Radio-Electronics

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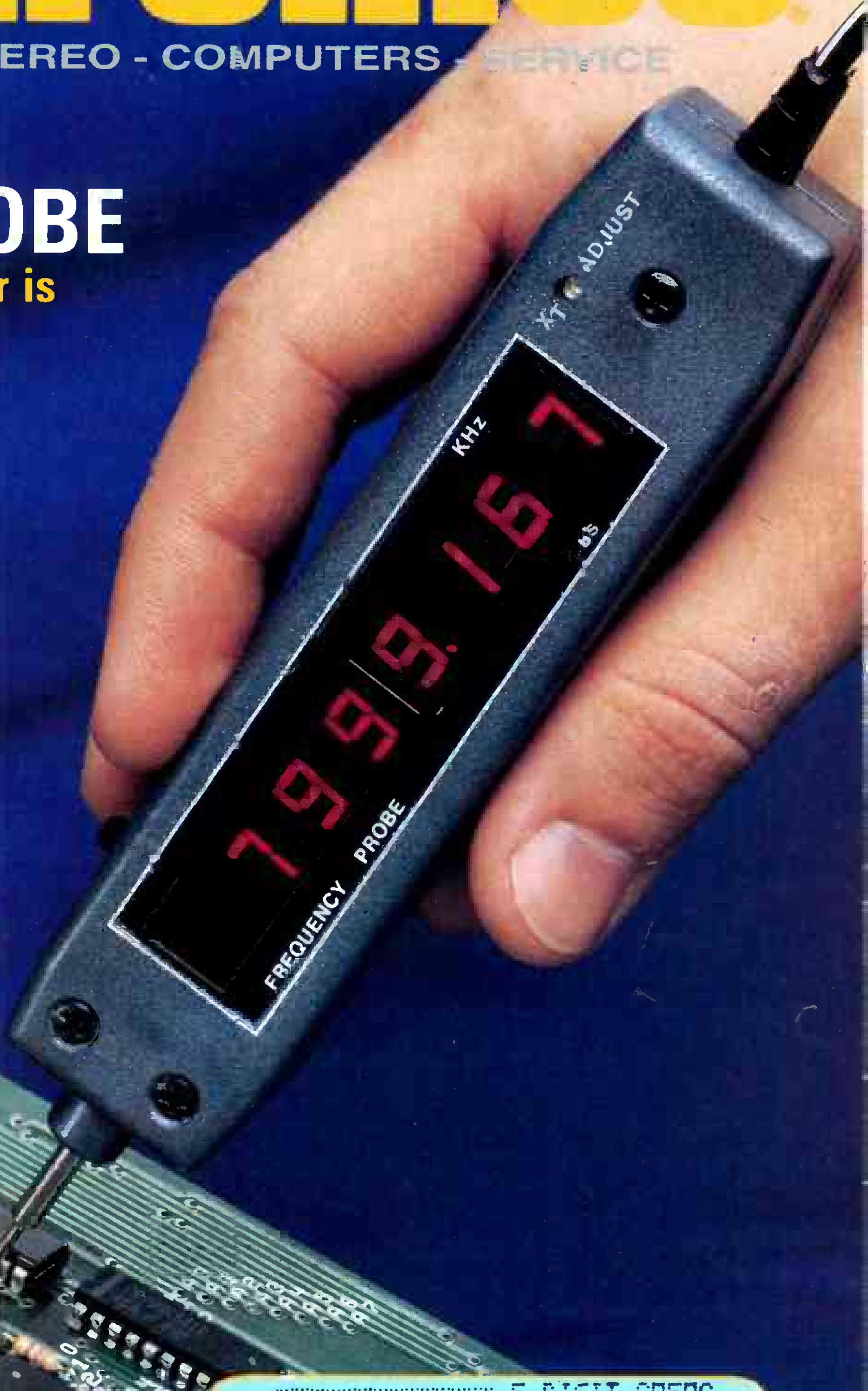
FEBRUARY 1990

TECHNOLOGY - VIDEO - STEREO - COMPUTERS - SERVICE



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FLUKE

February 1990 Radio-Electronics®

Vol. 61 No. 2

BUILD THIS

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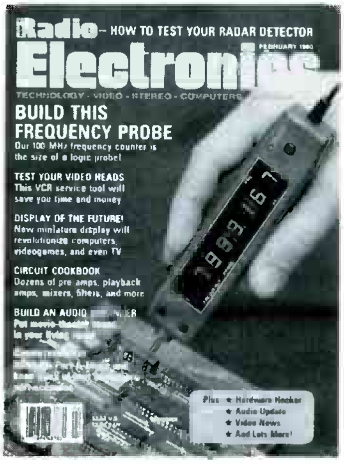
DEPARTMENTS

PAGE 75

PAGE 43

AND MORE

ON THE COVER



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POSTMASTER: Please send address changes to RADIO-ELECTRONICS, Subscription Dept., Box 55115, Boulder, CO 80321-5115.

Radio-Electronics

Radio-Electronics is indexed in *Applied Science & Technology Index* and *Readers Guide to Periodical Literature*.
Microfilm & Microfiche editions are available. Contact circulation department for details.

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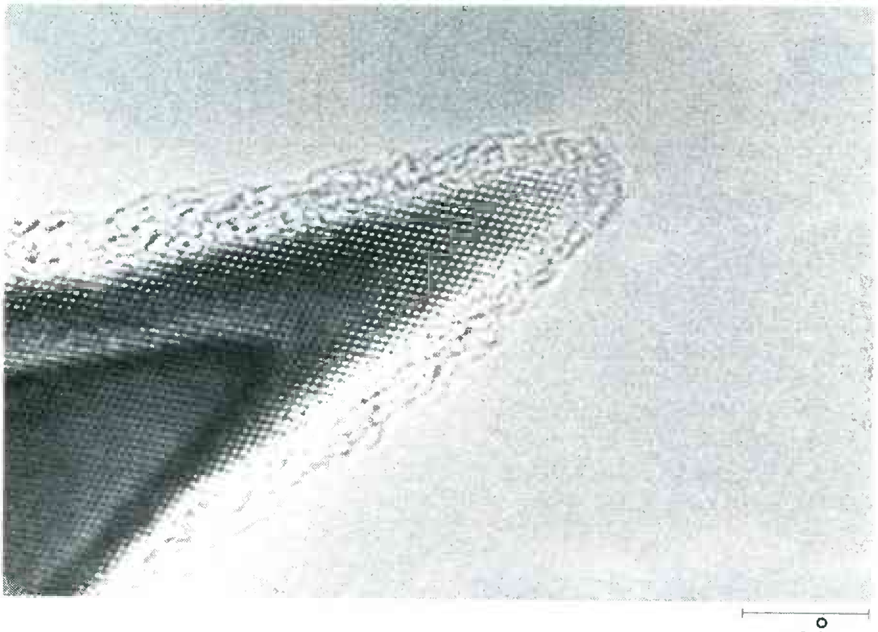
WHAT'S NEWS

Tubes making a comeback?



THIS TRANSMISSION ELECTRON MICROGRAPH of a silicon needle shows a radius of curvature of less than 10 angstroms—the distance of only a few atoms. The closely spaced lines are the 111 planes of the silicon atoms, spaced 3.13-angstroms apart.

Scientists at Bellcore (Middletown Township, NJ)—collaborating with scientists from the New Jersey Institute of Technology, the University of California at Davis, and Lawrence Livermore National Laboratory in California—have created a silicon needle whose tip is 50,000 times smaller than the diameter of a human hair. Only the width of a few atoms at its tip, the needle could play a vital role in the resurgence of vacuum tubes, serving as an electron emitter.

The new vacuum tubes are quite different from their predecessors. Today's tubes are so small that they can only be seen through a microscope, and electrons are produced in them by applying voltage to a very sharp tip, rather than using a hot filament. While the new vacuum-tube technology is still in its infancy, it could nevertheless offer several advantages over transistors. Electrons can be made to travel much faster in a vacuum tube than in a solid-state transistor, permitting faster speeds for data transmission. Vacuum tubes are also much less susceptible to temperature changes and various types of radiation, so they might be more suitable for use in hostile environments such as those that are found in outer space and nuclear reactors.

The problem facing researchers has been to create an emitter tip sharp enough to produce many electrons at low voltage. Until now, the sharpest tips were between 20 to 40 nanometers wide. By applying an oxidation-treatment process to tiny silicon cones, the research team has developed tips that are less than 1-nanometer wide. (A human hair is 50,000-nm wide; the diameter of an atom is about three tenths of a nanometer.) The microscopic silicon tips can produce substantially more electrons while using less voltage. Besides vacuum-tube applications, the needles could be used for examining atoms with scanning tunneling microscopes and as biological probes for medical research.

Diamond-film technology

A new diamond-film-coating process created by Professor Rointan Bunshah, Dr. Chandra Despandey, and colleagues at UCLA's School of Engineering and Applied Science offers key advantages over the deposition methods that are currently in use.

The new technique removes obstacles that have limited the applications of diamond-film technology—particularly the inability to deposit high-quality, smooth, transparent, and non-faceted diamond films. Called *P*lasma-*A*ssisted *P*hysical *V*apor *D*eposition (*PAPVD*), the process involves using an electron beam to evaporate graphite to form carbon vapors. The vapors are introduced into a gas-plasma that contains hydrogen. When the material to be coated is held in the gas plasma, the resulting reaction deposits a diamond film on the material's surface that has all of the required attributes. The process is also done at lower temperatures — 350°C, as compared to 850–1000°C.

The PAPVD process opens up a broad range of novel industrial applications, including protection of high-cost infrared and UV optical components, heat sinks for high-power and microwave devices, diaphragms for high-fidelity loudspeakers, and very-high-speed microelectronic devices that can operate at temperatures much higher than current silicon and gallium-arsenide devices. R-E

VIDEO NEWS

DAVID LACHENBRUCH,
CONTRIBUTING EDITOR

• **New VCR sources.** Not long ago, all VCR's sold in the United States came from Japan. With the increasing costs of Japanese production and the tough competition that is forcing prices down in the U.S., an increasingly large proportion of VCR's are now coming from other Far-Eastern countries. In the first seven months of 1989, more than 30% of all VCR's imported into this country came from sources other than Japan. Major source countries were Thailand (mostly Emerson recorders produced there by Orion, a Japanese manufacturer), Malaysia (made by a JVC subsidiary there), and Singapore. How about the U.S.? A few VCR's are being assembled here from Japanese parts—by Matsushita (Panasonic) in Vancouver, WA; by Hitachi in California; and by Toshiba in Tennessee.

In the same period, the major sources for imported color-TV sets were—in order of quantities—Mexico, Taiwan, Korea, Malaysia, Singapore, and mainland China. Japan came in seventh, followed by Hong Kong and Canada. Where did the U.S. rank as a source of color TV sets sold here? Despite what you might have read elsewhere, it was number one—ahead of all other countries.

• **New names in video.** Two well-known audio names are entering the video field—neither of them for the first time. Aiwa, which was a pioneer in Beta VCR's but has been out of the field for several years, is now moving back with VHS recorders. Aiwa, owned by Sony, will concentrate on high-end, four-head models. The company is also surveying the TV market, but has decided to stay out for the time being because of the tough price competition in that field.

Sansui, however, plans to jump into the television-receiver as well as the VCR field with both feet. The venerable producer of high-end audio products had fallen on hard times, but recently received a fresh transfusion of capital from the British firm, Polly Peck International, which is acquiring 51% of Sansui stock in an extremely rare instance of a western firm acquiring control of a major Japanese company. Polly Peck, which produces consumer-electronics equipment in the Far East and Turkey, plans to manufacture both TV sets and VCR's for sale under the Sansui label. Also in the works are Sansui-brand fax machines. Sansui once fielded VCR's without much success.

• **Movies on VHS-C?** One of the top priorities of JVC, inventor of VHS recording, is lengthening the recording time of the miniature VHS-C (for "compact") cassette to two hours. To date, the recording time in the SLP mode on the longest playing VHS-C cassette is 90 minutes—not quite enough for today's long-winded movies. JVC obviously is concerned about the inroads of the 8mm Video Walkman, developed by Sony, which is extremely compact and can accommodate full-length movies with carry-along portability. There are two Video Walkman models, both with LCD color screens. The VHS-C format is doing well in Japan and Europe, particularly for camcorders, but in the U.S. it is lagging behind 8mm. In addition to a longer-playing cassette, another high priority for JVC is the development of a VCR that can play both VHS and VHS-C cassettes without an adaptor. Prototypes of those so-called "F/C" (*F*ull-size/*C*ompact) recorders have been shown and JVC hopes to have them on the market late this year or early in 1991.

• **SAP is rising.** In 1984, when the FCC approved *M*ultichannel *T*V *S*ound (MTS), the breakthrough involved more than stereophonic audio. In addition to stereo sound, each TV station was authorized to transmit a *S*econdary *A*udio *P*rogram (SAP). Although a few stations have transmitted bilingual sound, SAP has not been widely utilized. PBS's flagship station, WNET, New York, is aiming at virtually full-time SAP some time this year. Its first major use of SAP was for descriptive commentary for the blind accompanying the musical, "Show Boat." WNET also is planning to add a Spanish translation of the "MacNeil-Lehrer News Hour," and might even present the BBC World Service from shortwave transmissions—as well as music, book readings, and even countdowns for videotaping—all on its extra audio channel. Out of about 550 TV stations with MTS capability, approximately 100 are equipped to transmit a SAP channel. **R-E**

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BINARY TO DIGITAL READOUT

I'm looking for a circuit to convert 8-bit binary into a digital readout. The solution is probably very simple and I'm just overlooking it. I'd be grateful if you could point me in the right direction.— H. Vaughn, Mt. Airy, NC.

The easiest way is to use an EPROM to translate binary to decimal. Think of the address pins as inputs and use the data outputs to drive a 7-segment display. Entering the binary number could be done via DIP switches, and the decimal equivalent would immediately appear on the display. Although that'd involve programming an EPROM, doing that is much easier now since most computer clubs, parts suppliers, and even some computer shops offer it as a service. The cost for such a service is minimal.

The circuit you'd have to set up is something like that in Fig. 1. The parts count is minimal, and it could be built using any construction method. Since each EPROM output controls a display segment, the best way to create the EPROM code is to use a chart like that in Fig. 2. If you're using a common-cathode display, as shown in Fig. 1, a high will light the segment, and a low will turn it off. Common-anode displays work just the opposite. That subject was covered in considerable detail in recent issues of "Drawing Board," so you should look them up.

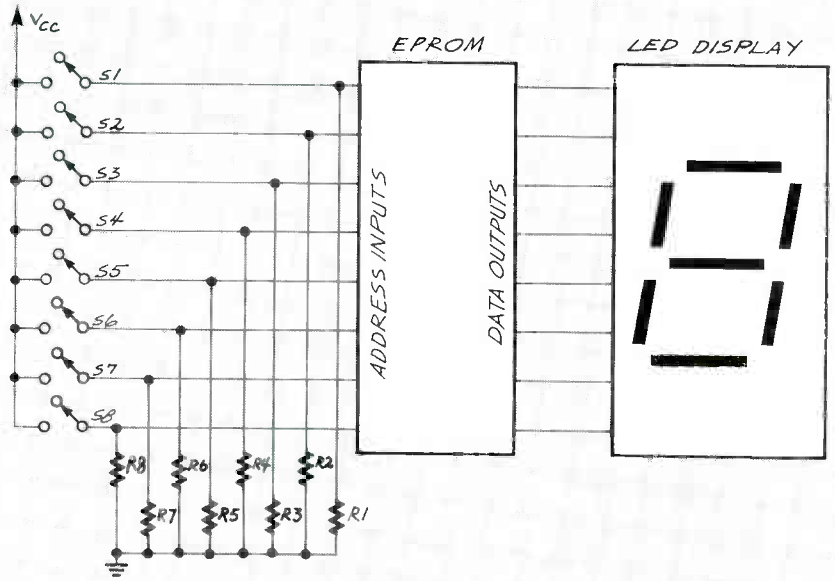

FIG. 1

DOS ON A MOTHERBOARD

I have an XT clone with a spare socket next to the one containing the BIOS EPROM. I've noticed that some manufacturers are building boards that have IBMIO.COM, IBMDOS.COM and COMMAND.COM burnt into EPROM's on the motherboard. That lets the computer boot DOS immediately without loading from a disk. I'd like to do the same using the empty socket on my motherboard, but I haven't been able to get any information. Any ideas?—T. Dunn, No. Miami Beach, FL.

Several, but first some observations. I've never seen the ads you mentioned and, although I don't doubt you've seen them, I'd take them with a grain of salt. You're right in assuming that those three ROM files would give you a permanent DOS, but there are some things you're probably overlooking.

IBM DOS (and IBMIO.COM and IBMDOS.COM which are part of PC-DOS) is owned exclusively by IBM. People sell it, but I've never heard of it being licensed for use in a PROM. IBM is very quick to jump on copyright infringement. MS-DOS is the version that's licensed to various manufacturers. The history of DOS and the reasons behind the two versions are interesting, but both are proprietary. Be careful that what you're buying is legal before you whip out your credit card.

If it's legal, and you want to do the same thing yourself, you need some information on your motherboard's EPROM sockets. Although there's a wide variety of XT clone boards around (a gross

EPROM TRUTH TABLE											
INPUTS		OUTPUTS									
BINARY DATA	HEX DATA	D7 DP	D6 'G'	D5 'F'	D4 'E'	D3 'D'	D2 'C'	D1 'B'	D0 'A'	HEX DATA	LED'S LIT
0000	0	0	0	1	1	1	1	1	1	3F	0
0001	1	0	0	0	0	0	1	1	0	06	1
0010	2	0	1	0	1	1	0	1	1	5B	2
0011	3	0	1	0	0	1	1	1	1	03	3

FIG. 2

understatement), most have empty socket space to let them copy IBM's PC and XT motherboards.

The IBM boards had a stripped-down BASIC in ROM on the motherboard. When you bought DOS (you did buy it, I hope), you got a file called BASICA.EXE. That BASIC wasn't the complete language; it was an overlay that enhanced the ROM version, that could only be run if you already had the more primitive half on the motherboard. Since clone makers want to produce clones, putting empty sockets on the motherboard was as close as they could legally get.

Real IBM's have five 64K ROM's on the motherboard, one for BIOS, and four for BASIC0. Given that, you can assume that the empty socket on your motherboard is mapped to the same address range occupied by BASIC0 on the real IBM boards, or F6000h–FDFFFh. Since you only have one empty socket on you board, I'd guess that it was designed for a 27256 EPROM. That'd let one chip hold the same amount of code as the four 64K PROM's on the IBM board. That is just an educated guess, but a pretty good one. The BIOS, of course, is mapped from FE000h–FFFFFh.

Unless your motherboard is radically different than those I've seen, its EPROM space is limited to 32K bytes (the addresses for BASIC0), and the 8K bytes used by BIOS, or a total of 40K to play around with. Since DOS usually takes up at least 60K for DOS 2X, and 80K for DOS 3X, it'd take mirrors and a lot of heavy equipment to squeeze both DOS and the BIOS into the available address space. But wait, there's more bad news.

DOS was designed for a particular place in memory, inside the 640K memory space. The EPROM space on your motherboard is way outside that, so you'd probably be faced with having to rewrite the DOS code (jumps, destinations, and any absolute address references). You could do that, but assuming you overcame those obstacles, you'd have a pretty strange version of DOS, and upgrading to a new version would be a Herculean task. The basic conclusion is, that you'll probably be better of if you boot DOS like the rest of us. **R-E**

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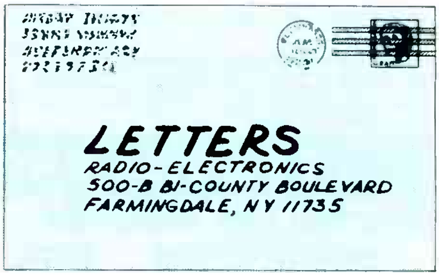
LETTERS



DIGI-COMPASS PARTS

I've heard from a number of "Digi-Compass" builders (**Radio-Electronics**, November 1989) that the TLC-548 ADC IC is impossible to find. It has been discontinued by Radio Shack, although it's possible that some stores may have still have a few available (part #276-1796, $6.95).

As a special service to **Radio-Electronics** readers, I will supply the part for $6.95. Those who don't want to download the software file can also purchase that from me, for $6.00. (That might be cheaper than downloading the 100K file at 1200 baud from the RE BBS.) It will be supplied on a 360K PC data floppy diskette.

To order, please send a check or money order only (California residents add 6.5% sales tax) plus $1.75 shipping and handling to Digital Products Company, c/o Thomas E. Black, 134 Windstar Circle, Folsom, CA 95630. This offer is subject to change and is valid for a short time only.

Thanks for publishing my article. I'm thrilled that it has stirred up some interest.
THOMAS E. BLACK
Folsom, CA

PCjr PROBLEMS

As a long-time reader of **Radio-Electronics**, I'd like to say thanks. Over the years I have literally taught myself how to design, build, program, and implement my own single-board computers from the articles and information you have presented. I have used what I learned to advance my career from a simple warehouseman to an operational research technician—and I'll be going back to school shortly to obtain the piece of paper that says I know what I know I know. It was your magazine and the interesting projects and theories that your staff brings to attention that stirred my interest and helped improve my life. I owe you a great deal.

Now, after all this time, I need to ask for some personal assistance from your readers and staff:

I recently fell into a tremendous piece of luck, and purchased an IBM PCjr (Peanut) for $30.00 at a garage sale. I've decided to use this machine for a dedicated process control in real time. Does anyone know where I can obtain any documentation for hard wiring my own interface boards for its very limited expansion slots, or where I can get a pin-out designation for same? I contacted IBM and, after finally finding someone who even remembered the IBM PCjr, was disappointed to find that IBM no longer has anything to do with any attachments or peripherals. It seems that IBM has virtually disowned the product.

Thanks again for all your help.
SHAWN D. BOBBITT
403 Green Street, #1
Martinez, CA 94553

UP TO DATE

I was amused with Michael Catudal's letter (**Radio-Eelctronics**, December 1989), chastising the magazine for not keeping up with "new technology."

In late 1995, the Galileo Probe will start its descent to a moon of Neptune. What will control its last 45 seconds before it is crushed by atmospheric pressure? Why, the venerable RCA 1802 microprocessor, of course. Remember the old "Cosmac Elf"?

As I recall, **Radio-Electronics** had a construction project on that in the 1970's!! I wonder if the project manager thought the designer was nuts when he saw the 1802 in the design. I think not.

Keep up the good work.

JOHN CONNELLY
Naperville, IL

BELATED THANKS

I just want to show my appreciation for the article and BASIC program, "Coping With Coils," that appeared in the November 1988 issue of **Radio-Electronics**. When I first got that issue, I didn't really look at the story, since I wasn't in need of any coils. Recently, however, I had to calculate coil sizes for several inductances, and I happened to remember seeing the program. I used it on my PC, and it worked much better than I expected—particularly in that it lets you select various wire and form sizes to determine the best arrangement.

Another thing I discovered from using the program was that there is a mathematical correlation between AWS wire gauges and equivalent inch diameter. I always thought that gauge sizes were just arbitrary. It's one of the most useful programs I've ever worked with.

J.F. BURTON
Downers Grove, IL

PC BOARD RECIPE

I would like to share the results of my experiments with re-flow solder plating of homemade printed-circuit boards with other **Radio-Electronics** readers. After the board is etched, but before drilling, the resist can be removed with a little paint stripper, and the copper can be cleaned with a mixture of vinegar and salt.

Solder can be smeared onto the PC board with a hot iron with a wide tip. Use a minimum of solder. At this point, the board looks ugly; the solder now needs to be reflowed to provide a uniform solder surface.

A hot bath of peanut oil (available at the supermarket) can facilitate the reflow process. I have found that heating the peanut oil slowly with the PC board supported above the surface of the pan with standoffs works well. If the board rests on the bottom surface of the pan it will de-laminate the fiberglass. I placed a piece of solder into the oil to determine when the temperature is high enough to reflow the solder; using a thermometer should work even better. The board can then be removed with tongs and wiped with a rag to remove the excess solder. It can then be dipped again to provide a shiny surface. It can be cleaned with some kind of grease-cutting cleaner (like Era, liquid Tide, or Freon TF) to remove the oily film.

That method will surely benefit those experimenting with surface-mount technology. I've tried electroless tin plating, but after building circuits on reflow-soldered boards I'll never go back to unplated copper or tin-plated copper again.

RON DOZIER
Wilmington, DE

NO MORE FRIED BATTERIES

For those of you who have numerous handheld transceivers—and, therefore, numerous batteries—here's an idea for a battery-charger shutoff that I have used for some time. Obtain the "garden-variety" light-timer from any drugstore, market, or junkbox. Remove the cam that turns the timer ON, leaving only the OFF cam intact. Plug the battery charger into the timer and set the timer to the appropriate time (8 hours or whatever). Then plug the timer in an AC outlet, turn the timer on manually, and forget it. The timer will turn it off but not on—thus, you won't have to deal with those fried batteries anymore.

DON R. SMITH, K6CHS
Palm Springs, CA

AMATEUR VIDEO CONTEST

The *Western Washington Amateur Television Society* (*WWATS*) and *Amateur Television Quarterly* (*ATVQ*) are sponsoring a contest for licensed amateur-radio operators. To enter, you must submit by March 1, 1990 a video tape about ham radio that you make on your home video equipment (VHS, Beta, or 8mm). It can be about any aspect of ham radio, and can be a documentary, educational, technical, or entertainment film. It must be less than 15 minutes in length and be made using only consumer-grade equipment. All licensed amateur-radio operators (except members and families of members of WWATS and ATVQ and publishers and staff of ham-radio magazines) are eligible to win some fantastic prizes including an *ICOM IC 1275* 1.2-GHz transceiver and an *AEA FS430* ATV transceiver.

Entry forms and complete rules and regulations for the contest can be obtained by writing to the address below.

WWATS/ATVQ VIDEO CONTEST
353 South 116th Street
Seattle, WA 98168 **R-E**

EQUIPMENT REPORTS

Sony CRF-V21 Visual World-Band Receiver

The first of a new breed of communications receivers.

CIRCLE 25 ON FREE INFORMATION CARD

IF WE ASKED THE READERS OF THIS MAGazine what features they would want in a communications receiver, we'd probably get a long and greatly varied list. At the top of the list would be frequency coverage from below the standard broadcast band up through 30 MHz, followed by the ability to receive AM and SSB signals. Undoubtedly, extensive memory and scanning features would be a popular request as well.

We doubt, however, if many people would request the ability to decode RTTY (*R*adio *T*ele*TY*pe) and radio facsimile. Although those features are desired, they're not expected on a communications receiver. Well, Sony Corporation (Sony Drive, Park Ridge, NJ 07656) apparently ignored standard expectations when building their *CRF-V21*. They've packed so many features in the receiver that it's likely to become the new standard against which all other communications receivers are judged.

```
XXXXX 221748Z
FICN5 CWIS 221500
ICE CONDITIONS AND FORECAST FOR THE WESTERN ARCTIC
ISSUED AT 1500 UTC SATURDAY 22 JULY 1989 BY
ENVIRONMENT CANADA ICE CENTRE OTTAWA

ICE EDGE ESTIMATED FROM THE COAST NEAR HERSCHELL ISLAN
D TO 6920N
13800W TO 6940N 13735W TO 7040N 13600W TO CAPE BATHURS
T. MOSTLY
OPEN TO VERY OPEN DRIFT INSIDE THE ICE EDGE SOUTH OF 7
ON.
THE SOUTHERN EDGE OBNLXALD ICE LIES ABOUT 50 MILES OFF
 THE
TUK PENINSULA AND ABOUT 80 MILES OFF THE ALASKA COAST
AS FAR WEST
AS BARTER ISLANG
HONNTHORWVINEPINCREASES TO ABOUT 100 MILES
NORTH OF BARROW.
```

FIG. 1

Basic specifications

The *CRF-V21* receives long-, medium-, and shortwave broadcasts from 9 kHz through 30 MHz; FM broadcasts from 76 through 108 MHz; satellite frequencies of 137.62 and 141.12 MHz; and, assuming an optional dish is used, 1.691 and 1.6945 GHz. Audio-detection modes include AM wide, AM narrow, wideband FM, narrowband FM, USB, and LSB. The *CRF-V21* can also decode and print RTTY, radio fax, and satellite fax broadcasts.

While most people are familiar with what is available on the standard broadcast and shortwave broadcast bands, RTTY and radio fax is a mystery to most—most of us know only the sounds that such transmissions make. The ability to decode fax and RTTY adds another dimension to monitoring and DXing. Figures 1–3 give a good feel for the types of activity that exists on the airwaves.

Figure 1 is a partial printout of a broadcast from Environment Canada that lists ice conditions for the western Arctic. Figure 2 is a transmission from the Naval Eastern Oceanography Center in Norfolk, Virginia that shows wave heights in the Atlantic. Figure 3 is a satellite image from GOES, the *G*eostationary *O*rbiting *E*nvironmental *S*atellite. While that is the sort of image that the satellite capability makes possible, we received the image as it was rebroadcast from Norfolk. We did not have the opportunity to give the satellite capability a workout. All the images here were received using Sony's active telescopic antenna, which is supplied as standard equipment with the receiver. Satellite reception requires the optional AN-P1200 satellite dish.

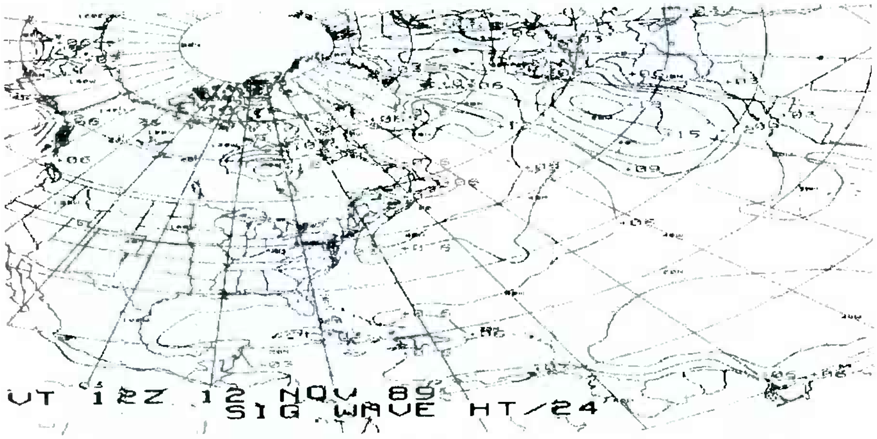


FIG. 2

Microprocessor power

The *CRF-V21* offers a host of features that its microprocessor control makes possible. For example, up to 50 "pages" of memory can be stored. Each page can hold

FIG. 3

up to seven stations, for a total of 350 stations. An identification tag can also be stored along with each page. We found that feature especially useful for finding the best frequency for a given time. For example, in one page, we programmed seven different frequencies on which the BBC broadcast. By calling up our "BBC" page, we found that we were able to easily switch between the seven entries to find the best possible reception conditions.

On another page, we stored some stations we happened across on the 25-meter band. Rather than listen and log the transmission times, we decided to let the receiver do the work for us. Using simple menu-chosen commands, we instructed the receiver to monitor the frequencies on that memory page for a 12-hour period. A printout of the activity is shown in Fig. 4. It shows rather clearly that there is a five-hour period where little activity takes place. While any active shortwave listener knows when the 25-meter band is active, that particular feature is invaluable when you're trying to determine the broadcast times and signal strength of, for example, a news bureau's wire service transmissions.

Of course, most SWL's would never be content in letting the receiver find stations to listen to. But even as you hunt around the bands finding new stations, the *CRF-V21* has ways to make the task of logging easier. A single push of a button will feed all of the display information to the built-in high-resolution printer. A sample printout, which also serves to illustrate the amount of information that the receiver's huge LCD read-

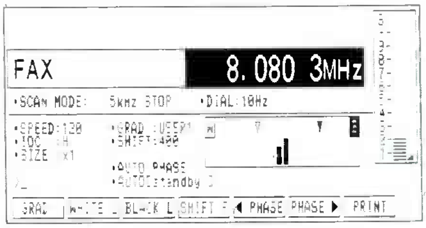


FIG. 4

out supplies, is shown in Fig. 5.

The receiver offers three scanning modes. First, it's possible to scan through the entire frequency range of the receiver. The receiver has enough "smarts" to change

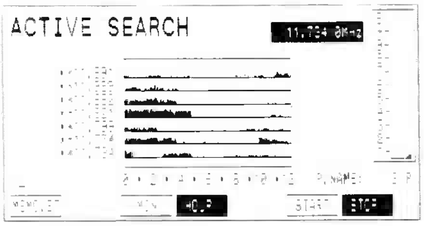


FIG. 5

the scanning steps and reception mode based on the frequency. For example, in the range between 88 and 108 MHz, the receiver would automatically set the reception mode to wideband FM, and the step frequency to 50 kHz. (It is possible to override any of the presets.) The second scanning mode allows the user to select the upper and lower limits between which scanning will take place. The third scanning mode scans only those stations stored in memory.

As if those scanning modes aren't adequate, Sony adds yet another way to search for broadcasting stations: a spectrum analyzer. Any part of the receiver's frequency coverage can be examined in spans of 200 kHz, 1 MHz, or 5 MHz. Fig. 6 shows a display of the activity of a 200-kHz segment in the 25-meter band. It is also possible to use a pointer to tune into only those stations that are strong enough to guarantee good recep-

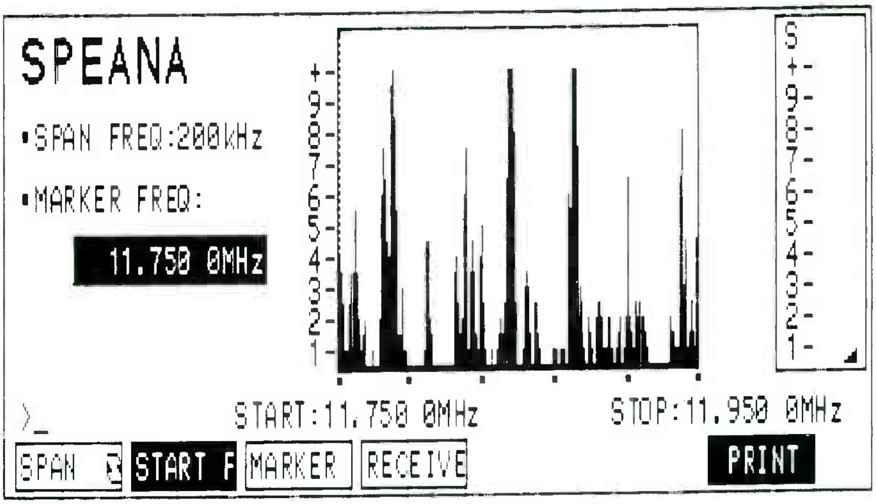


FIG. 6

tion. To those of us who take noise, interference, and fading as a necessary consequence of shortwave listening, the ability to bypass inter-station static and to stop at only clear, strong broadcasts is almost eerie.

We had a lot of fun examining Sony's *CRF-V21*. This review only touched the surface of the receiver's capabilities. For example, we've mentioned only a handful of the receiver's 7 knobs, 10 jacks, and 59 pushbuttons (many of which serve several different functions). If not for the $6000 price tag, we'd buy one tomorrow.

Despite the price, we expect that there is a market for this innovative receiver. The most enthusiastic shortwave enthusiasts will want one, as will, perhaps, government and embassy personnel, and navigators. R-E

NEW PRODUCTS

VIDEO/ALL-CHANNEL GENERATOR. Providing more than 80 test patterns, *Leader Instruments'* model *408* gen-lockable NTSC Video Test Signal Generator outputs in composite, S-VHS, RGB, Y, R-Y, and B-Y formats with RF channel coverage of all broadcast and cable channels. A sampling of those test patterns includes multiburst, video sweep, SMPTE color bars, modulated and unmodulated staircase, convergence, and crosshatch.

A menu-driven, multi-purpose data-control panel with LCD is used to set up channel frequencies and video signal-level specifications. On-screen programming makes the *408* easy to use. Control of key video-signal levels—such as burst, sync, luminance, chrominance, and setup—is provided, along with RF-frequency selection. As many as 100 sets of video-level specifications can be stored in memory, ready for instant recall.

CIRCLE 10 ON FREE INFORMATION CARD

The model *408* multi-format video/all-channel generator costs $3,395.00.—**Leader Instruments Corporation**, 380 Oser Avenue, Hauppauge, NY 11788; Tel. 1-800-645-5104 (in NY, 516-231-6900).

DIGITAL PANEL METER. A battery-powered, 3½-digit panel meter, the *DP-176S* from *Acculex*, offers true single-ended (built-in negative rail generator) input and very wide primary-power operation—from +3.5 to +7.5 volts DC at only 145 mA. That extremely low power drain allows up to 8000 hours—one year—of continuous operation from any battery source in that range. The meter can also be used for mobile, portable, and other applications using a 12-volt DC automotive-type battery with voltage divider. It is easy to mount, requiring only a small screwdriver; an optional bezel kit is available.

The *DP-176S* uses a highly accurate, dual-slope-integrating ADC in conjunction with a single-ended input, an integral DC-to-DC converter, and common-mode rejection ratio of 85 dB. It can be configured for analog inputs from ±200 mV through ± 200 volts DC. The enhanced-contrast LCD has user-selectable decimal-point placement, external-reference capability for ratiometric measurements, and an all-digits test pin for checking full functionality. Other features include automatic polarity changeover, over- and under-range indication, 100-megohms input impedance, and an input-offset adjustment.

CIRCLE 11 ON FREE INFORMATION CARD

The *DP-176S* digital panel meter costs $64.00; the optional bezel kit (*B-1B*) costs $3.00.—**Acculex**, A Metra-Byte Company, 440 Myles Standish Blvd., Taunton, MA 02780.

RADIO VCO'S *Z-Communications' D-900 Series* of 700- to 1000-MHz Voltage-Controlled Ocillators (VCO's), based upon coaxial resonator technology, are designed for use in cellular phones and for commercial and military radio applications, where low noise and high stability are required. The series has exceptional phase-noise characteristics of −95dBc/Hz at 1 kHz, −105dBc/Hz at 5 kHz, and −120 dBc/Hz at 25 kHz. The VCO's tune ±20 MHz from the user-specified center frequency. A modulation port has sensitivity of 0.3 to 0.9 RMS ±10% flatness, and maximum modulation distortion of 3%, for audio-modulation rates of 50 Hz to 5 kHz. The *D-900's* have buffered outputs of +3 ±2 dBm and operate off 8- or 12-volts DC at 25 and 40 mA, respectively. The completely enclosed VCO's have a standard operating-temperature range of 0 to 70° C. They are also available with an extended military temperature range of 55 to 105° C.

CIRCLE 12 ON FREE INFORMATION CARD

Sample units of the *D-900* each cost $85.00.—**Z-Communications Inc.**, 5450 NW 33rd Avenue, Ft. Lauderdale, FL 33309.

AC CURRENT METER. Designed for use by hobbyists as well as electricians, servicemen, and technicians,

CIRCLE 13 ON FREE INFORMATION CARD

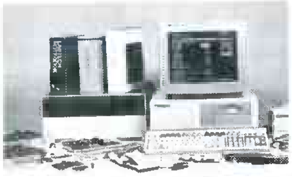
Elenco's ST-1010 AC current meter is reliable and completely portable. It measures AC current up to 1000 amperes, and has nine functions: AC and DC volts, resistance, AC current, diode test, data hold, peak hold, audible continuity, and insulation test (with an optional 500-volt insulation-tester unit. The hand-held instrument features a 3½-digit LCD readout, a wrist strap, and a carrying case. It runs for 150–200 hours on a standard 9-volt battery.

The *ST-1010* AC current meter costs $99.00.—**Elenco Electronics, Inc.**, 150 West Carpenter Avenue, Wheeling, IL 60090.

DATA-ACQUISITION SYSTEM. *Hewlett-Packard's HP 75000 System 10* is a data-acquisition package that requires no programming to collect data and obtain results. All the necessary measurement hardware and menu-driven software to attach to a personal computer are included in the system. For a total solution, a PC/printer option is available that provides the user with an *HP Vectra* PC and an *HP QuietJet* printer.

System 10's hardware includes a 5½-digit multimeter and a thermocouple-relay multiplexer for accurate temperature measurements on as many as 16 thermocouples. Two other multiplexers are also included, providing more than 100 channels of high-accuracy measurements. Two counters are available: a 4-channel counter measures counts, frequency, period, pulse width, interval, and up/down counts on signals up to 4 MHz and a 3-channel counter measures those same functions (except up/down) to 1 GHz. A 4-channel digital/analog device allows users to output either voltage or current on each channel. A built-in quad 8-bit digital I/O card allows the system to control devices and sense whether they are on or off. An *HP 75000* B-size cardcage contains five empty slots that can be used with a variety of other plug-in measurement cards. Additional cards can be factory installed if they are ordered at the same time as the system.

LABTECH NOTEBOOK data-acquisition software is used. The flexible, menu-driven package allows users



CIRCLE 14 ON FREE INFORMATION CARD

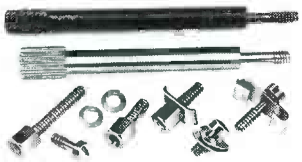
to set up multiple-scan lists that can be scheduled to begin at user-determined times and executed at user-determined rates. The display can be customized, and data can be stored in various formats. An on-line learning aid is included. Color graphics screens show the user how to attach transducers to the *System 10* and how to create setups on LABTECH NOTEBOOK. The software contains both Fast Fourier Transform and curve-fit analysis routines, and a seamless link to Lotus 1-2-3 is provided if you wish to do custom analysis and data sorting.

The *HP 75000 System 10* costs $5,750.00, and the PC/printer option costs an additional $4,650.00.—**Hewlett-Packard Company**, Inquiries, 19310 Pruneridge Avenue, Cupertino, CA 95014; Tel. 1-800-752-0900.

COMPUTER/CONNECTOR HARDWARE. Collections of computer and connector hardware—consisting of turnable jack screws, "D" subminiature jack screws, and captive screws—are offered by *Keystone Electronics*. The *Turnable Jack Screw* selections, primarily used to secure computer connections, are available in a variety of configurations and are supplied with or without screwdriver slots. The turnable jack screws have knurled heads and are available in lengths from 1.75 to 4.5 inches with 4–40 threaded lengths, and in 0.125- to 0.250-inch diameters. They are made of steel with a choice of black zinc-plate, yellow chromate, or nickel-plate finishes.

The *"D" Subminiature Jack Screws* include 0.250-, 0.312-, and 0.625-inch lengths, and are made of zinc-plated, gold-irridite steel that meets military standards. The devices are packaged both in bulk and in kits, and are complete with flat washers, lock washers, and nuts.

The *Captive Screw* set comes with "U" clips, sad-



CIRCLE 15 ON FREE INFORMATION CARD

dle washers, and bow-tie retaining clips, in a variety of lengths and sizes. The captive screw group is also made of zinc-plated steel with gold irridite.

The Computer/Connector hardware collections range in price from $6.00 per hundred to $11.00 per hundred, depending upon the quantity ordered.—**Keystone Electronics Corp.**, 31-07 20th Road, Astoria, NY 11105-2017.

SCOPE PROBE. Specially designed for durability and interference-free performance, *TPI's SP150* 150-MHz scope probe features risetime faster than 1.5 nanoseconds. Its design eliminates external interference and cable microphonics. The probe is sealed against moisture to withstand 95% humidity at 40°C. Specially designed strain relief and connector crimp more than triple the cable life of previous designs. The *SP150's* switch has self-cleaning contacts for longer life, and its ground lead is replaceable.

The model *SP150* scope probe costs $40.00.—**Test**

CIRCLE 16 ON FREE INFORMATION CARD

Probes Inc., 9178 Brown Deer Road, San Diego, CA 92121; Tel. 1-800-643-8382.

DIGITAL MULTIMETERS. The *Soar 3200 Series DMM's* (models *3210, 3220,* and *3230*) combine the features of a state-of-the-art digital multimeter with an analog bar-graph display. The 3½-digit 3200-count display provides high resolution, and the 32-segment bar-graph display is well-suited for reading that change—peaking, nulling, and observing trends. All of the meter's functions are selected with an 8-position rotary switch and test; the meter automatically selects the range with the greatest accuracy and resolution. The function and measurement range are displayed on the LCD.

Models *3220* and *3230* have a RANGE button that pre-

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vents the instrument from changing ranges, which saves time for repetitive go-no-go checks. Those two models each have an audible continuity feature that sounds a "beep" when the circuit under test is closed. When the DATA-H button on the model *3230* is pressed, the meter captures the measurement, beeps, and locks it on the display. All models come with test leads, manual, batteries, fuse, and a 3-year warranty.

The models *3210, 3220,* and *3230* digital multimeters are each very affordably priced under $100.00.—**HMC**, P.O. Box 526, Canton, MA 02021.

NEW LIT

ELECTRONIC-/COMPUTER-PARTS. Geared to the needs of manufacturers, engineers, and researchers, as well as hobbyists, students, and computer buffs, the *American Design Components* catalog features components such as IC's, crystals, connectors, switches, batteries, LED's, semiconductors, and power supplies. It also features computer-related products including disc drives, monitors, add-on boards, and complete computers. The 36-page, fully illustrated catalog is free.—**American Design Components**, 815 Fairview Avenue, Fairview, NJ 07022; 800-776-3700.

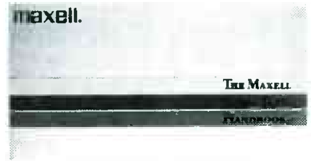
CIRCLE 21 ON FREE INFORMATION CARD

TOOLS AND TEST EQUIPMENT. The *1989 Supplement* to *Contact East's General Catalog* includes a wide range of top brand-name products for testing, repairing, and assembling all types of electronic equipment. The 47-page, full-color booklet describes all products in full detail with specifications, photos, and prices. The products come with an "iron-clad" guarantee, and are shipped under Contact East's "same-day shipment" policy to ensure fast delivery.

CIRCLE 22 ON FREE INFORMATION CARD

The *1989 Supplement* is free.—**Contact East**, 335 Willow Street South, North Andover, MA 01845; 508-682-2000.

VIDEO-TAPE TIPS. Providing answers to many of the questions that video enthusiasts are likely to have when they begin using camcorders, *The Maxell Video Tape Handbook* is filled with information on selecting tapes, producing videos that people will enjoy watching, and caring for video hardware. It explains the different types of video tapes available and how to choose the right one. The booklet offers helpful hints on achieving interesting, high-quality videos using advanced "plot" planning, effective lighting, and how to use different lenses. Simple maintenance procedures to prolong the life of video tapes and equipment are also included, along with a handy glossary of camcorder terminology.



CIRCLE 23 ON FREE INFORMATION CARD

The Maxell Video Tape Handbook is free upon request; send a self-addressed, stamped, legal-size envelope with $.75 postage.—**Maxell Video Guide Offer**, P.O. Box 4623, Monticello, MN 55365-4623.

AUDIO UPDATE

Progress in hi-fi hearing-aid design.

LARRY KLEIN,
AUDIO EDITOR

IT IS AN UNFORTUNATE FACT OF LIFE that weaknesses and disabilities begin to appear and multiply as we get older. Or as someone once said, "Time marches on—and leaves its heelprints on our bodies." Particularly troubling to those of us involved, professionally or otherwise, in audio pursuits is the gradual impairment of our hearing. In general, it takes three main forms: (1) an overall loss of sensitivity, which means that most sounds have to be louder to be heard at a satisfactory level, (2) a loss of relative high-frequency sensitivity, and (3) a loss of dynamic range, which audiologists refer to as "recruitment." (A persistent ringing in the ears called tinnitus is also a major hearing problem, but the present state of our knowledge and technology doesn't seem to offer much hope to its sufferers.)

As we get older, we frequently have problems in all three areas. For example, if you need to have the sound of your bedroom TV turned up slightly higher than your wife's preferred setting, then problem (1) is at work. If records or tapes that once bothered you because they had too much background hiss sound relatively hiss-free these days, problem (2) is the probable cause. (Assuming, that is, that you haven't upgraded to quieter audio equipment.) An early warning of problem (3) is an increased sensitivity to—and annoyance with—loud noises produced by motorcycles, lawnmowers, subway screeching, politicians, and so forth. Its proverbial manifestation is the old lady who demands that you speak up because she can't hear you—and then complains that you are shouting at her when you do.

Obviously, the main emphasis in hearing-aid design has always been to restore or enhance speech intelligibility. That is certainly a laudable goal, but anyone with a hearing loss who was interested in listening to music through an aid was inevitably left frustrated by distortions in the input and output transducers and inadequacies in signal bandwidth, noise, overload, and so forth.

Hi-fi hearing aid

With that once-over-lightly discussion as background, let's look at a hi-fi hearing-aid design approach used by the Swiss authors of a recent Audio Engineering Society paper ("High Fidelity Multiband Hearing Aid," Preprint 2793 B-4).

Oddly enough, the authors list as their first design objective the widening of frequency bandwidth downward to around 40 Hz. That strikes me as strange given the relative lack of music fundamentals down there and the fact that few people complain about—or are even aware of—the almost universal lack of 40-Hz capabilities in their home speaker systems. The author's choice of low-end cutoff frequency may have been influenced by the fact that their test subject for the aid design was a professional violoncello player.

The next step involved evaluating the "equal-loudness contours" of the potential hearing-aid user. In other words, at each level, how much gain had to be applied to equivalent strength frequencies for each to be heard as equivalently loud? When you think about it, it becomes obvious that the key to enhancing the audio quality of a hearing aid is to tailor its response to the specific needs of the user. Merely adding amplification as was done in the earliest aids simply results in ear overload at some frequencies and inadequate boost at others.

Today's conventional aids are all frequency-contoured to conform to the user's specific needs, but the hi-fi aid designers went a step further: They split the right- and left-ear channels each into three bands (40–400 Hz, 400 Hz–4 kHz, 4–8 kHz), each band having its own adjustable compression ratios and levels. The compression ratios can be adjusted from 1:1 (no compression) to 4:1 for each of the six bands. In addition, each channel has its own external Baxandall bass and treble tone controls and level controls to allow user adjustment of the aid's response within the basic parameters set by the internal calibrations.

Standard miniature input and output transducers were, of course, not up to the requirements of the hi-fi aid. The authors chose a somewhat bulky electrodynamic omnidirectional microphone (which feeds both channels) over the smaller, but noisier, electret type. Conventional sealed electrodynamic headphones intended for high-quality Walkman use served nicely as output transducers. Since, according to its picture, the prototype hi-fi aid and its phones could easily be mistaken for a Walkman, I expect that anyone wearing it to a live event will receive some strange glances from other concertgoers.

The digital future

As might be supposed, digital redesign is high on the agenda for hearing-aid design. In general, digitalization offers little for low-gain, straight-forward aids meant to correct minor hearing deficits. But when the demands are for multiple wide bandwidth, compressible channels, and simplified, but precise, tailoring to the specific needs of the user, then digital comes into its own. Although there was no attempt to incorporate digital circuitry in the hi-fi aid, the designers stated strongly that digital technology should ultimately be introduced into the equalization and compression stages. Altering the parameters of their existing prototype analog aid is a laborious and delicate task that digitalization will vastly simplify.

At least one U.S. company (Maico Hearing Instruments 612/832-4400) makes a "digital hybrid" aid whose parameters are programmable over a wide range. The manufacturer claims the availability of a million and a half settings, any of which can be stored by a built-in digital memory programmed by an external computer. That enables fairly rapid and precise conformation to the hearing needs of the user—and simplified readjustment as those needs change over time. Another U.S. company (Nicolet Instruments 800/843-1055) is the first company to have available a fully digital unit, but details were not available at press time.

It seems safe to say that in the next year or two we should see the introduction of a variety of fully digital aids. That implies that there's an A/D converter after the input microphone and fully digital signal processing from that point on. For those who can afford such devices—and I expect them to be very expensive—the sound that they deliver will be a cut above what is presently available. But no one ever said that good hi-fi equipment comes cheap!

System imbalance

Q. After a long struggle to find the reason for my having to operate the balance control on my preamplifier at the 3-o'clock position, I traced the difficulty to my speakers rather than my amplifier or preamp. It turned out that a readjustment of the midrange control on one of my speakers cured the problem. What would account for that?

A. The frequencies that contribute to the ear's perception of "loudness" are mostly in the midrange. (You can confirm that for yourself by noting the small effect on the overall loudness of music produced by boosting or cutting the highs and lows with the outermost sliders of a ten-band graphic equalizer.) Hence, any control intended to boost or cut the midfrequencies in a speaker system will also necessarily influence its relative "efficiency." R-E

U.S. Postal Service
STATEMENT OF OWNERSHIP, MANAGEMENT AND CIRCULATION

1A. TITLE OF PUBLICATION: RADIO-ELECTRONICS
1B. PUBLICATION NO.: 0 0 3 3 7 8 6 2
2. DATE OF FILING: 9/28/89
3. FREQUENCY OF ISSUE: MONTHLY
3A. NO. OF ISSUES PUBLISHED ANNUALLY: 12
3B. ANNUAL SUBSCRIPTION PRICE: $17.97
4. COMPLETE MAILING ADDRESS OF KNOWN OFFICE OF PUBLICATION: 500-B BI-COUNTY BLVD. FARMINGDALE, NY 11735
5. COMPLETE MAILING ADDRESS OF THE HEADQUARTERS OF GENERAL BUSINESS OFFICES OF THE PUBLISHER: 500-B BI-COUNTY BLVD. FARMINGDALE, NY 11735
6. FULL NAMES AND COMPLETE MAILING ADDRESS OF PUBLISHER, EDITOR, AND MANAGING EDITOR
PUBLISHER (Name and Complete Mailing Address): LARRY STECKLER 500-B BI-COUNTY BLVD. FARMINGDALE, NY 11735
EDITOR (Name and Complete Mailing Address): BRIAN FENTON 500-B BI-COUNTY BLVD. FARMINGDALE, NY 11735
MANAGING EDITOR (Name and Complete Mailing Address):

7. OWNER

FULL NAME	COMPLETE MAILING ADDRESS
GERNSBACK PUBLICATIONS, INC.	500-B BI-COUNTY BLVD. FARMINGDALE, NY
LAWRENCE STECKLER	500-B BI-COUNTY BLVD. FARMINGDALE, NY

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2. Mail Subscription (Paid and/or requested)	147,811	144,218
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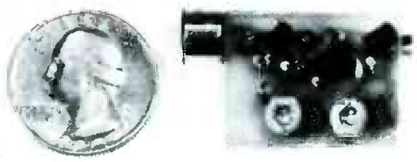
Radio-Electronics mini-ADS



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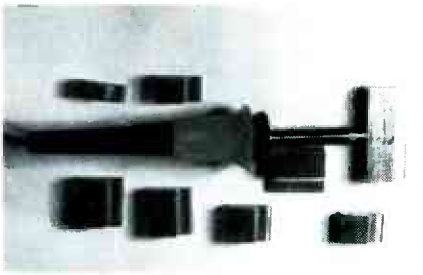

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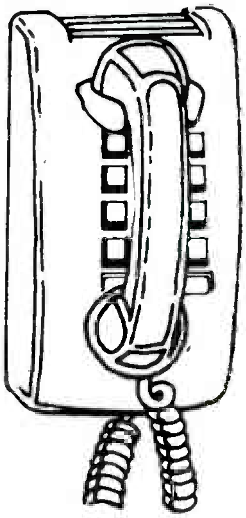

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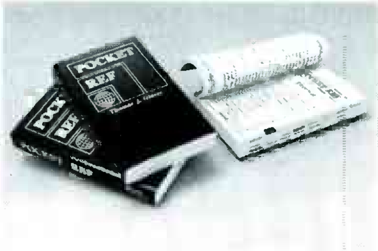

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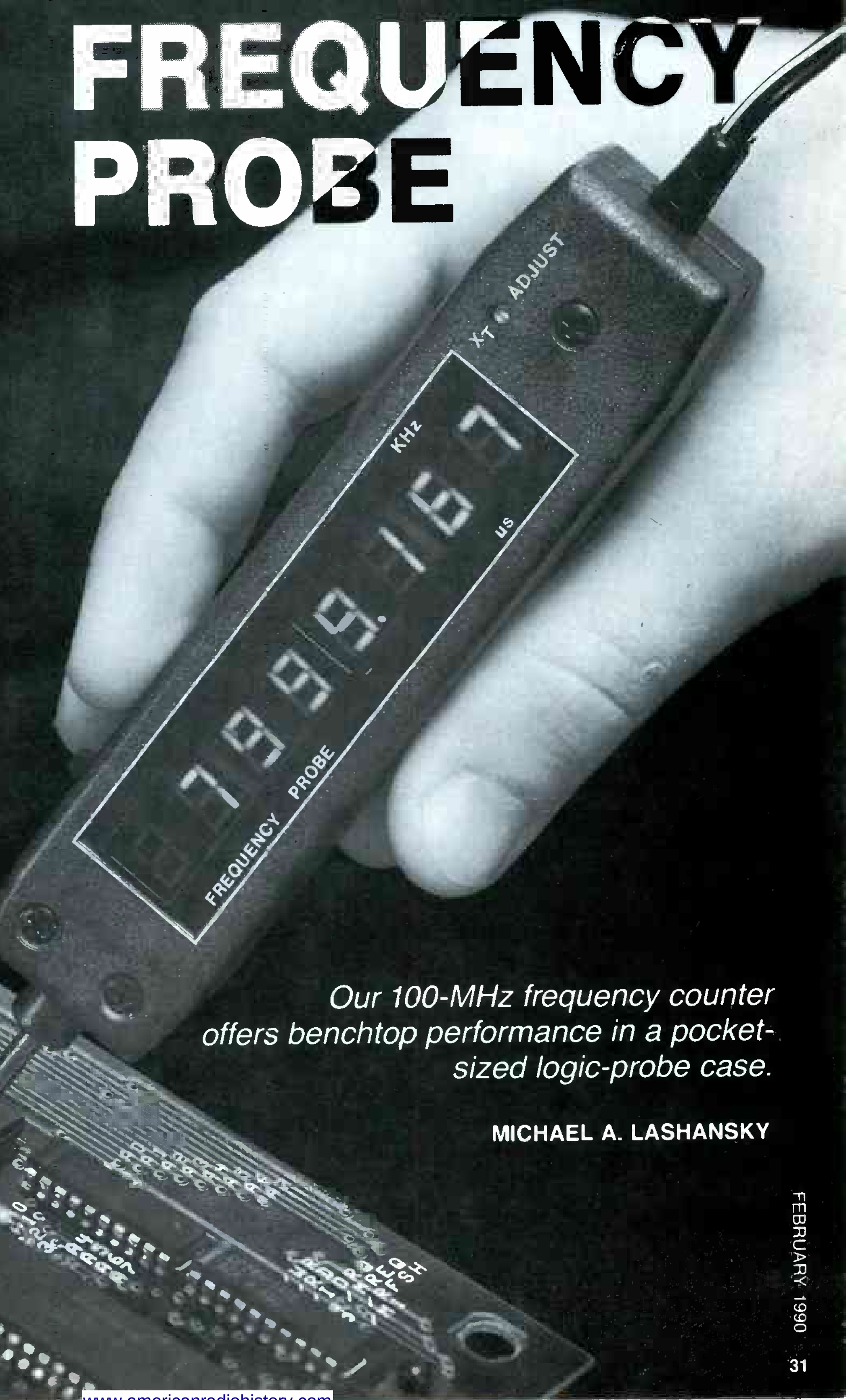
BUILD THIS

100 MHz FREQUENCY PROBE

TEST EQUIPMENT HAS SURE COME A long way since the days of the bulky analog meter. The newest generation of portable test gear boasts features that would make technicians of a decade ago green with envy. Single instruments can measure everything; voltage, resistance, capacitance, logic levels and even frequency. In fact, an entire test bench of equipment can now be packed away in a shirt pocket, and carried easily to the source of the trouble.

As good as those new meters are, they still have a few limitations that can be rather disconcerting at times. Frequency measurement is a good example: the highest range on most portable DMM-sized instruments is usually less than 1 MHz, and the 3-½–4-½ digit LED displays on most meters don't offer much resolution. It seems as if most manufacturers add frequency measurement as an afterthought. As newer designs hit the market, those shortcomings will improve. But why wait? You can build the frequency probe described here. It offers benchtop performance at a fraction of what you'd expect to pay.

The frequency probe is a unique combination of a logic probe and an 8-digit, 100-MHz frequency counter. It uses only three IC's,



Our 100-MHz frequency counter offers benchtop performance in a pocket-sized logic-probe case.

MICHAEL A. LASHANSKY

TABLE 1—FREQUENCY PROBE SPECIFICATIONS

Parameter	Waveform Type	Condition	Performance (*)	
			Frequency	Period
Measurement Range	Any	Unmodified PC Board, XTAL1 is 1 MHz	00000.000—99999.999 X 1 kHz, 10-s gate	00000.500—99999.999 X 1 μs, 10-s gate
		Modified PC Board (see text), XTAL1 is 1 MHz	000000.00—099999.99 X 1 kHz, 1-s gate	000000.50—099999.99 X 10 μs, 1-s gate
		Unmodified PC Board, XTAL1 is MHz	00000.000—0999.999 X 10 kHz, 1-s gate	00000.500—99999.999 X 10 μs, 1-s gate
		Modified PC Board (see text), XTAL1 is 10 MHz	000000.00—009999.99 X 10 kHz, 0.1-s gate	000000.50—099999.99 X 1μs, 0.1-s gate
Input Sensitivity	Sinusoid	N/A	35 mV p-p	
	Square	N/A	50 mV p-p	
Maximum Period	Any	N/A	2 MHz	
Logic High	Any	N/A	3 VDC	
Logic Low	Any	N/A	1.8 VDC	
Supply Voltage	Any	N/A	4.5–15 VDC	
Maximum Current	Any	N/A	190 mA DC	
Input Impedance	Any	n/A	51 ohms	

(*) NOTE: All leading zeros are suppressed during normal operation of the frequency probe for both frequency and period measurement, and are reproduced here merely for illustration.

and fits in a standard logic-probe case, modified for the purposes of the 8-digit LED display. Table 1 lists the probe's specifications. It features switchable AC/DC coupling and both frequency- and period-measurement capability. The builder of the probe can modify the useful frequency range by selecting a different crystal, and can also modify the gate time (or sampling time) by making a simple PC-board modification. The effects of the modifications are summarized in Table 1, and we'll discuss how they're made shortly.

The probe can be powered either by the circuit-under-test, or by connecting its leads to +9-volts DC. Building the probe isn't difficult, but it requires care and patience, because the components are very tightly packed.

Circuit operation

Figure 1 shows the block diagram of the frequency probe. The input can be AC- or DC-coupled to the divide-by-10 prescaler, whose output is fed to the main counter section and the LED display block. That counts the prescaler pulses, and includes the necessary logic for the 8-digit LED display. The logic block indicates with LED1 and LED2 which coupling mode is in use, and indicates logic levels.

The frequency-probe schematic is shown in Fig. 2. S1 either DC-couples the input through R1, or AC-couples it through C1. The center pole of S1 goes to the clock-pulse input (CP) of IC1, a National Semiconductor 11C90 prescaler. The 11C90 is an ECL divide-by-10 prescaler, uses +5 volts, has TTL-output, and operates over a DC–650 MHz bandwidth with only an RF-bypass capacitor on V_{CC}. Input sensitivity for AC-coupling is 350 mV p-p from DC–100 MHz, and 250 mV p-p above 100 MHz. The frequency response of the 11C90 is shown in Fig. 3, but that's the guaranteed minimum, and actual performance can exceed it substantially. S2 is located between the frequency counter and the LED display, and selects between the frequency- and period-measurement modes.

Triggering is simplified in IC1 by connecting the reference terminal (pin 15) to clock pulse (pin 16). By doing so, the probe input is automatically centered about the input threshold. A 50% duty cycle gives the fastest operation, and since the flip-flops are master-slaves with offset input thresholds, there are no minimum frequency restrictions. That ensures that the circuit will operate with inputs with very slow rise and fall times. The 11C90 can divide-by-10 or -11 depending on the levels on pins 1 and 2 (M1 and M2). A logic low on those pins places the divider into divide-by-11 mode, while tying them high produces divide-by-10 mode. IC1 is enabled by tying pin 1 (CHIP ENABLE) and pin 14 (ASYNC MASTER SET) low.

There are two V_{EE} terminals (pins 12 and 13). The TTL output operates from the same V_{CC} and V_{EE} levels as the counter, but a separate pin is used for the TTL V_{EE}. That minimizes noise coupling when the TTL-output switches, and reduces power consumption by leaving pin 12 open when the ECL outputs are used. Because the IC operates linearly with the transistors always on, the current drawn can go up to 80 mA, with 35 mA typical. Thus, the IC's run pretty warm, but heat-sinking isn't needed.

The TTL-output of IC1 is pulled up to CMOS levels by R6 and connected to the clock input of IC2, an ICM7216B frequency counter. The 7216B has gating, timebase, latching, decoding, and 8-digit LED display-driver circuitry. In addition, the 7216B measures period, frequency ratios (f_A/f_B), time intervals, or total

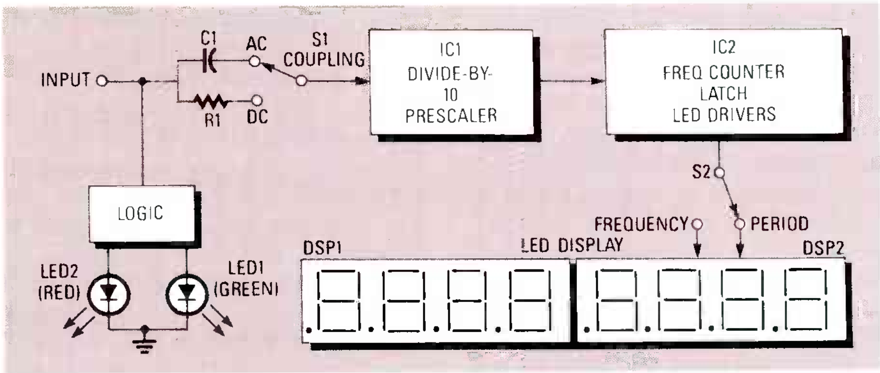


FIG. 1—FREQUENCY PROBE BLOCK DIAGRAM; the input is either AC- or DC-coupled to the divide-by-10 prescaler (IC1) then sent on to the counting (IC2) and LED display (DSP1 and DSP2) blocks.

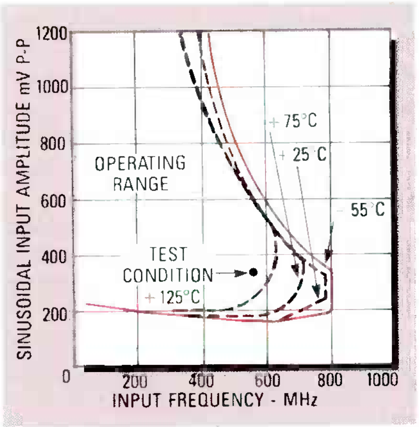


FIG. 3—SENSITIVITY OF IC1 AS A FUNCTION of sinusoidal input amplitude in mV p-p vs. frequency, for –55°C, 25°C, 75°C, and 125°C.

counts. Due to limited space, only the frequency and period functions were used.

The 7216B has a 10-MHz crystal timebase, and accepts inputs up to 10-MHz, which are divided internally by 10^5. Inputs are gated with that clock for a period determined by the RANGE INPUT (pin 14) setting, and passed to the main counter. The RANGE INPUT automatically adjusts the LED display decimal place, and allows longer gate periods for lower frequency inputs. When prescalers like IC1 are used, XTAL1 should be scaled accordingly. Thus, the input was divided-by-10 using IC1 and a 1-MHz crystal. That multiplies the internal gate time by 10 (from the original range times), allowing 100-MHz measurements with 1-Hz resolution.

Also, the 7216B has 10-ms, 100-ms, 1-s, and 10-s gate times. Selection of the gate time and decimal-point location is achieved by connecting the range input (pin 14) through R10 to digit-driver terminals D1–D4 (pins 4–7). The digit-drivers are time-multiplexed with the range, control, external decimal point, and func-

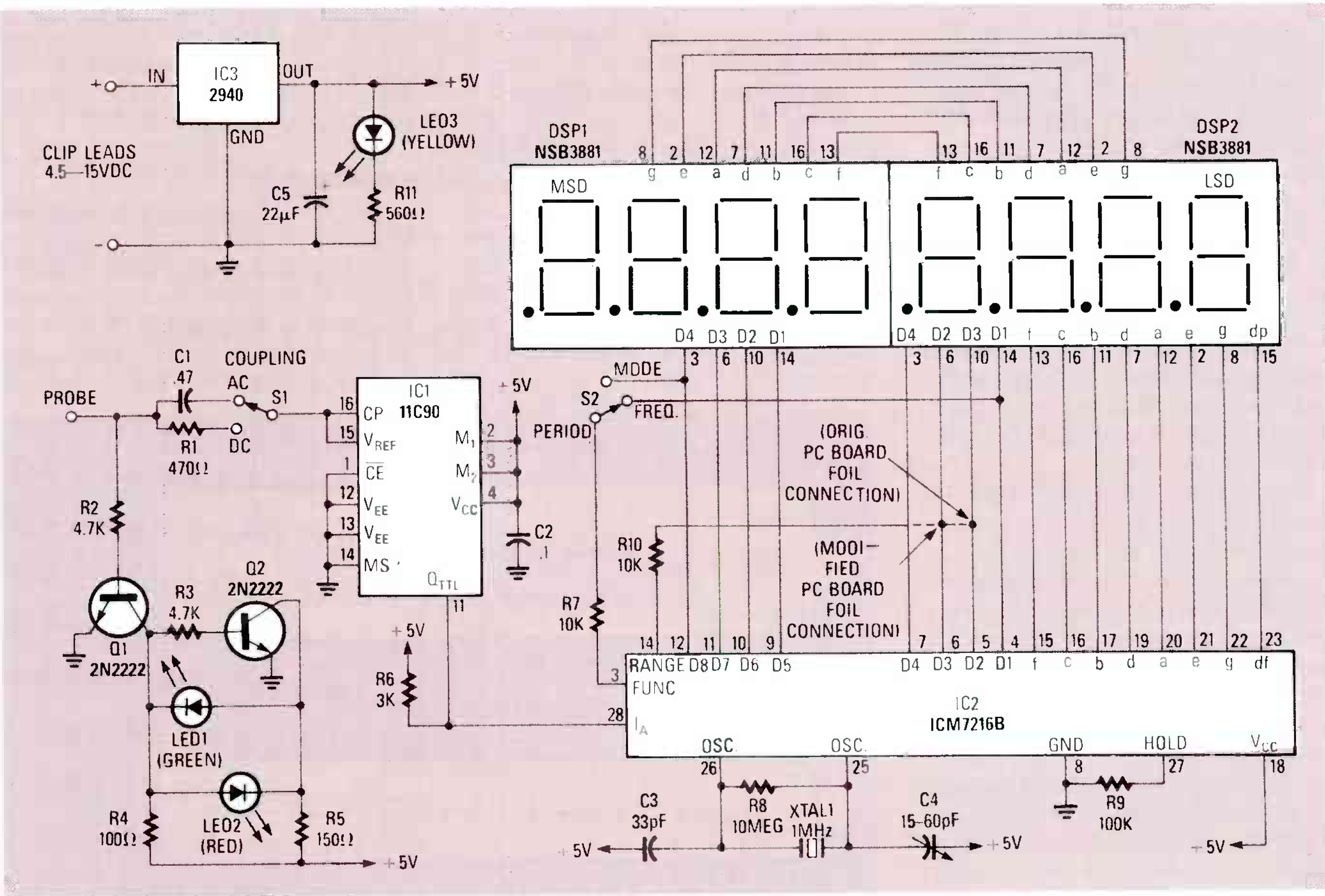


FIG. 2—SCHEMATIC DIAGRAM FOR THE FREQUENCY PROBE. Note the dotted line connecting R10 with pins 5 or 6 of IC2; that variable connection controls the decimal point and total count appearing on DSP1 and DSP2. The relative intensities and durations of ON/OFF time for LED1 (green) and LED2 (red) give a rough indication of logic level and duty cycle.

tion selects to save on pin count. The range was fixed at 1 s, or 100 counts of the 10-Hz reference counter (100 Hz/10). That gave a 10-s gate time, which is inconvenient at times, but necessary for 1-Hz resolution from DC–100 MHz, without using space-grabbing range-select switches.

To achieve a 1-s gate, you can either modify the PC board by connecting the RANGE input (pin 14) to D2 (pin 6), or you can use a 10-MHz crystal. If you modify the PC board, the decimal place shifts one digit right (XXXX-XX.XX instead of XXXXX.XXX), and the least-significant digit means 10 Hz, not 1 Hz. The interpretation of the display remains as multiples of 1 kHz, but the absolute range of the probe increases from 10 MHz to 100 MHz. To do that, cut the foil on the component side from pin 5 of IC2, and solder a jumper from the foil side to pin 6.

If you change the crystal frequency, the decimal place stays unchanged (XXXXX.XXX before and after); the LED display value reads in multiples of 10 kHz instead of 1 kHz. A 1-MHz crystal provides a 10-s gate, and a 10-MHz crystal provides a 1-s gate. The longer the gate, the more accurate the measurement, but the measurement itself will take longer. If you use a 10-s gate, the probe might slip off a connector or IC pin before the 10 seconds are up.

The best of both worlds would be to go with a 10-MHz crystal, because you'll save some money ($2.00 for 10-MHz vs. $12.00 for 1-MHz), and you'll also be able to take quicker, easier measurements. After all, a 10-s gate isn't that much more accurate than a 1-s gate, as to warrant the additional cost (see Table 1).

The 7216B crystal goes between pins 25 (OSC IN) and 26 (OSC OUT) in parallel with R8. Pin 26 goes to V_{CC} through C3; use a nonpolarized (NPO) version to minimize frequency drift due to temperature. Trimmer C4 on pin 5 lets the user adjust the oscillator output to 1 MHz for maximum accuracy. S2 selects the counter operating mode (FREQUENCY or PERIOD). The pole of S2 is connected through R7 to the FUNCTION INPUT (pin 3) of IC2. In the PERIOD position, S2 goes to D8 (pin 12), so IC2 is in period counting mode. In FREQUENCY position, S2 is connected to D1 (pin 4). Also, R7 and R8 prevent false triggering due to AC-coupled signals from the multiplexed digit drivers, which is a problem at higher multiplex frequencies.

Next, DSP1 and DSP2 are each 4-digit, common-cathode, multiplexed LED displays with the segment anodes wired together to form a single LED display. Each digit has a separate cathode which is sourced by IC2. Current-limiting resistors aren't needed with NSB3881 LED displays, but if a high-efficiency LED display is substituted, use 40-ohm resistors on the segment drivers. The LED display multiplex rate is directly related to the crystal frequency. For a 10-MHz crystal, the multiplex rate of the LED display is 500 Hz; the 1-MHz crystal yielded a 50-Hz rate. As was shown in Fig. 2, pin 28 (HOLD) is grounded through R9, which pulls pin 28 low, and allows the internal counter contents to be displayed after each measurement cycle.

Power is supplied by IC3, a National Semiconductor 2940 low-voltage dropout +5-volt regulator. Ordinary voltage regulators need an input voltage at least 2 volts above the desired output. The 2940, however, needs only an additional 500 mV, so if you put in 5 volts you're guaranteed 4.5 volts out. That's a must for the frequency probe, since it's supposed to operate from 4.5–15 volt supplies. IC1 and IC2 need from 4.5–6 volts maximum, so some voltage regulation is needed. That's not a problem if you attach the power leads to 12 volts, but the probe may be rendered useless when measuring 5-volt signals, because the output of a +5-volt regulator with a 5-volt input will be a maximum of 3 volts.

The 2940 is, however, noisy, and needs a filter capacitor, sometimes on each side. The output capacitor (C3) takes up considerable PC-board space. The level-indicating circuit composed of Q1, Q2, R2–R5, LED1, and LED2, is a easy way to indicate logic levels and the position of S1. The probe tip goes to the base of Q1 through R2, and when brought low or allowed to float, Q1 is cutoff and Q2 conducts, since the base is positive with regard to the emitter. With Q2 conducting, LED1 should light. Touching the probe to a logic high makes Q1 and Q2 complement states (Q1 conducting and Q2 cutoff), and LED2 should light.

That feature indicates the position of S1 since, in DC-coupled mode, the reference voltage of IC1 is coupled through R1 and R2 to the base of Q1. That's about 3 volts (a logic high), so LED2 should light. In AC-coupled mode, no DC voltage from IC1 is passed to the base of Q1, and it's allowed to float (a logic low), so LED1 lights. That's a useful way of visually checking the coupling mode with no signal applied. When a low frequency is applied, LED1 and LED2 should light, and a rough idea of duty cycle, whether high or low, can be made by inspection.

Construction

You should use the PC board in the kit (see the parts list), because it's double-sided with plated-through holes. If you wish to etch your own, foil patterns are given in PC Service. Before soldering the PC board, use a metal file along the edges to get it to

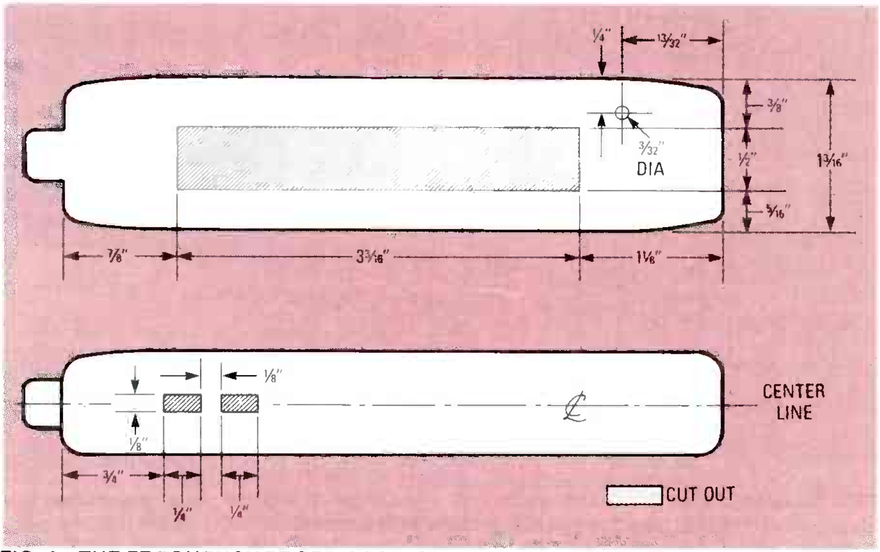


FIG. 4—THE FREQUENCY PROBE CASE. Cutout dimensions for DSP1, DSP2, and C4 are shown in (*a*). Cutout dimensions for S1 and S2 are shown in (*b*).

PARTS LIST

All resistors are ⅛-watt, 5%, unless otherwise indicated.
R1—470 ohms, ¼-watt
R2, R3—4700 ohms
R4—100 ohms, ¼-watt
R5—150 ohms, ¼-watt
R6—3000 ohms
R7, R10—10,000 ohms
R8—10 Megohms, ¼-watt
R9—100,000 ohms
R11—560 ohms, ¼-watt

Capacitors
C1—0.47 µF, ceramic
C2—0.1 µF, ceramic
C3—33 pF, nonpolarized (NPO) ceramic
C4—15–60 pF trimmer (Active Components # 17016)
C5—22 µF, tantulum

Semiconductors
IC1—11C90 National Semiconductor 650-MHz, divide-by-10 prescaler
IC2—ICM7216B Intersil 8-digit, frequency counter/timer
IC3—2940 National Semiconductor +5-volt regulator
Q1, Q2—2N2222 NPN transistor
DSP1, DSP2—NSB3881 National Semiconductor 4-digit, 7-segment LED display
LED1—green light-emitting diode (miniature)
LED2—red light-emitting diode (miniature)
LED3—yellow light-emitting diode (miniature)

Other components
XTAL1—1- or 10-MHz crystal (case size HC49)
S1, S2—SPDT switch (Active Components # 22196)
Miscellaneous: Logic-probe case with probe tip and clip leads (Global Industries # CPT-1), solder, wire, etc.

NOTE: A complete kit of parts, logic-probe case, and carrying case is available for $139.95 U.S. or $159.95 Canadian from Tristat Electronics, 66A Brockington Crescent, Nepean, Ontario, Canada K2G 5L1, (613) 225-9883. The kit without the PC board is $117.95 U.S. or $137.95 Canadian (Visa orders welcome). The PC board alone is $22.00 U.S. or $25.00 Canadian. All orders require $6.00 for shipping and handling. The sources for certain components are Active Components, 1023 Merival Road, Ottawa, Ontario, Canada K1Z 6A6, (613) 728-7900, and Electrosonic, 1100 Gordon Baker Road, Willowdale, Ontario, Canada M2H 3B3, (416) 494-1555.

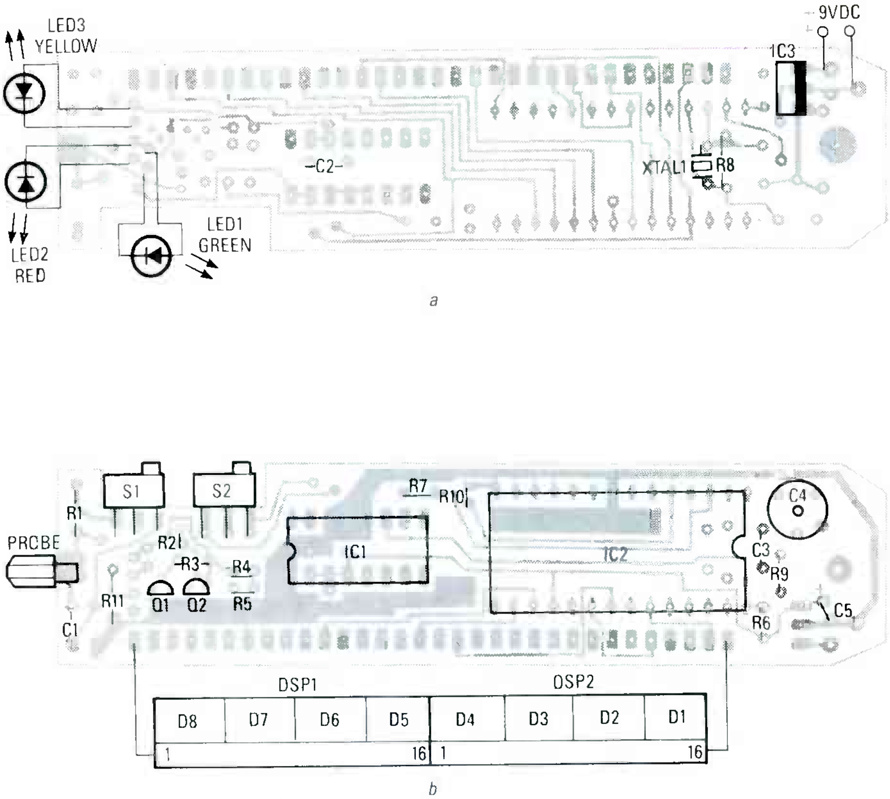


FIG. 5—THE PARTS-PLACEMENT DIAGRAM for the frequency probe, showing the foil (*a*) and component (*b*) sides. In (*a*), both IC3 and XTAL1 are bent flat.

fit in the case. If you're using the case in the parts list, clip the four plastic standoffs extending from the top with a pair of wire cutters as close to the base as possible. Next, cut the openings for the LED display and switches in the case as shown in Figs. 4-*a* and *b*. The case is polyethylene, so it can be cut initially with an X-acto knife, and finished with a jeweler's file or emery board.

Solder S1 and S2 first; clip the leads so their length is identical to that of the pads. Next, place each on top of its pads, and secure with solder, tweezers, or tape. Solder the three terminals to the pads, and repeat for the other switch. The bodies of S1 and S2 should fit snugly into the recess in the PC board, and the fronts of both switches should line up with the edge of the PC board. Then, solder all parts except IC3 and LED1–LED3, which go on the foil side. When soldering a component on a two-sided PC board without plated-through holes, you must solder the leads on both sides of the board. You must also solder short pieces of wire through any holes that do not have component leads going through them. Mount C2 on the foil side, leaving a slight space. Solder the leads as they go through the component side, clip as close as possible,

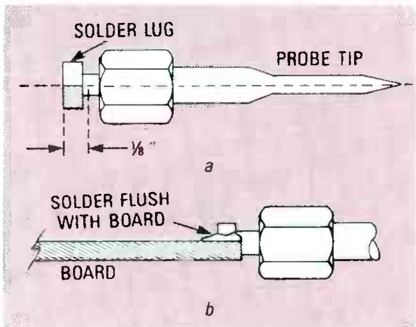


FIG. 6—TO MOUNT THE LOGIC PROBE TIP onto the frequency probe PC board, file ⅛-inch of the bottom of the hex-nut-shaped solder lug flat down to the centerline of the logic probe tip. Then, solder it flush to the correct pad on the component side of the PC board.

and inspect for poor solder joints. Care here will go a long way to having the probe work on power-up.

Next, install XTAL1; it lies flat along the PC board surface, so bend the leads at a 90° angle as close to the crystal housing as possible. Use heat-shrink tubing or electrical tape to insulate the housing against the foils. Next, solder R8, IC1, and IC2, inserting from the component side, and solder all the pins on the foil side. Solder the rest of the component-side components, paying attention to the parts-placement diagram of Fig. 5-*a* and *b*. Also, R2–R7 and R10 are mounted

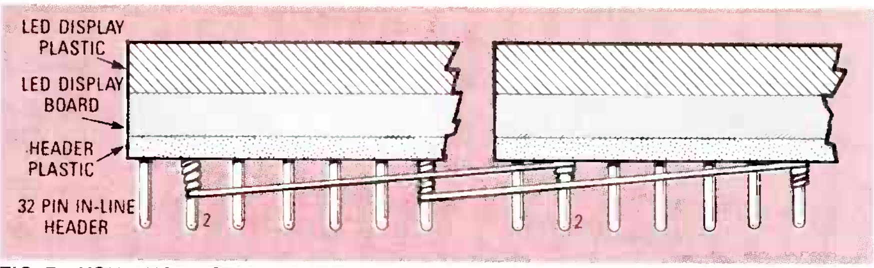


FIG. 7—YOU MUST CONNECT pins 2, 7, 8, 11, 12, 13, and 16 of DSP1 to the corresponding pins of DSP2 using wirewrap.

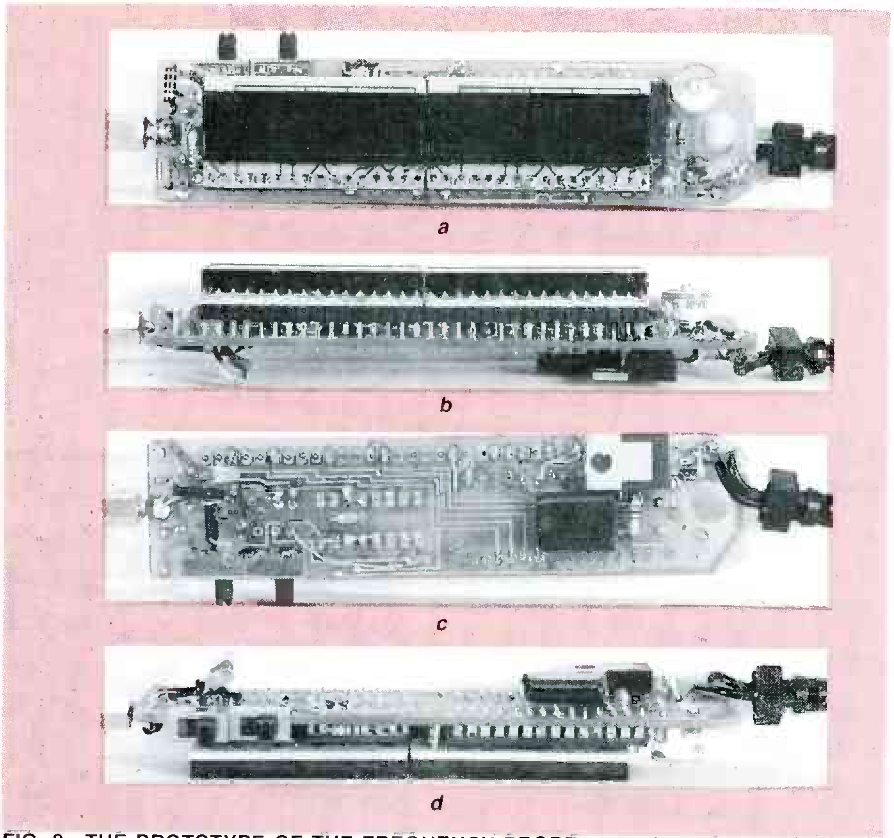


FIG. 8—THE PROTOTYPE OF THE FREQUENCY PROBE; note the callouts. Views are shown from the component side (*a*), edge-on showing the header strip for DSP1 and DSP2 (*b*), from the foil side (*c*), and edge-on showing C4, IC2, IC1, S1 and S2, from left to right (*d*).

vertically, and R1, R9, and R11 horizontally on the PC board.

The foil layout for C4 should accept different size trimmers, but they shouldn't exceed 0.5-inch in height or diameter. Strip 1 inch of insulation from the leads of the alligator clips. Solder the white stripped lead to the positive pad on the foil side, and the black lead to the negative pad. The probe tip should be 0.125 inch down to its center line as shown in Fig. 6-*a*, and soldered flush to the component side as shown in Fig. 6-*b*. Once the probe is soldered, let it sit for awhile because it'll get pretty hot.

The 8-digit LED display is composed of two National Semiconductor NSB3881 4-digit displays DSP1 and DSP2, and their segment anodes have to be wired together to form one complete display. Insert a 32-pin, single in-line male header through the underside of the LED display boards (LED side up), so that the LED display sits on the header insulation strip. Solder the LED display to the header from the top; don't apply excessive heat, or the LED display pads may lift. Using wirewrap or fine insulated wire, connect the pins of DSP1 indicated in Fig. 7 to the corresponding pins of DSP2.

If you use wirewrap, use 4–5 turns because you'll need to leave about ¼-inch of header pin bare to insert into the PC board. Wirewrap is recommended, and once the pin has been wrapped, a little solder will ensure that the connection is sound. Once DSP1 and DSP2 are wired correctly, insert the header into the PC board until the back of the LED display board touches the top of IC1 and IC2, and solder the header in place.

Fig. 8 shows the prototype from several perspectives, with component callouts. Fig. 8-*a* was taken from above and shows DSP1, DSP2, and the component side of the PC board, Fig. 8-*b* from the side of the header for DSP1 and DSP2, Fig. 8-*c* shows the PC board from the foil side, and Fig. 8-*d* shows the fronts of S1 and S2. The completed PC board fits very tightly in the PC board case, so there are several specific actions to take to ensure proper operation. Just note that there are several minor differences between the prototype and the plans we're giving you, so don't worry if you see something in the photos that does not agree with the plans.

Checkout and calibration

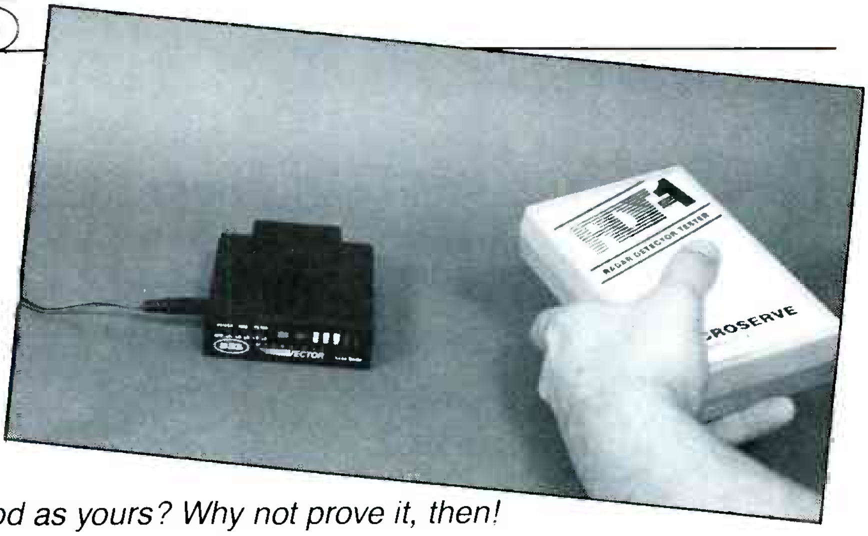
To check out the probe, connect the alligator clips to a 9-volt battery; the LED display should read 0.000 if it works. If not, use a meter to check voltages. Look for +5 volts on pin 3 of IC3; if it's not +5 volts, the display might be upside down. If it keeps changing, or segments flicker on and off, there's probably a cold joint. If you lightly flex the PC board, you'll usually find the trouble. If the LED display reads 0.000, you can calibrate the probe.

Connect a 500-Hz signal to the probe tip, and adjust C4 until the LED display reads correctly. Aim for maximum accuracy at the low end, because errors there will be substantial, compared to signals at 50 MHz or more. Next, try different frequency signals, and adjust C4 until satisfied. You don't need a function generator to check high-end operation; the average household has sources of suitable high-frequency test signals. Two examples used on the prototype were a Fisher-Price remote infant monitor (50 MHz), and an R/C model-car transmitter (72 MHz). To do that, just connect the clips to 9-volts DC, hold the probe nearby, and read the LED display.

The frequency probe can be used for RF, but is primarily for high-frequency logic circuits. When measuring a signal, use the second or later gating for best accuracy. Once you've gained experience with the probe, you'll be surprised by its simplicity. R-E

BUILD THIS

RADAR DETECTOR TESTER



Is your friend's radar detector as good as yours? Why not prove it, then!

JOHN B. AYER

HAVE YOU EVER WONDERED HOW SENsitive your radar detector is? Or have you ever had someone tell you that their detector was better than yours? Until now, the average radar-detector owner had no way to prove or disprove any claims made by the manufacturers concerning the performance of the various detectors on the market.

The radar-detector tester pictured in this article is an easy-to-build, low-power X- or K-band radar transmitter. With the device's low-level emissions, you do not need a license to use it. The average detection range is 12 feet, which is more than enough to determine the sensitivity of your radar detector. You can then do a side-by-side test with your friend who's been telling you his detector is better!

Operation

The heart of the circuit (see Fig. 1) is a one-transistor oscillator that operates at a fundamental frequency of 1169.44 MHz. The 9th harmonic of that frequency is 10.525 GHz, which happens to be the center of the X-band police radar assignment. The K-band unit operates at a fundamental of 1857.7 MHz with the 13th harmonic falling at 24.150 GHz. As you probably have guessed, 24.150 GHz is right in the center of the K-band police radar assignment.

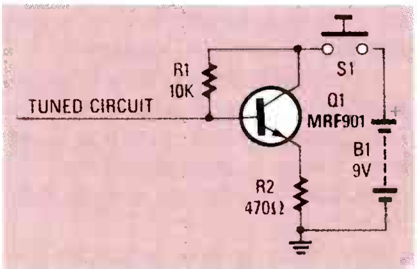


FIG. 1—THE HEART OF THE X-BAND UNIT is a one-transistor oscillator that operates at a fundamental frequency of 1169.44 MHz; the 9th harmonic of that frequency is 10.525 GHz, which happens to be the center of the X-band police radar assignment.

The oscillator uses a microwave transistor in order to maximize the X- or K-band output. The fundamental frequency is determined by the tuned circuit that is attached to the base of the transistor. The tuned circuit consists of a 50-ohm strip line that is etched onto a PC board, and then cut to the proper length during the tuning procedure.

The printed circuit board is made out of double-sided copper-clad teflon with fiberglass reinforcement. The teflon is necessary because of the high frequencies involved (standard G-10 epoxy printed circuit boards act like short circuits at frequencies above 3 GHz). Although teflon sounds exotic, it isn't, and it is readily available from the suppliers listed in the parts list.

Some people may not be familiar with strip-line circuitry. Any line that is etched on one side of a double-sided PC board will have inductance along its length and capacitance through the dielectric (the fiberglass, teflon, etc.) to the ground plane (the copper plating on the other side of the board). In a properly designed strip line, the inductance and capacitance cancel each other leaving the designer with just a resistive impedance to worry about. As it turns out, the width of the line and the thickness of the dielectric determine the resistive impedance.

In this particular case, it was determined that 50 ohms was the optimum impedance. After deciding which PC-board material would be best suited for this project, the following equation was used to determine the width of the strip line needed:

$$Z_o = (87/\sqrt{E_r + 1.41}) \times L_n[5.98H/(T + .8W)],$$

Z_o = characteristic impedance (50 ohms)
E_r = dielectric constant (2.48)
L_n = natural logarithm
H = thickness of dielectric (0.0156 inches)
W = width of line (0.038 inches)
T = thickness of copper cladding (0.0004 inches)

Once the width of the line is determined, all that's needed to finish the job is to determine the length of the line for the target frequency. (The oscillator is similar to a pipe organ where the length and diameter of a pipe determines the tone that is produced; the length of the strip line determines the resonant frequency.)

Construction

Etch the circuit board using the pattern provided in PC Service; a ready-made board is also available. The transistor has four leads; two are connected to the emitter, and you must determine which they are. Use an ohmmeter if you are not sure. (The

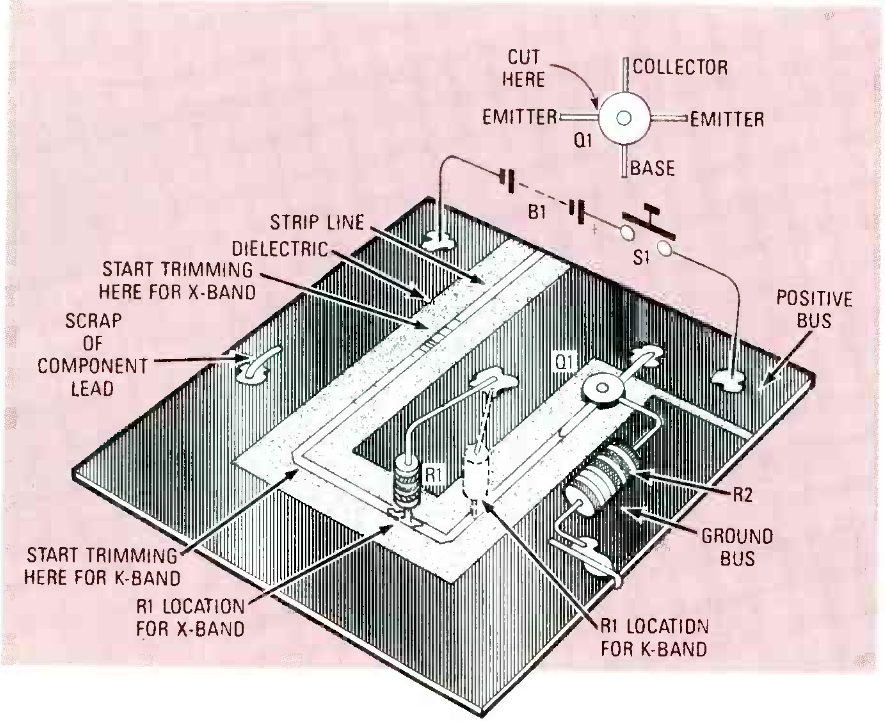


FIG. 2—PARTS-PLACEMENT DIAGRAM. Resistor R1 must be in a different location, depending on whether you're building an X- or K-band unit. Also, when aligning the unit, the strip line must be cut in a different location depending on the type of unit.

emitter leads are the only two that will exhibit a dead short from one to the other.) Cut off the left-hand emitter lead, as shown in Fig. 2.

After removing the extra lead, place the transistor in the hole on the board so that the base lead is on the strip line and the collector lead is on the positive bus, and solder them in place (see Fig. 2). Place R2 on the board and, keeping both leads as short as possible, solder one of its leads to the remaining emitter lead of Q1. The other resistor lead should go through the hole in the PC board, and soldered on both sides (a through hole, if you will). A scrap piece of component lead must go through the other hole on the left side of the board, and also soldered on both sides (another through hole).

Cut one lead of R1 so that it's ⅛-inch long. Refer to Fig. 2 for proper placement of R1 for either the X or K band. Then solder the shortened lead of R1 to the strip line so that the resistor is standing on end. The longer lead of the resistor should then be soldered to the positive bus of the PC board (see Fig. 2).

Using a silicone adhesive, glue the PC board into the enclosure that you have selected. DO NOT use a metal enclosure. The microwaves need to escape from the box, and you will defeat the entire project by using a metal box. Be sure to orient R1 so that it's closest to the front of the box, because most of the radiation is emitted from that point.

Attatch the battery and switch as shown in Fig. 2, being careful not to reverse the polarity. Route wires away from the strip line and components, because stray wires can de-tune the oscillator. Construction is now complete and you are ready to tune the transmitter (see Fig. 3).

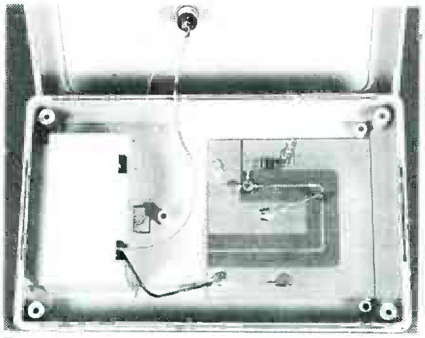


FIG. 3—GLUE THE PC BOARD into the *plastic* enclosure using a silicone-type adhesive.

PARTS LIST

R1—10,000 ohms, ¼-watt resistor
R2—470 ohms, ½-watt resistor
Q1—MRF-901 Motorola transistor for X band, *or* NE68137 California Eastern Laboratories transistor for K band.
B1—9-volt battery
S1—push-button switch
PC-board material—6 × 6-inch piece of 0.0158-inch thick teflon-fiberglass (Taconic Plastics, part number TLT-9-0150-C1/C1)
Plastic project case

Note: A complete parts kit is available from MICROSERVE, 60 Thompson Street, Maynard, MA 01754. Besides the parts, the kit also includes a custom plastic enclosure with an integrated battery holder and decorative face plate. X-band kits are $55, and K-band kits are $65. Shipping and tax extra. Spare parts list available on request.

Motorola Semiconductor Products
3102 N 56th St.
Phoenix, AZ 85018
602-952-3000 or 800-521-6274

California Eastern Laboratories
3260 Jay St.
Santa Clara, CA 95054
408-988-3500

Taconic Plastics LTD.
Petersburg, NY 12138
518-658-3202

Alignment

To align the unit, you will need a radar detector and an X-acto knife with a fine blade. Turn on the radar detector and the tester. Now make an initial cut in the strip line starting at the point specified in Fig. 2 for either the X- or K-band unit. Be sure to cut all the way across and through the copper trace. If your detector does not sound an alarm, make another cut about 1/16-inch closer to the transistor. At some point your detector will sound an alarm, and the tester will be properly tuned. Be careful not to cut too much at one time, because if you go too far you will have to carefully solder the line back together.

However, if you go just a *little* too far, you can save some work by cutting nicks in the remaining strip line (cuts that go part way across the strip line). That has the effect of making the strip line electrically longer.

If you find that your range is limited you may have tuned to the wrong harmonic resulting in low output. It will be necessary to experiment with different line lengths to achieve maximum range.

Your tester is now ready for use. Simply hold the unit near a detector and turn it on. The range of the X-band transmitter is about 12 feet, while the range for the K-band unit is about 5 to 10 feet. **R-E**

ACOUSTIC FIELD GENERATOR


ACOUSTIC
FIELD GENERATOR
TOD T. TEMPLIN

Our AFG will turn any livingroom into a full-sized movie theater or concert hall.

LAST TIME WE DISCUSSED THE AFG'S CIRcuitry. So, by now, you must be anxious to experience its special sound effects. Without further ado, let's continue with complete construction details.

Construction

All of the electronic components are mounted on a single PC board as shown in Fig. 9. The board can be made using the foil pattern provided in PC Service or purchased from the source mentioned in the parts list. Only the power transformer, the input and output jacks, and the function switches are mounted off-board.

The chassis shown is readily available, but it makes for a rather tight fit. If you plan to use a similar chassis, study the pictures of the prototype carefully before drilling. If you choose a different chassis, keep all the leads between jacks, switches, and the circuit board as short as possible. Locate the power transformer as far away from the circuit board as possible to avoid 60-Hz hum. If you must mount the transformer near the circuit board, wait until your unit is operational before you choose a final position for the transformer. Then, while listening, you can try the transformer in different positions until you find a location where no hum is coupled into the circuit.

Begin stuffing the board by mounting all of the fixed resistors and the small potentiometers. Note that R35 and R69 are mounted upright. Next mount the IC sockets. Position each socket's pin 1 identifier so that it matches the small dot indicating pin 1 on the circuit board (do not insert the IC's into their sockets at this time). Next mount the capacitors. Please note where polyester and metal-film capacitors are called for in the parts list. *Do not* substitute ceramic capacitors; they perform poorly in audio circuits and their use will destroy the performance of the AFG. Also, don't substitute polarized electrolytic capacitors where bi-polar units are specified in the parts list.

Using some of the excess leads clipped from the capacitors, install bare jumpers where indicated, except for the six long jumpers. The two long jumpers in the audio power amplifier should be made from insulated heavy-gauge wire, as they carry relatively high current—no. 18 will do. The other four long jumpers in the decoder section should be made from lighter gauge insulated hookup wire.

Finish stuffing the circuit board by installing D1, D2, IC7–IC10, and the three large potentiometers, R77, R78, and R79. You can plug in the IC's now, but you should take static-electricity precautions with them.

Finish up the wiring between the PC-board pads and the switches, the input/output jack panel, the speaker terminal jacks, the power transformer, and the pilot LED. Use shielded cables for the leads to the input/output jacks. Try to keep all wiring as short and direct as possible to avoid crosstalk and hum. Use no. 18 or heavier wire for the speaker connections. To simplify construction, the prototype used inline fuse holders in the positive speaker leads and the power transformer primary circuit, as indicated in the schematics.

The power-supply regulator IC's are being operated very conservatively and thus do not require heat sinks. However, the LM1875T audio power amplifiers must *always* be operated with a heat sink. Failure to use a proper heat sink will cause the IC's to quickly overheat and possibly destroy themselves. Although they contain on-board circuitry to shut them down in case of overheating under normal operating conditions, it is best to leave fate untempted and refrain from operating the AFG until after the heat sink has been installed.

The heat sink used on the prototype was homemade from a 2- × 2- × 1⁄16-inch thick piece of aluminum angle stock cut 5¼-inches long and notched out in the front to fit over R77. If you use a commercially made heat sink, be sure that it provides about 8 to 10 square inches of surface area for each IC. Assuming that you are using a homemade heat sink like the one shown, temporarily position it so that the bottom edge is even with the bottom of the IC cases, or about 3/8" above the circuit board. Be sure that it does not touch D1. Mark the heat sink where the holes in the IC tabs fall and drill mounting holes at those points. In order to provide additional support, holes were also added at the top corners of the heat sink in line with the PC-board mounting holes. 3-inch screws with double sets of nuts were then used to mount the PC board as well as to hold the heat sink in place. Carefully examine the photographs that are shown in Fig. 10 to see how that was accomplished.

Because the metal tab of the LM1875T is not at ground potential,

PARTS LIST

All resistors ¼-watt, 5%, except as noted.
R1—1500 ohms
R2, R3, R54—22,000 ohms
R4, R5, R32, R33—1000 ohms
R6, R7, R61, R62, R74—20,000 ohms
R8, R9—1 ohm, ½-watt, 5%
R10–R13, R19, R34, R35—47,000 ohms
R14–R17, R20–R25, R47–R49, R55, R56—100,000 ohms
R18, R57—330,000 ohms
R26–R31, R66, R70—150 ohms
R36–R43, R67—8060 ohms, 1%
R44–R46—16,000 ohms
R50, R51—5600 ohms
R52—2400 ohms
R53—8200 ohms
R58–R60, R63–R65, R71–R73—10,000 ohms
R68—9530 ohms, ¼-watt, 1%
R69—102,000 ohms, ¼-watt, 1%
R75, R80—100,000 ohms, potentiometer
R76—10,000 ohms, potentiometer
R77—50,000 ohms, PC-mount potentiometer
R78, R79—1000 ohms, PC-mount potentiometer

Capacitors
C1–C4—2200 µF, 25 volts, electrolytic
C5, C6—10 µF, 35 volts, radial electrolytic
C7–C12, C19–C22, C27, C28, C30, C31, C45, C49, C58—0.1 µF, 50 volts, metal film
C13, C14, C23, C24, C43—2.2 µF, 50 volts, bi-polar radial electrolytic
C15, C16—22 µF, 16 volts, bi-polar radial electrolytic
C17, C18—0.22 µF, metal film
C25, C26—0.047 µF, metal film
C32–C34—3300 pF, polyester
C36, C37—2700 pF, polyester
C38–C41—270 pF, 5% ceramic disc
C42, C47—0.47 µF, metal film
C44—120 pF, 5% ceramic disc
C46—0.56 µF, metal film
C48—0.039 µF, metal film
C50—0.012 µF, metal film
C51, C56—0.01 µF, metal film
C52—1000 pF, 5% polyester
C53–C55—0.027 µF, metal film
C57—5600 pF, 5% polyester
C58—4700 pF, 5% polyester
C59—470 pF, 5% ceramic disc

Semiconductors
D1, D2—1N5400 50 PIV 3-amp diode
IC1–IC4—LF347 quad JFET
IC5—MN3008 2048-stage bucket brigade device
IC6—MN3101 2-phase clock
IC7—7812T +12-volt regulator
IC8—7912T −12-volt regulator
IC9, IC10—LM1875T audio amp
LED1—light emitting diode pilot lamp

Other components
T1—Power Transformer 25.2 Volt Center Tapped 2 Amp.
F1–F3—1-amp fuse
J1–J8—8-pin RCA-style jack panel
J9–J12—4-position pushbutton speaker-terminal panel
S1, S2, S5—SPDT switch
S3, S4—DPDT switch
Miscellaneous: speakers of your choice, 5 14-pin IC sockets, 1 8-pin IC socket, 1 heat sink (2 × 2 × 5¼-inch aluminum angle stock), 2 T0-220 mica insulators with mounting hardware, silicone grease, 3 in-line fuse holders, 3 knobs, chassis, linecord, solder, etc.

Note: The following items are available from T3 Research, Inc., 5329 N. Navajo Ave., Glendale, Wisconsin 53217-5036: An etched, drilled, and plated PC board, $15.00; a basic parts kit consisting of all semiconductors, resistors, and capacitors, $55.00; a piece of aluminum stock for the heat sink, $3.00. Please include $2.50 for postage and handling with your order. Wisconsin residents please include appropriate sales tax.

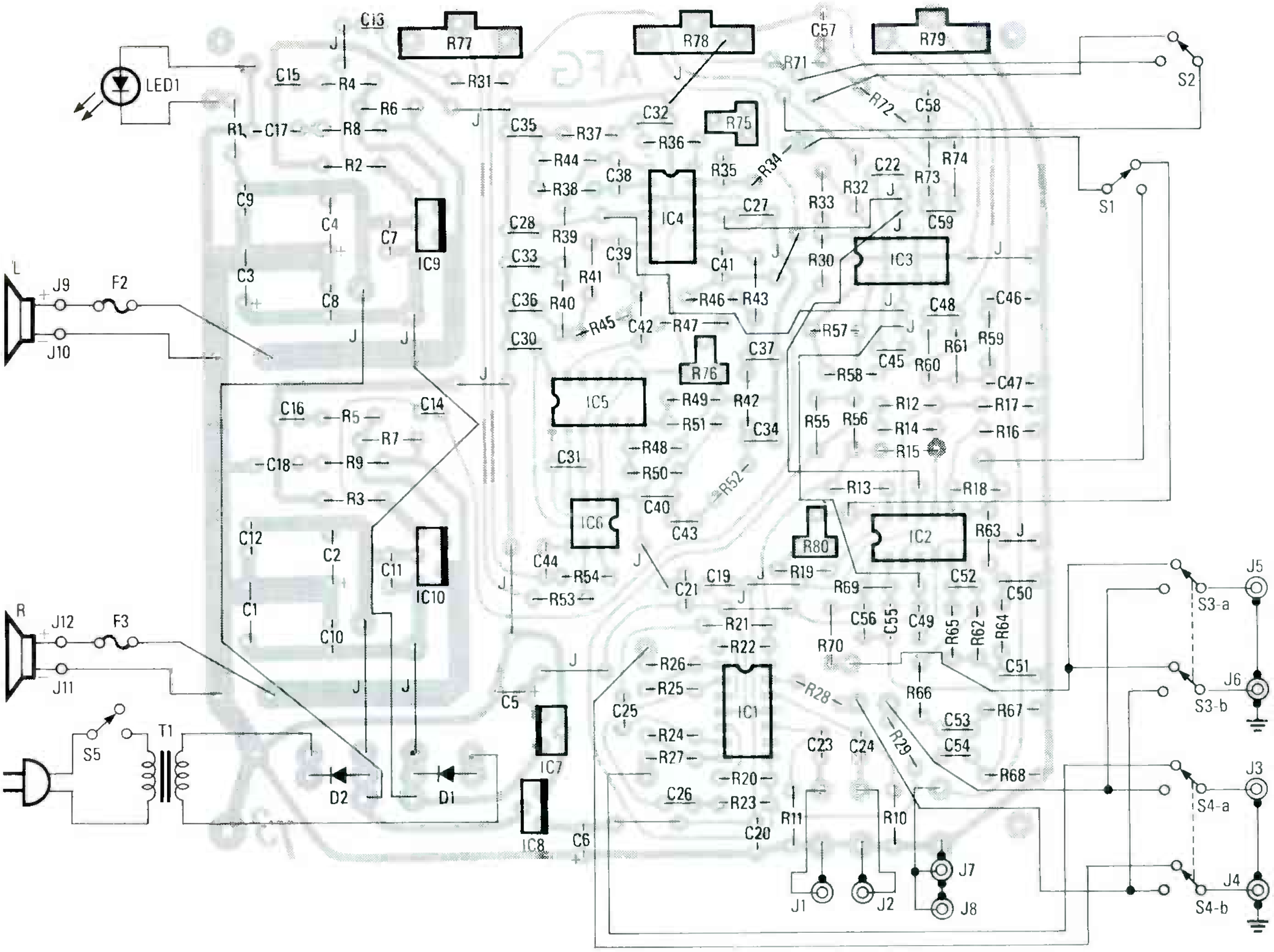
mica insulators and plastic shoulder washers must be used between the cases of the IC's and the heat sink. Use a small amount of silicone grease between the IC's and the heat sink to increase thermal conductivity. Make sure that the tabs of the IC's are actually insulated from the heat sink before operating the unit. Although adequate, the heat sink becomes moderately warm during operation, so be sure to provide good ventilation in your chassis.

Setup and operation

Figure 11 shows one method of integrating the AFG into a home audio-video system. As mentioned earlier, a separate power amplifier is required for the subwoofer channel, in addition to the subwoofer speaker itself. In the setup in Fig. 11, the center channel is connected to the audio inputs of a monitor-style television receiver which has provisions for amplifying external line-level audio signals. If your TV set doesn't have audio inputs, or if you use the AFG in a music-only system, you'll have to provide a separate amplifier and speaker for the center channel as well. Please note that although the subwoofer-channel and center-channel speakers are a desirable part of any audio system, they are not absolutely necessary. The AFG may still be used as an excellent surround-channel decoder simply by adding a pair of small speakers for the surround channels.

The best place to patch the AFG into your system is between the preamplifier outputs and the power-amplifier inputs of your receiver or amplifier. Most component receiver/amplifiers allow for that connection by providing removable jumpers between the appropriate phono jacks on their rear panels. By placing the AFG in that loop, all the audio signals selected by the amplifier will also pass through the AFG. Furthermore, the volume and tone controls of the main amplifier will have control over all the levels in the system simultaneously; i.e. the subwoofer, surround speakers, and the center channel, as well as the regular left and right speakers. If your amplifier doesn't provide preamp out/main input jacks, you may still use the AFG by connecting it into a tape-monitor loop, or even more simply, to the audio output of a stereo VCR; but then you will have to adjust the levels of the subwoofer and surround channels independently of the main amplifier via the level controls on the AFG.

Calibration of the AFG is easy. Begin by setting, R75, R76, and R80 to their center positions. Now feed a mono signal into the AFG from some source in your system (an FM tuner switched to mono operation is a good choice). Set the balance control on your amplifier to its exact center mark. With the AFG switched to the matrix position (L − R), adjust R80 for the minimum output from the surround speakers. Now switch the receiver back to stereo and the AFG to concert (L + R). Adjust R76 for minimum distortion. R75 provides a means for matching the drive level of the AFG delay section to your system's normal audio levels. The BBD delay line has a maximum recommended input-signal level of 1.5 volts. To maximize the signal-to-noise ratio of the delay amplifier, the signal going into the delay line should be as high as possible without driving it



9—ALL OF THE COMPONENTS mount on a single PC board as shown.

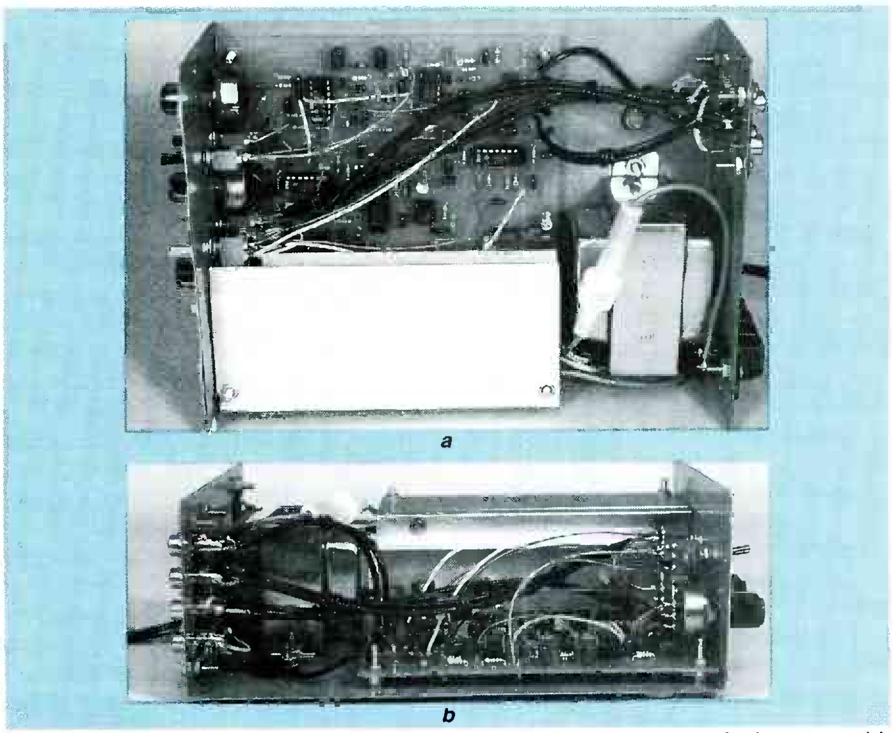


FIG. 10—THE HEAT SINK AND PC BOARD are installed as shown. Two 3-inch screws with double sets of nuts are used to mount the PC board on one side and hold the top of the heat sink in place (*a*). Two shorter screws hold down the other side of the board (*b*). Be sure to use spacers to prevent the board from touching the metal cabinet.

into distortion. While using the highest normal level you are likely to feed the AFG, adjust R75 to obtain the maximum level that does not cause distortion.

The speakers you choose for the surround channels don't have to match your front-channel speakers in sonic characteristics. The frequency response of the surround channel is limited at the time of encoding to a bandwidth from approximately 100 Hz to 7 kHz by the Dolby process. Small bookshelf-style speakers mounted toward the rear of the room at ear level or slightly above are adequate. Although it is customary to use two speakers for the surround channel, one placed to the right rear and one to the left rear of the listening position, the surround channel signal that feeds those speakers is really monaural. The internal power amplifiers in the AFG drive the signal to the two rear speakers 180 degrees out of phase. That tends to spread apart the sound field created between the rear speakers. However, that may or may

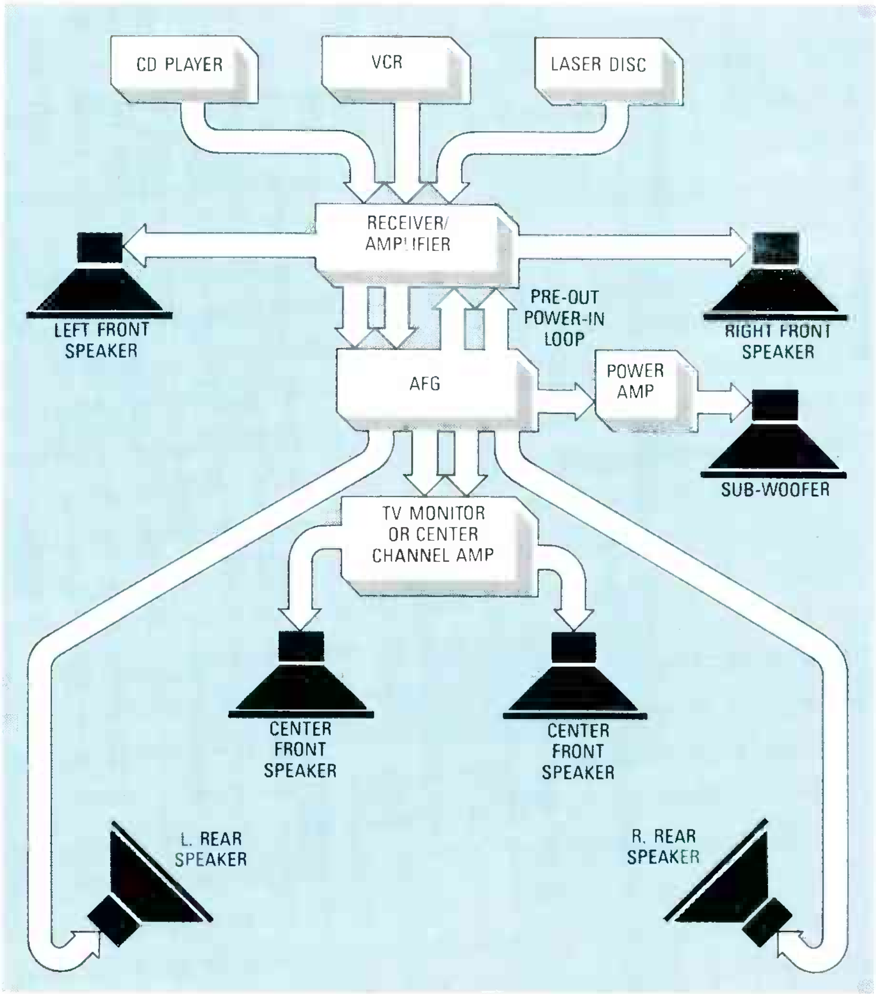
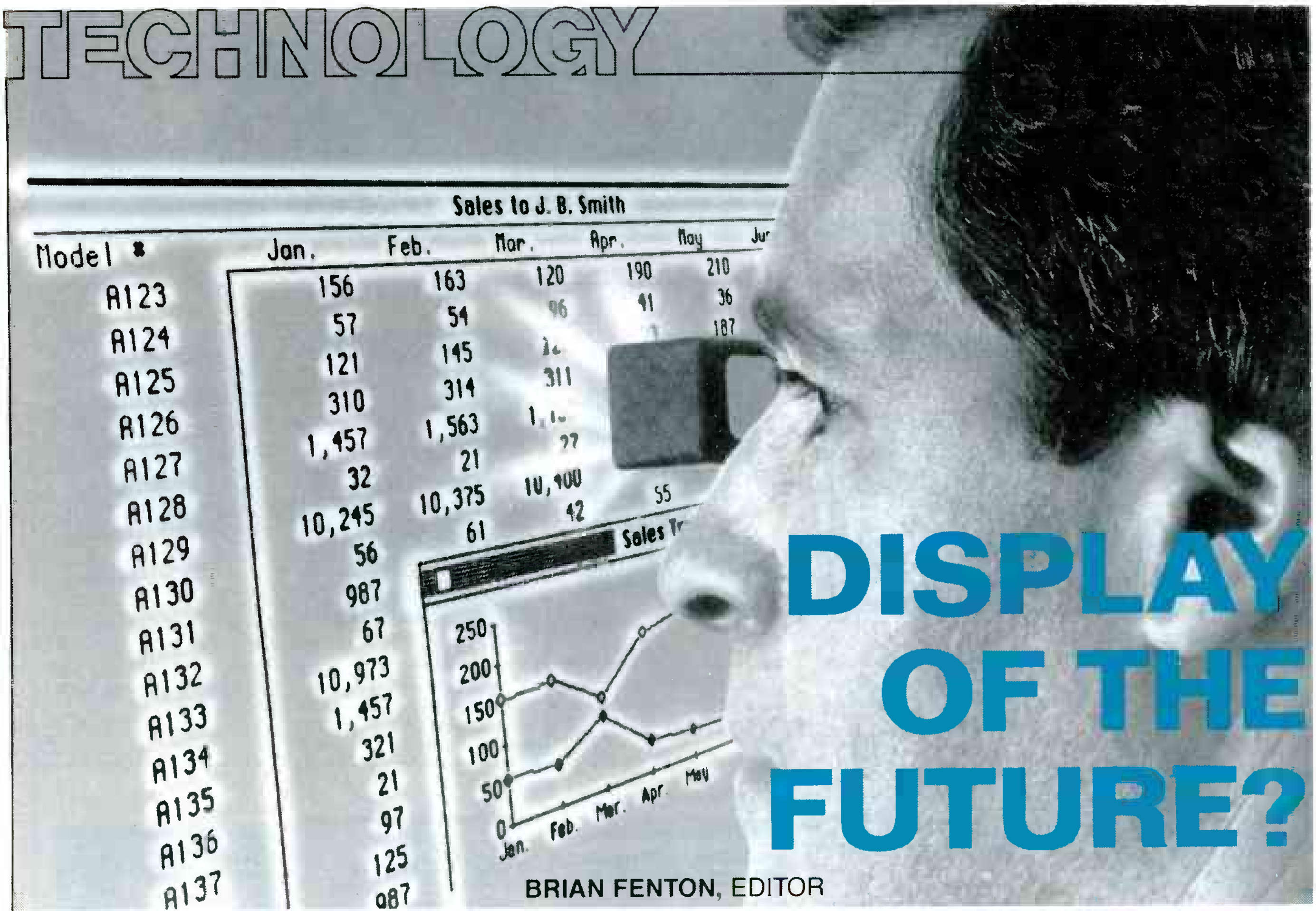


FIG. 11—HERE'S ONE METHOD OF INTEGRATING THE AFG into a home audio-video system. A separate power amplifier is required for the subwoofer channel, in addition to the subwoofer speaker itself.

not sound well in your listening environment, depending on such things as speaker placement and actual listening position. You may restore the speakers to in-phase operation by simply reversing the leads connected to one of the speakers. Try setting up both ways to find which sounds better to you. Note that phase integrity is maintained through the AFG for the left, right, center, and subwoofer channels.

Actual level adjustment of the surround channels, center channel, and subwoofer is a subjective process. The source material itself, the listening area, and personal preferences for tonal balance must be taken into account. Use the AFG in the matrix and wide modes for surround-encoded movies. Use the concert mode to add ambience and depth to musical performances. Generally speaking, don't set the level of the surround channel so high as to make it overwhelming. The surround signal is intended to supplement the main channel, not to be a separate channel that is always equal in level to the front channel. That is particularly true for surround-encoded movies.

The delay of the surround signal can be adjusted via R77 from about 5 to 35 milliseconds. In matrix operation, delaying the surround signal tends to acoustically mask any leakage of front-channel information into the surround channel. Setting R77 to the center of its range provides a delay of approximately 20 milliseconds, which is about right if your listening position is between 10 and 20 feet from your television screen and your surround speakers are located just to the left and right of that position. However, if your surround speakers are located any farther than that, subtract 1 millisecond for each added foot. Likewise, add 1 millisecond for each foot less. For concert operation, adjust the delay for a pleasing ambience effect. R-E



DISPLAY OF THE FUTURE?

BRIAN FENTON, EDITOR

Despite its size, you'll be seeing a lot of a new display called the Private Eye. It promises to change the way we look at portable computers, TV's, video games, and more.

IF SOMEONE WERE TO SUGGEST REPLACING your computer monitor with a 1-inch display, you'd probably consider that person crazy. But that's exactly what Reflection Technology, a Waltham, Massachusetts-based company would like to do.

Actually, no one—including Reflection Technology—thinks that computer monitors will be *replaced* by their display called the *Private Eye*. But just as Sony's *Walkman* created an entire new category of stereo equipment, this "*Walkman* for the eye" promises to do the same for many other products. Pocket-sized computers are only the first to hit the market. But just imagine the advantages of an oscilloscope display that is worn in front of your eye. Or imagine what the next generation of portable video games—with a true three-dimensional image—will be like.

Although the *Private Eye* is innovative, the technology it uses is neither new nor dramatic. Instead, the display is a new combination of existing technologies. At its heart is a hybrid circuit consisting of a column of red LED's and driver circuitry, along with a magnifying lens and a mirror. While those components are certainly not exotic, the way they're used, and the results, are impressive nonetheless. The entire display measures slightly more than 1 × 1 × 3½ inches and weighs 2½ ounces. It can display text and graphics at a resolution of 720 × 280 pixels, which is slightly better than a Hercules computer monitor. Total power consumption is just ½ watt.

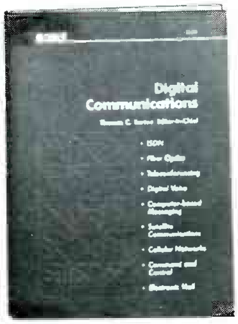
The idea of peering at a 1-inch display might not seem too comfortable. However, the *Private Eye* is a virtual screen display that creates an image larger than the screen itself—in this case 50 times larger. The user sees a completely readable, full-size, 12-inch screen by looking into a 1-inch window. The image appears to be floating in the air a few feet in front of the user. The result isn't as strange as the description sounds. The user isn't aware that the screen's plane of focus is a distance in front of him. Rather, he simply sees a perfectly readable screen that he doesn't have to strain to look at, despite the fact that it is only a couple of inches away from his eye.

It's all done with mirrors

As shown in Fig. 1, the main components of the display are a column of LED's, driver circuitry, a magnifying lens, a mirror, a counter weight, and a case.

At first glance, a column of LED's might not seem to be a logical way to create a display. The common question is, "Why not just use a matrix of LED's?" Unfortunately, while LED's are bright, efficient, fast, inexpensive, and easy to manufacture, current manufacturing technology is not ad-

STATE-OF-THE-ART



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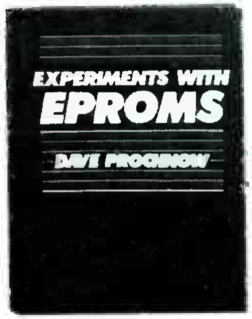

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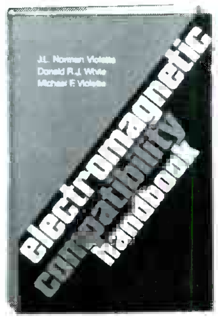

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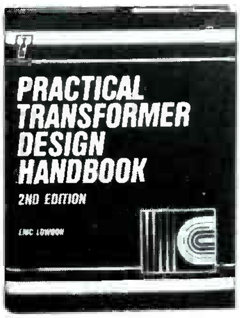
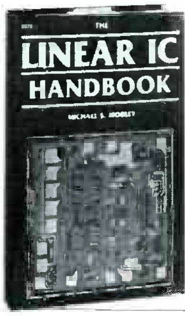
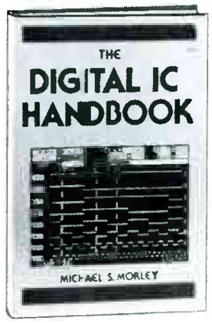
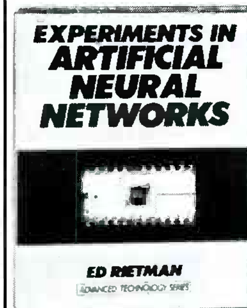
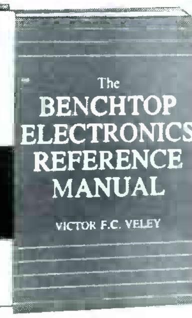
ELECTRONIC COMPONENTS

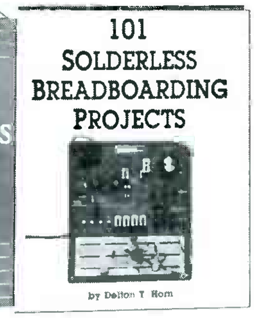












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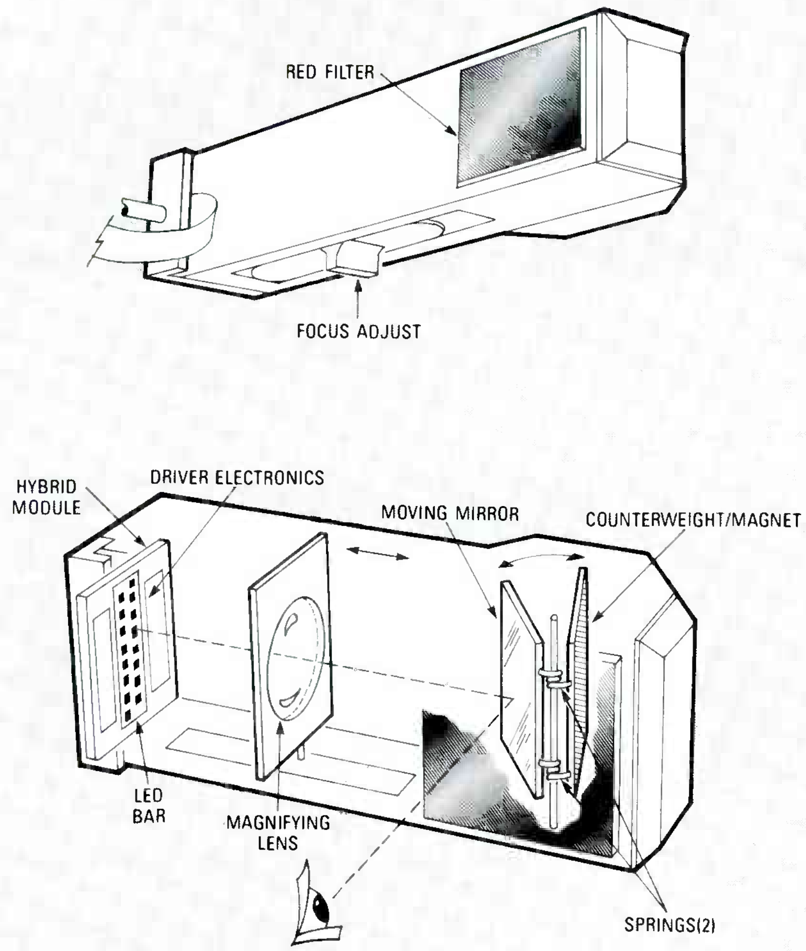


FIG. 1—A HIGH-RESOLUTION DISPLAY is packaged in a housing that measures about 3.5 × 1.2 × 1.2 inches (*a*). The heart of the display consists of an LED column, a magnifying lens, and a mirror (*b*).

vanced enough to produce a matrix that is dense enough.

An elegant solution was devised using a column of LED's, which can be manufactured reliably in long, dense arrays. Of course, a single column of LED's is not very useful as a computer display. But instead of trying to add dots (pixels) by brute force to make a matrix, the developers of the display combined the single LED column with a scanning mirror and magnified the result. One column of dots is shown at a time, and the mirror is moved to spread the single column across the full screen as the pattern on the column changes. As shown in Fig. 2, that makes it possible to create the perception of a full-screen display.

To improve the picture's resolution, two columns are used instead of one. They are laid out as a staggered, or zig-zag, array. The individual LED's (pixels) alternate between the columns. To create a single image, each LED column is illuminated at a slightly different time to allow the mirror's movement to combine the columns, making the pixels appear to touch each other, top-to-bottom. The image that results from this "hardware interlacing" is a solid field without any of the blank interrupt lines that are normally seen on a CRT.

Apparent brightness is achieved not by overpowering ambient light, as in most other displays, but by putting the display in a light-tight enclosure. The image appears as vibrant, high-contrast red characters on a deep black background.

While the LED column is important to the success of the display, the scanning mirror completes the picture. The mirror is hinged and supported by springs at one end. As shown in Fig. 3, a small voice coil, similar to that of a speaker, is attached to the back of the mirror and pushes against a magnetic counterweight.

The magnetic counterweight is also spring-mounted. The resonant frequency of the counterweight system is designed to be the same as the mirror's, so essentially the entire mirror/counterweight/coil mechanism acts like a tuning fork. Not only does it consume very little power—only 1/100 watt is needed to keep it going—but most of the vibration that would be created by the oscillation of the mirror alone is canceled out. The resonant system is also relatively immune to external shocks and vibration.

Synchronizing the movement of the mirror is achieved by using a photodetector sensor. As shown in Fig. 4, a tab mounted to the back of the mirror interrupts the photosensor light beam circuit as the mirror crosses maximum deflection. At that time, power is applied to maintain resonance. The advantage of this system is that the exact frequency of the vibration is not important.

The photosensor signal also provides the information to determine the right time to start turning on the LED's for each screen. Due to the sinusoidally varying speed of the mirror throughout its cycle (it slows down to a stop at each end), a timing correction must be applied to make the columns appear in the right locations.

The spring mounts for the resonant system act as frictionless pivots for

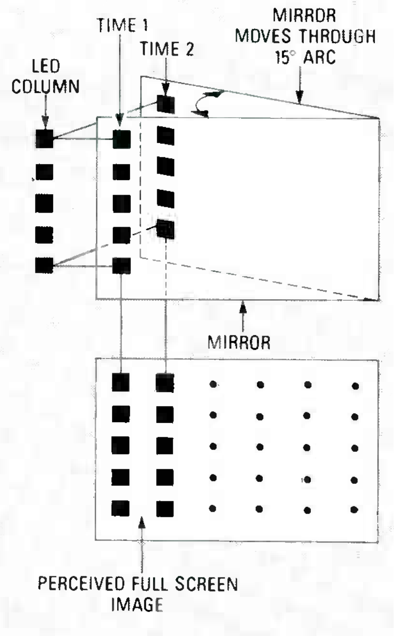


FIG. 2—THE MOVEMENT OF THE MIRROR forms a horizontal "raster" as the pattern on the LED column changes. In the actual display, the LED column is made up of two offset bars, which are blended together by the mirror's movement.

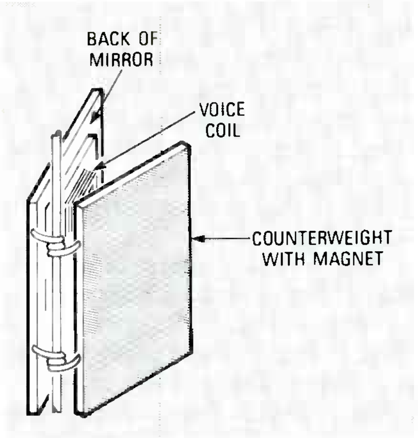


FIG. 3—THE SCANNING MOTOR. The mirror is set into motion by a small voice coil that is mounted on back of the mirror; the voice coil pushes against a magnetic counterweight.

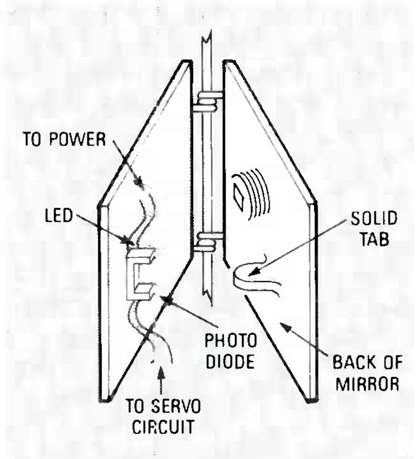


FIG. 4—ACCURATE TIMING is essential to keeping the pattern of the LED column in sync with the movement of the mirror. A photosensor assembly makes the job easy. When the mirror reaches the end of its travel, the photodetector sends a signal to the servo circuit, which gives the mirror a "kick" back.

the mechanism and create minimal power loss. And, because the motions required are small (the mirror travels only 15 degrees), the springs are stressed to a small fraction of their fatigue life. In addition, because of a resonant system's tendency to resist any disturbance to the system (such as rapid movement or outside vibration), the image is not only extremely stable and clear, but remains so under a broad range of conditions.

The magnifying lens that sits between the mirror and the LED array allows the user to adjust the optics so that the displayed image appears to be at a point in space anywhere between 9 inches and infinity. An image can therefore be located on the same plane as other objects in the user's field of view. Because the optics are adjustable, users do not suffer from eye strain and do not need to refocus their eyes when shifting their gaze from the display to other objects surrounding them.

Other features

If a portable display is to be successful, its power consumption must be kept to a minimum. We've already seen how the LED's and resonant vibrating mirror are very efficient. Additional power reduction is achieved by being able to use a low refresh rate of 50 Hz. Other displays that refresh at that rate, such as TV's in Europe, suffer from very noticeable flickering, particularly when viewed with peripheral vision. The *Private Eye* is flicker-free because it has high contrast and is seen through the central portion of the eye, which is relatively insensitive to flicker.

The *Private Eye* runs asynchronously from the host device. The display has an internal control chip and screen buffer memory. The control chip takes bit-map data transmitted as serial data up the cable to the internal memory. It then takes the bit map and places it into shift registers. The display is automatically and continuously refreshed with the current image until new data is sent by the host device.

Future developments

The technology we've described is still only in its infancy. In fact, the development kit that we examined when preparing this article used technology that is already outdated. For example, the development kit, which is used with a PC, requires two plug-in cards. One card contains logic circuitry, while the other contains the servo circuitry to control the mirror's motion. Most of that circuitry has been incorporated inside the display package for future versions. At the same time, the display has been made lighter and easier to manufacture, and the slight vibration of the development unit has been reduced to be even less noticeable. We wouldn't be at all surprised if future displays use a wireless radio-data link to receive their images.

Other improvements have been successfully demonstrated in the laboratory, but will have to wait for refinements in LED manufacturing before they become a commercial reality. Reflection Technology's five-year target is to produce a megapixel (1000- × 1000-pixel) full-color display in an even smaller, but substantial package. Before that goal—essentially HDTV in a matchbox—is reached, a number of smaller advances are planned.

First will be the addition of gray scale or, in the case of the *Privater Eye*,"red scale." Showing brightness levels merely requires redesigning the electronics to vary the light cycles of the LED's according to the desired brightness.

Resolution will increase continuously from model to model. Moderate increases within the existing packaging technology (perhaps to 640 × 480) will occur, and then larger increases as denser packaging becomes available. Only current wire-bonding manufacturing practices limit the development of higher-density displays. Integrating the components onto a single substrate and using conductive paths between them will certainly provide the leap that is needed for megapixel resolution.

Color can be attained when green and blue LED's become available in arrays similar to those used for red LED's today. The scanning mirror will combine the red, green, and blue pixels from individual LED arrays to visually superimpose the pixels and produce colors (in much the same way that it now combines the staggered red LED columns). Blue and green LED arrays are still a few years from commercial availability.

The price for the display can also be expected to drop. The only costly component is the LED hybrid, which, like other semiconductor components, will lower in price as production volume increases and new manufacturing techniques are used.

Potential applications

If you've ever used a laptop computer with an LCD screen, you're well aware of the need for improvements. Even the highest-resolution and easily read laptop screen has the disadvantage of having to be large enough to see. The *Private Eye* will dramatically shrink the minimum size of laptops. In fact, by the time you read this article, at least one company (Cyberspace of Norcross, Georgia) will have introduced a pocket PC about the size of a video cassette.

Another real product that uses the *Private Eye* is a pocket video fax (from Medbar of Queens, New York). Built-in memory allows the fax to store incoming pages for review. We expect that it's only a matter of time before that sort of feature becomes standard equipment on portable cellular phones.

There are also a number of products that, while not on the market as far as we know, are sure to be in the works. The *Private Eye* could easily be used to develop visual assembly and maintenance manuals. For example, someone testing an electronic product at the end of an assembly line could see a picture that would show where to place a probe. Because the technician would not have to look away from the task at hand, he could presumably work more efficiently and accurately.

Can you imagine being able to use an oscilloscope or meter without ever looking away from where you're placing the probe? The same technique could be used by automotive technicians, who could read an engine analyzer at the same time they're under the hood adjusting a carburetor. Surgeons performing microsurgery—who now must look away from their work to see a magnified image on a video display—would find a head-worn display to be an immensely valuable tool.

A miniature display could also be incorporated into radio pagers or other mobile data displays. Potential users might include field engineers needing technical documentation, salespeople wanting access to product documentation during a sales call, drivers needing maps to their destination, or subscribers to public service such as news, sports, or stock-market information.

Another application that you can bet on is videogames. We can imagine goggle-like headsets with one display mounted in front of each eye. That would allow for completely portable, very exciting, true three-dimensional games.

In short, the *Private Eye* will be used wherever the information content and clarity of desktop screens can be used—from pocket PC's, to electronic instrumentation, from pocket fax receivers to ISDN telephone displays, from educational devices to toys and games. Even more exciting are the applications that haven't yet been thought of. **R-E**

BUILD THIS

ED BATHGATE

VCR HEAD AMP TESTER

This inexpensive piece of equipment can turn a second VCR into a valuable troubleshooting tool.

THE MAJORITY OF PROBLEMS THAT OCCUR in a VCR are mechanical in nature. Problems caused by dirty heads, worn idlers, stretched belts, and jammed gears are perhaps most common, but VCR's also have their share of electrical problems. Such problems may be bad end sensors, burned out motors, power-supply problems, etc.

A good oscilloscope and a digital voltmeter can get you through the majority of VCR problems quickly and easily. However, problems involving the video heads, rotary transformer, head pre-amps, and head-switching circuits can be tough to troubleshoot. There are low-cost ($60) video-head testers, but they won't indicate if a head is contaminated or if the gap is clogged; in either case the output will seriously be degraded.

You could replace the video head in question, but that requires that you have a spare head for every make and model of VCR you service. Changing heads is time consuming, and keeping lots of heads in stock is expensive. What's really needed is an instrument that can generate a known-to-be-good video-head playback signal, and one inexpensive source for such a signal is another VCR. A VCR creates that signal whenever it plays a tape, so a working VCR can be used to troubleshoot a broken VCR (see Fig. 1).

If you are repairing VCR's as part of a service business, you probably have more than one working VCR in the shop at any given time. What's needed is a video jumper cable to take the signal from the source VCR and inject it into the VCR being repaired. This project makes it possible to do just that, with no modifications to either VCR.

VCR operation

There are several signals that a video head generates during playback. The luminance and sync is a signal from 3.4 to 4.4 MHz, frequency-modulated by video luminance and sync information. The chroma, or color information, is a 629.371-kHz signal recorded by amplitude modulating the 3.4 MHz FM carrier. The combined signals are usually referred to as video-head RF or RF envelope.

Two video heads are needed to "read" the information from a standard VHS videocassette (see Fig. 2). The two heads are mounted 180 degrees apart on a polished aluminum cylinder that spins counter-clockwise at 30 rpm. When one head completes a scan of the tape, the other head is ready to start its scan. In one scan, one video head generates a "field," a full top-to-bottom picture on the TV screen. The second video head also generates a field, but it is interlaced with the field from the first head. The two interlaced fields make one frame.

A standard four-head VCR uses only two heads at a time, one pair for "SP" (two-hour standard play), and one pair for "EP" (six-hour extended play). If one of the video heads is bad, the VCR will send a full-size picture to the TV, but with only half the picture information, with every other field composed of "snow."

Each head has its own pre-amp, and the output of each one goes to an

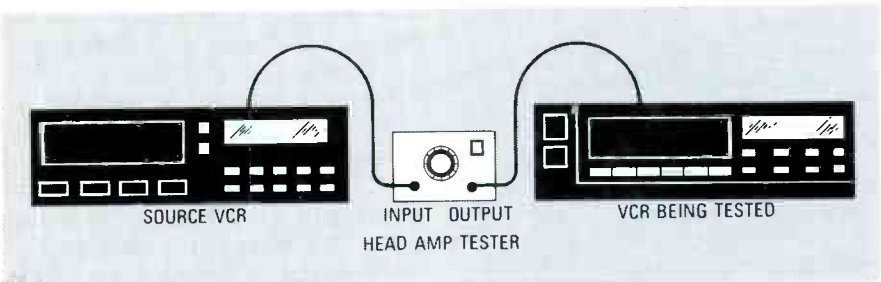


FIG. 1—THE VIDEO HEAD-AMP TESTER enables you to use a good signal from a working VCR to test a VCR with possible head problems.

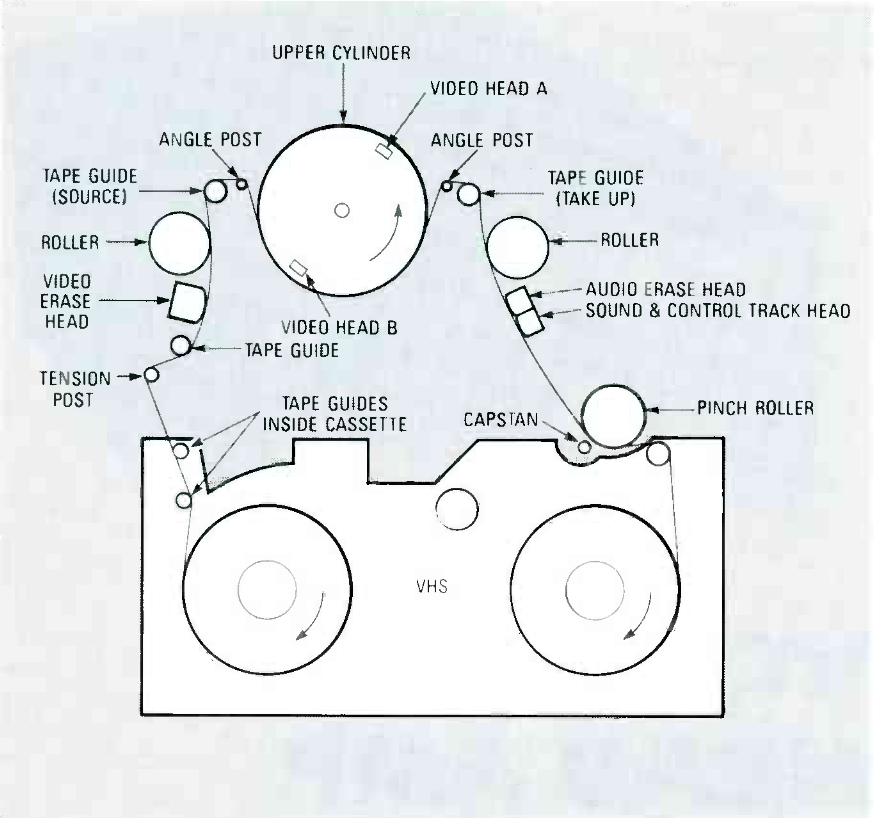


FIG. 2—VHS BASIC MECHANISM. Two video heads are needed to generate the standard VHS format. The two heads are mounted 180 degrees apart on a polished aluminum cylinder that spins counter-clockwise at 30 rpm.

electronic head switch (see Fig. 3). The head-switching circuit combines the outputs from each head pre-amp, by switching to the head which is in contact with the tape at that time. The head-switching control pulse is a 30-Hz square wave derived from the rotation of the head-cylinder motor. The output envelope (waveform *d*) is the sum of the two individual head pre-amp envelopes (waveforms *a* and *b*).

If the head-switching pulse is not present, or if it's distorted or inverted in phase, the symptoms will be similar to bad heads or a bad pre-amp. Some examples of bad waveforms are shown in Fig. 4. Waveforms *a* to *d* are caused by mechanical misalignment of the tape guides, and the waveforms in *e* and *f* indicate proper alignment, but show a problem with the video heads, pre-amps, or head switcher.

PARTS LIST

All resistors are ¼-watt, 5%, unless otherwise indicated.
R1, R4—100,000 ohms
R2—220,000 ohms
R3—10,000 ohms, audio-taper potentiometer
R5—150,000 ohms
R6—2200 ohms
R7—1000 ohms
Capacitors
C1, C3, C4—0.001 µF, ceramic disc
C2—39 pF, ceramic disc
Semiconductors
LED1—red light-emitting diode
Q1, Q2—2N2222 NPN transistor
Other components
J1, J2—RCA-type jack
S1—SPST on/off switch
Miscellaneous: Coaxial cable, PC board, metal case, solder, etc.

Head-amp tester circuitry

The schematic for the tester is shown in Fig. 5. The input is an RF envelope from a working VCR, applied to Q1 through coupling-capacitor C1. Q1 is connected as an emitter follower, with a high-impedance input and a low-impedance output, and a voltage gain of 1.

Potentiometer R3 is used as the emitter load for Q1 and level control for the signal applied to Q2. Capacitor C2 is for improving the frequency response of R3. Transistor Q2 is also a 2N2222, wired in the same configuration as Q1, but with a lower output impedance in order to drive circuits in the VCR under test. The circuit draws only 12 mA, so a 9-volt battery is well suited for the project.

Construction

The circuit should be built on a PC board, because RF as high as 4.5 MHz will be present. A single-sided board was used in the author's prototype with no problems. The board layout is very simple and can be drawn by hand directly on the copper with an etch-resist pen. See Fig. 6 for a parts-placement diagram; a foil pattern is provided in PC Service.

The assembled circuit should be mounted in a shielded box and coaxial leads should be used for input and output. Keep the lead length as short as possible (2-foot leads were used on the prototype with no problems).

Checkout

After assembly, check the voltages on Q1 and Q2, and the current draw, to verify proper circuit operation. Connect the VCR to be used as the signal

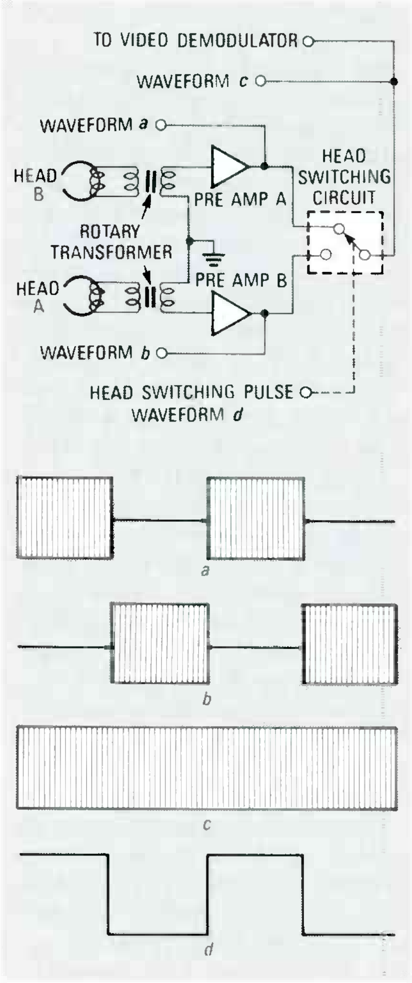


FIG. 3—EACH HEAD HAS ITS OWN PRE-amp, and the output of each one goes to an electronic switch that combines the outputs from each head pre-amp.

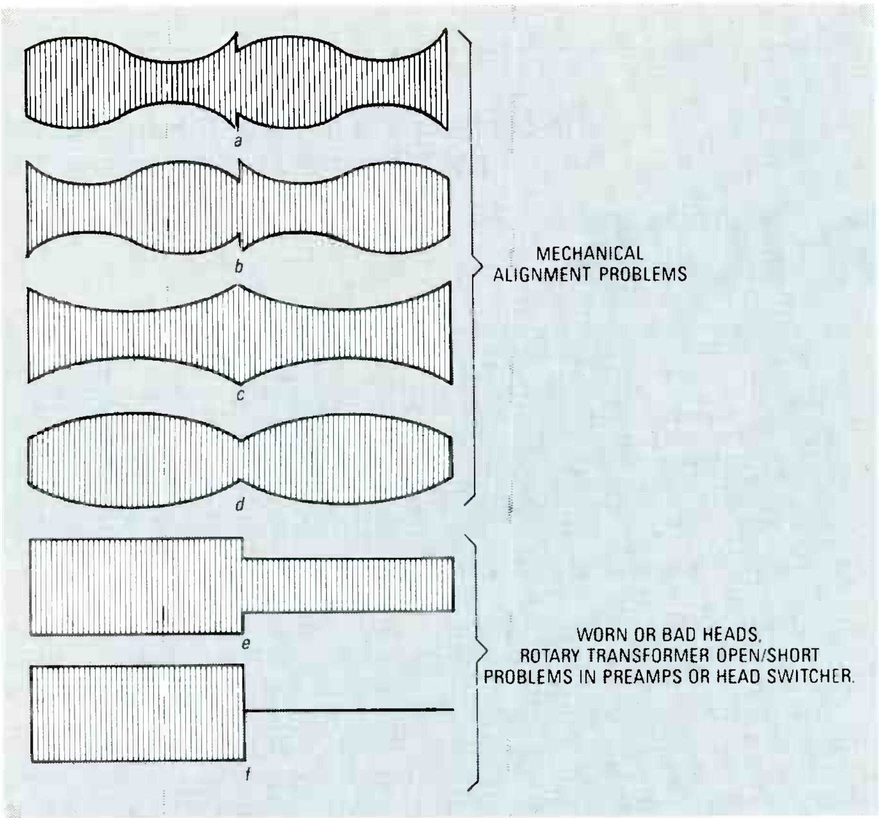


FIG. 4—IMPROPER WAVEFORMS. Waveforms *a–d* are caused by mechanical misalignment of the tape guides. The waveforms in *e and f* indicate proper alignment, but show that there's a problem with either the video heads, pre-amps, or head switcher.

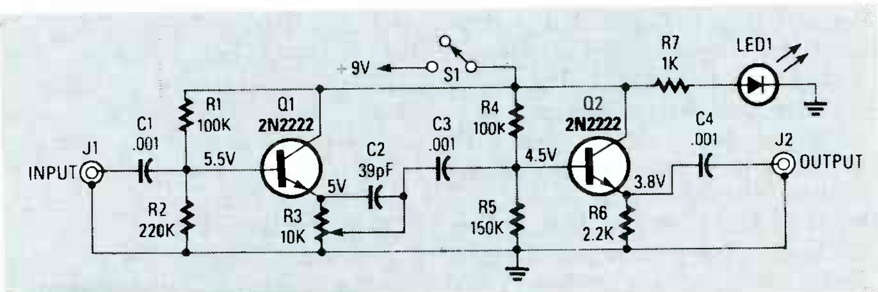


FIG. 5—THE SCHEMATIC for the head-amp tester.

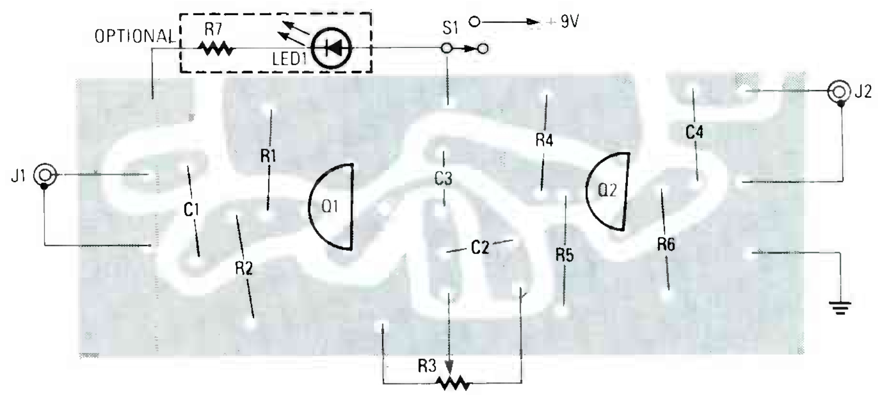


FIG. 6—PARTS-PLACEMENT DIAGRAM. Use the foil pattern provided in PC Service to make your own board.

source to a TV or monitor, and play a tape to use as the test signal; it can be a test pattern, or a home-made recording of the news or some other show. Use an oscilloscope to check out the head RF envelope (Fig. 3-*c*), from the source VCR for proper flatness. The RF envelope should be between 100- and 500-mV p-p in most VCR's.

Now turn on and connect the head-amp tester to the source VCR at the same point in the circuit that you measured the RF envelope (Fig. 3-*c*) with the oscilloscope. There may be a slight amount of signal degradation but if the entire picture disappears, it is loading down the source and the output signal will be unusable.

Check the output signal of the head-amp tester with the oscilloscope; it should be the same amplitude as the input signal with the level control at maximum. The output should be 0-V with the level control at minimum.

Using the tester

To substitute a signal in place of bad or questionable video heads, first put the source VCR into play, connect the head-amp tester, and adjust the output for 5–10-mV p-p. Put the VCR to be tested into play with a blank tape, and connect the output of the tester to the input of one of the head amps. That may be done at the connector end of the cable between the rotary transformer and the head amps. You can also capacitively inject the signal by clipping the output lead over the insulation of a non-shielded wire (no electrical connection), and increasing the output level to about ½ to ¾ of maximum. Signals can also be injected into the input and output of the head switcher. The output level should be high and direct electrical connections should be made.

The rotary transformer (one that can couple a signal from a rotating drum to the rest of the circuitry) can be tested with the VCR under test in "stop" mode, but the source VCR must be in "play" to supply a signal. Connect the output lead directly across one head at a time, and measure the output at the pre-amp input connector. You should disconnect the pre-amp connector from the pre-amps if possible. The signal from the rotary transformer should be equal or greater in voltage than the applied signal voltage. Test each head and the corresponding transformer winding.

The head-amp tester is not going to replace any major test equipment, but it does help you to troubleshoot some problems. And, after all, why wouldn't you want all the help you can get? **R-E**

CIRCUITS

AUDIO PRE AMP IC'S

An in-depth look at National Semiconductor's LM38X series of audio preamp IC's.

RAY M. MARSTON

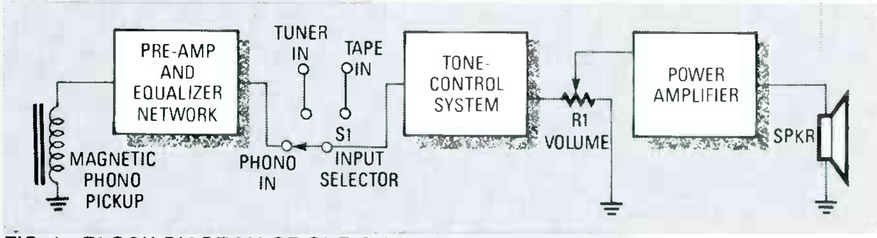


FIG. 1—BLOCK DIAGRAM OF ONE CHANNEL of a stereo system.

ONE OF THE MOST VERSATILE SERIES OF linear preamp IC's is the LM38X versions from National Semiconductor. They're extremely useful for audio and tone-control applications, and have excellent ripple rejection, low signal distortion, wide bandwidth, and low noise. You'll find them in virtually any modern piece of audio gear. This discussion will investigate how they work, and look at several useful applications.

The LM38X IC's

Figure 1 shows a representative block diagram of a conventional stereo system channel with both volume and tone control. National Semiconductor produces five low-noise dual preamps in the LM38X series, the LM381, LM381A, LM382, LM387, and LM387A; the "A" denotes versions with superior noise figure performance. Figures 2–4 show the configurations of the three different versions for one of the two amplifiers in each *D*ual-*I*nline *P*ackage (DIP), while Table 1 gives a performance summary.

Tone control may involve refinements like "scratch" and "rumble" filters. All five IC's in the LM38X family use single-ended power supplies, and have the same basic amplifier circuitry, but differ in internal details and pinouts. Also, all five have internal compensation, power-supply decoupling and regulation, large capacity for output-voltage swing, and wide power bandwidth. They'd be used for both the preamp and tone-control blocks in Fig. 1, since both functions occur prior to power amplification. The differences are:

- The LM381 and LM381A, shown in Fig. 2, allow external noise figure optimization and compensation (narrow-band or low-gain use). They're normally used differentially, but can be used single-ended for ultra-low-noise purposes.
- The LM382, shown in Fig. 3, doesn't provide for external compensation or single-ended operation, but has a built-in resistor matrix to let the user select from among several closed-loop gain and frequency-response options.
- The LM387 and LM387A, shown in Fig. 4, are utility versions of the LM381/1A, with only the input and output terminals accessible, and no provision for external compensation or single-ended operation.

LM381/1A basics

All the IC's in the LM38X family can be understood by examining the

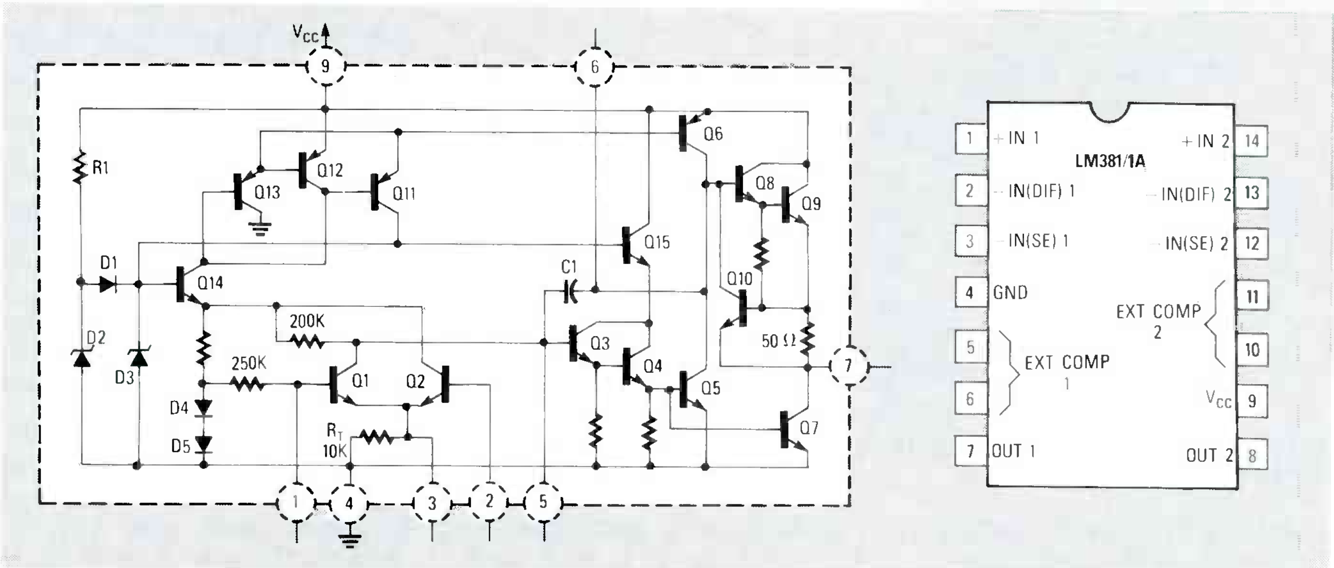


FIG. 2—THE LM381/1A DUAL LOW-NOISE PREAMP.

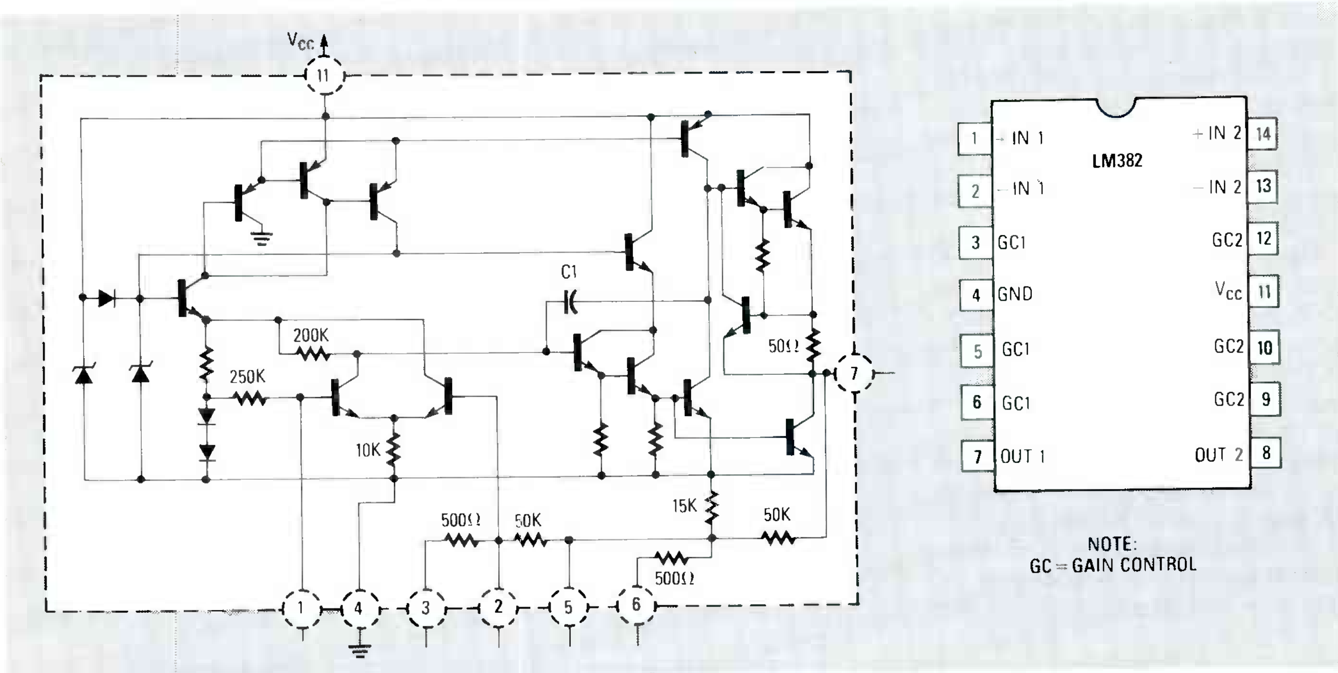


FIG. 3—THE LM382 DUAL LOW-NOISE PREAMP.

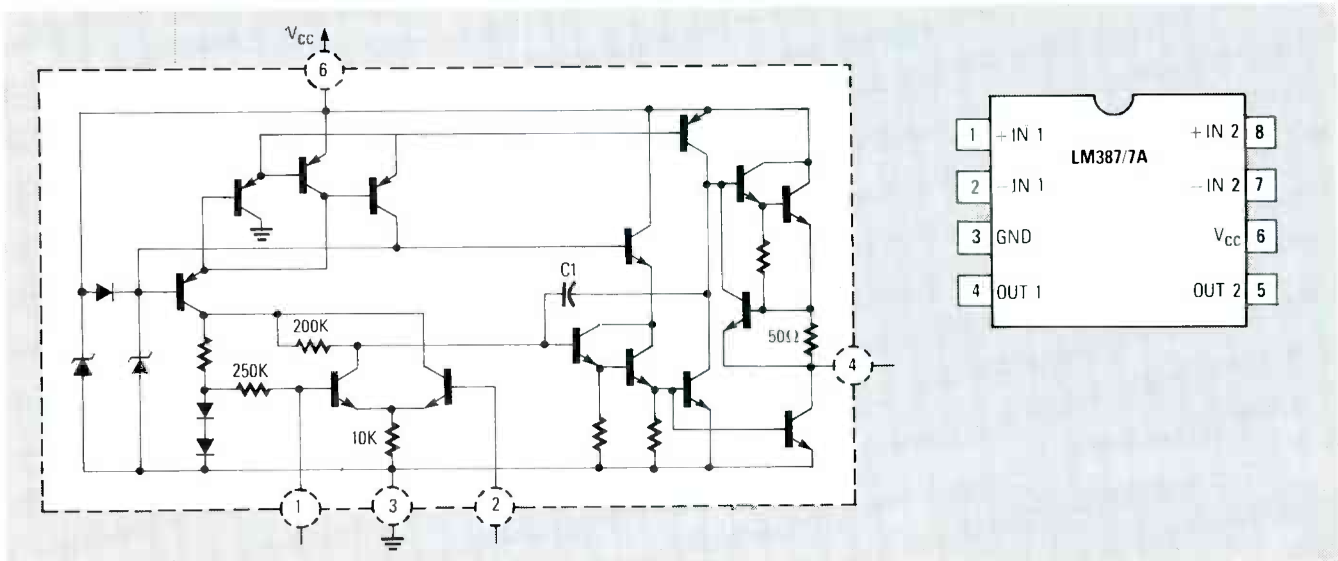


FIG. 4—THE LM387/7A DUAL LOW-NOISE PREAMP.

LM381/1A shown in Fig. 2. It has a first stage (Q1 and Q2), second stage (Q3–Q6), output stage (Q7–Q10), and bias network (Q11–Q15); Fig. 5 shows a simplified equivalent. The first stage is biased at 1.2 volts via R1, and can be operated either differentially or single-ended, although differential operation generates 41% more noise.

In differential use, the first stage has to be balanced by externally biasing the base of Q2 at 1.2 volts. In single-ended mode, Q2 has to be turned off by grounding its base, and Q1 has to be balanced by externally biasing the emitter of Q2 at 600 millivolts. The first stage has a differential voltage gain of 80, or 160 when used single-ended.

The second stage uses common-emitter Q5 and constant-current load Q6, and is driven by Q1 via Darlington emitter follower Q3-Q4. Its voltage gain is 2000, and it's internally compensated via C1 for unity gain at 15 MHz, giving stability at closed-loop gains of 10 or more. At lower gains, an external capacitor can go in parallel with C1 for compensation purposes.

The output stage uses Darlington emitter follower Q8-Q9, with active current sink Q7. Then, Q10 provides short-circuit protection by limiting output current to 12 mA. The bias network gives 120 dB of supply-signal rejection, and includes the high-impedance constant-current generator Q11-Q12-Q13, which generates ripple-free reference voltage across D3. That reference voltage operates the first two stages via Q14 and Q15, and biases the base of Q1 internally.

Differential operation

In differential mode, the IC output is given a positive quiescent value independent of supply-voltage variations, by connecting divider R1-R2 as a DC negative-feedback loop, as shown in Fig. 6. The inverting input is biased internally at 1.2 volts. When R1 and R2 are used as in Fig. 6, DC negative feedback makes the non-inverting input go to 1.2 volts, and the amplifier output to 1.2 volts × [1 + (R1/R2)]. In practice: R2<250K.

Figure 7 shows a non-inverting AC amplifier with an input impedance of 250K; input signals must be limited to 300 mV RMS to avoid distortion. The DC voltage gain is determined by R1 and R2, while the desired AC gain is set by AC shunting one of the bias resistors. Here, the DC gain is fixed by R1 and R2 at less than 10, but the AC gain is fixed by R1 and R3 at 100.

That shunting technique can be expanded for frequency-dependent AC gain in various filter applications. Figure 8 shows the same amplifier configuration used as a low-noise phono preamp with *R*ecording *I*ndustries *A*ssociation of *A*merica (RIAA) equalization, while Fig. 9 shows a similar tape-playback amplifier with *N*ational *A*ssociation of *B*roadcasters (NAB) equalization. Figure 10 shows an inverting AC amplifier; here, the non-inverting terminal is grounded, and the input signal is fed to the inverting terminal via R1. The AC gain is R3/R2 = 10, the quiescent output is +12 volts, and the input impedance is about R1. Figure 11 shows a unity-gain, 4-input audio mixer.

TABLE 1—PERFORMANCE OF THE LM381/1A/2/7/7A LINEAR IC'S

Characteristic		LM381	LM381A	LM382	LM387	LM387A
Supply Voltage (VDC)		9-40	9-40	9-40	9-30	9-40
Quiescent Current (mA)		10	10	10	10	10
Power Bandwidth (kHz)*		75	75	75	75	75
Supply Rejection Ratio (dB at 1 kHz)		120	120	120	110	110
Equiv. Noise Input Figure (μV RMS)	Typ.	0.5	0.5	0.8	0.8	0.65
	Max.	1.0	0.7	1.2	1.2	0.9

* NOTE: Power bandwidth is the audio frequency range over which an amplifier can produce half of its rated power, without exceeding its rated distortion. It indicates how much power is available at the critical high and low frequencies, and the wider the power bandwidth, the better the amplifier.

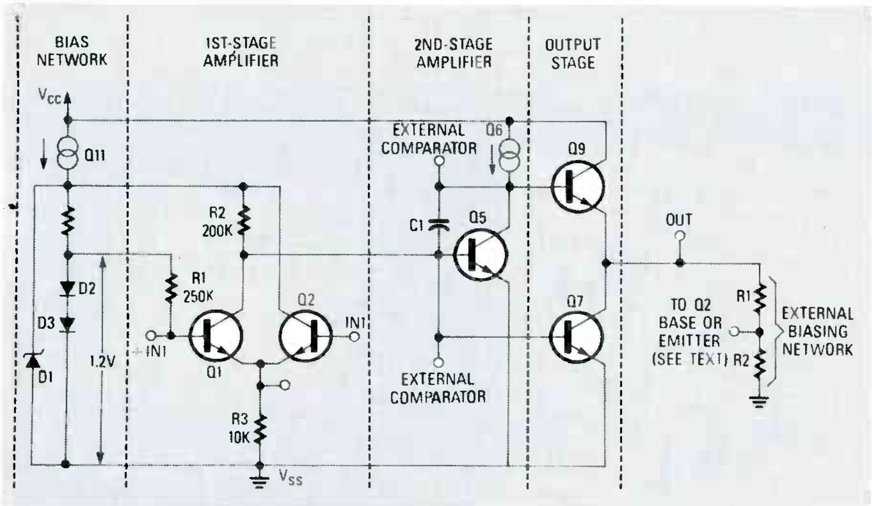


FIG. 5—EQUIVALENT CIRCUIT OF THE LM381/1A amplifier.

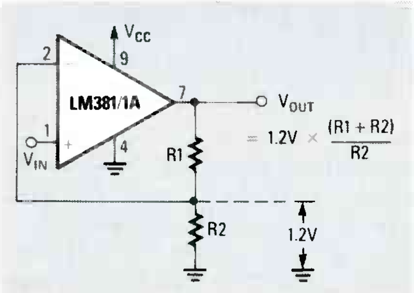


FIG. 6—DIFFERENTIAL BIASING OF THE LM381/1A.

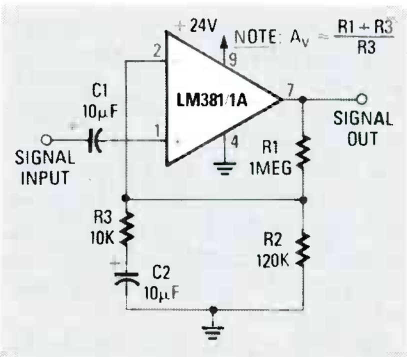


FIG. 7—A LOW-NOISE LM381/1A non-inverting amplifier, with a gain of 100.

Single-ended operation

The differential first stage of an LM381 composed of Q1-Q2 is powered via the internal 5.6-volt regulator, and the collector of Q1 is fed to the output via a DC amplifier. The IC can be operated in single-ended mode by grounding the base of (and disabling) Q2, but it needs to be biased

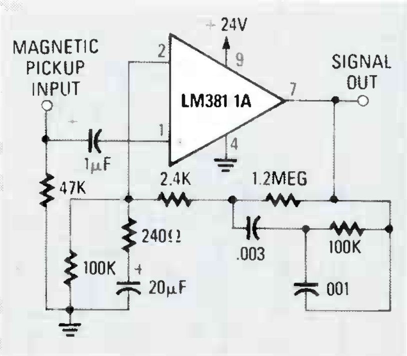


FIG. 8—AN LM381/1A USED AS A low-noise phono preamp with RIAA equalization.

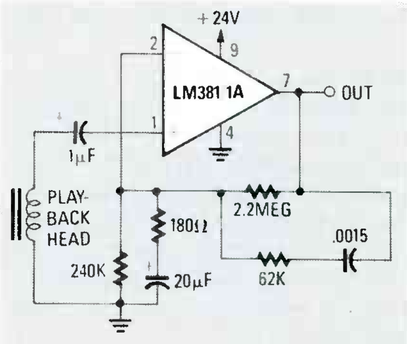


FIG. 9—AN LM381/1A used as a tape playback amplifier with NAB equalization.

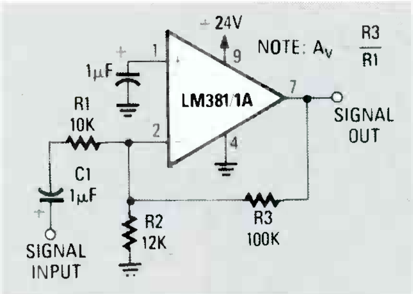
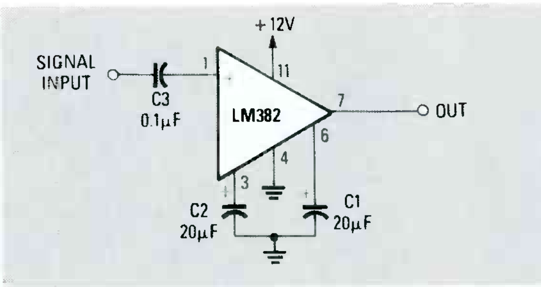


FIG. 10—THIS LM381A low-distortion (less than 0.05%) inverting amplifier has a gain of 10.



GAIN	REQUIRED CAPACITOR
40dB	C1 ONLY
55dB	C2 ONLY
80dB	C1 AND C2

FIG. 14—AN LM382 FIXED-GAIN non-inverting amplifier with a 12-volt power supply.

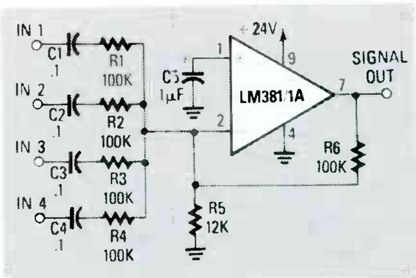


FIG. 11—THE LM381/1A is used here as a 4-input unity-gain audio mixer.

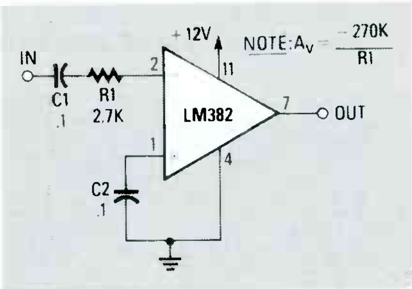


FIG. 15—THE LM382 is used here to make a 40-dB inverting amplifier.

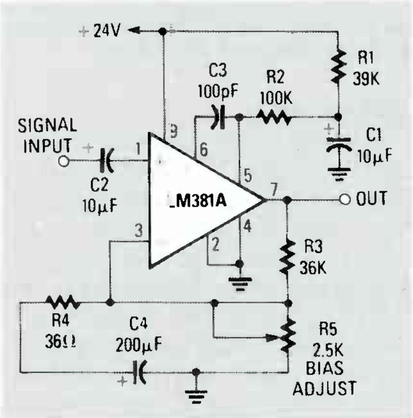


FIG. 12—THIS LM381A ultra-low-noise preamp has a gain of 1000.

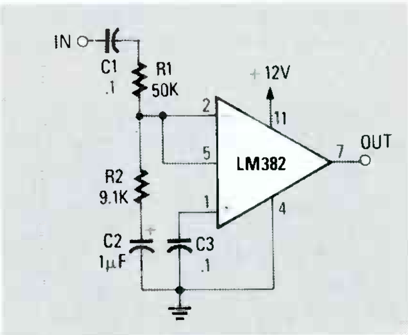


FIG. 16—SHOWN HERE IS AN LM382 unity-gain inverter.

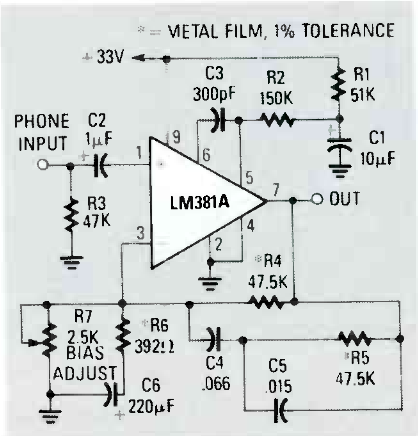


FIG. 13—LM381A ULTRA-LOW-NOISE magnetic phono preamp that includes RIAA equalization.

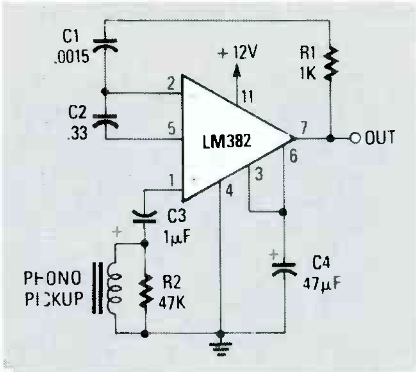


FIG. 17—LM382 phono preamp with RIAA equalization.

using emitter feedback.

Suitable DC biasing is obtained by connecting a voltage divider that applies 600 millivolts to pin 3 when the IC output is at the desired DC level. If a quiescent +12-volt output is needed, the divider needs a DC voltage gain of 20.

In practice, the noise from the input transistor varies with collector current, and is minimized at 170 µA.

A single-ended LM381 is intended for non-inverting use only, with a typical input impedance of 10K. Ideally, input signals should have source impedances below 2K, and all resistors should be of the low-noise, metal-film variety. Figure 12 is an ultra-low-noise version with a gain of 1000, where C3 limits the upper 3-dB frequency response to 10 kHz, and R5 adjusts the DC output voltage to half-supply value. Figure 13 is a magnetic phono preamp circuit that uses RIAA equalization, with the DC output voltage set by R7.

LM382 circuits

The internal circuitry of each half of a LM382 is identical to a LM381, except for a 5-resistor matrix and elimination of certain terminal connections. Eliminating those terminals means that an LM382 can't be used single-ended or externally compensated. The resistor matrix greatly simplifies bias- and filter-network design. The matrix is specifically intended for applications where the IC is powered from a +12-volt supply. Figures 14–17 show various ways to use the LM382 with a +12-volt supply. Figure 14 shows a non-inverting amplifier with 40, 55 or 80 dB of AC gain. Figure 15 shows an inverting amplifier with 40 dB gain, Fig. 16 shows a unity-gain inverting amplifier, and Fig. 17 shows a phono preamp with RIAA equalization.

LM387 circuits

The internal circuitry of each half of a LM387/7A is identical to an LM381, except for eliminating certain terminal connections, letting the IC be used differentially without external compensation. The IC is nevertheless quite versatile, and Figs. 18–24 show some practical applications. Figure 18 shows how to connect an LM387 as a non-inverting amplifier with an AC gain of 52 dB. The DC gain and quiescent output voltage of the amplifier circuit are determined

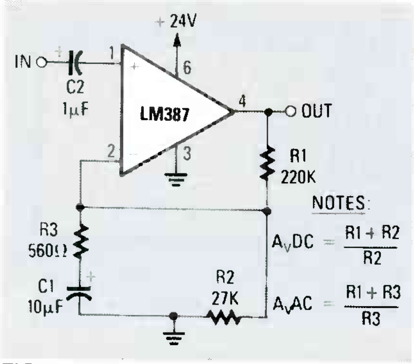


FIG. 18—LM387 NON-INVERTING AC amplifier with a gain of 52 dB.

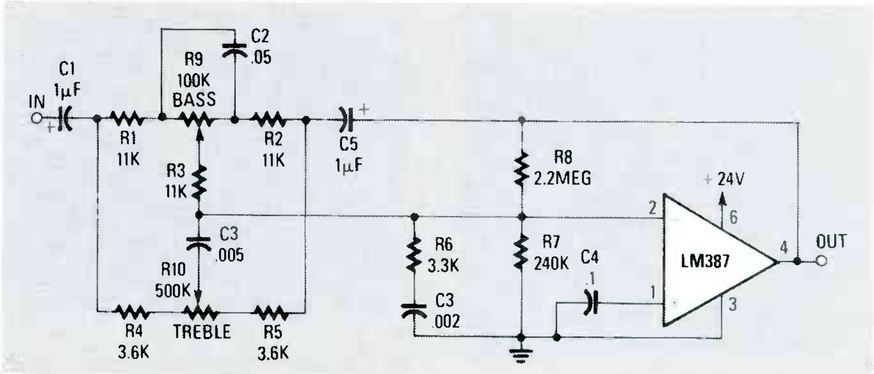


FIG. 21—THE LM387 CAN BE USED TO MAKE an active tone-control circuit.

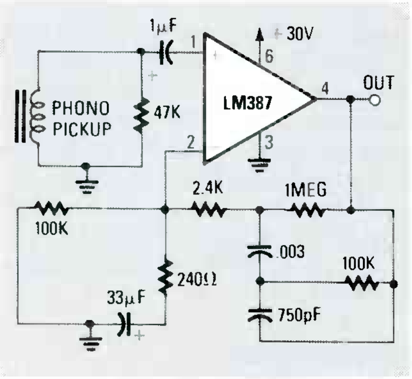


FIG. 19—LM387 PHONO PREAMP with RIAA equalization.

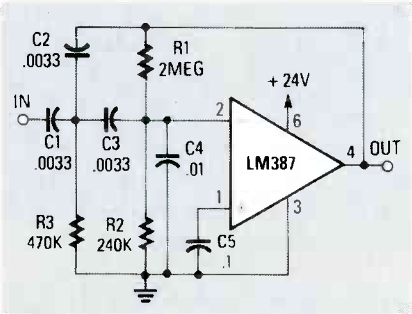


FIG. 22—AN LM387 USED AS A "rumble" filter.

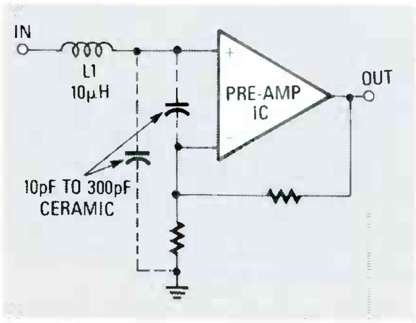


FIG. 25—THE CIRCUIT SHOWN HERE can be used to eliminate RF pickup.

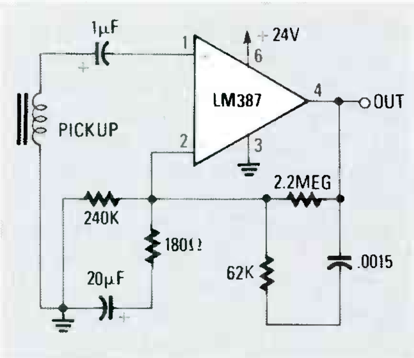


FIG. 20—AN LM387 USED AS a tape playback amplifier (NAB).

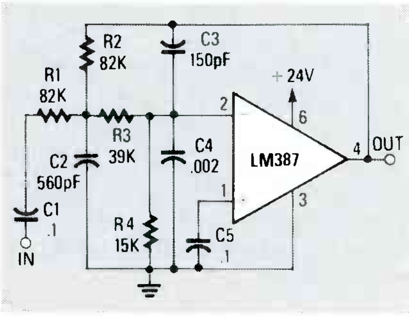


FIG. 23—AN LM387 USED AS A "scratch" filter.

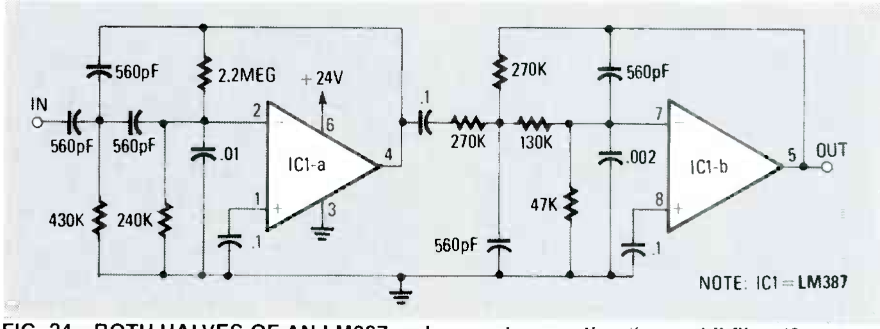


FIG. 24—BOTH HALVES OF AN LM387 make up a two-section "speech" filter (300 Hz–3 kHz).

by R1 and R2, and the AC gain by R1 and R3. Figure 19 shows an LM387 used as a phono preamp with RIAA equalization, while Fig. 20 shows how it can be used as a NAB tape playback amplifier for use in all kinds of devices ranging from cassette players to telephone-answering machines.

Figure 21 shows an active tone control giving unity gain with its controls in the "flat" position, or 20 dB of boost or rejection with the controls fully rotated. The "rumble" filter of Fig. 22 is a 2nd-order high-pass active filter that rejects signals below 50 Hz at 12 dB/octave. Figures 23 and 24 show various ways of using an LM387 in inverting mode in active filters. The "scratch" filter of Fig. 23 is a 2nd-order low-pass filter that rejects signals above 10 kHz. The "speech" filter of Fig. 24 consists of a 2nd-order high-pass and a 2nd-order low-pass filter in series, to give 12 dB/octave rejection to signals outside 300 Hz–3 kHz.

Usage hints

This article has examined various circuits using the LM38X linear IC's. These are high-gain, wide-band devices, and some care must be taken if they're to work. The two most frequent problems are RF instability and RF pickup. The former, RF instability, is usually caused by inadequate high-frequency power supply decoupling. In all preamps, the IC power supply has to be RF-decoupled by wiring a 0.1 μF ceramic or 0.001 μF tantalum capacitor across the IC power pins. The latter, RF pickup, manifests itself as AM demodulation. It can usually be eliminated with a 10-μH RF choke in series with an IC's input terminals, or by also decoupling the input with a capacitor, as in Fig. 25. R-E

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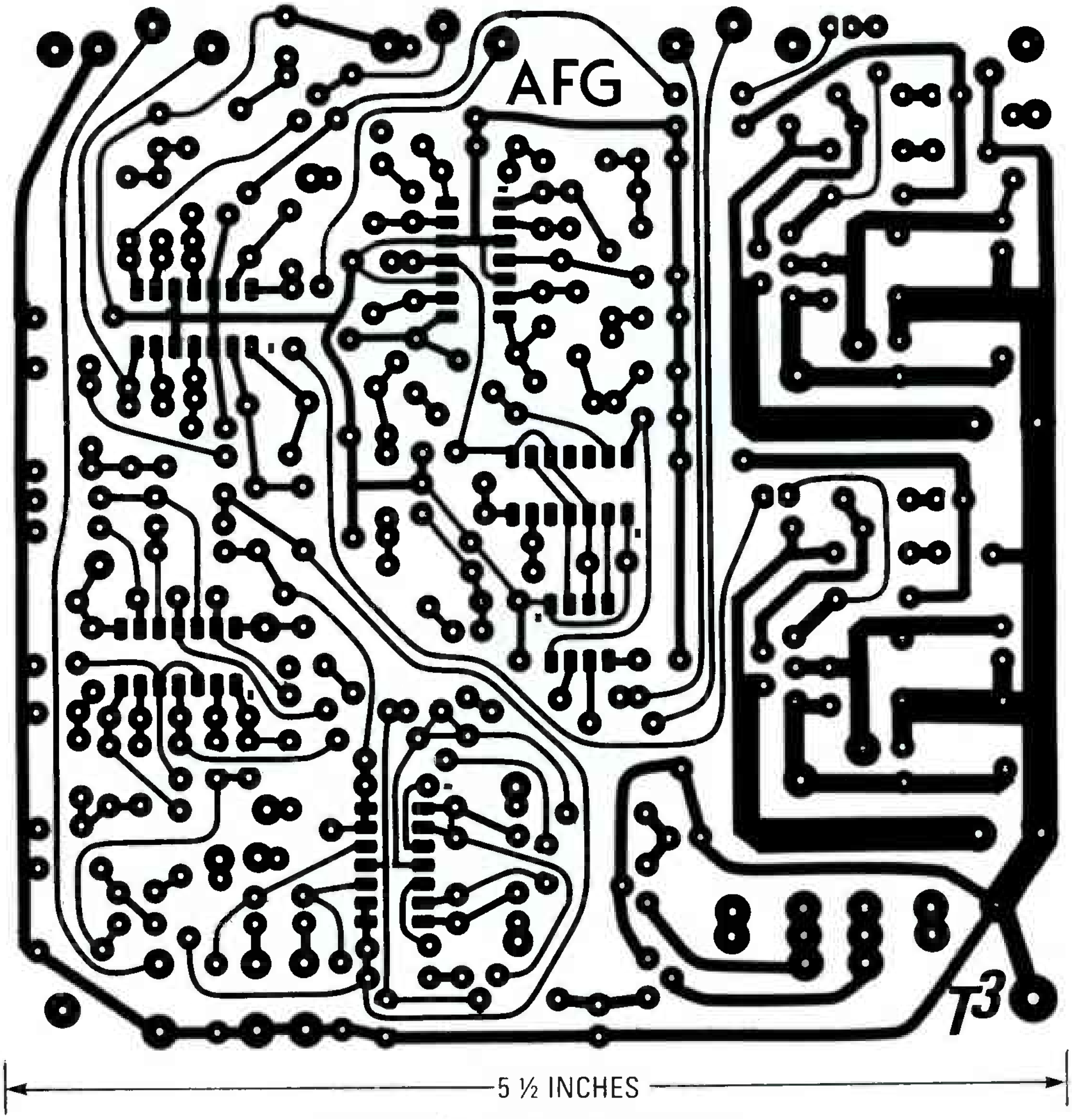

ACOUSTIC FIELD GENERATOR foil pattern.

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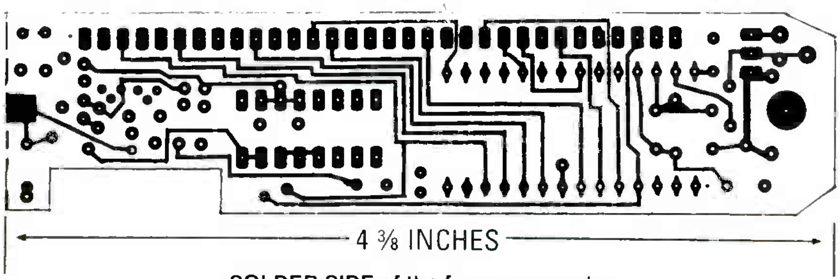
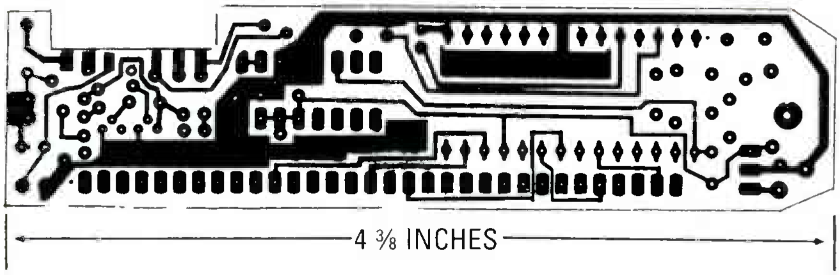
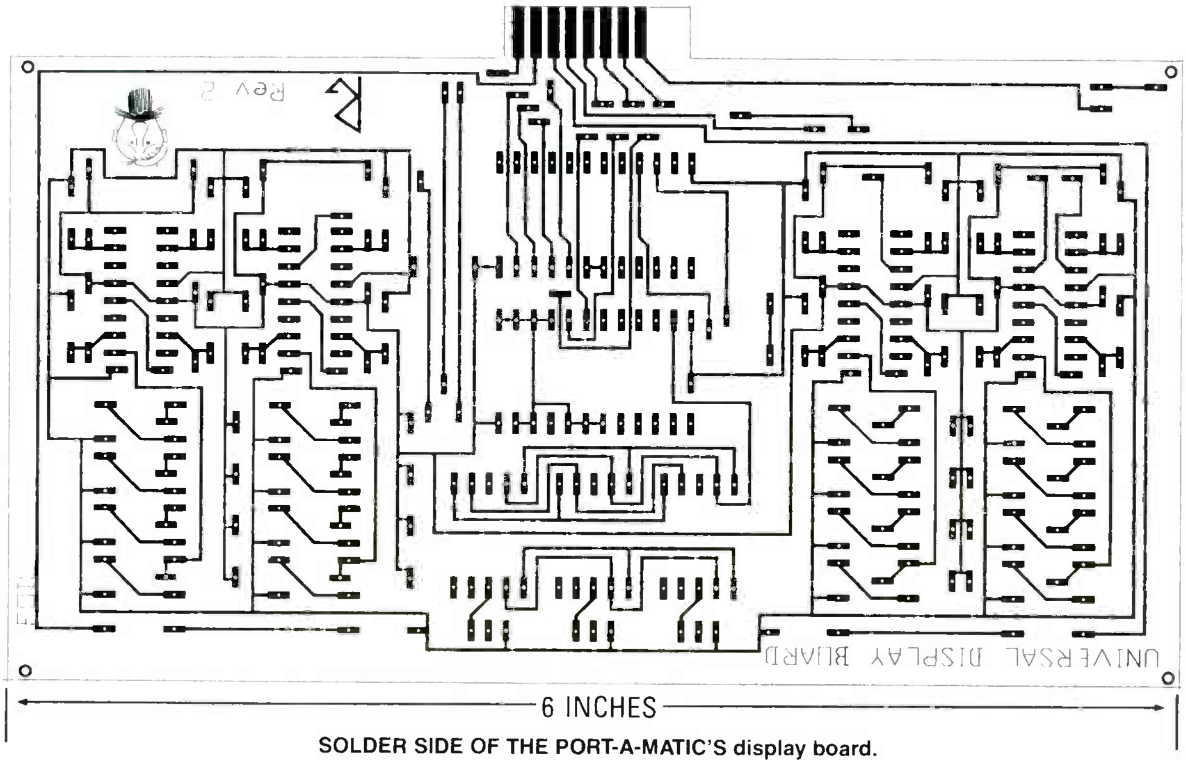


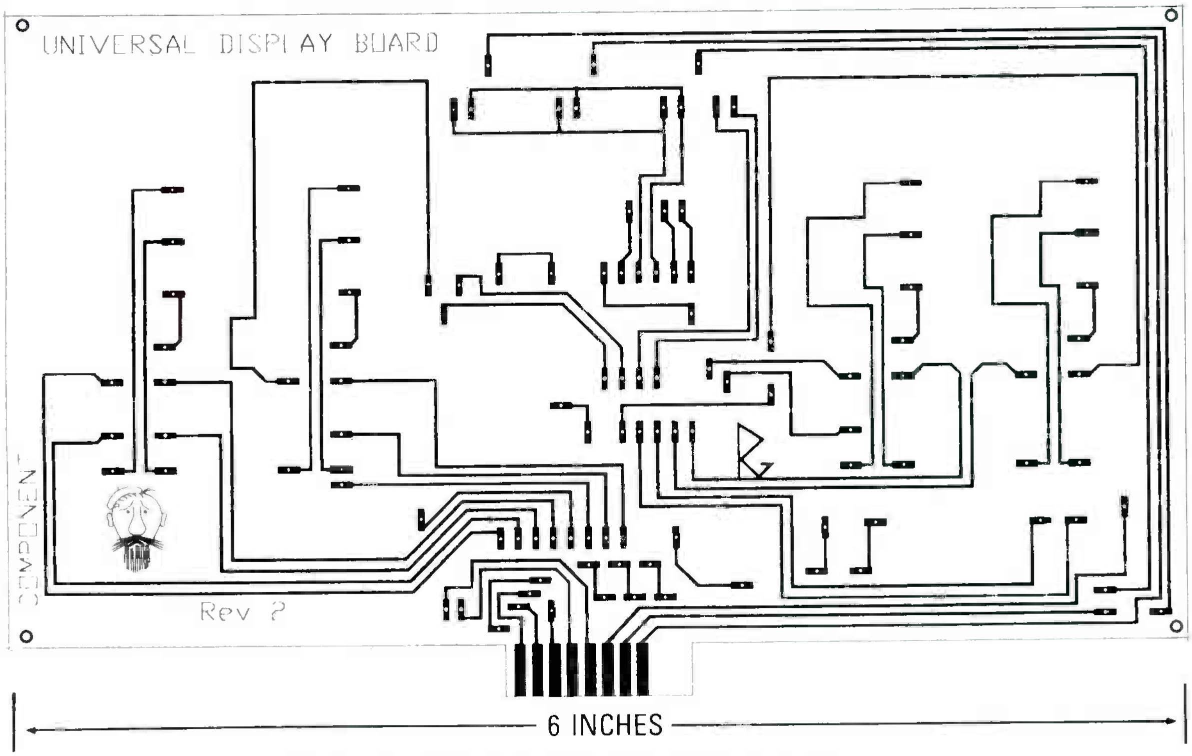
SOLDER SIDE of the frequency probe.



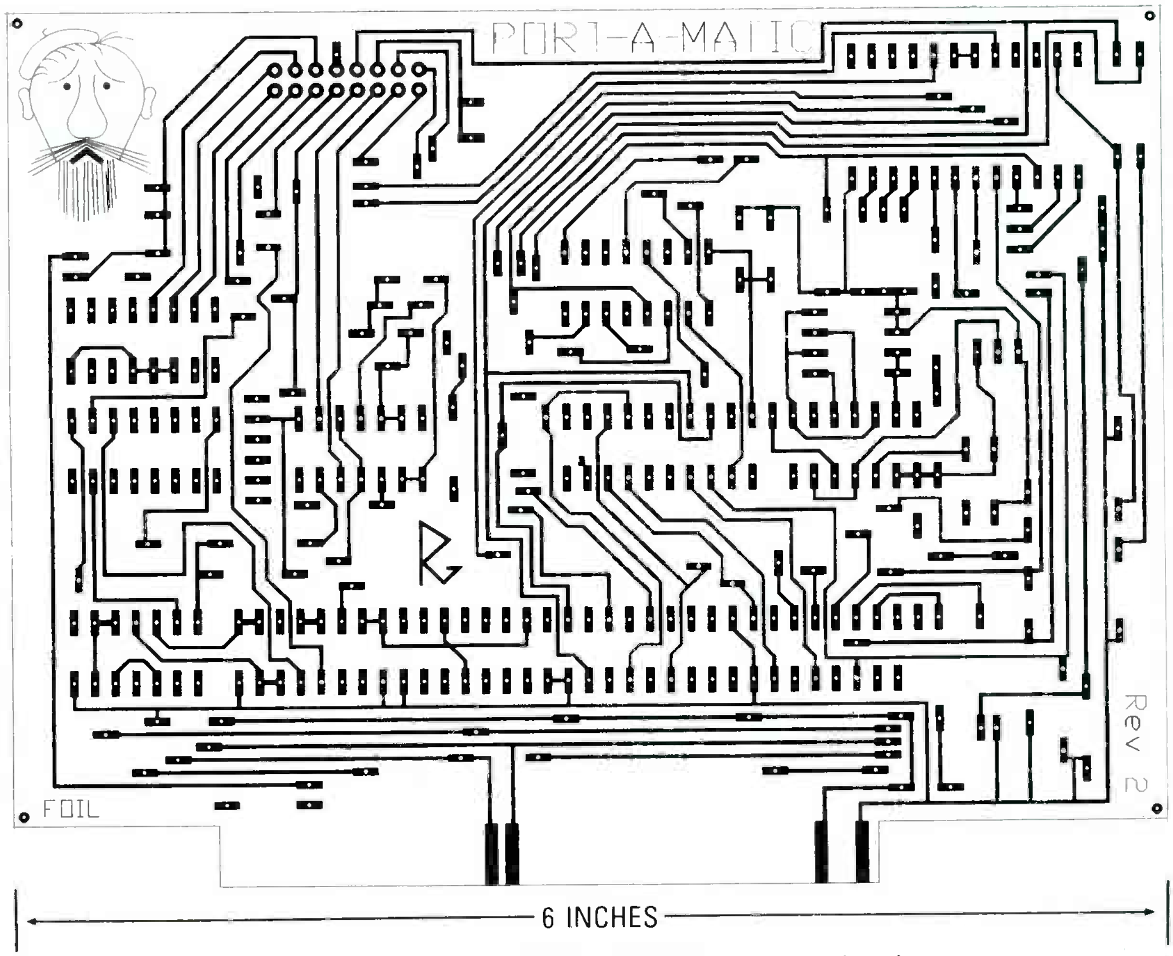
COMPONENT SIDE of the frequency probe.



SOLDER SIDE OF THE PORT-A-MATIC'S display board.



COMPONENT SIDE OF THE PORT-A-MATIC'S display board.



SOLDER SIDE OF THE PORT-A-MATIC'S bus-interface board.

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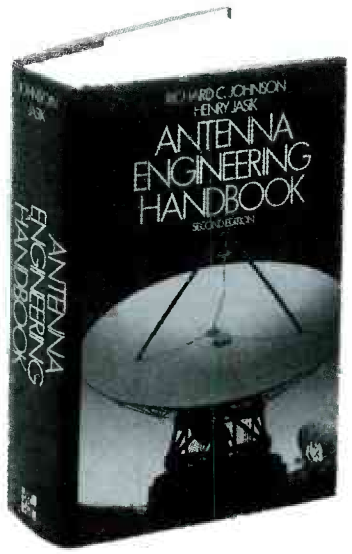

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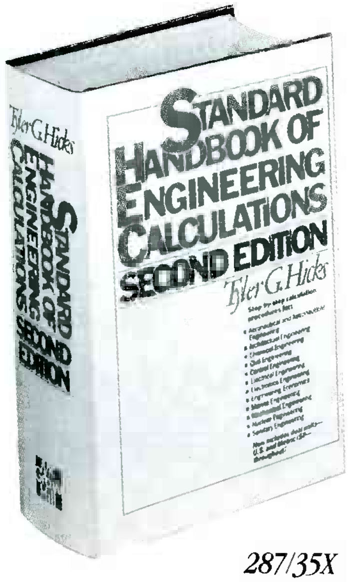

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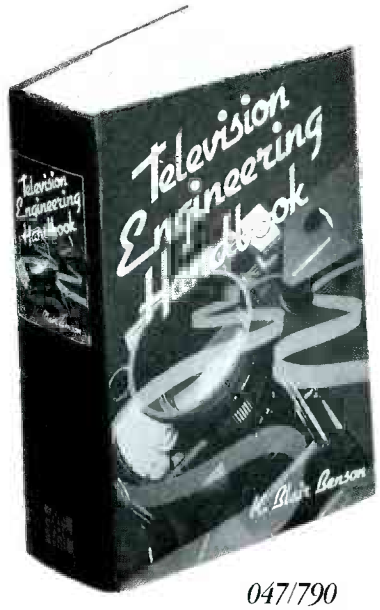

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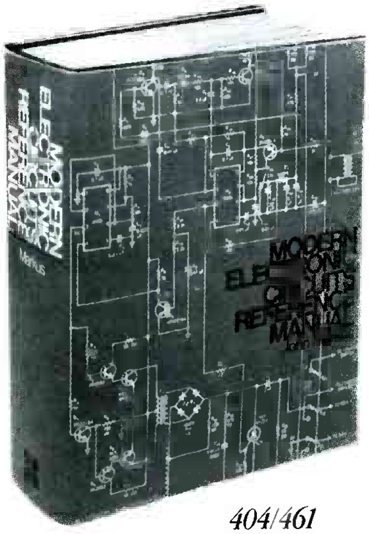

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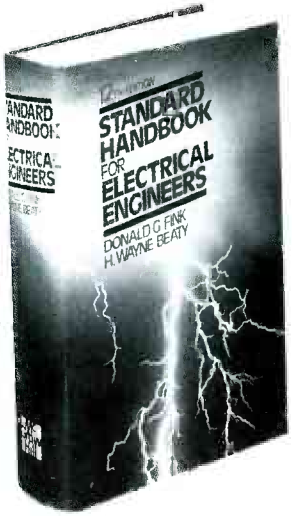

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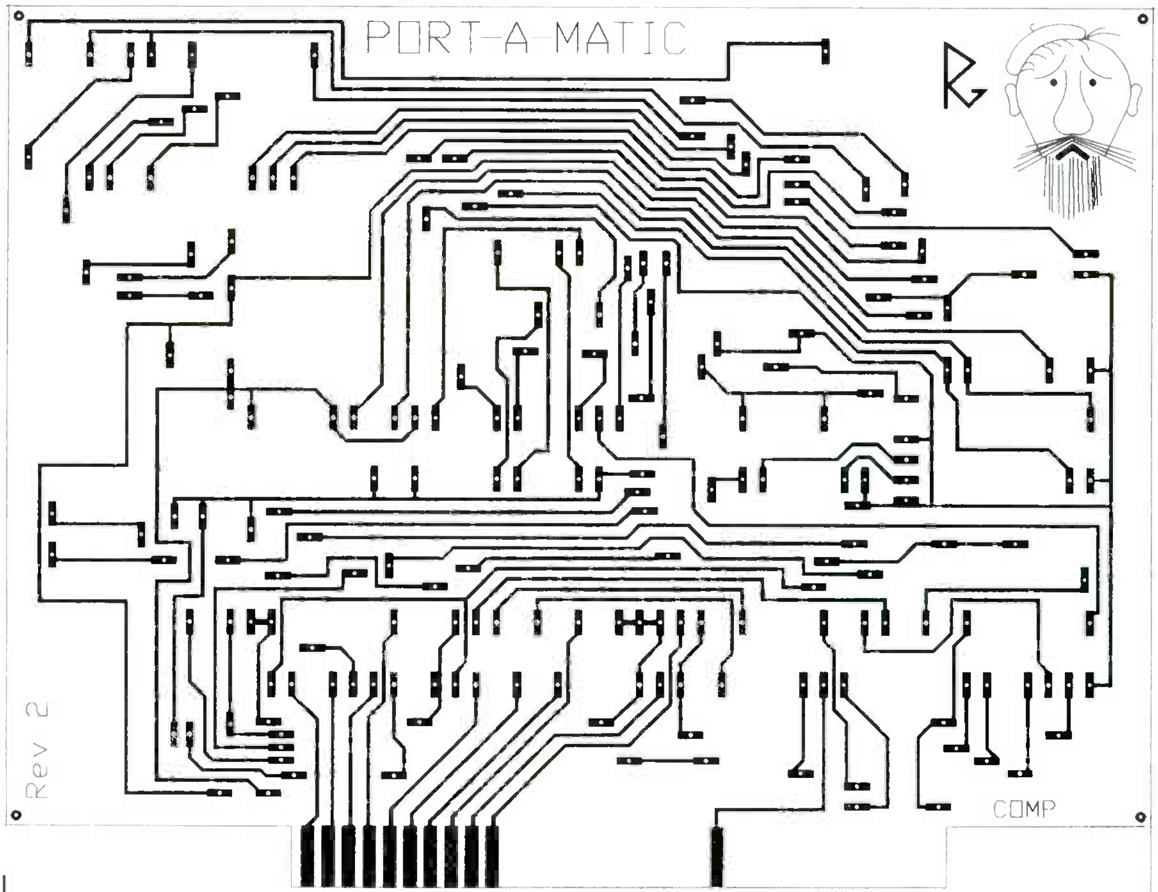

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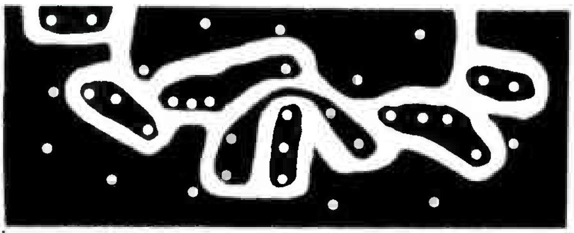

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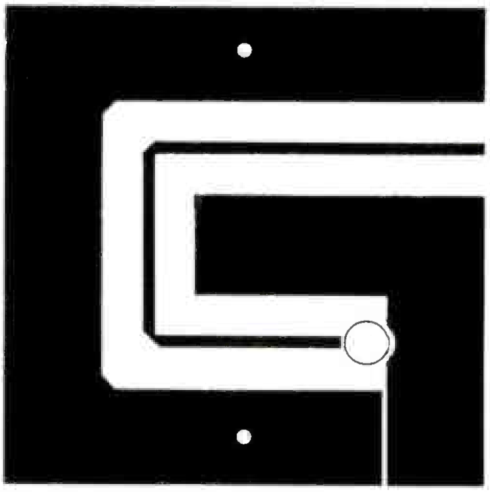

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HARDWARE HACKER

Dew sensor circuits
Direct toner pc update
Hacker cold fusion kits
Midnight Engineering mag
Alarm & security resources

Cold-fusion papers and kits

DON LANCASTER

THERE'S LOTS OF EXCITING NEWS THIS month, including cold-fusion kits, an update on the direct-toner printed-circuit process, a major new hacker magazine, and some details on unusual dew-sensor components. So, let's just jump right on in...

Cold fusion kits

There seems to be lots of good news on the cold-fusion front these days. At a recent conference, several more independent researchers confirmed those excess heat production effects, verified expected nuclear byproducts, and made lots of similar supporting observations.

See the October 27th, 1989 *Science* on page 449 for a good summary. The key sentence: "The experimental evidence for cold fusion, or at least some unknown nuclear phenomenon, is too great to ignore."

At the same time, many of those earlier measurements and experiments have been made far more precise, and many possible error sources seem to have been eliminated. In particular, tighter control experiments involving non-deuterium and non-reacting cells have been carried out to the satisfaction of several prominent skeptics. The general feeling seems to be that something really is happening here. And the most reasonable explanation for that something is that cold fusion is actually taking place, or else some previously unknown nuclear reaction seems to be occurring.

On the other hand, the excessive energy production is still very erratic, rather low, and highly unpredictable. Tremendous quantities of time and effort are usually required under extremely careful conditions to get any observable results at all.

There's been two major cold-fusion developments this month that should be of major hardware hacking interest. The first is that all of the key fusion papers are now readily available, and the second is that you can now get your own low-cost ($27) experimental cold-fusion kit.

By the time you read this, over a hundred key cold-fusion papers should be available by way of that *Dialog Information Service* that you will find through your local library. Figure 1 should get you started. I've listed two dozen earlier papers, gotten through the *INSPEC* service within *Dialog*.

The costs of generating your own complete and up-to-date cold-fusion abstract listing should be around $35, and should take twenty minutes.

As a reminder, the best sources for current info on cold fusion are in the *News and Comments* section found in *Science* magazine, and the *Technology* section that is usually found on page B-4 of your *Wall Street Journal*.

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On to those kits: Guy Wicker is a name-brand hardware hacker and a well-known energy researcher. By a special arrangement, Guy has offered to put together several cold-fusion minikits for all you **Radio-Electronics** hackers. The kits cost only $25, plus $2 shipping and handling.

As Fig. 2 shows us, the kit consists of a small test tube full of a 0.1-molar deuterium and lithium hydroxide solution, a short piece of 50-mil palladium rod, and a small loop of nickel wire. Nickel is used instead of platinum for the anode.

A classic cold-fusion cell is built up something like what you see in Fig. 3. Use a coiled nickel-wire anode, and a nickel suspended palladium-rod cathode. You apply a DC current in the 4 to 20 milliampere range, with positive to the nickel anode and negative to your palladium cathode.

Be sure to carefully monitor your temperatures at several locations. If possible, also monitor for radiation. A "charging" time of several hours or a few days seems normal for that size palladium rod. Look for both a very low level and a separate "burst mode" excessive heat production effects.

Some sort of a continuous temperature recorder, possibly based on a personal computer, is probably a very good idea. You'll want to work inside of a styrofoam block which itself sits inside a picnic cooler or other well-insulated box.

Guy reports that very small cells like that one are far more likely to produce a low-level tritium radiation than excess heat production. Getting both to happen at once when someone is watching is usually frustratingly difficult. It is also the Holy Grail of cold-fusion research.

Some warnings here. Your cell is extremely small and the excess heat production, if any, is likely to be correspondingly tiny. Opportunities of cell contamination are very great. Your odds of your cold-fusion cell working at all are only something like one in ten, and the odds of your being able to observe that operation when and as it occurs is also estimated as around one in ten or so. Thus, your estimated odds are only one in one hundred that you will be able to prove your cell actually works.

So, what we have here appears to be a crap shoot.

On the other hand, here you have a sure fire winner for a science fair entry, show-and-tell, or school report. And the "touchy-feely" and "See what I've got!" aspects of all those kits are completely off scale.

Golly gee, Mr. Science.

Guy also offers fancier cold fusion kits and other products for serious researchers. Contact him

Triple collision reaction of deutrons as a possible explanation of cold fusion
E. Becker, *Naturwissenschaften* (W. Germany), May 1989, Vol 76 #5, pp 214.

Cold fusion in metals
J. Kondo, *Journal of the Physical Society of Japan*, June 89, Vol 58 #56, pp 1869-1870.

Deuterium nuclear fusion in metals at room temperature
P. Tomas, *Fizika* (Yugoslavie), vol 21 #2, 1989, pp 209-214.

Exact upper bound on barrier penetration probabilities for cold fusion
A. Lettitt, *Physics Review Letters*, (USA), Vol 63 #2, 10 July 89, pp 191-194.

Cold fusion: how close can deuterium atoms come inside palladium?
Z. Sun. *Physics Review Letters* (USA), Vol 63 #1, 3 July 89, pp 59-61

Search for fusion reactions between deuterium atoms inplanted into titanium
R. Behrisch, *Nuclear Fusion* (Australia), Vol 29 #7, July 89, pp 1187-1190.

Can solid-state effects enhance the cold-fusion rate?
A. Leggett, *Nature*, (UK), Vol 340 #6228, 6 July 89, pp 45-46.

Upper limits on neutron and gamma ray emission from cold fusion
M Gai, *Nature* (UK), Vol 340 #6228 6 July 89, pp 29-34.

Calculated fusion rates in isotopic hydrogen molecules
S. Koonin, *Nature* (UK), Vol 339 #6227, 29 June 89, pp 690-691.

Search for neutrons during heavy water electrolysis on palladium electrodes
S. Blagus, *Physics of the atomic neculi* (Germany), Vol 333 #3, 1989, pp 321-322.

Search for neutrons from cold nuclear fusion
D. Alber, *Physics of the atomic neculi* (Germany), Vol 333 #3, 1989, pp 319-320.

Screening corrections in cold deuterium fusion rates
K. Langanke, *Physics of the atomic neculi* (Germany), Vol 333 #3, 1989, pp 317-318.

Cold fusion in the solid state?
J. Goedkoop, *Eenergiespectrum* (Netherlands), Vol 13 #6, June 89, pp 156-162.

Nuclear fusion
P. Bullo, *Elettrificazione* (Italy), #5, May 89, pp 57-61.

Neutron emission under particular nonequilibrium conditions
P. Perfetti, *Nuovo Cimento D* (Italy), Vol 11D ser. 1 #6, June 89, pp 921-926.

Theoretical considerations on the cold nuclear fusion in condensed matter
F. Parmigiani, *Nuovo Cimento D* (Italy), Vol 11D ser. 1 #6, June 89, pp 913-919.

Chemical forces associated with deuterium confinement in palladium
J. Mintmire, *Physics Letters A* (Netherlands), Vol 138 #1-2, 12 June 89, pp 51-54.

Cold fusion in condensed matter: is a theoretical description possible?
W. Schommers, *Modern Physics Letters B* (Singapore), Vol 3 #8, 20 May 89, pp 597-604.

Doubts grow as many attempts at cold fusion fail
B. Levi, *Physics Today* (USA), Vol 42 #6, June 89, pp 17-19.

Muon catalyzed fusion
C. Petitjean, *Fusion Engineering Design* (Netherlands), Vol 11 #1-2, June 89, pp 255-264.

Opening possibility of deuteron-catalyzed cascade fusion channel
A. Takahashi, *J. Nuclear Science Technology* (Japan), Vol 26 #5, May 89. pp 558-560.

Computation of the cold fusion rate
P. Dong, *New Physics* (South Korea), Vol 29 #2, April 89, pp 233-234.

The observation of 2.2 MeV gamma-ray in electrochemical cell
Y. Park, *New Physics* (South Korea), Vol 29 #2, April 89, pp 231-232.

First steps toward an understanding of "cold" nuclear fusion
T. Bressani, *Nuovo Cimento A* (Italy), Vol 101A ser. 2 #5, May 89, pp 845-849.

Emission of neutrons as a consequence of titanium-deuterium interaction
A. De Ninno, *Nuovo Cimento A* (Italy), Vol 101A ser. 2 #5, May 89, pp 841-844.

Fermi gas like hypothesis for Fleischmann-Pons experiment
O. Rossler, *Z. Nat. Phys. Chem. Kosmophys* (W Germany), Vol 44A #4, April 89, pp 329.

Observation of cold nuclear fusion in condensed matter
S. Jones, *Nature* (UK), Vol 338 #6218, 27 April 89, pp 737-740.

Electrochemically induced nuclear fusion of deuterium
M. Fleischmann, *Jour. Electroan. Chem.* (Switzerland), Vol 261 #2A, 10 April 89, pp 301.

Cold nuclear fusion
A. Rusu, *Energetica* (Romania), Vol 3 #6, June 88, pp 258-261.

On the practical use of the cold fusion (problems and prospects)
Y. Petrov, *Muon Catalyzed Fusion* (Switzerland), Vol 3 #1-4, 1988, pp 525-535.

Observation of enhanced low-energy charged-particles in cold fusion
U. Gollerthan, *Physics Letters B* (Netherlands), Vol 201 #2, 4 Feb 88, pp 206-210.

FIG. 1—SOME KEY COLD-FUSION PAPERS. For a complete and up-to-date list, use the Dialog Information Service at your local library. Start with their INSPEC resource data base. Fleischmann's paper started it all.

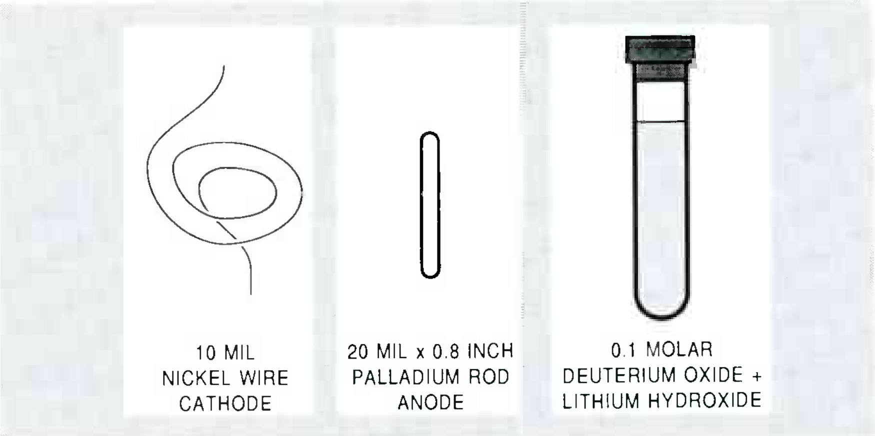


FIG. 2—LOW-COST HACKER FUSION KITS consist of a small test tube filled with heavy water, a short palladium-rod anode, and a nickel-wire cathode. While the odds of positive results are rather low, this is a great show-and-tell item.

directly for more information on those kits.

Needless to say, be sure to let us know the outcomes of all your test experiments. That is a wide open field with mind-boggling hacker potential.

Midnight engineering

There's a brand new magazine out called *Midnight Engineering*. It is specifically aimed at you hardware hackers and software developers who are trying to market their high-tech products on a small-scale or startup basis. Its shoot-from-the-hip style is very much cast in the same mold as my *Incredible Secret Money Machine*. Emphasis is on real-world solutions and new hacker opportunities. Free sample copies are available to you. It really is a "must have."

ALARM & SECURITY SYSTEMS RESOURCES

ADEMCO
165 Eileen Way
Syosset, NY 11791
(800) 645-7492
CIRCLE 200 ON FREE INFORMATION CARD

Alarm Installer & Dealer
2512 Artesia Boulevard
Redondo Beach, CA 90278
(213) 376-8788
CIRCLE 201 ON FREE INFORMATION CARD

ARIUS
959 Concord Street
Framingham, MA 01701
(800) 241-3278
CIRCLE 202 ON FREE INFORMATION CARD

Cain Security Systems
2593 Wexford Bayne Rd, S301
Sewickley, PA 15143
(412) 934-1000
CIRCLE 203 ON FREE INFORMATION CARD

Jensen Tools
7815 South 46th Street
Phoenix, AZ 85044
(602) 968-6231
CIRCLE 204 ON FREE INFORMATION CARD

King Alarm
145 English Street
Hackensack, NJ 07601
(800) 526-0162
CIRCLE 205 ON FREE INFORMATION CARD

Security Dealer
210 Crossways Park Drive
Woodbury, NY 11797
(516) 496-8000
CIRCLE 206 ON FREE INFORMATION CARD

Security Distributing
1350 E Touhy Avenue
Des Plaines, IL 60017
(312) 390-2117
CIRCLE 207 ON FREE INFORMATION CARD

TechniTool
5 Apollo Road
Plymouth Meeting, PA 19462
(215) 825-4990
CIRCLE 208 ON FREE INFORMATION CARD

Valley Security
PO Drawer J
Thatcher, AZ 85552
(602) 428-2142
CIRCLE 209 ON FREE INFORMATION CARD

Printed-circuit update

There sure were a lot of helpline calls and letters over our PostScript direct toner prototype printed-circuit breakthrough in the December issue. I thought I would summarize some of your hacker suggestions to date. They appear in Fig. 4.

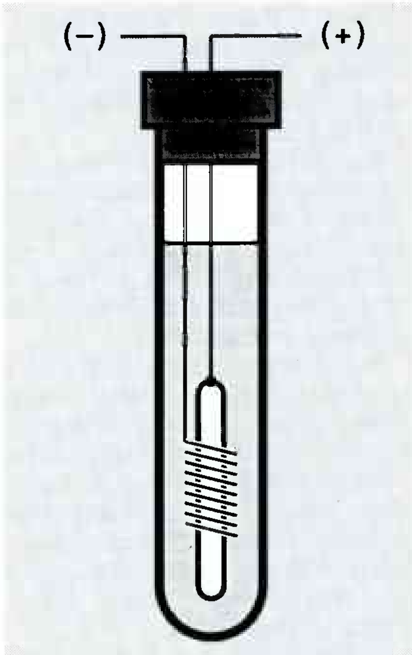


FIG. 3—A TYPICAL COLD-FUSION test setup. Apply a DC current around 10 mA. The anode and cathode should not contact. You measure for excess temperature, neutrons, and tritium.

Many of you totally and completely underestimated just how crucially important the PostScript language is to that breakthrough process. Among its many other advantages, PostScript lets you exactly trim your final image size to precisely 1:1; it is totally output-independent, meaning that you can use either a desktop laser printer or a more precise phototypesetter; it easily lets you work 1X, 2X, 4X, frontward or backward, normal or reversed, to as many as eight layers at once; it has no upper size or any complexity limit; it is totally host-independent, which allows you to use any old-world processor on any old personal computer; it simply lets you pass layouts over any BBS system in the world as a plain old textfile; and is compatible with virtually all of the existing CAD/CAM programs, either through a direct

PostScript driver or by a PostScript HPGL emulator.

Similarly, using the heated-roller method works far better than an iron. The obvious reasons for that are the far more uniform pressure and temperature. You also gain bunches in dimensional stability, since the Mylar transfer sheet does not get any chance to distort all at once. As we've seen, I recommend a fake *Kroy Kolor* machine to do the transfer. We'll look at some cheaper alternatives for that in a future issue.

Several readers have now suggested substituting *Kapton* film instead of the polyester overhead sheets since it has better high-temp stability. Two of the sources of Kapton include *DuPont* and *Rogers Corp*.

It also seems a very good idea to do your final cleaning wash of your bare copper board with distilled water. A brief pre-etch before transferring your toner image does appear to be quite important as well. The etch will both guarantee an extra-clean board and gives you just the right "tooth" for the toner to grab onto.

Some other suggestions: Preheat the copper board as much as you dare before doing the transfer. The idea is to keep the copper from acting as a giant heat sink. Something around 150 degrees Fahrenheit should work. Note that gloves are an absolute must at that temperature.

And run an ice cube on the back of the transfer sheet before separating it from the PC board. That seems to improve the transfer process bunches.

Be sure to send in your own tips and techniques for getting perfect 1:1 toner transfers. When all of the dust settles, we'll try to separate the black magic from the reality and standardize on a useful direct-toner process.

Alarm and security resources

To continue our ongoing series of resource sidebars, this month we'll look at what you need to know to pick up insider information on burglar alarms and security systems. Those magic names and numbers appear in that *Alarm and Security Resources* sidebar.

As with any field at all, your best bet is to start with the trade journals. A complete list of all trade journals is available as *Uhlrichts Periodicals Dictionary* on the ref-

NAMES AND NUMBERS

Analog Devices
One Technology Way
Norwood, MA 02062
(617) 329-4700
CIRCLE 210 ON FREE INFORMATION CARD

Dialog Information Services
3460 Hillview Avenue
Palo Alto, CA 94304
(415) 858-2700
CIRCLE 211 ON FREE INFORMATION CARD

DuPont
1007 Market Street
Wilmington, DE 19898
(302) 774-1000
CIRCLE 212 ON FREE INFORMATION CARD

IGLIDE/IGUS Bearings
PO Box 4349
Rumford, RI 02914
(800) 521-2747
CIRCLE 213 ON FREE INFORMATION CARD

Kroy Kolor
14555 North Hayden Road
Scottsdale, AZ 85260
(800) 521-4997
CIRCLE 214 ON FREE INFORMATION CARD

Lehman Scientific RD1 Box 580
Wrightsville, PA 17368
CIRCLE 215 ON FREE INFORMATION CARD

Midnight Engineering
PO Box 7041
Fort Collins, CO 80525
(303) 491-9092
CIRCLE 216 ON FREE INFORMATION CARD

Ming Engineering
977 S. Meridian Avenue
Alhambra, CA 91803
(818) 570-0058
CIRCLE 217 ON FREE INFORMATION CARD

muRata/Erie
2200 Lake Park Drive
Smyrna, GA 30080
(404) 436-1300
CIRCLE 218 ON FREE INFORMATION CARD

Panasonic
50 Meadowland Pkwy.
Secaucus, NJ 07094
(201) 348-7000
CIRCLE 219 ON FREE INFORMATION CARD

R&D Electronics
1224 Prospect Street
Cleveland, OH 44115
(216) 621-1052
CIRCLE 220 ON FREE INFORMATION CARD

Rogers Corp
100 S. Roosevelt Avenue
Chandler, AZ 85226
(602) 961-1382
CIRCLE 221 ON FREE INFORMATION CARD

Samsung
3725 N 1st Street
San Jose, CA 95134
(408) 434-5400
CIRCLE 222 ON FREE INFORMATION CARD

Science/AAAS
1333 H Street NW
Washington, DC 20005
(202) 326-6400
CIRCLE 223 ON FREE INFORMATION CARD

Synergetics
Box 809
Thatcher, AZ 85552
(602) 428-4073
CIRCLE 224 ON FREE INFORMATION CARD

Taiyo Yuden
714 W Algonquin Road
Arlington Heights, IL 60005
(312) 364-6104
CIRCLE 225 ON FREE INFORMATION CARD

Thompson Nyliner
Shore Road & Channel Drive
Port Washington, NY 11050
(516) 883-8000
CIRCLE 226 ON FREE INFORMATION CARD

Toshiba
1220 Midas Way
Sunnyvale, CA 94086
(408) 739-0560
CIRCLE 227 ON FREE INFORMATION CARD

Wall Street Journal
420 Lexington Avenue, 14th Fl.
New York City, NY 10170
(212) 808-6960
CIRCLE 228 ON FREE INFORMATION CARD

Guy Wicker
30437 Fairfax
Southfield, MI 48076
(313) 647-1820
CIRCLE 229 ON FREE INFORMATION CARD

1. The PostScript language is essential to the direct toner process. Its totally overwhelming advantages include precise scaling to 1:1, total format flexibility, host and printer independence, easy BBS downloads, and the ability to use nothing but a word processor.
2. Heated roller transfer methods work much better than an iron. Use a fake *Kroy Kolor* machine or its equivalent. The reasons include better stability and tighter temperature control.
3. Use a "dry" (silicon oil free) fuser wiper pad for several copies before your transfer sheet is run.
4. For extreme dimensional stability, try using a *Kapton* film, rather than polyester or mylar.
5. Do your final washing of your cleaned copper board with distilled water.
6. A brief etch before your final washing step is essential to give the proper "tooth" for toner transfer.
7. Preheat the copper to 150 degrees or so before the transfer to minimize any heat sinking effects.
8. Rub an ice cube over the back of the transfer sheet before seperating it from the pc board.

FIG. 4—HERE'S AN UPDATE on the direct-toner printed-circuit prototypes we first looked at in the December 89 issue.

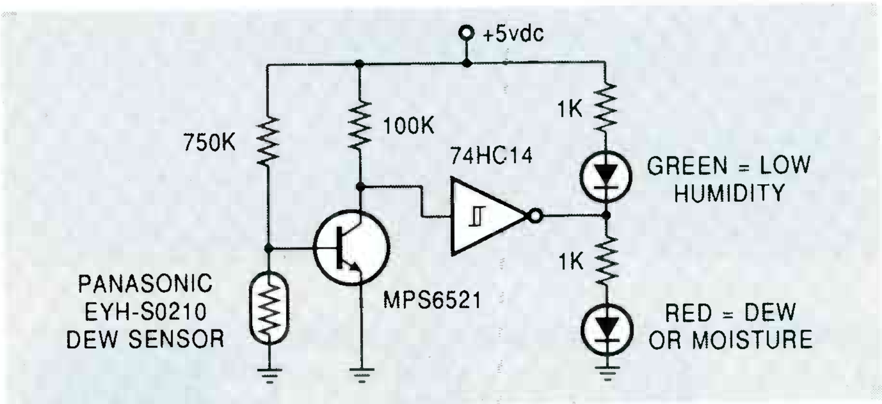


FIG. 5—A DEW-SENSOR TEST CIRCUIT. The red LED lights when the humidity exceeds 100 percent; the green one turns on in the absence of dew.

erence shelf at your neighborhood library. A second source that is almost as good is the *International Standard Periodicals Dictionary* on the same shelf.

Typical trade journals for the field include *Security Dealer*, the *Security Distributing and Marketing*, and the *Alarm Installer and Dealer*.

Trade shows play an important part of the alarm industry. A pair of the largest are the *International Security Conference and Exposition*, and *The Security Show*. They do move around from town to town. Check any of the trade journals for the show dates.

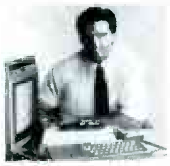
There are a number of specialty wholesale distributors that cater to the alarm trade. You'll find lots of ads for them in all the trade journals and their directories. Three larger examples are *King Alarm, Arius*, and *Ademco*.

Two sources of general installation tools and test instruments include *Jensen Tools* and *TechniTool*. Sadly, both of those yuppieized outfits are rather pricey. But all of their products happen to be both first-rate and top-quality.

There are now hundreds of security consultants that will be glad to help you for a sane and reasonable fee. Two examples here are Wyatt Palmer (no relation) of *Valley Security*, and Jeff Lancaster (my widdle brudder) of his *Cain Security Systems*.

Please let me know if you know of any other similar kinds of resources that you think should be added to the list.

continued on page 74



DRAWING BOARD

ROBERT GROSSBLATT,
CIRCUITS EDITOR

A crystal-controlled video timing generator.

WHEN YOU START FOOLING AROUND with video circuitry, there are three things you always have to keep in mind: timing, timing, and, above all else, timing. The key to designing video circuits is making sure that the right voltages show up at the right time. The values can be slightly off, but if they don't show up exactly when they're supposed to, they might just as well not show up at all.

Since video is fairly complex, everyone has his or her own ideas about the best way to get into it. Theory is important; after all, the video waveform is an agreed-upon standard, and you have to understand its component parts before you can design hardware to produce it. But the best way to learn is to do, and the easiest way to pick up theory is by having it demonstrated; so let's see what's involved in designing basic hardware.

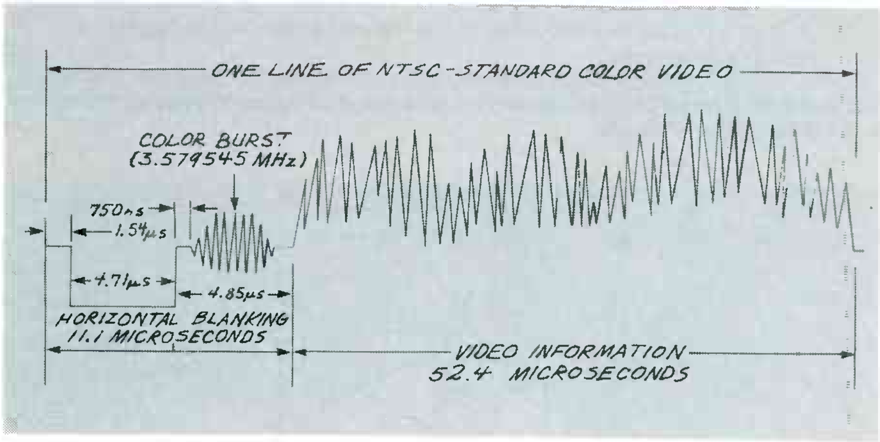


FIG. 1

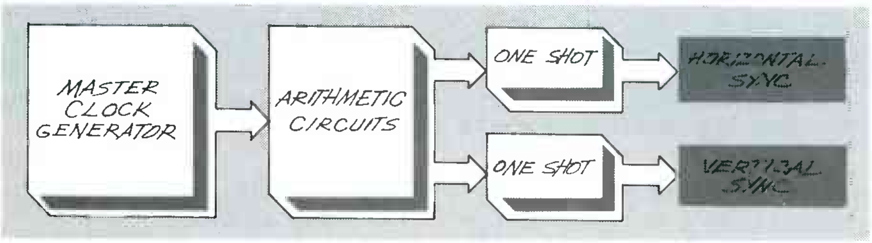


FIG. 2

Hardware basics

The waveform in Fig. 1 is one line of National Television Standards Committee (NTSC) standard horizontal color video. We've already discussed its component parts, but this time I've included all the timing. There are several basic frequencies to be generated, and the pulse width is strictly defined. National Semiconductor, and other manufacturers, make IC's that can take a basic clock frequency in at one end, and put out all needed video frequencies at the other end. They are good chips for designing real-world circuitry, and we'll look at some later; but first let's re-invent the wheel so we know how it works.

Designing a video sync generator is an exercise in pure logic and arithmetic. We need clock generators to control production of the needed frequencies, and one-shots to produce pulses of the right width. Since the most basic signal needed is horizontal sync, that's the place to start.

The block diagram in Fig. 2 gives a good overview of the circuit to be designed. There's a master clock generator, whose frequency is divided down to produce horizontal and vertical sync clocks. They will trigger pulse generators to output the actual sync pulses. By deriving everything from a master clock, the generated sync signals maintain constant timing with regard to one another, an absolute must for video. The sync-generator accuracy will depend completely on that of the master clock, so we have to use a crystal-based circuit. That creates certain problems, but it's the best way to go.

The master clock

Crystal oscillators used to be exotic and expensive, but are now cheap and easy to build. The issue now is what frequency to use, and what chip will produce it. Everyone has his or her preferences, but one that's often overlooked is the 8284 shown in Fig. 3, in an appropriate oscillator circuit. It was originally designed by Intel as the basic clock for the 808X microprocessors, and any 808X-based computer will have one on the motherboard. Its frequencies and duty cycles are really geared to Intel's microprocessors, but it's a handy general-purpose clock generator, also.

Most of the 8284 control pins like AEN1 (pin 3), AEN2 (pin 7), RDY1 (pin 4), RDY2 (pin 6), READY (pin 5), and CSYNC (pin 1) are used only when you're using the chip in a computer; we won't use them here. They have to be tied either high or low to make the chip work for our purposes.

All we want the 8284 to do is to act as a stable oscillator. That's easy to set up, and the 8284 has several free extras. The pins used here are crystal inputs X1 (pin 17) and X2 (pin 16), and clock outputs OSC (pin 12), CLK (pin 8), and PCLK (pin 2).

In Fig. 3, the 8284 takes the crystal and provides three different output clocks. The OSC output (pin 12) is a buffered version of the crystal frequency, the CLK output (pin 8) is ⅓ the crystal frequency at a 33% duty cycle, and PCLK (pin 2) is half the CLK frequency with a 50% duty cycle. The CLK output has an unusual duty cycle for use with an Intel microprocessor.

Also, note the F/C (*F*requency or *C*rystal) input on pin 13. Since the chip is a collection of flip-flops and buffers, it needs an input frequency divided down internally to provide the output clocks. The state of F/C determines the origin of the input clock. If F/C is tied low, the 8284 will look at its internal oscillator, the frequency of which depends on the crystal hanging off inputs X1 and X2. If F/C is high, the 8284 will look at the clock being fed to EFI (*E*xternal *F*requency *I*n) input at pin 14.

That means that you can change the output clocks simply by changing the logic level on F/C (pin 13). Most two-speed IBM-XT clones use that feature to switch from "normal" to "turbo" speed. By trapping a scan code from the keyboard and using it to toggle a flip-flop, they change the level of F/C, and switch the master clock speed of the microprocessor, giving a two-speed computer.

Now that we have a circuit to

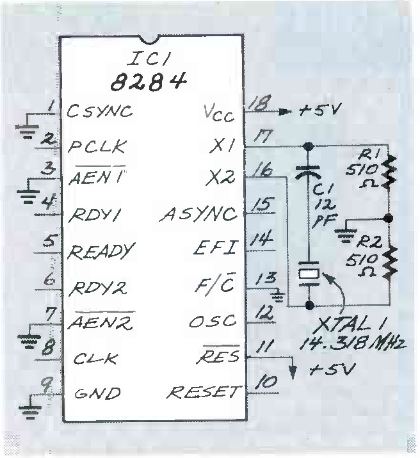


FIG. 3

produce our clock, we have to decide on what clock to produce. It would be really nice if all the frequencies needed were derivable from one easily available crystal frequency, but they're not. There's just no easy number to provide everything we need. For reasons that'll become apparent when we are farther along in our design, 14.318 MHz is a good choice. One obvious reason is that division-by-four will give 3.579545 MHz, the colorburst frequency. Getting a horizontal frequency of 15734 kHz, however, will take a little more work than that.

The 12-pF capacitor in series with the crystal helps start the 8284's internal oscillator. Since it's similar to an amplifier, the resistance of the crystal network has to be kept as low as possible. If it's too high, the gain drops; and if it's too low, it won't oscillate. The two resistors reduce the effects of stray board capacitance and voltage fluctuations on the frequency. A breadboard is a good choice for construction, but there's considerable capacitance between rows. Since the crystal frequency is pretty high, that stray capacitance can wreak havoc, so the two resistors will keep the oscillator frequency fairly stable.

If your oscillator frequency is outside the 14.3–14.4 MHz range, there's a problem on the breadboard. The easiest way to fix it is to accept the breadboard-induced error as unavoidable, and correct the frequency by varying the capacitor value over 4.7–47 pF. If you're really ambitious, replace it with a small trimmer capacitor. **R-E**

HARDWARE HACKER

continued from page 71

Dew sensors

We've looked at humidity sensors in several earlier columns. One unique and low-cost humidity detector is called a *dew sensor*. They cost only a dollar each and are intended to protect moisture-sensitive VCR drums.

Three typical part numbers would be the *Murata* HOS 101-100, the *Taiyo Yuden* TD-P-100, or that *Panasonic* EYH-S0210.

At a 100 percent humidity, the air retains all of the moisture it possibly can. Beyond that, the moisture in the air will condense out, forming a rain or a dew coating.

A special moisture-sensing paint dramatically raises its resistance well beyond 1 Megohm whenever it gets wet. Thus, your sensor is typically at 10K when dry and 1 Megohm when wet. A good decision point is to split up the difference on a log basis, and do your tripping at a 100K level.

Figure 5 shows you one possible sensing circuit. Because you have to keep the total system power under two milliwatts, the maximum DC voltage that you are allowed to apply is only 0.8 volts. The sensor acts as a current-robber. At low humidities, the sensor's resistance is around 10K and steals so much current, that the NPN transistor remains off. When wet, the sensor impedance goes above 1 megohm, and conventional current flows into the base of the NPN transistor, turning it on.

That inverting CMOS *Schmitt* trigger gives you an on-off snap action. Your red light-emitting diode lights when wet and the green when dry.

Tellyawhat. For this month's contest, just tell me about a new or unique use for dew sensors. There will be all of those usual *Incredible Secret Money Machine* book prizes going to the best dozen or so entries, with an all expense paid (FOB Thatcher, AZ) *tinaja quest* for two for the best of all.

As usual, all entries must be written and should be sent directly to me here at *Synergetics*, rather than to the editor of **Radio-Electronics**. Show me what you can come up with.

New tech literature

Data books this month include the *Data Conversion Products Databook* from *Analog Devices*, and an absolutely astounding new *Semiconductor Product Guide* from *Samsung*. That latter gem is chock full of new hacker integrated circuits for use as scientific calculators, speech synthesis, melody chips, cassette recorders, watches, for alarm clocks, and bunches more.

Two surplus catalogs are available from *R&D Electronics*, and *Lehman* has weather radiosonde transducers that include humidity, pressure, and temperature sensing for only $3.50. Stock number is MC-1019-MOD.

Some surprisingly cheap and high-quality digital voice recording and playback modules are available from *Ming Engineering*. The single-quantity prices start at $49. They are all fully EPROM-programmable. They apparently use that new *Toshiba* TC8830F speech synthesis chip.

Turning to mechanical stuff, low-cost nylon bearings and a free calculator are available from *Thompson Nyliner*, while the *IGUS* folks offer all sorts of the self-lubricating plastic bearings. Prices for them start at fifteen cents in quantity.

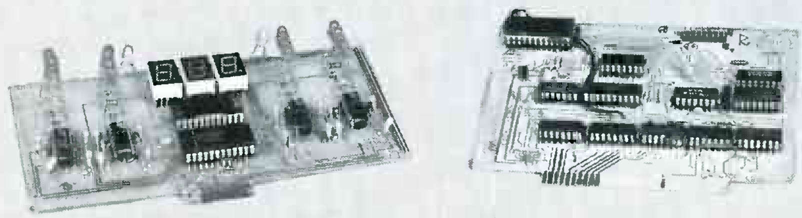
A reminder here that I am book-on-demand publishing a complete set of the edited, indexed, and updated reprints of everything you've seen here in these columns since day one. Ask for my *Hardware Hacker*, volume II, now available through *Synergetics*.

For those of you who are not yet into PostScript, I also stock an *Intro to PostScript* VHS video that shows you what you need in order

continued on page 88

COMPUTER DIGEST

BUILD THE PORT-A-MATIC



Building the Port-A-Matic

ROBERT GROSSBLATT

The Port-A-Matic is a fairly complex circuit that depends on tight signal timing. Although you could wirewrap it on perf board, you're better off using a PC board: patterns are shown in PC Service and a supplier is listed in the "ordering information" box.

The Port-A-Matic was designed to be built on two PC boards: an internal bus interface (that installs in any 8- or 16-bit PC-compatible expansion slot) and an external display board. The two boards are connected by ribbon cable, and the pins are arranged in the same order on both boards so you can use a straight-through ribbon-cable connection.

Sixteen conductors are required, but you'll probably want to use 20-conductor cables, because they're easy to obtain (and inexpensive) because they're used as data cables connecting controller cards and hard-disk drives in PC compatibles.

To install the components, use the diagrams shown in Fig. 1 and Fig. 2. Of course, be sure to observe the polarity of diodes, transistors, electrolytic capacitors, and IC's. None of the IC's on the board are rare or expensive, but you should still be careful when you're handling them since blown IC's look an awful lot like good ones.

Since you'll probably make occasional changes to the look-up table in the EPROM, you'll want to install it in an IC socket. In fact, all IC's should be socketed because there is no absolutely safe way to desolder a suspect IC. If you suspect that an IC is fried, desoldering it to check it may make your suspicion a reality if you don't know what you're doing!

Although you can put parts on the board in any order you want, assembly is easier if you start with the IC sockets, then go through the passive components (resistors and capacitors), and finally the active components (diodes and transistors). That's a good order to follow because

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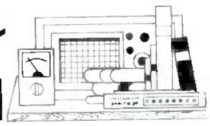
EDITOR'S WORK-BENCH



Announcement

Mario Maniscalco's $100 challenge to Computer Digest readers to crack the secret message published in the April 1988 issue has gone unanswered, so he will now send the key to anyone who sends an SASE to P.O. Box 110082, Cleveland, OH 44111. (The address published in the October 1989 issue is incorrect.) Mario also plans a newsletter on the encryption program; write to him at that address for more information.

Modular IC programming system

It wasn't so long ago when EPROM's were novelties, and 2716's (2K bytes) were considered high density. Now 64K EPROM's are common, 128K EPROM's are becoming economical, and there are several other types of programmable devices, including PAL's, EEPROM's, standard bipolar PROM's, and more. You can spend thousands of dollars for a universal programmer for different types of devices. Or you can latch onto JDR's modular system, let your PC provide the intelligence, and buy only the modules you need when you need them.

Several modules are available. I

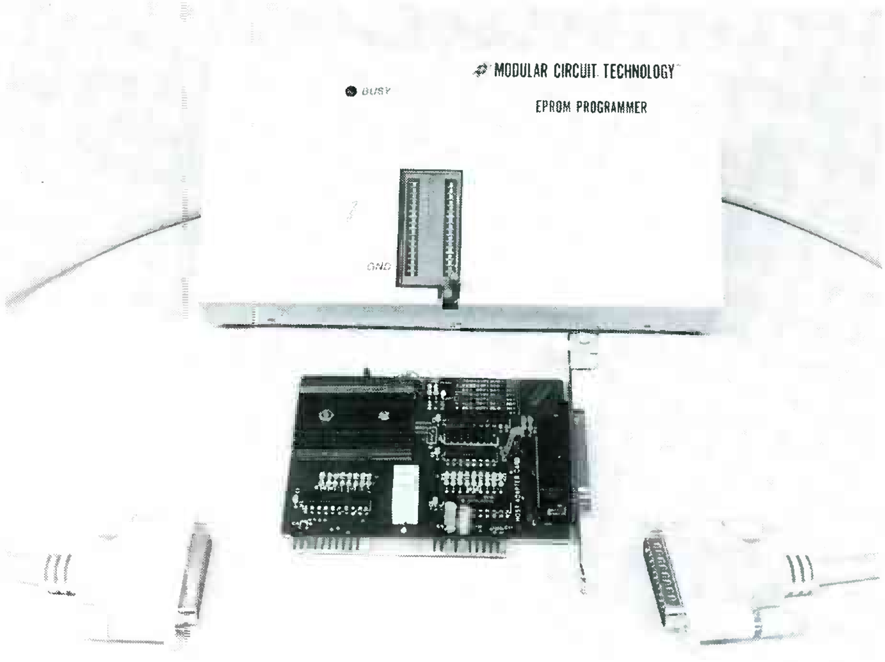


FIG. 1

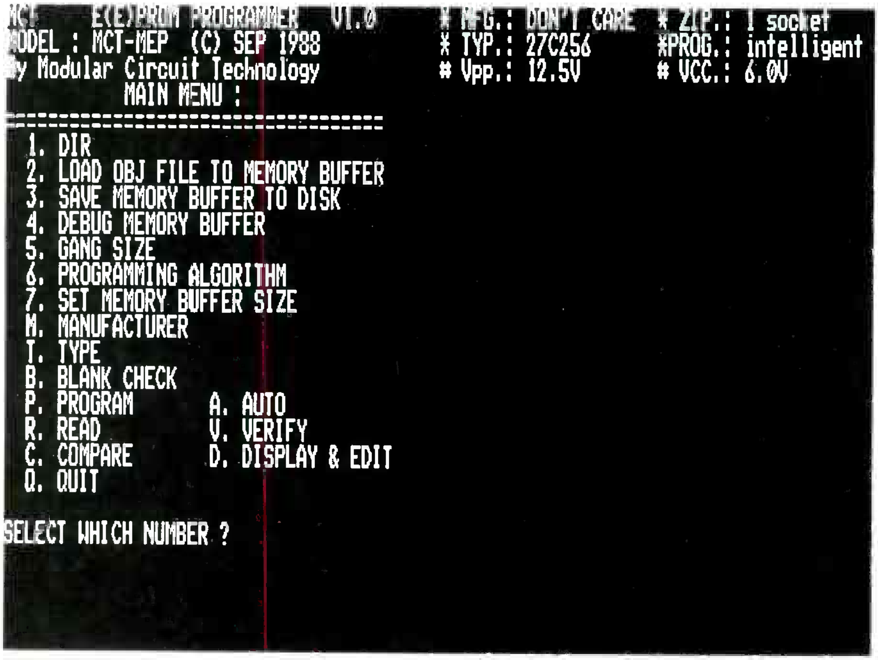


FIG. 2

tested the EPROM/EEPROM module (shown in Fig. 1), which lists for about $120; 4-, 8-, and 16-socket versions are available for volume production. Other programmers include one for PAL's ($250), one for microprocessors ($180), and one for bipolar PROM's ($260). An IC tester20is also available for $130, and PAL development software for $100. Each module includes a ZIF (*Z*ero *I*nsertion *F*orce) socket (or several, for the multi-gang models).

If you're planning to buy two or more modules, you'd probably be better off going with the Universal Module, which lists for about $500, and can perform all functions of the individual modules.

Whichever module(s) you choose, you'll need a $30 host adapter/cable. The adapter is a short card that fits in any 8- or 16-bit expansion slot. The cable is a quality molded 25-conductor job with 25-pin D connectors on both ends. Unfortunately, the connector on the card is identical to a standard PC printer connector; make sure you don't connect a printer cable to that port—a high-voltage pulse could have the misfortune of frying your printer instantly!

Installing the card requires setting a couple of jumpers that determine the card's I/O address. Installing the software consists of copying the contents of a 360K disk to a subdirectory on your hard disk, and then running a setup program in which you specify your computer type and speed. Neither my computer type nor its speed were listed, but I picked the closest match and had no trouble.

The module can program all common and several uncommon EPROM's that you might want to use ranging from the 2716 to the 27010, CMOS versions thereof, and 2816, 2817, and 2864 EEPROM's. However, it can't program paged EPROM's, such as the 27011.

The software is menu-driven, as shown in Fig. 2. You can list a directory and load a file into a memory buffer. You can then modify the contents of that buffer using either the software's built-in editor or DEBUG.COM, which

ITEMS DISCUSSED

- 75C188N driver, 75C189N receiver ($0.75/M), Texas Instruments, Literature Center, P.O. Box 809066, Dallas, TX 75380-9066.
  CIRCLE 48 ON FREE INFORMATION CARD
- The XT-AT Handbook ($9.95), John Choisser and John Foster, Annabooks, 12145 Alta Carmel Court, Suite 250-262, San Diego, CA 92128, (619) 271-9526.
  CIRCLE 47 ON FREE INFORMATION CARD
- (E)EPROM Programmer (MOD-MEP, $119.95) and host adapter (MOD-MAC, $29.95), JDR Microdevices, 2233 Branham Lane, San Jose, CA 95124.
  CIRCLE 46 ON FREE INFORMATION CARD

the software will load for you when you choose item 4 from the menu. The built-in editor is rather weak, but by using DEBUG you can search the memory buffer, fill it with a constant, assemble code into it, etc. You can also save all of the contents of the memory buffer to disk if you like.

Other functions allow you to set up the programming parameters, including (E)EPROM manufacturer, type, and programming algorithm. Not all manufacturers are represented, however, so you may have to do some research (or experimentation) to determine the proper programming voltage and algorithm for some types of EPROM's. I had no trouble burning Intel EPROM's, but I burned up several junk-box varieties of EPROM'S that the programmer didn't support. Also, the software doesn't allow you to set the programming voltage independently of the programming algorithm.

Other functions allow you to verify that an (E)EPROM is erased, to read the contents of an (E)EPROM into the memory buffer, to program an (E)EPROM, and to verify programming by comparing buffer contents to (E)EPROM contents. You can specify starting and stopping addresses for all activities. A separate utility is provided with the package that converts hex format files output by some assemblers and compilers to binary image format.

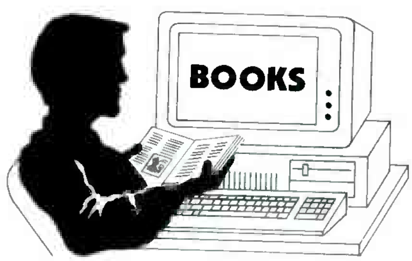
A short user's guide explains how to use the programmer, and outlines several programming algorithms, but it sorely lacks technical information on (E)EPROM pinouts, programming algorithms, and programming voltages.

My only other complaint is that it is possible to crash out of the program by pressing Ctrl-C at the wrong time. If you did so while the programming pulse was being applied, you could fry a chip. So the software should take control of the DOS interrupt 1Bh handler.

Otherwise, the product performed flawlessly. At $150, it's an excellent buy for anyone who needs that kind of equipment. ◆CD◆

TI's new RS-232 interfaces

Texas Instruments recently introduced an RS-232 line driver and a line receiver, both of which are pin-compatible with the 1488 and 1489 standards. Overall power consumption of the new devices is reduced by a factor of about 2000, compared with standard IC's. In addition, the new drivers contain on-chip slew-rate limiters that eliminate the need for external capacitors. The 75C188N and the 75C189N are priced at $0.75 in quantities of 1000. ◆CD◆



The XT-AT Handbook

This 70-page booklet fits in your shirt pocket and modestly proclaims that it consists of "a collection of hardware and software facts and data on

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PORT-A-MATIC

continued from page 75

there are lots of holes on the board and mounting the IC sockets first gives you reference points for locating the other components. Also, several components are mounted on pads by feedthroughs, so be sure not to install a component in the wrong pad!

Speaking of feedthroughs, both Port-A-Matic boards are double-sided, and several connections "jump" from one side of the board to the other by means of feedthroughs. The pattern was designed to make most of those jumps at component mounting holes, but there were several places where that wasn't possible. In each of those places you'll have to solder a piece of hookup wire to both the foil and the component sides of the board. (Of course, that applies only if you make your own boards. If you use plated-through boards, the connections will be made automatically by soldering one side.)

Several of the jumps are done on the legs of the IC's, and that can be a problem is you use standard low-profile IC sockets. You can get around the problem by using machined-pin sockets with long legs. Mount the socket slightly above the board so that you can solder the legs to both sides of it. A better solution is to use socket strips, which are single strips of machined socket pins. They're similar to Molex pins, but they have the advantage of being mounted in pieces of plastic. Wirewrap sockets are not recommended because their legs are too fat.

The three FND-500 digits on the display board have rows of pins that are spaced 0.6-inches apart. You can make a socket for them by doing a bit of surgery on a 40-pin socket. There's a space of 0.2 inches between each digit, so you really need a 38-pin socket. Make one by removing the unwanted pins from a 40-pin socket; you'll find that there's more than enough room at the sides of the digits to fit a 40-pin socket on the board.

Lookup tables

The Port-A-Matic needs two programmed EPROM's to work. Listing 1 shows the binary file for the character generator: Fig. 3 shows how the characters look. You can change them any way you want; just beware that it's difficult to distinguish between *6* and *b*. In our design, the *6* has a "tail" on the top segment, but it's still easy to mistake one for the other.

The Port-A-Matic won't work without a port-select EPROM in-

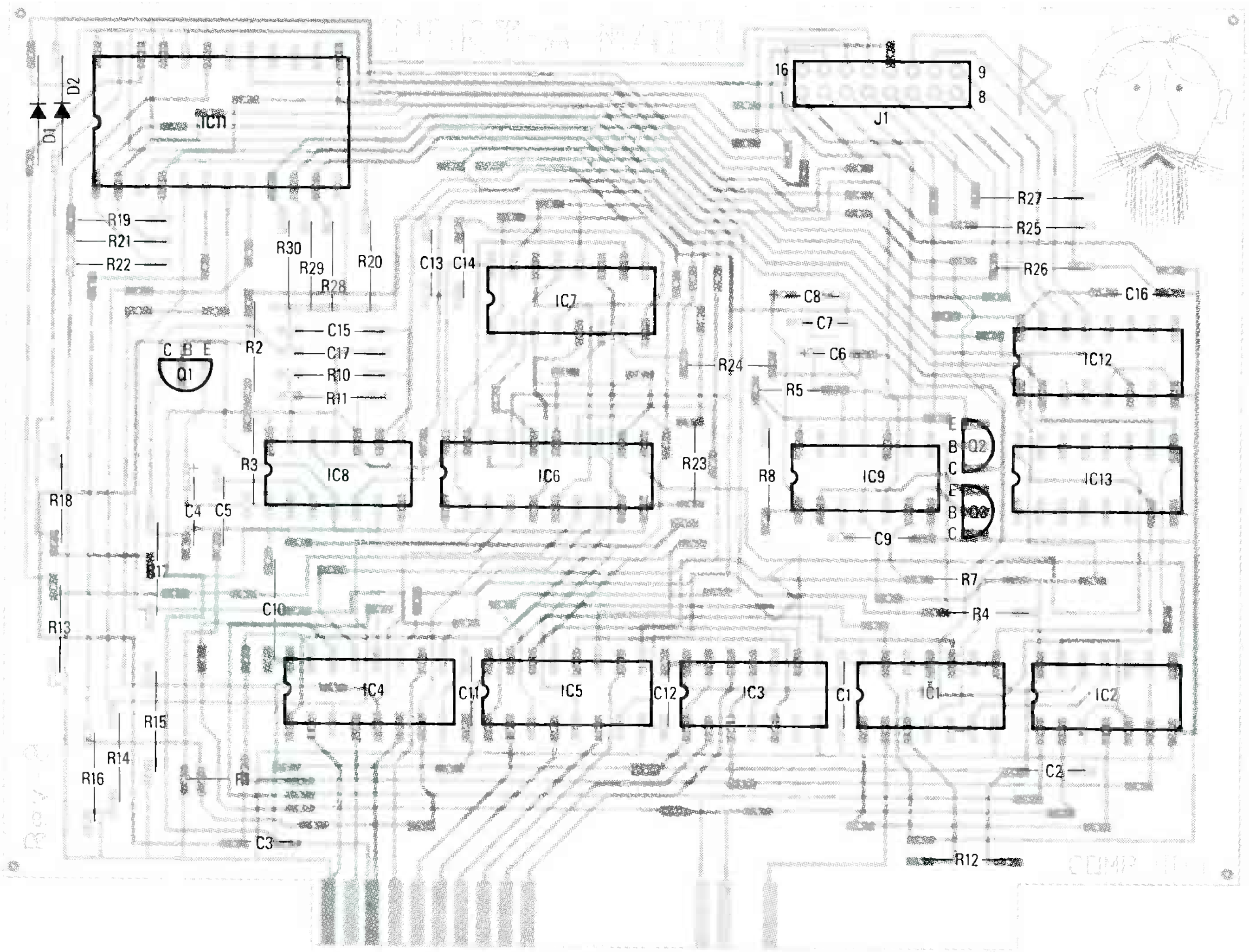

Fig. 1 BUS INTERFACE BOARD PARTS PLACEMENT DIAGRAM.

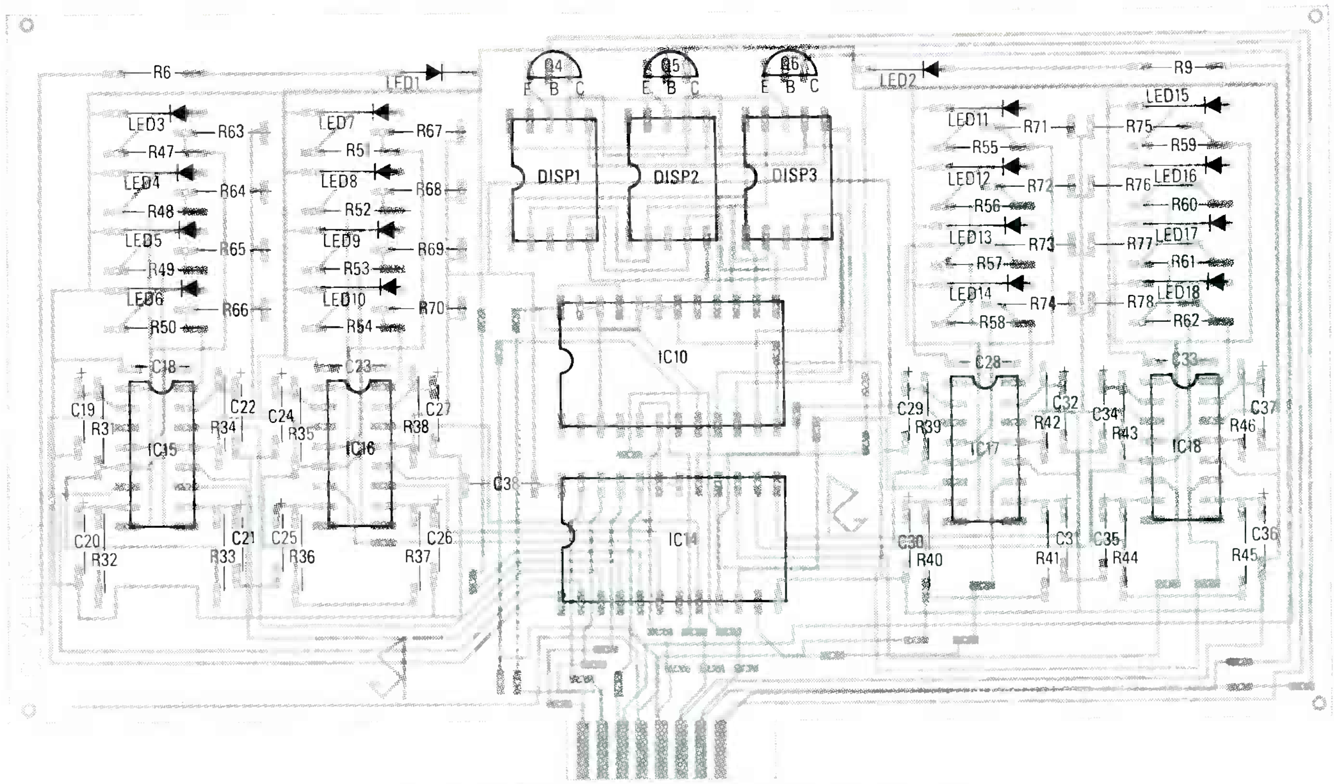

Fig. 2 DISPLAY BOARD PARTS PLACEMENT DIAGRAM.

stalled, and a blank EPROM produces the same effect as no EPROM. Listing 2 shows one possible port-decoding table. When your Port-A-Matic is up and working, you can alter the table to decode any addresses you want, but for the purposes of testing, go with the default. That table decodes the five most commonly used port addresses: COM1, COM2, LPT1, floppy disk, and joystick 1.

Oh no—it doesn't work!

If you build the Port-A-Matic on PC boards, you shouldn't have much trouble getting it to work. If you do have trouble, most likely you've made some sort of assembly error. Before you start any heavy-duty troubleshooting, check for solder bridges and cold solder joints.

Before we discuss troubleshooting, remember that the Port-A-Matic is sitting in an expansion slot, and even the best designed motherboards are noisy places, electronically speaking. Putting a scope probe on an expansion-slot pin is a real eye-opener; you'll find so much ringing, noise, and hash that you'll be amazed the computer can work at all.

Realize that the Port-A-Matic processes high-frequency signals, and there's no way you're going to be able to troubleshoot complex problems without an oscilloscope. Too much is happening too fast to be able to use logic probes and multimeters. However, as we go through the troubleshooting procedure, we'll try to provide alternatives for signal monitoring.

If the computer hangs up with the Port-A-Matic in a slot, but it works fine when the board is removed, you've probably got a short between two of the lines on the board that are connected directly to the bus. The cure for that is a strong light, a magnifier, and careful inspection.

Assuming that your computer works with the Port-A-Matic installed in a slot and that you have installed a suitably programmed port-selector EPROM in the Port-

LISTING 1—CONTENTS OF CHARACTER-GENERATOR EPROM IC10

```
=================================================================
000 - 3F 06 5B 4F   66 6D 7D 07   7F 6F 77 7C   39 5E 79 71
010 - FF FF FF FF   FF FF FF FF   FF FF FF FF   FF FF FF FF
020 - FF FF FF FF   FF FF FF FF   FF FF FF FF   FF FF FF FF
030 - FF FF FF FF   FF FF FF FF   FF FF FF FF   FF FF FF FF
040 - FF FF FF FF   FF FF FF FF   FF FF FF FF   FF FF FF FF
050 - FF FF FF FF   FF FF FF FF   FF FF FF FF   FF FF FF FF
060 - FF FF FF FF   FF FF FF FF   FF FF FF FF   FF FF FF FF
 |          |           |            |            |
 |          The rest of the EPROM is not used      |
 |          |           |            |            |
770 - FF FF FF FF   FF FF FF FF   FF FF FF FF   FF FF FF FF
780 - FF FF FF FF   FF FF FF FF   FF FF FF FF   FF FF FF FF
790 - FF FF FF FF   FF FF FF FF   FF FF FF FF   FF FF FF FF
7A0 - FF FF FF FF   FF FF FF FF   FF FF FF FF   FF FF FF FF
7B0 - FF FF FF FF   FF FF FF FF   FF FF FF FF   FF FF FF FF
7C0 - FF FF FF FF   FF FF FF FF   FF FF FF FF   FF FF FF FF
7D0 - FF FF FF FF   FF FF FF FF   FF FF FF FF   FF FF FF FF
7E0 - FF FF FF FF   FF FF FF FF   FF FF FF FF   FF FF FF FF
7F0 - FF FF FF FF   FF FF FF FF   FF FF FF FF   FF FF FF FF
```

LISTING 2—LISTING FOR BASIC PORT SELECTOR EPROM IC11

```
Port No.        LED   Comment
---------------------------------------------
   3F8h          0    First Serial Port (COM1)
   2F8h          1    Second Serial Port (COM2)
   3BCh          2    First Parallel Port (LPT1)
   3F5h          3    Floppy Disk Data Port
   201h          4    First Joystick Data Port

000 - FF 04 FF FF  FF FF FF FF  FF FF FF FF  FF FF FF FF
010 - FF FF FF FF  FF FF FF FF  FF FF FF FF  FF FF FF FF
020 - FF FF FF FF  FF FF FF FF  FF FF FF FF  FF FF FF FF
030 - FF FF FF FF  FF FF FF FF  FF FF FF FF  FF FF FF FF
040 - FF FF FF FF  FF FF FF FF  FF FF FF FF  FF FF FF FF
050 - FF FF FF FF  FF FF FF FF  FF FF FF FF  FF FF FF FF
060 - FF FF FF FF  FF FF FF FF  FF FF FF FF  FF FF FF FF
070 - FF FF FF FF  FF FF FF FF  FF FF FF FF  FF FF FF FF
080 - FF FF FF FF  FF FF FF FF  FF FF FF FF  FF FF FF FF
090 - FF FF FF FF  FF FF FF FF  FF FF FF FF  FF FF FF FF
0A0 - FF FF FF FF  FF FF FF FF  FF FF FF FF  FF FF FF FF
0B0 - FF FF FF FF  FF FF FF FF  FF FF FF FF  02 FF FF FF
0C0 - FF FF FF FF  FF FF FF FF  FF FF FF FF  FF FF FF FF
0D0 - FF FF FF FF  FF FF FF FF  FF FF FF FF  FF FF FF FF
0E0 - FF FF FF FF  FF FF FF FF  FF FF FF FF  FF FF FF FF
0F0 - FF FF FF FF  FF 03 FF FF  00 FF FF FF  FF FF FF FF
100 - FF 04 FF FF  FF FF FF FF  FF FF FF FF  FF FF FF FF
110 - FF FF FF FF  FF FF FF FF  FF FF FF FF  FF FF FF FF
120 - FF FF FF FF  FF FF FF FF  FF FF FF FF  FF FF FF FF
130 - FF FF FF FF  FF FF FF FF  FF FF FF FF  FF FF FF FF
140 - FF FF FF FF  FF FF FF FF  FF FF FF FF  FF FF FF FF
150 - FF FF FF FF  FF FF FF FF  FF FF FF FF  FF FF FF FF
160 - FF FF FF FF  FF FF FF FF  FF FF FF FF  FF FF FF FF
170 - FF FF FF FF  FF FF FF FF  FF FF FF FF  FF FF FF FF
180 - FF FF FF FF  FF FF FF FF  FF FF FF FF  FF FF FF FF
190 - FF FF FF FF  FF FF FF FF  FF FF FF FF  FF FF FF FF
1A0 - FF FF FF FF  FF FF FF FF  FF FF FF FF  FF FF FF FF
1B0 - FF FF FF FF  FF FF FF FF  FF FF FF FF  02 FF FF FF
1C0 - FF FF FF FF  FF FF FF FF  FF FF FF FF  FF FF FF FF
1D0 - FF FF FF FF  FF FF FF FF  FF FF FF FF  FF FF FF FF
1E0 - FF FF FF FF  FF FF FF FF  FF FF FF FF  FF FF FF FF
1F0 - FF FF FF FF  FF 03 FF FF  00 FF FF FF  FF FF FF FF
200 - FF 04 FF FF  FF FF FF FF  FF FF FF FF  FF FF FF FF
210 - FF FF FF FF  FF FF FF FF  FF FF FF FF  FF FF FF FF
220 - FF FF FF FF  FF FF FF FF  FF FF FF FF  FF FF FF FF
230 - FF FF FF FF  FF FF FF FF  FF FF FF FF  FF FF FF FF
240 - FF FF FF FF  FF FF FF FF  FF FF FF FF  FF FF FF FF
250 - FF FF FF FF  FF FF FF FF  FF FF FF FF  FF FF FF FF
260 - FF FF FF FF  FF FF FF FF  FF FF FF FF  FF FF FF FF
270 - FF FF FF FF  FF FF FF FF  FF FF FF FF  FF FF FF FF
280 - FF FF FF FF  FF FF FF FF  FF FF FF FF  FF FF FF FF
290 - FF FF FF FF  FF FF FF FF  FF FF FF FF  FF FF FF FF
2A0 - FF FF FF FF  FF FF FF FF  FF FF FF FF  FF FF FF FF
2B0 - FF FF FF FF  FF FF FF FF  FF FF FF FF  02 FF FF FF
2C0 - FF FF FF FF  FF FF FF FF  FF FF FF FF  FF FF FF FF
2D0 - FF FF FF FF  FF FF FF FF  FF FF FF FF  FF FF FF FF
2E0 - FF FF FF FF  FF FF FF FF  FF FF FF FF  FF FF FF FF
2F0 - FF FF FF FF  FF 03 FF FF  01 FF FF FF  FF FF FF FF
300 - FF 04 FF FF  FF FF FF FF  FF FF FF FF  FF FF FF FF
310 - FF FF FF FF  FF FF FF FF  FF FF FF FF  FF FF FF FF
320 - FF FF FF FF  FF FF FF FF  FF FF FF FF  FF FF FF FF
330 - FF FF FF FF  FF FF FF FF  FF FF FF FF  FF FF FF FF
340 - FF FF FF FF  FF FF FF FF  FF FF FF FF  FF FF FF FF
350 - FF FF FF FF  FF FF FF FF  FF FF FF FF  FF FF FF FF
360 - FF FF FF FF  FF FF FF FF  FF FF FF FF  FF FF FF FF
370 - FF FF FF FF  FF FF FF FF  FF FF FF FF  FF FF FF FF
380 - FF FF FF FF  FF FF FF FF  FF FF FF FF  FF FF FF FF
390 - FF FF FF FF  FF FF FF FF  FF FF FF FF  FF FF FF FF
3A0 - FF FF FF FF  FF FF FF FF  FF FF FF FF  FF FF FF FF
3B0 - FF FF FF FF  FF FF FF FF  FF FF FF FF  02 FF FF FF
3C0 - FF FF FF FF  FF FF FF FF  FF FF FF FF  FF FF FF FF
3D0 - FF FF FF FF  FF FF FF FF  FF FF FF FF  FF FF FF FF
3E0 - FF FF FF FF  FF FF FF FF  FF FF FF FF  FF FF FF FF
3F0 - FF FF FF FF  FF 03 FF FF  00 FF FF FF  FF FF FF FF

        The rest of the EPROM is not used

770 - FF FF FF FF  FF FF FF FF  FF FF FF FF  FF FF FF FF
780 - FF FF FF FF  FF FF FF FF  FF FF FF FF  FF FF FF FF
790 - FF FF FF FF  FF FF FF FF  FF FF FF FF  FF FF FF FF
7A0 - FF FF FF FF  FF FF FF FF  FF FF FF FF  FF FF FF FF
7B0 - FF FF FF FF  FF FF FF FF  FF FF FF FF  FF FF FF FF
7C0 - FF FF FF FF  FF FF FF FF  FF FF FF FF  FF FF FF FF
7D0 - FF FF FF FF  FF FF FF FF  FF FF FF FF  FF FF FF FF
7E0 - FF FF FF FF  FF FF FF FF  FF FF FF FF  FF FF FF FF
7F0 - FF FF FF FF  FF FF FF FF  FF FF FF FF  FF FF FF FF
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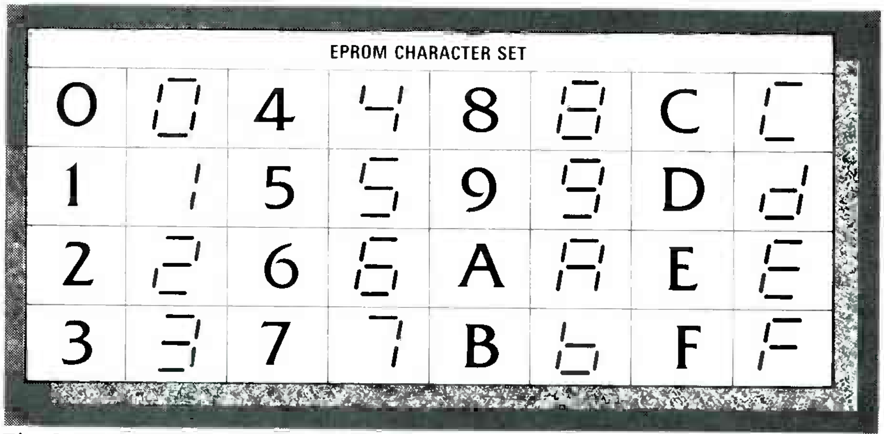

***Fig. 3** THE PORTAMATIC'S CHARACTER SET. You can modify any or all by programming the character-generator EPROM (IC10).*

A-Matic, here's a step-by-step procedure you can follow to troubleshoot the circuit.

Load BASIC and type in the simple program shown in Listing 3. That may not be the world's most elegant program, but it will repeatedly access a port that the Port-A-Matic is set to decode. The alternating reads and writes to the port will test both halves of IC9 (shown in Fig. 3 of the January 1990 installment) and the delay loop will cause a visible change on the activity LED's on the display board. You'll have to adjust the length of the delay loop to match the speed of your computer, but the number in the listing is a good starting point

The key to the operation of the circuit is pin 6 of IC2-b, which is where the master-enable signal is generated. If you have a scope you should see a series of negative-going pulses there. The frequency of the pulses will depend on the speed of your computer, but a 12-MHz AT will access the port at a rate of about 1 kHz, so set the scope's sweep speed accordingly. If the signal is there, you'll see a trace similar to the one in Fig. 4-*a*. You may have a hard time locking the scope to that signal because the time between pulses isn't constant. However, regularity isn't important, since all you want to do is make sure it's there. If you don't have a scope, you can use a logic probe, but it will be hard to tell whether the signal is actually present or you're just detecting noise. The presence or absence of the MASTER ENABLE signal determines what troubleshooting route to follow next.

With the master enable

If the signal is present, you've got a problem farther down the line. The most logical places to check are the outputs of the timers, since those are the signals that enable the displays. You should see something similar to the trace shown in Fig. 4-*b* at the output of IC8-a. The reason that signal doesn't swing closer to the supply rails is that the timer is retriggered so often that the output is driven high before it has a chance to go low.

The test program causes the outputs of IC9 to swing alternately high and low. The frequency will depend on the number in the delay loop and on the speed of your computer, but you should be able to see that activity with just about any test equipment there is: a scope, logic probe, even a multimeter.

If you're getting activity at the timer outputs, your problem is probably on the display board. Check the cable and make sure that you have the correct orientation on the connectors. If that's correct and the board is generating the MASTER ENABLE signal, you've narrowed the problem to the timer circuits, which are so simple that the problem should now be easy to find. Chances are you've got one of the assembly errors discussed earlier, such as poor soldering.

The presence of the MASTER ENABLE signal means that the majority of the Port-A-Matic is happy. Aside from the timers, there are several other places on the board that can help you locate the problem. Some of these points can be tested with logic probes and multimeters, but once again you should look at them with a scope. As with the other test points, the frequency will depend on your computer, but the exact number isn't important.

1. The Q2 output of IC7, the data multiplexer, should look like the trace in Fig. 4-*c*. If there's nothing there, check IC8-b, IC13, and the reset logic made up of IC2-d and IC1-b.

2. You should see square waves similar to Fig. 4-*d* at the outputs of IC12, the digit multiplexer. Look at IC8-a and IC13, as well as Q4–Q6 on the display board. If the waveform appears when you disconnect the ribbon cable, you've got a short somewhere on the display board.

3. The two least-significant outputs of IC13, Q0 and Q1 (pins 7 and 9), should have square waves like the ones in Fig. 4-*e*. A problem here can be caused by a constant high on the reset line (pin 11), or by the absence of input clock pulses on pin 10. Check IC2-b, IC1-b, and IC8-b.

4. The waveform in Fig. 4-*f* should be present on IC11, which is the port-select EPROM, at pins 22 and 23. Also make sure that you check IC1-c, diodes D1 and D2, IC5 pins 11 and 13, and the outputs of IC3.

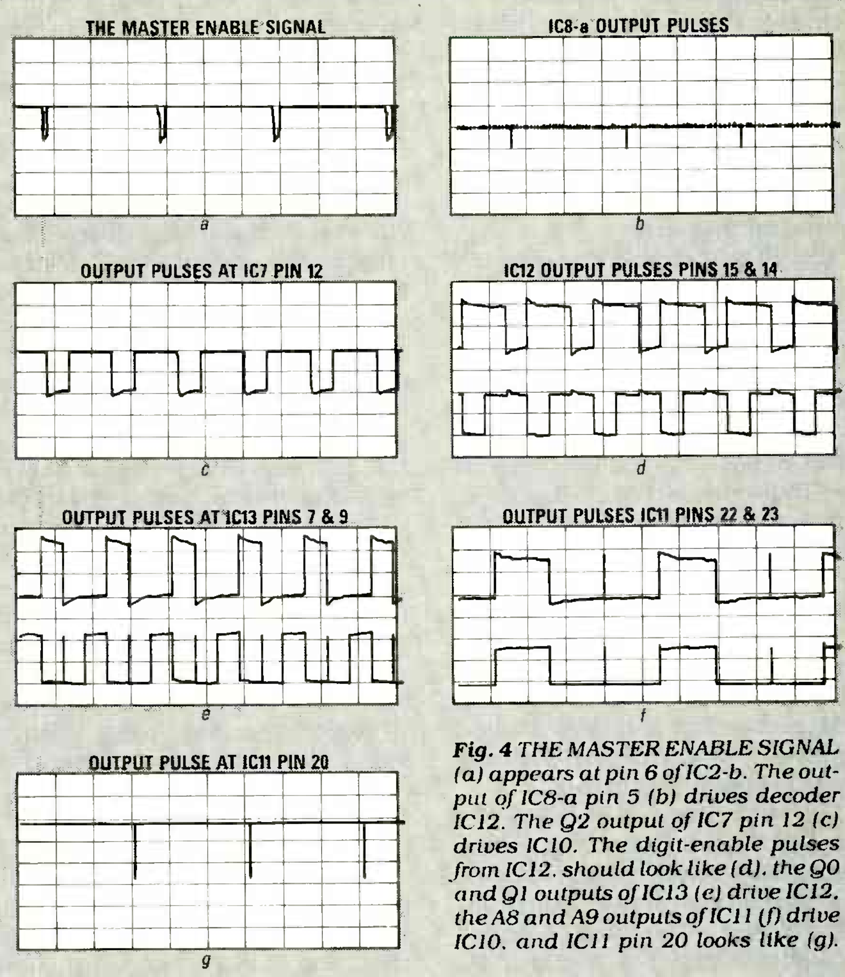

***Fig. 4** THE MASTER ENABLE SIGNAL (a) appears at pin 6 of IC2-b. The output of IC8-a pin 5 (b) drives decoder IC12. The Q2 output of IC7 pin 12 (c) drives IC10. The digit-enable pulses from IC12, should look like (d), the Q0 and Q1 outputs of IC13 (e) drive IC12, the A8 and A9 outputs of IC11 (f) drive IC10, and IC11 pin 20 looks like (g).*

LISTING 3—TEST PROGRAM

```
====================================

4 REM ******************************
5 REM *  Exercise the Port-A-Matic *
6 REM *  by reading and writing    *
8 REM *  to Port 3F5h              *
7 REM *                            *
8 REM ******************************
9 REM
10 X=INP(1013):FOR N = 1 TO 500:NEXT
20 OUT 1013,X:FOR N = 1 TO 500:NEXT
30 GOTO 10
40 END
```

ORDERING INFORMATION

A set of two double-sided printed circuit boards is available for $38.95 from Systems 80 Instruments Ltd., c/o CF Liebert, Inc., P.O. Box L, Blaine, WA 98230. The two programmed EPROMs (2716-1, 350 ns) as described in the article are also available from Systems 80 for $19.95. All prices include shipping and handling.

Without the master enable

No MASTER ENABLE signal means either an error in the IC3 latch, the control circuitry, or the input buffers. The first place to look is the control circuitry, since the rest of the circuit won't work at all unless the control circuitry is operating properly.

The output enable line (pin 20) of IC11, the port selector, is a good place to start. A signal here, as shown in Fig. 4-*g*, means that IC2-a and IC1-d are properly decoding the I/O pulses from the computer bus. That can be checked with a logic probe since the frequency isn't very high.

If you've got a constant high at that pin and you're sure there are no shorts or opens on the board, look at the output of IC2-a. That is only one step away from the computer bus and the absence of a signal there is an indication that either the 74LS00 is bad (unlikely), or that it isn't seeing the I/O lines from the bus.

The next place to check is the output of IC1-a (pin 1), since the signal here has a direct effect on the generation of the MASTER ENABLE signal. The pulses there should resemble Fig. 4-*g*, but delayed by the access time of IC11. You can catch them with any good logic probe but a scope is better. The general appearance of all the control-circuit signals will be the same; very narrow, irregularly spaced, positive- or negative-going spikes.

The input buffers (IC4 and IC5), are more difficult to check since nothing will happen there unless the MASTER ENABLE signal is being produced by the control circuitry. There is one trick you can use, but it's probably going to cost you an IC. Remove IC2 from the PC board (you do have them in sockets, don't you?), bend pin 6 out straight and put the IC back in the socket. Run a piece of hook-up wire from pin 13 of IC1 to the opening of pin 6 in the socket of IC1.

What we're doing is triggering the Port-A-Matic directly from the computer's I/O pulses. Check the outputs of IC4 and IC5 for data pulses. Since we're accessing the same port over and over, you may only see unchanging highs and lows on the various pins. That's fine. If you write down the state of the pins in binary order you'll find that they're carrying 11 1111 0101 or 3F5h, the port address in the test program.

If you're still not getting anything, there are a few things left you can check to help locate the source(s) of your problem(s).

1. Make sure the port-selector EPROM is properly programmed since any sort of error here may keep the Port-A-Matic from working completely.
2. Lift pin 6 of IC2-b from its socket and then check it for the presence of the MASTER ENABLE signal. If you see it when you do that, you've got a board problem further down the line (most likely a solder short).
3. Check the values of R1 and R12.
4. Check the value of C3. The Port-A-Matic will work with a value less than 0.001 μF (although operation may be flaky), but a larger value will stop the Port-A-Matic completely. If you substitute a 0.01 μF capacitor for C3, it will completely swallow the narrow MASTER ENABLE pulses, so the circuit won't work. There are several systems used to mark capacitor values, so let's just state for the record that a marking of 104 is 0.1 μF, 103 is 0.01 μF, and 102 is 0.001 μF.

Putting the Port-A-Matic to work

Although the Port-A-Matic was originally intended to be a diagnostic tool for hardware, it's also a terrific aid in debugging software. A standard troubleshooting technique in program development is to use a PRINT statement in BASIC (or the equivalent in whatever language you use) to track program flow.

The Port-A-Matic can decode sixteen different port addresses (or thirty two if you distinguish I/O reads and writes), so you could program some unused port addresses into IC11 and replace PRINT statements with INP and OUT arguments.

The operation of the Port-A-Matic is totally transparent to the computer and that makes it especially valuable for those times when you're doing graphics programming and PRINT statements can't easily be seen on the screen.

There's no reason why you can't use the Port-A-Matic to control a variety of external devices. Remember that accessing a valid port will result in a unique half-second pulse. Although they're being used to light LED's, there's no reason why they can't turn external hardware on or off, as well.

The Port-A-Matic is a valuable addition to any PC and the number of uses it has is limited only by your imagination. Even if all you need is something that tells you if that new I/O card is properly set up or not, the amount of time it will save you may very well be worth having one in your computer. **R-E**

WORKBENCH

continued from page 77

the PC-compatible family and its operating system." That's the truth, but it's not the whole truth.

The XT/AT Handbook contains in summary form darned near everything a systems integrator, technician, or designer needs to know about the PC family, including bus pin-outs, memory maps, cable connections, card dimensions, programmable registers in the DMA20 and other system controllers, interrupts, BIOS entry points, switch settings, keyboard scan codes, the hard-to-locate diagnostic error codes, DOS commands, and more. I'd like to see a complete listing of the DOS interrupt (21h) services, and printer codes for the IBM/Epson and HAP LaserJet families. But, as it is, the book can replace a foot of fancy (and expensive) documentation. At less than ten dollars, the price is criminally low. The company also sells some really neat software—stay tuned for details. **R-E**

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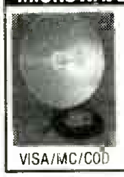

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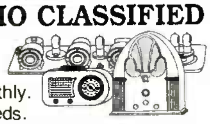

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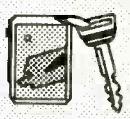

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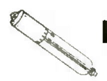

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JERROLD 400 HAND REMOTE CONTROL	29 00	18 00
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*JERROLD 450 HAND REMOTE CONTROL	29 00	18 00
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*M-35 B COMBO UNIT (Ch. 3 output only)	99 00	70 00
*M-35 B COMBO UNIT WITH VARISYNC	109 00	75 00
*MINICODE (N-12)	99 00	62 00
*MINICODE (N-12) WITH VARISYNC	109 00	65 00
*MINICODE VARISYNC WITH AUTO ON-OFF	145 00	105 00
ECONOCODE (minicode substitute)	69 00	42 00
ECONOCODE WITH VARISYNC	79 00	46 00
*MLD 1200-3 (Ch. 3 output)	99 00	62 00
*MLD-1200-2 (Ch. 2 output)	99 00	62 00
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INTERFERENCE FILTERS (Ch. 3 only)	24 00	14 00
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**CALL FOR AVAILABILITY*

Quantity	Item	Output Channel	Price Each	TOTAL PRICE
			SUBTOTAL	
			Shipping Add $3.00 per unit	
			COD & Credit Cards — Add 5%	
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DECLARATION OF AUTHORIZED USE — I, the undersigned, do hereby declare under penalty of perjury that all products purchased, now and in the future, will only be used on cable TV systems with proper authorization from local officials or cable company officials in accordance with all applicable federal and state laws. **FEDERAL AND VARIOUS STATE LAWS PROVIDE FOR SUBSTANTIAL CRIMINAL AND CIVIL PENALTIES FOR UNAUTHORIZED USE.**

Dated: ________ Signed: ____________________

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Please have the make and model # of the equipment used in your area. *Thank You*

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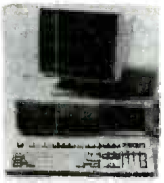
- Floppy Disk Controller
- One 5 1/4" 360KB Drive
- MonoGraphics Card w/ P
- 101 Key Keyboard
- Case (3LED,2Button,Key)
- 12" Amber Mono Monitor
- Installation Guide & Manual



12 MHz 80286 Compatible Kit $669

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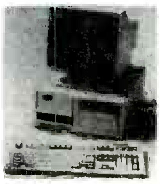
- 200W Power Supply
- Floppy Disk Controller
- One 5 1/4" 1.2 MB Drive
- MonoGraphics Card w/ P
- 101 Key Keyboard
- Case (3LED,2Button,Key)
- 12" Amber Mono Monitor
- Installation Guide & Manual



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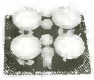

12 dB/octave rolloff. 800Hz, 5000Hz crossover points. 8 ohm. 100 watts RMS.

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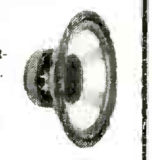
Panel with 50 watt L-pads for tweeter and midrange and built-in LED power meter. 5"x 2 1/2" 100 watt version available

#260-235 — $14.50 (1-5) — **$12.90** (6-up)

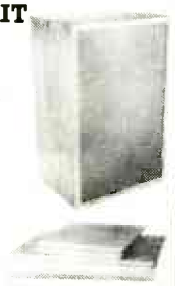
12" POLY WOOFER



Super duty, 40 oz. magnet. 100 watts RMS, 145 watts max. 4 and 8 ohm compatible (6 ohm). 2" voice coil. fs = 25 Hz. QTS = .166, VAS = 10.8 cu ft. Response: 25-1500 Hz. Net weight: 9 lbs. Pioneer #A30GU40-51D

#290-125 — $36.80 (1-3) — **$34.50** (4-up)

WALNUT SPEAKER CABINET KIT



Super quality, genuine walnut veneer cabinet. Kit includes: routed and mitred top, sides, and bottom in unfinished 3/4" walnut veneer. Cut your own custom holes in the front and rear to match your drivers. 15" x 24" x 11". Volume: 1.9 cubic feet.

#260-350 — $22.50 (1-3) — **$19.95** (4-up)

PIONEER HORN TWEETER

Mylar dome. 2.93 oz. barium ferrite magnet. 8 ohm. Response: 1800-20000 Hz. 35W RMS, 50W max. fs = 2000 Hz, SPL = 106 dB. Pioneer #AHE60-51F

#270-050 — $6.50 (1-9) — **$5.90** (10-up)

12" SUB WOOFER

Dual voice coil sub woofer. 30 oz. magnet, 2" voice coils. 100 watts RMS, 145 watts max. fs = 25 Hz. 6 ohm (4 and 8 ohm compatible). SPL = 89 dB 1W/1M. Response: 25-700 Hz. QTS = .31, VAS = 10.3 cu. ft.. Pioneer #A30GU30-55D, Net weight: 6 lbs.

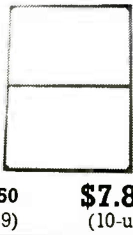
#290-145 — $39.80 (1-3) — **$36.80** (4-up)

15" THRUSTER WOOFER

Thruster by Eminence. Made in USA. Poly foam surround, 56 oz. magnet. 2-1/2", 2 layer voice coil. 150 watts RMS, 210 watts max. 4 ohm. fs = 23.5 Hz, QTS = .33, VAS = 17.9 cu ft. SPL = 94.8 dB 1W/1M. Net weight: 15 lbs.

#290-180 — $43.50 (1-3) — **$39.80** (4-up)

GRILL FRAME KIT



With this kit you can make speaker grill frames up to 30" x 40". Kit includes 4 corner pieces, 2 "T" brackets, and 7 frame bars. Grill mounting kit included.

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MADE IN USA

100 oz. magnet, 3" voice coil. 250 watts RMS, 350 watts max. 8 ohm, 30 Hz resonant frequency. 22-2700 Hz response. Efficiency: 95 dB 1W/1M. Paper cone, treated accordian surround. Net weight: 29 lbs.

#290-200 — $98.90 (1-3) — **$89.50** (4-up)

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Titanium is deposited on a polymer dome to combine the advantages of both hard and soft dome technologies. 8 ohm. Ferro fluid cooled voice coil. fs = 1200 Hz, SPL = 90 dB 1W/1M. 50 watts RMS, 70 watts max. 4" round. Polydax part #DTW100T125.

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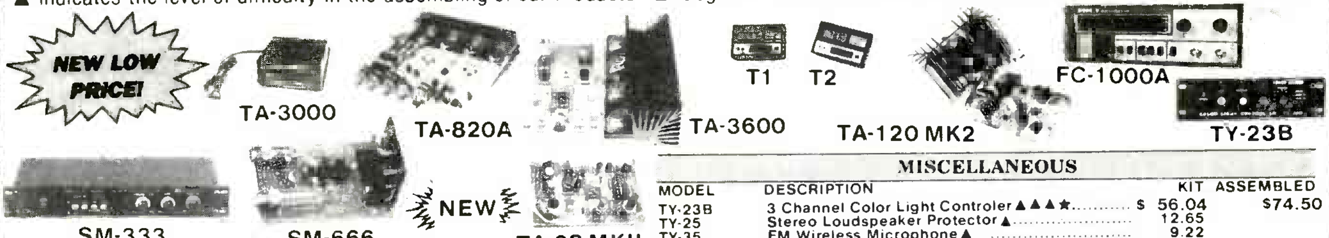

AMPLIFIERS

MODEL	DESCRIPTION	KIT	ASSEMBLED
TA-001	1 W Mini-Amplifier▲	$ 5.07	
TA-006	6W Mini-Amplifier▲	6.90	
TA-007	12W Mini-Amplifier▲	11.20	
TA-10	Stereo Pre-Amp. w/magnetic mic. amp▲	8.20	
TA-28MK2	Digital Voice Recorder▲▲	30.00	$ 40.00
TA-50A/B	Multi-Purpose Melody Generator▲	11.84	16.58
TA-50C	Multi-Purpose Melody Generator▲	12.55	17.71
TA-120MK2	Class "A" Main Power Mono Amp▲▲	27.16	38.81
TA-300	30W Multi-Purpose Single Channel Amp▲	20.00	
TA-302	60W Stereo Power Booster▲▲★	50.00	70.00
TA-3221	50W+50W IC Stereo Amp. w/led level display▲	35.50	
TA-323A	HQ 30W+ 30W Stereo Amp▲	29.50	
TA-377A	FET Stereo Pre-Amp.▲▲▲	59.95	75.00
TA-400	40W Solid State Mono Amp▲	28.00	
TA-477	120W Mostet Power Mono Amp.▲▲	68.00	
TA-800	80W+80W DC Pre-Main & Power Amp.▲▲	60.92	
TA-802	80W+80W DC Stereo Main Power Amp.▲▲	45.94	
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TA-1500	100W x 2 Class "A" DC Stereo Pre-Main Amp▲▲▲	73.70	95.81
TA-2200	DC FET Super Class "A" Pre-Amp.	47.70	58.24
TA-2400A	Electronic Echo & Revelation Amp▲▲▲★	93.30	116.80
TA-2500	HQ Pre-Amp. w/10 band graphic equalizer★		90.80
TA-2800	Hi-Fi Bi-Fet Pre-Amp. w/3 way tone control▲▲	48.90	
TA-3000	Stereo Simulator▲▲	30.20	41.38
TA-3600	300W HQ Hi-Fi Power Mono Amp.▲▲▲	79.00	103.00

MISCELLANEOUS

MODEL	DESCRIPTION	KIT	ASSEMBLED
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TY-25	Stereo Loudspeaker Protector▲	12.65	
TY-35	FM Wireless Microphone▲	9.22	
TY-36	AC/DC Quartz Digital Clock▲	18.00	
TY-38	Sound/Touch Control Switch▲	12.00	
TY-41MK111	Infrared Remote Control Unit▲▲▲	15.00	25.00
TY-41MKV	Infrared Remote Control Unit▲▲▲	20.00	35.00
TY-42	Bar/Dot Level Meter▲▲	24.15	
TY-43	3½ Digital Panel Meter▲	33.00	46.20
TY-45	20 Steps Bar/Dot Audio Level Display▲▲	38.45	
TY-47	Superior Electronic Roulette▲▲	19.46	
SM-328	4 Channel Professional Color Light Controller		150.00
SM-333	Audio/Video Surround Sound Processor▲▲▲★	62.00	83.00
SM-666	Dynamic Noise Reduction △	26.00	34.00
T-1	LCD Thermometer Clock w/in-outdoor sensor★		15.40
T-2	LCD Thermometer Clock w/ F & C measurement★		14.40

POWER SUPPLIES

MODEL	DESCRIPTION	KIT	ASSEMBLED
TR-100A	O-15V 2A Regulated DC Power Supply	59.50	69.50
TR-355A	O-15V 5A Regulated DC Power Supply	14.55	20.76
TR-355B	O-30V 3A Regulated DC Power Supply	14.55	20.76
TR-503	O-50V 3A Regulated OC Power Supply	15.75	22.65

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MODEL	DESCRIPTION	KIT	ASSEMBLED
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SM-48	4½ Hi-Precision D.P.M.	38.00	48.00
SM-49	3½ Multi-Functional LCD D.P.M (w/hold function)	36.00	44.50
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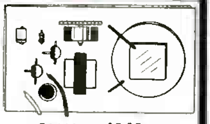
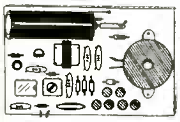


C6441 $5.95



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Wheel of Fortune Kit (9VDC)	C3806	$14.98
Logic Probe Kit (5VDC)	C6384	$12.00
Ultrasonic Pest Repeller Kit (9VDC)	C6350	$ 9.00
Burglar Alarm Kit (6VDC)	C6280	$ 8.75
Jungle Bird Kit (9VDC)	C6374	$ 6.25
Electronic Intercom Kit (9VDC)	C4743	$12.49
Micro Xenon Tube Flasher Kit (1.5VDC)	C6268	$14.95
Simulated Laser Kit (9VDC)	C6394	$ 8.00
Battery Tester Kit (Tests all Types)(9VDC)	C6414	$ 6.95

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5pf	47	390	2.2K	68K
10pf	56	470	3.3K	470K
12pf	82	560	8.2K	
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HARDWARE HACKER

continued from page 74

to get started with that outstanding graphics language.

I also have a new and free mailer for you that includes dozens of insider and top secret sources for all hardware hacking.

As always, this is your column and you can get technical help and off-the-wall networking per that *Need Help?* box. The best calling times are weekdays 8–5 in *Mountain Standard Time*. **R-E**

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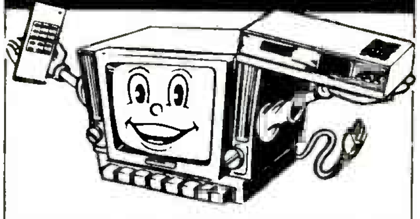

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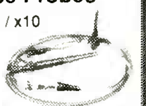

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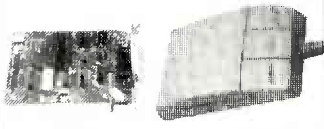

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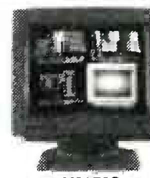

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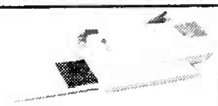

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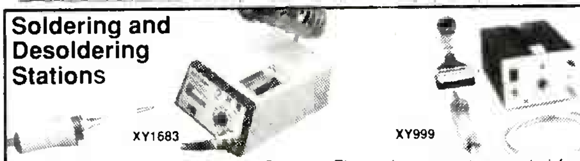

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I stopped recommending CGA display systems to my friends about 4 years ago. Then, the cost per pixel" was lower for CGA than EGA, and my suggestion was frequently ignored. Now, however, VGA has a lower cost per pixel than either CGA or EGA. In fact, expect to get about 60% more resolution for your dollar with VGA as compared to CGA.

This isn't just a numbers game. Operator comfort and display presentation are the real key issues. With more and more prog-rams using a GUI (graphical user interface), the need for high resolution color increases.

Reading text on a CGA display is not particularly easy for any length of time. The lines seen to run together and during scrolling the first few lines on the screen flicker.

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If the move to full color VGA isn't in your pocketbook, please let me suggest a monochrome VGA system as an alternate choice. With 16 or 64 levels of gray scale, it is particularly useful for desktop publishing where your printer doesn't do color anyway.

Derick Moore, Director of Engineering

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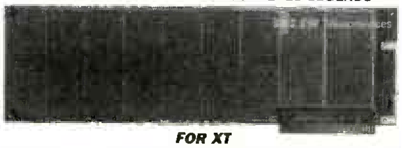

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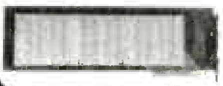

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2764-250	8192x8	250ns	12.5V	28	3.69
2764-200	8192x8	200ns	12.5V	28	4.25
27C64	8192x8	250ns	12.5V	28	4.95
27128	16384x8	250ns	12.5V	28	4.25
27128A-200	16384x8	200ns	12.5V	28	5.95
27256	32768x8	250ns	12.5V	28	4.95
27256-200	32768x8	200ns	12.5V	28	5.95
27C256	32768x8	250ns	12.5V	28	5.95
27512	65536x8	250ns	12.5V	28	7.95
27C512	65536x8	250ns	12.5V	28	8.95
27C101-20	131072x8	200ns	12.5V	32	24.95

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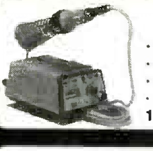

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7408	.24	74LS163	.39	74LS393	.79
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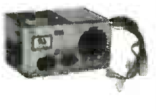

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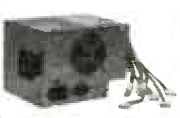

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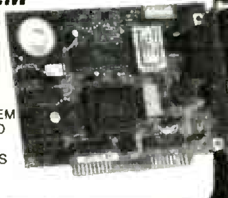

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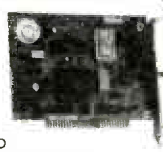

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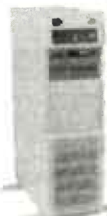

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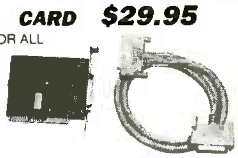

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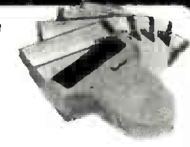

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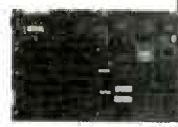

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