start communicating. ◇



"CORONA" 256-Color Peripheral

BY JEFF LOWENSON, ROBERT MARSH & JAMES SPANN

Upcoming S-100 bus compatible kit with full color graphics and alphanumerics.

E EDITORS AT POPULAR ELECTRONICS are frequently privy to exciting new products that are in the final stages of pre-production design. This information includes all the details on how it works and "hands on" experience with custom-wired samples. One such product about which we'd like to share information with readers is Processor Technology's "Corona," a high-resolution, full-color graphics accessory for microcomputers. The Corona will provide 256 colors (or shades of grey in a 256-by-208

display with graphics and alphanumerics mixed—all under software control.

The Corona is designed to be fully bus compatible with the SOL-20 microcomputer and VDM-1 video display module, both made by Processor Technology. However, it can be modified as required to operate with other S-100 bus formats. The Corona-1K kit with 8K of memory will be marketed through computer stores in the near future for \$395.

Technical Details. The display resolution of the Corona is 256 × 256, with a display size of 256 horizontal by 208 vertical. Its 53,248 pixels can be used with a selection of any 16 out of 256 pos-

sible colors (or grey levels). The alphanumerics can be mixed and overlaid with the graphics and/or external video input. The Corona uses 8K of 8-bit bytes in the low-color range and 24K of 8-bit bytes in the full-range version. (See Corona Specifications Table.)

In addition to game playing, this new graphics system is a powerful tool for business, artistic, scientific, and educational applications, since vivid graphics, poster-like displays, and full-color animation are available.

Since the Corona's signals can be mixed with video from a low-cost monochrome TV camera and with alphanumerics from a computer, the final video can display a scene from a camera with

Note: on the cover is an artist's conception of a computer game using the Corona.

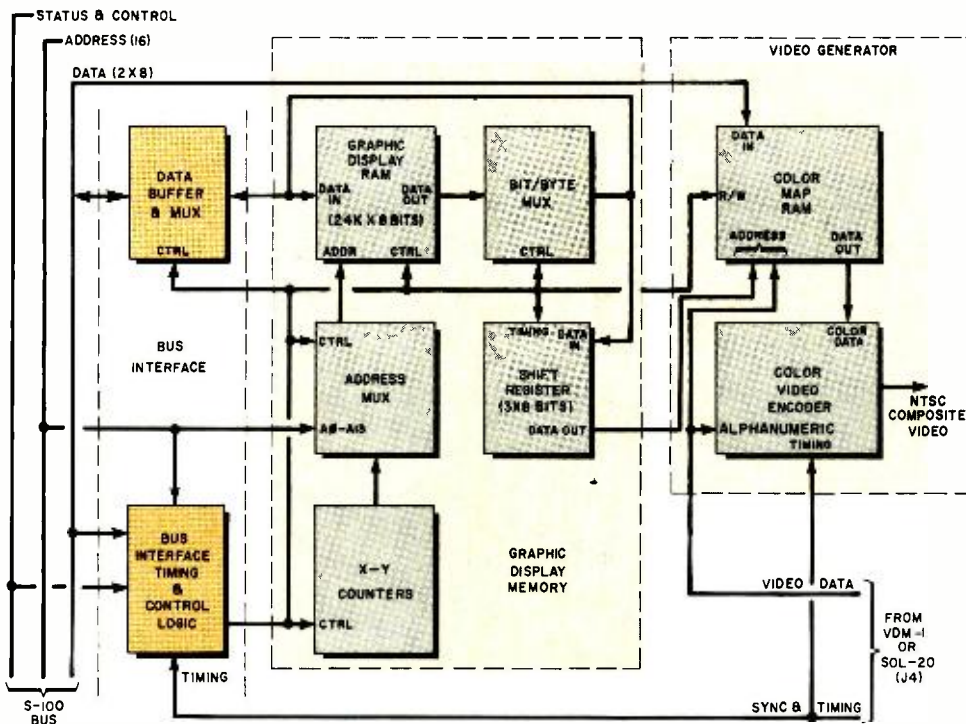


Fig. 1. Block diagram of Corona shows logic interconnections. The NTSC output means that it can be video recorded. Sync can also be obtained from an external source for interfacing to other video systems.

a set of color graphs superimposed on it. Scientific data can be transformed into a presentation that can be observed while an experiment is in progress. Alpha feedback experimenters will find this color approach valuable because of the wide range of its 256 colors.

It is recommended that the Corona be used with a color monitor to take advantage of the better color and crisper images available.

Circuit Operation. As shown in Fig. 1, the heart of the Corona system is the Graphic Display Memory that stores information in three $256 \times 256 \times 1$ bit planes, each of which represents a 256×256 CRT screen matrix. The three combined planes contain three bits of color information for each dot on the TV screen. The memory can be used in two ways—for color-picture storage or as conventional computer memory. This means that when the graphics are not used, the computer's memory is expanded by the amount of memory contained in the graphics interface (see Fig. 2 memory map).

Memory access by the computer is handled in two modes. In the *bit* mode, each full-color point can be individually read or written to by the computer. This mode simplifies interfacing with BASIC and FORTRAN to take advantage of their powerful trigonometric and matrix functions. (Matrix operations enable the programmer to write powerful software for scaling, translation, and rotation of

graphic images.) In this mode, the graphics display area looks to the programmer like a 256×256 Cartesian coordinate system, with the origin at the lower left corner.

In the *byte* mode, graphics data is transferred from the computer to the Corona, eight bits at a time, with the RAM organized as conventional 24K by 8-bit memory. The byte mode permits very fast loading of complete screens from peripheral devices, such as a floppy-disk or a cassette-tape system.

The bus interface and control logic section (Fig. 1) controls the flow of data between the computer and the Graphics Display Memory. This logic synchronizes the TV scan and computer memory requests. This functional block also contains the command registers, memory timing, and fast erase logic.

The address multiplexer selects the

source of the display memory address, which can originate either from the computer or from the X-Y logic. The X-Y counters generate the X-Y address coordinates that represent a point on the CRT screen. Data from the display memory is thus mapped on the TV.

The bit/byte multiplexer is used in the bit mode to change or read one bit into each of the three memory planes. The shift registers convert the eight and 24 bits of parallel data from the Graphics Display Memory into a serial address for the color-map RAM.

The video generator section can provide up to 256 different colors (or 32 shades of grey), eight of which can be displayed graphically at one time. Either SOL-20 or VDM-1 alphanumeric characters can be mixed under program control to interleave graphics and text information anywhere desired on the screen. All the video sync signals are provided by the SOL-20 or VDM-1.

Alphanumerics can be displayed in a distinct ninth color that is selected under software control to provide the best contrast with the eight graphics colors. There are also an additional eight colors where the graphics and alphanumerics intersect.

Any one or all of the displayed colors can be rapidly changed without rewriting the graphics memory contents (that is, without changing the form or shape of the picture). This unique feature can create a shimmering rainbow effect with very simple programming.

MEMORY MAP

FFFF	CORONA MEMORY
E000	NOT USED
D000	SOL/VDM-1 MEMORY
C000	PTDOS
8000	USER MEMORY SPACE
0000	

Fig. 2. Memory map shows RAM arrangement of Corona.

CORONA SPECIFICATIONS

Display resolution	256 × 256
Display size	256 horizontal × 208 vertical
Displayed pixels	53,248
Memory size	8192 8-bit bytes low version; 24,576 8-bit bytes full range
Memory access modes	bit/byte
Memory organization:	
Bit mode	53,248 3-bit pixels
Byte mode	Three 8K byte planes (can also be used for normal data storage)
S-100 bus memory space	8K maximum
S-100 bus I/O ports	Two input, two output
Possible colors	256 (or 32 levels of grey)
Displayed colors	Sixteen maximum.
Display options	Alphanumerics can be mixed and overlaid with graphics and/or external video input on color or monochrome displays
External video input	Software-selectable, accepts standard RS-170 video; external source must be synced to computer
One frame	Two identical fields (noninterlaced)
One field	16.667 ms (1/60 s)
Horizontal sweep cycle	64.1 μs
Horizontal blanking	From 6 to 14 μs
Active display	40.3 μs
Horizontal scanning	
frequency	15,600 Hz
Vertical scanning	
frequency	60 Hz
Color subcarrier	3.579 MHz
Scan lines per field (noninterlaced)	260
Vertical blanking field	833 to 1300 μs
Power requirements	+8 to +10 V dc, 2 A maximum +15 to +20 V dc, 0.2 A maximum -15 to -20 V dc, 0.2 A maximum

The color-map RAM is a high-speed 16-word by 8-bit RAM array. This organization permits the choice of 256 colors (more precisely, 64 colors, each of which has four intensities). Colors for each point on the screen are determined by the three-bit code stored in the Graphic Display Memory that addresses the color-map RAM. The color-map RAM is loaded under program control via the A register.

The function of the color-video encoder is to transform the red, green, blue, and luminance data from the color map into NTSC color signals. This encoder is comprised of timing, four two-bit D/A converter, and the actual color-encoder sections.

The timing section generates the color-burst flag and composite sync (from the SOL-20 or VDM-1 composite sync). The red/green/blue/luminance D/A converters accept digital data from their respective sections of the color map and convert it to analog color-difference signals (R - Y and B - Y). The encoder section is designed around an IC that modulates the color subcarrier with the color-difference signals and outputs the composite video that consists of the video, blanking, and sync signals.

Physical Details. The Corona's circuitry mounts on two large printed circuit boards. The larger board plugs directly into the S-100 bus of the computer and contains 73 ICs, four voltage regulators, and miscellaneous discrete components. The smaller board, which contains 32 ICs that include the RAM memory system and the data multiplexers, is then connected to a jack on the larger board. ◇

A CASSETTE CONTROL SYSTEM for Computers

If you store many computer programs on tape, use the Aux Box to retrieve them quickly and easily

BY A. A. MANGIERI

AUDIO CASSETTE tape recorders make excellent low-cost mass-storage devices for home and small-business computers. They provide an efficient approach for storing a single long program on a cassette tape. For short programs, however, it is usual to store a string of different programs, separated by guard bands, on a common tape track, which leads to retrieval problems. The "Aux Box" cassette deck controller presented here simplifies the process of saving and loading multiple programs that, of necessity, are stored serially on a tape. Although designed to interface directly between Radio Shack's Model

TRS-80 microcomputer and its mating cassette recorder without alterations, the Aux Box can be adapted to other systems.

There are two basic ways to locate a particular program on a cassette tape—strictly manually, using the tape deck's index counter, or with a computer-generated header that "tells" the computer when the named program is passing the playback head.

Working manually, you must "tease" the various tape-speed controls to get to the starting point of a desired program. When using the header approach, you may have to wait quite a while for the tape to get to the desired program. In many cases, including the header approach, you still must make the recorder move rapidly to the desired starting point, as specified by the tape counter. Also, with some computer/tape-deck systems, including the Model TRS-80, you must disconnect cables to regain manual control for rewinding, spotting tape, and monitoring. The Aux Box solves these problems.

With the Aux Box, you can transport tape at fast, medium, and slow speeds in either direction. This makes it very easy to accurately position the tape. Moreover, without removing any cables,

control can be transferred between the computer and the recorder at the flip of a switch, while retaining monitoring capability at all times. Another circuit in the Aux Box permits audio recording without the need to dismantle the setup. Finally, a separate circuit in the Aux Box provides backup protection for the computer's relay.

About the Circuit. The complete circuit for the Aux Box is shown in Fig. 1, along with the computer/cassette-recorder interface. With the plug removed, the recorder's REM (remote) jack is normally shorted to ground, which puts the recorder's negative bus at ground potential. With the plug inserted in the REM jack, the computer starts and stops the recorder via the computer's normally open, fully isolated relay contacts.

Switch S2 transfers control between the computer and the cassette recorder. With S2 set to its COMPUTER position, the computer controls the recorder via the solid-state switch made up of Q1 and Q2. This transistor switch eliminates the current surge through and provides full protection for the relay's contacts, which now carry only the very small base current for Q1.

Pushbutton switch S7 permits tape advance following a data dump without returning control to the recorder.

With S2 set to its RECORDER position and S3 set to its off (REM MIC/TAPE SPEED) position, pushbutton switches S4, S5, and S6 provide FAST, MEDIUM, and SLOW speed control, respectively, for the recorder's fast-forward and rewind modes. As selected by the pushbutton switches, diodes D1 through D5 vary the speed of the tape by controlling the voltage to the tape recorder's motor. The recorder's amplifier voltage is also varied, but monitoring is still available at a slightly reduced volume.

Switch S1 alternately breaks one of two circuit grounds between the computer and the recorder. This ground-loop break reduces or eliminates any slight ac hum that can otherwise be heard during monitoring.

Jack J3 accepts an earphone for audibly monitoring the signal from the tape recorder.

With S2 set to its RECORDER position, S3 is used to select either MIC or REM for audio recording with J4 and J6.

Construction. The circuit for the Aux Box can be assembled in a small plastic box, using the bottom of the box as the



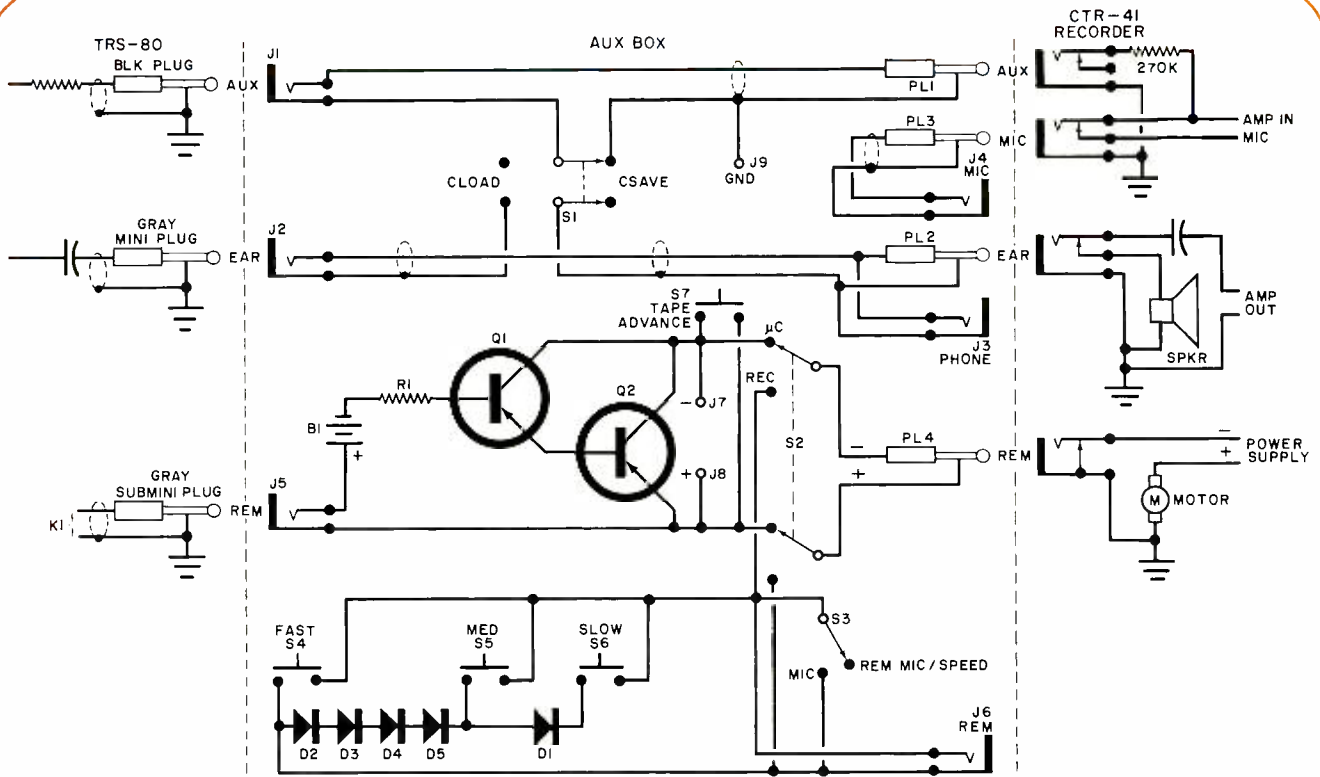


Fig. 1. Schematic of the Aux Box along with the computer/cassette-recorder interface.

PARTS LIST

B1—1.5-volt "C" cell
D1 through D5—1N4001 rectifier diode
J1 through J4—Miniature phone jack
J5, J6—Subminiature phone jack
J7, J8, J9—Phone tip jack
PL1, PL2, PL3—Miniature phone plug

PL4—Subminiature phone plug
Q1—HEP 251 (Motorola) or similar transistor
Q2—HEP 232 (Motorola) or similar transistor
R1—2200-ohm, 1/2-watt, 5% tolerance resistor
S1, S2—Dpdt toggle switch
S3—Spst toggle switch

S4 through S7—Spst normally open momentary-action pushbutton switch.
Misc.—Suitable plastic case; terminal strip; TO-3 transistor socket; battery holder; ear-phone; shielded cable; hookup wire; solder; machine hardware; etc.

control panel. Point-to-point wiring techniques are perfectly adequate for assembling the Aux Box. You can use a terminal strip for mounting Q1 and to provide a convenient means for connecting it into the circuit. Also, use a TO-3 socket, spacers, and machine hardware to mount Q2. Diodes D1 through D5 are best mounted on a tag or terminal strip to permit easy removal should you decide to alter the speed of the cassette transport.

The walls of the box in which the Aux Box is mounted are fairly thick. This means that you must use jacks with fairly long bushings. Alternatively, you can counterbore the mounting holes for the jacks and use standard-length jacks.

The AUX, EAR, and REM jacks (J1, J2, and J5) should be mounted on the rear wall of the box. Jacks J3, J4, and J6 (PHONE, MIC, and REMOTE jacks, respec-



Fig. 2. Photo shows controls and identification on front panel.

tively) go on the front of the box (see Fig. 2). CLOAD/CSAVE, COMPUTER/RECORDER, MIC/REM MIC, TAPE SPEED (FAST, MEDIUM, and SLOW), and TAPE ADV switches S1 through S7, respectively, all go on the bottom of the box, which becomes the control panel. After drilling the holes for but before mounting the jacks and switches in their respective locations, it is a good idea to label each with a white dry-transfer lettering kit as shown in Fig. 2.

Use insulated hookup wire for the REM circuit and shielded cable elsewhere. Check PL4 with an ohmmeter and wire the cable to S2 accordingly. Jacks J7 and J8 can be installed in any convenient location. The cables to which AUX plug PL1, MIC plug PL2, and EAR plug PL3 are attached should exit the box near the respective jacks on the rear of the box.

Inclusion of ground jack *J9* is optional. Use a battery holder for *B1*. Also, use either a 4-ohm or, preferably a 400-ohm, impedance earphone for low loading.

Test and Adjustment. Connect a dc milliammeter in series with a 10,000-ohm potentiometer across *J5* to measure the base current of *Q1* and a dc voltmeter between *J7* and *J8* to measure $V_{CE(sat)}$ of *Q2*. Set *S2* to COMPUTER and insert *PL4* into the recorder's REM jack.

Now, set the pot to minimum resistance and note the base current of *Q1*. With the recorder's PLAY lever engaged, $V_{CE(sat)}$ should be 0.2 volt or less. Advance the pot until $V_{CE(sat)}$ just begins to increase and note the base current of *Q1*. This is the minimum required base current for *Q1*. Note this current, multiply it by 2 or 3, and adjust the pot until the milliammeter indicates the result of your calculation.

Without disturbing the setting of the pot, remove it from the circuit and use an ohmmeter to measure its resistance. Then wire into the *R1* location in the circuit a fixed resistor whose value is as near as possible to your measurement. The reason for choosing a resistor whose value yields twice or three times the minimum base current for *Q1* is to allow for battery ageing.

Set *S2* to RECORDER and observe the speed of the cassette tape in both the fast forward and rewind modes with the recorder's PLAY lever engaged and disengaged. The speed can be altered by diode selection. If desired, a separate string of diodes can be used for *S5* and *S6*. On SLOW, different speeds can be observed on fast forward and rewind with the PLAY lever engaged and disengaged. This is of no consequence. A good choice for a MEDIUM tape speed is half the normal fast-forward speed.

Saving and Loading Programs.

Program locations on the tape are referenced to the recorder's tape-counter readings. Rewind the tape and reset the counter to 000. If the tape has a leader, advance the tape to just beyond the leader. Keep a record of the counter readings at the start and end of each program. Set the recorder up for recording and set *S1* and *S2* on the Aux Box to CSAVE and COMPUTER. Type CSAVE and hit ENTER on the computer to start recording data. Use the earphone at *J3* (PHONE jack) to verify that data is being transferred.

There will be very short blank spaces

on a tape if you allow the computer to space the programs. Therefore, it is a good idea to put the tape recorder in the play mode and press *S7* to advance the tape an additional three to five digits on the index counter after each program. (It has proven handy to assign program starting locations at numbers on the counter ending in 0 or 5. Then the actual recording can be started at, say, 23, 38, etc., to allow a short duration guard band. Also, allow two or three digits of blank tape on the other side of the assigned starting location.)

As an example of the foregoing, let us assume that a data dump ends at 144. Here, you might advance the tape to 153 and record the starting location of the program as being at location 150 on the index counter. When saving programs, remove the microphone from *J4* and *J6*.

The Aux Box also permits various procedures for loading programs. (You will eventually adopt your own.) First, the earphone monitor is active when the recorder is in fast forward, play, and re-

wind only when the PLAY lever is engaged. The monitor's volume drops slightly when the SLOW button on the Aux Box is pressed, but it will be adequate.

There are three general methods for positioning the tape, plus many variations. The tape can be positioned with the PLAY lever engaged at all times, with continual monitoring of the tape. As usual, the recorder's FAST-FORWARD and REWIND levers do not latch in the engage positions with the recorder in the play mode and, therefore, must be firmly held down to move the tape. Second, with the PLAY lever disengaged (monitor inactive), the tape can be run just short of the target location and then switched over to recorder play to access the monitor while setting the tape between data jumps. Finally, the tape can be positioned with the PLAY lever disengaged and use of the monitor deferred until a load is required. The last approach works well if you save programs as described above.

GRAPHICS STAR PROGRAM

The eye-catching star on the monitor in the lead photo can be duplicated with a TRS-80 computer. The program given here causes a star to be drawn, pauses, and then proceeds to draw the pattern in reverse. Conserving memory or execution time were secondary in this program; several improvements are possible. Look for them. Lines 40 through 90 draw three nested inverted V's. Lines 210 through 250 draw a left-to-right descending line. Lines 310 through 340 draw a right-to-left descending line. Lines 240 and 330 place lower limits on the screen.

The diagonal line routines merit close study for use in other graphic programs. In

line 210, try other integer and noninteger numbers for B along with several less than one. Some unexpected surprises are in store; try it! As you ponder the results, consider that screen X-Y coordinates are integers and that computation X/B is often a noninteger.

Lines 410 through 490 introduce a pause followed by reversal of screen. For some artistic effects, add STEP 5 to line 420. Add line 425 IF Y = 20 THEN NEXT Y and run. Isn't that something? Try other step increments in lines 420 and 430 alone and in combination. With a few more statements and functions, you can come up with some astonishing abstract stars.

```
10 REM * TRS-80 GRAPHICS STAR PRO-
PROGRAM *
20 REM * DRAW INVERTED V *
30 CLS
40 FOR Y = 0 TO 2
50 FOR A = 0 TO 47 - Y
60 SET (64 + A, Y + A)
70 SET (63 - A, Y + A)
80 NEXT A
90 NEXT Y
100 REM * DRAW HORIZONTAL LINE *
110 FOR X = 0 TO 127
120 SET (X, 20)
130 NEXT X
200 REM * DRAW LEFT DESCENDING DI-
AGONAL *
210 B = 4
220 FOR X = 0 TO 127
230 SET (X, 20 + X/B)
240 IF 20 + X/B > 47 THEN 310
```

```
250 NEXT X
300 REM * DRAW RIGHT DESCENDING DI-
AGONAL *
310 FOR X = 127 TO 0 STEP - 1
320 SET (X, 20 + (127 - X)/B)
330 IF 20 + (127 - X)/B > 47 THEN 410
340 NEXT X
400 REM * PAUSE AND REVERSE
SCREEN *
410 FOR N = 1 TO 2000: NEXT N
420 FOR Y = 0 TO 47
430 FOR X = 0 TO 127
440 IF POINT (X,Y) = 0 THEN 470
450 RESET (X,Y)
460 GOTO 480
470 SET (X,Y)
480 NEXT X
490 NEXT Y
999 GO TO 999
```

Here's an example of how the Aux Box can be used in conjunction with a cassette tape system. Assume that the assigned location of a program on tape is at 150 on the index counter. Rewind the tape by setting S2 to RECORDER and S3 to TAPE SPEED. Latch the recorder's REWIND lever and press S4 (FAST switch) to rewind a short tape. With long tapes, use S3 in the MIC position for rewinding. Reset the index counter and then operate the recorder's STOP lever.

To position the tape, press the recorder's FAST-F lever and latch it. Press S4

(FAST) and observe the counter's 10's and 100's digits. When 14X appears on the counter, release S4. The tape will probably coast to about 146. At this point, you must select between immediate use of the monitor (PLAY lever engaged) or defer use of the monitor (PLAY lever disengaged) and move the tape to 150 on the index counter, using S5 (MEDIUM) or S6 (SLOW).

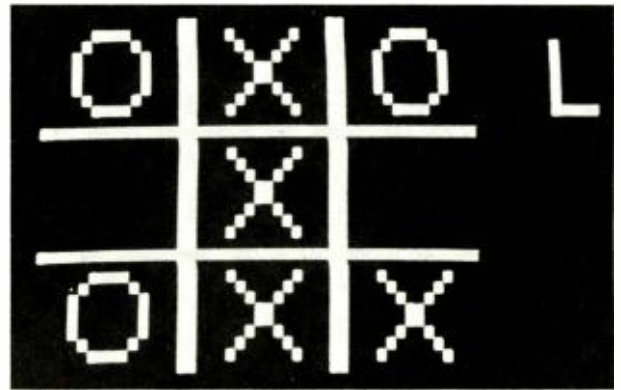
The tape can be run back and forth to access other programs without rewinding or resetting the index counter. Going backward (rewinding) from 175 to 20, use the REWIND lever on the recorder and S4 (FAST switch) on the Aux Box, letting go of S4 when 03X appears in the index counter. Use SLOW reverse to jog

the tape to its final position. On the MEDIUM speed, the counter's 1's decade is at least readable and tape coasting is reduced by one-half. This can be used to great advantage.

Summing Up. If you store many programs on one cassette tape, the Aux Box lets you see just how easy it can be to retrieve programs quickly and precisely. Without having to pull cables, you can transfer control between the computer and tape deck at the flip of a switch and monitor the tape at all times. And you can transport tape at any of three speeds in either direction. In short, the Aux Box takes much of the hassle out of loading programs. ◇

A TIC-TAC-TOE GAME for your Elf Computer

Use a simple light pen as an input selector and the programs given here.



BY EDWARD M. McCORMICK

AN ELF computer that contains 1K of RAM can be programmed to play Tic-Tac-Toe if it is equipped with a video (1861) display and a light pen, the latter to be described here. The computer, using an O, plays against the human (X), and either the computer or the human can go first.

Unless forced to make some other play, the computer will randomly select any open position as its response. This results in a wide variety of games, and although the computer can be beaten, it will also win more than one might expect.

Playing the Game. The playing sequence is straightforward. The IN switch is operated to clear the screen. If any toggle switch is on, the computer will indicate its O after a pause of two seconds. If the input toggle switches are all off, the computer will wait for you to make the first move.

Whenever you are to play, a P will be displayed at the upper-right corner of the screen. You place the light pen in front of the position you wish to play, then depress the IN switch. An X will appear at the selected position. The computer will then indicate its response and you play again. This cycle continues until the game ends.

A D for draw, W for win, or L for lose will be shown at the upper-right corner at the end of a game. To clear the screen and set up for another game, simply operate the IN switch.

The Light Pen. The light pen consists of a cadmium-sulphide cell (Radio Shack 276-116) connected between EF-3 and ground in the Elf. Make sure that a 47,000-ohm resistor is connected between EF3 and +5 volts.

The main program, subroutines, and data sets are given in Tables I through V. Program execution starts at 0400. Ta-

ble VI indicates the initial contents of page 6, the display area. Note that this forms the familiar Tic-Tac-Toe grid.

The program requires about 525 bytes, including main program, subroutines, and data storage. In addition, 256 bytes are used for the display area. The remainder of the RAM space can be used for embellishments to the program.

Initially, the program sets up the registers used. After the IN switch has been operated, the nine playing positions and the status position are cleared and N (the number of plays) is set to zero. If the input toggle switches are not set to zero, the program goes to the "any place" position (Table I). The computer randomly selects one of the unplayed positions and places an O in that location. The program then adds a 1 to N and checks to see if all nine positions have been played. If not, it allows the opponent to play an X. Note that when the input toggle switches are at zero, the program goes directly to X.

TABLE I—MAIN PROGRAM

Loc.	Program	Comments			
04 00	C0 05 20	Initialize Registers	04 7F	F8 00 A7	Get playing position
04 03	E9 69	Start video display	04 82	FC E0 A3 E3	from table
04 05	3F 05 37 07	Operate IN Switch	04 86	F0 A6 BC	If it is occupied
04 09	F8 E0 A3	Clear All Positions	04 89	E6 F0 32 A1	get next position
04 0C	E3 F8 14 A5	including 9 playing	04 8D	87 FF 08	If all unoccupied
04 10	F0 32 18	and the status	04 90	32 98	positions scanned but
04 13	A6 D4 13	position	04 92	87 FC 01 A7	not recognized, turn
04 16	30 0C		04 96	30 82	on
04 18	F8 00 A8	N = O	04 98	F8 2C A5	'?' as status but
04 1B	E9 6C 32 4D	Toggle .Sw On?	04 9B	F8 0F A6 D4	continue
04 1F	8B AC 8C	Any Place	04 9F	30 7F	scan
04 22	FF 09 32 2A	Determine random	04 A1	F8 1C A5 D4	Write 'X' in
04 26	33 22 FC 09	position to play,	04 A5	F8 01 59 DD	unoccupied position,
04 2A	FC E0 A3	if occupied go	04 A9	F8 00 A3	make tries to see
04 2D	E3 F0 A6 E6	back for another	04 AC	36 BE	if it is pen
04 31	F0 3A 1F	random position	04 AE	83 FC 01 A3	light position
04 34	F8 80 59 DD	'O'	04 B2	FF 20 3A AC	
04 38	F8 24 A5 D4	Write 'O'	04 B6	9C A6	If not recognized
04 3C	88 FC 01 A8	N = N + 1	04 B8	F8 14 A5 D4	erase 'X' and go to
04 40	FF 09 3A 4D	N = 9?	04 BC	30 8D	next position.
04 44	F8 44 A5	'D'	04 BE	F8 14 A5	When 'X' recognized
04 47	F8 0F A6 D4	If N=9, write 'D',	04 C1	F8 0F A6 D4	clear status.
04 4B	30 05	return to restart	04 C5	F8 1B A5 DA	Lost?
04 4D	F8 4C A5	Operate IN Switch	04 C9	86 32 D5	If so, write
04 50	F8 0F A6 D4	Write 'P' then	04 CC	F8 3C	'L'
04 54	3F 54 37 56	wait for IN switch	04 CE	A5 F8 0F A6	and return
04 58	F8 01 59 DD	'X'	04 D2	D4 30 05	to restart
04 5C	F8 00 A3	If area bright	04 D5	88 FC 01 A8	N = N + 1
04 5F	36 6B	then skip to turn on	04 D9	FF 09 32 44	N = 9?
04 61	83 FC 01 A3	'?' and retry after	04 DD	F8 06 A5 DA	Win?
04 65	FF 20 3A 5F	short wait	04 E1	86 32 F0	If so, write
04 69	30 78		04 E4	F8 80 59 DD	'O'
04 6B	F8 2C A5	Put '?' in status	04 E8	F8 24 A5 D4	to win then write
04 6E	F8 0F A6 D4		04 EC	F8 34 30 CE	'W'
04 72	F8 20 59 DD		04 F0	F8 12 A5 DA	Def?
04 76	30 5C		04 F4	86 32 1F	If so, play that 'O',
04 78	F8 14 A5	If area dark, start	04 F7	30 34	else go to Any Place
04 7B	F8 0F A6 D4	scanning			

TABLE II—CHARACTER PRINT SUBROUTINE WITH DATA FOR CHARACTERS USED.

Loc.	Program	Comments
07 00	DF E5 F8 08 AC F0 56	Write reg 5 8 byte
07 07	8C FF 01 AC 32 00	* character into reg 6
07 01D	15 86 FC 08 A6 30 05	* position on screen
07 14	00 00 00 00 00 00 00	Blank
07 1C	81 42 24 18 18 24 42 81	X
07 24	3C 42 81 81 81 81 42 3C	O
07 2C	00 0E 11 02 04 04 00 04	?
07 34	00 11 11 11 15 15 1B 11	W
07 3C	00 10 10 10 10 10 1F	L
07 44	00 1E 11 11 11 11 1E	D
07 4C	00 1E 11 11 1E 10 10	P

TABLE III—DELAY SUBROUTINE

Loc.	Program
05 F0	DF E9 8B F4 AC 59
05 F6	8B F7 3A F6 30 F0

Immediately after the opponent has played, the computer checks to see if it has lost. If it has lost, the computer displays an L and waits for the IN switch to be operated to start the next game. If the computer has not lost, it adds 1 to N to see if all nine positions have been played and, if so, displays a D and awaits a new game.

If the computer has not lost and the game is not a draw, the computer checks to determine if it can win. All eight sets of positions are checked to find one that has two O's and the third position blank. If it finds such a combination, it will display an O in that third position, display a W and return to restart.

If the computer has neither lost nor won, the program then takes defensive action. The eight sets of positions are examined to see if the opponent has two X's and the third position blank. If it finds such a situation, the computer inserts an O at that position, and continues. If not compelled to make a defensive play, the

TABLE IV—LOSE-WIN-DEFENSIVE (L-W-D) SUBROUTINE

Loc.	Program	Comments
05 60	DF F8 C0 A7	Set addr init position
05 64	F8 00 A3 AC	Clear counters
05 68	E7 F0 AE EE F0 32 7F	Examine location
05 6F	FF 81 32 79	* addressed,
05 73	8C FC 03 AC 30 81	* if 'O' add 3,
05 79	8C FC 09 AC 30 81	* if 'X' add 9, else
05 7F	8E A6	* store blank position
05 81	17 83 FC 01 A3	Repeat for all 3 positions
05 86	FF 03 3A 68	* of combination
05 8A	85 59 E9 8C F7 32 9B	If L-W-D match not found,
05 91	87 FF D8 3A 64	* go to next combination
05 96	F8 00 A6 30 60	Exit if all 8 combs fail
05 9B	86 3A 60	Set register 6 and exit
05 9E	F8 01 A6 30 60	* if L-W-D match found
05 C0	09 0B 0D 09 63 BD	The eight combinations
05 C6	09 61 B9 0B 63 BB	* of three positions
05 CC	0D 63 B9 0D 65 BD	* (rows, columns)
05 D2	61 63 65 B9 BB BD	* and diagonals)
05 E0	63 09 0D B9 BD	The 9 playing and the
05 E5	0B 61 65 BB 0F 00	* status positions

TABLE VI—DISPLAY AREA IN PAGE 6 WITH TTT GRID

Loc.	Data
06 00	00 00 18 00 18 00 00 00
06 08	00 00 18 00 18 00 00 00
06 10	00 00 18 00 18 00 00 00
06 18	00 00 18 00 18 00 00 00
06 20	00 00 18 00 18 00 00 00
06 28	00 00 18 00 18 00 00 00
06 30	00 00 18 00 18 00 00 00
06 38	00 00 18 00 18 00 00 00
06 40	00 00 18 00 18 00 00 00
06 48	00 00 18 00 18 00 00 00
06 50	07 FF FF FF FF FF E0 00
06 58	00 00 18 00 18 00 00 00
06 60	00 00 18 00 18 00 00 00
06 68	00 00 18 00 18 00 00 00
06 70	00 00 18 00 18 00 00 00
06 78	00 00 18 00 18 00 00 00
06 80	00 00 18 00 18 00 00 00
06 88	00 00 18 00 18 00 00 00
06 90	00 00 18 00 18 00 00 00
06 98	00 00 18 00 18 00 00 00
06 A0	00 00 18 00 18 00 00 00
06 A8	07 FF FF FF FF FF E0 00
06 B0	00 00 18 00 18 00 00 00
06 B8	00 00 18 00 18 00 00 00
06 C0	00 00 18 00 18 00 00 00
06 C8	00 00 18 00 18 00 00 00
06 D0	00 00 18 00 18 00 00 00
06 D8	00 00 18 00 18 00 00 00
06 E0	00 00 18 00 18 00 00 00
06 E8	00 00 18 00 18 00 00 00
06 F0	00 00 18 00 18 00 00 00
06 F8	00 00 18 00 18 00 00 00

TABLE V—INTERRUPT ROUTINE FOR THE 1861 CHIP

Loc.	Program
05 00	72 70 22 78 22 52
05 06	C4 C4 C4
05 09	F8 06 B0 F8 00 A0
05 0F	80 E2
05 11	E2 20 A0 E2 20 A0
05 17	E2 20 A0
05 1A	3C 0F 1B 30 00

TABLE VII—REGISTER USE IN TTT PROGRAM

Register	Use
0	Interrupt DMA pointer
1	Interrupt routine
2	Stack pointer
3	Page 5 pointer
4	Character print subr
5	'From' char pointer
6	'To' char pointer
7	Page 5 pointer
8	N, number of plays
9	Temp storage pointer
A	L-W-D subr
B	Refresh count
C	Temp storage
D	Delay subr
E	Win, Lose, Draw
F	Main program

TABLE VIII—INITIALIZATION OF THE REGISTERS

Loc.	Program
05 20	F8 05 BF F8 27 AF DF
05 27	F8 05 B1 B2 B3
05 2C	B7 B9 BA BD F8 06
05 32	B6 BE F8 07 B4 B5
05 38	F8 02 A1 F8 BF A2
05 3E	F8 E0 A3 F8 01 A4
05 44	F8 FF A9 F8 61 AA
05 4A	F8 F1 AD C0 04 03

program returns to "any place" and randomly selects its next response.

If the light pen is placed in front of an already lit position when it is the opponent's turn to play, a ? will be displayed. As soon as the pen is moved to a dark position, the program will start scanning all unplayed positions to display the X. If the light pen is away from all positions, a ? will be displayed. The ? is erased when a valid X is written.

Program. The program consists of the Main Program shown in Table I and four subroutines. These are Character Print in Table II, Delay in Table III, L-W-D (Lose-Win-Defensive) in Table IV, and Video Chip Interrupt in Table V.

The character-print subroutine can print a blank or any of the seven characters X, O, ?, W, L, D, or P in any of the 10 positions on the screen. The delay subroutine is used for various delays including the 2-second delay before displaying an O. The L-W-D subroutine is used for the three tests to determine if

the computer has lost, can win, or must play defensively. For each row, column, or diagonal, the computer examines each of the three positions. If it is an X, nine is added to a register; if a O, three is added; and if blank, nothing is added. Thus, a total of 27 indicates a loss, a total of 6 a potential win, and a total of 18 indicates that defensive action is required. The video interrupt instruction is conventional.

The random position for "any place" is determined by the B register, which is used to count the number of refreshes of

the TV screen. Whenever "any place" is entered, the program takes the modulo-9 value of this count for the position to be played. If that position is already occupied, another number is generated and the process is repeated until an empty position is found.

The use of the various registers is shown in Table VII.

The first seven bytes of the register initialization section (Table VIII) makes the switch if the program register upon entry is not F. If it is F, this part of the initialization must be skipped. ◇

16-Bit VS 8-Bit Microprocessors

BY GORDON LETWIN & HAMPTON MILLER

Heath Co.

IT IS OUR purpose here to provide a brief comparison of the recently introduced 16-bit microprocessors with their predecessors, the 8-bit CPU's. While we cannot do full justice to a complete comparison of all aspects of the two types, some broad generalizations can be made that will give a good idea of what to expect from the new 16-bit machines.

The Differences. Microprocessors deal with elementary units of digital information called "bits." An 8-bit processor's registers and data paths are all eight bits wide. Therefore, it operates on data and instructions eight bits (one byte) at a time. This does not mean that an 8-bit processor cannot deal with data larger than eight bits wide. The data can be broken up into 8-bit bytes and processed one byte at a time.

Many processor instructions, such as branches and memory references, are 16 and 24 bits long and are known as 2- and 3-byte instructions. These processors may also contain a few instructions that deal directly with 16-bit values. However, these multibyte instructions and 16-bit operations are handled eight bits at a time and, therefore, take more time to execute than do single-byte instructions dealing with 8-bit values. Typical applications are process control and communication, tasks that require minimal computation.

In contrast to the 8-bit processor, the registers and data paths of a 16-bit

processor are all 16-bits wide. Consequently, the 16-bit processor operates on data and instructions 16 bits at a time. Since the number of operations per second is roughly the same for both 8- and 16-bit processors, two times as much work gets done per instruction with a 16-bitter. Hence, a 16-bit processor can be much faster than an 8-bitter.

The 16-bit processor is more than a double-sized 8-bit device. Since the 16-bitter fetches instructions from memory 16 bits at a time, its instruction set usually includes 16-, 32-, and 48-bit instructions. The longer instructions allow a 16-bit machine to implement sophisticated instructions that tend to be more general-purpose to take better advantage of a given architecture than does the 8-bit device. For example, to interpret the BASIC statement $A=B(4)$ with an 8-bit 8080A, the BASIC interpreter might execute the code as follows:

```
LXI H,B
LXI D,4
DAD D ;(HL)=address of value
MOV E,M
INX H
MOV D,M ;(DE)=value
XCHG
SHLD A ;store in A
```

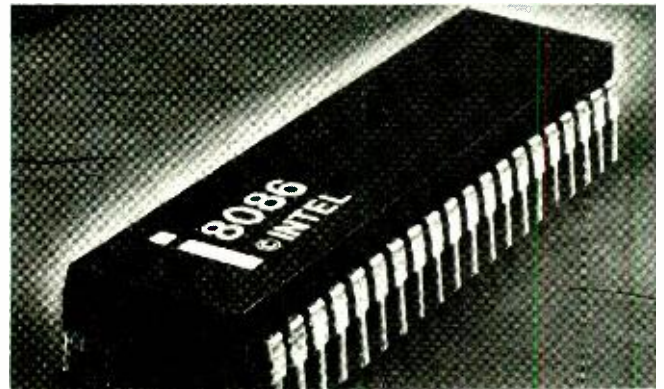
On the other hand, a 16-bit computer such as an LSI-11 could use the following code:

```
MOV #4,R1 ;(R1)=subscript
MOV B(R1),A ;look up and store
```

Note how the 16-bit machine avoids the clumsy and time-consuming memory-access gyrations required by the 8-bit device.

Although 8-bit devices deal with smaller values than do 16-bit devices, this does not mean that the former cannot perform all the computations that a 16-bitter can perform. It just requires more time because calculations must be processed in smaller pieces that must be "fetched" sequentially from memory. To perform the operation $A=B-C$ with the 8080A requires the following code:

```
LHLD C
XCHG
LHLD B
MOV A,L
SUB E ;subtract low 8 bits
MOV L,A
MOV A,H
SBB D ;subtract high 8 bits
MOV H,A
SHLD A ;store result
```



8086 CPU is part of Intel's new 16-bit family.

PROCESSOR COMPARISON TABLE

Processor	Data width	Register count	Memory (bytes)	Task timing in microseconds			
				Load	Subtract A=B-C	Code bytes	
8080	8	7	65K	8	14	273	22
6800	8	3	65K	8	14	266	30
LSI-11	16	7	65K	7	3.5	42.7	20
PACE	16	3	65K	9	9	61.0	36
9900	16	16	65K	7.3	4.7	49.9	24
8086	16	7	1M	2.8	0.6	17.6	24
Z8000	16	14	8M	2.25	1.0	14.0	24

The following very short code is required by the LSI-11:

```
MOV B,A ;store B in A
SUB C,A ;subtract C from B
```

The table lists the memory and time required by several popular 8- and 16-bit processors to execute the statement $C=B-A$, where A, B, and C are 32-bit integers. Many BASIC interpreters make use of 32-bit or larger numbers to provide the necessary accuracy.

Advantages and Disadvantages.

Since 16-bit devices operate on larger chunks of data and, thus, need perform fewer operations for a given task, their primary advantage is speed. This is usually several times faster than 8-bit devices. The larger the data items to be manipulated, the greater the advantage of the 16-bit design. This is true not only because the 16-bitter works with larger pieces, but also because the greater number of registers frequently reduce the number of memory references required.

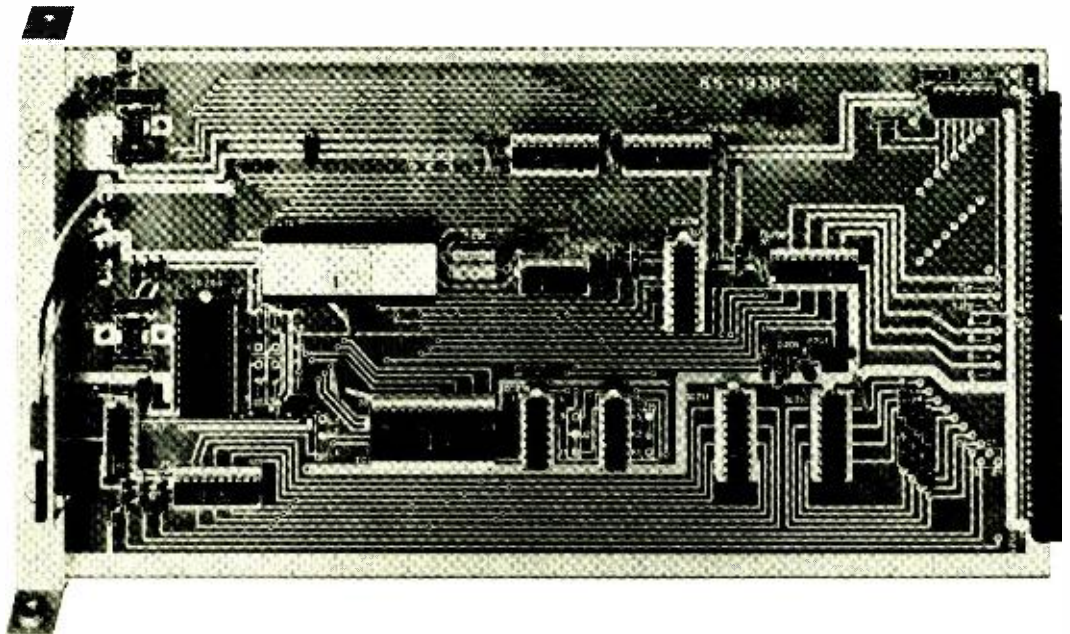
A second major advantage of the 16-bit machine is the volume of *profession-*

al software available for them, since many of these machines execute the instruction set used by well-established mini-computers. For example, the Digital Equipment Corp. (DEC) LSI-11 executes the instruction set for the PDP-11 family. As a consequence, with the proper peripherals, it can run the DEC PDP-11 operating systems, such as PTS, RT-11, RSX-11, etc.

Another advantage of the 16-bitter is that some 16-bit systems can accept peripherals designed for minicomputer

members of the family. This provides the option of purchasing high-level printers, disks, etc., and obtaining service contracts on them as well.

A major disadvantage of the 16-bit system is its higher cost, which results from multichip configurations and relatively expensive support circuitry. Since memory is accessed in 16-bit words, a computer that uses a 16-bit processor requires 16-bit data paths. This means more bus interface, control circuitry, and connectors



This photo, and the one on the facing page, illustrate the difference between an 8-bit CPU board (above) as used in the Heath H8 and the 16-bit CPU.

Also, current 16-bit processors tend to use more memory for a given task than do 8-bit machines. A program being run in a 16-bit machine may require 10% to 20% more memory bytes than the same program being run in an 8-bit machine. In addition, there are not, at present, many peripheral devices available for 16-bit machines, so 8-bit computers have the advantage here.

Candidates for 16-Bitters. Users with large computational needs (so-called "number crunchers") should definitely consider a 16-bit machine. Avid game players will find that many advanced and sophisticated games require the extra speed that a 16-bit machine can provide.

Some 16-bit machines have available optional floating-point hardware that can speed up numerical calculations by a factor of 20 or more. Users who are or plan to be sophisticated programmers will want a 16-bitter because of its sophisticated instruction set. As shown in the foregoing examples, assembly-language programming for these machines is many times easier for 16-bit machines than it is for 8-bit machines. In addition, the more powerful addressing capabilities allow the programmer to take advantage of algorithms that might be difficult to implement on an 8-bit machine.

If you plan to use your computer system primarily for business applications, you should consider factors other than just raw CPU speed. A primary concern in business applications is the availability of peripherals and loads of business software that have been in use for many years and are, thus, completely debugged. If the system under consideration is software-compatible with a mini-computer, it can take advantage of the already existing software for that mini-computer.

Much of the existing software is inexpensive or in the public domain and, therefore, available for a copying charge. However, much of it may be available from only the manufacturer of the "parent" mini-computer line and can be quite expensive. If you are interested in transferring existing minicomputer software to a compatible microcomputer, you should investigate this area closely with the microcomputer manufacturer and the manufacturer of the parent minicomputer before making a purchase. Either or both companies may sell software and/or have user groups that distribute programs.

The Future. The future appears bright for the 16-bit computer. Most of the new generation of 16-bit microprocessors will be single-chip devices that, together with high-volume production, will bring

chip prices to levels closer to current 8-bit processors. An important use of 16-bit μ P will likely be in military, automobile and large-system applications.

Chip designers are also working on memory utilization, which is another important cost factor. Due to their advanced architecture, the new generation of 16-bit chips will generally require less memory for a given program than do present 8- and 16-bit devices.

The new 16-bit chips will also provide vastly improved performance. Many of them will be capable of running faster than many present-day minis that cost \$60,000 or more.

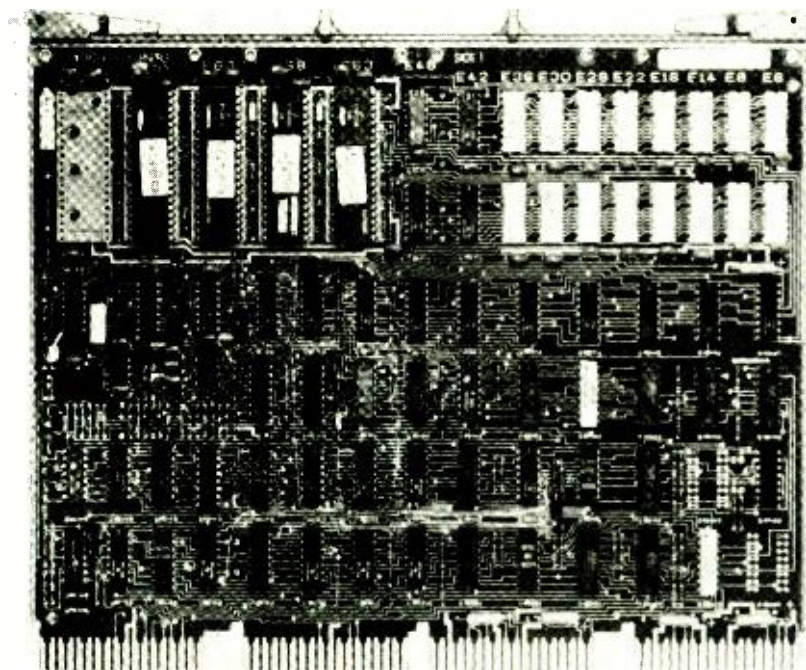
Semiconductor memory prices have plummeted in recent years and may drop even faster in the future as new memory devices (like bubble memories) come along. New 16-bit processor designs have anticipated this "problem" by providing the capability of addressing extended amounts of memory. Intel's 8086, for example, can handle up to 1 megabyte of memory, while Zilog's Z8000 can address up to 8 megabytes. The combination of processor speed and memory capacity makes these chips suitable for use in large multi-user computer systems as well as in smaller single-user systems.

Manufacturers also realize that customers will be reluctant to rewrite their expensive software (developed for their 8-bit machines) to use their new 16-bit processors. Most have, therefore, designed their new processors to be "upward-compatible" with their previous products. Hence, programs written for the 8080A can be reassembled to run with the 8086, and Z80 programs can be reassembled for the Z8000.

Conclusion. Although we've concentrated on the merits and features of 16-bit processors, the 8-bit processor is far from dead. It currently enjoys a wide customer base and an ever-increasing amount of software and peripherals, and will continue to do so for many years to come. Though they do not have the processing capability of the 16-bit systems, the 8-biters are certainly fast enough for most home and small-business applications.

As 16-biters come into their own, they will likely eclipse and supersede our present 8-biters. This will happen when complex applications require more effective addressing and where memory requirements in larger systems become an important consideration. ◇

(Computer section continues on next page.)



The 16-bit CPU above, used in the Heath H11, is much denser than the 8-bit unit at left. It also carries 4K of RAM; but both have necessary support chips.

How to Care for Diskettes

Correct handling and storage of diskettes ensures good data retrieval.

FLOPPY-DISK systems are being used in growing numbers in personal computing systems. Since about 70K of data can be stored on a small 5¼" (13.3-cm) diskette, you should be aware that all of the work put into creating and storing long programs can be catastrophically destroyed by improper handling. This problem can be caused by a single act like smoking near a disk system, touching a diskette with a fingertip, bringing metal tools near a diskette, and even by having an audio system or radio receiver too close to the disk system.

Let us take a brief look at how a disk system works and how improper handling can cause a diskette to lose data.

Physical Makeup. As shown in Fig. 1, a floppy diskette consists of a relatively heavy cardboard (or other nonmetallic) jacket whose dimensions vary with the size of the diskette. Inside the jacket is the actual diskette itself. The diskette is made of very thin, flexible Mylar on which is deposited a layer of magnetically active material similar to that used on audio magnetic recording tape.

When the diskette is inserted into the disk-drive mechanism, the large hole at its center is engaged by a spindle and the disk inside the jacket is made to revolve at high speed. This is similar to the playing of a conventional record on its player, except that the read/write head in the disk-drive mechanism does not contact the diskette. Also, there are no grooves on a diskette as there are on a record. Instead, the disk drive's mechanical system uses computer commands to position the read/write head at the correct track.

A large track-access slot extends part way along one radius of the protective jacket. This slot permits the read/write head to access the magnetic surface of the diskette. A small hole near the large disk-drive hole allows a sensor in the disk-drive system to detect the rotational position of the diskette.

Handling a Diskette. Before removing a diskette from its jacket, read the instructions printed on the back of

the jacket. Listed here are usually a lot of no-no's such as: do not touch the diskette's magnetic surface with fingers; keep the diskette away from magnetic fields; do not bend or fold the diskette; keep the diskette at a reasonable temperature; and keep the diskette in its protective jacket when not in use. Needless to say, heed the printed advice.

Since a diskette works because a magnetic track is laid down by the read/write head, the diskette's surface is extremely sensitive to magnetic fields. This means that a diskette should never be placed in a magnetic field. It is obvious that one would not intentionally bring a powerful magnet near a diskette, but accidents can occur if you are not on guard. For example, audio equipment and even a small pocket radio near a diskette can wreak havoc to the data on a diskette. Bear in mind that loudspeakers operate by powerful magnetic action and that the speaker's magnetic field does not stop at the surface of its enclosure or the plastic case of the radio.

It is best to keep all metal tools away from diskettes because chances are that the tools have become magnetized during use. You can easily check this by seeing how many paper clips your favorite screwdriver picks up. But even if your tools do not pick up paper clips, this is no guarantee that they are not slightly magnetized. So, play it safe; keep all tools away from diskettes.

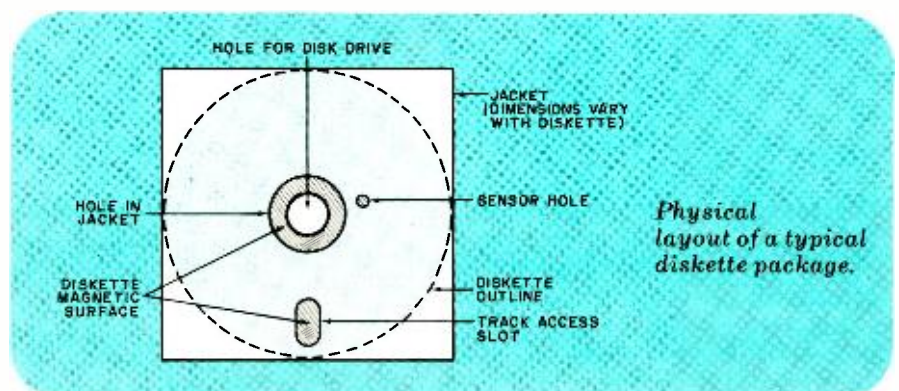
There is also the problem of the ac field that surrounds some transformers and turned-on soldering guns. This field

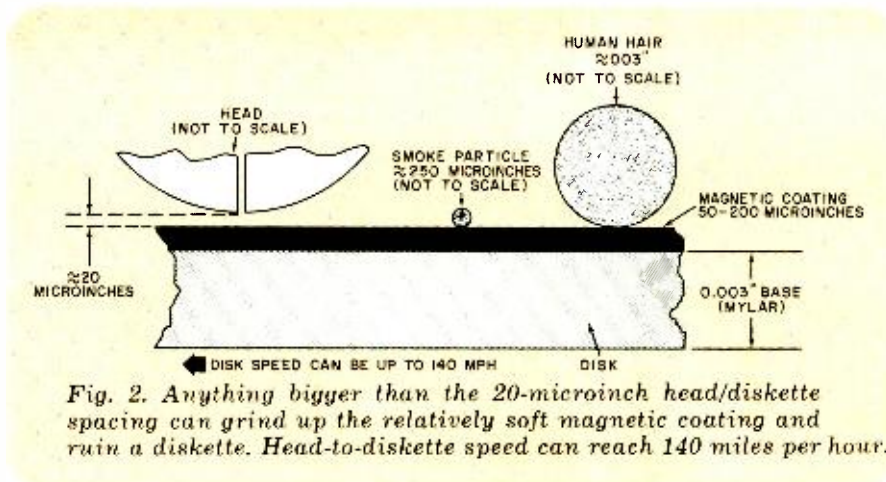
is very similar to the ac field used in degaussing devices for audio tape heads. The degaussing effect of these fields can erase a diskette as fast as they degauss a tape head.

Foreign Matter. Although the illustration in Fig. 2 is not drawn to scale, it does serve to explain some important points. On a typical diskette, the magnetic coating is a mere 50 to 200 microinches thick and is deposited on a flexible 0.003" thick Mylar base. The read/write head, which has a curved surface close to the diskette, does not actually touch the magnetic surface but is maintained about 20 microinches away. As the diskette spins inside its jacket, the head-to-diskette speed can be as great as 140 mph!

A typical smoke particle can be up to 250 microinches thick, while a human hair is typically 0.003" thick. Hence, you can imagine the pounding that the very thin magnetic layer on the diskette gets if any of these particulants is between the head and the moving diskette.

Dust and lint particles can appear to be as big as boulders when compared to the gap between the read/write head and diskette. Since most of us have slight oil deposits on our fingertips, even touching an exposed diskette's surface can cause a loss of data. Bending or folding a diskette can produce serious "hills and valleys" that can disrupt data acceptance and delivery. Even a minute scratch can produce dropouts that will ruin the depositing and fetching of data.





Identification labelling of a diskette's jacket can cause problems if you are not careful. Never write with a ballpoint pen on a label that is already in place on a jacket. (The pressure required to write with a ballpoint pen can transmit enough energy through the label and jacket to damage the relatively soft diskette surface.) In fact, it is a good idea to avoid using anything but a felt-tipped pen to write labels because these pens write cleanly, dry quickly, and cannot contaminate the surface of the diskette. Al-

ways write on your labels before attaching them to the diskette's jacket.

Do not attempt to erase a label after it is fixed to a diskette's jacket. Eraser particles can cause a lot of damage in the area between the diskette and read/write head, no matter how much care you exercise. It is far better and safer to simply make up another label and place it over the old one.

If possible, try to keep the read/write head scrupulously clean. Consult the manual supplied with your disk system

for the proper procedure to accomplish this. Be especially careful to avoid getting oil or grease on the head because they are contaminants themselves and they tend to attract dirt.

Storing Diskettes. Never stack diskettes on each other for storage. The proper way to store diskettes is to stand them vertically, preferably inside a metal cabinet to keep them safe from stray magnetic fields. The temperature in the room in which diskettes are stored should be between 60° and 90° F, with the humidity between 10% and 90%.

If you intend to store diskettes for long intervals, place them in their original heavy shipping boxes and store them just about anywhere the temperature is between -40° and +150° F. After prolonged storage, be sure to leave the diskettes in the room where they are to be used for at least 24 hours to allow them to stabilize.

On final word: store important diskettes inside antimagnetic, fire-resistant, and waterproof containers. For further protection, you might consider making duplicates of your important diskettes and storing them separately. ◇



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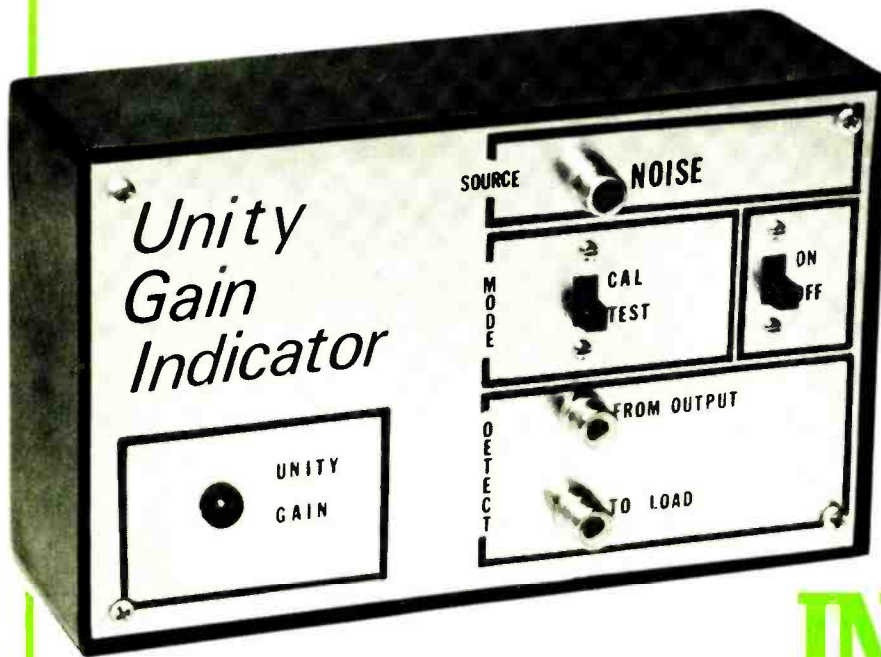
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BY JAMES BARBARELLO

BUILD A UNITY GAIN INDICATOR

AUDIO components such as mixers and equalizers can have appreciable gain at certain control settings. This gain is undesirable if it drives subsequent components into nonlinearity. The project presented here—a combination wide-band noise source/unity-gain indicator (UGI)—allows the user to adjust master gain controls for unity gain $\pm 1/2$ dB. It uses standard parts and can be built for about \$10.

About the Circuit. The block diagram of the UGI is shown in Fig. 1. A wide-band noise source generates the test signal. Overall gain measurements of equalizers and other components which do not have flat frequency re-

sponse can thus be accomplished. When *S1* is placed in the CALIBRATE position, the reference and test detectors are both driven by the wide-band noise signal. A calibration potentiometer in the test detector stage is adjusted so that the LED driven by the window comparator glows. This compensates for differences in the detector circuits, and ensures a unity-gain indication when the input levels to the comparator are equal. Next, *S1* is placed in the TEST position and the gain of the device under test is varied until the LED glows, indicating unity gain. This procedure is performed under dynamic conditions (with the device under test fully loaded) to produce results that are more meaningful.

The schematic diagram of the UGI is shown in Fig. 2. Transistor *Q1*'s base-emitter junction is reverse biased by the positive supply voltage. This results in an output signal closely approximating white noise. The signal is capacitively coupled by *C1* to op amp *IC1*, which boosts the signal level to approximately 200 mV p-p. The output of the op amp is applied to *J1* and *IC3A*, which provides additional gain.

Diodes *D1* and *D2* rectify the output of *IC3A*. The rectified signal is averaged by *C3*, *R9*, *R10* and *R11*, and the resulting dc level across *R11* determines the lower threshold of the window comparator. The upper threshold is determined by the voltage across *R10* and *R11*. Dual op amp *IC4* comprises the window comparator. When the voltage at the noninverting inputs is less than the lower threshold, *IC4A* and *IC4B* act as high-gain inverting amplifiers with a positive differential input. Therefore, both outputs are at the negative supply voltage. With no potential difference across *LED1*, the LED does not glow.

When the voltage at the noninverting inputs of *IC4A* and *IC4B* exceeds the comparator's upper threshold, a negative differential is applied, and the outputs reach the positive supply voltage.

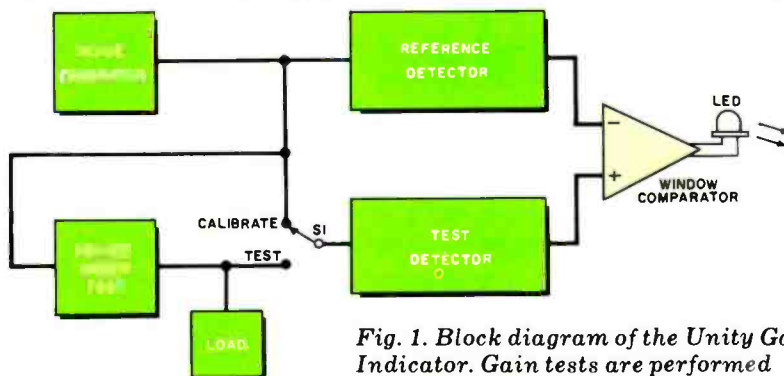


Fig. 1. Block diagram of the Unity Gain Indicator. Gain tests are performed with device under test fully loaded.

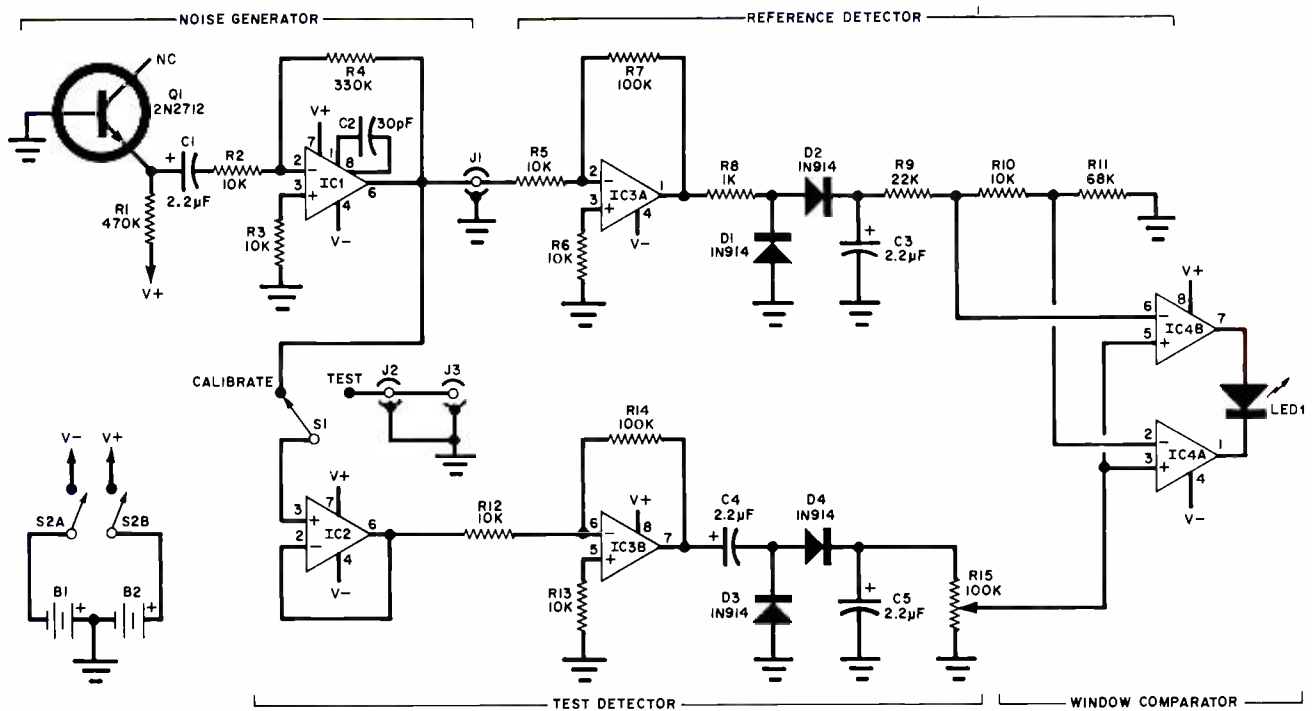


Fig. 2. Schematic Diagram. Reverse-biased transistor junction generates white-noise test signal.

PARTS LIST

B1, B2—9-volt transistor battery
 C1, C3 through C5—2.2- μ F, 25-volt electrolytic capacitor
 C2—30-pF disc ceramic capacitor
 D1 through D4—1N914 or 1N4148 silicon diode
 J1 through J3—RCA phono jack
 IC1— μ A748CV operational amplifier
 IC2— μ A741CV operational amplifier
 IC3, IC4—MC1458, LM1458N or 5558 dual operational amplifier

LED1—20-mA light emitting diode (TIL-32 or equivalent)
 Q1—2N2712 npn silicon transistor
 The following fixed resistors are $\frac{1}{4}$ -watt, 10% tolerance carbon composition components.
 R1—470,000 ohms
 R2, R3, R5, R6, R10, R12, R13—10,000 ohms
 R4—330,000 ohms
 R7, R14—100,000 ohms
 R8—1000 ohms

R9—22,000 ohms
 R11—68,000 ohms
 R15—100,000-ohm linear-taper trimmer potentiometer
 S1—Spdt switch
 S2—Dpnt switch
 Misc.—Printed circuit board, suitable enclosure, battery clips, battery holder, IC sockets or Molex Soldercons, shielded cable, hookup wire, solder, etc.

As before, there is no potential difference across the LED, which remains dark. However, if the voltage at the non-inverting op amp inputs is within the "window" established by the comparator thresholds the output of IC4B is positive and that of IC4A is negative. This

causes LED1 to conduct and glow. No series resistor is required to protect the LED because the op amps have on-chip output current limiting.

To prevent the test detector from being loaded down, input buffer IC2 is included. This op amp, a unity-gain, non-

inverting voltage follower, presents a very high input impedance. Gain is provided by IC3B. The output of this op amp is rectified by D3 and D4, which perform the same function as D1 and D2 in the reference detector. There is one important difference between these two de-

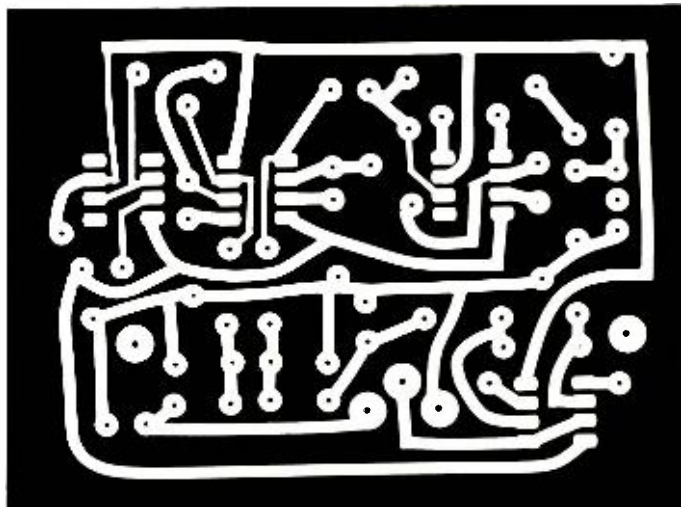
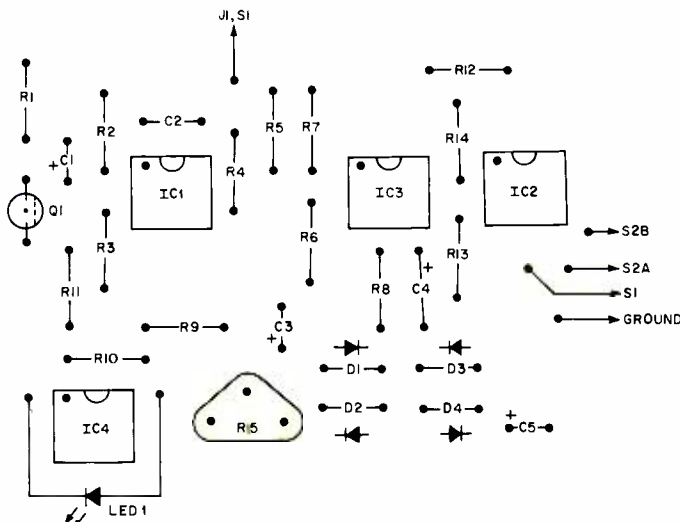
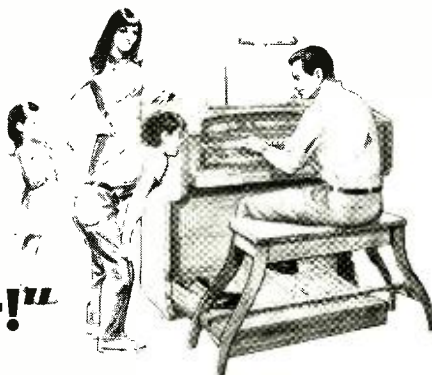


Fig. 3. Parts placement (left) and full-size etching and drilling (right) guides for pc board.

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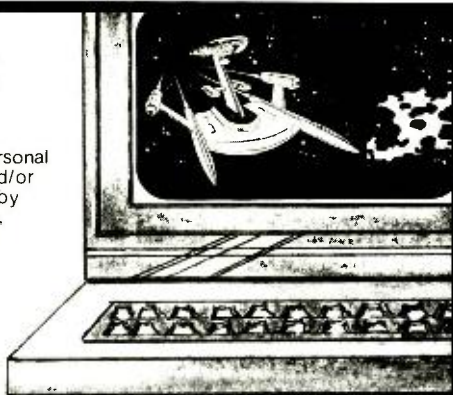
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tor stages. In the reference detector, the output of *IC3A* is dc coupled to *D1* and *D2* via *R8*. In the test detector, the output of *IC3B* is capacitively coupled by *C4* to diodes *D3* and *D4*. This is done to prevent any dc offset at the output of the device under test to be added to the averaged ac, which would produce an erroneous reading. A portion of the detected signal is tapped at *R15* and applied to the noninverting inputs of window comparator *IC4*. The circuit is powered by two 9-volt batteries.

Construction. Printed circuit guides are shown in Fig. 3. Wire the input and output jacks with shielded cable. Any suitable enclosure (metallic or plastic) can be used to house the project. When assembling the project, be sure to observe the polarities of battery leads, electrolytic capacitors, and semiconductors. The pin basing of *Q1* may vary from that shown in the parts placement guide. Be sure to orient *Q1* properly. Molex Soldercons or IC sockets can be used with the integrated circuit packages.

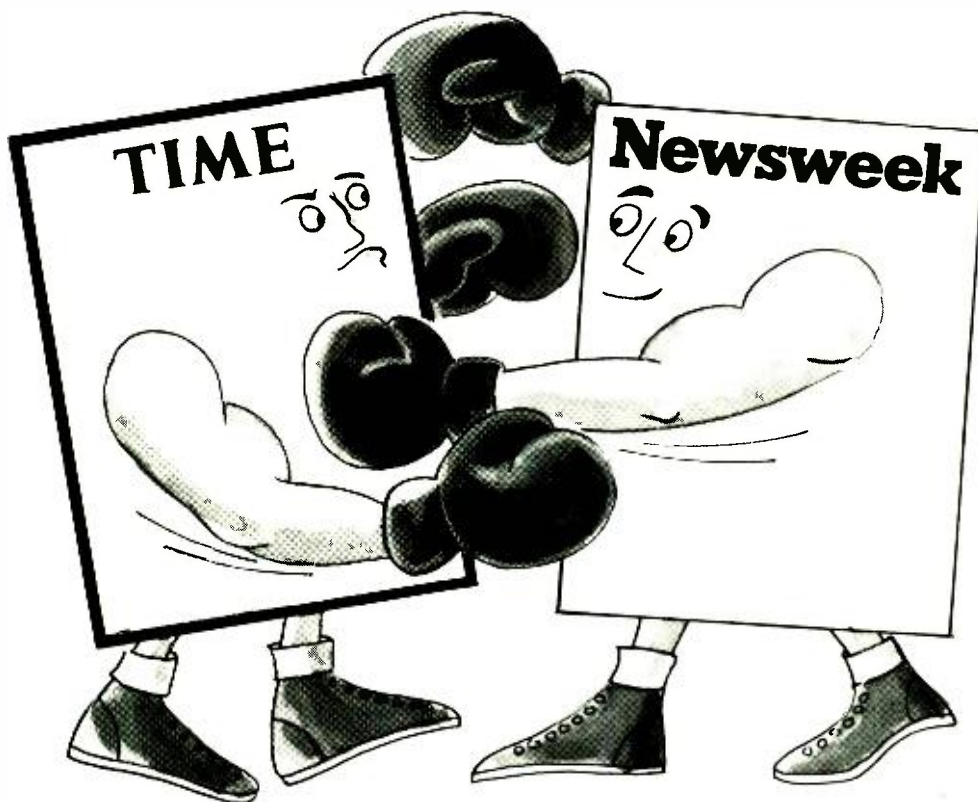
Calibration. When you have finished building the project, double check all wiring. Then connect the batteries and close switch *S2*. Patch the noise signal at *J1* to an external amplifier/loudspeaker combination and verify that the noise source is operating. Then place *S1* in the **CALIBRATE** position, and rotate the wiper of *R15* through its total range. You will notice that *LED1* will glow for a certain arc of *R15*'s rotation. Adjust the potentiometer so that the wiper is in the center of this arc. This is the only calibration adjustment necessary.

Using the UGI. When the project is first turned on, it takes a few seconds for the averaging capacitors to become fully charged and stabilized. It's therefore best to place *S1* in the **CALIBRATE** position, close *S2*, and wait until *LED1* glows before making any tests.

To adjust a component for unity gain, run a patch cord from *J1* to the component's input jack, and one from its output to *J2*. Then connect a patch cord from *J3* to the component's working load (power amplifier, tape deck, etc.). After the UGI's calibration has been verified, place *S1* in the **TEST** position. Adjust the component's master gain control for an indication by the LED. At that control setting, the component has unity gain. If the component has more than one output channel and individual gain controls, repeat the procedure for each. ◇

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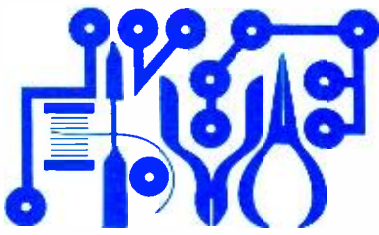
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Experimenter's Corner

THE 74150 MULTIPLEXER

By Forrest M. Mims

DIGITAL logic circuits are amazingly versatile, and the multiplexer or data selector is no exception. The multiplexer, sometimes abbreviated MUX, provides a means of selecting one of several inputs and steering the logic level at that input to a single output. The selected input is determined by a binary address applied to one or more data select inputs. That's why multiplexers are often called *data selectors*.

Multiplexers have many applications. We'll look at several of them in this column, but first let's find out how the multiplexer works.

A Simple 1-of-2 Multiplexer. Figure 1 shows a simple two-input MUX with a single data select input. The circuit is called a 1-of-2 multiplexer because one of the two inputs is routed to the output at any given moment according to the status of the data select input. The binary bit pattern at the data select input is called an address because each possible data select bit combination (in this case 0 and 1) selects one and only one input.

Assume the data select input is logic 0. This means one of the inputs to AND gate A is logic 1. The gate is then able to provide a high or low output depending upon the state of the DATA A input. Simultaneously, one of the inputs to AND gate B is low so its output will be low no matter what logic state appears at its

second input (DATA B). If DATA A input is low, both AND gates will have a low output. If DATA A is high, the output of AND gate A will go high. The OR gate (C) will respond to either condition with, respectively, a low or high output.

If this explanation seems hard to follow, Fig. 1 also shows the truth tables for the 1-of-2 MUX as well as those of the inverters and gates from which it is composed. With this information you should be able to decipher the circuit's operation on your own.

Advanced Multiplexers. The simple multiplexer shown in Fig. 1 illustrates the basic operating principal but has limited utility. You can easily breadboard a working version of it if you want to explore its operation in detail. Far more flexibility, however, is available in the form of single-chip multiplexers having eight or sixteen inputs. Several such chips are readily available. TTL versions include the 74150 1-of-16 multiplexer and the 74151 and 74152 1-of-8 multiplexers. Another TTL MUX is the 74153 dual 1-of-4 data selector.

A number of multiplexers that select one of several multiple-bit words rather than single bits are also available, as is a family of CMOS multiplexers.

The 74150 1-of-16 Multiplexer. The pinout of the 74150 1-of-16 MUX is shown in Fig. 2. This data selector has

sixteen data inputs, any one of which can be selected by applying the appropriate 4-bit data select word or address to the four-line data select input. The 74150 also has an *enable* or *strobe* input. This input must be low (grounded) for the 74150 to function. When the enable input is high (disconnected or tied to V_{CC}), the output will be high regardless of the status of the selected input.

The simple 1-of-2 MUX we looked at earlier has an OR gate output. The 74150, however, uses a NOR gate output. This means the output is an inverted version of the selected input. Be sure to keep this in mind when using the 74150 in an actual circuit.

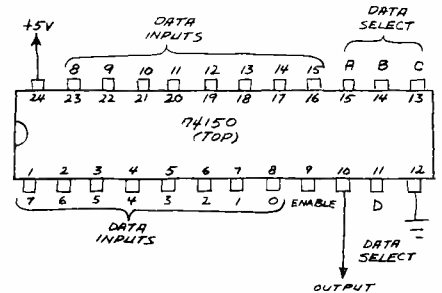


Fig. 2. Pin outline of 74150.

"Universal Logic Gate." It's often necessary for a digital circuit to generate the type of truth table that is not available from standard gates. Simple truth tables can be generated by interconnecting the gates in a 7400 quad NAND gate or other common gate package. Complex truth tables can be implemented with a ROM. The 74150 MUX offers a very simple way to generate a truth table with four inputs and a single output.

Since the 74150 has sixteen input addresses, there are 2¹⁶ or 65,536 possible input/output combinations. Here's a truth table for just one sequence.

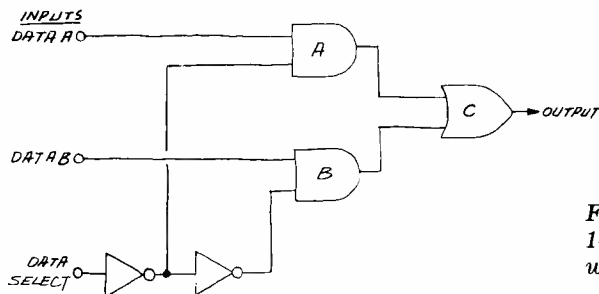


Fig. 1. A simple 1-of-2 multiplexer with truth table.

SELECT	DATA A	DATA B	OUTPUT
0	0	X	0
0	1	X	1
1	X	0	0
1	X	1	1

Address	Output
0	0 0 0 0
1	0 0 0 1
2	0 0 1 0
3	0 0 1 1
4	0 1 0 0
5	0 1 0 1
6	0 1 1 0
7	0 1 1 1
8	1 0 0 0
9	1 0 0 1
10	1 0 1 0
11	1 0 1 1
12	1 1 0 0
13	1 1 0 1
14	1 1 1 0
15	1 1 1 1

Designing a logic circuit to implement

this truth table would be both tedious and time consuming, but we can complete the entire design in less than a minute with the help of a 74150! All

that's necessary is to place the complement of the desired output for each address at the appropriate input.

Complements of the desired outputs

are placed at the inputs because the 74150 inverts the data at its inputs. Figure 3 shows how the 74150 is wired to implement the truth table. The 74150 in-

PROJECT OF THE MONTH

A HEXADECIMAL KEYBOARD ENCODER

The simple hex keyboard encoder described in this month's column can be significantly improved by adding a 4-bit register to store the hex code of the key that has been pressed. This means the LED readout will display the 4-bit code for a particular switch when the switch is initially closed and continue to display it *after* the switch has been released. The display will change only when the scanning circuit detects a new key closure.

Compare the complete circuit diagram for the hex encoder shown here with Fig. 7 and you'll note that a 74173 4-bit register has been added and the readout LEDs have been moved from the counter output to the register output.

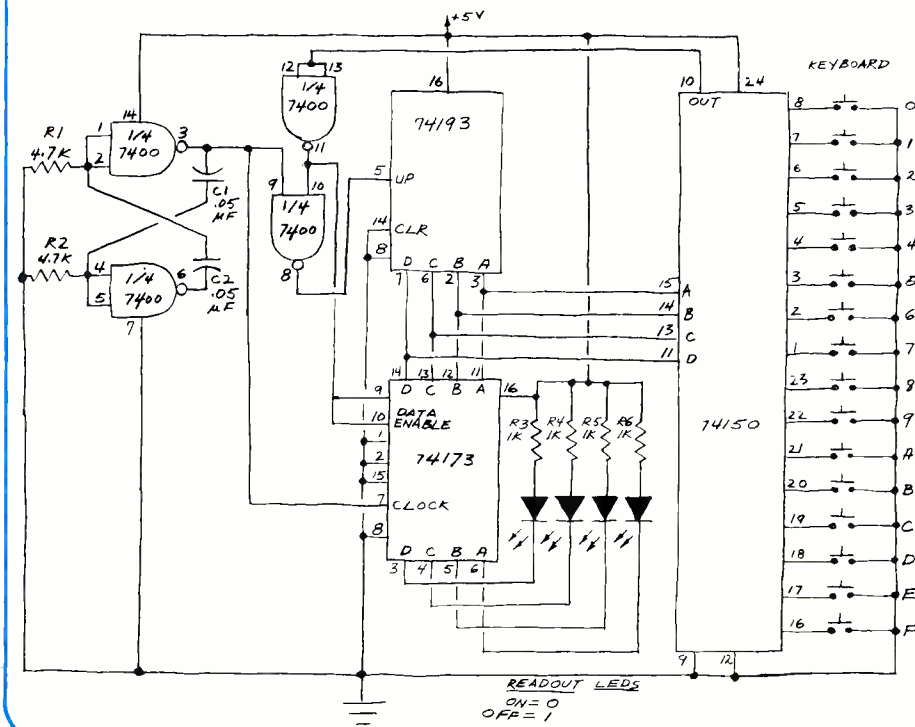
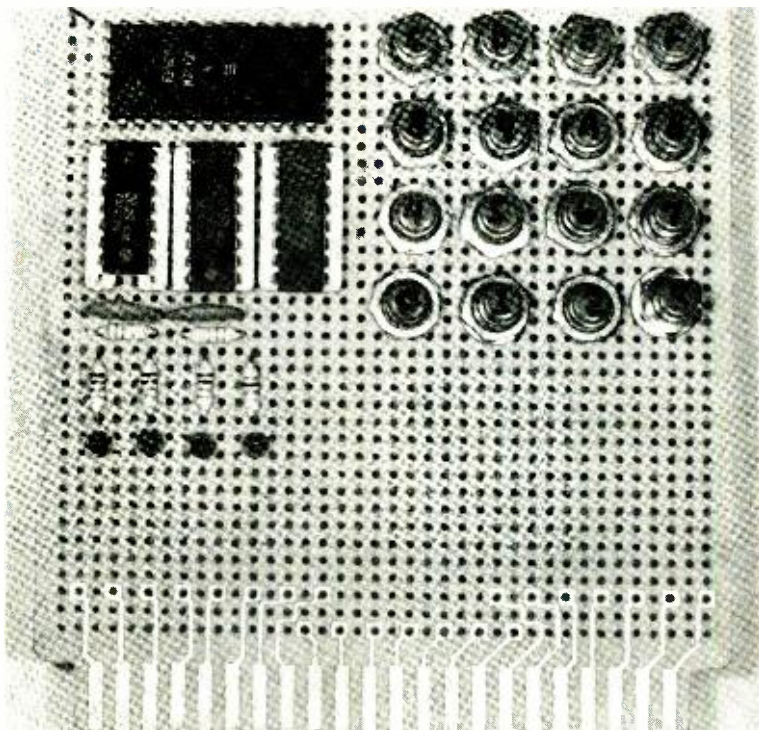
The clock and scanner portions of the circuit have already been analyzed, and the 74173 was described in the March 1978 Experimenter's Corner. It's a flexible storage register with 3-state outputs that can be readily tied to the address or data

bus of a microcomputer or controller.

When the scanner circuitry detects a switch closure, the output of the 74150 sends a data enable pulse to the 74173 through one of the 7400 gates. The next clock pulse then loads the counter address into the 74173, and the circuit resumes its sequential scan of the switches. The four bits describing the previously closed switch, however, remain safely stored in the register.

The photograph shows a prototype version of the encoder assembled on a perforated board (Radio Shack 276-152 or equivalent). Note the extra space on the board for the addition of other circuits such as a RAM. Also note that a standard calculator keyboard was *not* used. These keyboards are inexpensive and readily available, but the switches are arranged in x-y format not compatible with this circuit. Instead, individual normally open pushbutton switches were used to make a custom hex keyboard.

I used wrapped-wire construction throughout with the exception of solder connections to the switch terminals, the LEDs and several of the resistor and capacitor leads. Total assembly time was about three hours. In a subsequent Project of the Month we'll add a 16-word RAM to the encoder. You'll find the resulting circuit very interesting, so be sure to consider building the basic encoder in the meantime. ♦



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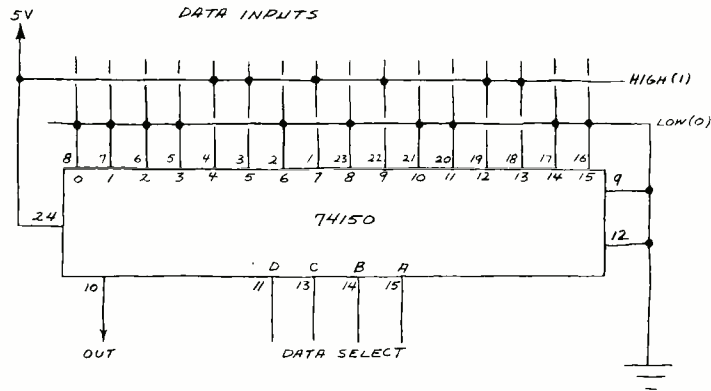


Fig. 3. How to connect a 74150 to implement truth table in text.

puts can be quickly rewired to provide any of the 65,536 possible combinations. For best results, a simple switching network can be used to speed up truth table changes. This is done by connecting each input to the pole of a spdt switch. The positions of each switch are connected to ground (low) and V_{CC} (high) as shown in Fig. 4.

Adding a Data Select Input.

There's a clever way to add a data select bit to the 74150 and other multiplexers. In the case of the 74150, the resulting 5-bit data select word gives 32 input addresses. This makes possible a truth table with an incredible 2^{32} or 4,294,967,304 input/output combinations!

Let's assume you want to implement the following 8-input (3-bit address) truth table with a 4-input (2-bit address) MUX:

Address	Output
C B A	
0 0 0	0
0 0 1	1
0 1 0	1
0 1 1	0
1 0 0	1
1 0 1	1
1 1 0	0
1 1 1	0

A 4-input MUX normally implements a truth table with a 2-bit address (00-01-10-11). Look back at the truth ta-

ble above and you'll notice this pattern is repeated *twice* under the B and A columns to give four pairs of 00, 01, 10 and 11. Rearrange the truth table so the identical B-A parts are adjacent to one another, and you'll notice the output for any of the four pairs can be low or high, C or the complement of C:

	A B C	OUTPUT
1.	0 0 0	0
	0 0 1	1
2.	0 1 0	1
	0 1 1	0
3.	1 0 0	1
	1 0 1	1
4.	1 1 0	0
	1 1 1	0

We're now ready to implement the truth table by connecting each of the four inputs of the MUX to low, high, C or the complement of C. The outputs of the first pair are identical to C, so C is connected to the first input. The outputs of the second pair are the opposite of C, so the complement of C is connected to the second input. Similarly, both outputs of the third pair are high so the third input is connected to logic 1. Both outputs of the fourth pair are low so the fourth input is

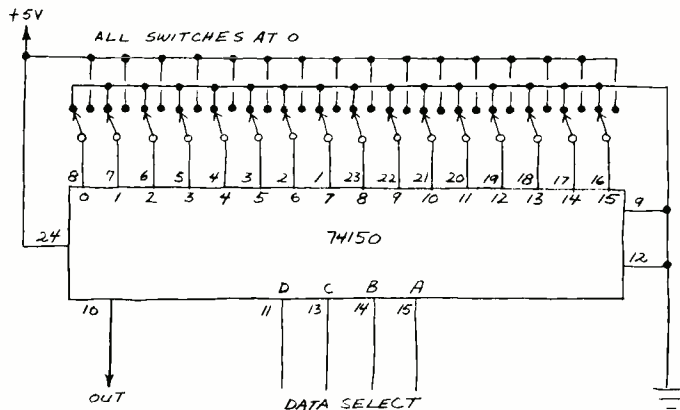


Fig. 4. Switch programmable 74150.

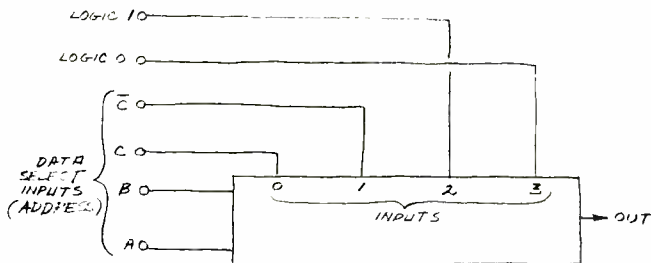


Fig. 5. Expanding a 4-input MUX to an 8-input MUX.

at logic 0. The resulting connection diagram for the expanded MUX is shown in Fig. 5.

Multiplexer Pattern Generator.

One application for a MUX truth table circuit like the one in Fig. 4 is a *binary pattern generator* that produces a string of sixteen preselected bits over and over again. This is accomplished by connecting a 4-bit, modulo-16 counter to the address inputs of the 74150. Each pulse from a clock connected to the counter produces the next output in the binary sequence.

Figure 6 shows a working version of a clock and counter that can be connected to a 74150 to make a pattern generator. This circuit is fairly straightforward, and you can use other clock and counter combinations if you prefer.

Pattern generators have many applications. One simple possibility is to use the 74150 output to strobe a tone generator on and off to produce programmed tone patterns. Another is to produce programmed LED flashing sequences.

Hexadecimal Keyboard Encoder.

A very useful application for the 74150 MUX is the hexadecimal keyboard encoder shown in Fig. 7. This circuit continuously scans each of sixteen normally open pushbutton switches. When a closed switch is detected, the LED read-out connected to the data select (address) inputs of the 74150 identifies in

binary form which switch has been closed.

Those of you who are microcomputer enthusiasts already know the value of a hex keyboard encoder, but *hexadecimal* probably sounds very intimidating to the uninitiated. The term simply means a number system based on sixteen. Binary, octal and decimal are number systems based, respectively, on 2, 8 and 10. Hexadecimal is important in digital logic because, as you already know, there are sixteen possible combinations of 0 and 1 in a 4-bit word (0000-1111). Here's a listing of the first sixteen decimal digits along with their binary and hex counterparts:

Decimal	Binary	Hexadecimal
0	0000	0
1	0001	1
2	0010	2
3	0011	3
4	0100	4
5	0101	5
6	0110	6
7	0111	7
8	1000	8
9	1001	9
10	1010	A
11	1011	B
12	1100	C
13	1101	D
14	1110	E
15	1111	F

A hex keyboard encoder allows any of the sixteen hex digits to be entered into a digital circuit by pressing a single key. This greatly speeds up the programming of read/write memories in microcomput-

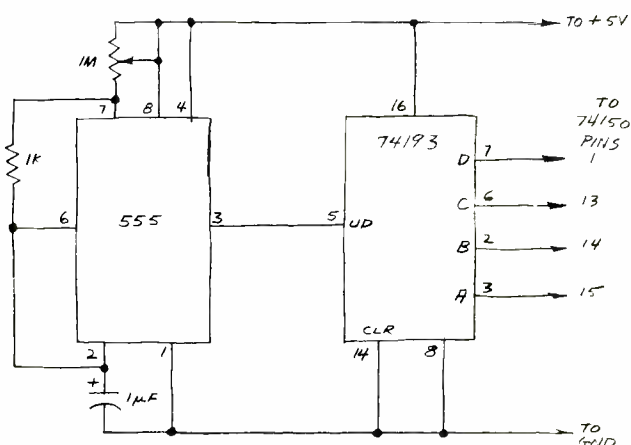


Fig. 6. Sequencer circuit for binary pattern generator.

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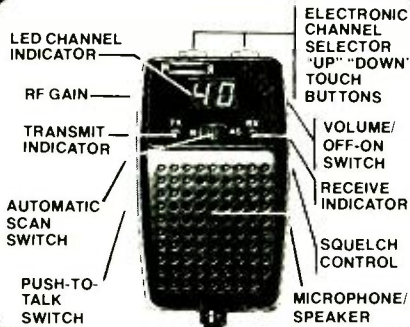


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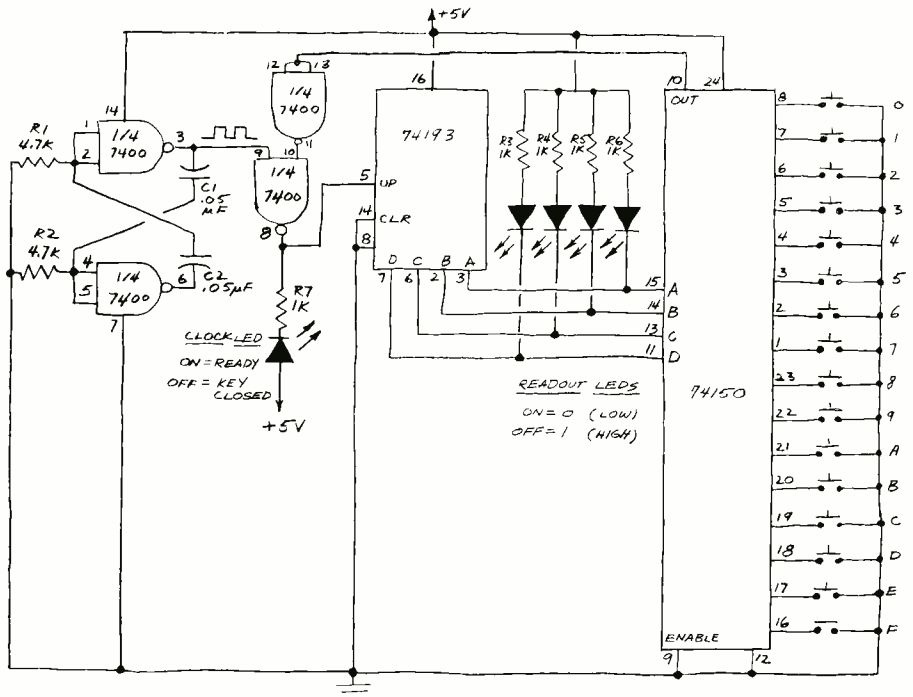


Fig. 7. Hex keyboard encoder circuit.

ers, controllers and other digital circuits that process data in 4-bit "nibbles."

Operation of the keyboard encoder shown in Fig. 7 is straightforward. An astable multivibrator comprising half the gates in a 7400 quad NAND gate serves as a clock. Pulses from the clock are steered to the count UP input of a 74193 counter through one of the remaining gates in the 7400. This gate permits clock pulses to pass as long as the output of the 74150 is low.

A switch closure causes the 74150 output to go high when the count from the 74193 matches the number of the closed switch. This, in turn, inhibits the clock gate, which prevents clock pulses from reaching the 74193. The four LED's connected to the 74193 output then indicate the bit pattern applied to the 74150 address in binary and thus the number of the closed switch.

When the closed switch is released, the 74150 output returns to the low state and the clock gate is no longer inhibited. The 74193 then continues to cycle the 74150 through a sequential scan of the switches.

An interesting feature of this circuit is that under normal conditions it operates as a form of *priority encoder*. This means it responds to the first of two or more key closures while ignoring all subsequent closures. Can you think of a circumstance where the encoder would respond to the *second* of two key closures? (Hint: Assume the clock is very slow or your fingers are very fast.)

The circuit shown in Fig. 7 is not necessarily usable in some applications. One reason is that the continuous scanning of the switches causes the four LEDs to appear continually on (binary 0000) between switch closures. This problem is partially alleviated by the single CLOCK LED that indicates when the clock pulses are getting through to the counter.

When the CLOCK LED is on, the circuit is ready to receive another switch closure. In other words, the 74150 is scanning the input switches and the fact that all four readout LEDs appear to indicate 0000 is irrelevant. When the CLOCK LED is off, a switch closure has been detected and the readout LEDs accurately indicate the selected switch. If, by coincidence, switch 0000 is selected, the four LEDs will all remain illuminated but their apparent brightness will increase significantly. This is because all four LEDs now receive a steady direct current rather than the very rapid pulsating current from the 0000-1111 count sequence.

Another drawback of the circuit in Fig. 7 is that it promptly "forgets" a switch closure once a switch has been released. Contrast this with the pocket calculator, which "remembers" each key closure until an operation is complete or a clear key is pressed. This disadvantage can be overcome by adding a data storage register to the circuit. For details, see the accompanying Project of the Month. ◇



By John McVeigh

HF'ERS AND LF'ERS

Q. *I own both a shortwave receiver and a CB base transceiver. It was my understanding that the frequencies allocated for the CB service were between approximately 26.9 and 27.4 MHz. However, as I was tuning my receiver, I heard stations below 26.9 MHz and above 27.4 MHz operating on single sideband from as far away as Colorado! Their callsigns did not resemble those issued to hams. Are these operators the "out-of-banders" I've heard about, and if they are, why doesn't the FCC stop them?—Don Wood, Westport, CT.*

A. Yes, the operators you heard are the "out-of-banders." It seems that those operating below 26.9 MHz call themselves "low-frequency operators" or "LF'ers." Those operating above 27.4 MHz call themselves "high-frequency operators" or "HF'ers." The origin of these bands can be traced to some CB operators with knowledge of electronics. They realized that by interchanging the 23 receive crystals and 23 transmit crystals in their transceivers they were able to create 23 "new" channels. Later, as crystal synthesizer designs were introduced, the five or six crystals these rigs contained were switched around and new frequencies were opened up.

Basically, there are two bootleg bands, displaced from the Citizens Band by the commonly used i-f of 455 kHz. The latest equipment development is that bootleggers are using Amateur equipment modified to work outside the 10-meter band. It's likely that such equipment was used in the SSB communications you heard, as AM has been almost totally abandoned on the Amateur bands below 30 MHz. Consequently, few ham rigs with AM capabilities are being produced.

Why doesn't the FCC do something about these bootleggers? The Commission is trying, but its field staff is so small and the number of illegal operators by comparison so large that the situation is really out of hand. Unless the FCC is

granted more funds from the Congress and more money is allocated to field activities, it's unlikely that the effectiveness of their policing will improve.

CLEANING UP RIPPLE

Q. *I have a 9-volt dc adaptor which, when connected to my small transistor projects, produces a loud 120-Hz hum. I suspect that the adaptor is just a diode/capacitor filter assembly. Is there some way of eliminating the ripple, or at least reducing it? I don't mind a change in supply voltage of about 20% if it will cure this problem. The supply is rated at 9 volts, 9 mA.—Tom Dycus, Albuquerque, NM.*

A. You can reduce the ripple in the output of the supply by supplementing its built-in filter capacitor. The addition of 500, 1000, or 2000 μF should reduce the ripple dramatically. The only potential danger posed by adding relatively large amounts of capacitance is that an increased surge current will flow through the diodes when the supply is first turned on. As you did not mention what diode type is used (probably the unit is sealed), I can't tell whether 2000 or more μF of capacitance will cause problems.

Another solution that immediately crossed my mind is to use a zener diode or IC voltage regulator. However, the rated current output of the battery eliminator is suspiciously low. A zener diode is not an acceptable solution because the current is so small that there's not enough to both power your circuits and keep a few mA flowing through the zener. Unless a sufficient current through the zener is maintained, the diode will not perform its regulating function. Similarly, most voltage regulators require a quiescent current of 6 or more mA. If the supply is rated at 90 mA of output current (as seems likely), an IC voltage regulator or zener diode and series resistor will eliminate your hum problems.

One other factor suggests that the

power supply is rated at 90 mA. In a power supply using a capacitive filter, the voltage regulation and lack of ripple is a function of the output current. The smaller the demand placed on the power supply, the less the capacitor discharges before being replenished by the diode(s). It seems highly unlikely that such a small current drain (9 mA) would cause serious ripple problems.

W1AW

Q. *I've read that the American Radio Relay League operates a radio station solely for the purpose of code practice. I would like to know when it is on the air and what frequencies are used. Can you help me?—David Reed, Jr., WDX4DR, Miami, FL.*

A. The ARRL does indeed operate Amateur station W1AW, but not solely for the purpose of transmitting code practice material. The current W1AW operating schedule shows that the station is on the air fourteen times each weekday. Four time slots are allocated to code practice sessions, and the remaining ten are devoted to the announcement of bulletins. These latter transmissions include news items about events of interest to Amateurs, such as FCC rule-making proposals, etc., propagation forecasts, information relating to the orbital paths of the OSCAR and weather satellites, and news of such operating events as contests.

At 9 a.m., 4, 7, and 10 p.m. EST, code practice text is transmitted. The early session is omitted on Saturday and Sunday. Depending on the day and time, a code session will be either a fast or slow one. Slow code practice includes eight-minute intervals of text at 5, 5, 7½, 7½, 10, 13 and 15 words per minute. Fast code practice comprises eight-minute intervals of text at 35, 30, 25, 20, 15, 13, and 10 wpm. The following frequencies are employed in the transmission of code practice: 1.835 MHz; 3.580 MHz; 7.080 MHz; 14.080 MHz; 21.080 MHz; 50.080 MHz and 147.555 MHz.

For complete details, consult a recent issue of QST magazine published by the American Radio Relay League, 225 Main Street, Newington, CT 06111. The operating schedule is reproduced in the Operating Events section.

Have a problem or question on circuitry, components, parts availability, etc? Send it to the Hobby Scene Editor, POPULAR ELECTRONICS, One Park Ave., New York, N.Y. 10016. Though all letters can't be answered individually, those with wide interest will be published.



Product Test Reports

J.I.L. Minicom SX-100 Scanning Monitor Receiver



*16-channel
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THE J.I.L. Minicom SX-100 is a 16-channel, programmable mobile scanning monitor receiver that uses digital frequency synthesis and a microprocessor. More than 32,000 different channels in the 30-to-50-MHz vhf low band, 140-to-174-MHz vhf high band, and 410-to-514-MHz uhf band can be programmed via the microprocessor-controlled memory system, without additional crystals. Included in the high-vhf band is coverage of the 144-MHz Amateur Radio band.

The desired frequencies on the selected channels can be "memorized" by the receiver. Alternatively, a band can be manually scanned to seek an unknown signal when it comes up, the frequency and channel number for which are indicated by a green-LED numeric display. In addition, the receiver can be set up so that the display gives the time and date.

The receiver measures $9\frac{1}{4}''\text{W} \times 8''\text{D} \times 3''\text{H}$ (23.5 × 20.3 × 7.6 cm). Suggested retail price is \$489.95.

General Description. The receiver has two automatic scanning rates, one at eight channels/second and another at four channels/second. Likewise, there are two seeking rates, one at 10 channels/second and the other at five channels/second. A scan delay of 0 to 4 seconds can be set up. The two U.S. Weather Bureau frequencies can be in-

dependently selected by switches.

The front panel of the receiver is dominated by 39 calculator-type pushbutton keys. A 15-key pad on the left side of the panel is used for entering a frequency, which appears in the eight-digit display in the center of the panel. This keypad section also contains buttons for stopping the scan (ST), displaying the frequency (FR), scan write (SW), memory write (MW), and controlling the speed (SP) for both seeking and scanning.

Arranged in two horizontal rows across the top of the panel are keys for recalling from memory and displaying the frequency of any of the 16 channels keyed into the receiver. There is a separate key for each of the receiver's 16 memory channels. Separate WB1 and WB2 keys in this group permit instant display of the two weather-band frequencies.

To the right of the display window is the final grouping of keys. The SEEK key is for locating an inexact frequency. The SCAN A and SCAN B keys are for memorizing the frequencies of 16 stations and scanning them automatically and for scanning the memory for 16 stations already memorized, respectively. Two CLOCK keys, labelled DAY and HOUR, are for setting the date and time. The last key is for push-on/push-off POWER.

Finally, there are slide-type SCAN DELAY, SQUELCH, and VOLUME controls. These controls are arranged in a straight

horizontal line along the bottom of the front panel.

The receiver's front panel is slightly tilted backward for easy view of its display and manipulation of its keys and controls. Its standard features include a telescoping antenna plus facilities for connecting an external antenna rated at 50 to 75 ohms impedance, built-in top-facing speaker, external speaker jack, and mobile mounting hardware. Operation is designed to be primarily from a 12-to-16-volt dc source, but an ac adapter (supplied) allows operation from 110-to-125-volt ac sources.

No circuit diagram or other technical data was supplied with the receiver. Hence, the only thing we can state with certainty about its circuitry is that the main i-f is at 10.7 MHz. Frequency selection is apparently obtained with the usual digital frequency synthesis system. This includes memory and a microprocessor for setting up the various functions.

When power is first applied to the receiver, the frequency displayed is either 30.000 or 162.400 MHz, the date is 1-1 (January 1), and the time is 12-00 (AM). These must be set properly.

Most operations begin by selecting the numerical component of the function and then subsequently selecting the function. For example, to set up 155.415 MHz and place it in memory for channel 2, the keys are pressed in the following order: 1, 5, 5, ST, 4, 1, 5, MW, M2. The ST key enters the decimal point, MW places the frequency in memory, which, in turn, is set up for channel 2 using the M2 key. The frequency will appear in the display if the memory operation is made within 5 seconds. After 5 seconds, the time is displayed (as is the case after any channel frequency is displayed for this length of time).

Laboratory Measurements. On the lower two bands, the measured sensitivity of the receiver was better than 0.5 μV for 20 dB of noise quieting. (It actually varied between 0.25 and 0.5 μV , depending on the section of the band being tested.) The image rejection was at least 20 dB throughout the vhf bands, while it dropped to less than 10 dB on the uhf band.

The spurious-response rejection was nominally 40 dB over the receiver's entire range. Overload birdsies set in with a nominal 100- μV signal. The useful selectivity was 15 to 20 kHz on the high side of the signal and approximately 10 kHz on the low side.

Maximum sine-wave audio output measured 1 watt at less than 10% THD. This measurement was taken at 1000 Hz into an 8-ohm load.

User Comment. The large number of calculator-like keys at first appears to be a formidable obstacle to using this receiver properly. However, as we gained familiarity with the keys, confidence in operating the receiver was measurably increased. This is due in no small part to the logical manner in which the keys are laid out according to function.

During our use tests, we noted that the memory system holds its contents when power to the receiver is switched off. The built-in clock also keeps running when power is turned off, even during operation from a dc source.

This scanning monitor has excellent sensitivity and selectivity. Its FM modulation acceptance was tops. Audio quality was exceptionally clear, too. In all, this is an ideal scanning monitor receiver for both mobile and fixed-station operation, thanks to its performance, its ability to be operated on both dc and ac power, and its built-in telescoping antenna and external antenna facilities.

CIRCLE NO 105 ON FREE INFORMATION CARD



DX Listening

By Glenn Hauser

RADIO CLARIN

THE Dominican Republic has an official government station, *Radio-Televisión Dominicana*, which in the past has operated a shortwave service on 5970-5975 and 9505 kHz, including an occasional English talk promoting tourism. However, a private station, *Radio Clarin*, has really put the Dominican Republic on the map as a source of international broadcasts. *Clarin* is the largest private station in the country and had close ties with the Balaguer government. This worked to the advantage of *Clarin* and of DX listeners, until Balaguer lost a reelection bid last May.

Clarin just happened to have a 50-kilowatt transmitter that could be used on the 25-meter band. So it was fired up on 11,700 kHz, and the domestic AM programming relayed to Dominicans overseas, primarily in New York.

Fortunately, the director of *Radio Clarin* was Rodolfo (Rudy) Espinal, who speaks English and a number of other languages. He saw the potential of this transmitter in encouraging American tourism and propagating a friendly image for his native country. Espinal began a five-days-a-week English half-hour, called "This Is Santo Domingo," which soon expanded to six days a week and then to a full hour. At its peak last May, it expanded to three further repeat broadcasts each day.

It was truly a breath of fresh air—a free-form hour with a 'live' sound that was extremely informal, with personal calls to listeners, lots of promotion for DX clubs, and for Dominican tourism. And it was all interspersed with peppy *merengues*, the national musical style. Old-timers compared Espinal's style to that of Eddie Startz, during the heyday of Radio Nederland's "Happy Station." One student of international broadcasting went so far as to credit Espinal with revolutionizing shortwave programming.

But it all came to an end on June 17, 1978, when the shortwave transmitter was taken off the air so parts of it could be used to keep the more important domestic AM transmitter on the air. This was only the final blow in a story that had been building for several months.

Though *Radio Clarin's* broadcasts in English had stayed away from domestic politics, it was clear from listening to the Spanish programs that the station was backing President Balaguer in his campaign for reelection. A few months before, Espinal had mentioned that he was serving as official interpreter for Balaguer during a visit to Miami.

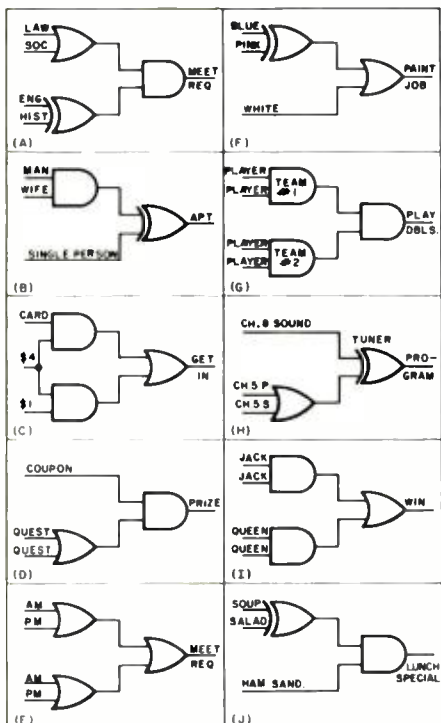
Following the May 16 election, we heard a different side of Rudy Espinal, as he staunchly maintained that there was no fraud and no problem with military intervention in the ballot-counting. He went on to criticize President Carter and Venezuelan President Pérez for meddling in Dominican affairs, all the while maintaining that everything was under control and people should continue planning their vacation trips to "this still-unspoiled half-island."

Some 10 days after the election, Espinal had to concede that Balaguer had lost to Guzmán. He then went on to predict that as a result, *Clarin's* international service would disappear. One explanation given was that *Radio Clarin* had had enough income from the government, for broadcasting the results of the National Lottery each Sunday ("120 pesos, 120 pesos"), to pay the costs of the international service, which he said amounted to about \$5000 a month. And since *Clarin* had supported the losing candidate, this income would be lost when Balaguer stepped down in August.

At about the time the SW transmitter was taken off for technical reasons, *Clarin* had to fire some 14 staffers because of a funding cut. Espinal said he had his

ANSWERS TO QUIZ (p.70)

- | | |
|-----|------|
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| 2-J | 7-C |
| 3-F | 8-E |
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hands full just running the AM station, as one could well imagine. However, 11,700 was soon back on the air for brief periods in Spanish only, and continued the lottery broadcasts through July.

Before the end, Espinal had appealed on the air for listeners to send in contributions to keep the international service on the air. All it would require were 5000 people sending in a dollar a month. Considering a previous unsubstantiated claim that *Radio Clarin* had 4,000,000 listeners, that shouldn't be too hard to accomplish. But this half-hearted attempt to undertake international listener-supported radio drew little response and criticism from Americans, in whose country domestic listener-supported radio does exist on a small scale.

Who is Rudy Espinal? Little is known about him, besides what he has rarely revealed on his program. His father was apparently in the diplomatic service or in business, when Rudy was born in Curacao. Later they were assigned to Lebanon. This accounts for some of his varied linguistic background. At one point, Rudy said he taught French in Santo Domingo. In March of this year he attended an international broadcasting conference at Syracuse University but cut short his stay in the U.S. for reasons unknown. No DX listeners are known to have met him while he was here, though he had invited contacts during his previous visit to Miami. He was invited to participate in this year's ANARC convention

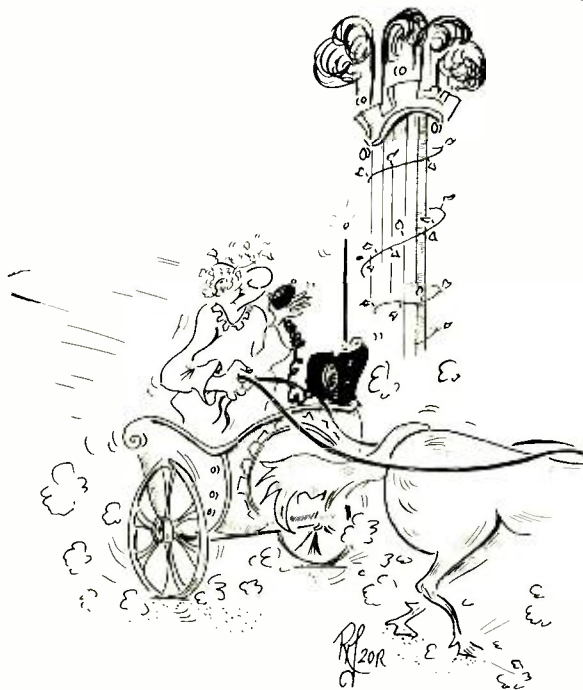
in Montreal, but by July, he could not get away—and besides, that was about the same time as the "Merengue Festival" he had been promoting.

QSL hunters soon soured on *Radio Clarin* because, despite frequent requests for reports, mail was slow to emerge from Santo Domingo. Finally in June, a number of QSL cards did go out, postmarked New York, through an arrangement with the Dominican tourist agency.

But Espinal's friendliness to DX listeners cannot be doubted. He had set aside a 30-minute weekly block for "ClarindX." It turned out that I was the primary contributor of DX information and program reviews, though the program was open to all DX organizations.

This story is in the past tense, because at press time, the English broadcasts were off the air. But *Radio Clarin* has had setbacks before, resulting in lengthy, but temporary, absences from 11,700. So any time now, the *Clarin* cheer may be spreading again.

U.S. Stations. The Billy Graham Evangelistic Association, through its station in Honolulu, KAIM, has a construction permit to build a shortwave station on the island of Maui. Although property has been acquired, little progress has been made in building the station. So KAIM has decided to turn over the CP (but not the property) if the FCC approves, to HCJB. The latter already has some experience in running a shortwave



"That's a big X-IV, Good Buddy!! I'm in IIIrd place now!!!"

station, from Equador. But "KCJB" is out. Those call letters already belong in Minot, ND.

The historic Scituate, Mass. shortwave site is about to be closed down for good. The latest owner of the facility, WYFR, has been moving the five transmitters out, one by one, to their new site in Florida. The move is expected to be complete by year's end. This past summer, WYFR earned the gratitude of DX listeners by moving off Austria's frequency of 6155 to 5985 kHz.

Frequency management of some other U.S. stations leaves something to be desired. In a comedy of errors, KGEI, San Francisco, extended its transmission on 9580 kHz beyond 1100 GMT. The frequency had been used for many years by *Radio Australia*, one of only two stations to be broadcast to North America at that hour on the 31-meter band. Then KGEI showed up on 9505 kHz, the even longer-established frequency of the only *other* station broadcasting to North America on that band at that hour, *Radio Japan*. Finally, KGEI landed on two less critical frequencies, 9575 and 9530.

Trans-World Radio's new station on Guam, KTWR, has even more problems, hopping from one frequency to another without any apparent knowledge of actual band occupancy, often conflicting with *Radio Australia* and other strong Pacific signals.

DX Listening Tips. If you're looking for a low-power challenge, try this one: *Radio Republik Indonesia*, Sorong, Irian Jaya. It reportedly has a 50-watt transmitter on 9610 kHz. There may be some interference from Perth, Australia on 9610, running 50,000 watts.

Gabon has begun an international service, with four new 500,000-watt transmitters. There are as many watts in one of those as there are people in the entire country of Gabon. First tests were carried out at 0700-1900 GMT on 15,300, 9650, 7200, and 6030 kHz.

A private or pirate station in Turkey makes a rare appearance on exactly 18,000 kHz. I've heard it once, and Tony Bugajiar in Toronto has heard it twice. It comes on the air Saturdays only, perhaps once a month or less often. But when it's on, it stays on for many hours, playing Turkish music well into the night. If you hear something on 18,000 kHz, it could also be the third harmonic of a station on 6000 kHz, such as *Radio Budapest*.

Some other harmonics, heard by overseas DX listeners include: *RRI*, Bengkulu, Indonesia, on 6530, at 1000 past 1415 (its fundamental, 3265 kHz, is usually blocked in Australia by another Indonesian); *Conakry*, Guinea, was heard in Mauritania on 9820 kHz at 1300 (2×4910); and *Radio Cultura da Bahia*, Brazil, was heard in Italy on 18,465, at 2145 GMT (3×6155).

Correction. In the September DX Listening Column, I overlooked the fact that Israel has been broadcasting to North America on 21- and even 25-MHz.

Join A Club. The information you see in this column is only the tip of the shortwave iceberg. To keep fully informed on developments in international broadcasting, I suggest you join the North American Shortwave Association. NASWA's monthly magazine, *FRENDX*, contains a wealth of data, articles, loggings and QSL reports. A sample copy is \$1; or you can join for a year at \$13. This includes first-class mailing of *FRENDX*. ◇

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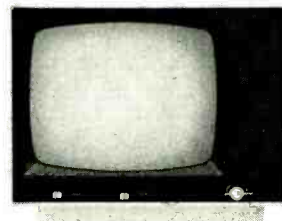
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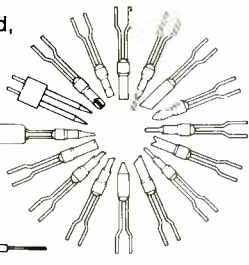
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By Hal Chamberlin

COMPUTER ARITHMETIC—FLOATING POINT

IN OUR September 1978 column, we discussed multiple precision computer arithmetic in which two or more bytes were used to hold a single number. But why would one want to go to the trouble of using multiple precision arithmetic?

Many applications may involve numbers that are larger than the -128 to +127 range of a single byte. For applications using binary fractions, accuracy better than the 0.4% of full-scale figure attainable in a single byte is required. However many, if not most, applications requiring computation may include mixed numbers of widely varying magnitude as well.

Scale Factor. One method of handling mixed numbers involves the concept of a scale factor. Most of us have used this concept without realizing it. For example, one does not ask a sales person in an electronics shop for a 0.0000001-farad capacitor. Instead, a "point one microfarad" capacitor would be requested. The term *micro* implies a scaling factor of 1/1,000,000. When using scaling factors, the real number (0.0000001) is equal to the scaled number (0.1) multiplied by the scaling factor (1,000,000). When people use scale factors, it is in an attempt to make the scaled number close to unity. Thus 100,000 picofarads would also be an unnatural expression. In a computer, the scale factor concept can be used to reduce numbers, no matter how large or small, to a range around unity. If they are kept less than 1.0, fractional arithmetic can be used for all computations.

The arithmetic routines given earlier of course do not recognize scale factors. It is the responsibility of the programmer to keep track of scale factors. The situation is much like having a calculator with no decimal point logic. The machine calculates the digits and it is up to the user to figure out where the decimal point should be. For example, if two scaled numbers are multiplied together, the scale factor of their product is the prod-

uct of the scale factors. For division it is the quotient of the scale factors. This means that if both dividend and divisor scale factors are the same, the quotient scale factor is one.

When performing addition or subtraction, the scale factors of the operands *must* be equal and the scale factor of the answer will be the same as the operands. If the operands do not have the same scale factor, one of them must be rescaled. For example the series combination of 3.3k ohms and 51 ohms can either be 3300 ohms plus 51 ohms or 3.3k ohms plus 0.051k ohms. Rescaling in either case is usually accomplished by shifting the decimal point.

A good programmer may be able to sit down with a definition of the problem to be solved and select scale factors for the variables that simultaneously prevent overflow and maintain the maximum number of significant bits throughout the computation. To do this however, a good knowledge of the magnitude of the numbers in the *intermediate results* is required. This usually means that the problem must be solved before programming it. If the calculation is well defined and highly repetitive, this may not be much of a limitation, but it is unsuitable for experimental computation.

Floating-point arithmetic is an ingenious way of having the computer keep track of scaling factors as well. In addition, it provides for automatically rescaling intermediate results based on the size of the numbers at the time. Thus the programmer can become less concerned about the magnitude of intermediate results. The floating point method of doing computer arithmetic is so powerful and popular that it is an expected feature of any high-level computer language. In assembly language programming however, it is only used as a last resort because of the memory requirements and execution time of floating point arithmetic subroutines.

Number Format. Floating-point num-

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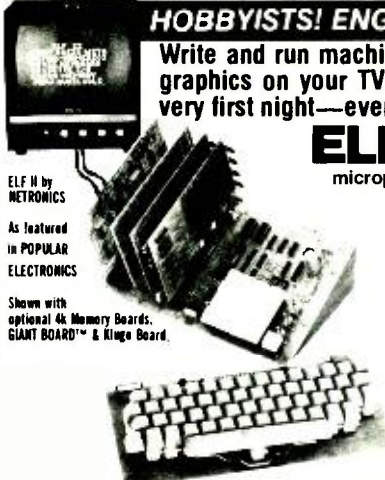
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bers are represented in a computer much like scientific notation. Basically the number is split into two parts usually called the *mantissa* and the *characteristic*. These are actually rather poor, misapplied names derived from logarithm theory so the term *fraction* will be used instead of mantissa and *exponent* will replace characteristic. The fraction part of a floating-point number is just what its name implies; a number above 0 and just shy of 1.0 in magnitude. The exponent is simply a signed integer. The value of the entire floating-point number is the fraction multiplied by the base raised to the exponent power. The base is a constant integer chosen by the person who wrote the floating-point arithmetic routines being used and never changes. A floating-point number is said to be *normalized* when the fraction is greater than the reciprocal of the base but less than unity.

Perhaps an example will clear things up a bit. Using decimal numbers, consider the floating-point number 0.454×10^4 . The 0.454 is the fraction, the 10 is the base, and the 4 is the exponent. Since 10 to the fourth power is 10,000, this number is equal to 4540 in conventional notation. Other floating point numbers might be 0.789×10^{-2} which is the same as 0.00789 and 0.065×10^2 , which is equal to 6.5. Note that the preceding number is not normalized since the fraction is less than 1/10; in normalized form it would be 0.65×10^1 . Note also that normalization simply amounted to moving the decimal point right one position which multiplied the fraction by 10 and then reducing the exponent by 1, which divided the number by 10 leaving the overall number unchanged in value.

When writing a floating-point arithmetic package for a computer, the choice of the base is very important. When people do calculations they naturally choose 10 for the base because of familiarity with decimal numbers. Computers on the other hand are more at home with 2 as a base because of their binary nature. Other popular bases are 8 and 16 which, because they are powers of two, are as easily handled by a computer as 2. When using a microcomputer, the only advantage of 8 or 16 as a base is exact emulation of the floating-point arithmetic of large machines which use these bases to make their hardware floating-point instructions faster.

A typical binary (base-2) floating-point number format is shown in Fig. 1. Four bytes are used to represent the

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number. The first byte is devoted to the exponent which can range between -128 and +127. This means that the scale factor applied to the fraction (base to exponent power) can range between 2^{-128} and 2^{127} which is equivalent to about 10^{-38} to 10^{37} . The fraction is a simple triple precision binary fraction ranging between, but not including, -1 and +1. This format gives an accuracy equivalent to 6 to 7 decimal places. Another popular format requires 8 bytes

plies the fractions together using a fractional multiply routine and adds the exponents together. Since the product of the fractions may be less than 1/2, normalization of the result might be necessary. In fact, only normalize left is ever required since the product will always be between 1/4 and 1.

Overflow is also possible. An overflow condition exists if the exponent ever exceeds 127 either as the result of the multiplication or during the normalization

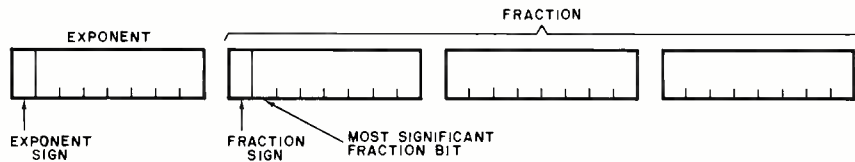


Fig. 1. Typical four-byte floating-point format.

and simply extends the fraction to 56 bits which is equivalent to about 17 decimal digits. Note that the fraction of a normalized base-2 floating-point number must be between 1/2 and 1 which means that the most significant fraction bit will always be a one. Some floating-point software packages take advantage of this fact and omit this bit. The fraction can then be shifted left one bit making room for an additional bit of accuracy at the right end with no increase in storage space.

process. Overflow is a serious error which renders any results useless. If the exponent should ever become more negative than -128, then underflow is said to have occurred. This means that the number has become so small that it cannot be distinguished from zero. This is a much less serious error and is usually handled by setting the result equal to zero and continuing.

Division is nearly as simple. One divides the fractions and subtracts the divisor exponent from the dividend exponent. Unnormalized results are again possible but this time they may range between 1/2 and 2 which means that a right shifting normalize may be required.

Floating add and subtract are more difficult and in fact may be nearly as slow as multiply and divide on a microcomputer.

Conversion Binary and Decimal.

Even though base-2 floating point is most efficient for the computer, people demand the use of decimal numbers. The conversion process, while relatively straightforward, is too complex to explain in detail here. One difficulty with the conversion is that round decimal fractions, such as 0.1, cannot be represented exactly in binary floating-point form. Likewise, round binary fractions such as $1/32,768$ cannot be represented exactly by fewer than 14 decimal digits. Integers smaller than about 8,000,000 for the 4-byte format discussed earlier are however converted exactly in both directions. The important point to remember is that the conversions are as accurate as the number of bits or digits allow, and that real-world data seldom involves "exact fractions" such as 0.1.

Normalization is a very important operation in floating-point arithmetic. As previously stated, a normalized binary floating-point number has a fraction between 1/2 and 1. An arithmetic operation however can produce an un-normalized result or even a "fraction" greater than 1. Normalization is accomplished by shifting the fraction in the appropriate direction and then either incrementing or decrementing the exponent to compensate, thus leaving the value of the number unchanged. For example, if an addition operation left the result 0.0813×2^9 (decimal representation of binary floating point) one would want to shift the fraction left which multiplies it by two for each shift. To compensate, the exponent must be decremented by one for each shift. After three shifts, the fraction becomes 0.6504 and the exponent becomes 6 which leaves the equivalent number, 41.6256, unchanged.

Arithmetic Operations. Floating-point number representation makes arithmetic on such numbers more difficult since now both the fraction and the exponent enter the arithmetic. Multiplication is probably the simplest floating-point operation. One simply multi-

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Software Sources

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6800 Extended BASIC Compiler.

Not an interpreter (like most BASIC's) but a compiler, this program generates compact application programs (about 60% of source size) which run with increased speed. The code can be stored in ROM, and can also be distributed without revealing the source code.

Other features include formatted output, strings, file I/O, 10-digit decimal arithmetic, floating point, PEEK/POKE and long variable names. The compiler (used only to generate code, not used at run time) requires 16K; the runtime package requires 10K, plus approximately 2K for an I/O package. A 16K machine can run a 225-line BASIC program, a 32K machine can run an 1100-line. On Smoke Signal floppy disk, \$325, with manual and assembler. BASIC and Assembler manuals only, \$10. Smoke Signal Broadcasting, Box 2017, Hollywood, CA 90028.

BASIC Programs for Pet. Nineteen tapes of BASIC programs for the Commodore Pet computer are now available from Don Alan enterprises. Most of the cassettes (which are priced from \$4.95 to \$19.95) are game programs, but the series also includes biorhythm, loan amortization, sketch-pad plotting, and a checkbook program. Don Alan Enterprises, Box 401, Marlton, NJ 08053.

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the H8 front panel, and one machine-language game for terminal use. Utility programs include: ham-code practice (front panel or terminal), calculator & clock (front panel), and Educator-8080, a programming-instruction program which displays registers after each command. BASIC programs will run in 8K, others in 4K. \$10 each. Multi-Micro Media, Box 1025, Arvada, CO 80001.

TRS-80 Machine-Language Software. Small System Software offers a series of TRS-80 utility and game program cassettes. For 4K machines, they offer a 21-command, 2K monitor (\$17.95), an expanded monitor with Z80 disassembler (\$23.95), the game of LIFE (\$14.95), and Microchess (\$19.95). For 16K machines, there is a TRS-80 version of Michael Shroyer's ESP-1 assembler/editor/monitor (\$29.95). Also a disassembled listing of Radio Shack's Level-I BASIC (\$7.95). Small System Software, Box 483, Newbury Park, CA 91320.

North Star Word Processor. SOL*STAR is a word processor designed for North-Star-equipped Sol computers. Also usable on any 8080 or Z80 system with keyboard. North-Star floppy disk system, at least 16K RAM beginning at 2000 hex, a Processor Technology VDM-1 and video monitor, and as a printer, either a Selecterm (Selectric II), Multiterm (Diablo) or Teletype. The system allows corrections, additions, deletions or movement of characters, words, phrases and large copy blocks, right and left justification, spacing and margin controls, character-string search and replacement, and word count. Disk "housekeeping" is handled automatically, and the system adds two disk commands (Append File and Insert File) not found in the North Star DOS. SOL*STAR is \$198, including manual (manual alone \$5, refundable with purchase). Micro Applications, 1913 Harbor Blvd., Costa Mesa, CA 92627.

8080 High-Level Language. OPUS, a high-level language for 8080 and Z80 computers, is now available in two versions, OPUS/ONE and OPUS/TWO. The command set shared by both versions includes many BASIC-like commands (GOSUB, GOTO, etc.), plus print formatting and extensive file-handling facilities. OPUS/TWO adds capabilities for error trapping, external and machine-code subroutines, jumping out of "blocks," extended substring search, overlays, and additional file and disc manipulation commands. OPUS/ONE programs are upward-compatible to run under OPUS/TWO. OPUS/TWO may also be run under TEMPOS, a multi-tasking operating system available separately. The programs are available on MITS (hard-sectored) or iCOM (IBM 3740-type) diskette, paper tape, or MITS cassette, at \$99 for OPUS/ONE, \$195 for OPUS/TWO. A User's Manual covering both versions is \$10.00. Write: Administrative Systems, Inc., 222 Milwaukee, Suite 102, Denver, CO 80206.

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Published by Computer Faire, Box 1579, Palo Alto, CA 94302. 334 pages. \$12 soft cover.

TESTS-ANSWERS FOR FCC FIRST AND SECOND CLASS COMMERCIAL LICENSE, REVISED 1978 EDITION

by Warren Weagant

Fifteen multiple-choice examinations based on actual FCC exams are included in this book to prepare the reader for the Commercial license tests given by the Federal Communications Commission. In addition to the actual exams, there are helpful tips on how to set up a home-study program, uncovering additional review material, how to register for the exam, and a "Self-Study Ability Test" to be taken before starting preparation for the FCC license exams. This test is designed to study and understand FCC test material.

Published by Command Productions, Radio Engineering Division, Box 26348, San Francisco, CA 94126. 198 p. \$9.95, soft cover.

HOME COMPUTERS: A BEGINNERS GLOSSARY AND GUIDE

by Merl K. Miller and Charles J. Sippl

This is a manageable reference text for newcomers to home computing. The book begins by enumerating possible home applications of computers and describes their widespread commercial use. An enlightening discussion of microcomputer systems and technology follows, and further chapters explain types and applications of microcomputer memory and illustrate the intricacies of computer-oriented number systems. Also covered are microcomputer peripherals, languages, and basic theory of logic gates. But the heart of the book is its glossary, which contains hundreds of plain-language definitions and facts of computer-related material, and from which

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Published by IEEE, 345 E 47th St., New York, NY 10017. 882 pages. \$24.95, hard cover.

THE SCIENCE OF HI-FIDELITY

by Kenneth W. Johnson and Willard C. Walker

This exciting text uses hi-fidelity as the vehicle for teaching basic college physics. It is an excellent reference for audiophiles who wish to increase their technical knowledge and gain a better understanding of the scientific laws governing their hobby. First, a basic hi-fi system is analyzed, while details of hi-fi components and features are related. Then the physics starts: the next few chapters cover waves and sound, including forced vibrations, the Doppler effect, sound power and decibels, the Fletcher-Munson curves, wave interference, and Fourier analysis. These principles are subsequently examined as applied to speaker systems, along with speaker specifications and properties. Next, basic electricity is investigated, followed by a detailed look at amplifiers, tuners, and preamplifiers and their functions, characteristics, and features. Electromagnetism is discussed too, with examples of applications to speakers, tape recorders, and phono cartridges. An in-depth look at records, turntables, phono cartridges, and tonearms is included. The final chapters of the book report on tape equipment, noise-reduction systems, recording aids, and four-channel sound. Each of the 14 chapters features numerous photographs and diagrams, a summary of terms with definitions, and multiple-choice exercises to test one's knowledge of the material covered.

Published by Kendall/Hunt Publishing Company, 2460 Kerper Blvd., Dubuque, IA 52001. 519 pages. \$14.95 soft cover.

FM ATLAS AND STATION DIRECTORY FIFTH EDITION

by Bruce F. Elving, Ph. D.

A comprehensive list of the FM radio stations

broadcasting in North America, this book's "FMaps" show cities with FM stations, giving their call letters and frequencies. Station Directories are arranged by geography and frequency, listing individual station musical formats, network affiliations, primary and secondary coverage radii in miles. Coverage figures have been calculated from new FCC curves. The book also notes whether a station broadcasts in stereo, has vertical polarization (best for reception in automobiles), and SCA service with specific SCA uses noted. Revised editorial content includes discussions of developments in FM broadcasting, "phony" stereo, quadrphony, tips on buying an FM radio for your car, improving reception, and "SCA: Radio's Great Unexploited Frontier."

Published by the FM Atlas Publishing Co., Adolph, MN 55701. 112 pages. \$3.95, soft cover.

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by R. M. Marston

The guide describes 110 alarm circuits suitable for use in homes, vehicles, and industrial applications. The leading chapter discusses contact-operated alarm circuits, along with bell, relay, and loudspeaker outputs. A comprehensive explanation of burglar alarms and sensor systems follows, with notes on accessory circuits and installation. Other alarm types include those sensitive to heat, light, liquid and steam, pressure, ultrasonic and audible sound, vibration, current, voltage, resistance, and capacitance. Typical applications presented use light-sensitive circuits as smoke detectors, ultrasonic transceiving systems as intruder alerts, capacitance-sensitive circuits as proximity detectors, and concealed switching circuits as automobile anti-theft devices. The theory of operation and a schematic diagram are provided for each of the 110 easy-to-build projects.

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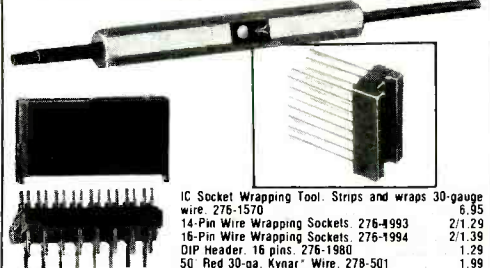
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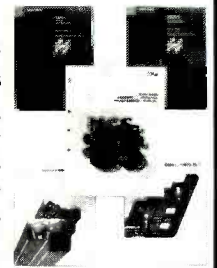
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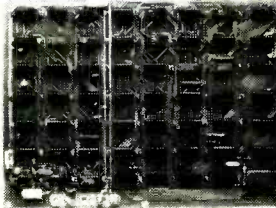
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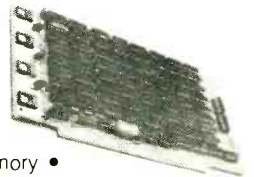
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• 32 char/line, 16 lines, modifications for 64 char/line included • Parallel ASCII (TTL) input • Video output • 1K on board memory • Output for computer controlled cursor • Auto scroll • Non-destructive cursor • Cursor inputs: up, down, left, right, home, EOL, EOS • Scroll up, down • Requires +5 volts at 1.5 amps, and -12 volts at 30 mA • All 7400, TTL chips • Char gen. 2513 • Upper case only • Board only \$39.00, with parts \$145.00



8K STATIC RAM

Part no. 300
• 8K Altair bus memory • Uses 2102 Static memory chips • Memory protect • Gold contacts • Wait states • On board regulator • S-100 bus compatible • Vector input option • TRI state buffered • Board only \$22.50; with parts \$160.00

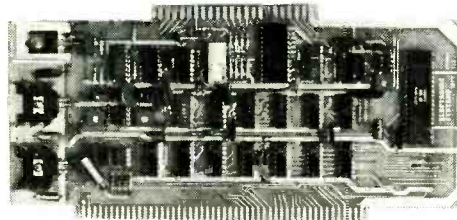


MODEM *

Part no. 109
• Type 103 • Full or half duplex • Works up to 300 baud • Originate or Answer • No coils, only low cost components • TTL input and output-serial • Connect 8 ohm speaker and crystal mic. directly to board • Uses XR FSK demodulator • Requires +5 volts • Board \$7.60; with parts \$27.50



TIDMA *



Part no. 112
• Tape Interface Direct Memory Access • Record and play programs without bootstrap loader (no prom) has FSK encoder/decoder for direct connections to low cost recorder at 1200 baud rate, and direct connections for inputs and outputs to a digital recorder at any baud rate. • S-100 bus compatible • Board only \$35.00; with parts \$110.00

RF MODULATOR *

Part no. 107
• Converts video to AM modulated RF, Channels 2 or 3. So powerful almost no tuning is required. On board regulated power supply makes this extremely stable. Rated very highly in Doctor Dobbs' Journal. Recommended by Apple. • Power required is 12 volts AC C.T., or +5 volts DC • Board \$7.60; with parts \$13.50



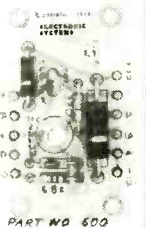
DC POWER SUPPLY *

Part no. 6085
• Board supplies a regulated +5 volts at 3 amps., +12, -12, and -5 volts at 1 amp. • Power required is 8 volts AC at 3 amps., and 24 volts AC C.T. at 1.5 amps • Board only \$12.50; with parts excluding transformers \$42.50



RS 232/TTY *

Part no. 600
• Converts RS-232 to 20mA current loop, and 20mA current loop to RS-232 • Two separate circuits • Requires +12 and -12 volts • Board only \$4.50, with parts \$7.00



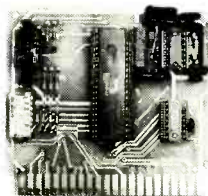
TAPE INTERFACE *

Part no. 111
• Play and record Kansas City Standard tapes • Converts a low cost tape recorder to a digital recorder • Works up to 1200 baud • Digital in and out are TTL-serial • Output of board connects to mic. in of recorder • Earphone of recorder connects to input on board • No coils • Requires +5 volts, low power drain • Board \$7.60; with parts \$27.50



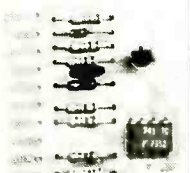
UART & BAUD RATE GENERATOR *

Part no. 101
• Converts serial to parallel and parallel to serial • Low cost on board baud rate generator • Baud rates: 110, 150, 300, 600, 1200, and 2400 • Low power drain +5 volts and -12 volts required • TTL compatible • All characters contain a start bit, 5 to 8 data bits, 1 or 2 stop bits, and either odd or even parity • All connections go to a 44 pin gold plated edge connector • Board only \$12.00, with parts \$35.00 with connector add \$3.00



RS 232/TTL *

Part no. 232
• Converts TTL to RS-232, and converts RS-232 to TTL • Two separate circuits • Requires -12 and +12 volts • All connections go to a 10 pin gold plated edge connector • Board only \$4.50, with parts \$7.00 with connector add \$2.00



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4	75/100	75/100	65/100	55/100	45/100
10	75/100	75/100	65/100	55/100	45/100
22	75/100	65/100	55/100	45/100	45/100
33	65/100	65/100	45/100	45/100	45/100
47	65/100	65/100	45/100	45/100	45/100
100	55/100	45/100	45/100	45/100	45/100
220	45/100	35/100	35/100	25/100	25/100
330	35/100	35/100	25/100	25/100	25/100
470	35/100	25/100	25/100	25/100	25/100
1000	4.40	2.85	2.50	2.50	2.50
2200	---	---	\$1.30	\$1.60	\$2.50

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10	50 pF	220 pF	470 pF	1000 pF	2200 pF	4700 pF	10000 pF	---
25	50 pF	220 pF	470 pF	1000 pF	2200 pF	4700 pF	10000 pF	---
47	50 pF	220 pF	470 pF	1000 pF	2200 pF	4700 pF	10000 pF	---
100	50 pF	220 pF	470 pF	1000 pF	2200 pF	4700 pF	10000 pF	---
220	50 pF	220 pF	470 pF	1000 pF	2200 pF	4700 pF	10000 pF	---
330	50 pF	220 pF	470 pF	1000 pF	2200 pF	4700 pF	10000 pF	---
470	50 pF	220 pF	470 pF	1000 pF	2200 pF	4700 pF	10000 pF	---
1000	50 pF	220 pF	470 pF	1000 pF	2200 pF	4700 pF	10000 pF	---
2200	50 pF	220 pF	470 pF	1000 pF	2200 pF	4700 pF	10000 pF	---

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LM118H	12.75	10.20
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LM206H	4.25	3.40
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LM209K	3.25	2.60
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APS6-2.5	6	2.5	DAPS 9-12.5	9-12	0.5
APS12-1.6	12	1.6	DAPS 12-15	12	0.75
APS15-1.5	15	1.5	DAPS 15-60	15	0.60
---	5	9	10 up	---	---
---	---	---	---	5	9
---	---	---	---	10 up	---

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1854LD	11.70	11.00	9.20	1854LE	8.50	8.00
1856LD	5.50	4.75	4.30	1856LE	1.10	1.05
1857LD	5.50	4.75	4.30	1857LE	1.10	1.05
1858LD	5.65	4.90	4.45	1858LE	1.45	1.40
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15	150	15K	15K	15K
16	160	16K	16K	16K
17	170	17K	17K	17K
18	180	18K	18K	18K
19	190	19K	19K	19K
20	200	20K	20K	20K
21	210	21K	21K	21K
22	220	22K	22K	22K
23	230	23K	23K	23K
24	240	24K	24K	24K
25	250	25K	25K	25K
26	260	26K	26K	26K
27	270	27K	27K	27K
28	280	28K	28K	28K
29	290	29K	29K	29K
30	300	30K	30K	30K
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33	330	33K	33K	33K
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DIODES/ZENERS			
1N914	100v	10mA	.05
1N4005	600v	1A	.08
1N4007	1000v	1A	.15
1N4148	75v	10mA	.05
1N4733	5.1v	1 W Zener	.25
1N753A	6.2v	500 mW Zener	.25
1N758A	10v	"	.25
1N759A	12v	"	.25
1N5243	13v	"	.25
1N5244B	14v	"	.25
1N5245B	15v	"	.25

SOCKETS/BRIDGES			
8-pin	pcb	.20	ww .35
14-pin	pcb	.20	ww .40
16-pin	pcb	.20	ww .40
18-pin	pcb	.25	ww .75
22-pin	pcb	.35	ww .95
24-pin	pcb	.35	ww .95
28-pin	pcb	.45	ww 1.25
40-pin	pcb	.50	ww 1.25
Molex pins	.01	To-3 Sockets	.25
2 Amp Bridge		100-prv	.95
25 Amp Bridge		200-prv	1.95

TRANSISTORS, LEDS, etc.		
2N2222	NPN (2N2222 Plastic .10)	.15
2N2907	PNP	.15
2N3906	PNP (Plastic - Unmarked)	.10
2N3904	NPN (Plastic - Unmarked)	.10
2N3054	NPN	.35
2N3055	NPN 15A 60v	.50
T1P125	PNP Darlington	.95
LED Green, Red, Clear, Yellow		.15
D.L.747	7 seg 5/8" High com-anode	1.95
MAN72	7 seg com-anode (Red)	1.25
MAN3610	7 seg com-anode (Orange)	1.25
MAN82A	7 seg com-anode (Yellow)	1.25
MAN74A	7 seg com-cathode (Red)	1.50
FND359	7 seg com-cathode (Red)	1.25

C MOS	
4000	.15
4001	.15
4002	.20
4004	3.95
4006	.95
4007	.20
4008	.75
4009	.35
4010	.35
4011	.20
4012	.20
4013	.40
4014	.75
4015	.75
4016	.35
4017	.75
4018	.75
4019	.35
4020	.85
4021	.75
4022	.75
4023	.20
4024	.75
4025	.20
4026	1.95
4027	.35
4028	.75
4030	.35
4033	1.50
4034	2.45
4035	.75
4040	.75
4041	.69
4042	.65
4043	.50
4044	.65
4046	1.25
4049	.45
4050	.45
4066	.55
4069/74C04	.25
4071	.25
4081	.30
4082	.30
MC 14409	14.50
MC 14419	4.85
4511	.95
74C151	1.90

- T T L -			
7400	.10	7473	.25
7401	.15	7474	.30
7402	.15	7475	.35
7403	.15	7476	.40
7404	.10	7480	.55
7405	.25	7481	.75
7406	.25	7483	.75
7407	.55	7485	.55
7408	.15	7486	.25
7409	.15	7489	1.05
7410	.15	7490	.45
7411	.25	7491	.70
7412	.25	7492	.45
7413	.25	7493	.35
7414	.75	7494	.75
7416	.25	7495	.60
7417	.40	7496	.80
7420	.15	74100	1.15
7426	.25	74107	.25
7427	.25	74121	.35
7430	.15	74122	.55
7432	.20	74123	.35
7437	.20	74125	.45
7438	.20	74126	.35
7440	.20	74132	.75
7441	1.15	74141	.90
7442	.45	74150	.85
7443	.45	74151	.65
7444	.45	74153	.75
7445	.65	74154	.95
7446	.70	74156	.70
7447	.70	74157	.65
7448	.50	74161	.55
7450	.25	74163	.85
7451	.25	74164	.60
7453	.20	74165	1.10
7454	.25	74166	1.25
7460	.40	74175	.80
7470	.45		
7472	.40		
74H72	.35	74H72	.35
74H101	.75	74H101	.75
74H103	.55	74H103	.55
74H106	.95	74H106	.95
74L00	.25	74L00	.25
74L02	.20	74L02	.20
74L03	.25	74L03	.25
74L04	.30	74L04	.30
74L10	.20	74L10	.20
74L20	.35	74L20	.35
74L30	.45	74L30	.45
74L47	1.95	74L47	1.95
74L51	.45	74L51	.45
74L55	.65	74L55	.65
74L72	.45	74L72	.45
74L73	.40	74L73	.40
74L74	.45	74L74	.45
74L75	.55	74L75	.55
74L93	.55	74L93	.55
74L123	.85	74L123	.85
74S00	.35	74S00	.35
74S02	.35	74S02	.35
74S03	.25	74S03	.25
74S04	.25	74S04	.25
74S05	.35	74S05	.35
74S08	.35	74S08	.35
74S10	.35	74S10	.35
74S11	.35	74S11	.35
74S20	.25	74S20	.25
74S40	.20	74S40	.20
74S50	.20	74S50	.20
74S51	.25	74S51	.25
74S64	.15	74S64	.15
74S74	.35	74S74	.35
74S112	.60	74S112	.60
74S114	.65	74S114	.65
74S133	.40	74S133	.40
74S140	.55	74S140	.55
74S151	.30	74S151	.30
74S153	.35	74S153	.35
74S157	.75	74S157	.75
74S158	.30	74S158	.30
74S194	1.05	74S194	1.05
74S257 (8123)	1.05	74S257 (8123)	1.05
74LS00	.20	74LS00	.20
74LS01	.20	74LS01	.20
74LS02	.20	74LS02	.20
74LS04	.20	74LS04	.20
74LS05	.25	74LS05	.25
74LS08	.25	74LS08	.25
74LS09	.25	74LS09	.25
74LS10	.25	74LS10	.25
74LS11	.25	74LS11	.25
74LS20	.20	74LS20	.20
74LS21	.25	74LS21	.25
74LS22	.25	74LS22	.25
74LS32	.25	74LS32	.25
74LS37	.25	74LS37	.25
74LS38	.35	74LS38	.35
74LS40	.30	74LS40	.30
74LS42	.65	74LS42	.65
74LS51	.35	74LS51	.35
74LS74	.35	74LS74	.35
74LS86	.35	74LS86	.35
74LS90	.55	74LS90	.55
74LS93	.55	74LS93	.55
74LS107	.40	74LS107	.40
74LS123	1.00	74LS123	1.00
74LS151	.75	74LS151	.75
74LS153	.75	74LS153	.75
74LS157	.75	74LS157	.75
74LS164	1.00	74LS164	1.00
74LS193	.95	74LS193	.95
74LS367	.75	74LS367	.75
74LS368	.65	74LS368	.65

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2102L-1	1.75	8T13	1.50
2114	9.50	8T23	1.50
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		2107B-4	4.95
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- Clocks mount anywhere with either 3M double sided tape or VELCRO, included.
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- LCD 102, runs on 12 VOLT system and is back lighted.
- LCD 101 or LCD 102 show choice.

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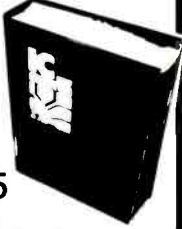
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74LS02	15	74LS49	89	74LS125	59	74LS174	69	74LS260	29	74LS374	175
74LS03	15	74LS51	19	74LS126	59	74LS175	69	74LS261	185	74LS375	65
74LS04	19	74LS54	19	74LS132	79	74LS181	250	74LS266	39	74LS377	150
74LS05	19	74LS55	19	74LS133	29	74LS183	350	74LS273	165	74LS378	125
74LS08	19	74LS63	150	74LS136	39	74LS190	89	74LS275	450	74LS379	135
74LS09	19	74LS73	29	74LS138	64	74LS191	89	74LS279	59	74LS386	49
74LS10	15	74LS74	35	74LS139	64	74LS192	95	74LS280	175	74LS390	150
74LS11	19	74LS75	49	74LS145	99	74LS193	95	74LS283	85	74LS393	125
74LS12	19	74LS76	39	74LS147	195	74LS194	75	74LS290	85	74LS395	150
74LS13	35	74LS78	39	74LS148	99	74LS195	66	74LS293	110	74LS396	170
74LS14	59	74LS83	79	74LS151	59	74LS196	109	74LS295	125	74LS398	265
74LS15	19	74LS85	99	74LS153	59	74LS197	109	74LS298	125	74LS399	150
74LS20	15	74LS86	35	74LS155	99	74LS221	125	74LS299	295	74LS424	450
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74LS22	19	74LS91	99	74LS157	59	74LS241	195	74LS325	255	74LS447	125
74LS26	25	74LS92	59	74LS158	69	74LS242	195	74LS326	255	74LS490	195
74LS27	21	74LS93	49	74LS160	84	74LS243	195	74LS327	255	74LS668	90
74LS28	21	74LS95	70	74LS161	84	74LS244	195	74LS347	125	74LS669	90
74LS30	15	74LS96	99	74LS162	84	74LS245	195	74LS348	175	74LS670	200
74LS32	25	74LS107	39	74LS163	84	74LS247	125	74LS352	135		
74LS33	27	74LS109	32	74LS164	89	74LS248	125	74LS353	135		
74LS37	23	74LS112	32	74LS165	125	74LS249	125	74LS362	700		
74LS38	23	74LS113	39	74LS166	145	74LS251	85	74LS365	55		
74LS40	19	74LS114	39	74LS168	150	74LS253	85	74LS366	55		
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5.7 Million	1N4004	300V 049	80000	W08M	800V 39
1.6 Million	1N4005	600V 055	7000	W10M	1000V 60
8 Million	1N4006	800V 065			
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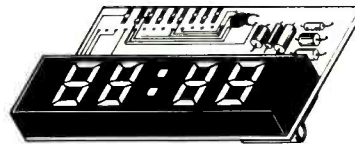


\$1.95 LIMITED STOCK

By Bowmar. .5 in. character common cathode. Designed for use with multiplexed clock chips 4 digits in 1 pack!

NATIONAL SEMICONDUCTOR JUMBO CLOCK MODULE

MA1008A BRAND NEW!



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- FEATURES
- FOUR JUMBO 1/2 INCH LED DISPLAYS
 - 12 HR REAL TIME FORMAT
 - 24 HR ALARM SIGNAL OUTPUT
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 - LED BRIGHTNESS CONTROL
 - POWER FAILURE INDICATOR
 - SLEEP & SNOOZE TIMERS
 - DIRECT LED DRIVE (LOW RFI)
 - COMES WITH FULL DATA

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We have a limited number of the 24 HR Real time version of this module in stock.
#MA1008D — \$9.95

PERFECT FOR USE WITH A TIMEBASE.

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99¢

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7412 .02 20	7496 .05 60	74197 .05 73	74LS86 .05 75	74S152 .05 75
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7457 .02 19	7499 .05 60	74242 .05 50	74LS134 .05 35	74S197 .05 75
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7460 .02 19	7499 .05 60	74245 .05 50	74LS137 .05 35	74S200 .05 75
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7462 .02 19	7499 .05 60	74247 .05 50	74LS139 .05 35	74S202 .05 75
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7482 .02 19	7499 .05 60	74267 .05 50	74LS159 .05 35	74S222 .05 75
7483 .02 19	7499 .05 60	74268 .05 50	74LS160 .05 35	74S223 .05 75
7484 .02 19	7499 .05 60	74269 .05 50	74LS161 .05 35	74S224 .05 75
7485 .02 19	7499 .05 60	74270 .05 50	74LS162 .05 35	74S225 .05 75
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7498 .02 19	7499 .05 60	74283 .05 50	74LS175 .05 35	74S238 .05 75
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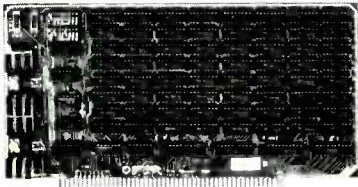
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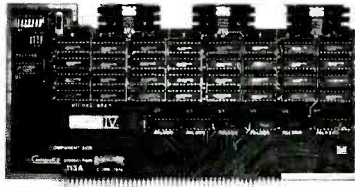
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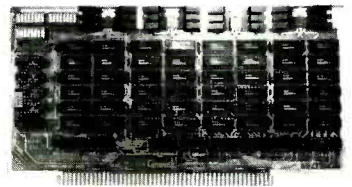
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*Certified Systems Components board are assembled, tested, serial numbered, burned in for 200 hours, and guaranteed to run at 4 MHz over full temp range. Board exchanged if failure occurs within 1 year of invoice date.

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	74C14	1.75	7432	.30	74164	1.45	8976	2.95	8556	3.25	
4000	20	74C20	.26	7437	.44	74165	1.35	75107	3.25	8599	3.25
4002	20	74C30	.26	7440	.18	74166	1.20	75450	1.00		
4007	20	74C32	.30	7442	1.00	74173	1.70	75451	.80		
4010	.36	74C42	1.40	7445	.70	74175	1.05	75452	.80		
4011	.20	74C48	2.75	7446	.70	74177	.90	75453	.80		
4012	.20	74C73	1.25	7448	.70	74182	.95	75491	1.25		
4013	.35	74C74	.75	7449	.25	74191	1.20	75492	1.40		
4014	.80	74C86	1.00	7451	.25	74192	1.45	75494	1.50		
4015	.80	74C90	1.10	7453	.25	74193	1.35				
4016	.35	74C93	1.25	7454	.35	74195	1.00				
4017	.92	74C151	2.75	7460	.22	74196	1.10				
4018	.92	74C154	3.00	7472	.40	74197	1.10				
4019	.20	74C157	1.10	7473	.40	74199	2.25				
4020	1.00	74C160	1.40	7474	.40	74367	.90				
4022	.83	74C162	2.70	7475	.55						
4023	.21	74C164	1.75	7476	.45						
4024	.75	74C165	1.75	7483	1.05	0025	3.50				
4025	.20	74C174	1.50	7485	1.10	002G	1.75	2513	9.50		
4027	.34	74C902	.85	7486	.43	8640	1.25	2516	9.50		
4028	.79	74C904	.85	7489	2.00	8861	2.75	1013	6.50		
4079	1.00	74C905	3.00	7492	.75	8906	3.00				
4030	.20	74C914	1.95	7493	.85						
4035	.95			7496	.78						
4040	1.00			7498	.85	8830	4.90	8797	1.75		
4041	1.00	7400	.16	74121	.35	8833	2.45	8092	.95		
4042	.70	7401	.17	74122	.49	8835	2.45	8094	.60		
4044	.60	7403	.17	74123	.65	8836	1.25	8095	.80		
4049	.35	7404	.19	74126	.65	8837	2.45	8096	.90		
4051	1.10	7406	.40	74132	1.25	8838	2.45	8098	.90		
4066	.70	7407	.40	74141	1.15	8859	1.50	8121	2.25		
4068	.40	7409	.25	74145	1.10	8865	1.50	8136	3.25		
4069	.40	7410	.18	741481	1.20	8866	1.50	8220	3.25		
4075	.20	7413	.78	74150	.90	8867	1.85	8231	2.25		
4082	.23	7414	.68	74153	1.10	8869	1.75	8242	1.75		
74C00	.25	7417	.38	74154	1.25	8879	2.25	8250	1.75		
74C02	.45	7420	.18	74155	.75	8880	2.75	8260	2.25		
74C04	.32	7421	.35	74157	1.00	8884	2.45	8281	1.00		

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G.E. "Ham News" Need any edition circa 1952. C. Wayne, Box E., Garden Grove, CA 92642.

B&K model 160 transistor tester. Operation manual. Dennis Blasberg 2501 45th St., Des Moines, IA 50310.

Hallicrafters SW-500 shortwave receiver. Schematic, alignment information and manual. Dennis Vanderhei, 1236 18th St., NW, Cedar Rapids, IA 52405.

RCA model 721 TS television. Circuit diagram and list of tubes. M.G. Cunningham, West Redding, Rd., Danbury, CT 06810.

Sony reel-to-reel tape recorder model TC-377. Service manual, schematics or any available information. Rocco Nicholas Arturo, 511 Hendee St., New Orleans, LA 70114.

Telequipment type S31 oscilloscope. Manual and schematic. Wayne Gunn, Rt. 1, Box 89A, Rusk, TX 75785.

CMI model SG-410 guitar amplifier. Schematic, instructions and service manual. Scott DellaPerata, 510 Country Club Rd., Bridgewater, NJ 08807.

Precision sweep generator series E-400. Operating manual. Nelson Baxter, RT 1, Box 41, Hager City, WI 54014.

Hallicrafters model SX100 shortwave receiver. Schematics and any information. Sam Murphy, 3413 Baldwin, Tyler, TX 75702.

Sencore CR 128A CRT tester. Need tube chart and operating instructions. Stephen Upchurch, 317 E. Elm, Elkhart, IA 50073.

Hickok 890 transistor tester. Operation manual and schematic. Dave Whitmore, 23 Jackson Heights, Essex Junction, VT 05452.

Hallicrafters model S 20R receiver. Operation and repair manual. Douglas Miller, 2035 Valley View Blvd., East Watahchee, WA 98801.

Hickok model 530B dynamic mutual conductance tube tester. Tube charts needed. Joe Montalbano, 1145 Larkin St., San Francisco, CA 94109.

Knight CB model Safan I. Schematic, parts list and other information. J.W. Haga, Box 33, Cates, IN 47927.

Heathkit model DX-40 transmitter with Heathkit vfo. Schematic and operating manual. Ted Wright, 3929 Wood Lane, Ft. Worth, TX 76117.

Rolecor RTA-630 solid-state FM stereo receiver. Parts list with substitution part numbers needed. Tim Mooney, 11 Cornell Dr., Delran, NJ 08075.

Becker model Europa-MU auto radio. Schematic, repair information. Jerome Knapp, 4243 West 8th St., Cincinnati, OH 45205.

Superior Instruments model TD-55. Schematic, manual and tube chart. Stanley Ondrusek, 7468 Larne La., Lorton, VA 22079.

Hickok dynamic mutual conductance multi-tester model 550X. Manual and schematic. Craig Smith, 421 Westminster, Wenonah, NJ 08090.

Callmaster model 330 (phone answering device). Schematic. Ellsworth Gosling, 3-A Oklahoma Way, Whiting, NJ 08759.

Hallicrafters model HT-40 transmitter. Operating manual and schematic. Bill Boyer, 6500 Poco Ct., Ft. Worth, TX 76133.

Bell T-337, RP-320A pre-amp reel recorder. Service and repair manual. H.A. Dobson, 1219 Nelson NE, Orangeburg, SC 29115.

Dumont type 304A, type 274, and type 411 oscilloscopes. Operation manuals and schematics. Eric Ericson, 7100 Hightower, Ft. Worth, TX 76112.

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LA1222	1.59	MN3006	5.90
LA1365	2.20	MN3007	19.95
LA1368	3.42	NPC5107	14.95
LA3101	3.75	PLL03A	14.95
LA4220	2.55	SG264A	7.80
LA4430	2.70	SG609	4.50
LD3000	2.25	SG629-3	3.40

SI1010	6.90	UPC572C	4.10
SI1020	13.95	UPC574	1.20
SI1030	19.00	UPC583C	3.30
SI1050	27.80	UPC1028	1.80
SM5104	8.90	UPC1031H	2.98
SM5107C	11.95	UPC1032H	1.35
STK013	11.25		
STK014	8.65		
STK041	17.40		
STK075	8.22		
STK413	6.75		
TA7092P	5.45		
TA7117P	3.60		
TA7206P	3.06		
TA7214P	5.15		
TA7217AP	3.30		
TA7222P	3.50		
TA7521M	3.55		
TA7607P	9.90		
TA7609P	4.80		
TBA810AS	3.30		
TBA810DS	3.30		
TBA810S	3.30		
TBA810SH	3.30		
TBA820	2.10		
TDA1190Z	6.50		
TDA2002	4.60		

ALL PARTS GUARANTEED AGAINST FACTORY DEFECTS			
2SA772	89	2SB509	2.79
2SA786	39	2SB528	.99
2SA811	54	2SB549	.79
2SA818	1.05	2SB567	2.30
2SA835	1.35	2SB618	2.65
2SA840	1.68	2SC352A	2.55
2SA841	.43	2SC356	.95
2SA842	.43	2SC583C	.81
2SA861	1.29	2SC895	4.90
2SA879	.93	2SC983	.89
2SA880	75	2SC1056	5.50
2SA911	6.33	2SC1424	2.98
2SA915	7.7	2SC1429	1.49
2SA922	3.98	2SC1452	1.40
2SA923	4.50	2SC1474	.96
2SA940	96	2SC1548	.79
		2SC1583	.68
		2SC1622	.49
		2SC1630	3.60
		2SC1681	.39
		2SC1682	.39
		2SC1761	1.58
		2SC1762	4.85
		2SC1775	54
		2SC1778	.45
		2SC1787	.62
		2SC1811	1.29

TRANSISTORS			
2SC867	3.95	2SC1885	.79
2SC871	.35	2SC1906	.48
2SC930	.35	2SC1923	.39
2SC943	.65	2SC1940	.64
2SC945	.35	2SC1945	6.75
2SC959	1.25	2SC1951	1.59
2SC982	.68	2SC1959	.39
2SC1000BL	.45	2SC1963	3.30
2SC1014	.83	2SC1981	2.60
2SC1018	.65	2SC1982	3.30
2SC1030	2.35	2SC2009	.85
2SC1034	5.45	2SC2120	.65
2SC1047	.49	2SC2122	45
2SC1051	2.80	2SC2124	1.65
2SC1060	1.10	2SC2125	1.45
2SC1061	1.00	2SC2214	2.95
2SC1076	25.80	2SD388	3.65
2SC1099	3.95	2SD477	1.65
2SC1096	.75	2SD528	3.30
2SC1098	.65	2SK58	4.45
2SC1114	.80	2SK97	4.85
2SC1116	3.95	2SK107	1.15
2SC1145	1.45	2SK120	1.20
2SC1163	1.35	2SK121	1.20
2SC1177	12.80	2SK125	1.75
2SC1209	.56	2SK130A	3.90
2SC1212A	1.15		
2SC1215	.65		
2SC1226A	.70		
2SC1237	2.15		
2SC1239	3.15		
2SC1243	.76		
2SC1279	.55		
2SC1306	2.45		
2SC1307	3.85		
2SC1308	5.45		
2SC1312	.45		
2SC1316	8.25		
2SC1317	.35		
2SC1318	.40		
2SC1325A	7.40		
2SC1347	.59		
2SC1358	4.70		
2SC1359	.39		
2SC1362	.45		
2SC1364	.65		
2SC1377	4.10		
2SC1383	.45		
2SC1384	.55		
2SC1407	.75		
2SC1445	2.95		
2SC1447	.85		
2SC1448	.95		
2SC1451	1.75		
2SC1475	.90		
2SC1509	.65		

POPULAR TYPES			
AN211	2.40	TA7054P	2.29
AN214	2.75	TA7055P	2.50
AN217	1.70	TA7060P	1.05
AN239	6.50	TA7061AP	1.05
AN240	2.10	TA7062P	1.50
AN241	2.10	TA7063P	1.10
AN245	5.50	TA7064P	1.20
AN247	4.10	TA7066P	1.04
AN264	2.25	TA7074P	2.90
AN274	2.60	TA7075P	3.50
AN277	2.90	TA7076P	3.50
AN277B	2.90	TA7089P	2.75
AN289	6.50	TA7106P	3.00
AN315	2.80	TA7108P	1.95
AN328	2.70	TA7120P	1.05
AN343	3.60	TA7122AP	1.35
AN380	7.25	TA7124P	1.40
BA511A	2.65	TA7130P	2.20
BA521	2.75	TA7146P	3.70
CX101G	6.20	TA7150P	3.50
CX104A	6.20	TA7159P	2.30
CX157	6.00	TA7200P	3.05
HA1137	3.18	TA7201P	3.15
HA1138	3.00	TA7203	3.60
HA1151	3.20	TA7204	3.20
HA1156	2.40	TA7205	2.60
HA1158	3.90	TA7310P	2.95
HA1159	4.40	TA78005P	3.50
HA1201	1.30	TA78012M	3.50
HA1202	1.20	TC5080P	4.90
HA1211	1.25	TC5081P	3.05
HA1306W	3.50	UH1C002	5.60
HA1322	3.65	UH1C003	5.60
HA1339A	3.75	UH1C004	5.60
HA1342A	3.70	UH1C005	5.60
LA1201	1.95	UPC16C	1.85
LA1364	3.50	UPC27C	2.75
LA3155	1.85	UPC30C	3.40
LA3300	2.40	UPC41C	2.70
LA3301	2.40	UPC554C	1.80
LA3350	2.70	UPC555H	1.80
LA4030P	3.08	UPC563	3.65
LA4031P	2.65	UPC566H	1.15
LA4032P	2.75	UPC571	3.80
LA4051P	2.70	UPC573	3.05
LA4400	3.10	UPC575C2	3.35
LD3120	2.30	UPC576	2.10
M5115AP	4.90	UPC577	1.65
M5152L	2.30	UPC592H2	1.05
M51513L	3.90	UPC595C	2.65
MN3001	19.50	UPC596C	2.50
MN3002	11.70	UPC1001H	3.40
MN3003	11.70	UPC1008C	5.75
PLL01A	8.60	UPC1020H	3.05
PLL02A	8.40	UPC1025H	2.85
PLL02A-G	8.40	UPC1026H	2.29
STK011	5.80	UPC1028	1.75
STK015	6.15	UPC1152H	3.25
STK016	8.20	UPD858C	7.20
STK032	13.80	UPD861C	12.29
STK415	8.10	2SA49	.45
STK435	7.80	2SA102	.39
STK439	10.10	2SA473	.65
TA7027M	3.10	2SA483	2.45
TA7028M	3.10	2SA484	2.25
2SA493	.49	2SB507	1.05
2SA495	.39	2SB511	.90
2SA497	1.39	2SB531	2.70
2SA509	.45	2SB541	3.70
2SA562	.39	2SB554	7.50
2SA564A	.39	2SB556	4.60
2SA606	1.39	2SB557	3.20
2SA607	1.48	2SB600	5.90
2SA624	.99	2SC372	.35
2SA628	.49	2SC373	.35
2SA634	.65	2SC380	.35
2SA636	1.25	2SC381	.35
2SA640	.45	2SC382	.55
2SA643	.55	2SC387A	.45
2SA659	.49	2SC388A	.59
2SA661	.62	2SC394	.39
2SA671	1.25	2SC403	.45
2SA673	.55	2SC454	.45
2SA678	.55	2SC458	.45
2SA679	4.75	2SC460	.45
2SA682	1.35	2SC461	.45
2SA683	.45	2SC481	1.45
2SA684	.45	2SC482	1.35
2SA695	.45	2SC484	1.25
2SA699A	.80	2SC485	1.20
2SA705	.65	2SC495	.79
2SA706	1.25	2SC515A	1.20
2SA715	1.20	2SC517	3.25
2SA719	.45	2SC535	.45
2SA720	.45	2SC562	.65
2SA721	.45	2SC563	.90
2SA726	.45	2SC605	.65
2SA733	.35	2SC620	.45
2SA740	1.85	2SC627	1.35
2SA743A	1.08	2SC632A	.39
2SA747	.49	2SC634A	.45
2SA755	1.32	2SC642A	3.90
2SA765	4.60	2SC681A	2.80
2SA777	.59	2SC696	1.65
2SA794A	.89	2SC710	.37
2SA815	.85	2SC711	.37
2SA816	.55	2SC712	.43
2SA818	.55	2SC717	.37
2SA839	1.75	2SC730	3.95
2SA885	.59	2SC732	.35
2SA913	1.10	2SC733	.35
2SB22	.45	2SC734	.35
2SB54	.35	2SC735	.35
2SB77	.35	2SC738	.38
2SB173	.38	2SC741	3.64
2SB175	.39	2SC756A	2.40
2SB178	.48	2SC773	.55
2SB303	.45	2SC776	2.40

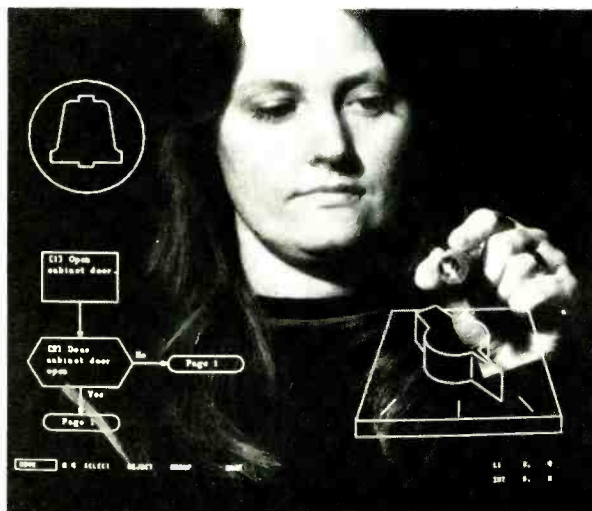
ELECTRONICS WORLD® *News Highlights in Brief*

Magnetic Listening Centers

The Murdock Audio Deck® Listening Center is a vinyl-covered metal plate which can be connected to any audio source and will accommodate as many as 16 headphones. The latter are attached to the deck by magnetic couplers instead of conventional phone plugs. Each coupler remains firmly attached to the deck even if the cord is twisted, but disengages completely if the listener walks away wearing the headset. The Audio Deck Listening Centers are said to be ideal for use by students, including the handicapped. Headphones are available with or without volume control.

Electronic Drafting Device

MAGIC™ is Western Electric's acronym for Machine Aided Graphics for Illustration and Composition and has been designed to enable the rapid construction of line drawings and supportive text for technical docu-



ments. A technical illustrator sits before a 21-inch CRT screen, points a lightpen at it and, working the pushbuttons with one hand and occasionally entering text on a keyboard, produces complex drawings up to 32 inches square in an average time of 30 to 45 minutes. Software for the system is being offered for license to other industries. The total package provides a computer graphics system for preparation, editing, production and storage of line pictorials, diagrams, and technical data.

Two Card Calculators

Casio, Inc. has introduced two new "card" calculators—a Time Card and a Math Card. The former, Model ST-24, is a credit-card size 8-digit calculator with four basic math functions, independent memory system and a perfect seven function percent key. It is also a time-piece, giving the time in hours, minutes and seconds on the 24-hour system. It can be used as a stopwatch in that it records standard as well as lap time. It can be set to

count down to zero and then emit a tone or it can be set as a continuous loop timer. The Model FX-48 Math Card has 32 essential scientific functions in addition to the basic math functions. It includes trigonometrics, parenthesis, logarithms, factorials, square root, powers, power extraction, etc. The ST-24 is 1/8" thick and weighs 2 oz. The FX-48 is 1/4" thick and weighs 1.6 oz. Each retails at a suggested price of \$39.95.

Experimental FM Station Identifier

Tuning to FM stations can be made easier with "Station Programme Identification," a display system developed



by the Philips Research Laboratories, Eindhoven, the Netherlands, in co-operation with the Dutch Broadcasting Corporation. The system would respond to a specially coded signal from the station by displaying the station and program on an alphanumeric readout. Introduction of this new product will depend upon international agreements and on the cooperation of broadcasting authorities.

Ideographic I/O

Until recently, users of the complicated Chinese language and character set could not efficiently use it to communicate with technologically advanced telecommunications and digital computing equipment. The crux of the problem is that the language is not conducive to phonetic classification, as are Western languages, for example. Now, Cable and Wireless Ltd., a British concern, has acquired a patent for an ideographic encoder originally developed by the Chinese Language Project of Cambridge University. This system can code, store, and decode ideographs. It then identifies each by two seven-bit words. A total of 43565 characters is stored on a revolving drum (read by optical sensors) and selected by a cursor, while additional, more rarely used characters are also available, bringing the number of usable characters up to 20,000. Cable and Wireless Ltd. hopes to market the device in commercial form this year.



It may be a hobby, or it may be an asset... It SHOULD be a Heathkit® Computer System

No matter what your computer system needs may be, Heathkit computers make sense! Heathkit "total design" computer systems give you a wide selection of peripherals, software programs to get you up and running fast; plus the reliability, service and responsibility that come from being a leader in the electronics industry for some 50 years!

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Every Heathkit Computer Product is designed to offer substantial benefits over competitive products on the market. Our 8080A-based H8 for example, is more than just a simple 8-bit machine. With its "intelligent" front panel and keyboard entry and digital display, it actually lets you compute and program without the addition of any peripherals. It's an ideal computer training system, and when you're ready to advance, it's ready too. It's one of the most expandable computers around, and now with its NEW floppy disk system, it could be the only computer you'll ever need.

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If you need the power, speed and versatility of a 16-bit machine, there's nothing better than our H11A. Based on the famous DEC LSI-11/2, the H11A provides complete DEC compatibility and access to the thousands of practical software programs and applications that entails. Along with our own complete systems software and our line of DEC-compatible peripherals including the DEC Writer

II and our new floppy disk, you'll have state-of-the-art computing power at its very best!

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The Heathkit Computer peripherals offer the same competitive advantages of our two computers. Our H9 CRT terminal, H10 paper tape reader/punch, ECP-3801 cassette storage recorder/player, and our new WH14 line printer, plus the new floppy disk storage systems all give you the quality, performance and value that Heath company is famous for. And we sell the memory, I/O interfaces and accessories you need to custom design a system to your particular specifications!

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One of the most important parts of ANY computer system is documentation. And Heath documentation is quite simply, the best around. If you buy our computer products in kit form, you get a comprehensive step-by-step assembly manual that takes you every step of the way from unpacking to final plug-in. The knowledge you gain in building your Heathkit computer is invaluable—for service if it's ever needed, for quick troubleshooting and correction, and just for understanding the workings of the machine. In both our kit and fully assembled products, our comprehensive operating and instruction manuals are fully detailed, thorough and accurate. This documentation, plus Heathkit technical consultants and service nationwide, make your Heathkit computer system one you can depend on—to work right the first time, and to last for years!

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We didn't have to make a better 2 track than our RS-1500. So we made a 4 track. Introducing the RS-1506.



Ingenuity is truly rare. Repeated ingenuity is true genius. Like the Technics 4-track RS-1506. It offers twice the program time of our 2-track RS-1500.

It also offers the award-winning RS-1500's "Isolated Loop" tape transport with a quartz-locked, phase-controlled, direct-drive capstan.

By isolating the tape from external influences we minimized tape tension to a constant 80 mgs. Providing extremely stable tape transport and low head wear. While reducing modulation noise and wow and flutter to a point where they are barely measurable on conventional laboratory equipment.

Electronically, too, Technics RS-1506 provides the same level of professional control as its predecessor. A separate microphone amplifier. Mixing amplifier. And separate three-position bias/equalization switches. While IC full-logic function permits absolute freedom in switching modes. Also available is an optional full-feature infrared wireless remote control (RP-070). It lets you operate

all transport functions and record from up to 20 feet.

For the same performance as the RS-1506 with the convenience of auto reverse, there's the RS-1700.

Component specifications. Even with the best 2-track decks TRACK SYSTEM: 4-track, 2-channel recording, playback and erase. 2-track, 2-channel playback 4-head system. **FREQ. RESP.:** 30-30,000Hz, ± 3 dB (-10 dB rec. level) at 15ips. **WOW & FLUTTER:** 0.018% WRMS ± 1 15ips. **S/N RATIO:** 57dB (NAB weighted) at 15ips. **SEPARATION:** Greater than 50dB. **RISE TIME:** 0.7 secs. **SPEED DEVIATION:** $\pm 0.1\%$ with 1.0 or 1.5mil tape at 15ips. **SPEED FLUCT.:** 0.05% with 1.0 or 1.5mil tape at 15ips. **PITCH CONTROL:** $\pm 6\%$.

Technics 4-track RS-1506 and auto-reverse RS-1700. A rare combination of audio technology. A new standard of audio excellence.

Technics
Professional Series

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