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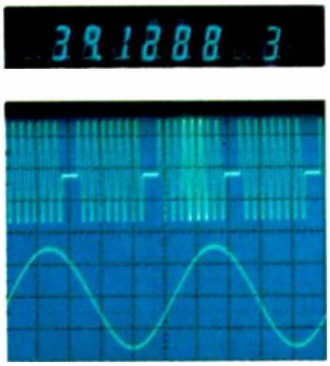
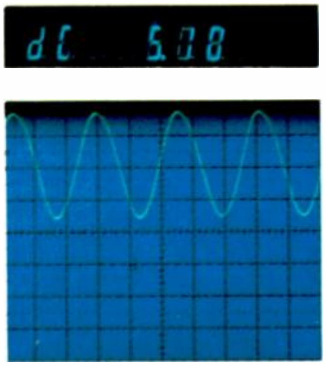


Gated frequency measurement. B sweep triggering during the intensified portion of the A sweep. Intensified portion frequency is measured with the counter/timer/DMM.

Delay time measurement. Delay time from the start of A sweep to the start of the B sweep is measured with *crystal accuracy.*



Channel 1 dc volts measurement. The average dc component of a waveform is measured directly through channel 1 with direct digital fluorescent readout.

The Tek 2236 combines 100 MHz, dual timebase scope capability with counter/timer/DMM functions integrated into its vertical, horizontal and trigger systems. For the same effort it takes to display a waveform you can obtain digital readout of frequency, period, width, totalized events, delay time and Δ-time to accuracies of 0.001%.

The same probe is used to provide input for the CRT display and the digital measurement system, resulting in easy set-up, greater measurement confidence and reduced circuit loading. Probe tip volts can also be measured through the Ch 1 input.

Precision measurements at the touch of a button. Auto-ranging frequency, period, width and gated measurements are push-button-simple. And the 2236 offers an independent floating 5000 count, auto-ranging multimeter with side inputs for DC voltage measurements to 0.1%.

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The 2236: scope, counter, timer, DMM plus a 3-year warranty —all for just $2,650. Contact your nearest distributor or call Tek toll-free. Technical personnel on our direct-line will answer your questions and expedite delivery. Orders include probes, 30-day free trial and service worldwide.

Bandwidth	100 MHz
No of Channels	2 + Trig. View
Max. Sweep Speed	5 ns/div
Digital Readout Features	Direct Ch 1 Voltage Meas. 0.5% DC; 2.0% AC RMS Resistance: .01Ω to 200 MegΩ Continuity/Temp: Audible/C° or F° Totalizing Counter: —1 counts to 8,000,000 Direct Freq. Meas: 100 MHz to 0.001% acc. Period, Width Meas: 10 ns with 10 ps max. resolution
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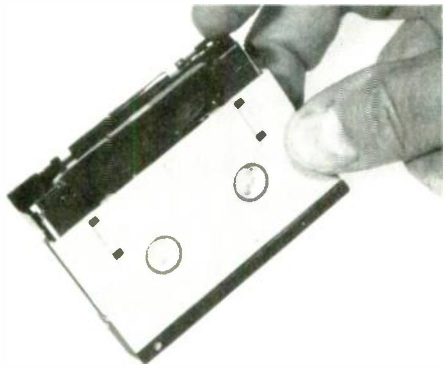

DIGITAL AUDIO TAPE: It's coming in the future. We'll cover the technical details of this promising new audio tape format in an up-coming issue.

RADIO-ELECTRONICS, (ISSN 0033-7862) July 1987. Published monthly by Gernsback Publications, Inc., 500-B Bi-County Boulevard, Farmingdale, NY 11735 Second-Class Postage paid at Farmingdale, NY and additional mailing offices. Second-Class mail registration No. 9242 authorized at Toronto, Canada. One-year subscription rate U.S.A. and possessions $16.97, Canada $22.97, all other countries $25.97. Subscription orders payable in US funds only, international postal money order or check drawn on a U.S.A. bank. Single copies $1.95.
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COVER 1

Hi-Fi autosound has come a long way since the days of 8-track tape. This month, we'll look at some of the latest and the greatest that the autosound industry has to offer, like Pioneer's *DEX-77* CD player and tuner. Included in our discussions are high-tech receivers, cassette players, CD players, CD changers, and speakers, and what makes them special. We'll also look ahead to the next wave in autosound, the DAT player.

But there's more to great mobile sound than just selecting a system and throwing it in your car. And today's downsized vehicles offer tough challenges for even the most skillful installer. However, with effort, electrifying results can be achieved. To prove that, we'll show you how car manufacturers and independent installers have merged automobiles and high-fidelity sound systems to produce concert halls on wheels.

Our two-part special look at autosound begins on page 31.

NEXT MONTH

THE AUGUST ISSUE IS ON SALE JULY 2

HDTV
The next wave in television is brought into sharp focus.

BUILD AN SCA RECEIVER
Build this special FM receiver and hear what you've been missing.

BUILD THE TALKING BOX
It digitizes your speech and stores it electronically.

R-E ROBOT
Part 9 looks at the robot's control language.

TRANSISTOR AMPLIFIER DESIGN
Hints and pointers for your next project.

Radio-Electronics

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Radio-Electronics is indexed in *Applied Science & Technology Index* and *Readers Guide to Periodical Literature.*
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Advertising Sales Offices listed on page 102.

the fourth law of robotics
A robot shall make learning fun for man and thereby improve the quality of life for mankind.
A robot is a robot is a robot... was a robot. Until HERO 2000.
HERO 2000 is much more than a robot. It's a walking, talking 16-bit computer. With 64K ROM and 24K RAM expandable to more than half a megabyte. And a fully articulated arm with five axes of motion. Yours to program. Command. Modify and expand. Total system access and solderless experimenter boards provide almost limitless possibilities. Its remote RF console with ASCII keyboard gives total control. Available with three self-study courses. Backed by Heath Company, world leader in electronic kits.
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The tough just got tougher. When Beckman Industrial introduced heavy-duty DMMs tough enough to withstand accidental drops, input overloads and destructive environments, they quickly became the industry's most popular.

Now they're even tougher, thanks to the best dual-fuse protection you can buy and a new case. Covered by a one-year, no-fault guarantee against damage to the meter other than gross abuse.

For overloads, all voltage ranges can withstand transients up to 6KV. Resistance ranges are protected to 600 volts. Current ranges are protected by a 2 amp/600 volt fuse. The 10 amp range is protected by a 15 amp, 600 volt high energy fuse with 100,000 amp interrupt rating.

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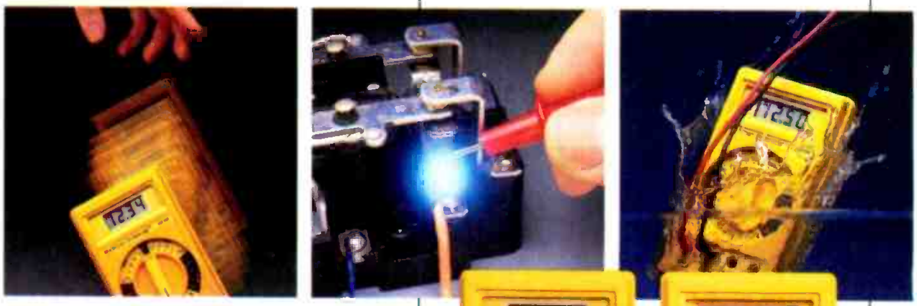

Our heavy-duty DMMs can withstand accidental drops, literally bouncing back for more, thanks to a new case made of Valox,® one of the most impact and corrosive chemical resistant thermoplastics around. Sensitive components are shock mounted for impact protection.

Even oil, water and industrial grime can't keep our heavy-duty DMMs away from the action. *Everything* is sealed with o-rings for maximum protection.

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or with a 4½ digit display required by the HD-140's accuracy.

HEAVY DUTY DMMS	HD100	HD110	HD110T	HD130	HD140
Digits	3½				4½
Accuracy (Vdc)	0.25%			0.1%	0.05%
Input Impedance	22 Megohms				10 Megohms
AC Conversion Type	Average			True RMS	True RMS
Bandwidth (AC Volts)	10KHz			40KHz	10KHz
Current Range Min. Reading	0.1µA				0.01µA
Max. Reading	2A	10A (20A for 30 Seconds			
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WHAT'S NEWS

Superconduction possible at room temperatures?

Recent reports in superconductivity research make it seem that the science is on the verge of performing the impossible—developing a material that has nearly no resistance at room temperatures.

Superconductivity is the condition in which a metal loses all its electrical resistance. That normally happens only at extreme low temperatures, near absolute zero (–459.4° F). If conductors could be made superconductive at practical temperatures, our whole electrical world could be revolutionized. Motors could be drastically miniaturized, computers could be made to operate at even higher speeds, and high-voltage transmission lines could be abandoned. In short, a complete change in most electrical techniques could take place.

Since superconductivity was discovered in 1911, in metals at 4° C above absolute zero (4° Kelvin), the threshold of superconductivity has been raised in slow steps, largely through the discovery of new materials. In 1973, a maximum of 23 degrees Kelvin (–419° F) was apparently obtained.

However, in January 1986, a breakthrough occurred. Superconductivity was obtained in a new class of materials at 30° K. This past December, a new record was set at 39° K. In February 1987, superconductivity at a temperature of 98° K was reached using an oxide material composed of yttrium, barium, copper, and oxygen, a combination that would be a pretty fair resistor at ordinary temperatures.

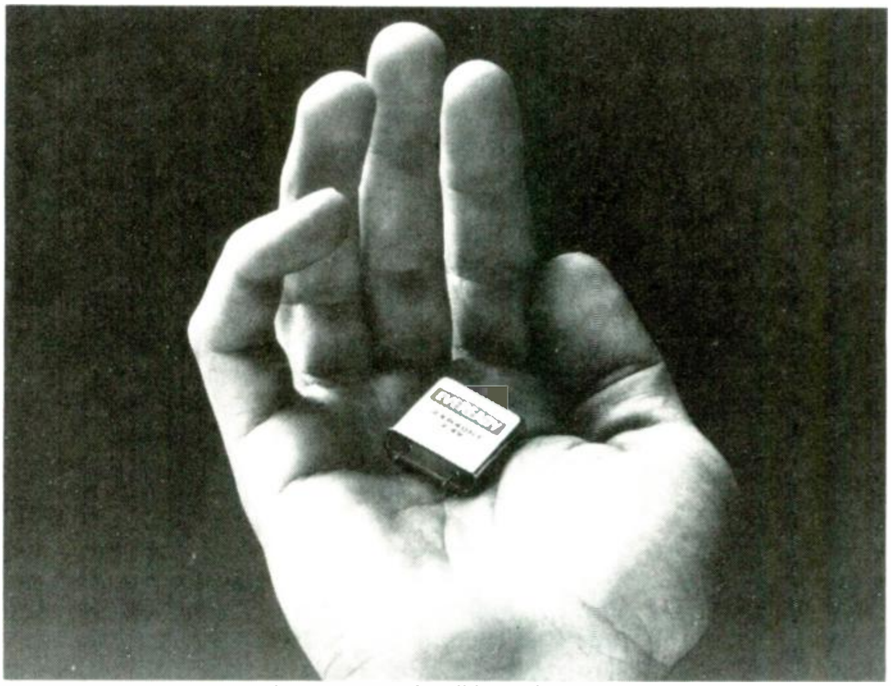
Since then there have been reports of "indications" of superconductivity at 240° K (–28° F) and even hints of "superconducting phenomena" at room temperature. Old theories have been abandoned, and many scientists believe that there is no theoretical temperature limit for superconductivity. Research is going on at a feverish pace, with new results being reported daily, or even faster. One report from Bell Labs bore the dateline: Update, noon, 3/19/87. R-E

New Solid-state battery operates at 200° Celsius

A high-performance hermetically sealed 2.4-volt solid-state battery that will operate continuously at 200° C (392° F) has been developed by the Eveready Battery Co. The high-temperature performance of the new battery has been achieved while preserving both the high discharge rate (greater than that of most conventional solid-state batteries) and the outstanding shelf life of solid-state batteries.

A patented isostatic-compression process (see "What's News", **Radio-Electronics**, Feb. 1986) is used to assemble the batteries from a lithium anode, an inorganic solid-state electrolyte, and a titanium disulphide cathode. The high temperature—far above the limits of ordinary battery systems—can be tolerated because there are no liquids in the battery. That feature makes it particularly attractive for use in applications that require high-temperature memory retention or sensor operation (as in automotive engine compartments, or in military applications). It will also survive heavy shock or vibration at 200° C.

Initial sample batteries will be provided in 2.4- and 4.8-volt configurations. Each will contain two 40-milliampere-hour cells.



ONE TOUGH CUSTOMER. This new Eveready solid-state battery can operate at temperatures as high as 200° C (392° F) and withstand severe shocks. It is ideal for applications in harsh environments.

VIDEO NEWS

DAVID LACHENBRUCH,
CONTRIBUTING EDITOR

• **Sony answers Super VHS.** Sony has fired an answering salvo in the latest phase of the war between VHS and Beta. And in announcing a new version of their Beta recording format, called ED Beta (*E*xtended *D*efinition *Beta*), Sony appears to have recaptured its long-held technological advantage over VHS.

Like Super VHS (*Video News*, June 1987), ED Beta provides a better-than-broadcast-quality picture. However, Sony's ED-Beta system is claimed to provide 500 lines of horizontal definition, as compared with about 430 for Super VHS. Also, ED Beta raises the luminance bandwidth to 6.8–8.6 MHz, as opposed to Super VHS's 5.4–7 MHz, with a deviation of 1.8 MHz (vs. Super VHS's 1.6). Where Super VHS uses a high-coercivity oxide tape, ED Beta uses metal particle tape in a standard Beta cassette. As in the Super-VHS system, the new Beta machines can play back the older conventionally recorded tapes and record tapes in the conventional (standard Beta) manner, but the new higher definition tapes can't be played on standard machines.

ED-Beta cassettes use newly developed TSS (*T*ilted *S*puttered *S*endust) heads and a tape stabilizer system to reduce jitter. Sony claims third- and fourth-generation copies made with ED Beta are almost indistinguishable from the original. Super-VHS machines will be available in the United States soon. Sony says ED Beta will be on the Japanese market this fall, but hasn't disclosed export plans. Both Super VHS and ED Beta were developed in anticipation of a new compatible high-resolution broadcasting system in Japan, which could be inaugurated as early as next year.

• **Next stop, S terminal.** The back of an up-to-date TV set has begun to resemble a piece of Swiss cheese. There are video inputs and outputs, audio inputs and outputs, RGB terminals, etc. Now, add the "S" terminal to all of that. That's the name JVC gives to a two-connector input for the Y (luminance) and C (chrominance) output signals of the Super-VHS recorder. Of course, Super-VHS recorders will also have standard RF and video/audio outputs, but to get the super performance of the system, you will need a high-resolution set equipped with Y and C inputs. JVC, in fact, has already introduced four monitor-receivers with S terminals. Of course, a good monitor receiver without a Y/C input presumably can be modified to inject the super signal into the proper circuits. It's probably only a matter of time before we see Sony TV's with "ED" terminals.

• **Digital videodisc.** A completely unexpected development brought the audience at a recent CD-ROM seminar to its feet with a spontaneous round of applause. A project initiated by RCA at what is now SRI's David Sarnoff Research Center (**Radio-Electronics**, June 1987) has resulted in what could be the first relatively low-cost digital-storage system for full-motion, full-resolution video pictures. Until now, pictures stored digitally on CD-ROM's have been stills, or at best, limited-motion, cartoon-like diagrams. The demonstration by GE/RCA made it clear that the developers' claim of one full hour or more of digital full-motion video plus audio on a standard five-inch optical Compact Disc is now attainable. The developers say that production models could be available for less than $1,000 within two years. As shown on a PC monitor, the system currently has a resolution of 256 × 200 pixels, which is nearly TV quality.

The DVI (*D*igital *V*ideo *I*nteractive) system uses data compression to get full motion on the disc. Without compression, only 30 seconds of full-motion video would fit on a five-inch disc and it would require a full hour to play it back. The home-video potential of DVI is clear, Sarnoff Center engineers say, but they stress the interactive capabilities of the system. "This is much too powerful a medium to just put movies on," said one. The DVI breakthrough casts some doubt on the future of CD-I (*C*ompact *D*isc-*I*nteractive), for which standards have just been finalized to permit still video along with data and audio, as well as on Philips' CDV (*C*ompact *D*isc *V*ideo), essentially a reinvention of the videodisc that provides five minutes of analog video and 20 minutes of digital audio on a Compact Disc (**Radio-Electronics**, March 1987). **R-E**

ASK R-E

CROSSOVER NETWORKS

I am putting together a speaker system and need information on the values for components in the crossover network. —S.P., Corona, NY.

A two-way crossover network consists of a low-pass filter to feed the woofer and a high-pass filter to feed the tweeter. The high- and low-frequency outputs are equal at the crossover frequency. The sharper the desired rate of attenuation outside the crossover point, the more complex the divider network becomes. The rate of attenuation is usually expressed in terms of decibels per octave. (An octave is the interval between two frequencies that have a ratio of 2:1 or 1:2. For example, if the crossover is at 1 kHz, one octave below is 500 Hz and one octave above is 2 kHz.)

If you are simply adding a tweeter to an existing system, you can use a capacitor in series with the tweeter as a high-pass network. The value of the capacitor in microfarads is determined from:

$$C = 79{,}6000/(f_C \times R_O)$$

where f_C is the crossover or cutoff frequency and R_O is the speaker impedance. The simplest crossover network is shown in Fig. 1. There, we have a capacitor feeding the high frequencies to the tweeter and an inductor feeding the lows to the woofer. That circuit is a single element of a constant-resistance type filter. The values of the inductor in millihenries and the capacitor in microfarads are easily found from the following equations:

$$L = (159 \times R_W)/f_C$$
$$C = 159{,}000/(f_C \times R_T)$$

where R_W is the impedance of the

woofer, R_T is the impedance of the tweeter, and f_C is the crossover frequency in hertz. The network's attenuation is 6-dB per octave.

Two types of filters are used in crossover networks. One is the M-derived filter, which, in its basic form, has a rolloff at 12 dB per octave. Each half-section has two capacitors and two inductors. The inductors have different values, as do the capacitors. The other type of filter is the constant-resistance type. We are showing the latter here because the values of both capacitors are equal; the same is true of the two inductors. Both the constant-resistance and M-derived filters can be arranged so the speakers are fed either in series or in parallel.

Figure 2 shows the four most common constant-resistance networks. Series and parallel quarter-section filters with 6-dB/octave rolloffs are shown in Figs. 2-*a* and 2-*b*, respectively; half-sections with 12-dB/octave rolloffs are shown in Figs. 2-*c* and 2-*d*, respectively. The values of the inductors in henries and capacitors in farads in those networks are as follows:

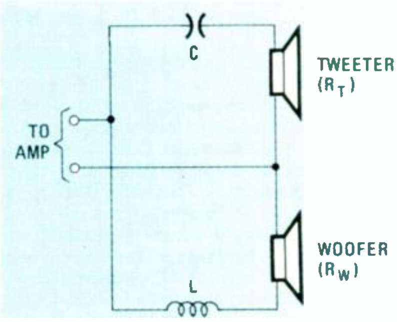


FIG.1

$$L1 = R_O/(2\pi f_C)$$
$$L2 = R_O/(2\sqrt{2}\pi f_C)$$
$$L3 = (\sqrt{2}R_O)/(2\pi f_C)$$
$$C1 = 1/(2\pi f_C R_O)$$
$$C2 = \sqrt{2}/(2\pi f_C R_O)$$
$$C3 = 1/(2\sqrt{2}\pi f_C R_O)$$

where f_C is the crossover frequency in hertz and R_O is the speaker (and input) impedance in ohms.

Your choice of a series or parallel arrangement will probably be determined by component availability and cost. For example, when we compute the values for

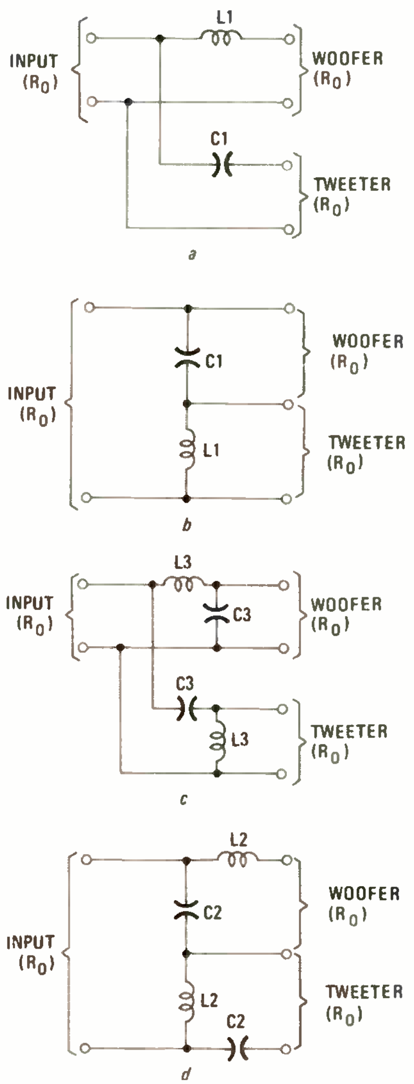


FIG. 2

the inductors and capacitors in the 12-dB half-section networks, we find that the values of the capacitors in the series configuration are twice that of those in the parallel configuration. On the other hand, the values of the inductors in the series configuration are half that of the inductors in the parallel configuration. If you've priced enameled copper wire lately (used for winding the inductors), you'll realize that economy will probably dictate using the series network.

Ideally, the capacitors should be paper or oil-filled types with a tolerance not greater than 10%. Practically, we use non-polarized or back-to-back electrolytics.

The inductor must be wound with fairly heavy wire, such as 16 or 18 gauge, so its resistance will be negligible when compared to the speaker impedance. R-E

LETTERS

OLD CAR RADIOS

After reading your article, "New Life for Old Car Radios," in the April 1987 issue of **Radio-Electronics**, I was inspired to make use of an old AM/FM cassette deck that had been sitting in my closet idly for over a year.

I integrated the unit into the shelf of a computer desk, using an old pair of bookshelf speakers, a 12-volt power supply from my junkbox, mounting brackets that had come with the radio, and a 16-inch rubber car antenna that I purchased for less than $6.00.

The cassette deck was mounted on the underside of the top shelf of the desk. The antenna was mounted through a hole that was drilled in a rear corner of that shelf. The speakers were placed on top of the shelf. The setup provides me with an excellent sound system that takes up little space at my computer workstation.

MICHAEL K. MIZOTE
Gardena, CA

THE R-E ROBOT

I have enjoyed the "Build the R-E Robot" series that is currently appearing in **Radio-Electronics**. In fact, I have just re-subscribed, after an absence of some years, because of it. I've been a roboticist since I was a boy, long before it was fashionable, and I'm currently involved with developing a mobile robot for artificial intelligence research. I also teach robotics for the State University of New York, on a part-time basis. Now for a few comments about Mr. Sarns' design, as presented to date.

Automated equipment is more dangerous than non-automated equipment, because it can start—under computer control—without warning. Program bugs or electro/mechanical failures can result in runaway machines, which (as Mr. Sarns correctly points out) can cause a lot of damage. I would recommend the addition of the following safety features to the design:

- A clearly marked and easily accessible cutoff switch that would be in series with the motor(s)' power bus. That will allow quick disabling of a runaway machine without interrupting power to the computer/memory.
- A motor-bypass switch on each motorized subassembly that would redirect motor power to a set of forward/reverse/on/off indicators. That is invaluable for troubleshooting and program debugging.
- Lead acid batteries pose three risks—hydrogen gas production during charge/discharge cycles; very high voltage-discharge rates in the event of a short circuit; and finally, the acid itself. You should ventilate the battery compartment, fuse the main power bus at the battery post, and line the battery compartment with an acid-resistant material. Plastic boxes are available at low cost. It may be desirable to add baking soda to the packing material in the battery compartment to neutralize spilled acid. (I can assure you, from personal experience, that all mobile robots turn over sooner or later.)

Also, any machine that uses a chain or belt drive, as does the R-E Robot is a potential hazard. A ¼-horsepower motor geared down to 12:1 can sever young fingers caught between the belts/chain and pulleys/sprockets. *Please* put guards over the drive trains. They are easy to fashion and will add mere ounces to the machine.

Thank you for **Radio-Electronics'** continued interest in robotics. I hope that my comments here will not be taken as overly critical; Mr. Sarns' overall design has been excellent, and I am looking forward to reading the rest of the series.

JOSEPH A. COPPOLA
Sherrill, NY

Mr. Coppola is absolutely correct. The R-E Robot was designed as a heavy-duty workhorse quite unlike most hobby robots. The standing joke here at Vesta is to equip a unit with over-sized, knobby tires and take pictures of it crushing Hero 2000's. Seriously though, the safety issues cannot *be overstated. Mr. Coppola's suggestions are well taken. We have added a main power switch to each of our units that shuts everything off. One solution to the risks posed by using lead acid batteries is to substitute sealed gel type batteries. However, they cost about 5 to 10 times more than the conventional variety. I agree, all mobile robots do turn over. Sometimes it's simply a result of not tightening the axle retaining bolts sufficiently (one learns the ramifications fast!)*

The external drive system is dangerous—old fingers may be equally in jeopardy. I know of one company (Micro K Systems) that is considering offering a set of vacuum formed chain guards.

Perhaps I have not stressed the safety issues as much as I should have. I have assumed that if you, as a robot hobbyist, are intelligent enough to assemble, program, and test the robot, most of the safety issues will be self-evident.

Many of the issues raised relate to the difference between a project and a product. A product with the price/performance advantages that the R-E Robot offers would be impossible. But as a project, one is not forced to protect the "innocent" with expensive safety features that are not needed in your specific application, and the basic cost is kept down.

It is also worth pointing out that the series, from the beginning, has encouraged robot experimenters to use our robot only as a guide or an example. We are most happy when we hear of builders modifying our basic design.—Steven E. Sarns

THE "FOX-HOLE" RADIO

As a follow-up to the razor-blade detector discussions in "Letters" in December 1986 and April 1987, I thought that you and the readers might be interested in the following item about Lt. M. L. Rupert of Springfield, MO, who made a most ingenious radio during World War II. The information, including part of a letter from Lt. Rupert., is on a plaque that has been hanging on a wall at the Armed Forces Radio and Television Service as long as anyone can remember. The letter reads:

"...Your Marlin double-edged blade is used to make a foxhole radio for the Yank infantrymen on this beachhead. All that's needed is a coil of wire, insulated, a safety pin, a headset, and a used blade. The blade is tacked down, with a wire attached to it and going to one side of the coil and on to the aerial. The other side of the coil goes to the ground and to one side of the headset. A wire from the other side of the headset goes to a safety pin driven into the wood, leaving the other end of the pin free to be moved across the unground part of the Marlin blade to find your station. Reception is very good and at night we get several stations including the Berlin Sally propaganda put out in English."

Have any of your readers seen any earlier references to the "razor detector?"

THOMAS P. SMITH IC1-USN
Sun Valley, CA **R-E**

EQUIPMENT REPORTS

AVCOM PSA-35A Portable Spectrum Analyzer

An indespensible tool for TVRO installation and servicing.

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IF YOU THINK OF SPECTRUM ANALYZERS as instruments that cost tens of thousands of dollars and are at home on—and are hardly ever moved from—a laboratory test bench, you better think again! The TVRO industry has fueled many advances in microwave components. The same technology and components that have helped the cost of satellite receiving equipment to drop so dramatically during this decade has benefited test equipment for microwave frequencies as well. We recently had the opportunity to inspect one of the benefactors: the *PSA-35A* portable spectrum analyzer from Avcom of Virginia, Inc., (500 South Lake Blvd., Richmond,VA 23235).

A spectrum analyzer is a scanning radio receiver that displays the signals present in a given part of the RF spectrum. It can be an extremely valuable tool for a TVRO installer. Using it, a technician can greatly speed up the dish-aiming process and polarizer adjustment. He can measure the performance of LNA's and downconverters, troubleshoot cabling and connector problems, and even spot *T*errestrial *I*nterference (TI) problems. Before we look at how the analyzer can be put to work in practical applications, let's take a look at its general specifications and features.

The *PSA-35A* offers 5 low bands of coverage from less than 10 MHz to greater than 1500 MHz, and a single high band from 3.7 to 4.2 GHz. The low bands are configured as follows:

a) less than 10 MHz to 500 MHz
b) 270 MHz to 770 MHz
c) 400 to 900 MHz
d) 950 to 1450 MHz

The fifth low-frequency band can be preset by the user to cover any 500-MHz band between 300 MHz and 1500 MHz (or up to 1900 MHz on special order).

The *PSA-35A* offers two input connectors: The low band connector is a BNC type, and the high-band connector is an N type. Because it is a TVRO service tool, the

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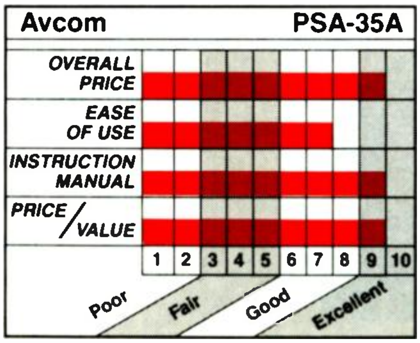

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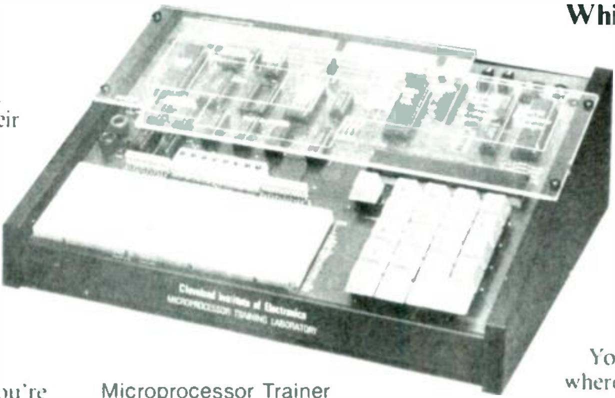

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connectors can supply (at the flick of a front-panel switch) +18 volts DC (Which is required by most LNA's and block downconverters).

Signals are displayed behind a 10 × 7 graticule. The horizontal (frequency) scale can be adjusted using the continuoulsly variable SCAN control from 1 MHz per division to 50 MHz per division. In other words, you could expand the entire display to show a 10 MHz bandpass, or compress it to show the signals in a 500 MHz bandpass—all the transponders on a given satellite, for example. The vertical (amplitude) scale can be either 10 dB per divsion or 2 dB per division.

Using the analyzer

A TVRO installation technician could use the *PSA-35AA* in a number of ways—even before the actual installation. The first step in any TVRO installation procedure is a *site survey*, which determines the suitability of a given site for installation. A clear view of the southern horizon is not the only factor determining site suitability; the site must also be free of interference from terrestrial microwave links. That's where the *PSA-35A* comes in. When used along with an auxiliary feedhorn that Avcom calls the TISH (*T*errestrial *I*nterference *S*urvey *H*orn), the spectrum analyzer can indicate the presence or absence of TI.

Knowing whether TI is present *before* a dish is installed can save an installer a lot of headaches and a lot of extra work. In many cases, a suitable site can be found not too far from the first, but with some tree, building, or other obstruction blocking the TI.

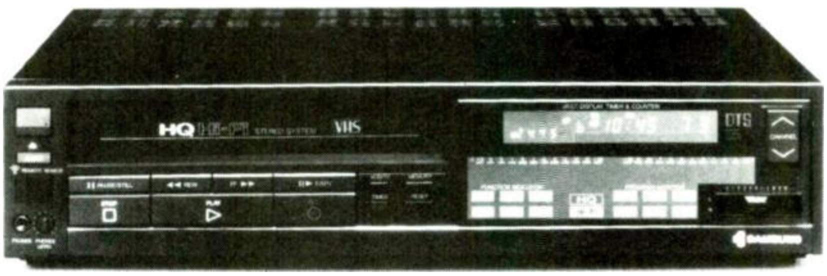
Once a site is found, and a dish and feedhorn are installed, a spectrum analyzer can again make the job easier. At a glance, the analyzer can show the signals in a given band and their strengths. It can make homing in on the Clarke belt a breeze. And because the spectrum analyzer is so sensitive, using it to aim the dish is much more reliable than using a receiver and a monitor. Small adjustments of the dish that would make little difference on the picture seen with a strong transponder would be seen quite dramatically on the display, especially when the unit is switched to an amplitude sensitivity of 2 dB per division. The result is better overall TVRO operation.

The spectrum analyzer again shows its strengths when it's time to align the polarizer. You can display the outputs of several transponders on the screen and watch the cross-polarized transponders null out.

The manual included with the *PSA-35A* is written directly for the TVRO installer. Its application section gives several excellent examples of how to use the instrument in TVRO installation and service. It also includes several pre-cut acetate sheets that can be slipped directly over the display so that the signal and switch settings can be traced and kept on record. It also includes a form that Avcom calls a SASAR (*S*pectrum *A*nalyzer *S*ystem *A*nalysis *R*eport) for recording all pertinent information of an installation. If problems develops in the future, a comparison of SASAR measurements could allow the serviceman to quickly solve the problem.

The *PSA-35A* is an excellent servicing tool. It has a suggested list price of $1965. If you are involved in TVRO service, you can expect to recoup the cost quickly. **R-E**

NEW PRODUCTS



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HI-FI VHS VCR, the model *VR6600F,* is a front-loading recorder and it offers two video heads with HQ circuitry for virtually noise-free pictures; hi-fi stereo audio recording/playback; built-in MTS decoder for stereo-TV broadcasts; and 110-channel, cable-compatible, frequency-synthesized tuning. The recorder also features a 14-day/6-event programmable timer, three-speed record and playback functions, auto rewind, picture search, pause/still, and one-touch recording.

The model *VR6600F* measures $3\frac{7}{8}$ inches high, by $16\frac{15}{16}$ inches wide, by $13\frac{9}{16}$ inches deep. The suggested retail price is $649.95.—**Samsung Electronics, America**, 301 Mayhill Street, Saddle Brook, NJ 07662.

SURGE PROTECTOR, the model *DE-LSP,* is designed to protect valuable video equipment against induced transients from lightning. The simple-to-install in-line device is designed with extremely low capacitance circuitry for minimal insertion loss; there are external ground connections for extra protection against high-potential surges from chassis ground to earth ground.

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The model *DE-LSP* is priced at $92.00.—**Diamond Electronics, Inc.**, P.O. Box 200, Lancaster, OH 43130.

SCANNER, the model *R1090,* is 45-channel and includes bank scanning, weather scan, and a priority control. It is designed for beginners as well as veteran scanning enthusiasts, and covers more than 15,000 frequencies from six of the most popular VHF and UHF bands. Coverage includes VHF low (30–50 MHz), VHF amateur (144–148 MHz), VHF high (148-174 MHz), UHF amateur (440–450 MHz), UHF (450–470 MHz), and UHF-T (470–512 MHz). 45 popular frequencies are preprogrammed at the factory, so that the unit can be operated right out of the box.

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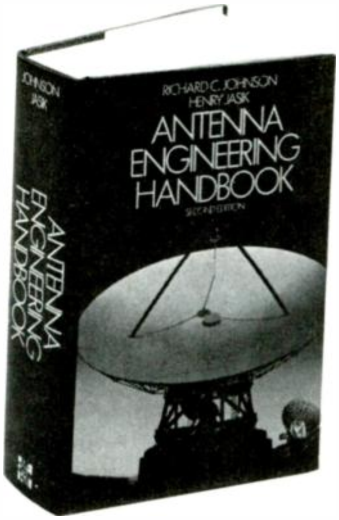

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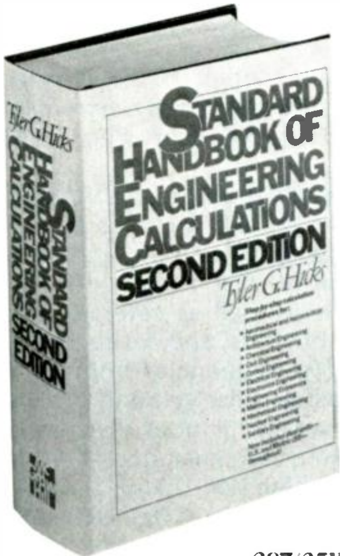

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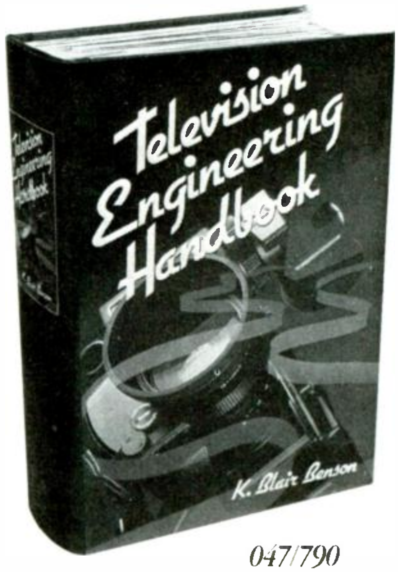

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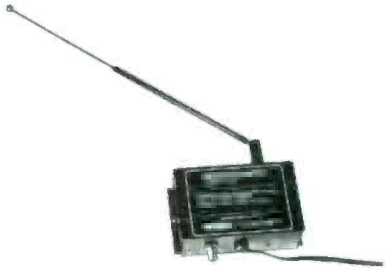
For added convenience, frequencies can be grouped into any of four channels for "bank scanning". (For example, "Bank One" could include all common police frequencies; "Bank Two" can include fire channels, etc.) All four banks can be scanned at once, or individual banks can be scanned to speed up the scanning cycle. When the "weather scan" key is pressed, the scanner automatically searches all National Weather Service frequencies to find the active frequency in a few seconds.

The model *R1090* has a suggested retail price of $239.95.—**Regency Electronics,** 7707 Records Street, Indianapolis, IN 46226.

ANTENNA/AMPLIFIER, the model *RF-36*, is designed for FM-stereo, VHF- and UHF-TV, or police-scanner applications. Features include 50- to 950-MHz bandwidth, 12-dB signal gain, 75-ohm output, and 117-volt AC operation.



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The unit's small size and construction allow it to be remotely mounted, hidden, or placed on a shelf. The model *RF-36* is priced at $79.95.—**Rhoades National Corp.,** P.O. Box 1316 Dept. ZN9, Columbia, TN 38402.

CABLE CHECKER, the model *DX-50*, is pocket-sized, and instantly evaluates the integrity of any 2, 3, or 6-wire RJ-11 modular telephone or data cables. To use, simply plug in both cable ends and examine the three two-color LED's on the front panel to determine the integrity of the cable pairs. Si-

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multaneously, the color of the LED's determine whether the cable is properly wired for data use with straight-through pinning (lights red), or for voice communication with crossed pinning (lights green). The high-impact case is 2.4" × 3.8" × 1" and operates from one alkaline 9-volt battery (supplied). The model *DX-50* is priced at $26.95.—**L-Com Data Products**, 1755 Osgood Street, North Andover, MA.

DIGITAL THERMOMETER, the model *DT-160*, is pocket-sized and, in addition to its extendable temperature probe, has a temperature sensor mounted on its front panel. That allows the user to switch between reading room temperatures and probe temperatures in seconds. There is also a built-in clock that displays time when selected, and the unit is programmable at two individual temperature limits that trigger an audible alarm. The model *DT-160* has a built-in tilt stand and spring clip that allows it to be placed in almost any location. Its range is 0°s–159.8 F (−19.9° to 71° C).

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The model *DT-160* comes with battery, 34" attached probe lead, and one-year warranty; it is priced at $45.00.—**A. W. Sperry Instruments, Inc.**, 245 Marcus Boulevard, Hauppauge, NY 11788.

CASSETTE TERMINAL, the model *5450XL*, is microprocessor-based, with extended baud-rate capability. The new model now oper-

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ates at 4800, 9600, and 19,200 baud, in addition to its existing rates of 110–2400 baud. Existing units can be upgraded through the purchase of an upgrade kit. It is fully compatible with ANSI/ECMA, RS-232C-BUS, and CCITT V.24-BUS standards, and cassette interchangeability is guaranteed. Each terminal incorporates cassette tape drive, microprocessor controller, and dual interface ports; it is particularly designed for data-collection and data communications applications.

The model *5450XL* is priced at $2495.00.—**Memtec**, Keewaydin Drive, Salem, NH 03079. **R-E**

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Dynamic memory

UP UNTIL ABOUT EIGHT OR NINE YEARS ago, systems designers would avoid dynamic memory like the plague. The reason for that was simple: the disadvantages far outweighed the advantages. You could plop static RAM in a circuit and use it without much other thought, but dynamic RAM required a lot of support circuitry. In fact, back in those days a 16K dynamic RAM was a big deal: it needed three supply voltages and was very particular about timing.

Things have changed.

Today's cheap 64K dynamic RAM's are much easier to use and, since they give so many bits for the buck, any designer worth his salt has to be familiar with them. Lots of special dynamic RAM controllers are available that take care of all of a dynamic RAM's special needs, and make them almost as easy to use as static RAM. To help you get a good grasp on how to use dynamic RAM, we'll put together a simple system; and although the system won't be state-of-the-art, once you understand how it works you'll have a good grasp of the basic considerations of designing with dynamic RAM.

Keeping in mind the DRAM (*Dynamic Random Access Memory*) characteristics we discussed last month, you can see that any system using them has to have certain building blocks. The block diagram in Fig. 1 describes not only the system we're putting together,

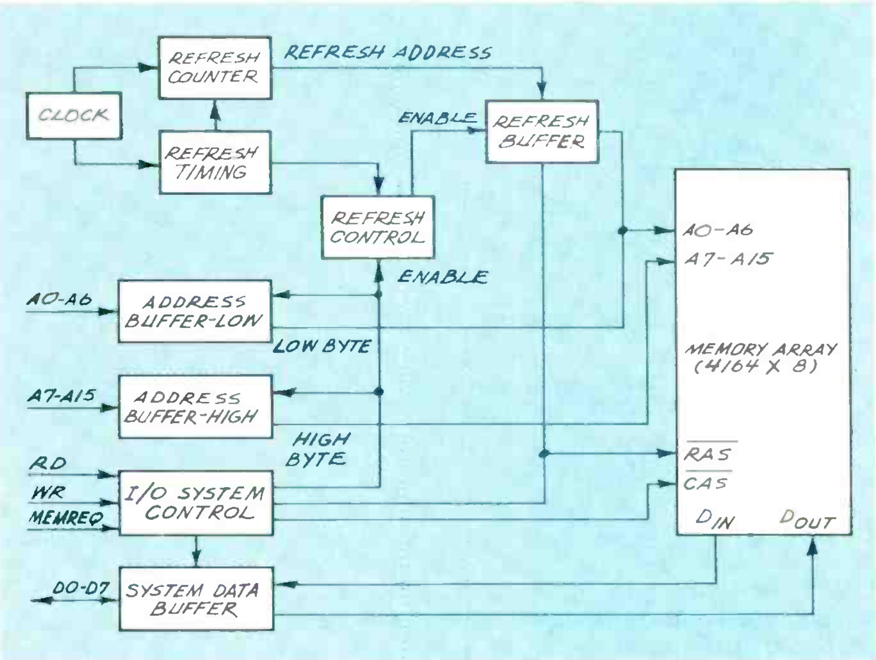

FIG. 1

but also one that uses the most sophisticated LSI DRAM controller. The difference between the two is where the elements are found. A lot of the discreet parts we'll be using are packed together in the substrate of LSI devices such as Intel's 8208 family. Once you're familiar with our system, putting together an LSI system will be a relatively easy task.

The system has three main sections, and although each one does a separate job, they have to interact as well.

1. The memory array: That section contains only the actual storage devices. In our circuit it's made up of eight 4164's, each of which is organized as 64K × 1 bit.

2. The refresh circuit: That produces the control signals, sequential addresses, and the timing logic to maintain the data in the memory array.

3. The I/O circuitry: That circuitry generates the necessary timing and control signals to let an external device get access to the memory array.

Let's look at each of the sections individually.

First section

You should be familiar with the memory array because we've already spent lots of time talking about dynamic RAM in general and 4164's in particular. Each of the eight IC's has its address and control lines bused together. The DATA IN and DATA OUT pins on each IC are also tied together, because the direction of data flow will be controlled by the rest of the system, and the 4164 can be told to three-state its output.

Second section

The refresh circuitry is designed to count systematically through all the addresses needed to maintain the stored data. That is, of course, the big drawback of using dynamic RAM. IC designers have made refresh as easy as possible and, if you read a 4164 data sheet, you'll see that there are several ways in which it can be done. We'll be doing a *RAS-only refresh*, which means that we present a row address to the A0 to A6 address pins of the memory array and then bring the RAS line low. That will

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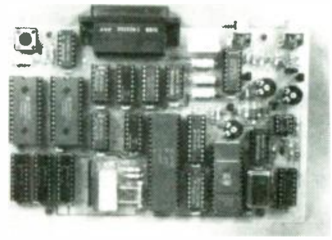

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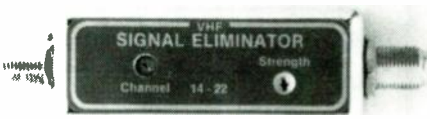

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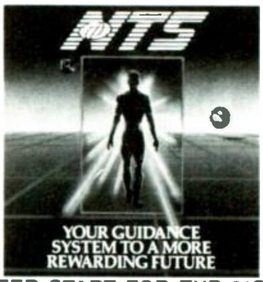

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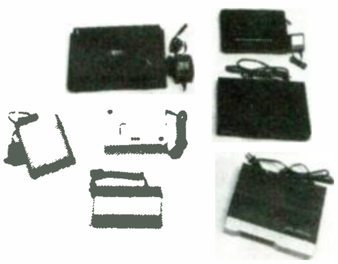

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automatically refresh all the memory cells located in that row.

A 4164's memory matrix is organized as 128 rows by 512 columns, so it's only necessary to sequence through 128 addresses to completely refresh the device. We're using 7 address lines, (A0 to A6), because two to the seventh is 128. On the simplest level, refresh is done by putting out a 7-bit address and strobing RAS, but there are other things to deal with as well. As we'll see, timing is the really critical factor and the state of the other memory-control pins has to be considered as well.

Third Section

The last section of our circuit handles the I/O. It's all well and good to build a system that can properly massage dynamic RAM, but it's not much good unless there's some way to store and access the data in the RAM. Any system wanting access to our circuit only has to give it an address, data, and a read or write request, and then sit back until it's notified that the job is done. Doing that with static RAM is simple, but the constant refresh activity that is going on in a dynamic RAM system complicates things.

Servicing a memory request means accessing a location somewhere in the memory array's address space. The chances are slight that the requested location is going to be on the row that's currently being refreshed; and it would take too long, and require a lot of extra circuitry, to wait until the refresh circuitry reaches the particular row containing the requested location. An external memory request means that the refresh activity has to be halted, access has to be given to the requested location, and then the refresh circuit can regain control of the memory.

If you're beginning to think that here is a real nightmare for a circuit designer, you're starting to appreciate and understand the reservations that most circuit people have about using dynamic RAM. Given all the needs of our system, putting one together with a gates-only approach would be extremely complex, even if the job were done using MSI components.

One of the major problems when dealing with dynamic RAM is the strict timing parameters. A standard 4164 will retain the data stored in its pint-sized capacitor cells for only 2 milliseconds. That means that your circuit has to perform a refresh on each cell within 2 milliseconds or the data is lost.

Since a RAS-type refresh works on a whole row at a time, and since there are 128 rows in a 4164, the refresh must be performed at least every 16 microseconds. The circuit that takes care of all that for you must be designed to sequence through several steps for each refresh operation.

1. The refresh counter has to increment to the next address.

2. That address has to be put on the address bus for the RAM.

3. A RAS signal has to be generated and fed to all the RAM.

continued on page 81

Great Systems

Highway hi-fi isn't as good as being in the concert hall, but it can come close.

FRANK VIZARD

UNTIL THE INVENTION OF THE TRANSistor, car radios had a reputation for outstanding sound quality. Compared to the typical table radio of its day—which was no slouch when it came to a well-balanced sound—the car radio had more output power and less distortion, a tracking loudness-compensated volume control, and a relatively large speaker of 6 × 9 inches that was specifically designed to handle the extra output power and the extended low frequency response of a car radio. Most important of all, the labyrinthine dashboard served as a superb enclosure for the speaker, thereby providing an enhanced bass response. In fact, one often looked to purchase a home radio that had the solid-bass sound quality of a car radio.

Unfortunately, transistors allowed manufacturers to cheapen the overall design of car radios, while the downsizing of the average family-size vehicle made it difficult to squeeze large speakers into a small dashboard, which by itself no longer functioned as a decent speaker enclosure. In a sense, we might say that the transistor radio and the compact car led to second-rate autosound, and several generations of young, new-car owners never had the thrill of hearing truly outstanding autosound.

However, as highway sound got progressively worse, high-fidelity systems for the home became less expensive. The "hi-fi player" became a common household appliance, and listeners soon demanded hi-fi sound for their cars (never knowing that grandma and grandpa used to sit out in the car when they wanted to hear "concert hall" sound).

Early highway hi-fi

The first of the so-called "high-fidelity autosound systems" was really a misnomer, for it was not much more than an 8-track or cassette player piggybacked on a conventional car radio. By any standard of reference, the sound quality ranged from poor to miserable.

Fortunately, today's listeners are more demanding. When manufacturers realized that audiophiles were willing to spend considerable sums to put high-fidelity sound in their cars, many well-known companies specializing in hi-fi components for the home entered the autosound field. Those companies, as well as a number of new firms that chose to specialize in autosound, actually succeeded in approximating the sound quality of a home system in the restricted confines of

the modern, downsized vehicle In fact, once hi-fi was available for cars, like early home stereo it soon attained cult status, becoming the latest "must have" for the up-and-coming young professional—or anyone else who wanted to be part of the "having it all generation."

To fulfill their fantasy of sitting in Philharmonic Hall while barreling to the next stoplight, the new generation of autosound stereophiles actively sought out the small coterie of installers having the acoustical expertise needed to compensate for the harsh environmental conditions posed by a moving vehicle. The best among those installers learned how to match specific products to individual car models to get the best sound possible. The lessons learned by the early pioneers in autosound passed into the mainstream of high-fidelity sound, and sound systems tailored to specific cars are now a commonplace objective that is being met on two different and distinct levels.

On one level, car manufacturers have recognized that high-fidelity highway-sound can be an important consideration to potential new-car buyers, so many models either are supplied initially with a high-fidelity sound system, or make it available as an optional package. Generally, the factory-installed hi-fi systems are acoustically tailored to a particular model car through the expertise of recognized hi-fi experts; in particular, speaker manufacturers. For example, General Motors' Delco Radio Division has developed a partnership with Bose Corporation. Similarly, Ford relies on the expertise of JBL, and Chrysler seeks the advice of Infinity Systems.

On another level, a legion of autosound retailers who specialize in installing various brands and types of equipment have become what is collectively called the "aftermarket." The aftermarket survives because its offerings are generally more advanced than the equipment sold with most new cars. The "advancements" are principally in the area of features and flexibility. While the car companies can offer a good, basic autosound system, the array of aftermarket equipment available is such that you may find:

1. Products having more conveniences and better performance than the factory-installed equipment.

2. Equipment as good as what is usually supplied factory-installed, but at lower cost than what the car dealer charges. Although the car dealers do offer the convenience of one-stop shopping, if you're willing to spend time checking out several dealers the chances are that you'll end up with better sound and features for the same basic cost.

Buying an autosound system necessitates making choices in three areas: signal source, power, and speakers. Each area, however, has a common consideration: the space limitation of your vehicle. Different cars have variously-sized holes slated for radios and speakers. A particular cassette/receiver, for example, might not fit into a dashboard without extensive, and often expensive, cutting to enlarge the opening. Conversely, a small unit may not fit without the use of an adapter to fill up the extra space left in the opening. Likewise, the almost "standard" 6 × 9-inch speaker will not fit easily—if at all—into compact and sub-compact cars.

Choosing a signal source means opting for a product that offers a radio, tape, or *C*ompact *D*isc (CD) combination. To complicate your decision, the coming months will see the arrival of *D*igital *Au*dio *T*ape (DAT), a new cassette format that rivals the performance of even the compact disc.

Although existing autosound speakers and amplifiers are compatible with DAT, because of the projected high initial expense of the early DAT players, at least for the foreseeable future the primary pre-recorded signal source for highway hi-fi will be Dolbyized cassette tapes; followed by the Compact Disc, which is only now starting to make significant inroads into autosound installations.

Autosound CD player equipment is available in a number of configurations. CD/receivers are similar to cassette/receivers in that they combine an all-stereo AM/FM or an AM/FM-stereo receiver with a compact disc player. Typical of CD/receivers is the Audiovox *HCD-1000*. The tuner section includes 12 station presets that you can program with your favorite radio stations, a station seek that automatically locates the next strongest station, and a scan for easy sampling of many different stations.

The *HCD-1000*'s CD section offers an auto-index that allows the user to preview each disc "track" or selection for eight seconds, a repeat button for playing the track over again, fast-forward and fast-reverse selection search, and digital indicators for the track number and elapsed time. Suggested list price for the *HCD-1000* is $699.95.

While the *HCD-1000* is a typical CD/receiver, it is somewhat unusual in that the disc must be inserted into a cartridge before it can be played. The cartridge system is also used by JVC, Yamaha, Clarion, and Blaupunkt to facilitate loading while also providing the disc with much added protection.

Pioneer's DIN-mount *DEX-77* CD/receiver is one of the most high-tech models available; it is specifically designed to withstand the rigors of an automotive environment. It uses a three-beam tracking system to insure error-free tracking, and a "Last-Address Memory" function that ensures pickup on the right track even on rough, jarring roads. The CD player can be programmed for the order of track play, automatic scan, all track repeat, and random play, whereby the player automatically shuffles the order of track play. The receiver section features a "Best Station Memory," which remembers the six strongest stations in descending order of signal strength. The Pioneer *DEX-77* is priced at $850.

Player-only models are another CD configuration. These tuner-less CD players may be suitable if your car is already equipped with a cassette/receiver and you simply want to have the option of CD.

If you want to listen to both CDs and cassettes, you may want to buy a cassette receiver that is equipped with an input jack for a CD player. The jack gives you the option of easily adding a personal CD player by simply plugging it into the jack. Conversely, Sanyo's CD players have an input jack for "Walkman-type" personal tape players.

Sony offers an alternative to those wanting to listen to both cassettes and CD's: That product is a slim cassette-only player to be used in conjunction with its companion model *CDX-R88* CD receiver.

WORRIED ABOUT THEFT? Some receivers, like this one from Alpine, can be slipped out of the dash easily for concealment.

List price for the CD/receiver is $750, while the add-on cassette player has a suggested list price of $270.

A related product is the Philips *CD-10*, an autosound CD player that slides out of the dashboard for use as a personal or portable CD player. List price for the *CD-10* is $400.

Another approach to CD is provided by Sony and Alpine. Both companies offer CD disc changers that mount in the trunk. A cable from the changer to a control unit mounted up front near the driver's seat allows the driver (or passenger) to control the music selection. The Alpine changer holds 12 discs in a removable "magazine," while the Sony *DiscJockey* holds 10 discs. The Alpine control unit mounts in-dash while the Sony controls can be hand-held or mounted. Optional tuners are available for both units so that the CD changer can also function as an AM/FM-stereo radio.

The cassette/receiver may represent an older technology, but they are still the mainstay of most autosound systems. Because of its nearly universal use, development of cassette/receivers has not ground to a halt since the introduction of CD. The old "tin can" with two knobs on either side is giving way to sleek, flat-panel (no knobs) models housing more features than some of the older models could ever hope to offer.

NEXT STOP: DIGITAL

What's coming in car audio in the future? DAT or Digital Audio Tape. DAT, which has specifications rivaling those of compact discs, is a practical format for car audio because it is easy to handle. A digital audio tape cassette, is about half the size of a standard cassette, yet it has a two-hour capacity. A self-closing door protects the tape, so that special handling isn't required.

At press time, there is still some doubt about whether the DAT format will ever reach the U.S. market because the recording industry is insisting that anti-taping devices be included in all DAT recorders (so that pre-recorded material cannot be taped) and the CD player manufacturers are concerned that DAT players could cut into their market and perhaps kill the CD industry. However, as you can see from the photos, the tape manufacturers and the hardware manufacturers are ready for the new format.

We'll keep you posted on the legal questions regarding DAT, and on its technical specifications in upcoming issues.

High-tech

A number of companies, in fact, are offering cassette/receivers in which only the cassette mechanism represents older technology. A case in point is Blaupunkt's *Berlin TQR 07* model listing for $1500. The *TQR 07* incorporates so many features that many of the buttons on the faceplate have multiple functions defined by the mode selected. Possible modes are tape, radio, security, and ARI, the latter being a system that either turns up the radio volume or interrupts tape play during traffic advisories from participating radio stations. An LCD (*Liquid Crystal Display*) indicates the selected mode.

In addition to the more commonplace features found on virtually every cassette/receiver, the *TQR 07* features AM stereo, 16 station presets, last-station memory, and an automatic volume control that adjusts to changes in ambient noise, plus *Dolby-B* and *Dolby-C* noise reduction for eliminating tape hiss.

Coordinating all the functions of the *TQR 07*, including monitoring the tuning and adjusting the AM and FM filtering, is the task of a 16-bit, 32K microprocessor that uses a digital data bus to relay information between the dash-mounted control panel and cassette deck, and an independent module that houses the tuners and the volume- and tone-control components. Use of a separate mounted-out-of-sight module is a technique used by an increasing number of other manufacturers, including Kenwood and Sony.

Technology is also having a great effect on the appearance of cassette/receivers. Among the most dramatic is the appearance of Pioneer's *KEX-900*. A single LCD faceplate displays information on five key functions: AM/FM tuning, cassette deck, graphic equalizer, spectrum analyzer, and time (clock). A seven-band equalizer offers more precise adjustment of the frequency response than does conventional tone controls, while the spectrum analyzer presents a visual indication of the program's frequency content.

Cassettes are loaded into the *KEX-900* by flipping down the front panel. Behind the door is the cassette mechanism and a number of less-frequently used controls. The "hidden door" trick is used by other manufacturers as well. The flip-down door on Sharp's *RG-F882*, for example, conceals a seven-band equalizer. List price for Pioneer's *KEX-900* is $580. Sharp's *RG-F882* lists for $449.95.

Most technological advancements appear first in the higher-priced cassette receivers. There are exceptions, of course. Fujitsu's model *Ten*, for example, includes a dual azimuth adjusting system in its series of cassette/receivers that list between $250 and $350. (The head-to-tape alignment of auto-reverse decks can sometimes be accurate in one direction but skewed in the opposite direction—an error that can severely effect high frequency response. Dual-azimuth adjustments optimize the alignment for each of the directions.)

A feature becoming increasingly common on high-end autosound equipment is a built-in security system. Generally, the security system requires that a three to five digit code be entered via the preset station buttons before the CD or cassette/receiver can be used: The equipment is inoperable until the correct code is entered. Another anti-theft system allows the user to simply slide the radio or the tuning unit from a dash-mounted sleeve so it can be concealed in the trunk, or even carried away from the vehicle.

More volume

As a general rule of thumb, high-end autosound systems usually provide more output power than "original equipment" or "replacement" receivers. The reason for the extra power, of course, is to avoid amplifier overload when the volume is cranked up to overcome ambient road and car noises. Power capabilities vary enormously. For example, the specialty autosound amplifier maker HiFonics Corp. offers amplifiers ranging from a low of 16 watts per channel to a high of 275 watts per channel.

Although the average autosound stereo

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10-07

IF YOU LIKE YOUR MUSIC to go on forever, you can install a compact disc remote changer in the trunk of your car and play music from up to 12 CD's.

system contains only one stereo amplifier that is intended for use with a single pair of left and right speakers, many autosound installations have multiple speaker systems (perhaps front and rear), and the two stereo speaker systems are simply connected in parallel (left front to left rear and right front to right rear, or criss-cross). Connecting the speakers in parallel splits each channels output power, which was intended for one speaker, between two speakers. The alternative to sharing one stereo amplifier between two speaker systems is a receiver such as Kenwood's *KAC-8070*, which has two independent stereo amplifiers, each specifically intended to drive a single stereo speaker system. The *KAC-8070* lists for $279.

One brand, manufactured by the ADS Company, has gone as far as to develop two six-channel amplifiers, the *PH12* and the *PH15*, which allow a subwoofer to be easily added to an autosound system. List prices for the *PH12* and *PH15* are $320 and $560 respectively. The *PH12* provides 20 watts per channel, while the *PH15* delivers 40 watts per channel. ADS also makes four-channel amplifiers, the *PQ8* and the *PQ20*, listing for $200 and $680 respectively.

TO AVOID DAMAGE, and to make it easier to handle CD's without fingerprints, some autosound compact disc players require that each disc be installed in a special protective cartridge.

Speakers

Speakers come in a wide variety of configurations and sizes. The material used for the cone itself can range from traditional paper to polypropylene, a flexible material that is more resistant than paper to heat, cold and moisture.

The magnet, the other critical speaker component, is also being improved. The GM Delco/Bose system in the Cadillac *Seville* and *Eldorado*, and the Chevrolet *Camaro*, uses a new high-energy neodymium magnet. The high energy potential of neodymium allows Bose to use a smaller magnet, thereby reducing the overall size of the speaker, particularly in its depth.

Speakers range in size from ¾-inch tweeters to 6 × 9-inch woofers, and there are various two, three, and even four-way combinations of tweeters, midranges, and woofers available. Two companies, Sparkomatic and Philips, even have models with the speakers and their amplifiers built into the same enclosure.

Some autosound systems use one or two subwoofers to reproduce extremely low bass frequencies. One large woofer is often enough considering the omnidirectional characteristics of low frequencies. Two smaller subwoofers are used when space limitations prohibit the use of a larger woofer.

Special speakers have also been developed for light trucks and other types of sports/utility vehicles. Typical of that new breed if speakers is *The Force* from Jensen, which consists of a large, wedge-shaped enclosure housing an eight-inch woofer and an upward-firing tweeter. Its list price is $299.95.

Crossover networks handle the routing of specific frequencies to the appropriate speaker. Most crossover networks are offered as separate components. Some speakers, such as the the *ALS-500* from Altec Lansing, have built-in, highly efficient crossover networks.

DOOR MOUNTING SPEAKERS can either provide the only full-range sound in a vehicle, or work in conjunction with in-dash and rear-shelf speakers to completely envelope the listener.

An autosound system can be a very complex purchase. A vehicle's environment is hostile to the the reproduction of high-fidelity sound. The amount of equipment sometimes needed can be intimidating, and its installation can be tricky and time-consuming. In fact, tackling anything beyond the most basic installation is probably not advisable unless you have the time and skill required. However, you should keep in mind that most dealers won't do installation work unless they have sold you some or all of the necessary components.

When all is said and done, however, you should have a system that will rival your home system. When that happens, you'll probably be joining the thousands of people who do most of their music listening on the road. R-E

Like writing a great novel, designing and installing a great auto sound-system is part inspiration, and part perspiration.

Great Installations

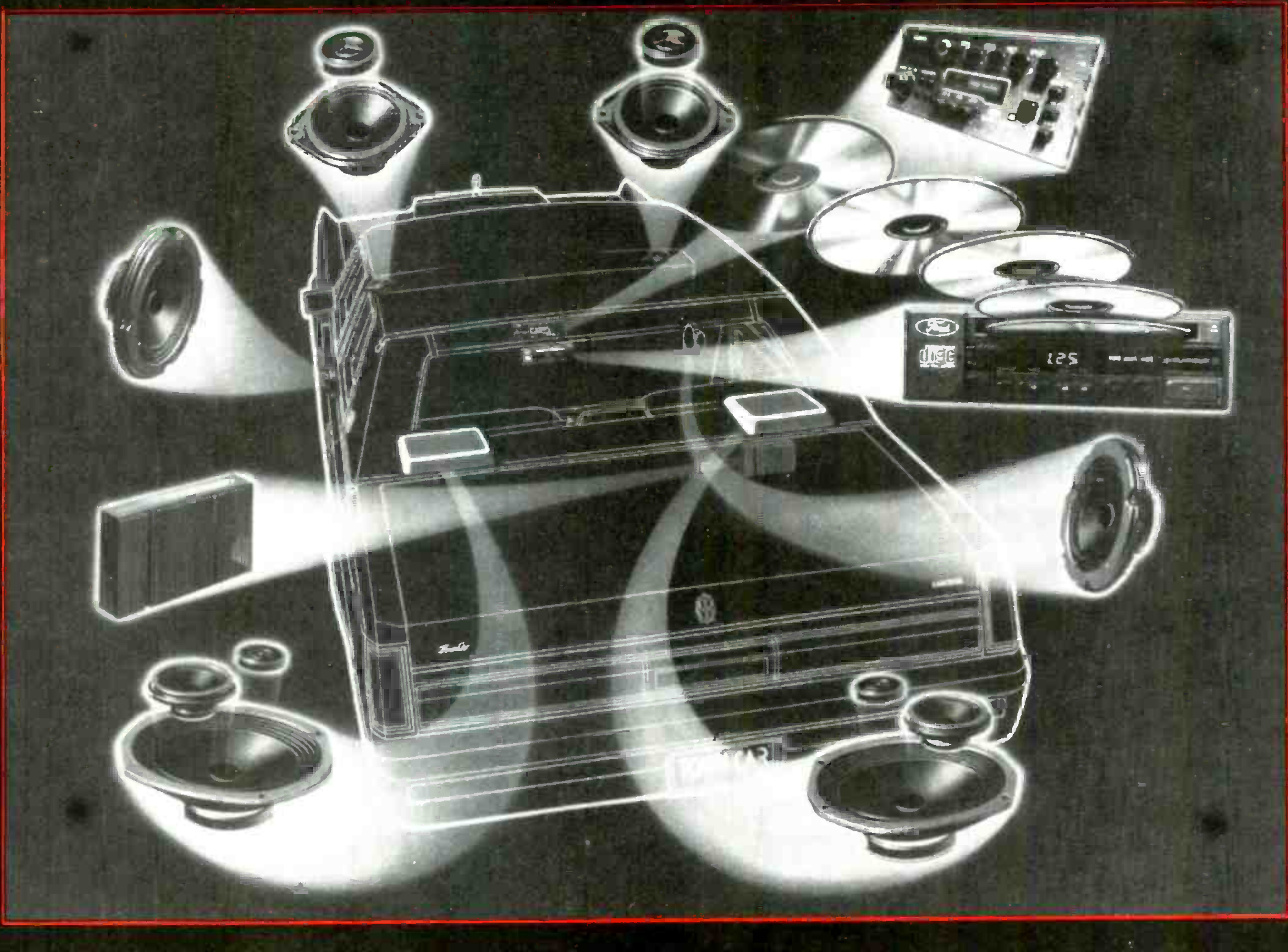
FRANK VIZARD

WHEN INSTALLED PROPERLY, AN AUTOmotive sound system can become a concert hall on wheels. In fact, many owners of high-end systems find themselves listening to music almost exclusively in their cars since the acoustical effects are often superior to those offered by their home systems.

But there can be more to installing a system than meets the eye. When selecting a system, the type of vehicle it is to be installed in should be carefully considered. Space limitations, for example, may restrict the size of the speakers used. Likewise, every dashboard doesn't have the same size radio hole, which means that not every cassette/receiver or CD/tuner will fit in every car.

Compounding the problem is a lack of standardization that can confound even the most-gifted do-it-yourselfer; one manufacturer's green wire is another's yellow wire. And improper wiring can lead to blown speakers and amplifiers. Further, unidentifiable noise can be caused by almost any electronic component in the car, including the alternator or ignition system. Such noise can render a system unlistenable, and finding its source can be a time-consuming nightmare. Therefore, it's not all that surprising that a $2000 installation often can take up to 35 hours to accomplish if the installer is a pro; an amateur installer is almost sure to be at it a lot longer.

Despite all of that, a top-notch sound system can be found for just about any application and for just about any car. To prove that, **Radio-Electronics** has assembled a portfolio of eight car-audio systems. Four systems are available as original equipment from car manufacturers. The remainder use aftermarket equipment installed by car-audio retailers to satisfy particular needs and varying installation requirements. All the systems have one thing in common: They'll please even the most discriminating listener.



Chevrolet *Camaro*: Delco/Bose

General Motors was the first car maker to turn to a well-known loudspeaker company, Bose Corp. for help in developing a premium sound system. While Delco, GM's radio division, and Bose have joined forces to outfit a number of GM cars with top-flight auto sound-systems, the Delco/Bose system installed in the 1987 Chevrolet *Camaro* shown in Fig. 1 represents the best the partnership has to offer.

The most noticeable difference between the Delco/Bose system in the *Camaro* and the Delco/Bose system installed in other GM cars is the size of the speaker enclosures. Each enclosure is also required to house a 25-watt amplifier. Such enclosures generally take up a lot of room, which is not much of an issue in a large Cadillac but of definite concern in a much smaller *Camaro*.

For the 1987 *Camaro*, Bose reduced the size of the speaker to a thin wafer only 32-mm deep. That reduction in size at no cost to sound quality is made possible by one of the first commercial uses of neodymium, a high-energy magnetic material. The "wafer" speakers are also four times lighter than their predecessors. The new speaker/amplifier modules, like the old enclosures, are mounted in the doors and on the rear deck. The same technology is also being used in the new Cadillac *Allante*, *Seville*, and *Eldorado*.

FIG. 1—SHALLOW CLEARANCES in this Chevrolet *Camaro* required designing a speaker only 32-mm deep.

FIG. 2—THIS DELCO/BOSE cassette/receiver features automatic recognition of *Dolby-B* encoded tapes

Like its competitors, a Delco/Bose system positions its loudspeakers so that the listener is off-axis to the near speaker and on-axis to the far speaker. Delco/Bose believes it has accomplished its task so successfully that they omit the left/right balance control typical of other systems.

System Configuration
Cassette/receiver, 4 speaker/amp modules (Delco/Bose)
Key Features
Wafer-thin (32mm) speakers, automatic Dolby-B recognition, AM stereo
Power (per channel)
25 watts
Price
$900

The cassette/receiver, shown in Fig. 2, does include most of the other features found in competitive models. Those features include auto reverse, bi-directional music search, seek/scan and *D*ynamic *N*oise *R*eduction (DNR) for the radio, and five AM and FM presets. AM stereo is also available.

More unusual is the fact that the cassette/receiver automatically recognizes *Dolby-B* encoded tapes and makes the appropriate adjustment for playback.

The Delco/Bose system in the *Camaro* lists for about $900. Add about $200 for the standard radio that comes with the car and the overall cost is roughly $1100. A compact disc player is not available.

Dodge *Lancer*: Chrysler/Infinity

The premium sound system offered by Chrysler in its 1987 Dodge *Lancer* (Fig. 3) is the least expensive and perhaps the most unusual of the auto sound offerings made by the "big three" U.S. car-manufacturing companies.

FIG. 3—THE CHRYSLER/INFINITY sound system is offered as standard equipment in this Dodge *Lancer*.

Like Ford and General Motors, Chrysler entered into a partnership with a major audio company to develop that system. In Chrysler's case, the audio partner is Infinity Systems, Inc., a well-known maker of home and car loudspeakers.

The Chrysler/Infinity system uses six speakers. One pair of ¾-inch tweeters are installed in the dashboard. Another pair of 5¼-inch midrange/woofer speakers are in the front doors. Lastly, a pair of 5 × 7-inch coaxial speakers are mounted on the rear deck.

How those speakers are powered is the unusual feature of the Chrysler/Infinity system. While many auto sound systems are bi-amplified, meaning that separate amplifiers are used to power woofers and tweeters/midranges, the Chrysler/Infinity systems use an unusual method of bi-amplification. The tweeters in the dashboard and in the rear deck are powered by amplifiers built into the cassette/receiver. The door speakers and the woofers in the rear, however, are independently powered by miniature amplifiers attached to the back of each speaker. The audio signal must also pass through a low-pass filter before reaching each woofer. A total of 32 watts power the speakers while an additional 56 watts power the woofers.

The Chrysler cassette/receiver has many of the features common to the genre, including auto reverse, *Dolby B*, DNR, AM stereo, and 10 AM and 10 FM radio presets.

The digital display is a vacuum-fluorescent type. It shows radio frequency, tape type, noise-reduction status,and tape-play direction. When the unit is shut off, the display doubles as a clock, accurately showing the time of day. The display is clearly visible in sunlight. It's visible at night, too: All displays and controls are backlighted.

Less common is a built-in, five-band equalizer that takes the place of the tone controls. With it, sound can be tailored for the listener's preference. Slide controls allow the adjustment of bass, midbass, midrange, upper midrange, and treble. There is also an "ambience" feature, which is designed to create a "concert hall" effect.

System Configuration
Cassette/receiver, 6 speakers (Chrysler/Infinity)
Key Features
Bi-amplification, 5-band equalizer, ambiance control, joystick balance control, AM stero
Power (per channel)
See text
Price
$600

The relative merit of the ambience feature is questionable, however, since even the owner's manual advises against its overuse. Also, Chrysler has opted to have front/rear and left/right balance controlled by a joystick that rotates in all directions, making placement of the soundstage even easier than usual.

The price of the Chrysler/Infinity system is $600. The same system you'll find also available in the *New Yorker* and *LeBaron GTS*.

Lincoln *Town Car*: Ford/JBL

The Ford/JBL sound system in the Lincoln *Town Car* (shown in Fig. 4) offers the most power and uses the highest number of drivers of any auto sound-system offered by an American car company. Like its two major competitors, Ford used an audio company, JBL, as its partner in developing its system.

The Ford/JBL system, which is shown in its entirety in the opening of this article on page 39, uses six speakers—a pair of speakers is mounted in the dashboard, in the front doors, and on the rear deck. The five-inch dashboard speakers are coaxial units, the 6×9-inch rear deck speakers are three-way units, and the 5¼-inch door speakers are full-range units. The speakers are powered by a 140-watt four-channel amplifier.

FIG. 4—THE LINCOLN *TOWN CAR* is equipped with the Ford/JBL system illustrated at the beginning of this article.

FIG. 5—THIS SEPARATE CD PLAYER is offered as an option in the *Town Car*.

The Ford/JBL system in the *Town Car* has three potential sources of music—radio or tape from the cassette/receiver, and compact disc from a separate player. See Fig. 5. The cassette/receiver is rather unusual in that the radio is digitally tuned but the controls for the cassette section operate very mechanically, albeit efficiently. Features include *Dolby B*, DNR, four-AM and four-FM presets, auto reverse, seek/scan, and bi-directional music search for tape.

The Ford cassette/receiver lacks AM stereo, a feature provided by GM and Chrysler. However, Ford's unit automatically sets the correct tape equalization for tape playback.

The compact-disc player offers most of the features you would expect to find, including automatic music search to locate any track at the touch of a button, scan, and a dual repeat mode for replay of an individual track or the entire disc.

The Ford/JBL system is priced at about $1500. Without the CD player, system cost is about $850. That price includes the cost of the equipment that is supplied as standard on the *Town Car*; that equipment must be removed before the Ford/JBL system can be installed.

System Configuration
Cassette/receiver, 6 speakers, optional CD player; (Ford/JBL)
Key Features
Optional CD player, automatic tape equalization
Power (per channel)
35 watts
Price
$1500 (with CD player)

Sterling *825S/825SL*: Philips/Elac

One of the newest car lines on the market is the Sterling, the product of a joint development program between Great Britain's Austin Rover Group and Japan's Honda Motor Co. The engine and the exterior are of Japanese design while the interior creature comforts are of European design. There are two models of the Sterling, the *825S* and the *825SL* (shown in Fig. 6).

The sound system in the *825SL* is a mixture of Dutch and English expertise. The cassette/receiver is made by Philips, the Dutch electronics manufacturer. The unit includes most of the standard features you would expect to find, including auto reverse, *Dolby-B* noise reduction, and five-AM and five-FM presets.

The cassette/receiver also has two rather unusual features as well. The first is an anti-theft system; it is armed using a three-digit code that is entered into the cassette/receiver using the five preset buttons. The second is an "auto-store" feature; that feature lets you override the permanently stored presets, without erasing them, and select the five strongest radio stations in an area. It can be an especially handy feature if you're traveling out-of-town.

THE CASSETTE/RECEIVER in the Sterling *825SL* is made by Philips.

Power is supplied by an amplifier capable of delivering 20 watts to each of four channels. (The sound system in the *825S* comes without the amplifier, reducing power to only seven watts through each of four channels.)

The speakers in the *825SL* are supplied by Elac, a British company. The rear deck houses a pair of 6½ inch coaxials, while a pair of 5¼-inch full range and ¾-inch tweeters are separately installed in the front doors. The speaker setup is standard for a car of the Sterling type, providing a balanced sound radiation pattern, front and rear.

The sound systems in the Sterling *825SL* and *825S* come as standard equipment in the cars. The *825SL* carries a sticker price of $23,900; the estimated retail value of the sound system is about $1000. The *825S* has a sticker price of $19,000; its lower powered sound system is somewhat less expensive than that of the *825SL*.

System Configuration
Cassette/receiver, amp (Philips); 6 speakers (Elac)
Key Features
Anti-theft system, temporary preset override
Power (per channel)
20 watts
Price
$1000

Porsche *911 Carrera*: Custom installation

For a little more money, you sometimes get a lot more. A case in point is the Autotek (855 Cowan Rd., Burlingame, CA 94010) sound system shown in Fig. 7, which has been installed in the 1985 Porsche shown in Fig. 8. At $1000, that system is only slightly more expensive than auto sound-systems offered by car companies, but offers more power and features.

Why is more power better? Assuming that the amplifiers meet acceptable standards, higher power levels allow us to hear low music levels more clearly. Therefore, due to road and wind noise, power is very critical in a car.

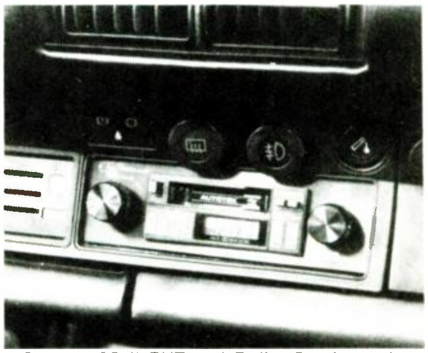


FIG. 7—A CD INPUT and *Dolby-C* noise reduction are two of the advantages offered by the Autotek *SR500*.

FIG. 8—THE PORSCHE *911 Carrera*.

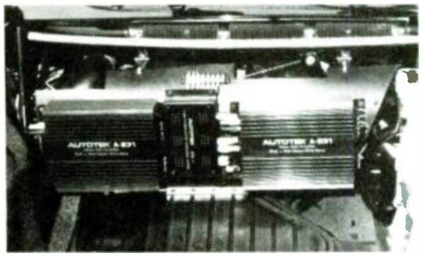


FIG. 9—THE AMPS and the crossover.

The *SR500* cassette/receiver that is part of the system has many of the usual features: auto reverse, 12 radio presets, seek/scan, and electronic tuning. But two features of the *SR500* can not be found in the cassette/receivers offered by the major U.S. car companies. One is *Dolby-C* noise reduction (in addition to the more usual *Dolby B*). The other is a CD input that allows a personal compact-disc player to be plugged into the system.

System Configuration

Cassette/receiver, 2 amplifiers, two-way crossover network, 6 speakers (Auto Tek)

Key Features

Dolby C, CD input

Power (per channel)

See text

Price

$1000

The *SR500* supplies a great deal of power on its own: 20 watts per channel. In that installation, the 20 watts are used to power a pair of coaxial speakers mounted beneath the dashboard at the extreme right and left.

In addition, a pair of amplifiers with a rating of 130-watts each power the other four speakers in the system: a pair of four-inch three-way speakers in the doors and a pair of 6 × 9-inch three-way speakers in the rear deck. Signal routing chores are performed by an *XOU-1* two-way crossover (Fig. 9).

Ford *Thunderbird*: Custom Installation

Installing a new sound system doesn't necessarily mean junking all the original equipment that came with the vehicle. The sound system in the 1983 Ford *Thunderbird* shown in Fig. 10 uses the standard Ford cassette/receiver, but adds a variety of equipment from ADS (One Progress Way, Wilmington, MA 01887) and Sony (Sony Drive, Park Ridge, NJ 07656). The end result is a fine sound system that uses three sound sources and produces 320 watts of power.

Two of the sound sources are, of course, the standard radio and the cassette; the third is an add-on compact-disc player. Having a CD player in a car is becoming less unusual, but this installation is different in that it incorporates a Sony *DiscJockey* CD changer. Installed in the trunk, the *DiscJockey* stores 10 discs in a removable magazine. See Fig. 11. A cable connects the CD changer to a control unit mounted into the dashboard beneath the cassette/receiver. The Sony CD changer comes with an optional tuner pack, but because of the existing Ford cassette/receiver, this installation didn't require it.

FIG. 10—THE FORD *THUNDERBIRD*.

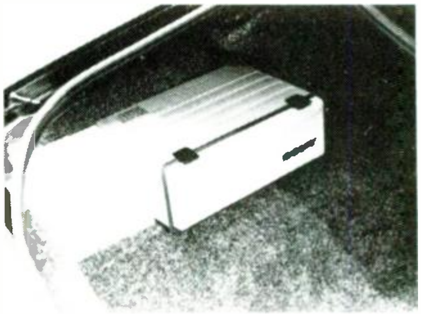


FIG. 11—THE SONY *DISCJOCKEY*.

To fully appreciate the dynamic range provided by compact discs, the installation has plenty of power. A pair of ADS *320i* 5¼-inch coaxial speakers are installed in the doors, while a pair of ADS *L200CC* mini-speakers, a four-inch midrange and a one-inch tweeter housed in their own cabinet, sit atop the rear deck. Adding punch to the system is a single 10-inch subwoofer mounted beneath the rear deck.

The division of labor among the speakers is handled by the ADS *642CSi*, a unit that acts both as an electronic crossover and signal processor. That unit, which serves as the interface between the Ford cassette/receiver and the Sony *DiscJockey*, is equipped with four inputs and six outputs and directs high and low frequencies to the appropriate speaker. In this installation, a constant bass signal is applied to the door speakers to augment the signal at the subwoofer. Fading between the front and rear speakers is independent of the subwoofer.

System Configuration

Cassette/receiver, (Ford); CD player/changer (Sony); 5 speakers, 2 amplifiers, crossover network, (ADS)

Key Features

CD player with 10-disc changer, 10-inch subwoofer

Power (per channel)

See text

Price

$3400

Power is supplied by two ADS *PQ10* four-channel amplifiers. One amplifier powers the door speakers while the second powers the rear speakers and the subwoofer. In terms of power, 80 watts is supplied to each door speaker, another 80 watts is supplied to the subwoofer, and 40 watts to each rear deck speaker.

The price of the system is about $3400.

GMC *Jimmy*: Custom installation

Where normal passenger cars fear to travel, four-wheel drive vehicles like the GMC *Jimmy* love to go. To provide off-road music for an off-road vehicle, a Kenwood (1315 E. Watsoncenter Rd., Carson, CA 90745) music system was added to the *Jimmy*.

The heart of the Kenwood system is the *KRC-838* cassette/receiver shown in Fig. 12. It is one of a new breed of "theft-proof" models available from several aftermarket manufacturers. The *KRC-838* is considered theft-proof because it can be removed by the owner easily; the cassette/receiver is installed inside a sleeve. A lever on the left side of the *KRC-838* releases the unit from the sleeve so that it can be taken with you when you leave the vehicle.

The *KRC-838* offers most of what we've come to expect in the way in of features, and adds a few others as well. Both *Dolby-B* and *Dolby-C* noise reduction are available, as is Kenwood's own *ANRCII* circuitry—the latter providing roughly the same benefit as the DNR circuitry found in cassette/receivers offered by other suppliers.

Other features include a signal meter to judge station strength, 24 presets that can be arranged in any combination of AM

FIG. 12—THE LEVER AT THE LEFT lets you remove the Kenwood *KRC-838* receiver.

and FM stations, and a "tuner-call" feature that automatically switches on the radio when a tape is in fast-forward or rewind. Lastly, the *KRC-838* features a mute button that lowers the volume 20 dB; that's handy for toll booths.

While standard bass and treble controls are incorporated into the cassette/receiver, the system's sound can be more precisely adjusted using the *KQC-9400* graphic equalizer installed under the cassette/receiver. That unit lets you contour the sound over seven bands.

Space is limited in the *Jimmy*, so all the speakers are installed in the door. High frequencies are reproduced using a pair of 1½-inch tweeters that feature a built-in overload protection circuit. Midrange and some higher bass frequencies are handled by a pair of five-inch speakers mounted next to the tweeters. Very low bass frequencies are reproduced by a pair of eight-inch woofers that are installed below the tweeters and midranges.

System Configuration
Cassette/receiver, 6 speakers (Kenwood)
Key Features
Dolby C, ANRCII, graphic equalizer, mute, removable cassette/receiver unit
Power (per channel)
See text
Price
$2000

The eight-inch woofers are very power hungry, requiring a minimum of 35 watts each. That power is supplied by a *KAC-8020* amplifier, which feeds 80 watts to each woofer. A second amplifier, a *KAC-8070*, powers the tweeter and the midrange. That amplifier is unusual in that it is a four-channel amplifier delivering two different power levels through each pair of channels. In our system, it is used to deliver 20 watts per channel to the tweeters and another 37 watts per channel to the midranges.

The entire system costs $2000.

Chevrolet *Corvette*: Custom installation

At first glance, the sound system in the 1985 *Corvette*, appears to be a perfect marriage of original equipment that came with the car and aftermarket gear. Looks can be deceiving.

In truth, all that's left of what was once a GM Delco/Bose system is the speaker grilles and the cassette/receiver. What's more, the cassette/receiver doesn't work. Its only purpose is cosmetic; it's used to cover the hole in the dash.

The owner of that Corvette has opted solely for a CD/tuner system using Sony's *DiscJockey*. Unlike the *Thunderbird* installation discussed previously, this setup makes use of the *DiscJockey's* optional AM/FM tuner pack, making the Delco radio redundant. Adding the tuner pack was a less expensive alternative to incorporating the Delco/Bose cassette/receiver into the system; the lack of line outputs on the original equipment, as well as some voltage-level problems, would require the use of complicated and expensive switching devices that are also unattractive.

The *DiscJockey* is built into a special enclosure that sits in the rear of the *Corvette*. That enclosure also houses two Sony *L20* subwoofers, which reproduce all bass frequencies below 100 Hz. Also installed in the enclosure are two Hifonics (845 Broad Ave., Ridgefield, NJ 07657) *Callisto* electronic crossovers. The *DiscJockey's* operation is controlled via a wired remote control that is stowed away in an accessory compartment in the center console. See Fig. 13.

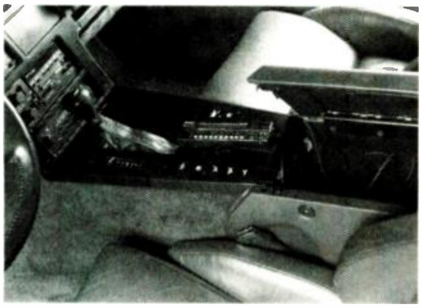


FIG. 13—THE CD CHANGER'S remote control is stowed away in the center console.

The original Delco/Bose speakers in the car were replaced with Hifonics units. A pair of one-inch tweeters were installed in the dashboard so that the sound will reflect off the windshield and radiate throughout the car. Four-inch midranges were installed in the doors. Another pair of one-inch tweeters and four-inch midranges were placed side-by-side in each of the larger speaker cavities in the rear of the car. The new Hifonics speakers were covered with the original Delco/Bose grilles except for the front tweeters which were covered with acoustically transparent cloth.

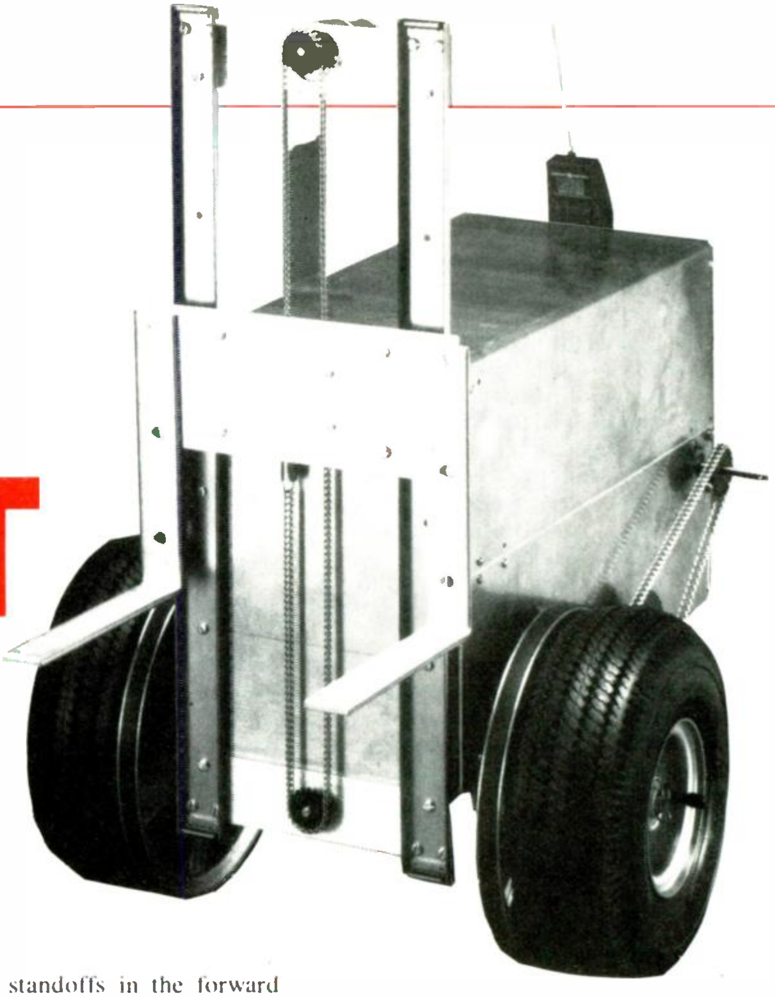
The system also incorporates two Hifonics amplifiers. A *Thor* amplifier supplies 125 watts to the rear subwoofers while a *Gemini* four-channel amplifier is used to supply 70 watts to the front and rear speakers.

System Configuration
CD player/changer/tuner, 2 subwoofers (Sony), 2 crossovers, 2 amplifiers, parametric equalizer, 8 speakers (Hifonics)
Key Features
10-disc CD changer/player, parametric equalizer, 2 subwoofers
Power (per channel)
See text
Price
$3260

The system's sound can be tailored to suit your taste with a Hifonics *Ceres IV* parametric equalizer. The *Ceres IV* is the only parametric equalizer we know of that is designed for automotive applications. With a graphic equalizer response can be raised or lowered only along predetermined bands. Parametric equalizers, on the other hand, allow you to adjust response within a range of frequencies.

The cost of the upgrade, while ignoring the cost of the original equipment, was $3260. **R-E**

R-E ROBOT



This month we show you how to build the control board.

Part 8

THE PAST TWO MONTHS we've looked at how the robot's control circuitry works. Now its time to get our hands dirty and build the control board.

Construction

Building the control board is a straightforward operation. The double-sided pattern is shown in PC Service. Note that because of its large size, the pattern is shown half size, so it must be enlarged before etching. The board is also available from the supplier mentioned in the Sources box. The supplier provides a board with two-ounce copper, plated-through holes, and a solder mask. If you choose to etch your own board we recommend that you use a blank with two-ounce plating, solder all components on both sides of the board, and install feedthroughs at any unused pads. The reason for the heavier copper is that it provides better power handling capacity and better noise margins.

Once you've either bought or etched the board, check it for power to ground shorts. Those will be very difficult to locate after all of the components have been installed. Then stuff the board following the parts-placement diagram that is shown in Fig. 1.

All of the control-board components can be obtained from most electronics distributors. The Fujitsu relays specified can be found at many relay specialists. If you have trouble finding them, you can substitute units from other manufacturers as long as they have a contact rating of more than 10 amps. If you make any substitutions, you may also need to modify the board to accommodate the substitutes.

The control board is designed to be mounted on standoffs in the forward bulkhead of the chassis as shown in Fig. 2. When mounting the board, it should be oriented so that the terminal strip is located at the top edge of the chassis.

The RPC mounts over the board on one-inch standoffs. Use fixed standoffs at the top edge of the board, and hinged standoffs at the bottom. That will allow the RPC to be swung down and out of the way during troubleshooting.

Holes should be punched in the forward bulkhead for the wires. The motor-power, battery-power, and return wires should all be fed through one hole. All other wires, such as the leads from the shaft encoders, should be fed through a second, separate hole. The return wire from the control board's single-point ground should be as heavy as possible. Also, the motor-power wires should be as heavy as required to handle the current they must carry.

If you are going to use large drive motors with current requirements over 10 amps, the two main switching transistors and their associated diodes may be removed from the circuit board and mounted on the forward bulkhead to take advantage of the huge heat-sinking capacity of the robot's chassis. Use sockets, of course, and connect the sockets to the board with short lengths of heavy-gauge wire. After the control board has been assembled and both it and the RPC have been installed, the forward bulkhead will contain all of the robot's electronics. Now we're ready for bench testing.

Testing

To do the testing you will need a DC supply capable of producing 14–30 volts at 3 amps. If you can't find a suitable supply, you can build one using a high-current transformer, a full-wave bridge, and a suitable filter circuit. Be sure to select diodes (for the bridge) and capacitors (for the filter) whose ratings are appropriate. We built a unit that supplied 18-volts DC at 3 amps for our testing. Whenever the motors were accelerated too quickly, the power supply sagged, the motor relays dropped out, and that brought the motors to a stop. The power supply was completely adequate for testing, however.

Begin testing by connecting the control board to the power supply, but not to the RPC. Apply power and examine the sleep circuit for proper operation. If it is being clocked at 10-Hz as designed, the state of pin 4 should change once every 15 seconds. If all is well, you have confirmed that power is correctly bused to the board.

Proceeding, defeat the sleep circuit by soldering a jumper from R10 to ground, causing RY1 to close. That will energize the system. (Don't forget to remove that jumper when testing and troubleshooting are completed!) Now you should verify that IC9 delivers +5-volts DC and that IC30 delivers +12-volts DC. Also check that +5 volts is available at the correct pins at PL4, the RPC connector.

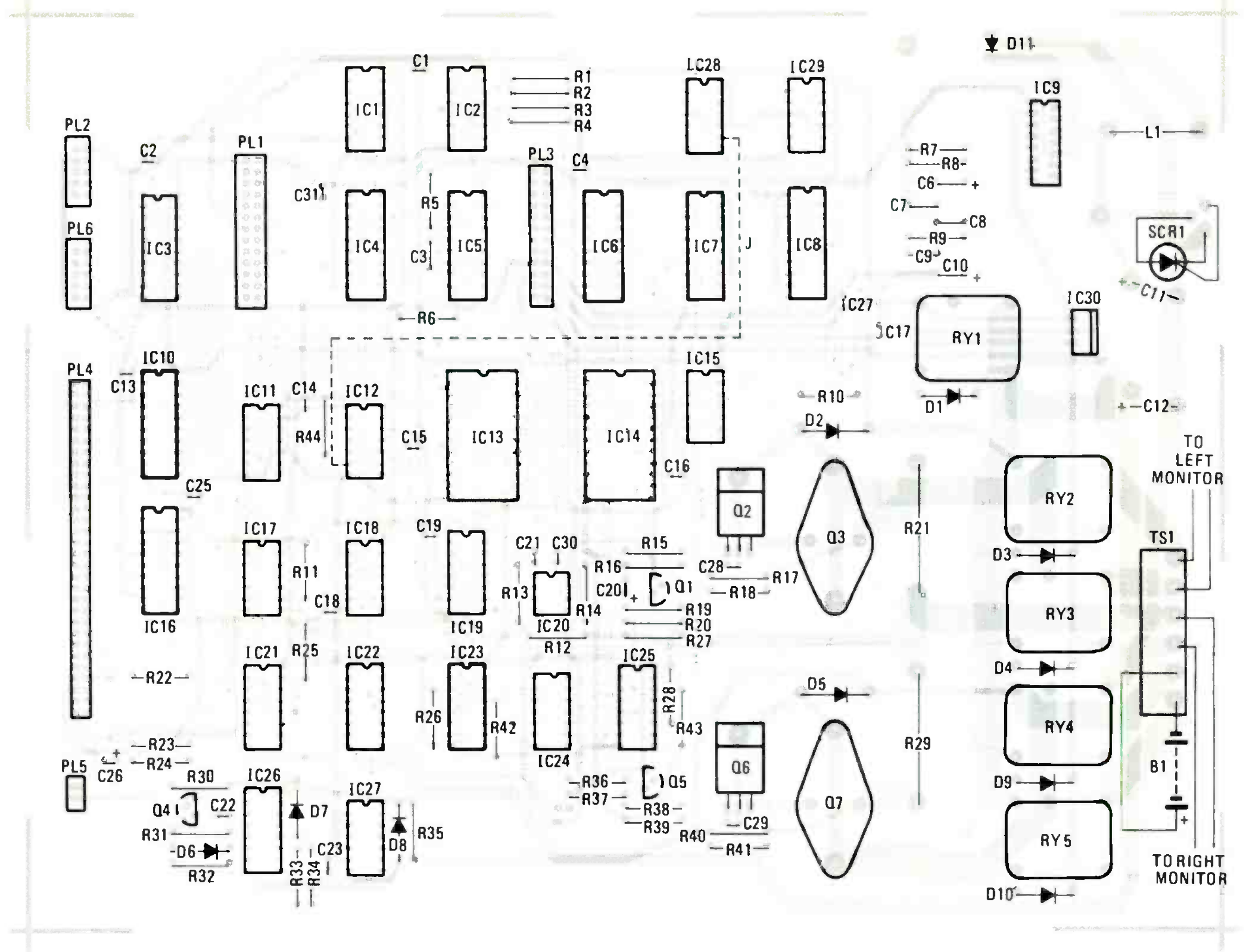


FIG. 1—ALL OF THE CONTROL CIRCUITRY mounts on one double-sided board. Follow this guide when assembling the board; the patterns can be found in PC Service.

PARTS LIST

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

R1, R4, R6, R7—not used
R2, R12, R16, R18–R20, R22, R23, R26–R28, R30, R34, R36, R37, R39, R41, R44—10,000 ohms
R3—62,000 ohms
R5, R9—15,000 ohms
R8—4700 ohms
R10—220 ohms
R11, R35, R42, R43—1000 ohms
R13, R14—1 megohm
R15, R38—47 ohms
R17, R24, R40—100 ohms
R21, R29—0.1 ohms, 5 watts, 1%
R25, R31–R33—100,000 ohms

Capacitors

C1, C2, C4, C5, C13–19, C22, C25, C27, C31—0.1 µF, monolithic ceramic
C3—100 pF, 50 volts, ceramic disc
C6, C10, C21, C30—2.2 µF, 50 volts, ceramic disc
C7—0.002 µF, 50 volts, ceramic disc
C8—330 pF, 50 volts, ceramic disc
C9—0.047 µF, 50 volts, ceramic disc
C11, C12—2200 µF, 25 volts, electrolytic
C20, C23, C24, C26—10 µF, 16 volts, electrolytic
C28, C29—not used

Semiconductors

IC1, IC2—4051 multiplexer
IC3, IC6—74LS541 octal buffer/line driver
IC4—74LS377 octal D-flip-flop
IC5—ADC0804 8-bit A/D converter
IC7, IC8—74LS374 octal D-flip-flop
IC9—L296 switching regulator (SGS)
IC10—74LS645 octal three-state bus transceiver
IC11—74LS125 quad three-state buffer
IC12—74LS266 quad 2-input exclusive NOR gate
IC13, IC14—8253 programmable interval timer
IC15—74LS32 quad 2-input OR gate
IC16—74ALS520 8-bit comparator
IC17—74LS164 8-bit serial-in/parallel-out shift register
IC18—74LS393 dual 4-bit binary ripple counter
IC19—74LS138 1-of-8 decoder
IC20—LM358 dual op-amp
IC21—74LS259 8-bit addressable latch
IC22—ULN2003 Darlington array
IC23, IC25—4046 PLL
IC24—74LS00 quad 2-input NAND gate
IC26—4060 14-stage ripple counter
IC27—4078 8-input NOR/OR gate
IC28, IC29—dual D-flip-flop
IC30—LM340-12 12-volt regulator
Q1, Q5—2N3906 PNP transistor
Q2, Q6—TIP29A NPN transistor
Q3, Q7—2N3772 NPN transistor
Q4—2N3904 NPN transistor
SCR1—C106Y1 (GE) SCR
D1, D3, D4, D9, D10—1N4001 rectifier
D2, D5, 1N5400 rectifier
D6, D7—1N4148 switching diode
D8—1N754 6.8-volt Zener diode
D11—8R05 Schottky diode (SGS)

Other Components

L1—300 µH
RY1–RY5—DPST relay, 12-volt coil, Fujitsu FBR-631D012 or equivalent
PL1, PL3—26-conductor plug, dual row, 0.025-inch spacing
PL2, PL6—10-conductor plug, dual row, 0.025-inch spacing
PL4—60-conductor right-angle plug, dual row, 0.025-inch spacing
PL5—2-conductor plug, single row, 0.025-inch spacing
TS1—6 connector terminal strip
B1—see text

Miscellaneous: PC board, IC sockets, heat sinks (Thermalloy 601 or equivalent for IC9, Thermalloy 286 or equivalent for IC30), mounting hardware, nuts, bolts, wire, solder, etc.

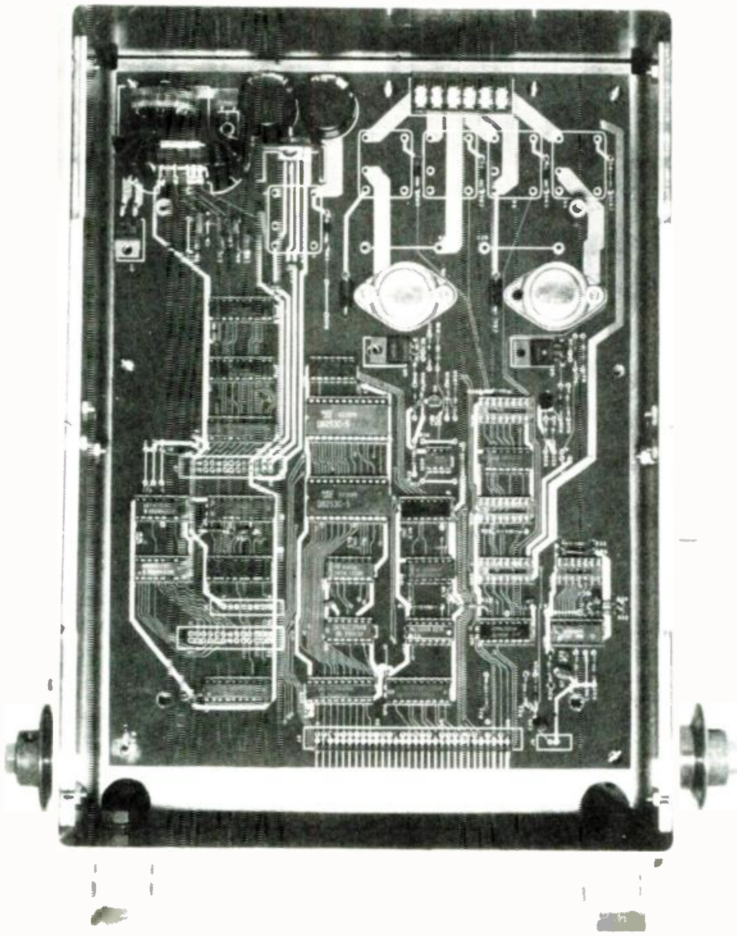


FIG. 2—THE ROBOT'S ELECTRONICS mount on standoffs in the forward bulkhead. The control board is shown here; the RPC mounts above it on hinged standoffs.

TABLE 1—OUTPUT FUNCTIONS

Address	Function
120	Left forward relay
121	Left reverse relay
122	Right forward relay
123	Right forward relay
124	Left motor control enable
125	Right motor control enable
126	Beeper
127	not used

If all is well, connect the RPC. Write the following diagnostic word (in the hex-number base) and execute it:

```
: TESTO BEGIN 0 127 PC! 1 127 PC!
    ?TERMINAL UNTIL ;
```

As mentioned last time, the scope of this article prevents us from going into a detailed discussion of Forth and its structure. However, note that the while Forth requires statements like the preceding one to be entered as a single line, for space reasons it is impossible for us to show it that way. When you enter such statements, be sure to enter them as single lines or they will not be processed correctly. If you are not familiar with Forth, we recommend the book *Starting Forth*, by Leo Brodie; it is published by Prentice-Hall. You can probably obtain a copy from the Forth Interest Group or at your local computer bookstore.

SOURCES

The following are available from Vesta Technology, 7100 W. 44th St., Wheatridge, CO 80033 (303-422-8088): Bare RE-Robot controller board, $41; assembled and tested RE-Robot controller board, $200; assembled and tested RPC, fully populated for the robot function, $294. Add $8.00 shipping per board. Colorado residents add appropriate sales tax. Mastercard and Visa accepted.

Optical endocers (100 counts/revolution, quadrature output) are available from EMC Corp., 373 Hillsboro Way, Goleta, CA 93117 (805-968-3060) for $40 each. California residents must add appropriate sales tax.

Let's briefly look at what TEST0 is, and how it works. The colon tells the interpreter to compile the following word called TEST0 into the dictionary. That word is a begin–until loop that will loop until activity from the terminal (?TERMINAL) is detected. The loop itself stores a 0 to port 127H, then stores a 1 to port 127H. Compilation stops at the semicolon and the interpreter returns to the interpretive mode. After compiling TEST0, you can execute your new word simply by typing TEST0 and a carriage return on the keyboard. The word will execute until you touch any key.

During execution, you should observe the output of IC16, the 74ALS520. The address-latching pulse should be about 1 microsecond long, indicating that the wait-state generator is working correctly. Now examine the state of pin 12 of IC21 with an oscilloscope; you should see it toggling. That shows that the RPC and the control board are working together.

Testing the digital inputs and outputs is a very simple process with our operating system in ROM. We have only to write a few diagnostic words and execute them.

The individual outputs can be toggled with the following test word:

```
: TEST1 BEGIN 8 0 DO 0 120 I + PC!
    1 120 I + PC! LOOP 0 UNTIL ;
```

The function of each of the individual outputs is as shown in Table 1.

Next, connect a speaker to the J6 and test the beep function:

```
: DELAY 0 DO 10 0 DO LOOP LOOP ;
: BEEP 1000 0
   DO 1 126 PC! 2 DELAY
        0 126 PC1 2 DELAY
   LOOP ;
```

Notice that here we used "pretty" source-code formatting techniques. That becomes increasingly important as the complexity of our code increases.

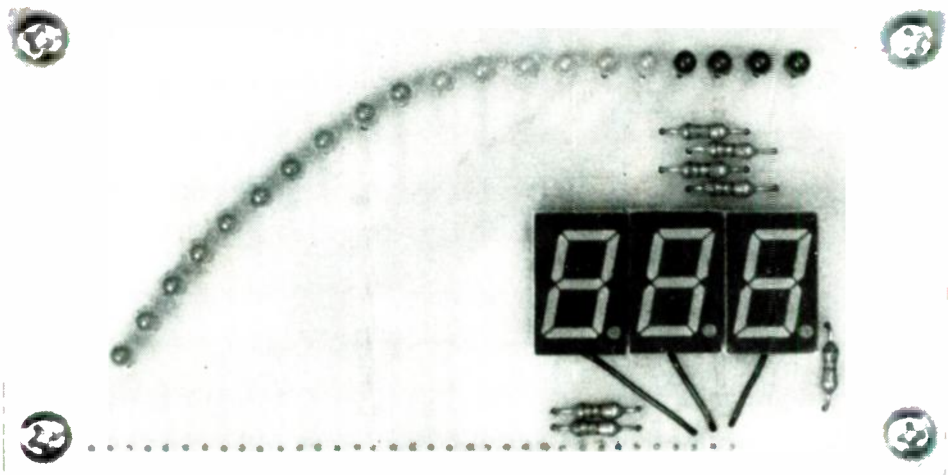
continued on page 78

TABLE 2

```
: PCX!                 ( data address --- )      ( address is 0 to F )
    SWAP 130 PC!                                 ( write data to latch )
    F AND DUP  C0 OR 140 PC!                     ( write address )
    DUP        40 OR 140 PC!                     ( set write strobe lo )
    C0            OR 140 PC! ;                   ( set write strobe hi )

: PCX@                 ( address --- data )
    F AND DUP  80 OR 140 PC!                     ( write addr, read lo )
    130 PC@                                      ( get data )
    SWAP C0 OR 140 PC! ;                         ( set strobes hi )
```

Digital Speedometer for your Car



Dual display delivers both an accurate digital readout and a rapid-read analog display.

ROSS ORTMAN

YOU PROBABLY SPEND MORE TIME WATCHing your speedometer than any other part of your dashboard. However, because most speedometers are mechanical devices and analog in nature, they are prone to error. And just as other parts of your car wear out and must be replaced, so must your speedometer. Besides, the most common speedometer is simply a pointer with a background scale; so exact speed is hard to determine accurately.

Our digital speedometer will accurately display vehicle speed both on a three-digit seven-segment display for precise speed readings, and on a quick easy-to-read analog bar-graph display. The speedometer can be calibrated to read in miles per hour or in kilometers per hour, whichever is preferred. In addition, the bar-graph's "red line" can be set to any desired speed—probably 55 mph.

Theory of operation

The digital speedometer operates by monitoring the speed of driveshaft rotation (on a rear-wheel-drive vehicle) or one of the transaxle output shafts (on a front-wheel-drive vehicle.) Rotational speed is monitored by sensing four magnets (that are secured to the driveshaft or output shaft) with a pickup coil that is mounted to the chassis or body of the automobile. As each magnet passes the pickup coil, a pulse is generated and sent to the digital speedometer, which then counts the number of pulses that occur during a preset time interval and converts this number to display the vehicle's actual speed. The pickup coil and magnets are commercial units that are available from many auto-parts stores.

Because the speedometer uses magnets

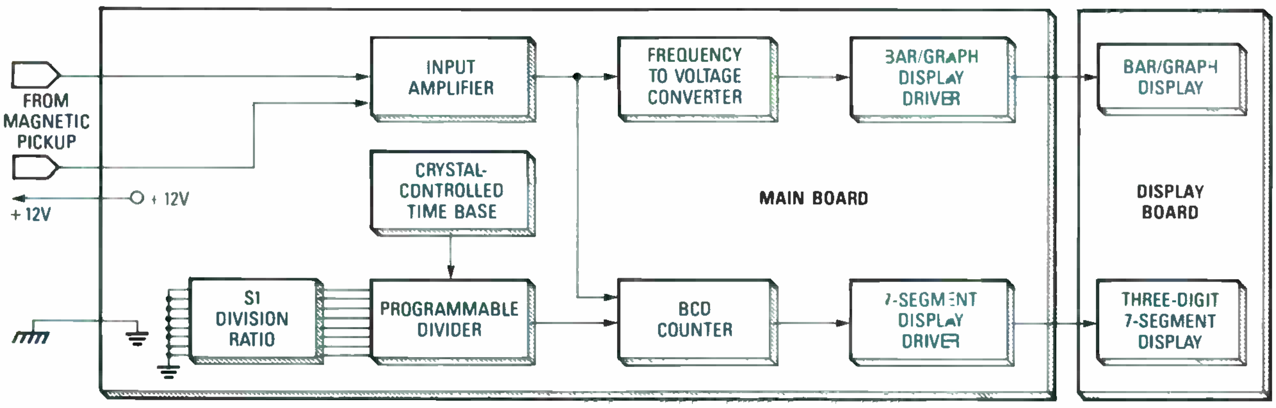


FIG. 1—BLOCK DIAGRAM OF THE SPEEDOMETER: The input amplifier conditions the signal from the magnetic pickup for processing by the counting and display circuitry.

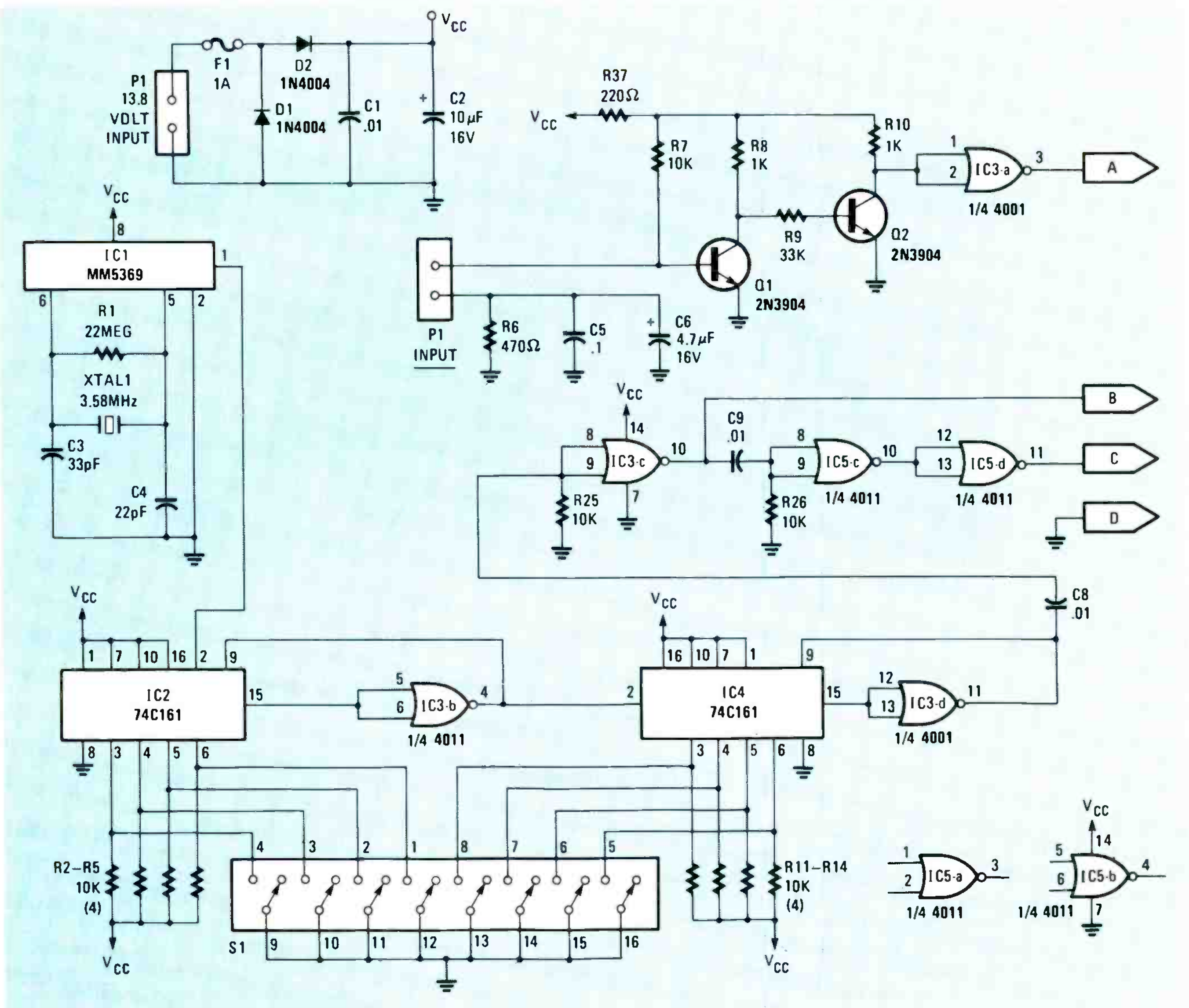


FIG. 2—THE INPUT AMPLIFIER AND TIMEBASE circuitry are shown here. DIP switch S1 sets the divide ratio for calibrating the speedometer.

for sensing (just as many aftermarket cruise-control devices do), dirt, moisture, and weather will not affect its operation. Also, because the speedometer is digitally calibrated, it will remain accurate in all conditions ranging from the coldest winter morning to the hottest summer day.

Referring to the block diagram shown in Fig. 1, pulses from the magnetic pickup are amplified and shaped by the input circuitry. Because all input pulses may not be the same amplitude (due to different magnet strengths and possible distance variations between the magnets and the pickup coil), input-pulse shaping increases the speedometer's accuracy by eliminating multiple counts, missed counts, or both.

The conditioned input pulses are sent to the counter and then to the digital and analog displays. The counting section counts the number of input pulses for a period of time that is determined by the setting of the programmable timebase.

Let's take an example of how the timebase is set for a particular vehicle. On most vehicles, the gear ratio in third (or high) gear is 1:1. In other words, driveshaft speed is equal (or very close) to engine speed. On an eight-cylinder engine, the engine is running at approximately 2200 RPM when the vehicle's speed is 60 mph. With 2200 RPM as our driveshaft speed, we know that the input-pulse rate to the speedometer will be 8800 pulses per minute (2200 RPM times four magnets). Dividing that number by 60 gives us our input frequency in Hertz, in this case, 146.66 Hz.

We now determine that the time for one complete pulse cycle is 6.818 ms (1 ÷ 146.66 Hz). In order to display 60 mph on our digital readout, we must count 60 of those 6.818-ms pulse cycles. That gives us a timebase of 0.41 seconds (60 × 6.818 ms), or 2.44 Hz.

The analog display indicates relative speed by converting the input frequency to a voltage that is then processed for display by the bar-graph display driver IC's (IC8 and IC9).

Circuit description

Referring to Fig. 2, the pickup coil is connected to P1 of the digital speedometer via a twisted-pair cable and a 0.1" female Molex connector. One side of the coil assembly is AC coupled to ground through C5 and C6, and the other side is passed on to the input amplifier, which is composed of Q1, Q2, and the associated bias resistors. The pickup coil is biased slightly positive to ensure that Q1 turns on reliably. After buffering by IC3-a, the input signal is ready for processing by the counting section of the speedometer.

The 60-Hz signal is generated by IC1, an MM5369 17-stage programmable oscillator/divider, and its support components. Here, IC1 uses a 3.58 MHz colorburst crystal to produce a stable and accurate 60-Hz reference.

The programmable divider uses two

PARTS LIST

All resistors are ¼-watt, 5% unless otherwise noted.
R1—22 megohms
R2–R5,R7,R11–R14,R25,R26,R30, R32—10,000 ohms
R6,R33—470 ohms
R8,R10,R22–R24,R27—1000 ohms
R9—33,000 ohms
R15–R21,R37—220 ohms
R28—22,000 ohms
R29—50 ohms, 5 watts, wire-wound
R31—220,000 ohms
R34—10,000 ohms, vertical trimmer potentiometer
R35—2,200 ohms
R36—22,000 ohms

Capacitors
C1—0.01 µF disc
C2—10 µF, 16 volts, electrolytic
C3—33 pF disc
C4—22 pF disc
C5,C12—0.1 µF disc
C6—4.7 µF, 15 volts, electrolytic
C7—0.001 µF disc
C8,C9—0.01 µF disc
C10—0.022 µF mylar
C11—1 µF, 16 volts, electrolytic

Semiconductors
IC1—MM5369 17-stage oscillator/divider
IC2,IC4—74C161 synchronous binary counter
IC3,IC5—4001 quad NOR gate
IC6—MC14553 three-digit BCD counter
IC7—74C48 BCD to 7-segment decoder/driver
IC8,IC9—LM3914 dot/bar display driver
IC10—LM2917N frequency-to-voltage converter
D1,D2—1N4004 rectifier diode
D3—1N4001 rectifier diode
Q1,Q2—2N3904 NPN transistor
Q3–Q5—2N3906 PNP transistor
LED1–LED10—0.125" greeen diffused
LED11–LED16—0.125" yellow diffused
LED17–LED20—0.125" red diffused
DISP1–DISP3—7-segment common-cathode display (Panasonic LN516RK, Digi-Key P351; P352, P353, & P354 may also be used)

Miscellaneous
F1—1 amp slo-blow fuse
S1—eight-position DIP switch
P1,P2—0.1" 2-pin Molex connector
XTAL1—3.58-MHz color-burst crystal

Other components
L1—pick-up coil (ARA part #2701278), magnets, strap mount (ARA part #2701279), wire, solder, PC boards, etc.

Note: ARA cruise control parts are available through your local automotive supply house. They may also be ordered as follows from Dakota Digital, R.R. 1 Box 83 Canistota, SD 57012: display PC board (#430105), $6.95; main PC board (#430106), $12.95; Pick-up coil (#2701278), $11.95; Magnets (#2701279) $4.75 (for a set of 4). Add $1.50 for shipping and handling. South Dakota residents add 5% sales tax.

74C161 synchronous 4-bit counters (IC2 and IC3) to produce a divider that can be programmed to divide by a factor ranging from 4 to 256. The division ratio is set via eight-position DIP switch S1. The text box that appears elsewhere in this article indicates how switch positions correspond with different division ratios.

The output of the programmable divider is fed to two pulse generators consisting of: IC3-c, C8, and R25; and IC5-c, C9, and R26. The pulse generators produce two sequential pulses: a latch pulse followed by a clear pulse. The latch pulse latches the current counter value for display, and the clear pulse resets the 14553 counter (IC6, shown in Fig. 3) so that it begins counting from zero for the next sample period.

The heart of the digital display section (shown in Fig. 3) is IC6, an MC14553 three-digit BCD counter. That IC counts the incoming signal for the duration of the timebase and outputs the value through IC7, a 74C48 BCD to 7-segment decoder, and on to displays DISP1, DISP2, and DISP3. Resistors R15–R21 limit the amount of current that passes through the displays. The three digits are multiplexed by Q3, Q4, and Q5.

The analog display section (shown in Fig. 4) consists of IC10, an LM2917N frequency-to-voltage converter, and its associated components. That IC produces a DC voltage that is proportional to the frequency of the input signal. That relative voltage is then used to drive two cascaded LM3914 bar-graph display drivers (IC8 and IC9), which, in turn, drive the 20-element discrete LED display. The analog display is calibrated simply by setting potentiometer R34.

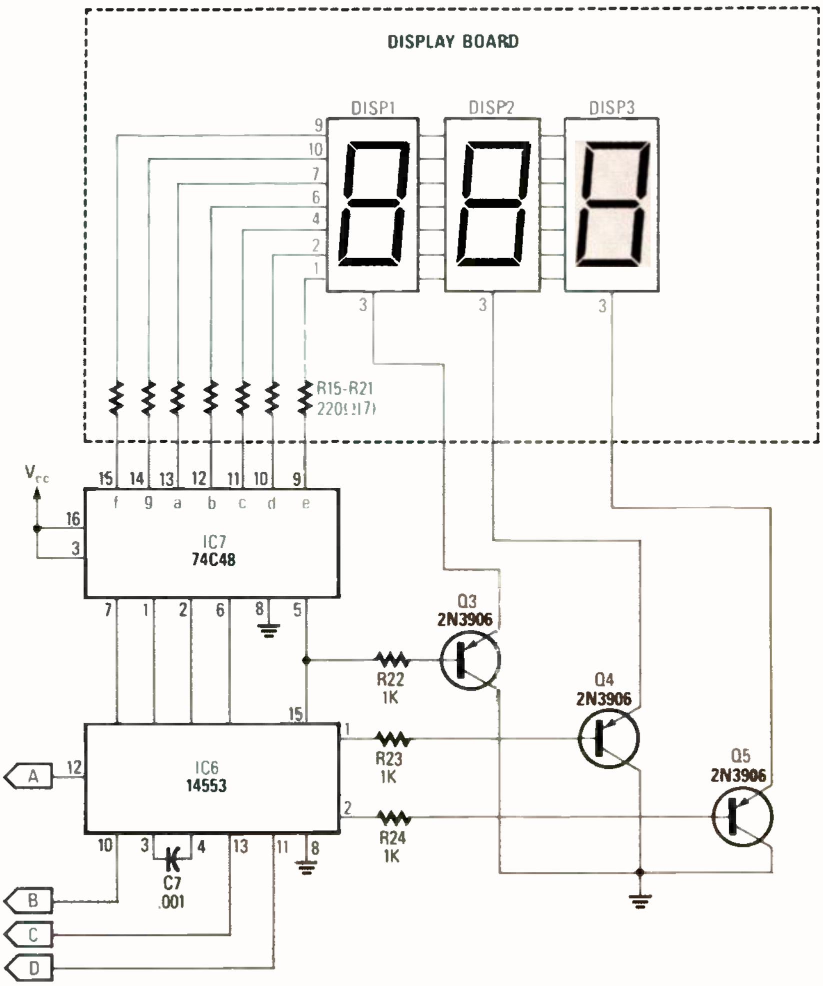


FIG. 3—THE DIGITAL DISPLAY section of the circuit uses a 14553 (IC6) to count pulses, and a 74C48 (IC7) to display the count.

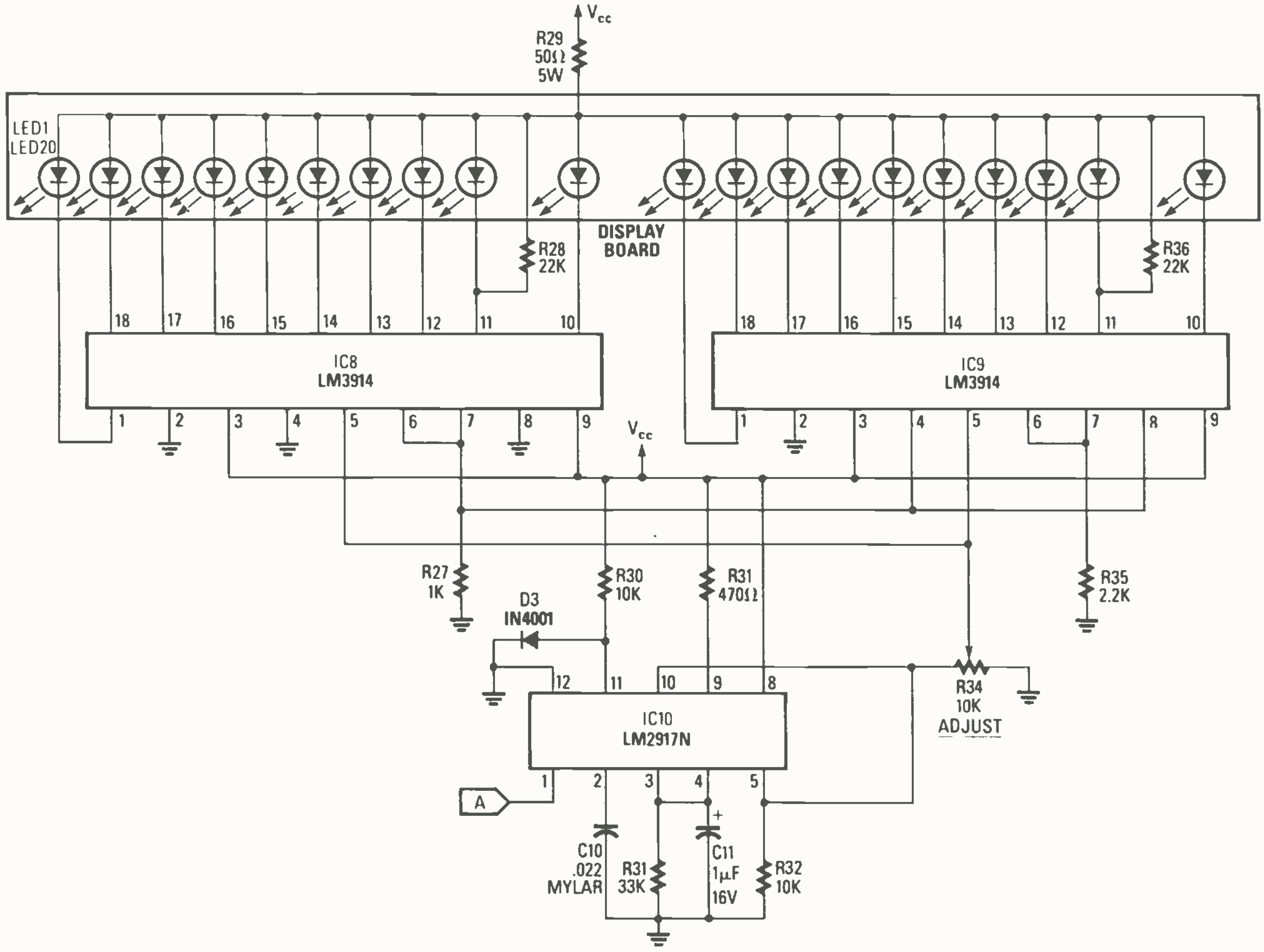


FIG. 4—THE ANALOG DISPLAY uses a frequency-to-voltage converter (IC10) to convert the counted pulses into displayable form.

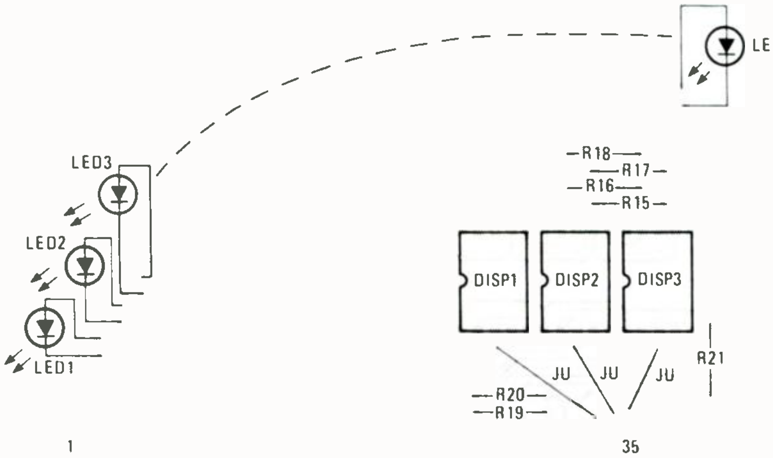


FIG. 5—STUFF THE DISPLAY BOARD as shown here. Don't forget to install the three jumpers. The flat sides of all LED's should face the row of holes at the bottom of the board.

Construction

Construction of the digital speedometer is nearly identical to that of the digital tachometer presented last month. The circuit is built on two PC boards: a display board and a main board. The two boards are connected by 35 jumpers.

The display board contains the seven-segment readouts, the twenty LED's and several resistors; the main board contains everything else. The display board is single-sided; the main board is double-sided. The PC boards can be made using the foil patterns shown in PC Service, or they may be purchased from the supplier mentioned in the Parts List. If you etch your own boards, be sure to solder both sides of the main board.

Begin stuffing the boards with resistors, diodes, and other low-profile parts. Refer to Fig. 5 and Fig. 6 for part locations. If you are using IC sockets, which we recommend, install them next. If you don't use sockets, install the IC's last and solder only a few legs of each IC at a time to prevent overheating. Whether sockets are used or not, observe CMOS handling precautions: use a ground strap, ground your soldering iron, and work only on an anti-static surface.

Continue installing the rest of the parts, including the DIP switch, the capacitors, and the crystal, on the main board. The transistors are installed with the base or center leg bent toward the flat side of the body of the device. Install each transistor about ¼ inch above the board.

When stuffing the display board, begin by inserting and soldering the three seven-segment displays. And don't forget to install the three jumpers located just below the displays. Then insert the discrete LED's into the board with ten green

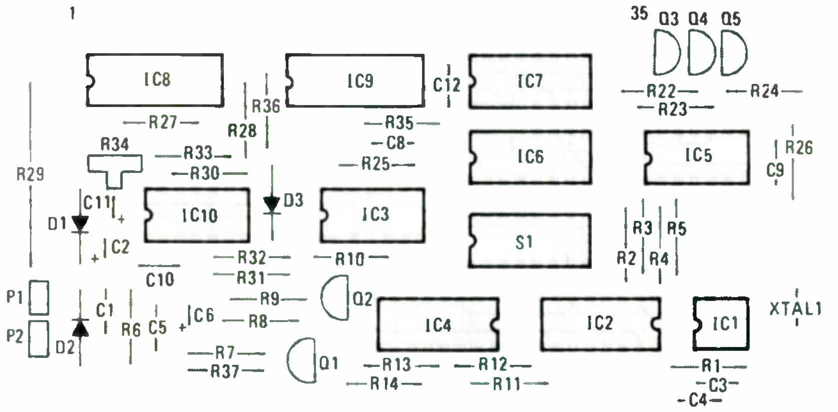


FIG. 6—STUFF THE MAIN BOARD as shown here, and, after checking both boards for errors, connect them together with 35 pieces of short bare wire. The solder sides of the board should face each other.

LED's (LED1–LED10) starting in the lower left corner. Do not solder them in yet. Next insert six yellow LED's and then four red LED's. Double-check to be absolutely certain that the LED's are oriented properly; the cathode (usually the flat side) of the LED should face the bottom of the board.

Next, turn the board over and lay it down on a flat surface, being careful not to allow any LED's to fall out. That's accomplished easily by holding a piece of stiff cardboard against the LED's while turning the board over. Now, to keep the board parallel to your working surface, apply pressure to the board where the seven-segment displays are mounted, and solder one lead of the end and middle LED's. Next, carefully look across the surface that the board is lying on to see whether the LED's are at the same height as the seven-segment displays. If not, correct their positions and then continue soldering one lead each of the remaining LED's.

Turn the board over and align the LED's so that they stand up straight and follow a smooth curve. When you're satisfied with their positions, solder the other leg of each LED.

WARNING

Although the speedometer can be mounted above, below, or inside the dashboard, some conditions must be met if the unit is to be installed in place of the original speedometer. First, Federal law prohibits any tampering with the odometer section of the speedometer and imposes harsh penalties on those in violation of that law. That does not mean that a person is forbidden to replace the original speedometer with the digital speedometer presented here. However, if the device is installed, it must be done in a manner that will keep the vehicle's odometer fully operational.

To replace the original speedometer with the digital speedometer, remove the face plate and pointer of the original, making sure that you leave the original gearing and odometer mechanism intact. The digital speedometer can then be installed in the space left by the old face plate and pointer. Also, the original speedometer cable must be left connected; to remove it is also a violation of Federal law. Check your state laws, too, as they may have additional restrictions.

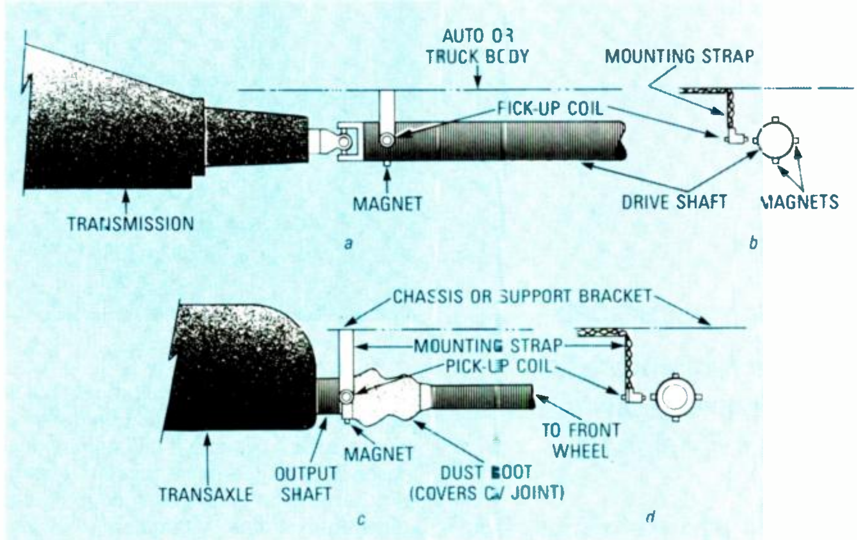


FIG. 7—MAGNET AND PICKUP-COIL MOUNTING METHODS: For a car with a transmission and driveshaft, mount the magnets and pickup coil as shown in *a* and *b*, respectively. For a car with front-wheel drive, mount those parts as shown in *c* and *d*.

SWITCH SETTINGS

For a front-wheel-drive vehicle, the transaxle output shaft's speed can be determined from this formula:

$$DF = 5.355 \cdot R$$

where DF is the division factor, and R is the radius of the front wheel. For a rear-wheel-drive vehicle, the driveshaft's speed can be estimated from the engine speed. If you have an overdrive transmission, use the gear ratio found in the owner's manual to convert the engine speed to the driveshaft speed. The output of each programmable divider (IC2 and IC4) can be determined from the chart below. The total division factor provided by the two IC's is the product of the individual DF's provided by each separately.

For example, a 10" wheel requires a division factor of $5.355 \times 10 = 53.55$. We could approximate that value by setting IC2 to divide by 5 and IC4 to divide by 10. To do so, the DIP switch would be set like this: 01001001.

After you have installed and soldered all components, check your work carefully for errors. Fix any errors, and then complete the assembly by connecting the boards, mechanically and electrically, to each other. Mount the boards back to back (foil side to foil side) with #6 hardware. The boards must be spaced at least ¼-inch apart using spacers or standoffs. Keep in mind that the board will be mounted to the dashboard (or custom-built case) by the same bolts that hold the boards together.

After the two boards are mechanically secured to each other, run short pieces of solid bare hook-up wire between corresponding pads on the two boards. Make sure that the wires are straight and do not touch each other. The boards can be "folded apart" for troubleshooting or repair, if necessary.

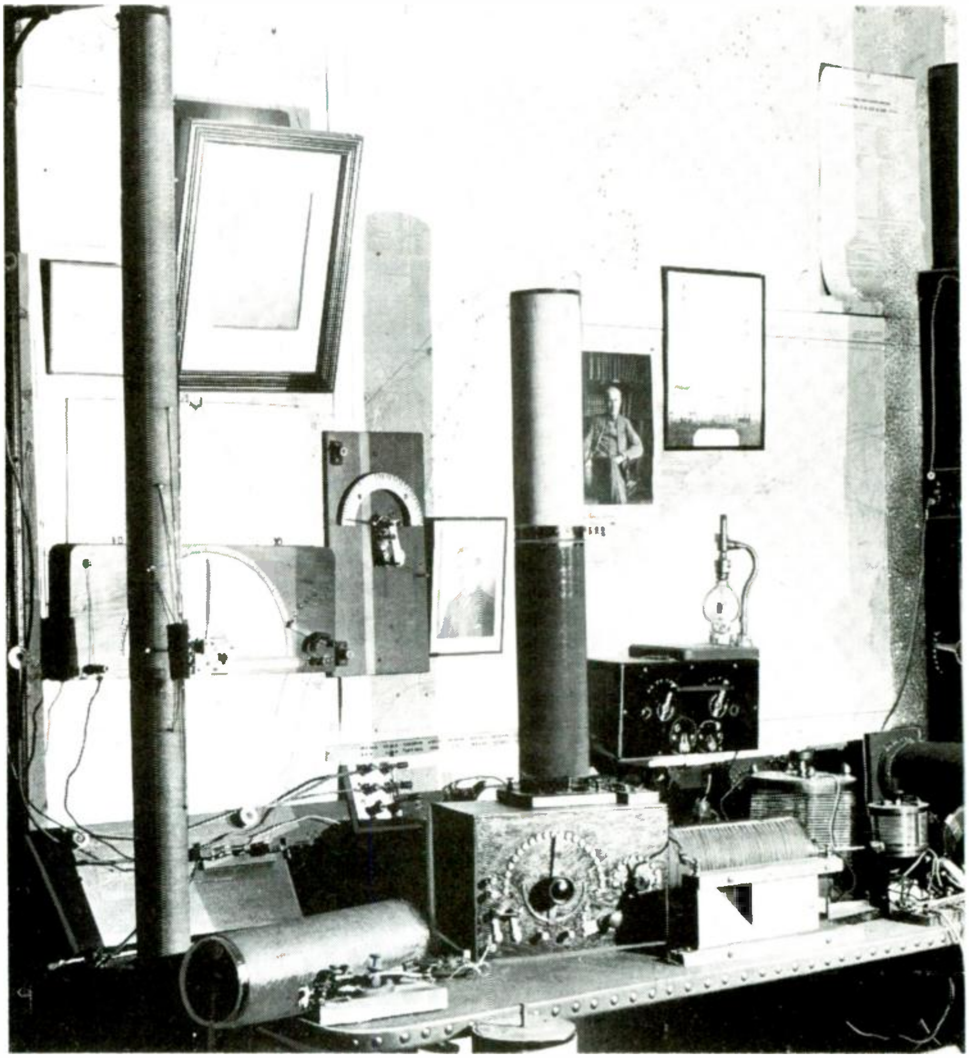
Bench testing

The next step is to test the speedometer to ensure that it is completely operational before installing it in an automobile. Apply twelve volts to power connector P2, which is located on the main board. Note that the positive pin is the one closest to five-watt resistor R29. After power is applied, the two right-hand digits should display zeros, and none of the LED's should be lit.

If your displays differ, check the supply

continued on page 82

The Early Days of RADIO



MARTIN CLIFFORD

The radio pioneers discover how to amplify signals.

Part 4 THE INVENTION OF THE triode vacuum tube by de Forest opened the floodgates to the design of high-gain circuits. Although the crystal and the vacuum-tube diode were adequate radio signal detectors, neither could amplify; hence, circuit design was sharply circumscribed. But once the experimenters had a device that could amplify, there was almost nothing the early pioneers could not and did not try.

Tube design

Some early tube designs were "off the wall"; some because they were attempts to bypass de Forest's patent; others because their designers thought they had invented devices with better performance. One of those unusual designs—now practically unknown—was the "horned triode" (Fig. 1), a tube in which the plate- and control-grid leads were brought out at the top. The idea didn't take hold for receiving tubes, because it had no practical reason to justify its existence; but a variation subsequently became adopted for transmitting tubes. Ultimately, tube design went on a four-pin base, although there were commonly used tube types having a base with five and six pins.

Early radio tubes such as the WD-11, UX-199, UX-120, UX 201A, and the UX-200A had a filament made from a mixture of tungsten and thorium, which was, in turn, coated with metallic thorium. Tungsten was used because of its ability to withstand high temperatures; thorium was used because it is a prolific source of electrons. When electron emission became low, the filament could be reactivated by simply raising the filament voltage to increase the filament temperature, thereby "boiling off" the oxidation products that were interfering with release of the electrons. Generally, the voltage was raised 200–300% for 10 to 15 seconds. For users without the necessary equipment to adjust the filament voltage (see Fig. 2), a "filament renewal service" was available in radio stores for a nominal charge of 25 cents per tube.

If the tungsten/thorium filament was good, something else must be better, so the search for a "better filament" was something like the search for the Holy Grail. Just about everything was tried, including various alloys of platinum, pure nickel, and alloys of nickel such as chromium nickel and titanium nickel. Barium and strontium carbonates in oxide form were also used as the electron source; but, unlike oxide-coated filaments, they could not be reactivated.

Soft and hard tubes

Any trace of air remaining in a tube following its manufacture resulted in a higher plate current that usually could not be controlled by the grid, which resulted in erratic operation. Typically, an electric light bulb had an internal gas pressure of 150 millionths of atmospheric pressure (which is 14.7 lbs/square inch at sea

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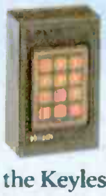

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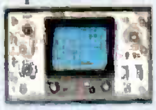

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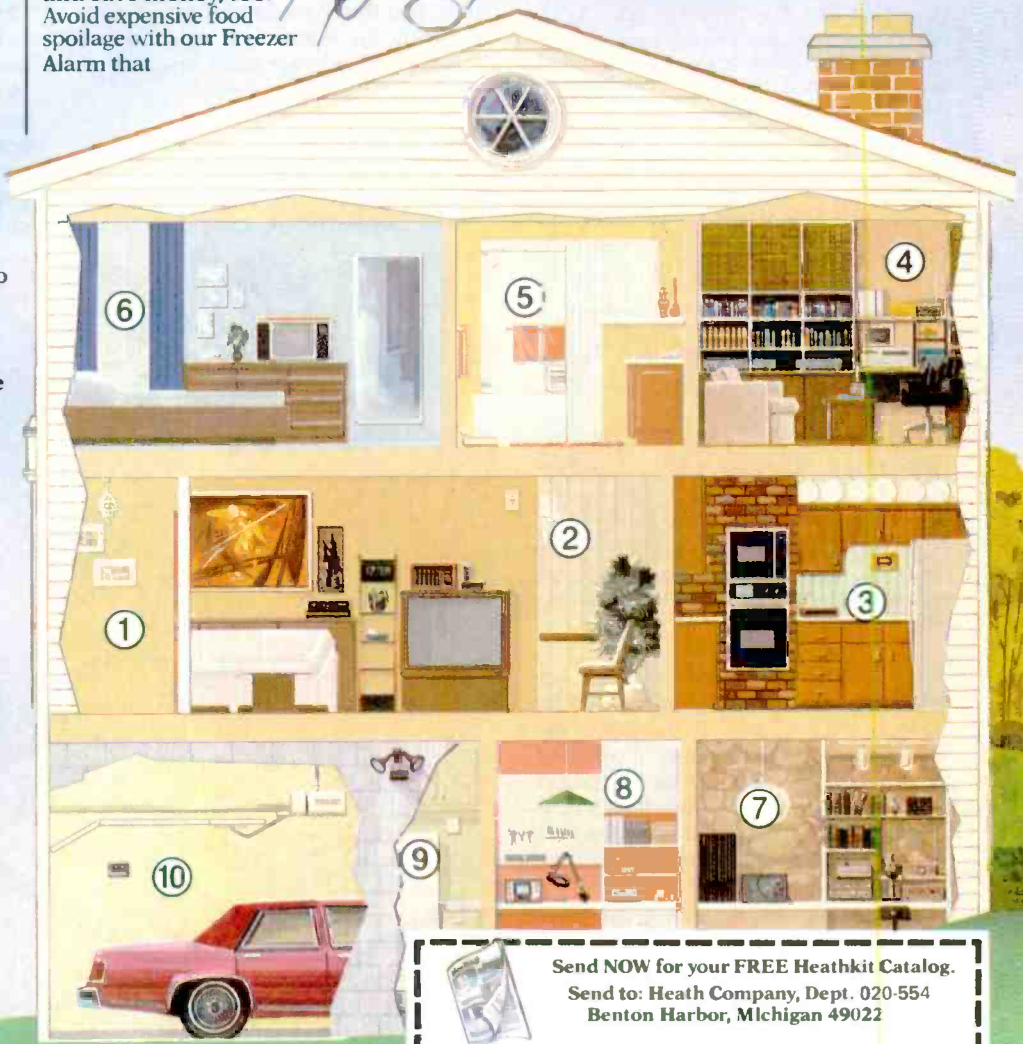

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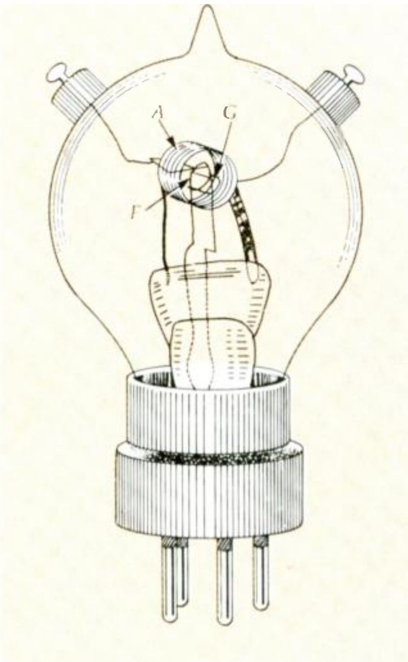


FIG. 1—THE HORNED TRIODE had the plate (anode A) and grid (G) leads at the top of the tube. The base had four pins, but only two were used for the filament (F).

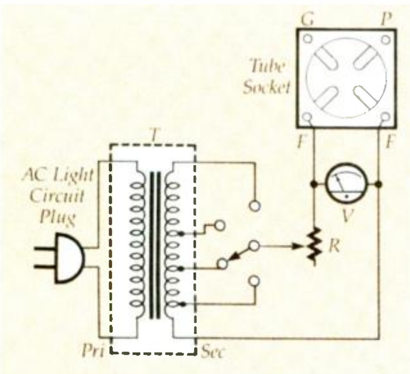


FIG. 2—AN ADJUSTABLE VOLTAGE was often used to reactivate tubes having thoriated tungsten filaments.

level), but that was much too high for radio tubes, whose gas pressure could be made as low as 2 or 3 millionths of atmospheric pressure. One way of ensuring the least possible air following evacuation of the tube was to "flash" a chemical inside the tube. That was done by including a tiny saucer-like structure that contained a chemical such as magnesium, calcium, strontium, barium, or mercury. A current-carrying coil surrounding the tube ignited the chemical and the "flash" depleted any oxygen remaining in the tube. The result of the process was the deposition of a silvery substance on the interior surface of the tube.

The presence in a tube of even a trace of oxygen resulted in collisions between the filament-to-plate current and the air molecules, thereby ionizing the gas atoms. As a result, the ions, having lost one or more electrons, were positively-charged and migrated toward the filament. Because of their relatively large structure (compared to electrons), the ionic bombardment was able to destroy sections of the filament. Tubes that contained oxygen displayed a flickering blue glow toward the bottom end of the glass bulb and were called "soft." A "hard" tube, on the other hand, was one that produced no glow, thereby indicating little internal air.

Microphonics

As tubes were made smaller, the internal pins that supported the various elements were so small they didn't provide adequate support, so the elements were more susceptible to vibration. Element vibration resulted in microphonics, whose chief characteristic was a variation in sound volume that was sometimes accompanied by howling. The problem was relieved somewhat by putting lead weights on top of the tube to give it greater mass, and thereby reduce vibration. Subsequently, the lead-weight technique was also applied to larger tubes that had microphonic tendencies.

A riot of color

The 1920's was the age of the experimenter. Although most people purchased complete ready-to-operate radios, many purchased parts and assembled their own radios, using circuits they designed or tweaked. Aesthetic beauty was often an important aspect of circuit-design and assembly, so it wasn't unusual to find that the wiring used in early radios was covered with "spaghetti," a varnished cambric insulation that was available in most of the colors of the rainbow. The innards of many an early radio were a riot of color—and beauty.

Early experimenter receivers were actually built on a breadboard, and so was at least one commercial receiver: the five-tube Atwater Kent *Model 10*. Although cabinets were available to experimenters, many breadboard receivers were left open to solicit the *oh*'s and *ah*'s of friends and neighbors. It's on record that one builder, who wanted both protection for the for the receiver and neighborly acclaim, used sheets of glass for both the front panel and the cabinet so that the radio could be used even while it was on display.

Circuit diagrams

Like the radio itself, circuit diagrams have gone through many changes. Early builders made use of pictorial diagrams, such as the one shown in Fig. 3, to show how the equipment was assembled. In some instances the diagram was a combination of a pictorial and a schematic circuit, as in Fig. 4.

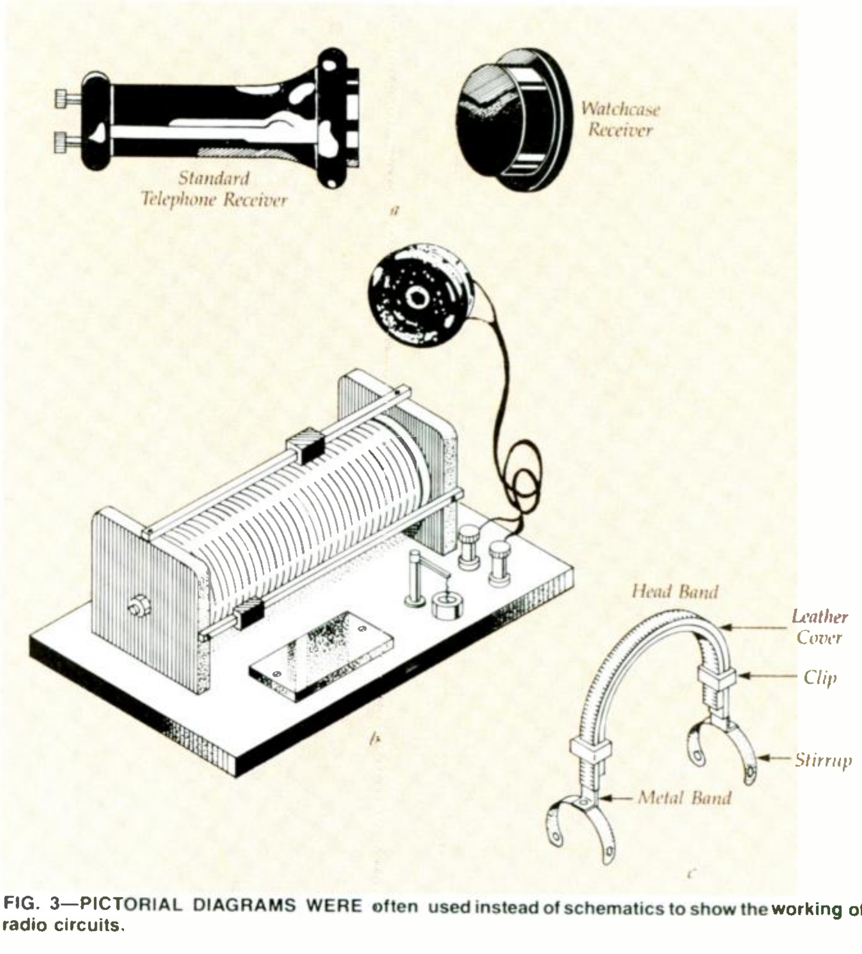


FIG. 3—PICTORIAL DIAGRAMS WERE often used instead of schematics to show the working of radio circuits.

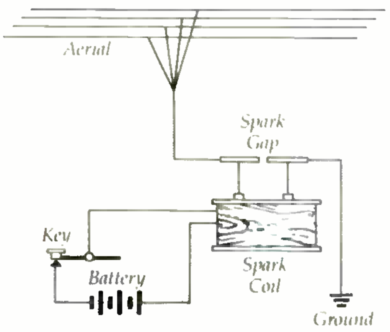


FIG. 4—SOMETIMES, A CIRCUIT was described by using both pictorials and component symbols in the same schematic.

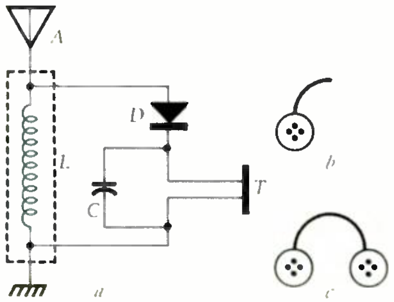


FIG. 5—STEPS IN THE DEVELOPMENT of the circuit symbol for headphones. Originally, the vertical bar identified by the letter T represented a telephone receiver.

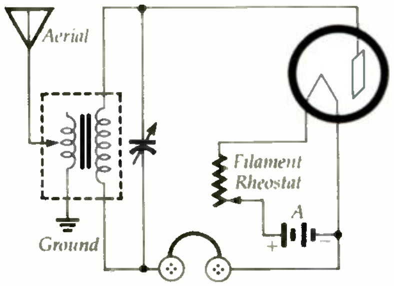


FIG. 6—THIS IS HOW THE FLEMING diode was used in early receivers.

The symbols used in drawings and schematics also evolved along with the components and circuits they represented. Figure 5 shows how the simple symbol representing a headphone developed over the years. In Fig. 5-*a*, an original schematic from the early days of radio, the headphone is represented by a vertical bar followed by the letter T; the T being used to indicate that the bar represented a telephone receiver. The bar eventually evolved into the single headphone symbol shown in Fig. 5-*b*, which in turn evolved into the symbol shown in Fig. 5-*c*, the one used today to represent a headphone having two receivers.

Early circuits

The first use of the vacuum tube was as a detector. Figure 6 shows a common (for its time) receiver that used a Fleming diode instead of a crystal for the detector. As you can see, except for the tube the circuit is essentially the same as that of a conventional crystal receiver. The rheostat in the filament circuit was used as a way to apply higher-than-normal filament voltage, which was an early attempt to increase plate current, and therefore, the output volume. (It also shortened the life of the filament.)

De Forest's triode was initially regarded strictly as an amplifier. Early experimenters were not aware that it could be used as a detector/amplifier, so one early circuit used the crystal as a detector, followed by the triode as an audio amplifier (Fig. 7). In time, experimenters learned that the triode could be used as a detector/amplifier, which eliminated the need for a separate detector. Initially, it was known that the control grid of the triode needed bias, a fact that was brought home when the action of an unbiased grid blocked plate current flow. Initially, grid bias was provided by batteries, which were labeled C to indicate they were used for biasing the grid. Although a C battery could last its entire shelf life, since they often were not replaced until their acid had oozed out and damaged the radio, experimenters searched for a better way to bias the grid. The better way was a large resistor connected from grid to ground—called a *grid leak*—that was usually shunted directly or indirectly by a capacitor (that stored the voltage developed across the grid leak).

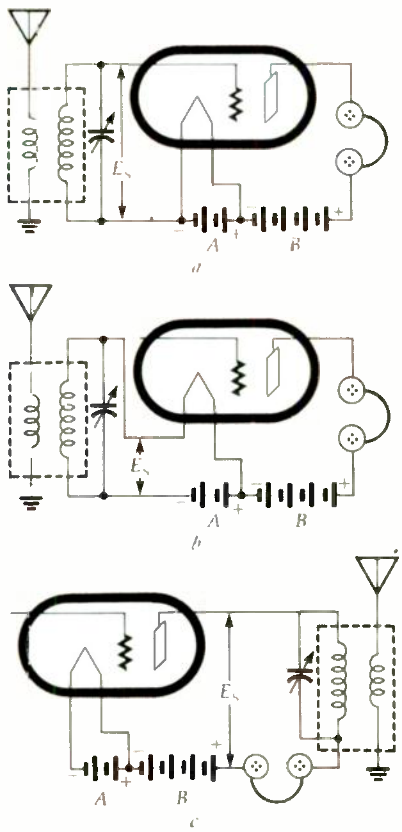


FIG. 8—SEVERAL METHODS WERE USED to feed a signal into a triode. Note that in *b* and *c* the grid is floating.

As shown in Fig. 8, various techniques for getting extra oomph from the triode were tried. It was learned early that the best triode circuit was the one shown in Fig. 8-*a*, wherein the input signal (E_s) is injected between the control grid and the filament. Some attempts were made to put the signal across the filament (Fig. 8-*b*), or between the plate and the filament as shown in Fig. 8-*c*.

Although it offered superior performance, it took a number of years for the triode vacuum tube to replace the crystal detector because crystals were considerably less expensive than tubes and required no power source other than that supplied by the signal itself. Also, in many areas radio signals could supply satisfactory reception using a crystal detector; there was no need for additional sensitivity (amplification).

In fact, the primary concern with early radio reception was not sensitivity but selectivity. In the next installment of this series, we'll look at ways that selectivity was increased and at some audio-coupling schemes that were used. **R-E**

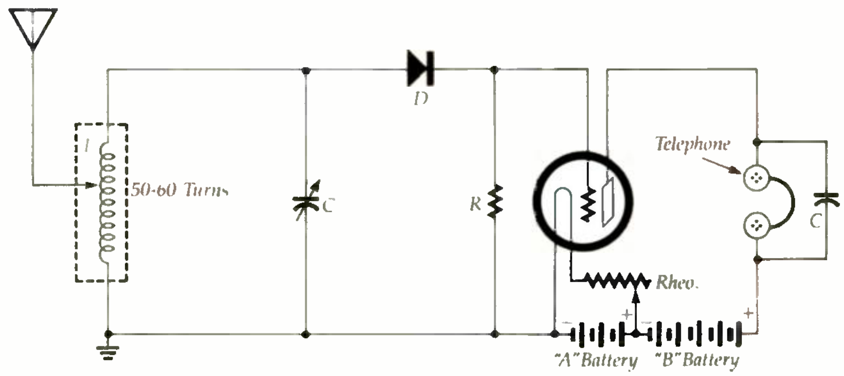
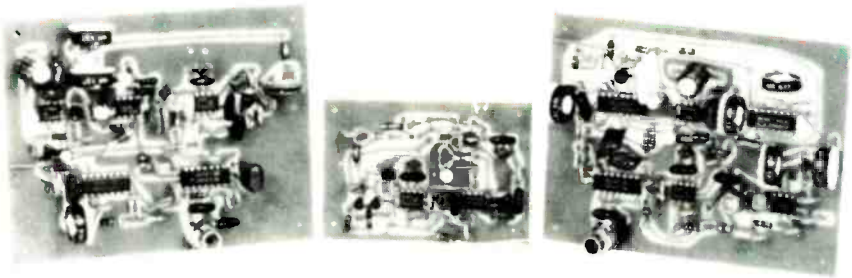
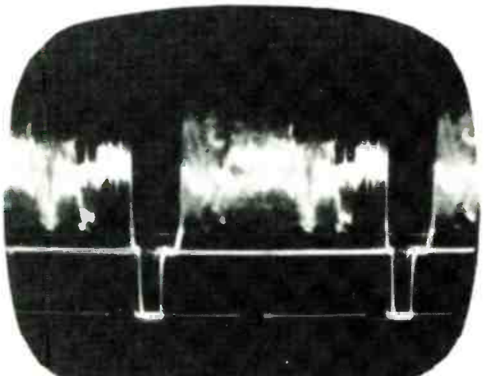


FIG. 7—AN EARLY CRYSTAL SET having one stage of audio amplification. Subsequently, it was realized that the tube could be used as a detector as well as an amplifier.

TV SIGNAL DESCRAMBLING





This month we digitally encode the sound.

WILLIAM SHEETS and RUDOLF F. GRAF

Part 9

IN PREVIOUS PARTS OF this series, we discussed encryption of audio signals using an analog method. Basically, all that was done was to remove the audio from the main channel and place it on a subcarrier. Since the subcarrier, by itself, is inaudible, the audio could not be heard by casual or unauthorized listeners. The recovery of the audio program was accomplished by demodulation of the subcarrier.

Although subcarrier-based scrambling techniques are fairly effective, they are relatively easy to defeat; they are suitable primarily for low-to-moderate security applications. A more secure encryption system that uses digital encoding (the Oak *Orion* and MA/-Com Videocipher II) has been developed for satellite audio systems.

In the *Orion/Videocipher II* kind of encoding, a digital representation of the audio signal is substituted for the TV signal's horizontal sync pulse, which is located within the horizontal blanking interval. Figure 1 shows how the substitution is made. Since the audio is moved to the horizontal blanking interval, the TV signal's aural (sound) carrier has no program modulation. It can be left unmodulated, or modulated by sound having no relation to the TV picture—perhaps music or "billboard" announcements. Naturally, to hear the program sound, the digitized audio must be restored to an analog signal.

There are several way by which conventional audio signals can be digitized (converted to digital form). The best approach for a given situation depends on the signal frequency, accuracy required, and cost considerations. We will discuss several approaches to A/D and D/A conversion.

First, a word about basic digitizing theory. Analog signals are digitized by taking minute discrete samples of the analog waveform. Digital sampling theory tells us that a signal of length T and a frequency bandwidth of f_m can be completely specified by $2 \times f_m T$ samples of the signal. (In this instance, "completely specified" means that the analog signal can be digitized and then restored to back to analog with essentially no distortion.)

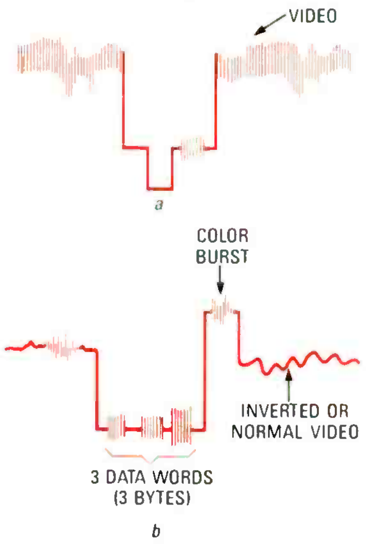


FIG.1—DIGITIZED AUDIO IS SUBSTITUTED for the video signal's horizontal sync pulse. Only the first two data words represent audio. The third is used for housekeeping.

Alternately, it may be said that if T = 1 second, then $2 \times f_m$ (or twice the bandwidth samples per second) are required to specify the signal; which means that a typical TV-audio signal having a 12-kHz bandwidth must be sampled at a 24-kHz rate (or higher) in order to completely specify the signal. (Because "it's already available," a convenient audio sampling rate is twice the horizontal scan frequency, or 31.5 kHz.) Why sample at a rate higher than necessary? Because sampling at the highest possible rate reduces aliasing distortion, thereby reducing the anti-aliasing filtering requirements.

Aliasing products

Aliasing distortion is the production of spurious waveforms caused by too low a sampling rate. The distortion appears as unwanted and unrelated very-low-frequency or in-band signals. For example, in an audio application, the baseband signal may be in the 0–12 kHz range and would theoretically be sampled at a 24 kHz rate. However, because of distortion within the audio amplifiers, some audio

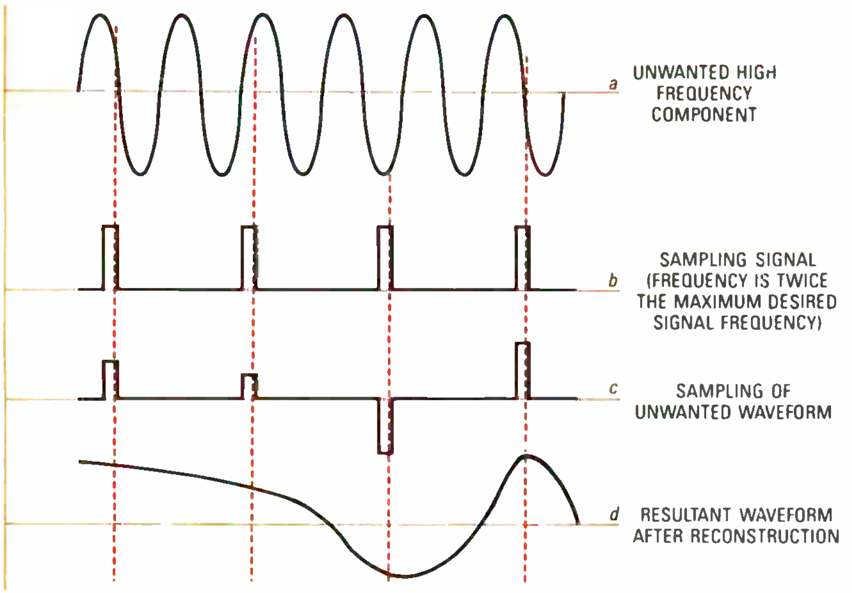


FIG.2—ALIASING IS THE PRODUCTION of false, unwanted signals caused by too low a sampling rate.

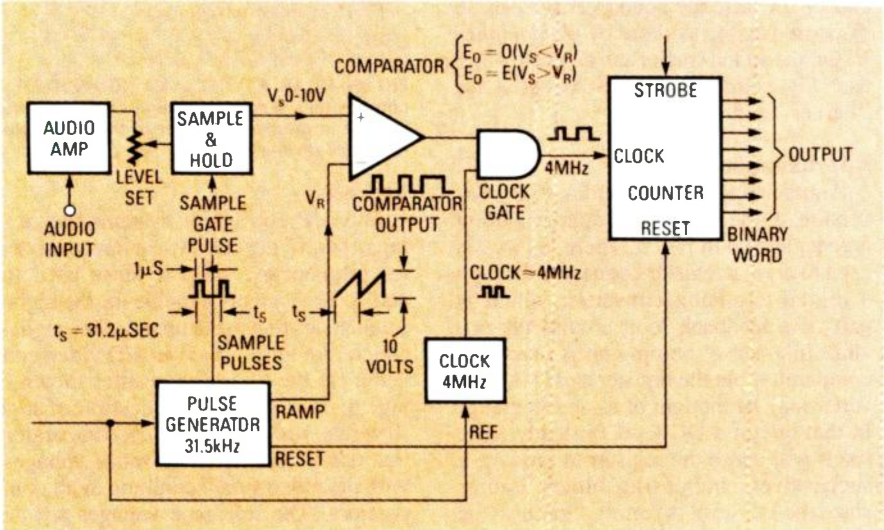


FIG. 3—A COMPARATOR can be used to digitize an analog signal at TTL levels.

components as high as 24 or 30 kHz might be present, and they would also be sampled during the digitizing process. Figure 2 shows what might occur. The top waveform (Fig. 2–*a*) represents audio frequencies above 12 kHz caused by distortion within the analog audio amplifiers. The sampling pulses (Fig. 2–*b*) are obviously not twice the frequency of Fig. 2–a, so they produce the unwanted sampling pulses shown in Fig. 2–*c*. After normal filtering, we get the unwanted reconstructed waveform—caused by aliasing distortion—shown in Fig. 2–*d*: a distorted waveform of very low frequency having no relation to the original analog audio signal. Aliasing can be reduced by adequate audio-bandwidth limiting, and by using as high a sampling rate as possible.

Binary numbers

Typically, the audio is digitized by generating discrete binary numbers to represent the analog level. If we have a binary word *n* bits long, we can specify 2^n discrete levels. Obviously, it is necessary to specify a large number of samples to reproduce minute changes in analog level. One hundred levels would take care of 1% (-40 dB) uncertainty, meaning a 40 dB dynamic range. And if 256 levels were used, uncertainty would now be less than -46 dB, which is adequate for TV audio. A single data byte can do that.

However, since we only have horizontal blanking pulses at a 15.75 kHz rate, how can a 31.5 kHz sampling rate be produced? Simply by having each blanking interval contain two bytes rather than one byte. In this way, 31,500 bytes-per-second are available, which is adequate for a 12-kHz audio baseband. In addition, a third byte is inserted in the blanking interval: It is a coded digital word that can be used to determine where the horizontal and vertical starting points are located (to ensure proper vertical and horizontal timing). It can also be used for other purposes: for example, to obtain two 12-bit audio samples (total 24 bits).

Figure 3 shows how an audio signal can be digitized. The output from the audio amplifier is level-set for proper dynamic range, and then sampled every 31.2 microseconds (31.5 kHz rate). The analog value is stored in a sample and-hold circuit until the next sample is taken: let us assume it may be any value between zero and ten volts. That analog level is then fed to one input of a comparator. The other comparator input is fed with a linear ramp (sawtooth) whose amplitude rises from 0 to 10 volts. (The ramp starts slightly after the sampling interval and ends just before the next audio sample is taken, because some time must be reserved for sampling and resetting the ramp to zero.) If the audio sample is relatively large (say 7 to 10 volts) in amplitude, the ramp will have to rise to that value before the comparator's output voltage will drop to zero. If the analog sample is small (say 1 volt), the comparator will drop to zero when the ramp exceeds one volt. (The comparator's output is a logic high (1) when $V_S > V_R$, it is a logic low (0) when $V_S < V_R$. Therefore, the comparator output is a train of pulses having a frequency of 31.5 kHz and a pulse width ranging from nearly zero to 30 microseconds (depending on the sample amplitude.)

The variable-length pulse represents the analog value of the audio sample's amplitude. A narrow (5 microsecond) pulse represents low values (say 0 to 2 volts). A wide pulse of 25 microseconds would represent 8 or 9 volts. (Ideally, we should get about 3 microseconds pulse-width per volt in this instance.) Next, the pulse has to be converted to a binary value, which can be done by using the pulse as a gating pulse for a counter that is clocked by a much higher clock frequency. If we had a 4-MHz clock, 120 clock pulses would be counted in 30 microseconds. By using two separate (alternating) systems and the full line-scan time (63.5 microseconds), it is possible to count up to 240 clock pulses, therefore generating a full 8-byte binary word. That is possible because each byte is only needed every 63.5 microseconds, and there are two bytes.

Therefore, the counter can be reset to zero, the high-frequency clock signal can be gated by the variable-length pulse, and the width of the variable-length pulse will determine how many cycles of the high-frequency clock will be input to the counter. The counter will count to a state that is proportional to the length of the variable pulse, whose width depends on the analog

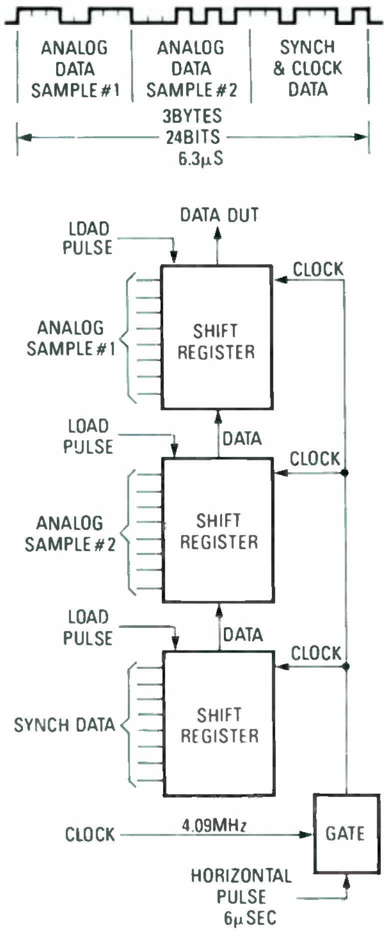


FIG. 4—SHIFT REGISTERS CAN BE USED to organize three digital samples into a serial data stream.

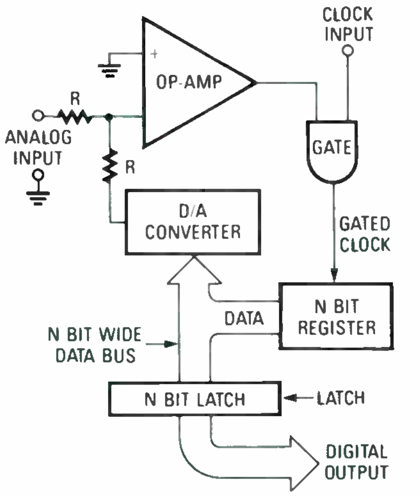


FIG. 5—THIS IS THE FUNCTIONAL circuit of a successive-approximation register-type A/D converter.

value of the audio sample. Therefore, a binary number appears at the output of the counter that is proportional to the analog value of the audio sample and is its digital equivalent in parallel format.

Next, as shown in Fig. 4, the binary number—which we'll call *Sample 1*, is stored in parallel format in a shift register. During the horizontal blanking interval, it is clocked out in serial format, appearing as an 8-bit digital word. The clock frequency of 4.0909 MHz shown in Fig. 4 has a 6-microsecond interval, which permits 24 bits (3 bytes) of digital information to be transmitted during the sync pulse. By using two additional shift registers, as shown, it's possible to serially-transmit three bytes. The first two bytes, *Sample 1* and *Sample 2*, are generated because we need 31,500 samples per second—we must transmit two bytes in every blanking interval, and there are 15,750 blanking intervals per second. The third byte can be used for system housekeeping or overhead. As previously mentioned, it can represent signals for determining horizontal and vertical sync references, and have special-purpose coding.

Because the audio is both digitized and piggybacked on the sync interval, it is no longer found on the TV signal's sound carrier. In fact, the sound carrier can be dispensed with, as done by *Videocipher II*. Or, the sound carrier can be put to other use; for example, it could be used for "barker" audio.

Approximation

Another approach to audio A/D conversion is the successive-approximation register shown in Fig. 5. There, a clock is used to drive a register connected through a digital-to-analog converter, which is part of a feedback loop around the op-amp. In a sense the op-amp is used as a comparator, but the register and D-A converter may be thought of as an integrator. In that circuit a DC level (a steady logic level) will cause the register to produce a successively increasing binary count, since the DC level is merely "gating" the clock signal. As the register is counting, the D/A converter produces a rising ramp output. When the D/A converter's ramp output voltage is equal to that of the analog input to the op-amp the output of the op-amp will flip low, thereby shutting off the clock gate. (At that point, the binary number seen at the register's input or the D/A converter input is the digital equivalent, in parallel form, of the analog input signal. That signal can be stored in a latch or another register for later use.)

The speed of conversion of the successive-approximation system depends on the clock frequency, the bandwidth of the operational amplifier, and the system's stability. Normally, the clock frequency must be much higher than the input signal frequency. For example, if a 256-level (8-bit) resolution is wanted, the clock must be 256 times faster than the analog sampling rate. Actually, it must be even greater to allow for setup times, latching, and sampling of digital-data output to the bus

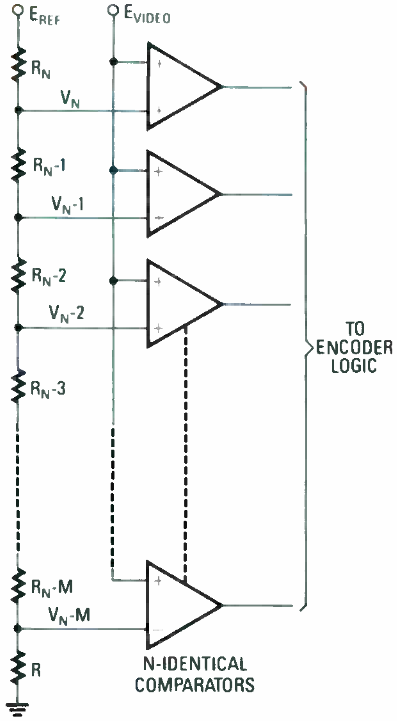


FIG. 6—IN AN A/D "FLASH" CONVERTER, a comparator's output goes high when the video voltage is greater than that of the associated reference divider tap-off.

interface.

The A/D conversion systems shown in Figs. 4 and 5 are effective at low to moderate frequencies, such as those used for audio. They are not suitable for the higher frequencies that make up the video signal. One of the most effective A/D video converters is the "flash" converter shown in Fig. 6. It is simply a collection of high slew-rate wideband op-amp comparators that use independent reference voltages, with the video signal common to all comparators. The reference voltages are derived from a resistive voltage divider.

Each of the 256 steps that make up a data byte requires its own comparator, so a practical circuit would require LSI technology. The "flash" comparator's output feeds encoding logic that provides 8-bit binary data corresponding to the analog value of the video signal sample.

Bear in mind that regardless of the kind of digitizing used for video, a bandwidth of 4.2 MHz is required for NTSC video, and digitized video is processed either a line or a frame at a time. Generally, eight bits or more must be used to describe the signals adequately and to avoid visible deterioration of the picture. That corresponds to 256 levels (0 to 255), each step being 48 dB below peak video. Since the sample rate must be at least 2 × 4.2, or 8.4 MHz, more likely 10 MHz would be used so there would be a small amount of leeway. To allow for glitches and pulse-settling time, and to reduce aliasing, bandwidths of 20 MHz are necessary.

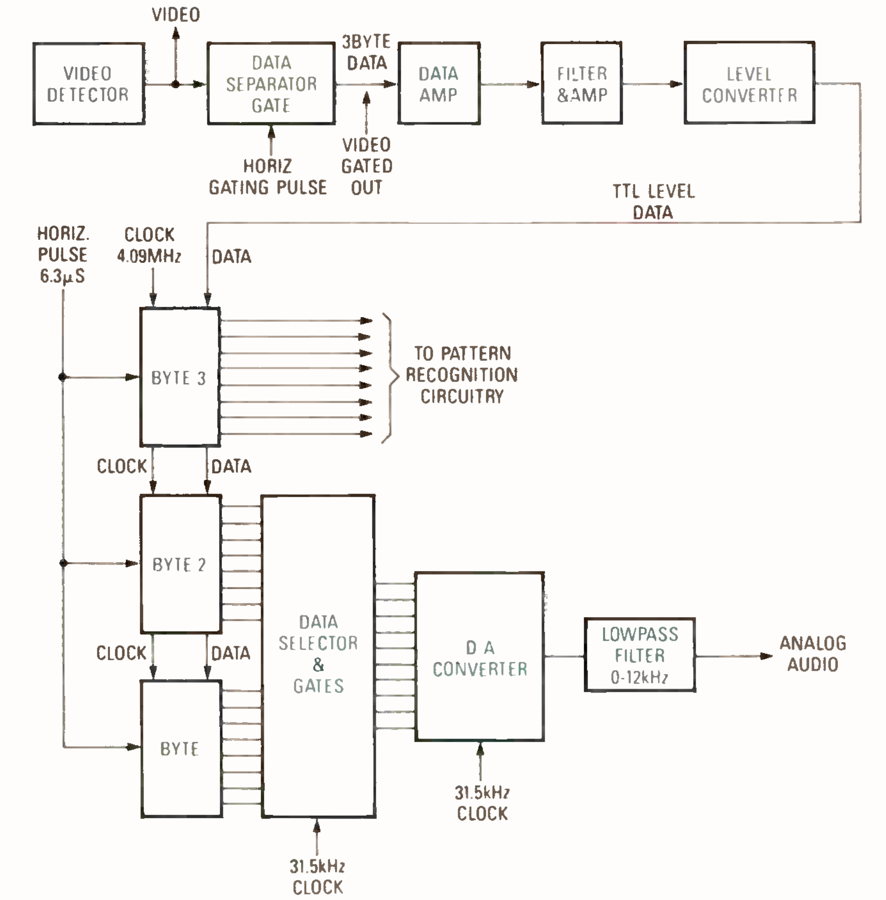


FIG. 7—A COMPLETE DIGITAL DECODER. The analog output from the lowpass filter is an accurate reproduction of the original audio signal.

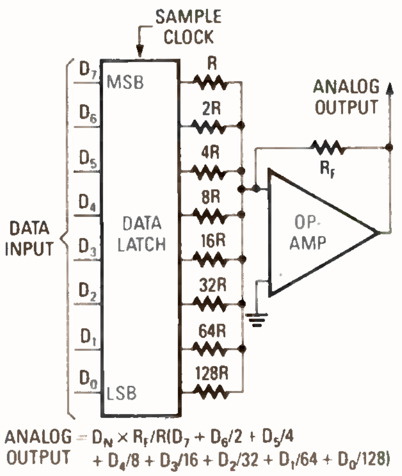


FIG. 8—A SINGLE OP-AMP and a precision voltage divider can also be used for digital decoding. The analog output is proportional to the active data inputs.

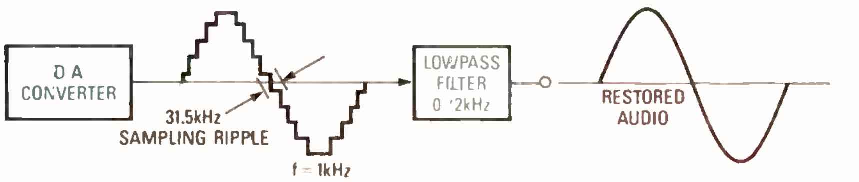


FIG. 9—A RESTORED WAVEFORM contains a 31.5 kHz sampling-frequency ripple that must be removed by a lowpass filter

Descrambling

To demodulate digitized audio, the digitizing process is simply reversed. Figure 7 shows the block diagram of a sync-interval digital-audio decoder. A data-separator gate following the TV's video detector extracts the audio-data pulses from the video signal. The output from the separator is a squarewave containing unwanted components, among them possibly video "spill," and a 15-Hz sinewave that is used to prevent the the accidental use of the digital data as TV synchronizing pulses. All extraneous signals, regardless of type, are removed by the filter/amplifier so that only the digital data appears at the input to the level converter.

The level converter makes the data signal TTL compatible (or whatever is necessary for the logic circuitry that follows). The compatible data is clocked into a 24-bit shift register, which can easily be made up of three 8-bit shift registers, as shown. One shift register contains the first audio sample, another the second sample, and the remaining register contains the encoded third byte. The third byte is fed to a pattern-recognition system that specifically interprets the encoding of the third byte.

Byte 1 and byte 2 are fed in parallel form to a data selector that is driven by a 31.5-kHz clock, which is derived from the horizontal-sync circuit. Bytes 1 and 2 are alternately selected and fed in parallel form to a D/A converter, which converts the audio data back to analog form. The filter, which we'll get to shortly, completes the restoration process by "smoothing" the analog waveform.

Figure 8 shows how an op-amp and a resistor network create an elementary D/A converter. Resistor R_F is the feedback resistor from the op-amp's output to its inverting input. Using a ±15-VDC supply and TTL signal levels, values for R_F and R might be 10K and 5K respectively.

The converter works this way: Assume that data-input D_7 is the most-significant data bit, having 128 times the effect on the output compared to D_0, which is the least-significant bit. And assuming that R_F is 10K and that R is 5K. If D_7 is high and all other data lines are low, we would get 10 volts out of the D/A converter. If D_7 were low and D6 were high, the D/A output would be 5 volts. A high D_5 would produce 2.5 volts; a high D_4 would produce 1.25 volts, and so on, until D_0, which would produce 5/64 volts. Note that each data line produces twice the effect of its lower neighbor. Any binary number would therefore produce a definite analog voltage.

As shown in Fig. 9, due to the sampling process the output of a D/A converter used for decoding is an analog signal having a 31.5 kHz component. The lowpass filter, (also shown in Fig. 7) removes the 31.5 kHz component, thereby producing a low-distortion waveform that closely resembles the input signal.

Not really scrambled

Although we have been referring to "scrambled" audio, as you can see by now, the audio signal itself is not really scrambled, it is simply digitized. But since it cannot be received by a con-

continued on page 82

SATELLITE TV

High-definition DBS

BOB COOPER, JR.
SATELLITE-TV EDITOR

THE C-BAND HOME SATELLITE-TV INdustry came into being quite accidentally; no one thought that relatively small dishes for C band would be developed, much less proliferate. Instead, most thought that the Ku-band (12 GHz) would be the likely home for any *Direct-Broadcast Satellite* (DBS) system. Plans for such systems have been on the drawing board for more than ten years, and Ku-band allocations have been reserved for DBS since 1979. But to date, with the exception of some very limited testing by the French, nothing has really happened on that front anywhere in the world. Further, nothing is likely to happen before 1990, at the earliest. But after that, watch out!

Here comes HDTV

Now there is serious planning underway to change the very nature of television broadcasting.

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Bob Cooper's *CSD Magazine* maintains a 24 hour per day *Scramble-Fax-Hotline* telephone service (305/771-0575) which you may call to obtain a 3-minute recorded update on the latest happenings in the satellite scrambling world. *Scramble-Fax Newsletter* is also published to keep you abreast of the latest events in descrambling, including sources for descrambling chips and equipment. For information, write *Scramble Fax*, P.O. Box 100858, Ft. Lauderdale, FL. 33310 or telephone 305-771-0505.

If you have a dish of your own, tune in the Caribbean Super Station (Western 5, transponder 23) Tuesdays at 7 PM eastern for a special weekly Bob Cooper report. Also tune-in *Boresight* at 9 PM Thursday nights (Spacenet 1, transponder 9) for a weekly one-hour report on the activities in the home TVRO field.

Our present 525-line, NTSC color system grew out of a proprietary RCA black-and-white system and was, for all intents and purposes, adopted in 1939. Back then, that represented the highest resolution that was technologically possible. Now, however, almost 50 years later, *High Definition TV* (HDTV) with more than 1,000 scan lines per frame at last has become very practical.

But what do you do with all the millions of 525-line TV sets currently in place? The FCC has a plan: They would like to allow existing TV broadcasters to operate in the Ku band using high definition (1,125-line, 5 × 3 aspect-ratio) video; the broadcasters would continue to operate their existing VHF or UHF local stations simultaneously. Using spot-beam techniques at Ku or even Ka frequencies, the satellite footprint could be shaped to more or less duplicate a broadcaster's terrestrial-signal coverage area.

Japanese HDTV

The Japanese will launch 1,125-line high-definition TV service using Ku-band satellites in 1990. The double-bandwidth transponders required for HDTV will transmit their signals to an entirely new generation of TV receivers designed to process the signals. The audio will be digital, stereo, and capable of supporting multiple languages and even closed captioning in the same transmission. The aspect ratio or width of the pictures will be enlarged from the present 4 × 3 format (see Fig. 1-*a*) to 5 × 7 (see Fig. 1-*b*).

This past January, Japanese scientists conducted a public demonstration in the U.S. Using a special side-by-side allocation, approved for the occasion by the FCC, two UHF channels were used to allow the Japanese to demonstrate their high-definition video. The demonstration was widely applauded by the National Association of Broadcasters (NAB), which represents U.S. broadcasting interests before the FCC and Congress. It's now clear that the NAB, and apparently the FCC, both are in favor of allowing wideband, high-definition transmission to develop here as well.

Because our present VHF- and UHF-TV spectrum is filled, and because high-definition video requires twice the bandwidth of present NTSC video, the only logical home for HDTV is on microwave frequencies using direct satellite transmission. But who is to own and operate such a system?

Turning it over to the broadcasters is one way to allay their worries that a superior technology might erode the value of their licenses. In late 1986, a VHF television station in New York City sold

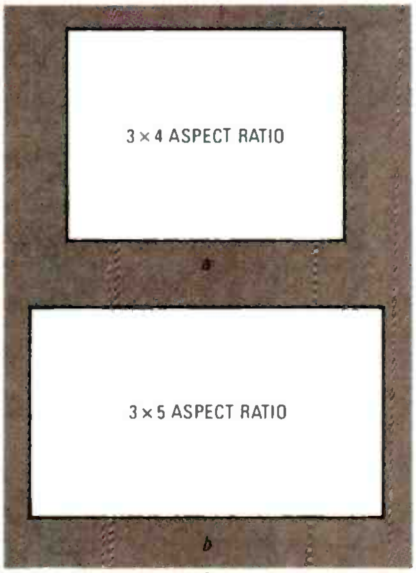

FIG. 1

for more than the cost of buying and launching more than three 24-channel C-band satellites!

Best laid plans

All of that flies contrary to the present on-record plans for Ku-band DBS. Under the original FCC plan, DBS was to be a separate service allowing programmers to provide a sort of wireless cable. But with the entry of HDTV, the best-laid plans for DBS seemed to be headed out the window.

High-definition TV requires twice the bandwidth per transponder as DBS, and it has a ready-made user list that includes all of the existing TV broadcasters in the U.S. That seems to exclude any other use for Ku or Ka frequencies. In fact, it will take some very careful allocation planning to ensure that all of the broadcasters who might like access to the service will receive it. But through frequency re-use techniques, transponder assignments can be repeated often enough to allow each terrestrial broadcaster a viewing area that's essentially the same as the one it now serves.

That sort of change in television service will have profound and long-lasting impact on everything related to television in North America. After 50 years of NTSC as our standard, there is serious energy now being devoted to updating the system and to adapting it to the improved techniques. **R-E**

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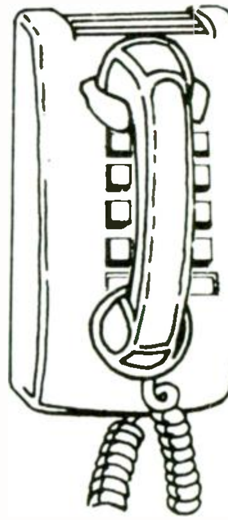

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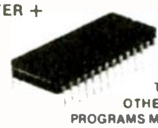

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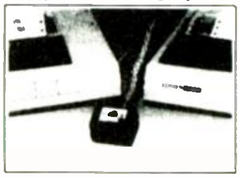

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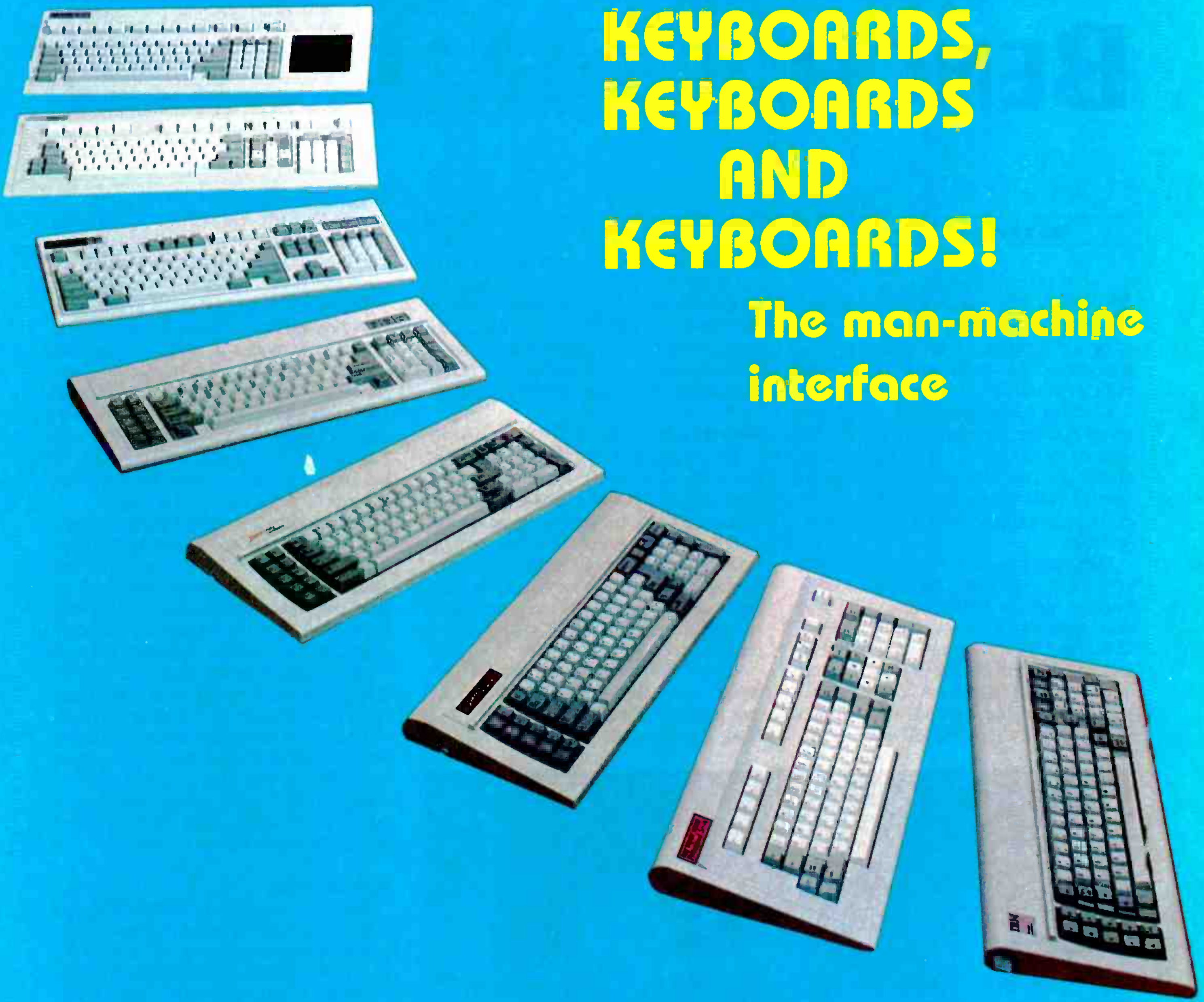
VOL. 4 NO. 7 JULY 1987

COMPUTERDIGEST

A NEW KIND OF MAGAZINE FOR ELECTRONICS PROFESSIONALS



KEYBOARDS, KEYBOARDS AND KEYBOARDS!

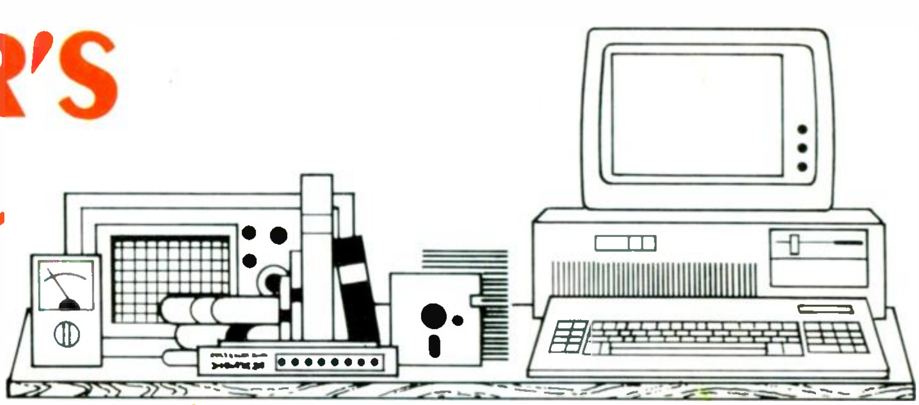
The man-machine interface

IBM's NEW PC's

First impressions of Big Blue's new entries

A GERNSBACK PUBLICATION

EDITOR'S WORK-BENCH



IBM's Personal System/2

Following months of speculation and rumor, IBM has finally released a quartet of new computers, a new version of DOS, and a slew of new peripherals, including an optical disk drive.

It's immediately apparent that the new computers are intended to open new directions for IBM, as well as to maintain continuity with past machines. And it doesn't seem that IBM has made the kind of marketing blunder it did with the PC JR and the PC Portable.

There are four new Personal System/2 computers, as shown in Fig. 1; they're dubbed the Models 30, 50, 60, and 80, and base models of each list for $1695, $3595, $5295, and $6995, respectively. As you can see, the Models 30 and 50 are desktop models, and the others are floor-standing.

The Model 30 is basically an upgraded PC (or XT); the Models 50 and 60 are basically upgraded versions of the AT; and the Model 80 is IBM's long-awaited 386 machine. The Model 30 has been rated to run about twice as fast as the PC, and the Models 50 and 60 (which differ mainly in the number of expansion slots each contains), twice as fast as the AT. The Model 80 is rated twice as fast the Models 50 and 60 Specifications are summarized in Table 1.

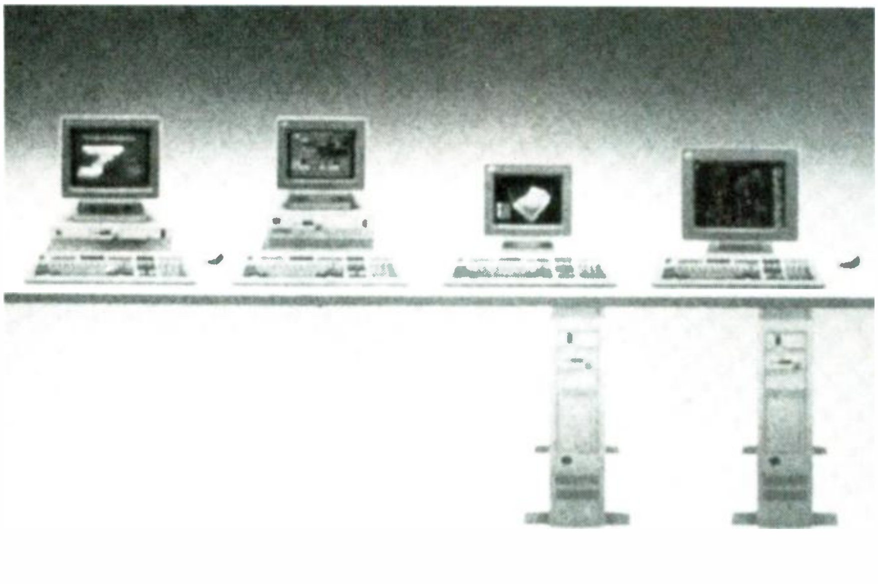


FIG. 1

New features

Technical details are hard to come by at this early date, but here's what we've learned so far. (We hope to have a hands-on review next month.) The main features that distintuish the Personal System/2 computers from the old models are the new disk drives, the new video hardware, the new expansion slots, and the new unreleased operating system called Operating System/2 (OS/2).

All the new models come with 3½" disk drives. Each Model 30 disk holds 720K (twice that of a standard 5¼ inch disk); new disks for the other machines hold 1.44 megabytes each, and the Model 50, 60, and 80 disk drives can read both types of disks. The 720K disks are used in many portables currently on the market.

The new video hardware is compatible with the old CGA standard, but it also adds several new modes that are incompatible with all other standards, including IBM's own EGA as well as the Hercules standards. The new video modes offer higher resolution and more colors than the CGA, and they require new analog monitors that are incompatible with all other IBM-compatible monitors currently on the market.

The Models 30 and 50 have three expansion slots each; the Models 60 and 80 have seven slots. The slots in the Model 30 are electrically compatible with the old-style slots, but expansion slots shouldn't be necessary because the Model 30 includes most common add-on hardware: 640K of RAM, a video adapter, serial and parallel ports, mouse adapter, and a battery-backed clock/calendar. The expansion slots in the other models are totally incompatible with the old-style slots, but the new bus, which IBM calls the Micro Channel, can operate at a much higher speed than the old bus. The Models 50 and 60 have 16-bit buses; the Model 80 has a 32-bit bus.

DOS and OS/2

There is a new version of DOS (DOS 3.3) and a totally new operating system, which won't be released before the end of the year. DOS 3.3 has a few added commands (including a CALL statement for use in batch files), and has enhanced some old programs (BACKUP and RESTORE, for example), but all in all the new DOS does very little more than provide support for the new hardware. It runs on all past and present IBM PC's.

The other new operating system is called Operating System/2, and it contains many of the advanced features power users and network managers have been clamoring for.

OS/2 supports three "environments" and will come in three versions. The three en-

TABLE 1—IBM PERSONAL SYSTEM/2

	Model 30	Model 50	Model 60	Model 80
Microprocessor	8086	80286	80286	80386
Potential system throughput	Up to 2½ times PC XT™	Up to 2 times PersonalComputer AT®	Up to 2 times Personal Computer AT	Up to 3½ times Personal Computer AT
Standard memory Expandable to	640KB	1MB 7MB	1MB 15MB	Up to 2MB 16MB
Diskette size and capacity	3.5-inch 720KB	3.5-inch 1.44MB	3.5-inch 1.44MB	3.5-inch 1.44MB
Fixed disk Additional options	20MB	20MB	44, 70MB 44, 70, 115MB	44, 70, 115MB 44, 70, 115MB
Maximum configuration	20MB	20MB	185MB	230MB
Expansion slots	3	3	7	7
Operating system(s)	PC DOS 3.3	PC DOS 3.3 and Operating System/2™	PC DOS 3.3 and Operating System/2	PC DOS 3.3 and Operating System/2

vironments (DOS, Family, and OS/2) allow various levels of software compatibility. The DOS environment should be totally compatible with existing programs; the OS/2 environment will allow full access to the features of the new computers (what we call the M & M's: Multi-tasking and extended Memory); and the Family environment provides a bridge between the two.

The Standard Edition Version 1.0 of OS/2 will include extensive on-line help facilities and support for the M & M's. IBM expects to release 1.0 in the first quarter of 1988. The Standard Edition Version 1.1 will include all the capabilites of 1.0, plus a Macintosh-style graphics/window user interface. IBM expects to announce a release date for 1.1 by the end of 1987. According to the rumor mill, the window interface may be Microsoft Windows, IBM's own (and neglected) Top View, or some combination thereof.

IBM calls the third version of OS/2 the Extended Edition, and it will include an advanced relational database manager, an advanced communications program (that will allow background communications), and terminal emulation. The extended edition seems to be aimed primarily at users who do a great deal of work on both PC's and mainframes.

Price and performance

It's easy to see that IBM is not going after the rock-bottom clone market, although the new models are not hopelessly expensive, either. For example, one week after IBM's announcement, Model 30's were being sold across the counter in New York City for about $1400 for the dual-floppy model and about $1800 for the floppy/hard-disk model. That price doesn't include a monitor, which runs an extra $225 or $475 (street price) for monochrome or color, respectively. However, that price does include everything IBM and the clone makers previously sold separately—video adapter card, ports, RAM, etc. Meanwhile, prices of the old models have dropped on the order of 30%, so now you can get a real IBM for the cost of a clone.

Technically speaking, the new machines indicate that 5¼" disk drives are on the way out and that 3½" drives are on the way in. The takeover will be gradual, but it is inevitable—as was the transition from 8" to 5¼" disks—because the new disks are much more durable and hold much more information than the old ones.

The problem with video is much more difficult to discuss, mainly because at this early date there is little hard data. We know that the new graphics hardware is not compatible with EGA and Hercules standards, but we've been unable to find out whether it's possible to run an EGA or Hercules card in a Model 30. (The bus structure of the more powerful machines precludes EGA/Hercules use in those machines.) If it's not possible, until present-day graphics software is adapted to the new video standard, it will have to run in CGA mode. On the other hand, it appears that text-mode software will be able to take advantage of the new higher-resolution hardware, so word processors, outline processors, and the like should benefit immediately.

What to buy

If you want to buy a PC now, first you must choose between IBM and non-IBM equipment. If you choose IBM, you have to choose between old technology and the Model 30, on the one hand, and the Models 50, 60, and 80 on the other. And the choice may not be easy, depending on your needs. If you're quite sure of your present and future needs, and an old-technology machine or a Model 30 will meet those needs, buy one. Present hardware and software will power those machines for perhaps another five years without looking too dated. However, beware that software developers will gradually shift the focus of their efforts over to the new machines, and that development efforts for the old machines will gradually cease (as happened with CP/M). Choosing among a Model 30, an IBM PC (or XT), and a clone is difficult, but if I were buying today I'd lean strongly toward a Model 30 because it bridges past and future technologies.

On the other hand, if you want a machine that you can grow with, one that will be able to take advantage of the M & M's and the applications software that will put the hardware to work, buy one of the more-powerful new machines.

KEYBOARD MEDLEY

Keyboards are not all created equal. Like people, they come in a variety of sizes and shapes, and they all work differently. The differences among keyboards may seem trivial, but if you spend much time pounding on one, you'll want to ensure that it has the right feel for you. If you work on a number of different keyboards, trying to adapt to the differences among them can make you yearn for a long rest in a well-padded cell.

We want to keep you out of that cell, so here's the lowdown on various keyboards. We've got fat ones, thin ones, plain ones, fancy ones—there are eight in all, and they cover the majority of styles (PC, AT, and Enhanced) in common use. And several have features that make them attractive for special applications (typing, CAD, use by untrained users, etc.)

The original

IBM introduced the PC in 1981. The first thing many people noticed was that IBM completely abandoned the layout it had standardized on the Selectric series of typewriters (See Fig. 1.) The major faults are that the Return key is small and hard to reach, and that the Backslash key is located between the "Z" key and the Left Shift key. Other features (which some users love, but many hate) are that the keys must be depressed far to get a response, and each depression causes the keyboard to emit a loud mechanical click (as opposed to a soft, electronically controlled one).

In addition, the Caps Lock, Num Lock, and Scroll Lock keys have no indicator lights, so you can't tell which mode you're in without typing something (and then erasing it!). Also, the layout of the numeric keypad leaves much to be desired. For example, there is no Enter key, but the " + " key occupies the space of three keys!

Key Tronic 5151

The first attempt to improve that unpopular layout was made by the Key Tronic company; it has become a standard in its own right, although it is not without its problems too.

The 5151 keyboard addressed many of the faults of the original. The biggest difference is that an additional keypad was added so that it is not necessary to toggle the Num Lock key to alternate between using the keypad to type numbers and move the cursor. The Return key was also enlarged, the Backslash key was moved to the far side of the Right Shift key, and the Grave key ( ) was moved above the Return key, to leave more room for the latter.

In addition, the function keys were moved from the dual row on the left side of the keyboard to a single row above the main portion of the keyboard. Indicator lights were added to the toggle keys, and an Enter key (which is equivalent to the Return key) was added to the existing numeric keypad.

The feel of the keys is mushy, and, although you're unlikely to press the backslash key accidentally with the 5151's layout, it's also hard to get to it (without looking) when you do want to press it. In addition, KeyTronic placed the Caps Lock key between the "A" key and the Ctrl key, so it's easy to hit it by mistake.

A Zenith clone

The keyboard Zenith Data Systems sells with several computers is shown in Fig. 3. It corrects many of the faults of the original IBM board, has a slightly mushy feel (but not as much as the KeyTronic model), and emits a nice keyclick (through the speaker in the system unit). The Return key is large, and there is an Enter key in the numeric keypad. The Backslash key was moved down a row, so that it's between the Spacebar and the Alt key. You're not likely to hit it accidentally, but it can be hard to home in on, especially if you also use an IBM or other keyboard. One nice feature is that the toggle keys all have internal LED's. The keyboard is available separately; see Table 1 for more detailed information.

The AT layout

Everyone in the industry knew that there was widespread dissatisfaction with the original IBM layout, but IBM ignored that dissatisfaction when it introduced the XT in 1983. In fact, it wasn't until the AT was introduced in 1984 that IBM attempted to correct its error. We were unable to obtain an AT keyboard to photograph, but the layout of the AT-style clone keyboard (shown in Fig. 4) is quite similar. Notice that the Enter key is much larger now. However, the BackSpace key is smaller, and the Backslash key has been moved to the upper row (between the BackSpace and the " = " keys).

The clone board shown in the photo has an Enter key in the keypad, but the AT does not. In addition, on the AT, the upper right keypad key is labeled SysReq; that key is not normally used by DOS. Beneath it is the PrtSc key, followed by the "-" key and the " + " keys. On the AT, the " + " key occupies the space of two keys.

The strangest thing about the AT layout is that the Esc key has been moved from its traditional place at the upper left corner of the main keyboard to the upper left corner of the numeric keypad. One can only speculate why that was done. The Grave key was moved to the normal Esc position. The AT keyboard also has indicator lights for the toggle keys.

IBM's Enhanced keyboard

Two years after the announcement of the AT, IBM introduced the XT 286, a machine

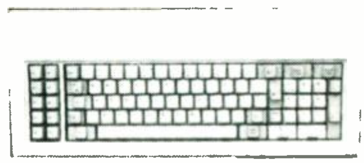


FIG. 1—IBM'S ORIGINAL KEYBOARD

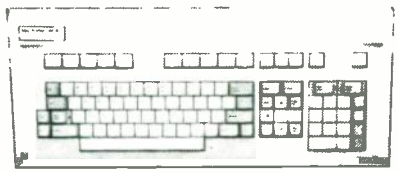


FIG. 2—THE KEY TRONIC KB5151, AN EARLY CLONE

FIG. 3—A ZENITH CLONE

FIG. 4—A FOREIGN CLONE (IN THE AT STYLE)

TABLE 1—PRODUCTS REVIEWED

Product	Manufacturers
RapidWriter $595	Quixote Corporation One East Wacker Drive Chicago, IL 60601. 800-325-1850 (Illinois) 800-523-8356 (Elsewhere)
KB5151 $255 **KB5153** $299	Key Tronic Corporation P.O. Box 14687 Spokane, WA 99214 800-262-6006
Turbo-101 $149.95	DataDesk International 7650 Haskell Avenue Van Nuys, CA 91406 800-826-5398
100-1861 $125	Heath Company Parts Department Benton Harbor, MI 49022 616-982-3571

Contact your local IBM representative for information on the IBM Enhanced keyboard.

FIG. 5—IBM'S ENHANCED KEYBOARD

FIG. 6—THE DATADESK TURBO-101

FIG. 7—QUIXOTE CORPORATION'S RAPIDWRITER

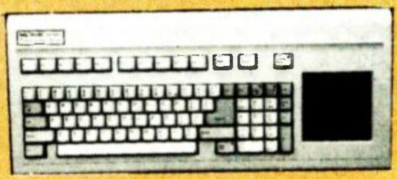


FIG. 8—THE KEY TRONIC KB5153

halfway between the XT and the AT in computing power. Along with the XT 286 came a new keyboard, the so-called Enhanced keyboard. If you had never seen a computer keyboard before, you'd probably say that it's a work of art. (See Fig. 5.) The main keyboard has a symmetrical layout and there are separate numeric and cursor keypads. Also, there are two new function keys, for a total of twelve function keys, and 101 keys overall.

The feel of the new keyboard is wonderful; you don't have to press the keys very far or very hard. There's no audio feedback, but you don't need it; the keys themselves provide a pleasant yet unobtrusive click.

In fact, there's only one real problem with the Enhanced keyboard: the Ctrl key. Actually there are two Ctrl keys and two Alt keys, located symmetrically on both sides of the Spacebar. The normal position for the Ctrl key is now occupied by the Caps Lock key. If you're used to a keyboard with Ctrl in the normal position, you may go wild trying to adapt to the new position.

Another anomaly of the Enhanced keyboard is that the Esc has been moved yet again—now it's at the left edge of the upper row of keys, by the Function keys. At least that's the same general area as normal.

The numeric keypad finally has an Enter key, and the Backslash key is now in a reasonable location: just above the Enter key in the main keyboard. In addition, the BackSpace key is now large and easy to find; it's located just above the Backslash key.

The DataDesk Turbo-101

There's always someone waiting to correct an IBM mistake. The Turbo-101 has much going for it, including a switch that allows you to swap the functions of the Caps Lock and the Left Ctrl keys, and keycaps to make it look as if the keyboard had been designed that way from the beginning.

In addition, another switch adapts the board for use with either a PC (or XT) or an AT. The board can also be used with either the old BIOS ROM (which doesn't recognize the new function keys) or new BIOS ROM's (which do). If you use the Turbo-101 with an old BIOS ROM, F11 generates Alt-F9 and F12 generates Alt-F10 key codes. By cutting the leads of two diodes, you can force the keyboard to generate the new scan codes for those keys. Further, the Turbo-101 comes with a copy of Borland's Turbo Lightning, a combination spelling checker and thesaurus.

The only problem with the keyboard is that each key has a soft detent that is inferior to that of IBM's Enhanced keyboard. Other than that, the Turbo-101 is a good deal.

Special keyboards

Several firms have taken the idea of improving the IBM keyboard further than merely re-arranging the layout. For example, the RapidWriter (shown in Fig. 7) is a hardware/software combination that is designed to increase secretarial efficiency by automating the process of typing repetitive words and phrases.

The keyboard is identical to the KeyTronic 5151. (Just as we were going to press Quixote Corporation informed us that future versions of RapidWriter will come with a 101-key enhanced keyboard. The software has also been upgraded.)

The software loads a special keyboard driver that senses when several keys are pressed simultaneously. That condition is called a "chord" by Quixote. When the keys corresponding to a previously stored chord are pressed, an entire word or phrase flows into the current document, just as if that word or phrase had been typed at the keyboard. Chords are stored in dictionaries; each dictionary can contain 250 chords for a total of 16,000 characters. You can have an unlimited number of dictionaries, as each is stored in a separate disk file.

You can cause the first letter of a chord to be capitalized by pressing a Shift key when you press the chord. Or you can capitalize the entire chord by pressing Caps Lock with the chord. In addition, you can define chords that pause one or more times during chord expansion, allowing you to type information at the keyboard. And a chord can "call" another chord, expand it, and return to the calling chord. You can also edit and print chords.

KeyTronic 5153

The most innovative and useful special keyboard we've seen is the KeyTronic 5153 (shown in Fig. 8), because it contains a programmable keypad (on the right side of the unit) instead of separate numeric and cursor keypads.

The basic keyboard layout is in the AT style, with the Escape key in the numeric keypad. The keyboard has the typical KeyTronic feel—mushy, but not so mushy as some inexpensive clones. The programmable keypad is like a digitizing tablet; it can resolve motion to a precision of about 0.001 inch. You use the keypad by pressing it with your finger or with a plastic stylus.

The keypad has several modes of operation. You can use it as a cursor keypad, in which each press is converted into equivalent cursor-key codes. In the function-key mode, the pad is divided into a number of squares, each of which is freely programmable. KeyTronic supplies program files (and plastic overlays) for common DOS commands (DATE, TIME, TYPE, FORMAT, etc.), and for popular applications programs, including WordStar and Lotus 1-2-3. KeyTronic also supplies software that allows you to create your own keypad macro files (for matrix sizes of 2 × 2, 3 × 3, 4 × 4, or 5 × 5), and blank overlays.

In the mouse mode, the keypad emulates operation of the Microsoft mouse; to use it, you run the stylus across the keypad. A graphics mode functions similarly, but each point on the keypad corresponds to a point on the display screen. You can also use the keypad in several modes that combine the above modes.

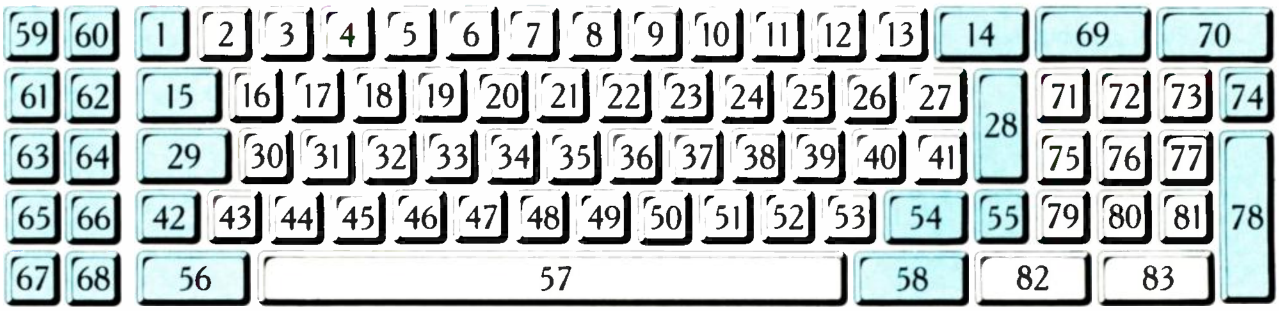
Conclusions

Each of the keyboards we examined has merit; some are better for particular applications than others. The main features you'll want to consider when buying a keyboard are the overall layout, indicator lights, feel (mushy, "clicky," or somewhere between the two), and extra features (bundled software, for example). The most important feature is layout, so examine it carefully; layout can make the difference between productive and non-productive use of a machine. Try before you buy.

Which would we choose? For general use, the IBM Enhanced keyboard. It has by far the best feel, and is now the standard of IBM's entire line of PC's.

The KeyTronic 5153 is our runner-up. It has a good feel, and the keypad can save the cost of a mouse, a digitizing tablet, or both. A person just starting out in computing could get by with it until he or she could justify the cost of the extra peripheral.

FROM KEYPRESS TO SCAN CODE



IBM keyboards come in a variety of sizes and shapes—here's how they work and how they differ from one another.

JEFF HOLTZMAN,

TECHNICAL EDITOR

IBM's *Technical Reference* manuals are notorious sources of both information and misinformation—or perhaps we should say non-information. Keyboard documentation is a perfect example. The "schematic diagram" (from the manual for the original PC) is little more than a block diagram, and is little help in understanding how the keyboard works. The circuit functions basically as discussed in our other article on keyboards this issue, except that the 8048 microprocessor performs the matrix scanning that the logic IC's do in the discrete-logic versions.

The most informative (and interesting) information about how the keyboard functions in the IBM PC is contained in the software listings in IBM's *Technical Reference* manuals. In this article we'll discuss how the software processes the raw key codes generated by the hardware, and we'll present a BASIC program that demonstrates graphically how your keystrokes are interpreted at various levels by the computer.

Hardware, BIOS, DOS

You can view the IBM PC from three different perspectives, as shown in Fig. 1. At the lowest level is the hardware: the microprocessor, RAM and ROM memory, the disk drives, the display adapter card, the monitor—and the keyboard. Controlling the hardware, of course, is software; and, in the IBM, there are two levels of control software.

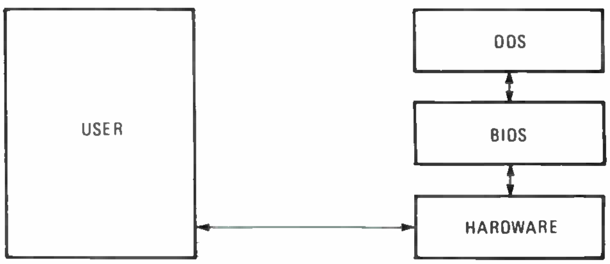


FIG. 1—HARDWARE AND TWO LEVELS OF SOFTWARE comprise the IBM PC. The user interacts with the hardware, which communicates with the BIOS. DOS provides a number of high-level functions for programmers to use in accomplishing a wide variety of tasks, including reading and writing disk drives, communications ports, and the keyboard.

The lower of those two levels is the BIOS (Basic Input/Output System); it is contained in a ROM (or in an EPROM on most clones). Code in the BIOS ROM is responsible for all of the low-level functions of the computer: displaying characters on the screen, sending them to the printer, transferring data to and from the disk drives, getting keystrokes from the keyboard, etc.

The upper software level is the DOS (Disk Operating System), which is contained in several files on disk. DOS is the level through which programmers are *supposed* to display data, manipulate disk files, and get keystrokes. However, to improve performance (or sometimes just by preference), many programmers go to the BIOS (or even to the hardware itself).

Interrupts

To understand how the hardware communicates with the software, you must understand the basics of interrupts. A device (the keyboard, for example) can interrupt the normal processing of the computer's 8088 microprocessor. When you press a key at the keyboard, it generates a signal that is sent to the computer; that signal says "Hey! Somebody pressed a key!"

The microprocessor then stops what it is doing and loads the address corresponding to the keyboard handler (interrupt 9) from a special location in memory. (Unless otherwise specified, all numbers in this article are in decimal notation). Processing continues at that address as the 8088 reads the keyboard port, converts the raw key code into something meaningful, and stores it for use by whatever program was running before the interrupt occurred. Last, the 8088 performs a special instruction (IRET, for Interrupt Return) that allows it to continue where it left off before the interrupt took place.

Devices other than the keyboard (the disk drives and the serial ports, for example) generate their own interrupts, which the 8088 processes in the same fashion. The difference is that each interrupt is directed to a different location in memory.

In addition to hardware interrupts, the 8088 also allows software interrupts for many commonly used functions. For example, when you press Shift-PrtSc, whatever is displayed on the screen is sent to the printer. That works as follows: First the two keypresses (Shift and PrtSc) generate their own interrupts. The computer processes those interrupts one at a time, and, when it realizes that a print-screen operation should be performed, it generates interrupt 5 (from within the interrupt-9 handler). Interrupt 5 does the screen-print and then returns to the interrupt-9 handler, which then returns to whatever program was in control when Shift-PrtSc was pressed.

Other software interrupts, at both BIOS and DOS levels, allow many operations, including displaying characters, getting user input from the keyboard, reading and writing disk drives, reading and writing communications ports, etc. As we saw, interrupts can interrupt each other (sometimes—but that's a story that we'll not get into here.) With the basics of interrupts in mind, now let's see how the keyboard-interrupt-processing software works.

Keyboard hardware, BIOS software

Keyboard processing on the IBM provides a good example of how the hardware meshes with the software. As we said, each keypress generates an interrupt 9. That interrupt is processed in the BIOS ROM and then passed on to DOS for further, more sophisticated handling.

There are 83 keys on the standard IBM keyboard; each has an associated eight-bit *scan code*. The keys and their scan codes are shown in our lead illustration and in Table 1. Each time you press a key (any key, including the ones you don't normally think of as generating a code—the Shift keys, Alt, Ctrl, etc.), the keyboard interrupts the microprocessor, sending it the scan code. Each time you release a key, the keyboard generates another interrupt, sending it the same scan code, but now with the high bit set (i. e., the scan code + 128).

The BIOS then translates the scan codes into ASCII and other codes, depending on the state of eight keys: Control, Alt, Delete, Insert, Left Shift, Right Shift, Num Lock, Caps Lock, and Scroll Lock. For example, the "A" key has a (hardware-level) scan code of 30. So when that key is pressed, the 8048 in the keyboard sends a 30 to the IBM BIOS through Interrupt 9. When the key is released, the keyboard sends a 158 (30 + 128) to the computer. If the "A" key is pressed continuously, the 8048 continuously sends 30's until the key is released, at which time a 158 is sent.

The BIOS would translate that 30 into a lowercase "a" (ASCII 97). But suppose that one of the shift keys were pressed simultaneously with the "A." In that case, the BIOS would translate that 30 into an uppercase "A" (ASCII 65). If the Control key were pressed, the hardware-level 30 would become a BIOS-level Cntl-A (ASCII 1). If Caps Lock were on and one of the shift keys were pressed, a lowercase "a" would be generated.

However, if the Alt key is pressed with the "A" key, something funny happens: The BIOS now generates two codes, the first of which is a zero, and the second of which is often (but not always) the scan code for that key. And the scan code, of course, bears no relation to standard ASCII codes. The Function keys, the arrow keys,

TABLE 1—IBM KEYBOARD CODES

Code	Label	Code	Label	Code	Label	Code	Label
1	Esc	22	U	43	\	64	F6
2	1	23	I	44	Z	65	F7
3	2	24	O	45	X	66	F8
4	3	25	P	46	C	67	F9
5	4	26	[	47	V	68	F10
6	5	27	]	48	B	69	NumLk
7	6	28	Retn	49	N	70	ScrLk
8	7	29	Ctrl	50	M	71	Home
9	8	30	A	51	,	72	UpArw
10	9	31	S	52	.	73	PgUp
11	0	32	D	53	/	74	—
12	—	33	F	54	RShft	75	LftAr
13	=	34	G	55	PrtSc	76	5
14	Bksp	35	H	56	Alt	77	RgtAr
15	Tab	36	J	57	Space	78	-
16	Q	37	K	58	CapLk	79	End
17	W	38	L	59	F1	80	DwnAr
18	E	39	;	60	F2	81	PgDn
19	R	40	/	61	F3	82	Ins
20	T	41	\	62	F4	83	Del
21	Y	42	LShft	63	F5		

LISTING 1

```
10 REM Computer Digest Keyboard Demo
20 REM Copyright        Jeff Holtzman           03-27-87
30 GOSUB 2000
100 REM main loop ----------------------------------------------
110 GOSUB 150                          : REM update shift key display
120 A$=INKEY$
130 IF A$<>"" THEN GOSUB 200          : REM update DOS display
140 GOTO 110
150 REM Update status key display ------------------------------
160 YBOX=21:XBOX=-7:FLAG1=PEEK(&H17)
170 FOR SK=1 TO 8
175     XBOX=XBOX+10
180     IF FLAG1 AND 2^(SK-1) THEN GOSUB 500 ELSE GOSUB 400
185 NEXT
190 RETURN
200 REM Display DOS keys ---------------------------------------
205 A=ASC(A$)
210 LOCATE 13,36:PRINT A;
220 IF A=0 THEN PRINT ASC(MID$(A$,2)); ELSE PRINT "    ";
230 LOCATE 5,22
235 IF INSTR(NOPRINT$,A$)=0 THEN PRINT A$; ELSE PRINT " ";
240 LOCATE 5,32:PRINT "                        ";
250 LOCATE 5,32
260 IF A > 127 THEN PRINT "Extended (8-bit) ASCII";:GOTO 300
270 IF A > 31 THEN PRINT "Regular (7-bit) ASCII";:GOTO 300
280 IF A > 0 THEN PRINT "Cntl-";CHR$(A OR &H40);:GOTO 300
290 PRINT DESC$(ASC(MID$(A$,2)));
300 RETURN
400 REM Clear box ----------------------------------------------
410 REM inputs: xbox,ybox
420 LOCATE YBOX,XBOX
430 PRINT "      ";
440 LOCATE YBOX+1,XBOX
450 PRINT "      ";
460 RETURN
500 REM Fill box -----------------------------------------------
510 REM inputs: xbox, ybox
520 LOCATE YBOX,XBOX
530 PRINT FILL$
540 LOCATE YBOX+1,XBOX
550 PRINT FILL$
560 RETURN
600 REM draw box -----------------------------------------------
610 REM inputs: xbox,ybox : start position
630 REM         xlen,ylen : length
640 REM first do corners
650 LOCATE YBOX,XBOX
660 PRINT CHR$(201);
670 LOCATE YBOX,XBOX+XLEN-1
680 PRINT CHR$(187);
690 LOCATE YBOX+YLEN-1,XBOX
700 PRINT CHR$(200);
710 LOCATE YBOX+YLEN-1,XBOX+XLEN-1
720 PRINT CHR$(188);
730 REM now do horiz lines
740 FOR BOX=1 TO XLEN-2
750    LOCATE YBOX,XBOX+BOX
760    PRINT CHR$(205);
770    LOCATE YBOX+YLEN-1,XBOX+BOX
780    PRINT CHR$(205);
790 NEXT BOX
800 REM now do vert lines
810 FOR BOX=1 TO YLEN-2
820     LOCATE YBOX+BOX,XBOX
830     PRINT CHR$(186);
840     LOCATE YBOX+BOX,XBOX+XLEN-1
850     PRINT CHR$(186);
860 NEXT BOX
870 RETURN
900 REM Draw shift keys ----------------------------------------
910 YBOX=20:XLEN=8:YLEN=4
930 FOR FKEY=2 TO 72 STEP 10
940    XBOX=FKEY
950    GOSUB 600
960 NEXT
970 RESTORE 1070
980 FOR FKEY=3 TO 73 STEP 10
990     LOCATE 18,FKEY
1000    READ A$
1010    PRINT A$
1020    LOCATE 19,FKEY
1030    READ A$
1040    PRINT A$
1050 NEXT
1060 RETURN
1070 DATA Right,Shift,Left,Shift,,Control,,Alt
1080 DATA Scroll,Lock,Num,Lock,Caps,Lock,,Insert
1100 REM Draw BIOS box ----------------------------------------
1110 LOCATE 11,30
1120 PRINT "BIOS-level scan code ";
1130 XBOX=35:YBOX=12:XLEN=10:YLEN=3
1140 GOSUB 600
1150 RETURN
1200 REM Draw DOS boxes ---------------------------------------
1210 XBOX=20:YBOX=4:XLEN=5:YLEN=3
1220 GOSUB 600
1230 LOCATE 7,20
1240 PRINT "ASCII";
1250 XBOX=30:YBOX=4:XLEN=26:YLEN=3
1260 GOSUB 600
1270 LOCATE 7,32
1280 PRINT "Description";
1290 LOCATE 3,31
1300 PRINT "The DOS Interpretation";
1310 RETURN
2000 REM Initialize -------------------------------------------
2010 KEY OFF:CLS:DEFINT A-Z:DEF SEG=&H40
2020 FOR I=1 TO 6:FILL$=FILL$+CHR$(219):NEXT
2030 FOR I=1 TO 10:KEY I,"":NEXT
2040 NOPRINT$=CHR$(7)+CHR$(9)+CHR$(10)+CHR$(12)+CHR$(13)
2050 LOCATE 1,19,0
2055 PRINT "Computer Digest Keyboard Demonstration";
2060 GOSUB 900  : REM draw shift keys
2070 GOSUB 1100 : REM draw BIOS box
2080 GOSUB 1200 : REM draw DOS box
2090 DIM DESC$(132)
2100 RESTORE 3010
2110 FOR I=1 TO 132:READ DESC$(I):NEXT
2120 RETURN
3000 REM Key label data ---------------------------------------
3010 DATA ,,Null,,,,,,,,,,,
3020 DATA Back-Tab
3030 DATA Alt-Q,Alt-W,Alt-E,Alt-R,Alt-T,Alt-Y,Alt-U,Alt-I,Alt-O,Alt-P
3040 DATA ,,,
3050 DATA Alt-A,Alt-S,Alt-D,Alt-F,Alt-G,Alt-H,Alt-J,Alt-K,Alt-L
3060 DATA ,,,,
3070 DATA Alt-Z,Alt-X,Alt-C,Alt-V,Alt-B,Alt-N,Alt-M
3080 DATA ,,,,,,,
3090 DATA F1,F2,F3,F4,F5,F6,F7,F8,F9,F10,,
3100 DATA Home,Up-arrow,PgUp,,Left-arrow,,Right-arrow,,End,Down-arrow
3110 DATA PgDn,Ins,Del
3120 DATA Shift-F1,Shift-F2,Shift-F3,Shift-F4,Shift-F5
3130 DATA Shift-F6,Shift-F7,Shift-F8,Shift-F9,Shift-F10
3140 DATA Cntl-F1,Cntl-F2,Cntl-F3,Cntl-F4,Cntl-F5
3150 DATA Cntl-F6,Cntl-F7,Cntl-F8,Cntl-F9,Cntl-F10
3160 DATA Alt-F1,Alt-F2,Alt-F3,Alt-F4,Alt-F5
3170 DATA Alt-F6,Alt-F7,Alt-F8,Alt-F9,Alt-F10
3180 DATA Cntl-PrtSc,Cntl-Left-arrow,Cntl-Right-arrow
3190 DATA Cntl-End,Cntl-PgDn,Cntl-Home
3200 DATA Alt-1,Alt-2,Alt-3,Alt-4,Alt-5
3210 DATA Alt-6,Alt-7,Alt-8,Alt-9,Alt-0
3220 DATA Alt-,Alt=,Cntl-PgUp
```

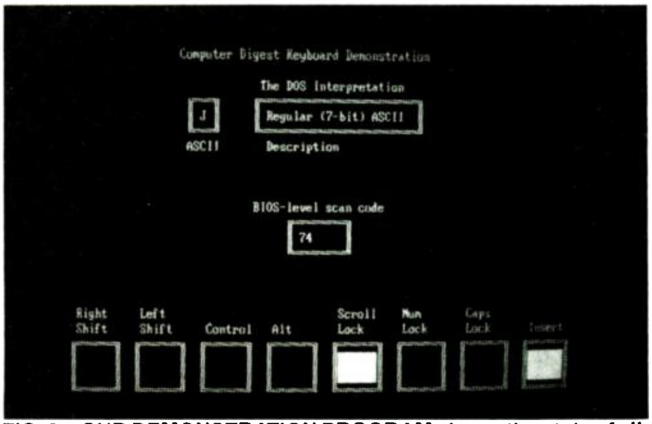


FIG. 2—OUR DEMONSTRATION PROGRAM shows the state of all shift keys, BIOS-level scan codes, and the high-level interpretation of those codes.

Home, etc., all generate the two-byte codes.

If you want to see which codes are generated by which keys (and combinations of keys), the program in Listing 1 provides a graphic representation of how those keys are interpreted. You can download the program (KEYMON.BAS) from our BBS (516-293-2283); if you type it in yourself, make sure you enter all the commas in the DATA statements.

For example, after pressing Scroll Lock, Insert, and the "J" key, the screen appears as shown in Fig. 2. You'll notice that the boxes corresponding to the Shift keys, Ctrl, and Alt light up as long as you press those keys and go dim when you release them. By contrast, Num Lock, Scroll Lock, Caps Lock, and Insert are toggles—each time you press one of those keys, an internal flag is alternately set and reset that indicates the given state (on or off).

You'll notice that some keys and key combinations produce no display. For example, the "5" key in the keypad produces no code when Num Lock is off. It's important to understand that every time you press *any* key the keyboard generates an interrupt (unless the keyboard buffer is full, at which point the keyboard will beep). If pressing a key produces no apparent result, that's because the BIOS has defined no code for that key (or combination).

Some programs make use of the "undefined" keys. For example, Cruise Control (reviewed in this month's Editor's Workbench), uses that "5" key (when Scroll Lock is off) as a special hotkey for controlling various functions. However, to get at those undefined keys, you have to write a complete Interrupt 9 handler—and that's no trivial pursuit.

Our demonstration program has several "bugs." Those bugs are due to differences between the ways that BASIC and DOS treat the keyboard. For example, if you print a CHR$(12) to the screen in BASIC, the screen will be cleared. In DOS, however, you'll see the "female" symbol (a circle over a cross). There are several such anomalies; tracking them down will teach you much about BASIC and DOS, as well as the keyboard.

ASCII, extended ASCII, and special codes

Basically, ASCII is a seven-bit code that provides a total of 128 (2^7) unique codes. However, personal-computer memory is organized in eight-bit (or 16-bit) chunks. So why didn't IBM encode all the special keys in the upper 128 ASCII codes? The reason is that IBM wanted to retain the upper codes for use by displayable characters. For example, most of the codes from 128 to 167 are foreign-language characters. Others include box-drawing characters, special math symbols, etc.

You know how to type in standard ASCII codes and the two-byte special codes—but how do you type in the extended ASCII codes? Some programs let you do so directly (for example, by associating special characters with the Function keys); the IBM BIOS lets you type in *any* ASCII code from 1 to 255 as follows. Press the Alt key, and hold it down. Now type the three-digit decimal code that corresponds to the desired character. Use only the keypad keys, not the number keys above the main keyboard. After you release the Alt key, the character will be displayed. That procedure works in BASIC, at the DOS command line, and in some (but not all) applications programs.

New keyboards

When IBM introducted the IBM PC AT in 1984, it introduced a new keyboard. The AT keyboard has a new layout (as shown in the review in Editor's Workbench this issue), and it works differently. The biggest hardware difference is that the keyboard now both transmits and receives data. You can force it to stop scanning temporarily, resume scanning, set the "Typematic" (repeat) rate, and turn the status-indicator LED's on and off.

In addition, the hardware-level scan codes have changed. The keys have different numbers, and there is one new key. However, those hardware differences are transparent at all levels above (and including) the BIOS. So our demonstration BASIC program works on the AT. But any program that works with the keyboard at the Interrupt 9 level must know whether it is running on an AT or a standard PC.

IBM still wasn't satisfied with the state of keyboard confusion, so, when the company introduced the XT 286 last fall, it introduced yet another keyboard. The new keyboard has 101 keys, even more commands issuable by the system, and three (!) software-selectable sets of scan codes. The first set is similar to the PC/XT set; the second set is similar to the AT set; and the third set is similar to the AT set, except that every key generates a unique code, regardless of the state of any of the shift keys (including Cntl, Alt, etc.) The last set should make it unnecessary for keyboard-enhancement programs to take over the keyboard-processing interrupts completely. However, such programs will still have to contend with the PC/XT and AT keyboards. Set 2 is the power-up default set.

To give you some idea of how the three sets of scan codes are related, consider this example. The enhanced keyboard has two Insert keys, one in the numeric pad (key 99), the other in the new cursor-control pad (key 75) located between the typewriter and the numeric-keypad sections. Table 2 shows the codes that are generated from each set when Insert is pressed and no shift keys are pressed.

TABLE 2—ENHANCED KEYBOARD INSERT CODES

Code	Key 75		Key 99	
Set	Make	Break	Make	Break
1	E0 52	E0 D2	52	D2
2	E0 70	E0 F0 70	70	F0 70
3	67	F0 67	70	F0 70

Programming and the special keys

In BASIC, you can use the normal INKEY$ function to get both standard and special keys. Normally INKEY$ collects single characters, but when a special key is pressed, INKEY$ returns two characters, the first of which is a CHR$(0). As at the BIOS level, that's a sign that another character is available. You can test for the existence of a special code by checking the length of the string that INKEY$ returns. Our demonstration program illustrates the procedure; see lines 100–220.

If you're interested in working with the keyboard in assembly language, you'll want to understand how BIOS interrupts 9 and 16, and DOS interrupt 33 (function calls less than 10) work. The best sources of information for BIOS listings and scan codes are IBM's *Technical Reference* manuals for the PC (or the XT), the AT, and the XT 286, as well as the DOS *Technical Reference* manual. Some of those manuals are hard to obtain (and expensive), so you may wish to consult Peter Norton's *Programmer's Guide To The IBM PC* and Ray Duncan's *Advanced MS DOS*. Both are published by Microsoft Press, and both are excellent sources of information on the BIOS, DOS and other subjects.

WORKING WITH SURPLUS KEYBOARDS

How they work, and how to use 'em.

Robert Grossblatt

Once upon a time, most of us had to throw switches and turn dials, but if you spent some extra bucks, you could talk to your equipment by pressing buttons. Things stayed like that until calculators showed up. When computers hit the market, keyboards became commonplace.

Adding a keyboard to your own circuit is easy. And with the parts market loaded with surplus keyboards, it's inexpensive. But using a keyboard successfully means understanding how it works, how it's driven, and what you need to get it working. Once we know the theory, we'll talk about how to use those surplus keyboards sold in the back of this magazine.

All keyboard circuits are made up of three parts—the switches themselves, decoding circuitry, and encoding circuitry. The keys are wired so that each one produces a unique code that can be passed on to the decoder, the circuit's main section. The encoder will take the keypress and translate it into whatever kind of information is needed by the equipment the keyboard is talking to. Let's discuss each circuit in turn.

Two methods

The two methods most frequently used to wire up switches are with a common leg and in a row-and-column matrix. In Figure 1 you can see that both arrangements will let each keypress generate a unique code. A common-leg set-up (Fig. 1-a) is much simpler to design but is only suited to applications where a few switches are needed. Since each switch you add means another lead coming from the keyboard, large numbers of switches become wiring nightmares. A matrix keyboard (Fig. 1-b) has fewer connections but it usually needs more support circuitry.

The break-even point for connections is eight switches. A common-leg keyboard that size will need nine leads, and a matrix keyboard will need eight. Since there are advantages and disadvantages to both, which is best depends on what you're doing.

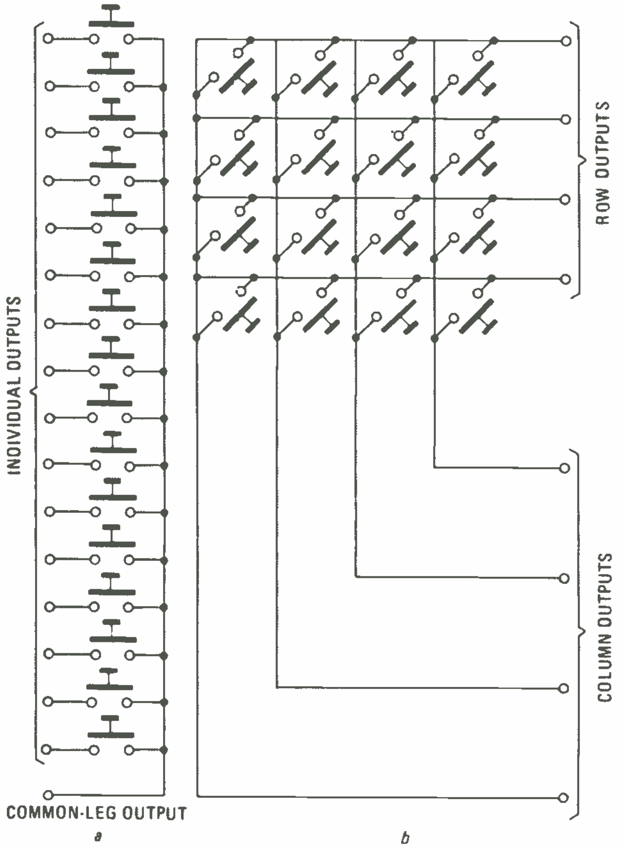


FIG. 1—A KEYBOARD can be wired from a linear array of switches (*a*) or in an X-Y matrix (*b*).

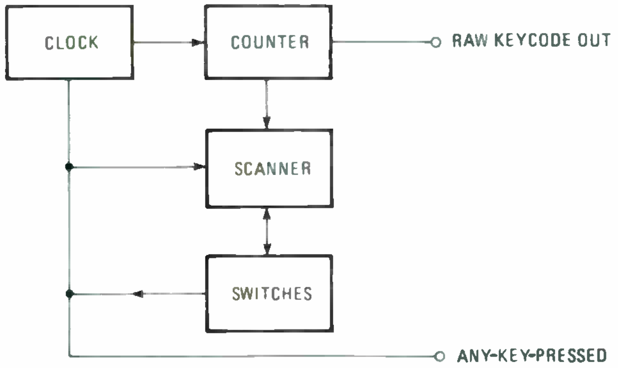


FIG. 2—THE TYPICAL KEYBOARD ENCODER uses a clock to increment a counter that controls matrix scanning.

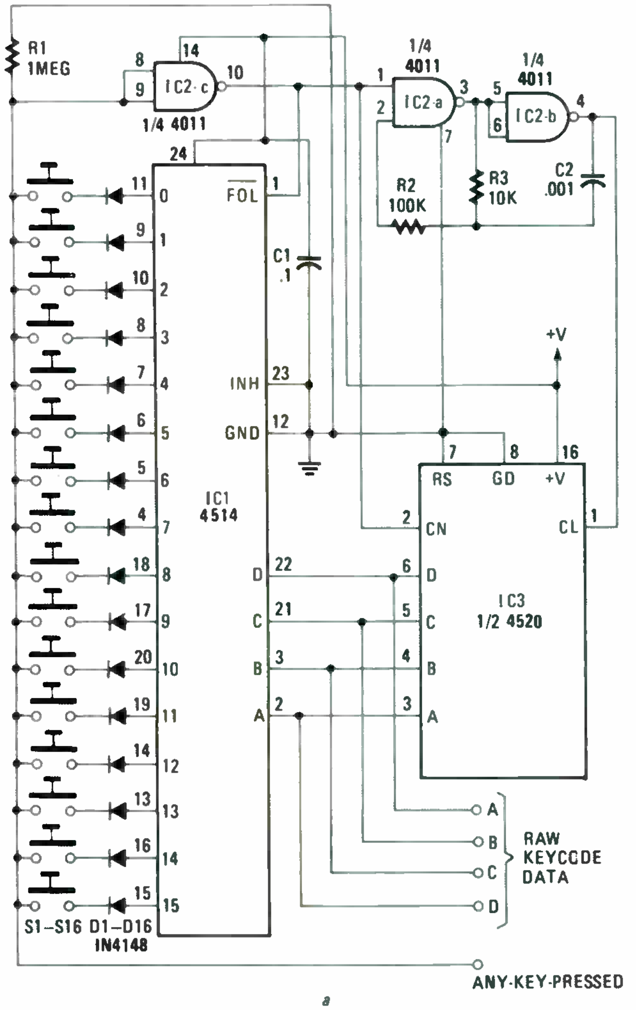


FIG.3—A KEYBOARD ENCODER. The scanning circuitry for a common-leg keyboard is shown here.

However you wire your switches, the signals they generate must be decoded. The circuit must recognize that a key is being pressed, figure out which one it is, and then put the appropriate code elsewhere. Decoders can be put together with anything from a handful of resistors and diodes to a microprocessor and a little bit of digital glue.

In all but the simplest keyboards, the decoder uses some sort of clock to scan the switches looking for a keypress. Figure 2 is a block diagram of this kind of circuit. The output of the counter makes the scanner sample each switch on the keyboard. When a key is pressed, the clock is stopped, the count is frozen, and the Any-Key-Pressed line becomes active. That signal tells some other circuitry down the line that the keyboard is putting out data.

That circuit could be used for both matrix and common-leg keyboards. The difference between the two would be in how the keyboard was scanned. Figure 3 shows the scanning circuitry for a common-leg keyboard, and Fig. 4 shows a similar setup using a matrix keyboard. The clock and counting circuitry is the same.

In Fig. 3, the values of R2, R3, and C2 give the clock composed of IC2-b and IC2-c an output frequency of about 100 kHz. That signal drives both IC3, half a 4520 binary counter, and IC1, a 4514 1-of-16 line decoder. As the count cycles from 0 (0000) to F (1111), each of IC1's outputs goes high in turn. R1 serves two purposes—it holds the common leg of the switches low, and, with C1, helps to debounce the switches.

When a key is pressed, nothing happens until that output of the 4514 is selected by the count of the 4520. When the output does go high, the Any-Key-Pressed line goes high, IC2-a inverts the signal and disables the clock and the counter, and puts a low on pin 1 of the 4514 to disable it also. The result of this is that a keypress freezes the output data lines at the selected number and generates a signal to indicate that valid data is on the bus.

There are two features of the circuit that should be noticed. First, although the switches are debounced, the design of the keyboard eliminates switch bounce. If you used noisy switches, the worst that would happen is that the switch would be in an open con-

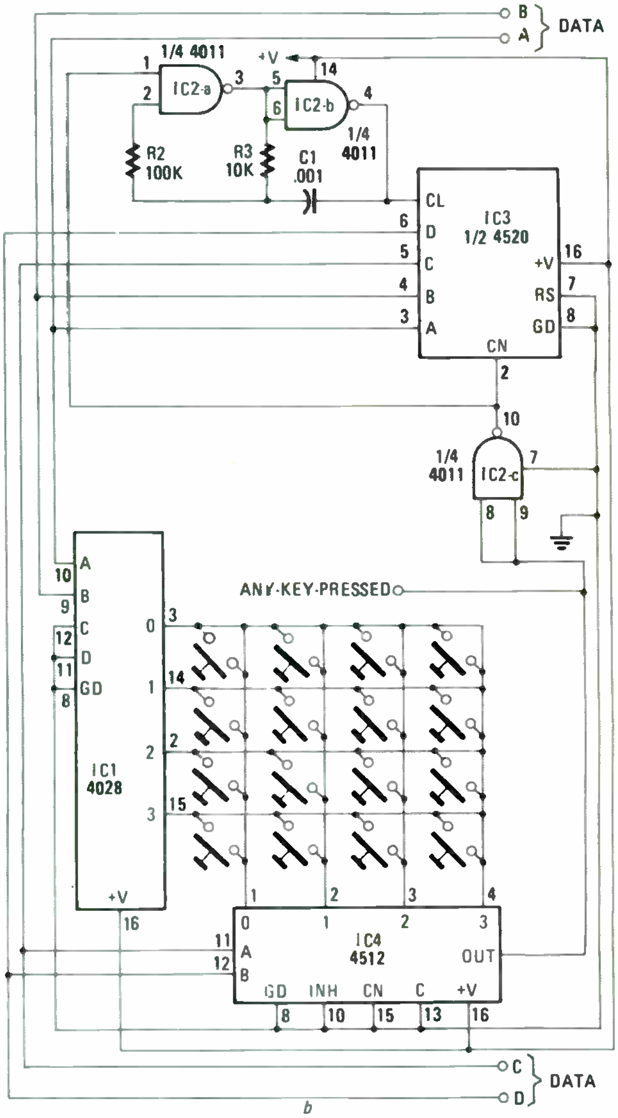


FIG. 4—SCANNING CIRCUIT for a matrix keyboard.

dition when its output was selected. In that case, the circuit would cycle through another count as the clock kept running. Only a valid keypress would produce valid data.

Two-key rollover

That circuit has two-key rollover. D1 to D16 isolate each of the 4514's output lines, so, if two keys are closed at the same time, the circuit will output the second bit of data as soon as the first key is released.

Figure 4 shows a circuit for a matrix keyboard. Though we're encoding the same number of switches as we did in the common leg arrangement, we only need nine leads from the keyboard instead of seventeen. The setup is different too. The basic idea behind using a matrix keyboard is to have the control signal come in on one side of the matrix and leave on the other. In Fig. 4, IC4 is a 4028 BCD-to-decimal converter. A binary address on the inputs causes the selected output to go high while all the rest remain low. As we're only handling a four-by-four switch matrix, we only need two of the inputs.

The two low-order bits from the 4520 are routed to the 4028, and the two high-order bits are routed to the 4512, an eight-channel data selector. When one of its inputs is selected, the signal at the input appears at the output. If a key is pressed, the high signal at the output of the 4028 is channeled through the 4512 and serves the same function as the common switch leg did in Fig. 3. It disables both the clock and the counter and also becomes our Any-Key-Pressed line to let other circuitry know that there's valid data on the bus. The circuit also has two-key rollover.

Look at Fig. 4—what about all those unused inputs and outputs on the 4028 and 4512? And what about the other half of the 4520? Even though we're only using a four-by-four keyboard, this same circuit can be set to handle a ten-by-eight keyboard! We'd cascade

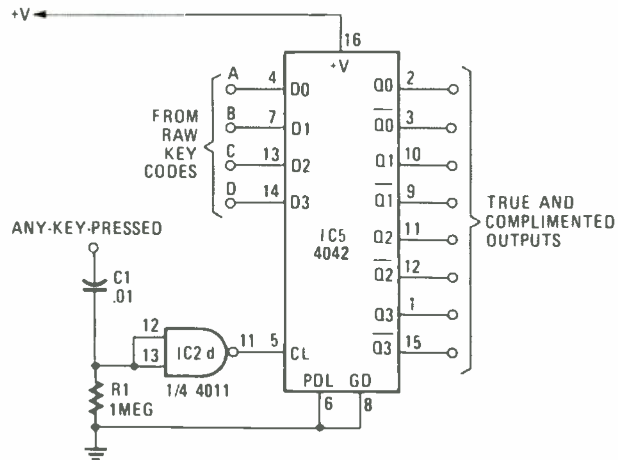


FIG. 5—YOU CAN LATCH THE OUTPUTS of the previous keyboard encoders with the circuit shown here.

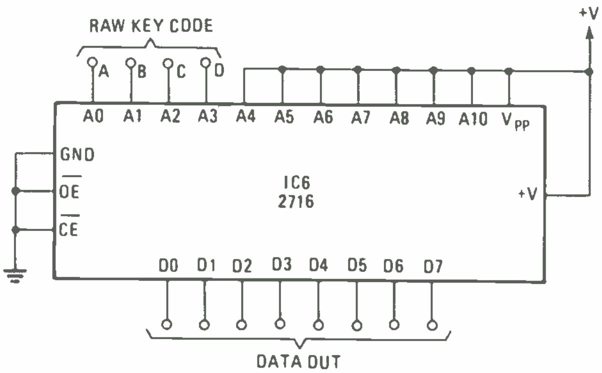


FIG. 6—A 2716 EPROM makes an inexpensive yet highly flexible keyboard decoder. It can be re-programmed an essentially unlimited number of times.

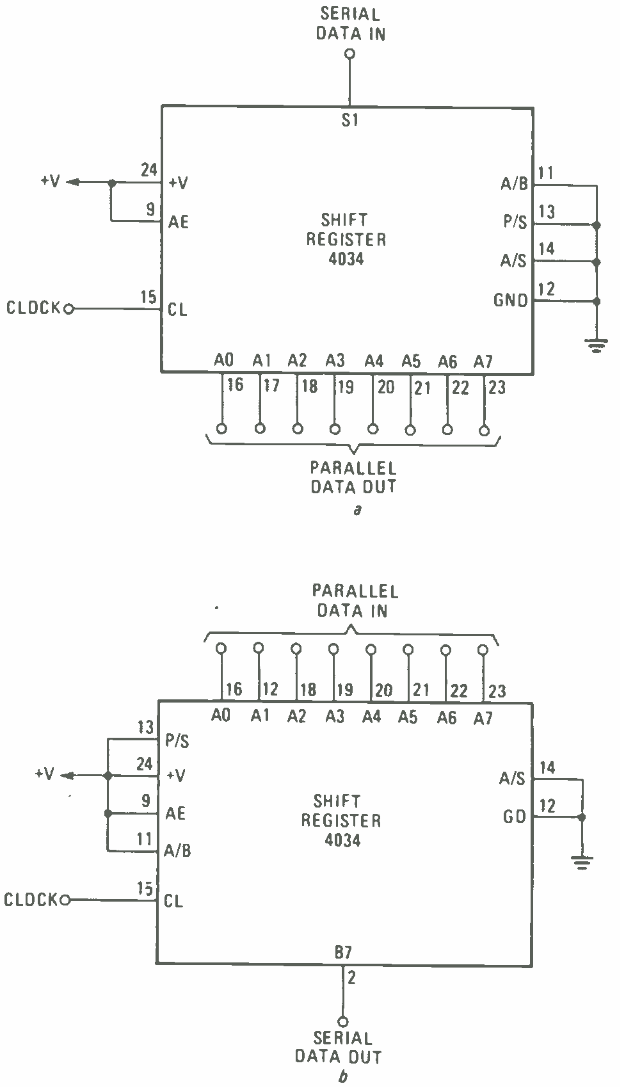


FIG. 7—A SHIFT REGISTER can be used to convert the output of a serial keyboard to parallel form (*a*), or the output of a parallel keyboard to serial form (*b*).

the two halves of the 4520 to get the seven-bit word length we need and use the last bit to reset the counter.

Now that we've looked at these two basic approaches to keyboard design, it's plain to see why large keyboards use matrix switches instead of common-leg arrangements. But all we have is a keyboard that puts out raw code, and not elegantly. To remedy the situation, the first thing is to hang a latch on the bus. Which latch you use depends on what you want to do with the keyboard. As we're dealing with a four-bit word length, the 4042 seems a good choice, but we have to do something to control how data is clocked into the latch.

If we use the Any-Key-Pressed line to directly control storing data in the latch, there's a chance we're going to get flaky behavior because of timing problems. Things have to happen in sequence. First valid data has to be on the bus, then it has to be clocked into the latch. The Any-Key-Pressed line has to signal something else that waits a while and then opens the latch for storage.

Since we have a NAND gate left over, we'll use it to build an edge detector and control the latch as shown in Fig. 5. Since the latch's polarity control, pin 6, is tied low, the latch will ignore its inputs as long as the store control, pin 5, stays high. Bringing the store input low will write data into the latch. The edge detector made from IC2-d will generate a negative-going pulse when it sees a positive pulse at its input. With the values given for C3 and R4, the pulse will be about 10 milliseconds wide.

So there they are, two complete keyboard circuits that will latch unique keycodes from matrix and common-leg keyboards. While you could use the circuits as they are, the data they generate is raw... We still need the third basic part of any keyboard—an encoder.

The encoder

The encoder takes raw data from the keyboard and translates it into something useful—ASCII, custom data, control signals, etc. And there are lots of ways to build one. You can do it with gates, but that buys you a lot of complexity at the cost of flexibility. ROM is a much better way to go. It only takes one chip and the whole configuration of the keyboard can be changed by switching memory. Unless you've got a lot of money, the best memories to use are EPROM's. They're cheap, easy to program, and erasable.

In Fig. 6 you can see how an EPROM would be connected to the circuits we've put together. Since Chip Enable (pin 18), and Output Enable (pin 20), are both held low, a unique address on the address lines (the inputs), will result in programmed data at the outputs. And the data you put in the EPROM is whatever you want for your particular application. It can be discrete code, or, if you add a bit of clocking, whole strings of data.

Now that we know how keyboards work, what about those keyboards that are available on the surplus market? There are different types—some are ASCII encoded, some are oddball encoded, and some are not encoded at all. The data can come out of the keyboard in either parallel or serial form. You can convert between parallel and serial with only a shift register and a clock. The circuit of Fig. 7-a will convert from serial to parallel, and the circuit of Fig. 7-b will go the other way. You can build a small clock circuit or steal some pulses from the keyboard you're converting.

One last point: Although we've built our keyboards with discrete IC's, there are lots of IC's around that do all the work for you. All you do is connect the switches and add a handful of parts. Most commercial keyboards will use either this approach or do the whole job with something like an 8048 and some software. A gates-only design is a good compromise between cost and complexity. The important point is that no matter how the keyboard works, it has to have the three basic parts we covered. R-E

R-E ROBOT

continued from page 46

The byte-wide input and output ports can also be tested. The following word tests the output latch.

: TEST2 BEGIN 0 150 PC! FF 150 PC!
?TERMINAL UNTIL ;

The parallel input port can be tested with the following test word. Four lines are available to you at PL1:

: TEST3 BEGIN 120 PC@ 10 / . CR
?TERMINAL UNTIL ;

Execute TEST3 and then short some of the inputs to ground. As you short each input, you should see the display on the screen change.

Expansion

The robot can be expanded in various ways. If your expansion project requires full use of the RPC, simply couple your circuits to the RPC bus. To interface the circuitry, you need only duplicate the wait-state generator and the bus-buffer interface described in Part 6 (May, 1987). Select a block of I/O space between 0100H and E000H and start designing.

If your circuit is simple and needs only one or two I/O locations connect it directly to the RERBUS, PL3. Address decoding is accomplished with a single integrated circuit and no bus drivers are needed. For simple digital inputs, digital outputs, and analog inputs, connect the circuit directly to the user connector, PL1.

Operation

Now that we have our electronics in place, it is time to consider the software required to make it all work.

The software commands to be sent to the motor control circuits should follow this sequence:

- Set up timer 0 of each 8253 (left and right wheel control) for mode 3 operation. We write control word 36H to register 3.
- Write a frequency representing a slow speed into timer 0. We write 0200H to register 0.
- Close the forward or reverse relay. Write 1 to location 0120H.
- Now enable the PLL. Write 1 to location 0124H.

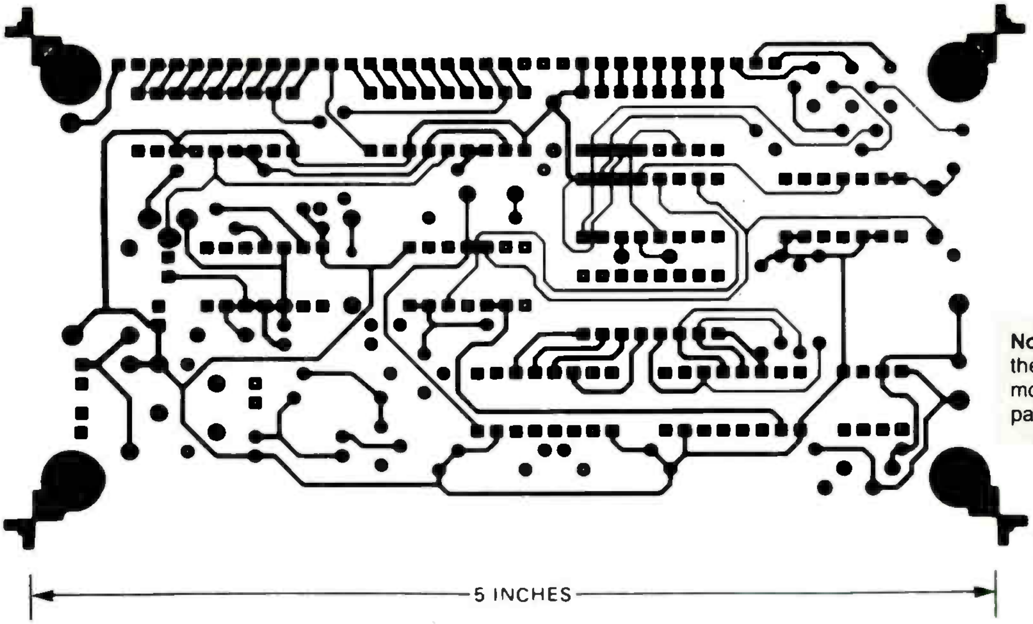
Notice that the relays are closed before the circuit is enabled. That prevents arcing when the contacts close or open.

All those functions are programmed using RCL (*R*obotic *C*ontrol *L*anguage), a sophisticated language that is implemented in Forth. The RCL lets us control the robot's motions and functions using simple commands. Further, because Forth is extensible, RCL is extensible. That means that any code we write becomes part of the language.

That last feature is especially valuable. For instance, to control circuits connected to the RERBUS we have to change the way in which the byte store and byte fetch words operate—it's like writing new PEEK and POKE words in BASIC.

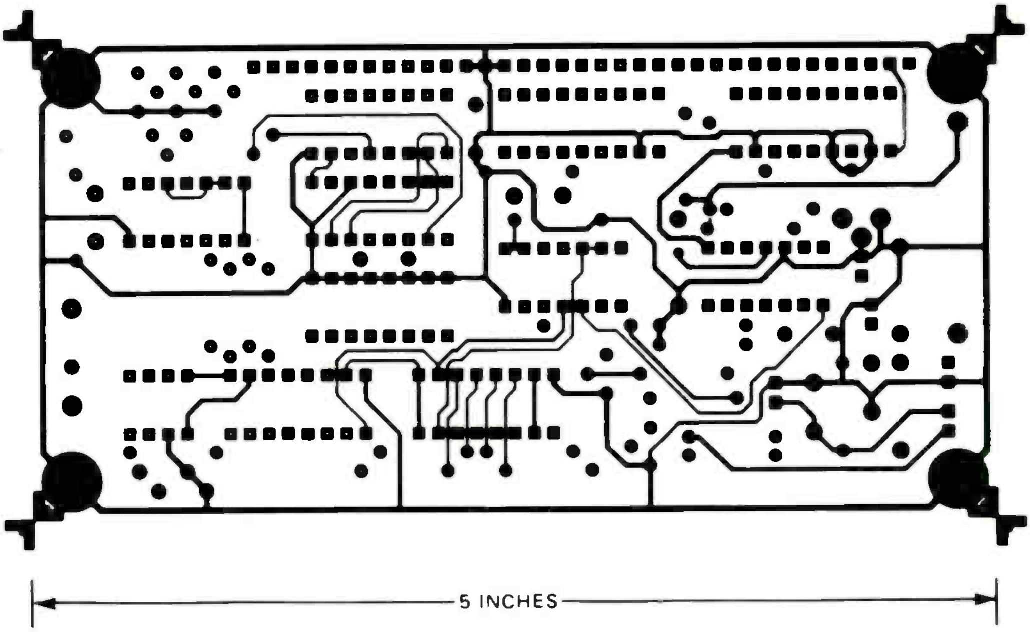
Forth's extensibility allows us to create two new words, PCX! and PCX@, that we can use to access the RERBUS. Those words will operate just like PC! and PC@ but they'll do all of the data manipulation required by the RERBUS. The computer code used to create those words is shown in Table 2.

Notice that we have documented our code with comments to allow you to determine how it operates in case something goes wrong or you want to change it. The comment immediately after the word being defined is a standard Forth-notation comment showing the effect of the word on the stack. For example, PC@ pops one argument off the stack (the address) and pushes one argument on the stack (the data). Next time, we will examine the RCL in greater depth. **R-E**

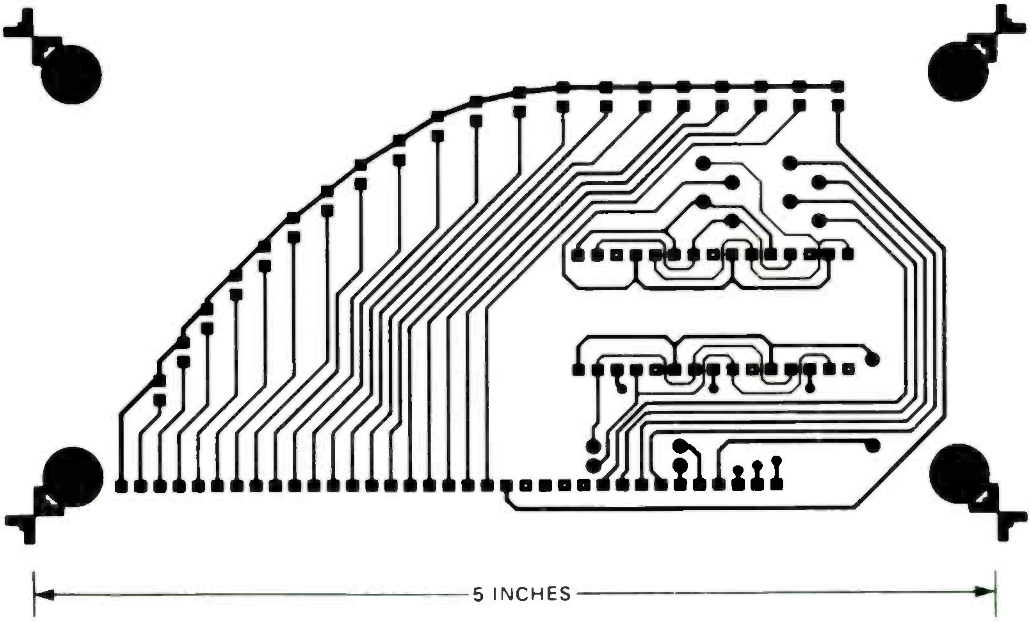


Note: The pattern for the display board of the tachometer will be presented next month along with the robot control board patterns.

THE SOLDER SIDE of the speedometer's main board is shown here.



THE COMPONENT SIDE of the speedometer's main board. When mounting components, be sure to solder all leads completely.



THE SPEEDOMETER'S DISPLAY BOARD. It is connected to the main board using 35 jumper wires.

DRAWING BOARD

continued from page 29

Timing is important

As you can see, the sequence and timing of those steps have to be done properly if you want the system to work. And all that we've been talking about so far is the refresh operation. Somewhere in there we have to allow for the time needed for data to be stored to, or read from, the memory. After all, that's the whole reason for building the system in the first place.

The interaction between all the components of a dynamic memory system has to be carefully controlled in order for the circuit to work properly. Refresh has to be constant, and memory access has to be kept to a short operation that won't interfere with maintaining the data. Since a gates-only solution to the problem is so complex as to be impractical, it's obvious we have to look elsewhere for a way to handle all the problems.

Although we can use LSI controllers, they are expensive and hard to locate. The route we're going to follow should already have crossed your mind. Since we're putting together a complex system in which timing and access are the major problems, we can use a microprocessor to handle the job.

Microprocessor control

The Z-80 is the perfect CPU for the job. It has many memory-control signals as well as built-in circuitry especially designed for controlling dynamic RAM. An internal refresh counter will automatically provide the sequential addressing we need to take care of refresh, and the address is put on the bottom of the address bus during the tail end of each op code fetch.

The beauty of that scheme is that the Z-80 doesn't have any need for the address bus once it's loaded the op code. During portions of the instruction cycle the memory is idle. That gives us the time we need to use the address to refresh the RAM. Since the Z-80 is busy elsewhere during that time, it doesn't have to slow down or wait for the refresh operation to be carried out.

When we pick this up again next time, we'll start designing the circuitry that is needed to handle the system shown in Fig. 1, and we'll show how to calculate the system speed, timing parameters, and so on. So pull out your Z-80 data books; you'll be needing them because we'll be poking around the Z-80 anatomy.

Finally, next time I'll be announcing the free-subscription winners of the DTMF remote control system contest. R-E

NEW PRODUCTS

continued from page 25

OPTICAL FIBER TOOL SET, model *06808*, is designed for preparing single-mode and multimode optical fibers and cables.

CIRCLE 37 ON FREE INFORMATION CARD

The tool set consists of *Kevlar-Strip* tool—a hand tool designed to remove any length of Kevlar-reinforced protective sleeving between 2.5mm and 6.5mm diameter; sleeve guides to ensure correct positioning of the sheath (the guides are selected according to the sheath diameter); *Opti-Strip* tool—designed to remove secondary coatings from optical fibers and small cables less than 2.5mm in diameter; guide bushings; *Silicon-Strip tool*—used for fast removal of silicone coatings; cutters, and screwdrivers.

The model *06808* costs $157.25. —**Davle Tech, Inc.**, 2-05 Banta Place, Fair Lawn, NJ 07410. R-E

SCRAMBLING

continued from page 61

ventional TV receiver, it is, for all intents and purposes, scrambled. To actually scramble the signal we must rearrange the bits and bytes that represent the audio. For example, we could scramble the audio by encoding the data bits themselves—the 16 audio bits in each horizontal blanking interval. That could be done by adding a random set of digital numbers to the binary numbers that represent the audio signal. Or, we could use matrix encoding to generate a non-related encoding of each binary number. For example, binary 63 might be transformed to binary 35, while binary 94 is transformed to binary 181, etc. For 256 words (a 16-bit system) there are 256! possible combinations. (256! represents 256 *factorial*, which means: 256! = [256 × 255 × 254...× 2 × 1].

The algorithm used in *Videocipher II* is the NBS Data Encryption Standard. In that method, the data is encoded using a 64-bit algorithm (eight of which are used for parity checking), leaving 2^{56} possible combinations for a de-encryption key. 2^{56} is a rather large number—about 72 thousand million million (72 quadrillion). Unless the correct key is known, it is therefore essentially impossible to decode the audio.

In review

Over the last year or so, we've highlighted a number of scrambling and descrambling topics. For those newcomers who have picked up the series in midstream, here's a review of those topics, and when they appeared:

In the June, 1987 issue we looked at the basic structure of a video signal and some of the simpler scrambling techniques, such as inverting the video and suppressing the sync. Also discussed were the ways in which audio signals are hidden.

In July we discussed a hypothetical digital video-scrambling system.

In the August issue we showed some of the basic circuitry used in POPULAR scrambling systems such as in-band gated sync and SSAVI. Those circuits included several different variable-attenuators and variable-gain amps. We also showed some rudimentary but workable descramblers including one built around a *Phase Locked Loop* (PLL) that was used to recover a suppressed sync pulse.

In September we looked at PLL's in greater depth, and briefly discussed sinewave, SSAVI, and outband decoding. The SSAVI system was discussed in greater depth in November.

In December we moved from the theoretical to the practical by presenting a functional sinewave descrambler for experimenters. In January and March, 1987 we did the same for those interested in the in-band gated sync and the outband scrambling systems.

To make getting the parts easier, North Country Radio (P.O. Box 53, Wykagyl Station, New Rochelle, NY 10804) provided kits of parts, including PC boards. The following are still available.

- Pulse Decoder: Item PD–1: PC board plus all components on the PC board. $54.95 + $2.50 shipping and handling.
- Outband Decoder: Item OB–1: PC board plus all components on the PC board. $34.95 + $2.50 to cover shipping and handling.
- Sinewave Decoder: Item SW–1: PC board plus all components on the PC board including C13, C14, C15, CR1, and R17 necessary for the interface box. $52.95 + $2.50 postage and handling.
- All three items, PD–1, OB–1, and SW–1, $129.95 + $3.50 shipping and handling.

New York State residents please add the appropriate sales tax.

Finally, the authors of this series have written a book on the topic entitled *Video Scrambling and Descrambling for Satellite and Cable TV*. It is published by Howard W. Sams and can be purchased at most local bookstores and electronics distributors. It can also be purchased direct from the publisher (ask for book number 22499). It retails for $19.95. **R-E**

DIGITAL SPEEDOMETER

continued from page 51

voltage at the appropriate pins of each IC. After debugging any problems, apply a test signal to the speedometer. Connect a sinewave generator to P1 and apply a one-volt peak-to-peak signal. For test purposes, set S1 so that the first three switches are off, the next three are on, and the last two are off (00011100). Also, set the generator's frequency to 138 Hz. If everything is working correctly, the seven-segment LED's should display a value of 60, and at least some of the discrete LED's should be lit.

Installation

The most difficult part of construction is installing the speedometer in an automobile. The two main tasks are installing the PC-board assembly and installing the magnetic sensor and magnets.

To install the boards, first choose a suitable mounting location for the unit, one that provides a good view of the device, but does not obstruct the driver's field of vision. After choosing your mounting location, prepare it to receive the speedometer. Whether you are building a custom enclosure or planning to install the assembly in the dash, use a front panel that will both protect the display and make it readable in bright sunlight.

Smoked Plexiglass makes an excellent front panel, especially if it is lettered and masked. Masking is accomplished by painting the area not occupied by displays or LED's. The easiest method is to mask all areas that are occupied by displays and LED's on the *back* side of the front panel and then paint the back side of the panel with black spray paint. Apply several coats to ensure a uniform covering. After the paint dries, peel off the masking tape and install the front panel.

The next step is to secure the magnets to the driveshaft (or output shaft) and mount the pick-up coil to the body or chassis of the automobile. To do that, you'll probably have to drive your car up on ramps. If you do not have a set of ramps, borrow or buy a set. Never get under a car that is supported only by jacks. It's also a good idea not to work under a car alone.

After raising the car, find a suitable location for mounting the magnets. On rear-wheel-drive vehicles, the best location is at the front of the driveshaft, near the transmission. At that place the driveshaft has the least vertical movement, so the magnets will maintain a constant distance from the pick-up coil. To mount the magnets, locate them around the driveshaft at 90° intervals and secure them in some way. The magnets we used in our prototype come with a strap that simplifies installation; you can purchase the set at a local auto-parts store or from the source mentioned in the Parts List.

On a front-wheel-drive vehicle, the magnets can be mounted reliably to the outer ring of the constant-velocity joint's dust boot near the transaxle. In that type of installation, there should be a metal strap on each side of the dust boot. Mount the magnets to the strap that is located nearest the transaxle, and secure the pick-up coil and its metal strip. If the boot is not easily accessible, the magnets may be mounted directly to the output shaft or one of the drive shafts, but be sure to place them where the least amount of vertical movement takes place.

Next mount the pick-up coil to the underside of the automobile using a strip of inch-wide metal. Of course, the length of the strip and the locations of the mounting holes will depend on your installation. But you'll probably want to bend the strip so that the front of the mounting coil and its bolt are about ½ inch from the magnets. Figures 7-*a*–7-*d* indicate several mounting schemes for driveshaft and transaxle installations.

After the magnets and pick-up coil are installed, run the signal wires from the pick-up coil through the fire wall to where the PC boards are located. Use plenty of wire ties or plastic tape. If you purchase the pick-up coil mentioned in the Parts List, you must replace its connector with a Molex-style connector.

Run a power wire from the mounting location to the fuse box and connect it to a circuit that is active only when the ignition key is in the *on* position. Remember to hook the ground wire to the chassis ground of the automobile.

Calibration

To calibrate the speedometer, first decide whether you want the readout to be in miles or kilometers per hour. The next step can be accomplished in several ways. You can either calculate the speed of your driveshaft as discussed in the text box, or you can use the trial-and-error method.

To use the trial and error method, have a friend drive on an open stretch of highway, and, while watching your old speedometer, try setting S1 in different positions until the speedometer displays the correct value. Make sure your friend watches the road and his speed while you calibrate the speedometer! Next, have your friend drive at the "red line" speed, and set R34 so the first red LED lights up.

If the digital speedometer reads erratically while the vehicle is standing still, reduce the value of R6 from 470 ohms to 330 ohms or less. That reduces input sensitivity and prevents the unit from picking up electrical noise.

After calibration is complete, it's time for final installation. Mount the unit in its permanent housing, then secure and conceal all cables. R-E

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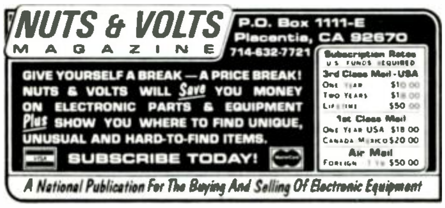

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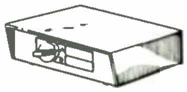

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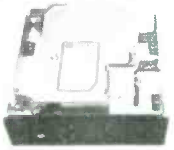

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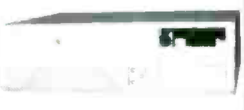

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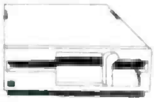

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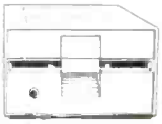

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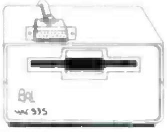
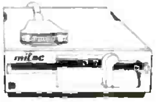


MAC535
$249.95
- 3.5" ADD-ON DISK DRIVE
- 100% MACINTOSH COMPATABLE
- DOUBLE SIDED 800K BYTE STORAGE
- HIGH RELIABILITY DRIVE HAS AUTO-EJECT MECHANISM
- FULL ONE YEAR WARRANTY



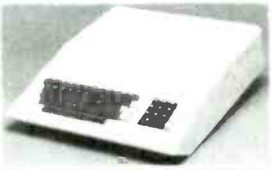
AD-3C
$139.95
- 100% APPLE IIc COMPATIBLE, READY TO PLUG IN, W/ SHIELDED CABLE & MOLDED 19 PIN CONNECTOR
- FAST, RELIABLE SLIMLINE DIRECT DRIVE
- SIX MONTH WARRANTY

DISK DRIVE ACCESSORIES

FDD CONTROLLER CARD	$49.95
IIc ADAPTOR CABLE	$19.95

ADAPTS STANDARD APPLE DRIVES FOR USE WITH APPLE IIc

KB-1000 $79.95
CASE WITH KEYBOARD FOR APPLE TYPE MOTHERBOARD
- USER DEFINED FUNCTION KEYS
- NUMERIC KEYPAD W/ CURSOR CONTROL
- CAPS LOCK
- AUTO-REPEAT

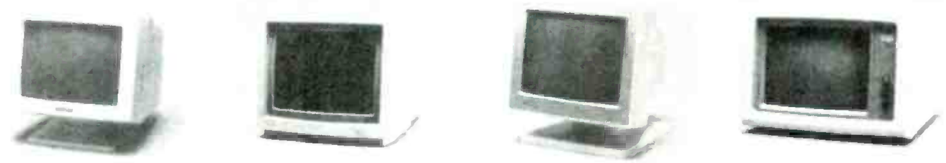


KEYBOARD-AP $49.95
- REPLACEMENT FOR APPLE II KEYBOARD
- CAPS LOCK KEY, AUTO-REPEAT
- ONE KEY ENTRY OF BASIC OR CP/M COMMANDS

JOYSTICK CB-10 $19.95
- SET X-Y AXIS FOR AUTO CENTER OR FREE MOVEMENT
- FIRE BUTTON FOR USE WITH GAME SOFTWARE
- ATTRACTIVE, SOLID, PLASTIC CASE
- INCLUDES ADAPTOR CABLE FOR IBM, APPLE II, IIe, II c, ATARI & VIC 20/64

POWER STRIP $12.95
- UL APPROVED
- 15A CIRCUIT BREAKER

CRT MONITORS FOR ALL APPLICATIONS



CASPER EGA MONITOR
- EGA & CGA COMPATIBLE
- SCANNING FREQUENCIES 15.75 - 21.85 KHz
- RES 640 x 200 - 350
- .31mm DOT PITCH, 25 MHz
- 16 COLORS OUT OF 64
- 14" BLACK MATRIX SCREEN

$399.95

CASPER RGB MONITOR
- COLOR/GREEN/AMBER SWITCH ON REAR
- DIGITAL RGB IBM COMPATIBLE
- 14" NON-GLARE SCREEN
- RESOLUTION: 640H x 240V
- .39mm DOT PITCH
- CABLE FOR IBM PC INCLUDED

$299.95

SAMSUNG MONOCHROME
- IBM COMPATIBLE TTL INPUT
- 12" NON-GLARE AMBER, LOW DISTORTION SCREEN
- RESOLUTION: 720H x 350V
- ATTRACTIVE CASE WITH SWIVEL BASE
- ONE YEAR WARRANTY

$119.95

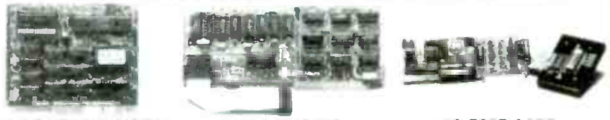
FORTRONICS MONOCHROME
- IBM COMPATIBLE TTL INPUT
- 12" NON-GLARE SCREEN
- VERY HIGH RESOLUTION: 1100 LINES (CENTER)
- 25 MHz BANDWIDTH
- CABLE FOR IBM PC INCLUDED

AMBER OR GREEN AVAILABLE

$99.95

TILT & SWIVEL MONITOR STAND $12.95 WITH POWER CENTER $39.95

APPLE COMPATIBLE INTERFACE CARDS



EPROM PROGRAMMER
- DUPLICATE OR BURN ANY 27xx SERIES EPROM (2716 TO 27128)
- MENU DRIVEN SOFTWARE
- HIGH SPEED WRITE ALGORITHM

RP-525 $59.95

16K RAMCARD
- FULL 2 YEAR WARRANTY
- EXPAND YOUR 48K MACHINE TO A FULL 64K OF MEMORY
- CAN BE USED IN PLACE OF THE APPLE LANGUAGE CARD

RAM-CARD $39.95

IC TEST CARD
- QUICKLY TESTS MANY COMMON ICs
- DISPLAYS PASS OR FAIL
- TEST 4000 & 74HC SERIES CMOS, 7400, 74LS, 74L, 74H & 74S

IC-TESTER $129.95

Seagate
5¼" HARD DISK DRIVES

ST-225	HALF HT 20MB 65ms	$275
ST-238	HALF HT 30MB 65ms (RLL)	$299
ST-251	HALF HT 40MB 40ms	$599
ST-277	HALF HT 60MB 40ms (RLL)	CALL
ST-4038	FULL HT 30MB 40ms	$559
ST-4096	FULL HT 80MB 28ms	$1195

½ HEIGHT FLOPPY DISK DRIVES

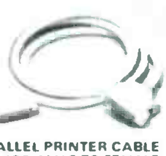
5¼" TEAC FD-55B DS/DD	$109.95
5¼" TEAC FD-55F DS/QUAD	$124.95
5¼" TEAC FD-55GFV DS/HD	$154.95
5¼" MITSUBISHI DS/HD	$129.95
3½" TOSHIBA KIT DS/DD	$149.95

KIT INCLUDES MOUNTING HARDWARE TO FIT 5¼" & FACEPLATES FOR AT & XT

DISK DRIVE ACCESSORIES

TEAC SPECIFICATION MANUAL	$5.00
TEAC MAINTENANCE MANUAL	$25.00
½ HT MNTG HARDWARE FOR IBM	$2.95
MOUNTING RAILS FOR IBM AT	$4.95
"Y" POWER CABLE FOR 5¼" FDDs	$2.95
5¼" FDD POWER CONNECTORS	$1.19

MOLDED INTERFACE CABLES
6 FOOT, 100% SHIELDED, MEETS FCC



IBM PARALLEL PRINTER CABLE	9.95
CENTRONICS (MALE TO FEMALE)	15.95
CENTRONICS (MALE TO MALE)	14.95
MODEM CABLE (FOR IBM)	7.95
RS232 SERIAL (MALE TO FEMALE)	9.95
RS232 SERIAL (MALE TO MALE)	9.95
KEYBOARD EXTENDER (COILED)	7.95
APPLE II JOYSTICK EXTENDER	4.95

C. ITOH RITEMAN II PRINTER

- 160 CPS DRAFT, 32 CPS NLQ
- 9 x 9 DOT MATRIX
- SUPPORTS EPSON/IBM GRAPHICS
- FRICTION AND PIN FEEDS
- VARIABLE LINE SPACING AND PITCH

$219.95

IBM PRINTER CABLE	$9.95
REPLACEMENT RIBBON CARTRIDGE	$7.95

SWITCH BOXES
ALL LINES SWITCHED, GOLD PLATED CONNECTORS, QUALITY SWITCHES

2 WAY $39.95
- CONNECTS 2 PRINTERS TO 1 COMPUTER OR VICE VERSA

AB-P *(CENTRONICS PARALLEL)*
AB-S *(RS232 SERIAL)*

3 WAY $99.95
- CONNECTS 3 PRINTERS TO 1 COMPUTER OR VICE VERSA

SWITCH-3P *(CENTRONICS PARALLEL)*
SWITCH-3S *(RS232 SERIAL)*

NASHUA DISKETTES
NASHUA DISKETTES WERE JUDGED TO HAVE THE HIGHEST POLISH AND RECORDED AMPLITUDE OF ANY DISKETTES TESTED (COMPARING FLOPPY DISKS, BYTE 9/84)

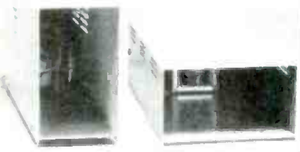
N-MD2D	DS DD 5¼" SOFT	$9.90
N-MD2F	DS QUAD 5¼" SOFT	$19.95
N-MD2H	DS HD 5¼" FOR AT	$24.95
N-FD1	SS DD 8" SOFT	$27.95
N-FD2D	DS DD 8" SOFT	$34.95

BULK DISKETTE SALE
5¼" SOFT SECTOR, DS/DD W/TYVEC SLEEVES & HUB RINGS

$9.90 BOX OF 10 — **69¢ea** BULK QTY 50 — **59¢ea** BULK QTY 250

DISK DRIVE ENCLOSURES WITH POWER SUPPLIES

CAB-2SV5	DUAL SLIMLINE 5¼"	$49.95
CAB-1FH5	FULL HT 5¼"	$69.95
CAB-2SV8	DUAL SLIMLINE 8"	$209.95
CAB-2FH8	DUAL FULL HT 8"	$219.95



300B MODEM $49.95
FOR APPLE OR IBM
INCLUDES ASCII PRO-EZ SOFTWARE
- FCC APPROVED
- BELL SYSTEMS 103 COMPATIBLE
- INCLUDES AC ADAPTOR
- AUTO DIAL
- DIRECT CONNECT

CABLE FOR APPLE IIc $14.95

DISKETTE FILES
5¼" DISKFILE HOLDS 70 $8.95
3½" DISKFILE HOLDS 40 $9.95

BUILD STEVE CIARCIA'S INTELLIGENT EPROM PROGRAMMER
AS SEEN IN BYTE, OCT. 86
- STAND-ALONE OR RS-232 SERIAL OPERATION
- MENU SELECTABLE EPROM TYPES—NO CONFIGURATION JUMPERS
- PROGRAMS ALL 5V 27XXX EPROMS FROM 2716 TO 27512
- READ, COPY OR VERIFY EPROM
- UPLOAD/DOWNLOAD INTEL HEX FILES
- PROGRAMMER DRIVER USER MODIFIABLE

ONLY $199

KIT INCLUDES PCB AND ALL COMPONENTS EXCEPT CASE & POWER SUPPLY

CALL FOR VOLUME QUOTES

CIRCLE 176 ON FREE INFORMATION CARD

EGA CARD AND MONITOR NOW ONLY $569!

QUALITY IBM COMPATIBLE MOTHERBOARDS

FROM MODULAR CIRCUIT TECHNOLOGY

TURBO 4.77 / 8 MHz $129.95

JDR PART #: MCT-TURBO

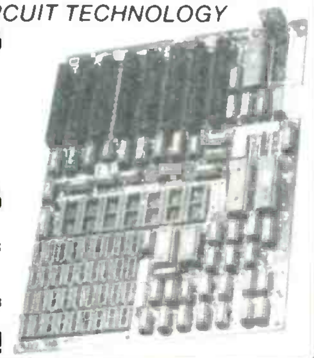
- 4.77 OR 8 MHz OPERATION WITH 8088-2 & OPTIONAL 8087-2 CO-PROCESSOR
- DYNAMICALLY ADJUSTS SPEED DURING DISKETTE OPERATION FOR MAXIMUM THROUGHPUT AND RELIABILITY
- CHOICE OF NORMAL TURBO MODE OR SOFTWARE SELECT PROCESSOR SPEED

STANDARD 4.77 MHz $109.95

JDR PART #: MCT-XTMB

- 8088 CPU, OPTIONAL 8087 CO-PROCESSOR
- 8 EXPANSION SLOTS
- EXPANDABLE TO 640K ON-BOARD MEMORY (0K RAM INSTALLED)
- ALL ICs SOCKETED-HIGHEST QUALITY PCB
- ACCEPTS 2764 OR 27128 ROMS

BOTH WITH FREE MCT BIOS!



EASYDATA MODEMS

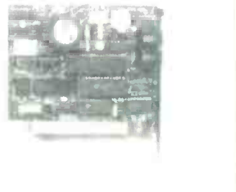
All models feature auto-dial/answer/redial on busy, Hayes compatible, power up self test, touchtone or pulse dialing, built-in speaker, PC Talk III Communications software, Bell Systems 103 & 212A full or half duplex and more.

INTERNAL

EASYDATA-12H $99.95
1200 BAUD HALF CARD

EASYDATA-12B $119.95
1200 BAUD 10" CARD

EASYDATA-24B $199.95
2400 BAUD FULL CARD



EXTERNAL

NO SOFTWARE INCLUDED

EASYDATA-12D $119.95
1200 BAUD

EASYDATA-24D $219.95
2400 BAUD

FARADAY FDD CONTROLLER

JDR PART #: FAR-FDD

- SUPPORTS UP TO 4 INTERNALLY MOUNTED FDDs
- IBM COMPATIBLE, INTERFACES TO 360K OR 720K USING DOS 3.20
- INCLUDES CABLE FOR 2 DISK DRIVES

$24.95

IBM COMPATIBLE FLOPPY DISK DRIVE

JDR PART #: FDD-360

GOOD QUALITY DRIVES BY MAJOR MANUFACTURERS SUCH AS QUME, TANDON & CDC

- 5¼" HALF HEIGHT
- 360K STORAGE CAPACITY
- DS/DD
- 48 TPI

$69.95

IBM STYLE COMPUTER CASE

AN ATTRACTIVE STEEL CASE WITH A HINGED LID. FITS THE POPULAR PC/XT COMPATIBLE MOTHERBOARDS

- SWITCH CUT-OUT ON SIDE FOR PC/XT STYLE POWER SUPPLY
- CUT-OUT FOR 8 EXPANSION SLOTS
- ALL HARDWARE INCLUDED

$34.95

SLIDE TYPE CASE $39.95

BUILD YOUR OWN 256K XT COMPATIBLE SYSTEM

XT MOTHERBOARD	$109.95
PRO-BIOS (A $20 VALUE)	FREE!
256K RAM	$26.55
130 WATT POWER SUPPLY	$69.95
FLIP-TOP CASE	$34.95
KEY TRONIC™ KEYBOARD	$49.95
360K DRIVE	$69.95
FARADAY CONTROLLER	$24.95
MONOCHROME ADAPTOR	$49.95
FORTRONICS MONITOR	$99.95
TOTAL:	$536.15

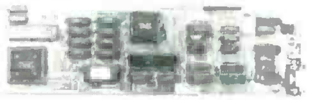
DISPLAY CARDS

FROM MODULAR CIRCUIT TECHNOLOGY

MCT-EGA $179.95

100% IBM COMPATIBLE, PASSES IBM EGA DIAGNOSTICS

- COMPATIBLE WITH IBM EGA, COLOR GRAPHICS AND MONOCHROME ADAPTORS
- TRIPLE SCANNING FREQUENCY FOR DISPLAY ON EGA, STANDARD RGB OR HIGH RESOLUTION MONOCHROME MONITOR
- FULL 256K OF VIDEO RAM ALLOWS 640 x 350 PIXELS IN 16 OF 64 COLORS
- LIGHT PEN INTERFACE



MCT-CG $49.95

COMPATIBLE WITH IBM COLOR GRAPHICS STANDARD

- SHORT SLOT CARD USES VLSI CHIPS TO INSURE RELIABILITY
- SUPPORTS RGB, COMPOSITE MONOCHROME & COLOR AND AN RF MODULATOR OUTPUT
- 320 x 200 COLOR GRAPHICS MODE
- 640 x 200 MONOGRAPHICS MODE
- LIGHT PEN INTERFACE

SHORT SLOT

MCT-MGP $59.95

COMPATIBLE WITH IBM MONOCHROME AND HERCULES GRAPHICS STANDARDS

- SHORT SLOT CARD USES VLSI CHIPS TO INSURE RELIABILITY
- PARALLEL PRINTER PORT, CONFIGURABLE AS LPT1 OR LPT2
- 720 x 348 GRAPHICS MODE
- LOTUS COMPATIBLE
- CAN RUN WITH COLOR GRAPHICS CARD IN THE SAME SYSTEM

SHORT SLOT

MCT-MG $79.95

COMPATIBLE WITH IBM MONOCHROME AND HERCULES GRAPHICS STANDARDS

- SERIAL PORT OPTION
- PARALLEL PRINTER PORT
- 720 x 348 GRAPHICS MODE
- 80 x 25 TEXT MODE
- LOTUS COMPATIBLE
- SELECTABLE TO RUN ALONG WITH COLOR GRAPHICS CARD IN THE SAME SYSTEM

MG-SERIAL OPTIONAL SERIAL PORT $19.95

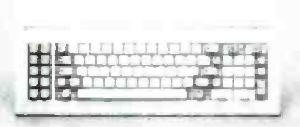
MCT-MONO $49.95

ANOTHER FANTASTIC VALUE FROM JDR!

- IBM COMPATIBLE TTL INPUT
- 720 x 348 PIXEL DISPLAY

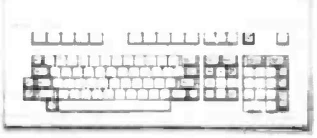
PLEASE NOTE: THIS CARD WILL NOT RUN LOTUS GRAPHICS AND DOES NOT INCLUDE A PARALLEL PORT

IBM COMPATIBLE KEYBOARDS



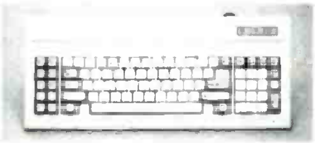
MCT-5150 $59.95

- "5150" STYLE KEYBOARD
- FULLY IBM COMPATIBLE
- LED STATUS INDICATORS FOR CAPS & NUMBER LOCK
- LARGE, EASY TO REACH SHIFT & RETURN KEYS
- 83 KEY TYPEWRITER LAYOUT



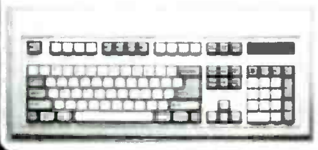
MCT-5151 $79.95

- REPLACEMENT FOR KEY TRONIC™ KB-5151 KEYBOARD
- SEPARATE CURSOR & NUMERIC KEYPAD
- CAPS LOCK & NUMBER LOCK INDICATORS
- IMPROVED KEYBOARD LAYOUT



MCT-5060 $59.95

- IBM AT STYLE LAYOUT
- SOFTWARE AUTOSENSE FOR XT OR AT COMPATIBLES
- EXTRA LARGE SHIFT & RETURN KEYS
- LED INDICATORS FOR SCROLL, CAPS & NUMBER LOCK
- AUTO REPEAT FEATURE



MCT-5339 $89.95

- IBM ENHANCED STYLE LAYOUT
- SOFTWARE AUTOSENSE FOR XT OR AT COMPATIBLES
- 12 FUNCTION KEYS
- EXTRA LARGE SHIFT & RETURN KEYS
- LED INDICATORS FOR SCROLL, CAPS & NUMBER LOCK
- AUTO REPEAT FEATURE
- SEPARATE CURSOR PAD

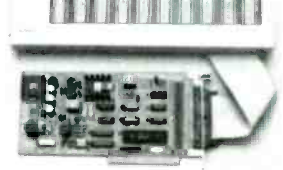
EPROM PROGRAMMERS

FROM MODULAR CIRCUIT TECHNOLOGY

MCT-EPROM $129.95

PROGRAMS 27xx AND 27xxx SERIES EPROMS UP TO 27512

- SUPPROTS VARIOUS MANUFACTURERS FORMATS WITH 12.5, 21 AND 25 VOLT PROGRAMMIMG
- MENU-DRIVEN SOFTWARE ALLOWS EASY MANIPULATION OF DATA FILES
- SPLIT OR COMBINE THE CONTENTS OF SEVERAL EPROMS OF DIFFERENT SIZES
- READ, WRITE, COPY, ERASE CHECK AND VERIFY WITH EASY ONE KEY SELECTION
- INCLUDES SOFTWARE FOR STANDARD HEX AND INTEL HEX FORMATS



4 GANG PROGRAMMER $189.95

10 GANG PROGRAMMER $299.95

MCT PRODUCTS CARRY A ONE YEAR WARRANTY

CIRCLE 177 ON FREE INFORMATION CARD

1200B MODEM $99.95 FOR IBM W/ SOFTWARE 2400B MODEM $199.95

BARGAIN HUNTERS CORNER
NEW FROM RIM ELECTRONICS
NICKEL EXPRESS $69.95
PC/XT SPEED UP KIT

- INCREASE THE SPEED OF YOUR PC BY 67% OR MORE!
- SIMPLE NO-SLOT INSTALLATION
- SOFTWARE OR HARDWARE SPEED SELECTION
- 8 MHz V20 PROCESSOR & SOFTWARE INCLUDED
- SELECT FOR 3 TURBO FREQUENCIES
- EXTERNAL RESET SWITCH
- OPTIONAL 8088 8 MHz PROCESSOR AVAILABLE

Certain early PCs may not run at 8 MHz-these machines may be switched to one of the slower speeds
6.66 MHz 40% 7.37 MHz=56% 8.0 MHz 67%

SPECIAL ENDS 7/31/87

PAGE WIRE WRAP WIRE
PRECUT ASSORTMENT
IN ASSORTED COLORS $27.50
100ea: 5.5", 6.0", 6.5", 7.0"
250ea: 2.5", 4.5", 5.0"
500ea: 3.0", 3.5", 4.0"

SPOOLS

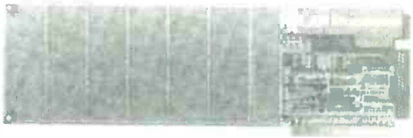
100 feet	$4.30	250 feet	$7.25
500 feet	$13.25	1000 feet	$21.95

Please specify color: Blue, Black, Yellow or Red

EXTENDER CARDS

IBM-PC	$29.95
IBM-AT	$39.95

WIRE WRAP PROTOTYPE CARDS
FR-4 EPOXY GLASS LAMINATE
WITH GOLD-PLATED EDGE-CARD FINGERS



IBM-PR2

IBM
BOTH CARDS HAVE SILK SCREENED LEGENDS AND INCLUDES MOUNTING BRACKET

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

S-100

P100-1	BARE - NO FOIL PADS	$15.15
P100-2	HORIZONTAL BUS	$21.80
P100-3	VERTICAL BUS	$21.80
P100-4	SINGLE FOIL PADS PER HOLE	$22.75

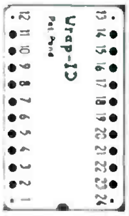
APPLE

P500-1	BARE - NO FOIL PADS	$15.15
P500-3	HORIZONTAL BUS	$22.75
P500-4	SINGLE FOIL PADS PER HOLE	$21.80
7060-45	FOR APPLE IIe AUX SLOT	$30.00

SOCKET-WRAP I.D.™
- SLIPS OVER WIRE WRAP PINS
- IDENTIFIES PIN NUMBERS ON WRAP SIDE OF BOARD
- CAN WRITE ON PLASTIC, SUCH AS IC #

PINS	PART#	PCK. OF	PRICE
8	IDWRAP 08	10	1.95
14	IDWRAP 14	10	1.95
16	IDWRAP 16	10	1.95
18	IDWRAP 18	5	1.95
20	IDWRAP 20	5	1.95
22	IDWRAP 22	5	1.95
24	IDWRAP 24	5	1.95
28	IDWRAP 28	5	1.95
40	IDWRAP 40	5	1.95

PLEASE ORDER BY NUMBER OF PACKAGES (PCK. OF)



ID WRAP 24

FRAME STYLE TRANSFORMERS

12.6V AC CT	2 AMP	5.95
12.6V AC CT	4 AMP	7.95
12.6V AC CT	8 AMP	10.95
25.2V AC CT	2 AMP	7.95

25 PIN D-SUB GENDER CHANGERS
$7.95

SWITCHING POWER SUPPLIES

PS-IBM $69.95
- FOR IBM PC-XT COMPATIBLE
- 135 WATTS
- +5V @ 15A, +12V @ 4.2A
- -5V @ .5A, -12V @ .5A
- ONE YEAR WARRANTY

PS-IBM-150

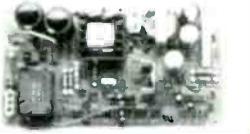
PS-IBM-150 $79.95
- FOR IBM PC-XT COMPATIBLE
- 150 WATTS
- +12V @ 5.2A, +5V @ 16A
- -12V @ .5A, -5V @ .5A
- ONE YEAR WARRANTY

PS-130

PS-130 $99.95
- 130 WATTS
- SWITCH ON REAR
- FOR USE IN OTHER IBM TYPE MACHINES
- 90 DAY WARRANTY

PS-A $49.95
- USE TO POWER APPLE TYPE SYSTEMS, 79.5 WATTS
- +5V @ 7A, +12V @ 3A
- -5V @ .5A, -12V @ .5A
- APPLE POWER CONNECTOR

PS-A



PS-1558 $34.95
- 75 WATTS, UL APPROVED
- +5V @ 7A, +12V @ 3A
- -12V @ 250ma, -5V @ 300ma

PS-1558

CAPACITORS

TANTALUM

1.0µf	15V	.35	.47µf	35V	.45
6.8	15V	.70	1.0	35V	.45
10	15V	.80	2.2	35V	.65
22	15V	1.35	4.7	35V	.85
.22	35V	.40	10	35V	1.00

DISC

10pf	50V	.05	680	50V	.05
22	50V	.05	.001µf	50V	.05
27	50V	.05	.0022	50V	.05
33	50V	.05	.005	50V	.05
47	50V	.05	.01	50V	.07
68	50V	.05	.02	50V	.07
100	50V	.05	.05	50V	.07
220	50V	.05	.1	12V	.10
560	50V	.05	.1	50V	.12

MONOLITHIC

.01µf	50V	.14	.1µf	50V	.18
.047µf	50V	.15	.47µf	50V	.25

ELECTROLYTIC

RADIAL			AXIAL		
1µf	25V	.14	1µf	50V	.14
2.2	35V	.15	10	50V	.16
4.7	50V	.15	22	16V	.14
10	50V	.15	47	50V	.20
47	35V	.18	100	35V	.25
100	16V	.18	220	25V	.30
220	35V	.20	470	50V	.50
470	25V	.30	1000	16V	.60
2200	16V	.70	2200	16V	.70
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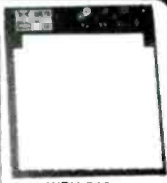

WBU-208

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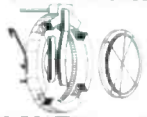

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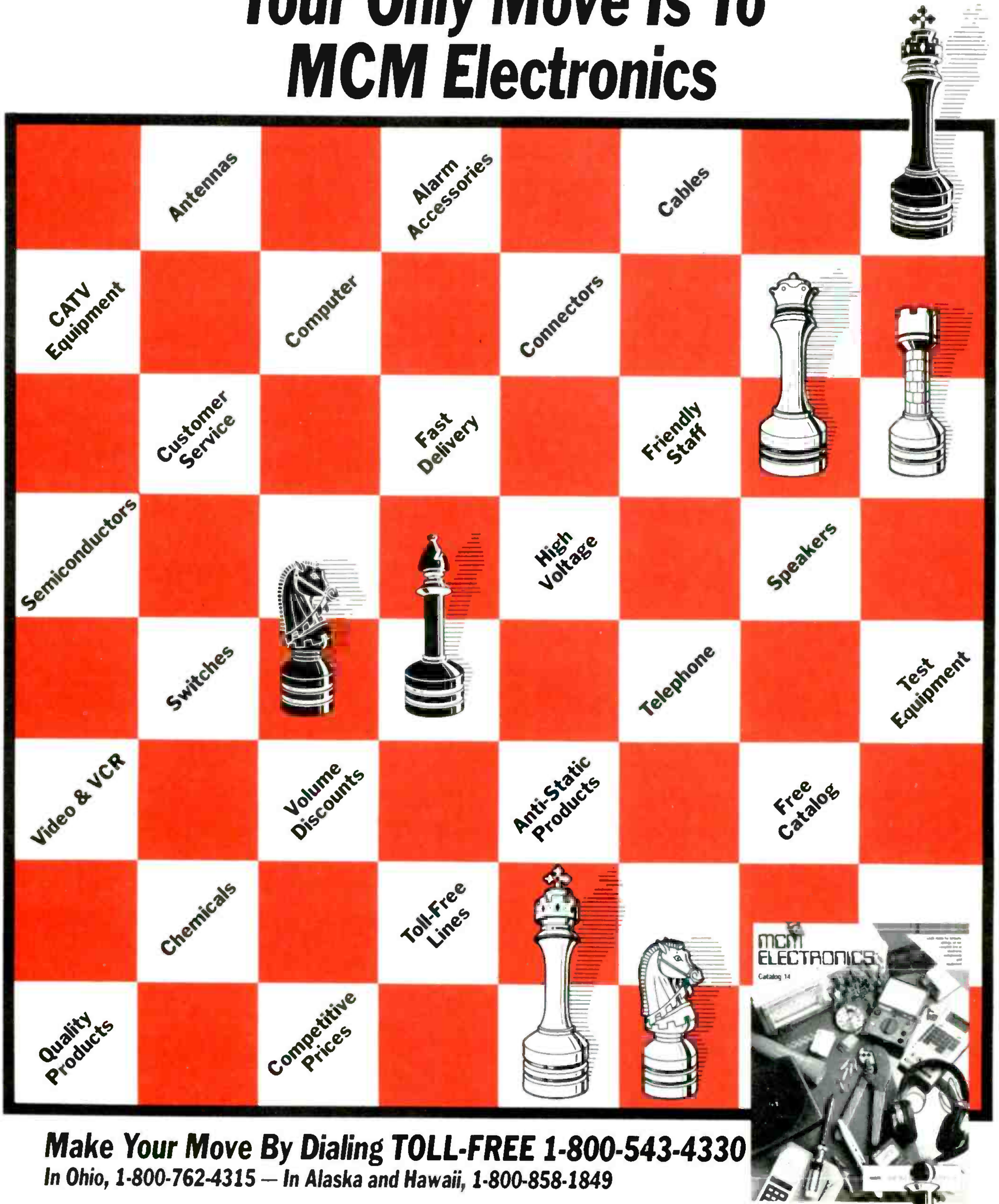

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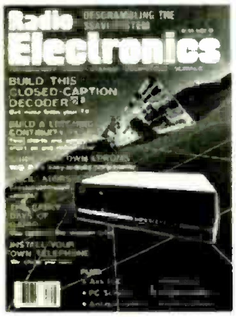

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