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ht and the Apple.

If you could talk to Thomas Edison, he'd tell you what it was like to turn the lights on in 1879. You could tell him about some bright ideas of the 20th century... particularly, a technological phenomenon that can handle everything from solar heat control to lighting your home via voice command. The Apple personal computer.

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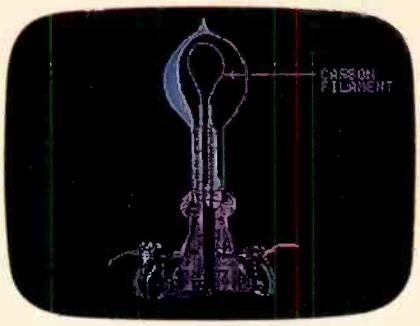

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JULY 1980
VOLUME 18, NUMBER 1

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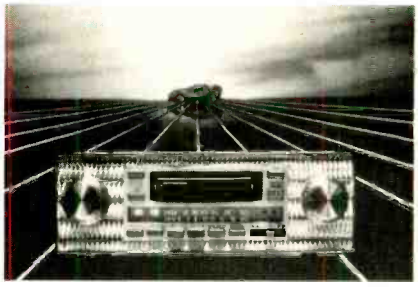

About the cover:

In this issue eight top-model car stereo in-dash AM/Stereo FM receivers with cassette playback are examined in depth.

Cover photo by Don Carroll

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Editorial

PE Reader Profile

Every year or two, our market research department samples subscribers to obtain views on editorial matter in POPULAR ELECTRONICS, as well as to gather demographic information. The latest editorial study is most revealing, as were all past ones.

This PE reader profile indicates that readers average two years older than they did two years ago (median age was 33 years compared to 31 years). Highest level of education attained and median income rose, too. Almost 74% of you guys (and gals also, since 0.7% of readers are female) have attended or graduated from college compared to 63% in 1977. And 10.8% of our readership have post-graduate degrees. In the income area, the 1979 median was $23,239, compared to $17,800 in '77. On the personal side, 61.7% of respondents noted they're married.

The most popular column in PE—*numero uno*—was Forrest Mims's "Experimenter's Corner." Forrest won the number two spot also, with his "Project of the Month" column. This was followed by John McVeigh's "Tips and Techniques" and "Hobby Scene." Number five was "Product Test Reports," while this column ("Editorial") hit the sixth spot out of 11 columns. For departments, "New Products" was first, as usual.

In the general article topics area, new developments in electronics was cited as capturing the most "reading about" interest, followed by how things work. Close on its heels were electronics experimentation and construction projects. More specialized subjects followed, headed by microcomputers, with testing/test equipment and electronic games not far behind. A few percentage points below them were product test reports, new TV designs, and audio.

Regarding the technical level of PE, 74.8% said that its contents were at the right technical level, compared to 1977's 71.6%. The remainder was divided almost equally between too technical and not technical enough, a not surprising result since our readership is so broad-based. More than 54% of PE's subscribers are currently employed in electronics or a related field, according to the study, while 11.6% observe that they plan to make it their career.

It was clear from the study that, while construction projects were among the most popular features in PE, readers pick and choose from among them for ones that they truly want. Fifty percent, in fact, had not built a PE project in the past 12 months, though virtually *all* readers expressed great interest in this topic, ostensibly for the circuit/device learning experience and for as wide an application choice as possible.

I hope the above gives you a better picture of the POPULAR ELECTRONICS reader. Summing up the research data, I guess one could say that the typical PE reader is a well-educated male with a substantially larger disposable income than the national average and is disposed to continually learn more about consumer electronic circuitry and developments.

Special thanks to respondents who made this market research study possible.

Art Salsberg

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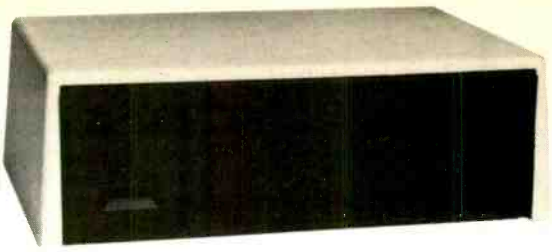
Burglar Alarm Breakthrough

A new computerized burglar alarm requires no installation and protects your home or business like a thousand dollar professional system.

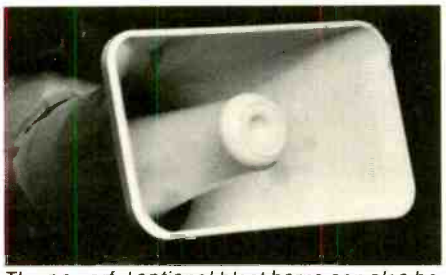


The Midex security computer looks like a handsome stereo system component and measures only 4"x 10½"x 7."

It's a security system computer. You can now protect everything—windows, doors, walls, ceilings and floors with a near fail-safe system so advanced that it doesn't require installation.

The Midex 55 is a new motion-sensing computer. Switch it on and you place a harmless invisible energy beam through more than 5,000 cubic feet in your home. Whenever this beam detects motion, it sends a signal to the computer which interprets the cause of the motion and triggers an extremely loud alarm.

The system's alarm is so loud that it can cause pain—loud enough to drive an intruder out of your home before anything is stolen or destroyed and loud enough to alert neighbors to call the police.



The powerful optional blast horns can also be placed outside your home or office to warn your neighbors.

Unlike the complex and expensive commercial alarms that require sensors wired into every door or window, the Midex requires no sensors nor any other additional equipment other than your stereo speakers or an optional pair of blast horns. Its beam actually penetrates walls to set up an electronic barrier against intrusion.

NO MORE FALSE ALARMS

The Midex is not triggered by noise, sound, temperature or humidity—just motion—and since a computer interprets the nature of the motion, the chances of a false alarm are very remote.

An experienced burglar can disarm an expensive security system or break into a home or office through a wall. Using a Midex system there is no way a burglar can penetrate the protection beam without triggering the loud alarm. Even if the burglar cuts off your power, the four-hour rechargeable battery pack will keep your unit triggered, ready to sense motion and sound an alarm.

ARRIVE HOME SAFE

There's personal danger in arriving home and finding a burglary in progress. And, if you surprise the burglar, you risk the chance of serious injury. With the Midex 55 protecting your home, you can open your front door with the confidence of knowing that no burglar lurks inside.

When the Midex senses an intruder, it remains silent for 20 seconds. It then sounds the alarm until the burglar leaves. One minute after the burglar leaves, the alarm shuts off and resets, once again ready to do its job. This shut-off feature, not found on many expensive systems, means that your alarm won't go wailing all night long while you're away. When your neighbors hear it, they'll know positively that there's trouble.

PROFESSIONAL SYSTEM

Midex is portable so it can be placed anywhere in your home. You simply connect it to your stereo speakers or attach the two optional blast horns.

Operating the Midex is as easy as its installation. To arm the unit, you remove a specially coded key. You now have 30 seconds to leave your premises. When you return, you enter and insert your key to disarm the unit. You have 20 seconds to do that. Each key is registered with Midex, and that number is kept in their vault should you ever need a duplicate. Three keys are supplied with each unit.

As an extra security measure, you can leave your unit on at night and place an optional panic button by your bed. But with all its optional features, the Midex system is complete, designed to protect you, your home and property just as it arrives in its well-protected carton.

The Midex 55 system is the latest electronic breakthrough by Solfan Systems, Inc.—a company that specializes in sophisticated professional security systems for banks and high security areas. JS&A first became acquainted with Midex after we were burglarized. At the time we owned an excellent security system, but the burglars went through a wall that could not have been protected by sensors. We then installed over $5,000 worth of the Midex commercial equipment in our warehouse. When Solfan Systems announced their intentions to market their units to consumers, we immediately offered our services.

COMPARED AGAINST OTHERS

In a recent issue of a leading consumer publication, there was a complete article written on the tests given security devices which were purchased in New York. The Midex 55 is not available in New York stores, but had it been compared, it would have been rated tops in space protection and protection against false alarms—two of the top criteria used to evaluate these systems. Don't be confused. There is no system under $1,000 that provides you with the same protection.

YOU JUDGE THE QUALITY

Will the Midex system ever fail? No product is perfect, but judge for yourself. All components used in the Midex system are of aerospace quality and of such high reliability that they pass the military standard 883 for thermal shock and burn-in. In short, they go through the same rugged tests and controls used on components in manned spaceships.

Each component is first tested at extreme tolerances and then retested after assembly. The entire system is then put under full electrical loads at 150 degrees Fahrenheit for an entire week. If there is a defect, these tests will cause it to surface.

PEOPLE LIKE THE SYSTEM

Wally Schirra, a scientist and former astronaut, says this about the Midex 55. "I know of no system that is as easy to use and provides such solid protection to the homeowner as the Midex. I would strongly recommend it to anyone. I am more than pleased with my unit."

Many more people can attest to the quality of this system, but the true test is how it performs in your home or office. That is why we provide a one month trial period. We give you the opportunity to see how fail-safe and easy to operate the Midex system is and how thoroughly it protects you and your loved ones.

Use the Midex for protection while you sleep and to protect your home while you're away or on vacation. Then after 30 days, if you're not convinced that the Midex is nearly fail-safe, easy to use, and can provide you with a security system that you can trust, return your unit and we'll be happy to send you a prompt and courteous refund. There is absolutely no obligation. JS&A has been serving the consumer for over a decade—further assurance that your investment is well protected.

To order your system, simply send your check in the amount of **$199.95** (Illinois residents add 5% sales tax) to the address shown below. Credit card buyers may call our toll-free number below. There are no postage and handling charges. By return mail you will receive your system complete with all connections, easy to understand instructions and a one year limited warranty. If you do not have stereo speakers, you may order the optional blast horns at **$39.95** each, and we recommend the purchase of two.

With the Midex 55, JS&A brings you: 1) A system built with such high quality that it complies with the same strict government standards used in the space program, 2) A system so advanced that it uses a computer to determine unauthorized entry, and 3) A way to buy the system, in complete confidence, without even being penalized for postage and handling charges if it's not exactly what you want. We couldn't provide you with a better opportunity to own a security system than right now.

Space-age technology has produced the ultimate personal security computer. Order your Midex 55 at no obligation, today.

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Letters

Microprocessor Applications

Your choice of the 1802 as the lead-off for the microprocessor application series ("Microprocessor Applications for the 1980's . . . It's a Whole New Ballgame!" May 1980) was inspired. The 1802 must be the most underrated microprocessor ever made. I have followed it ever since your original "Elf" article and now have my own 1802 system. It was my first venture into digital electronics and a very satisfying one.—*John R. Powers, III, Columbus, OH.*

The article on microprocessor applications is informative, but there appears to be an error in the program (Table II). The switches in Fig. 2 are in the normally open position and therefore there would normally be a "high or a one" on the EF1 through EF4 microprocessor inputs. The instructions in the program, mnemonics B1, B2, B3, and B4 look for a "one" on the EF inputs and if a "one" is found, the program branches to the specified address.—*Gaylord Waisath, Oxnard, CA.*

The EF inputs to the 1802 are said to be active low. So a low input to any one of them is interpreted as a logic 1 by the processor. This might have been clearer if we had put vinculums (or lines) over EF1, EF2, EF3, and EF4 in both the text and the diagram, but the program and the logic would still have been the same.—Ed.

I wonder if the system depicted in Fig. 2 of this article will operate as intended. I would suggest that each of the four pushbutton switches be debounced.—*Kenneth J. Christensen, Gainesville, FL.*

Debouncing circuits are not required in this case since the routine in the program inherently debounces the circuit.—Ed.

Three-Way Speaker System

I found "A 3-Way Drive System for Speakers" (April 1980) to be a fascinating project, but I believe the parts list is in error. The TIP30 and TIP31 power transistors are not a matched pair. The matched pairs are TIP29 and TIP30 or TIP31 and TIP32.—*R. E. Gierman, Salinas, CA.*

While Texas Instruments specifies TIP29 and 30 and TIP31 and 32 as matched pairs, other manufacturers cross-reference the pairs to the same devices. The differences lie mainly in breakdown voltages, which are not critical here. Any of the possible combinations should provide satisfactory results.—Ed.

Noise Generator Patented

With regard to the Shift Register Digital Noise Generator described in the March 1980 "Experimenter's Corner," your readers should be cautioned that use of this for any other than private purposes would be an infringement of the patent our company holds for such devices and their applications (Pat. #4,191,175).—*William L. Nagle, President, Paratronic Systems Inc., Honeybrook, PA 19344.*

Out of Tune

In "Experimenting with a Sound-Effects Generator" (May 1980), in Fig. D on page 79, the resistor between pins 7 and 8 on the 555 timer should be 47k not 4.7k and in Fig. 3, p.81, transistor *Q1* should be a 2N3704 and *Q2* a 2N3703, instead of vice versa as shown.

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PHONE WIZARD

This incredible phone dialer let's you regulate outgoing phone calls using a secret lock command.

DICTOGRAPH® the producer of communication systems for the White House and Pentagon, introduces a space age computer phone. An amazing futuristic instument capable of 25 functions and memory bank storage of 30 numbers — convenient compact size — all at a price that will make you smile!

No one's got it. And if they do, it's twice the size and triple the price. The Phone Wizard is based on a unique 'Logical Language Sequence', which gives each key multiple use. This feature is activated by pressing a predetermined code onto a multiple use key (like a multi-function digital watch). The 'Logical Language Sequence' is why Phone Wizard has twice the capabilities at half the size. It is the most advanced phone dialer on the market. And at a price far below any other dialer.

It's an automatic dialer.

Think of the number of people you frequently call. The Phone Wizard stores up to 30 often used phone numbers (up to sixteen digits each) in its Memory Bank. Simply pencil in the name on the handy index pads, just press the appropriate key — one time!

Dial "Hands Free"

When dialing don't pick up the phone, just push the right button and listen. The built in loud speaker lets you hear the other person answer or the busy signal.

You actually see the number dialed.

Glance at the big bright LED display. You'll immediately know the right number is being dialed — no matter whether you're using the automatic dialer or are dialing manually.

More Outstanding Features

- Pressure sensitive keys, solid face (no buttons).
- Beep tones tell you that each digit is being dialed or stored correctly.
- Back-Space Erase lets you 'erase' a wrong number. Easy as pie.
- Want to confirm a stored number? Just press the storage button twice. Instantly you'll see a big read-out so you can verify.
- Automatically rings your number up to six times, then stops when your party isn't home.
- A three-position pulse switch allows the Phone Wizard to be connected to virtually any phone system in the world. Rotary dial or Touch tone.

Busy Number Buster and Emergency Dialer

Suppose the number you're calling is busy, just touch the Redial Key, to recall. Still busy? Just program the Phone Wizard to redial later on (up to 15 times, one per minute). A special sign on the display will indicate that the number is being redialed.

Emergency! Here's the quickest and easiest mechanism for dialing the Police or Fire Dept. This feature alone is worth the price of this amazing Dialer. Program the machine before you leave. Then the babysitter or Grandma just presses the Re-Dial Key. Instantly the call is put through.

Conference Speaker For Group Conversations

Activate the Conference Speaker by depressing a button. Everyone on your end and the receiving end can listen in and have his say-so — with the voice coming through loud and clear. Meet by phone, you'll save time, effort, and not to mention those high gas bills!

Digital Clock, Stop Watch and Timer

Time of day displayed in hours, minutes and seconds.

Stop Watch Feature times all calls automatically — great for gauging long-distance calls, keeping records, cutting down on expenses by limiting calls, etc.

You can even time a particular PART of a call. That's how exact this special feature is.

Want to recheck the time of the last call? You can — easily. Press the Clear Key and the Time Key. A big read-out will appear instantly.

How To Place A Call On Hold

Simply touch the hold button, the word 'hold' will flash on the screen. To resume your conversation touch the button again, and you're ready to continue your conversation.

Prevents Unauthorized Use

An ingenious combination electronic lock allows you to prevent unauthorized long distance out going calls while allowing you local calls. Simply press in the secret code. This locks the dialer unit and the phone itself. No long distance calls can be made, but all incoming calls will be received. To reactivate, simply press the secret opening code and a beep tone tells you the phone and dialer are ready for long distance calls. Only you know the codes for this amazing dialer. An instruction kit is included and explains all the secret codes.

Also is designed for wall mounting or desk, contour designed to allow you to locate emergency numbers even at night, gives you an adjustable voice control, no moving parts, LED,readout numbers. Quartz crystal clock for accuracy, sloping display for easy reading, quick change of name labels — and more!

We can't even come close to listing all of the exciting features this outstanding Phone Dialer brings you. See for yourself! Use it for 15 days if you're not completely satisfied return it at our expense. Every cent will be refunded promptly.

The price? Not those inflated prices you may have seen around town — but only **$119.95** plus **$2.75** for insured shipping. For two or more, **$109.95** each plus **$2.75** each for insured shipping. You'll receive complete, easy-to-follow instructions plus a 90-day Parts and Labour Warranty, and service (if ever needed) is readily available. Phone now so we can get your tryout unit right out to you. You're not risking a cent.

Call TOLL FREE:

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In New Jersey, Call: 800-322-8650

Call any time, 7 days a week. Be sure to have your credit card handy — either Visa, Master Charge, American Express, Carte Blanche or Diners Card.

If ordering by mail, include the following: your name, full mailing address, signature, type of credit card, account number and expiration date. Or send check or money order.

Save while this offer last. You'll not find a better bargin on a top-quality handsome, easy-to-use Phone Dialer anywhere.

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Circle 39 on Reader-Service Card

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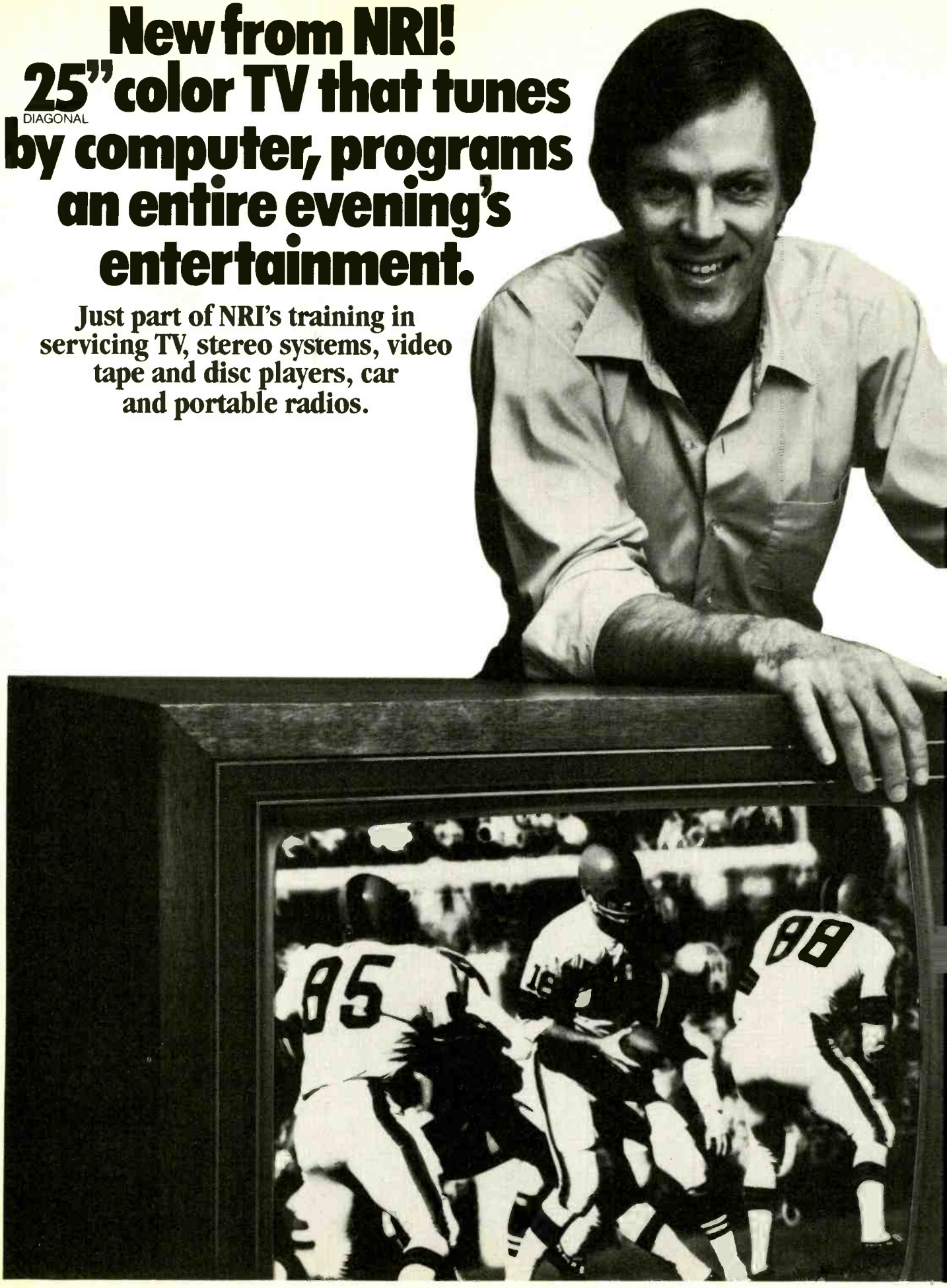
New from NRI! 25" DIAGONAL color TV that tunes by computer, programs an entire evening's entertainment.

Just part of NRI's training in servicing TV, stereo systems, video tape and disc players, car and portable radios.



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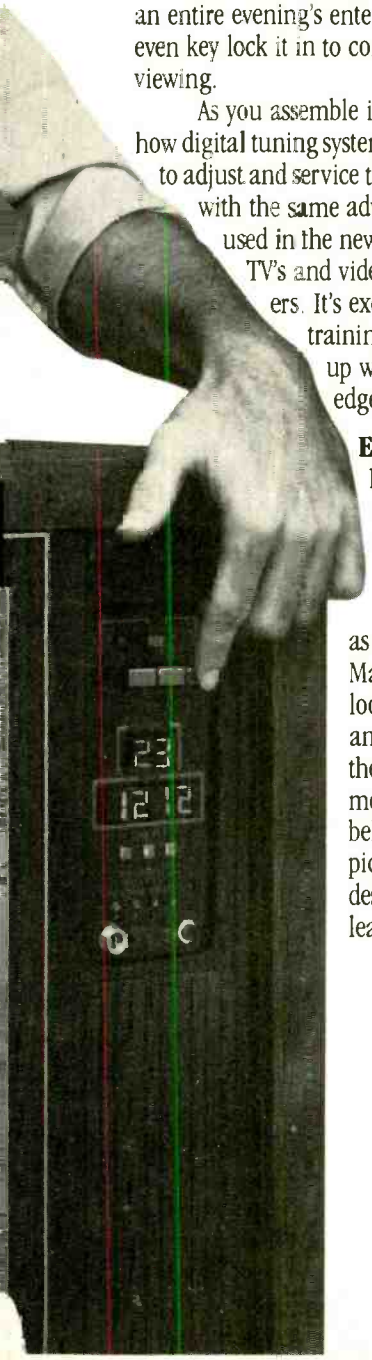
Only NRI home training prepares you so thoroughly for the next great leap forward in TV and audio...digital systems. Already, top-of-the-line TV's feature digital tuning, computer programming is appearing, and new digital audio recording equipment is about to go on the market.

NRI is the only home study school to give you the actual "hands-on" training you need to handle servicing problems on tomorrow's electronic equipment. Because only NRI includes this designed-for-learning, 25" diagonal color TV with electronic tuning, built-in digital clock, and computer programmer as part of your training. With this advanced feature, you can pre-program an entire evening's entertainment... even key lock it in to control children's viewing.

As you assemble it, you learn how digital tuning systems work, how to adjust and service them. You work with the same advanced features used in the new programmable TV's and video tape recorders. It's exclusive NRI training that keeps you up with the leading edge of technology.



Exclusive Designed-for-learning Concept

The color TV you build as part of NRI's Master Course looks, operates, and performs like the very finest commercial sets. But behind that pretty picture is a unique designed-for-learning chassis...

the only such unit in the world. Rather than retrofit lessons to a hobby kit or an already-built commercial set, NRI instructor/engineers have designed this television so each step of construction is a learning experience.

As you build it, you perform meaningful experiments. You see what makes each circuit work, what it does, how it interacts with other circuits. You even introduce defects, troubleshoot and correct them as you would in actual practice. And you end up with a magnificent, big-picture TV with advanced features. One you can sell or use in your home.

Also Build Stereo, Test Instruments

That's just a start. You demonstrate basic principles and circuits on the unique NRI Discovery Lab,® then apply them as you assemble a fine AM/FM stereo receiver, complete with speakers. You also get practical experience as you build your own test instruments, including a 5" triggered sweep oscilloscope, CMOS digital frequency counter, color bar generator, and transistorized volt-ohm meter. Use them for learning, use them for earning as a full- or part-time TV, audio, and video systems technician.

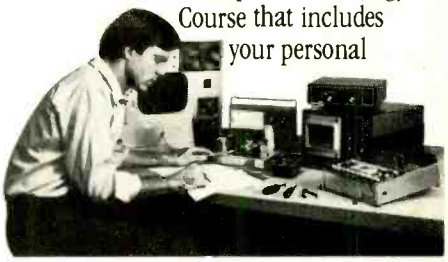
Complete, Effective Training Includes Video Systems

Using NRI's exclusive methods, you learn far more than TV servicing. You'll be prepared to work with stereo systems, car radios, record and tape players, transistor radios, short-wave receivers, PA systems, musical instrument amplifiers, electronic TV games, even video tape recorders and tape or disc video players. Your training covers just about every kind of electronic entertainment equipment available now or in the near future.

And because NRI has unmatched experience gained in over 60 years and a million students worth of training, your course is designed for ease of learning and practical utility. You need no previous experience of any kind. Starting with the basics, exclusive "bite-size" lessons cover subjects thoroughly, clearly, and concisely. "Hands-on" experiments reinforce theory for better comprehension and retention. And your personal NRI instructor is always available for consultation, ready with explanations, answers, and advice.

Send for Free Detailed Catalog... No Salesman Will Call

Get all the facts on this exciting course and its potential for you by mailing the postage-paid card today. Our free 100-page catalog includes color photos of all kits and equipment, complete lesson plans, convenient time payment plans, and information on other electronics courses. You'll also find out about NRI's new Computer Technology Course that includes your personal



microcomputer. Or Complete Communications with 2-meter transceiver that gets you ready for opportunities in broadcasting, 2-way radio, microwave, and other growing fields. If card has been removed, write to:

NRI Schools
McGraw-Hill Continuing Education Center
3939 Wisconsin Ave.
Washington, D.C. 20016

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New Products

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

Low-Cost 500-MHz Counter

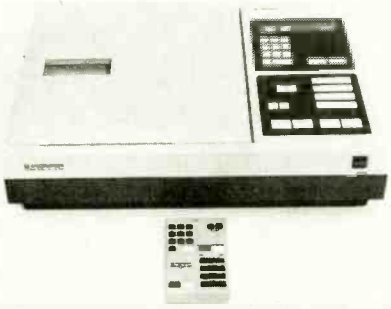
The 50-Hz-to-512-MHz Model 5500, 8-digit LED display frequency counter from DSI Instruments, Inc., is designed around a TCXO (temperature-compensated crystal oscillator) said to be stable within 1 ppm between 17° and 40°C. Other features include an input sensitivity of 10 to 15 mV, floating decimal point and automatic blanking, resolution of 1 Hz at 50 MHz and 10 Hz at 450 MHz, and either a 1-megohm or 50-ohm input impedance. The unit is 1.5" thick, 5" wide, and 5.5" deep (38 × 127 × 139 mm). $134.95 with rechargeable battery pack and ac adapter, or $109 without the battery capability.

CIRCLE NO. 86 ON FREE INFORMATION CARD

Tailored Keyboard Titles

The basic nonelectronic, 32-key, matrix keypad KA2 from Danyl has letters and fixed function codes for START, COMPLETE, CANCEL, CLEAR ENTRY, LETTER, and SPACE. All other key titles and legends are printed on overlay materials available with or without adhesive backing, allowing user to tailor key functions to specific needs. Key closures and lines for optional display are carried by a 26-conductor, ribbon cable. Address: Danyl Corp., 310 Cooper Center, Pennsauken, NJ 08109.

Pioneer Videodisc Player



Pioneer is currently marketing a laser-optical videodisc player in Minneapolis/St. Paul, Dallas/Fort Worth, Madison, WI, and Syracuse, NY, with four new markets planned every 60 to 90 days. The new Model VP-1000 player complies with MCA Philips specifications, uses a helium-neon laser, and plays for up to 30 minutes per side (60 minutes per side on extended discs). It features two-channel high-fidelity sound, with 40 Hz to 20 kHz ±3 dB response, less than 0.3% THD, and greater than 55 dB S/N. Functions include play, pause, fast X3, scan, slow, and still/step controls. Other features include frame number, elapsed-time, and chapter-number displays; search and auto-repeat modes; and chapter and picture stop functions. Remote control is available optionally. $749.

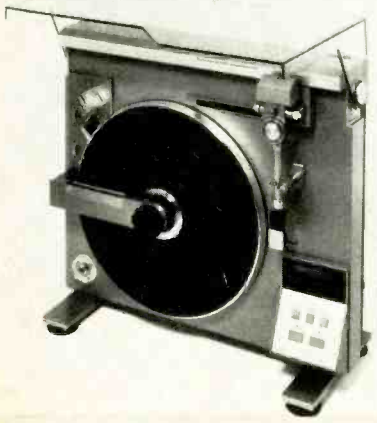
CIRCLE NO. 88 ON FREE INFORMATION CARD

Unusual Power Amplifier

Apt Corporation's Apt 1 Power Amplifier is rated at 100 watts per channel continuous output, 20 to 20,000 Hz, with no more than 0.03% THD. Additionally, its dynamic headroom is said to be 3 dB. Its adjustable power supply is designed to allow it to drive any and all loudspeaker loads—including loads that are purely reactive—from 2 to 10 ohms. Newly conceived driver and output stages offer low static and dynamic distortion as well as eliminating the need for conventional protection circuitry, which is reputed to degrade sonic quality in some cases. The Apt 1 also features relay muting and short-circuit protection, LED displays, and a rack-mount option. $641 (eastern states); $656 (western states).

CIRCLE NO. 89 ON FREE INFORMATION CARD

Mitsubishi Linear-Track Turntable



The fully automatic Model LT-5V vertical linear-tracking turntable from Mitsubishi combines logic-controlled operation and belt drive. At 33⅓- and 45-rpm speeds, its PLL dc servo motor offers a rated 0.045% wrms wow and flutter and 76-dB S/N, and its 8¾" (222-mm) straight tonearm is statically balanced. Among the turntable's automatic functions are: lead-in and lead-out, speed and size change, reject and repeat, lift/cue, free left and right movement, and cue prevention when no record is on the platter. Size: 18¾"W × 16⅞"H × 7⅞"D; weight: 27.6 lb (12.5kg).

CIRCLE NO. 87 ON FREE INFORMATION CARD

Dictograph Phone Controller

Dictograph Corporation's Phone Controller™ is a multifunction telephone appliance that can be used with either Touch-Tone or rotary-dial lines. It can store up to 30 different 16-digit telephone numbers in a memory that receives back-up power from a 9-volt transistor battery if the ac line fails.

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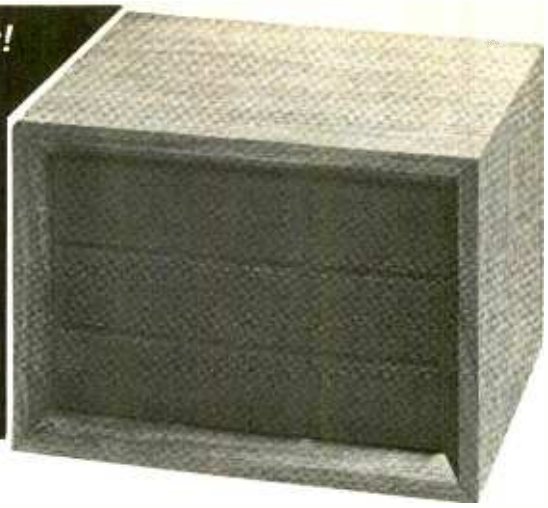
guardex™

Protects Every Square Inch Of Your Building

Turns On Lights Automatically

Powerful Electronic Siren



Low Cost Computerized Burglar Alarm System Home - Office - Business

The Guardex 8000 Alarm System is walnut grained and disguised to look like a small stereo speaker (6¾" × 9¾" × 8") and weighs less than 6½ pounds.

NO INSTALLATION

Just plug the Guardex 8000 alarm system in, make several simple control adjustments to suit your particular building and it works! There are no other wires to run. This totally self-contained burglar alarm can completely seal off every square inch of the surface of your building. It protects doors, windows, and what most alarms miss... your roof, walls and floors.

HOW CAN ONE SMALL COMPUTER PROTECT MY WHOLE BUILDING?

Guardex 8000 Alarm System works on the principle of audio discrimination. This, put simply, is the process of electronically separating normal everyday sounds, such as voices, telephones, etc. from break-in type noises such as breaking glass, prying metal, or forcing a door open. The Guardex 8000 protects one story homes and offices up to 2000 square feet and open commercial buildings up to 10,000 square feet. The Guardex 9300 with wireless remote sensor capability is available for multi-story homes and offices or single story with more than 2000 square feet. Call the factory for more detailed information.

TURNS ON LIGHTS AUTOMATICALLY

When the first break-in type sound is detected, the system will instantly turn on lights, radio, or other electronic equipment that you have plugged into the back of the alarm. These lights or other equipment will remain on for a period of five minutes, then automatically turn off.

POWERFUL ELECTRONIC SIREN

The Guardex 8000 alarm is equipped with a loud built-in siren. If during the five minute period the lights or other electronic equipment has been activated, a second break-in sound is detected, (it can be only a second or two after the first break-in sound) the built-in siren will start blasting for 90 seconds. At the end of approximately 90 seconds the siren will shut off and the alarm listens again. If another break-in sound is heard, the siren will come on for another 90 seconds. If no other break-in sound is detected, the siren will stay off and at the end of the five minute period the lights will shut off and the alarm instantly resets.

The rear control panel contains two standard AC plug receptacles for a table lamp, spot lights, radio, etc.; terminals for connecting optional outside siren and back-up battery (not included); entry delay time control and sensitity control.

EXIT AND ENTRY DELAY

The Guardex 8000 alarm has a built-in exit delay allowing you approximately one minute to lock up and leave the building before the alarm is armed. When you enter your building you may find that just your normal entering sounds activate the siren. You may delay it from starting for up to 30 seconds by turning up the siren entry delay control.

BATTERY BACK-UP

Burglars rarely cut power. However, to give you total protection from a burglar and possible power failure, our alarm has provisions for a battery back-up. (Batteries not included). 12 volt lantern batteries are available at most hardware stores.

THE BURGLARY PROBLEM

The F.B.I. statistics show that at the present rate, one out of every four Americans are going to be burglarized. That is not a very pleasant fact, but it is true. You have a greater chance of being burglarized than being a victim of a fire or automobile accident. The time is now to help protect yourself and your valuables with a Guardex 8000 alarm system.

OUTSIDE SIREN

The Guardex 8000 alarm is equipped with a loud, built-in siren, but if you desire an additional siren to mount outside or in an area away from the main alarm, they are available with 50 feet of wire for $24.95. (Connecting terminals are provided on the back of the alarm).

30 DAY NO RISK TRIAL

This is your opportunity to purchase an alarm system directly from the factory for only $199.95. Try it in your home or business for thirty days without risking one cent. Put our Guardex 8000 alarm to your own test. See for yourself! It will protect every window and door from break-in. If you are not completely satisfied, return the alarm within 30 days for a complete refund. To order your Guardex 8000 alarm, CALL TOLL FREE to charge your credit card or send your check to Guardian Electronics, Inc. in the amount of $199.95. If you want the optional outside siren, add $24.94. (California residents add 6% sales tax.)

(If you require more information, call during California business hours, Monday - Friday)

VISA

master charge

Dealer Inquiries Invited

CALL TOLL FREE
(800) 423-5499

California residents:
(213) 889-1414 collect

GE GUARDIAN ELECTRONICS, INC.

31117 Via Colinas, Dept. PE Westlake Village, Calif. 91361

CIRCLE NO. 27 ON FREE INFORMATION CARD

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Numbers are identified on replaceable overlays on the memory keypad. A built-in speaker functions as a tone monitor during on-hook dialing and can be used for group listening once the connection has been established. The Phone Controller can automatically redial the last number called and can be programmed to redial a number up to 14 times at one-minute intervals. Other features include compatibility with Centrex systems, access codes, and non-telephone company toll systems, a hold control and LED readout which displays number dialed, actual time, or elapsed time of a call. Calls can be made manually using a built-in Touch-Tone keypad. A Hidden Touch Lock, Flocom floating combination lock, and an audible alert discourage unauthorized use. $99.95.

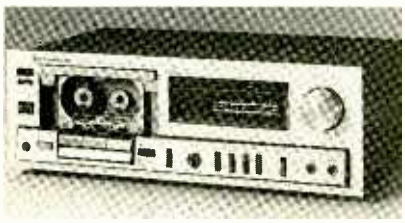
CIRCLE NO. 91 ON FREE INFORMATION CARD

Emergency CB Transceiver

General Electric's Model 3-5900 "Help" is a two-way CB communications package for those who only want to have the security of CB radio for emergency and information purposes. It requires no permanent installation and includes a compact, full-legal-power 40-channel transceiver that plugs into a car's cigar lighter socket for power when it's to be used. Otherwise it's stowed away in a case, along with supplied antenna and 12-V adapter attachment. Features are: LED channel readout, S/RF bargraph indicator, an r-f gain ("receiving range") control, anl, a built-in condenser microphone, and a channel 9 activity indicator. A push-to-talk bar is incorporated onto the small transceiver, which includes a dynamic speaker. A magnet-mount telescoping whip antenna is fed through a 10-ft (3-m) coaxial cable. $115.95.

CIRCLE NO. 94 ON FREE INFORMATION CARD

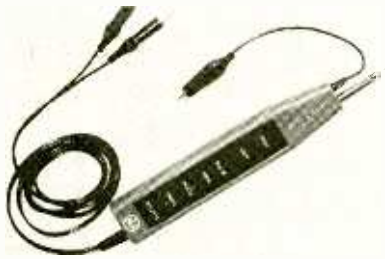
Kenwood Metal-Tape Cassette Deck



A cassette deck with Dolby noise reduction, metal-tape capability, and fluorescent peak meters has been introduced by Kenwood as Model KX-500. It features "soft-touch" controls, claimed to give the feel of expensive solenoid switches, and a tape selector switch and variable-bias control permit optimum results with any of today's tape formulations. With Dolby on and chrome, ferrichrome, or metal tape, frequency range is rated to be from 30 to 16,000 Hz, S/N at 64 dB. The drive system produces less than 0.05% wrms wow and flutter. Special features include: automatic shut-off in all modes; single RECORD button; RECORDING MUTE switch; and timer-standby. $225.

CIRCLE NO. 92 ON FREE INFORMATION CARD

Digital Logic Probe



The NLS Model MLB-1 Digital Logic Probe from Non-Linear Systems can be used to test DTL, TTL, or CMOS devices. Modes include "pulse" for dynamic testing or "memory" for stored indication. LED indicators are provided for high and low states, and a pulse indicator LED flashes during dynamic testing. Waveforms to 10 MHz with minimum pulse widths of 50 nanoseconds can be observed. Powered from the circuit under test or an external source, the probe uses go-no-go voltage thresholds for high and low states determined by supply voltage. $41.95.

CIRCLE NO. 95 ON FREE INFORMATION CARD

Winegard Indoor VHF/UHF/FM Antenna

Designed for urban and suburban locations where outdoor antennas are impractical or forbidden, the Winegard Model AT-5001 indoor antenna is said to replace and outperform "rabbit ears" on television channels 2 through 60 and stereo FM. The three-element antenna mounts on a gold-color, floor-to-ceiling pole whose height is adjustable from 7½′ to 8¼′ (2.3 to 2.5 m). Included with the antenna are a length of transmission line, a vhf/uhf/FM signal splitter, the mounting pole and two plant-hanger hooks $44.75.

CIRCLE NO. 93 ON FREE INFORMATION CARD

Posey Jogger's Aid

The new Pacesetter from John Posey Co. is a miniature beep-tone metronome designed to help you jog more efficiently. Its beep rate is adjustable from 100 to 240 per minute, simply by setting a dial control to the desired pace. The device is worn on the wrist like a watch. Includes battery. $39.95. Address: John Posey Co., 2485 Mohawk St., Pasadena, CA 91107.

Sony Portable Stereo Cassette Deck

Sony's Model TC-D5M portable stereo cassette deck is said to have features and performance comparable to those of home stereo decks. Its dc-to-dc converter is designed to maintain a high performance level, even toward the end of battery life, and assure stable high voltages. Rated operating time is up to 4 hours on two D cells. An efficient coreless motor and fre-

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quency-generator system give stable tape speed and fast start-up, while a Sendust and ferrite head make the deck metal-tape-compatible. The unit

incorporates: true VU recording meters, peak-level LEDs, Dolby noise reduction, switchable limiter, and low-impedance microphone inputs. Rated power consumption is 5.5 watts maximum. Size: 9⅜" × 6⅝" × 17/8" (237 × 168 × 48 mm); weight: 3.75 lb (1.7 kg), with battery. $700.

CIRCLE NO. 96 ON FREE INFORMATION CARD

Dc-Powered Portable Soldering Iron

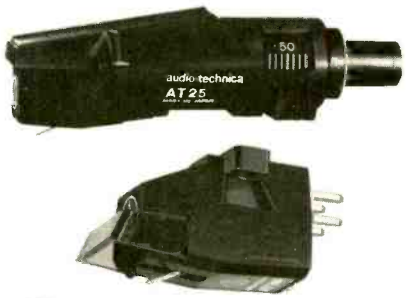
M.M. Newman Corp., has introduced the Antex Model MLX 12 portable soldering iron. The iron can be powered by any 12-volt dc source capable of supplying 2 amperes, such as car or boat batteries. Employing replaceable, plated tips that slide over the heating element, the iron is said to attain a tip temperature of 800°F (427°C) in less than two minutes from a cold start. Its 8-inch, 1.25-oz plastic handle is claimed to be heat-resistant and to remain cool during use. Leads 15-ft (4.6-m) long terminate with large alligator clips for connection to the power source. Comes with a vinyl carrying case. $19.95.

CIRCLE NO. 97 ON FREE INFORMATION CARD

Home Remote Control System

Consumer Electronics Systems' Command Base is a digital remote control system for the home. The Model TXR Command Base Transceiver, the heart of the system, impresses a digital pulse train onto the ac power line to turn on or off any of a number of remote appliance controllers. The Model CS-300 Table Top Station will control up to 300 watts; the Model

No matter how good your present stereo system, we can improve it! Here's proof:



Add effortless clarity and transparency with our new Omnitec™ series Vector-Aligned™ dual magnet cartridge or AT30E moving coil cartridge with *user*-replaceable stylus.

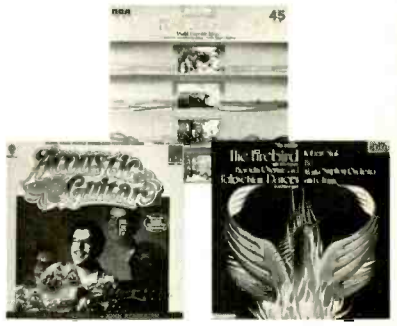
Laboratory precision is the hallmark of every A-T tone arm for home, studio, or disco.

You might pay $1000 or more for speakers almost as good as these remarkable electret stereophones.

Use our complete line of record and stylus cleaners to keep your collection sounding great years from now.

LIFESAVER is the first truly *complete* record preservative. Stops static and record wear for years.

Create your own award-winning tapes with Audio-Technica studio-quality microphones.



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When you *add* Audio-Technica, you *multiply* listening enjoyment. At leading audio stores. Write for catalog and dealer list, today.

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Catch the fastest C-meter under $200

the autoranging B&K-PRECISION 830

Model 830 $199
Model 820 $140 (not shown)

B&K-PRECISION was the first company to offer a lab-quality capacitance meter for under $150, now we're first with autoranging for under $200. The new **830** is fast, accurate and built with famous B&K-PRECISION dependability.

The 830 offers features that are tough to match at any price, such as 0.1 pF resolution, large 3½-digit LCD display and fuse protection against charged capacitors. Basic accuracy is 0.2%, much greater than the tolerance of most capacitors. Measurement range extends to 199.9 mF.

Simplicity of operation is another strong suit for the 830. For checks limited to a narrow value range, the "range hold" capability can lock the 830 onto one range —an added time saver. This feature, along with its fast reading time, makes the 830 especially valuable for incoming inspection applications.

For applications suited to manual ranging, B&K-PRECISION offers the LED readout **820** at an even lower cost.

With either B&K-PRECISION C-meter you can, measure unmarked capacitors... verify capacitor tolerance... measure cable or switch capacitance... match capacitors for critical applications ...measure complex capacitor networks ...set trimmer capacitors.

For more information, contact your local distributor and see why B&K-PRECISION is now the leading supplier of digital capacitance meters.

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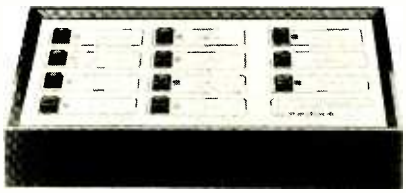
CIRCLE NO. 9 ON FREE INFORMATION CARD

CS-500 Wall Switch Station up to 500 watts; and the Model CS-1000 Plug-In Station as much as 1000 watts. The Command Base Transceiver has LEDs to indicate whether or not the appliance that has been ordered on is in fact drawing power.



Each remote controller also has a manual on/off switch. A sequencing mode can be used to enhance security controllers in a predetermined order. Command Base system units can be connected to a single-phase 117-volt line or to either phase or both phases of a two-phase, 117-volt line. Each Command Base package includes one Model TXR Transceiver, one Model CS-300 Table-Top Station, and one Model CS-1000 Plug-In Station. Additional transceivers and power controllers (as well as optional Alert Stations and Surveillance Motion Sensors) can be added.

CIRCLE NO. 98 ON FREE INFORMATION CARD

Cambridge Bookshelf Speaker System

With its rated −3-dB point of 27 Hz, the Cambridge Model 310 three-way acoustic-suspension speaker system is said to have a deeper bass response than any other bookshelf speaker on the market. Overall power response is rated at 30 to 20,000 Hz ±1.5 dB. Harmonic distortion is rated at less than 0.5% down to 40 Hz at a 20-watt input level. The Model 310 is said to deliver peak sound-pressure levels of 100 dB. $350.

CIRCLE NO. 99 ON FREE INFORMATION CARD

5/8-Wavelength CB Base Antenna

Antenna Specialists' new Model M-2117 is a 5/8-wavelength omnidirectional antenna designed for CB base station use. It employs a 22-foot (6.6-meter) vertical radiator made from aircraft-grade aluminum with swaged joints. Four 9-foot (2.5-meter) quarter-wavelength aluminum radials provide a ground plane for the vertical element. The antenna's input transformer is said to be dc grounded for both lightning protection and reduced noise pickup, and is protected from the elements by a plastic jacket. Rated gain is 5.3 dB over a conventional quarter-wave ground plane antenna. Mounting hardware is included. $42.95

CIRCLE NO. 100 ON FREE INFORMATION CARD

Handy RCA Phono Plug Adapter

A plug-in adapter that converts an RCA phono jack to single or double banana plugs and binding posts has been announced by ITT Pomona. The adapter is isolated and has gold-flashed solder turrets that allow permanent noise-free addition of components for series/parallel compensation networks. The Model 4728 adapter's binding posts are on standard 19.05-mm (0.75") centers with 4.22-mm (0.166") diameter banana jacks. Also available is the Model 4729 which has no solder turrets or isolation. $10.85 for Model 4728, $9.50 for Model 4729. Address: ITT Pomona Electronics, 1500 E. 9 St., Pomona, CA 91766.

Cetec Vega Wireless Microphones

Cetec Vega is introducing two handheld, FM wireless microphones: Model 80 is equipped with an Electro-Voice No. EV-671 cardioid dynamic microphone element, and Model 81 employs a Shure No. SM-58 cardioid dynamic element. Of the two, Model 80 is 2 ounces (57 g) lighter and ½" (1.3 cm) shorter. Rated frequency response of each is ±1 dB from 100 to 12,000 Hz and ±2 dB from 40 to 15,000 Hz; rated r-f power output is 50 mW for a claimed range up to 1000 ft. (305 m). The antenna is incorporated in the microphone housing. A 9-volt alkaline battery is said to power the unit for up to 9 hours in continuous use. Operating frequencies lie from 150 to 216 MHz. Cetec Vega wireless systems are available with or without the company's Dynex 2:1 compander. Rated S/N is 70 dB without Dynex and 90 dB with Dynex.

CIRCLE NO. 84 ON FREE INFORMATION CARD

Real-Time Audio Analyzer Kit

Logical Systems' Model 1081 Real-Time Audio Analyzer employs a matrix of 81 LEDs to display a musical signal's energy distribution across the ten audible octaves. Active filters with Qs of 2.9 and ISO center frequencies (31.2, 62.5, 125, 250 and 500 Hz; 1, 2, 4, 8 and 16 kHz) are used, and the display's vertical resolution is 3 dB per step with a rated accuracy of 0.5 dB per step. Nominal input level is 1 volt across 100,000 ohms. Barrier-block and phono-jack inputs are provided, as well as an input jack for a dynamic microphone. Built into the Analyzer is a diagnostic frequency-swept signal source. The Model 1081 Real-Time Analyzer comes in kit form with all components, an assembly and operations manual, and a black anodized, rack-mountable enclosure measuring 19" × 7" × 3½" $179.00.

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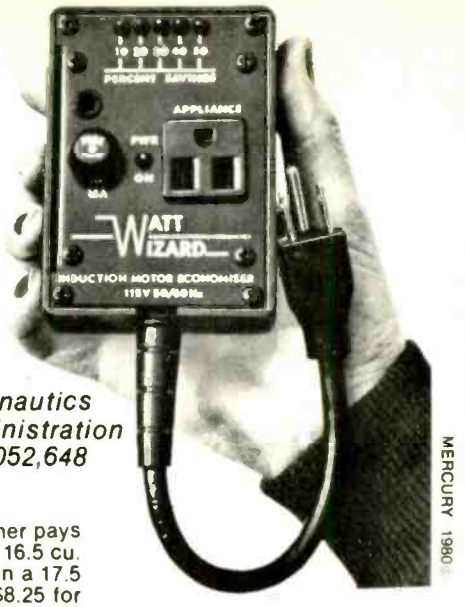

National Aeronautics and Space Administration Patent No. 4,052,648

For over a year now, in magazines and newspapers the world over, there have been enthusiastic write-ups on a remarkable new device that can cut your electric bill while helping the U.S. save huge quantities of fuel.

"The NASA/Nola power saver," wrote a **Popular Science** senior editor, "was developed by Frank Nola at NASA's George C. Marshall Flight Center as an offshoot of a program to reduce power consumption in spacecraft motors. Nola calls it a PFC — power-factor controller. I prefer to call it a power saver, however, because that's what it does."

NASA TESTED IT

According to Clyde S. Jones of NASA, "The device has been tested at Marshall Center on over 40 types of motors, with power savings ranging up to 60%, depending on the loading. The motors tested were both single-phase and three-phase, ranging from ½ H.P. to 5 H.P. Most motors will show up to 40-to-50% savings when running lightly loaded or unloaded, and some will show 5-to-7% savings at rated load."

NASA's Technical Support Package showed the test results and noted that "The Power Factor Controller applies to induction type electric motors — the most commonly used type in all major home appliances and the most commonly used by industry."

HOW IT SAVES POWER

Popular Electronics explained it this way: "AC induction motors characteristically run at a nearly constant speed that's fixed by power-line frequency and independent of load and supply voltage. When heavily loaded, the motor draws line current that is nearly in phase with the applied voltage . . . Under light load conditions, the motor develops less torque by allowing more lag between the voltage and current. This reduces the power factor while leaving the current essentially the same in magnitude.

"Though the low power factor means that conversion of electricity to mechanical power is small, the large current causes considerable (heat) losses in the supply lines and motor windings. This is what reduces efficiency.

"To minimize this waste, Nola's device monitors the motor's power factor and, when it detects light load conditions, it reduces the supply voltage . . . The current, now more nearly in phase with the voltage, therefore does as much useful work as before, but it and the voltage are smaller, resulting in a net savings of electrice power."

THE SAVINGS CAN ADD UP

Like everything else, the cost of electric power keeps going up. Not only is the basic rate you pay going up, the power companies have now added on a "fuel adjustment" charge to help pay for running their generators. In 1980, 1981 and beyond, you'll pay more and more for the privilege of running your electric appliances.

Right now, the typical consumer pays about $8 per month to operate a 16.5 cu. ft. frost-free freezer . . . $10 to run a 17.5 cu. ft. frost-free refrigerator . . . $8.25 for an attic fan operating 12 hours a day . . . and about $60 for an air conditioner used during summer months. It's not hard to figure out what you're paying per year just to run **one** of these appliances. And in many parts of the country, the cost is even higher.

That's why Nola's power saver can soon pay for itself, then start reducing your electric bills — the amount of savings, of course, depending on which appliance(s) you usetit with.

There's just one catch. Until now, the device has not been **available** — except for industrial models prices at $80 or more.

INTRODUCING THE WATT WIZARD

Cynex, an American manufacturer of electrical and electronic products and a prime contractor for the U.S. Government, has been licensed by NASA to manufacture Frank Nola's power saver. Cynex calls it the Watt Wizard.

"The Watt Wizard," says Ray Beauchea, the firm's Marketing Director, "regulates the voltage fed into an induction motor, reducing or boosting power as required, when loads go up or down. Simply stated, it makes motors run more efficiently, especially when idling. It reduces motor heat, affording longer motor life and reducing the amount of air conditioning required for cooling (rooms) in summer months. It saves electric power, because kilowatt hours are greatly reduced. And it causes the motor to run quieter."

SIMPLE TO USE

Cynex makes several models of the Watt Wizard (all with solid state design), including the 110 V AC plug-in model we're offering. It's for single phase fractional H.P. motors (less than 1 H.P.) which is the type used in most made-for-the-home freezers, refrigerators, window and attic fans, swimming pool pumps,furnace fans, vacuum cleaners, sewing machines, power drills, etc.

Simply plug the Watt Wizard into any electric outlet, then plug the appliance into the Watt Wizard. There's no wiring required. Unlike some competitor's models (if and when available), the appliance does **not** have to be turned on before being plugged into the power saver. You can leave the appliance — whether on or off — plugged into the Watt Wizard all the time. Or you can move the Watt Wizard to various locations, depending on which appliance is being used. (Better yet, order several Watt Wizards.)

OTHER MODELS AVAILABLE

Air conditioners, washers and dryers require wire-in model. If you lack mechanical skill, you probably need an electrician to install it. We also offer it in 220 VAC single or three-phase.

ADVANCE FEATURES

The Watt Wizard also includes two more unique features. It's fused, so if you accidently overload the device, it won't burn out. Just change the fuse, which is available at any auto supply store.

And the Watt Wizard features an LED readout, so you can actually tell, at any moment, exactly how much power you're saving — 10%, 20%, 30%, 40% or 50%.

There's a "Power On" light, too. And the Watt Wizard comes with the manufacturer's 1-year limited warranty.

LOW COST — AND A TAX CREDIT

We're offering the Watt Wizard for only **$39.95,** with **immediate delivery.** Want two? Then it's just **$37.95** each. Or splurge and get three at **$34.95** each. Wire-in models for heavy duty motors are **$6** more for each unit. Add just **$2.50** postage/handling for each **order** (not each unit).

And next year, when you fill out your tax return, you can deduct a full 15% energy tax credit — for additional savings.

30-DAY MONEY-BACK GUARANTEE

Try the Watt Wizard for up to 30 days. If not completely satisfied, return it (insured) for a full refund.

The sooner you send for the Watt Wizard, the more you can save on your electric bills. To order, send your check or money order to the address below. Or charge it to your Visa, MasterCharge, American Express or Carte Blanche credit card. If using your charge card, you can also order via our toll-free phone number:

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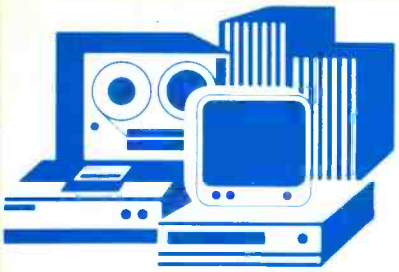

Entertainment Electronics

By Harold A. Rodgers
Executive Editor

Pseudoacoustics

THE listening environment, it has been said, is the final frontier of high fidelity. While its finality as a domain of endeavor may be in doubt, its importance to the faithful rendition of music is undeniable. This is borne out to a degree by the increasing number of signal-processing devices—graphic and parametric equalizers and delay "boxes"—addressed to the improvement of room acoustics and the emergence of loudspeakers designed to couple to room boundaries in ways that are close to optimum. The quadraphonic era itself can be seen as an expression of concern with room acoustics.

Most of the attention allotted to the listening room has been based in conventional wisdom: Is the frequency response at the listening position essentially flat? Is the reverberation time of the room correct? Do the speakers have "good" dispersion (whatever that may be)? While these approaches have yielded some worthwhile results, they have rarely been completely satisfactory. It seems now that there is another, possibly more productive, way of looking at the entire problem.

Using Psychoacoustics. In the early 1970s, the researchers M.R. Schroeder, D. Gottlob, and K.F. Siebrasse investigated what people actually heard in concert halls and what they prefer to hear. This they did by recording music in over 20 European halls using a dummy head with microphones as its "ears." The recordings were then played back in an anechoic chamber to simulate the sound of the concert hall.

In actuality, carrying out this simulation is far from a simple task. If the sound is reproduced for the listener via headphones, it tends to become localized inside his head and does not remain stationary with small shifts in head position. Loudspeaker reproduction, an alternate possibility, allows crosstalk from the right channel to reach the left ear, and vice versa. Solution of the "inverse scattering" problem for sound diffraction around the human head allows this crosstalk to be cancelled.

Data amassed from analysis of listener preferences establish that after sufficient reverberation, good bass response, and freedom from echoes, the most important parameter associated with a good concert-hall location is that the signals reaching the two ears be highly dissimilar. To put it another way, the signals at the left and right ears should show a low cross-correlation. This is an interesting result, and if we permit ourselves to speculate that listeners retain a similar preference for low interaural correlation when listening to their stereo systems, it may have important ramifications for listening-room acoustics.

A New Type of "Box". If the approach to the "inverse scattering" problem used by Schroeder et al sounds familiar, it may well be because the "Sonic Hologram Generator" included in the Carver preamp works much the same way. Actually, the idea is not new. The earliest mention of it seems to be in a paper by the late Ben Bauer, and workers at JVC have experimented with variants of it as well. Bauer discussed it at the same time he introduced his well-known headphone crossfeed circuit to simulate loudspeaker listening via headphones. He noted that the process could be reversed to give a headphonelike experience via loudspeakers, but apparently did not create a working prototype.

Carver's introduction of interaural crosstalk cancellation to commercial reality was a breakthrough in the sense that sonic enhancement comparable to, and in many ways superior to, what could be achieved by quadraphonics and time delay was now available from just two channels, not four. Since that time, others have developed processors designed to produce improved stereo from two channels. One of these new devices is the Omnisonic Imager, made by Omnisonix, Ltd., P.O. Box 307, Wallingford, CT 06942.

Where Carver has specifically stated that the operation of the Hologram depends on the use of delayed signals crossfed between the channels and phased to cancel interaural crosstalk at the listener's ears, Omnisonix makes no such claims. The Omnisonic Imager is said to "create a . . . sound environment that allows the listener to experience what amounts to three-dimensional sound reproduction . . . ."

On the basis of subjective experience, I can attest that the Omnisonix product works quite well. It seems to remove virtual sound sources from the plane of the loudspeakers and distribute them at various positions in the listening space, adding a sense of front-to-back dimension at the same time. At times, some sounds appear to come from in back of the listener, which is a startling effect, given that sound is being radiated only from the front. Another effect the device produces is a greatly increased sense of ambience or "spaciousness." As one might expect from a modern electronic device, no traces of audible noise or distortion sully the Omnisonic Imager's output.

On comparison of the Omnisonix and the Carver, I found no immediately obvious basis for concluding that one sounds more "right" than the other, but the two sound quite different. The Omnisonix has the edge on dramatic ambience, while the Carver produces a wider stereo image and a somewhat more definite location of sound sources. Both sound best at the "sweet spot" midway between the speakers, but where the Carver image deteriorates quickly as one moves from that favored location, the Omnisonix is more tolerant of off-center location. Bass boost, unintentional in the Carver but purposeful in the Omnisonix, is characteristic of both; in each I preferred to cancel this with tone controls as best I could. Interestingly, although it is not clear why this should be the case, the devices are compatible and produce interesting effects in combination. Explanations of how these arise will have to wait until both companies reveal more details about how the products work. All we know of the Omnisonic Imager is that it uses interchannel crossfeed and bass boost.

The Omnisonic Imager.

The Ambient Benefits. Curiously, both of these devices, although capable of optimum effect only for a listener at a fairly precise location in the room, enhance the sound at other locations too. Clearly, this cannot be a result of crosstalk cancellation, for

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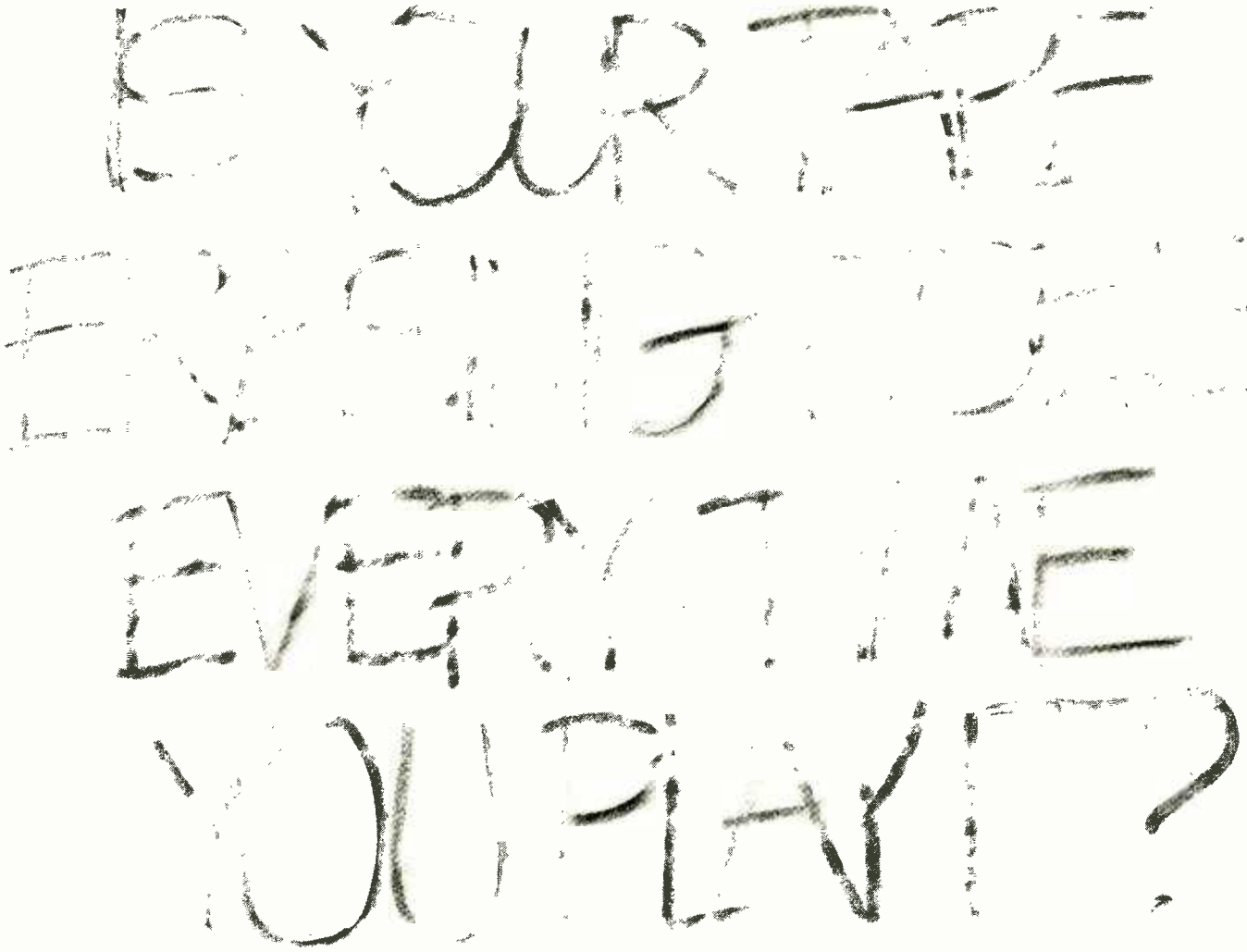

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this cannot be accomplished more than a short distance away from the intended location. Corroborating this conclusion is the observation that a noticeable change is heard in headphone listening when these devices are used, and significant interaural crosstalk, of course, cannot arise under these conditions at all.

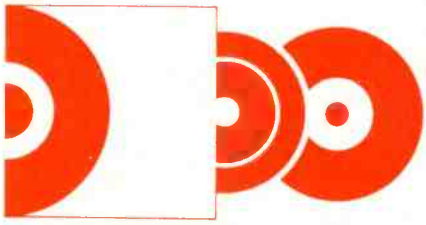
On the basis of listener preference for relatively uncorrelated signals at the ears, it is possible to conjecture that in each of these systems, the crossfed signals make the left and right channels less correlated than they otherwise might be. As a result, the "acoustics" of the recording, stereo system, and room in combination improve. Interesting too is the fact that low ceilings—one of the factors found to create strongly *correlated* reflections in concert halls—are common in living rooms. As the Omnisonic and Carver processors, unlike that used by Schroeder and co-workers, are not intended for use in anechoic chambers, their designers may have had to take room reflections into account. Compensation for such reflections may well improve the acoustics at many points in the room.

Whatever the exact explanation of the workings of these devices, they are certainly enjoyable. Another tantalizing property that we've noted in them is the ability to make near-field listening (sound sources within a few inches of the ears) more plausible. A report on that will come in the future. Also on the way is an image-enhancement box from Sound Concepts.

Some Thoughts on Signal Processing. Recently, while listening to a dbx-encoded disc, I heard something in the dynamics of the music that seemed a bit strange. My first thought was: "Aha—something fooled that box into making a false transient." Some reflecting on this convinced me that this was not necessarily a fair conclusion, as the only reason I had fixed on that particular transient was that I hadn't expected it to sound that way. Considering the very short time for which I had heard it, to conclude that the transient was not as the conductor and engineer had planned was rash. Were it otherwise, any unexpected happening in a recording could be dismissed by the listener as an error.

If there is any lesson that is to be learned here, it is that full enjoyment of a signal-processing device depends on trusting it implicitly. Most manufacturers of these devices have not told us enough to inspire such trust. Even demonstrating a double-ended compander (a la dbx, Dolby, or High-Com) against master tapes does not settle the issue, for no manufacturer seems likely to demonstrate his product at its worst. Yet the worst-case performance is precisely the point of greatest interest.

What would help, in my opinion, is more information: psychoacoustic theory on which operating parameters are decided, results of tests, simple checks to establish that the equipment is working correctly, etc. Often, in the service of keeping proprietary secrets, such information is concealed. However, releasing more of it to the public could make a substantial contribution to credibility. ◇



Audiophile Recordings

DUKAS: ***The Sorcerer's Apprentice***; CHABRIER: ***España***; DEBUSSY: ***Fetes*** from ***Nocturnes***; and ***Prelude*** to the ***Afternoon of a Faun***. Zoltan Rozsnyai conducting the Philharmonica Hungarica. M & K Realtime Records RT-202 (dbx PS-1005). This is another of the new digital recordings, preencoded in the dbx compander format and playable only with a dbx decoder. This disc makes good use of the fact that dbx processing allows lower cutting levels, for its loudest passages are free of the incipient signs of strain heard from even fine phono cartridges when recorded velocities get too high. Let the system gain wiggle instead of the stylus. The sound of the orchestra is very well captured, and the performances are, in general, very neat as well as expressive and elegant. But here, as elsewhere in specialty discs, the tendency to produce excerpts rather than whole selections and keep the program "light" is still evident.

JON JARVIS: ***EVOLUTIONS I***. Crystal Clear CCS-8004. Each side of this album consists of a single, nonstop free improvisation. There are some nice moments in the music, and some luscious, well recorded piano sound, too. It may be that I am missing the essential spontaneity of the work, but I found the arbitrary sequences of musical ideas a bit distracting and in need of some unification. The music darts, dodges, and changes direction as though it were the background for an animal cartoon (there he is running from the dog . . . now climbing . . . now falling . . . whew, safe home at last), but without the cartoon. It is unfortunate that Jarvis didn't tell *what* he was improvising on. That would let the listener into the game too. Th-th-that's all folks!

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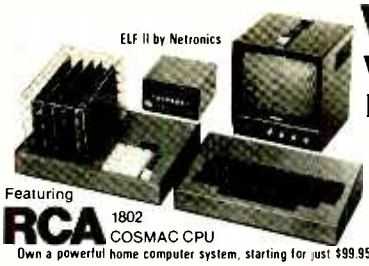

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Netronics proudly announced the release of the first 1802 FULL BASIC, written by L. Sandlin, with a hardware floating point RPN math package (requires 8k RAM plus ASCII and video display boards), $79.95 plus $2 p&h. Also available for RCA VIP and other 1802 systems Board includes area for a ROM version.

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ELF II Gives You The Power To Make Things Happen!

Expanded, ELF II can give you more power to make things happen in the real world than heavily advertised home computers that sell for a lot more money. Thanks to an ongoing commitment to develop the RCA 1802 for home computer use, the ELF II products—being introduced by Netronics—keep you right on the outer fringe of today's small computer technology. It's a perfect computer for engineering, business, industrial, scientific and personal applications.

Plug in the **GIANT BOARD** to record and play back programs, edit and debug programs, communicate with remote devices and make things happen in the outside world. Add **Kluge** (prototyping) **Board** and you can use ELF II to solve special problems such as operating a complex alarm system or controlling a printing press. Add **4k RAM Boards** to write longer programs, store more information and solve more sophisticated problems.

ELF II add-ons already include the **ELF II Light Pen** and the amazing **ELF-BUG Monitor**—two extremely recent breakthroughs that have not yet been duplicated by any other manufacturer.

The ELF BUG Monitor lets you debug programs with lightening speed because the key to debugging is to know what's inside the registers of the microprocessor. And, with the ELF-BUG Monitor, instead of single stepping through your programs, you can now display the entire contents of tha registers on your TV screen. You find out immediately what's going on and can make any necessary changes.

The incredible ELF II Light Pen lets you write or draw anything you want on a TV screen with just a wave of the "magic wand." Netronics has also introduced the ELF II Color Graphics & Music System—more breakthroughs that ELF II owners were the first to enjoy!

ELF II Tiny BASIC

Ultimately, ELF II understands only machine language—the fundamental coding required by all computers. But, to simplify your relationship with ELF II, we've introduced an **ELF II Tiny BASIC** that makes communicating with ELF II a breeze.

Now Available! Text Editor, Assembler, Disassembler And A New Video Display Board!

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ELF II's **Assembler** translates assembly language programs into hexidecimal machine code for ELF II use. The Assembler features mnemonic abbreviations rather than numerics so that the instructions on your programs are easier to read—this is a big help in catching errors.

ELF II's **Disassembler** takes machine code programs and produces assembly language source listings. This helps you understand the programs you are working with—and improve them when required.

The new **ELF II Video Display Board** lets you generate a sharp, professional 32 or 64 character by 16 line upper and lower case display on your TV screen or video monitor—dramatically improving your unexpanded $99.95 ELF II. When you get into longer programs, the Video Display Board is a real blessing!

Now Available!

☐ **A-D/D-A Board Kit** includes 1 channel (expandable to 4) D-A, A-D converters, **$39.95** plus $2 postage & handling. .

☐ **PILOT Language**—A *new* **text-oriented** language that allows you to write educational programs on ELF II with speed and ease! Write programs for games. . . unscrambling sentences. . . spelling drills. . . "fill in the missing word" tests, etc.! PILOT is a must for any ELF II owner with children. *PILOT Language on cassette tape, only $19.95 postpaid!*

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☐ Deluxe Metal Cabinet with plexiglas dust cover for ELF II $24.95 plus $2.50 p&h

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Computer Terminal

COMPLETE FOR ONLY . . . $149.95

The Netronics ASCII/BAUDOT Computer Terminal Kit is a microprocessor-controlled, stand alone keyboard/terminal requring no computer memory or software. It allows the use of either a 64 or 32 character by 16 line professional display format with selectable baud rate, RS232-C or 20 ma. output, full cursor control and 75 ohm composite video output.

The keyboard follows the standard typewriter configuration and generates the entire 128 character ASCII upper/lower case set with 96 printable characters. Features include onboard regulators, selectable parity, shift lock key, alpha lock jumper, a drive capability of one TTY load, and the ability to mate directly with almost any computer, including the new Explorer/85 and ELF products by Netronics.

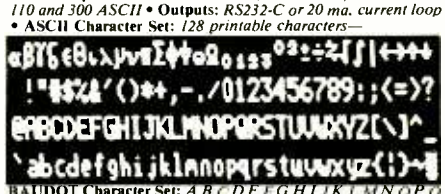
The Computer Terminal requires no I/O mapping and includes 1k of memory, character generator, 2 key rollover, processor controlled cursor control, parallel ASCII/BAUDOT to serial conversion and serial to video processing—fully crystal controlled for superb accuracy. PC boards are the highest quality glass epoxy for the ultimate in reliability and long life.

VIDEO DISPLAY SPECIFICATIONS

The heart of the Netronics Computer Terminal is the microprocessor-controlled Netronics Video Display Board (VID) which allows the terminal to utilize either a parallel ASCII or BAUDOT signal source. The VID converts the parallel data to serial data which is then formatted to either RS232-C or 20 ma. current loop output, which can be connected to the serial I/O on your computer or other interface, i.e., Modem.

When connected to a computer, the computer must echo the character received. This data is received by the VID which processes the information, converting to data to video suitable to be displayed on a TV set (using an RF modulator) or on a video monitor. The VID generates the cursor, horizontal and vertical sync pulses and performs the housekeeping relative to which character and where it is to be displayed on the screen.

Video Output: *1.5 P/P into 75 ohm (EIA RS-170)* • **Baud Rate:** *110 and 300 ASCII* • **Outputs:** *RS232-C or 20 ma. current loop* • **ASCII Character Set:** *128 printable characters—*



BAUDOT Character Set: *A B C D E F G H I J K L M N O P Q R S T U V W X Y Z - ? : • 3 $ # ( ) . , 9 0 1 4 ' 5 7 ; 2 / 6 8* • **Cursor Modes:** *Home, Backspace, Horizontal Tab, Line Feed, Vertical Tab, Carriage Return. Two special cursor sequences are provided for absolute and relative X-Y cursor addressing* • **Cursor Control:** *Erase, End of Line, Erase of Screen, Form Feed, Delete* • **Monitor Operation:** *50 or 60Hz (jumper selectable.*

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☐ **Video Display Board Kit** alone (less keyboard), **$89.95** plus $3 postage & handling.

☐ **12" Video Monitor** (10 MHz bandwidth) fully assembled and tested, **$139.95** plus $5 postage and handling.

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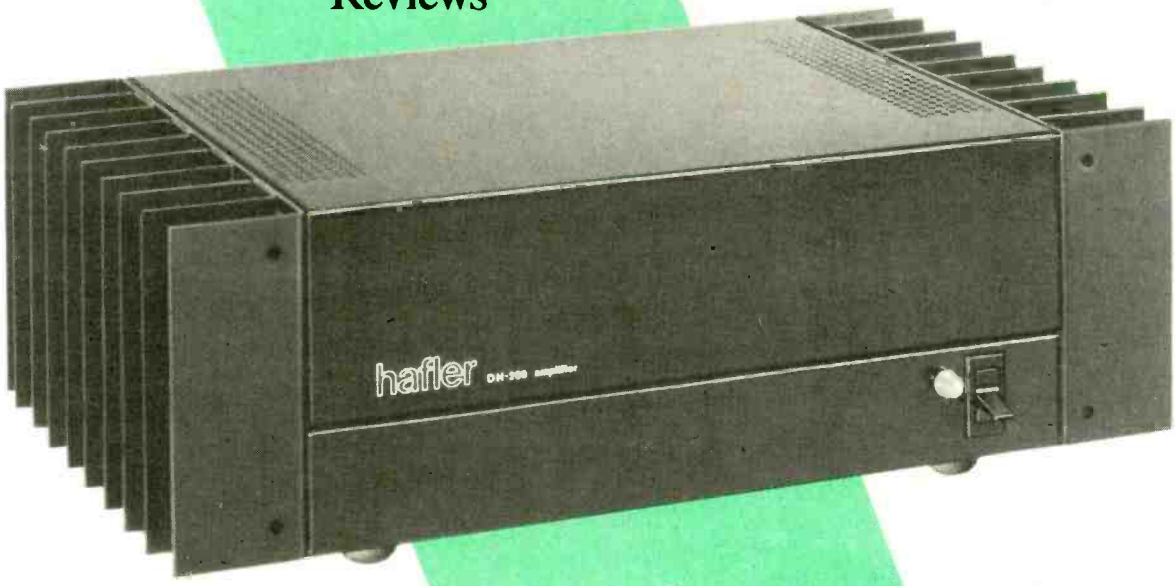
Audio Equipment Reviews



Hafler Model DH-200 Basic Power Amplifier

by Julian Hirsch

Power MOSFETs in output stages provide awesome current capability.

THE Model DH-200 basic power amplifier from the David Hafler Company is a new design that, in some respects, advances the standards of audio performance. Its salient feature is the use of power MOSFETs instead of bipolar transistors in its output stages. Power delivery is rated at 100 watts/channel into 8 ohms from 20 to 20,000 Hz with no more than 0.002% total harmonic distortion and 0.005% intermodulation distortion from 1 to 100 watts. Rise time is specified at 2 microseconds, and slew rate is given as 30 volts/microsecond.

Unlike the bipolar transistor, whose gain increases as it becomes hotter until it catastrophically destructs, the MOSFET's gain falls off with rising temperature. This makes the MOSFET immune to thermal runaway and greatly simplifies the circuitry needed for its protection. It also eliminates the sonic aberrations attributed to some of the protective circuits used with bipolar transistors. In the DH-200, a power-line fuse, thermal circuit breakers, individually fused dc power lines to the output stages, and speaker fuses provide all the necessary protection. None of these has any effect on the dynamic operation of the amplifier or its sound.

Finished in flat black, the amplifier measures 16"W × 10½"D × 5⅛"H (406 × 267 × 130 mm) and weighs 26 lb (11.8 kg). Price is $299.95 for the kit, $399.95 for the factory-wired version. Options include: 19" (483-mm) rack-mount panel for $24.95; an input bridging circuit that converts the DH-200 into a 200-watt mono amplifier for $24.95; multitap power transformer for operating the amplifier from 100-to-120-volt to 200-to-240-volt, 50/60-Hz power sources (standard transformer is for 117-volt, 60-Hz operation only) for $25.00.

Laboratory Measurements. The FTC-mandated preconditioning period left the top cover of the DH-200 fairly hot directly above the output transistors but the heat sinks themselves were relatively cool. THD with an 8-ohm load at 1000 Hz was extraordinarily low, reaching a mere 0.003% at 130 watts. (The outputs clipped at about 135 watts/channel.) IM distortion was 0.012% at 130 watts. With a 4-ohm resistive load, THD reached only 0.003% at 170 watts, with clipping at 193 watts.

Normally, to protect 8-ohm speakers from overdrive, the output lines of the DH-200 are fused at 2 amperes; but with low-impedance speakers, 5-ampere fuses can be used with safety. These, of course, limit the maximum continuous output into 2-ohm loads to 50 watts, a level at which THD was only 0.0022%. Short-term output capability was extraordinary—180

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HEAR WHAT YOU'VE BEEN MISSING!

Listen with an 801 Omnisonic Imager,™ a quantum leap forward in stereo reproduction!

OMNISONIC IMAGERY™ IS HERE!
Our innovative state-of-the-art electronics create a totally unique sound environment never before possible. With an 801 Omnisonic Imager™, you can now experience the physiological sensation of what amounts to three-dimensional sound reproduction — what we call omnisonic imagery™ — from just *two* speakers! Sound appears to come from many sources in the listening area, depending on the quality of the signal source. A common reaction is to look about for other speakers. *And you don't have to sit rigidly fixed at a focal point between the speakers to enjoy omnisonic imagery™!*

RETROFITS TO MOST STEREO SYSTEMS!
Any unit with a tape monitor facility (internal tape loop) can mate with an 801 Omnisonic Imager™. It also has a built-in tape monitor button so you don't lose your existing tape monitor facility.

The 801 Omnisonic Imager™ works on any stereo source — FM, tapes, and records. You can record selections via the 801 Omnisonic Imager™ and replay them on conventional home-use stereo equipment.

THREE DIMENSIONS IN SOUND!
Stereo without an 801 Omnisonic Imager™ produces sound from two distinct sources. Music from the speakers arrives at your ear, but most of it falls to the floor. The result is often "muddiness" and loss of presence. Only two dimensions result — volume level and stereo separation.

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LIFETIME WARRANTY!
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watts into 8 ohms (equivalent to an IHF Dynamic Headroom of 2.6 dB), 312 watts into 4 ohms, and a staggering 478 watts into 2 ohms. Clearly, the excellent performance of the amplifier is maintained even with extremely low load impedances. IHF clipping headroom, relative to the rated 100-watt output, was 1.3 dB at 8 ohms.

The low distortion of the DH-200 was maintained over the full audio bandwidth. Driving 8-ohm loads, the worst-case reading was 0.0012% at 20,000 Hz and rated power.

Frequency response was as flat as we could measure, with less than ±0.25 dB variation between 20 and 20,000 Hz. Rise time was 2 microseconds, and the slew rate was 33 volts/microsecond, both figures slightly better than ratings. IHF slew factor was 7.5 With a full-power input drive level, the output waveform began to distort at 150 kHz. Input sensitivity, as rated, was 150 millivolts for a reference output of 1 watt (1.5 volts for the rated 100 watts). A-weighted noise output was less than 100 microvolts, which is better than the rated −90 dB relative to a 1-watt output, or −110 dB referred to rated output power.

User Comment. The test data for the DH-200 speaks eloquently for the excellence of its performance. Even an approximate measurement of the distortion levels in this amplifier requires the most advanced test equipment and special techniques. As for the sound of the amplifier, we can only state that, to us, a really good, properly operating amplifier has none of its own. Under any reasonable listening conditions that we could devise, the DH-200 sounded no different from other high-quality amplifiers to which we compared it. Of one thing we feel certain—it will never limit the sound quality of a music system and, hence, deserves the best possible signal source and speaker systems.

One respect in which we would expect the DH-200 to excel (although it would be needed in relatively few home music installations) is its ability to deliver very high currents. We were told by Hafler that the amplifier can drive 10 amperes into a short circuit without damage. (It soon overheats and is shut off by its thermal circuit breakers.) We did not verify this, but in driving almost 500 watts into a 2-ohm load without clipping, the amplifier delivered a current exceeding 15 amperes on a short-term basis. Combined with the excellent stability of the amplifier (it is not significantly disturbed by heavy capacitive loads), this current capability suggests to us that it should be able to drive any speaker systems likely to be used in a home music system.

The toughest use test we could devise was to parallel several pairs of speaker systems presenting the amplifier with a load of slightly less than 2 ohms. We drove the speakers at the highest volume levels our ears would tolerate, switching between the DH-200 and another good amplifier of conventional design rated at only slightly less power. When the other amplifier was plainly clipping—and sounding "mushy"—the DH-200 was still delivering clean, undistorted sound. This is a *big* 100-watt amplifier that might well outperform amplifiers with higher power ratings when load impedances get low.

Considering the extraordinary performance of the Hafler DH-200, its price, especially in kit form, makes it something of a bargain. The kit represents one of the easier ways we know to save $100 when assembling a music system.

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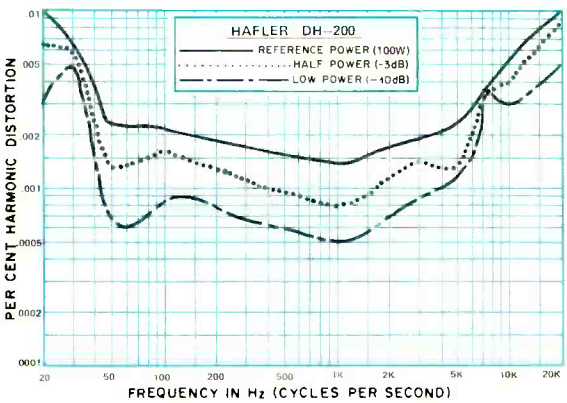
Building the Kit

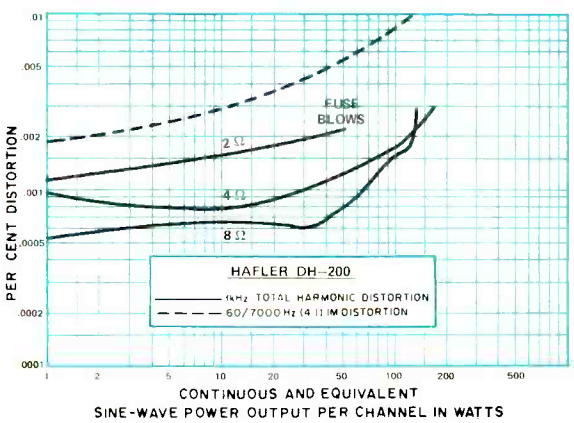
The Hafler DH-200 is the easiest kit I have ever built. Working very slowly and triple-checking each step, I was able to complete it in 6 hours, 15 minutes. The amplifier worked perfectly on its initial trial and thereafter.

I do have some suggestions for anyone building this kit. Attaching the green wire to the RM lug No. 1 in step 43 is better done *before* capacitor CL is installed. In step 45, the 2 3/4" wire is a little too short; 3" would be fine.

My biggest complaint is that, while the assembly manual states that soldering leads to the circuit boards is simplified by temporarily removing the boards from the heat sinks, the builder is instructed to attach the heat sinks before the soldering is complete. I found it better to provide adequate working room by temporarily disconnecting the heat sinks. The few minutes required by these extra steps do not significantly lengthen assembly time.—*Ed Buxbaum, Art Director*



Distortion with 8-ohm load for three power levels.



1000-Hz THD, both channels driven, left measured.

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Vector Research VCX-600 Cassette Deck

otor transport is programmable
tomatic stop, rewind, and replay

THE Vector Research VCX-600 is a deluxe three-head cassette deck with a logic-controlled two-motor transport. Among its operating conveniences is a MEMORY system for automatic stop or replay when the tape has rewound to a 000 index counter reading. Rewind can be made to occur automatically at the end of a tape, permitting automatic repetition of a tape in whole or part.

The VCX-600, which is compatible with metal tapes, has a vernier bias adjustment for optimizing performance with different tape formulations. A programmable music search feature gives fast access to up to 8 recorded selections per cassette. Recording and playback levels are indicated on parallel rows of fast-responding green LEDs from −20 dB to 0 dB, with red LEDs from 0 to +8 dB.

The Vector VCX-600 is finished in black, with clearly contrasting white panel markings. Its overall dimensions are 17⅜"W × 5⅝"H × 14¾"D (440 × 142 × 375 mm), and it weighs 22 lb (10 kg). Suggested retail price is $750.

General Description. The door over the cassette well is opened by pushing the EJECT button. Small momentary-contact pushbuttons, whose functions can be duplicated by an optional, plug-in remote-control accessory, actuate the transport solenoids. Lights adjoining the buttons show the recorder's operating mode. It is possible (except while recording) to go from any mode to any other without first using the STOP button.

With the recorder in PLAY, pressing either the REW/RVW or the FF/CUE button moves the tape at high speed, allowing modulation on the tape to be heard at a low level to aid in locating specific passages. When the button is released, the machine returns to PLAY. For normal FAST FORWARD or REWIND, the tape is first brought to a stop and one of the fast-speed buttons is touched momentarily.

The MEMORY system stops the tape when it has rewound to a 000 index counter reading. If the AUTO PLAY button is also engaged, the machine goes immediately into PLAY. In addition, AUTO REWIND automatically switches the machine to REWIND at the end of a tape.

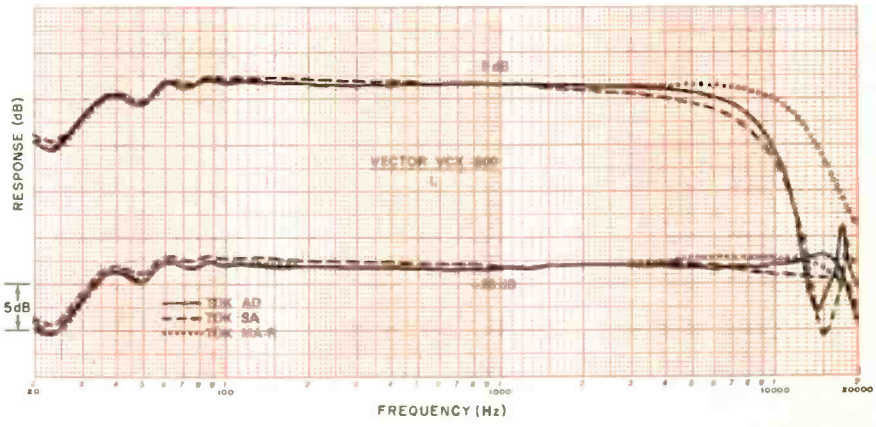
When MUSIC SEARCH is touched (in normal PLAY) a warning light on the panel starts to blink. A touch of REW/RVW or FF/CUE will, respectively, cause the tape to rewind to the beginning of that selection or advance to the beginning of the next selection; the recorder then goes back into normal PLAY.

A system called PROGRAMMABLE MUSIC SEARCH is controlled by buttons marked from 1 through 8, plus CLEAR. The user chooses the selections to be played by touching the appropriate buttons before pressing PLAY. The tape advances rapidly to the first selected segment and plays it, after which it advances to the next one, and so on. The program can be erased at any time by touching CLEAR. This feature, like MUSIC SEARCH, operates by sensing the quiet intervals between recorded selections, provided these are at least 3 seconds long.

The LED level display reads peak program levels; its 0-dB index corresponds to the standard Dolby level of 200 nW/meter. Concentric knobs with a slip-clutch coupling set the recording levels for the two channels, and there is a separate playback level knob. Switches select bias and equalization for FE, CO, and METAL tapes. Equalization time constants are identified as 70 or 120 microseconds, and bias levels are expressed in terms of relative percentages: FE = 100%; CO = 150%; METAL = 250%. A small bias vernier knob adjusts each of these over a nominal ±10% range.

A single three-position switch turns on the Dolby system, with or without the 19-kHz FM stereo pilot filter. Another switch connects either the SOURCE or the TAPE playback programs to the line outputs.

Laboratory Measurements. The Vector VCX-600 is biased for TDK AD (FE), TDK SA (CO), and TDK MA-R (METAL) tapes, which were used for our laboratory evaluation. A 0-dB recording level was obtained with a line input of 55 millivolts; the corresponding playback output was 0.575 volts regardless of tape type.



Frequency response for three types of tape.

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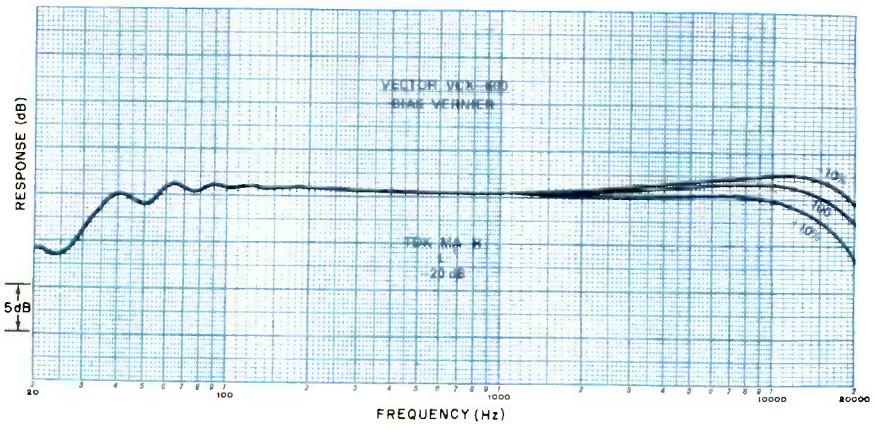

Frequency response for MA-R tape showing effect of bias vernier.

Sensitivity of the MIC input was 0.24 millivolts, with overload at a safe 53-mV level.

Recorded at a 0-dB level at 1000 Hz, AD and SA tapes produced about 1% third-harmonic distortion, while MA-R produced 1.4%. The respective levels corresponding to 3% (reference) distortion were +4, +5, and +4.5 dB. Signal-to-noise ratio was measured unweighted, with A-weighting, and using the Dolby system with CCIR/ARM weighting, for each of the tapes. AD gave readings of 50.5, 58, and 64.5 dB; SA 53.5, 59.7, and 66.5 dB; and MA-R 50, 59, and 65.5 dB. Noise increase for the MIC input at maximum gain was 3.5 dB, indicating a very quiet microphone preamp.

Erasure of a 0-dB, 1000-Hz recording left a residual signal level of −66 dB on SA and unmeasurable levels on the other tapes. Crosstalk between tracks (at 1000 Hz) was −58 dB, with a TDK AC-352 test tape.

Flutter of the transport, measured with a TDK AC-342 test tape, was a very low 0.04% weighted rms (JIS) and ±0.07% weighted peak (CCIR). Speed, measured on the basis of the 3000-Hz tone on the TDK AC-342 tape (whose accuracy is specified as 0.03%) was fast by about 0.9%. FAST FORWARD moved a C-60 tape over its length in 79 seconds; REWIND took 86 seconds.

Record/playback frequency response was measured for each tape with the bias adjustment control at its nomimal (center) setting. At a −20-dB recording level, all three tapes gave exceptionally flat response; AD was ±1 dB from 40 to 17,500 Hz, SA was within +0.5, −1 dB from 40 to 18,000 Hz, and MA-R was within ±1 dB from 40 to 16,000 Hz. The high-frequency response of each tape could be trimmed slightly with the bias control, but the center settings were close to optimum. We made a check of the METAL setting with Scotch Metafine and found that a −10% bias gave results much like those obtained with MA-R tape at the nominal setting.

Substantial differences between tapes were evident at a 0-dB recording level. With AD and SA tapes, the 0-dB playback curve intersected the −20-dB curve at 12,500 to 13,000 Hz; MA-R, on the other hand, gave about 15 dB more output at 13,000 Hz than the others, and its 0-dB and −20-dB curves did not intersect within the audio range. The test results confirmed the existence of additional headroom in metal-alloy tapes.

Spectrum-analyzer photographs give a dramatic illustration of the difference between metal alloy and oxide based tapes. The input signal (lower trace in each photo) consisted of 14,000 and 15,000 Hz at equal amplitudes, with a combined peak level equal to that of a 1000-Hz tone that gave a 0-dB meter reading. Frequency scan extends from 0 to 20,000 Hz, with a vertical scale of 10 dB per division. The upper trace is the playback from the recorder. Levels of the 14,000- and 15,000-Hz signals in the playback from the TDK AD and SA tapes are down by 23 to 25 dB compared to the input level. In addition, a large number of odd-order intermodulation products (up to the 13th order) fills the spectrum between 8000 and 20,000 Hz. TDK MA-R gives the two input tones a playback level 18 to 20 dB hi... odd-ord... and 7th).

Playbac... 600 was mea... 120 microseco... ing test tapes fr... BASF. In genera... within ±1 dB from... the range covered by...

The LED readout ... rapidly to short-durat... reading 100% of steady-s... on the 0.3-second tone burs... verify the ballistic response of ... ters. A standard Dolby level tap... a reading of about +1 dB on ... recorder's indicators. The resolut... of the LED segments is about 1 d... near a 0-dB reading and from 3 to 5 dB elsewhere.

The headphone output of the VCX-600, which is unaffected by the volume control, is nominally specified for 8-ohm phones. We found the level inadequate to drive phones that, like most high-fidelity models, have impedances of 200 ohms or more.

User Comment. Although the operation of the Vector VCX-600 cassette deck is basically straightforward, familiarization is needed in order to realize the full potential of some of its unusual features. The MUSIC SEARCH feature allows the attractive option of exploring the content of a tape containing a number of recorded selections, much as one would sample a phonograph record by cueing the pickup manually to the beginning of each band. If a few seconds listening to a taped selection shows that it is not to one's liking, a touch of MUSIC SEARCH and FF/CUE speedily advances the tape to the next selection, which begins automatically.

Recording and playback performance of the VCX-600 was first rate. Even such demanding signals as interstation FM tuner hiss could be recorded and reproduced with no audible differences, even at rather high levels. (Such hiss makes a good test signal for fine adjustment of bias.)

Lower flutter readings than those of the VCX-600 are hard to find, and the S/N with Dolby is very good, with little dependence on choice of tape. The convenience features of the deck and its ability to "fine-tune" bias represent definite advantages. While the VCX-600 is not cheap, it affords excellent value for its price.

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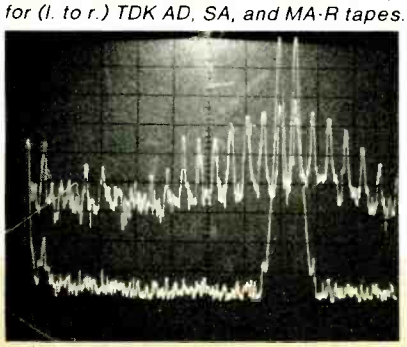
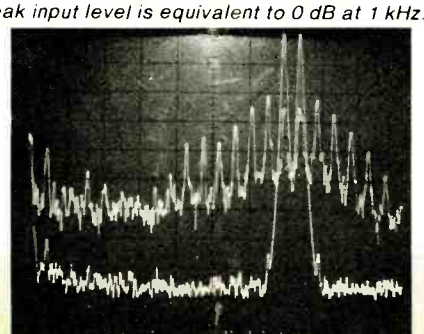
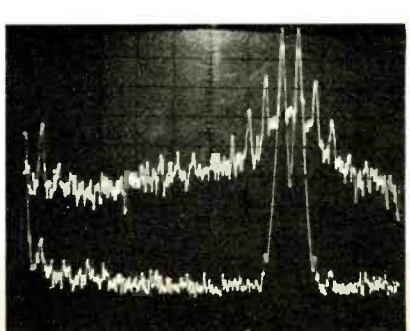
(More Reports on page 29)

Spectra (upper traces) of playback response from combined 14- and 15-kHz tones for (l. to r.) TDK AD, SA, and MA-R tapes. Peak input level is equivalent to 0 dB at 1 kHz.







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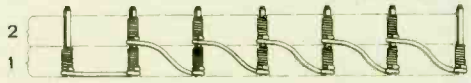

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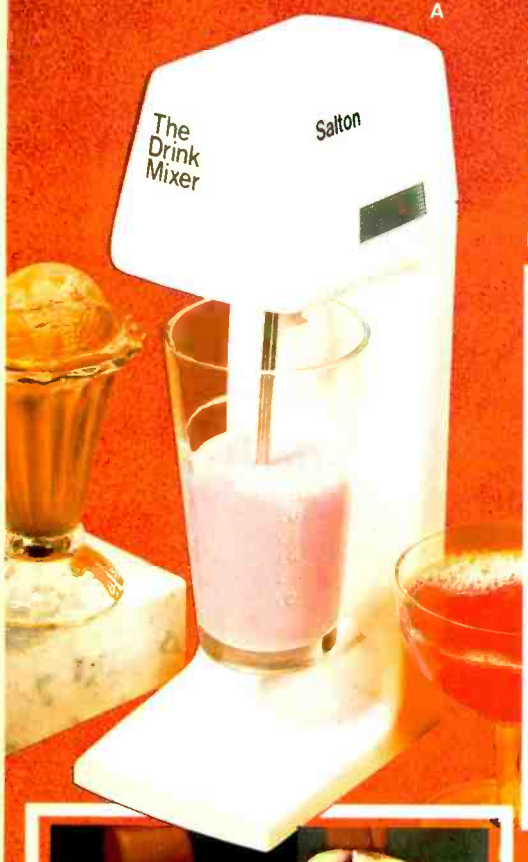

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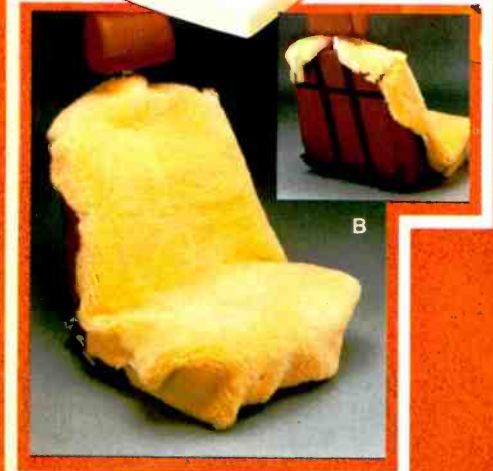

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Avid Model 110 Speaker System

Designed for "minimum diffraction" to reduce "boxy" sound caused by surface discontinuities

THE Avid Model 110 is a compact two-way speaker system, suitable for either bookshelf or floor installation. It incorporates Avid's "minimum diffraction" design, intended to reduce the "boxy" coloration that can arise from diffraction of the sound at sharp discontinuities of the cabinet and drivers.

Model 110 is moderately efficient, and is meant for use with amplifiers delivering from 15 to 100 watts of program power. It has an 8" (20 cm) woofer, operating in a sealed enclosure and crossing over at 2500 Hz to a 1" (25.4 mm) soft dome tweeter. There are no external level or balance adjustments. Nominal impedance rating is 8 ohms.

The model 110 cabinet is finished in walnut vinyl veneer. It is 21 3/8" × 12 1/4" × 9 3/8" deep (543 × 311 × 238 mm). The snap-on grille is covered in brown cloth. Weight of the speaker is 28 lb (12.7 kg). Suggested retail price is $145.

General Description. The Avid "minimum diffraction" design is in evidence as soon as the grille is removed. The wooden front of the cabinet is completely finished, and except for the function that the grillework performs in reducing diffraction, there would be no aesthetic objection to operating the speaker without it.

The woofer and tweeter are as close together as possible, and surrounding each is a ring that extends 3/8" in front of the front cabinet surface. In the case of the tweeter, the inner portion of the ring is flared to serve as a matching device for the dome radiator. Avid calls this an "optimum dispersion coupler" and says that it improves dispersion as well as reducing diffraction. The grille cloth is mounted on a 3/8" thick board, cut out to form a junction with the "optimum dispersion coupler" and the similar ring around the woofer. Thus, there is no discontinuity between the front of each driver and the front surface of the grille. Finally, the solid front grille has smoothly rounded nondiffracting edges.

The Avid Model 110 has a rated frequency response of 48 to 20,000 Hz ±3 dB and a nominal impedance of 8 ohms with a minimum of 6 ohms. Polar response curves supplied by the manufacturer indicate relatively wide dispersion over the audio band.

Laboratory Measurements. The mid- and high-frequency response curve of the Avid Model 110 was as flat as our measurement process can show. It varied by only ±1 dB from 100 to 6000 Hz. A gradual rise to +4 dB at 13,000 Hz and a drop to −2 dB at 20,000 Hz relative to the midrange level was actually within our measurement uncertainty. The bass response curve, which probably exceeds the treble curve in accuracy of measurement, was flat within about 1 dB from 200 to 1000 Hz, rising gently to +3.5 dB between 60 and 80 Hz and falling off at 12 dB per octave below about 50 Hz. Our composite frequency response curve of the Model 110, made by splicing the bass and mid/high curves together, showed a variation of ±3 dB from 43 to 20,000 Hz, slightly surpassing Avid's ratings.

The fine transient response suggested by frequency response such as this was confirmed by our tone-burst measurements. These showed clean, undistorted bursts throughout the operating frequency range of the speaker, with envelope shapes almost completely independent of microphone position.

At a nominal 1-watt input, woofer distortion was between 0.5% and 0.9% down to 50 Hz, rising to 2.8% at 40 Hz and 5.6% at 35 Hz. Increasing the drive to 10 watts gave typical distortion readings between 2% and 3% down to below 50 Hz, increasing to 8.5% by 40 Hz.

Impedance of the Model 110 was exceptionally constant with frequency, measuring between 7 and 10 ohms from 80 to 20,000 Hz. The maximum of about 28 ohms occurred at the bass resonance frequency of 53 Hz. Sensitivity, for an acoustic suspension system, is relatively high: a sound pressure level of 88 dB at 1 meter is produced from a drive signal of 2.83 volts (1 watt) of random noise in an octave centered at 1000 Hz.

User Comment. Despite the uncertain correlation between measured frequency response and subjective qualities of a loudspeaker, it has been our experience that flat, uniform response is likely to come from any speaker with a really good sound, and vice versa. Thus, we were not surprised by the neutral, transparent sound of the Model 110. Its deep-bass capability is limited, but sufficient to fill a room of moderate size. Although its power ratings (up to 100 watts of program material) are realistic, and we used most of the output of a 200-watt-per-channel amplifier on our pair of 110's with excellent results, we would not drive this speaker at sustained high levels, especially in a large room.

Perhaps the most outstanding characteristic of the Model 110 is the absence of upper-bass coloration. It is as free of "boom" as any speaker we have ever heard, and rendered male voices with unusual naturalness. If this banishment of "boxiness" can be traced to Avid's minimum diffraction design, the extra effort needed to realize it has certainly been worthwhile.

Installed in midwall positions, a pair of 110's gave a markedly more "open" sound than some fairly similar speakers we had on hand. The measured frequency response of these speakers (except for the low bass) matched that of the Model 110 well, but the difference in spatial character was striking. Perhaps this, too, was because of reduced cabinet diffraction. Whatever the explanation, we liked the results.

It is hard to think of these as "bookshelf" speakers, since there is nothing small about the sonic image they project. Furthermore, their excellent sonic characteristics belie their modest price.

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JULY 1980

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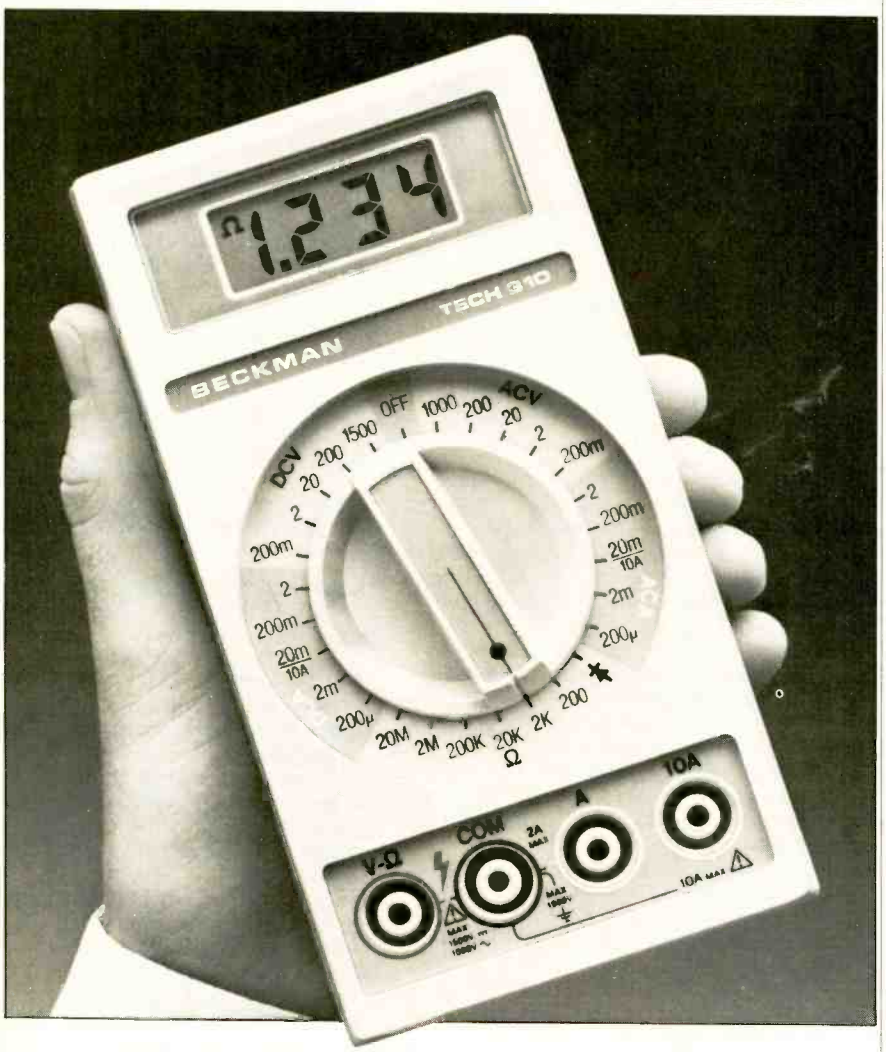

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tions. Among its many features are both hi- and low-resolution color graphics, and a sound synthesizer to add realism to games provided by the company or the ones you create yourself using APF BASIC.

Should education be your bag, and you have been considering using a computer in some way, Radio Shack is willing to lend a hand. It has recently made available a 27-page booklet that briefly describes a microcomputer in the classroom, and provides some guidelines for selecting a system. Although the booklet carries a price tag of $1.00, it is available free from most Radio Shack retail stores.

Using Your Computer. When you bought your personal computer, and perhaps tried justifying it to your spouse, the first question that probably popped up was: "Now that you have it, what will you do with it?" When the personal computer industry got started, the only answer was to learn about computers. But that has changed a great deal. This is most likely owing to the efforts of software makers such as Personal Software®. The goal of this company, whose president is Dan Fylstra, is to provide software that makes the microcomputer really worthwhile to own, in the home and the office.

One of the first things that Dan and his company did was to determine who bought and used personal computers, and for what. Basically, they found that the microcomputer was bought as an entertainment system and for learning purposes.

Among the company's many software offerings are: A backgammon-type of game called "Gammon Gambler" at $19.95 for either the Apple or Commodore PET. This one's a hard one to beat because it thinks along with you and learns with every move. Also in the game field is "Checker King" for the Apple, TRS-80, and Commodore PET. This game is really a challenge, and for $19.95 will keep you busy for hours.

Although there are more games than the foregoing, Personal Software has other types of offerings. Specifically, it has either developed or acquired software packages that are designed for the professional. These include VisiCalc®, which stands for visual calculator. This package, priced at $150, is for the Apple, TRS-80, PET, and, by the time you read this, the Atari 800 personal computers.

VisiCalc is a dynamic program that allows you to build tables of virtually any type of data important to you. Further, you can take some form of action on the data by specifying, through user-defined formulas, how each data item is to act with or react to another data item. For example, the total of columns or rows can be

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generated or percentages taken of various items and placed into separated data fields, without user intervention.

This software package is only the tip of the iceberg since the company is making all the business-type software inter-compatible. For instance, one of the newly acquired packages is the CCA Data Management system for the Apple ($99.50) which features Index Sequential Access Method (ISAM) files. This data manager can be used with VisiCalc-created files to allow you to pull various types of data from the individual records. Personal Software has made this package available for the Radio Shack TRS-80 ($74.50), but without the ISAM feature.

Following the same line is Desktop Plan® ($99.50) for the Apple computer. This package, like the data base manager, can use the file created by VisiCalc and is intended for financial analysts who want to create models for complex business problems.

According to company spokesman Bill Langenes, two other software systems geared for the professional will be available later this year. These new systems are called TrendCalc®, for statistical analysis, and VisiPlot®, to create graphs of data in various formats on the CRT or printer. These packages will be for the Apple computer at first, with similar packages for the TRS-80, Atari-800, and PET to be made available at a later date. All the professional programs are geared to work in tandem and give the businessman the flexibility he or she may be looking for with his microcomputer.

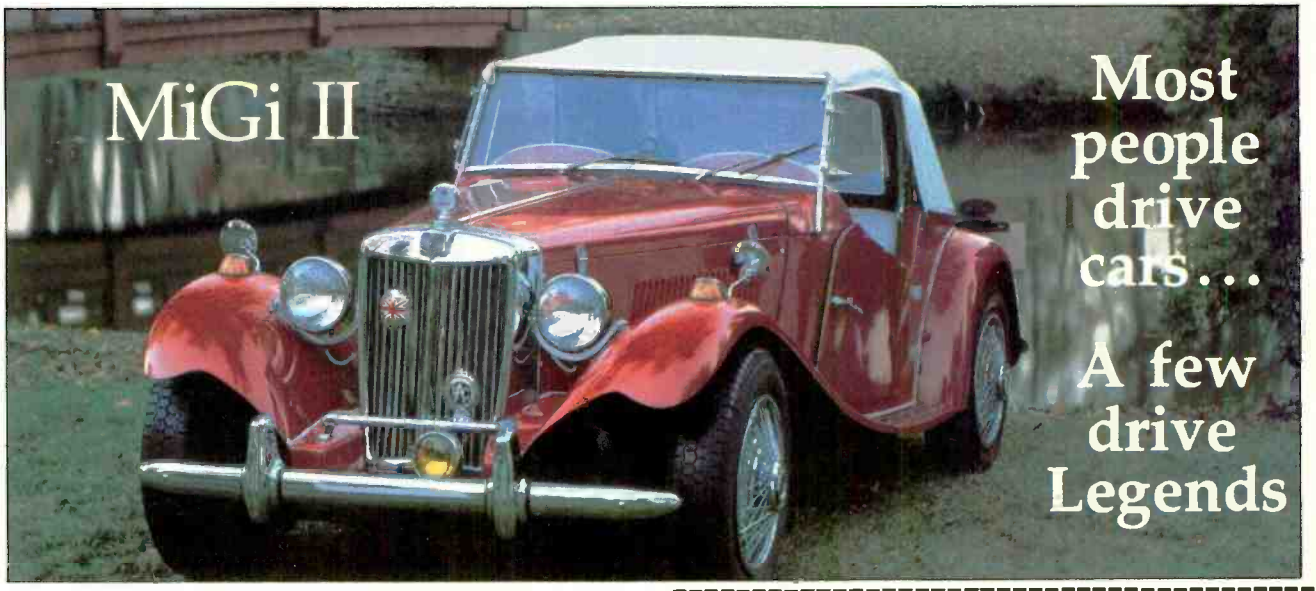
VisiCalc being used on an Apple II.

Although most of the programs being developed by Personal Software are for either the Apple or TRS-80, the company does have plans to develop similar packages for the Heath/Zenith H-89 microcomputer. As you read this, VisiCalc is being made available for users of this machine.

Word-processing is another important application for microcomputers. Several different types of editors and formatters are available on the market today. Among the most useful is a formatter named "Textwriter." This software system was developed by Organic Software for systems of the CP/M and Northstar type. However, Lifeboat Assoc. has modified it for a number of systems, including Heath and Radio Shack.

Although this formatter is designed to be used with your system editor (or one of the editors available from Lifeboat), it offers more power than the so-called integrated packages. With the Textwriter system, you can format text in just about any way you want. This includes specifying footnotes. The footnoting is very important because the note goes at the proper loca-

(Continued on page 39)



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BASIC PROGRAMMER'S SHEET

Program Name: ASCII HANDLER Page 1 of 2

Programmer: CARL WARREN Date: 4-9-80 Project no/name DEMO

Program length in lines: 12 Bytes: _____ Version of BASIC: TRS-80 1.1

Cross reference: _____

LINE #	BASIC STATEMENT	REMARKS
10	CLEAR 800:CLS	CLEAR SOME SPACE IN MEMORY AND CLEAR THE SCREEN
20	OPEN "I",1,FN$	OPEN FOR INPUT ONLY ON CHANNEL NO.1 THE FILE NAME POINTED TO BY THE VARIABLE FN$. THIS IS USED SO THE CALLING PROGRAM CAN NAME FILES.
30	FOR I=1 TO 15	COUNT LINES
40	IF EOF(1) THEN 120	IF FILE POINTER IS AT END GO TO ENDING ROUTINE
50	LINE INPUT #1,M$	GET THE MESSAGE FROM FILE
60	M$=MID$(M$,5,255)	ADJUST THE VARIABLE M$ TO BEGIN AT 5TH POSITION (ALLOWS FOR SPACES)

BASIC PROGRAMMER'S SHEET

Program Name: ASCII HANDLER Page 2 of 2

Programmer: CARL WARREN Date: 4-9-80 Project no/name DEMO

Program length in lines: 12 Bytes: _____ Version of BASIC: TRS-80 1.1

Cross reference: _____

LINE #	BASIC STATEMENT	REMARKS
70	IF I=15 THEN 100	GET READY TO PAGE IF TEST IS TRUE
80	PRINT M$	OUTPUT THE MESSAGE
90	NEXT I	NOT AT END KEEP GOING
100	LINE INPUT "DEPRESS ENTER TO CONTINUE";CC$	PAGE COMMAND
110	GO TO 30	GO BACK AND RESET COUNTER I
120	CLOSE:END	SEVERAL DIRECTIONS CAN BE HERE INCLUDING A RETURN IF USED AS A SUB-ROUTINE

A program such as this can be used to call up data stored in a TRS-80.

tion on the page without causing an overflow on the page. Also, should the footnote be larger than the space available on the page, the remainder of the note is passed onto the page buffer for the next page so it appears at the bottom as it should.

The Textwriter package is patterned after larger mainframe-type processors and, consequently, is made for professional use. This, naturally, has two connotations. Yes, there are a number of commands required to make the package work correctly. So it is not intended for use by the average, unskilled worker. Second, the formatter allows the professional bookwriter, researcher, et al, to format his or her copy in a manner that is most suitable for publication.

Features of the system include: chaptering, where the system allows you to name a chapter and provides running heads and title pages; indexing as the text is being built, or at any convenient time (key words or phrases can be identified to be included in an index). Textwriter will not only form the index, but alphabetize it with correct page numbers. These are only a few of the functions in the package, but by themselves they make it worth the $125.

File Programs. Along the software line, here is a helpful hint for the month.

You may not be aware that you can handle some of your data files in an efficient manner to assist you in the creation of messages, typing letters, etc. You can do this by developing your files with either a program written in BASIC or with your text editor, saving the information in ASCII (so that the information is in the same form in which it was written, without compressing it in anyway).

Files that are saved in ASCII format can then be read using a BASIC program sheet like the one shown here, and manipulated in almost any manner that you want. The program that is shown assumes that you have data saved in a file, in this case on a Radio Shack TRS-80, and want to call it up for some kind of help.

This routine can be incorporated into any one of your programs. With a little imagination, the calling routine can specify parameters to be passed to open different information files. A programming worksheet such as that shown is a valuable item, and is designed by you. Its use will save you moves when designing a program from scratch. ◇

MORE INFORMATION

Further information about products mentioned in this month's column can be obtained by contacting the companies directly.

APF Electronics Inc.
444 Madison Ave.
New York, NY 10022
212-758-7550

Centronics
Data Computer Corp.
Hudson, NH 03051
603-883-0111

Lifeboat Assoc.
2248 Broadway
New York, NY 10024
212-580-0082

LOBO Drives International
935 Camino Del Sur
Goleta, CA 93017
805-685-4546

Organic Software
1492 Windsor Way
Livermore, CA 94550
415-455-4034.

Personal Software, Inc.
592 Weddell Dr.
Sunnyvale, CA 94086

Radio Shack
Dept. NR-17,
1300 One Tandy Center
Fort Worth, TX 76102
817-390-3272.

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Computer Sources

By Leslie Solomon
Technical Director

Hardware

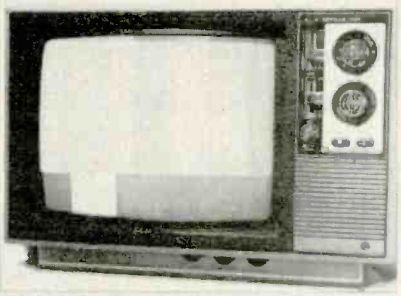
Apple Serial Port. The 7710A Asynchronous Serial Interface allows the Apple computer to communicate with all RS232C serial devices. It is compatible with Apple PASCAL, has full handshaking, supports full or half duplex operation, and uses a DCE-type interface. It also has 14 standard baud rates, bit selection, a programmable control register, software programmable interrupts, and a power-down ROM. It supports interrupt and DMA daisy chains. Address: California Computer Systems, 250 Caribbean, Sunnyvale, CA 94086 (Tel: 415-734-5811).

Video Graphics for S-100 Bus. The VG100 for the S-100 bus is designed for text-oriented applications. It has totally programmable fonts that allow up to 256 characters to be defined in on-board RAM. This permits musical notes, logic or math symbols as characters. Each 8-bit character may be modified in 256 different combinations—for example, blink, dim, bright, blank, reverse, etc. Other features include 16 grays or 16 colors or combinations (4 colors, 4 intensities). Character field is 9 × 16 or 144 pixels with raster scan line of 621 pixels. Maximum vertical pixels is 704. The entire character field can be changed at one time allowing animation. It is configured in 12K of RAM selectable in three blocks. When none of these are selected, the board occupies no address space. $645. Address: International Product Dev. Inc., 1708 Stierlin Rd, Mountain View, CA 94043 (Tel: 415-969-6086).

STD-Bus Boards. These three new "do it yourself" boards are size and plug compatible with Pro-Log 7801.2 and 3, Mostek MD-SBC-1, or other systems using the STD bus. The 4610 board ($18.95) is designed for soldered interconnections and can mount up to twenty 16-pin DIP's or combinations of DIP's and discretes. The 4610-2 board ($18.95) is for Wire-Wrapping and can accommodate up to thirty-five 16-pin DIP's. The 4610-1 board ($15.95) is unclad except for the edge connector to allow maximum layout freedom. This board can support up to fifty-nine 16-pin DIP's. Address: Vector Electronic Co. Inc., 12460 Gladstone Ave., Sylmar, CA 91342 (Tel: 213-365-9661).

S-100 Control Panel. This S-100 bus control panel features a 20-key matrix and a 6-digit LED display controlled by on-board 2708 or 2716 EPROM. This permits user-designed firmware to be used. Standard firmware for 8080/Z80 systems are available. $139.50 with blank keys less EPROM. Add $55 for 8080/Z80 firmware. Address: Pike Electronics, 8190 Watsonville Rd., Gilroy, CA 95020 (Tel: 408-842-1235).

Color Monitor. This combined color-TV receiver and monitor has a resolution of 300 lines horizontal and 350 lines vertical. In the monitor mode (switch selectable), input impedance is 75 ohms. It also features looping



input for multiple use. The 13" version (VM-1300) is $449 and the 19" version (VM-1900) is $575. Address: VAMP, Box 29315, Los Angeles, CA 90029 (Tel: 213-466-5533).

Diskette Head Cleaner. These head cleaning diskettes are manufactured by attaching a lint-free nylon mat to a Mylar substrate. The design avoids damaging abrasion, keeps head wear to within industry standards, and is used in the same way as any diskette. It should be used once per day as a prevention against oxide buildup. $20 for the 8-inch and mini-diskette versions. Address: Lifeboat Associates, 2248 Broadway, New York, NY 10024 (Tel: 212-580-0082).

CRT Optical Filter. This black nylon mesh device, held under tension by a plastic frame, prevents ambient light from striking the CRT screen surface and reflecting back to the viewer to cause glare. The overall effect is one of enhanced contrast, apparent improved resolution, no glare and minimal reflections. Nine-inch size for the PET type is $16.95, 12" for TRS-80 types is $22.50 and a 15" type is $25.00. Address: SunFlex Co., 3020 Kerner Blvd, San Rafael, CA 94901 (Tel: 415-456-8482).

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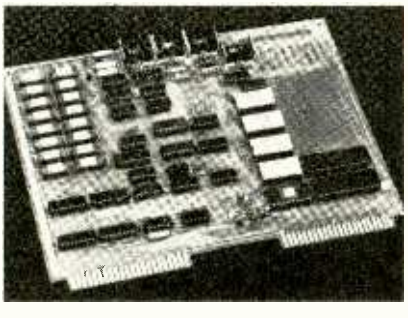
TRS-80 Listener. The VOXBOX uses a Level II system with 16K of RAM and can recognize a vocabulary of up to 32 spoken words. Words or phrases may be used to enter data, control and instruct the TRS-80 without having to type on the keyboard. The machine-language driver program, three demo programs, a dynamic microphone and a comprehensive manual are included. Available for $169.95 at Radio Shack Computer Centers and stores.

Hard Disk For Micros. The Lobo Model T, (TRS-80), A (Apple), and S (S-100) disk system provides 10 megabytes of mass storage for these machines. It comes with an IMI 7710 Winchester disk drive, controller, power supply, interface, and software. It requires little or no change in existing software to use, and is interchangeable with conventional floppy disk drives. Mounting can be either rack/slide vertically or horizontally, or it may be placed on a table top. Price is $4995. Address: Lobo Drives International, 935 Camino Del Sur, Goleta, CA 93017 (Tel: 805-685-4546 or 714-641-1436).

RFI Filters. A new line of ac power outlet boxes features RFI filters and transient voltage protection. Filters operate between 150 kHz and 30 MHz; each outlet is line-to-line (differential mode) and line-to-ground (common mode) filtered and can accommodate 10 amperes. High-voltage transient protection is to 6000 amperes and 8 to 20 microseconds. Energy absorption is 50 joules. A six-foot 3-wire power line is used. Address: PMC Industries Inc., 1043 Santa Florencia, Solona Beach, CA 92075 (Tel: 714-481-7422).

KIM Memory Expansion. The DRAM PLUS expansion board adds up to 32K of dynamic RAM (with transparent refresh) and up to 16K of



EPROM to AIM-65, SYM-1, and KIM-1 computers. Both RAM and ROM are addressable in independent 4K segments and an on-board EPROM programmer is included. A general-purpose prototyping area allows addition of custom circuits. Two 6522 chips provide 32 I/0 lines, handshaking, four timers, and two serial-to-parallel shift registers. It is electrically compatible with the AIM/SYM/KIM bus. $295 for 16K version (expandable to 32K), and $395 for 32K version. Address: The Computerist, Inc., Robert M. Tripp, 34 Chelmsford St., Chelmsford, MA 01824 (Tel: 617-256-3649).

Computer Desk. The CompuDesk has a split-level top for elbow-height CRT viewing, and printer height that is eye-level while sitting, waist-level while standing. It has two adjustable shelves and a self-closing door with an attached storage rack for manuals. Convection cooling is used in the shelf area, and a power fan is available for high-heat situations. The desk is constructed from birch plywood with walnut stain finish and Formica tops. $359, plus freight and packing charge. Address: ComputerGoods, Box 2635, Eugene, OR 97402 (Tel: 503-687-2387).

Studio II Conversion. The RCA Studio II video game can be converted into a basic microcomputer by the addition of ROM and RAM. This package consists of three cards, one for PROM, one for RAM, and the third for a backplane that connects these two boards to the Studio II via the game cartridge slot. The package provides 1560 bytes of RAM and 512 bytes of ROM and includes the Monitor program. Six issues of a newsletter devoted to the Studio II are also included. Address: Aresco, Box 1142, Columbia, MD 21044.

Software

TRS-80 Sort/Merge. DSM is a new disk sort/merge for the TRS-80 I and II. The machine-language program sorts large multiple diskette files on a minimum one-drive or two-drive system. It physically rearranges all records and no key files are required; sorts random files created by BASIC including sub-records spanning sectors; sorts on one or more fields in ascending or descending order with fields in character, binary integer or floating point; and provides optional output field deletion, rearrangement and padding. Sort commands are saved for reuse in production applications. Designed for mailing lists, inventory control, and other business uses. $75 for Mod I and $150 for Mod II. Address: RACET Computers, 702 Palmdale, Orange, CA 92665 (Tel: 714-637-5016).

Apple Teacher. The "Teacher Plus" features 17 lessons covering all frequently used BASIC commands, as well as logic techniques. The package also includes Apple Tricks, teaching

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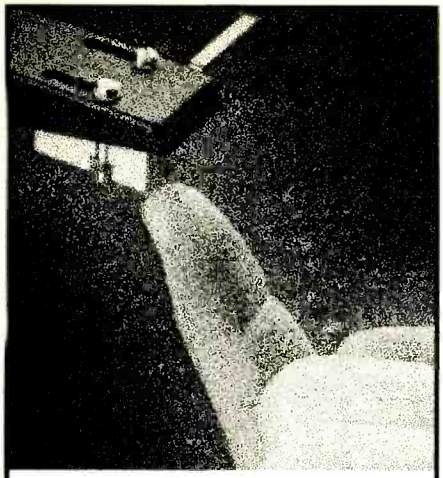

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sound and graphic routines. The system refers to the Apple Manuals and includes tests and problems. The "Plus Teaching Pac" includes a floating-point dictionary and the lessons teach with runable programs. The "Teacher Plus" comes on two linked diskettes for $59.95, with cassette version $24.94. The "Plus Teacher", also on two diskettes, is $34.95. The floating point dictionary alone is $24.94. and a 12-lesson integer BASIC version of the Teacher is $19.95 for tape, $29.95 for diskette. Address: Charles Mann and Associates, Micro Software Div., 7594 San Remo Trail, Yucca Valley, CA 92284 (Tel: 714-365-9718).

CP/M Music System. The MUSICRAFT Development System uses five machine language programs called Setup. Editor, Waveform Generator, Interactive Play and a fast two-pass compiler. In conjunction with a Newtech Model-6 Music Board, it produces four voices, each with a 7-octave range. It also supports measures, line numbers, repeats, refrains, key signatures, accidentals, microtones, etc. It requires an 8080, 8085, or Z80 S-100 bus with 24K or larger CP/M, a terminal with an addressable cursor, and the Model-6 board. Currently available on 8" single density IBM, North Star and Micropolis Mod II CP/M formats. $79.95. Model-6 Music Board is $99.95. Address: Newtech Computer Systems, Inc., 230 Clinton St., Brooklyn, NY 11201 (Tel: 212-625-6220).

Heath BASIC Programs. All 76 programs in the Osborne and Associates book, *Some Common BASIC Programs*, are now available for Heath cassette systems. All programs will run with any version of Heath BASIC and four require Extended BASIC. The programs include business, finance, math, statistics, plotting and various general-interest applications. Cassette is $15. Address: J.E. Bracheau Eng. Co., Box 67, Trenton, MI 48183.

TRS-80 Animation. ELECTRA SKETCH is an animation and graphics compiler for the TRS-80 that claims continuous, fast action without flicker or jumping. Graphics and text can be combined. One-key commands can control cursor direction, draw, erase, draw vectors, fill in backgrounds with any sequence of characters, create titles, save on disk, recall frame from disk, review all stored frames, change graphics, and print the frame on a line printer. Saved frames can be animated by display in either forward or reverse sequence. Speed can be changed from slow to fast in ten increments. Demonstrations are included. $14.95. Address: Macrotronics, 1125 N. Golden State Blvd., Suite G, Turlock, CA 95380 (Tel: 209-667-2888 or 634-8888).

6809 Memory/Disk Package. Designed to run under the 6809 FLEX Operating System, this package has a memory diagnostic portion, including random pattern, walking bit, dynamic RAM dropout and convergence tests. All tests are position independent. The disk portion features three diagnostic utilities that report unreadable sectors and structural inconsistencies among the files on the diskette, two utilities for recovering data when the disk directory is not readable, a utility to remove bad or intermittent sectors from free space, retrieve deleted files from the diskette free chain, a single-sector read/write/modify routine and a copy routine that ignores CRC errors. $75 on 5" or 8" diskettes. Address: Technical System Consultants, Inc., Box 2570, West Lafayette, IN 47906 (Tel: 317-463-2502).

Datestones of Ryn. Available for the PET (16K RAM), TRS-80 (Level II, 16K) and Apple (with Applesoft), this fantasy adventure is written in Microsoft BASIC. It allows 14 options, and excellent graphics create a map of the playing area. This is another game in the DUNJONQUEST series, in which the player can compete against another player or himself in a race against time. It comes with a colorful 16-page illustrated manual. $14.95 at many computer stores or from Automated Simulations, Box 4232, Mountain View, CA 94040.

CMB Word Processor. The WordPro III features global functions, instant editing and full documentation retention up to 170 pages on-line. It will global search, replace, and print an entire 170K-byte diskette without operator intervention. It has a complete range of screen positioning commands and over 50 control functions, including center titles, indent paragraphs, set tabs and hyphenate words. Real-time screen editing functions such as delete, insert, erase, move, search, and replace are provided. Letters can be merged and a status line on top of the screen indicates functions in progress. Hard-copy output includes formatting, line spacing, right/left margins, and justification. It operates on the Commodore CBM 2022 and 2023 matrix printers and is compatible with NEC, Diablo and Qume printers. Address: Commodore Business Machines, Inc., 3330 Scott Blvd., Santa Clara, CA 95051 (Tel: 408-727-1130).

The PEARL. This program, called Producing Error-free Automatic Rap-

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id Logic (PEARL), allows the user to generate customized programs. It generates data fields, edit routines and 1/0 facilities. PEARL produces a combination of source code and precoded utility routines (BASIC source code) and through a series of menus and prompts, allows defining system and report controls, and the interrelationship between data elements and files. It requires CP/M and CBASIC with 48K of RAM. Level 1 for personal computing is $90, Level 2 for business is $200. Address: Computer Pathways Unlimited, Inc., 2151 Davcor St., SE, Salem, OR 97302 (Tel: 503-363-8929).

APF Packages. Designed for the APF Imagination Machine, the Space, Size and Surface Guide program can assist the homeowner in problems involving maintenance, covering surfaces and materials required. It can be used for fertilizing, seeding and lawn coverings, wall papering, painting, paneling, or tiling. The program tabulates the amount of material required. It also computes cost difference between products and allows for extra material due to patterns, door and window fittings, and the user abilities. The Personal Business Machine Program allows calculation of financial status and loan amortization, interest and principal payments, interest rates, etc. Both programs are available through catalog showrooms, department stores, and other outlets carrying the Imagination Machine.

Compucolor Utilities. Soundware includes the necessary hardware and software to create sounds on the Compucolor II system. It is programmable from BASIC and melodies of three octaves can be created. $49.95. Three diskettes called Statistics I, Statistics II and Statistics III are also available. Statistics I includes a regression analysis; capability to plot up to three graphs; and ability to compute and display several measures of central tendency and other quantiles, dispersions, skew, kurtosis, and moment about the mean from grouped or ungrouped data, and a graph program that displays histograms/polygonal graphs for grouped or ungrouped data. Statistics II includes multiple linear regression up to six variables, with or without transforms; polynomial regression using a polynomial of degrees up to five; the fit of binomial, norm, or Poisson distributions to input data; and a chi-squared test. The last element uses data from a set of samples of varying sizes to compute statistics for each sample, to analyze variance between samples, and to provide estimates of the evaluation mean. Statistics III features trend regression, deseasonalization, or other cyclic adjustments and smoothing of a time series; the ability to compute eight types of index numbers for several sets of data with any set used as the data for the base period; or computing capability for variation within or between pairs of data series using Mann-Whitney test and rank correlation. Statistics I is $24.95, Statistics II, $29.95 and Statistics III, $29.95. Address: Compucolor Corp., Box 569, Norcross, GA 30091.

PET Array Handling. Matric, an array handling package, transforms PET/CBM machines into powerful research and teaching instruments. The 5K assembly language program expands Commodore BASIC with 14 new statements. Variations lead to more than 25 distinct operations. A single MATRIC statement displays a matrix on screen and the values can be changed and entered. Another statement transfers data between matrices, transfers diagonals between matrices or fills a matrix with a constant. Other statements transpose matrices, transfer diagonals between matrices or from a matrix to a vector (and vice versa), or fill the diagonal with a constant. Vector and matrix addition, squares, and square roots are provided. Matrices can be inverted and the absolute value of determinant obtained. Eigenvalues and Eigenvectors for symmetrical matrices can be computed. All statements can be used in BASIC programs or entered directly. Many other matrix operations are provided. Versions for 8K, 16K or 32K machines are available. $125. Address: Cognitive Products, Box 2592, Chapel Hill, NC 27514.

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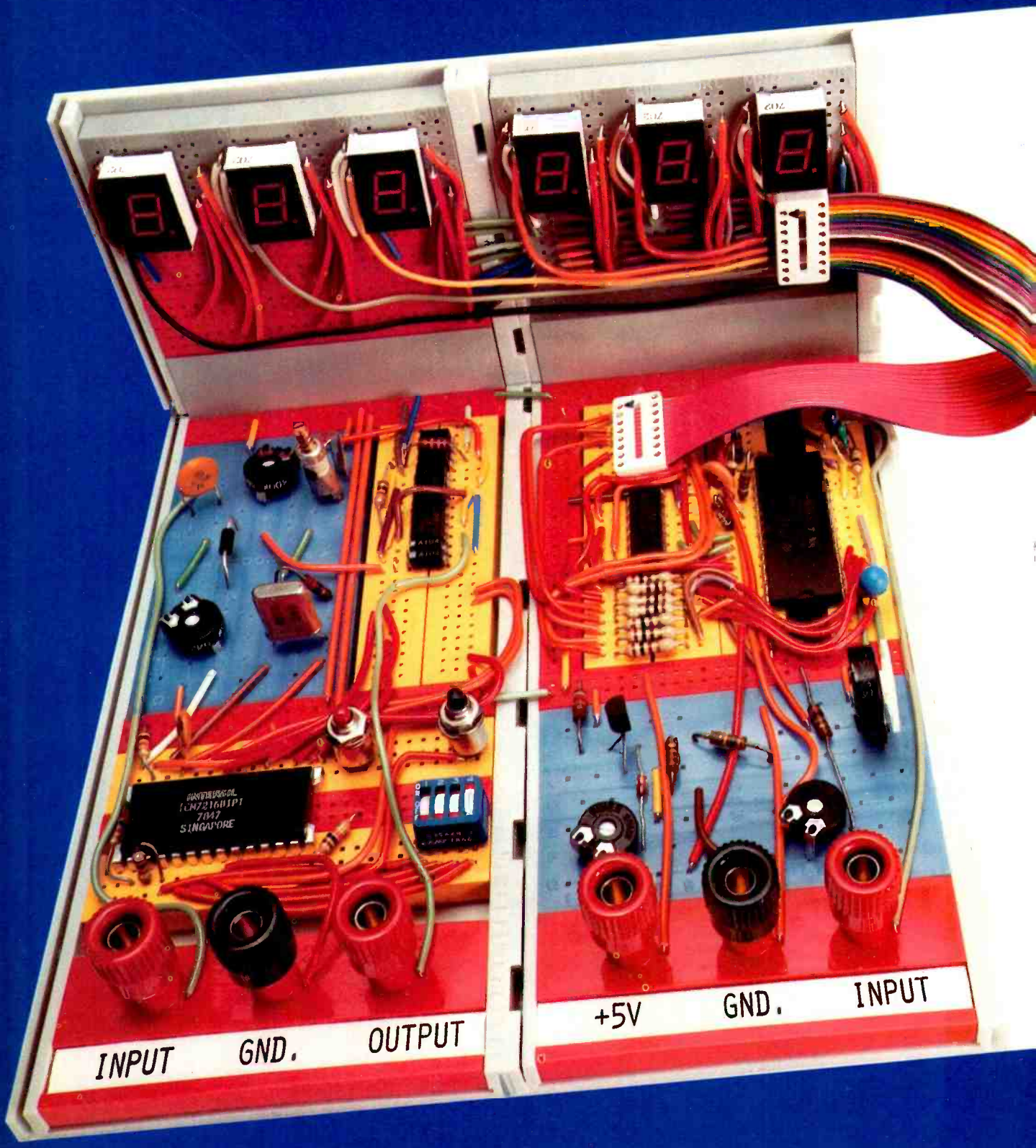

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HOBBY-BLOX™. The new modular circuit building system designed especially for electronic hobbyists.

Until now, hobbyists had to buy "professional" solderless breadboards for their projects and pay "professional" prices. But now there's Hobby-Blox,™ a brand new solderless breadboarding system that's not only economically priced but offers far more advantages to the hobbyist.

At the core of the system are two starter packs, one for discrete component projects, the other for integrated circuit projects. Each comes with a number of Hobby-Blox system modules that fit into a tray and an illustrated project booklet which shows you step-by-step how to build ten projects with the existing modules of each pack. Either starter pack is available for under $7.00.

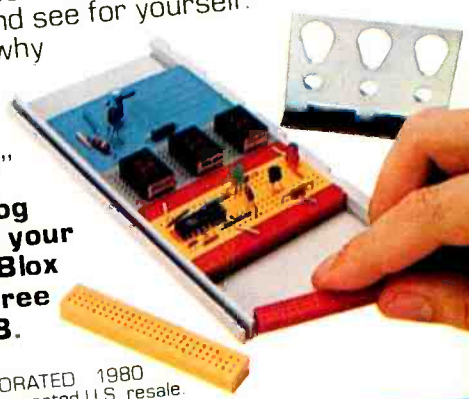
You can add modules at any time to build new projects or expand on existing ones. The Hobby-Blox system includes 14 separate module packs that can be purchased individually.

Modules include Tray, Terminal Strip Pack, Distribution Strips, Bus Strip, 3 x 16 Terminal Strip, Discrete Component Strip, L.E.D. Strip, Vertical Tray Pack, Speaker Panel Pack, Control Panel Pack, Blank Panel Pack, Battery Holder Pack, Binding Post Strip, Tray Extender Clips. Modules are priced from $1.29 to $3.59.

All modules are color-keyed and letter-number indexed to make circuit building even easier.

The Hobby-Blox system is compatible with DIPs of all sizes and a wide variety of discrete components. Simply plug in your components and interconnect with hookup wire. No soldering, and all components can be used again and again.

How far can you go with the Hobby-Blox system? Take a look at the example on the page to the left and see for yourself. Then you'll know why we say, "with Hobby-Blox, your only limit is your imagination!"



For a free catalog and the name of your nearest Hobby-Blox dealer call Toll Free (800) 321-9668.

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Popular Electronics Tests

Magnavox T809 19" Color TV Chassis

MAGNAVOX is presenting essentially the same color TV lineup in 1980 that it had last year, with the exception of a "cost-effective" T809-10 and new 13" sets. Otherwise, allowing for the usual cosmetic knob and cabinet changes, the major T809 (19") and T815 (25") console receivers carry over the exciting electronic "firsts" from 1979.

These include the first microprocessor tuner control for channel change and programming, an expanded midband CATV tuning arrangement, as well as its justly famous comb filter, whose 4-MHz bandpass from tuner to cathode ray tube is an industry mark yet to be duplicated.

Other 4-MHz receivers will likely appear among the better TV receivers in time. After all, what's the use of buying a quality TV that won't reproduce full bandpass from a video disc or first-rate broadcast? The same reasoning applies to cable TV: either your new receiver tunes at least the midband cable channels, or you're wasting at least the extra cost of an outboard converter.

The T809 19" chassis we've chosen for examination this month, which is the basis of 14 new Magnavox color TV models (Fig. 1), includes all of these niceties. It is assembled from nine plug-in modules, an accessible U-shaped mother board, and eight prov-

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en integrated circuits, seven of which are ordinary off-the-shelf items available from Magnavox, or distributors. Only the low-level luminance IC on the low-level video (LLV) module is proprietary (a generic number is not yet released). Best of all, six of these ICs also fit the 25" T815 chassis and

'. . . bandpass of 4 MHz from tuner to CRT is an industry mark. . . '

can be identified by both semiconductor manufacturer names and specific Magnavox part numbers.

Chassis Features. Three particular features of the T809 deserve special consideration: the dual i-f (intermediate-frequency) strip, the LLV module, and its accompanying comb filter in the top models.

Early versions of the T809 were blessed with a trio of n-channel depletion-mode MOSFETs. Their leakage currents were little affected by ambient temperature and the devices displayed good square-law transfer characteristics and high input impedances. So they are especially useful as low-capacitance feedback amplifiers with negligible cross-modulation. In these 358F3s, charge carriers are always present and flowing unless a reverse gate bias voltage inhibits (depletes) the flow and decreases conductivity.

MODEL T809 CHASSIS LABORATORY DATA

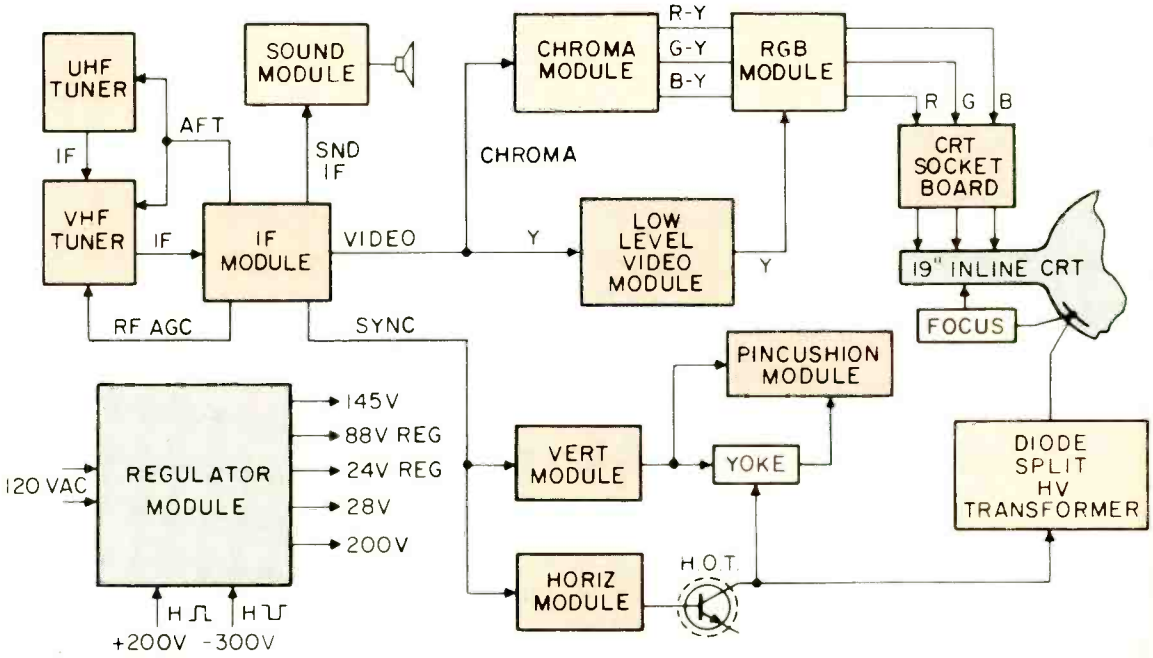
Parameter	Measurement
Tuner/receiver sensitivity (before snow):	vhf: −60 dBm uhf: −48 dBm
Voltage regulation (line varied from 104 to 130 V):	Low voltage: 24 V (100%) 250 V (97%) High voltage: 25 kV (97%)
Luminance bandpass at CRT (with comb filter):	4 MHz
S/N at CRT:	38 dB
Horizontal overscan:	13%
Chassis power requirements (signal applied):	105 W
Agc response (smooth swing)	>40 dB
Direct coupling (or dc restoration):	>90%
Convergence:	>85%
Audio bandpass:	50 Hz to 10 kHz

A second gate, of course, makes these metal-gate FETs excellent gain-controlled amplifiers, very similar operationally to multigrid electron tubes.

In the late T809 and T815 chassis, a single IC supplants the discrete MOSFET devices just described, combining i-f amplifier, age, detector, and video amplifier functions. Happily, it is a solid retrofit for the older i-f module and may be interchanged at will. Magnavox claims that in performance and picture quality you won't know the difference.

A fourth-generation IC, RCA's CA3153G, features improved keyed age response, low noise, good linearity, an internal shunt regulator, and gold chip metalization; and it interfaces appropriately with RCA's CA3139, an aft. It employs a special sample-and-hold (capacitor-charge) circuit that allows fast age response and also reduces vertical sync effects on the video output that could cause undesirable modulation. A special noise configuration is added to reduce age gain during both spikes and overvoltage noise.

The special Magnavox comb filter effectively separates chroma and luminance, while providing a full 330 lines of horizontal resolution (4 MHz) at the high bi-potential 100° in-line



All artwork courtesy Magnavox.

Fig. 1. Simplified block diagram of the T809 19-inch chassis, on which 14 new Magnavox color-TV models are based.

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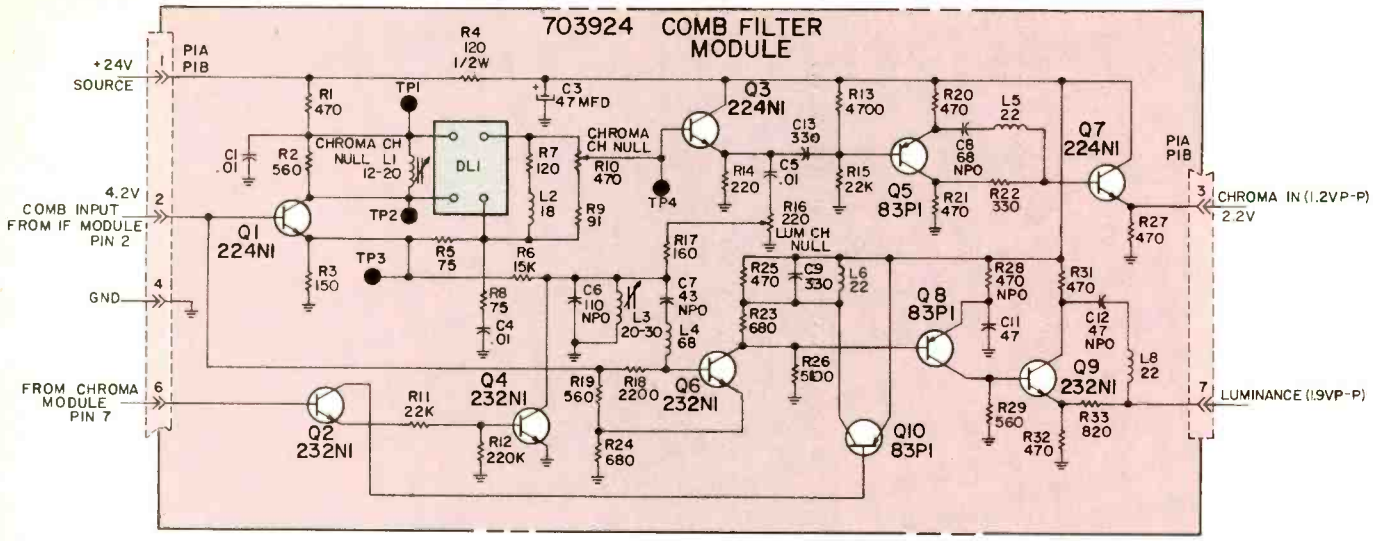


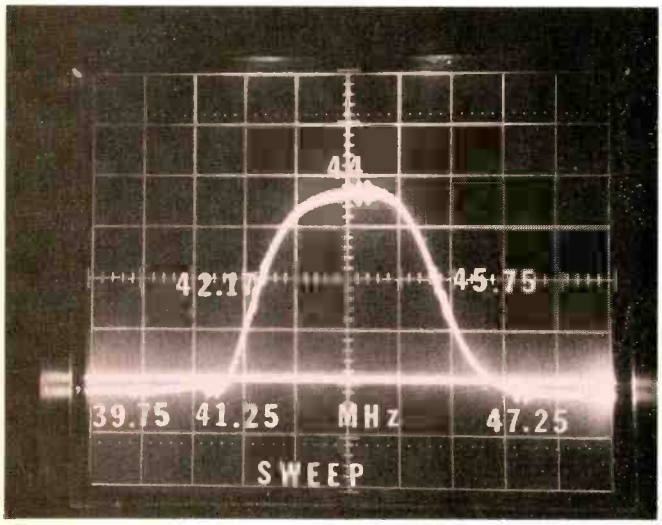
Fig. 2. Schematic of the comb-filter module with chroma defeat and full chroma/luminance circuitry.

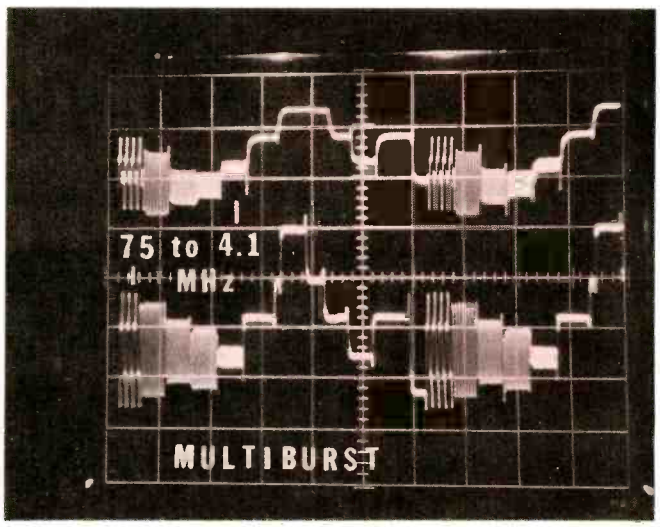
picture tube. And greater resolving power makes for sharper pictures. This video bandpass (at the CRT) is the widest of any consumer TV set now marketed in the U.S., based on manufacturer claims. Available with and without comb-filter defeat, the circuit is offered in the lesser version as Module 704203, and with full circuitry as Module 703924. Technically, here's how the comb filter works:

The assembly amounts to a series of amplifiers, a glass delay line (Fig. 2) and a series of LC filters, one of which is adjustable. Composite video applied to the base of *Q1* is output in opposing phases across its collector and emitter resistors. One phase is delayed for a full line width of 63.5 μs through *DL1*, with in-phase and out-of-phase components summed across chroma null potentiometer *R10*, cancelling out-of-phase luminance to leave only chroma. Follower *Q3* passes this chroma through complementary amplifiers *Q5* and *Q7* for the succeeding chroma processor. As this occurs, a sample of the chroma develops across luminance null potentiometer *R16*, and is filtered by parallel *C6-L3*. It is next applied to the base of *Q6* through a series tuned circuit, *C7* and *L4*, that resonates at 2.95 MHz and passes the chroma double sideband signal (3.08 to 4.08 MHz) to this amplifier.

A second composite video input is also routed to the base of *Q6*, which acts as the chroma-luminance separator. Since chroma alternates phase every other line, color information at the base of *Q6* cancels chroma in the composite signal, leaving pure luminance to be further amplified by pnp and npn complementary amplifiers *Q8* and *Q9*. When only monochrome is broadcast, a high from the chroma module turns on *Q2*, which causes gate *Q4* to remove all noise and other signals at *R6*, permitting only luminance information through *Q9* to be processed. At the same time, pnp *Q10* is turned on, supplying additional current to the collector of *Q6* and the base of *Q8*, ensuring full amplitude luminance output.

The final chassis module of special interest is the low-level video configuration and its still proprietary 612105 integrated circuit. Developed and produced jointly by Kenneth Skinner of Magnavox Consumer Electronics and William Cocke, National Semiconductor, the chip itself contains three luminance amplifiers, a dc level shifter, regulator, adder, enhance amplifier, and comparator. Comparison lev-





Scope photos show that the T809 chassis has a 4.1-MHz bandpass at both the video detector and cathode-ray tube and can easily be sweep-aligned.

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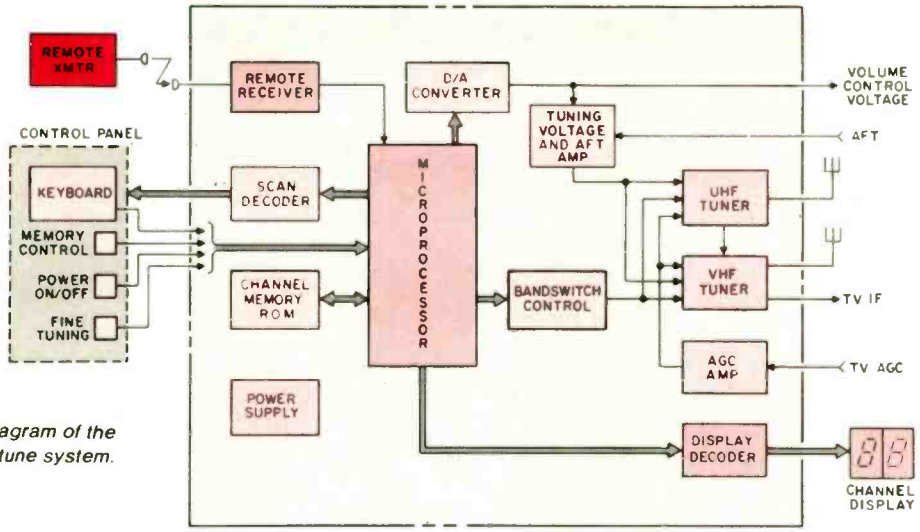

Fig. 3. Block diagram of the microprocessor touch-tune system.

el is set by an operator preference control, referenced to the back-porch level of the horizontal sync pulse, and compared each time the flyback transformer pulses during its usual 11–12-μs horizontal blanking interval. Any disparity between operator-set dc reference and the back-porch clamp will make the comparator charge or discharge an external capacitor, shifting dc levels in the luminance-signal path to regain a steady dc reference for constant black-level control. Dc coupling prevails throughout the circuit.

There is also a picture enhancement/dehancement function that originates from a tap on the delay line. When zero crossing of the signal at the particular summing junction reaches midpoint of the luminance-signal transition from low to high, *en*hancement can be varied by the adjustment of an external sharpness control. With detail signal polarity reversal, however, a *de*hancement occurs which is useful when signals have been previously overpeaked or when signal/noise ratios are poor.

A picture operator control is common to both luminance and chroma stages and is nothing more than a dc bias set for two pairs of differential amplifiers connected to current source luminance and chroma inputs. Voltages higher or lower than reference biases permit more or less signal current to flow, but a clamp capacitor can compensate for dc current changes so that the output voltage is held constant for various picture and contrast control settings. Additional circuitry prevents double compensation for chroma level variations, ensuring that only Auto Contrast and *IC1* on the LLV module affect chroma gain.

The Remaining Circuits. The chroma module consists of standard monolithic integrated circuits having only automatic chroma control (acc), automatic phase control (apc), 3.58-MHz oscillator adjustments, and RGB-Y demodulation. Luminance and chroma recombination occur on the RGB module in the final amplifiers before the CRT. There are preset controls for those who refuse or are unable to tune a color receiver themselves and don't care if fleshtones do expand across picture detail where they shouldn't. There is also a Magnetic Pincushion module, controlled by pulse energy from the vertical windings on the deflection yoke, that straightens raster sides, while top and bottom pincushion correction originates in special torroidal and saddle-wound deflection yoke design.

Although this receiver hasn't a self-regulating power transformer—which the author considers advantageous for both initial voltage regulation and line-transient reduction—it does feature an 88-volt regulator for the horizontal output that's switched at the receiver's horizontal rate from pulses developed by the flyback transformer. An SCR in this circuit shuts down the regulator whenever overloads, especially abnormal currents, occur in the horizontal output.

'. . . an unusually fine receiver, even among deluxe models.'

Tuners in these 14 new 19" sets (BK4166 through BK4466) employ diode bias switching (vhf high/low) and Varactor oscillators for both vhf and uhf bands, since back-biased diode capacitance (in Varactors) is sufficient to select channels among the three groups of frequencies. Discrete voltage tuning does the trick for individual station location, and Magnavox's Touch Tune calculator-like control does the rest, aided by a microprocessor in either local or remote-controlled receivers (Fig. 3). Channels are placed in a ROM, and there's a scan decoder return to the keyboard. The microprocessor routes information to a D/A converter, bandswitch control, and display (LED) decoder. Midband CATV channels B through I (derived from uhf channels 84 through 91) may be directly tuned since Ch. 69 is the highest channel in broadcast use.

Comments. As the various measurements show, this is an unusually fine receiver, even among deluxe models. Very good color, brightness, contrast, control functions, voltage regulation, and audio, along with outstanding detail and resolution, are all highly positive recommendations.

The luminance gray scale and vertical/horizontal linearity are very good, as are interlace and color fidelity. Serviceability, in addition, should be fairly convenient. Exchange module prices range from $4.72 to $65 in regular chassis, and ICs from $3.32 to $20.17. Special remote-control modules and ICs are somewhat higher because of their complexity and limited production.

One might like to see a little better than 38-dB S/N ratio at the CRT, a bit more resistance to CB signals on Ch. 2, and the removal of a slight audio lag when channels are changed by remote control. But with up/down and direct-address remote tuning, CATV midband reception, efficient signal pull-in on most stations, a very clean picture, and sharp picture detail through super video bandpass, this new receiver approaches ideal color-TV performance.—*Stan Prentiss.*

CIRCLE NO. 105 ON FREE INFORMATION CARD

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A TOURIST INFORMATION RADIO SERVICE

New AM broadcasts provide motorist information on local traffic, road conditions, etc.

BY LEO G. SANDS

THANKS to a recently adopted ruling of the FCC, commuters, tourists, and other drivers around the country are going to be reaping the benefits of a new Tourist Information service. They simply set their car radios to either 530 or 1610 kHz and listen to whatever words of wisdom the local authorities want to put out. Under the new rule (FCC Rule 90.242), a state, county, city, town, village, or similar government entity, or a park district or authority, is eligible to apply for a license to operate a Tourist Information Station. Such a station may broadcast descriptions of local points of interest and news such as road and traffic conditions, where to find lodging, where to get a meal, and often more important, where to find an open gas station.

Although intended to be of help to motorists, there low-power radio stations can be used by boaters and private pilots. A boater can use his radio direction finder to take a fix on a TIS station or home in on it. A pilot can use the TIS location as a point of reference and both can listen to weather news broadcast over a Tourist Information Station.

TI stations are likely to be located near airports, railroad stations, bus depots, sports stadiums, and other places where there is often a lot of traffic. They may also be located at important intersections. In addition, a TI station can be used on a bridge or in a tunnel to feed a radiating cable antenna.

The Technical Side. TI stations are licensed in the Local Government Radio Service to an agency of a state, city, or other local government; to a highway, tunnel, or bridge authority or district; or to a park district. Transmitting range is limited by restricting a TI station to a 10-watt AM transmitter with a 15-meter vertically polarized antenna or a 50-watt transmitter whose output is fed to a leaky transmission-line antenna of up to 1.9 miles (3058 m) in length.

For optimum coverage, the vertically polarized antenna should be at least a quarter-wave long—46 m at 1610 kHz or 141 m at 530 kHz. However, by means of a loading coil, a 49′ (15-m) antenna can be made to resonate at 530 or 1610 kHz. (Boats have long used 13′ center-loaded antennas that are an eighth the height of a full quarter-wave antenna for operation on 2182 kHz, or 138 m, and other medium-frequency channels. Most CB antennas have loading coils that make a short whip the electrical equivalent of a 9′ quarter-wave whip.)

A leaky transmission-line antenna is nonresonant and can be slotted coaxial or two-conductor parallel-wire cable; the latter is similar to TV twin-lead line but heavier. When supported above the ground alongside a road, the cable radiates a signal over its entire length. A cable antenna suspended from the roof of a tunnel or above the roadway of a bridge sends a signal that can be picked up by vehicles below.

It would be impossible for all TI stations to operate on only two frequencies without conflict unless they had adequate spacing. The rules provide that two stations using conventional antennas be at least 9.3 miles (15 km) apart; two stations using a cable antenna be at least 0.31 mile (0.5 km) apart; and a station with a conventional antenna be 4.66 miles (7.5 km) from another station with a cable antenna. A TI station can be locally controlled at the transmitter site, or it can be remotely controlled from one or more locations.

You will be able to tune in TI stations with an ordinary car radio. Even though their dials are labeled from 54 to 160 (540 to 1600) kHz, most AM radios will actually tune down to 530 and up to 1610 kHz. A radio can be made to tune through this expanded range easily by adjusting its oscillator trimmer and padder circuits.

Additional Benefits. A TI signal can be used as a beacon by pleasure boats for homing and navigational purposes. A TI station at the south end of Manhattan, for example, could serve boats in the harbor as well as motorists approaching the Staten Island ferry and those trying to get through the heavy street traffic.

As TI begins to catch on, enterprising manufacturers are likely to offer fixed-tuned receivers that alternately sample each channel and activate the speaker or give indication when a signal is present on one or the other.

Adaptors for use with autosound systems and CB rigs should start to appear too. Such converters will probably preempt the systems to which they are attached, giving only TI capability when engaged. Eventually systems that automatically scan the TI channels the way modern rigs scan CB channel 9 may be included in CB and autosound rigs.

It is anticipated that TI stations will soon be in operation all over the country. After all, what local government could resist the opportunity to promote the tourist attractions in its area directly to passing motorists? ◇

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Audio Time Delay Systems

AN AUDIO BUFF is constantly seeking ways to make the sound from his audio system more realistic. That's why there's been a high level of interest in a family of audio components known as audio delay lines or "room expanders." Such a component is intended to create an auditory illusion that simulates the environment in which music is ordinarily performed—a large concert hall, a night-club, etc.—rather than the sense of being reproduced in a small listening room.

IN THIS three-part series, we present two different types of audio delay lines, either of which can be built by a technically inclined audiophile for a relatively moderate cost. The delay line described this month and next is an analog design. Part three's project employs digital signal-storage techniques.

1. A Low-Cost Analog Audio Delay Line

BY JOHN ROBERTS

Analog system employs a bucket-brigade device and companion to provide adjustable delays and wide dynamic range

THE analog audio delay line described here employs a high-performance, "bucket-brigade" analog shift register and a 2:1 companion system to preserve as much of the input signal's dynamic range as possible. According to its designer, it offers an adjustable delay time of from 5 to 68 ms, a frequency response of 30 to 12,000 Hz (+0, −1 dB), an output noise rating ("A" weighted) of −91.5 dBm at 5-ms delay, and a THD + N content of 1% at 10 kHz. A complete stereo delay-line kit including an ac or dc power supply and a custom enclosure is available for $250.

Delay Lines and Reverberation. Perhaps the most significant difference between a large concert hall and the typical home listening room lies in their reverberation times. Reverberation time can be defined as the amount of time it takes for a steady-state sound field to decay to −60 dB relative to the level that existed before the sound source was deactivated. The size of a room and the materials used to construct it affect its reverberation time.

Because the speed of sound in air is relatively constant (approximately one foot or 0.3 meter per millisecond) for given atmospheric conditions, sound waves travelling in a very large room will experience fewer energy-absorbing collisions with the walls, floors, and ceiling per unit time than will similar sound waves travelling in a small room. Accordingly, sound waves in the large room decay less rapidly.

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A listener in a reflective room receives a series of sound waves starting with the wave that reaches him on a direct path from the source. The reflected waves arrive at some time after the direct signal. The human ear derives from these differences in arrival times clues as to the size of the listening space.

When the reflections arrive so soon after the direct wave that they merge with it, the room "sounds" small. By contrast, larger differences in arrival times and more protracted reverberation tell the listener that he is in a large hall.

In operation, an audio delay line accepts signals from the main audio channels, stores them for a given amount of time, and then presents them to a power amplifier which drives one or more speaker systems. The speakers driven by the main-channel signals are placed in front of the listener, and the speaker(s) driven by the delayed information is (are) placed behind him or off to the sides. The goal is to synthesize the reverberative characteristics of the type of environment in which the recorded program material would ordinarily be performed.

Delaying the Signal. Various means, electromechanical and electronic, are available for providing delayed signals; but cost, complexity, and space requirements make most of these impractical for use in the home. It seems fair to say that use of delayed signals to enhance home music reproduction was brought about by the availability of purely electronic delay systems.

State-of-the-art reverberation synthesizers derive suitable audio delays by means of analog or digital shift registers. In either method, the audio signal is divided at a given rate into samples that describe its instantaneous amplitude. These are sequentially deposited in a shift register that stores them for a given amount of time. The samples are clocked through the register, the end of which is connected to a circuit that reconstructs a smoothly varying analog signal out of the series of discrete samples applied to it.

The difference between analog and digital delay lines lies in the manner in which the input signal is sampled, stored, and reconstructed. In an analog system, the input signal is sampled and its instantaneous amplitude is applied to the input of an analog shift register. What happens next depends on the type of analog shift register that is employed.

If the register is a *bucket-brigade de-*

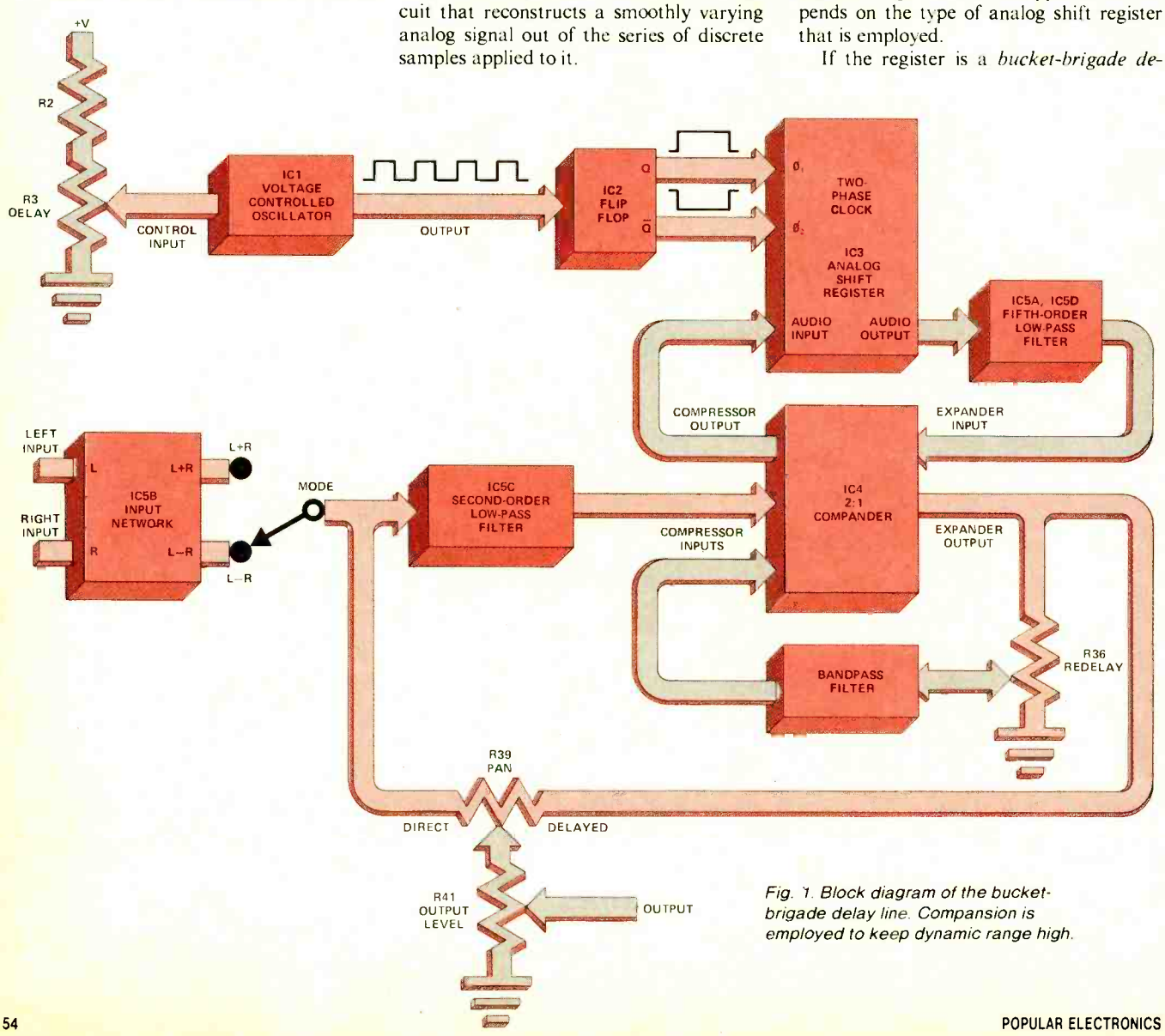

Fig. 1. Block diagram of the bucket-brigade delay line. Companion is employed to keep dynamic range high.

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Photograph of the author's prototype. The large control knob adjusts vco frequency and, hence, delay time.

vice, the sampled voltage charges a small input capacitor. This charge is then transferred to the first of a long series of storage capacitors by means of a voltage-controlled switch (a FET driven by one component of a two-phase clock). Next, a new sample charges the input capacitor and the first sample is transferred to the second in the string of storage capacitors. The sample in the input capacitor is then transferred to the first storage capacitor; the input capacitor receives a new sample; the sample in the second storage capacitor is transferred to the third while that in the first is transferred to the second; and so on.

This process goes on continuously and the analog samples of the input waveform make their way down the bucket-brigade device in the form of packets of charge being shifted from one capacitor to the next. At the end of the register, a low-pass filter integrates the staccatto sequence of samples delivered to it into a smoothly varying replica of the input waveform.

The second type of analog shift register, the *charge-coupled device*, functions in a similar manner but employs a different method of storing and transferring the analog samples of the input waveform. Instead of using actual capacitors to store the charge packets, a charge-coupled device or CCD employs the equivalent capacitances of a series of MOSFET channels which form under gate structures biased by voltages greater than the MOS threshold.

The MOS elements of a CCD are close enough to each other that the free charge consisting of minority carriers stored in the inversion layer associated with one MOS capacitor (the channel) can be transferred to the channel region of the adjacent device. The transfer of charge is governed by the multi-phase clock voltages applied to the gate structures of adjacent MOS devices. In a CCD, an analog sample of the input signal is stored as a channel charge. Because CCD gates are very small (typically a few square micrometers in area), tiny amounts of charge are involved—usually from approximately 10 electrons (!) to 10^7 electrons.

In an analog delay line, the amount of delay that is obtainable depends on both the rate at which the samples are clocked through the shift register and the number of storage elements in the register. Current IC fabrication techniques have made possible the construction of BBD or CCD delay lines containing hundreds and even thousands of storage elements. Such devices offer delays as long as 100 milliseconds or more—longer than necessary for most reverberation synthesis applications.

The faster the clock frequency, the shorter the delay and, for a given device, the more closely the output signal resembles the input signal. As a rule, longer delays result in some loss of high frequencies and degradation of dynamic range. Advanced delay-line ICs offer impressive performance in spite of these limitations. For example, the Reticon SAD-4096 employed in the project to be described here has 2048 storage elements, a clock-frequency range of 8 kHz to 2 MHz, and a delay range of 1 millisecond (2-MHz clock) to 250 milliseconds (8-kHz clock). The dynamic range of its output is 65 dB when the clock frequency is a relatively low 20 kHz. The use of compansion can provide even greater dynamic range.

In a digital system, the input waveform is sampled at an appropriate rate. Each sample is applied to an A/D converter which transforms it into a sequence of bits describing its instantaneous amplitude in digital form. Each digital word describes a specific sample and is applied to either a digital shift register or to a RAM, depending on the design of the delay line. If a shift register is employed, the words are clocked through the register at a specific clock rate and eventually appear at its output. If a RAM is used, the words are written into specific memory locations, stored in them for a certain period of time, and then read out of the memory locations in the appropriate order.

As the digital words stream out of the register or are read out of the RAM, they are applied to the input of a D/A converter which changes them back into analog form. Low-pass filtering smooths out the reconstructed analog waveform. The total delay provided by a digital system depends on the length of the shift register and the rate at which data is clocked through it or on the size of the RAM and the rate at which digital data is written into and read out of it.

Some delay line designs employ *delta modulation*. That is, the input waveform is sampled continuously and compared to the previous sample. The circuit that processes the input waveform generates an output signal that describes the result of this comparison—whether the input signal has decreased or increased in amplitude, or remained constant. If this is done, only "change" information need be clocked through a register or written into memory, rather than information completely describing the instantaneous amplitude of the input signal at each moment that it is sampled. At the output of the storage circuit, a demodulator reconstructs an analog replica of the input waveform that is low-pass filtered to remove abrupt level changes introduced by the delta modulator.

Design Considerations. A digital system's greatest advantage is that the signal degradation it introduces is fixed and independent of the length of the delay. Once a signal sample has been converted into digital form, it can be manipulated any number of times without loss. The quality of the output signal is affected only by the linearity and dynamic range of the A/D and D/A converters at the input and output.

The dynamic range of a digital system in which the digital words directly describe the corresponding input samples is approximately 6 dB per bit. A 16-bit linear digital system thus offers a dynamic range of approximately 96 dB, but is horrendously expensive. To obtain an acceptable dynamic range using fewer bits, various "nonlinear" coding schemes have been developed.

Analog delay systems bypass the complexities of A/D and D/A conversion but degrade signals more as delays become longer. Because analog shift registers are

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more-specialized, lower-volume devices than their digital counterparts, analog registers are considerably more expensive. In the author's opinion, analog systems offer superior price/performance ratios for delays of less than 100 milliseconds. For longer delays, he would give digital systems the nod. As 100 ms was considered a suitable upper limit for delay time in the system, the analog approach was used.

The length of delay required depends on the reverberation times that the designer is attempting to synthesize. In the author's opinion, audibly believable reverberation can be generated by feeding the output signal of the delay device back to the input. The resulting multiple repetitions simulate the arrivals of reflected sounds along paths of different lengths. In such a system, the reverberation time can be calculated from the length of the delay and the gain of the feedback loop. For example, if the signal is delayed 50 ms and the gain of the loop is −3 dB, it will take 20 recirculations of the signal before the output level decays to −60 dB relative to its initial amplitude. The reverberation time is thus one second.

Natural-sounding reverberation can be achieved with a maximum shift-register delay of 40 to 60 ms as long as the recircu-

PARTS LIST
DELAY CIRCUIT

C1, C18, C19, C32—0.1-μF, 50-V disc ceramic capacitor
C2—100-μF, 16-V radial-lead electrolytic
C3, C13, C16, C25, C27—4.7-μF, 16-V radial-lead electrolytic
C4—0.01-μF, 5% Mylar capacitor
C5, C11, C21, C22, C24—100-pF, 5% polystyrene capacitor
C6, C7, C8, C12, C17—1-μF, 25-V radial-lead electrolytic
C9, C14—5-pF, 50-V disc ceramic capacitor
C10—2200-pF, 5% polystyrene capacitor
C15, C26—0.47-μF, 25-volt radial-lead electrolytic
C20—1000-pF, 5% polystyrene capacitor
C23—510-pF, 5% polystyrene capacitor
C28—0.0022-μF, 5% Mylar capacitor
C29, C30—470-pF, 50-V disc ceramic capacitor
D1, D2—1N914 diode
IC1—CD4007AE dual complementary pair plus inverter
IC2—CD4013AE dual D flip-flop
IC3—SAD-4096 bucket-brigade analog shift register (Reticon)
IC4—NE570N compander
IC5—TL074CN quad BiFET op amp
J1, J2, J3, J4—phono jacks

The following, unless otherwise specified, are ¼-watt, 5%, fixed carbon-composition resistors.
R1, R6, R7—1000 ohms
R2, R10 through R15, R22, R31, R32, R34—100,000 ohms
R3, R36, R41—100,000-ohm, linear-taper potentiometer
R4, R25, R26—3300 ohms
R5—300,000 ohms
R8, R40—100 ohms
R9—75,000 ohms
R16, R17—22,000 ohms
R18, R35—68,000 ohms
R19, R20, R37, R38—43,000 ohms
R21—10 ohms
R23—36,000 ohms
R24, R27, R28—15,000 ohms
R29—62,000 ohms
R30—180,000 ohms
R33—20,000 ohms
R39—10,000-ohm, linear-taper potentiometer
S1—Dpdt pc-mount push-on/push-off switch
Misc.—Printed circuit board, IC sockets or Molex Soldercons, circuit board standoffs, control knobs, suitable enclosure, shielded patch cords, hookup wire, etc.

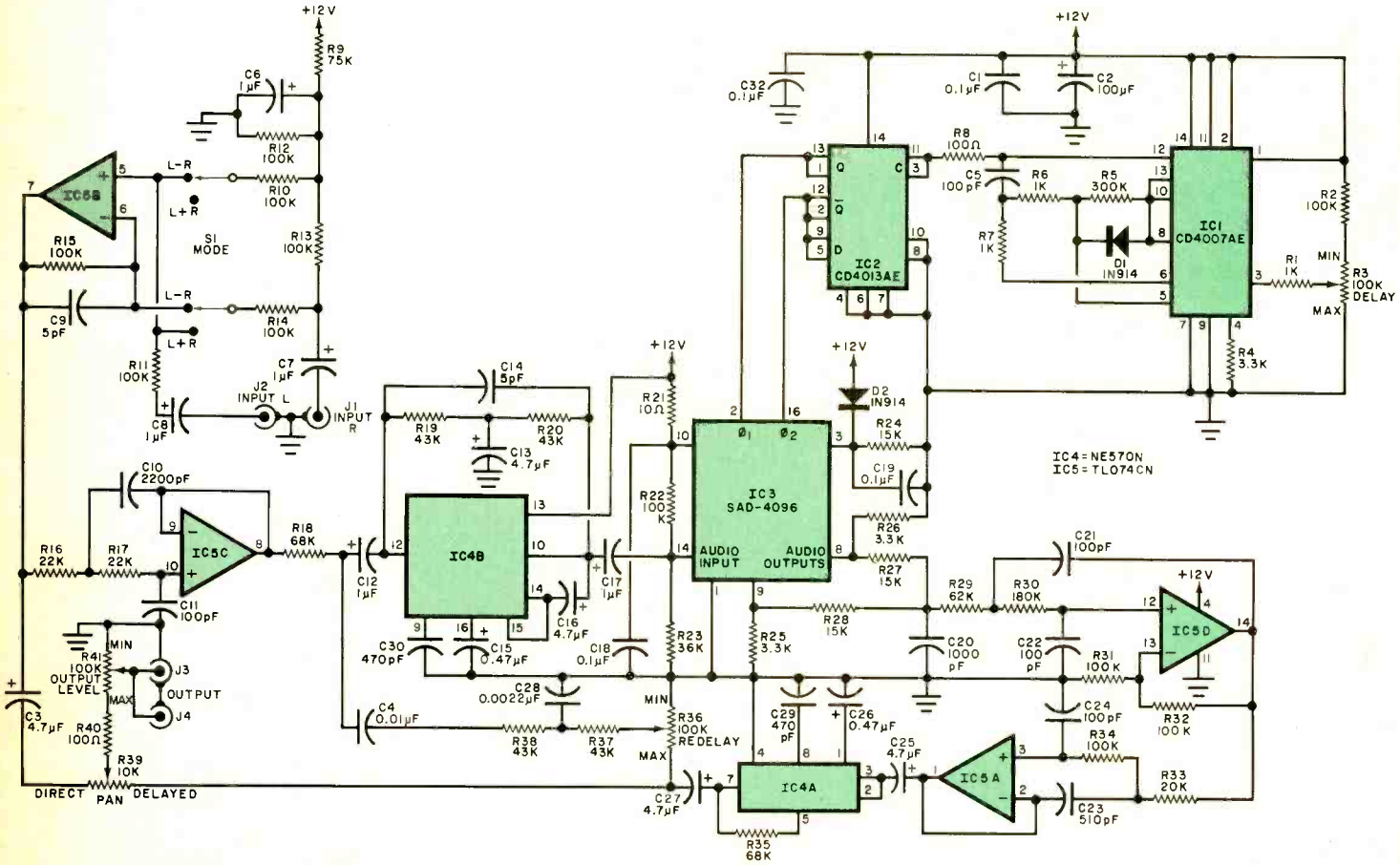

Fig. 2. Schematic diagram of the delay line. Two audio input channels are combined by IC5C into a single channel which is delayed by IC3.

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lation loop gain is well below 0 dB. A loop gain of more than 0 dB will make the system unstable.

The bandwidth of the delay line and the rate at which its input signal is sampled are intimately related. Although standard high-fidelity practice would dictate a flat frequency response between 20 and 20,000 Hz, a narrower bandwidth is appropriate for a delay line. The principal reason for this is that natural reverberation generally causes high-frequency attenuation.

Sampling theory indicates that a signal must be sampled at least twice every period if it is to be reconstructed into continuous form without error. The sampling frequency thus should be at least twice that of the highest frequency in the signal. Furthermore, a rolloff caused by the reconstruction process itself results in a response 3 dB down at approximately one-third of the sampling frequency. (This rolloff is in addition to any due to a smoothing filter at the output.)

Any signal frequency greater than one-half of the sampling frequency will stimulate the production of aliases or beat tones that fold back into the useful passband. For example, if a 22-kHz signal is sampled at a rate of only 40 kHz, an alias will appear at 18 kHz. Accordingly, for all of the above reasons, it is good design practice to band-limit the signal to be sampled to about one-third of the sampling rate.

About the Circuit. The Analog Audio Delay Line appears in block-diagram form in Fig. 1 and schematically in Fig. 2. The block diagram shows the principal function stages of the project.

A voltage-controlled oscillator generates a train of pulses at a rate determined by the setting of the DELAY potentiometer. The oscillator drives a flip-flop which provides a two-phase clock signal by means of its complementary (Q and $\overline{Q}$) outputs. This two-phase clock governs the transfer of signal samples within the analog shift register.

An op-amp input stage accepts signals from the two main stereo channels and generates either an L+R or L−R output, depending on the position of the MODE switch. A considerable saving in system cost and circuit complexity can be realized by combining the main stereo channels to form one channel of delayed information.

Summing the two main channels before delaying them results in a conventional monaural signal that is then delayed, amplified and reproduced by a single loudspeaker. The usefulness of the L−R mode can be dramatically demonstrated by listening to a stereo FM broadcast. During the musical portion of the broadcast, relatively high levels of L+R or stereo reverberation can be introduced to provide a pleasing audio effect. When the announcer's voice is heard, it sounds as if he is talking from the bottom of a well. This can also happen when a centered vocal or instrumental soloist predominates.

The L−R mode, in which the direct center components are cancelled out, can prevent this from happening. An additional benefit provided by the L−R mode is realized because of the common mixdown practice of placing room or ambience microphones and studio reverberation unit output signals away from center. Although it is not possible to completely characterize the differences in sound quality provided by the two modes, the author's experience is that L−R reverberation sounds "softer" or more subtle. The type of music and the particular mix-down will determine which mode is more pleasing.

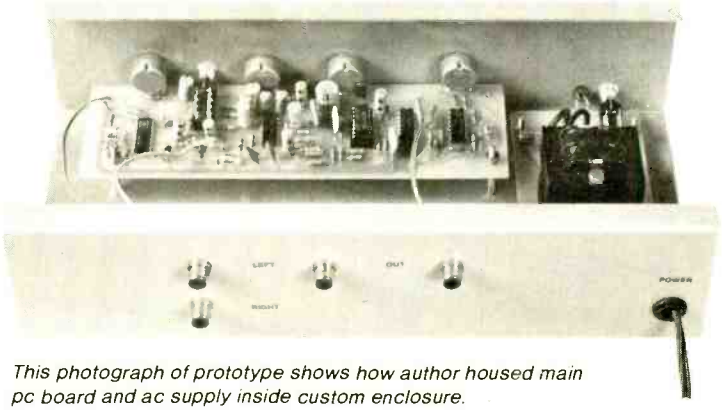
The signal from the input network is applied to a second-order active low-pass filter with a cut-off frequency of 15 kHz. This prevents foldback/aliasing problems that might otherwise occur. A 2:1 IC compressor acts on the filter output before it is applied to the analog shift register. Also applied to the compressor input is a signal component that is provided by the recirculation loop.

Delayed audio signals appearing at the output of the analog shift register are treated by a fifth-order active low-pass filter before being processed by a 1:2 IC expander. This filter smooths out the signal provided by the delay line and suppresses any ultrasonic clock energy contained in it. One portion of the expander output makes its way back to the compressor input by means of a recirculation loop. This loop comprises *R36*, the REDELAY potentiometer, which permits adjustment of the amount of delayed signal fed back to the input compander, as well as a passive bandpass filter (*R37*, *R38*, *C4* and *C28*). The bandpass filter provides additional high-frequency rolloff for each recirculation of the signal and some low-frequency rolloff. The accelerated absorption of high-frequency components simulates the treble loss of natural reverberation; the low-frequency attenuation prevents the reverberant signal from sounding muddy.

Complementary compression and expansion make it possible for the delay line project to have an impressive dynamic range. The rated S/N of the SAD-4096 analog shift register varies from more than 75 dB for its shortest delays to approximately 65 dB for its longest delay time. The compansion employed in this project allows the delay system to have a very large dynamic range. As measured by the author, the IHF "A" weighted noise at the project's delayed output is −91.5 dBm at 5 milliseconds and −89 dBm at 100 milliseconds. Input-level adjustments are therefore unnecessary.

Output signals are presented to PAN control *R39*. This potentiometer allows the user to drive the subsequent stages in the signal chain with a fully undelayed audio signal (when the wiper is set to the DIRECT extreme of its travel), a fully delayed signal (when the wiper is set to the DELAYED extreme of its travel), or with a mixture of the direct and delayed versions of the input signal (when the wiper is set between the two extremes of its travel). Potentiometer *R41* can be adjusted for the desired balance of front to back sound levels.

(To be continued next month)



This photograph of prototype shows how author housed main pc board and ac supply inside custom enclosure.

KIT AVAILABILITY

The following are available from Phoenix Systems, 375 Springhill Rd., Monroe, CT 06468: complete kit of parts including enclosure for a single-channel, dc-powered-delay line, No. P-25-DLC, for $145; complete kit of parts including enclosure for a single-channel, ac-powered delay line, No. P-25-DL, for $150; complete kit of parts including enclosure for a two-channel, ac- or dc-powered (specify) delay line, No. P-25-SDL, for $250. All items postpaid within continental US. COD orders subject to $2 surcharge. Connecticut residents, add state sales tax. Information on subassemblies and individual parts will be published next month.

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How a PLL circuit works, how it is used in communication equipment, and how to locate circuit defects

Troubleshooting Phase-Locked-Loop Circuits

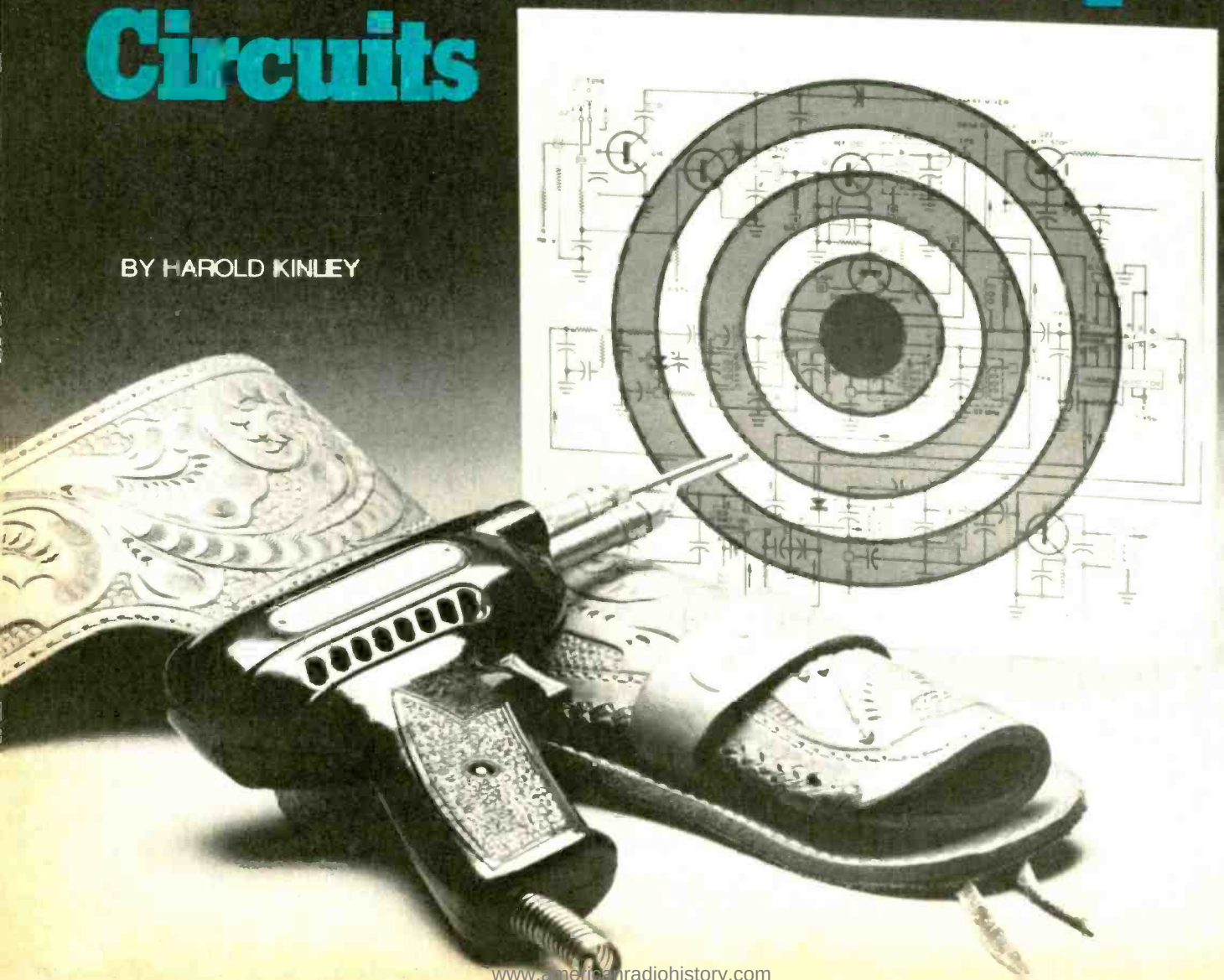
BY HAROLD KINLEY

THE phase-locked-loop (PLL) circuit has been around for many years now. It wasn't until it was introduced in integrated circuit form in 40-channel CB transceivers, however, that it truly came into prominence. Now it's conspicuously used in other electronic equipment, such as FM tuners and amateur radio gear.

Presented here is detailed information on how a PLL circuit works in CB applications, followed by step-by-step troubleshooting analysis of a typical PLL CB system. The principles are applicable to other equipment using PLLs.

Why Use PLLs? The switch to PLLs was necessitated by the CB move from 23 to 40 channels. The old system, in which a bank of crystals in a "Crystal-plexer" arrangement was used, would have been prohibitively expensive. By switching to the PLL, it was possible to synthesize all channel frequencies with just two or three crystals. Increased accuracy and stability were bonuses.

Another advantage of the PLL is that its digital circuitry is compatible with electronic numeric displays, which provide large, easy-to-read numerals.



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Actual PLL Circuit. Shown in Fig. 1 is an actual circuit commonly used in many CB transceivers. The one shown here appears in the Boman Model CB-930 transceiver. The total system, including delta-tune and transmit-stop circuits, is composed of five transistors and three integrated circuits. The small boxes in Fig. 1 are used to indicate interconnections to other circuits within the overall system.

Divider *IC1* can be programmed to divide the input frequency present at pin 2 by a divisor selected via CHANNEL SELECTOR switch *S1*. This switch provides either 5.36 volts (logic 1) or zero volts (logic 0) to programming pins 9 through 15 of *IC1*.

Each programming pin has a "weight" (value) that increases in binary fashion (each number is twice the previous one) as the pin numbers go down. For example, pin 15 is weighted 1, pin 14 is 2, pin 13 is 4, etc., proceeding down to pin 7 weighted 256. Since pin 7 is permanently connected to 5.45 volts, it is always a 1 hence 256 must be added to the divisor. Pin 8 (which should be 128) is permanently connected to ground, hence it has no weight and can be disregarded.

As shown in Table I, the truth table for the *IC1* programming pins, each channel has a unique array of 1's and 0's. In the case of channel 1, pins 9, 12 and 14 are selected high (1). Therefore, the divisor is 256 (pin 7) + 64 (pin 9) + 8 (pin 12) + 2 (pin 14) which equals 330, the divisor for channel 1.

Also contained in *IC1* is a phase comparator and a constant divider, the latter dividing the input at pin 3 by 1024. Both inputs of the phase comparator are fed with separate 10-kHz signals and the comparator's output frequency is determined by the relative frequency or phase differences between the two input signals. This output is then filtered to obtain a steady dc-level "error" signal that is used to control a voltage-controlled oscillator (vco).

Vco and Mixer. Contained in *IC2* are a vco and a mixer. When two different frequencies are fed to pins 2 and 4, their sum and difference appear at pins 6 and 9, respectively.

The heart of the vco is Varactor diode *D1*, whose capacitance varies with changes in bias voltage. The oscillator in *IC2* is controlled by the external components connected to pin 1. The LC network that parallels *D1* also has an effect on the nominal 17-MHz operating frequency of the vco.

Although *IC2* and *IC3* are identical, the oscillator in *IC3* is crystal controlled at 10.695 MHz. The outputs from pin 6 of *IC2* and the 10.695-MHz oscillator go to *IC3*'s mixer. Their difference appears at pin 9 of *IC3*.

The basic reference frequency is generated by oscillator *Q1*, which operates at 10.240 MHz. The secondary of *T1* is tuned to the 20.480-MHz second harmonic of the oscillator signal.

Detailed Analysis. Let us use channel 1 (throughout this article) to analyze system operation. Refer to both Fig. 1 and Table I. Since pin 7 (not listed) is always high, its weight of 256 must be added to the final tally to obtain the divisor on *all* channels.

Also shown in the chart is the divider input at *TP3* (3.300 MHz for channel 1) and the receiver and transmitter outputs at *TP4*.

The 3.300-MHz signal is obtained as follows. The *IC2* mixer is fed a 20.480-MHz signal from *T1* and another signal from the vco. The latter goes to the mixer at pin 2. The 20.480-MHz signal goes into the mixer via pin 4. The sum and difference of the two signals appear at pins 6 and 9, respectively, of *IC2*.

Calculate the vco frequency as follows. From Table I, the *IC2* sum output frequency is 37.660 MHz. Since the vco frequency is mixed with 20.480 MHz to obtain 37.660 MHz, F_{vco} = 37.660 MHz − 20.480 MHz = 17.180 MHz. The difference of the vco frequency and 20.480 MHz is 3.300 MHz, which is present at pin 9 of *IC2* and pin 2 of *IC1*. The programmable divider then divides the input by 330 to yield 10 kHz. This 10-kHz signal is fed, within *IC1*, to one of the inputs to the phase comparator.

The other 10-kHz signal used for the reference is derived as follows. A 10.240-MHz signal from the emitter of *Q1* is amplified by *Q2* and fed to pin 3 of *IC1*, where it is divided by 1024. This yields the 10-kHz reference signal required for the reference input to the phase comparator.

The comparator constantly compares the phases of the two 10-kHz signals fed to it, and its output varies with the differences. Since the reference oscillator is crystal controlled, its output is very stable. The frequency of the signal from the vco, on the other hand, is likely to drift. Any drift is interpreted by the comparator as a phase change, which results in an error voltage at pin 5 of *IC1*.

The error voltage is fed to *D1*, where it changes the bias (hence, capacitance) and, in turn, changes the vco frequency. The vco "hunts" for the correct frequency. When it finds it, the error voltage stabilizes to keep the voltage-controlled oscillator on frequency.

In the receive mode, the 37.660-MHz signal from pin 6 of *IC2* goes to the first r-f mixer, where it combines with the 26.965-MHz channel-1 signal to yield 10.695 MHz. This is the first i-f. In the second r-f mixer, the 10.695-MHz i-f combines with 10.240 MHz (from the reference oscillator) to yield the second i-f 455-kHz signal.

On transmit, the 37.660-MHz signal from pin 6 of *IC2* goes to pin 4 of transmit-oscillator/mixer *IC3*. The other mixer input at pin 2 is fed the 10.695-MHz oscillator signal. When 37.660 and 10.695 MHz are mixed, the result is 26.965 MHz. This is the channel-1 frequency, which is then fed to the following transmitter stages.

Delta Tune & Transmit-Stop. With delta TUNE switch *S2* set to 0, *Q17* conducts and grounds one end of *C132*, which is part of the frequency-determining circuit. This removes *C131* from the circuit. When *S2* is set to −, *Q17* cuts off and *Q16* conducts. Capacitor *C131* is now in and *C132* is out of the circuit. The larger capacitance of *C131* lowers the frequency and makes it possible for stations off-frequency to the low side to come in better.

The delta-tune circuit is designed so that when the transmitter is keyed on, *Q17* is forward biased. With *S2* set to − and the MODE switch set to RECEIVE, *Q16* conducts. Supply point 8 has 7.88 volts applied to it on transmit and 0 volt on receive. Similarly, point 9 is "live" only on transmit. So, when the transmitter is keyed, forward bias on *Q16* is removed because point 8 is dead. Simultaneously, point 9 is "hot" and *Q17* conducts, returning the oscillator to the proper frequency.

When *S2* is set to +, both *Q16* and *Q17* are cut off and remove *C131* and *C132* from the circuit. A decrease in circuit capacitance and an increase in oscillator frequency result.

The purpose of the transmit-stop circuit is to kill the transmitter if the PLL system should go out of lock to prevent off-frequency transmission. When an out-of-lock condition occurs, pin 6 of *IC1* goes low and forward biases *D22* and kills forward bias on *Q22*. Since forward bias to *Q3* is supplied through *Q22*, if the latter cuts off, forward bias on *Q3* is killed. This shuts down the transmitter until lock is restored to the PLL system.

Getting Acquainted. To properly troubleshoot a PLL system, you should get to know all its nuances through actual hands-on experience. Begin by monitoring the dc "command" voltage that keeps the vco on track at pin 5 of *IC1*. The actual measurement here is about 3.7 volts on channel 1. The reading will steadily decrease as you switch up-channel, until it is about 1.9 volts on channel 40.

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An exception to the foregoing is that there will be an *increase* in voltage as you go from channel 23 to channel 24 because the latter is actually *lower* in frequency. (See last column in Table I) When 17 new channels were added to the existing 23, channels 24 and 25 were sandwiched between channels 22 and 23. This is less confusing than it would have been if a new frequency had been assigned to channel 23 just to maintain consecutive order for the 40 channels that now make up the band.

You can determine what occurs at pin 6 of *IC2* if one input to the comparator is missing by temporarily connecting a 0.05-μF capacitor from pin 3 of *IC1* to ground. This kills the reference signal here and places about 5.5 volts on pin 5 of *IC1*. Connecting the capacitor from pin 2 of *IC2* to ground cuts off the other input to the comparator. Again, 5.5 volts appears at pin 5 of *IC1*. With either input missing, the voltage on pin 5 of *IC1* will remain at 5.5 volts as you tune through the channels. This can be an important clue to troubleshooting a PLL system.

Repeat the experiment while monitoring the potential at pin 6 of *IC1*. When the reference signal disappears, the potential on pin 6 drops to about 0.3 volt, reverse biasing *Q22* and killing transmitter output. Interrupting the signal at pin 2 of *IC2* causes the monitored potential to drop to practically 0, again triggering the transmit-stop circuit.

Substitute the output of a variable-frequency signal generator in the PLL system when you suspect vco failure as follows. Disconnect pin 2 of *IC2* to simulate a missing vco signal at mixer-input pin 2. The vco frequency on channel 1 is 37.660 MHz − 20.480 MHz = 17.180 MHz. Using a frequency counter, tune the generator to 17.180 MHz and set it for about a 100-mV output. Feed a signal from a CB generator to the input of the receiver so that you know when the PLL begins operating.

When the 17.180-MHz output of the signal generator is fed to pin 2 of *IC2*, the signal from the CB generator should come through loud and clear, indicating that the PLL is working. When the transmitter is keyed, there may be no output at first. Then there may be a brief output that comes and goes as if the PLL is attempting unsuccessfully to lock. Confirm this by monitoring the lock voltage at pin 6 of *IC1*, where there should be regular fluctuation. Whenever the voltage at pin 6 rises to a level sufficient to reverse bias *D22*, there will be an output from the transmitter. This output will not remain since the PLL cannot lock because it does not have the control over the signal generator it has over the vco.

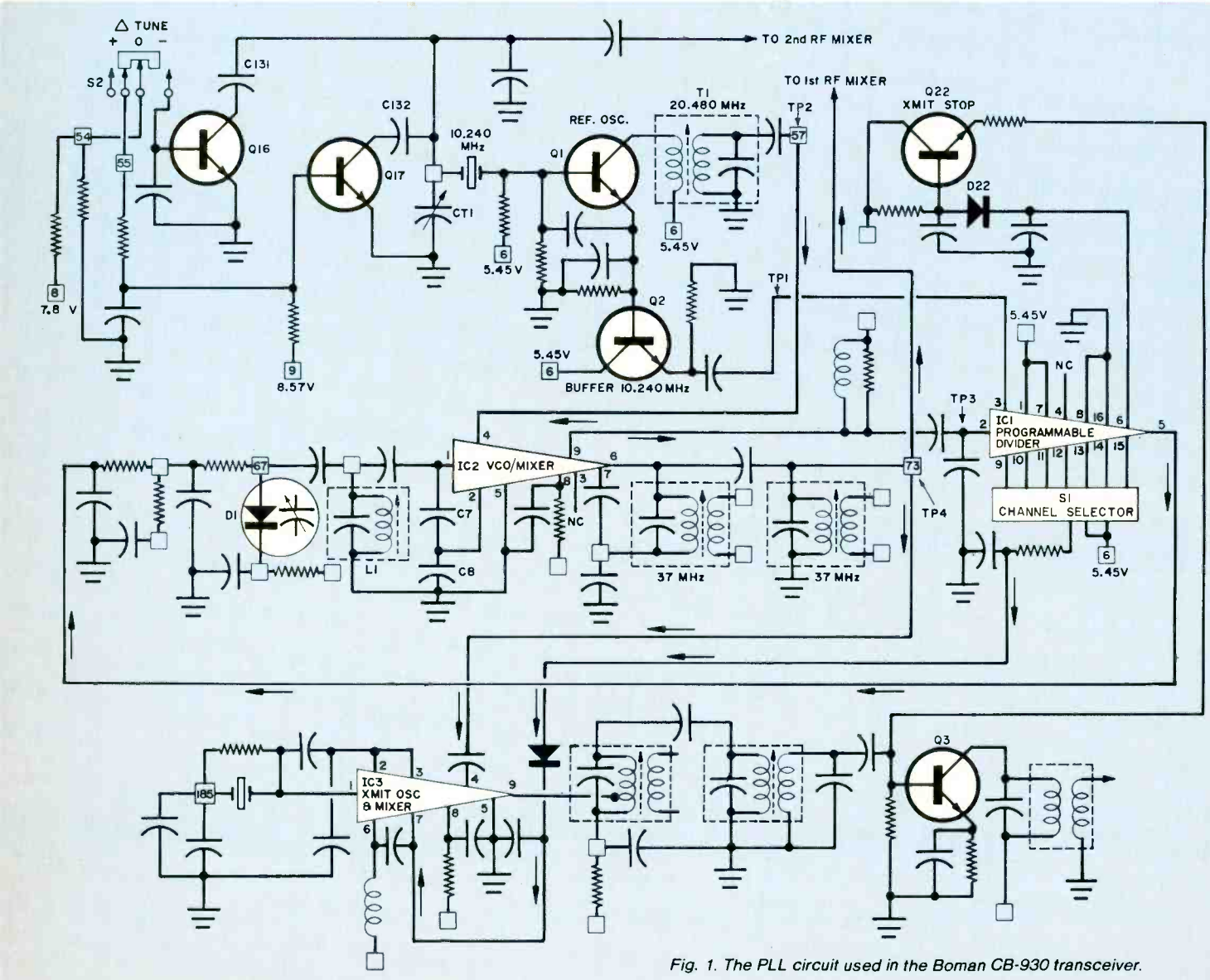

Fig. 1. The PLL circuit used in the Boman CB-930 transceiver.

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Due to instrument loading effects, very few frequency-counter readings are possible around the PLL. When the test probe is touched to pins 1, 2, 4, and 6 of *IC2*, PLL operation will cease. The 3.300-MHz mixer output at pin 9 is the only frequency you will be able to measure on *IC2* (on channel 1). However, you can measure 10.240 MHz at the emitters of *Q1* and *Q2* and at pin 3 of *IC1*. You can also measure 3.300 MHz on pin 2 of *IC1*. On *IC3*, you can measure the signal frequency at pin 9 with the transmitter keyed, but the transmitter's output will cease every time the probe tip is touched to pin 9. If you use a frequency counter with a top end of 50 megahertz or greater, you can even measure 37.660 megahertz at *TP4* (point 73 in Fig. 1).

If any frequency obtained by mixing two other frequencies can be measured, the two mix frequencies must be present. For example, if you cannot measure the *IC2* vco signal nor the 20.480-MHz signal but are able to measure 3.300 MHz on pin 9, you automatically know the other two signals must be present.

Troubleshooting Examples. Many conditions can render a PLL system inoperative. Suppose, for example, that the reference oscillator stops working. Without a reference, the PLL would not operate and the voltage on pin 5 of *IC1* would be high and would not vary when switching through the channels. This is a clue that one of the inputs to the phase comparator is missing. Also the voltage on pin 6 of *IC1* would be near 0, another clue that one of the comparator's inputs is missing.

First, check for a 10.240-MHz signal at pin 3 of *IC1*. Finding nothing here, go directly to the oscillator. Check for the presence of r-f at the emitter of *Q1*; no r-f here pinpoints the trouble.

A missing vco signal will also cause one of the comparator's inputs to be absent. If the 1024 divider or the programmable divider is not working properly, it can cause one comparator input to be missing. A malfunctioning mixer in *IC2* can also cause a comparator input to be missing.

Now, suppose the PLL is dead. About 5.5 volts is on pin 5 of *IC1* and there is no output at pin 9 of *IC2*, but the reference oscillator is working. You must determine if the voltage at pin 5 of *IC1* is high because the vco stopped working or the vco stopped working because the voltage is so high as a result of some defect in *IC1*.

To determine where the fault lies, tune to channel 1 and feed a 3.300-MHz signal to the input of *IC1* via pin 2. Assuming *IC1* is working properly, there should be near 0 volt on pin 6 until the correct frequency is applied to pin 2, at which time, the voltage should rise and fall as the PLL tries to lock. Monitor the voltage at pin 5 as you vary the frequency above and below 3.300 MHz. There should be a voltage below but none above 3.300 MHz. These results are a good indication that *IC1* is okay.

Suspicion is now on the vco or mixer in *IC2*. Generator substitution for the vco output is called for. Remove all connections from pin 2 of *IC2* by cutting through the foil trace on the pc board. Feed a 17.180-MHz (on channel 1) signal through a coupling capacitor to pin 2. Have a modulated signal feeding the input of the receiver so you know when and if the PLL starts to work. If it does, the problem is in the vco.

To determine if the trouble is within *IC2* or in the external circuitry, measure the voltages on the IC pins. If this fails to produce results, you may have to substitute another IC and/or check all external components.

Summing Up. The material presented here is the result of actual tests and measurements on a commonly used PLL system. Using the material presented here as a guide, you should be able to troubleshoot virtually any CB PLL system you encounter. Note, however, that FCC regulations require anyone repairing or adjusting the frequency-determining sections of a CB transceiver to have a First-Class Commercial license. However, a radio amateur who is modifying a CB PLL rig for 10-meter operation need not have the license. ◇

TABLE I—TRUTH TABLE FOR IC1 PROGRAMMING PINS

	IC1 Program Divider Pins									
Chan.	(64) 9	(32) 10	(16) 11	(8) 12	(4) 13	(2) 14	(1) 15	Divider Input in MHz at TP3	Rec. & Xmt. Synthesizer Output in MHz at TP4	Channel frequency
1	1	0	0	1	0	1	0	3.300	37.660	26.965
2	1	0	0	1	0	0	1	3.290	37.670	26.975
3	1	0	0	1	0	0	0	3.280	37.680	26.985
4	1	0	0	0	1	1	0	3.260	37.700	27.005
5	1	0	0	0	1	0	1	3.250	37.710	27.015
6	1	0	0	0	1	0	0	3.240	37.720	27.025
7	1	0	0	0	0	1	1	3.230	37.730	27.035
8	1	0	0	0	0	0	1	3.210	37.750	27.055
9	1	0	0	0	0	0	0	3.200	37.760	27.065
10	0	1	1	1	1	1	1	3.190	37.770	27.075
11	0	1	1	1	1	1	0	3.180	37.780	27.085
12	0	1	1	1	1	0	0	3.160	37.800	27.105
13	0	1	1	1	0	1	1	3.150	37.810	27.115
14	0	1	1	1	0	1	0	3.140	37.820	27.125
15	0	1	1	1	0	0	1	3.130	37.830	27.135
16	0	1	1	0	1	1	1	3.110	37.850	27.155
17	0	1	1	0	1	1	0	3.100	37.860	27.165
18	0	1	1	0	1	0	1	3.090	37.870	27.175
19	0	1	1	0	1	0	0	3.080	37.880	27.185
20	0	1	1	0	0	1	0	3.060	37.900	27.205
21	0	1	1	0	0	0	1	3.050	37.910	27.215
22	0	1	1	0	0	0	0	3.040	37.920	27.225
23	0	1	0	1	1	0	1	3.010	37.950	27.255
24	0	1	0	1	1	1	1	3.030	37.930	27.235*
25	0	1	0	1	1	1	0	3.020	37.940	27.245*
26	0	1	0	1	1	0	0	3.000	37.960	27.265
27	0	1	0	1	0	1	1	2.990	37.970	27.275
28	0	1	0	1	0	1	0	2.980	37.980	27.285
29	0	1	0	1	0	0	1	2.970	37.990	27.295
30	0	1	0	1	0	0	0	2.960	38.000	27.305
31	0	1	0	0	1	1	1	2.950	38.010	27.315
32	0	1	0	0	1	1	0	2.940	38.020	27.325
33	0	1	0	0	1	0	1	2.930	38.030	27.335
34	0	1	0	0	1	0	0	2.920	38.040	27.345
35	0	1	0	0	0	1	1	2.910	38.050	27.355
36	0	1	0	0	0	1	0	2.900	38.060	27.365
37	0	1	0	0	0	0	1	2.890	38.070	27.375
38	0	1	0	0	0	0	0	2.880	38.080	27.385
39	0	0	1	1	1	1	1	2.870	38.090	27.395
40	0	0	1	1	1	1	0	2.860	38.100	27.405

*Out of sequence—see text.

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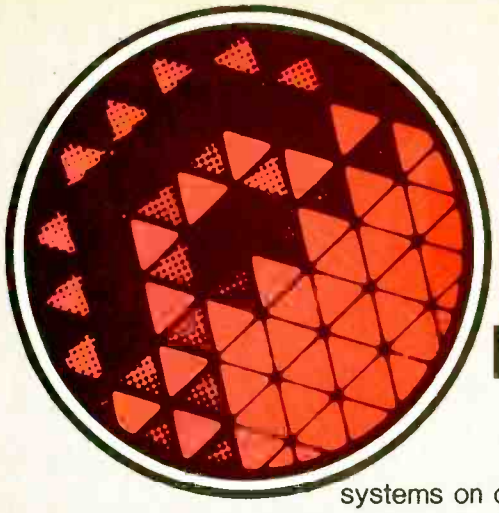


BY IMRE GORGENYI

TURN/BRAKE INDICATOR FOR TRAILERS

Simple solid-state circuit permits use of 3-wire systems on older trailers with 4-wire systems on new cars

ON AUTOMOBILES manufactured after 1977, the turn-indicator and brake lights are independent. This may present a problem when one wants to haul a trailer that is equipped with the older 3-wire system in which turning and braking are indicated by the same rear light.

The interface circuit shown here permits coupling the old 3-wire system to a modern car. The circuit for only one side is shown so it must be duplicated for the other side. When using this circuit, the car light flasher does not have to be replaced with a heavy-duty version as in some trailer systems. As a further advantage, there are no moving or electromechanical parts such as relays that can be affected by moisture or vibration encountered on the highway.

Operation. Each time the vehicle turn signal is operated, its line alternately goes high and low as determined by the flasher. When the line goes high, diode *D1* is forward-biased, turning on the *Q3/Q4* combination and causing the common turn-brake lamp to glow. When this line goes low, the transistor pair is turned off and the turn/brake lamp is extinguished. Thus, the turn/brake lamp glows in step with the lamp flasher.

When the brake is applied, that line goes high and forward biases *D2*. The transistor pair is turned on and the turn/brake lamp glows. Since the brake line remains high as long as the brake is depressed, the lamp remains lit.

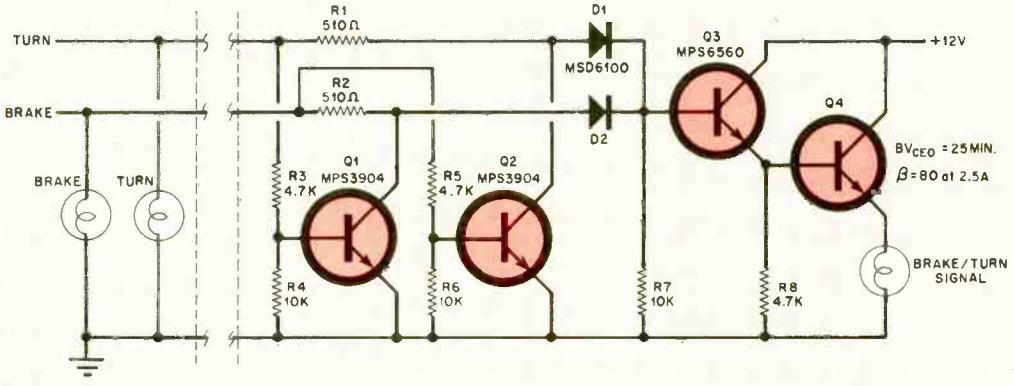
Now let us consider what happens when the turn indicator level is actuated and the brake is applied at the same time. Initially, the turn signal drives the *Q3/Q4* pair through *R1* and *D1* with the base voltage for *Q3* developed across *R7*. Each positive voltage signal on the turn line causes the lamp to go on. Note that the pulsating signal on the turn line is also applied to the base of *Q1* through *R3* and *R4*. This signal does nothing to *Q1* since the brake line (collector source of power) is low, and reverse-biased *D2* keeps the positive voltage across resistor *R7* from appearing on the turn line.

When the brake line goes high, the transistor pair is driven through *R2* and *D2* with the base voltage for *Q3* developed across *R7*. Transistor *Q2* is also turned on by the positive voltage applied to its base through *R5* and *R6*, making *Q2* draw current through *R1* each time the line goes high, thus bringing the *D1/R1* connection effectively to ground. In essence, this action shuts off the turn signal input to *Q3/Q4*. But then *Q1* takes over. Driven by the "turn" line, it alternately releases and pulls down the "brake" voltage at its collector. Therefore, one trailer light flashes but it is 180 degrees out of phase with the car's orange light. The other is on steadily, indicating that the brakes are on.

Construction. Since the circuit is relatively insensitive, it can be fabricated in any desired fashion. Two identical systems should be made, one for each side of the trailer. The turn signal is taken from the appropriate line, while the common brake signal is used.

A power Darlington can be substituted for the *Q3/Q4* combination as long as you make sure that the output transistor in the last stage can carry the current required by the lamp.

The circuit can be mounted in the car with the two lamp wires, battery wire and ground fed to the trailer. Taking the taillight wire, electric brake, and back-up light connection into account, we should use a seven-pole connector. ◇



The conversion circuit above must be built twice—one for each side of the car.

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State-of-the-Art CAR STEREO 1980

How a sampling of new, sophisticated models measures up

by Julian Hirsch
Contributing Editor

and Harold A. Rodgers
Executive Editor

THE relatively new car stereo test standards (see POPULAR ELECTRONICS, March 1980) parallel those that the IHF prescribes for home audio component equipment. That's good, right? In a way, it is, as it will make specifications consistent and meaningful from brand to brand and, therefore, subject to comparison by the consumer. But in another perspective, we must be careful not to let it blur the distinction between audio in the home and audio in the car. These are still distinct breeds, requiring different design philosophies to meet different operating conditions.

Whereas home equipment is listened to in an environment that allows a user to appreciate its rarified performance, the hardships of noise, poor acoustics, and restricted options for speaker placement present in an automotive environment largely preclude notice of many sonic subtleties. On the other hand, a cassette transport designed for use in the home would probably have a short, unhappy life on the road—and it might well carry a few valued cassettes along to disaster as well.

Another point of difference between car and home equipment is that the designer of home gear can expect the user to pay reasonable attention to operating and adjusting it, while operation of a car unit must always be subordinate to operation of the vehicle itself. In addition, the volume of space allotted to a car stereo package is decided by the vehicle design—and not, obviously, according to the principles of audio engineering. Thus, car equipment has a higher than usual percentage of its cost invested in making it fit where it must, ensuring that it is operable by a driver, and keeping it from breaking down when faced by the constant abuses of vibration, extreme temperature variations, etc. All of this, naturally, must divert some effort away from providing pure performance.

Even a cursory glance at the laboratory data will give clear indication that car stereo equipment does not compare favorably with that used at home. To some extent, this reflects the fact that home equipment is in many respects a good deal better than it has to be, and this luxury is difficult to provide in mobile equipment. More to the point, we hope we have established that, in the application at hand, test numbers that are impressive in the conventional way are not necessarily meaningful.

The Equipment. For evaluation in this article, we chose a number of sophisticated auto stereo receivers comprising AM-FM stereo radio and cassette tape playback. In the case of Alpine and Sparkomatic, whose top units do not include a power amplifier section, a separate power amplifier was tested as well.

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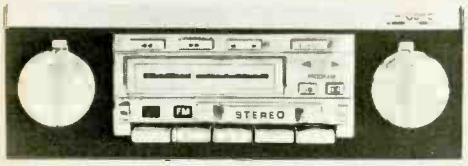
The Jensen receiver is meant to drive four speakers, but uses an outboard amplifier to drive two of them. Accordingly, we included the companion amplifier in the test. Here's an overview of the eight top-of-the-line car stereo models we examined. (Prices noted are nationally advertised value, and will vary from one area to another.)

The Eight Units We Tested:

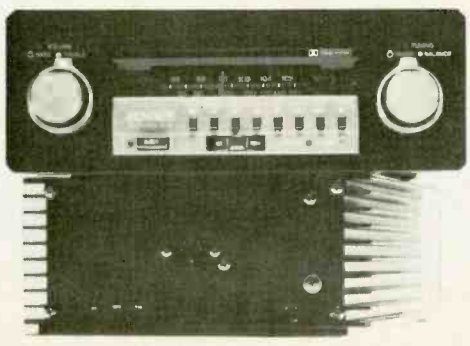
Alpine 3002/7307 ($380). This is a two-unit combination consisting of a "head end" (radio, tape and control center) and a power amplifier that was the most muscular of all. The head end (7307) contains a cassette section capable of playback with 70-μs and 120-μs equalization, thereby accommodating chrome and metal tapes as well as ferric. Dolby decoding that can be used for broadcasts as well as tape is included too. The transport automatically goes into play at the end of REWIND, and FAST FORWARD and REWIND can both be locked in for hands-off operation. MUSIC SENSOR can be used with either high-speed mode to stop at the beginning of the preceeding or following selection. A noise eliminator switch is provided, and mechanical presets accommodate up to five radio stations. Readout is from a slide-rule dial, and independent bass and treble controls are provided.



• Audiovox HCC-1030 ($420). This model, housed in a single enclosure, includes an auto-reverse cassette player and Dolby noise reduction for tape and radio. Metal and chrome tapes (70 μs EQ) can be played as well as ferric (120 μs EQ). A choice of four 8-ohm speakers or two with impedances as low as 4 ohms can be driven by the unit. A fader controls the relative levels of the front and rear speakers. Frequency readout for the radio is a slide-pointer dial, and five mechanical presets are included. A local/distance switch sets sensitivity of the FM reception. Tone controls are separate for bass and treble. If an outboard power amplifier is to be used, driving signals are available at two pin jacks.

Cobra 221GTL ($330). One of the more notable features of this receiver is that station frequency is read out digitally when the tuning knob is touched or when the volume control knob is pushed in. At other times, if the ignition is on, the same readout acts as a digital clock. This unit, too, uses a local/distant switch to adjust FM sensitivity for best reception. Five mechanical presets are provided for the radio. Two pairs of speakers can be accommodated as long as the total load impedance is 4 ohms per channel or more, with a fader setting the relative levels of the pairs of speakers. The cassette player is of the auto-reverse type, and separate tone controls, bass and treble, are included.

Jensen R430 ($470). Featuring a separate power amplifier section for the rear speakers in addition to self-contained stages that drive the front speakers, this receiver also has an electronic crossover that allows the two amplifiers to work in a bi-amped configuration. Dolby noise reduction can be applied to signals from either tape or FM radio. Playback equalization of the cassette section is, according to our data, a better match for 120-μs than for 70-μs tapes. Apparently considering the extra "hot" high end that results to be advantageous in the car, Jensen recommends chrome tapes "for ultimate performance." A slide-rule dial provides station-frequency readout; there is no provision for presetting stations. FM sensitivity is set by a local/distant switch.



Motorola TC-894AX ($390). The cassette player of this receiver is an auto-reverse type and is equipped with Dolby noise reduction that can also be used for FM. Playback equalization is provided for both ferric and chrome tapes. A conventional slide-rule dial supplies readout of station frequencies, and FM sensitivity is set by means of a local/distant switch. No station presets are included. The amplifier section can drive two pairs of speakers provided the total load on each channel is 4 ohms or more. Balance with four speakers can be adjusted left/right and front/back. Separate bass/treble tone controls are included.

Panasonic CQ-8530EU ($450). In this receiver, which uses an electronic tuning system with digital readout, station selection is done exclusively by means of pushbuttons. In one mode, called "seek tuning," the tuner section advances upward or downward in frequency and stops at the next available station each time the appropriate button is touched. Manual tuning is accomplished by holding one of a pair of buttons (for upward or downward shifting) until the frequency desired turns up on the display. In yet another mode, up to six stations can be selected by use of presets. When the cassette player, which reverses automatically, is used, the display indicates the direction of tape travel. At other times the display functions as a digital clock. The display can be made to dim when the car headlights are turned on. Playback EQ of the cassette section is correct for ferric tapes only. Equipped with separate bass/treble controls, the amplifier section can drive up to four speakers (4 ohms per channel minimum) with fader control of front/rear balance. A local/distant switch sets FM sensitivity.

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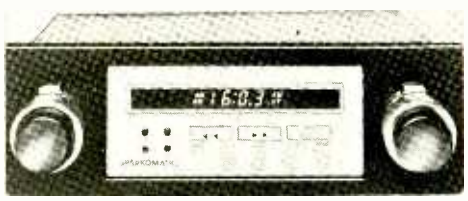
Pioneer KE-5000 ($400). The tuner section of this receiver uses a digital display and operates under the control of a microprocessor. Tuning can be accomplished by means of electronic presets (five AM stations, five FM stations), through touch tuning with scan and seek buttons, and manually via a knob. Dolby noise reduction is provided for the cassette player only; both 70-μs and 120-μs equalization are available for tape playback. Sensitivity of the tuner is controlled by a local/distant switch. A touch of the appropriate button converts the digital display to a clock. The amplifier can drive up to four speakers (load impedance 4 ohms minimum per channel) with fader control of front/rear balance. Tone control affects treble only.

Sparkomatic SR3400 ($270). This is a two-section model consisting of a head end and power amplifier. Station frequency readout for the tuner is a digital display that doubles as an electric clock. An additional control sets the clock to record elapsed time. The power amplifier can drive up to two speakers per channel, with fader control of front/rear balance, as long as the minimum load impedance is 4 ohms per channel. Tuning can be accomplished by pushbuttons or by turning a knob. The cassette player, automatically engaged by inserting a tape, is equalized for ferric tape; there are no Dolby provisions. Separate bass/treble controls, a high filter, and a loudness control are included.



Test Procedure. For practical reasons, we decided against installing all eight of the models successively in a vehicle for use tests. The procedure would have been extremely tedious and time-consuming without contributing much to the evaluation, as the environmental conditions in a vehicle are, of course, nonrepeatable.

We confined ourselves, therefore, to bench testing of the units, although we did take operating convenience into account as an additional factor. To be certain that none of the units would starve for power, we ran them from an Astron RS-35M power supply capable of a continuous 25-ampere or an intermittent 35-ampere output. Equivalent output power at the 14.4 volts called for by the standard is 360 watts continuous, 504 watts intermittent. Where power or distortion measurements were made on the amplifier sections, both channels were driven. No tests were made on the AM-radio sections.

In some respects, it was not possible to follow the procedures established by the Ad Hoc Committee's test standards. The major problem was the inability to separate the tuner (or cassette player) from the amplifier section. As a result, in most cases distortion and S/N measurements for the entire receiver had to be lumped. It is likely, therefore, that the tuner performance is better than our figures suggest, and virtually certain that the amplifier performance surpasses our measurements.

On the first unit we tested (Motorola), we made some measurements at the volume control, and injected signals at the point for some tests. This is a clumsy procedure at best, and inaccessibility of the volume control on other units led us to abandon it. Another problem was that some of the receivers use bridged output stages that will not tolerate grounding of either side of the load. Fortunately it was possible to lift the grounds on some of our test equipment, and isolate other pieces with transformers to avoid grounding of the "low" side of the output. Nevertheless, the testing process was hampered. Our A-weighting filter, for instance, could not be used; S/N measurements, therefore, are all unweighted.

After a few measurements, using both 8- and 4-ohm loads, we settled on 4 ohms, as this is realistic for car speakers, and none of the units can even approach its output ratings in any higher load impedance. For practical reasons, we measured THD+N (total harmonic distortion plus noise) at 1-watt output across the frequency range, and then determined the clipping power output over that range. Some of the amplifiers distorted well below the clipping point, but we ignored that and used actual peak clipping as the criterion for maximum output. Since our input signal came from an FM signal generator, through a Sound-Technology 1100A modulator, we were limited to the maximum audio signal that could be obtained from a 100% modulated FM signal. In some cases, the audio amplifier could not be driven to clipping at 10,000 Hz or higher due to this limitation. In one case (Jensen) the amplifier broke into oscillation when driven hard at high frequencies.

For tape player tests, we used the TDK AC-337 tape for frequency response measurements (120 μs) and the BASF standard calibration tape for the 70-μs measurements. Flutter was measured with the TDK AC-342 tape, and crosstalk with the AC-352. Unweighted S/N was expressed relative to a standard 250-nW/m level. Dolby noise reduction worked well (subjectively) where present, but could not be measured because of grounding problems caused by the needed CCIR or A-weighting filters.

Generally speaking, the ingenuity with which these sets are packaged is impressive indeed. They squeeze most of the major functions of a full-sized home receiver into an incredibly small space—and then throw in tape to boot. This density leads to a proliferation of controls—concentric or triple-concentric knobs and numerous pushbuttons—that can be cumbersome to use and may divert too much of a driver's attention from his vehicle. Niceties like digital readout and automatic tuning make matters easier, but there is still the task of locating the button that initiates the action you want. With daily use, however, most of the challenges will likely be minimized.

Even on the test bench, we had occasional difficulties with adjustments. The Motorola, for example, could not be set up so that its channel balance was consistent enough with respect to frequency to allow meaningful tape separation measurements.

Tables I, II, and III summarize the results of our lab testing. As can be seen in Table I, power output in many cases varies considerably with frequency. This, of course, may occur because the driving signal had to be introduced via the FM radio. In any case, the values derived represent a realistic appraisal of performance. Reference to Table III will show that the power bandwidths of the amplifier sections is adequate, as none of the cassette units offers high-frequency response that would challenge or outdistance it significantly. On the basis of our experience, we would expect

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the tuner sections as well to overload at high frequencies before the amplifier sections do. (Incidentally, in making power comparisons, the figures in parentheses—decibels with respect to 1 watt of output power—are the important ones to use.)

Where possible, tone-control responses are given as decibels of boost and cut at the frequencies of interest; if there was no well-defined center position of the control, the total range is given. Total harmonic distortion (THD) at 1-watt output looks high by comparison with home equipment. Despite this, it is unlikely that such levels of distortion would be audibly objectionable even in a quiet listening room, and virtually certain that they would be practically inaudible in a car.

FM results are given in Table II. Note that FM frequency response falls off at high frequencies, further suggesting that the loss of power at high frequencies will not cause overload. Where there is little difference between usable sensitivity and 50-dB quieting sensitivity, the inference to be drawn is that distortion is the major impediment to the former and noise to the latter.

The capture-ratio column is important in that it gives an index of immunity to amplitude modulation. Thus, it is a reasonable supposition that models with the better (lower) capture ratios will be more resistant to "picket fencing" and other effects of signal fading. Image rejection is apt to be noticed most when you are driving near an airport; a higher

TABLE I—AMPLIFIER PERFORMANCE

Model	Max. Clipping Power Output [watts (dB re 1 watt)]			Tone Control Range [boost, cut (dB)]		THD at 1 Watt (%)		
	100 Hz	1000 Hz	10,000 Hz	100 Hz	10,000 Hz	100 Hz	1000 Hz	10,000 Hz
Alpine 3002/7307	*53.5(17.3)	55.5(17.4)	57(17.6)	+9.5,−7.5	+10.5,−4.5	0.6	0.5	0.9
Audiovox HCC-1030	10.9(10.4)	13(11.1)	13(11.1)	+10,−6.5	+9.5,−8.5	1.15	0.7	1.2
Cobra 221GTL	6.8(8.3)	7.4(8.7)	6.4(8.0)	+10.5,−11	+10,−10	0.65	0.57	1.5
Jensen	**2.0(3.0)	4.2(6.2)	3.6(5.6)	+11,−10	+10.5,−10	1.6	0.5	2.4
R430	*8.4(9.2)	16(12.0)	2.4(3.8)	—	—	1.4	1.0	1.3
Motorola TC-894AX	5.3(5.4)	6.5(8.1)	6.7(8.0)	+6.5,−7.5	21 overall	1.0	0.76	0.85
Panasonic CQ-8530EU	7.6(8.8)	9.3(9.7)	2.8(4.5)	9 total	17 total	1.35	0.7	1.6
Pioneer KE-5000	2.9(4.6)	4.0(6.0)	3.8(5.8)	NA	10.5 total	1.8	2.2	0.34
Sparkomatic SR-3400	*8.4(9.2)	13(11.1)	5.7(7.6)	+11,−12	+11.5,−8.5	1.9	0.34	1.2

* External amplifier
** Internal amplifier

TABLE II—FM PERFORMANCE

Model	Mono Usable Sens. (dBf)	Mono 50 dB Quieting Sensitivity (dBf)	Freq. Resp. 30–15,000 Hz (±dB)	Mono THD+N (%)	Stereo Separation (dB) 100 Hz	1000 Hz	10,000 Hz	Capture Ratio (dB)	Image Rejection Ratio (dB)	Alternate Channel Selectivity (dB)	FM/Audio S/N Unwtd. (dB)
Alpine 7307/3002	20	25.8	+1,−5	0.4	21	27	21.5	1.3	69	68	53
Audiovox HCC-1030	21	21	+1,−5	0.3	18.5	31	30.5	1.8	88	69*	71
Cobra 221GTL	22	30.3	+0,−4	0.36	34.5	34	28.5	2.6	**	70*	57.5
Jensen R430	19	21.5	+0.5,−3	1.1	28	32	33.5	1.55	52	57	57.5
Motorola TC-894AX	21	22.5	+3,−10	0.5	33.3	31.5	21.5	1.7	63.5	56*	64.5
Panasonic CQ-8530EU	28	29	+0,−3.5	0.8	33.5	33	21	6.3	60	60	60.5
Pioneer KE-5000	14.3	19.8	+0,−2	0.3	34	38.5	36	3.2	46	73	66
Sparkomatic SR-3400	27	25	+1.5,−4	0.4	26.5	33.5	27	1.2	71	52*	67.5

* I-f bandpass is highly asymmetrical, making this average value of doubtful validity.
** Not measurable.

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TABLE III—TAPE PERFORMANCE

Model	Tape S/N Unwtd. 120 μs (dB)	Tape Freq. Response ±3 dB (Hz)	Flutter (%wrms)	Speed Error (%)	Tape Channel Separation (dB)
Alpine 7307/3002	50.5	40-12,500	0.17	+0.3	42
Audiovox HCC-1030	56	40-11,000	0.11	−0.3	40
Cobra 221GTL	47	45-9300	0.10	+2	50
Jensen R430	44	45-12,500	0.12	+2	45
Motorola TC-894AX	NA*	48-12,500	0.13	+2.2	NA*
Panasonic CQ-8530EU	51.5	75-12,500	0.10	+2	37
Pioneer KE-5000	52.5	40-12,500** 75-12,500***	0.32	+0.2	70
Sparkomatic SR-3400	56	40-12,500	0.12	+1.15	50

* On this unit, it was impossible to balance channel gains closely enough, or obtain a sufficiently flat frequency response, to make these measurements.
** 120 microseconds.
*** 70 microseconds.

dB measurement here can help to suppress interference from all aeronautical communications. Alternate-channel selectivity is most critical in urban regions where many stations crowd the band.

Frequency response of the tape sections appears to be somewhat anemic at high frequencies. However, if the situation is considered in perspective, the bandwidth lost is in most cases less than an octave. The ambient car noise is sufficient to mask such frequencies anyway, so the units are about adequate in this respect. Were we looking at home gear, we would regard the flutter data with suspicion, as most of them hover right around the threshold of audibility. The highest level we found is an odds-on bet to be heard in a quiet room, but here again, the automotive environment is likely to mask these effects. Persons with absolute pitch may want to choose units with the lowest speed errors; a discrepancy of 2% is equal to about 1/3 of a semitone.

What does seem a bit surprising is that, without exception, the units tested perform significantly more quietly with a good, strong mono FM signal than with a tape. But a stereo FM signal loses approximately 23 dB of S/N ratio compared with mono. This still leaves tape the better medium for stereo.

Comments. We avoided comparing measured data with the specifications given by manufacturers. The reason for this is that the poor correspondence between the two might be viewed as a significant issue, when it is in fact minor. It must be remembered that these units were designed in the absence of standards and to test them according to a fairly severe standard, as we have done, is bound to put them at a disadvantage. It is quite likely that these units will do what is claimed for them if they are tested under conditions matching those used in deriving their specs. As those conditions are not the ones chosen by the Ad Hoc Committee, we have let this point remain moot. It seems highly likely that the next generation of car equipment will meet specifications as well as house equipment does.

Looked at overall, these receivers are well suited to their application. Choosing between them is largely a matter of picking the power output level your speaker installation and vehicle require, and checking to see that no significant weak points lie in areas that will annoy you. (For instance, an FM devotee would probably not want a unit with a fine tape section and a weak tuner.) You should also be aware of features such as single-touch tuning and digital readout offered in the various units. These can add materially to ease of operation.

List prices for top-of-the-line units such as these may seem high, especially if the levels of performance to which we are accustomed in home equipment are used as bases of comparison. Clearly, however, utilizing the engineering necessary to realize them as the measuring stick gives a fairer—and more favorable—picture. ◇

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CONVERT A LANGUAGE TRANSLATOR TO A LOW-COST COMPUTER TERMINAL

BY BILL PORTER

A simple hardware addition and some software allows portable language translator to be used as a computer peripheral

ALTHOUGH marketed as a language translator, the Nixdorf LK-3000 is actually a far more powerful device. It contains a microprocessor, RAM, ROM, an alphanumeric keyboard for data entry and an alphanumeric display for data readout; and it can apply these elements to a wide variety of other applications. One notable use of the LK-3000 is as an alphanumeric terminal. This article discusses hardware/software aspects of the translator and details how it can be converted for use as a hand-held computer terminal by adding simple hardware and some software.

Basic Operation. The language translator consists of a hand-held case that contains a keyboard, a 16-character one-line alphanumeric display, and a rechargeable battery. A module that contains an 8-bit CPU and a language-translation program in ROM plugs into the case via an edge connector. The combination thus formed is a dedicated microcomputer.

Since the edge connector carries data and address lines and the needed "handshake" (system control) hardware, it is possible to substitute a computer parallel I/O (input/output) port for the plug-in module. When this is done, the display section of the language translator can be used as a relatively low-cost (approximately $140) alphanumeric terminal. Since there are no hardware changes, the LK-3000 can still perform its language translation function when the language module is in place.

As shown in the photograph, the translator, which is sold in many retail establishments, is a hand-held, battery-powered device about 6" long, 3½" wide and 1" thick. The upper surface contains 27 dual-purpose data keys and six control keys with a window for displaying the 16-character alphanumeric readout. Each of the 16 characters is formed on a 16-segment (plus decimal point) LED readout.

All capabilities are determined by the plug-in module. A typical language translation module, shown in Fig. 1, consists of a 3870 CPU and the 64K ROM containing the language "package." The 3870 CPU includes an internal 2K ROM, 64 bytes of RAM, four I/O ports, a programmable timer, and a built-in crystal oscillator. It requires a +5-volt power supply.

System logic is shown in Fig. 2. If the plug-in module is ignored, a look at the circuit shows that, if the proper signals are applied to the edge connector, it is possible to cause this system to "look" like a simple alphanumeric terminal.

At present, there are three plug-ins that can be used to convert the translator into a terminal. Two are serial ports, while the easiest to implement is the parallel interface discussed here.

From a construction viewpoint, the parallel interface consists of a 16-conductor, color-coded ribbon cable interconnected between the LK-3000 edge connector and a conventional 16-pin DIP connector as shown in Table I, with the elements shown in Fig. 1.

In the breadboard stage, this technique was used to successfully interface

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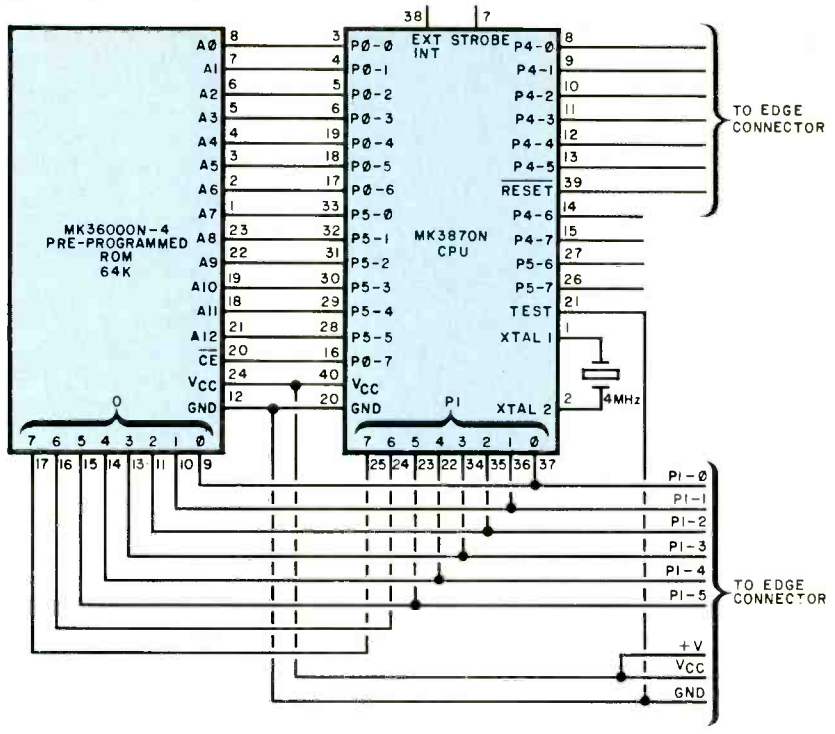

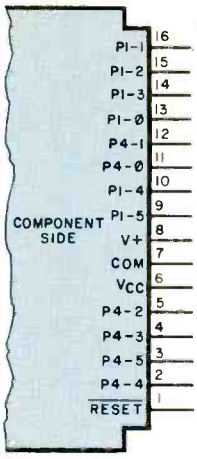

Fig. 1. A typical language translation module consists of a 3870 CPU and the 64K ROM containing the language package.

to 3870, 3872, F8, 8080, Z80, 8048, 8748, 8035, 8039 and 8085A systems.

Write Mode. Without the keyboard service routine contained in the plug-in language module, neither the LK-3000 keyboard, nor the external computer can write to the display. When using the computer parallel port, the ASCII data and position address must be latched to the data and address lines as defined in Table I. Once this data is correct, the display write strobe line $\overline{\text{DWSTB}}$, which is normally held in the high state, is dropped to the low state for at least 400 ns, then raised high. The display driver within the LK-3000 will do the rest. Display strobe subroutines for selected microprocessors are shown in Table II.

The following examples make use of the display. In both cases, the existence of a DISPLY (display) subroutine like that shown in Table II is presumed to be loaded within the computer.

For example, the 8085 code to write a space character to all 16 positions is:

```
CLDISP:  MVI B, 15        ;position and
                            loop control
CLDLUP:  MVI A, 20        ;an ASCII space
         CALL DISPLY      ;display and
                            increment
         MOV A, B         ;test if position
         INR A            ;went below zero
         JNZ CLDUP
         RET
```

The second example will show how to display a previously defined message on the right side of the display. This message is stored as a string of ASCII characters preceded by a length character. An example could be:

```
TITLE:   DB 6 'NIXDORF'
```

To use the following subroutine, the length parameter must be one less than the actual number of characters in the message. The routine will display the message found in memory location pointed to by H,L.

```
MESSAG:MOV B, M          ;get length and
                          ;starting position
MEXLUP:INX H             ;bump address
       MOV A, M          ;get next message
                          ;character
       CALL DISPLY       ;display and
                          ;decrement
       MOV A, B          ;test position
                          ;for below zero
       INR A
       JNZ MESLUP
       RET
```

Key Read. There are four basic steps required to read the keys on the display case. The first is to select one of the 8 rows of keyswitches, the second is to write a zero to the keyboard read strobe ($\overline{\text{KYRSTB}}$) which is normally kept high. Four column bits are then input on the data bus, with a zero indicating a closed switch. Finally, the keyboard read strobe is returned to the high state.

Although these four steps are all that is required for utilization of the keyboard, in practice there are other considerations. In the language translation mode, the problem of key scanning, code translation, buffering of data and keyswitch debounce are all handled by a short program within the language

TABLE I—
CONNECTIONS BETWEEN SYSTEM AND DIP SOCKET

Edge Contact	Name	Nominal Direction	DIP Pin Number
1	$\overline{\text{RESET}}$	←	1
2	$\overline{\text{KYRSTB}}$	→	16
3	$\overline{\text{DWSTB}}$	→	2
4	Address 3	→	15
5	Address 2	→	3
6	V+ IN	←	13
7	0 volts	→	4
8	+5 volts	→	14
9	Data 5	↔	5
10	Data 4	↔	12
11	Address 0	→	6
12	Address 1	→	11
13	Data 0	↔	7
14	Data 3	↔	10
15	Data 2	↔	8
16	Data 1	↔	9

The edge connector pads are 0.05" wide on 0.1" centers.
All signals TTL compatible.
Data 0-5: bidirectional data bus, 4 bits from keyboard, 6 bits to display.
Address 0-3: select one of 16 display positions, 1 of 8 keyboard rows.
$\overline{\text{DWSTB}}$: negative true display write strobe (400 ns min.) to write data to an addressed position.
$\overline{\text{KYRSTB}}$: negative true keyboard read signal to read a key from addressed keyboard row. This signal must be 0 (low) while column data is read.
$\overline{\text{RESET}}$: negative true indicating CRL key depressed. May be used as system reset, shift key, or as 33rd data key.

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TABLE II—DISPLAY STROBE SUBROUTINES

```
'80/Z80/8085A                    8048                    3870

 n A                      ;data in A              ;data in SP 0
ion in B                  ;position in R1         ;position in SP1
LY: OUT DISPOT    DISPLY: XCH A, R1         DISPLY: LR A, 0
    MOV A, B              ANL A, #15                COM
    ANI 0FH               SWAP A                    OUTS 1
    ORI 30H               OUTL P2, A                LR A, 1
    OUT DKCONT            SWAP A                    COM
    ANI 0DFH              XCH A, R1                 NI 15
    OUT DKCONT            ORL A, 0C0H               OUTS 4
    ORI 20H               OUTL P1, A                OI H '20'
    OUT DKCONT            ANL A, #7FH               OUTS 4
    DCR B                 OUTL P1, A                NI 15
    RET                   ORL A, #80H               OUTS 4
                          OUTL P1, A                OS 1
                          DEC R1                    POP
                          RET
;does display for one position
;OISPOT= display output
;DKCONT= display and keyboard control
;16 display position, 15 is left, 0 is right
```

ROM. Since this ROM is not used in this application, the remainder of this section will discuss how these items can be handled by the associated computer and its keyboard. No actual machine-language code will be listed, and the emphasis will be placed on flow charts so that the process can be implemented on any system.

The following assumptions control the design of the keyboard implementation: (1) all data keys should generate ASCII codes when operated; (2) the keyboard need not be fast; (3) key noise should be eliminated; (4) only one key at a time should be used; and (5) there should be a buffer between the key switch service function and the mainline program in the user computer system.

Figure 3 is the flow-chart required to satisfy the assumptions. Only 4 bytes of RAM (5 if debounce logic is used) are required to implement the keyboard active flag, keyboard current row, keyboard active column and the keyboard data buffer.

Translation of keyswitch row and column into ASCII is accomplished by constructing an index into a table like that shown in Table III. The translation value used for modules is row+8 (column)+32 (mode) where row is 0 through 7, column is 0 through 3 and mode is 0 or 1 depending on whether a shift-lock key is implemented.

The following example will help to explain how Table III and Fig. 3 make the keyboard useful. One presumption is that the keyswitch service subroutine will be called every 2 ms. When no key is depressed and the 2-ms interval expires, the routine is invoked. The routine examines its own flags and determines that the keyswitches are not active.

The next step is to add 1 to the working storage register that holds the representation of the current row. Since there are 8 rows on the keyboard, and since a 1-byte memory location can contain values up to 255, the results of the addition are "wrapped around." By ANDing the sum with a 7 (binary 0000 0111), the new value must be in the set 0,1,2,3,4,5,6,7. Each of these eight values represents a row. This current row value is used to enable (send power to) four switches representing the columns. The switches are wired to connect a column to ground.

Thus, open switches are input as binary 1 and closed switches as binary 0, with a single port used to read the data thus presented. If all four column bits are 1, no switches are closed and control is returned to the main program. As long as no keyswitches are depressed, the keyswitch service will continue to scan all eight rows (one row every 2 ms) looking for a new closure.

As soon as a keyswitch is found closed, the routine sets an internal flag to indicate an active state. This flag will be used to ensure that the key is fully released before any other key is accepted. The remainder of the new key processing is easier to explain if a typical example is used, as follows.

Assume that the "Y" key is found to be newly closed. This key could only be found when the current row is 5. (Table III, the ASCII code translation table, shows the mapping of the keys into the switch matrix.) When the columns are

TABLE III—ASCII TRANSLATION TABLE

LOC	OBJ	SEQ	SOURCE STATEMENT					
		243 ;	KEYBOARD TRANSLATE TABLE					
		244 ;						
		245 ;						
		246 ;	LOOKUP VALUE IS ROW + (8*COLUMN) + (32*MODE)					
		247 ;						
		248 ;				ROW	COLUMN	GRAPHIC
		249	KBTBL:					
00EE	41	250		DB	'A'	;0	0	A
00EF	4A	251		DB	'J'	;1	0	J
00F0	53	252		DB	'S'	;2	0	S
00F1	45	253		DB	'E'	;3	0	E
00F2	4E	254		DB	'N'	;4	0	N
00F3	57	255		DB	'W'	;5	0	W
00F4	3F	256		DB	3FH	;6	0	?
00F5	3D	257		DB	3DH	;7	0	DEFINE
00F6	42	258		DB	'B'	;0	1	B
00F7	4B	259		DB	'K'	;1	1	K
00F8	54	260		DB	'T'	;2	1	T
00F9	46	261		DB	'F'	;3	1	F
00FA	4F	262		DB	'O'	;4	1	O
00FB	58	263		DB	'X'	;5	1	X
00FC	3C	264		DB	3CH	;6	1	BACKSPACE
00FD	3B	265		DB	3BH	;7	1	STEP
00FE	43	266		DB	'C'	;0	2	C
00FF	4C	267		DB	'L'	;1	2	L
0100	55	268		DB	'U'	;2	2	U
0101	47	269		DB	'G'	;3	2	G
0102	50	270		DB	'P'	;4	2	P
0103	59	271		DB	'Y'	;5	2	Y
0104	52	272		DB	'R'	;6	2	R
0105	20	273		DB	' '	;7	2	SPACE
0106	44	274		DB	'D'	;0	3	D
0107	4D	275		DB	'M'	;1	3	M
0108	56	276		DB	'V'	;2	3	V
0109	48	277		DB	'H'	;3	3	H
010A	51	278		DB	'Q'	;4	3	Q
010B	5A	279		DB	'Z'	;5	3	Z
010C	49	280		DB	'I'	;6	3	I
010D	3A	281		DB	3AH	;7	3	FUNCTION

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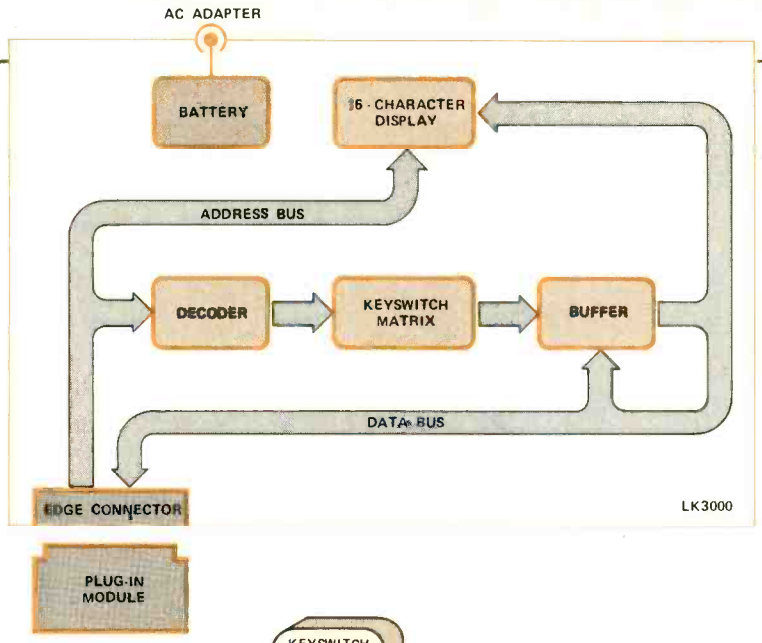

Fig. 2. Without the plug-in module, the syste... the appearance of a "dumb" alphanumeric t...

input, the value will be ... where the underlines indica... able (don't care) bit values. ... stores the row (5) and the ... The row and column are con... an index into the ASCII cod... tion table by first multiplying ... umn by 8 to yield 16, adding t... yield 21, then adding the base ... table in system memory to yield ... tual address of the character "Y".

The code value for "Y" is binary ... 1001, and this value is left in a mem... buffer for use by the main program. T... routine then returns control to the main ... program. The keyswitch will be auto-matically debounced by the scanning process during the active state processing as described next.

The next time that the 2-ms interval expires, the keyswitch service routine will determine that the keyboard is active. However, the current row will be 6 at that time, instead of the 5 where the key was found. This means that there will be more processing during that scan. After six more scans, the routine will find that the current row is the same 5 that was stored when the switch closure was found to be newly closed. The columns are read to see if column 2 is still a zero and if it is, no more processing is required since the key is still held down.

If a 1 is encountered, the key is released. In this case, the flag is set to indicate that the keyboard is inactive and that new keys may be accepted. Row 5 will not be examined again for 8 scan cycles, and each of the other rows will be examined first. If the "Y" key was bouncing upon release, it will not be examined again for 16-ms after it was found open. Since the bounce time for the switches is about 6 ms, debouncing has been successfully accomplished.

Thus, it can now be seen that with almost no hardware addition, and just using software routines, the LK-3000 can be used as a low-cost computer terminal. The basic language translator, including the recharger and case (but excluding a language module) is available for $140 from many retail outlets. The parallel interface, including ribbon cable and DIP connector, will be available in late summer for $35 from various computer stores. ◇

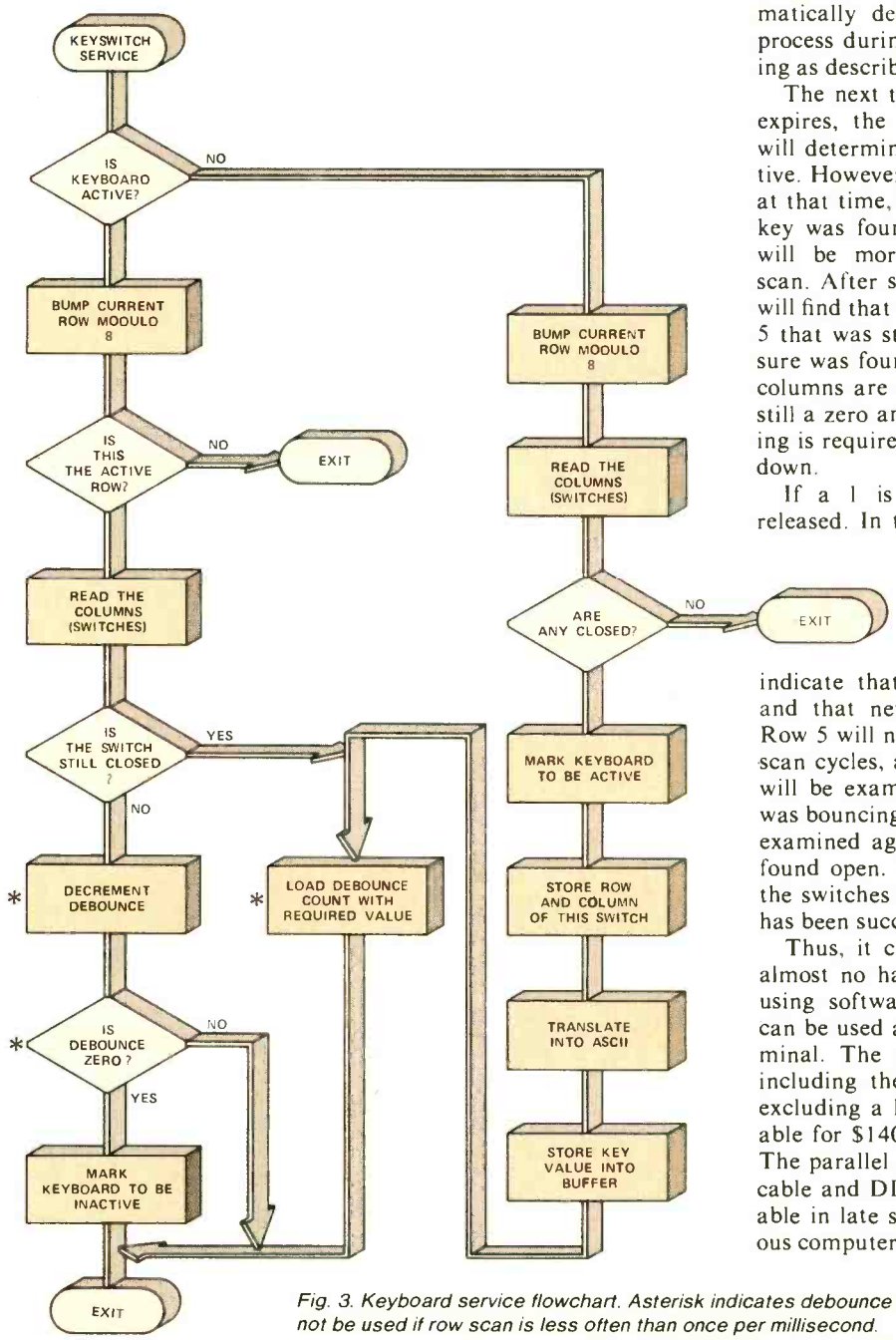

Fig. 3. Keyboard service flowchart. Asterisk indicates debounce logic need not be used if row scan is less often than once per millisecond.

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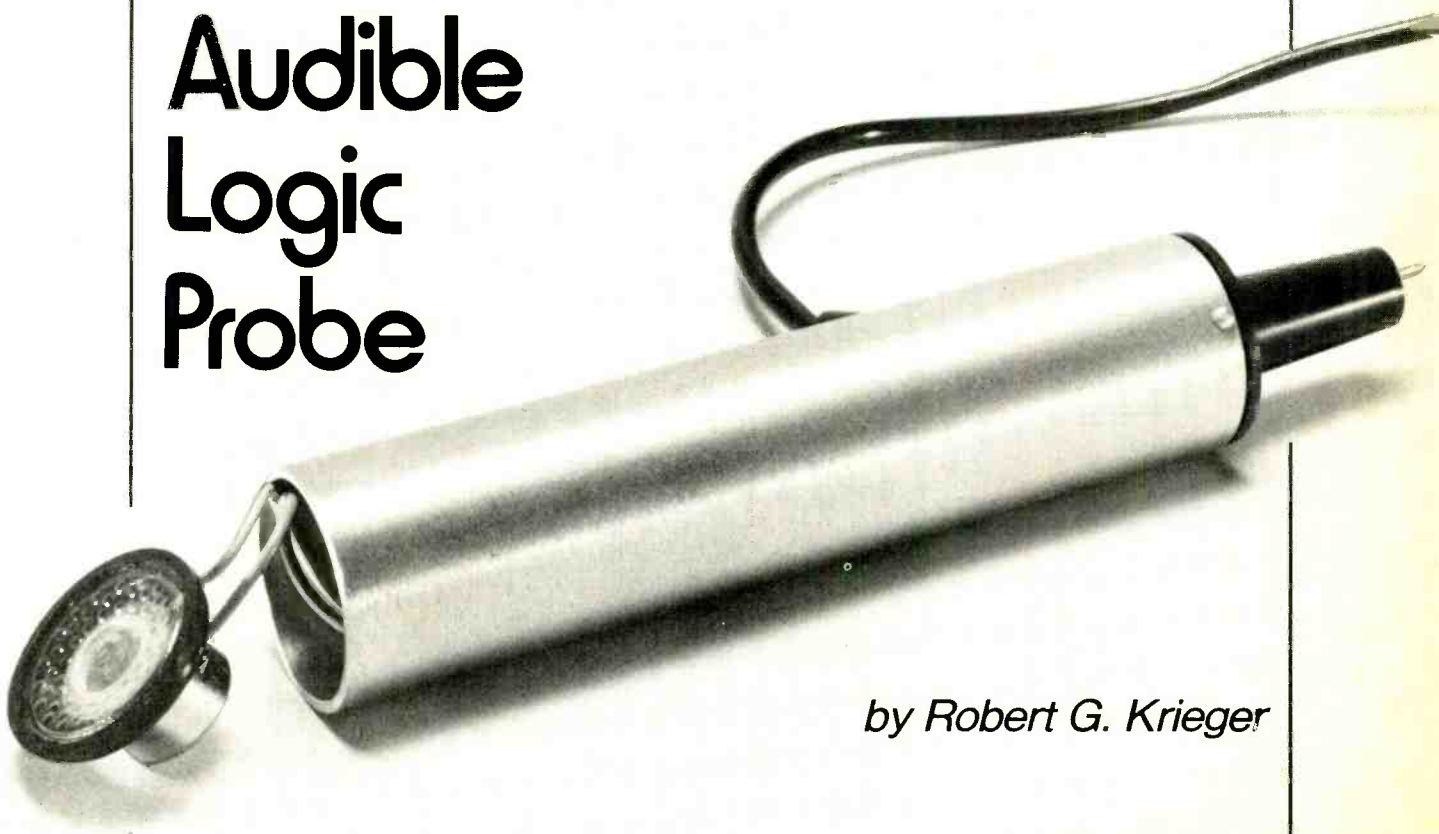

by Robert G. Krieger

A HAND-HELD probe to indicate the status of a logic circuit is very useful in troubleshooting modern electronic equipment. Most digital probes use LEDs to indicate visually a logic state. This requires that the user watch the point being tested and the LED indicator simultaneously. This eye-shifting procedure can result in inadvertent probe slips which damage equipment.

The logic probe described here overcomes this problem by employing an audible indication—a high-frequency tone when its tip senses a high signal, a low-frequency tone when the signal is low, and a warbling tone (high-low-high . . .) when encountering a pulse train. The audible probe can be used with either TTL or MOS devices. Operating power, from 4 to 15 volts, is derived from the circuit being tested. Current demand is 10 mA from a 5-volt system and 35 mA from 15 volts. The input stage is protected against overload.

Circuit Operation. As shown in Fig. 1, two comparators (elements of a four-comparator chip) are used to sense the high and low input levels. A voltage divider (*R4*, *R5*, and *R6*) sets the reference levels.

When the input voltage from the probe tip at pin 5 of *IC1A* becomes greater than the reference voltage applied at pin 4, the output of this comparator (pin 2) goes high. This, in turn, forward-biases *D2* and the timing resistance of *R7* and *R9* causes astable oscillator *IC2* to produce a tone at approximately 3.5 kHz. This tone is the logic-high signal.

At low-level detector *IC1B*, when the

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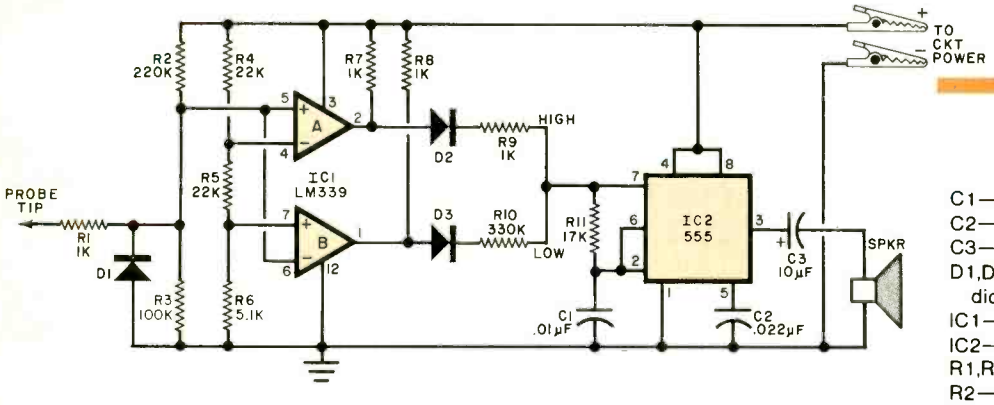

Fig. 1. One comparator detects logic high while the other detects logic low inputs. This causes the audio oscillator to change tone contingent on which comparator is operating.

voltage at pin 6 is lower than the reference at pin 7, the output at pin 1 goes high. This, in turn, forward-biases *D3* to place *R8* and *R10* in the *IC2* timing circuit. Since this combination has a greater resistance than *R7* and *R9*, the oscillator delivers an output tone at about 300 Hz. This becomes the logic-low signal.

Divider network *R2* and *R3* maintain a resting state of about one volt on the input line so that when the probe is not connected to a signal source, neither comparator will trigger, and no tone will be generated.

If you wish to use LED logic indicators, simply eliminate *D2, D3, IC2* and their associated components. Retain *R7* and *R8*, however, and connect a LED between each comparator output and ground (anode to the comparator).

Input Levels. TTL low level is usually specified as 0.8 volt and the high level at 2 volts. MOS levels are generally specified as 1.5 volts for zero and 3.5 volts for the high level. Therefore, some compromise was made in the design of the probe. The levels selected by the *R4, R5,* and *R6* network are 0.6 volt for logic low and 2.5 volts for logic high. If you wish to change levels, the network values will have to be recalculated. With 15-volt systems, the probe senses logic low as about 2 volts and below, and logic high as 8 volts and higher. Diode *D1* ensures that only positive-going signals are presented to the comparator inputs. The output of tone generator *IC2* is coupled via *C3* to a small (it must be capable of fitting into the aluminum tube that holds the complete probe) dynamic microphone or earphone element.

Construction. Although any type of construction may be used, a 1-inch diameter, 5½-inch long thin-walled aluminum tube was used in the prototype. In this case, the pc board shown in Fig. 2 can be used for the circuit.

The tip is formed from a sharpened nail passed through a tapered piece of wood to form a cone that can be press-fit into one end of the tube. A circular piece of perf board can be used to seal the transducer end. The power cable (two leads) is brought out of the tube via a small grommetted hole an inch or so up from the transducer end.

Since the operating dc voltage and ground lie on each side of the pc board, electrical tape insulation can be used to prevent accidental shorts. The transducer leads are kept short and soldered to their pads on the pc board.

After testing the assembled circuit insert it into the tube, transducer end first—passing the power leads out of the grometted hole first. The wood tip is press-fit into place. Ends of the color-coded power leads are terminated with suitable alligator clips.

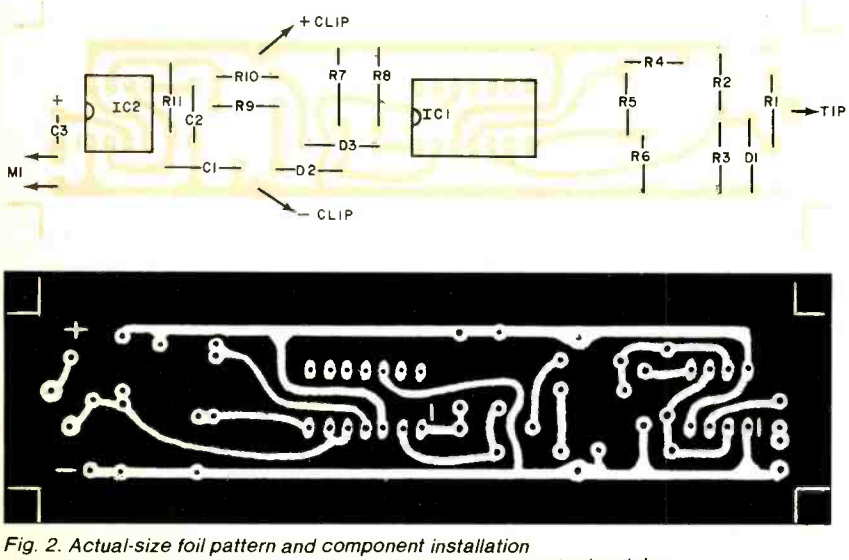

Fig. 2. Actual-size foil pattern and component installation for printed-circuit board of suitable size for placing the probe in a tube.

PARTS LIST

C1—0.01-µF small disc capacitor
C2—0.022-µF small disc capacitor
C3—10-µF tantalum capacitor
D1,D2,D3—Germanium signal diode (Radio Shack 276-1123 or similar)
IC1—LM339 quad comparator
IC2—555 timer
R1,R7,R8,R9—1000-ohm, ¼-watt resistor
R2—220,000-ohm, ¼-watt resistor
R3—100,000-ohm, ¼-watt resistor
R4,R5—22,000-ohm ¼-watt resistor
R6—5100-ohm, ¼-watt resistor
R10—330,000-ohm, ¼-watt resistor
R11—17,000-ohm, ¼-watt resistor
SPKR—Medium- or low-impedance earphone or microphone element
Misc.—Suitable thin-walled 1" by 5½" aluminum tube, wood block for tip, sharpened nail, small piece of perf board, glue, power twin-lead, alligator clips.

Operation. Since power for the audible probe is derived from the circuit under test, connect the ground clip to circuit ground and the positive clip to the circuit's positive bus. With the probe tip isolated from a signal, no sound should be heard from the transducer.

When the probe tip is connected to the circuit positive bus, a high-pitched (about 3500 Hz) tone will be heard, and when connected to circuit ground, a low (about 300 Hz) tone should be heard. In use, a warbling tone indicates that a pulse train is being monitored. The probe will sense such activity to about 10 kHz.

It is possible to use a switch that connects the audio output back to the probe tip, so that the probe can also be used as a signal injector. ◇

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The Ferroresonant AC Voltage Regulator

BY DON MORAR, W3QVZ

Unfamiliar to many electronics enthusiasts, here's a device to smooth out power-line voltage variations and protect sensitive equipment

THERE are numerous devices and circuits that can deliver regulated dc voltages. One voltage-regulating device—the ferroresonant transformer—gives regulated *ac* voltages and incorporates some special advantages. Capable of acting as a step-up or step-down voltage transformer as well as an ac voltage regulator, this component delivers a more or less constant ac output voltage even if the magnitude of the input voltage changes. In addition, the ferroresonant transformer is efficient, inexpensive, rugged, and requires no heat sink. It generates no high levels of electrical noise and provides a degree of protection from transients riding on the ac power line. Ferroresonant transformers are available in a variety of winding configurations and VA ratings and at reasonable cost from several surplus electronics dealers.

How It Works. A ferroresonant transformer has several windings and an air-gapped ferromagnetic core. It combines a high leakage-reluctance magnetic circuit and a resonant *LC* electrical circuit. A cross-sectional view of a typical ferroresonant transformer appears in Fig. 1A, and the schematic diagram appears in Fig. 1B. The transformer's primary winding (1) is wound first on the *X* portion of the core, and then the *compensation winding* (3) is wound on top of it. Similarly, the *resonant winding* (2) is wound on the *Y* portion of the core, and the secondary winding (4) is wound on top of it. Two air gaps form a magnetic shunt that isolates the resonant (2) and secondary (4) windings from the primary (1) and compensation (3) windings.

When an ac voltage is applied across the primary winding, a magnetic flux is set up in the ferromagnetic core. This flux induces voltages in the other three windings. Because of the reluctance of the air gaps in the magnetic shunt path, the induced voltages essentially correspond to the turns ratios between the primary and three other windings. If the magnitude of the voltage applied across the primary is increased, the flux in the *Y* portion of the core increases. If the flux density attains a sufficient value, the magnitude of the inductive reactance of winding (2) equals the capacitive reactance of external capacitor *C*. The *LC* network then resonates at the power-line frequency, and the voltage appearing across winding (2) increases to a stable value greater than the primary/resonant turns ratio would suggest.

This increases the flux density in the magnetic circuit path traversing the resonant winding and significantly decreases the relative reluctance of the magnetic shunt. Any variations in flux density caused by changes in the voltage applied across the primary winding are for the most part swamped by the mag-

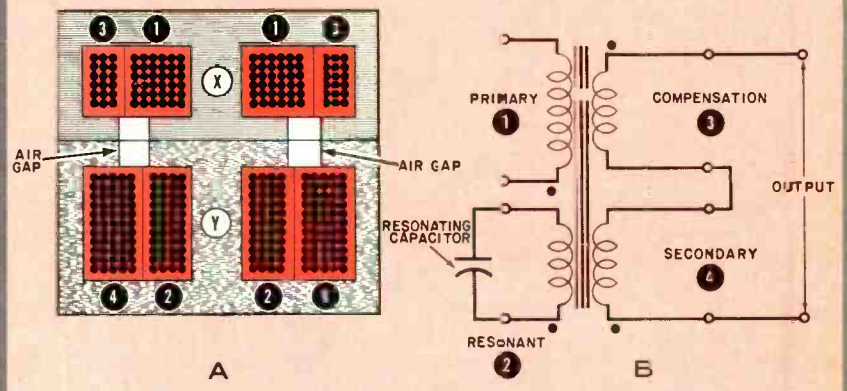

Fig. 1. Cross-sectional view of a typical ferroresonant transformer (A) and the transformer's schematic diagram (B).

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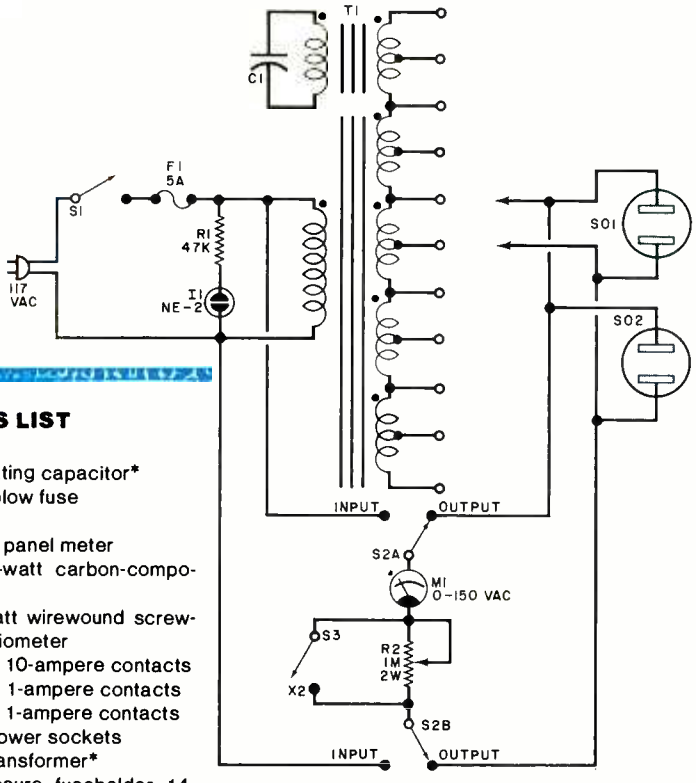

Fig. 2. Schematic diagram of the author's project employing a ferroresonant transformer.

PARTS LIST

C1—Nonpolar resonating capacitor*
F1—5-ampere slow-blow fuse
I1—NE-2 neon lamp
M1—0-to-150-volt ac panel meter
R1—47,000-ohm, ½-watt carbon-composition resistor
R2—1-megohm, 2-watt wirewound screwdriver-adjust potentiometer
S1—Spst switch with 10-ampere contacts
S2—Dpdt switch with 1-ampere contacts
S3—Spst switch with 1-ampere contacts
SO1, SO2—Duplex power sockets
T1—Ferroresonant transformer*
Misc.—Suitable enclosure, fuseholder, 14-gauge stranded insulated hookup wire, banana plugs and jacks, machine hardware, solder, etc.
*See text.

netic shunt, and variations in the voltage appearing across the resonant winding are suppressed.

The compensation winding (when present) acts in a complementary way to compensate for variations in the voltage applied across the primary. This winding is designed so that any variation in the voltage induced across it caused by a change in the primary voltage is approximately equal to the change in the secondary voltage. However, this voltage change is 180 degrees out of phase with respect to the change in secondary voltage. (Note the phasing dots shown in Fig. 1B.) Because the compensation winding is connected in series with the secondary winding, the resulting voltage appearing across the two windings remains almost constant. The voltage across the two series-connected windings will remain relatively constant even though the primary voltage varies within a prescribed range. Thus, the compensation winding (which is not found in every ferroresonant transformer) enhances the component's voltage-regulating action.

In normal operation, the *X* portion of the core (on which the primary and compensation windings are wound) does not magnetically saturate. However, the *Y* portion of the core (on which the resonant and secondary windings are wound) does. Owing to this, the waveform set up across the secondary is nonsinusoidal and has significant harmonic content. Certain types of electronic equipment are sensitive to such harmonic distortion, so some ferroresonant transformers have a fifth, *neutralization* winding. This winding is wound on the *Y* portion of the core. It's connected in series with the secondary and compensating windings in such a way that it introduces the proper amount of inverse distortion to cancel out most (if not all) of the harmonic content in the secondary waveform. Such transformers typically produce a sinusoidal output waveform with approximately 3% harmonic distortion.

Employing the Transformer. The following project, assembled by the author, uses a surplus ferroresonant transformer that generates a regulated ac output ranging from approximately 24 to 187 volts rms. This wide range of output voltage is made possible by the transformer employed—a multisecondary device whose secondary windings can be connected in series.

A schematic diagram of the author's ferroresonant ac regulator appears in Fig. 2. Ferroresonant transformer *T1* is a surplus component obtained from Delta Electronics, 7 Oakland Street, Amesbury, MA 01903, Part No. 9859. Its sec-

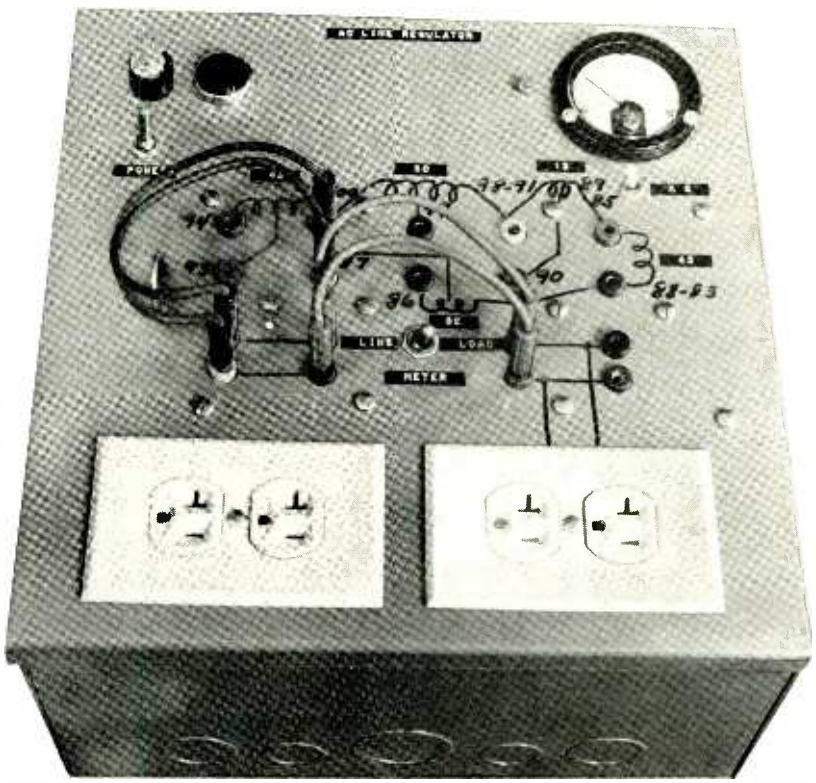

Fig. 3. Top view of the prototype shows how components were mounted in a NEMA electrical junction box.

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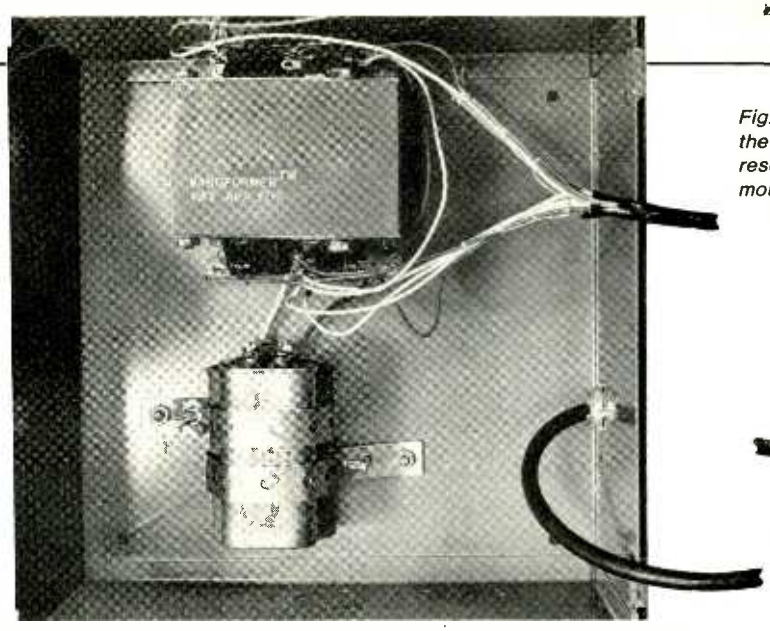

Fig. 4. Interior view illustrates how the transformer, T1, and the resonating capacitor, C1, were mounted in the enclosure.

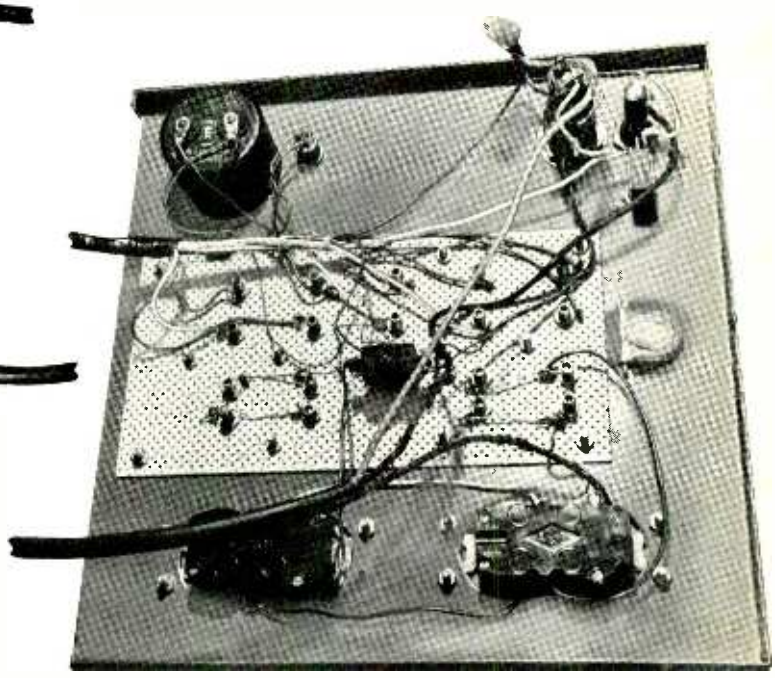

Fig. 5. This view shows the bottom of the board in the prototype with point-to-point wiring using No. 14 stranded copper hookup wire.

ondaries have the following ratings:

- •60 volts center-tapped at 3 amperes;
- •36 volts center-tapped at 4 amperes;
- •34 volts center-tapped at 4 amperes;
- •33 volts center-tapped at 5 amperes;
- •24 volts center-tapped at 4 amperes.

The author connected the secondaries of *T1* in series and brought each side as well as the center taps out to banana jacks mounted on the project enclosure. Power sockets *SO1* and *SO2* facilitate connection of the regulator to the loads with which it will be used. They are connected to short jumper wires terminated with banana plugs and to two of the position lugs of dpdt switch *S2*, which is part of the metering circuit. Banana plugs simplify the selection of particular points on the secondary string.

Nonpolar capacitor *C1* (usually supplied with the transformer) is the resonating capacitor and is connected across the resonant winding of *T1*. The transformer's primary winding is energized by the ac power line via *S1* and is protected by fuse *F1*. Neon indicator *I1* functions as a pilot light. Current through it is limited to a safe value by resistor *R1*.

The transformer's primary is also connected to the remaining two position lugs of switch *S2*. The poles of this switch are connected to the meter circuit comprising *M1*, a 0-to-150-volt ac panel meter, *R2*, a one-megohm, screwdriver-adjust potentiometer, and *S3*, an spst switch which when closed halves the sensitivity of *M1*.

Photographs of the author's prototype appear in Figs. 3, 4, and 5. The top view, Fig. 3, shows how the author mounted the switches, meter, banana jacks, power sockets and other components in the enclosure. (A standard NEMA hinged electrical junction box measuring 12″ × 12″ × 6″ or 30.5 cm × 30.5 cm × 15.3 cm was used to house the prototype.) Also visible in this photograph are jumper wires used to select taps on the secondary string and a labelling system which identifies transformer windings and their voltages. Figures 4 and 5 are interior views of the prototype showing the ferroresonant transformer and resonating capacitor, and the wired side of the panel seen in Fig. 3. Note that point-to-point wiring using No. 14 stranded copper hookup wire was employed in the construction of the prototype.

Project Performance. Several experiments were conducted to determine how effective a regulator the prototype was. The results of some of these tests appear in Figs. 6 and 7.

First, a variable autotransformer connected to the ac power line was used as a source of variable-voltage ac. Loads drawing various amounts of power were connected to the output of the project and the input and output voltages were monitored as the input voltage was slowly brought up to 130 volts. The resulting input/output voltage characteristics appear in the plots of Fig. 6. Then the autotransformer was adjusted to provide a constant 115-volt ac input and a test load was adjusted to draw varying amounts of power from the prototype. The output voltage was monitored as the power demand of the load was increased from 30 to 250 watts, and the resulting output-power/output-voltage was plotted as shown in Fig. 7.

Voltage-regulating action of the ferroresonant transformer is clear from an inspection of Fig. 6. When a 40-watt load was connected to the output of the prototype, the output varied only three volts (from 112 to 115 volts) even though the input changed from 90 to 130 volts! When a 150-watt load was connected to the output of the prototype, the output voltage varied over the same three-volt range while the input voltage was increased from 110 to 130 volts.

In Fig. 7, it can be seen that the output voltage slowly decreased from 115 to 110 volts when the power drawn by the test load increased from 30 to 180 watts. This might not seem to be good voltage regulation, but it is impressive when compared to the performance of a standard isolation transformer with a comparable VA rating. Also, the author's ferroresonant transformer does not have compensation or neutralization windings. A compensation winding would, of

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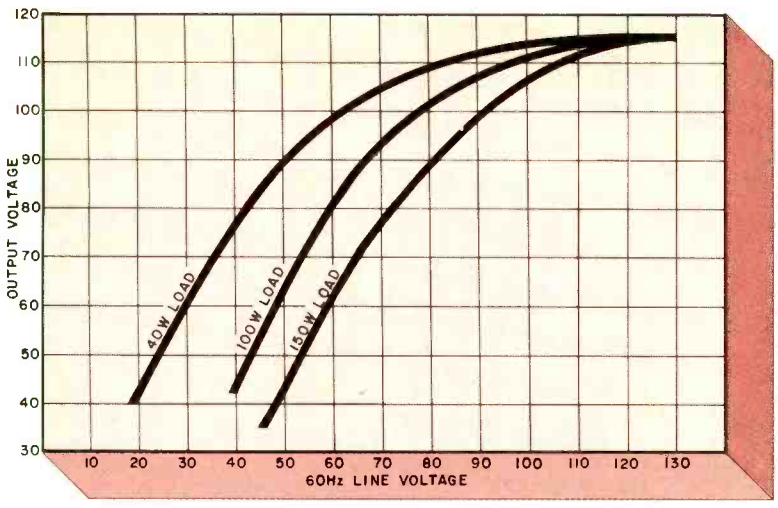

Fig. 6. Family of curves for three different loads shows prototype's input/output voltage characteristic.

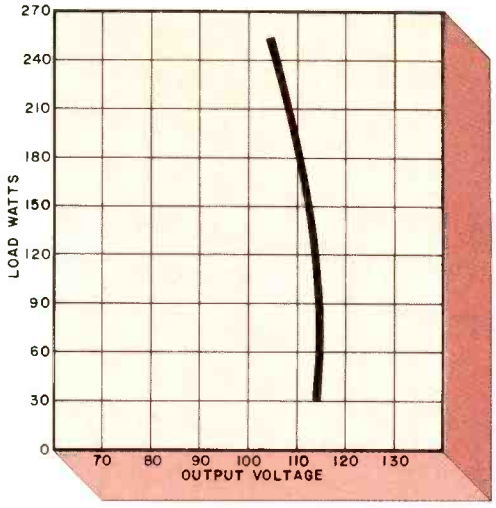

Fig. 7. Curve shows transformer's relatively constant output for an increasing load.

course, further enhance the prototype's voltage regulation. To determine how distorted the output waveform was, it was observed on an oscilloscope. The waveform had a more rounded appearance than a true sinusoid would, but at no time was flattening of the peaks (clipping) observed.

In Conclusion. We have seen that ferroresonant transformers are efficient, relatively inexpensive ac voltage regulators. Their benefits include some degree of protection from high-amplitude power-line transients and isolation from the ac power line. The former is useful if transient-sensitive solid-state equipment is to be powered. The latter makes ferroresonant transformers especially useful in computer applications where a transformerless TV receiver is employed as a video terminal. It eliminates the possibility of a catastrophic pyrotechnics display when the TV chassis is connected to the data system's ground. ◇

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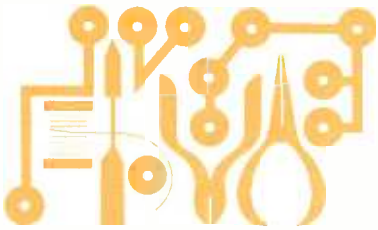

By Forrest M. Mims

The Digital Phase-Locked Loop (Part 1)

RECENTLY, I was talking to the parts buyer for an electronics supplier about sales volumes of various integrated circuits. The most surprising thing I learned was that sales of the 4046 digital CMOS phase-locked loop (PLL) are only a trickle compared to those of other ICs.

This is puzzling, because the 4046 is is one of the most versatile CMOS chips. It is also unfortunate—the 4046 is very handy if you know how to use it. Among the many applications of the 4046 are those in frequency modulation and demodulation, voltage-to-frequency conversion, frequency synthesis, tone decoding, FSK demodulation, and frequency multiplication.

One possible reason for the low sales volume of the 4046 is that little descriptive or applications information about this chip has appeared in electronics magazines and books. To rectify this situation, we will unravel some of the mysteries surrounding the digital PLL and present some basic circuits. By the time you finish experimenting with some of the more advanced application circuits, you'll be well acquainted with the operating principles of the digital PLL, an exceptionally versatile CMOS chip.

Phase-Locked Loop Basics. The simplest PLL consists of a phase comparator, a voltage-controlled oscillator (vco), and a low-pass loop filter, all arranged as shown in Fig. 1. In operation, the vco oscillates at a frequency determined by an external *RC* network. This frequency is applied to one input of the phase comparator. An external signal applied to the second input of the phase comparator causes it to generate an *error voltage* whose magnitude is proportional to the difference between the external source and vco frequencies.

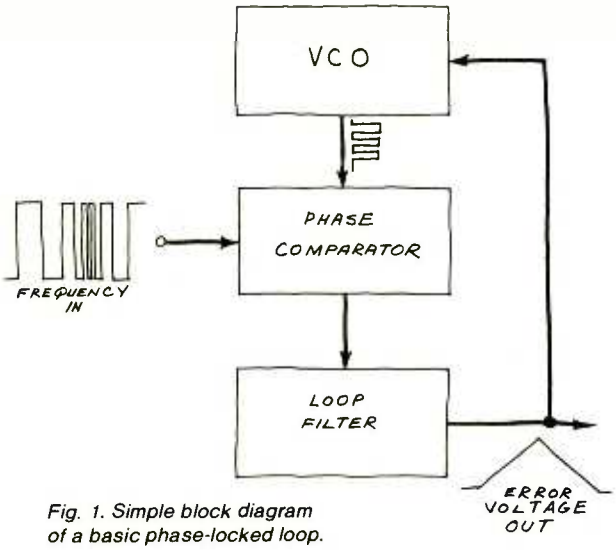

Fig. 1. Simple block diagram of a basic phase-locked loop.

The low-pass loop filter smooths the pulsating error voltage into a dc level which is applied to the control input of the vco. The vco responds to the error voltage by moving its frequency of oscillation toward that of the input signal. This *capture* process continues until the vco frequency equals the input frequency. When this occurs, the PLL is said to be *locked* or *phase-locked* to the input signal.

When the PLL is locked to the input frequency, the vco automatically tracks any changes in the input frequency that fall within a window called the *lock range*. The lock range is always greater than the *capture range*, the band of frequencies over which the PLL can hunt for and "capture" an incoming signal.

It is important to understand that, although the loop filter is essential for proper operation of the PLL, its time constant limits the speed with which the system can track changes in the input frequency. It also limits the capture range. On the other hand, the loop filter helps prevent noise voltages from adversely affecting loop operation. The charge stored in the loop filter's capacitor helps the quick recapture of a signal temporarily lost because of a noise spike or other transient.

In short, the loop filter is a necessary part of the PLL, but it imposes certain operating restraints and tradeoffs. Be sure to keep this in mind when you experiment with PLL circuits, because optimizing PLL performance often requires experimentation with loop-filter component values.

Inside the 4046 PLL. Figure 2 is a block diagram of the 4046 CMOS micropower PLL. One of the most obvious features of this chip is that it includes *two* phase comparators. Phase Comparator I is an exclusive-OR gate that provides a high degree of noise immunity. Unfortunately, this comparator has a tendency to lock onto input signals having frequencies close to harmonics of the vco frequency. Also, it requires a square-wave input with a 50% duty cycle.

Phase Comparator II is a relatively complex network of four edge-triggered flip-flops with control gates and a 3-state output stage. While this detector is less susceptible to the harmonic problem that plagues Phase Comparator I, it is much more sensitive to noise.

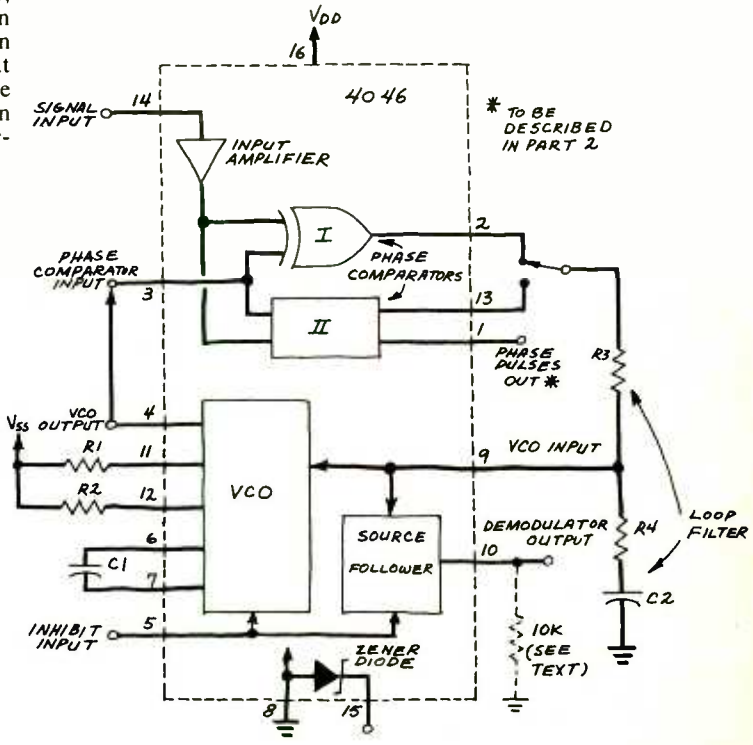

Fig. 2. Block diagram of the 4046 CMOS micropower phase-locked loop.

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Both phase comparators are simultaneously driven by an input amplifier which will be described later. Their outputs, however, are brought out to separate pins (2 and 13). This means that the user can select either comparator for a specific application by simply connecting its output pin to the vco through the loop filter.

Because the flip-flop comparator has a frequency-tracking range of more than 1000:1, it is often a better choice than the exclusive-OR comparator which tracks over a range of only ±30 percent. Another advantage of the flip-flop comparator is that it can accept input pulses of any duty cycle (for example, very narrow pulses).

The vco incorporates an NMOS input stage that provides an input impedance of 10^{12} ohms. Its linearity ranges from 0.1 percent (V_{DD} = +5 V) to 0.8 percent (V_{DD} = +15 V). The oscillator's maximum operating frequency typically ranges from 0.7 MHz (V_{DD} = +5 V) to 1.9 MHz (V_{DD} = +15 V).

Figure 2 shows a source follower connected to the vco input. This buffer stage is intended specifically for frequency-demodulation applications. It allows an external amplifier or other circuit to be driven by the output signal from the loop filter (the filtered error voltage) without loading down the filter. When the DEMODULATOR output (pin 10) of the source follower is used, a load resistor of at least 10,000 ohms must be connected between pin 10 and ground (V_{SS}). Otherwise pin 10 should be left floating.

Both the vco and source follower are provided with a common INHIBIT terminal (pin 5) to reduce standby power consumption. A logic 0 (V_{SS}) at pin 5 enables the vco and follower, and a logic 1 (V_{DD}) inhibits them.

The final component in the 4046 is a 5.2-volt zener diode. This zener is intended for voltage-regulation applications, and its use is optional.

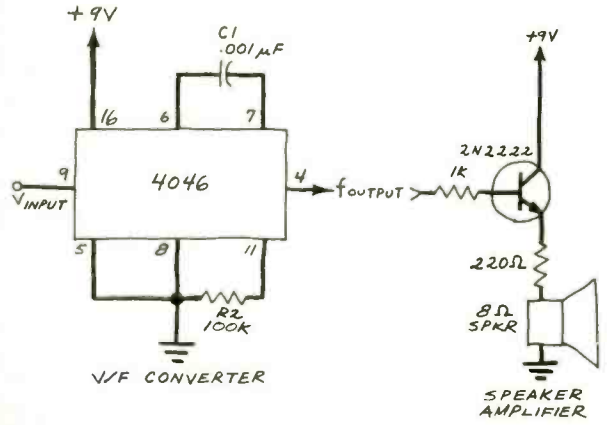
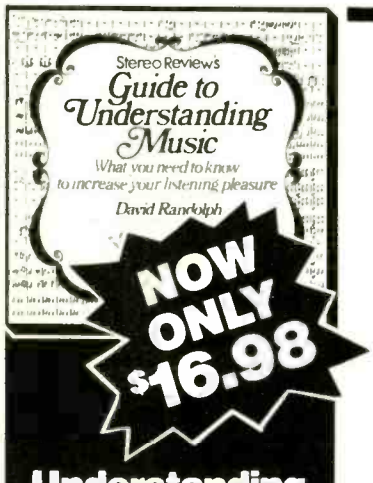


Fig. 3. A basic 4046 vco circuit used as a V/F converter with a speaker amplifier.

Using the 4046. The 4046 requires a power supply that can furnish from 3 to 18 volts at modest current levels. Power consumption depends upon both the vco frequency and what percentage of time the vco is enabled. For example, at a frequency of 10 kHz, the 4046 consumes only 600 microwatts—about 1/160th the power required by a typical analog bipolar PLL such as the 565. Suffice it to say that the 4046 is ideally suited for battery-powered operation!

A minimum number of external components is required to use the 4046. The center frequency of the vco is determined by one capacitor (*C1*) and one or two resistors (*R1* and *R2*) as shown in Fig. 2. When only *R1* is used, the vco frequency can be varied from 0 Hz when the control voltage at pin 9 is V_{SS} to a maximum frequency given by the equation: $f_{max} = 1/R1(C1 + 32\ pF)$ when the control voltage is V_{DD}. For proper



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operation, the resistance of *R1* should be between 10,000 ohms and 10 megohms.

Resistor *R2* is included when it is desirable to move the minimum vco frequency to some point above 0 Hz. For this reason, it is called the *offset resistor*. The minimum frequency resulting from the inclusion of *R2* is determined by solving the equation: $f_{min} = 1/R2(C1 + 32\ pF)$ when the control voltage at pin 9 is V_{SS}. When *R2* is used, the maximum vco frequency when the control voltage is V_{CC} is found by adding f_{min} to the f_{max} obtained from the previous equation.

These vco design equations are extracted from Motorola's MC14046B specifications sheet. They apply only when the values of *R1* and *R2* are between 10,000 ohms and one megohm and when that of *C1* is between 100 pF and 0.01 μF. Nevertheless, the manufacturer's specifications sheet observes that experimentation is in order to determine the exact component values required for a particular application because, ". . . calculated component values may be in error by as much as a factor of 4." This poses no problem because it's a simple matter to use trimmer potentiometers for *R1* and *R2* and to adjust them to get the desired frequency range.

The loop filter, like the vco, also requires a capacitor (*C2*) and one or two resistors (*R3* and optional *R4*). The best explanation of this rather touchy circuit that I have found is in Don Lancaster's *CMOS Cookbook* (Howard W. Sams, 1977, pp. 363-364).

Earlier, we briefly covered some of the loop-filter design tradeoffs. Don, who seems to know more about the real-world idiosyncrasies of the 4046 than the data-sheet authors, says that both *R3* and *R4* are necessary to avoid driving the loop into near-oscillation. He reports that best operation is obtained when the resistance of *R4* is from 10 to 30 percent of that of *R3*. This provides enough damping to eliminate loop overshoot and oscillation, but still ensures a reasonably quick response to changes in the input frequency.

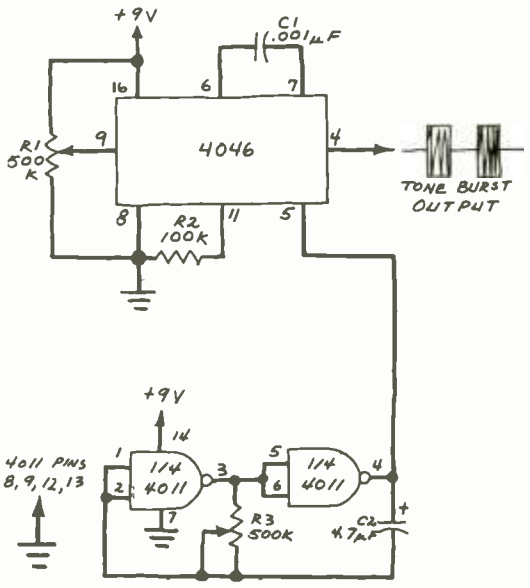

Fig. 4. A tone-burst generator in which R1 controls frequency and R3 burst rate.

Don recommends nominal values of 470,000 ohms for *R3*, 47,000 ohms for *R4*, and 0.1 μF for C2. A longer *RC* time constant means excessive delay when the loop is tracking quickly changing input voltages. A smaller *RC* product can cause erratic changes in the vco frequency as the loop tracks a rapidly changing signal.

I said that we would have more to say about the 4046 input amplifier later. Don comes directly to the point on this subject, so let's hear from him again. "*The linear amplifier operation of pin 14 is an unmitigated disaster when the wideband phase detector is being driven. Don't use it this way!* Linear operation causes extra amplitude-variation sensitivity, jitter, tearing and generally poor noise immunity" (*CMOS Cookbook*, p. 363).

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One solution to this problem is to apply only full logic levels to the input. If this isn't possible or practical, pin 14 should be pulled up with a 10,000-ohm resistor to V_{DD}. The input signal can then be coupled into pin 14 by means of a 0.1-μF capacitor. In any event, if the input is a low-frequency train of slowly rising and falling pulses, the pulses must be conditioned with an appropriate pulse-shaping circuit.

VCO Application Circuits. An important feature of the 4046 is that the vco section can be used on its own for many practical applications, several of which will now be described. Experimenting with them will provide important experience for working with the chip as a complete PLL.

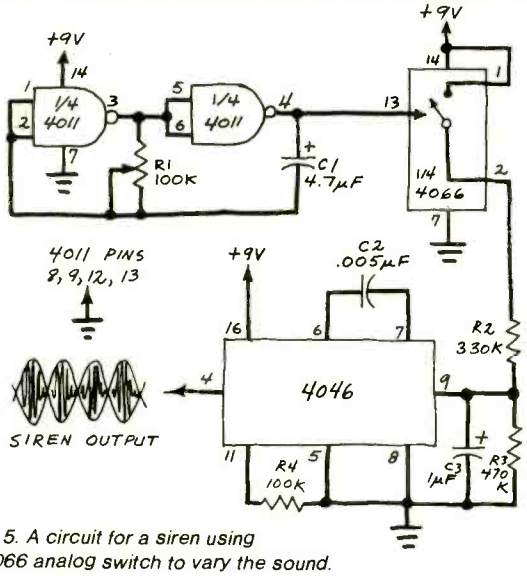

Fig. 5. A circuit for a siren using a 4066 analog switch to vary the sound.

Voltage-to-Frequency Converter. Figure 3 shows the most basic 4046 vco circuit possible, a simple V/F converter. Varying the input voltage from V_{SS} (ground) to V_{DD} will shift the output frequency over a range of 0 Hz to 18.5 kHz. You can use this circuit as a tunable oscillator by connecting the opposite ends of a 500,000-ohm potentiometer to V_{DD} and ground and by connecting the rotor to pin 9.

Figure 3 also includes a basic speaker amplifier that can be used with this and other 4046 circuits.

Tone-Burst Generator. Figure 4 is a simple tone-burst generator. Potentiometer *R1* controls the tone frequency and *R3* controls the burst rate.

Siren. The operation of the siren shown schematically in Fig. 5 is controlled by a 4066 analog switch. When the super-low-frequency NAND gate oscillator closes the switch, capacitor *C3* charges to V_{DD} through *R2*. When the analog switch is opened, *C3* discharges through *R3*. Because the voltage across *C3* controls the vco frequency, the result is an up-down siren effect.

Experiment with the various *RC* time constants to alter the sound of the siren. Components *R1* and *C1* control the cycle time, *R4* and *C2* control the frequency, and *R3* and *C3* control the wail.

To be Continued. In Part 2 we'll examine several PLL applications for the 4046. In the meantime, get some practical experience with this versatile chip by experimenting with circuits presented this month. ◇

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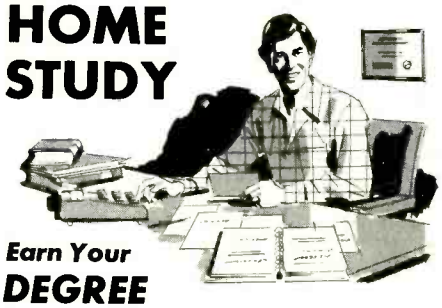

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Hobby Scene

By John McVeigh, Technical Editor

Wireless Microphones

***Q.** Do you have a schematic for a broadcast-band wireless microphone?—Randy Drezdon, Milwaukee, WI.*

A. Your question is ambiguous—do you want the schematic of a wireless microphone for the AM broadcast band or the FM broadcast band? To cover both possibilities, I am including two schematics. Shown at A is the schematic diagram of a wireless microphone for the AM band that employs two germanium transistors. The circuit functions as follows. Audio stage *Q1* amplifies signals from the crystal microphone and amplitude-modulates oscillator *Q2*. The frequency of oscillation is governed by the resonant *LC* network *L1C2* and can be varied by rotating the shaft of *C2*. Feedback necessary to sustain oscillation is provided by the tap on *L1*. R-f energy generated by the circuit is radiated by the antenna connected to the tuned circuit.

Radio Shack pnp germanium transistors (RS2007) are suggested for use in the wireless microphone. Inductor *L1* is a J.W. Miller No. 2004 ferrite strip antenna/coil with an inductance of 240 μH. It has a frequency range of 540 to 1650 kHz and is designed for use with a variable capacitor having a maximum capacitance of 365 pF such as the J.W. Miller No. 2112. A short length of copper wire (one to two meters) connected to the top of the *L1C2* tuned circuit functions as an antenna.

To use the microphone, tune an AM broadcast receiver to a dead spot on the dial. Then speak into the transducer and, with the antenna positioned near the receiver, adjust *C2* until you hear your voice coming through the radio's loudspeaker. Range of the wireless microphone is typically 50 to 100 feet (15 to 30 m).

Shown at B is a wireless microphone for the FM broadcast band that first appeared as a reader's circuit by Thomas Duncan in the Solid State column for October 1971. It employs a standard rectifier (*D1*) as a voltage-variable capacitance in the frequency-determining network of modified Hartley oscillator *Q3*. The circuit operates as follows.

Dc bias is applied across *D1* through *R8*, *R9* and *RFC1*. The instantaneous bias across the diode varies in step with the amplified microphone signal delivered by *Q1* and *Q2*. The capacitance of the diode junction and the frequency of oscillation vary accordingly. In this manner, an FM signal detectable by a standard vhf receiver is generated.

Good vhf wiring practice should be observed in the r-f portion of the circuit. Either printed-circuit or point-to-point wiring construction techniques can be employed to reproduce the wireless microphone. Standard components are used except for *L1*. This is a hand-wound coil consisting of four turns of No. 18 AWG solid copper wire wound on a ¼-inch (6.4-mm) noninductive form 1 inch (2.54 cm) long. The turns should be evenly spaced and the coil tapped at the second turn above ground.

A Radio Shack No. 273–102 choke can be used for *RFC1*, and Radio Shack RS-2009 general-purpose npn silicon transistors for *Q1*, *Q2* and *Q3*. The Radio Shack replacement for the 1N4817 is the 276–1114, a 1000-volt, 2.5-ampere rectifier. The circuit can be driven by a crystal or dynamic microphone. Switch *S1* functions as a push-to-talk switch, controlling the application of power and microphone output to the circuit. Plug *P1* and jack *J1* are standard ¼-inch (6.4-mm) phone-type stereo connectors. A short length of copper wire connected to the emitter of *Q3* functions as an antenna.

After the circuit has been assembled, position its antenna near that of an FM broadcast receiver. Apply power to the receiver and tune to a dead spot on its dial. Close *S1* and speak into the microphone with the wiper of *R9* set to the midpoint of its travel. Adjust *C7* until you can hear your voice coming through the receiver's speaker. Finally, adjust *R9* for optimum modulation and the best quality audio as reproduced by the receiver. Retune *C7* if necessary.

These circuits have relatively short ranges but many uses such as monitoring a baby in another room, paging another member of the family, etc. They also act as self-contained broadcast stations that allow you to entertain friends and family by putting on your own radio shows.

Adding a Center Tap

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A. No, I don't.

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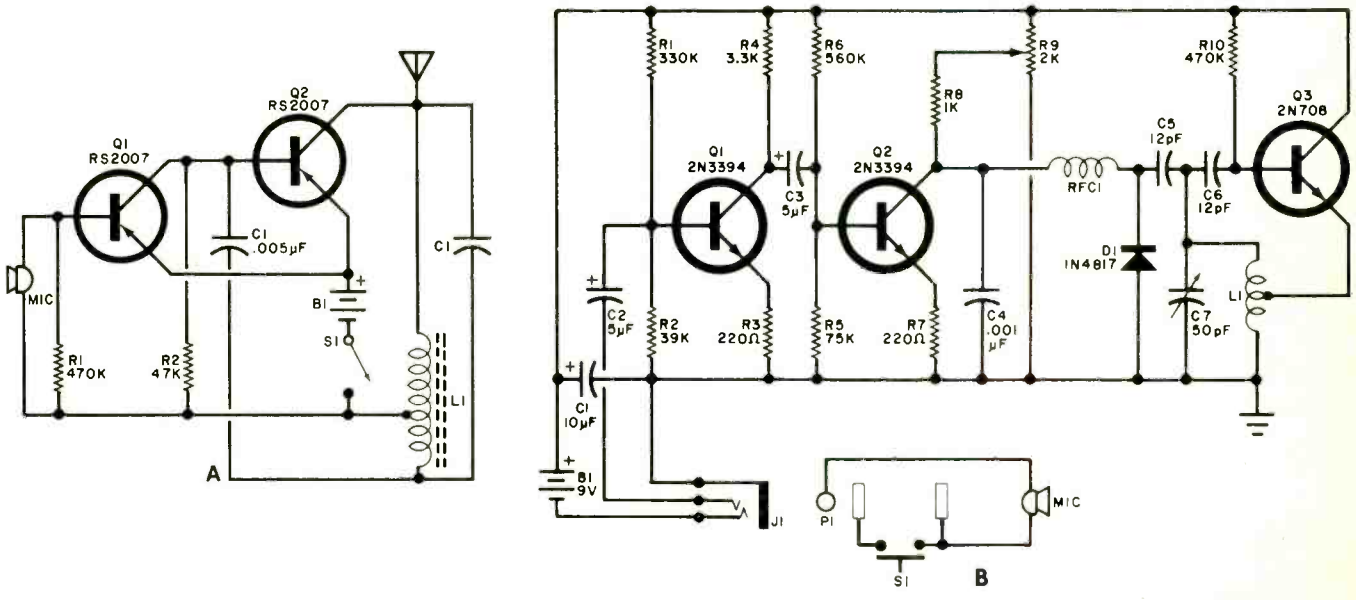

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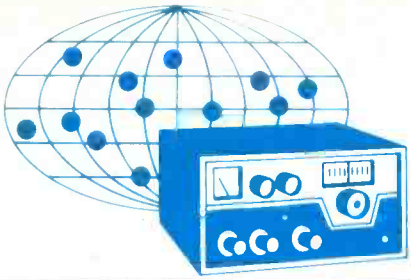

DX Listening

By Glenn Hauser

Fantastic Intercontinental TV-DX

LAST autumn, a hardy breed of TV DXers had their heyday during the peak of solar Cycle 21. They succeeded in pulling in European TV stations via the heavily ionized F_2 layer of the ionosphere. Some used imported or modified domestic TV receivers to pick up sound or pictures or both while others employed scanners or police-band radios to detect sound portions only. The reception window was in the hours of sunrise to noon local time.

Here's a summary of some of the F_2 TV-DX reported in *VHF-UHF Digest*, by members of the Worldwide TV-FM DX Association (P. O. Box 97, Calumet City, IL 60409). Glenn Jacobs, Moscow, PA, had snow-free video from Dublin, Ireland, on 53.25 MHz (close enough to American Ch. 2—55.25 MHz—that it could be tuned in on an unmodified U.S. set, with nothing but rabbit ears for antenna!). It was so strong on Nov. 11 that his closest Ch. 2 station, Utica, NY, was unwatchable. Jacobs reported another peak Dec. 8-16 with Ch. F-4 audio on 54.40 MHz and lots of stations on Ch. E-2, including West Germany. Jerry Pulice, Staten Island, NY, with an impressive array of equipment, logged Swiss and German video; Czechoslovakia tentatively. On Nov. 4, using a modified TV set, he viewed a credit roll on Russian Ch. 1 (49.75 MHz) with Cyrillic letters.

During November, Pat Dyer in San Antonio, TX, had frequent reception of video on 49.75 MHz, from the northeast in the morning (eastern Europe), and from the northwest in the afternoon (China and Soviet Far East). Pat had a few days of watchable 45-MHz BBC Ch. 1 video, and Ch. B-2 video received as radio signals on 51.75 MHz. By careful attention to offset frequencies, DXers such as Rich Turcsany in Shelton, CT, were able to identify several different stations in different parts of Great Britain on channels B1 and B2.

Television DXers farther to the north and west were not so fortunate, since their more northerly paths to Europe were subject to lower maximum frequencies and more auroral absorption. Still, Buck Battin in Duluth, MN, had almost daily English and French TV audio just above 41 MHz; and Fred McCormack in Fargo, ND, logged some weak audio on Ch. B-1.

It worked both ways. Television DXers in Europe caught signals on American channels. Mike Allmark, for instance, in Leeds, England, received stations on American Chs. 2 and 3 on various dates in October, November and December. Another "season" of intercontinental TV DX is expected during those same months in 1980, but since the solar flux and sunspot counts are declining from their peak, reception will probably not be as exciting as it was last year. After that, it may be another nine years or so before another solar cycle peak produces such DX and by then many of these lower-frequency European TV channels are expected to have been phased out in favor of uhf.

Slow-Scan Broadcasting? Intercontinental TV DX of another kind can take place regardless of the solar flux, if SSTV experimenters encourage a few stations that have launched trial balloons on SSTV broadcasting. Owing to its narrow bandwidth, SSTV can be transmitted on ordinary shortwave equipment. The definition is much inferior to regular TV, and each picture takes seven seconds to form. Nevertheless, the prospect of a visual aspect to international broadcasting is exciting. A station with at least two frequencies could run its newscast or feature programming on one, and accompanying slides on another. The catch is, hardly any SWLs have SSTV receiving equipment. Lots of hams do, however, and it's up to them to get the ball rolling (or, should we say, get the electron beam scanning), by writing to the individuals thinking of trying SSTV on their stations (both of whom are hams themselves): Ben Dalfen, DX Corner, Kol Israel, Box 1082, Jerusalem, Israel; and, Warren Moulton, Radio Australia, Melbourne 3000, Victoria, Australia.

Summer Conventions for DX listeners. The major convention is sponsored by the Association of North American Radio Clubs—a rare opportunity for North American listeners to meet each other by the hundreds, and to meet some international broadcasters in person. Among those planning to be at ANARCON 1980 are George Wood, DX Editor of Radio Sweden; Alfonso Montealegre of Radio Nederland; Ian McFarland of RCI (who is also a superb auctioneer); and the editors of the World Radio-TV Handbook, Jens Frost and Andy Sennitt.

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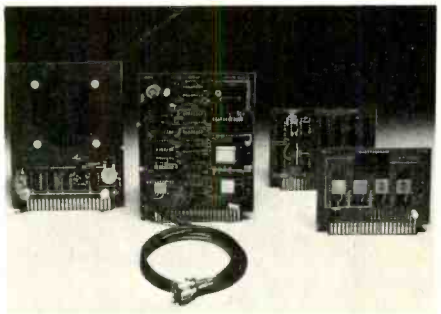

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The ANARC Convention has a good mix of formal and informal activities, is open to all interested DX listeners, whether or not they are club members, and prices are extremely reasonable. This year's takes place July 18-20 on the campus of the University of California at Irvine. For further information, send a business-size, self-addressed stamped envelope to convention chairman Stewart MacKenzie, 16182 Ballad Lane, Huntington Beach, CA 92649.

ANARCON is "all wave", but the emphasis is on shortwave. Two other conventions are mediumwave oriented, sponsored by the two major clubs in this field: International Radio Club of America, Aug. 15-17, Louisville, KY; send SASE to Ted Fleischaker, 3023 Tremont Dr., Louisville, KY 40205. Ted has hosted a number of DX conventions before, and assures a good time. The other: National Radio Club, Aug. 30-Sept. 1, Los Angeles. SASE to John Clements, P. O. Box 33188, Granada Hills, CA 91344, for info.

Frequency Mismanagement. The shortwave broadcast bands are crowded, resulting in inevitable frequency conflicts. Yet these can be kept to a minimum by astute frequency management. Unfortunately, a number of stations operate oblivious to the real situation on the bands, very much to their own detriment and that of would-be listeners. Some rely exclusively on registrations made with the ITU, some of which are imaginary or out of date (and the ITU pretends jamming does not exist). Others believe that a frequency can be shared with another station broadcasting to a different target zone. In truth, no antenna is wholly unidirectional. Quite often radiation from the back or side is more than sufficient to seriously disrupt a "share." Some examples are:

Radio Bras was doing fine on 15290 to North America at 0300 during our winter, and decided to stay for spring—but by then *Radio Liberty*'s jammed service at the same time on the same frequency, wiped out Brazil! If Brazil had been sufficiently alert, it would have changed frequencies before or shortly after the beginning of the conflict.

Radio Lebanon is becoming a laughingstock for its poor choice of frequencies in its North American service. One was underneath the much more powerful *TWR-Bonaire*; another was underneath *Deutsche Welle*; and still another mixed with *BBC*. To make matters worse, *Radio Lebanon* goes on new frequencies without publicizing them, forcing listeners to search or give up.

Far East Network, Tokyo, used 11750 and 15260 years ago, so when they decided to resume transmissions on those bands in 1980, they came up on the same frequencies—now interfered with in both cases by the BBC, as anyone who took the trouble to turn on a radio would find out.

The *Voice of Greece*, for reasons unknown, left two good frequencies for two awful ones—both already subject to jamming against *RFE/Radio Liberty* (17835 and 21455 at 1200 and 1500 GMT).

Other stations make propagation work against them, instead of for them. Argentina's external service is a good example—both 11710 and 9690, the only two frequencies they ever use, are ineffective because of interference and absorption, while much better propagation and clear frequencies could be found on the bands above 15 MHz.

Country by Country. *Falkland Islands.* Many North American DX listeners got the thrill of a lifetime when they finally received that rarest of catches, *FIBS*, until sign-off at 0130 GMT on 2370 kHz. Reception peaked during December, when the northern hemisphere was darkest, and it may peak again in July when the southern hemisphere is darkest. *FIBS'* April-September schedule runs later, to 0200 GMT, except local Sundays to 0100. The reason for *FIBS'* success in reaching North America at last is a more powerful 2.5-kW transmitter and a directional antenna favoring our azimuth. But according to Bob Donly in SPEEDX-GRAM, they are very partic-

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ular about the accuracy of reception reports and stingy with their newly designed QSL cards. However, there have been unconfirmed reports of a pirate in Connecticut pretending to be *FIBS* at the same time on the same frequency. Beware! Should you get tired of hearing *FIBS* on 2370, no one in North America has yet reported its other frequency, 536 kilohertz!

Guatemala. Union Radio is a new shortwave station operated by Adventist World Radio. The station made a big splash during its first five days on the air in March, since it was radiating a powerful harmonic on 18266 or 17935 kHz, much more easily heard than fundamentals one third of those frequencies (its two intended frequencies are 5980 and 6090). *AWR* then went off the air for a week, returning with much weaker harmonics and slightly stronger fundamentals. A power increase to 100 kilowatts is planned.

Iceland has long been a tough country to hear—nothing but a domestic program for mariners half an hour per day at 1200 on 12175 kHz using a low-powered transmitter on a frequency with lots of interference. But for the summer, Iceland has registered a new broadcast to Europe at 1800-2000 GMT on 9565 and/or 11855 and/or 15420 kHz. A registration is far from a certainty, and the language is not specified, but it's worth checking.

Malaysia is upgrading its external service with two new 500-kW senders now supposed to be in use on 11900, 15295 and 17725 kHz. They've not said anything about using them to broadcast to North America.

United Arab Emirates. Dubai Radio & Color TV seems seriously dedicated to starting an international service from a place most Americans have never heard of. They advertised for English language newscasters, offering salaries as high as 17,000 pounds, and carried out test transmissions mainly to Asia and the Pacific, but also heard in North America testing on 21485 and nearby frequencies around 0700 GMT. However, 300 kW transmitters are registered on some frequencies toward us: 11755 at 0030-0230 GMT and 9505 at 0300-0430.

Vanuaatu is the name for the newly independent New Hebrides. Its radio station adopted the name *Radio Vanuaatu* as early as March, per Arthur Cushen. Once a prime DX catch on 3945 kHz, Vila became somewhat easier to hear in North America this year by using 7260 kHz at 0800-1030 GMT. Don't confuse with *R. Hong Kong*, which has returned to 3943 at 1100 to 1115 only.

Yugoslavia has been promising a major expansion in its external broadcasting for years, but this suffered continual delays, topped by Pres. Tito's long illness. Once Yugoslavia's future course is set, perhaps Radio Yugoslavia will fulfill its plan to add new high-powered transmitters and antennas more suitable for serving North America and many other regions.

(continued overleaf)

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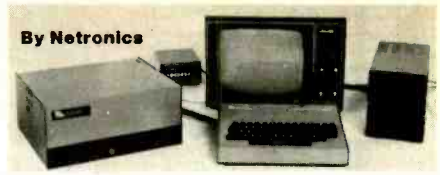
System Monitor (Terminal Version): 2k bytes of deluxe system monitor ROM located at F*000* leaving *0000* free for user RAM/ROM. Features include tape load with labeling...tape dump with labeling...examine/change contents of memory ...insert data...warm start...examine and change all registers...single step with register display at each break point, a debugging/training feature...go to execution address... move blocks of memory from one location to another...fill blocks of memory with a constant...display blocks of memory ...automatic baud rate selection...variable display line length control (1-255 characters/line)...channelized I/O monitor routine with 8-bit parallel output for high speed printer... serial console in and console out channel so that monitor can communicate with I/O ports.

System Monitor (Hex Version): Tape load with labeling... tape dump with labeling...examine/change contents of memory...insert data...warm start...examine and change all registers...single step with register display at each break point ...go to execution address. Level "A" in the *Hex Version* makes a perfect controller for industrial applications and can be programmed using the Netronics Hex Keypad/Display.



Hex Keypad/Display.

Hex Keypad/Display Specifications

Calculator type keypad with 24 system defined and 16 user defined keys. 6 digit calculator type display which displays full address plus data as well as register and status information.

Level "B" Specifications

Level"B" provides the S-100 signals plus buffers/drivers to support up to six S-100 bus boards and includes: address decoding for onboard 4k RAM expansion select-able in 4k blocks...address decoding for onboard 8k EPROM expansion selectable in 8k blocks...address and data bus drivers for onboard expansion...wait state generator (jumper selectable), to allow the use of slower memories...two separate 5 volt regulators.

Explorer/85 with Level "C" card cage.

Level "C" Specifications

Level "C" expands Explorer's motherboard with a card cage, allowing you to plug up to six S-100 cards directly into the motherboard. Both cage and cards are neatly contained inside Explorer's deluxe steel cabinet. Level "C" includes a sheet metal superstructure, a 5-card gold plated S-100 extension PC board which plugs into the motherboard. Just add required number of S-100 connectors

Level "D" Specifications

Level "D" provides 4k or RAM, power supply regulation, filtering decoupling components and sockets to expand your Explorer/85 memory to 4k (plus the original 256 bytes located in the 8155A). The static RAM can be located anywhere from *0000* to EFFF in 4k blocks.

Level "E" Specifications

Level "E" adds sockets for 8k of EPROM to use the popular Intel 2716 or the TI 2516. It includes all sockets, power supply regulator, heat sink, filtering and decoupling components. Sockets may also be used for soon to be available RAM IC's (allowing for up to 12k of onboard RAM).

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☐ **Hex Keypad/Display Kit, $69.95** plus $2 p&h.

☐ **Deluxe Steel Cabinet** for ASCII Keyboard/Terminal, **$19.95** plus $2.50 p&h.

☐ **Power Supply Kit** (±8V @ 5 amps) in deluxe steel cabinet, **$39.95** plus $2 p&h.

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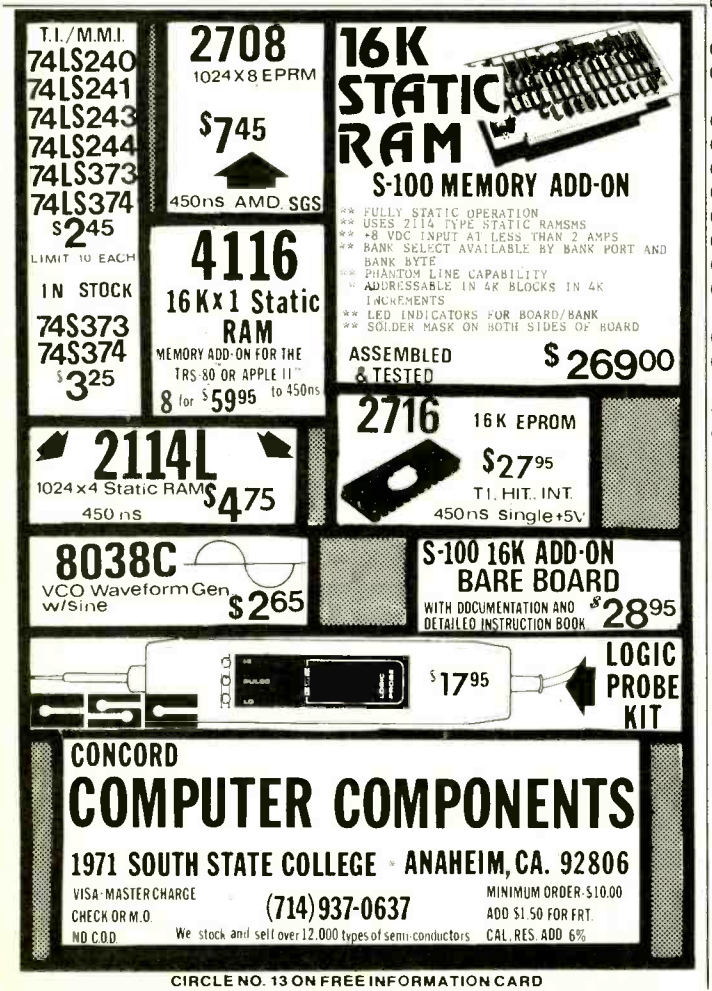
Publication. Radio Communications Guide is the latest compilation of utility station frequencies and schedules by Steve Handler. The 80-page spiral-bound booklet covers mostly military and governmental transmitters on hf and vhf in 51 different categories. Cost is $6.95 (plus 42¢ tax for Illinois residents; $1 extra for first class mailing), payable to Handler Enterprises, Inc., P.O. Box 48, Deerfield, IL 60015.

Updating Listing. The following changes and additions should be made in the "English Broadcasts" listing that appeared in the June issue.

GMT	Station	Frequencies
0900-0930	NSB, Tokyo	delete
0900-1030	R. Australia	15145
1100-1200	AFRTS-Washington	6030
1100-1330	BBC	11775 (continuous)
1200-1230	R. Tashkent	11785 9715, 9750, not 11730, 11925, and 15125
1200-1245	R. Berlin Int'l	delete
1200-1300	V. of Turkey	17860, 15185, ex-17820, 11800
1230-1255	Austrian R.	15290, ex-21655
1230-1551	WYFR	21525, ex-21615 (Sunday)
1300-1345	R. Berlin Int'l	21540, 21465, 17700 (ex-1400-1445)
1300-1600	CBC Southern Service	9580 (17880, 1300-1400, 17710, 1400-1600) (Sunday)
1400-1430	R. Portugal	delete
1530-1615	NSB, Tokyo	delete
1600-1615	Vatican Radio	17900, ex-1700
1600-1709	BBC	17830, 15260
1605-1655	R. France Int.	25900, 21515, ex-21675
1700-1730	HCJB, Ecuador	26020, 21480, 17790† (ex-1700-1800)
1700-2000	4VEH, Haiti	11835, 9770 (Sunday)
1709-1745	BBC	21710, 15070
1800-1830	R. Norway	25730
1800-2150	R. New Zealand	15485, ex-15345
1900-2000	HCJB Ecuador	17825†, 15435†, ex-17885, 15405
2000-2115	BBC	delete 17840
2030-2130	V. of Turkey	11895, 11855, ex-11955
2045-2230	All India R.	15110
2050-2100	R. Free Europe	17835, 15420, 11825, ex-15290 (Friday)
2100-2150	R. RSA	11900, 9585, ex-17780, 21535
2130-2200	HCJB Ecuador	17825†, 15435†, ex-17885, 15405
2200-2215	R. Japan	15180, ex-15230 (via Portugal)
2200-2300	BBC	6120
2200-2300	V. of Turkey	15360, ex-11955
2200-0200	AFRTS-Washington	17765, ex-25615
2245-2300	UN Radio	11920, ex-11830 (Fri.)
2300-2330	R. Sweden	15380 ex-15275
2300-2330	R. Vilnius	15275, 11735
2300-0300	R. Moscow World Service	15460
2305-2320	Austrian R.	delete
0000-0030	Kol Israel	21710, not 21555
0000-0045	R. Berlin Int'l	11975, 9730, ex-0100-0145
0000-0155	R. Peking	not 15520
0030-0100	R. Kiev	15275, 11735, 9800
0030-0200	HCJB, Ecuador	151556†, ex-1525
0100-0115	Vatican R.	9645, ex-9605
0100-0125	Kol Israel	21710, not 21555
0100-0130	R. Budapest	6000, ex-6105 (Wed & Fri 0030-0130)
0100-0500	WYFR	9715, ex-15130 and 11740
0120-0220	V. Germany	15235
0130-0215	R. Berlin Int'l	11975, 9730, ex-0230-0315
0130-0700	HCJB, Ecuador	11910, ex-11915
0200-0230	R. Budapest	6000, ex-6105
0200-0250	R. RSA	9610, 9585, 5980, ex-17770, 15265, 15155
0200-0300	Radiobras	15290
0200-0430	AFRTS-Washington	15430, 9755
0200-0455	R. Peking	15230 not 15600
0230-0245	R.Pakistan	delete 21730
0230-0300	R. Lebanon	11820†, ex-11785
0230-0300	R. Sweden	15290†, ex-9695
0230-0315	R. Berlin Int'l	11975, 11890, ex-0330-0415
0230-0445	BBC	15070
0230-0500	HCJB Ecuador	15155, ex-15250
0300-0315	R. Budapest	6000 ex-6105 (Wed & Sat; Mon-0330)
0300-0330	R. Portugal	15125, ex-6025
0330-0400	R. Finland	15400, 15430, ex-9760 and 11755
0330-0500	R. Tanzania	delete
0330-0500	AWR, Guatemala	5980, 17940, ex-0100-0300
0350-0410	RAI, Italy	21560 not 21561
0400-0530	Capital R, Transkei	3950†
0400-0600	R. Moscow	12060 not 12030
0430-0630	TWR, Swaziland	7175† ex-7290
0430-0700	AFRTS-Washington	17765, 15430
0500-0515	Kol Israel	21710 not 21555
0500-0530	R. Portugal	9575, ex-6185
0500-0600	R. Australia	21650
0530-0600	R. New Zealand	17860, 15345 (Mondays; fortnightly)
0600-0630	R. Australia	17795
0600-1100	HCJB Ecuador	11900, 6135, (0700-1030, also 9745)
0625-0800	TWR, Monte Carlo	9495† ex-9485
0700-0730	Swiss R. Int'l	21520

Note: For late information on schedule changes, monitor 'DX Digest' on Radio Canada International: Sundays 1807, 1915, 2015; GMT Mondays 0007, 0407; Wednesdays 2145. ◇



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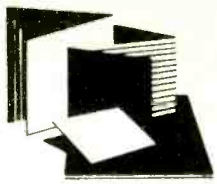

New Literature

SHAKESPEARE FIBERGLASS ANTENNAS

The 1980 Shakespeare Catalog describes over 100 products, including accessories, for CB, CB marine, land mobile and amateur applications. Featured are the Super Big Stick™, a fully insulated bast station antenna; the two Load™, a duo-phased mobile antenna; and the company's new generation of magnetic mounts, whose holding powers are said to be increased 400% over older models. Add: Shakespeare , Electronics and Fiberglass Div., P.O. Box 246, Columbia, SC 29209

AAL SPEAKER CATALOG

Thirty-six models of hi-fi speakers are covered in a new catalog from America Acoustics Labs. Engineering, construction, and performance specifications are given for the Classic, Studio, Micro and new Equation series of speakers. Also included are special units for discos, clubs, etc., and individual drivers for homespeaker builders. Address: American Acoustics Labs, 629 W. Cermak Rd., Chicago, IL 60616.

PHILLIPS INSTRUMENT CATALOG

A new catalog of Phillips products marketed in the U.S. and Canada by PTMI includes specifications and illustrations of oscilloscopes, counters and counter timers, pulse generators, a logic analyzer and a logic scope. Address: Phillips Test & Measuring Instruments, 85 McKee Dr., Mahwah, NJ 07430.

SEMICONDUCTOR REPLACEMENT GUIDE

The 1980 edition of the Archer Semiconductor Replacement Guide is a 224-page description of Radio Shack's Archer-brand semiconductors and includes data and pin connections for ICs, diodes, SCRs, LEDs, and other devices. It also features a cross-reference/substitution listing for over 100,000 devices available from Radio Shack. Information is included on the care and handling of semiconductors, and there is a glossary of words, symbols and abbreviations. $1.99 from Radio Shack stores and dealers.

AVIONICS KITS CATALOG

A 16-page catalog from Radio System Technology describes its line of light aircraft avionics and test equipment kits, including audio panels, transceivers, intercoms, battery packs, and antenna splitters. Address: Radio Systems Technology, Inc., 10985 Grass Valley Ave., Grass Valley, CA 95945.

SPEAKER MINI-CATALOG

A pocket-size 12-page catalog of speakers and related components from Heppner Sound includes illustrations and specifications for horns, domes, and compression drivers. Speakers range from 3' to 18', including elliptical and are for use in 2- and 3-way systems. Address: Heppner Sound, Rt. 120, Belvidere Rd., Round Lake, IL 60073.

COMPUTER SUPPLIES AND ACCESSORIES

Included in International Minicomputer Accessories Corp.'s 1980 catalog are new items such as preformatted flexible disks, microcomputer cables, sound enclosures, flexible-disk hanging file folders, and mini-data cartridge binder leafs. In addition to its product line, the catalog contains product/supply compatibility indexes and cross-reference guides for computer accessories and supplies. Address: Dept. BPR, INMAC, 2465 Augustine Dr., Santa Clara, CA 95051.

RECTIFIER TECH TIP

Westinghouse's Tech Tip 1-9 "What Is a Fast Recovery Rectifier—Where and Why Is it Used?" explains the relationship between fast recovery and soft or abrupt recovery, the factors that determine this relationship, and whether a rectifier will be usable in specific applications. Reverse recovery time, voltage rating, circuit design, snubber circuits, and operating frequency are discussed as determinants for such applications as high-frequency rectification, freewheeling diodes, and feedback or clamp diodes. Address: Semiconductor Div., Westinghouse Electric Corp., Youngwood, PA 15697.

INTEL COMPONENT CATALOG

The "1980 Component Data Catalog," available from Intel Corp., contains specifications for commercial, industrial and military devices, support products and services, including megabit bubble memory devices, the 2920 signal processor, and the 8089 16-bit I/O processor and peripherals. LSI memory and microprocessor devices are included along with the 8086 16-bit VLSI CPU and support components. The catalog is $7.50. Address: Literature Dept., Intel Corp., 3065 Bowers Ave., SC3-3, Santa Clara, CA 95051.

LED CATALOG

The 1980 short-form Catalog from OPCOA features its complete line of LED lamps, display modules, and "chip-on-board" display assemblies. Specifications and dimensions are given on a new line of bi-color LEDs in red, green, orange, and yellow combinations in T-1¾ low-profile and T-1 packages. Digit heights are 0.3" to 1.0". Address: OPCOA, 330 Talmadge Rd., Edison, NJ 08817.

TEST INSTRUMENTS

Features and specifications of test equipment made by 14 concerns are given in a catalog from The Instrument Mart. Included are oscilloscopes, digital multimeters, frequency counters, function and pulse generators, audio analyzers, power supplies, etc. Address: The Instrument Mart, 295 Community Dr., Great Neck, NY 11021.

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Z80 Assembly Language Programming

by Lance A. Leventhal

Written for the serious programmer, this book discusses Z80-based assembly language programming in depth. It presents software development concepts and contains more than 80 programming examples. Included are flow charts, source programs, and object codes. Comparisons between Z80 and 8080A/8085 instruction sets, interrupts, and other pertinent areas are detailed. Separate sections are devoted to subroutines, programming the Z80 interrupt system, I/O devices, interfacing, debugging, and two sample projects. With about 600 pages, small type size and a rather challenging subject, this is not a text that is easily digested. But supported by clear writing, good paper stock, bold type where important, and helpful drawings, a determined person can become truly knowledgeable about assembly programming. *Published by Adam Osborne & Associates, Inc./McGraw-Hill Publishing Co., 630 Bancroft Way, Berkeley, CA 94710. Soft cover. $9.50.*

How to Build Your Own Self-Programming Robot

by David L. Heiserman

The aim of this book is to show the reader how to build a microcomputer-based robot that can "learn" (program itself) based on its environment. The latter need not be static since the robot (based on an 8085 CPU and called "Rodney" by the author) undergoes continuous learning, adapting to any changes in its environment. Fully illustrated, the book contains schematics, photos, and programs to build Rodney and get him into operation. The obvious omission of pc foil patterns and the mechanical work required may restrict the number of readers who actually try to build the robot. So this is an exciting project for only the most daring hobbyist, though others will get vicarious satisfaction by reading how it's all done. *Published by Tab Books, Blue Ridge Summit, PA 17214. Soft cover. 237 pages. $7.95.*

The Video Primer

by Richard Robinson

This is a revised and updated version of a book originally published about 1974. The new edition reflects the latest innovations in telecommunications technology. Without assuming an extensive background in electronics and optics or resorting to complex language, the author gives a sophisticated view of a difficult subject. The first part covers equipment, along with its characteristics and pitfalls, while part two covers techniques and philosophy. You will not be an expert after having read this book, but you will have your feet solidly planted and a good idea of where you are going. *Published by Quick Fox, 33 W. 60th St., New York, N.Y. 10023 Paperbound. 400 pages. $8.95*

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Operation Assist

If you need information on outdated or rare equipment—a schematic, parts list, etc.—another reader might be able to assist. Simply send a postcard to Operation Assist, POPULAR ELECTRONICS, 1 Park Ave., New York, NY 10016. For those who can help readers, please respond directly to them. They'll appreciate it. (Only those items regarding equipment not available from normal sources are published.)

Howard Radio Co., model 318 AM receiver. Need schematic. R. J. Simon, 5555 Shepherdess Ct., Columbia, MD 21045.

Jackson model 648 dynamic tube tester. Need chart listings, schematic and instruction manual. W. F. Menard, 6801 Russell Ave. So., Minneapolis, MN 55423.

General Electric YGS-3 R-F signal generator. Need schematic and instruction manual. Dale Le Stourgeon, 3 Sugar Creek Rd., North Little Rock, AR 72116.

Monarch model SAT-460X stereo tuner amplifier. Parts list and schematic needed. Joseph P. Stefani, 43 Livingston Ave., New Providence, NJ 07974.

Korting Dynamic model 1030 receiver. Need schematic and/or any other data. Theodore Zahorodny, 1626A Reinburg Cir., Bolling AFB, Washington, DC 20332.

Mostek series MK 50310 calculator. Need pc board layout. Duane Kinchelos, Box 287, Iola, KS 66749.

Armstrong model 626 tube-type AM/FM receiver. Need service manual, schematic or address of company in England. Pierre Oliver, 830 Melancon #305, St. Jérôme, Québec, Canada J7Z 5X9.

Webcor model 12-8300 AM/FM 8 track. Need schematic or service manual. Carl H. Harp, 3632 Modlin, Ft. Worth, TX 76107.

Kinsman Organ Corp., Crown Princess organ. Need service information. M. Ploennies, 224 Riverside Rd., Marquette, MI 49855.

Unicom model 1610 ac powered desktop calculator. Need schematic, power transformer or electrical specifications of power transformer. Erwin Stanley, Rt. 3, Box 813, Benton, AR 72015.

Hallicrafters model HT 40 transmitter. Schematic and instruction manual needed. Dennis L. Whitson, RR1, Box 99, Greenfield, IN 46140.

Hewlett-Packard model 211B square-wave generator and model 431C power meter. Need schematics and operation manuals. Robert J. Zmudzinski, 65 Marie St., N. Lindenhurst, NY 11757.

Knight model KG-2000 scope. Need power supply transformer, service manual or any other information. A. G. Spence, 629 Henderson Ave., Staten Island, NY 10310.

Hammarlund model HQ-129X receiver. Need schematic or operating and technical manuals. Fred Goldberg, 29 Clearview Rd., E. Brunswick, NJ 08816.

Hallicrafters model S-38B shortwave receiver. Need owner's manual. Troy Stuart, 11938 N. Vega Ave., Mequon, WI 53092.

Allen B. DuMont Laboratories, Inc., type 304-AR cathode ray oscillograph. Need schematics and manuals. Alan Pattee, 3690 Madison Ave., Boulder, CO 80303.

Grundig model RTV250 stereo receiver. Need schematic or any information on power and preamp pc boards. G. A. De Pietro, 752 Commerce St., Thornwood, NY 10594.

Split-Dort model R-V-695 battery-operated radio. Need schematic and information on types of tubes used. Jim Lynn, Cecil Lake, British Columbia, Canada V0C-1G0.

Hammarlund Super Pro model SP-600-J-11 receiver. Need operation manual, parts source, schematic and r-f gain control pot. R. Holzapfel, 7249 Old National Rd. East, Richmond, IN 47374.

Allied Radio Knight Kit Star Roamer II SWR. Schematic and/or assembly manual needed. R. Tomeo, P.O. Box 2362, San Diego, CA 92112.

Amphenol Commander model 870 voltmeter. Need schematic and calibration instructions. David Potter, 406 E. 32, Austin, TX 78705.

General Radiotelephone Co., model MC-5 AM-transceiver. Need schematic or any available information. John Stefancic, 6201 Atlantic #5, Long Beach, CA 90805.

Friden 132 electronic calculator. Need schematic, operating and service manual. Zvi Rozensher, 141-42 Pershing Crescent, Briarwood, NY 11435.

Polymorphic 8813 microcomputer. Need compatible chess program in BASIC or machine language. John C. Therriault, Box 225, RR 1, Newcastle, ME 04553.

New London Instrument Co., model 160 amplifier. Need all available information. Allan Vontorak, 17301 Mapleboro Rd., Maple Hts., OH 44137.

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Precision Apparatus Co. Inc., Series 654 tube and high sensitivity set tester. Need operator's manual. Lyle Mahlberg, 11605 W. Hwy. 23, Duluth, MN 55808.

Gonset G150 FM base and mobile transceivers and Communicator III. Manuals and schematics needed. Sam J. Esposito, 719 Florence Ave., Vineland, NJ 08360.

Measurements Inc., model 65-B signal generator. Need service information. P. Young, 16 W. 76 White Pines, Bensenville, IL 60106.

Standel Co., model 530B bass guitar amplifier. Schematic, parts list and service manual needed. Andrew Poston, 209 Hayes Ave., Hartsville, TN 37074.

Measurements Inc., model 82 and model 65B signal generators. Need manual and/or schematics. A. Reges, 16 W. 761 White Pines, IL 60106.

Allied model 435 receiver. Need service manual. Garth Fisher, Walla Walla College, College Place, WA 99324.

Gonset model 3220 antenna. Need schematics, manuals and any available information. C. Cazares Calvillo, Calle B. Juarez No. 27, Patzcuaro, Mich., Mexico.

Eico model 722 VFO. Need schematic and manual. Tom Cook, 1262 Mississippi Ave., Pittsburgh PA 15216.

Sonar FS-23 CB radio. Schematic needed. Billy H. Leonard., Rt. 1, Box 193-A, Blue Ridge, VA 24064.

Solar CF160 exameter and **Triplett** 2432 signal generator. Need manuals. James Humphrey, 1006 E. 28 St., Los Angeles, CA 90011.

Knight model R-195 communications receiver. Need schematic and alignment information. Donald Scripter, 5235 N.E. 57th, Portland, OR 97218.

Astrocom-Marlux model 407 tape recorder. Need schematic and manuals. B.H. Mealy, 553 Blue Ridge Dr., Medford, NY 11763.

Edison model R5 radio receiver (with Edison power unit type 8P and receiver type 7R). Need schematic and/or manual. Jerome Galiley, 1303 Justin Rd., Cardiff by Sea, CA 92007.

Tektronix 531 oscilloscope. Schematic and manuals needed. Ken Kloppenborg, Jr., 5037 Shimerville, Clarence, NY 14031.

Dowvue serial No. SD 013-72 5 video monitor. Need schematic or other information. **Honeywell** model No. 74100903-003 terminal console. Need keyboard pinout, description of function of other boards and all other information. Michael Olah, 2892 Mogadore Rd., Apt. 1-B, Akron, OH 44312.

Philco model 6100 vacuum tube voltmeter. Need circuit diagram and instructions. J. Goldstein, 2002-4th St., Santa Monica, CA 90405.

Roberts 1770D tape deck. Need mechanical and electronic service manuals. Charles Crawford, PO Box 818, Lomita, CA 90717.

Lafayette model HA-230. Need schematic and operating manual. Mark Schutt, 2403 Peach Stone Ct., Silver Spring, MD 20904.

Precision Apparatus series ES-500 A oscilloscope. Need schematic and operating manual. Walter V. Canon, 542 Butter St., Grass Valley, CA 95945.

Solar model CBB capacitor analyzer. Schematic and operating manual needed. Kurt Bendit, 3927 19th St., San Francisco, CA 94114.

Concord model VTR600-1 video tape recorder. Schematic needed. Daniel Bartko, Rt. 2, Box 377, Greensboro, NC 27405.

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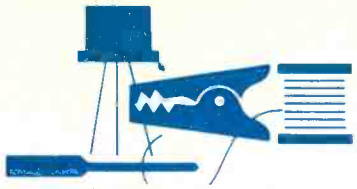
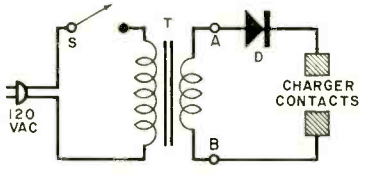


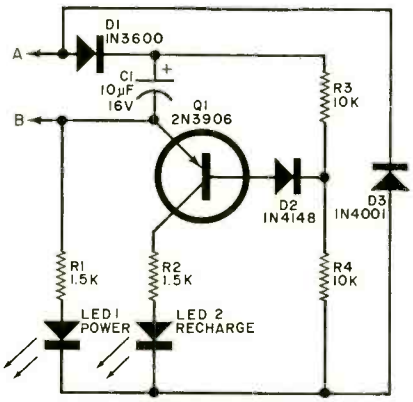
Tips & Techniques

Charge Indicator

Keeping track of the operation of a cordless soldering iron's recharging stand is the function of the circuit shown. The stock charger for a typical quickly rechargeable iron is labelled CHARGER CIRCUIT, while the supplemental indicator circuit is the MONITOR CIRCUIT. A simple half-wave dc supply comprising stepdown transformer *T* and diode *D* is the stock charger. Power switch *S* permits manual control over the flow of ac to the charger. This can prevent continuous application of charging current after the NiCd cells have been fully replenished—something that can shorten useful battery life. The charger circuit delivers pulses of charging current to the iron's NiCd cells when the voltage between points *A* and *B* is positive enough to overcome the forward voltage drop of diode *D* and the voltage of the cells to be charged.



CHARGER CIRCUIT



MONITOR CIRCUIT

The monitor circuit does not affect the recharge rate at all. It functions as follows. Diode *D3* conducts during the negative half-cycle of the power waveform, when point *B* is positive with respect to point *A*. Current flows through *R1*, *LED1* and *D3*, causing the LED to glow. Light from the LED indicates that power is applied to the charger.

If the iron is not in its stand, *C1* charges during the positive half-cycle of the ac waveform up to the full secondary voltage (neglecting diode voltage drop), which is approximately 10 volts. Diode *D2* is reverse biased, so *Q2* receives no base drive and *LED2* remains dark. This indicates that no NiCd cells are being recharged.

When an iron containing discharged batteries is placed in the stand, the voltage across the charger contacts decreases to approximately 3 volts. Capacitor *C1* charges through *D1*, but only to a lower voltage level. This forward biases *D2* and drives *Q1* into conduction during the negative (noncharging) half-cycle of the ac waveform. This LED, like *LED1*, pulses on and off so fast that it appears to glow continuously.

Power for the two LEDs is derived from the charger during the noncharging half-cycle of the ac waveform, so the recharging rate is not affected. Only 0.4 mA or so is taken from the charger circuit during the intervals when the NiCd cells are receiving pulses of charging current. —*Scott A. Woods, Madison, WI.*

Tools Help In PC Pattern Design

I have developed a set of useful tools for making printed circuit foil patterns with cut-and-peel Mylar paper. The tools are made from brass tubes of various diameters and are very effective foil pad cutters. Grind or file one end of a 6-inch (15.2-cm) length of brass tubing to a sharp point so that it will make a clean circular cut. I use tubes with diameters of 1/16" (1.6 mm), 1/8" (3.2 mm), 1/4" (6.4 mm), and 3/8" (9.6 mm) in my pc work, but you can choose other sizes to suit your particular needs.

To use a tool, hold it above and perpendicular to the sheet of cut-and-peel paper. Press the tube down on the desired spot. Twist it about 180° clockwise, then back up to the starting point, and twist the tube 180° counterclockwise. —*Dave Nichelini, Oakland, CA.*

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PROJECT OF THE MONTH

Digital Color Organ

BY FORREST M. MIMS

THE Project of the Month for March 1980 was a pocket color organ designed around three active filters. This month's project is a digital color organ using an LM3915 LED dot/bar display driver. Both color organs are sensitive to the frequency and amplitude of an incoming audio signal, but their visible reactions to these parameters are quite different.

The analog color organ has three fixed frequency-response ranges indicated by red (low), yellow (midrange), and green (high) LEDs. The brightness of a single color at any instant indicates the relative amplitude of that portion of the signal in the appropriate frequency range.

In the digital color organ, the opposite is true. The number of glowing LEDs indicates something about frequency, while increasing amplitude is indicated by changing colors. A more dramatic difference between the two kinds of color organs is the apparent motion of the lights. The LEDs in the analog circuit brighten and dim in fixed spots on the screen, but the LEDs in the digital version appear to bounce about in flashing clusters and moving strings.

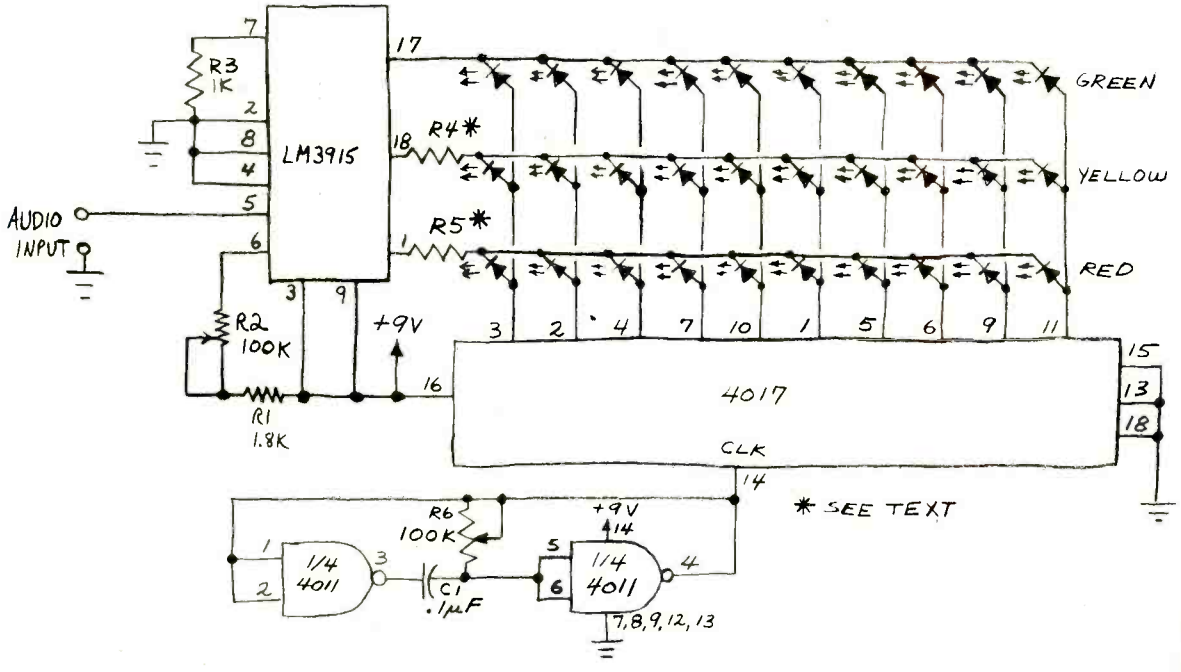
The schematic diagram here is for one of several digital color organs with which I've been experimenting for several years. In operation, signals generated by a transistor radio are coupled via its phone jack directly to the input of an LM3915 LED dot/bar display driver.

The sensitivity of the LM3915 is adjusted by means of potentiometer *R2* so that radio signals having maximum amplitude activate the green LEDs while low and intermediate levels activate the red and yellow LEDs, respectively. Potentiometer *R2* might have to be readjusted if the radio's volume is changed.

The total display consists of ten tricolor clusters, each of which is scanned by a 4017 counter/decoder at a rate determined by a clock made from two of the gates in a 4011. In accord with good design practices, the inputs of the remaining two 4011 gates are grounded. When the radio is silent, the display is blank. Sound from the radio causes a flurry of scintillating activity, as lights appear to bounce up and down while racing across the display in bursts and filaments. Slow, smooth music with restricted dynamic range does not cause a dramatic display, but a strong beat gives a very flashy show.

Before making a permanent version of the circuit, build a test circuit on a pair of solderless breadboards (one for the circuit and one for the display). This will allow you to evaluate both the circuit's operation and the relative brightness of the LEDs. For best results, operate the circuit in a darkened room and select the brightest LEDs you can find. Once the circuit is operating, experiment with the values of *R4* and *R5* to balance the brightness of the LEDs. You can initially use 1000-ohm potentiometers for *R4* and *R5*, and then substitute fixed resistors having the appropriate values after achieving a good brightness match. Also, be sure to experiment with the clock frequency by adjusting *R6* to find the most interesting level of display activity.

If you build a permanent version of the circuit, don't be afraid to experiment! Arranging the LEDs in concentric circles (with red LEDs the innermost) will produce starburst patterns. Finally, you can expand the display by adding additional 4017s and LEDs. ◇



Schematic of a color organ having a display of ten tricolor clusters.

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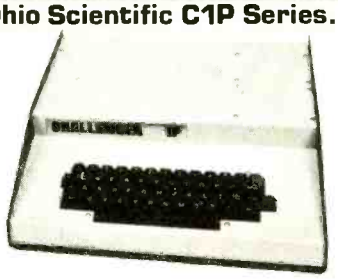

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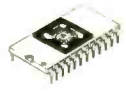

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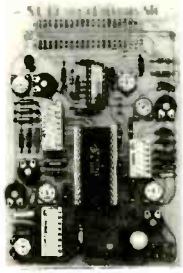

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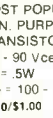

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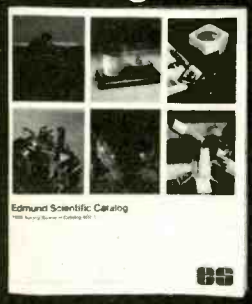

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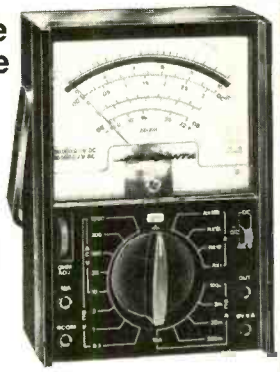

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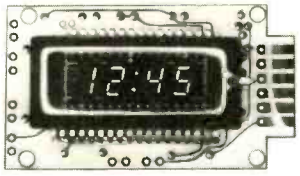

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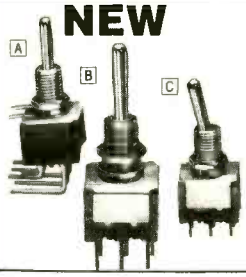

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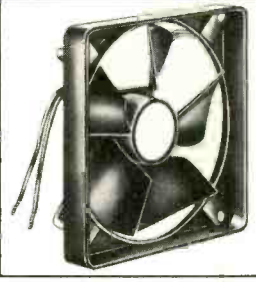

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■ Sine-, square-, triangle- and separate TTL square wave output ■ Frequency range: 1Hz-100KHz

Attache Style Tool Case

Weller® Xcelite®

Model TC100-ST Reg. $499.95 **$299.95**

Service Master Tool Kit

Model 99-SM Reg. $79.95 **$49.95**

B&K PRECISION Portable Digital Capacitance Meter

Model 820 ■ Measures capacitance from 0.1pF to 1 Farad ■ Resolves to 0.1pF ■ 10 ranges for accuracy and resolution ■ 4 digit easy-to-read LED display ■ 0.5% accuracy

WAHL ISOTIP 60 Cordless Soldering Iron

$29.95 Model 7800

Thermal-Spot Circuit Tester

Model 5800 **$29.95**

Miniature High Fidelity 3-Way Stereo Speakers

$69.50 PR Reg. $149.95

Model HF-9

CSC Logic Probe

■ Compact circuit powered ■ Detects pulses as short as 50 μsec ■ DTL/TTL/HTL/CMOS compatibility **$44.95** Model LP-1

Proto Preassembled Boards

Model PB-104 **$49.95**

Fully assembled breadboard contains four QT-59S sockets, seven QT-59B bus strips and four 5-way binding posts

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■ Regulated ■ Short-proof Reg. $154.95 **$129.95** Model PB-203A

CSC 3½-Digit 0.1% Digital Capacitance Meter

Model 3001 ■ 9 ranges from 1999 pF to 199.9 μF ■ 0.1% of reading accuracy Reg. $190.00 **$170**

DIGITAL MULTIMETER Simpson 461

Complete with nickel-cadmium batteries, AC charger/adapter, test leads **$149.95**

In-Dash Car Stereos

8-Track Tape Player with AM/FM/MPX Radio

Model C-777 **$52.50**

Cassette Tape Player with AM/FM/MPX Radio

Model CAS-888 **$57.50**

RC Circuit Box

■ 36 resistors (15 Ω to 10 MΩ) ■ 18 capacitors (100 pf to 0.22 μf) Reg. $49.95 includes test leads **$42.**

VIZ Model WC 412A

Magnifier Lamp

Precision ground and polished magnification lens **$49.50**

Model MG10A

30 MHz LEADER Dual Trace with Delay Line

$899.95 Model LBO-520

BSR X-10

Remote Control for Lights & Appliances

4 Pc Standard Starter Kit ■ One (1) Standard Command Console ■ Two (2) Lamp Modules ■ One (1) Appliance Module **$79.50** Reg. $87.95

5 Pc Ultrasonic Starter Kit ■ One (1) Deluxe Ultrasonic Command Console ■ One (1) Hand Held Remote Unit ■ Two (2) Lamp Modules ■ One (1) Appliance Unit **$99.95** Reg. $112.95

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Standard Command Console **$36.00** Ultrasonic Command Console with Hand Held Remote **$59.95**

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Model POW-40 ■ 40W stereo **$24.95**

Chess Challenger 7

Reg. $110.00 Model BBC **$79.95**

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Reg. $130.00 **$65.** Model 1827

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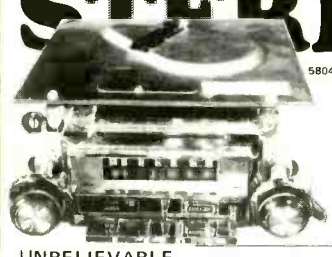

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AUTOMATIC RADIO

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PUSH BUTTONS

5803

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44.50 $170 STEREO 8-TRAK TAPE

$3.00 FOR SHPG.

AM-FM-MUX

BY POPULAR DEMAND! Delta is the first in the world to offer these new, first-grade stereo radios at surplus!!! They are 100% solid state AM-FM-MPX stereo radios & stereo 8-track player. With knobs and 5 push buttons!

AM-FM **Convert Your Car Into A Concert Hall!**

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Delta S785P

UNBELIEVABLE

FACTORY CLOSEOUT! One of America's largest manufacturers of auto radios has given up. We've been fortunate in acquiring the last auto radios in production. These are AM-FM sets.... designed for new cars. All are tested 100% operational and — come with knobs and push buttons. Ideal for installing in your auto, van, camper, boat, truck.

NEWS ITEM! Auto hi-fi has become as sophisticated as home hifi — and nearly as expensive. You can spend $200 for simple components—which means hi-fi can be out of reach for many folks and 2nd cars. If you want hi-fi FM, you can start with the purchase of a $100 radio for a mere $19.95....This price will not last long — order today while our limited supply lasts!

TOO GOOD TO BE TRUE! This sale is not available to the general public as they would sell out instantly. However, our loyal customers have the opportunity to scoop ups these new SURPLUS GEMS and save big dollars.

Delta No.	Size	Compare	SALE
5801P	7¼ x 2½ x 7¼"	$160.00	$39.95*
5802P	7¼ x 2-5/16 x 7	$160.00	$39.95*
5803P	7-3/8x3¼x6¼"	$170.00	$44.50†
5804P	7½x3-3/8x7¼"	$170.00	$44.50†

* Manual tuning. † Push buttons! Negative ground. 5¾" knob spacing.

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176 SECOND AVE. WALTHAM, MASS. 02154

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NOW CHANEY ELECTRONICS MAKES IT POSSIBLE TO BUILD YOUR OWN SOUND EFFECTS GENERATOR WITHOUT SPENDING A FORTUNE. WE SUPPLY YOU WITH THE T176477 SOUND CHIP PLUS AN ETCHED AND DRILLED GLASS EPOXY PC BOARD WITH SCHEMATIC AND LAYOUT INSTRUCTIONS. THIS BOARD MAKES IT SIMPLE TO BUILD A GENERATOR CAPABLE OF PHASER SOUNDS, LOCOMOTIVE, SIRENS, AIRPLANES, CLOCKS, ETC. DOES NOT REQUIRE DIP SWITCHES OR OTHER EXPENSIVE/UNUSUAL COMPONENTS. YOU SUPPLY ONLY A FEW STANDARD RESISTORS, CAPACITORS, SWITCHES, POTS, SPEAKER, 2N2222 TRANSISTOR AND 9V BATTERY.

BASIC KIT CONTAINING T176477, PC BOARD AND INSTRUCTIONS C23883 ONLY **$5.95**

2N2222 TRANSISTOR FOR ABOVE C23884 .39 EACH

IF YOU HAVE ALREADY PURCHASED THE T176477 CHIP YOU MAY BUY THE PC BOARD AND INSTRUCTIONS ONLY. C23885 $4.00

Strobe Tube & Trigger C24081 **$1.75**

BRAND NEW 1 7/8" LONG FLASH TUBE WITH MATCHING MFG "TRIGGER TRANSFORMER. RATED 350+ VOLTS 300MJ FOR ELECTRONIC FLASH

LED Flasher Kit

Simple to build kit uses the popular 555 timer IC to alternately flash a red and green LED. Comes complete with all parts, including the PC board. (9V battery not included) C23287 **$2.49**

6VDC Xenon Flasher Kit

Battery operated device emits intense bursts of light at approximately 1 per second rate. Complete with all parts & PC board (Less battery) C23808 **$8.00**

Digital Counting Module

Made for given interval start and Push button units flashes for period of time then advances to next number. Operates on 9V battery that will **$1.79**

120 VAC Xenon Strobe Kit

Complete variable rate strobe light kit. Can take all parts, PC board, line cord and instructions C23071 **$7.50**

Wheel of Fortune

Popular game device uses LED's transistors & IC to give the effect of a bright red ball spinning around numbers. When device stops on a number that all parts receivers & PC board C23806 **$8.99**

HIGH OUTPUT SILICON SOLAR CELLS

WE NOW STOCK A FULL LINE OF THESE HARD TO FIND CELLS WHICH CONVERT LIGHT DIRECTLY INTO ELECTRICITY. EACH CELL GENERATES APPROXIMATELY .45 VOLT AND GENERATES CURRENT AS SHOWN BELOW. CONNECT CELLS IN SERIES FOR MORE VOLTAGE AND CONNECT CELLS IN PARALLEL FOR MORE CURRENT. MANY OTHER TYPES ARE LISTED IN OUR CATALOG!

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3" WHOLE CELL	750MA	C24159	$8.50
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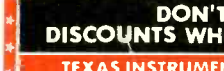
TEXAS INSTRUMENTS I.C. SOCKETS

SOLDER TAIL DIP SOCKETS



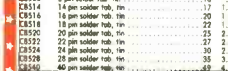
- Low profile
- Force grip design for maximum contact tension
- Redundant contact points
- YOUR CHOICE — TIN OR GOLD*
  (*Affixation of 50 microinches gold later on gold sockets)
- TEXAS INSTRUMENTS QUALITY

Part No.	Description	1	10	100
CB508	8 pin solder tail, tin	.10	.88	8.00
CB514	14 pin solder tail, tin	.11	1.53	14.00
CB516	16 pin solder tail, tin	.20	1.76	16.00
CB518	18 pin solder tail, tin	.22	1.98	18.00
CB520	20 pin solder tail, tin	.25	2.21	20.00
CB522	22 pin solder tail, tin	.27	2.43	22.00
CB524	24 pin solder tail, tin	.30	2.65	24.00
CB528	28 pin solder tail, tin	.35	3.11	28.00
CB540	40 pin solder tail, tin	.49	4.61	40.00

GOLD INLAY SOLDER TAIL
Series C-85 Min. .50 Microinches Gold Inlay

Part No.	Description	1	10	100
CB508	8 pin solder tail, gold	.28	2.48	22.00
CB514	14 pin solder tail, gold	.32	2.81	25.00
CB516	16 pin solder tail, gold	.37	3.28	29.00
CB518	18 pin solder tail, gold	.42	.372	33.00
CB520	20 pin solder tail, gold	.47	4.17	37.00
CB522	22 pin solder tail, gold	.50	4.50	40.00
CB524	24 pin solder tail, gold	.54	4.84	43.00
CB528	28 pin solder tail, gold	.63	5.63	50.00
CB540	40 pin solder tail, gold	.90	8.10	72.00

WIRE WRAP DIP SOCKETS



- Standard profile
- Universal mounting and packaging capabilities
- Contacts accommodate leads .015" through .021" rectangular or round dual-in-line leads
- Wire wrap posts hold to true position of .015" providing a true position of .020" on boards for efficient automatic wire wrapping
- YOUR CHOICE — TIN OR GOLD*
  (*Affixation of 50 microinch gold inlay on gold sockets)
- TEXAS INSTRUMENTS QUALITY

TIN PLATED WIRE WRAP
Series C-81 Min. .200 Microinches Tin

Part No.	Description	1	10	100
CB108	8 pin wire wrap, tin	.32	2.93	26.00
CB114	14 pin wire wrap, tin	.38	3.70	36.00
CB116	16 pin wire wrap, tin	.43	4.10	40.00
CB118	18 pin wire wrap, tin	.55	4.95	44.00
CB120	20 pin wire wrap, tin	.78	6.98	62.00
CB122	22 pin wire wrap, tin	.80	7.20	64.00
CB124	24 pin wire wrap, tin	.83	7.43	66.00
CB128	28 pin wire wrap, tin	1.05	9.45	84.00
CB140	40 pin wire wrap, tin	1.58	14.18	126.00

GOLD INLAY WIRE WRAP
Series C-91 Min. .50 Microinches Gold Inlay

Part No.	Description	1	10	100
CB108	8 pin wire wrap, gold	.49	4.35	41.10
CB114	14 pin wire wrap, gold	.82	7.65	69.95
CB116	16 pin wire wrap, gold	.91	8.20	77.75
CB118	18 pin wire wrap, gold	.99	8.95	84.60
CB120	20 pin wire wrap, gold	1.30	11.75	111.00
CB122	22 pin wire wrap, gold	1.35	12.15	114.80
CB124	24 pin wire wrap, gold	1.38	12.25	115.60
CB128	28 pin wire wrap, gold	1.75	15.75	148.70
CB140	40 pin wire wrap, gold	2.58	23.20	218.90

MOLEX I.C. SOCKET PINS
.085/C 8.20/M 38.20/5M 275.00/50M

TEXAS INSTRUMENTS GOLD EDGEBOARD CONNECTORS

RELIABLE, COST-EFFICIENT CONTACT DESIGN

- 50 (Wire Wrap to Solder Tail) micro-inches gold inlay over a nickel diffusion barrier.
- Copper-nickel-tin CA 725 alloy.
- Bifurcated contact points.
- Preloaded, cantilever spring design.
- Contacts are over removable.
- NOTE — Maximum failure rate per contact per center to center disconnect/connect followed by the distance separating the two pin rows.

M4 SERIES .100" x .200" EDGEBOARD CONNECTORS

Position	Part No.			Part No.		
10/20	C4-10	2.22	20.40	C5-10	2.10	19.35
15/30	C4-15	2.55	23.40	C5-15	2.37	21.70
17/34	C4-17	2.73	25.00	C5-17	2.52	23.10
18/36	C4-18	2.88	26.40	C5-18	2.61	23.90
20/40	C4-20	3.09	28.30	C5-20	2.76	25.30
22/44	C4-22	3.36	30.80	C5-22	2.97	27.20
25/50	C4-25	3.75	34.40	C5-25	3.27	30.00
28/56	C4-28	3.99	36.60	C5-28	3.54	32.50
30/60	C4-30	4.14	38.00	C5-30	3.75	34.40
31/62	C4-31	4.32	39.60	C5-31	3.84	35.20
35/70	C4-35	4.89	44.80	C5-35	4.20	38.50
36/72	C4-36	4.95	45.40	C5-36	4.32	39.60
40/80	C4-40	5.49	50.30	C5-40	4.71	43.20
43/86	C4-43	5.91	54.20	C5-43	4.98	45.70
49/98	C4-49	6.72	61.60	C5-49	5.58	51.20
50/100	C4-50	6.81	62.40	C5-50	5.64	51.70

For polarizing keys order P/N C3114-2 10/ea 2.50/100

M4 SERIES .125"x .250" EDGEBOARD CONNECTORS

Position	Part No.			Part No.		
10/20	C4-10	2.37	21.70	C5-10	2.13	19.50
15/30	C4-15	2.73	25.00	C5-15	2.46	22.60
18/36	C4-18	2.97	27.20	C5-18	2.67	24.50
20/40	C4-20	3.24	29.70	C5-20	2.85	26.10
22/44	C4-22	3.48	31.90	C5-22	3.09	27.50
25/50	C4-25	3.90	35.80	C5-25	3.39	31.10
28/56	C4-28	4.11	37.70	C5-28	3.69	33.80
30/60	C4-30	4.29	39.30	C5-30	3.81	34.90
31/62	C4-31	4.44	40.70	C5-31	4.05	37.10
35/70	C4-35	5.01	45.90	C5-35	4.50	41.30
36/72	C4-36	5.10	46.80	C5-36	4.56	41.80
40/80	C4-40	5.64	51.70	C5-40	5.04	46.20
44/88	C4-44	6.09	55.80	C5-44	5.49	50.30
50/100	C4-50	6.90	63.30	C5-50	5.98	54.80

For polarizing keys order P/N C3114-2 10/ea 2.50/100

M4 SERIES .156"x .200" EDGEBOARD CONNECTORS

Position	Part No.			Part No.		
10/20	C1-10	2.49	22.80	C2-10	4.08	37.40
12/24	C1-12	2.64	24.20	C2-12	4.32	39.60
15/30	C1-15	2.94	27.00	C2-15	4.71	43.20
18/36	C1-18	3.18	29.20	C2-18	4.98	45.70
22/44	C1-22	3.54	32.50	C2-22	5.49	50.30
25/50	C1-25	3.84	35.20	C2-25	5.91	54.20
28/56	C1-28	4.29	39.30	C2-28	6.36	58.30

For polarizing keys order P/N C3114-3 10/ea 2.50/100

5% CARBON FILM RESISTORS

¼ WATT RESISTOR ASSORTMENTS

RS125 — Set of 5 each of the 73 standard 5% ¼ watt carbon film resistors in the series 1.0, 1.2, 1.5, 1.8, 2.2, etc., through 9.1 megohm (365 total pcs.) **$9.90**

RS225 — Set of 5 each of the 72 standard 5% ¼ watt carbon film resistors in the series 1.1, 1.3, 1.6, 2.0, 2.4, etc., through 910 kilohm (360 total pcs.) **$9.90**

½ WATT RESISTORS ASSORTMENTS

RS150 — Set of 5 each of the 73 standard 5% ½ watt carbon film resistors in the series 1.0, 1.2, 1.5, 1.8, 2.2, etc., through 1.0 megohm (365 total pcs.) **$9.90**

RS250 — Set of 5 each of the 72 standard 5% ½ watt carbon film resistors in the series 1.1, 1.3, 1.6, 2.0, 2.4, etc., through 910 kilohm (360 total pcs.) **$9.90**

TIME-TEMPERATURE PROGRAMMABLE MODULE

USER PROGRAMMABLE FOR:

- 12 or 24 Hour Display
- °F and/or °C, as well as virtually any number of temperature contexts
- Fixed or flashing colon format
- 50/60 Hz line frequency operation

MA 1026 by National Semiconductor

FEATURES

- Giant 0.7 inch - 4 digit LED display with red lens
- Time of day, alarm, degree and alarm "ON" LED indicators
- 6 display modes - temperature, time, seconds, alarm, sleep and lamp test
- Exclusive Digi-Key switching panel available to simplify hook-up
- Leading zero blanking
- Time is normal display mode, with temperature display at push of switch.
- provides for measurement and display of temperatures in range of -40°C to 90°C
- multiple temperature sensors may be used
- power fail condition indicated by flashing
- addition of simple circuit will allow switching of small to medium AC loads
- optional switching panel to simplify hook-up

Catalog No.	Description	COST
MA1026B	MA1026 Clock Module (Assembled and Tested with data sheet)	$ 19.95
MA1026P	Digi-Key Switching Panel Kit for MA1026M (includes P.C. Board; 12 low profile switches, wireposts, standoffs, hardware, components, two LM334 temperature sensors, two KOA37 trimpots, and instructions)	11.95
MA1026T	Special transformer for MA1026M suitable for most applications	3.95
MA1026B	Alarm buzzer for MA1026M	3.00
MA1026E	Includes MA1026M, P, T, and B	34.95
MA1026C	Conventional Switch Set for applications where MA1026P is not used. Includes one SO1PB and two SO2PB switches and special wiring instructions	$ 3.95
MA1026M	Includes MA1026M clock module, MA1026C conventional switch set, MA1026T special transformer, two LM334 temperature sensors, and two KOA37 trimpots	29.95

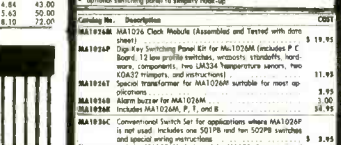
For each additional sensor unit, the following are suggested:

LM334	Temperature transducer for MA1026M module	$ 1.30
LD432	300 mV resistor for LM334 transducer	.75
50290	Normally open switch	.45

THE "PROGRAMMABLE" CLOCK MODULES

USER PROGRAMMABLE FOR:

- 12 or 24 hour display
- Fixed or flashing colon
- 50/60 Hz line frequency operation



NEW! Two Giant Sizes — 0.7" and 0.84"

FEATURES:

- display brightness can be controlled by introduction of potentiometer
- will adapt for continuous time keeping with introduction of 5M potentiometer and 9V battery
- alarm interfaces with existing buzzer — no interviewing circuitry
- Your Choice — 0.7" or 0.84" red LED display
- low power consumption
- leading zero blanking
- Time is normal display mode, with temperature display at push of switch. Provides for measurement and display of temperatures in range of -40°C to 90°C. Multiple temperature sensors may be used. Power fail condition indicated by flashing. Addition of simple circuit will allow switching of small to medium AC loads. Optional switching panel to simplify hook-up.

MA1023 — 0.7" HIGH DIGITS

Catalog No.	Description	COST
MA1023M	MA1023 Clock Module Only (Assembled and Tested)	$9.95
MA1023P	Digi-Key Switching Panel Kit for MA1023 (includes P.C. Board; 12 Switches, Wireposts, Standoffs, Hardware, Components)	6.95
MA1023T	Special Transformer For MA1023	3.95
MA1023B	Alarm Buzzer For MA1023	3.00
MA1023E	Includes MA1023M, P, T, & B	19.95
MA1023C	Conventional switch set for applications where MA1023P is not used, includes one SO1PB and six SO2PB, and a 3M resistor, trimmer, battery snaps	$3.50
MA1023M	Clock Module, Conventional Switches, Transformer	$14.95

MA1020 — 0.84" HIGH DIGITS

Catalog No.	Description	COST
MA1020M	MA1020 Clock Module (Assembled and tested)	$13.95
MA1020P	Digi-key Switching Panel Kit for MA1020 (includes P.C. Board; 12 Switches, Wireposts; Standoffs, Hardware, Components)	6.95
MA1020T	Special Transformer For MA1020M	3.25
MA1020B	Alarm Buzzer For MA1020M	3.00
MA1020E	Includes MA1020M, P, T, and B	26.95
MA1020C	Conventional switch set for applications where MA1020P is not used; includes one SO1PB and six SO2PB and a 3M resistor, trimmer, battery snaps	$3.50
MA1020B	Includes MA1020M clock module, MA1020C conventional switch set and MA1020T transformer.	29.95

DIGI-CLOCK KIT

- 12 VDC — Ideal for Car, Van or Boat!
- Trouble Free Wire Order
- .270" Solid Round
- Installs Either Vertically or Horizontally
- Chrome Trim Bezel
- Ideal for Car, Van or Boat
- 3-3/8"x3-3/16"x1-3/8" Deep
- Quick and Easy to Install

Part No. SO01K ONLY $24.95

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FREE CATALOG

Digi-Key Stocks The Entire AP Products Line

STRANDED HOOK-UP WIRE

30 ga PVC	2.50/100' 10.00/1000'
22 ga PVC	2.80/100' 11.25/500'
24 ga PVC	2.80/100' 11.25/500'

HARDWARE

2-56 1/4 SCREW	.39/
2-56 1/2 SCREW	.39/
4-40 1/4 SCREW	.99/
4-40 1/2 SCREW	.99/
6-32 1/4 SCREW	.99/
6-32 1/2 SCREW	.99/
8-32 3/8 SCREW	.99/
8-32 5/8 SCREW	.99/
2-56 HEX NUT	.75/
4-40 HEX NUT	.75/
6-32 HEX NUT	.75/
8-32 HEX NUT	.75/
NO. 2 LOCKWASHER	1.25/
NO. 4 LOCKWASHER	1.00/
NO. 6 LOCKWASHER	1.00/
NO. 8 LOCKWASHER	1.00/

INTEGRATED CIRCUITS

2400 TTL | 54LS00/74LS TTL | 4000 CMOS | LINEAR I.C.'S

7400N	32	74LS01N	39	4000	40	LF347N	1.75
7401N	32	74LS03N	39	4001	31	LF351N	.75
7402N	32	74LS04N	39	4002	35	LF353N	1.40
7403N	32	74LS08N	39	4006	1.36	LF356N	1.40
7404N	35	74LS10N	39	4007	49	LF357N	1.40
7405N	35	74LS20N	39	4008	1.12	LF13741N	.70
7406N	41	74LS27N	39	4009	56	LM301AN	.58
7407N	41	74LS09N	39	4010	56	LM307N	.60
7408N	35	74LS10N	39	4011	33	LM308N	1.00
7409N	37	74LS11N	39	4012	33	LM311N	.90
7410N	32	74LS12N	39	4013	62	LM317K	5.25
7411N	35	74LS13N	59	4014	1.08	LM317MP	2.00
7412N	41	74LS14N	59	4015	1.08	LM317T	3.00
7414N	85	74LS15N	39	4016	55	LM318N	2.50
7416N	41	74LS20N	39	4017	1.08	LM320MP-5	1.79
7417N	41	74LS27N	39	4018	1.08	LM320MP-6	1.79
7420N	32	74LS22N	39	4019	56	LM320MP-8	1.79
7423N	40	74LS26N	39	4020	1.30	LM320MP-12	1.79
7425N	41	74LS27N	39	4021	1.14	LM320MP-15	1.79
7426N	37	74LS30N	39	4022	1.08	LM320MP-18	1.79
7427N	41	74LS32N	41	4023	35	LM320MP-24	1.79
7430N	32	74LS37N	39	4024	94	LM320MP-24	1.79
7432N	37	74LS38N	39	4025	38	LM323K	8.95
7437N	41	74LS40N	39	4027	74	LM324N	.95
7438N	41	74LS42N	85	4028	1.19	LM325N	3.44
7440N	41	74LS47N	1.08	4029	1.19	LM326N	3.44
7442N	73	74LS48N	1.08	4030	.46	LM327N	3.44
7445N	93	74LS49N	1.18	4034	2.75	LM334Z	1.55
7446N	93	74LS51N	39	4035	1.42	LM336Z	2.75
7447N	1.06	74LS54N	39	4040	1.24	LM337K	6.00
7448N	1.06	74LS55N	39	4041	1.07	LM337T	2.45
7450N	32	74LS73N	59	4042	1.08	LM339N	1.15
7451N	32	74LS74N	46	4043	1.08	LM340K-5	2.10
7453N	32	74LS75N	59	4044	1.08	LM340T-5	1.32
7454N	32	74LS76N	54	4046	1.19	LM340T-6	1.32
7460N	35	74LS78N	49	4047	1.45	LM340T-8	1.32
7470N	49	74LS83N	1.08	4048	80	LM340T-10	1.32
7472N	49	74LS85N	1.08	4049	58	LM340T-12	1.32
7474N	46	74LS86N	1.00	4050	58	LM340T-15	1.32
7476N	46	74LS90N	73	4051	1.19	LM340T-18	1.32
7480N	62	74LS93N	73	4052	1.19	LM340T-24	1.32
7483N	85	74LS109N	48	4060	1.58	LM341P-5	1.04
7485N	95	74LS112N	52	4066	79	LM341P-6	1.04
7486N	41	74LS114N	52	4069	35	LM341P-8	1.04
7489N	1.75	74LS114N	49	4070	46	LM341P-12	1.04
7490N	53	74LS122N	75	4071	35	LM341P-15	1.04
7492N	53	74LS123N	1.08	4073	58	LM341P-18	1.04
7493N	57	74LS125N	64	4075	35	LM341P-24	1.04
7495N	57	74LS126N	64	4076	1.19	LM348N	1.62
7496N	71	74LS132N	93	4081	37	LM350K	4.95
74100N	1.46	74LS133N	64	4089	2.75	LM350T	3.85
74107N	46	74LS138N	84	4093	76	LM358N	1.10
74109N	46	74LS139N	84	4099	2.10	LM377N	2.40
74110N	46	74LS151N	73	4503	.90	LM378N	3.50
74123N	71	74LS153N	84	4510	1.17	LM379S	5.60
74125N	64	74LS154N	1.44	4511	1.26	LM380N-8	1.30
74126N	64	74LS157N	1.44	4512	1.30	LM381N	3.50
74132N	82	74LS158N	91	4514	2.80	LM382N	1.75
74141N	1.19	74LS157N	77	4515	2.80	LM383AT	3.64
74145N	99	74LS158N	1.26	4516	1.23	LM386N-1	1.10
74147N	1.73	74LS160N	1.07	4518	1.17	LM387N	.45
74148N	1.33	74LS161N	1.07	4519	.63	LM1310N	1.90
74150N	1.12	74LS162N	1.07	4520	1.17	LM1458N	.80
74151N	73	74LS163N	1.07	4522	1.75	LM1496N	.94
74153N	73	74LS164N	1.18	4526	1.75	LM1800N	1.75
74154N	1.21	74LS168N	1.51	4527	1.68	LM1801N	1.75
74155N	73	74LS169N	1.51	4528	1.61	LM1812N	6.25
74156N	79	74LS170N	1.84	4723	1.53	LM1830N	1.75
74157N	73	74LS173N	1.34	4724	1.53	LM1889N	2.50
74158N	79	74LS174N	1.20	40106	.73	LM7111N	2.50
74161N	1.02	74LS175N	.90	40160	1.19	LM2907N	2.50
74162N	92	74LS190N	1.30	40161	1.19	LM2917N	2.50
74163N	92	74LS191N	1.30	40162	1.19	LM3080N	.69
74164N	98	74LS192N	1.17	40163	1.19	LM3086N	.69
74165N	1.15	74LS193N	1.17	40174	1.12	LM3089N	2.00
74166N	1.15	74LS194N	1.03	40175	.92	LM3302N	.92
74170N	1.87	74LS197N	1.34	40193	1.30	LM3900N	1.07
74173N	1.35	74LS221N	1.37	40193	1.30	LM3905N	.85
74174N	90	74LS247N	1.19	40195	1.30	LM3909N	.85
74175N	71	74LS248N	1.19			LM3911N	1.95
74176N	96	74LS249N	1.19			LM3914N	3.75
74177N	96	74LS253N	1.02			NE555CN	.35
74180N	1.12	74LS257N	.97			NE556CN	.70
74181N	2.00	74LS258N	.97			NE560N	3.24
74182N	1.10	74LS266N	.50			NE561CN	3.33
74184N	1.12	74LS273N	1.30			NE562CN	1.50
74185N	2.36	74LS283N	1.03			NE567CN	1.33
74S189N	2.49	74LS290N	1.12			UA709CN	.82
74190N	1.12	74LS293N	1.12			UA710CN	.87
74191N	1.01	74LS352N	1.30			UA733CN	.94
74192N	1.03	74LS353N	1.44			UA741CN	.53
74193N	95	74LS365N	.70			UA747CN	.80
74194N	91	74LS366N	.70			UA748CN	.70
74195N	.88	74LS367N	.70			UA780S5CK	2.10
74196N	91	74LS368N	.70			UA780S12CT	.95
74197N	91	74LS373N	.70			UA780S12CK	2.10
74198N	1.49	74LS670N	2.59			UA780S15CT	.95
74199N	1.49	74LS395N	1.76			UA780S15CK	2.10
74221N	1.76	74LS399N	1.76			UA781CT	.95
74284N	3.50	81LS97N	1.76			UA781CK	2.10
74285N	3.50	81LS98N	1.76			UA781QCT	.95
74366N	.80					UA781QCK	2.10
74367N	.80					UA78L05ACZ	.49
74368N	.80					UA78L06ACZ	.49
						UA78L08ACZ	.49
						UA78L10ACZ	.49
						UA78L12ACZ	.49
						UA78L15ACZ	.49
						UA78L24ACZ	.49
						UA7905CT	.70
						UA7908CT	.70
						UA7909CT	.70
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2N3906	.20	1.79	16.25	146.25
2N4124	.21	1.93	17.50	157.50
2N4126	.22	2.01	18.25	164.25
2N4401	.21	1.93	17.50	157.50
2N4403	.21	1.93	17.50	157.50
2N4410	.30	2.70	24.38	219.38
2N5087	.24	2.20	20.00	180.00
2N5089	.24	2.20	20.00	180.00
PN2222A	.27	2.48	22.50	202.50
2N5457	.54	4.86	43.88	394.88
2N6010A	.38	3.42	30.88	277.88
2N6027	.38	3.42	30.88	277.88
2N6040	.41	3.69	33.32	299.82
2N6045	.38	3.42	30.88	277.88
MJ2955	1.47	13.48	122.50	1102.25
MJE172	.74	6.66	60.13	541.13
MJE182	.72	6.48	58.50	526.50
MJE3439	.56	4.80	40.00	360.00
MJE344	.68	6.12	55.25	497.25
MJE370	.89	8.12	72.35	650.85
MJE371	1.10	9.90	89.38	804.38
MJE520	.86	7.74	69.88	628.88
MJE521	.86	7.74	69.88	628.88
MJE703	1.13	10.17	91.82	826.31
MJE712	.74	6.66	60.13	541.13
MJE722	.74	6.66	60.13	541.13
MJE803	1.01	9.09	82.07	738.57
PN4102	.54	4.95	45.00	405.00
MPS2222A	.21	1.93	17.50	157.50
MPS2369A	.24	2.20	20.00	180.00
MPS2907A	.24	2.20	20.00	180.00
MPS3392	.23	2.07	18.75	169.00
MPS3393	.21	1.93	17.50	157.50
MPS3394	.24	2.20	20.00	180.00
MPS3395	.24	2.20	20.00	180.00
MPS3563	.21	1.93	17.50	157.50
MPS3565	.21	1.93	17.50	157.50
MPS3638A	.21	1.93	17.50	157.50
MPS3641	.21	1.93	17.50	157.50
MPS3643	.21	1.93	17.50	157.50
MPS3702	.22	1.98	17.88	160.88
MPS930	.21	1.93	17.50	157.50
MPSA13	.27	2.48	22.50	202.50
TIP112	.98	8.40	70.00	630.00
TIP117	1.12	10.08	91.00	819.00
TIP120	1.17	10.73	97.50	877.50
TIP122	1.54	13.20	110.00	990.00
TIP127	1.54	13.20	110.00	990.00
TIP132	2.32	20.88	188.50	1696.50
TIP135	2.32	20.88	188.50	1696.50
TIP29C	.81	6.90	57.50	517.50
TIP30C	.81	6.90	57.50	517.50
TIP31C	.98	8.40	70.00	630.00
TIP32C	1.02	8.70	72.50	652.50
TIP61C	.81	6.90	57.50	517.50
TIP62C	.81	6.90	57.50	517.50

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Wire, 100 Wires per package Stripped 1" Both Ends — $3.25

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W4	30-AWG Red Wire, 4" Overall Length	3.40
W5	30-AWG Blue Wire, 5" Overall Length	3.65
W5	30-AWG White Wire, 5" Overall Length	3.65
W5	30-AWG Red Wire, 5" Overall Length	3.65
W6	30-AWG Blue Wire, 6" Overall Length	3.90
W6	30-AWG White Wire, 6" Overall Length	3.90
W6	30-AWG Red Wire, 6" Overall Length	3.90
W7	30-AWG Blue Wire, 7" Overall Length	3.50
W7	30-AWG White Wire, 7" Overall Length	3.50
W7	30-AWG Red Wire, 7" Overall Length	3.50
W8	30-AWG Blue Wire, 8" Overall Length	3.75
W8	30-AWG White Wire, 8" Overall Length	3.75
W8	30-AWG Red Wire, 8" Overall Length	3.75

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Part No.	Stand Up	Resist.	Price 1	Price 10	Price 100	Price 1000
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Q1A23	Q0A

NEW PRODUCTS!

Super Color S-100 Video Kit $129.95
Expandable to 256 x 192 high resolution color graphics. 6847 with all display modes computer controlled. Memory mapped. 1K RAM expandable to 6K. S-100 bus 1802, 8080, 8085, Z80 etc. Delivery January '80.

1802 16K Dynamic RAM Kit $149.00
Expandable to 32K. Hidden refresh w/clocks up to 4 MHz w/no wait states Addl. 16K RAM **$63**

Elf II Adapter Kit $24.95
Plugs into Elf II providing Super Elf 44 and 50 pin plus S-100 bus expansion. (With Super Expansion). High and low address displays, state and mode LED's optional **$18.00.**

Gremlin Color Video Kit $ 69.95
32 x 16 alpha/numerics and graphics; up to 8 colors with 6847 chip; 1K RAM at E000. Plugs into Super Elf 44 pin bus. No high res. graphics.

Quest Super Basic

Quest, the leader in inexpensive 1802 systems announces another first. Quest is the first company worldwide to ship a **full size Basic** for 1802 systems. A complete function **Super Basic** by **Ron Cenker** including floating point capability with scientific notation (number range $\pm .17E^{38}$), 32 bit integer ± 2 billion; Multi dim arrays; String arrays; String manipulation; Cassette I/O, Save and load, Basic. Data and machine language programs; and over 75 Statements, Functions and Operators.

Easily adaptable on most 1802 systems. Requires 12K RAM minimum for Basic and user programs. Cassette version in stock now. ROM versions coming soon with exchange privilege allowing some credit for cassette version. New improved version with improved speed and accuracy now avail. Source list for I/O now incl.

Super Basic on Cassette	$40.00

Tom Pittman's 1802 Tiny Basic Source listing now available. Find out how Tom Pittman wrote Tiny Basic and how to get the most out of it. Never offered before. $19.00.

S-100 4-Slot Expansion	$ 9.95
Super Monitor VI.I Source Listing	$15.00

Coming Soon: Assembler, Editor, Disassembler, DA/AD, Super Sound/Music, EPROM programmer, Stringy Floppy System.

RCA Cosmac Super Elf Computer $106.95

Compare features before you decide to buy any other computer. There is no other computer on the market today that has all the desirable benefits of the **Super Elf** for so little money. The Super Elf is a small single board computer that does many **big** things. It is an excellent computer for training and for learning programming with its machine language and yet it is easily **expanded** with **additional memory, Full Basic, ASCII Keyboards, video character generation, etc.**

Before you buy another small computer, see if it includes the following features: ROM monitor; State and Mode displays; Single step; Optional address displays; Power Supply; Audio Amplifier and Speaker; Fully socketed for all IC's; Real cost of in warranty repairs; Full documentation.

The **Super Elf** includes a **ROM** monitor for program loading, editing and execution with **SINGLE STEP for program debugging** which is not included in others at the same price. With **SINGLE STEP** you can see the microprocessor chip operating with the **unique Quest** address and data bus displays **before, during** and **after** executing instructions. Also, CPU mode and instruction cycle are decoded and displayed on 8 LED indicators.

An RCA 1861 **video graphics** chip allows you to connect to your own TV with an inexpensive video modulator to do graphics and games. There is a **speaker system** included for writing your own music or using many music programs already written. The speaker amplifier may also be used to drive relays for control purposes.

A 24 key **HEX keyboard** includes 16 HEX keys plus **load, reset, run, wait, input, memory protect, monitor select** and **single step**. Large, on board displays provide output and optional **high and low address**. There is a 44 pin standard connector slot for PC cards and a 50 pin connector slot for the Quest Super Expansion Board. Power supply and sockets for **all** IC's are included in the price plus a detailed 127 pg. instruction manual which now includes over 40 pgs. of software info. including a series of lessons to help get you started and a music program and graphics target game. Many schools and universities are using the Super Elf as a course of study. OEM's use it for training and R&D.

Remember, other computers only offer Super Elf features at additional cost or not at all. **Compare before you buy. Super Elf Kit $106.95, High address option $8.95, Low address option $9.95. Custom Cabinet** with drilled and labelled plexiglass front panel **$24.95.** Expansion Cabinet with room for 4 S-100 boards **$41.00. NiCad Battery Memory Saver Kit $6.95.** All kits and options also completely assembled and tested. **Questdata**, a 12 page monthly software publication for 1802 computer users is available by subscription for $12.00 per year. Issues 1-12 bound $16.50.

Tiny Basic Cassette **$10.00,** on ROM **$38.00,** original Elf kit board **$14.95. 1802 software;** Moews Video Graphics **$3.50.** Games and Music **$3.00,** Chip 8 Interpreter **$5.50.**

Super Expansion Board with Cassette Interface $89.95

This is truly an astounding value! This board has been designed to allow **you** to decide how you want it optioned. **The Super Expansion Board comes with 4K of low power RAM** fully addressable anywhere in 64K with built-in memory protect and a **cassette interface**. Provisions have been made for all other options on the same board and it fits neatly into the hardwood cabinet alongside the **Super Elf**. The board includes slots for up to 6K of **EPROM** (2708, 2758, 2716 or TI 2716) and is **fully socketed**. EPROM can be used for the monitor and Tiny Basic or other purposes.

A IK Super ROM Monitor $19.95 is available as an on board option in 2708 EPROM which has been preprogrammed with a program loader/editor and error checking multi file cassette read/write software, (relocatible cassette file) another exclusive from Quest. It includes register save and readout, block move capability and video graphics driver with blinking cursor. Break points can be used with the register save feature to isolate program bugs quickly, then follow with single step. The Super Monitor is written with subroutines allowing users to take advantage of monitor functions simply by calling them up. Improvements and revisions are easily done with the monitor. If you have the **Super Expansion Board** and **Super Monitor** the monitor is up and running at the push of a button.

Other on board options include **Parallel Input and Output Ports** with **full handshake**. They allow easy connection of an ASCII keyboard to the input port. **RS 232 and 20 ma Current Loop** for teletype or other device are on board and if you need more memory there are two **S-100** slots for static RAM or video boards. Also a 1K Super Monitor version 2 with video driver for full capability display with Tiny Basic and a video interface board. **Parallel I/O Ports $9.85, RS 232 $4.50, TTY 20 ma I/F $1.95, S-100 $4.50.** A **50 pin connector** set with ribbon cable is available at $15.25 for easy connection between the **Super Elf** and the **Super Expansion Board.**

Power Supply Kit for the complete system (see Multi-volt Power Supply below).

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INTEGRATED CIRCUITS

7400TTL

7400N	.19	LM323K-5	5.95	CD4026	2.50
7402N	.20	LM320K-12	1.50	CD4027	.66
7404N	.25	LM320K-15	1.50	CD4028	.85
7409N	.23	LM320T-5	1.35	CD4029	1.35
7410N	.20	LM320T-12	1.35	CD4030	.45
7414N	.70	LM320T-15	1.35	CD4035	1.35
7420N	.20	LM324N	1.40	CD4042	.85
7422N	.39	LM339N	1.00	CD4043	.85
7430N	.20	LM340K-5	1.35	CD4044	.85
7442N	.58	LM340K-8	1.35	CD4046	1.67
7445N	.74	LM340K-12	1.35	CD4049	.45
7447N	.58	LM340K-15	1.35	CD4050	.49
7448N	.77	LM340K-24	1.35	CD4051	1.13
7450N	.20	LM340T-5	1.25	CD4060	1.42
7474N	.35	LM340T-8	1.25	CD4066	.71
7475N	.49	LM340T-12	1.25	CD4068	.40
7486N	.88	LM340T-15	1.25	CD4069	.40
7489N	1.85	LM340T-18	1.25	CD4070	.50
7490N	.43	LM340T-24	1.25	CD4071	.45
7492N	.43	LM350	7.50	CD4072	.45
7493N	.43	LM377	3.50	CD4073	.45
7495N	.89	LM379	5.00	CD4075	.45
74100N	1.20	LM380N	1.00	CD4076	1.65
74107N	.35	LM381	1.60	CD4078	.40
74121N	.34	LM382	1.60	CD4081	.35
74123N	.59	LM703H	65	CD4082	.35
74125N	.45	LM709H	.28	CD4116	.47
74145N	.77	LM723H/N	.50	CD4490	5.50
74150N	1.20	LM733N	.85	CD4507	1.00
74151N	.69	LM741CH	.35	CD4508	4.25
74154N	2.00	LM741N	.38	CD4510	1.02
74157N	.69	LM747H/N	.75	CD4511	.94
74161N	.87	LM748N	.35	CD4515	2.52
74162N	1.25	LM1303N	1.75	CD4516	1.10
74163N	.87	LM1304	1.10	CD4518	1.02
74174N	.96	LM1305	1.27	CD4520	1.02
74175N	.95	LM1307	2.00	CD4527	1.51
74190N	1.15	LM1310	2.75	CD4528	.79
74192N	.87	LM1458	.47	CD4553	3.50
74193N	.85	LM1800	1.75	CD4566	2.25
74221N	2.75	LM1812	7.50	CD4583	2.35
74298N	1.65	LM1889	3.00	CD4585	1.10
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MM57100	4.50	.8
GIAY38500-1	9.95	.14
MCM66751A	9.95	.16
9368	3.50	.18
4100	10.00	.20
416	16.00	2 level 14 pin ww

WIRE WRAP LEVEL 3		
PIN		PIN
14	.32	24 .86
16	.33	28 1.00
18	.57	40 1.23

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4 MHz	4.25
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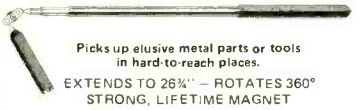

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- Uses MM5314 clock chip
- Switches for hours, minutes and hold modes
- Hrs. easily viewable to 20 ft.
- Simulated walnut case
- 115 VAC operation
- 12 or 24 hr. operation
- Incl. all components, case & wall transformer
- Size: 6¾" x 3-1/8" x 1¾"

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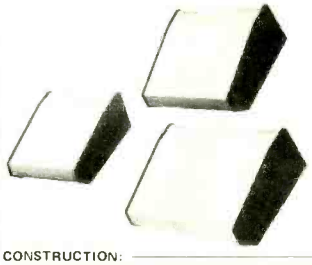
Blank Desk-Top Electronic Enclosures



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Transmit Channel Frequencies	Switch selectable. Low (normal) = 1070 space, 1270 mark. High = 025 space, 2225 mark.
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Transmit Level	-15 dbm nominal. Adjustable from -6 dbm to -20 dbm
Receive Frequency Tolerance	Frequency reference automatically adjusts to allow for operation between 1800 Hz and 2400 Hz
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Kit comes complete with:
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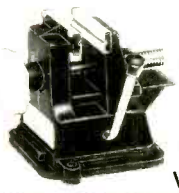

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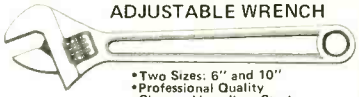

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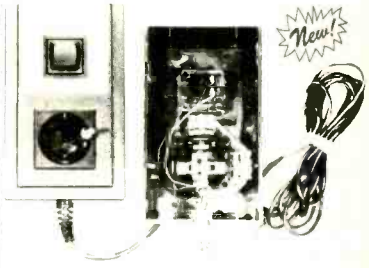

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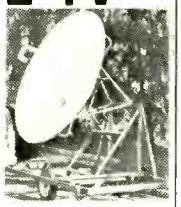

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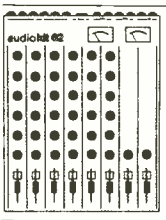

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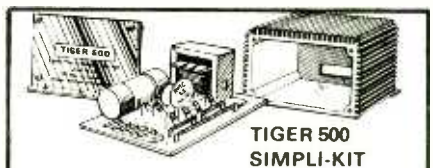

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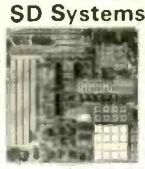
SD Systems Z-80 STARTER SYSTEM



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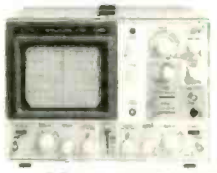

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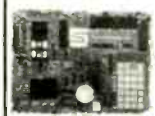

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Personal Electronics News

AM STEREO BROADCASTING WINS FCC APPROVAL. The stereo system chosen was designed by Magnavox Consumer Electronics Co. Criteria used to evaluate systems suggested as standards included the effect of the AM stereo signal on adjacent-channel protection ratios, directional antenna operation, out-of-band emissions, and compatibility with existing monophonic receivers. AM stereo is expected to find its major use in automobile radios.

XEROX OPENED COMPUTER RETAIL STORES in two test market areas (Dallas/Ft. Worth and Denver) to sell and service Apple II computers, Centronics printers, Hewlett-Packard calculators and ADT office security systems. They will also sell The Xerox 510 small business computer. Xerox will buy Apple computers and related products direct from the factory, and plans to perform service on-site or in an authorized repair center.

MICROPROCESSORS CREATE THE SOUND OF BAGPIPES without the need to master difficult blowing techniques. "Keltic Pipes," produced in Scotland, is expected to retail for $495. It consists of an electronic chanter, an amplifier, and a sound box with pitch, volume and tuning electronically controlled. Traditional fingering is used on the pipes, but the notes are created electronically. For group music playing, the pipes can be switched from the bagpipe scale or mode to the standard tonic major scale. A 9-volt battery is said to provide 30 hours of playing time. (British Information Services, 845 Third Ave., New York, NY 10022).

A SOLAR-POWERED FM/AM RADIO will soon be available to the public at a cost of about $70. Developed by Aldermaston, Inc. (Locust Valley, NY), the "Solar-E" radio, believed to be the first of its kind, is powered by six solar cells. (An AM-only Solar-E has been available for about a year.) It has a ferrite bar antenna for AM and a monopole FM antenna, an earphone jack, and provision for inserting two AAA batteries for use when sun power is not available.

PERSONAL COMPUTERS FOR EDUCATION at home and in schools are getting a boost from an agreement between Atari (supplying the computers) and Science Research Associates, Inc. (developing educational courseware programs). The latter will cover reading, language arts, mathematics, science and social studies. Atari will market the courseware to its computer owners. SRA will also produce courseware for schools and market it, along with Atari computer systems, to educational institutions.

A DIGITAL EARPHONE capable of executing digital-to-analog conversion as well as transduction was demonstrated recently at the Salt Lake City meeting of the Acoustical Society of America. Invented by James L. Flanagan of the Acoustic Research Department of Bell Telephone Labs., the device reproduced speech recordings made in a four-bit code with high intelligibility and surprisingly tolerable quantization noise. The earphone works by associating either a fixed radiating area or a fixed excursion with each bit of the PCM word, according to its significance. Thus, the least significant bit might have a unit area, the next most significant bit twice that, etc. Or the same thing can be done using the amount of excursion of an area. Smoothing of the acoustically generated sampled signal is performed by an acoustic low-pass filter that fits onto the transducer. For larger digital words (for better resolution and S/N ratio) it would be necessary to use elements of area and excursion in combination as either alone would have to encompass an impractically large range.

SPEECH COMPRESSION OF TV COMMERCIALS might come to broadcast and you'll never know the difference. Compression is achieved without changing the actual frequency of the audio. The secret is in removing the pauses and lapses that occur in normal speech and providing a faster style of delivery, which is reported to be imperceptible to listeners. And there are no "chipmunk" side effects, say the developers. The system is reported to enable commercial producers to compress 30 seconds of voiceover information into as little as a 20-second time span. By doing this, recording retake costs to eliminate running overtime will be reduced. The system was developed by Integrated Sound Systems, Long Island City, NY.

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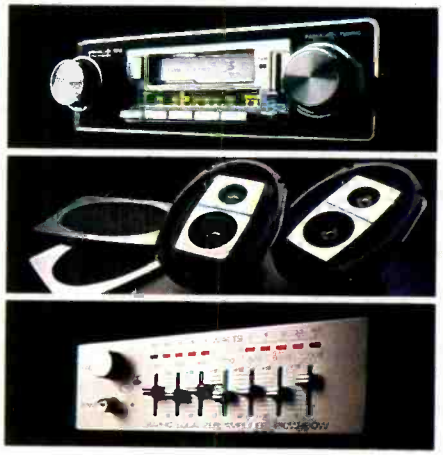

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