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NEW CONCEPT

Dial Free

The Supreme Court of the United States, GTE, and a major new telephone breakthrough open the door to new consumer savings.

The new pocket-sized Flip-Phone T.M. telephone from GTE will save consumers millions.

The Flip-Phone flips open to reveal the keyboard and the privacy switch.

America's phone system is the world's greatest. No country can compare. But what has made our phone system even greater is the recent Supreme Court decision that permits consumers to plug in their own phones—phones that they can buy themselves.

We are now free to choose which phone we want to plug in. And that creates competition and competition usually results in lower prices, innovative products, and better service.

We now do have lower prices and a very exciting new product which we have selected as the best example of the new telephone ownership decision. The big breakthrough, however, is not the product itself, but an attitude. But more on that later.

THE NEW PHONE

It's called the Flip-Phone and it's manufactured by General Telephone and Electronics (GTE), a supplier of phones to other telephone companies. The Flip-Phone is a major breakthrough described by GTE as "the most advanced new telephone in the last ten years."

Most telephones contain a handset (the thing you talk over) and the base (where the electronics are located). GTE was able to condense the electronics on tiny integrated circuits which have been placed in the handset making the telephone base unnecessary.

THE MISSING MOUTHPIECE

Telephones contain large magnets which add to the handset's weight. The new Flip-Phone uses a very small and lightweight condenser microphone so sensitive that it picks up your voice even better than the conventional phone with its large mouthpiece.

And then there's the dial itself. It's gone. And in its place is a keyboard—a device that lets you tap out numbers without having to dial. This is a major breakthrough for three reasons: 1) It is a very fast way to dial. 2) It works on telephone systems that do not even accept *touch-tone** dialing, and 3) Even if you owned a *touch-tone* phone, you could plug in the Flip-Phone and not be charged for the extra service. You actually are able to push-button dial for free.

We're now going to tell you a few of the other new features, but the really big breakthrough, we'll tell you about later.

Privacy Switch Just flip a switch and you turn off the phone's ringer. It's ideal when you go to sleep, at dinner, or when you want privacy.

New Ring Most telephone ringers sound the same. The Flip-Phone emits an electronic warbling sound—a very pleasant tone.

New Cord Even the cord on the Flip-Phone is different. It's 14 feet long—twice as long as a conventional cord. One end is coiled and the other is straight. You can use either end to connect to your phone while the other end connects to the wall. And if your cord gets twisted, dirty, or plain chewed up, just unplug it and put in a new one. It's just that easy.

Low Cost The Flip-Phone costs only $49.95 which means that it will pay for itself quickly—not only in convenience, but with savings of up to $4 a month in some cities. When you determine the true cost of telephone ownership, you compare costs over a five-year period. In five years even a $2.00 telephone charge per month equals $120 or over twice the cost of the Flip-Phone telephone.

Small Size The Flip-Phone is the size of a large stapler. When you pick it up, a panel flips open revealing the touch-pad dial, and the panel acts as a guide to funnel your voice to the condenser microphone. The Flip-Phone is only 2¼" wide x 1¼" high x 7" long and weighs only seven ounces.

THE BIG BREAKTHROUGH

The really big breakthrough is not the Flip-Phone. GTE did indeed spend several million dollars developing the item, and we feel that it will be the single most important phone in America within a few short years. No, the real breakthrough is the change in attitude of the telephone companies. We can remember when even putting a telephone answering unit on your line almost caused you to lose your phone service.

TIMES HAVE CHANGED

The telephone companies are now so cooperative that they deserve great respect. After all, they lose money every time you plug in your own phone, so their cooperation in light of their loss must be commended.

And they have made connecting your phone easier than ever before. Remember those big four-pronged jacks? Now there's a small connector which the phone company installs for around $15 (depending on your city). Where can you find an electrician or a plumber to come to your home for $15?

If you want to plug in your own phones and don't have the modular receptacles, just call the phone company and see how courteous they are. Tell them that you are ordering a phone with a ringer equivalent of 1.2B, an FCC registration number of AB898Y-62927-TE-R, and that you want them to remove your phones and stop charging you for them. That's all you have to do.

They'll promptly send a repairman to your home to attach the modular connector for the Flip-Phone. If you already have a four-pronged jack you can use a modular adapter and avoid the service charge completely.

Then order a Flip-Phone from GTE. They'll be in most retail stores sometime this year. Or avoid the wait and order one now directly from us. We were the first major national distributor of the Flip-Phone and have already delivered thousands to homes throughout the country.

Put one in your kitchen, in your study, in your children's room, or even in your office. You'll appreciate the convenience and savings.

If service is ever required, GTE has a prompt service-by-mail center. About the only thing that goes wrong with today's phones is the tangled cord. With the Flip-Phone telephone, you just unplug the old cord and plug in the new one. It's just that simple.

A PERSONAL TEST

We urge you to at least give the Flip-Phone a personal test right in your own home under your everyday conditions. Order one from JS&A under our 30-day trial period. Plug it in. See how easy it is to dial numbers by pressing buttons. See how good it looks and how little space it takes up. Find out how much better you sound at the other end. Then within 30 days decide if you want to keep it. If you are not convinced that the GTE Flip-Phone is a very good investment, return your phone and we'll promptly refund your money—every penny including our $2.50 postage and handling charge. You can't lose.

To order your Flip-Phone, simply send your check for **$49.95** plus $2.50 for postage and handling to the address shown below. (Illinois residents, please add 5% sales tax.) Or credit card buyers may call our toll-free number.

The Flip-Phone comes in four colors: white, yellow, brown and beige. Just specify the color, and we'll send you the phone, cord, 90-day limited warranty, and simple instructions. If you have four-pronged jacks, just order the adapter plugs for $2 each.

Why not act ahead of the crowd and order an exciting new space-age way to cut down on your phone bills? Order your Flip-Phone at no obligation, today.

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POPULAR ELECTRONICS, February 1979, Volume 15, Number 2. Published monthly at One Park Avenue, New York, NY 10016. One year subscription rate for U.S. and Possessions, $13.00; Canada, $16.00; all other countries, $18.00 (cash orders only, payable in U.S. currency). Second Class postage paid at New York, NY and at additional mailing offices. Authorized as second class mail by the Post Office Department, Ottawa, Canada, and for payment of postage in cash.

POPULAR ELECTRONICS including ELECTRONICS WORLD, Trade Mark Registered. Indexed in the Reader's Guide to Periodical Literature.

Editorial correspondence: POPULAR ELECTRONICS, 1 Park Ave., New York, NY 10016. Editorial contributions must be accompanied by return postage and will be handled with reasonable care; however, publisher assumes no responsibility for return or safety of manuscripts, art work, or models.

Forms 3579 and all subscription correspondence: POPULAR ELECTRONICS, Circulation Dept., P.O. Box 2774, Boulder, CO 80302. Please allow at least eight weeks for change of address. Include your old address, enclosing, if possible, an address label from a recent issue.

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Editorial

A VISIT TO JAPAN

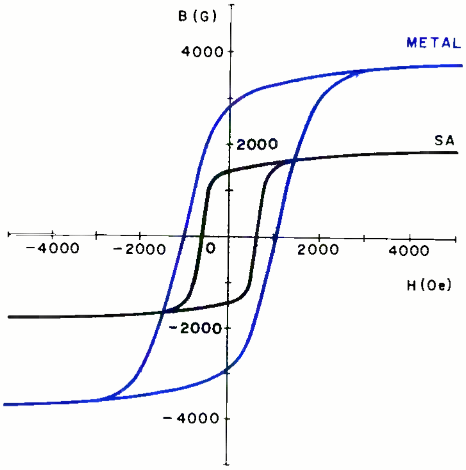
Last November I withstood the debilitating effects of a 15-hour nonstop flight to Japan as part of a small group of electronics press people invited by TDK Electronics. It was worth it.

Uppermost in my business thoughts was the progress being made with metal-particle tape, the new formulation that promises to deliver a significantly higher level of performance capability to slow-speed audio tape machines, whether cassette or microcassette. How close are they to finalizing bias and equalization standards for metal tape? How many tape deck manufacturers are prepared to enter machines into the marketplace to record these tapes, which require higher bias and greater erase current than non-metal-alloy tapes do? What comes first, the chicken or the egg?

Happily, both tapes and machines are moving along at a brisk pace. TDK, in fact, gave us a sample metal-particle cassette. We learned, too, that Tandberg is not the only deck maker with a machine that can record on metal tape. At the October Japan Audio Fair, cassette decks with metal-tape record provisions were said to have been displayed by Aiwa, JVC, Lux, Marantz, Matsushita, Nakamichi, NEC, Pioneer, Sony, and Toshiba.

On the tape side, the first standards meeting by EIAJ (Electronics Industries Association, Japan) was held July 26, with a fourth one scheduled at the end of '78. It's expected that test results will be firmed down by that time and passed on to tape-deck makers and to the IEC for their consideration and comments.

TDK kindly showed us how metal particles were extracted from metal salt by a reduction process with sodium borohydride in an aqueous solution. It was a fascinating lab demonstration! We were also treated to a dubbing session from a master tape running at 15 ips to a metal particle cassette tape (at 1 7/8 ips, naturally). Three types of music were played, dubbed, and replayed on metal tape—the Beatles' "Yesterday," Stockhausen's percussion music, and a Beethoven piano sonata. The results were impressively good at first listen.



Hysteresis loops of TDK metal and SA magnetic tapes.

Metal-alloy tape research has been going on for some three decades now, with the knowledge that metal's high coercivity and remanence were most desirable attributes for magnetic tape. (As the drawing here illustrates, metal tape has four times the magnetic energy of ferric-oxide tapes.) Two basic problems had to be whipped, however—tape-head technology had to advance and rust had to be prevented. I understand that both challenges have been met, the latter with a chemical substance that provides a rust-preventive coating around each particle so that the magnetic stability of metal tapes will be high.

We had an opportunity, too, to question audio critics for Japan's *tape sound* magazine on how they tackle equipment and raw tape reviews. They recently dropped publication of test results, we were told, and substituted personal review observations.

(Continued on page 6)

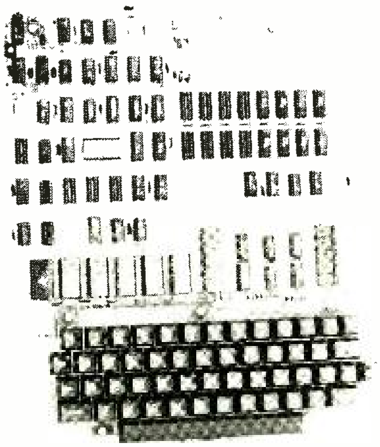
The Age of Affordable Personal Computing Has Finally Arrived.

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

This new machine can entertain your whole family with spectacular video games and cartoons, made possible by its ultra high resolution graphics and super fast BASIC. It can help you with your personal finances and budget planning, made possible by its decimal arithmetic ability and cassette data storage capabilities. It can assist you in school or industry as an ultra powerful scientific calculator, made possible by its advanced scientific math functions and built-in "immediate" mode which allows complex problem solving without programming! This computer can actually entertain your children while it educates them in topics ranging from naming the Presidents of the United States to tutoring trigonometry all possible by its fast extended BASIC, graphics and data storage ability.

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

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



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Standard Features

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

Extras

- Available expander board features 24K static RAM (additional), dual mini-floppy interface, port adapter for printer and modem and an OSI 48 line expansion interface.
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EDITORIAL (Continued from page 4)

Our visit to Tokyo's consumer electronics shopping area, the *Akihabara*, was a mind-boggling experience. I've never seen such breadth and depth in electronics gear in my life! I was assured, too, that merchandise was not on a consignment basis. It was here that I viewed a number of miniaturized true hi-fi stereo components on the shelves. An AM-stereo FM model with digital frequency readout (blue color) measures only 2¾" high, with matching integrated amp, and a twice-as-high matching cassette deck. They can be stacked atop each other and still come in under one-foot! A pair of miniature three-way powered speaker systems are par for the system setup, too. There was also a mini, high-power basic power amplifier that was the smartest-looking amplifier we've seen owing to its chrome-plated

Electronic micrographs of TDK SA ferric-oxide (left) and metal-alloy tapes illustrate the individual, needle-like shape of SA and the strung-together nature of metal particles, which has more magnetic ions in a given area.

chassis. For sure, the U.S. market will have the Lilliputian audio components at some future time.

TDK, which also manufactures VHS-and Beta-format video tape, arranged for us to visit a "Victor Video Center," opened last year in mid-Tokyo. Here, consumers can bring in movie film for transfer to a VHS video tape cassette, get first-hand experience on video cassette recorders, etc. And it was here that I heard a video tape playback of a TV broadcast that included stereo multiplex sound. A-B'ing mono and stereo, the latter was obviously a quantum advance in quality.

These very brief highlights are indicative of the new level of electronics technology coming out of this island country. Add double-screen TV receivers, pulse-code-modulation disk players, and other developments, and one can see where a large part of consumer electronics products emanate from. Economic pundits note, though, that the pendulum should swing back to the U.S. owing to the depressed value of dollars versus yens, which amounts to about a 20% loss in a dollar's worth in the past year alone. One cannot raise prices 20% in one fell swoop, they say, so the advantage should move to U.S. makers.

Art Salsberg

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Language Translator

Communicate in any language without saying a word, or learn a new language with the world's first computerized language translator.

Learning languages is not easy. It takes books, classes, cassettes, and hard work.

Now, however, you have a choice. You can communicate in a foreign country without speaking the language, or you can learn the language more easily thanks to a new electronic miracle.

Craig Corporation has just introduced the Translator—a pocket-sized personal computer that stores up to 7,000 words and translates them from one language to another at the touch of a button.

You enter a word in English on the alphabetical keyboard, press the translate button, and the word is shown on the display in the foreign language. You have a choice of languages such as Japanese, French, German, Italian, and Spanish. And you can translate from any one language into another.

You program the unit with four small memory capsules which contain approximately 1500 words each. By swapping capsules, you can change languages, so the unit will hold a total of 7,000 words in its four memory capsules.

WORLD COMMUNICATION

The Craig Translator is truly a pocket-sized translation computer that will help you communicate in practically every major nation in the world—even if you don't want to learn the language. There are a series of numbers listed on the back of the computer which correspond to 50 of the most commonly used and most practical phrases. 25 of the phrases are complete statements such as: "How much does this cost?" The remaining 25 statements require one or two additonal words like: "May I please have the..." You simply press the number for the phrase you want and then enter the missing word on the keyboard which has keys with both letters and numbers.

When you press the translate button, your phrase is flashed on the display in the foreign language. If the phrase is longer than the 16 character width of the screen, it rolls to the left—just like on a movie marquee.

Armed with the 50 phrases and up to a 7,000 word vocabulary, you can take your small information retrieval system throughout the world and literally carry on complete conversations without saying a word. Just enter the translated phrase or word and show it to the person with whom you are communicating. Have that person enter the answer, and before long you'll be carrying on complete conversations. You can negotiate prices at an outdoor market, order from menus, clarify statements, read newspapers, and street signs.

Phrase books are handy for travelers because all the most common words and phrases are indexed by category. The Craig Translator is also indexed, but for instantaneous retrieval. Just enter the subject, press a button, and you can recall a subject and its related words in alphabetical order. You can index travel, shopping, business, or medical terms and scan them faster than turning the pages of a book.

FOR THOSE WHO WANT TO LEARN A LANGUAGE

Learning a language is not easy, and the Craig Translator is not a substitute for practice and hard work. The Translator is, however, a very valuable teaching aid—one that can accelerate the learning process and teach you more vocabulary faster.

The most rewarding aspect of learning a language with the Craig system is "memory retention." When you need to know a word and can look it up at that very moment, your chances of remembering it are several times greater than in a classroom environment.

The Craig Translator not only gives you the answer, it does so immediately—at that moment—so it provides a very useful learning function. And it's fun to use and carry with you all day long.

The Craig Translator uses four systems of reinforcement. Reinforcement is a teaching concept in which the teacher praises you when you're right and gives you the correct answer when you're wrong.

FOUR TEACHING SYSTEMS

The Craig's four reinforcement systems are:

Frequency You can sort out words by how frequently they come up in normal conversation and then learn these words. Each one will be flashed on the display for a few seconds, and you say aloud the correct translation.

Spelling A word is flashed in English and you guess the spelling of the foreign word which you then enter on the keyboard. If you enter it wrong, the unit tells you and then flashes the correct answer on the display.

Category You can learn by category. Select a subject and access the associated words alphabetically. If you are preparing for a trip, you can learn all the words that relate to travel.

Alphabet You can learn by the alphabet. Start at any letter and the unit will display all the words that start with that letter.

ALL THE ANSWERS

There are other features that make the Craig Translator an outstanding teacher:

Spelling Program If you enter a misspelled word, the display will flash a question mark. By pressing a key, you instruct the unit to find the correct spelling. On the display will flash a series of words it thinks are the correct ones, and you simply select the right one.

Double Meanings When you enter an English word that has two meanings in the foreign language, the unit will ask you which meaning by listing the possible choices. Again you select the right one by pressing a key. For example, "watch" would be two different things depending on whether it was meant as a verb or a noun.

MEMORY CAPSULE

The languages are contained in small memory capsules four of which hold up to 256,000 bits of information or 7,000 words. The Craig Translator will accept other data so that eventually you will be able to store complete dictionaries, recipes, calorie equivalents, useful statistics, and other learning programs and then display this data on your pocket-sized information retrieval system. Language capsules cost only $24.95 each—about the cost of a few language textbooks, so the unit can inexpensively grow to fit many different applications.

You don't even have to read the instructions to operate the unit. A free starter Memory Capsule that comes with the unit will tell you how in six different languages. The capsule also contains the programs necessary to use your unit as a calculator or for currency con-

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Materials and workmanship of PERSUADER ANTENNAS (Models 13505 & 17605) are guaranteed for a full five years if this antenna is installed by the dealer and a full three years if this antenna is installed by the consumer.

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Antenna Incorporated

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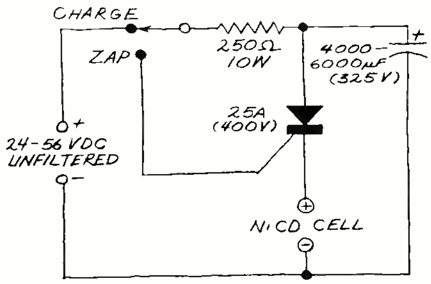
CIRCLE NO. 4 ON FREE INFORMATION CARD

Letters

NiCd ZAPPER WORKS

When I first read the article on the NiCd "Zapper" in your July 1977 issue, I didn't think it would work so I didn't build it. Then I saw a reader's recent comments on the device in your "Letters" column so I decided to give it a try after all. Surprise! It works great! So far, I've run into only two cells that haven't responded to the treatment. The secret seems to be to catch the cells before they've been shorted too long. However, the heavy current through the cell burns the switch contacts. Therefore, I've modified the circuit slightly



with good results. Perhaps your readers might like to try the modification as shown here.—*Zack T. Hinckley, Melbourne, FL.*

DIRECT-DRIVE IS OLD TECHNOLOGY

In reference to Julian Hirsch's Audio Reports in the February 1978 issue, I would like to point out that the concept of direct-drive turntables is not new. Many years ago I had an RCA Victor 78-rpm phonograph with an AM radio broadcast oscillator built into it. It was probably manufactured in the late 1930's. The bottom of the turntable had an internally toothed metal ring attached to it, and spaced around the spindle bearing there were stationary electromagnet coils that were driven by 60-Hz power, providing the turntable drive. This "motor" operated similarly to what we call today an outer-rotor or Pabst motor (used mostly in tape decks as reel-drive motors).

The RCA turntable motor was low in torque, requiring an initial spin to get it started, and it was noisy in operation. Even so, it was an old idea that required today's technology and refinements to bring it back to life. —*Barry Feurst, Oak Park, IL.*

LARGER RECTIFIERS NEEDED

The Digital Frequency Readout featured in your February 1977 issue has been one of the most useful accessories I have built for my ham or SWL receivers. However, the rectifier diodes (1N4002) specified for the power supply were pushed to their limit by the current of nearly one ampere drawn by the unit. After about a year of operation, the rectifiers aged and began to fail intermittently, causing the operating voltage to fall to 4.2 V, with a subsequent stalling of the counter and incorrect configurations on the readout. Eventually, the failures became worse until the unit was inoperative. Substituting three-ampere rectifiers in the power supply fixed the problem.—*W.J. Kreamer, Troy, NY.*

ADDENDUM TO CARING FOR DISKETTES

In preparing for publication the article "How to Care for Diskettes," in the November 1978 issue, one page of the original manuscript was inadvertently omitted. As a result, some additional information is necessary to clear up some misconceptions that may have been created due to the omission.

In small diskette systems, the type most popular with computer hobbyists, the actual diskette rotates within a protective jacket. After the diskette is loaded and the loading door closed, the internal mechanical arrangement forces a pressure pad to "squeeze" the flexible diskette to the head. In a sense, this produces a "dimple" in the relatively soft diskette at the point of contact.

Depending on the diskette and drive used, the relative head-to-diskette speed can reach about 8 mph. Thus, if there are any scratches on the head or if any foreign substance gets on the diskette so that it is forced between the head and the soft diskette surface, minute physical grooves can be cut creating data dropout. Figure 2, shown for what is called a "flying head" disk system, dramatically illustrates how foreign matter on the surface can create data loss on the disk.

During diskette operation, the pressure pad on the other side of the diskette "scours" the surface. It is possible for the pad to accumulate a layer of relatively hard dust, or even minute (metal) oxide particles scraped from the diskette—in most cases, even though only one side of a diskette is used, both sides are coated with magnetic oxide.

After some hours of use, the tiny hard particles adhering to the pressure pad can scratch the diskette surface. If the other side of the diskette is to be used, the rotation is then "backwards," which can cause surface damage and result in loss of data. It is probably for this reason that no small diskette drives use both sides of the diskette.

It should have been stated at the beginning of the "Foreign Matter" section that the mechanical data was for a large disk system whose diameter and drive speed are much higher than those of a small diskette. Thus the rpm is much higher. However, the information on the damage that can be caused by foreign matter—including smoke particles, dust, and grease—holds true for all diskettes.—*Les Solomon, Technical Director.*

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.

Sansui Direct-Drive Automatic Turntable

The Sansui Model SR-5090 two-speed single-play turntable has a servo-controlled dc direct-drive motor and a single knob which controls automatic operation, including power turn-off at the end of play, with the tonearm returned to rest position.

It is also equipped with a repeat control for one to five plays and an option for endless play. Automatic play can be interrupted at any time for manual operation. The manufacturer claims wow and flutter are down to 0.038%, rumble is better than 67 dB, S/N better than 57 dB. A built-in strobe light permits visual check of speed using patterns on the edge of the platter. Platter speed adjustment of ±3.5% can be made. An arm-lift lever is oil damped. $280, including base, dustcover, and 45-rpm spindle. Address: Sansui Electronics Corp., 55-11 Queens Blvd., Woodside, NY 11377.

CIRCLE NO. 89 ON FREE INFORMATION CARD

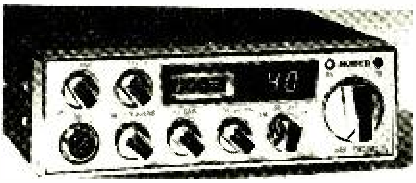
Royel Soldering Iron

The Royel "Duotemp" soldering iron delivers full power on demand with the press of a button but idles at half power. The latter serves two purposes—it saves wear and tear on the soldering tip itself and delivers the correct safe temperature for delicate soldering jobs on printed-circuit boards. For heavy-duty joints and long sequences of solder connection, the operator simply presses a BOOST button on the soldering iron's handle to double the heating power available. Address: Royel Soldering Systems, Inc., 213 S. Brand Blvd., Glendale, CA 91204.

CIRCLE NO. 91 ON FREE INFORMATION CARD

Robyn AM/SSB Mobile CB

The Robyn Model SB-505D CB mobile 40-channel transceiver, for AM and SSB operation, is said to be the first such unit with a clarifier switch on the microphone. Other

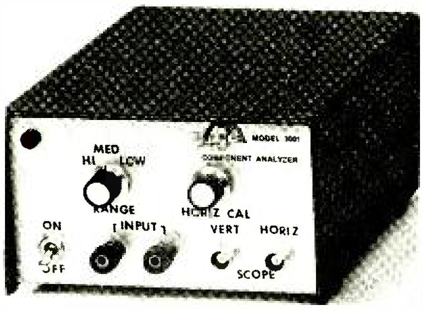


features include an S/r-f meter, LED digital readout with dimmer, mike gain control, tone control, and noise blanker switch. Specifications are: 0.5 microvolt sensitivity, 65 dB min. adjacent channel rejection, 75 dB min. image rejection, 100% modulation max. and −68 dB min. spurious harmonics. Dimensions are 2¼"H × 7¼"W × 9¼"D (6 × 19 × 24 cm). $259.95. Address: Robyn International Inc., 10901 Northland Dr., Rockford, MI 49341.

CIRCLE NO. 92 ON FREE INFORMATION CARD

PTS Component Tester

PTS Electronics has introduced a component tester for troubleshooting solid-state circuitry. The Model PTS 8001 component analyzer works both in- and out-of-circuit



with any standard oscilloscope to test ICs, transistors (all kinds), diodes (all kinds), and thyristors. A high/medium/low range switch is provided for adjusting conditions for the given component being tested. The analyzer also has a comparator function for comparing circuit boards with ICs and solid-state hybrid circuits and in-circuit testing for electrolytic capacitors. Address: PTS Electronics, Inc., P.O. Box 272, Bloomington, IN 47401.

CIRCLE NO. 93 ON FREE INFORMATION CARD

Tape Recorder Care Kit

A Tape Recorder Care Kit from Maxell Corp. is intended especially for the cleaning of tape heads in hard-to-reach places. It contains a variety of specially shaped plastic tools which can be plugged into each other to reach around and into places where tape heads are otherwise hard to clean. A mirror is included for inspecting heads in remote locations. A variety of replaceable felt applicator tabs and a specially formulated tape head cleaner are supplied for cleaning purposes. $8.95. Address: Maxell Corp. of America, 60 Oxford Dr., Moonachie, NJ 07074.

CIRCLE NO. 94 ON FREE INFORMATION CARD

TRS-80 Power Interface

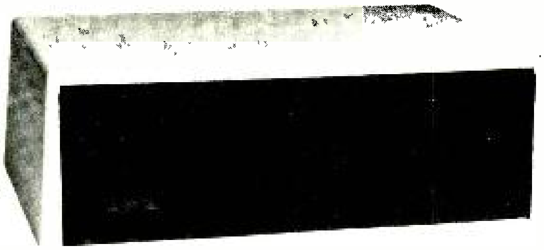
JC Enterprises has developed a new power interface module, A828 AC-P, for the Radio Shack TRS-80 computer. It provides 4 channels of programmable ac, with 600

W in each channel or 1600 W total. Advantages to be gained with the modules use are said to include expansion of the computer's capability to include sensing switch closures, photo sensors and 5-volt logic levels, driving LED displays, and operating motors, solenoids, alarms, etc. The A828 has its own 5V power supply, interface cable, I/O port connector cable, enclosure, and sample programs. The 8-bit input and output ports are addressed with LEVEL II BASIC, or with T-BUG and LEVEL I BASIC. $165. Address: JC Enterprises, Box 23445, San Diego, CA 92123.

CIRCLE NO. 95 ON FREE INFORMATION CARD

(Continued on page 14)

Burglar Alarm Breakthrough



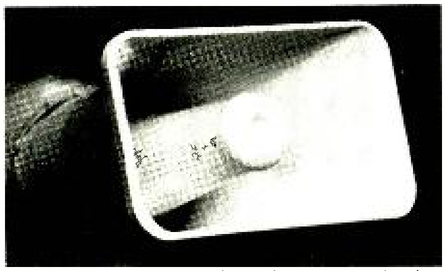
The Midex security computer looks like a handsome stereo system component and measures only 4"x 10½"x 7."

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

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.

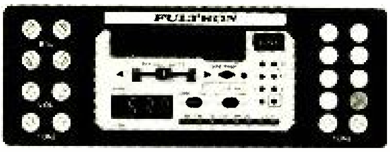
Space-age technology has produced the ultimate personal security computer. Order your Midex 55 at no obligation, today.

JS&A PRODUCTS THAT THINK

Dept. PE One JS&A Plaza
Northbrook, Ill. 60062 (312) 564-7000
Call TOLL-FREE 800 323-6400
In Illinois Call .... (312) 564-7000

"No-Knob" Microprocessor-Controlled Car Stereo

The Fultron[R] Ultra II (Model 16 6800), by Arthur Fulmer, is an in-dash cassette tape player with AM/FM stereo radio. The unit is designed around a microprocessor, which allows up to 14 stations to be preprogrammed and recalled. Touch-sensi-

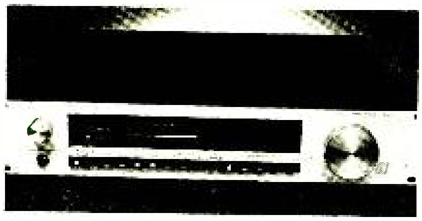


tive electronic controls are used to control volume, balance, fader, treble and bass. Four-way balance is adjusted by a touch control for each speaker that increases its volume while reducing the volume of the opposite speaker. Other features include: 12 W continuous power per channel at 10% THD, auto reverse, locking fast-forward/rewind, dimmable LED digital readout, and mono-stereo and local-distance sensitivity controls. Stereo separation is said to be more than 32 dB; frequency response 30 to 18,000 Hz −3 dB; and wow and flutter less than 0.20%. Dimensions are: 7"W and 2¾"H × 5⅞"D (17 × 7 × 15 cm). Address: Arthur Fulmer, 260 Monroe, Memphis, TN 38103.

CIRCLE NO. 96 ON FREE INFORMATION CARD

Dynaco FM Tuner

Dynaco's Model 2501 FM tuner features a Varactor front end with six tuned stages, numeric time/frequency display, and four station presets. It also has PLL multiplex circuitry driven by a double-tuned quadra-

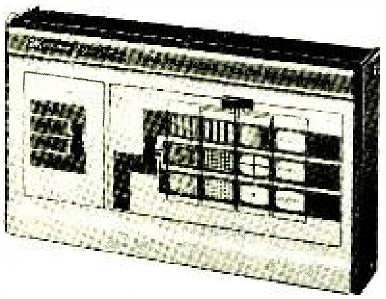


ture detector; a DYNATUNE feature that automatically locks in on a desired station and continues to precisely track the center of the channel; and a LED signal-strength indicator with a 60-dB display range in 10-dB steps. Other features include a full-time clock, front-panel selectable deemphasis (25/50/75 μs), and low-impedance 600-ohm audio outputs. Specifications: 16-dBf mono, 36-dBf stereo 50-dB quieting sensitivity; 1.75-dB capture ratio; 80-dB alternate-channel selectivity; 100-dB image rejection; 30-to-45-dB stereo separation; 0.19% to 0.4% THD; 0.15% IM distortion; 70-dB mono, 65-dB stereo S/N ratio; 65-dB hum and noise in mono. Address: Dynaco Inc., Box 88/Coles Rd., Blackwood, NJ 08012.

CIRCLE NO. 97 ON FREE INFORMATION CARD

Compact Color Pattern Generator

The Model 1210 color pattern generator from B&K Precision generates 10 patterns for color-TV servicing and setup. Patterns include vertical lines, horizontal lines; large and small crosshatch; large and small dots; single horizontal and vertical lines; single dot; gated and ungated rainbow; and purity. Video and sync signals are derived from and synchronized to a crystal-



controlled oscillator. A color-level control permits adjustment from zero to 100%, while another control permits adjustment of the r-f output level from 10,000 to 35,000 μV (into 75 ohms). Five different output channels (2, 3, and 7 on vhf and 23 and 52 on uhf) can be selected. Power for the generator is from a 9-volt battery (not supplied). Size is 6½"W × 3⅝"H × 1⅜"D (16.5 × 9.1 × 3.5 cm) and weight is 1 lb (about 0.45 kg). $97.50. Address: B&K-Precision, Dynascan Corp., 6460 W. Cortlandt St., Chicago, IL 60635.

CIRCLE NO. 98 ON FREE INFORMATION CARD

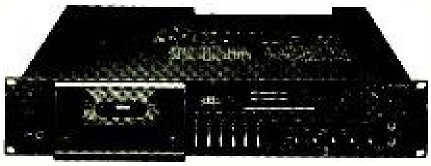
Audioanalyst Mini Speaker

The Phasematrix M2 is a walnut-veneered mini-speaker (9⅝ × 6 × 7 in.) designed for home or car use. The two-way system has a 5", polymer-cone low-frequency driver, crossing over at 2 kHz to a 1" tweeter. Response is rated at 46-20,000 Hz ±4 dB; sensitivity, 89 dB SPL at one meter for one-watt input; and maximum SPL at 2 meters, 100 dB average and 102 dB peak. Recommended amplifier power is 10 watts minimum, 50 watts maximum; nominal impedance is 4 ohms. $139. Address: Audioanalyst, P.O. Box 262, Brookfield, CT 06804.

CIRCLE NO. 99 ON FREE INFORMATION CARD

Technics Cassette Deck

A rack-mounting, front-loading cassette deck occupying only 3⅞ inches of rack height has been announced by Technics.



The RS-M85 uses linear flourescent bar-graph displays, which can be set to glow brightly or dimly and to display peak or average (VU) levels. It also features a record-mute switch; memory rewind and timer-recording facilities; separate input and output level controls; a full-visibility cassette well; a quartz-locked, direct-drive capstan motor; and a coreless reel motor. There is also a three-position tape selector, plus a fine-bias adjust. Wow and flutter are claimed to be less than 0.035% wrms, speed deviations no more than 0.3%. $700. Address: Technics by Panasonic, One Panasonic Way, Secaucus, NJ 07094.

CIRCLE NO. 100 ON FREE INFORMATION CARD

Digital Logic Trainer

The Broder Model 100 Logic Trainer is really a "hands-on" course in digital electronics. It is built around a plastic box (with removable plastic cover) and a series of cards. The box contains a number of digital logic devices, a row of nine slide switches, and a liquid-crystal display bar graph. The cards, on which are printed 40 logic problems, fit between and are keyed to the column of switches and display. Represented on the cards are all gates (AND, NAND, OR, NOR, XOR), flip-flops (D, JK, T, RS, one-shot), positive and negative edge triggered devices, master/slave clocking, preset and clear functions, etc. Switch circuit and Venn diagram, as well as BCD and binary counting, problems are presented. Problems are related to computers, communications, etc. In operation, the student operates logic switches to force a 1 to be displayed on the designated bar indicator. A manual is included. $69.95. Address: L.J. Broder Enterprises Inc., 3192 Darvany Dr., Dallas, TX 75220 (Tel: 214-357-7763).

FISHER INTRODUCES THE WORLD'S FIRST CASSETTE DECK WITH WIRELESS REMOTE EDITING.

Tape recording will never be the same.

In Fisher's 41 years of audio leadership, we've introduced many important high fidelity "firsts." But we honestly think the new CR4025 tape deck is one of our most exciting and practical innovations.

Remote electronic editing is as important an advance in tape recording as the cassette.

Now for the first time, you *can really* enjoy creating your own personal music library from FM broadcasts or record albums. The editing is done electronically while recording. A great leap forward from the old way of recording... without jumping up and down every 3 minutes to edit.

Fisher's wireless remote electronic editor makes tape recording a pleasure. The CR4025 tape deck has a built-in wireless receiver that operates the deck's solenoid-actuated Pause mechanism. The remote control transmitter operates the Pause control instantly from up to 20 feet away. Relax, listen, and capture the selections you want to keep at the push of a button.

Zap! You eliminate any commercial or announcer's voice from your off-the-air FM broadcast recording . . . or skip any unwanted track on an album you're taping from.

Of course, this fantastic convenience wouldn't be worth much if you had to sacrifice performance. Fortunately, you don't — the CR4025 has the excellent frequency response and extremely low wow & flutter that you expect from Fisher, plus Dolby noise reduction for clean, noise-free recordings.

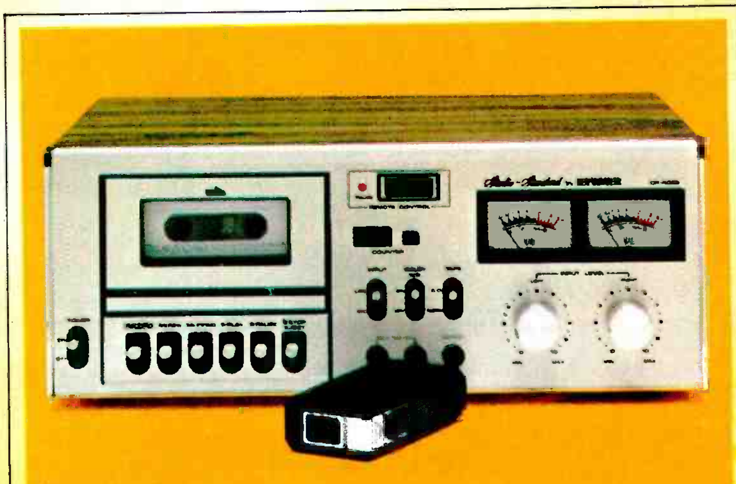
The Fisher CR4025 is priced at $270* and is available at selected audio stores or the audio department of your favorite department store.

New guide to buying high fidelity equipment. Send $2 for Fisher Handbook, with name and address to Fisher Corp., Dept. H, 21314 Lassen St. Chatsworth, Calif. 91311.

*Manufacturer's suggested retail value. Actual selling price is at the sole discretion of the individual Fisher dealer.

FISHER

The first name in high fidelity.



CR4025

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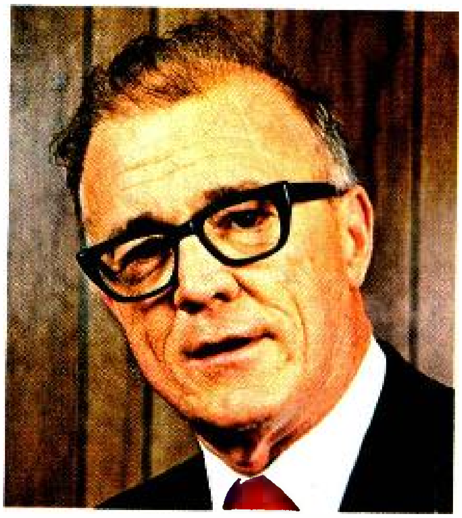

Stereo Scene

By Ralph Hodges

PLAYING BY THE NUMBERS AND OTHER RUMINATIONS

AS I WRITE, the 61st Convention of the Audio Engineering Society is in full swing and the corridors of New York's Waldorf Astoria are abustle with convocations of the great, the near great, the just-getting-started, and the thoroughly bewildered. The energy level of this year's New York convention is exceptionally high, and the impetus seems to be the new digital recording techniques that are already impinging on the sound industry with perhaps unexpected vigor. The Soundstream digital mastering recorder, which is generally toted around by the company's chief executive, Dr. Thomas Stockham, seems to be everywhere these days, backing up direct-to-disc recording sessions, undergoing close scrutiny by the record-industry majors, and frequently winning the place of honor as *the* source for the master tape from an important recording project. 3M has sworn that initial deliveries of its fabulous 32-track recorder will have taken place by the time you read this. Also, the associated editing system, seen for the first time at this convention, is scheduled for availability later on in the year. Sony has managed to sneak a U-matic video recorder and a PCM adapter into a recent recording session of Beethoven's Ninth Symphony by the St. Louis Symphony. The digital system was plugged straight into CBS's mixing console; and while the results were not overwhelming, the Sony tape still managed to attract considerable interest. The Ampex people have yet to demonstrate an actual digital tape machine; but they are clearly close to it.

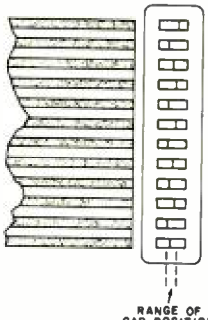

Fig. 1. Gap scatter makes phase-time errors between tape tracks.

The Quality Question. Now over the years "God's Gift to Audio" has appeared in various forms and guises, but no one has noticed that the big recording outfits like CBS, RCA, and Capitol are celebrating its advent to any extent. In the case of digital of course, we are hardly talking about a gift, because with the possible exception of RCA, virtually all digital purchases or rentals are going to come from outside sources. And they are going to cost. So why are the majors taking such a pointed interest in the problematic technology of digital recording at this time? I could be wrong, but I think we audiophile types may have finally succeeded in hounding them to death. The Angel division of Capitol Records has recently announced that it will take all its final production to Wakefield Manufacturing, a pressing plant in Phoenix, Arizona that has earned an enviable reputation for quality work. This is despite the fact that Capitol has its *own* pressing plants scattered about the country. Presumably Capitol has enough pop-music releases to keep them working at capacity. Still, Capitol's willingness to take its classical production "out of the house"—incurring significant additional costs, no doubt—is a very gracious admission of past problems and an encouraging sign of determination to do better. Other companies have made similar concessions.

God's Gift to Audio. At this point, when direct-to-disc and other activities of relatively small producers have raised the quality-consciousness of the major record companies to new highs, along comes digital with what seems to be the ideal way out. Digital is clean, and digital is quiet. It permits editing—very precise editing as we shall soon see—and retakes; and it evokes images of "Technology" with a capital "T." (In other words, it will look very good emblazoned on the front cover of a record jacket.) Direct-to-disc may be clean and quiet, but it permits none of the mechanical processes to which the big companies have become accustomed in assembling the best possible performance. Hence, expensive or not, digital seems a godsend in a world in which consumers are becoming very particular about the technical quality of records they buy.

But is it actually a godsend? Let's look at two aspects of digital performance: one on the positive side of the ledger and the other (possibly) on the negative. The positive one occurred to me while puzzling over the magnificent violin sound on a tape of Copland's *Appalachian Spring* that was brought to the convention by 3M. The tape was initially recorded on 3M's 32-track digital mastering machine; and it certainly had many of the sonic "signatures" of a multitrack production: close-up perspectives on the orchestra, a relatively low content of ambient sound, some subtle discontinuities in the stereo image, etc. It was not, in other words, exactly the way I like to hear an orchestra reproduced. However, the violins and lower strings still sounded glorious in a way that I just don't associate with close-miked, multitrack recording sessions.

Explanation? Well, there's a hypothesis that I can't absolutely vouch for, but which seems to fit some of the facts. It goes like this.

Suppose you are conducting a multitrack recording session involving a large symphony orchestra. You send your assistants out to various positions right in front of the orchestra—and sometimes in its very midst—and have them set up microphones wherever they look right. When this process is completed, you may have as few as two or as many as six or more mikes directed at the violin section alone. At this point you may assign each of the violin mikes to its own track on the master tape recorder, or you may mix their outputs down into just a few tracks. But in any case, you know that sooner or later the contributions of all those mikes are going to have to be electrically mixed together in complex ways to create the final recording. And here—if you know what you're doing—is where you foresee trouble. All over the left-hand side of that orchestra, there are microphones picking up the same violin, but the mikes are not equally distant from that violin. The phase relationships between the outputs of those microphones become very interesting indeed; and, when they are electrically mixed, there are a host of severe or minor signal reinforcements and cancellations that, at worst, can reduce those

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glorious string choruses to the sound of an overage soprano with a bad cold.

So you do a preliminary mix, just to get an approximation of the way you hope the final record will sound. As necessary while doing this, you move microphones to reduce interference and perhaps subtract or add a few. Then you roll some tape so that the conductor and others can come back into the control room to hear how it's all working out. Finally, once they've given their approval, the session gets down to business trying to produce some acceptable outtakes.

With the session successfully completed, you hop a plane back to wherever your studio headquarters are located and begin to mix the multitrack tape. But suddenly there is trouble; the approved mix doesn't sound right in the mix-down room. Why? Because, although you paid close attention to microphone positioning at the session itself, you had no control whatever over lack of gap colinearity in the multitrack head stacks (Fig. 1). Such a lack of colinearity is called "gap scatter," and even the best tape heads have some, but never in exactly the same pattern, of course. So here you are, back home, trying to mix your tape on an entirely different machine (you have presumably left the session recorder back in the orchestra's home city for reuse in the next session), and its differing pattern of gap scatter is giving you much the same trouble with phase-interference effects that you suffered with microphone placement.

Digital really comes to the rescue here. The gap-scatter problem on something like the 3M 32-track machine, would have to be at least an order of magnitude worse to have any effect on its operation. This is because the rate at which information is retrieved from the tape depends not on whether one gap in the head stack leads or lags another, but on the intervals defined by a carefully controlled clock frequency. If one gap "reads" the tape a little ahead of another, no problem. The system will place the signals from *all* the gaps into memory and release them, with precise simultaneity, when the clock so directs. This means that, for the first time, one studio tape recorder can be functionally identical to any other. What's more, gap-scatter problems between the record and playback heads of a single machine are also taken care of.

A Slight Difficulty. Now, although we can show that any digitized signal we manage to get on a tape is almost literally carved in stone, getting the signal on to the tape is quite another story. Take, for example, a 20-kHz signal that we want to record on a digital system with a 40-kHz sampling rate (all the practical digital audio-recording systems have a higher sampling rate than this, but not all that much higher). Figure 2 shows the 20-kHz waveform and the points along it that are quantized by the recording system. (These quantization points could occur anywhere along the waveform, depending only on how the evolution of the waveform synchs with the clock rate.) The second part of Fig. 2 shows the output, before low-pass filtering, of the D/A converter we are using to retrieve the signal. Note that there is an amplitude error "built into" the recording. The third part of the figure illustrates the output of the low-pass filter, with an obvious shift in the zero crossing of the waveform—a phase shift, that is.

Digital systems introduce these amplitude and phase errors in a relatively random fashion. The only thing certain is that their occurrence and probability of severity increase as the input-signal frequency approaches the sampling rate. Analog audio systems introduce them with fair predictability. They can be measured and plotted in the form of frequency-response curves and group-delay characteristics. Those authorities inclined to worry about phase/time dislocations are particularly concerned over gradually evolving standards that would seem likely to peg the sampling rate of professional digital recording systems somewhere in the neighborhood of 50 kHz. This is too low a rate, they believe, and the resulting ambiguities in quantization at the highest audio frequencies are certain to show up as intermodulation-distortion products well within the audio band.

How do they account for the easy tolerance most humans have exhibited for similar effects during the analog era? Some think that the other conspicuous faults of analog recording systems have masked these aberrations, but that the superior overall performance of digital systems will bring them right out in the open for all to hear. Another camp proclaims that the randomness with which these distortions will come and go in a digital system is sure to become an irritant. In other words, everything will be fine at one moment and terrible at the next. But all seem agreed that we deserve something better than the present proposals for digital standards, the idea being that the technology is too good to be introduced in a half-baked form, and that we risk widespread consumer rejection if we don't take preliminary pains to ensure that everything works as well as it can.

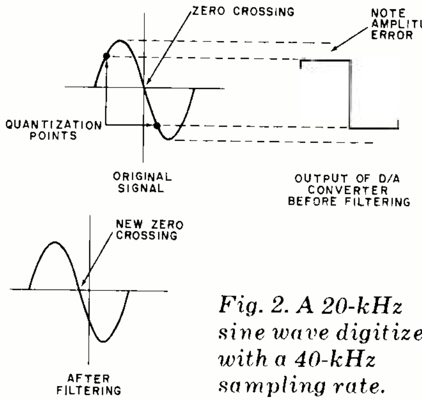

Fig. 2. A 20-kHz sine wave digitized with a 40-kHz sampling rate.

I hope you've notice that I have been careful to avoid taking a stand on this issue. In general I have been quite happy with what I have heard from the professional studio recorders that employ digital techniques. I am almost equally satisfied with the PCM disc and video-càssette systems that are intended for consumer use (and which have come in for a much greater amount of preliminary criticism than the professional tape systems). Granted that an open demonstration of these systems before audio professionals would be handled in a rather painstaking way, and any recorded material that did not measure up to standards would be scratched. Yet some of the digital machines have behaved superbly in actual recording sessions, during which there is no time to sort out difficulties in the hardware. Thus it seems to me that neither the pro's nor the con's have contructed an irrefutable case as yet.

Standards. The critics of digital recording want standards that will ensure—or at least permit—evolution or recording systems to encompass significantly higher sampling rates and bit density. Those who favor digital want to get on with it. Neither group is having its way at the moment because an importer (from Europe) of high-quality *analog* recording equipment has successfully shut down the activities of the Audio Engineering Society's committee on digital standards with a court injunction claiming restraint of trade. Is this individual protecting us from our own worst inclinations, or is he merely trying to strengthen his own market position? I certainly don't know, but I would like to. And the rest of you would certainly not be ill advised to take an interest in this question also. ◇

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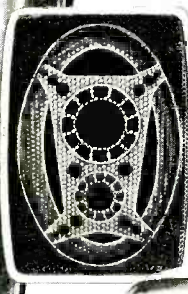

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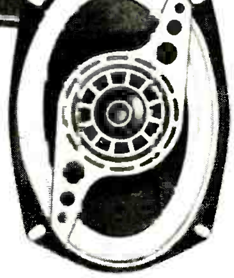

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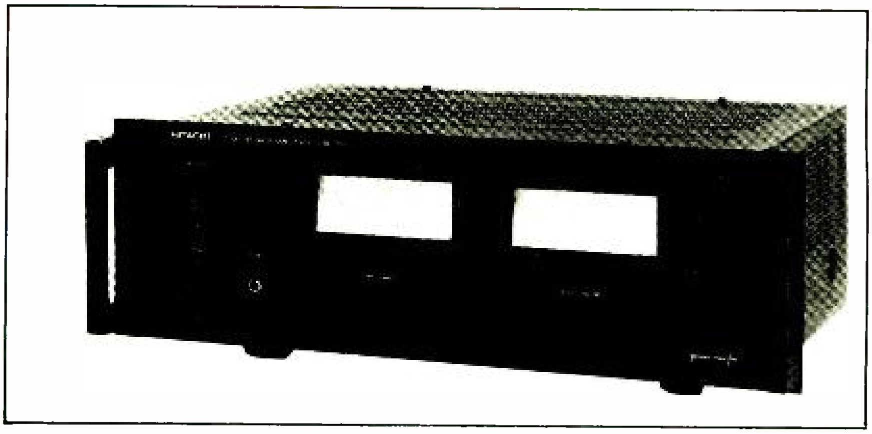
Julian Hirsch Audio Reports

basic stereo power amplifier provides 75 W/ch at 0.02% THD

The new Hitachi Model HMA-7500 basic power amplifier is rated to deliver 75 watts/-channel into 8 ohms from 20 to 20,000 Hz with no more than 0.02% total harmonic distortion. It uses high-power MOSFET output transistors instead of the customary bipolar devices. The FET (field effect transistor) offers several major advantages over bipolar transistors, including high linearity, extremely fast switching time, and high input impedance.

The amplifier measures 17¼"W X 14"D X 6½"H (43.8 X 35.5 X 16.5 cm) and weighs 34.8 lb (15.8 kg). Optional handles are supplied. Suggested retail price is $500.



MOSFET output transistors simplify circuitry in the Hitachi HMA-7500 stereo power amplifier

General Description. The most prominent physical feature of the amplifier is a pair of large, well-lighted power meters on the front panel. They are logarithmically calibrated over a range from 0.1 to 200 watts (based on 8-ohm loads) and respond fast enough to follow program peaks. Separate pushbutton switches energize two sets of speaker outputs. A toggle power switch and a headphone jack complete front-panel features.

On the rear apron are the input jacks, binding-post speaker terminals, a single unswitched ac outlet, and a slide switch labelled NORMAL and DC. In the first position, the switch inserts a capacitor into the signal input path. In the DC mode, the amplifier is completely direct-coupled from input to output (including all internal feedback paths). Internal sensing circuits actuate a relay that cuts off the speaker outputs if any significant dc potential appears at the amplifier's output. (The latter might occur if the drive is from a signal source that has a leaky output coupling capacitor or if too great a signal amplitude is applied to the inputs.)

Since the power MOSFET is a high-impedance device and is driven by a voltage instead of a current, the HMA-7500's circuitry differs considerably from that of the typical bipolar-transistor power amplifier. In the latter, much of the circuitry is devoted to stabilizing the operating conditions of the transistors against temperature changes and protecting the output transistors against damage from thermal runaway or excessive drive. The MOSFET, on the other hand, is inherently stable and free from runaway and secondary breakdown problems. As a result, the circuits of the Model HMA-7500 are unusually simple.

outputs clipped at 88½ W/ch into 8 ohms

The amplifier has a differential bipolar transistor input stage, which is followed by a differential driver stage with an active collector load (so-called "current mirror" operation). This latter stage drives the complementary output MOSFETs directly. The overall negative feedback goes from the output to the second input of the input differential stage.

Hitachi and several other amplifier manufacturers believe that very low frequency transients in one channel of an amplifier, which can also affect the supply voltages on the other channel, are responsible for crosstalk effects that can cause a "wandering" of the stereo image. The most obvious solution is to power each channel from its own power supply. This is what Hitachi has done in the Model HMA-7500, providing separate power transformers, rectifiers, and filters for the ±52 volts supplied to the output stage of each channel. Second windings on each transformer are combined to feed a common rectifier and voltage regulators that supply ±12 volts and ±58 volts to the low-level stages of both channels. Since these stages operate in class A mode, their current drain is constant.

Laboratory Measurements. The characteristics of a MOSFET power amplifier are so different from those of a conventional bipolar power amplifier that few of our test results followed a familiar pattern. For example, following a one-hour preconditioning period

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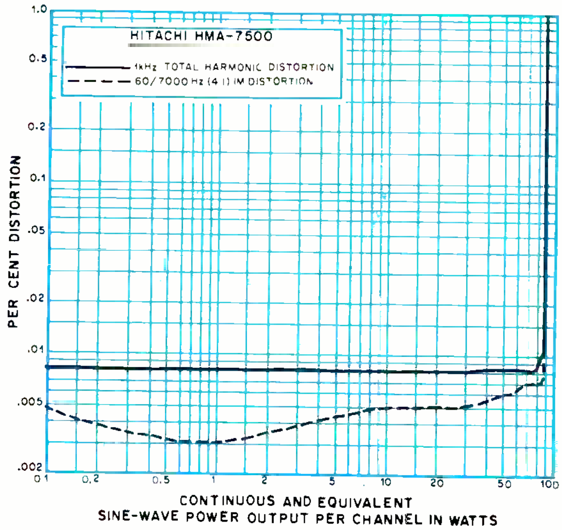
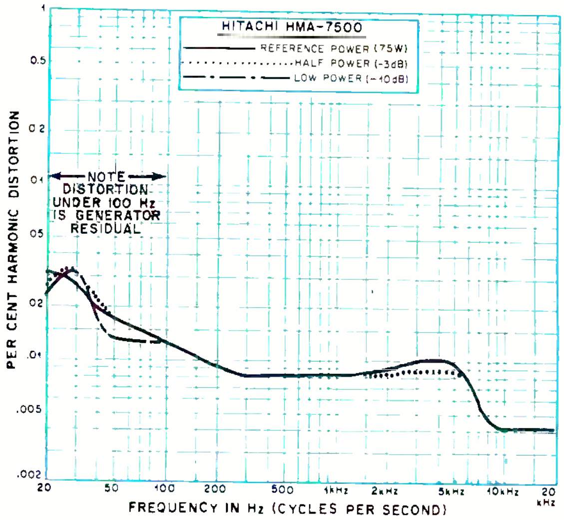


THD and IM distortion at 8 ohms.



Percent harmonic distortion at three power levels.

at 25 watts output, the amplifier was barely warm. Outputs clipped at 88.5 watts/channel when driving 8-ohm loads at 1000 Hz (for an IHF clipping headroom rating of 0.72 dB). Into 4 and 16 ohms, the amplifier delivered 93 and 48 watts, respectively. IHF dynamic headroom rating was 1.25 dB, since the amplifier was able to deliver 100 watts for short periods.

Input sensitivity was 0.11 volt for a reference output of 1 watt, while out-

slew factor was 16½... most amps are pressed to achieve 2 or 3

put noise was below our measurement limit of 100 microvolts (−90 dBV). The input resistance of 50,000 ohms was shunted by 200 picofarads of capacitance.

The wide frequency range of the MOSFET was effectively demonstrated by the amplifier's low-level frequency response and its IHF slew factor. The frequency response was flat within ±0.1 dB from dc to about 50,000 Hz and was down 1.5 dB at 200 kHz and 6 dB at 500 kHz. With the input switch set to NORMAL, the low-end response was down only 1 dB at 5 Hz.

The slew factor is measured by driving the amplifier to rated power at 1000 Hz and maintaining the same input level while increasing the frequency until the distortion in the output reaches 1%. We were unable to make distortion measurements above the audio range, but we watched the waveform on an oscilloscope and did not see any departure from a sinusoid up to 330 kHz. Assuming that to be the 1% distortion point, the slew factor was 330/20, or 16.5. Since most amplifiers are pressed to achieve a slew factor of 2 or 3, this suggests that the HMA-7500 will be unlikely to suffer from any kind of transient intermodulation distortion caused by its ability to deliver substantial power outputs at very high frequencies.

We are accustomed to finding amplifiers with less distortion at low frequencies than that of our Radford oscillator (which has figures of about 0.01% at 100 Hz to 0.25% at 20 Hz). However, most amplifiers reveal a definite increase in distortion at the higher audio frequencies. In the case of the HMA-7500 amplifier, the low-end distortion followed the expected pattern, and the distortion remained at a fixed 0.008% from 300 to 5000 Hz at any power level from 7.5 watts to the rated 75 watts. Beyond 5000 Hz, the distortion dropped to 0.004% at 10,000 Hz and up. This was consistent with the amplifier's behavior in the slew factor tests, but was nevertheless surprising.

At 1000 Hz, distortion was a constant 0.008% from 0.1 to 80 watts output and 0.012% at 90 watts, just as clipping occurred. IM distortion was 0.003% to 0.005% from less than 1

Performance Specifications

Specification	Rating	Measured
Continuous output, 8 ohms, 20-20,000 Hz	75 W at 0.02% THD	Confirmed
Power bandwidth (IHF) at 50% rated output	5 to 100,000 Hz at 0.05%	Not measured
Frequency response (DC) (at 1 watt output)	Dc to 200,000 Hz +0/-1 dB	Dc-200,000 Hz +0/-1.5 dB
(NORM)	6 to 200,000 Hz +0/-1 dB	5 to 200,000 Hz +0/-1.5 dB
Input sensitivity	1 volt	0.11 V/1 W (50k) (equiv. 0.95 V/75 W)
Channel separation	100 dB (1000 Hz, input shorted)	20 Hz: 115 dB 1000 Hz: 100 dB 20,000 Hz: 87 dB (1000-ohm input term.)
S/N ratio (IHF-A)	120 dB	Better than 90 dB re 1 W (equiv. better than 109 dB re 75 W) Measurement limit
Speaker impedance	4-16 ohms	—

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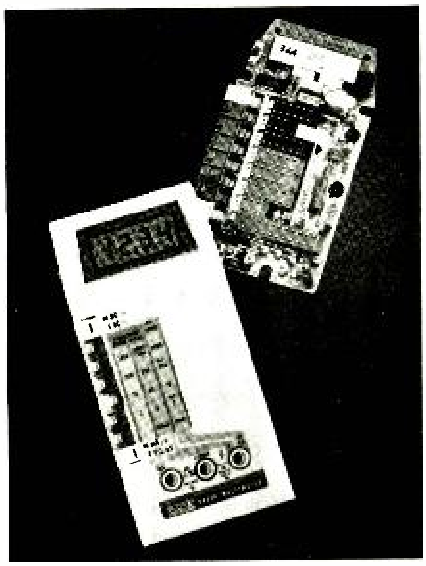

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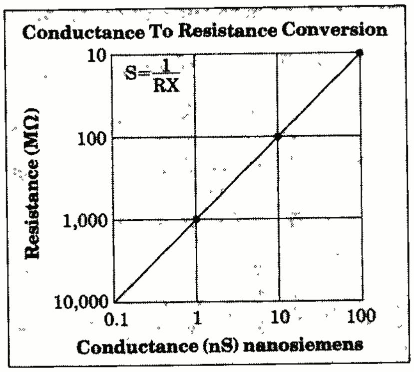

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Product Focus

The MOSFET has some powerful advantages over bipolar transistors, including its inherent linearity, wide frequency response, fast switching speed, and freedom from thermal runaway effects and secondary breakdown. For some time, MOSFET applications were limited to low-level r-f and audio stages, but several years ago a type of transistor known as the "vertical FET" (or VFET) made its appearance. It combined the basic characteristics of the lower power MOSFET with a high power handling ability and has been used in a few amplifiers. The VFET is an expensive device to manufacture and has not made much headway in penetrating the lower-price ranges of consumer hi-fi equipment.

Hitachi has succeeded in developing a MOSFET with different internal construction from that of the VFET. Its power MOSFET is now available in fully complementary forms for use in audio output stages. In the Model HMA-7500 power amplifier, the MOSFET's extreme linearity is evidenced by very low distortion, which our measurements revealed to be entirely second harmonic (and thus the least offensive from a musical standpoint). The frequency response of a power MOSFET extends into the megahertz region, compared to bipolar power transistors whose gain falls rapidly even in the upper part of the audible range.

With this wide frequency range comes a high switching speed, which gives the power MOSFET its ability to generate high power at ultrasonic frequencies with very low distortion when compared to any bipolar device. Since the MOSFET is inherently stable and will not "self destruct" from thermal runaway, many of the circuit components that serve to protect the output transistors in a conventional amplifier are not needed in a MOSFET amplifier. The high gain and high input impedance of the power MOSFET give it many of the properties of vacuum tubes, with a corresponding reduction in overall circuit complexity.

Hitachi's use of power MOSFETs in the Model HMA-7500 has resulted in an amplifier with virtually ideal properties. It is relatively immune to damage from overdriving; does not overheat (in fact, it runs far cooler than most amplifiers we have tested); and even if it did get hot, the output devices would not be in danger of destruction. Presumably, the Hitachi MOSFET process is capable of a higher yield (and therefore a lower per unit cost) than the current VFET manufacturing process. If this proves to be the case, we can look forward to seeing these devices in lower-priced amplifiers. While the Model HMA-7500 is by no means inexpensive, one should realize that, in addition to using the MOSFETs, it is a heavily constructed, deluxe amplifier with two separate power supplies.

watt to about 50 watts. It reached 0.007% at 90 watts. The distortion, in all cases, was purely second-harmonic. We never detected any higher-order distortion components.

Channel separation measured 100 dB at 1000 Hz, exactly as rated. We drove one channel, terminated the input of the other in an IHF standard of 1000 ohms, and measured the output of the undriven channel. At 20 Hz, the separation was 115 dB; and at 20,000 Hz, it was 87 dB. No doubt this extreme isolation can be credited, at least in part, to Hitachi's use of entirely separate power supplies for the two channels. The power meters were about as accurate as most we have seen. Typical errors were 30% to 40%, but the fast response of the pointers made the meters useful indicators of output power.

User Comment. We could detect no audible differences between the Hitachi Model HMA-7500 and other fine amplifiers to which we compared it. The Hitachi amplifier is completely free of any unwanted sound, whether it be a turn-on or turn-off transient (eliminated by the time-delay circuit that keeps the speakers disconnected until the amplifier has been on for about seven seconds and all transients have decayed), or hiss and hum (which are unmeasurable as well as inaudible).

Although Hitachi recommends that the amplifier be operated in its dc mode unless a dc offset voltage is known to be present in the input signal, there is no particular advantage to doing this. When operated in the dc mode, it can cause some baffling apparent malfunctions in the system. For example, when we inserted certain accessories between the preamplifier and the power amplifier, the outputs remained silent. At first, we thought a cable had come off or that some component had failed. We soon found, however, that the "fault" was caused by a very low-level dc leakage in the output of the device connected to the amplifier that activated its protective circuit. When we switched to NORMAL, all was well. Since there is no signal indicator to notify the user that the protective circuit has been activated, one has no clues to the cause of the silence. (The power meters indicate zero under this condition, since they are driven by the speaker outputs.)

For a 75-watt/channel amplifier, the Hitachi HMA-7500 is far from inexpensive. On the other hand, even though one can buy a more powerful amplifier, we doubt that there are any that are "better" in any substantive respect. We are agnostic on the matter of the audibility of transient-intermodulation (TIM) or slew-induced distortion under real-world listening conditions, as readers might know. However, true believers may find solace in the thought that this amplifier can deliver a healthy power output in the range of hundreds of kilohertz and will certainly not be fazed by *any* signal reaching it from an audio source.

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the Akai PRO-1000 is a "semiprofessional" three-speed, open-reel tape recorder

The Akai Model PRO-1000 is a deluxe open-reel stereo tape recorder whose features and performance bridge the gap between good home recorders and true professional equipment. As such, it is an excellent example of a genuine "semiprofessional" tape recorder.

fact: dramatic freedom from distortion comes to a mid-priced cartridge: the new Shure M95HE...

the Shure M95HE

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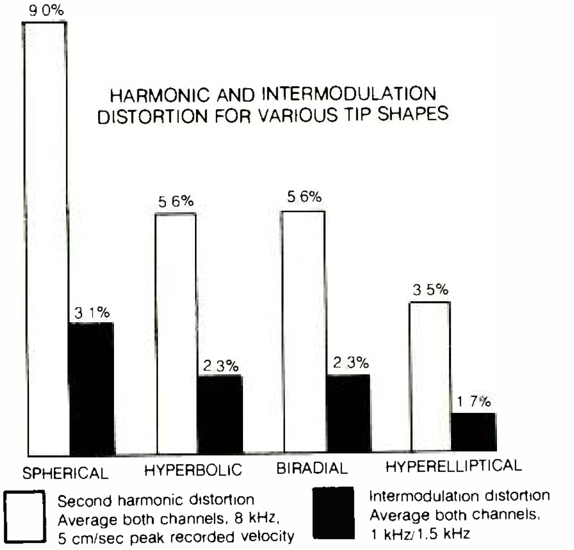
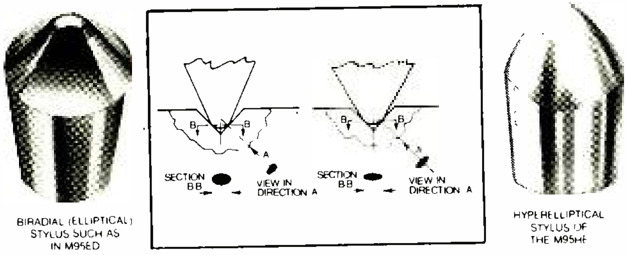


a measurable drop in distortion

As a result of the optimized contact area of the Hyperelliptical tip, both harmonic distortion (white bars in graph above) and intermodulation distortion (black bars) are dramatically reduced.

the Hyperelliptical stylus tip



The Hyperelliptical nude diamond tip configuration represents a significant advance in tip design for stereo sound reproduction. As the figures show, its "footprint" (represented by black oval) is longer and narrower than the traditional Biradial (Elliptical) tip-groove contact area. Because the Hyperelliptical footprint geometry is narrower than both the Biradial and long-contact shapes such as the Hyperbolic, it is pre-eminent for reproduction of the stereo-cut groove.

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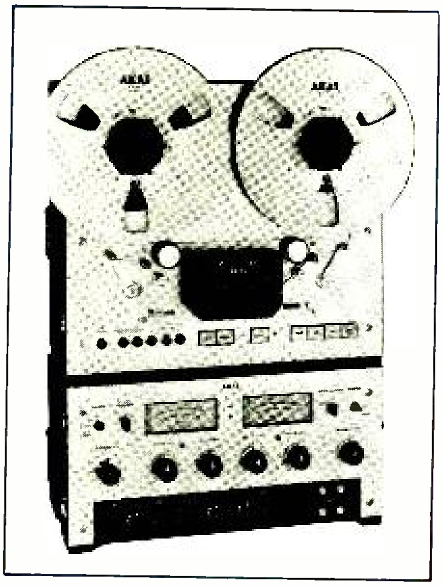


tape transport and electronics are housed in separate portable sections

The PRO-1000 is a three-speed recorder that accommodates 10½" (26.6 cm) reels and operates at 15, 7½ and 3¾ ips (38, 19, and 9.5 cm/s). It is designed for two-track recording and playback, although it also has a separate quarter-track playback head to give it compatibility with tapes recorded in that format. The recorder also has extensive input mixing facilities and front-panel controls for adjusting the bias and recording equalization to match any specific tape.

The PRO-1000 is packaged in a "portable" form consisting of two units, each with handles and a cover to protect it in transit. The exterior of the recorder is covered in black leather-grain vinyl. The tape transport section measures about 19"W × 16¼"H × 11"D (486 × 412 × 284 mm) and weighs 62¼ lb (28.3 kg). The amplifier section is 19"W × 12"D × 9"H (486 × 231 × 309 mm) and weighs 22½ lb (10.2 kg). The two units are joined by three cables that allow them to be placed side-by-side or with the transport atop the amplifier. Suggested retail price is $1995.

General Description. Front panels of the Model PRO-1000 are finished in satin aluminum with contrasting black knobs whose large index arrows make their settings visible at a glance. The tape is driven by a dual capstan system, with a servo-controlled ac motor, that maintains a constant tape tension across the heads for minimum flutter. Tension arms on both sides of the heads control tape movement during start-up and shut-off. The arms also stop the transport when the tape runs out or if it should break. Each reel is driven by its own six-pole eddy-current motor.

The tape transport has a button on the control panel to adjust reel tension for either 10½" or 7" reels. Other pushbuttons are provided for selecting tape speed, controlling ac power to the entire recorder, and activating the AUTO PLAY system. The last switches the machine from fast forward or rewind to play at a point where a piece of conducting foil is attached to the back of the tape. Removable hub adapters for large-hub 10½" reels are supplied, as is a 10½" metal reel that is stored in the transport's cover. The cover over the tape heads is hinged for easy access to adjust and clean the heads.

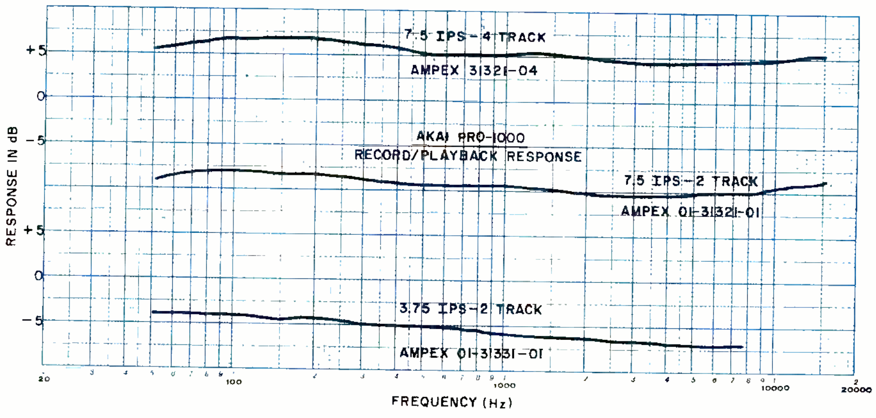
Other pushbuttons control the transport solenoids. They include the usual basic tape-speed and direction selectors, a REC (recording) button with a red indicator light, and a PAUSE button with a yellow light. A CUE button allows a partial contact between the tape and the heads during fast winding so that recorded portions can be located easily. In this mode, the output level is automatically reduced by 15 dB to prevent tweeter burnout, since signal levels in the ultrasonic range can be generated. On the back of the transport unit are two unswitched ac outlets, the line cord, a socket for a remote-control accessory, and three integral cables whose plugs mate with connectors on the amplifier unit.

The amplifier unit has four separate inputs, each with its own recording-level control, and a master recording-level control. Each level knob has a concentric metal ring that functions as a preset stop mechanism. The ring

four separate inputs provide mixing flexibility

can be set to any point of a knob's rotation; and when that point is reached, a definite resistance to the knob's movement is felt. The knobs normally have a very light, effortless "feel." This makes it very easy to drop the recording gain on any input to zero and fade it in smoothly to the desired preset level without having to look at panel markings.

Each of the four recording inputs has a three-position switch that connects it to either a LINE or a MIC input. The third position introduces a 20-dB attenuation into the microphone circuit to prevent amplifier overload on very loud program material. INPUT 1 and INPUT 4 go to the left and right channels, respectively. However, the INPUT 2 and INPUT 3 signals can be positioned anywhere on the stereo stage, from full left to full right, by means of their individual PAN POT controls. The latter have center detents for a mono (center-channel) placement. Dots on either side of center correspond to a placement 45° off-center.



Playback responses at 7½ ips on 4 and 2 tracks and at 3¾ ips on 2 tracks.

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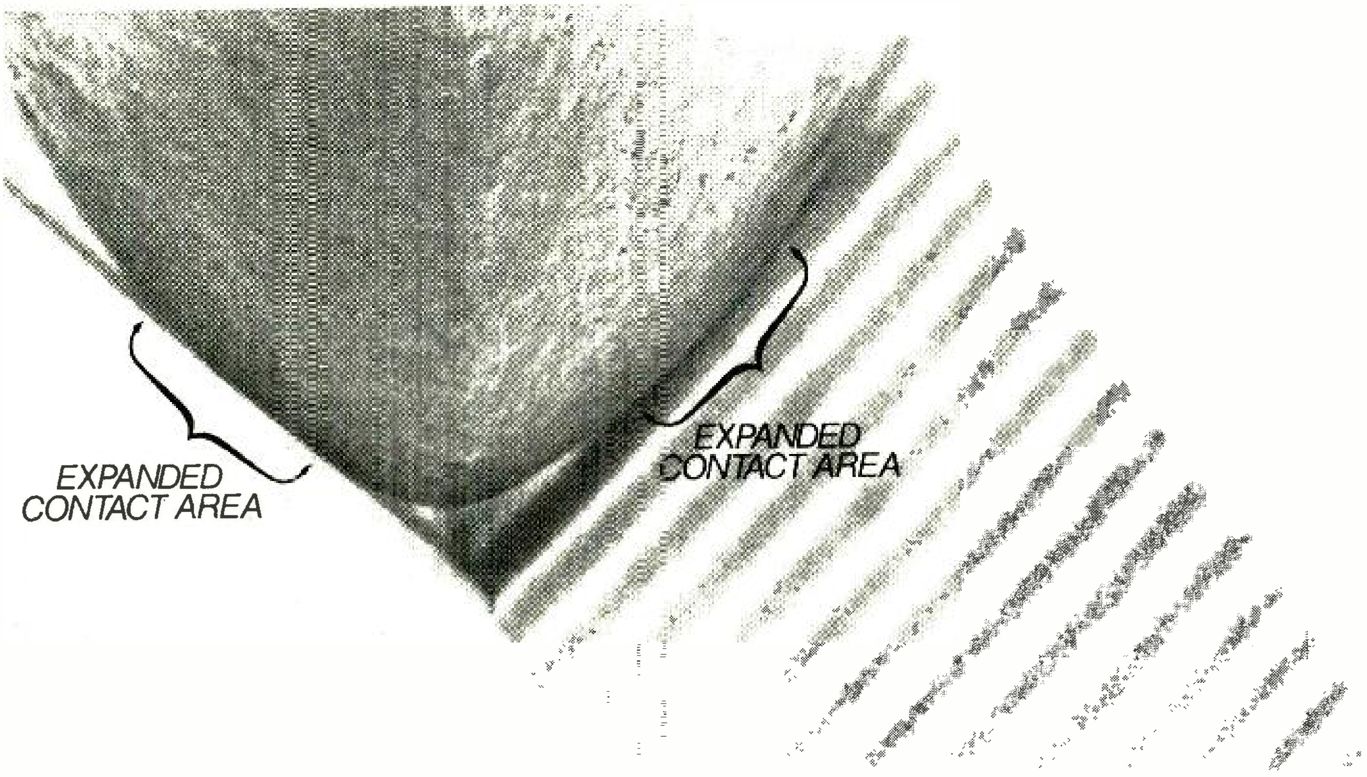
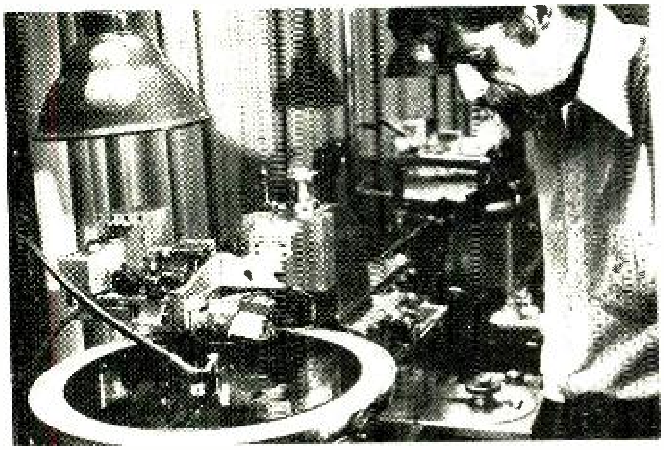


Scanning Electron Beam Microscope photo of Stereohedron stylus. 2000 times magnification. Brackets point out wider contact area.



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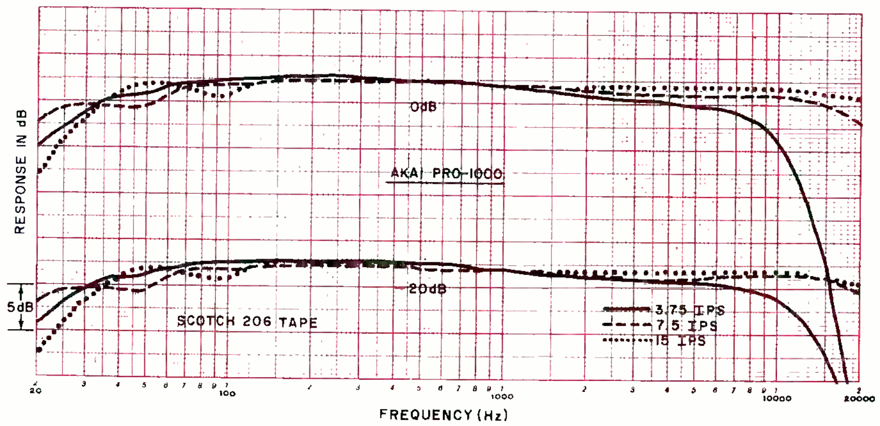

Frequency responses at 0 and −20 dB for Scotch 206 tape at three speeds.

The PLAYBACK knob is similar in size and appearance to the recording level controls. The ring around it, however, is the playback level control for the right channel—not a preset stop. This permits the playback levels in the two channels to be adjusted independently. A detent at the center of rotation gives the reference playback level of zero VU (0.775 V) from a signal recorded at zero VU. The two large illuminated meters serve a triple function. They have separate scales for VU and PEAK levels, as selected by a knob to the right of the meters. In the VU mode, the meters have the ballistic characteristics specified for VU meters. The VU scale covers the prescribed range from −20 to +3 dB, while the PEAK scale is logarithmic over a range of −40 to +5 dB. A sine wave that indicates 0 VU will read −8 dB on the PEAK scale. The PEAK readings can be used as an accurate indication of recording level, with the assurance that program peaks that do not exceed a 0-dB reading will not overload the recording.

The third position of the METER switch is labelled BIAS. In this mode, the meters indicate relative bias current, which is adjustable separately for the two channels. The nominally correct bias is at zero (center) on the meter scale. There is a range of ±40% about the zero point. The bias controls are center-detented at the point corresponding to a zero percent meter reading, which is the factory-set level for optimum performance with Scotch 206 tape. Two knobs labelled EQ are for adjusting the recording equalization. They are calibrated from 0 to 10 and are detented at the center setting of 5, which is also the optimum equalization for Scotch 206 tape. The instruction manual lists the recommended BIAS and EQ settings for some 20 popular tapes. (Of course, with an external oscillator, one can adjust the deck for any tape, using these controls.)

A stereo headphone jack is provided. It is driven from its own amplifier stage, which is rated to deliver up to 50 mV into 8-ohm loads. The headphone level control operates on the playback signals after their level has been set with the PLAYBACK control. (It does not affect the LINE outputs.)

The remaining controls include a MONITOR switch for channeling either the incoming (SOURCE) or playback (TAPE) signals to the LINE outputs and the headphones, and a switch that selects either the half- or quarter-track playback head. A small knob permits the recording and playback equalization to be simultaneously changed to match the tape speed.

On the rear of the amplifier unit are four phono jacks for the LINE inputs and four ¼" (6.35-mm) phone jacks

(Continued on page 38)

Product Focus

Among the more interesting features of the Akai Model PRO-1000 open-reel tape recorder are its front-panel controls for adjusting recording bias and equalization and its AUTO PLAY system. Although the importance of matching the bias closely to the tape requirements is recognized by users and manufacturers of cassette recorders, it has been little publicized in relation to open-reel recorders for the home. This is probably because bias is much less critical for open-reel recording than it is for the cassette medium. Although the necessary adjustments are generally available within the machine, as a rule they are not made accessible to the consumer, who rarely has the equipment, know-how, or actual need to optimize the bias.

In true professional recorders, where every bit of performance must be extracted from the tape, the bias adjustment is accessible for trimming prior to any major recording session to match the particular tape being used. In the model PRO-1000, the adjustments are accessible on the front panel, and the instruction manual tells where to set them for each type of tape.

The other important factor in optimizing tape recordings is the recording equalization. This is conveniently ignored in virtually every home tape deck we have seen. The internal factory-set adjustments are assumed to be sufficiently close to ideal. As a rule, they are, but when one wishes to obtain the flattest possible frequency response with very low noise and distortion, the equalization characteristics cannot be ignored. The PRO-1000 is the first consumer tape recorder we can recall that places the equalization and bias controls on the front panel. The user is not encouraged to do more than set them to the positions recommended for the tape being used. But anyone who has an inexpensive audio oscillator can learn much about the interrelationship of bias and equalization and their effect on the recorder's overall performance by experimentation.

The AUTO PLAY feature is somewhat similar to the "auto-stop" devices used on a number of tape recorders. Its actual function and purpose, however, are totally different. On some tape decks, the metallic foil attached to the back of a tape can close a contact to stop the tape at normal playing speed or sometimes to reverse the tape's direction so that all four tracks of a quarter-track stereo tape can be played without interruption or interchanging reels. In the PRO-1000, its chief application will be for playing master-wound tapes, which are normally stored in a fully wound state and must be rewound before being played. This is done because the tape winds more evenly on the reel at normal operating speed than in its fast operating modes. Master tapes are normally stored in the wound condition and must be rewound just prior to being played.

As used in the Model PRO-1000, the AUTO PLAY system (which operates from both fast speed modes) can be set so that the master-wound tape is loaded and put into rewind. At the beginning of the reel (where the metallic foil has been previously attached), the tape comes to a stop and automatically enteres the playback mode. The convenience of this feature to anyone who normally stores his tapes in a wound condition is obvious.

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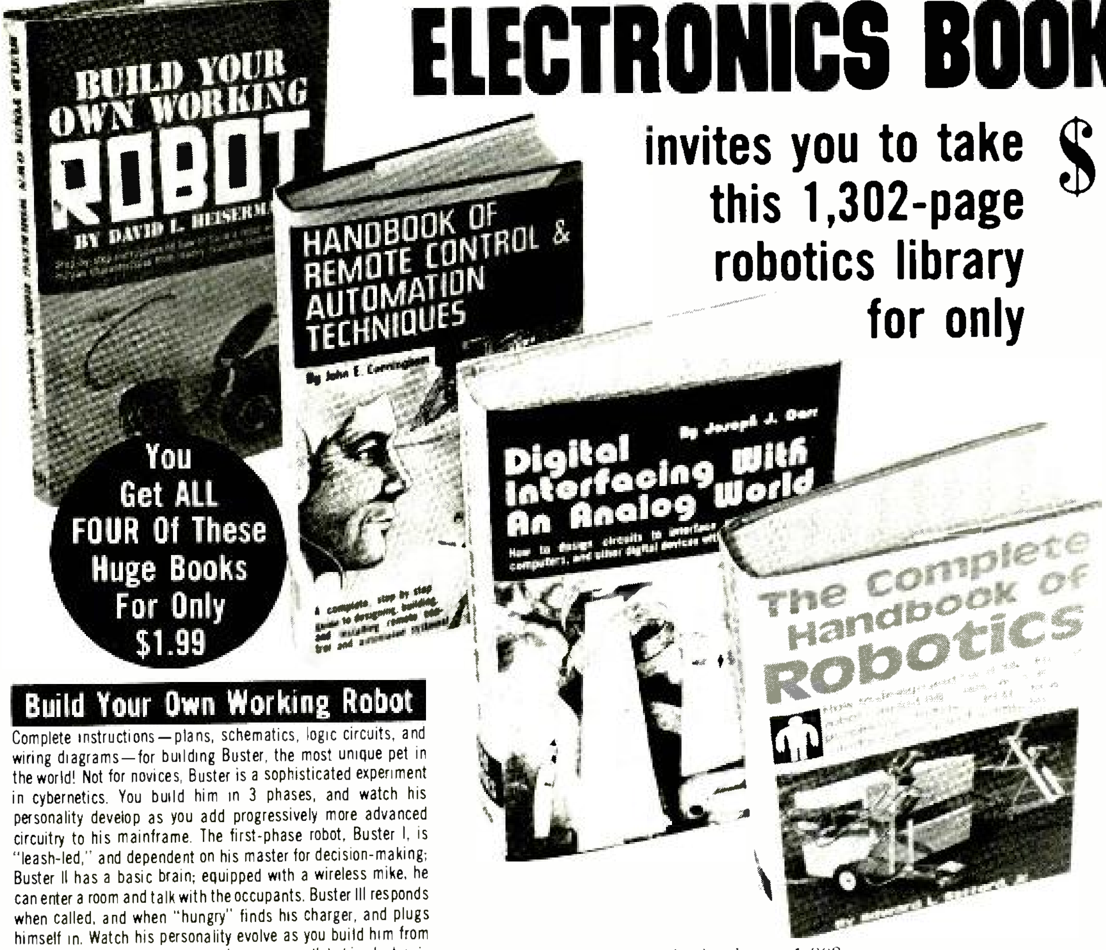

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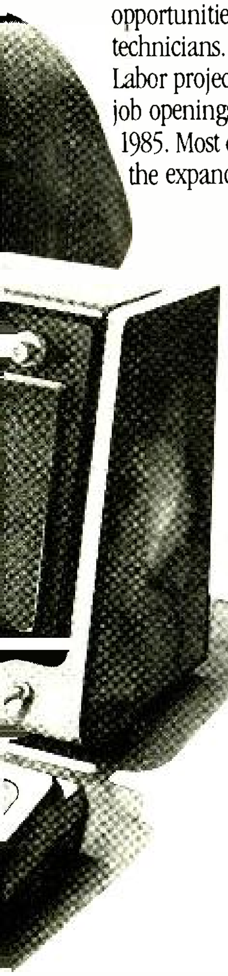

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(Continued from page 32)
for the microphones (which should be medium-impedance types in the range of 600 to 10,000 ohms). There are also two parallel sets of LINE output phono jacks and two MIXER output jacks that carry the SOURCE program, the latter, regardless of the setting of the MONITOR switch. Three sockets accept the cables from the transport unit to the power supply, the record and erase heads and the playback heads.

A novel and convenient feature of the PRO-1000 is its provision for inserting a noise-reducing processor into its recording and playback circuits. This is done through two groups of phono jacks on the rear of the amplifier section, which are normally connected through by a slide switch.

Laboratory Measurements. Basic specifications of the Model PRO-1000 were derived with Scotch 206 tape, which we used for all our record/playback measurements. Playback equalization was checked with Ampex standard alignment tapes at 7½ and 3¾ ips (19 and 9.5 cm/s). At 7½ ips, the response was within ±1.25 dB from 50 to 15,000 Hz. The 3¾-ips tape was recorded with a 120-microsecond time constant, while the recorder uses 90 microseconds. In spite of the discrepancy, the measured response was flat within ±1.6 dB from 50 to 7500 Hz.

At 3¾ ips, the record-playback frequency response was within +1/−5 dB from 23 to 12,000 Hz at a −20-dB recording level. At 0 dB, it covered a 25-9000-Hz range with the same variation. At 7½ ips, the recorder's true capabilities became more obvious. The −20-dB response was +0.5/−5 dB from 20 to 26,000 Hz. Not surprisingly, the recorder was at its most impressive at 15 ips. There were no signs of tape saturation, so the 0-dB and −20-dB response curves were identical. Including the small low-frequency "head contour" ripples, the response was within +0.5/−5 dB from 28 to 29,500 Hz.

A LINE input of 75 mV or a MIC input of 0.26 mV was required for a zero-VU recording level. The MIC preamplifier overloaded at a very safe 183 mV, which increased to 1.45 volts when we used the 20-dB microphone attenuator. The playback output from a zero-VU recording read zero VU on the meter when the PLAYBACK control was set to its center detent. The corresponding output voltage was the rated 0.78 volts. (At the lowest speed, the playback level registered −1 dB). The headphone volume was fairly good with 200-ohm phones, although the design is for 8-ohm phones.

response at 0 VU is impressive 32-24,000 Hz ±1 dB at 15 ips

The meter ballistics were close to those specified, though not exactly correct. In the VU mode, the meters registered −1 dB on the 0.3-second tone bursts that should read the same as a steady-state signal of the same level. The PEAK mode gave a +3-dB reading on the same signal and read −1.5 dB on 10-ms bursts. A sine wave of exactly 0 VU gave the rated −8-dB reading on the PEAK scale.

Third-harmonic distortion in the playback was low at all three speeds. At a 0-VU level, it measured 0.32% on the two lower speeds and 0.22% on the higest speed. The reference 3% playback distortion was reached at a recording input of +6.5 to +7 dB, depending on the speed. At low levels (−10 dB), the distortion was the lowest we have measured from any tape recorder. It was 0.032% to 0.056%, depending on the speed.

The A-weighted S/N ratio, relative to the 3% distortion reference level, was about 66 dB at the highest speed and 67 dB at the lowest speed. By a small margin, the S/N was best (68 dB) at 7½ ips, but it should be noted that the S/N differences between all three speeds were negligible. Noise level through the microphone input at maximum recording gain was 10 dB greater than through the line inputs. At the maximum recommended setting of the microphone gain (7 on a scale of 10) the increase was only 3 dB.

We measured the playback flutter at the two lower speeds with Ampex test tapes. The weighted rms (JIS)

Performance Specifications

Specification	Rating	Measured
Tape speed	38, 19, 9.5 cm/s	Confirmed
Tape speed deviation	±0.5%	Confirmed
Wow/flutter (wrms)		
15 ips	0.025%	0.023% (R/P)
7½ ips	0.04%	0.05%
3¾ ips	0.08%	0.065%
Tape start time	0.8 s at 38 cm/s	Not checked
Frequency response		
15 ips	50-20,000 Hz ±1 dB	32-24,000 Hz ±1 dB
7½ ips	40-24,000 Hz ±3 dB	20-24,000 Hz ±1 dB
3¾ ips	60-12,000 Hz ±3 dB	23-12,000 Hz ±3 dB
Harmonic distortion	Less than 1% at all speeds (1000 Hz, 0 VU)	Less than 0.32%
S/N ratio	60 dB	Over 66 dB
Playback equalization	NAB	Confirmed, ±1.6 dB
Erase ratio	70 dB	Not checked
Recording bias frequency	150,000 Hz	Not checked
Fast forward/rewind time	Within 120 s for 2400 ft of tape	62 s for 1000 ft
MIC inputs	600/10,000 ohms, min. input 0.3 mV	Min. input 0.26 mV
Line inputs/outputs	10,000 ohms in	Not checked
	100 ohms out	Not checked
	Ref. out 0 dB = 0.775 V	Confirmed
Level meter	PEAK—DIN	
	0.01 s response	Confirmed
	0.8 s decay	Confirmed
	VU—Stand. response	Approx. confirmed
Power supply	120 V, 60 Hz, 116 W	Not checked

flutter was 0.065% at 3¾ ips and 0.05% at 7½ ips. The weighted peak (DIN) readings were ±0.09% at both speeds. We also measured the combined record/playback flutter at all three speeds. The DIN and JIS measurements were ±0.11% and 0.085% at 3¾ ips and ±0.1% and 0.06% at 7½ ips. At 15 ips, the recorder again delivered its most outstanding performance, with a DIN flutter of ±0.04% and a JIS of 0.023%.

In its fast-wind modes, the recorder wound a 1200-ft (366-m) reel in 62 seconds.

User Comment. Anyone who thinks that open-reel tape recording is "dead" for home users should get acquainted with the Akai Model

bias and equalization are front-panel adjusted

PRO-1000. True, it is not "everyman's" tape recorder. It is very heavy and expensive, and it does much more than most home recordists will ever need. But it is well-suited to the needs of the serious amateur recordist, for whom it was obviously designed. Standard phone plugs are employed rather than "Cannon-type" connectors used universally for microphone inputs in professional recording (where balanced microphone circuits are the norm). The input and output jacks are also standard phono types, for easy interfacing with other home audio components.

The tape transport operated perfectly. Its logic system made it practical to operate the controls in any sequence with no risk of damaging the tape. Touching the PLAY button during fast-wind operation brought the tape to a swift stop for an instant before it resumed at normal speed. "Flying-start" recordings can be made at any time while playing a tape by holding in the PLAY button and touching the REC button at the desired point. The reverse is also possible; while recording, a touch of the PLAY button instantly returns the machine to playback.

As for actual performance, at 7½ ips, this is a very fine home recorder, with many of its qualities optimized at that speed. This is an important consideration for the nonprofessional user, most of whose tapes will probably be in the quarter-track format at 7½ ips. At 15 ips, on the other hand, the recorder is nothing less than superb in its frequency-response, headroom, and flutter performance. Even at 3¾ ips, it is creditable.

As we see it, the special virtue of the PRO-1000, compared to some other fine open-reel recorders, is its highly versatile input mixing arrangement. It will not do the synchronized multitrack recording of a four-channel recorder, but it will enable the imaginative amateur to create professional-quality tapes from live program sources. That is what it was made for, we think, and it is admirably equipped for the task.

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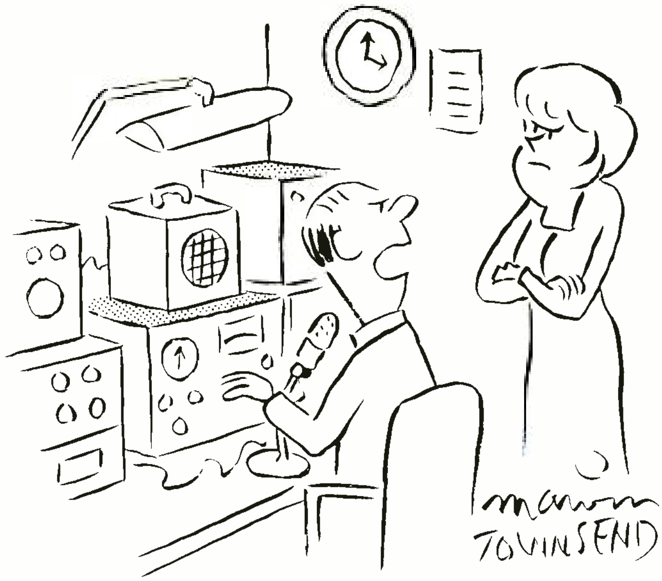

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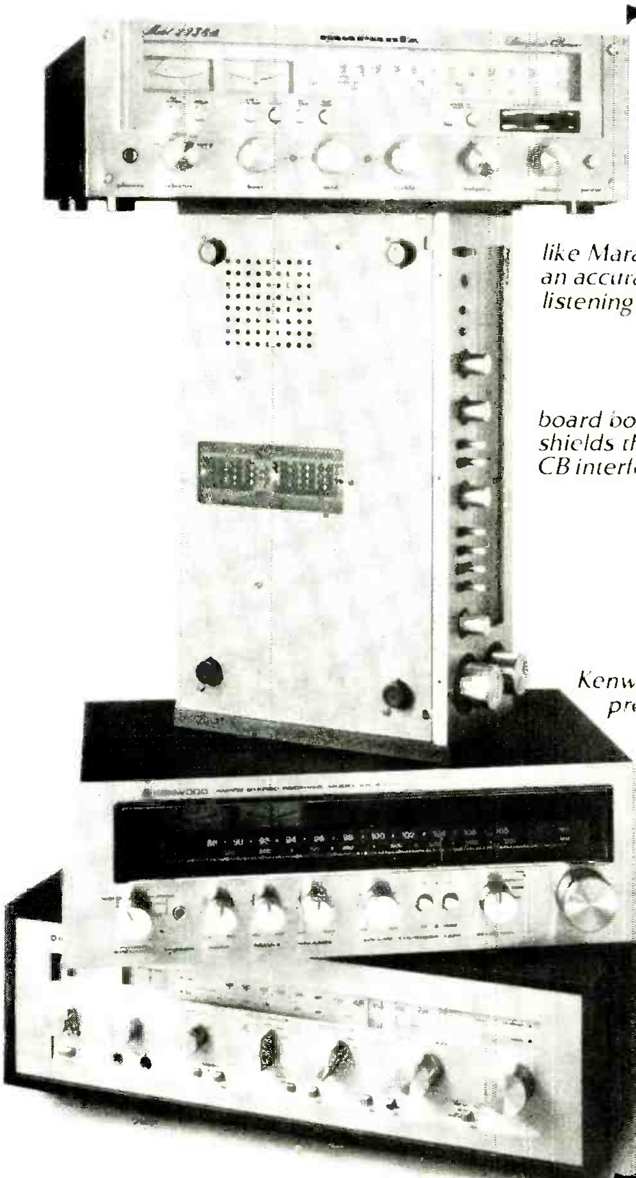

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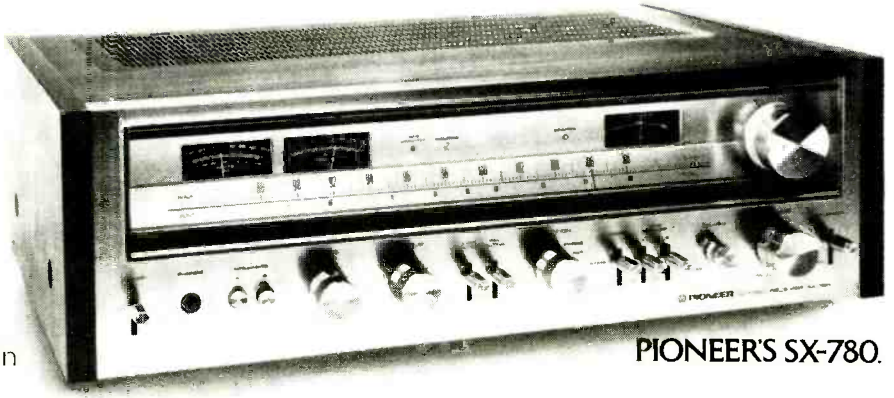

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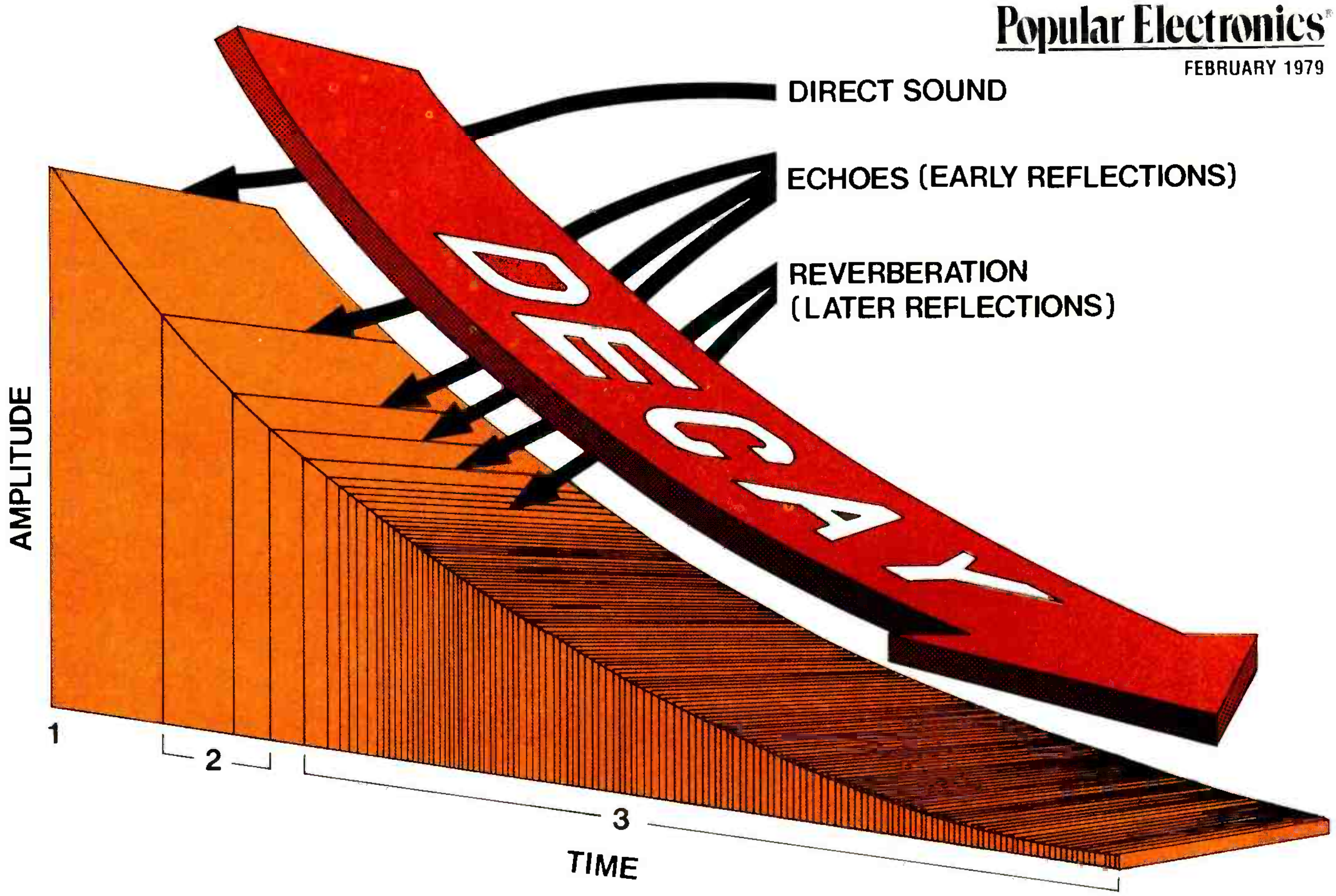


AUDIO "LISTENING-ROOM" EXPANDERS

- How time delay enhances sound reproduction
- Buyer's guide to eight models
- Performance comparisons

By JULIAN HIRSCH
Hirsch-Houck Laboratories

MOST RECORDINGS are unlikely to make you believe you are truly listening to "live" musicians. There are several reasons for this, a major one being that the ambience of a typical home listening environment is totally different from that of a concert hall or night club. In brief, indirect sounds caused by sound reflection and absorption in a large hall are different from those experienced at home. Consequently, one's listening sensation is clearly influenced by room size, room material, etc.

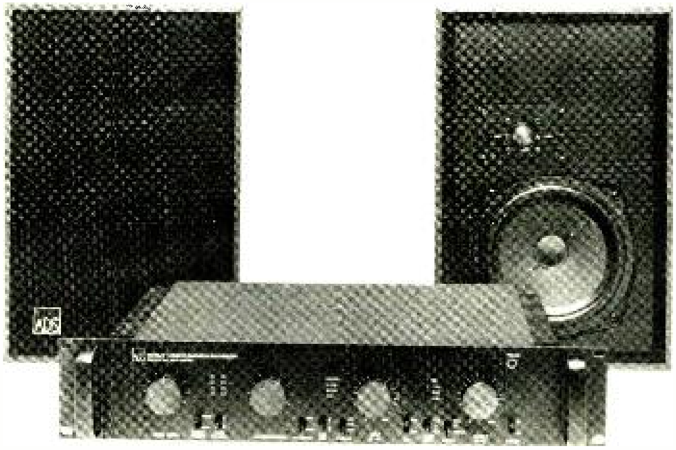
A new crop of audio components designed to apparently expand the size of a listening room insofar as hearing is concerned has aroused much interest among audio enthusiasts. All of these components introduce signal delays to simulate selectable degrees of reverberation, making reproduced program material sound more realistic. Here's a close look at each model currently available to the consumer, with an examination of special features and how well the units perform.

Reflections. The first sound to reach a listener from any point in a room arrives by a direct path. Our ability to localize the source of the sound depends heavily on this direct signal. It is soon followed by a number of reflections from the various surfaces of the room, all of which travel a longer distance than the direct sound. In general, the later arrivals have less high-frequency content than the earlier ones due to absorption by room furnishings and the audience. This combination of reflected and direct sound gives the listener a sense of the size and acoustic properties of the room, as well as his spatial relationship to the sound source. A recording that lacks these reflected or indirect sounds is dead and lifeless, but most do contain at least some of the ambience of the original environment. Ambience is often captured by suitable microphone placement or artificial means. If the latter is done properly, the result is a more pleasing and "natural" sound as compared to a recording of the same material without a satisfactory sense of ambience.

Unfortunately, the program material is usually reproduced in a room that differs drastically from the recording environment. It has its own reflection paths and delay times which are, as a rule, much shorter than those of the original location. The ambience of the listening room thus tends to conflict with the recorded ambience, contributing to the listener's awareness that he is hearing an artificial, "out-of-context" sound. No matter how effectively the ambience of the recording environment is captured, it will not sound natural in another room of very different size and proportions.

One of the most promising solutions

ADS Model 10



The ADS (Analog & Digital Systems) Model 10 Acoustic Dimension Synthesizer is described by its manufacturer as a "third generation" product. Built-in is a power amplifier rated to deliver 100 watts per channel to 4-ohm loads. Rounding out the ADS "package" is a pair of small speaker systems whose properties have been optimized for this application.

The Model 10 is a digital system using a proprietary form of Delta Modulation. Shift registers act as the delay storage elements. It has a choice of four short delays, selected by a STAGE DISTANCE switch. Momentarily toggling this switch up or down from its center neutral position increases or decreases the initial delay time, respectively, as indicated by a series of LEDs on the panel. The LED string is calibrated in feet: 10, 24, 33, and 45 feet. Because sound travels approximately 1 foot per millisecond in air, these numbers also correspond to the delay in milliseconds (ms). A second group of delays, selected in a similar manner with a HALL SIZE switch, are identified as CLUB, SM. HALL, LG. HALL, and CATHEDRAL. These terms are self-explanatory. Each operation of the HALL SIZE switch simultaneously changes two delay times, the ratio of one to the other being a predetermined optimum value.

The instantaneous program level is shown by four LEDs, labelled PEAK, −10, −20, and −40, dB. An input selector switch and level control allow the user to drive the Model 10 with a wide range of available signal levels. So long as one of the dB LEDs is flashing but the PEAK LED is dark, the program level is suitable for correct operation of the system. Other controls govern the output level of the delayed signal, the amount of reverberation introduced, and the STAGE DEPTH (a controlled injection of the delayed signal into the front channels). Toggle switches set the upper cutoff frequency of the delayed channels at 5000, 8000 or 13,000 Hz, and connect either the direct or the delayed signals to the rear speakers.

A unique feature of the ADS Model 10 is its SOURCE AMBIENCE switch. In its MONO position, the delay circuits respond in the normal manner to both stereo and mono input signals. One problem associated with ambience synthesis is the "announcer in a cave" effect. When an amount of reverberation optimum for many kinds of music is used, an FM station announcer's voice sounds as though he was speaking at a great distance in a huge cave. This is most unnatural and disconcerting, destroying the illusion of reality that was created for the music by the time delay system.

ADS has virtually eliminated this problem by providing a mode of operation selected by the STEREO position of the SOURCE AMBIENCE switch. In this condition, the delay circuits respond only to the difference between the input channels (L-R signal). Not only does this give a very pleasing quality to much of the stereo program material transmitted on the FM band, but because announcers are usually located "center stage", the ADS Model 10 does not delay their voices. Rather, it leaves them at front center without the disturbing effect of delay and reverberation. The system is not perfect, but it does greatly ameliorate one of the few "bugs" seemingly inherent in the concept of time delay ambience enhancement.

Separate access to the delayed outputs and the power amplifier inputs can be had via rear panel jacks. Also provided is a pair of outputs, called DELAY 2, which carry the same delay components as the regular outputs, but with a different reverberant pattern that simulates the reflections from the ceiling and rear wall of the concert hall. They can be used to drive a *second* delay power amplifier and pair of speakers, on the ceiling and rear wall of the listening room, for a further enhancement of the overall effect.

A headphone jack mounted on the front panel can drive stereo headphones with a mixture of the direct and variously delayed signal components. Plugging in the phones silences the rear speaker outputs. The power switch of the ADS Model 10 has a gradual turn-on characteristic, that brings the unit into operation over a period of several seconds in order to avoid any transient noises.

The ADS L10 speakers, supplied with the Model 10 system, are small two-way systems with 7" woofers and 1" soft dome tweeters. Each speaker is 5"H x 9.75"W x 6.5"D (38 x 24.8 x 16.5 cm) and weighs 12.5 pounds (5.7 kg).

The ADS Model 10 is completely finished in flat black and measures 15.75"W x 12"D x 3.5"H (40 x 30 x 8.9 cm). An optional set of rack-mount adapters can be installed, making the unit 10" (48.3 cm) wide. It weighs 23.5 pounds (10.7 kg). The price of the ADS Model 10 system is $995.

to this problem was quadraphonic sound. It still is, perhaps, the best solution. In theory, it is possible to capture the ambience of a recording environment in a four-channel recording and effectively reproduce it in a different listening room. The necessary time delays are "built into" the recording and allow the four speakers to recreate the acoustics of the original hall. Some quadraphonic recordings were able to achieve this goal, but recording companies soon began to concentrate on "gimmicks" and flashy effects that, however impressive, were completely unreal and unconvincing. Moreover, one had to pay for a second amplifier and another set of speaker systems. The result has been the rejection of quadraphonics by many people.

At about the same time that quadraphonics began to fade from the high-fidelity market (1976), a few small companies announced the development of time-delay ambience synthesizers. The principles on which they were based had been known for many years, but hardware was not practical until the development of suitable integrated circuits. Their purpose was to delay, electronically, the normal stereo program material (usually by several different amounts to simulate different path lengths) and recirculate the delayed signals sufficiently to approximate the effect of multiple reflections in a hall. When these delayed signals were reproduced through a second pair of speakers, located along the sides or toward the rear of the room, the "spaciousness" of a large hall could be transferred to a much smaller listening room with remarkable success.

These first-generation ambience enhancers were quite expensive, and once the amazement of experiencing their effects had worn off, their limitations became more apparent. Second- and even third-generation ambience synthesizers are now made available to the audiophile by at least seven or eight manufacturers. To varying degrees, they have overcome many of the limitations of the early units, although none is completely free of idiosincrasies. They are still expensive, and because of their inherent complexity will probably remain an expensive "add-on" to a music system. There might be some decrease in cost if delay circuits are incorporated into receivers and integrated amplifiers.

To assess the current state of the art in time delay ambience synthesis, we undertook to compare major consumer models on the market. We were well aware that this would be a very difficult task because of the peculiarly subjective nature of the entire process. Not only are measurements of an orthodox nature difficult to perform, they probably convey nothing about the strengths and weaknesses of the individual units except, perhaps, to an expert in the design of such equipment. The usual numerical test data associated with preamplifiers and power amplifiers really do not tell us much about how these devices sound. Nevertheless, we tried to do more than simply listen to them and evaluate their comparative merits.

Analog vs. Digital. Before examining any specific units, let's consider some of the basic concepts employed in designing them. The two broad classifications of time delay circuits are analog and digital. There are, of course, advantages and disadvantages associated with each. We will first look at the basics of analog delay techniques and then those that are digital.

Analog delay lines in the form of mechanical spring reverb units have been used for many years. In fact, one of the units tested (the Phase Linear Model 6000 Series Two) employs springs to obtain long delay times. State-of-the art analog delay circuits, however, employ electronic circuits in place of springs to overcome certain less-than-ideal performance characteristics usually associated with them.

Contemporary analog delays are built around integrated circuits generally known as Charge-Transfer Devices or CTDs. There are two types of CTDs, each of which is essentially a clock-controlled analog shift register. The first to be developed is commonly referred to as a "bucket brigade." This nickname comes from an analogy to the fire-fighting technique of passing buckets of water from one person to the next to move

Advent Model 500 SoundSpace Control

This is a digital PCM system using RAM storage. The delay time, selectable from 1 to 100 ms in 1-ms steps, is displayed on a large two-digit, seven-segment display whose reading of 0 to 99 is always 1 ms less than the actual delay. To adjust the delay, a spring-loaded SIZE switch is held up to increase delay, or down to decrease it. The delay increments or decrements in 1-ms steps at a rate of about 10 ms per second. Two green fluorescent bar indicators show when the program levels are within the normal operating range of the unit, and red lights flash if an overload occurs. A three-position switch selects one of three fixed input sensitivities to match the levels of the incoming signal.

In addition to the SIZE control, the only control of the Model 500 that requires regular attention is the continuous reverberation adjustment knob. Smaller knobs control volume and the bass and treble tone controls. The treble tone control injects more and more undelayed high frequencies (above 6000 Hz) into the rear outputs as it is advanced from its minimum setting. The response of the delay circuit drops off sharply above 6000 Hz. A three-position switch cuts off the delayed sound, or replaces it with the direct sound, and another switch silences the front (undelayed) program. A rear-panel DELAY switch allows the Model 500 to be used only as a delay device (no mixing or reverberation) whose two channels can be cascaded to obtain a mono delay up to 100 ms. No power switch is included because the unit is intended to be powered by a switched ac receptacle on the associated amplifier or receiver.

The Advent Model 500 SoundSpace Control is finished entirely in black, with contrasting white panel and knob markings. The cabinet and panel are rounded, making the unit look more compact than it really is. Actual dimensions are 15.75"W x 10.75"D x 3.25"H (40 x 27 x 8 cm) and weight is 10.25 pounds (4.7 kg). The price of the Model 500 is $595.

the water over a considerable distance.

In this type of analog shift register, the instantaneous amplitude of the input signal is sampled upon receipt of a clock pulse and is used to charge a small input capacitor within the IC. When the next clock pulse arrives, the packet of charge is transferred via a MOSFET to the following capacitor in the shift register, leaving the first to be subsequently charged by the next sample of the input signal. At the end of the string of capacitors, the sampled analog voltages are recovered (delayed by the time it took them to pass through many hundreds or even thousands of intermediate storage elements) and are smoothed together to reconstruct the original waveform. The total delay time is determined by the number of storage elements in the shift register and the clock frequency.

The second generation of Charge-Transfer Devices has been given the name Charge-Coupled Devices (CCD's). In many respects CCDs are similar to bucket brigades, but instead of passing packets of charge through a string of capacitors, these delay line ICs transfer *bias levels* from one MOSFET to the next. Each sample of the input signal biases a FET at a particular point on its load line, and this bias level is shifted from one FET to the next until it reaches the end of the shift register. The stream of continuously changing bias levels is converted after having been delayed into a reconstructed version of the input signal. In terms of performance, CCD's offer longer delays and higher S/N ratios as compared to bucket brigades. As before, the total delay time depends on the number of storage elements (MOSFETs rather than capacitors) and the frequency of the clock oscillator.

Digital delays use either Pulse Code Modulation (PCM) or Delta Modulation (DM). In both systems, the analog signal is first converted into digital form by an analog-to-digital (A/D) converter, whose output is a group of logic levels that define in binary form the instantaneous amplitude at the moment the waveform was sampled. In DM, the end result of the encoding is a signal that specifies the change in amplitude since the last sampling interval. This information is employed after having been suitably delayed to reconstruct the input signal's waveform.

Once the program has been digitally encoded, the binary information is transferred through a shift register composed of a series of interconnected flip-flops. The transfer is under the control of a clock oscillator; and, as with the analog systems, the total delay is a function of the number of shift register elements and the clock frequency. In some digital units, delay is achieved by storing the binary information in a random access memory (RAM) for a given length of time before being retrieved for further processing.

After the desired delay interval, the digitally encoded signal, whether stored in shift registers or a RAM, is applied to a digital-to-analog (D/A) converter. In a PCM system, the D/A converter recreates an analog version of the input signal directly. In a Delta Modulation unit, the output of the D/A converter is not a replica of the input signal itself, but rather a control signal describing the way in which the input signal has changed. This signal governs the operation of a ramp generator, whose output (after being smoothed by a low-pass filter) is the reconstructed input signal. As a practical matter, all of the commercial time delay units incorporate special precautions to keep the signal-to-noise ratio from being degraded, and to allow circuits with limited range to accommodate signals with a large dynamic range. To this end, all of them have some form of preemphasis and deemphasis, and, in many cases, a compressor/expander (compander).

Adding Ambience. As mentioned earlier, an ambience synthesizer must supply a number of different time delays in order to achieve realistic effects. Most of the models commercially available provide at least two different delays as well as provisions for recirculating them to add reverberation to the sound. This is accomplished by feeding a portion of the output of one channel back to the in-

Audio/Pulse Model One

Audio/Pulse was the first manufacturer to offer a digital time delay to the consumer and its Model One is still in production. It has been joined by the slightly less expensive Model Two, which includes a power amplifier (but no speakers).

The Audio/Pulse Model One employs Delta Modulation and shift register storage elements. Its operating controls might seem to be unconventional but they were designed to avoid the formidable appearance of a large number of knobs and switches without any loss of flexibility. The front panel contains only a row of LED level indicators and two slider controls that adjust the output levels of the delayed channels. The other controls are pushbutton switches mounted along the top front of the unit, inset slightly from the front. To set the input level within the dynamic range capabilities of the unit's A/D converters, one of six interlocking buttons simultaneously reduces the input signal and increases the gain of the stage processing the reconstructed analog signal to maintain a constant output level. A gross misadjustment of these buttons can produce either audible noise or distortion in the rear speakers, but correct adjustment is easily obtained with the aid of the LED indicators.

The Audio/Pulse Model One has four initial time delays, selected from a group of six by a pushbutton switch with SHORT and LONG positions. The available delay ranges from 8 to 94 ms. Delayed signals are recirculated for a time determined by the settings of the five DECAY TIME pushbuttons, which can be energized singly or in groups to produce a reverberation decay of 0.2 to 1.2 seconds. The Model One also has auxiliary outputs that can supply short- or long-delayed signals to additional speakers near the front or rear of the room to form a six- or even eight-channel ambience system.

The Audio/Pulse Model One is finished in black with walnut side panels. It measures 14.5"W x 10"D x 4.5"H (36.8 x 25.4 x 11.4 cm) and weighs 10 pounds (4.6 kg). Its price is $700.

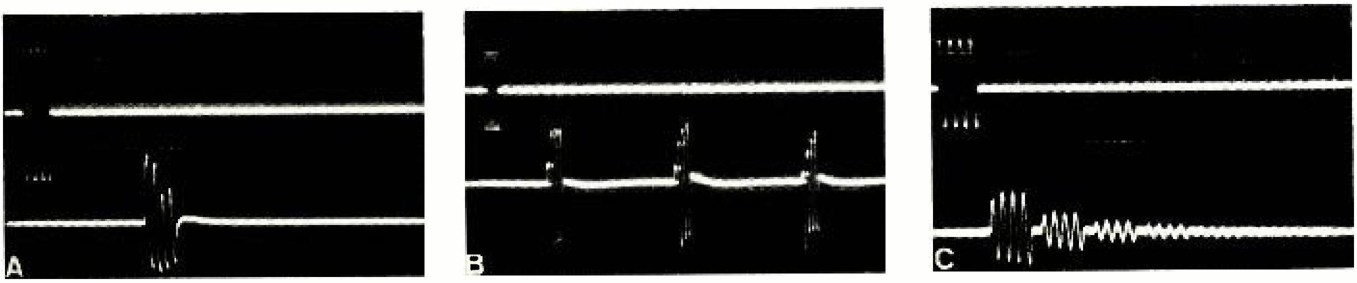


Fig. 1. Typical outputs when a single time delay is introduced (A, horizontal scale is 5 ms/cm), when multiple delays are generated (B, scale 10 ms/cm), and when a single delay is used in conjunction with recirculation to simulate decaying reveration (C, scale 5 ms/cm).

put of the other channel. The result is a decaying reverberation that can take a second or more to fade away, as it would in a real concert hall. Scope traces of typical time delay outputs with one delay, multiple delays, and a single delay interval with recirculation are shown in Figs. 1A, 1B, and 1C respectively. The amount of reverberation that should be added is a function of the original signal, as well as personal taste. A "dry" recording will benefit from considerable reverberation while a "live" sounding recording will be muddied and confused by adding too much.

One fundamental difference between the units we tested is the coherence of their delayed outputs (or lack of it). When a mono signal is fed to both inputs of a delay unit, and the two delayed outputs are in phase, they are said to be *coherent*. Some designers feel that this is a desirable quality, while others hold that there should be no fixed phase relationship between the two delayed outputs. This is based on the assumption that the multiple reflections in a real concert hall do not have any defined phase relationship. Consequently, some of the delay units contain "randomizing" circuits that give completely random phase between the two outputs. Oscilloscope traces of coherent, partially coherent, and noncoherent outputs are shown in Fig. 2.

Connecting an ambience enhancer to a stereo system is a fairly straightforward process, and all are treated in the same manner. The best place to connect them is between the preamplifier output and the power amplifier input so that the preamplifier's volume control will affect all output signals. This point is accessible in many receivers and integrated amplifiers. The time delay unit provides both front- and rear-channel outputs. The front-channel signals are returned to the power amplifier inputs of the integrated amplifier or receiver. In most models they pass through a straight-wire connection, though in some cases there is an active stage in which some of the delayed signals can be mixed with the front-channel signals.

The rear (delayed) channels require a separate stereo power amplifier, but not one with elaborate control facilities. Its power output, as a rule of thumb, should be roughly one half that of the "front" amplifier. In a few of the units we tested, the power amplifier is built in. However, those audiophiles who have a spare amplifier on hand will not accord this feature as much weight as those who don't. The delayed channels also call for an additional pair of speakers, whose optimum placement and performance characteristics are a matter of debate among users of time delays.

It is most generally held that the rear speakers should be along the side of the room, preferably in front of the listener. Wherever they are placed, it is most important that they are not heard as distinct sound sources (sometimes placing them at a wall/ceiling junction, or on the floor facing upward, will produce the most suitable results). To further ensure that the rear speakers cannot be aurally localized, wide dispersion is desirable. Extended frequency response is not needed, because most of the time delay units have restricted high-frequency response. This corresponds to the reduced high-frequency content of natural reverberant signals. One of the most interesting subjective effects of time delay ambience synthesis is its apparent enhancement of the audio system's bass response. It also makes the overall program sound louder, without in itself having much real bass or contributing much to the acoustic output of the system.

At least two of the manufacturers who build power amplifiers into their time delay units also supply speakers with the system, but the units can be purchased without speakers if desired. In general, the systems we tested are priced very comparably when allowance is made for the cost of an amplifier and pair of speakers. Although some of the accessory delay units have a full complement of controls, the system will, after initial set-up, normally be controlled entirely by the main stereo preamplifier or integrat-

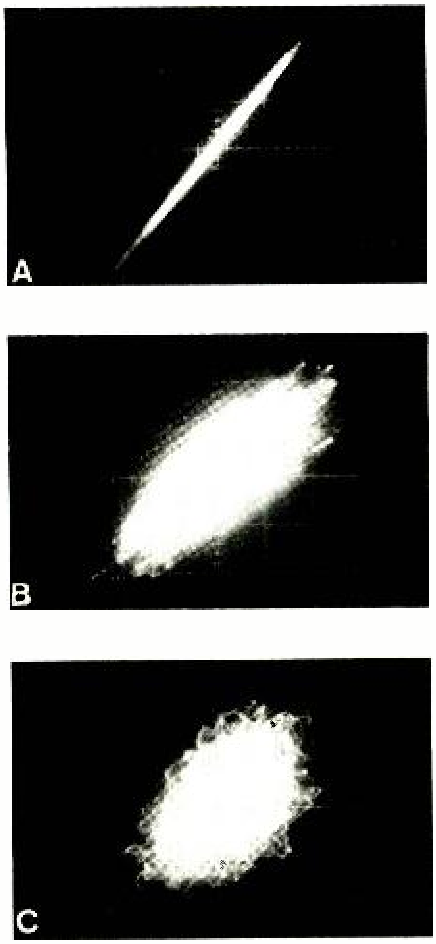


Fig. 2. Some time delay components have coherent (in-phase) outputs (A) as in Bozak Model 902. Others, such as the Advent Model 500, are partially coherent (B). Still others, such as the Audio/Pulse Model One, are noncoherent (C).

ed amplifier. Once the controls of the time delay unit have been set for the desired effect, they will need re-adjustment only to accommodate different types of program material. One of the inherent disadvantages of time delay ambience synthesis is that the optimum amount of delay and reverberation is not the same for all types of program material, so a certain amount of fussing with the controls will be necessary when shifting from one type of material to another.

Having examined the basic operating principles of both analog and digital time delay units, the reader should take a close look at each of the eight products available to our test lab, as they are described in the accompanying boxes.

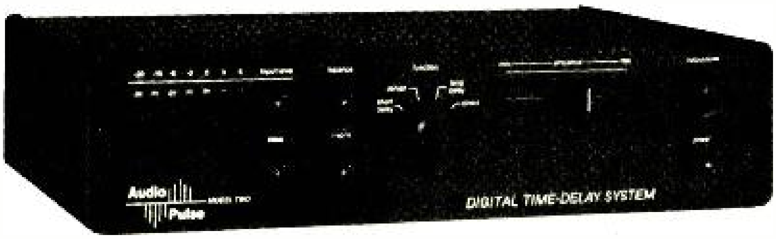
Test Procedures. The data supplied by the various manufacturers, either in the form of specifications or actual measurements, ranged from virtually nothing (SAE) to extremely complete test information (from ADS). Rather than attempt to duplicate their figures, we preferred to accept any manufacturer's rating as valid (especially since almost all of the information would be difficult for anyone not highly skilled in the techniques involved to understand or interpret).

We limited our measurements to frequency response under various delay and other operating conditions, and in most cases, the output noise and distortion. Driving one input with a 4-cycle burst of 1,000-Hz sine waves, we examined the delayed and reverberated outputs on an oscilloscope, to see how densely the delayed and reverberated pulses were "packed" or if the burst shape was altered materially. One of the more informative tests was to drive both inputs from a pink noise source, and connect the two delayed outputs to the X and Y axes of the scope. This shows whether the delayed outputs are coherent, partially coherent, or completely phase randomized.

Perhaps the most meaningful test one can make on an ambience synthesizer is to listen to it, to hear what it does *to* and *for* the sound, and to learn how easy it is to adjust for most pleasing results. Although this is completely subjective, it is still possible to compare different units in listening tests. The ADS Model 10 comes with its own amplifier and speakers, and was set up in a different room where it could not be compared directly to the others. The Bozak Model 902 was made available to us for only a few hours, so our evaluation was very brief. However, we bypassed its power amplifiers and did not use its speakers so that its delay circuits could be evaluated on a more or less even basis with the other models.

For a listening comparison, we set up all the time delay units with their inputs in parallel, driving them with the same preamplifier. Their delayed outputs were connected to high-level inputs of an integrated amplifier that drove our rear speakers (a pair of AR-7's, mounted at the wall-ceiling boundary). The front speakers were usually AR-LST's, although some other types were also used. We tried to adjust the time delay units for roughly similar operating conditions, but this was not really possible because they each have different combinations of delayed signals and many are not calibrated. We did match their rear

Audio/Pulse Model Two



This unit was received too late for complete testing, but was set up for comparative listening tests with the other units.

A second-generation time delay, the Model Two employs some of the circuitry of the Audio/Pulse Model One, especially its "delta modulation with memory" used to convert the analog input signal to digital form. However, storage of the digital information is accomplished with a RAM rather than shift registers as in the Model One. Furthermore, the Model Two has built-in power amplifiers rated to deliver 25 watts per channel into 8-ohm loads from 40 to 8000 Hz with no more than 0.5% THD. The power bandwidth of this amplifier is much more restricted than that of even a modest contemporary component amplifier. It must be remembered, however, that the upper cutoff frequency of the delayed channels is only 8000 Hz so the limited bandwidth of the amplifier section does not compromise the performance of the unit as a whole.

In appearance, the Audio/Pulse Model Two is more like other second-generation delay units and bears little external resemblance to the Model One. It is about the same size as the Model One (but an inch lower in height), finished in flat black, with rounded corners on the cabinet. Its general styling is not unlike that of the Advent Model 500. In place of the pushbutton switches used in the Model One, the Model Two has knob controls for most of its functions. A row of LEDs to monitor input level is used in conjunction with an INPUT LEVEL potentiometer. This control is not ganged with an output level control (as is accomplished by the pushbutton system of the Model One), so it is necessary to readjust the OUTPUT LEVEL control when the input level is changed. Bass and treble tone controls affect only the delayed signals. Once adjusted to suit the requirements of the delayed channel speakers and the room layout, they need not be changed. The operation of the unit is governed by a main FUNCTION control, a four-position switch marked SHORT DELAY, DEFEAT, LONG DELAY, and DIRECT. In the SHORT DELAY mode, the signal undergoes initial delays of 19, 33, and 51 milliseconds. The LONG DELAY mode gives delays of 39, 66, and 103 milliseconds. In DEFEAT, the delayed outputs are silenced, and in DIRECT, they are driven with an undelayed signal. Like the Audio/Pulse Model One, the Model Two has incoherent outputs, bearing a random phase relationship to each other.

The remaining major control is a horizontal slider marked AMBIENCE. This adjusts the mixing weights of the fully and partially delayed signals as they are recirculated through the system. At MIN, the shorter, partially delayed signals are emphasized, but at MAX the fully delayed ones are emphasized and maximum reverberation is added. The rear apron of the unit accommodates circuit breakers which protect the rear-channel speakers. The INPUT phono jacks accept a signal from the preamplifier output or a tape monitor loop. Two jacks carry an unmodified front channel signal back to the main amplifier and a DIN socket is provided for driving the Audio/Pulse Two from the front speakers if this is more convenient. Finally, delayed outputs are furnished for driving an external power amplifier if more power than is available from the built-in amplifier is required.

The Audio/Pulse Two is 15"W x 10½"D x 3½"H (38.1 x 26.7 x 8.9 cm). It weighs 14 lb (6.4 kg). The price is $539.

channel levels, however, by switching off the front speakers and listening to the delayed outputs as we switched from one unit to another. Also, a cassette recording was made of the delayed output of each unit, using the same program material under various adjustment conditions, so that we could hear the delayed sounds of all the units under controlled conditions.

For the most part, however, we simply listened to records and FM broadcasts, selecting one or another delay unit to see how they could be adjusted to enhance the sound (or how they could degrade it if incorrectly adjusted). This procedure took several weeks, and left us with some fairly solid conclusions and many more unanswered questions.

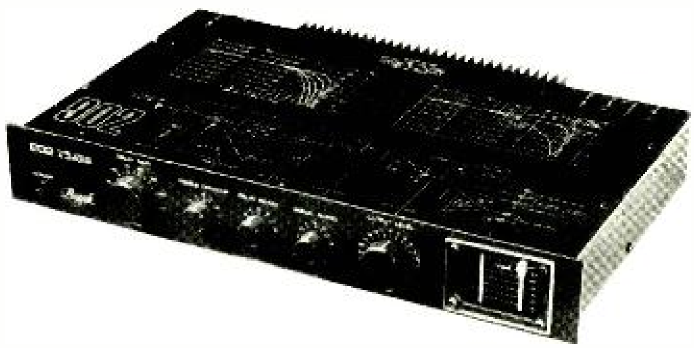
Test Results. The test data (see Table) shows that, for the most part, the frequency response ratings of the delay circuits of the tested components are quite accurate. Signal-to-noise data is less easily correlated with published ratings because most are based on A weighting, which reduces the output noise voltage below our 100-microvolt minimum. (−80 dB re 1 volt). Also, the noise of most units varies somewhat with different control settings. The important thing to know about their S/N performance is that noise cannot be heard in the output of any of the tested units when operated in accordance with the manufacturer's instructions. It is not even possible to operate most of them incorrectly in this respect. (The Audio/Pulse Model One *can* be set up so that hiss can be heard, but it requires a deliberate effort.)

The measured THD in the delayed outputs varies over a wide range, from a small fraction of a percent to about 2 percent at a 1-volt output level. This is of no practical significance because the sound from the rear speakers is never heard as a separate source if the system is adjusted correctly. Furthermore, the distortion is composed entirely of low-order components and thus is not audibly offensive even when one listens only to the delayed channels.

Two genuine points of distinction can be seen among the tested units, however. The upper frequency limit of the delayed sound varies from a few thousand to 13,000 Hz. In the analog delay lines, the highs roll off appreciably as delay is increased, although this can be compensated for with suitable circuits as in the Sound Concepts SD550. The digital systems have a constant bandwidth *independent* of the delay setting. They do not necessarily have *wide* bandwidths, merely constant ones. The Advent Model 500, for example, has a fixed 6000-Hz bandwidth, and the Audio/Pulse Model One has a fixed 7000-Hz bandwidth. The ADS Model 10 has an impressive 13,000-Hz bandwidth at its maximum setting. ADS does not suggest using the full bandwidth of its unit on any but the finest program material, and in practice there seems to be little reason to go above 8000 Hz or so in light of the spectral content of the naturally occuring reverberant signals sought to be recreated.

The coherence of the delayed channels varies from being fully in-phase as is the case with the Sound Concepts, SAE, and Bozak units through partially random in the Advent to fully random in the ADS, Audio/Pulse, and Phase Linear models. Each of these companies claims that *their* approach is the most correct one, so it is difficult to be dogmatic about the matter. Logically, it would seem that multiple reflections will never be in phase on both sides of the room, suggesting that a coherent-output device is inherently incapable of simulating real concert-hall ambience. Offsetting this is the fact that the program material on one stereo channel is not in phase with respect to that on the other (if it were, the program material would be monaural), so that even a "coherent"

Bozak Model 902



The Bozak Model 902, which includes a 35-watt/channel power amplifier, is a second-generation product from that company. Its delay is derived from the latest type of analog shift register, a charge transfer device capable of longer delays and much better signal-to-noise characteristics than the original CCD (charge-coupled device) bucket brigades. The delay time is continuously variable by a large front-panel knob from about 20 to 120 ms. Another control of the same size adjusts the output level. The other controls are slightly unconventional but highly effective.

A small SIGNAL BLEND control provides only delayed signals to the speakers at its extreme clockwise setting, and only undelayed (direct) signals at its fully counterclockwise position. Between these extremes, it varies the mix of direct and delayed sound to the rear speakers in "pan pot" fashion. Reverberation is governed by a DELAY REMIX control which gives a smooth transition from a rather "dead" sounding room to one that is very "live". The TREBLE CONTOUR control boosts or cuts the high-frequency response of the delayed channels to suit one's taste. At a 25-ms delay, the response of the delayed channels is flat to about 6000 Hz, decreasing to approximately 2000 Hz at 120 ms.

A novel level monitor at the right of the panel spans about 40 dB in two 20-dB ranges. It is an auto-ranging LED bargraph display whose scales shift automatically with changes in input level. The level in each channel is seen as an expanding and contracting vertical red bar whose height is calibrated by an adjacent scale. A 0-dB reading is the maximum recommended input, and the word CLIP appears on the display if that value is exceeded.

The Model 902 has a built-in power amplifier rated at 35 watts per channel into 8-ohm loads. It is supplied with a pair of Bozak Model DS1800 speakers, which are compact floor-standing units having upward-radiating, essentially omnidirectional outputs. Low-level delayed outputs are also available at panel jacks for use with another amplifier. The delay circuits are also packaged without the power amplifier and speakers as the Model 901.

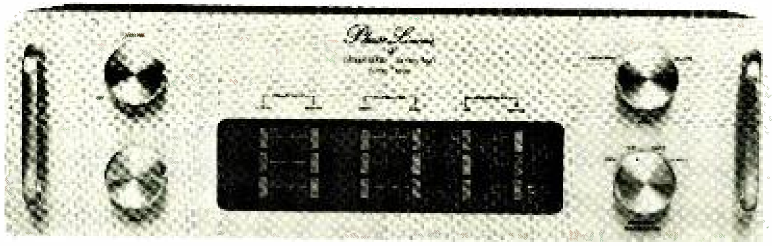
The Bozak Model 902 is finished in black, with its basic performance curves and a functional block diagram screened in white on its top cover. It measures 17¾"W x 11¾"D x 2½"H (45 x 29.8 x 6.4 cm) and weighs 14¼ lb (6.5 kg). The price of the complete system, including speakers, is $975. The Model 901 Delay Unit alone (less amplifier and speakers) is $625.

delay unit would have random phase between its delayed outputs. Probably, the distinction between these types of systems will be apparent only in the way they treat mono programs, and our listening tended to confirm this.

One cannot help wondering about the amplifier power requirements of the delayed channels. Bozak's amplifier is a modest 35-watt/channel (into 8 ohms) unit, but ADS can deliver 100 watts per channel into 4-ohm rear speakers. Does this seem reasonable in view of the fact that the rear speakers are never to be audible as sound sources? Yes, because they are usually played at only slightly lower (perhaps −3 to −6 dB) levels than the front speakers. They are not heard directly because of the Haas effect, which causes us to localize the sound from its first arrival at our ears. This leaves no doubt where the sound is coming from (the front speakers), and the sound from the delay speakers arriving a number of milliseconds later merely adds ambience and is not sensed as the same program. (If the direct sound is fed to the rear speakers, the change is dramatic, yet the power level of the rear channels might not change at all.)

Conclusions. We come now to the specifics of our evaluation of time delay ambience enhancers. Ultimately, opting to add ambience enhancement and the

Phase Linear 6000 Series Two



This unit employs analog bucket-brigade devices as well as mechanical (spring) delay lines for long reverberation times of up to 4 seconds. Most of its control operations are handled by eighteen pushbutton switches grouped functionally. Large knobs control the front and rear speaker volume (separately), the application of either direct (undelayed) or delayed signals to the rear speakers, and select one of four rear-channel, frequency-response characteristics. In addition to a nominally flat response, the switch provides LO or HI CUT response or both simultaneously.

The Phase Linear unit has two primary delay times, one 15 or 20 ms and the other 60 or 90 ms, depending on the clock frequency. Each is selected individually, with a choice of three signal levels (+3, 0, or −3 dB). There are two groups of recirculated signals, identified as SHORT and LONG (signifying that they have been recirculated through the 15- or 20-ms or the 60- or 90-ms primary delay register, respectively). The levels of the recirculated signals can also be set at +3, 0, or −3 dB.

The REVERBERATION controls affect the signals that are passed through the mechanical delay line. The SOURCE buttons derive the inputs to the reverberation section from either the SHORT or LONG primary delay registers, and the MASTER CLOCK pushbutton changes the clock frequency by about 20%. This affects all time delay functions in the Model 6000 and is thus a fine adjustment for the entire delay circuit. Taps on the mechanical delay line are selected by the TIME pushbuttons, giving reverberation times of 1, 2, or 4 seconds. There are no overload or other level indicators on the Model 6000, but its dynamic range is sufficient to accommodate the normal output of a preamplifier.

The Phase Linear Model 6000 is styled to match other Series Two Phase Linear components, with a pale gold panel and matching knobs. It is 19"W x 10"D x 5.5"H (49.3 x 25.4 x 14 cm) and weighs less than 20 pounds (9.1 kg). The price of the Model 6000 is $600.

Measured Performance

Model	HF response @ −3 dB re 1 kHz (kHz)	S/N unwtd re 1 volt output (dB)	THD @ 1 V. output (%) 1 kHz	Input volts operating range	Coherent delay outputs	Comments
ADS	12.2	66	0.14	NA	No	Built-in Amplifier (100 W/channel into 4 ohms)
Advent	6 (undelayed can be boosted to +11 dB in rear outputs)	72	0.3	0.015-3.0	Partial	
Audio/Pulse Model One	7 (CONTOUR can boost 10 dB in 40-60 Hz)	54-63	NA	NA	No	
Audio/Pulse Model Two	NA	NA	NA	NA	NA	
Bozak	7.7	60 (more than 80 with A-wt)	0.5 @ 0.25 volt out (1 v. in)	0.03-1.75	Yes	Built-in amplifier (35 W/channel into 8 ohms)
Phase Linear	4.5 SHORT	More than 80	2 @ 1v 0.45 @ 0.3v	3 max.	No	
SAE	5	57-60	0.2 @ 1.8v. Much higher at LF	0.08 or more	Yes	High regeneration puts large 400-Hz component in output
Sound Concepts	8	70	0.8	NA	Yes	

choice of a particular model are subjective decisions. Our experience with these devices has convinced us that conventional measurements and specifications are of little or no value to an audiophile making a choice from among these products. If the usual undesirable contributions of distortion and noise cannot be heard (and they cannot, by any stretch of the imagination, in any of the units we tested), then all that is left that should influence the choice is their combinations of available time delays and reverberation, and to some extent their delay-channel frequency response properties.

We suspect that a multiplicity of delay times might give a more realistic simulation of concert hall sound than a simple single delay plus reverberation. This is probably true, yet nothing in our experience convinces us of that fact. Plainly put, every one of the tested units is capable of providing a *tremendous* enhancement of the natural qualities of sound. A good time delay system can do more to improve the realism of home music reproduction than any other $1000 investment we can imagine (assuming that one already has good front-channel components).

The other side of the coin is that virtually every one of the units tested can also create a terribly unnatural, obviously artificial sound when misadjusted. Some are more capable of such misadjustment than others. This should not be held against them because they can just as easily be adjusted correctly. For example, the Phase Linear Model 6000 can be set to give bizarrely long

SAE Model 4100

This component is so new that specifications and a complete instruction manual were not available when we received the unit for evaluation. The preliminary instruction manual, apart from a basic description of the unit's controls, told us only that the Model 4100 has three separate delay times, labelled SHORT, MEDIUM, and LONG roughly corresponding to delays of 10, 30 and 50 ms.

Except for three pushbutton switches, all controls are horizontal slider potentiometers. A DIRECT pushbutton feeds the input signal, undelayed, to the rear outputs when it is engaged. When the switch is disengaged, the rear outputs furnish the delayed signals. The Model 4100 is designed to be compatible with quadraphonic systems and has input jacks for externally derived rear-channel signals.

Pressing the DISCRETE pushbutton routes the externally derived rear input signals directly to the output jacks, allowing full quadraphonic operation if the unit is connected to a four-channel system. Finally, the BLEND pushbutton injects some delayed signal into the front channel outputs to improve ambience when listening to some types of closely miked program material. For normal ambience enhancement, all three pushbuttons are left in their OUT positions.

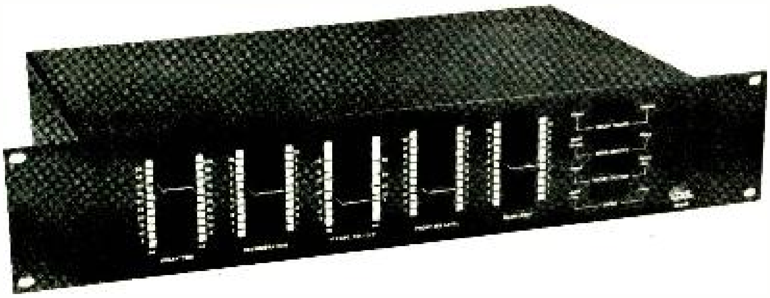
An INPUT LEVEL slider matches the unit's sensitivity to the incoming program material with the aid of a red PEAK LED. Once this control has been adjusted so that the LED does not flash on the loudest program peaks, there is usually no need for further adjustment. Each of three delay circuits has its own level control slider, and the outputs of the three are added according to the settings of the SHORT, MEDIUM, and LONG level controls. The REGENERATION slider governs the amount of delayed signal that is recirculated through the delays to produce a reverberative effect. The final control is an OUTPUT LEVEL adjustment. Because the three delayed signals are summed, any substantial change in the summer control settings may require readjustment of the output level control which affects only the delayed channels.

The SAE Model 4100 has distinctive SAE styling with a black cabinet and walnut side panels. It measures 15.75"W x 8.4"D x 3"H (40 x 21.3 x 7.6 cm) and weighs approximately 7 pounds (3.2 kg). The price of the Model 4100 is $500.

Manufacturers' Specifications

Model	No. of initial delays	Range of initial delays (ms)	Longest delay (ms)	Reverb. time (s)	Input sens. range (volts)	S/N (dB)	Delay bandwidth (kHz)
ADS	3	10-40	100	0-1.6	0.75-3	80	13
Advent	2	1-100	100	NA	0.3-3	80	6
Audio/Pulse Model One	4	8-94	94	0.2-1.2	0.14-2	65	8
Audio/Pulse Model Two	3	19-103	103	0.1-0.6	0.05-3.3 V (low) 1.2-60 V (high)	72	8
Bozak	1	20-120	120	up to several	NA	NA	7.7
Phase Linear	2	15-90	90	0.2-4	2.5 max	94	6 (short) 2.5 (long)
SAE	3	10-50	50	NA	NA	NA	NA
Sound Concepts	1	5-50 (100 in mono)	50 (100 in mono)	NA	NA	85	8

Sound Concepts Model SD550.



One of the early time delay devices for home music systems was a Sound Concepts product, and the current Model SD550 is a second-generation device. A bucket-brigade delay system, it is designed for use with four-channel as well as stereo systems. Its operation is controlled by five sliders and a group of four rocker switches. A DELAY TIME control has a calibrated range of 5 to 50 ms. The REVERBERATION slider calibrated over an arbitrary range of 0 to 10, governs the amount of signal injection from the delayed output of one channel to the input of the other.

The high-frequency response of any bucket-brigade system drops off rapidly as delay time increases. Fortunately, this effect is consistent with the natural increase in absorption of highs as one moves back in a concert hall and longer delays are involved. It therefore does not result in any unnatural or grotesque effects. Nevertheless, one school of thought holds that wide bandwidth is desirable or even necessary in the delayed channels, and Sound Concepts has provided a means to achieve this result. The HI FREQ ROLLOFF slider is calibrated in decibels from +6 to −3 dB, and has a separate scale of 5 to 50 matching the delay time scale. When it is set to correspond to the delay in use, the high frequencies are boosted to maintain the frequency response out to approximately 8000 Hz, where it is down 3 dB nominally.

A FRONT MIX LEVEL slider controls the amount of delayed signal that is injected into the front outputs of the SD550 and a REAR LEVEL control governs the overall output of the delay channels.

The DELAY RANGE rocker switch parallels the two input channels and cascades the delay channels to provide a mono output delayed up to 100 ms. The REAR OUTPUT switch routes either the delayed channels or the back channels of a gradraphonic system to the rear outputs. A DELAY MIX rocker switch allows the delayed outputs to be injected into the front channel outputs to a degree determined by the setting of the FRONT MIX slider control. The INPUT switch enables the delay processing to be applied to the usual stereo or mono input signals or to the front channels of a quadraphonic system. Sound Concepts suggests that the latter alternative will often given a more natural result than that obtained using a standard four-channel decoder.

The Sound Concepts Model SD550 is exceptionally noncritical in its level requirements. Included is a 2:1 compander that reduces internal noise to negligible levels. There is no risk of overloading it from any normal preamplifier output signal. In fact, the unit has no obvious level controls, unlike most other ambience enhancers. Actually, there are two screwdriver-adjustable input level controls in the rear, together with overload LEDs, but they are preset and it is best not to disturb them.

The delay unit is finished in flat black, measures, 15.5″W x 9″D x 3.5″H (39.4 x 22.9 x 8.9 cm) and is also available with a rack mounting panel 19″ (48.3 cm) wide. It weighs 7 lb (3.2 kg) and is $675.

reverberations which are intolerable with most kinds of music. With some choral works, however, the effect is uncannily like "being there". At the other extreme is the ADS Model 10, which is the most subtle of the group in the nuances of its sound modifications. It is difficult to make anything sound really wrong through this unit, the only one to have solved, at least partially, the "announcer in a barrel" sound effect.

If all these units work so well, and sound so much alike, are there any real distinctions to be made between them? Yes, indeed, but first let it be said that they do *not* all sound alike. True, most of them sound more alike than different, but the one that could never be mistaken for any other is the Phase Linear. Its drastic loss of highs and general emphasis on mid-bass output make it sound extremely muffled and heavy when heard without any contribution from the direct channel. Nevertheless, when used as a time-delay device, its sound is not as objectionable.

The *real* distinctions are in the area of human engineering. That is, how easy or difficult the units are to set up and adjust for the desired effect. Here we have some definite conclusions, although they must be qualified as being purely subjective.

The easiest and most logical time delay device to adjust and use, without question, is the Advent Model 500 SoundSpace Control. The single-lever SIZE control, and the small REVERBERATION knob, are the only controls that must be touched on this unit, once the initial installation has been made. The unit is so noncritical in matters of level adjustment that we consider it to be close to a "set and forget" device. In spite of this, it has all the flexibility most would ever want, and sounds superb.

The most refined and sophisticated of the group (referring to its capabilities, not necessarily its internal design) is the ADS Model 10. It has, in our view, an overabundance of controls, most of which have such subtle effects that we frequently could not detect them. They do give the panel a cluttered appearance, in spite of the use of miniature toggle switches for many of them, and we never could manage to handle the unit without accidentally disturbing the setting of something. This complexity is offset to a great extent by the superior sound from the Model 10. It was especially impressive on mono discs, which acquired an ambiance that put to shame most current stereo records when they were played through the time delay system. Also, the speakers of the Model 10 are small, unobtrusive, and deliver an excellent sound quality.

Although we had a very limited exposure to the Bozak Model 902, we could see that it is one of the simplest to use, and probably comes close to the Advent 500 in that respect.

The Audio/Pulse Model One has been a part of one of our music systems for some time. Its performance as a time-delay device is first rate, but the need to reset the input level switches every time a large change in signal level occurs is disconcerting. Also, operating the decay-time and level pushbuttons can sometimes introduce an audible "twang" in the sound.

With respect to sound quality and delay effects, the Audio Pulse Model Two appears to be very comparable to the Model One and several other delay units. That is, it can give a very satisfying sense of ambience or can be set for an exaggerated and unnatural echo sound or any condition in between.

The major difference from the Model One, from the user's standpoint, is the vastly simplified operating control configuration of the Model Two. It is effectively almost identical with the Advent unit in its control complexity and ease of use, except that the level indicator LEDs of the Audio Pulse give the impression of requiring more frequent level adjustments as program conditions change. Because the output level must be adjusted at the same time, this is rather awkward compared to the three-position input sensitivity switch of the Advent, which hardly ever requires attention. However, we found the setting of the sensitivity to be much less critical than that in the Model One; and so long as some of the green LEDs are flashing, noise in the output is inaudible.

Considering the substantially lower price of the Model Two compared to the Model One, and its greatly simplified operation and built-in amplifier, it is clearly an outstanding value. To our ears, it was not quite as undetectable in operation as the Advent or ADS units, but the difference was slight.

The Sound Concepts SD 550 has also been in use here for some time, and we find it to be one of the easiest to set up. Not only does it not make any noise, but we have yet to be able to flash its rear-mounted overload lights. Despite its relative simplicity as to the number of available delays and their processing, it sounds natural so long as maximum reverberation is not used. This can introduce a "boing" sound sometimes.

The SAE Model 4100 is especially interesting because of its price which is appreciably less than the others. It has all the versatility one would desire and sounded, for the most part, as good as any of the other units in our comparative tests. On the human-engineering side, we suspect that a proper instruction manual would overcome most of our objections. We set the controls by guesswork, and could not fault the results. Our two criticisms deal with first the manner in which the three delay signals are summed, which affects the overall volume of the delayed sound when the delays are changed, and second the regeneration control, which can produce a hard, "twangy" sound when set too high. If its setting was limited to the lower half of its range, it sounded fine. We note also that, although it is a bucket-brigade unit, the delays are fixed and apparently compensated for a uniform frequency response, thus, the upper frequency limit remains about 5000 Hz no matter where the level adjustments are set.

Finally, we come to the Phase Linear Model 6000. We are "turned off" by the prospect of punching our operating conditions into a panel of eighteen pushbuttons. In fairness, it is not as difficult to use as it seems, once one has had some practice, but it is still the least convenient of the group to operate. We also find its lack of highs sometimes noticeable and objectionable. Although the unit has a knob that can reduce the highs, we cannot imagine the need for this. Rather, it could use a considerable treble boost. Perhaps the ease with which the Phase Linear can be set to give unnatural effects was another factor that influenced our reaction to it.

Whatever type of time delay device is used, the most important thing to remember is "IF YOU CAN HEAR THE REAR SPEAKERS, THEY ARE TOO LOUD!!!" The delayed volume can be turned up until it is audible, and then backed off until the rear channels can no longer be heard as distinct sound sources. Check by shutting off the rear speakers. (Many of the delay units have a switch for this. It can be done at the amplifier.) If the level is correct, shutting them off will cause the sound to contract to the front, becoming dull and comparatively lifeless. Restoring the ambience will make you wonder how your ever got along without it! ◇

For More Information:

ADS
1 Progress Way
Wilmington, MA 01887

Advent Corporation
195 Albany St.
Cambridge, MA 02139

Audio/Pulse, Inc.
Bedford Research Park
Crosby Drive
Bedford, MA 01730

Bozak, Inc.
P. O. Box 1166
Darien, CT 06820

Phase Linear Corporation
20121 48th Ave. West
Lynnwood, WA 98036

Scientific Audio Electronics, Inc.
P. O. Box 60271 Terminal Annex
Los Angeles, CA 90060

Sound Concepts, Inc.
P. O. Box 135
Brookline, MA 02146

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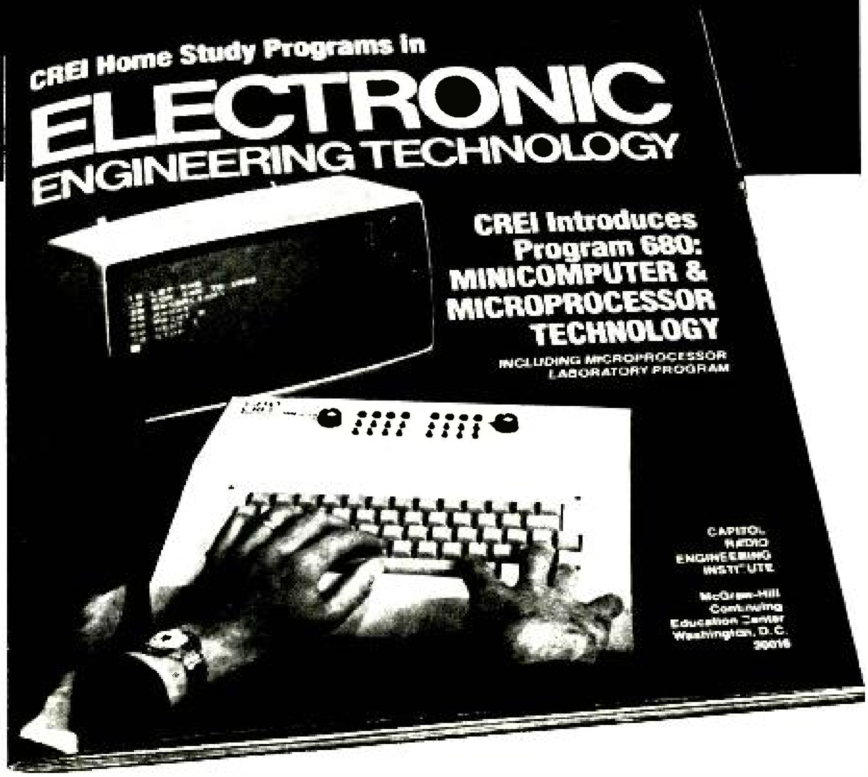

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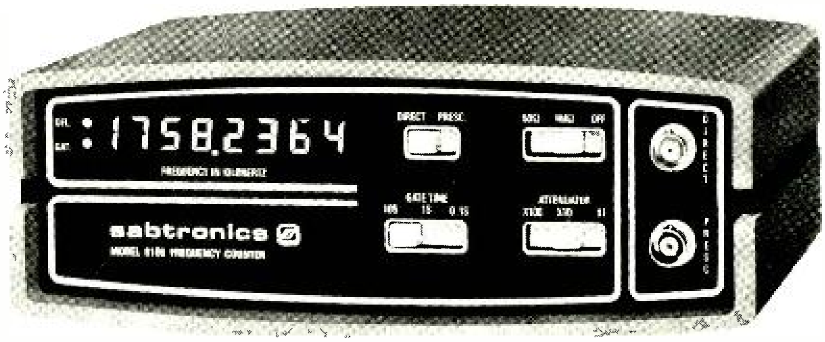

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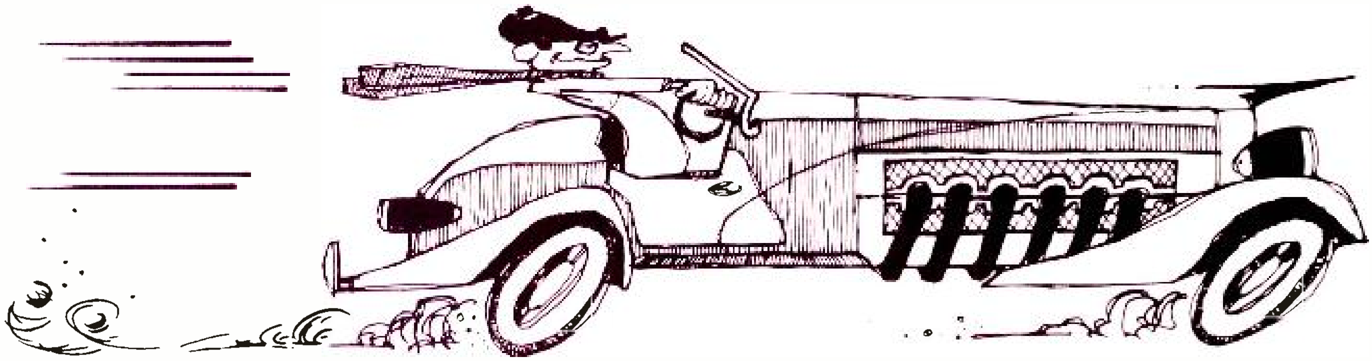
BY ROBERT P. BISEY

BUILD "CRUISEALERT" A 55 MPH SPEED-LIMIT ALARM



Automobile add-on device for highway safety

TO STAY within the 55-mph national highway speed limit, one must keep one eye on the road and the other on the speedometer. This can be a dangerous situation at highway speeds when your whole attention should be fixed on the road. It would be far safer, therefore, if you could keep a constant eye on the road and have some audible means for alerting you when you have exceeded the speed limit. This is exactly what the "Cruisealert" described here was designed to do.

The Cruisealert works on the principal that, with a given vehicle, there is a close relationship between engine rpm and road speed. It constantly monitors engine rpm and is preset to sound an alarm when engine rpm reaches a value that causes your vehicle to travel at 55 mph (or some selected lower speed). When this happens, the Cruisealert sounds a beeper to alert you that you are at the legal speed limit. At no time do you have to take your eyes from the road. And the Cruisealert can be used with 4-, 6-, and 8-cylinder engines.

Circuit Operation. A schematic diagram of the Cruisealert is shown in Fig. 1. Components *R1*, *R2*, *C1*, and *D1* both filter and clip the raw signal coming from the engine's distributor contacts. Resistor *R1* and capacitor *C1* form a single-stage low-pass filter that has a time constant of about 1.5 ms, which is long enough to provide smoothing for the transient, oscillatory-like waveforms present at the points. The frequency range is between 40 and 170 Hz, which approximately corresponds to a four-cylinder engine at a road velocity of about 30 mph and an eight-cylinder engine at approximately 70 mph.

Zener diode *D1* clips the input voltage swing to approximately +7 and −0.7 volts, suitable for use by the following circuitry.

Positive-edge retriggerable monostable multivibrator *IC1A* functions as a frequency discriminator, while *IC1B* forms the annunciator section. The filtered and limited signal from the input filter is applied to *IC1A* via input current limiting resistor *R2*. This portion of the dual multivibrator is arranged to deliver an output pulse at pin 6 when triggered by a positive spike. The pertinent waveforms for *IC1A* are shown in Fig. 2.

Resistors *R5* and *R6*, potentiometers *R12* and *R7*, and capacitor *C3* control the on time (T_{on}) of the multivibrator. For the three relationships shown in Fig. 2, the on time of *IC1A* remains constant, regardless of the input frequency, while the off time (T_{off}) changes with the input frequency. As the input frequency increases and approaches the threshold frequency of the multivibrator, T_{on} remains constant while T_{off} diminishes. At the critical threshold frequency, T_{off} diminishes to zero. The resulting output is a constant logic 1 as shown in Fig. 2C.

Diode *D3*, resistor *R13*, and capacitor *C5* form a negative-going integrating pulse detector. As long as the cathode of *D3* (pin 6 of *IC1*) remains at logic 0, *C5* remains fully charged.

For all input frequencies lower than the threshold frequency of the multivibrator, a negative-going T_{off} signal appears at pin 6 of *IC1A*, which forces *C5*'s

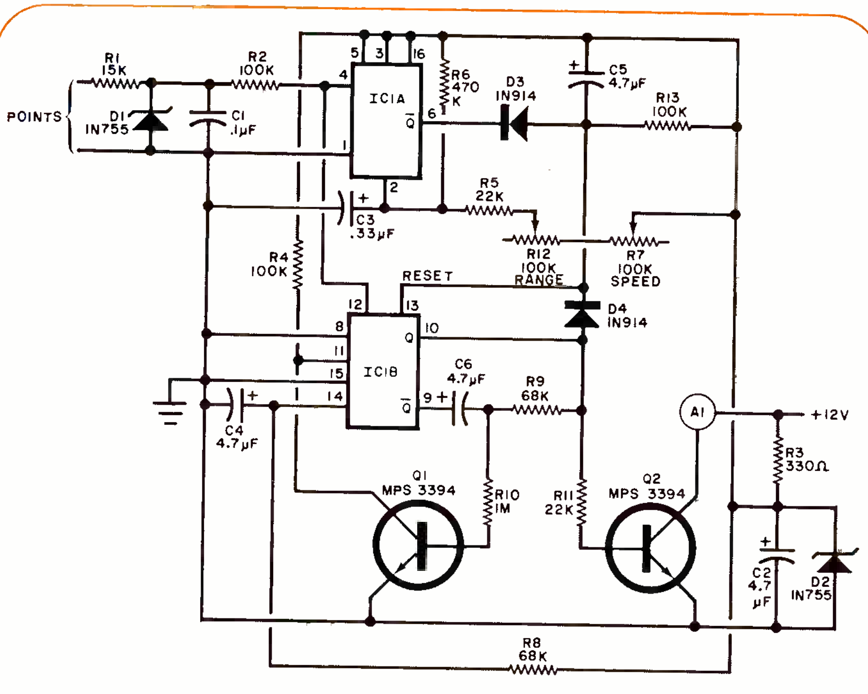


Fig. 1. Frequency discriminator IC1A triggers IC1B to sound alarm when input frequency from distributor points exceeds predetermined limit.

PARTS LIST

A1—SNP Sonalert or similar alarm
C1—0.1-μF, 50-V tantalum
C2, C4, C5, C6—4.7-μF, 50-V tantalum
C3—0.33-μF, 50-V tantalum
D1, D2—1N755 (7.5-V, 400-mW) zener
D3, D4—1N914 switching diode
IC1—MC14528CP dual monostable multivibrator
Q1, Q2—MPS3394 or similar transistor
Following are ½-W, 10% resistors unless otherwise noted:
R1—15,000 ohms
R2, R4, R13—100,000 ohms
R3—330 ohms
R5, R11—22,000 ohms
R6—470,000 ohms
R7—100,000-ohm panel-mount potentiometer
R8, R9—68,000 ohms
R10—1 megohm
R12—100,000-ohm, pc-mount potentiometer
Misc.—4" x 2¼" x 2¼" (10.2 x 5.7 x 5.7 cm) box; control knob; dry-transfer lettering kit; 16-pin IC socket (optional); hookup wire; solder; machine hardware; etc.
Note—A complete kit of parts is available for $29.95 from EALAB Associates, Box 737, Smithtown, NY 11787.

negative terminal to near ground potential. When the input frequency exceeds the critical threshold frequency, the voltage step T_{off} disappears and becomes a logic 1 (Fig. 2C). At this instant, diode *D3* then becomes reverse biased, causing the negative side of *C5* to rise towards the +V through *R13*.

Retriggerable monostable multivibrator *IC1B* and transistors *Q1* and *Q2* form the annunciator section. The main triggering input at pin 12 responds only to voltage transitions, while master reset at pin 13 responds to dc levels. In this circuit, *IC1B* is arranged so that to initiate astable action, a constant ac trigger signal must be present at pin 12. This is accomplished by connecting this input to the filtered and clipped ac signal source generated by the distributor points.

When the input frequency is below the discriminator's threshold frequency, the negative end of *C5* is near ground. Since this point is connected to pin 13, a logic 0 at this input forces *IC1B* to assume a reset condition in which the Q and not-Q outputs are held at logic 0 and logic 1, respectively. At this time, *C6* (connected between the two outputs via resistor *R9*) is fully charged to the voltage difference between the two outputs. The logic 0 level at Q also holds *Q1* in the off condition via *R9* and *R10*. The collector of *Q1* is held at a logic 1 to allow the input pulses at pin 12 to trigger *IC1B*.

When the input frequency rises above the discriminator's threshold frequency, the voltage at the negative end of *C5* assumes a positive (logic 1) potential. The logic 1 at pin 13 causes *IC1B* to be triggered by the input pulse train present on pin *12*. When triggered, the Q and not-Q outputs change state with a logic 1 and logic 0 appearing at the Q and not-Q outputs, respectively.

The logic 1 at the Q output turns *Q2* on via *R11*, which activates alarm *A1*. At this time, the voltage at the junction of *C6* and *R9* instantly drops below ground and then gradually rises above ground due to the charging current through *R9* whose source is the logic 1 at the Q output. When this voltage eventually rises above 0.7 volt above ground (one diode drop), *Q1* switches on and its collector drops to ground level. By virtue of logic-gate action, a logic 0 at pin 11 inhibits the input pulse stream at pin 12 from further triggering the multivibrator. In the absence of triggering pulses, the multivibrator eventually times out as determined by the *C4/R8* time constant.

The subsequent change of state at the Q and not-Q outputs causes *Q2* to switch off, silencing the alarm. Since *R9* now "sees" a logic 0 source at the Q output, the voltage at the *C6-R9* junction eventually drops to ground potential. When this junction reaches 0.7 volt, *Q1* turns off and its collector assumes a logic 1 state via *R4*. This allows the pulse train at pin 12 to once again trigger the multivibrator. It is in this manner that the astable action of *IC1B* is sustained only when the master reset at pin 13 is maintained at logic 1. The waveforms associated with *IC1B* are shown in Fig. 3.

Hysteresis Dead-Band Circuit. The frequency of the mechanical cam-rotor points breaker system used in the majority of engines is inherently unstable. Even if the engine's rpm were to be held absolutely constant, careful examination of the instantaneous frequency of the points would reveal some frequency modulation. This is due to a variety of factors such as a bent distributor shaft, variations in machining tolerances of the cam lobes, and, most of all, badly burned points.

Since the Cruisealert functions solely as a frequency discriminator, frequency modulation of the breaker points can lead to random and erratic triggering. To make the circuit immune to small incremental frequency variations, diode *D4* was added. It's function is to increase and hold the dc voltage at the negative end of *C5* when *IC1B* is operating (Q output is at logic-1). The result of this addition is illustrated in Fig. 4, which depicts the relationship between the point frequency and the alarm state. Examination of this chart shows that the alarm's turn-on frequency is slightly greater than its turn-off frequency. The difference between these two frequencies defines the hysteresis deadband, which in terms of vehicle road velocity is less than 2 mph.

Construction. The circuit can be built on a printed circuit board, the etching-and-drilling and components-placement guides for which are shown in Fig. 5. Note that SPEED control potentiometer *R7* and the alarm are both mounted on the box in which the circuit is housed.

After *R7* is mounted, attach a pointer knob to its shaft and provide some kind of marking surface below the knob. Starting at the fully counterclockwise position, mark off 10 equally spaced points to the clockwise limit stop.

Drill a small hole in the Cruisealert's front panel so that trimmer adjust potentiometer *R12* can be reached with a screwdriver after the pc board is in place. Connect the alarm and *R7* to the pc board as shown in Fig. 5. Then connect three long insulated leads to the vehicle's electrical system to provide input.

Select a suitable mounting position in the vehicle. Route the INPUT lead through the firewall and connect it to the screw connector of the ignition coil that goes to the distributor points. Connect the GROUND lead to a convenient metal screw or bolt and the 12-volt lead to a switched +12-volt source, such as the lead that feeds the radio. Insulate all connections.

(Continued on page 60)

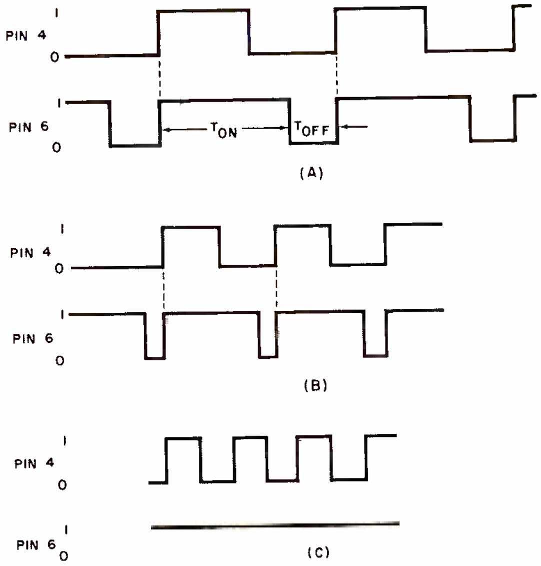


Fig. 2. Waveforms for IC1A show how off time of output (pin 6) varies as frequency of input at pin 4 increases.

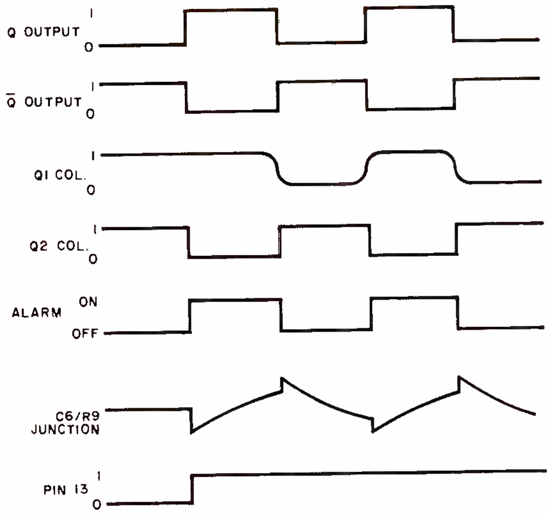


Fig. 3. Timing diagram for IC1B shows waveforms which can be expected at various points in circuit.

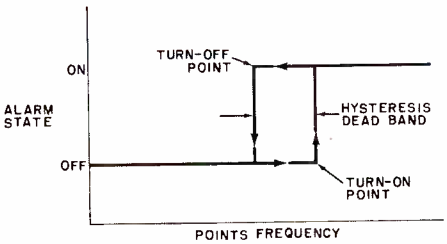


Fig. 4. Hysteresis of input frequency versus alarm state. Difference is less than 2 mph.

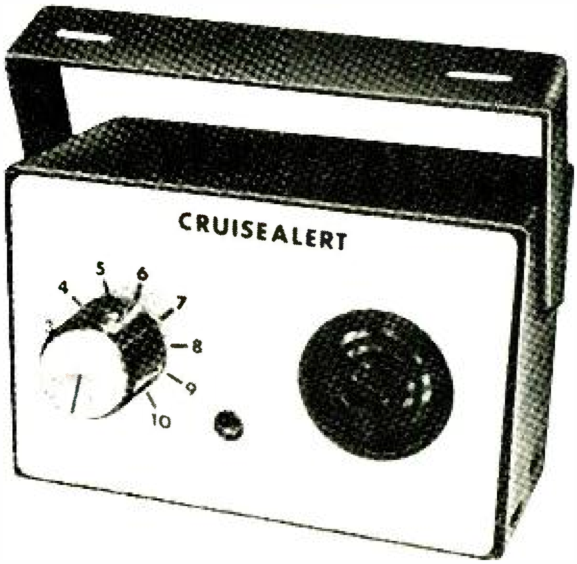


Photo at right shows the author's prototype with speed control potentiometer R7 at left and loudspeaker at right. The hole in center is to gain access to R12 in making final adjustments with passenger's aid.

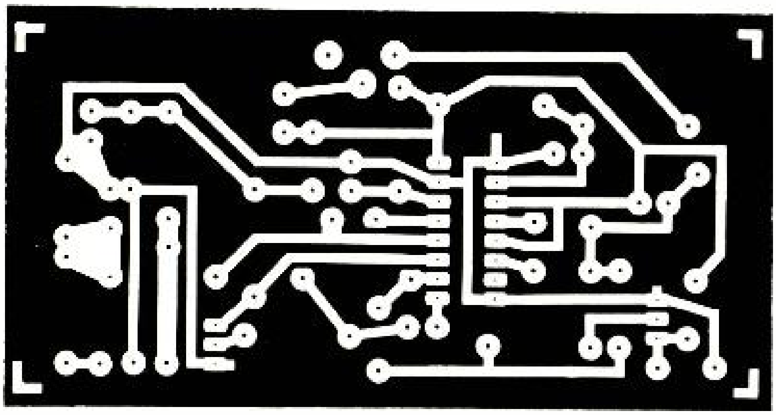
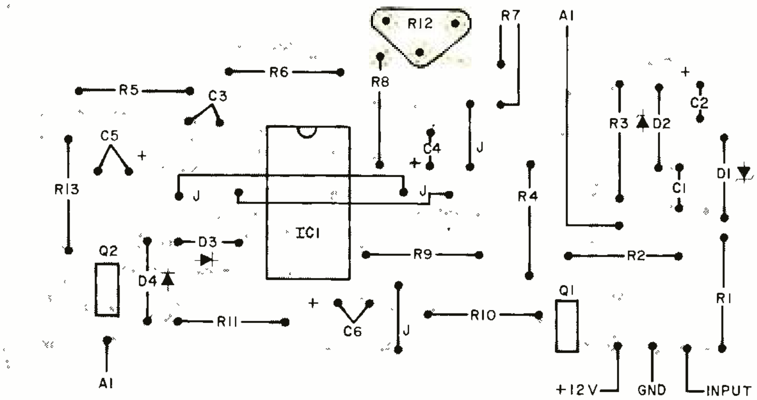


Fig. 5. Actual size etching and drilling guide (above) and components placement (below) for printed circuit board.



Adjustment. The Cruisealert is designed to provide an overspeed alarm indication for selected road speeds between 30 and 70 mph for a four-, six-, or eight-cylinder engine. In the interests of safety, it is recommended that the following adjustments be made by a passenger and not the driver.

Using a small screwdriver, rotate *R12* (RANGE) fully clockwise via the access hole in the front panel and leave the screwdriver engaged in the trimmer slot. Set the front-panel SPEED control (R7) knob to the fifth mark on its scale.

Drive the car until the speedometer indicates 55 mph and try to maintain this speed. Very slowly adjust *R12* until the Cruisealert just starts to beep. Then remove the screwdriver. This completes the range setting, and the SPEED control is set to 55 mph. Note that the SPEED control's scale indications are only relative and do not correspond to vehicle speed.

To preset the Cruisealert to operate at another road speed, rotate the SPEED control fully clockwise, drive the car at the desired speed, and while maintaining this speed, slowly adjust the SPEED knob until the alarm sounds. ◇

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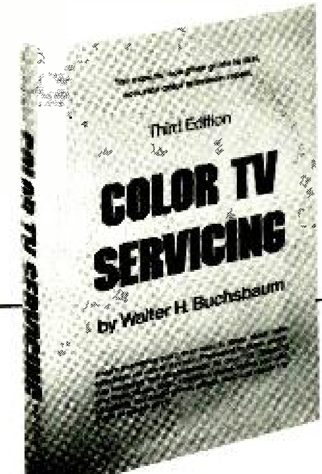

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BUILD A

MULTIPLE-CHOICE DIGITAL MULTIMETER

BY JOHN T. BAILEY

A 3½ -digit meter with either LED or LCD displays, plus a variety of options including a temperature probe

THE introduction of two new 3½-digit A/D converter ICs by Intersil now makes it possible for you to build a low-cost state-of-the-art digital multimeter with a variety of options. Here are details on building an instrument with a choice of LED or LCD display. Included are instructions for several options, such as an ac precision rectifier, an ohms converter, ac and dc current modifications, and a temperature probe. With such a choice available, you can mix and match according to your needs and desires. By changing some component values, you can even modify the basic ranges.

The basic DMM described in this article can measure ac and dc voltages in five ranges from 200 mV full-scale to 2000 volts full-scale; ac and dc currents from 200 μA to 2 amperes; resistance from 2000 ohms to 20 megohms; and temperature from 0° C to 100° C(32° F to 212° F). Simple modifications can extend the basic ranges to 200 ohms, 20 μA, and 20 amperes, all full-scale.

There are two versions of the new Intersil A/D converter. The ICL7107 is designed to directly drive 3½ digits of conventional seven-segment light-emitting diode display, while the ICL7106 can directly drive 3½ digits of seven-segment liquid-crystal display. Both chips contain a precision dual-slope converter, BCD-to-seven-segment decoding, display drivers, clock, and reference. Only 10 passive components are required to turn either chip into a 200-mV or a 2-volt full-scale dc meter. The basic meter also features automatic zeroing and polarity indication.

About the Circuit. The basic circuit for the LCD version is shown in Fig. 1, while the circuit for the LED version is shown in Fig. 2. Both circuits feature the same 3½-digit display capability. Since both chips have a noise level of about 15 μV, the associated display should be quite stable. With the inputs shorted, the display should indicate 000, with no roll-over of the last digit.

With the component values shown, both circuits have full-scale displays of 200.0. To change this to 2.000, change *C2* to 0.047-μF, *R2* to 470,000 ohms, and *R4* to 25,000 ohms.

The decimal points in the LED display (Fig. 2) are driven by switching a 150-ohm resistor from ground to the decimal point in the desired decade.

LCD displays, such as that shown in Fig. 1, are driven by a symmetrical square wave applied to the backplane. Each digit segment is then turned on by applying an identical waveform (but reverse-phase) to it. For this reason, the decimal points of the LCD display are driven by inverting the backplane signal using NOR gate *IC4*. (LCD displays can be permanently damaged by prolonged application of a dc voltage. Any dc potential greater than 50 mV applied to the LCD for more than two minutes will permanently damage the display.)

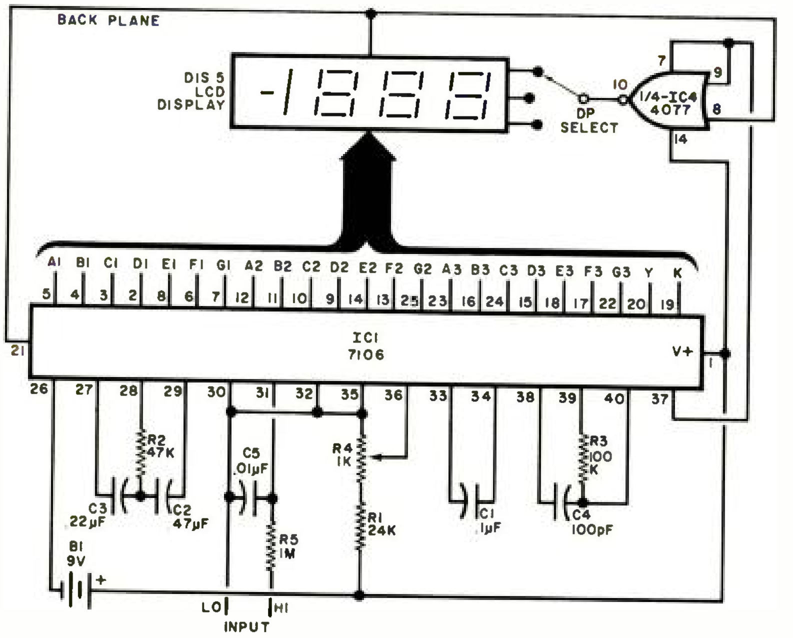


Fig. 1. As single 3½-digit A/D converter 7106 can directly drive an LCD display, using a NOR gate for decimal selection.

PARTS LIST
BASIC METER

B1—9-volt battery (not in kit)
C1—0.1-µF Mylar or polypropylene
C2—0.47-50-µF Mylar or polypropylene
C3—0.22-µF polypropylene
C4—100-to-200-pF disc
C5—0.01-µF disc
DIS1 thru DIS3—Common-anode 7-segment light-emitting diode display*
DIS4—Common-anode ±1 light-emitting diode display*
DIS5—3½-digit liquid-crystal display (Hamlin No. 3902 or similar)**
IC1—7107* or 7106** A/D converter (Intersil)
IC4—4077 NOR gate**
R1—24,000-ohm, ¼-watt, 5% resistor
R2—47,000-ohm, ¼-watt, 5% resistor
R3—100,000-ohm, ¼-watt, 5% resistor
R4—1000-ohm, 10-turn potentiometer
R5—1-megohm, ¼-watt, resistor
R11—150-ohm, ½-watt, 10% resistor
Misc.—Battery holder (not in kit); printed-circuit board; 40-pin and 14-pin** IC socket; 14-pin sockets for LED displays (4).
*These items required for LED version only.
**These items required for LCD version only.

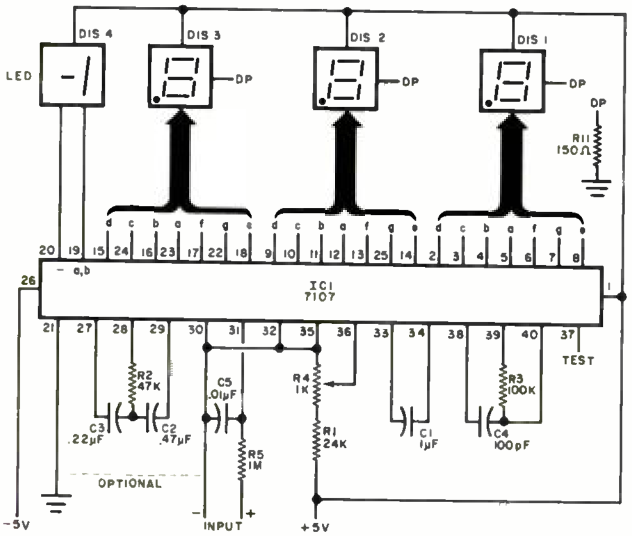


Fig. 2. The LED circuit, using a 7107 is similar to that in Fig. 1. Decimal point is selected through R11 to ground.

Construction. The actual-size etching-and-drilling and component-placement guides for the LCD version of the meter are shown in Fig. 3. Similar guides for the LED version are shown in Fig. 4. Note that the board for the LED (7107) version is arranged so that the display section can be cut from the main board to permit it to be mounted at a right angle to the latter.

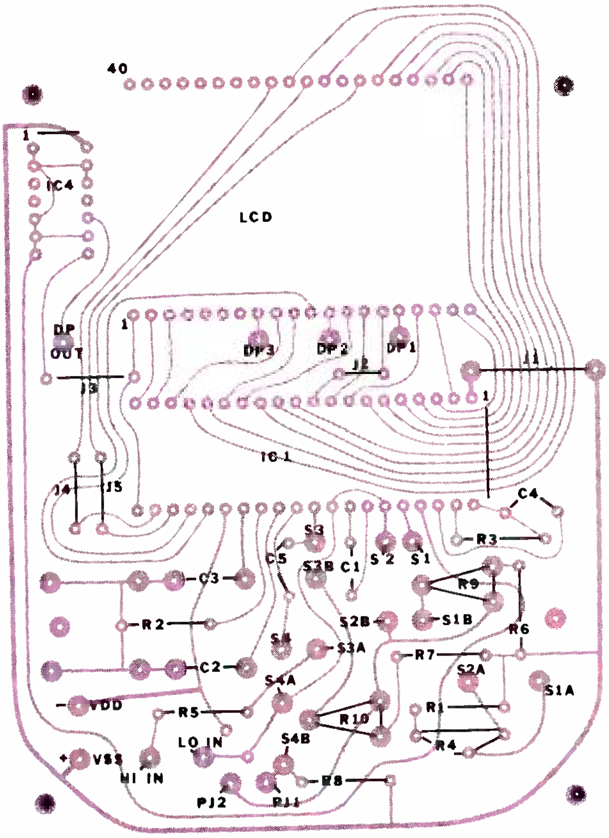
In the LCD (7106) version, the display comes with an edge connector. Mount and solder this connector to the board at the appropriate location.

The components used in the circuit are not critical in determining the accuracy of the meter. However, it is important that integrating capacitor *C3* have a low dielectric loss. Use either a polypropylene or a polystyrene capacitor. Mylar capacitors are satisfactory for reference capacitor *C1* and auto-zero capacitor *C2*.

Temperature Probe. The addition of a few components can add a temperature-measuring feature to your basic instrument. The circuit shown in Fig. 5 illustrates how this feature can be added. Note that a four-pole double-throw switch (*S1*) is used to transfer from regular DMM functions and the temperature function.

The temperature probe operates on the principle that a diode forward-biased at a constant but low forward current changes forward voltage linearly over a relatively wide range (−40° C to +150° C) at about 2 mV/°C. In Fig. 5, the emitter of a metal-cased npn transistor is used as one diode lead, while the base/collector combination is used as the other lead. The transistor's metal case makes a convenient probe tip. (A zener diode rated at less than 20 volts would work as well.)

The probe itself is fabricated from an ordinary ballpoint pen with screw-on top, a transistor sensor, shielded two-conductor cable, and a subminiature phone jack and plug. Open the pen and remove the ink cartridge, spring, and retractor mechanism. Then trim away the pen's top until its diameter is the same as that of the rim on the transistor's metal case. Slide the cable through the top and bottom of the pen and assemble the pen. Separate the cable's conductors for a distance of 2″ (50.8 mm) at the point end of the cable and trim away ¼″ (6.4 mm) of insulation from each. Twist together the fine wires in each conductor and lightly tin with solder. Slide over each conductor a 1″ (25.4-mm) length of heat-



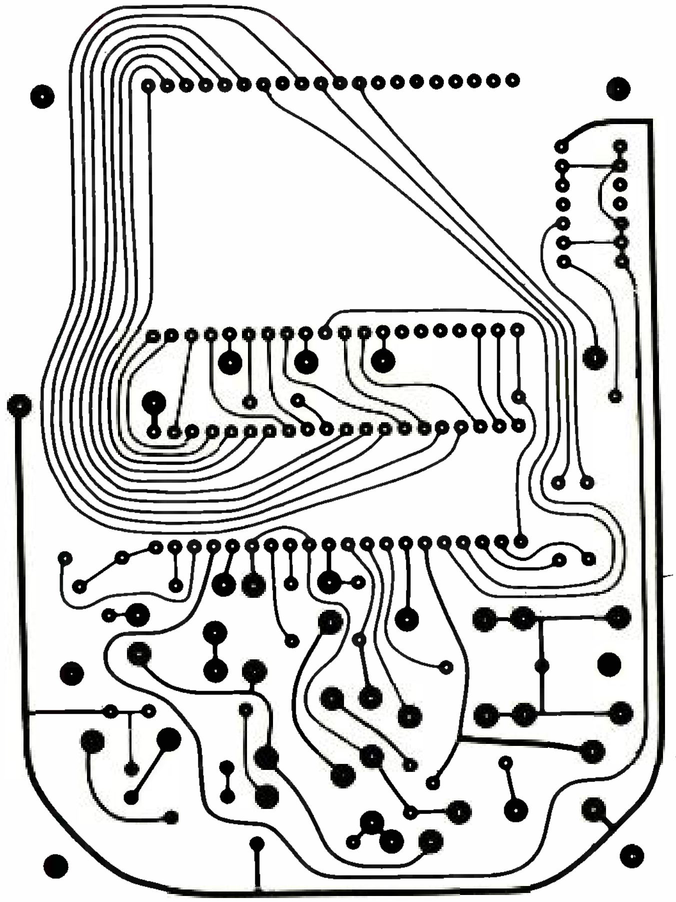
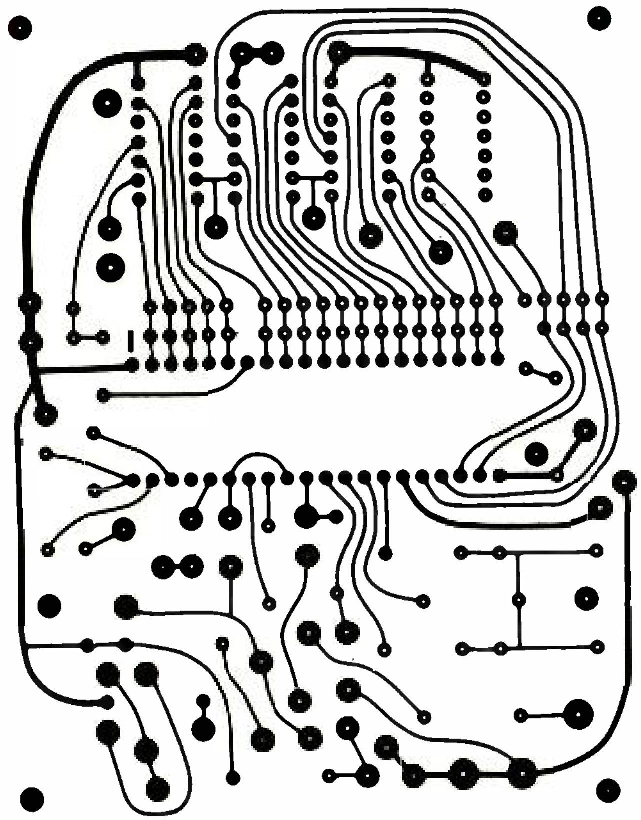


Fig. 3. Actual size etching and drilling guide for the pc board for the LCD display meter is shown at right, component placement above.



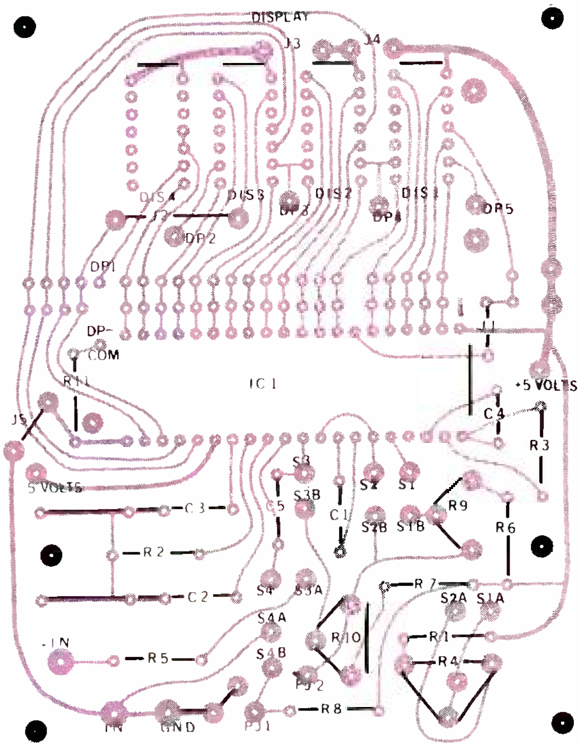


Fig. 4. Actual size etching and drilling guide for pc board for LED meter is at left, component placement above. The display can be separated from main electronics if desired.

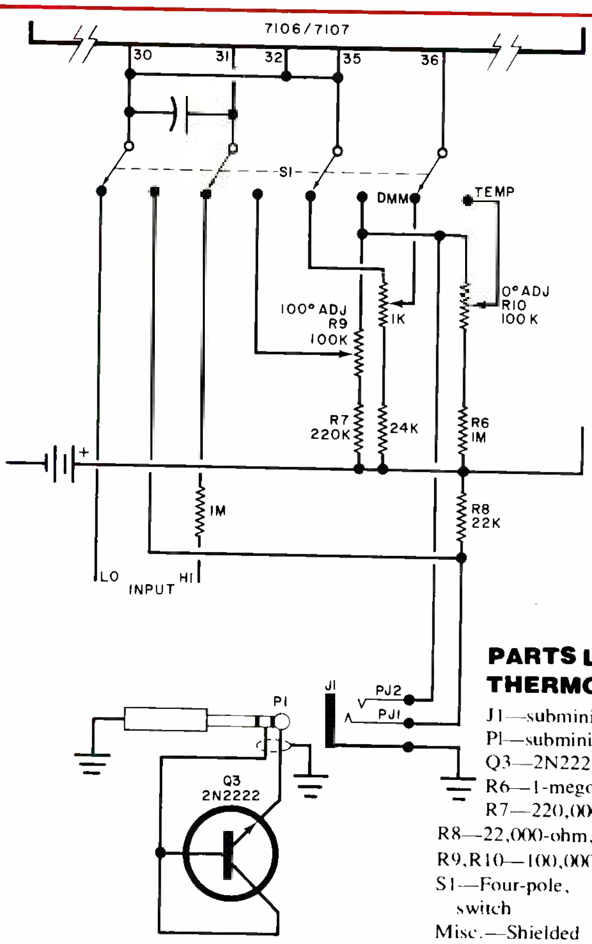


Fig. 5. By adding a switch, some passive components, and a transistor, the meter can be used as a thermometer.

PARTS LIST THERMOMETER

J1—subminiature stereo phone jack
P1—subminiature stereo phone plug
Q3—2N2222 or similar transistor
R6—1-megohm, ¼-watt, 5% resistor
R7—220,000-ohm, ¼-watt, 5% resistor
R8—22,000-ohm, ¼-watt, 5% resistor
R9,R10—100,000-ohm potentiometer
S1—Four-pole, double-throw nonshorting switch
Misc.—Shielded cable, ball-point pen, heat shrinkable tubing, solder, (not in kit).

shrinkable tubing. Then twist together the base and collector leads of the temperature-sensor transistor, trim the lead pair to ½" (12.7 mm) and solder to one of the cable's conductors. Connect the solder and transistor's emitter lead to the other cable conductor. Then slide the heat-shrinkable tubing down over the respective connections and shrink into place.

Connect and solder a subminiature phone plug to the conductors at the free end of the cable. Epoxy the bottom of the heat-sensing transistor's case to the tip of the pen body and the cable to the top of the pen where it exits the body of the pen.

DMM Circuit. The circuit shown in Fig. 6 can be used to convert the basic dc meter into a digital multimeter. Note here that two new circuits have been added. One is a constant-current source for measuring resistance (ohms converter) and the other is a precision ac rectifier for the ac converter.

As shown in Fig 7, the ohms converter employs a constant-current FET regulator (*D9*) in one leg of the *IC3* operational amplifier circuit to generate a reference voltage.

For ac measurements, the input signal from the voltage divider is fed to the

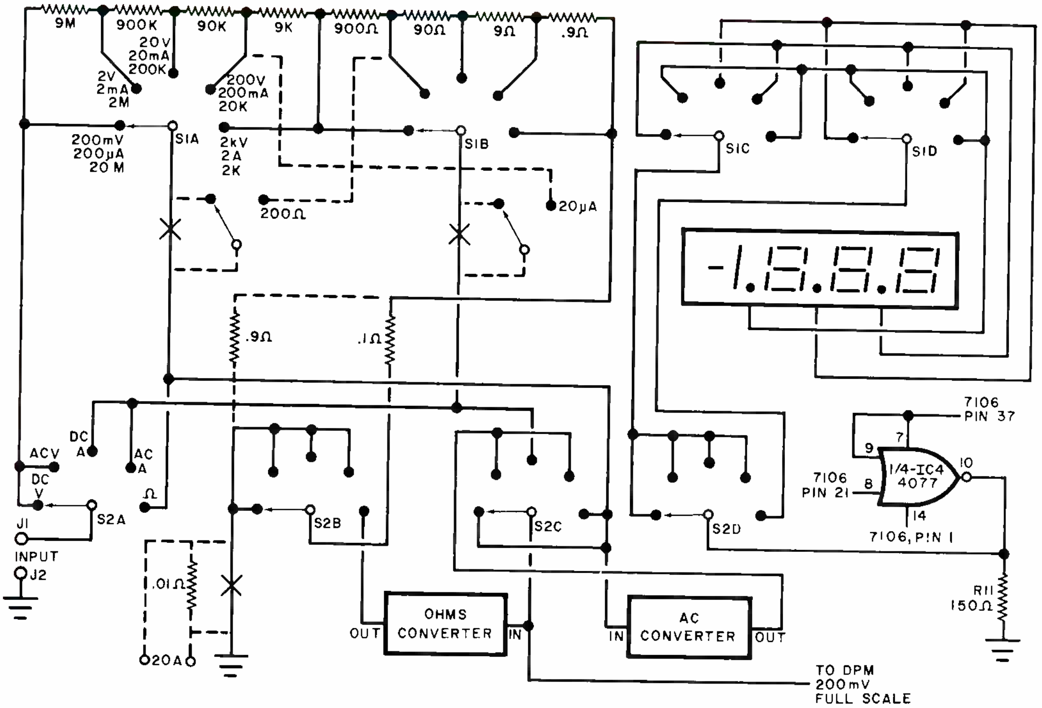


Fig. 6. Front-end switching converts the basic dc meter into a full-fledged digital multimeter. The ohms and ac converter must be added also.

PARTS LIST SCALING CIRCUIT

One each of the following 1% resistors:
9.00 to 9.09 megohms
90,000 to 90,900 ohms
9000 to 9090 ohms
900 to 909 ohms
90 to 90.9 ohms
0.9-ohm 2% resistor
0.1-ohm, 10% resistor
J1, J2—Banana jack (not in kit)
Misc.—Four-pole, five-throw switches (2); solder; hookup wire; (not it knit).

PARTS LI$T
AC AND OHMS CONVERTERS

C8 thru C11—4.7- to 6-µF electrolytic
C12—0.1-µF ceramic or film
C13,C14—100-to-200-pF disc
D5 thru D8—1N914 or similar switching
D9—330-µA FET regulator
IC2, IC3—LF13471, CA3130, CA3140 or similar op-amp

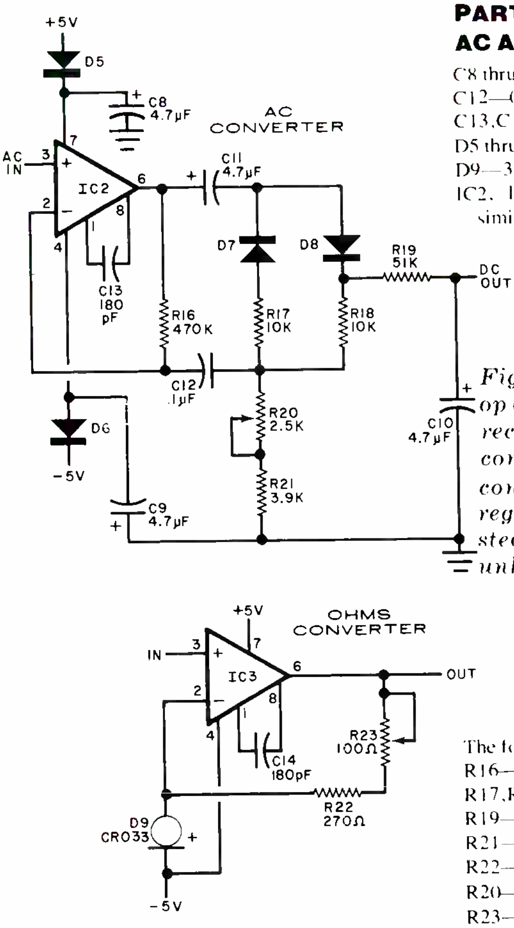


Fig. 7. The ac converter uses an op amp in a basic precision rectifier circuit. The ohms converter uses a constant-current regulator (D9) to maintain steady output for measuring unknown resistances.

The following resistors are ½ or ¼ watt, 10%:
R16—470,000 ohms
R17,R18—10,000 ohms
R19—51,000 ohms
R21—3900 ohms
R22—270 ohms
R20—2500-ohm trimpot
R23—100-ohm trimpot

precision rectifier shown in Fig. 7. The dc output from the rectifier can be scaled to indicate rms voltage by adjusting *R20*. FET input op amps are used to produce the high input impedance required when the full 10 megohms of the input divider is in the circuit.

A useful power supply for the LED version of the DMM is shown in Fig. 8. This supply can operate from a 12.6-volt center-tapped transformer or from a conventional 6.3-volt transformer, both of which are shown in Fig. 8.

DMM Construction. The ac and ohms converters and power supply can be assembled on a single printed-circuit board, the etching-and-drilling and component-placement guides for which are shown in Fig. 9. If desired, the power-supply portion can be separated from the op-amp circuits.

When using the 6.3-volt transformer in the power supply, connect one output lead to point CT and the other output lead to one of the 6.3 points. This converts the power supply from full wave to half wave.

The LCD version of the instrument requires only a single 9-volt battery to drive both the logic and display. A line-powered 9-volt dc charger can be used with a 9-volt rechargeable battery in this version of the DMM.

The circuit shown in Fig. 10 can be used with the LCD DMM if you wish to use four small-sized cells to supply both the +6 and −5.6 volts required by the circuit.

Options. As shown in Fig. 6, additional ranges can be added to the instrument by switching into other points on the voltage-divider network. For example, to add a 200-ohm full-scale range to the ohms function, another switch is required to transfer the ohms input line to the 100-ohm point on the divider.

In a similar manner, the current range

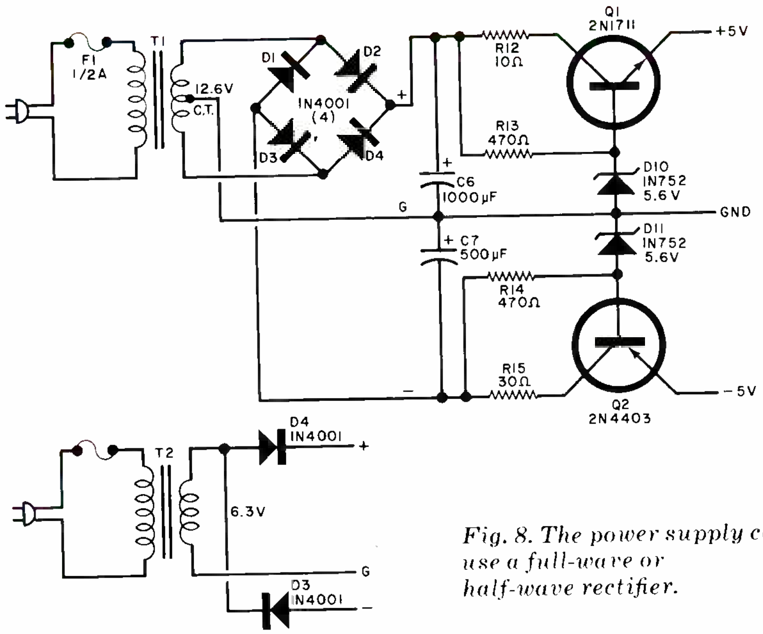
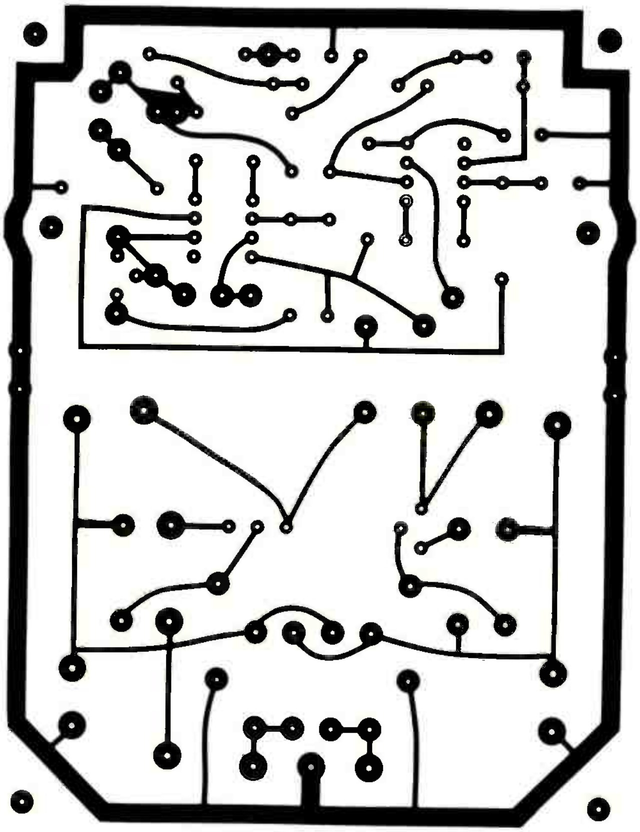


Fig. 8. The power supply can use a full-wave or half-wave rectifier.

PARTS LIST
POWER SUPPLY

C6—1000-µF (minimum), 10-volt electrolytic
C7—470-µF (minimum), 10-volt electrolytic
D1 thru D4—1N4001 rectifier or similar
D10,D11—5.1- to 6.2-volt zener (1N752 or similar)
F1—½-ampere fuse and holder (not in kit)
Q1—2N1711 or similar transistor
Q2—2N4403 or similar transistor
R12—10-ohm, 1-watt resistor
R13,R14—470-ohm, ½-watt resistor
R15—30-ohm, ½-watt resistor
Note: The following items are available from Hobb-Y-Tronics, 957 Ball Ave., Union, NJ 07083: complete kit of parts for LED version, including case, for $49.95; complete kit of parts for LCD version, including case, for $53.95. Add $1.50 for shipping and handling. Also available separately: case (specify version) for $4.95; pc board, ICs, and D9 for either version for $17.95. New Jersey residents, please add 5% sales tax. Outside continental USA, add necessary extra postage.



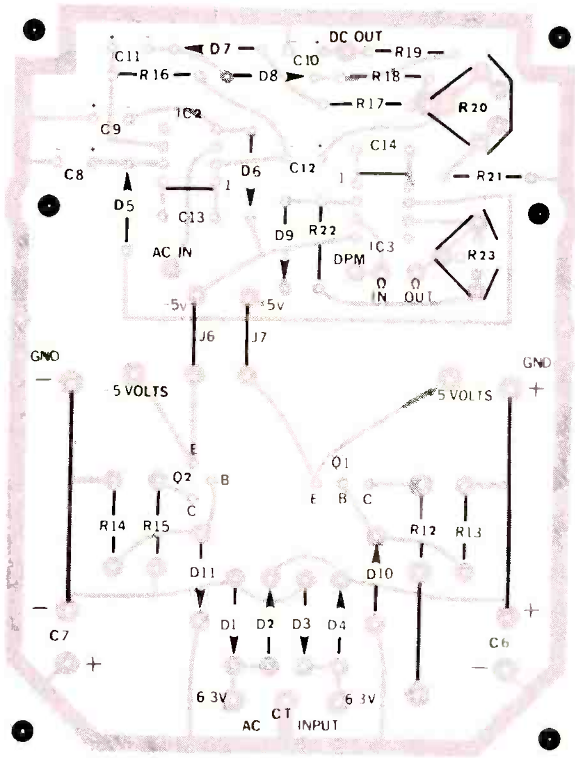


Fig. 9. Actual size etching and drilling guide for pc board for the ohms and ac converter is shown at left, components placement above. Board can be separate from power supply if desired.

can be extended downward by switching into higher points on the divider network. A high-current range can best be added by using a separate 0.01-ohm input shunt, with the shunt current feeding into the current line. The three options, with the required lead breaks, are shown in Fig. 6.

To add the 20-ampere option, use heavy-duty terminals and bus-bar wiring to minimize voltage drops and contact resistance. The 0.01-ohm resistor should have a minimum 10-watt rating. The circuit is arranged so that the current being measured does not flow through switch contacts.

The 20-μA current option increases the low-current measuring capacity.

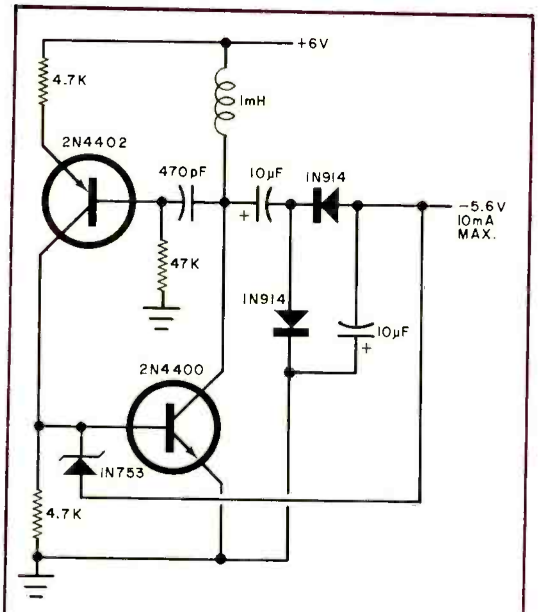


Fig. 10. This −5.6-volt supply can be used with battery supplying the LCD circuit.

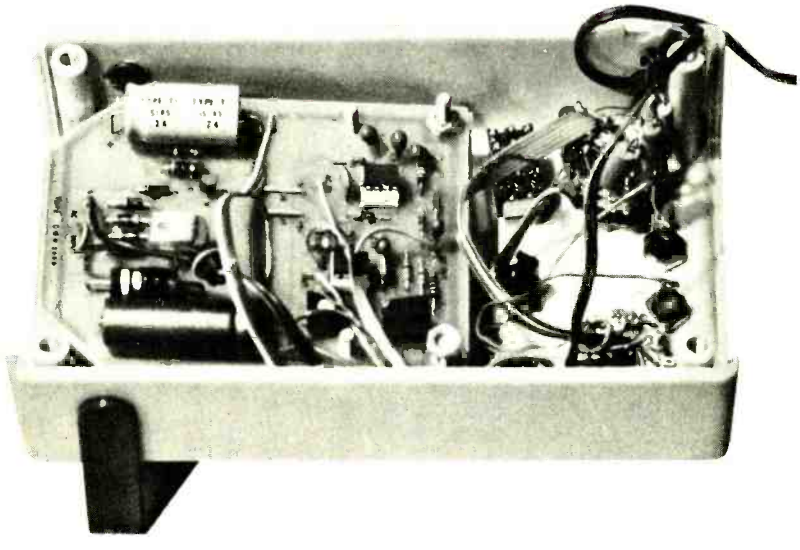


Photo shows inside of author's prototype meter. Switches on front can be arranged to suit builder.

However, it should be noted that the current shunt will be 10,000 ohms, a value that will limit current measurements to high-resistance circuits.

In the 200-ohm resistance option, when the range switch is set to 20 volts, the decimal point energized for all three options will be correct even though this option has a three-decade scale range.

Calibration. The unloaded potential of a fresh mercury cell is 1.35 volts. A voltage-divider network consisting of 0.5% or better tolerance resistors can be applied to this voltage source to arrive at almost any potential in the 150-to-200-mV range. There is no need to obtain resistors that yield exact decade voltages. Instead, you can use Ohm's law to determine what the voltage will be between any two points in a voltage divider. Let us assume you have a voltage divider made up of a precision-tolerance 500- and a 3000-ohm resistor. Using Ohm's law, the current through this series network with a mercury cell would be 1.35 volts divided by 3500 ohms, or 3.86 mA. Then the voltage dropped across the 500-ohm resistor would be 3.86 mA times 500 ohms, or 192.86 mV.

Ac calibration is achieved by setting the FUNCTION switch to AC VOLTS and the RANGE switch to the setting for which you have an accurate calibration voltage. Then adjust *R20* in the ac-converter section for the known voltage level being applied to the input, while observing the display.

The resistance ranges can be calibrated by adjusting *R23* in the ohms converter section for exactly 100 mV between pins 2 and 6 of *IC3*. An alternative method is to use a known 0.1% tolerance resistor value and adjust *R23* for a display of its value. Bear in mind, however, that the calibration will be only as good as the accuracy of the test resistor and the setting of *R23*.

Calibration of the temperature-measuring circuit is performed by immersing the probe tip in ice water and adjusting the 0° C ADJ potentiometer for a 00.0 display. Then, with the probe tip immersed in boiling water, adjust the 100° C ADJ pot for a 100.0 display. If you prefer a °F display in degrees Fahrenheit, use a 32.0 indication in ice water and 212.0 in boiling water.

Conclusion. As you can see from the foregoing, you can just about custom tailor a digital multimeter to your needs and/or desires with the new 3½-digit A/D converters. ◇

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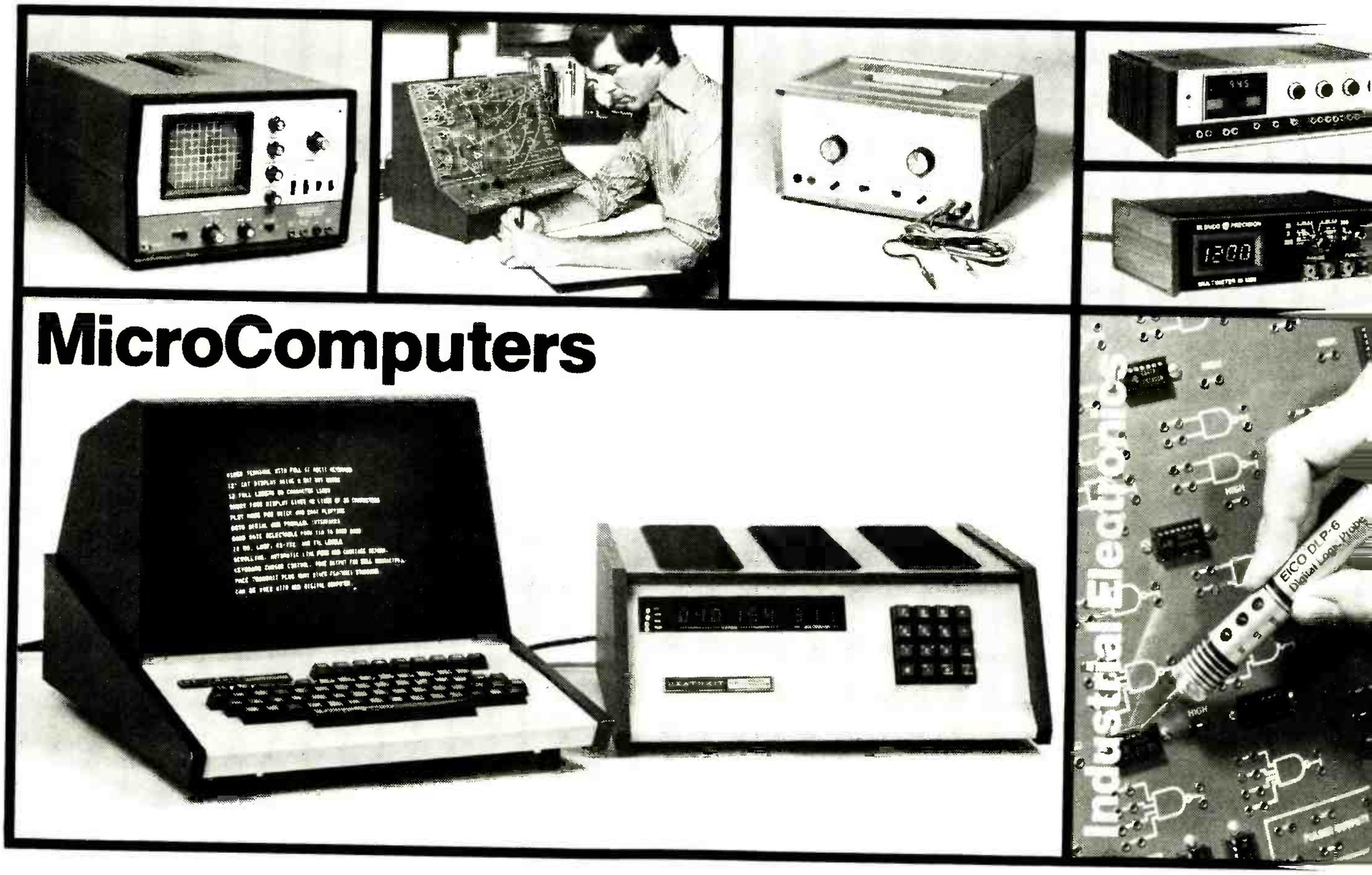

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BY LESLIE SOLOMON
Technical Director

A NEW APPROACH TO DATA STORAGE: BUBBLE MEMORIES

With attributes of both ROM and RAM, a typical bubble memory can store up to 92K bits with an access time of 4 ms.

A WHOLE new approach to mass data storage is soon to become available at reasonable cost. Called "bubble memories," the new storage devices have attributes of both the RAM and the ROM. Like a RAM, data can be written into and read from a bubble-memory device. And, like a ROM, once power is removed from the bubble memory, the data remains intact, ready to be read out when power is restored.

Typical bubble-memory devices contain at least 92K bits of data-storage capacity. With an access time of 4 ms and a 50K bits/second data rate, the bubble device "looks" more like a disk system than it does a cassette system. Note that the bubble memory system does not make a good substitute for a RAM system—unless you have lots of time.

A bubble-memory system, which might include several 92K bubble devices and their associated interface electronics, can be mounted on a single circuit board that can be plugged into almost any bus system. Since each bubble device requires less than 700 mW of power for continuous operation, the power supply in a microcomputer will not be strained.

Formation of a Bubble. A basic "bubble" begins as a magnetic domain that exists within a thin magnetic film and can assume any shape, as shown in Fig. 1A. These domains form in the film in a manner that minimizes the total magnetic energy of the film. Shown in Fig. 1A is a typical set of domains when there is no external magnetic field applied normal (at right angles) to the film.

If a small steady-state magnetic field, such as from a permanent magnet, is applied normal to the plane, the magnetic domains tend to shrink within themselves to form smaller domains. (Fig. 1B). As the strength of the external magnetic field increases, the domains continue to shrink until they are between 2 and 30 microns in size (Fig. 1C). If the external magnetic field's strength is increased, the bubbles essentially disappear. Experiments have revealed that the most stable bubbles are formed with an applied steady-state magnetic field of about 100 oersteds. Hence, the first hint of bubble operation is that magnetic bubbles are sensitive to applied magnetic fields.

Physical Construction. The basic arrangement of a bubble-memory chip is shown in Fig. 2. The actual bubble device (with one corner enlarged) reveals that the thin magnetic film is diffused on a nonmagnetic substrate, along with small bars that are shaped like the letters I and T.

The bubble device is mounted between two thin permanent magnets to create the tiny bubbles. Surrounding the bubble device is a pair of orthogonal coils (right angles to each other). Since we know that the magnetic bubbles are affected by magnetic fields, passing a current through the orthogonal coils, 90° apart and in-phase, will cause the bubbles to move around. Using the current flow shown in Fig. 2, the magnetic field will rotate.

Bubble Motion. Once a bubble has been established, it must be moved around so that it can be used as a data bit. How this motion is achieved is shown in Fig. 3. The "track" along which the bubble is to be moved is composed of a series of soft magnetic bars shaped like I's and T's that are also deposited on the nonmagnetic substrate. A "parent" bubble is located under a disc of mag-

The bubble memory held by an engineer contains two garnet chips and stores 250,000 bits. Sixteen chips are in system at rear, which was developed for the Air Force by Texas Instruments.

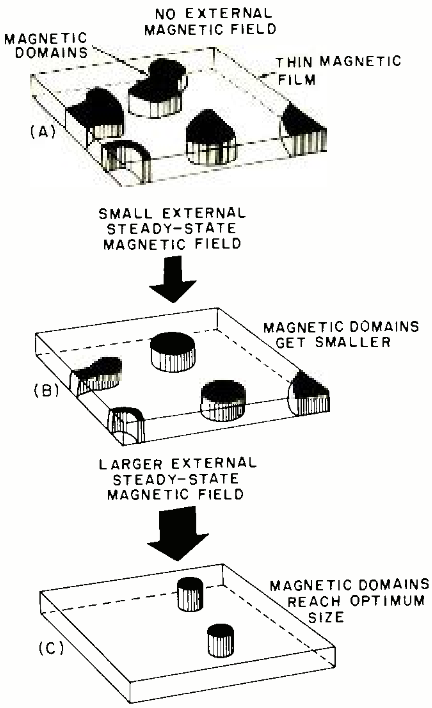


Fig 1. Small bubbles in magnetic film are shown at (A). With an external field applied, bubbles get smaller (B). They reach best size as field is increased (C).

netic material. Note in Fig. 3 that another bubble is located under the first T bar and is assumed to have moved to that location during a previous cycle.

The first I bar has a tiny hairpin wire loop covering one end. When the rotating magnetic field is as shown, and when a current of about 150 mA is applied to the loop for 500 ns, a portion of the parent bubble is transferred to the vicinity of the I bar. The parent bubble is not depleted because its size is strictly a function of the local magnetic conditions. As the rotating magnetic field continues, the newly created bubble moves across to the next T bar that has the temporary magnetization shown. As the applied magnetic field continues to rotate, the slender magnetic "link" between the parent bubble and the newly formed bubble under the T bar snaps, leaving a new bubble at the T bar (first T bar in bottom row).

As the applied magnetic field continues to rotate, the right side of the T bar assumes the magnetic characteristics shown in the top row (second bubble) and further field rotation causes the bubble to move along the track, going from T bar to I bar, and so forth. Each rotation of the applied magnetic field causes a bubble to move a distance of slightly greater than 20 microns.

There are other track formations besides the T and I bars. Examples are: a chevron-shaped set of bars, a Y-shaped set, and a set of contiguous discs.

Bubble Annihilation. When the bubbles reach the end of the track or when the data is no longer needed, a means must be provided for removing the unwanted bubbles. One method is to use a current pulse in a hairpin loop to disintegrate the bubble when it passes under the intense magnetic field. Another is to allow the bubble to run into a magnetic guard rail that surrounds the substrate. The bubble simply joins the magnetic field under the guard rail and vanishes. The magnetic field of the guard rail does not increase in size when this occurs. The field is a function only of the local magnetic conditions.

Bubble Detection. The most common way to detect the presence of a magnetic bubble is to measure the change in resistance of a magnetoresistive strip as the bubble passes over it. To reject the interference from the rotating field that drives the bubbles, a dummy detector, exposed to the magnetic field but not to the bubble, is also used. The signals from the two detectors are mixed and the difference between them (the effect of the bubble) forms the output signal.

Once the bubbles are allowed to flow to the detector (magnetoresistive) elements, the bubbles are "stretched" into wide strips. This increases their effect on the detectors and is equivalent to preamplification. Under these conditions, the detected signal can be several millivolts in amplitude.

Memory Operation. Since bubbles can be made to follow each other along a special "track," the easiest approach to obtaining memory operation is to create a long shift register. However, because bubble memories will be in the 100K range, such a long shift register would be awkward to create and would have a very long access time. Hence, a different technique such as that used by Texas Instruments and shown in Fig. 4 is used.

Bubbles are introduced into the major loop by applying a current through a hairpin wire loop that covers the GENERATE bar. Each bubble created during a 10-µs interval forms a 1, while the lack of a bubble during a similar interval signals a 0. Note that the 10-µs period is determined by the device's operating frequency, which is 100 kHz.

The major loop can transfer data to any of 157 minor loops (641-bit serial shift registers). If all minor loops are operating, the storage capacity becomes 100,637 bits. However, since the production of bubble devices is still in the developmental stage, the actual yields are low. Therefore, up to 13 minor loops are permitted to be defective. This means that total memory capacity can be as low as 92,304 bits. The defective loops are located during final device testing and a "map" is supplied to the end user who can eliminate the defective loops from his system.

A data block of 157 bits is shifted along the major loop until the first bit is

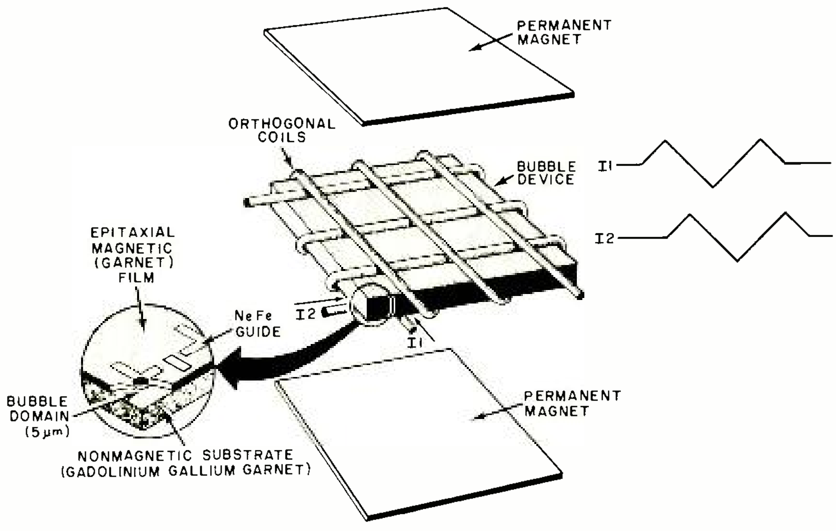


Fig. 2. Basic arrangement of a bubble-memory chip. Thin magnetic film is diffused on substrate with small bars in shapes of letters I and T.

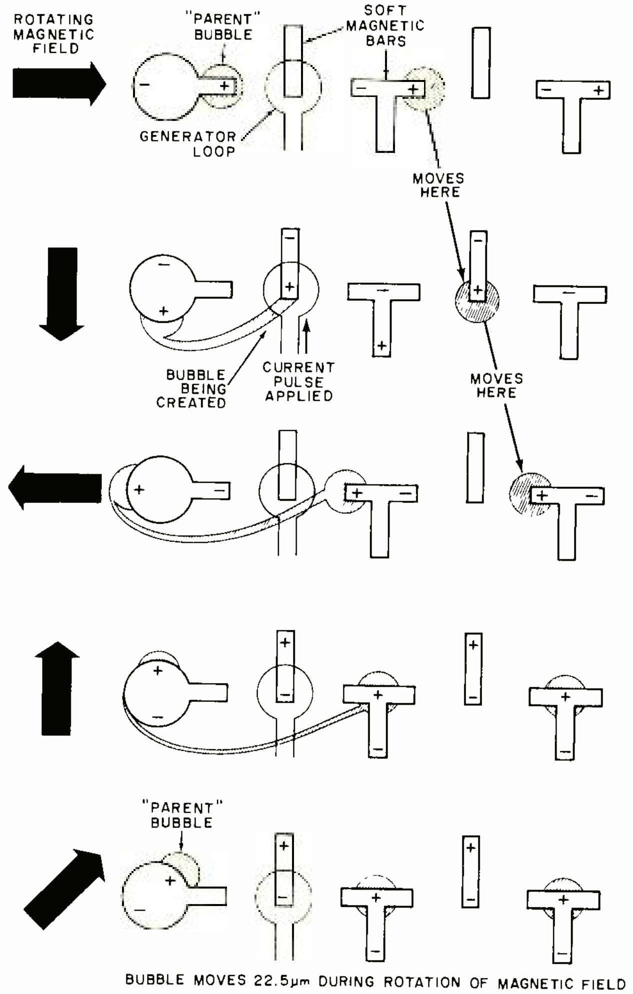


Fig. 3. A bubble, once established, is moved around between soft magnetic bars by rotating magnetic field at left.

aligned with the most remote minor loop (loop 1 in Fig. 4). At this time, all other data bits are aligned with the other minor loops so that when the TRANSFER-POINT elements all receive a simultaneous current pulse, the localized magnetic fields at each transfer point "dump" (actually replicate) the data into the minor loops. The major loop is shifted along for another 157 bits, and the process repeats itself.

Special circuitry is used to insert a 0 at each point where the major loop encounters a bad minor loop. Other circuitry takes care of the extra 0's when reading out the data.

To read data from memory, the data in the minor loops must be moved until the first bit in each loop is present at the major-loop transfer elements. The transfer elements are all activated by the same current pulse, which causes bubbles and nonbubbles to be placed on the major loop. The data words are then moved along the major loop until they encounter the detector/replicate element.

If a destructive read is desired, a current pulse is passed through the replicate loop that deflects the bubble into the detector track. If the data must be read out but retained in memory, the replicate loop's timing generates a pulse to replicate the data in both the detector track and the major loop. In this case, identical data exists in two places: the detector track and the major loop.

Bubbles drifting along the detector track are stretched by special circuits and made to pass over a bar made from magnetoresistive material. As the bubble passes across the material, it causes a change in the resistance, which is reflected as a small voltage change within the circuit that makes up the detector. After passing the detector, the "used" bubbles reach a guard rail, where they are annihilated.

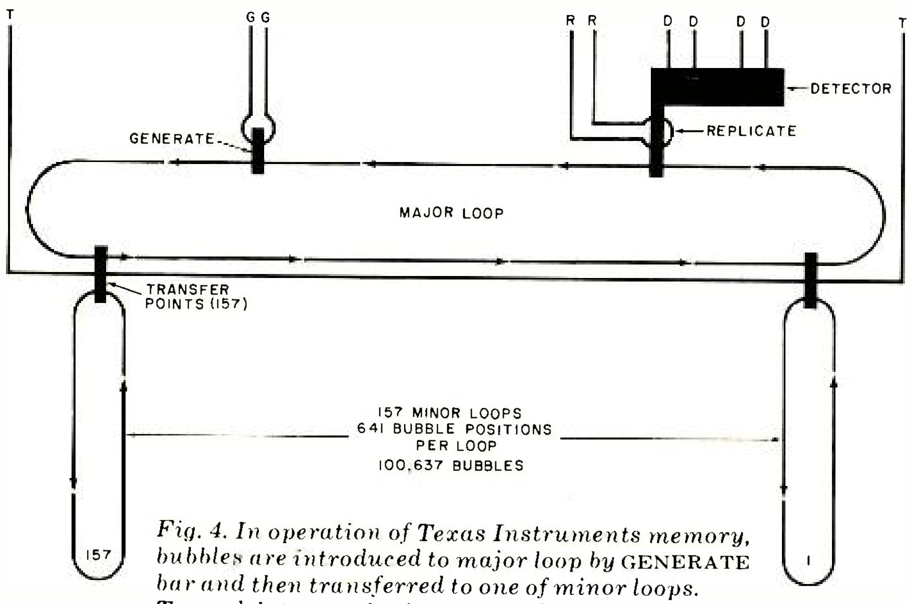


Fig. 4. In operation of Texas Instruments memory, bubbles are introduced to major loop by GENERATE *bar and then transferred to one of minor loops. To read data, a pulse is generated in detector track.*

Physical Package. A typical bubble memory package, Texas Instruments' TBM-0101, comes in a DIP configuration that is 1" (25.4-mm) square by ⅜"

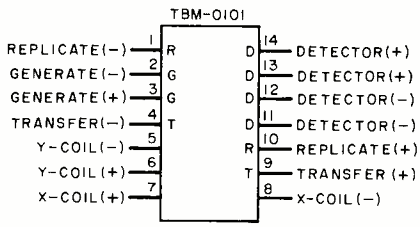


Fig. 5. Pinout for TBM-0101, made by Texas Instruments.

(9.5-mm) thick. It has both coils and bias magnets built in. The pinout for this package is shown in Fig. 5.

The operating frequency of the typical bubble memory device is 100 kHz. Its average access time is 4.0 ms, average cycle time is 12.8 ms, and data rate is 50K bits/second. The package weighs 25 grams and has a shielding capability of 40 oersteds.

Several IC's are used as support for a bubble-memory system. These include a controller, timing generator, coil drivers, and a detector circuit. ◇

A SIMPLE TOUCH CONTROL SWITCH

BY GEORGE PETERKA

Single FET amplifier circuit can be used to control relay or other low-current device

A TOUCH control is an electronic switch that can be activated simply by touching a small conductive plate with a fingertip.

Such controls are easy to build and can be used to enhance many projects. They can also be added to an existing circuit, such as forming an alarm "off" switch for a digital clock.

Circuit Operation. A basic touch control circuit is shown in Fig. 1A. Essentially, it consists of a FET amplifier with a high input impedance (10 megohms) and a conductive touch plate connected to its gate. Operation occurs when the ambient 60-Hz ac field flooding the area is impressed on the touchplate during the finger contact. This signal is amplified and appears at the drain as a 60-Hz square wave, alternating between ground and supply voltage.

Capacitor *C1* shunts any r-f picked up by the "antenna effect" of the touchplate, while capacitor *C2* acts as a transient suppressor.

The drain of *Q1* can be connected to the alarm-off pin of a clock chip, since most of these ICs require that the alarm-off pin be momentarily connected to the supply voltage to silence the alarm.

The circuit of Fig. 1B uses the same FET input stage, but, via *D1*, rectifies the ac waveform at the *Q1* drain and uses the generated positive voltage to turn on transistor *Q2*. The positive voltage developed across *C3* will keep *Q2* turned on until the capacitor is discharged by base current and resistor *Rx*. The value of this latter resistor determines how rapidly the switch will shut off and should be between 10,000 and 100,000 ohms.

The load on *Q2* can be a low-current relay or a resistor (1000 to 5000 ohms) with the signal generated across the resistor used to turn on a high-power transistor. Using the transistor shown for Q2, any device that requires 50 mA or less can be powered.

Construction. Any form of construction may be used since the circuit is relatively simple. It should be powered from an ac-line supply for reliable operation.

The touch plate should be relatively small—several square inches are enough. It must be insulated from ground. But it need not be a discrete metal plate; a metal door-knob on a wooden door will suffice. This latter type of touchplate makes an excellent sensor in an alarm project. ◇

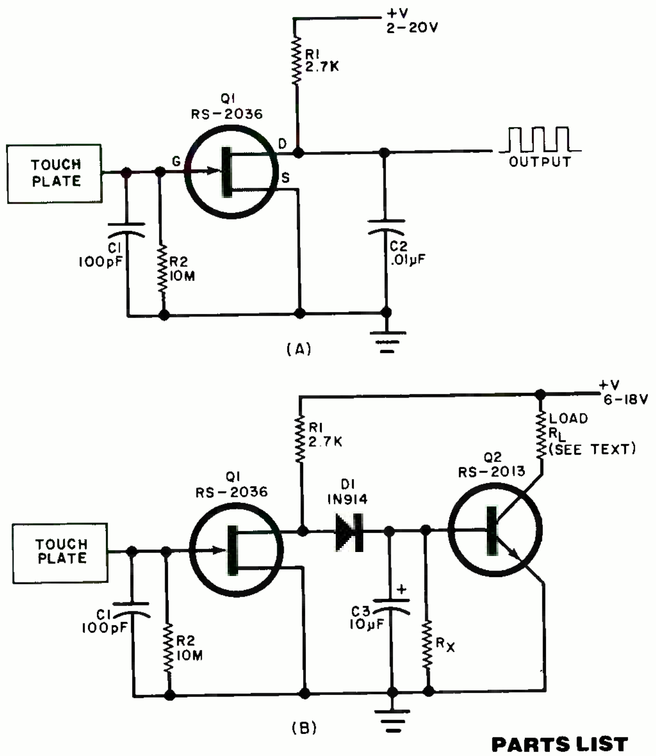


Fig. 1. At (A), high input impedance FET developes a square-wave output when gate is touched by fingertip. Transistor Q2 (B) is added to drive external devices.

PARTS LIST

C1 — 100-pF, disc
C2 — 0.01-µF, disc
C3 — 10-µF, electrolytic
D1 — 1N914 or similar
Q1 — N-channel FET, RS2036 or similar
Q2 — Npn transistor, RS2013 or similar
R1 — 2700 – ohm resistor
R2 — 10 – megohm resistor
Rx — 10,000 to 100,000 ohms (see text)
Touchplate — see text.
Misc. — Perf board, mounting hardware, power supply, etc.

Product Test Reports

Electra Bearcat 250 Scanning Monitor Receiver

Five-band receiver with microprocessor control can store up to 50 channels

THE ELECTRA Bearcat 250 is a five-band scanning monitor receiver whose synthesized local oscillator and microprocessor control systems give it some capabilities well beyond the norm for receiving public-service and 2-meter ham radio transmissions. The receiver is designed to cover FM bands of 32 to 50, 146 to 148, 148 to 174, 420 to 470, and 470.0125 to 512.0125 MHz. (Stations in the last band are assigned frequencies ending in .0125.) Its local oscillator frequency is synthesized. Accuracy and stability are determined by a single quartz crystal. The frequency and other information are presented on an 11-digit LED display.

The Bearcat 250 can be operated from a 117-volt ac line power or a nominal 13.8-volt dc source such as any mobile electrical system with a negative ground. The receiver is 10¾″W × 8″D × 3½″H (27.3 × 20.3 × 8.9 cm) and weighs 5 lb (2.3 kg). Suggested retail price is $399.95.

General Description. Electra gives virtually no information on the Bearcat 250's circuits, except to say that seven custom-designed ICs are used. Even the intermediate frequency is not stated. Therefore, we are limited to describing the features of the receiver and our measurements of its performance.

The Bearcat 250 has no conventional tuning controls. One of its two knobs is used for adjusting the squelch threshold (even that has an automatic operating mode that makes the control somewhat redundant). The other knob is for volume control and turning on and off the power. All other functions are controlled by a 30-key calculator-type keyboard.

The receiver's nonvolatile memory, which is not affected when power is removed, can store the frequencies of as many as 50 channels within its tuning range, in any sequence. Any channel can be accessed instantly by selecting its assigned number (1 to 50) on the numeric keys and touching the MANUAL key. The frequency of the selected channel and its assigned channel number appear in the display.

The receiver can also be tuned instantly to any frequency in its range without first assigning it to a specific channel in the memory. First, any channel number is arbitrarily selected via the keyboard. Then the MANUAL key is operated, and the desired frequency is punched up on the keyboard. Finally the E (for enter) key is pressed. Frequencies can be selected in 5-kHz steps.

In the automatic mode, pressing the SCAN key starts a scan of all the programmed channels except those that have been locked out by the LOCKOUT key at a rate of either 5 or 15 channels per second as selected by the SPEED key. Touching MANUAL at any time stops the scan. Repeated operations of the MANUAL key step the receiver upward one channel at a time.

The receiver also has a SEARCH/STORE mode for scanning between any two limit frequencies, in either direction. (When it reaches one limit, it instantly starts over at the other limit.) Every time a signal is intercepted, its frequency is stored in a separate memory for a maximum of 64 frequencies. Afterwards, the stored frequencies can be recalled by sequential operations of the RECALL key. If desired, these frequencies can be assigned to channels in the main memory.

The 50 memory channels are divided into groups of 10. A row of keys at the left of the keyboard activates each group of 10 channels individually. Dots in the display indicate which groups are activated at any time and which group is being scanned in the SEARCH/STORE mode. By programming different radio services into different number groups (for example, 1 to 10 for police; 11 to 20, fire; 21 to 30, amateur; etc.), it is easy to set up the scanner for any specific service, ignoring the others, by appropriate settings of the channel bank keys.

The PROGRAM key group has, in addition to the numeric selectors and the E key, keys labelled PRIORITY, DELAY, LOCKOUT, and ./AUX. LOCKOUT causes any specific channel assignments to be omitted during the SCAN mode of operation. DELAY causes the receiver to wait 2 seconds after the disappearance of a carrier before resuming its scan. This permits both sides of a conversation on the same channel to be monitored. Otherwise, the scan would resume the instant one station stood by. The PRIORITY key causes channel 1 to be sampled every 2 seconds no matter where the receiver is tuned. If a signal is present on channel 1, the receiver tunes to that channel and remains there until it disappears. Then it returns to the originally programmed frequency. When these keys have been activated, the letters L, d, and P appear in the display.

The ./AUX key programs the decimal point during frequency selection and activates a special AUXILIARY terminal in the rear of the receiver when a signal is received on a channel for which the key has been pressed. The contact is internally closed to ground and can supply up to 500 mA of current to control an external circuit, such as a tape recorder or alarm, though an external relay is necessary.

SEARCH buttons include a LIMIT key that sets the upper and lower scan limits. (The frequencies are keyed in numerically and entered in the microprocessor by touching the LIMIT key.) Below the LIMIT key are two keys that permit the receiver to scan up or down through the channels. If the STORE key is touched, the receiver remembers all frequencies of all signals it intercepts during the scan and later displays them sequentially one at a time as the RECALL key is pressed.

In the OPER. group of keys, the MANU-

AL key is used to single-step the receiver through its assigned channels, to stop automatic search or scan, or as a preliminary step when changing from one operating mode to another. The SCAN key initiates a scan of all programmed channels. The SPEED key changes the rate of scan, alternately selecting either 5 or 15 channels per second. The COUNT key causes the receiver to keep a running total of the number of times (up to 99) that a signal appears on the single channel it is monitoring. This information appears at the right of the display, instead of the frequency. A second operation of the COUNT key restores the frequency display without interfering with the totalizing process. Finally, the TIME key causes the time (hours, minutes, and seconds on a 12-hour basis) to be displayed instead of the frequency. Like the COUNT display, the TIME display can be activated at any time without affecting the operation of the receiver. In addition, whenever the receiver is turned off, the time is continuously displayed as long as primary power is connected.

On the rear panel are an antenna jack (which accepts the standard automobile antenna plug) for a 50-to-75-ohm antenna and two audio output jacks. One jack is for an external speaker. It silences the receiver's built-in speaker when a plug is inserted. The other jack is a tape-recording output, which carries the same signal but does not silence the speaker. Since its level is controlled by the receiver's volume control, this feature is not analogous to the tape recording output of a stereo receiver or amplifier. There are also sockets for the ac line cord and for a 13.8-volt dc source and the AUX and GND screw terminals for controlling an external device from the receiver.

The receiver is normally operated with a short (21") vertical telescoping whip antenna inserted in a hole in the top of the cabinet. An external antenna may be preferable in mobile service. A mounting bracket is supplied for installing the receiver in a car or boat.

Laboratory Measurements. The only measurements we made on the Bearcat 250 receiver were of its sensitivity and audio output. The sensitivity is rated at 0.4 microvolts below 174 MHz and 0.8 microvolts above 420 MHz for a 12-dB SINAD (signal-to-noise and distortion) with ±5 kHz deviation. Our signal generator does not cover the high band, but we measured a sensitivity of better than 0.1 microvolt at 147 MHz. The squelch sensitivity is rated at 0.3 and 0.6 microvolt in the low and high bands, respectively. At 147 MHz, the measured squelch sensitivity was adjustable from less than 0.1 to about 0.5 microvolt. In the AUTO position of the squelch threshold control, it was about 0.4 microvolt.

Audio output into an 8-ohm load is rated at 2 watts with no more than 10% THD. In our measurements, it was exactly 2 watts at 1000 Hz at the clipping point, which corresponds approximately to the 10% THD condition.

User Comment. The Electra Bearcat 250 is a remarkably fine monitoring receiver for Public Service, two-meter ham, and uhf government communication bands. It has all the bells and whistles one could wish for, thanks to its microprocessor control and memory.

Using its own whip antenna, approximately at ground level, we had no difficulty picking up a dozen or so two-meter repeater transmissions, countless mobile communications, and a number of stations in the 420–470-MHz band, many of them 30 miles or more away.

If there are any shortcomings to mention, they are common to the few microprocessor-type scanners on the market or scanners in general. For example, we found that full mastery of the Bearcat 250's marvelous control functions required rereading of the complete instruction manual provided with the model and considerable practice. One has to learn, for instance, that if the receiver is not in MANUAL, touching the COUNT key erases all the programmed channels. Moreover, having to punch in six digits every time we wished to move the receiver frequency, even by only 5 kHz, is somewhat bothersome. This factor is traded off easily for the many excellent operating features provided, of course.

Also, a problem shared with all other sensitive scanners is that a transmission can stop on the skirt of a strong signal since scanning is in 5-kHz steps. This happened to us with a two-meter repeater signal. Also, the Model 250, along with all other scanners, does not encompass the new FM signals in the 144-MHz band, such as the recently opened 144.5–145.5-MHz repeater sub-bands.

In all, the Bearcat 250 can be pronounced to be a state-of-the-art scanner that's especially useful for serious listeners who wish to "catch" all the happenings, from weather reports to marine phone conversations to myriad emergencies for many miles around.

CIRCLE NO. 104 ON FREE INFORMATION CARD

Experimenter's Corner

By Forrest M. Mims

ANALOG COMPUTER CIRCUITS, PART 2

IN PART 1 we looked at ways to use resistors to add and multiply. We also learned how to use op amps to multiply, divide, add, average and subtract. Although an op amp and a few resistors can multiply and divide, manual adjustment of at least one potentiometer is necessary. We noted in Part 1, however, that there are many analog computer circuits that respond to incoming voltages rather than manually adjusted potentiometers. The op amp adder, averager and subtracter circuits described in Part 1 have this ability.

One way to multiply or divide two voltages is to convert both to their logarithms. Multiplication is accomplished by adding the two logs with a summing amplifier. Division can be performed by subtracting the log of the divisor from the log of the dividend with a difference amplifier. The antilog of the result is the product or quotient, as the case may be.

Now that the pocket calculator has replaced the slide rule, logarithms are not used nearly as often as they once were. So let's take time out for a brief refresher course before moving on.

Logarithms. Any decimal number can be expressed as a power of ten. For example, 1,000 is 10^3 and 736 is $10^{2.8669}$. In both cases, the exponent of the base 10 is referred to as the number's logarithm. One important aspect of logarithms is revealed by the following table.

Number	Power of Ten	Logarithm
1	10^0	0
10	10^1	1
100	10^2	2
1,000	10^3	3
10,000	10^4	4
100,000	10^5	5
1,000,000	10^6	6

As you can see, a very wide range of decimal numbers occupies a very small range of logarithms. The resulting compression provides a handy shorthand method for processing very large numerical variations.

We noted earlier that two numbers can be multiplied by adding their logs or divided by subtracting their logs. That's how a slide rule works. It's also possible to add and subtract numbers using ordinary rulers. Place one ruler atop the other. Then align the 0 on the top ruler with one of the numbers being added on the bottom ruler. Next, find the second number being added on the top ruler. This number will point to the sum on the bottom ruler.

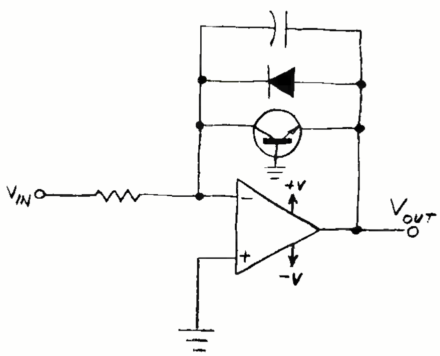


Fig. 1. Schematic of a basic logarithmic amplifier.

Rulers have a linear scale—their divisions are equally spaced. A slide rule, on the other hand, has a logarithmic or compressed scale. When you multiply two numbers with a slide rule, you are actually adding their logs.

Look back at the table and multiply 1,000 × 100 to see how this works. The log of 1,000 is 3 and the log of 100 is 2. 3 + 2 = 5 so the log of 1,000 × 100 is 5. From the table, 5 is the log of 100,000 (or 100,000 is the antilog of 5) so 1,000 × 100 = 100,000. Try dividing a few numbers in the table by subtracting the log of the divisor from the log of the dividend and taking the antilog of the remainder to obtain the quotient.

Before the advent of the pocket calculator, the use of logarithms was standard procedure when multiplying and dividing very large or very small numbers. Logs are also handy for extracting roots. The cube root of 27, for example, is found by dividing the log of 27 by 3 and extracting the antilog of the result. (The log of 27, 1.4314, divided by 3 is 0.4771; the antilog of 0.4771 is 3, the cube root of 27.)

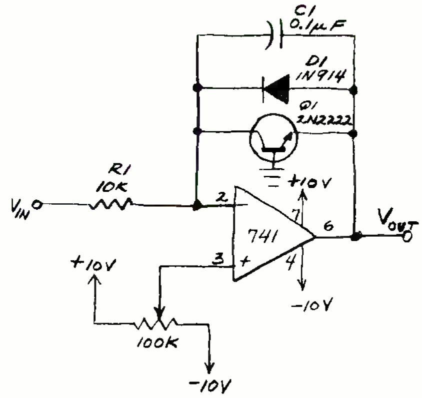


Fig. 2. A practical logarithmic amplifier circuit.

Incidentally, numbers in any number system can be expressed as logarithms. Can you figure out the logarithms of the binary sequence 1, 10, 100, 1000 . . . 10000000? (Hint: 1000 is 2^3.)

The Logarithmic Amplifier. The voltage drop across a diode is related logarithmically to the current flowing through it. This makes possible the conversion of a voltage into its log.

Practical log conversion is best achieved by using a transistor in a common- or grounded-base configuration instead of a diode. Figure 1 shows how the transistor is connected in place of an op-amp's feedback resistor to give what is called a *transdiode logarithmic amplifier.* Although the circuit is an amplifier, you can think of it as a log generator to avoid confusion.

Not all transistors exhibit logarithmic properties over as wide a range as might be required. Many, however, do and one readily available type is the 2N2222 (equivalent to Radio Shack type RS2009).

You can easily assemble a breadboard log amplifier with the help of a 741 or any other frequency-compensated op amp. Figure 2 shows the details of a practical version of the circuit in Figure 1. Capacitor *C1* does not assist in the log conversion process. Instead, it reduces the ac gain of the op amp and helps eliminate high-frequency oscillation which might otherwise occur. Diode *D1* protects the transistor from excessive reverse base-emitter bias from the op amp's output.

On the following page are the results I obtained from a breadboard version of the circuit in Fig. 2.

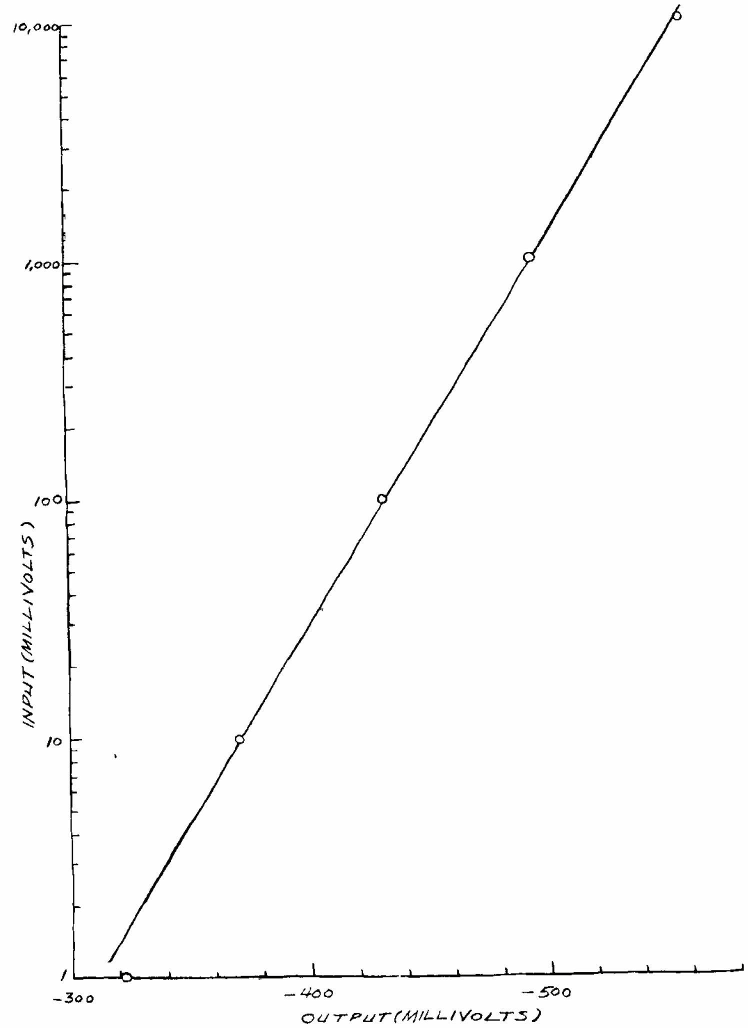


Fig. 3. Operation of a log amplifier plotted on semi-log graph paper.

Input (mV)	**Output** (mV)
1	−322
10	−371
100	−432
1,000	−494
10,000	−557

In all cases, the output voltage was inverted (negative), but this is of no major consequence as we can either ignore the polarity or, if desired, change it with an inverting buffer.

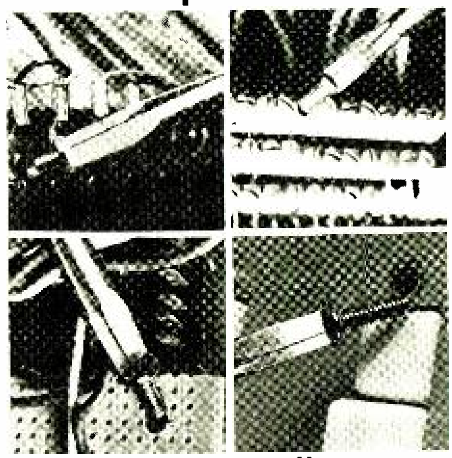
Figure 3 shows the data in the table plotted on a semi-log graph. The graph is called semi-log because one axis is linear (the output voltage) and the other is logarithmic (the input voltage). A plot of the data produces a straight line on the semi-log graph, so we know the log amplifier is reasonably accurate over the given range.

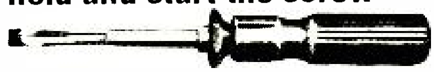
Now that we've seen how a real log amplifier works, let's look at a few of its characteristics. First, notice the very small range in output voltage (a few hundred millivolts) that results from the huge swing in input voltage (10,000 millivolts). This characteristic of log amplifiers is ideal for compressing very large voltage excursions into more manageable form.

A second characteristic is that the transfer function of our log amplifier is *not* − VOUT = log (Vin). Rather, it's approximately − Vout = 0.06 log Vin + K where K is a constant. For the log amplifier I built, K is 0.495. Your amplifier might yield a slightly different K. You can use a programmable calculator to compute the exact transfer function.

A third characteristic of our log amplifier is that it is temperature sensitive. That's not good because the current flowing through the 2N2222 causes heating which can alter the accuracy of the circuit. The error this introduces can be substantial, easily several percent.

Yet another characteristic of the amplifier is that the input offset voltage of the op amp can cause a substantial but predictable error when the input voltage is small. This problem can be alleviated by connecting a 10,000-ohm potentiometer to the 741 as shown in Fig. 4. Pin 2 of the 741 is then temporarily shorted to ground and the offset potentiometer is





adjusted until V_{OUT} is exactly zero volt.

A more significant error is introduced by the op amp's bias current. This ranges from 80 to 500 nonoamperes for the 741. Figure 4 also shows how to compensate for this problem by temporarily replacing the components in the feedback loop with a 100,000-ohm resistor and adding a bias current potentiometer. The pot is then adjusted until $-V_{OUT}$ exactly equals V_{IN} over as wide a voltage range as you expect the amplifier to receive.

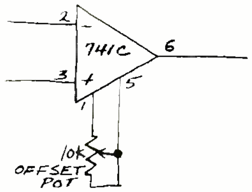


Fig. 4. Adding an offset pot to the log amplifier.

You don't have to make all these calibration adjustments when building a simple log amplifier for experimental purposes. But if you decide to build your own analog computer, for best results you'll need to calibrate or *trim* each op amp using the methods described.

The Antilogarithmic Amplifier. Analog computing circuits that use log amplifiers require one or more antilog amplifiers to convert results back into linear form. Antilog amplifiers can also be used to expand narrow ranging input voltages into much wider and therefore more easily resolved form.

PROJECT OF THE MONTH

LED TRANSMITTER MODULE

Here's a miniature LED transmitter module you can assemble in half an hour or so. It makes an ideal mate for the miniature phototransistor receiver module described in the last Project of the Month. Alternatively, it can be used on its own as a miniature infrared beacon.

Figure A is a complete circuit diagram of the transmitter. The circuit uses a 3909 LED flasher IC for the utmost in simplicity. This IC is designed to drive red LEDs and *not* IR (infrared) LEDs. IR LEDs have a lower forward voltage drop (about 1.2 volts) than red LEDs (about 1.7 volts). This means you can fool the 3909 into driving an IR LED by adding an ordinary silicon diode in series with the LED. A diode like the 1N914 has a drop of 0.6 volt and this gives a total drop of about 1.8 volts when connected in series with an IR LED.

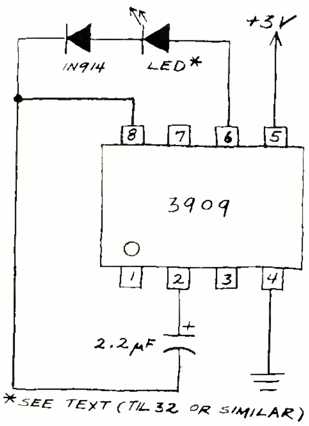


Fig. A. An infrared light emitting diode transmitter.

For best results, use a GaAs:Si LED instead of a GaAs LED. Both types are available from companies that advertise in the Electronics Marketplace section of this magazine. GaAs LEDs emit at a peak wavelength of 900 nanometers (nm) while GaAs:Si LEDs have a peak wavelength of about 935 nm. Visible light ranges from about 400 nm to 700 nm.

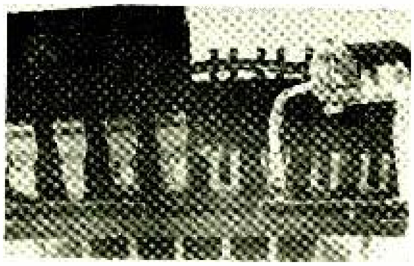


Fig. B. LED transmitter module.

Most GaAs:Si LEDs are at least twice as efficient as GaAs units, and that's why they will work better in this project. GaAs units have a much faster rise time, but this is irrelevant because the rise time of the transmitter is not fast enough to tax a GaAs:Si diode.

Figure B is a photo of the interior view of the transmitter module and Fig. C shows its assembly details. Begin assembly by installing the capacitor and diode in the bottom of the module header and inserting their leads deep in the indicated pin slots. Then install the LED as shown in Fig. C, making sure its leads are oriented properly and that it doesn't protrude too far over the edge of the header. Secure all the leads in place with a small amount of solder and clip off the excess lead lengths close to the header pins.

Next, place the pins of the IC adjacent to or inside the slots in the appropriate header pins. Make sure they don't protrude too far or the module cover will not fit. Then carefully solder the pins in place. Use a small file to remove excess solder from the outside edges of the header pins so that the module cover will fit. Then bore a hole (⅛-inch if you use a TIL32 LED) in the module cover and snap the cover in place.

Unless you use a red LED, you'll need a receiver such as the phototransistor receiver module described in the previous Project of the Month to test the transmitter. Insert the module in a solderless breadboard and connect a 3-to-6-volt supply to the power connections. With a 3-volt supply, the transmitter LED will flash on and off at 360 Hz. If you connect an earphone to the receiver module and point the LED toward the phototransistor, you will hear a loud tone. Block the path between the two modules and the tone will stop.

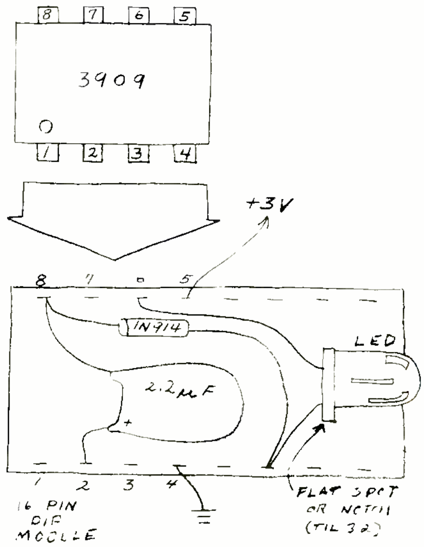


Fig. C. Assembly details of LED transmitter module.

Remember to be careful if you connect an earphone to the output of the receiver module instead of a small speaker. The sound generated by the earphone can be *very* loud.

Try experimenting with the two modules to see how far you can separate the receiver module from the transmitter module and still recover a usable signal. Also, try using the two modules as an object detector by pointing both units at a white card and seeing how far away the card can be placed without losing the signal. ◇

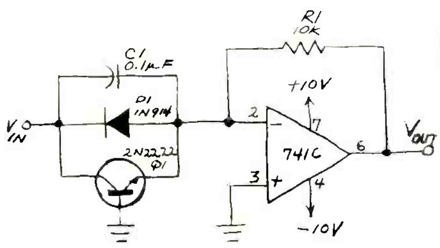


Fig. 5. Schematic of an anti-logarithmic amplifier.

If the transfer function of an ideal log amplifier is V_{OUT} = log (V_{IN}) then the transfer function of an ideal antilog amplifier is $V_{OUT} = 10^{V_{IN}}$. In an actual circuit, however, the transfer function is the inverse of the log amplifier's. The differneces between ideal and actual transfer functions are therefore compensated.

Figure 5 shows the circuit for a working antilog amplifier you can make. An interesting experiment is to connect the input of the antilog amplifier to the output of the log amplifier in Figure 2. If both amplifiers are perfectly accurate, the transfer function for the combination will be $V_{OUT} = V_{IN}$.

Here are the results I obtained from a log-antilog combination with *no* calibration adjustments:

V_{IN} (mV)	V_{OUT} (mV)
1	1
10	−6
100	−111
1,000	−1,205
10,000	−11,490

As you can see, the error is fairly high. Calibrating both amplifiers using the methods previously outlined will provide much better results.

The Analog Multiplier. Now that we've built log, antilog and summing amplifiers, we can build an analog multiplier. A block diagram for the multiplier is shown in Fig. 6 and a complete circuit in Fig. 7.

The maximum error of the multiplier is easily in excess of 10 percent. Can you improve this figure over several decades of input voltage? (Hint: Use careful calibration procedures and try to keep all feedback transistors at the same temperature by, say, bonding them together with epoxy cement.)

You can convert the multiplier into an analog divider simply by changing the summing amplifier into a difference amplifier. See last month for details.

Single-Chip Multipliers. Contrary to

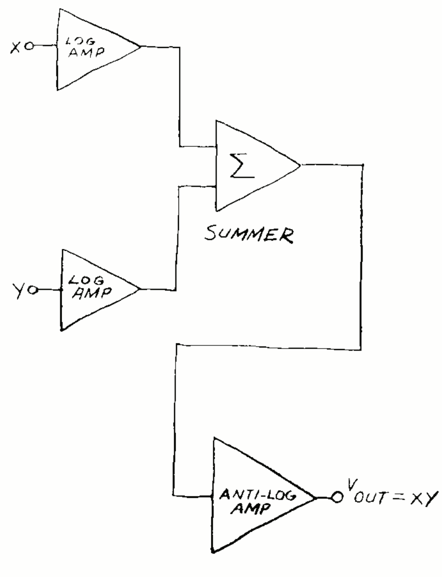


Fig. 6. Block diagram of a logarithmic multiplier.

my usual practice of breadboarding every circuit that appears in this column, I must confess to not having assembled the multiplier in Fig. 7. Several single IC multipliers that include all necessary amplifiers and transistors on the same silicon chip are now available, and they're much easier to use and more accurate because all circuit elements on the chip are at the same temperature. One such multiplier is Motorola's MC1595.

Single-chip multipliers like the MC1595 require many external calibration resistors, but recently Raytheon and Analog Devices introduced single-chip multipliers that include built-in error correcting features. Raytheon's chip is the 4200 and Analog Devices' is the AD534.

The 4200 is much less expensive than the AD534, but the latter is far superior to any previous single-chip multiplier because it includes 12 calibration resistors that have been factory-trimmed to a high degree of accuracy by a pulsed laser. The laser zaps away bits of thin-film calibration resistors that have been previously deposited directly on the silicon chip until a specified accuracy is reached.

The AD534 is being billed as the first single-chip analog computer. Having experimented with both overly demanding, temperature-sensitive log amps and now the AD534, I'm more than willing to accept this enthusiastic claim. Figure 8 shows why. All the circuits shown are complete—*no* calibration resistors are required.

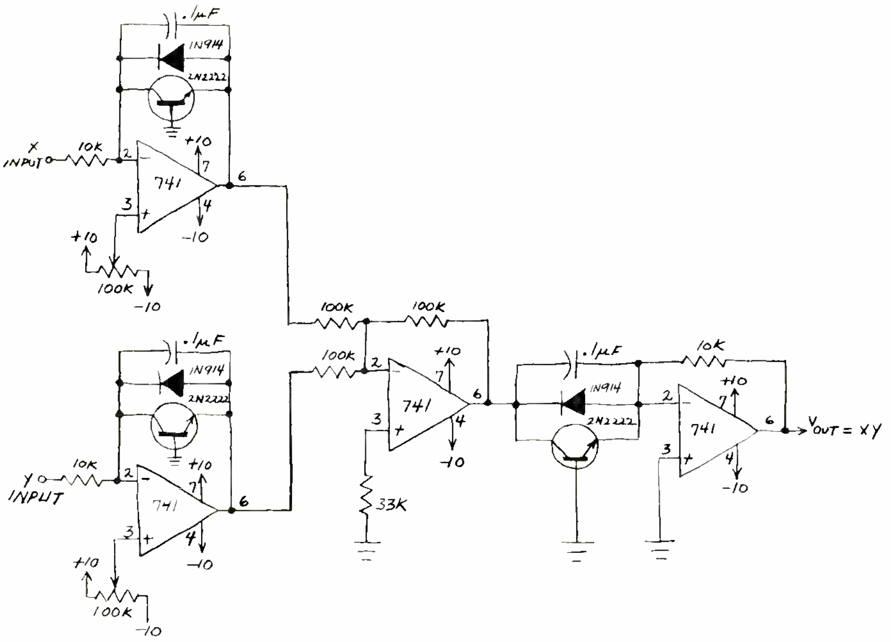


Fig. 7. Analog logarithmic multiplier circuit.

Here's an example of the results I obtained for an AD534 connected as a multiplier and a square rooter:

X	X^2	AD534	$\sqrt{10X}$	AD534
1	1	.95	3.16	3.09
2	4	4.08	4.47	4.51
3	9	9.20	5.48	5.52
4	16	16.24	6.32	6.36
5	25	24.40	7.07	7.11
6	36	35.20	7.75	7.72
7	49	48.20	8.37	8.42
8	64	63.20	8.94	8.90
9	81	79.80	9.49	9.50
10	100	98.70	10.00	10.05

As you can readily see, the AD534 is exceptionally accurate. If you want to experiment with the AD534, you'll have to order one from an Analog Devices representative. Write the company for a list of reps and a specification sheet (Route One, Industrial Park, Box 280, Norwood, MA 02062). The single-quantity price is $26.00 for the lowest accuracy version (AD534J; ±1% total error). If the price seems high, look at it again after you've spent a frustrating evening trying to calibrate a homebrew multiplier. If you prefer digital circuits, consider the cost of the hardware and the time to develop software for a microprocessor that will perform the same functions. ◇

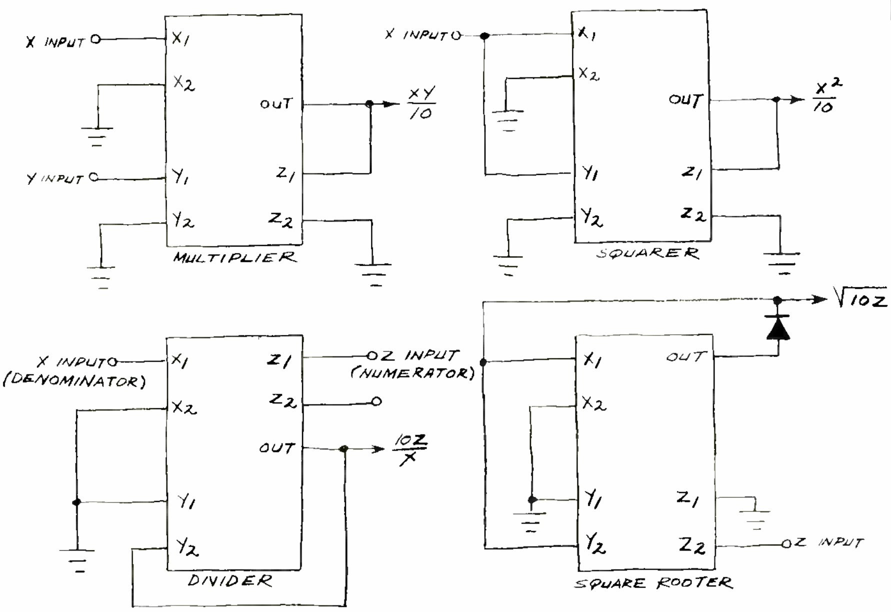
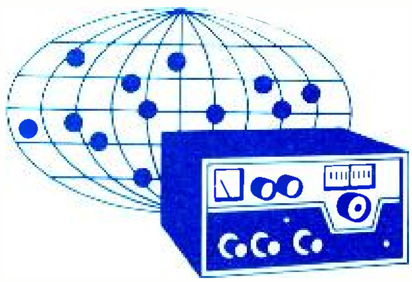


Fig. 8. Applications for the AD534 multiplier.



DX Listening

By Glenn Hauser

FINE ARTS SHORTWAVE SERVICE

SHORTWAVE listeners around the world are getting an incomplete image of U.S. broadcasting. They can hear AFRTS, which is talk, talk, talk, from domestic commercial networks (minus the commercials, but sounding more commercial than military); the government-operated Voice of America; or religious hucksters from the only privately operated American shortwave stations. And that's all there is!

"Fine-arts" broadcasting has been missing from American shortwave; though on the domestic radio bands, it is a growing oasis in a vast wasteland. Now, however, a 13-week experiment is underway to provide three hours a week of fine music on shortwave from the U.S. Listener response will determine whether the project continues and grows or comes to an end after January.

A patron of the arts has bought air time on station WINB, Red Lion, PA. This commercial, 50-kW shortwave station sells most of its time to preachers, until now the only type of broadcaster believing the potential audience justifies the price. WINB also has an antenna system for Europe, but these programs are beamed toward South America on 15145 kHz, Fridays at 8-9:30 and Saturdays at 8-10 p.m. (EST). The signal can also be heard in much of North America, except for a skip zone surrounding southeastern Pennsylvania. The fine-arts programs include "Music from Oberlin," "Adventures in Good Music," and Cleveland Orchestra pops concerts. Listeners who appreciate this service and would like to have it continue are urged to write: Fine Arts, P.O. Box 1003, Waterloo, IA 50704.

Canada. In some respects, the CBC Northern Shortwave Service inadvertently provides a "fine arts" radio service from Canada to other parts of the world. You may request their new program schedule from Box 6000, Montreal, PQ H3C 3A8. CBC is also publishing a separate, more detailed fortnightly schedule of national network CBC AM & FM (known as Radio & Stereo) programs. Some are carried simultaneously, some at other times on the Northern SW Service. A year's subscription is $6 Canadian payable to CBC. Order from CBC Radio Program Guide, c/o Bowden's Print/Mail, 296 Richmond St. West, Toronto, Ont. M5V 1X2.

Owing to political pressures to cut government spending, Radio Canada International is threatened with bearing much of a $71-million cutback for the fiscal year beginning next April 1. The president of CBC has said that RCI will undergo a "rigorous reexamination," since its function is ancillary to the CBC's main purpose of providing Canadian programming to Canadians. It would not hurt for DX listeners who value RCI to express their support. Letters may be directed to Jack Lusher, CBC P.R. Manager, Box 8478, Ottawa, Ont. K1G 3J5.

Botswana. As administrative costs rise, more shortwave stations are reassessing the value of sending out QSL verification cards on request. The collecting of QSLs has become an end in itself, with picking up the stations merely the means. The basic purpose of broadcasting, to provide programming to be listened to for its content, tends to get shoved aside by those whose only interest in a station is to get a card in the mail.

But QSL chasers were still shocked when they read in the World Radio-TV Handbook *Newsletter* (this message from D. W. Harris, Acting Director of Broadcasting at Radio Botswana): "We do *not* QSL under any circumstances. I make no apology for this but would point out that we are far too short staffed to spend time verifying reports which are invariably worthless to us anyway." Radio Botswana does not seek an audience outside southern Africa, obviously. Coincidentally, the Voice of America has signed an agreement to install six 250-kilowatt relay transmitters in Botswana. So QSL collectors may still have some hope of verifying Botswana.

France. Radio France International for some time ignored the lobbying of the RFI Listeners Club of North America for an evening broadcast in English. But finally, RFILC president Matthew Brown received this from RFI P.R. agent M. Rick: "There will be no extension to the western hemisphere in 1979, but Spanish and English broadcasts are possible by 1980. We are collecting letters from American listeners in order to prepare a special document meant to prove to our government that there are really interested listeners who wish a special transmission of RFI for the USA." Now's the time to write M. Rick, at RFI, B.P. 9516, Paris, France.

The Beeb and the Bugs. The BBC World Service survived the notorious "think tank" proposal that it be cut to 16 hours a day—and gained a £20-million appropriation for transmitter improvement in the process. As a result, an engineering team has been scouting around the Indian Ocean for a new relay site. One possibility is the Seychelles, which would assure a good signal into East Africa, long one of BBC's main trouble spots in coverage. It may be expensive: the other SW station there, FEBA, found its license fee raised from £25 to £60,000 when the government changed hands.

Operating a radio station on an exotic island has other drawbacks. In London, the BBC opened a box from its Ascension station to find a 3-inch cockroach; and the relay then offered to send along scorpions, mosquitos, cicadas and foot-long centipedes. In another ocean, Radio Cook Islands made news when a centipede got into its transmitter, requiring them to be off the air for a few hours.

The Pacific. The NBC in Papua New Guinea, has bugs of a different kind in its transmitters. Within the past few months, Port Moresby has shown up for periods of a week or so on 4760, 4787.5 and 9780 kHz with semi- and second harmonics, instead of three nominal frequencies of 9520, 9585 and 4890. This was supposedly due to a "defective crystal switch."

Solomon Islands has been putting a good signal into North America on 5020 kHz until sign off at 1130 GMT, except

Sundays when Herbert W. Armstrong extends the schedule to 1200.

Radio New Zealand is a fine station that does a lot for its two 7½-kW transmitters. It doesn't finalize its schedule far enough in advance to be included in our Broadcasts in English schedules, so here is the schedule through February: Transmitter I: 1700-2005 GMT on 11960, 2015-0415 on 17770, 0425-0715 on 11945, 0730-1115 on 6105. Transmitter II: 1700-0145 on 15345, 0200-0530 on 15280, 0540-1115 on 6105 kHz.

Voyageur Busted. After six months of regular weekly broadcasts on 5850 kHz, Mike Martin voluntarily closed down his *Voice of the Voyageur* pirate station in Minneapolis, Aug. 20. He was off to college and other staff members had begun to scatter, some to the army. A week after the closing, the FCC busted him anyway, in a cordial visit, subsequently marred by threats to revoke his FCC licenses. But Martin seems to think his stint as Top Man at the *Voice of the Voyageur* was a valuable experience. The station made a brief comeback on 6220 kHz. *Voice of the Vikings* might have been a successor, but after a test broadcast on 7445 kHz, nothing further was heard.

Nicaragua. No shortwave broadcasting was heard from either side during the September war, until Somoza's Radiodifusora Nacional returned to the air on 5950 kHz at the end of that month, testing a 100-kW transmitter at half-power. Back in June, Aaron Hywarren in Manitoba heard the clandestine Radio Sandino at 0510-0524 GMT on 7449 kHz. We know of not a single other logging of this station by a DXer. It reportedly often changed frequencies.

Costa Rica. Radio Universidad was widely heard on 6097-98 kHz, then 6103, instead of 6105, with lots of classical music and some jazz. They were reportedly testing a new 10-kW transmitter, and have been authorized 100 kW.

Dominican Republic. After our November story on Radio Clarin had gone to press, we learned that Rudy Espinal was no longer working for Radio Clarin or at any other Santo Domingo station. There seemed to be no possibility that Radio Clarin would resume its international service in English, but the government station, Radio-TV Dominicana, plans to do some international broadcasting on 9505, and might buy new transmitters to operate on the 16-through-60-meter bands.

Brazil. Fears that Brazil would close down its many tropical-band stations seem to have been groundless. Instead, many more such stations have been authorized, such as a 50-kW Radio Nacional de Manaus on 4875. A new station already on the air and heard in North America is Radio Iguatemi, in Sao Paulo state, on 3295. Try for it in the early evening hours.

Wee Hours, Wee Powers. Though it is *not* necessary to stay up all hours of the night to enjoy DX listening, it can pay off. Richard M. Utter in New York heard a Venezuelan no one else had, at 0830 GMT on 6080 kHz. A station listed inactive, Radio Zaraza, was heard with a definite ID on a very weak signal. A Minnesota DX Club all-night gathering succeeded in pulling in another rare station, also on 6080—CKFX, Vancouver, supposedly using a 10-watt transmitter beamed north!

New Mediumwave Plan. International mediumwave DX listening is an entirely different game now, following massive frequency changes in Europe, Africa, Asia and the Pacific. In general, Eurafrican frequencies are one kHz higher than before, at 9-kHz spacings. This opens new windows and closes old ones to North American DX listeners, who must DX foreign stations who transmit on "split" frequencies between our 10-kHz-spaced stations.

For readers with very selective receivers, Australasian stations now have a much better chance of being heard farther east into North America since they have replaced 10-kHz spacing with 9 kHz. However, this comes as the low point in mediumwave DX propagation approaches with the sunspot peak. We may have to wait another few years until the next sunspot trough is reached to learn if predictions come true that Australian and New Zealand MW stations will be easily and frequently heard throughout North America, as happened in the 1930s. Gene Martin, in Denver, found regular reception from Tahiti on 738 kHz and New Zealand on 756 kHz, following the November 23, 1978 frequency changes.

Addresses. In November, I urged you to join the North American Shortwave Assoc., but omitted the address! It's Box 13, Liberty, IN 47353. If you'd like to take part in the 1979 Tropical Bands Monitoring and Contest during January, send an SASE for full details to: Jim W. Young, Box 576, Wrightwood, CA 92397.

UPDATING ENGLISH BROADCAST LISTINGS OF DECEMBER

GMT	Station	Frequencies, changes
1100–1156	R. RSA	15125, not 25790
1130–1200	R. Veritas Asia	9590, 11805, 15165
1200–1215	Vatican R.	21485
1200–1230	Israel R.	add 21565
1200–1600	HCJB	ex to 1630
1230–1255	Austrian R.	21530 ex–17725
1230–1300	R. Sweden	21690 ex–21700
1300–1330	R. Veritas Asia	9590, 11955, 15165 (ex. 1400–1500)
1300–1550	R. RSA	not 25790
1330–1430	R. Finland	15210, ex–15105 (Sun.)
1400–1800	AFRTS, Washington	15430 or 15425, 15330
1500-1709	BBC	17830, ex-17840
1515–1530	V. of Greece	17830, 15345 (both not Tues.)
1530–1615	NSB, Tokyo	9595, 6055
1600–1630	R. Korea	9720, not 9740
1700–1800	HCJB, Ecuador	17865 & 15380, ex–17745 & 15295
1705–1755	R. France Int.	add 21580, 17860, 17850, 17795, 17720, 15200
1710–1755	BRT, Belgium	17735
1745–2230	All India Radio	11620
1800–1900	R. Australia	11800
1900-1930	R. Afghanistan	11805 (frequent changes)
1900–2030	HCJB, Ecuador	17865, ex–17770
2000–2030	R. Algeria	ex 1800–1900
2000–2030	V. of Iran	9022 (ex 1930–2000)
2000-2115	BBC	17830, ex-17840
2045–2115	Malta Calling	6010 (Sat.) (frequent changes)
2130–2200	R. Sofia	7115 & 5915, ex 11850 & 11750
2130–0400	AFRTS-Washington	add 21650
2200–2300	R. Canada International	11855, 9575 (Mon-Fri)
2300–2330	R. Vilnius	17870, 15240, 15100, 9580, 7150; ex 7400 and 7360
0030–0100	R. Kiev	15240, 15100, 7215, ex–15180, 12000, 6020, 5980
0030-0200	HCJB, Ecuador	15115
0050–0135	TWR, Bonaire	ex 0035–0135
0100–0120	RAI, Italy	6010, ex–11810
0100–0300	WYFR	5985, ex to 0500
0200–0215	R. Japan	15105, ex–17755
0200–0250	R. RSA	15220, ex–5980
0200–0530	R. New Zealand	15280
0215–0230	V. of Greece	drop 9515, ex-9610
0300–0315	R. Japan	15105, ex–17755
0300–0330	R. Kiev	7320, 7260, 7215, 7175, 5970, ex–11860, 9780, 7400, 7245, 6020, 5980
0300–0500	WYFR	6155, ex–5985
0430–0455	Austrian R.	5945, ex–6015
0430–0500	R. Sofia	7115 ex–9530
0500–0515	Israel R.	add 11635
0500–0515	R. Japan	9505 ex–15105
0515–0615	Spanish Foreign R.	6065, ex–11880
0540–1115	R. New Zealand	6105
0600–0615	R. Japan	9505 ex–15105
0700–0715	R. Japan	9505 ex–15105
1100–1200	AFRTS-Washington	ex 0700–1200

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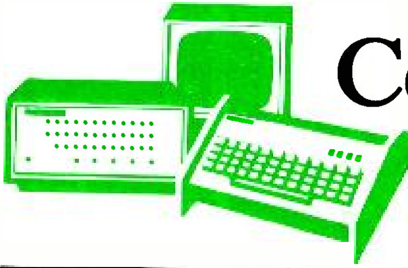

Computer Bits

By Leslie Solomon, Technical Director

APL/S—A BETTER LANGUAGE?

THE EASIEST way to provoke a debate among a group of computer users is to claim that one high-level language is better than another. BASIC afficionados claim that their language is "human," making it easier to program and read when it comes on-screen. FORTRAN users claim all sorts of wondrous things for this language; while PILOT, FOCAL, *et al*, users provide vociferous defense for their selection. Almost all computer users admit, however, that the language they would like to use is that tremendously powerful one—APL.

While APL may be a "first-choice" language, its popularity is restricted because a special character generator is needed to reproduce the special APL symbols required. Moreover, most people are awed at the amount of memory usually thought to be required to support APL. This need not be the case with the APL/S language soon to be introduced by Video Brain (2950 Patrick Henry Dr., Santa Clara, CA 95050; tel.: 408-988-3020). (The S in APL/S stands for "structured" or "simple.")

The new Video Brain language is a small APL. It combines the array manipulation capabilities of APL with structured control words of PASCAL. It is contained in a plug-in cartridge that has 13K of ROM. When plugged into the Video Brain computer, APL/S comes up in conventional alphanumeric characters. Price for the cartridge is to be about $150, which will include a user and reference manual.

APL/S features such commands as LIST, ERASE, SAVE, LOAD, BACK, NEXT, PREVIOUS, and SPECIAL. It also has a large selection of statements including BARH to control bargraph height and BARC to determine bargraph colors (16), in addition to argument and reduction functions. Other features include values of variables in either scalar or array; all values stored in 4-byte floating point (the largest number is 10^{75}); seven-digit precision; and E notation in both input and output.

The same features that make APL/S a problem-solving language—it is structured, readable, and problem oriented—allow one to learn programming concepts without the bother of syntactical burdens and the unnecessary constraints of some typical computer languages. There are no line numbers in APL/S. By carefully documenting a program on paper, you essentially write it at the same time. This is similar to the approach used in PILOT. As an example, a "Lunar Lander" program that used more than 90 lines in BASIC (and lots of REMs) was easily duplicated in 28 lines of APL/S that was self-documenting and required no REMs.

Chess and Bridge. Personal Software (P.O. Box 136, Cambridge, MA 02138; tel.: 617-783-0694) has some news for chess and bridge players. If you have a Radio Shack Model TRS-80 computer with Level I or Level II BASIC, Microchess 1.5 ($19.95) is for you. It offers three levels of play, every move is checked for legality, and the program handles castling and en-passant captures. Moreover, depressing "N" on the keyboard causes each square to be numbered so that play is truly simplified. If you have an 8K PET or a 16K Apple computer, there is Microchess 2.0 ($19.95) which offers eight levels of play to examine up to six moves ahead, and includes an on-screen clock. If bridge is your game, Bridge Challenger ($14.95) is available for the 8K PET, 16K Level-II TRS-80, and 16K Apple. This program allows you and the dummy to play four-person contract bridge using the computer as the other hands.

Z80 for S-100 Bus. Connecting a Z80 to an S-100 bus is easy with the "Single Card Computer" from Cromemco, Inc. (280 Bernardo Ave., Mountain View, CA 94043; tel.: 415-964-7400). Available in kit ($395) and assembled and tested ($450) forms, it features 4-MHz operation, 8K of PROM, and 1K of RAM. The board also contains an RS-232 or 20-mA loop; serial interface with baud rates up to 76,800; vectored interrupts; 24 bits of bidirectional parallel I/O; and five programmable timers. Cromemco also has software to be used with the new board.

Build a Terminal. You can build a professional-style terminal with the ESAT 200B Communicating Terminal ($239) as the basic element. The kit is available from Electrolabs (P.O. Box 6721, Stanford, CA 94305; tel.: 415-321-5601).

The terminal produces 80 characters on each of 34 lines on-screen. It contains a single 14" × 18" (35.6 × 20.3 cm) board that generates upper- and lower-case ASCII characters. On-board is an empty socket for an optional EPROM that allows the terminal to have two fonts of up to 120 characters per font. User-alterable fonts are programmed into 256 groups of 7 × 8 cells that are displayed contiguously. This permits the use of extended characters in two or more adjacent cells. Anything can be programmed into the cells, including Farsi and APL characters, graphic symbols, etc. Keyboard input is seven or eight bits with negative strobe. Video output is selectable composite or separate sync. Baud rates are from 110 to 19,200 at RS-232C, 20-mA or TTL levels.

Ten Megabytes. Alpha Micro (17881 Sky Park No., Irvine, CA 92714; tel.: 714-957-1404) has announced the Model AM-500, an S-100 bus-compatible, 10-megabyte disk system for $7995. The system consists of a single-board controller, interconnecting cable, and a 10-megabyte Control Data "Hawk" disk drive.

A 5-megabyte fixed disk and a 5-megabyte removable cartridge are used in the system to provide the 10-megabyte capability. The controller board is interrupt driven, requires a simple interface to the CPU system, and does complete 512-byte transfers. Although it was designed for the AMOS operating system, the Model Am-500 will work on the S-100 bus. This DOS permits multiple users, multiple tasking, time sharing, and memory management. Up to four drives can be daisy-chained to one controller.

The General. A new computer from Xitan Inc. (1101-H State Rd., Princeton, NJ 08540; tel.: 609-921-0321), called the "General," features a Z80A microprocessor. It also features memory-mapped interrupt-driven DMA-controlled architecture to fully support multitasking software; 630K of mass storage on two 5 " (13.3-cm) disk drives; 32K of RAM; and space display is 80 characters wide on 24 lines, with blink, invert, half-intensity, zero-intensity, and underline functions. It provides three software definable character sets and interfaces.

VIP News. RCA "VIP" owners can now play in color, using the Model VP-500 color board ($69), or make exciting music with the Model VP-550 Super Sound board ($49). The color board provides up to eight colors. The music board comes with a PIN (play it now) program that permits transcribing sheet music or creation of new sounds. The board has a range of four octaves and can play two-part harmony.

Other VIP items are also available: Model VP-595 simple sound board ($24) includes speaker and amplifier; Model VP-570 memory-expansion board ($85) contains 4K of RAM; Model VP-580 expansion board ($15) plugs into color board or Model VP-585 keyboard interface board ($10) to allow two people to use the VIP in games; Model VP-560 EPROM board ($34) allows use of two Intel 2716s; Model VP-565 EPROM programming board ($99) allows programming Intel 2716s for Model VP-560; Model VP-700 Tiny BASIC ROM board ($39) requires an external ASCII keyboard; Model VP-900 ASCII keyboard ($50) has upper- and lower-case and control characters. There is also a VIP newsletter now available, called *Viper*, from Box 43, Audubon, PA 19407, at $15 for 10 issues.

Smart Cassette-I/O Controller. Xecon Micro (P.O. Box 267, Hawthorne, CA 90250; Tel 213-676-8346) has announced its MS-CIO audio cassette and serial I/O controller with a built-in relocatable operating system for $205 assembled and tested. This device, for the S-100 bus, supports two cassette tape units, and has an RS-232 or 20-mA serial port. The cassette operates at 1200, 2400, or 4800 bits/second using a modified KC format. Integral motor control drivers are provided. The cassette operating system handles motor control, file formatting, labelling, searching and generation of inter-record gaps. There is no need for control program boot-strapping. To perform a tape search, load or dump, the user calls the desired routine. ◇

Software Sources

COBOL for 8080/Z80/8085. The world's most widely used computer programming language is now available for 8080-compatible microprocessors. COBOL-80 is based on the 1974 ANSI standard, and contains all Level-1 features and some Level-2 options for file handling and the "Nucleus." Level-1 Table Handling, Library and Interprogram Communication facilities are provided. A data format called COMP-3 allows numeric data to be packed two digits to the byte, reducing mass-storage requirements. Also included are a batch-style Debug, and Microsoft's Linking Loader. The system consists of two packages: a compiler, generating machine-independent pseudo-code (which has also been implemented on some minicomputers) plus a runtime module which interprets the pseudocode in 8080 machine code. The compiler plus interpreter occupy about 25K bytes; operating system and table space add about 7K and 12K bytes respectively, for a total of about 44K. Price on CP/M or ISIS-II disks is $750 per copy; documentation (supplied with the system), is $20 separately. Microsoft, 300 San Mateo N.E., Suite 819, Albuquerque, NM 87108.

Pet Educational Programs The Peninsula School Computer Project now offers three educational program tapes for 8K Pets, each supplied with listings and other information. Tape 1 includes PILOT, an easy-to-learn programming language oriented toward computer-assisted instruction, plus five sample game programs in PILOT; $20. Tape 2 ($15) includes a BASIC line-renumbering program, a Kaleidoscope graphics program, a lemonade-stand business simulation game and WSFN, a control language for a graphically simulated "robot." Tape 3 ($10) includes QUEST, a maze game similar to , but more difficult than Wumpus, and a graphics picture-drawing program whose output may be saved on tape or included as subroutines in other programs. Peninsula School Computer Project, Peninsula School, Peninsula Way, Menlo Park, CA 94025.

North Star DOS +, for MECA, too. DOS+ is a 1K add-on for North Star DOS which will also execute all Meca tape commands. It provides a simple protocol for transfer of ASCII data between programs (useful, for example, in translating programs from one BASIC interpreter to another) and between I/O devices. It allows BASIC programs to list the directory and create or delete disk files, and also works with assembler-language programs. Other features include facilities for programmed creation of operation-lists in memory with single or repeated execution, and command transfer to other programs, as well as decimal and hex I/O. Starting addresses can be at 1C00, 5C00, 6C00 or 7C00. Manual and diskette (source-code not included), $35. Interactive Microware, Inc., 116 S. Pugh St., State College, PA 16801.

8080 Disassembler. Available in Byte (K.C.) and Polyphase (Polymorphic) cassettes with documentation, this program provides full object and source code display of 8080 programs, detects out-of-range addresses, and incorporates up to 999 pseudo labels. Written for Polymorphic 88 systems, it can easily be modified to run on most 8080 systems in 8K through 24K. Nominal configuration uses less than 4K of RAM. Two versions are available: object code is $20, source code (including listings) is $40. Specify Byte or Polyphase cassette. Micromatics, Box 5710, Columbus, OH, 43221.

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.)

Polytechnic Research and Development precision frequency meter TY560s1 serial #151. Need operation manual and any information. **Amplidyne Laboratories** 220-MHz converter model C14 serial #203. Need manual and information. Jung Y. Lem, 5222 Coringa Drive, Los Angeles, CA 90042.

H.H. Scott model 340-B Stereomaster receiver. Need owners manual and source for parts. S. Hoffman, 3689 Elmore Ct., Cols, OH 43224.

Knight kit receiver, model R100A. Schematic and manual. E.H. Willi, 2280 N.W. 79th Avenue, Ft. Laucerdale, FL 33322

Hickok Company Stark model 20C universal crystal-controlled signal generator. Manual and electronic diagram. Uri Gordon, 51/3 Hatzvi Street, Beer-sheva, Israel

Sperry Remington Rand EDC-1 office calculator. Schematic and service information. David Gardner, North View Trailer Ct., Gerald, MO 63037

Braun multi-band German table radio, type RC61A. Need schematic. Isaac W. Eaves, 10113 Pillot St., Houston, TX 77029.

E.H. Scott Laboratories SLR 12-B SW receiver. Need any information. **Accurate Instrument Company** model 151 tube tester. Need tube chart. Matthew Currie, Belden St., Falls Village, CN 06031.

Superior Instruments Co., genometer, model TV-50A. Need operating instructions and schematic. Charles Peterson, Box 45, Langford, SD 57454

Jackson model CRO-2 oscilloscope. Need schematic and manual. J. Pederson, 1701-150th S.W., Lynnwood, WA 98036.

Tektronix oscilloscope model 561A. Need manual and schematic. Bill Seeley, 1139-Taraval St., San Francisco, CA 94116.

Brewer Labs Varmint mobile linear model XL400. Schematic, service manual and any other information. Dale L Schneider, 10 W. Sycamore St., Apt. 11, Oxford, OH 45056.

Concord model 501D. Need schematics. **Teak** model A-1200. Need schematics. Wesley Jensen, Box 13, Fond Dulac, WI 54935.

Unitrobe transistor U13T1, 7215, NX12C. Need specifications. P.J. Mischkot, 2510 Turtle Creek Dr., Sherman TX 75090.

Meisel Electric Co., Ltd. model MDK-800 A (Challenger) 23-channel CB. Need schematic diagram. Philip L Weller, 46 S. Madison St., Allentown, Pa 18102

Sears 1954 21" TV. Need horizontal output transformer. Paul B. Sanderlin, 12821 Chambers Rd., Sunbury, OH 43074.

Akai tape recorder model M-7. Need operation manual or any other information. P L Knox, 14644 Fallbrook Ct., Sun City, AZ 85351.

De Jur model TK820 open reel tape recorder. Operation manual needed for sections F, G and H. Walter Mesko, R.F.D. 1, Box 414, Lake George, NY 12845.

Sparton model 121 receiver chassis #8L9. Need schematics. **Audio Instrument Co.**, inter-modulation meter model 167D Series 223. Need schematic and operating manual. Barry Fuerst, 218 Floumoy St., Oak Park, IL 60304

Zenith model 12H689 FM/Am/SW receiver. Need schematic, operating instructions or any other information. Ronald Rubin, 1722 Canterbury Circle, Casselberry, FL 32707.

Teletronics Laboratory Navy model LAJ-4 audio oscillator #941. Need schematic, operating and alignment information. Barry Fuerst, 218 Floumoy St., Oak Park, IL 60304.

Pearce-Simpson model Bemini 550 marine radio telephone transceiver. Need schematic and operating information. **Army Signal Corps** model PP-949-TGC power supply, need Army training manual. John T. Matyas, 6815 San Miguel, Lemon Grove, CA. 92045.

Crosley models 51, 52, VI Pup, X, XJ Trirdyn Newport 5-38. Need factory service manuals. B. Dingman, 3752 Orange Ave., Long Beach, CA 90807.

Accurate Instrument Co. Inc. tube tester model 257. Need copy of wiring diagram and instruction manual. Bill Stipick, 272 Overbrook Dr., Newtown Square, PA 19073.

Systron-Donner 1240 RMS/DC converter. Need manuals and schematics. **Sierra** 219B transistor checker. Need manuals and schematics. Bob Sandell, 26 G.H. Baker Dr., Urbana, IL 61801.

Defense Electronics, Inc., model TR-711 (1234) and (123) telemetry receiver. Need manual for maintenance, schematics and octal-base oscillators. Ken Raynore, 127 Temple Circle, Lynchburg, VA 24502.

Radio Manufacturing Engineers RME-84 SW receiver. Need schematic or address of manufacturer. Erich Noll, 7507 E. 52nd St., Kansas City, MO 64129.

Tektronix 535 oscilloscope. Manual needed. Have 531 manual to trade. Bill Hocutt, 926 S. Shades Crest Rd., Bessermer, AL 35020.

Norden-Hauck Super DX5, Ross 4-C, Silver 5C, and Sargent 8-34 communication receivers. Need schematics, owners manuals, and other information. H.L. Chadbourne, 530 Midway St., La Jolla, CA 92037.

Berkeley Universal EPUT and timer model 7350R. Need operating instructions, schematic and parts list. C.A. Allen, 805 Chatterson Rd., Huntsville, AL 35805.

Heathkit DX-40 Transmitter. Need schematics and/or operating manual. Ted. K Wright, 3929 Wood Lane, Ft. Worth, TX 76117.

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1N914	100v	10mA	.05
1N4005	600v	1A	.08
1N4007	1000v	1A	.15
1N4148	75v	10mA	.05
1N4733	5.1v	1 W Zener	.25
1N753A	6.2v	500 mW Zener	.25
1N758A	10v	"	.25
1N759A	12v	"	.25
1N5243	13v	"	.25
1N5244B	14v	"	.25
1N5245B	15v	"	.25

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8-pin	pcb	.20	ww	.35
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2N3904	NPN (Plastic - Unmarked)	.10
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2N3055	NPN 15A 60v	.50
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MAN82A	7 seg com-anode (Yellow)	1.25
MAN74A	7 seg com-cathode (Red)	1.50
FND359	7 seg com-cathode (Red)	1.25

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4006	.95
4007	.20
4008	.75
4009	.35
4010	.35
4011	.20
4012	.20
4013	.40
4014	.75
4015	.75
4016	.35
4017	.75
4018	.75
4019	.35
4020	.85
4021	.75
4022	.75
4023	.20
4024	.75
4025	.20
4026	1.95
4027	.35
4028	.75
4030	.35
4033	1.50
4034	2.45
4035	.75
4040	.75
4041	.69
4042	.65
4043	.50
4044	.65
4046	1.25
4049	.45
4050	.45
4066	.55
4069/74C04	.25
4071	.25
4081	.30
4082	.30
MC 14409	14.50
MC 14419	4.85
4511	.95
74C151	1.90

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7400	.10
7401	.15
7402	.15
7403	.15
7404	.10
7405	.25
7406	.25
7407	.55
7408	.15
7409	.15
7410	.15
7411	.25
7412	.25
7413	.25
7414	.75
7416	.25
7417	.40
7420	.15
7426	.25
7427	.25
7430	.15
7432	.20
7437	.20
7438	.20
7440	.20
7441	1.15
7442	.45
7443	.45
7444	.45
7445	.65
7446	.70
7447	.70
7448	.50
7450	.25
7451	.25
7453	.20
7454	.25
7460	.40
7470	.45
7472	.40

7473	.25
7474	.30
7475	.35
7476	.40
7480	.55
7481	.75
7483	.75
7485	.55
7486	.25
7489	1.05
7490	.45
7491	.70
7492	.45
7493	.35
7494	.75
7495	.60
7496	.80
74100	1.15
74107	.25
74121	.35
74122	.55
74123	.35
74125	.45
74126	.35
74132	.75
74141	.90
74150	.85
74151	.65
74153	.75
74154	.95
74156	.70
74157	.65
74161	.55
74163	.85
74164	.60
74165	1.10
74166	1.25
74175	.80

74176	.85
74180	.55
74181	2.25
74182	.75
74190	1.25
74191	.95
74192	.75
74193	.85
74194	.95
74195	.95
74196	.95
74197	.95
74198	1.45
74221	1.00
74367	.75
75108A	.35
75491	.50
75492	.50
74H00	.15
74H01	.20
74H04	.20
74H05	.20
74H08	.35
74H10	.35
74H11	.25
74H15	.45
74H20	.25
74H21	.25
74H22	.40
74H30	.20
74H40	.25
74H50	.25
74H51	.25
74H52	.15
74H53J	.25
74H55	.20

74H72	.35
74H101	.75
74H103	.55
74H106	.95
74L00	.25
74L02	.20
74L03	.25
74L04	.30
74L10	.20
74L20	.35
74L30	.45
74L47	1.95
74L51	.45
74L55	.65
74L72	.45
74L73	.40
74L74	.45
74L75	.55
74L93	.55
74L123	.85
74S00	.35
74S02	.35
74S03	.25
74S04	.25
74S05	.35
74S08	.35
74S10	.35
74S11	.35
74S20	.25
74S40	.20
74S50	.20
74S51	.25
74S64	.15
74S74	.35
74S112	.60
74S114	.65

74S133	.40
74S140	.55
74S151	.30
74S153	.35
74S157	.75
74S158	.30
74S194	1.05
74S257 (8123)	1.05
74LS00	.20
74LS01	.20
74LS02	.20
74LS04	.20
74LS05	.25
74LS08	.25
74LS09	.25
74LS10	.25
74LS11	.25
74LS20	.20
74LS21	.25
74LS22	.25
74LS32	.25
74LS37	.25
74LS38	.35
74LS40	.30
74LS42	.65
74LS51	.35
74LS74	.35
74LS86	.35
74LS90	.55
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SN7423N	25	SN7497N	3 00	SN74185N	1 95
SN7425N	29	SN74100N	89	SN74186N	9 95
SN7426N	29	SN74107N	35	SN74188N	3 95
SN7427N	25	SN74109N	59	SN74190N	1 25
SN7429N	39	SN74116N	1 95	SN74191N	1 25
SN7430N	20	SN74121N	35	SN74192N	79
SN7432N	25	SN74122N	39	SN74193N	79
SN7437N	25	SN74123N	49	SN74194N	89
SN7438N	25	SN74125N	49	SN74195N	69
SN7439N	25	SN74126N	49	SN74196N	89
SN7440N	20	SN74132N	75	SN74197N	89
SN7441N	89	SN74136N	75	SN74198N	1 49
SN7442N	49	SN74141N	79	SN74199N	1 49
SN7443N	75	SN74142N	2 95	SN74S200	4 95
SN7444N	75	SN74143N	2 95	SN74251N	1 79
SN7445N	75	SN74144N	2 95	SN74279N	79
SN7446N	69	SN74145N	79	SN74283N	2 25
SN7447N	59	SN74147N	1 95	SN74284N	3 95
SN7448N	79	SN74148N	1 29	SN74285N	3 95
SN7450N	20	SN74150N	89	SN74365N	69
SN7451N	20	SN74151N	59	SN74366N	69
SN7453N	20	SN74152N	59	SN74367N	69
SN7454N	20	SN74153N	59	SN74368N	69
SN7459A	25	SN74154N	99	SN74390N	1 95
SN7460N	20	SN74155N	79	SN74393N	1 95
		SN74156N	79		
		SN74157N	65		

20% Discount 100 pcs combined order 25% -1000 pcs combined order

C/MOS

CD4000	23	CD4028	89	CD4070	55
CD4001	23	CD4029	1 19	CD4071	23
CD4002	23	CD4030	49	CD4072	49
CD4006	1 19	CD4035	99	CD4076	1 39
CD4007	25	CD4040	1 19	CD4081	23
CD4009	49	CD4041	1 25	CD4082	23
CD4010	49	CD4042	99	CD4093	99
CD4011	23	CD4043	89	CD4098	2 49
CD4012	25	CD4044	89	MC14409	14 95
CD4013	39	CD4046	1 79	MC14410	14 95
CD4014	1 39	CD4047	2 50	MC14411	14 95
CD4015	1 19	CD4048	1 35	MC14419	4 95
CD4016	49	CD4049	49	MC14433	19 95
CD4017	1 19	CD4050	49	MC14506	75
CD4018	99	CD4051	1 19	MC14507	99
CD4019	49	CD4053	1 19	MC14562	14 50
CD4020	1 19	CD4056	2 95	MC14583	3 50
CD4021	1 39	CD4059	9 95	CD4507	95
CD4022	1 19	CD4060	1 19	CD4510	1 39
CD4023	23	CD4066	79	CD4511	1 29
CD4024	79	CD4068	39	CD4515	2 95
CD4025	23	CD4069	45	CD4518	1 29
CD4026	2 25			CD4520	1 29
CD4027	69			CD4566	2 25

74C00

74C00	39	74C85	2 49	74C163	2 49
74C02	39	74C90	1 95	74C164	2 49
74C04	39	74C93	1 95	74C173	2 60
74C08	49	74C95	1 95	74C192	2 49
74C10	39	74C107	1 25	74C193	2 49
74C14	1 95	74C151	2 90	74C195	2 49
74C20	39	74C154	3 00	74C922	5 95
74C30	39	74C157	2 15	74C923	6 25
74C42	1 95	74C160	2 49	74C925	8 95
74C48	2 49	74C161	2 49	74C926	8 95
74C73	89			80C95	1 50
74C74	89			80C97	1 50

LINEAR

78MG	1 75	LM340K 18	1 35	LM710N	79
LM106H	99	LM340K 24	1 35	LM711N	39
LM300H	80	LM340T 5	1 25	LM723N H	55
LM301CN H	35	LM340T 6	1 25	LM733N	1 00
LM302H	75	LM340T 8	1 25	LM739N	1 19
LM304H	1 00	LM340T 12	1 25	LM741CN H	35
LM305H	60	LM340T 15	1 25	LM741-14N	39
LM307CN H	35	LM340T 18	1 25	LM747N H	79
LM308CN H	1 00	LM340T 24	1 25	LM748N H	39
LM309H	1 10	LM358N	1 00	LM1310N	2 95
LM309K	1 25	LM370N	1 95	LM1458CN H	59
LM310CN	1 15	LM373N	3 25	MC1488N	1 95
LM311N H	90	LM377N	4 00	MC1489N	1 95
LM312H	1 95	LM380N	1 25	LM1496N	95
LM317K	6 50	LM380CN	99	LM1556V	1 75
LM318CN H	1 50	LM381N	1 79	MC1741SCP	3 00
LM319N	1 30	LM382N	1 79	LM2111N	1 95
LM320K 5	1 35	NE501N	8 00	LM2901N	2 95
LM320K-5.2	1 35	NE510A	6 00	LM3053N	1 50
LM320K 12	1 35	NE529A	4 95	LM3065N	1 49
LM320K-15	1 35	NE531H V	3 95	LM3900N(3401)	49
LM320K 18	1 35	NE536T	6 00	LM3905N	89
LM320K 24	1 35	NE540L	6 00	LM3909N	1 25
LM320T-5	1 25	NE544N	4 95	MC5558V	59
LM320T 5.2	1 25	NE550N	1 30	8038B	4 95
LM320T 8	1 25	NE555V	39	LM75450N	49
LM320T 12	1 25	NE556N	99	75451CN	39
LM320T 15	1 25	NE560B	5 00	75452CN	39
LM320T 18	1 25	NE561B	5 00	75453CN	39
LM320T 24	1 25	NE562B	5 00	75454CN	39
LM323K 5	5 95	NE565N H	1 25	75491CN	79
LM324N	1 80	NE566CN	1 75	75492CN	89
LM339N	99	NE567V H	99	75493N	89
LM340K 5	1 35	NE570N	4 95	75494CN	89
LM340K-6	1 35	LM703CN H	69	RC4136	1 25
LM340K 8	1 35	LM709N H	29	RC4151	5 95
LM340K 12	1 35			RC4194	5 95
LM340K 15	1 35			RC4195	4 49

74LS00TTL

74LS00	23	74LS47	69	74LS138	69
74LS01	23	74LS51	23	74LS139	69
74LS02	23	74LS54	23	74LS151	69
74LS03	23	74LS55	23	74LS155	69
74LS04	29	74LS73	35	74LS157	69
74LS05	29	74LS74	35	74LS160	89
74LS08	23	74LS75	49	74LS161	89
74LS09	29	74LS76	35	74LS162	89
74LS10	23	74LS78	39	74LS163	89
74LS11	60	74LS83	75	74LS164	99
74LS13	49	74LS85	99	74LS175	79
74LS14	99	74LS86	35	74LS181	2 49
74LS15	29	74LS90	49	74LS190	89
74LS20	23	74LS92	59	74LS191	89
74LS21	29	74LS93	59	74LS192	89
74LS22	29	74LS95	79	74LS193	89
74LS26	29	74LS96	89	74LS194	89
74LS27	29	74LS107	35	74LS195	89
74LS28	29	74LS109	35	74LS253	79
74LS30	23	74LS112	35	74LS257	69
74LS32	29	74LS123	99	74LS258	1 39
74LS37	35	74LS125	69	74LS260	55
74LS40	29	74LS132	79	74LS279	59
74LS42	69	74LS136	39	74LS367	59
				74LS368	59
				74LS670	1 95

Jameco ELECTRONICS — New Kits

Digital Stopwatch Kit

- Use Intersil 7205 Chip
- Plated thru double-sided P C Board
- LED display (red)
- Times to 59 min 59 59 sec with auto reset
- Quartz crystal controlled
- Three stopwatches in one single event split (cummulative) and taylor (sequential timing)
- Uses 3 penlite batteries
- Size 4 5 x 2 15 x 90

JE900 $39.95

6-Digit Clock Kit

- Bright 300 ht common cathode display
- Uses MM5314 clock chip
- Switches for hours minutes and hold functions
- Hours easily viewable to 20 feet
- Simulated walnut case
- 115 VAC operation
- 12 or 24 hour operation
- Includes all components case and wall transformer
- Size 6-3 4 x 3 1 8 x 1-3 4

JE701 $19.95

ALSO AVAILABLE:

JE200 5v lamp power supply $14.95 JE2206B Function Generator $19.95
JE730 4-digit clock kit 14.95 JE747 Jumbo 6-digit clock kit 29.95

DISCRETE LEDS

.200" dia.			.125" dia.		
XC556R	red	5/$1	XC209R	red	5/$1
XC556G	green	4/$1	XC209G	green	4/$1
XC556Y	yellow	4/$1	XC209Y	yellow	4/$1
XC556C	clear	4/$1			
.200" dia.			.185" dia.		
XC22R	red	5/$1	XC526R	red	5/$1
XC22G	green	4/$1	XC526G	green	4/$1
XC22Y	yellow	4/$1	XC526Y	yellow	4/$1
.170" dia.			XC526C	clear	4/$1
MV10B	red	4/$1	.190" dia.		
.085" dia.			XC111R	red	5/$1
MV50	red	6/$1	XC111G	green	4/$1
INFRA-RED LED 1/4"x1/4"x1/16" flat		5/$1	XC111Y	yellow	4/$1
			XC111C	clear	4/$1

TIMEX T1001 LIQUID CRYSTAL DISPLAY

FIELD EFFECT

4 DIGIT 5 CHARACTERS
THREE ENUNCIATORS
2.00" X 1 20" PACKAGE
INCLUDES CONNECTOR

T1001-Transmissive $7.95
T1001A-Reflective 8.25

DISPLAY LEDS

TYPE	POLARITY	HT	PRICE	TYPE	POLARITY	HT	PRICE
MAN 1	Common Anode red	270	2 95	MAN 6730	Common Anode red ± 1	560	99
MAN 2	5 x 7 Dot Matrix-red	300	4 95	MAN 6740	Common Cathode red D D	560	99
MAN 3	Common Cathode-red	125	25	MAN 6750	Common Cathode red ± 1	560	99
MAN 4	Common Cathode-red	187	1 95	MAN 6760	Common Anode-red	560	99
MAN 7G	Common Anode green	300	1 25	MAN 6780	Common Cathode-red	560	99
MAN 7Y	Common Anode yellow	300	99	DL701	Common Anode red ± 1	300	99
MAN 72	Common Anode-red	300	99	DL704	Common Cathode-red	300	99
MAN 74	Common Cathode red	300	1 25	DL707	Common Anode red	300	99
MAN 82	Common Anode-yellow	300	99	DL728	Common Cathode-red	500	1 49
MAN 84	Common Cathode yellow	300	99	DL741	Common Anode-red	600	1 25
MAN 3620	Common Anode orange	300	99	DL746	Common Anode red ± 1	630	1 49
MAN 3630	Common Anode-orange ± 1	300	99	DL747	Common Anode red	600	1 19
MAN 3640	Common Cathode-orange	300	99	DL749	Common Cathode red ± 1	630	1 49
MAN 4610	Common Anode orange	300	99	DL750	Common Cathode red	600	1 49
MAN 4640	Common Cathode orange	400	99	DL338	Common Cathode red	110	35
MAN 4710	Common Anode-red	400	99	FND70	Common Cathode	250	69
MAN 4730	Common Anode red ± 1	400	99	FND358	Common Cathode ± 1	357	99
MAN 4740	Common Cathode red	400	99	FND359	Common Cathode	357	75
MAN 4810	Common Anode-yellow	400	99	FND503	Common Cathode(FND500)	500	99
MAN 4840	Common Cathode yellow	400	99	FND507	Common Anode (FND510)	500	99
MAN 6610	Common Anode-orange D D	560	99	5082 7730	Common Anode red	300	1 30
MAN 6630	Common Anode-orange ± 1	560	99	HDSP 3400	Common Anode red	800	2 10
MAN 6640	Common Cathode orange-D D	560	99	HDSP 3403	Common Cathode red	800	2 10
MAN 6650	Common Cathode orange ± 1	560	99	5082 7300	4 x 7 sgl Digit RHDP	600	19 95
MAN 6660	Common Anode-orange	560	99	5082 7302	4 x 7 Sgl Digit LHDP	600	19 95
MAN 6680	Common Cathode orange	560	99	5082 7304	Overrange character (± 1)	600	15 00
MAN 6710	Common Anode-red D D	560	99	5082 7340	4 x 7 Sgl Digit Hexadecimal	600	22 50

RCA LINEAR

CA3013T	2 15	CA3082N	2 00
CA2023T	2 56	CA3083N	1 60
CA3035T	2 48	CA3086N	85
CA3039T	1 35	CA3089N	3 75
CA3046N	1 30	CA3130T	1 39
CA3059N	3 25	CA3140T	1 25
CA3060N	3 25	CA3160T	1 25
CA3080T	85	CA3401N	49
CA3081N	2 00	CA3600N	3 50

CALCULATOR CHIPS/DRIVERS

MM5725	$2 95
MM5738	2 95
DM8864	2 00
DM8865	1 00
DM8887	75
DM8889	75
9374 7 seg C A LED driver	

CLOCK CHIPS

MM5309	$4 95
MM5311	4 95
MM5312	4 95
MM5314	4 95
MM5316	6 95
MM5318	9 95
MM5369	2 95
MM5387 1998A	4 95
MM5841	9 95

MOTOROLA

MC1408L7	$4 95
MC1408L8	5 75
MC1439L	2 95
MC3022P	2 95
MC3061P	3 50
MC4016(74416)	7 50
MC4024P	3 95
MC4040P	6 95
MC4044P	4 50

IC SOLDERTAIL — LOW PROFILE (TIN) SOCKETS

	1-24	25 49	50-100		1-24	25 49	50-100
8 pin LP	$17	16	15	22 pin LP	$ 37	36	35
14 pin LP	20	19	18	24 pin LP	38	37	36
16 pin LP	22	21	20	28 pin LP	45	44	43
18 pin LP	29	28	27	36 pin LP	60	59	58
20 pin LP	34	32	30	40 pin LP	63	62	61

SOLDERTAIL STANDARD (TIN)

14 pin ST	$ 27	25	24	28 pin ST	$ 99	90	81
16 pin ST	30	27	25	36 pin ST	1 39	1 26	1 15
18 pin ST	35	32	30	40 pin ST	1 59	1 45	1 30
24 pin ST	49	45	42				

SOLDERTAIL STANDARD (GOLD)

8 pin SG	$ 30	27	24	24 pin SG	$ 70	63	57
14 pin SG	35	32	29	28 pin SG	1 10	1 00	90
16 pin SG	38	35	32	36 pin SG	1 65	1 40	1 26
18 pin SG	52	47	43	40 pin SG	1 75	1 59	1 45

WIRE WRAP SOCKETS (GOLD) LEVEL #3

8 pin WW	$ 39	38	31	22 pin WW	$ 95	85	75
10 pin WW	45	41	37	24 pin WW	1 05	95	85
14 pin WW	39	38	37	28 pin WW	1 40	1 25	1 10
16 pin WW	43	42	41	36 pin WW	1 59	1 45	1 30
18 pin WW	75	68	62	40 pin WW	1 75	1 55	1 40

1/4 WATT RESISTOR ASSORTMENTS – 5%

ASST. 1	5 ea	50 PCS	$1.75
ASST. 2	5 ea	50 PCS	1.75
ASST. 3	5 ea	50 PCS	1.75
ASST. 4	5 ea	50 PCS	1.75
ASST. 5	5 ea	50 PCS	1.75
ASST. 6	5 ea	50 PCS	1.75
ASST. 7	5 ea	50 PCS	1.75

ASST. 8R Includes Resistor Assortments 1-7 (350 PCS.) $9.95 ea.

$5.00 Minimum Order – U.S. Funds Only
California Residents – Add 6% Sales Tax
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AY-5-9500	CMOS Clock Generator	4 95
AY-5-2376	Keyboard Encoder (88 keys)	14 95
HD0165	Keyboard Encoder (16 keys)	7 95
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ICM7045	CMOS Precision Timer	24 95
ICM7205	CMOS LED Stopwatch/Timer	19 95
ICM7207	Oscillator Controller	7 50
ICM7208	Seven Decade Counter	19 95
ICM7209	Clock Generator	6 95

NMOS READ ONLY MEMORIES

MCM6571	128 X 9 X 7 ASCII Shifted with Greek	13 50
MCM6574	128 X 9 X 7 Math Symbol & Pictures	13 50
MCM6575	128 X 9 X 7 Alphanumeric Control Character Generator	13 50

MISCELLANEOUS

TL074CN	Quad Low Noise bi-fet Op Amp	2 49
TL494CN	Switching Regulator	4 49
TL496CP	Single Switching Regulator	1 75
11C90	Divide 10/11 Prescaler	19 95
95H90	Hi-Speed Divide 10/11 Prescaler	11 95
4N33	Photo-Darlington Opto-Isolator	3 95
MK50240	Top Octave Freq Generator	17 50
DS0026CH	5Mhz 2-phase MOS clock driver	3 75
TIL308	27" red num display w/integ logic chip	10 50
MM5320	TV Camera Sync Generator	14.95
MM5330	4½ Digit DPM Logic Block	5 95
LD110/111	3½ Digit A/D Converter Set	25 00/set

LITRONIX ISO-LIT 1
Photo Transistor Opto-Isolator
(Same as MCT 2 or 4N25)
2/99¢

SN 76477
SOUND GENERATOR
Generates Complex Sounds
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3.95 each

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AY-3-8500-1 and 2 01 MHZ Crystal (Chip & Crystal includes score display, 6 games and select angles, etc **7.95/set**

EXAR

XR205	$3 40			XR2242CP	1 50
XR210	4 40			XR2264	4.25
XR215	4 40			XR2556	3 20
XR320	1 55	JE2206KA	14.95	XR2567	2 99
XR-L555	1 50	JE2206KB	19.95	XR3403	1 25
XR555	39	XR1800	3 20	XR4136	1.25
XR556	99	XR2206	4.40	XR4151	2 85
XR567CP	99	XR2207	3.85	XR4194	1 45
XR567CT	1 25	XR2208	5 20	XR4202	3 60
XR1310P	1 30	XR2209	1 75	XR4212	2 05
XR1468CN	3.85	XR2211	5.25	XR4558	75
XR1488	1 39	XR2212	4.35	XR4739	1 15
XR1489	1 39	XR2240	3 45	XR4741	1 47

DIODES

TYPE	VOLTS	W	PRICE	TYPE	VOLTS	W	PRICE
1N746	3 3	400m	4 1 00	1N4002	100 PIV 1 AMP		12 1 00
1N751	5 1	400m	4 1 00	1N4003	200 PIV 1 AMP		12 1 00
1N752	5 6	400m	4 1 00	1N4004	400 PIV 1 AMP		12 1 00
1N753	6 2	400m	4 1 00	1N4005	600 PIV 1 AMP		10 1 00
1N754	6 8	400m	4 1 00	1N4006	800 PIV 1 AMP		10 1 00
1N757	9 0	400m	4 1 00	1N4007	1000 PIV 1 AMP		10 1 00
1N759	12 0	400m	4 1 00	1N3600	50	200m	6 1 00
1N959	8 2	400m	4 1 00	1N4148	75	10m	15 1 00
1N965	15	400m	4 1 00	1N4154	35	10m	12 1 00
1N5232	5 6	500m	28	1N4305	75	25m	15 1 00
1N5234	6 2	500m	28	1N4734	5 6	1w	28
1N5235	6 8	500m	28	1N4735	6 2	1w	28
1N5236	7 5	500m	28	1N4736	6 8	1w	28
1N5242	12	500m	28	1N4738	8 2	1w	28
1N5245	15	500m	28	1N4742	12	1w	28
1N456	25	40m	6 1 00	1N4744	15	1w	28
1N458	150	7m	6 1 00	1N1183	50 PIV 35 AMP		1 60
1N485A	180	10m	5 1 00	1N1184	100 PIV 35 AMP		1 70
1N4001	50 PIV 1 AMP		12 1 00	1N1185	150 PIV 35 AMP		1 70
				1N1186	200 PIV 35 AMP		1 80
				1N1188	400 PIV 35 AMP		3 00

SCR AND FW BRIDGE RECTIFIERS

C36D	15A @ 400V	SCR(2N1849)	$1 95
C38M	35A @ 600V	SCR	1 95
2N2328	1 6A @ 300V	SCR	50
MDA 980 1	12A @ 50V	FW BRIDGE REC	1 95
MDA 980 3	12A @ 200V	FW BRIDGE REC	1 95

TRANSISTORS

C106B1	50			2N3904	4 1 00
MPSA05	30	2N3055	89	2N3905	4 1 00
MPSA06	5 1 00	MJE3055	1 00	2N3906	4 1 00
TIS97	6 1 00	2N3392	5 1 00	2N4013	3 1 00
TIS98	6 1 00	2N3398	5 1 00	2N4123	6 1 00
40409	1 75	PN3567	3 1 00	PN4249	4 1 00
40410	1 75	PN3568	4 1 00	PN4250	4 1 00
40673	1 75	PN3569	4 1 00	2N4400	4 1 00
2N918	4 1 00	MPS3638A	5 1 00	2N4401	4 1 00
2N2219A	3 1 00	MPS3702	5 1 00	2N4402	4 1 00
2N2221A	4 1 00	2N3704	5 1 00	2N4403	4 1 00
2N2222A	5 1 00	MPS3704	5 1 00	2N4409	5 1 00
PN2222 Plastic	7 1 00	2N3705	5 1 00	2N5086	4 1 00
2N2369	5 1 00	MPS3705	5 1 00	2N5087	4 1 00
2N2369A	4 1 00	2N3706	5 1 00	2N5088	4 1 00
MPS2369	5 1 00	MPS3706	5 1 00	2N5089	4 1 00
2N2484	4 1 00	2N3707	5 1 00	2N5129	5 1 00
2N2906	4 1 00	2N3711	5 1 00	PN5134	5 1 00
2N2907	5 1 00	2N3724A	65	PN5138	5 1 00
PN2907 Plastic	7 1 00	2N3725A	1 00	2N5139	5 1 00
2N2925	5 1 00	2N3772	1 25	2N5210	5 1 00
MJE2955	1 25	2N3823	1 00	2N5419	3 1 00
2N3053	2 1 00	2N3903	5 1 00	2N5951	3 1 00

CAPACITOR CORNER

50 VOLT CERAMIC DISC CAPACITORS

10 pf	05	04	03	001μF	05	04	035
22 pf	05	04	03	0047μF	05	04	035
47 pf	05	04	03	01μF	05	04	035
100 pf	05	04	03	022μF	06	05	04
220 pf	05	04	03	047μF	06	05	04
470 pf	05	04	035	1μF	12	09	075

100 VOLT MYLAR FILM CAPACITORS

001mf	12	10	07	022mf	13	11	08
0022	12	10	07	047mf	21	17	13
0047mf	12	10	07	1mf	27	23	17
01mf	12	10	07	2mf	33	27	22

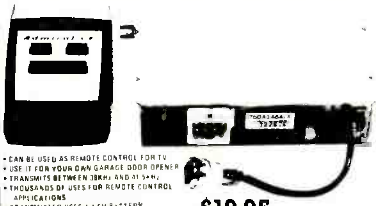
+20% DIPPED TANTALUMS (SOLID) CAPACITORS

1 35V	28	23	17	1 5 35V	30	26	21
15 35V	28	23	17	2 2 25V	31	27	22
22 35V	28	23	17	3 3 25V	31	27	22
33 35V	28	23	17	4 7 25V	32	28	23
47 35V	28	23	17	6 8 25V	36	31	25
68 35V	28	23	17	10 25V	40	35	29
1 0 35V	28	23	17	15 25V	63	50	40

MINIATURE ALUMINUM ELECTROLYTIC CAPACITORS

Axial Lead				Radial Lead			
47 50V	15	13	10	47 25V	15	13	10
1 0 50V	16	14	11	47 50V	16	14	11
3 3 50V	14	12	09	1 0 16V	15	13	10
4 7 25V	15	13	10	1 0 25V	16	14	11
10 25V	15	13	10	1 0 50V	16	14	11
10 50V	16	14	12	4 7 16V	15	13	10
22 25V	17	15	12	4 7 25V	15	13	10
22 50V	24	20	18	4 7 50V	16	14	11
47 25V	19	17	15	10 16V	14	12	09
47 50V	25	21	19	10 25V	15	13	10
100 25V	24	20	18	10 50V	16	14	12
100 50V	35	30	28	47 50V	21	21	19
220 25V	32	28	25	100 16V	19	15	11
220 50V	45	41	38	100 25V	24	20	18
470 25V	33	29	27	100 50V	35	30	28
1000 16V	55	50	45	220 16V	23	17	16
2200 16V	70	62	55	470 25V	31	28	26

REMOTE CONTROL TRANSMITTER & RECEIVER



- CAN BE USED AS REMOTE CONTROL FOR TV
- USE IT FOR YOUR OWN GARAGE DOOR OPENER
- TRANSMITS BETWEEN 38KHz AND 41.5KHz
- THOUSANDS OF USES FOR REMOTE CONTROL APPLICATIONS
- TRANSMITTER USES A 1.5V BATTERY
- SCHEMATIC INCLUDED

$19.95

Custom Cables & Jumpers

DB 25 Series Cables

Part No.	Cable Length	Connectors	Price
DB25P-4-P	4 Ft	2-DP25P	$15.95 ea
DB25P-4-S	4 Ft	1-DP25P 1-25S	$16.95 ea
DB25S-4-S	4 ft	2-DP25S	$17.95 ea

Dip Jumpers

DJ14-1	1 ft	1-14 Pin	$1.59 ea
DJ16-1	1 ft	1-16 Pin	1.79 ea
DJ24-1	1 ft	1-24 Pin	2.79 ea
DJ14-1-14	1 ft	2-14 Pin	2.79 ea
DJ16-1-16	1 ft	2-16 Pin	3.19 ea
DJ24-1-24	1 ft	2-24 Pin	4.95 ea

For Custom Cables & Jumpers. See JAMECO 1979 Catalog for Pricing

CONNECTORS

25 Pin-D Subminiature

DB25P (as pictured)	PLUG (Meets RS232)	$2.95
DB25S	SOCKET (Meets RS232)	$3.50
DB51226-1	Cable Cover for DB25P or DB25S	$1.75

PRINTED CIRCUIT EDGE-CARD

156 Spacing Tin Double Read-Out — Bifurcated Contacts — Fits .054 to .070 P.C. Cards

15/30	PINS (Solder Eyelet)	$1.95
18/36	PINS (Solder Eyelet)	$2.49
22/44	PINS (Solder Eyelet)	$2.95
50/100 (.100 Spacing)	PINS (Wire Wrap)	$6.95
50/100 (.125 Spacing)	PINS (Wire Wrap) R681-1	$6.95

MINI-BUZZER

- Thousands of applications
- Operates on 6 to +9 VDC
- Output Frequency 800 Hz
- Draws only 15 MA @ 600 ohms
- Size: 1¼" x ⅝"

PART NO. MB-1

1-24	$1.95 ea
25-49	$1.75 ea
50-99	$1.49 ea

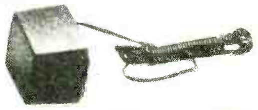
SONALERT AUDIBLE SIGNAL DEVICE

Use as a warning Device or Audible Reminder

- Turns on and off with low power transistor, SCR or IC
- Can be battery operated 6-28 volts
- Solid State — No moving parts
- Panel mounts in 1.25 round hole
- Black Plastic case includes MTG nut
- Operating Volts (DC): 6 (Min) 28 (Max)
- Current MA: 3 (Min) 14 (Max)
- dBA: 68 (Min) 80 (Max)
- Frequency: 2900Hz ±500

#SC628 $7.50 each

AC Wall Transformer



Ideal for use with clocks, power supplies or any other type of AC application

Part No.	Input	Output	Price
AC 250	117V/60Hz	12 VAC 250mA	$3.95
AC 500	117V/60Hz	12 VAC 500mA	$4.95

Regulated Power Supply

- Uses LM 309K
- Heat sink provided
- P.C. board construction
- Provides a solid 1 amp @ 5V
- Includes components, hardware and instructions
- Sizes 3-1/2" x 5" x 2" high

JE200 $14.95

INSTRUMENT/CLOCK CASE

This case is an injection molded unit that is ideal for uses such as DVM, COUNTER, or CLOCK cases. It has dimensions of 4½" in length by 4" in width by 1-9/16" in height. It comes complete with a red bezel.

PART NO: IN-CC $3.49 each

MICROPROCESSOR COMPONENTS

8080A/8080A SUPPORT DEVICES

8080A	CPU	$9.95
8212	8-Bit Input Output	3.25
8214	Priority Interrupt Control	5.95
8216	Bi-Directional Bus Driver	3.49
8224	Clock Generator Driver	3.95
8226	Bus Driver	3.49
8228	System Controller Bus Driver	5.95
8238	System Controller	5.95
8251	Prog. Comm. I/O (USART)	7.95
8253	Prog. Interval Timer	14.95
8255	Prog. Periph. I/O (PPI)	9.95
8257	Prog. DMA Control	19.95
8259	Prog. Interrupt Control	19.95

6800/6800 SUPPORT DEVICES

MC6800	MPU	$14.95
MC6802CP	MPU with Clock and Ram	24.95
MC6810API	128X8 Static Ram	5.95
MC6821	Periph. Inter. Adapt (MC6820)	7.49
MC6828	Priority Interrupt Controller	12.95
MC6830L8	1024X8 Bit ROM (MC68A30-8)	14.95
MC6850	Asynchronous Comm. Adapter	7.95
MC6852	Synchronous Serial Data Adapt	9.95
MC6860	0-600 bps Digital MODEM	12.95
MC6862	2400 bps Modulator	14.95
MC6880A	Quad 3-State Bus. Trans. (MC8T26)	2.25

MICROPROCESSOR CHIPS—MISCELLANEOUS

Z80(780C)	CPU	$19.95
Z80A(780-1)	CPU	24.95
CDP1802	CPU	19.95
2650	MPU	19.95
8035	8-Bit MPU w/clock, RAM, I/O lines	19.95
P8085	CPU	19.95
TMS9900JL	16-Bit MPU w/hardware, multiply & divide	49.95

SHIFT REGISTERS

MM500H	Dual 25 Bit Dynamic	$.50
MM503H	Dual 50 Bit Dynamic	.50
MM504H	Dual 16 Bit Static	.50
MM506H	Dual 100 Bit Static	.50
MM510H	Dual 64 Bit Accumulator	.50
MM5016H	500/512 Bit Dynamic	.89
2504T	1024 Dynamic	3.95
2518	Hex 32 Bit Static	4.95
2522	Dual 132 Bit Static	2.95
2524	512 Static	.99
2525	1024 Dynamic	2.95
2527	Dual 256 Bit Static	2.95
2528	Dual 250 Static	4.00
2529	Dual 240 Bit Static	4.00
2532	Quad 80 Bit Static	2.95
2533	1024 Static	2.95
3341	Fifo	6.95
74LS670	4X4 Register File (TriState)	1.95

UART'S

A-Y-5-1013	30K BAUD	5.95

MICROPROCESSOR MANUALS

M-Z80	User Manual	$7.50
M-CDP1802	User Manual	7.50
M-2650	User Manual	5.00

ROM'S

2513(2140)	Character Generator(upper case)	$9.95
2513(3021)	Character Generator(lower case)	9.95
2516	Character Generator	10.95
MM5230N	2048-Bit Read Only Memory	1.95

RAM'S

1101	256X1	Static	$1.49
1103	1024X1	Dynamic	.99
2101(8101)	256X4	Static	3.95
2102	1024X1	Static	1.75
21L02	1024X1	Static	1.95
2111(8111)	256X4	Static	3.95
2112	256X4	Static MOS	4.95
2114	1024x4	Static 450ns	9.95
2114L	1024X4	Static 450ns low power	10.95
2114-3	1024X4	Static 300ns	10.95
2114L-3	1024X4	Static 300ns low power	11.95
5101	256X4	Static	7.95
5280/2107	4096X1	Dynamic	4.95
7489	16X4	Static	1.75
74S200	256X1	Static Tristate	4.95
93421	256X1	Static	2.95
UPD414 (MK4027)	4K	Dynamic 16 pin	4.95
UPD416 (MK4116)	16K	Dynamic 16 pin	14.95
TMS4044-45NL	4K	Static	14.95
TMS4045	1024X4	Static	14.95
2117	16,384X1	Dynamic 350ns (house marked)	9.95
MM5262	2KX1	Dynamic	4/1.00

PROM'S

1702A	2048	FAMOS	$5.95
TMS2516 (2716)	16K*	EPROM(Intel 2716) *Requires single +5V power supply	49.95
TMS2532	4KX8	EPROM	89.95
2708	8K	EPROM	10.95
2716 T.I.	16K**	EPROM **Requires 3 voltages —5V +5V +12V	29.95
5203	2048	FAMOS	14.95
6301-1(7611)	1024	Tristate Bipolar	3.49
6330-1(7602)	256	Open C Bipolar	2.95
82S23	32X8	Open Collector	3.95
82S115	4096	Bipolar	19.95
82S123	32X8	Tristate	3.95
74186	512	TTL Open Collector	9.95
74188	256	TTL Open Collector	3.95
74S287	1024	Static	2.95

NEW!! IN STOCK... POWERACE

ALL-CIRCUIT EVALUATORS WITH POWER

- 1680 solderless plug-in tie points will hold up to 18 14-pin DIPs
- Breadboard elements accept all DIP sizes including RTL, DTL, TTL and CMOS devices, TO-5's and discretes with leads up to .032 dia
- All connections to/from switches, indicators, power supplies and meters are made via solderless, plug-in tie-point blocks on control panels
- Interconnect with any solid 20 to 30 AWG wire
- Breadboard elements are mounted on ground plane — ideal for high frequency and high speed low-noise circuits
- Short-circuit-proof fused power supplies
- Operate on 110 to 130 VAC at 60 Hz
- Space-age compact styling and high-grade components permit convenient, organized and quick prototyping
- All models are 7.5" wide 11.5" deep and 4.0" high (rear) 0.75" high (front) and weigh approx. 2.5 lbs

POWERACE 101 -General purpose model for prototyping all types of circuit
#923101 $84.95

POWERACE 102 -Complete digit prototyping lab with built-in logic probe
#923102 $114.95

POWERACE 103 -Triple-output power supply for prototyping both linear and digit circuits
#923103 $124.95

B&K PRECISION 3½-Digit Portable DMM

Ranges
DC AC Current 0-100mA

Model 2800 $99.95

Accessories:

AC Adapter BC-28	$9.00
Rechargeable Batteries BP-26	20.00
Carrying Case LC-28	7.50

CSC 100 MHz 8-Digit Counter

CONTINENTAL SPECIALTIES CORPORATION

- 20 Hz-100 MHz Range
- 6 LED Display
- Crystal-controlled timebase
- Fully Automatic
- Portable — completely self-contained
- Size — 1.75 x 3.38 x 5.63
- Four power souces i.e. batteries, 110 or 220V with charger, 12V with auto lighter adapter and external 7.2-10V power supply

MAX-100 $134.95

ACCESSORIES FOR MAX 100:

Mobile Charger Eliminator — use power from car battery — Model 100 — CLA $3.95

Charger/Eliminator — use 110 V AC — Model 100 — CAI $9.95

New CSC Mini-Max 6 Digit 50MHz Frequency Counter

- Guaranteed frequency range of 100 Hz to 50 MHz
- Full 6 digit display with antiglare window
- Fully automatic-range, polarity, slope, trigger, input level switching not required
- Lead-zero blanking—All zeros to the left of the first non-zero digit are blanked. Kilo Hertz and Mega Hertz decimal points automatically light up when the unit is turned on
- Built in input overvoltage protection
- Use 9V Battery or 110/220V power
- Complete with mini antenna
- Lightweight — Only 8oz

MINI-MAX $89.95

Accessories For Mini-Max

Part No.	Description	Price
MM-A4	Antenna	$3.95
MM-C5	Carrying case	5.95
MM-IPC	Input cable with clip leads	3.95
MM-AC2	110V adapter	9.95
MM-AC3	220V adapter	9.95

$5.00 Minimum Order — U.S. Funds Only
California Residents — Add 6% Sales Tax

Spec Sheets — 25¢
1979 Catalog Available—Send 41¢ stamp

NEW 1979 Catalog

Jameco ELECTRONICS

A division of JAMES ELECTRONICS of California

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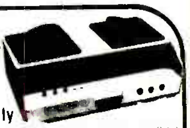
MAIL ORDER ELECTRONICS — WORLDWIDE

1021 HOWARD AVENUE, SAN CARLOS, CA 94070

ADVERTISED PRICES GOOD THRU FEBRUARY

The Incredible "Pennywhistle 103"



$139.95 Kit Only

The Pennywhistle 103 is capable of recording data to and from audio tape without critical speed requirements for the recorder and it is able to communicate directly with another modem and terminal for telephone, hamming, and communications. In addition, it is free of critical adjustments and is built with non-precision, readily available parts.

Data Transmission Method	Frequency-Shift Keying, full-duplex (half-duplex selectable)
Maximum Data Rate	300 Baud
Data Format	Asynchronous Serial (return to mark level required between each character)
Receive Channel Frequencies	2025 Hz for space, 2225 Hz for mark
Transmit Channel Frequencies	Switch selectable: Low (normal) = 1070 space, 1270 mark. High = 025 space, 2225 mark
Receive Sensitivity	46 dbm accoustically coupled
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
Digital Data Interface	EIA RS-232C or 20 mA current loop (receiver is optoisolated and non-polar)
Power Requirements	120 VAC, single phase, 10 Watts
Physical	All components mount on a single 5" by 9" printed circuit board. All components included

Requires a VOM, Audio Oscillator, Frequency Counter and/or Oscilloscope to align

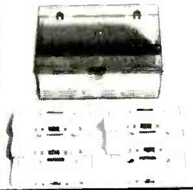
TRS-80 16K Conversion Kit

Expand your 4K TRS-80 System to 16K. Kit comes complete with:
* 8 each UPD416 (16K Dynamic Rams)
* Documentation for conversion

TRS-16K $115.00

Special Offer - Order both your TRS-16K and the Sup'R' MOD II Interface kit together (retail value $144.95) for only $139.95

COMPUTER CASSETTES



- 6 EACH 15 MINUTE HIGH QUALITY C-15 CASSETTES
- PLASTIC CASE INCLUDED 12 CASSETTE CAPACITY
- ADDITIONAL CASSETTES AVAILABLE #C-15-$2.50 ea

CAS-6 $14.95 (Case and 6 Cassettes)

SUP 'R' MOD II

UHF Channel 33 TV Interface Unit Kit

Wide Band B/W or Color System
- ★ Converts TV to Video Display for home computers, CCTV camera, Apple II, works with Cromeco Dazzler, SOL-20, TRS-80, Challenger, etc
- ★ MOD II is pretuned to Channel 33 (UHF)
- ★ Includes coaxial cable and antenna transformer

MOD II $29.95 Kit

RS-232 CONTROL CENTER

Plug in your modem, computer, prom programmer, terminal, printer, etc. and selectively control data flow.

- Same Contour as Pennywhistle 103
- Totally self-contained
- Includes 2 master ports and 3 slave ports

PART NO. RS-232CC $89.95 kit only

CASSETTE CONTROLLER

Ideal for use with the TRS 80 and others

Plug/Jack interface to any computer system requiring remote control of cassette functions

The CC100 controls cassette motor functions, monitors tape location with its internal speaker and requires no power. Eliminates the plugging and unplugging of cables during computer loading operation from cassette.

#CC-100 $29.50

63-Key Unencoded Keyboard

This is a 63-key, terminal keyboard newly manufactured by a large computer manufacturer. It is unencoded with SPST keys, unattached to any kind of PC board. A very solid molded plastic 13 x 4" base suits most application. IN STOCK $29.95/each

Hexadecimal Unencoded Keypad

19-key pad includes 1-10 keys, ABCDEF and 2 optional keys and a shift key. $10.95/each

ELECTRONICS Market Place

CIRCLE NO. 28 ON FREE INFORMATION CARD

Thousands of Communications Electronics customers
OWN A BEARCAT® SCANNER.
But since we've introduced the Bearcat® 250 crystalless 15,600 frequency, 50 channel synthesized scanner, *our specifications have been improved:*

Sensitivity
0.4 microvolts for 12dB SINAD on VHF bands. UHF band slightly less

Selectivity
Better than −60dB @ ±25 KHz

Audio Output
At least 2.0 Watts rms

Audio Quality
The BC-250 audio is more noise-free and suffers less distortion than comparable models by a margin of 10dB or more

Image Rejection
The BC-250 rejects image frequencies by at least 8dB better in all bands than comparable models

This month, **we've got a special price** on the Bearcat® 250. Now, you can own this fantastic professional monitor for only $319.00. That's a **savings of over $80.00**. Order now for Christmas.

To start Bearcatting, Master Charge and Visa card holders may call and **order toll free** 800-521-4414. Outside the U.S. and Michigan dial 313-994-4441. To order by mail, send $319.00 plus $5.00 for U.S. U.P.S. shipping. Foreign orders invited at slightly higher cost. Mail your orders or requests for a **free** catalog completely describing all Bearcat® scanners to: **Communications Electronics**, Box 1002, Dept. HF1, Ann Arbor, Michigan 48106 U.S.A.

CIRCLE NO. 58 ON FREE INFORMATION CARD

NEW! 32K x 8 boards...

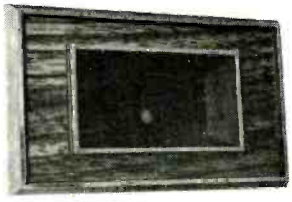
Cost-effective, low power, reliable memory ... backed with a 1 year warranty. Available as unkits (sockets, bypass caps pre-soldered in place for easy assembly), assembled/tested, or qualified under the Certified System Component (SCS) program. CSC boards are burned-in for 200 hours and immediately replaced if failure occurs within 1 year of invoice date.

Name	Storage	Design	Buss	Guar. Speed	Unkit	Assm	CSC
ECONORAM X™	32K X 8	static	S-100	4 MHz	$599	$649	$789
ECONORAM IX™	32K X 8	static	DigGrp	4 MHz	$650	N/A	N/A
ECONORAM XI™	32K X 8	static	SBC	4 MHz	N/A	N/A	$1050

We have other Econorams, too . . .

Name	Storage	Design	Buss	Guar. Speed	Unkit	Assm	CSC
ECONORAM II™	8K X 8	static	S-100	2 MHz	$139	$159	N/A
ECONORAM IV™	16K X 8	static	S-100	4 MHz	$279	$314	$414
ECONORAM VI™	12K X 8	static	H8	2 MHz	$200	N/A	N/A
ECONORAM VII™	24K X 8	static	S-100	4 MHz	$445	$485	$605

MA1003 with case $19.95!



What's better than an MA1003? An MA1003 in a case. Woodgrain front, mtg. bracket & hardware, and blue filter included. **Case available separately for $5.95.**

TRS-80 Conversion Kit $109 (3/$320)

Our kit includes DIP shunts, 250 ns chips for 4 MHz operation, and 1 year guarantee. Upgrades 4K TRS 80 to 16K or populates Memory Expansion Module — our novice level instructions show you how. **Also suitable for APPLE computers.**

★★★★★★★★★★★★★★★★★★★★★★

MEMORY SPECIAL: 2102-L1 (high speed/low power) **1K STATIC RAM NOW ONLY 99¢ EACH** (sorry, only good on order of 10 or more)

★★★★★★★★★★★★★★★★★★★★★★

TERMS: Orders under $15 add $1. Cal res add tax. VISA®/Mastercharge® ($15 min) call **(415) 562-0636**. 24 hrs. Allow 5% shipping, excess refunded. COD OK with street address for UPS.

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SEND FOR OUR FREE FLYER
(OR SEND 41¢ IN STAMPS FOR 1ST CLASS DELIVERY)

CIRCLE NO. 20 ON FREE INFORMATION CARD

INTERNATIONAL ELECTRONICS UNLIMITED

METAL FILM RESISTORS — Rohm

445 VALUES IN STOCK - 10 ohm to 475K ohm
± 1% ¼ WATT CRA ¼ (RN60)
TEMP. COEF. ± 50 PPM/° C

TOTAL QTY	PRICE (each)	PRICE (Min 10 per value)	PRICE (Min 25 per value)	PRICE (Min 100 per value)
1-99	.25ea	.20ea	2.25/25	
100-999	.20ea	.15ea	2.10/25	1.50/100
1000-	.15ea	.10ea	2.00/25	[illegible]/100

CARBON FILM RESISTORS — Rohm

± 5% ¼, ½ W

QTY.	PRICE (each)	PRICE Minimum 10 per value	PRICE Minimum 100 per value
0-10	$.10 ea		
10-100	$.10 ea	$.05 ea	
100-1000		$.04 ea	$3.00 100
1000-			$2.50 100

CERAMIC CAPACITORS

1pf	22pf	56pf	120pf	270pf	820pf	.0047uf	.030uf
5pf	27pf	68pf	150pf	390pf	.001uf	.01uf	.050uf
7pf	33pf	82pf	180pf	470pf	.0015uf	.015uf	.1uf
10pf	47pf	100pf	220pf	600pf	.003uf	.022uf	

	1pf-.050u	.1uf
1-9 per value	$.10	$.15
10-99	.06	.10
100-	.05	.08

POLYESTER FILM CAPACITORS

	1-9	10-99	100-		1-9	10-99	100-
.001u/100V	.12	.09	.06	.022u/100V	.13	.08	.07
.0033u/100V	.12	.09	.06	.023u/50V	.13	.08	.07
.0042u/100V	.12	.09	.06	.033u/100V	.15	.09	.08
.01u/100V	.12	.09	.06	.047u/100V	.19	.16	.12
.015u/100V	.12	.09	.06	.1u/100V	.24	.20	.15
.018u/100V	.12	.09	.06	.22u/100V	.33	.20	.17
.02u/50V	.13	.08	.07	.47u/100V	.50	.30	.25

TANTALUM CAPACITORS

	1-9	10-		1-9	10-		1-9	10-
.22u/35V	.25	.20	6.8u/6V	.30	.25	22u/16V	.45	.40
.33u/35V	.25	.20	6.8u/16V	.30	.25	33u/10V	.55	.50
1u/35V	.25	.20	6.8u/50V	.35	.30	47u/6V	.55	.50
2.2u/20V	.28	.23	10u/16V	.35	.30	47u/20V	.65	.55
2.2u/35V	.30	.25	10u/20V	.38	.33	56u/6V	.75	.65
3.3u/35V	.35	.30	15u/6.3V	.38	.33	100u/20V	1.45	
4.7u/16V	.30	.25	15u/20V	.45	.40			

write for info on kits of all above products

COMPLETE SATISFACTION GUARANTEED. SHIPMENT TO US AND CANADA PREPAID UNLESS INDICATED OTHERWISE. OTHER COUNTRIES ADD 10% - EXCESS REFUNDED. ORDERS SHIPPED IN 3 WORKING DAYS FROM RECEIPT. MINIMUM ORDER $10.00

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225 Broadway, Jackson, Ca. 95642

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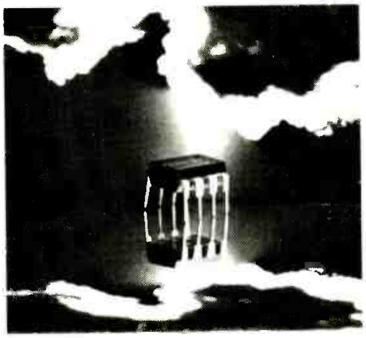

THE NEW HOBBY WORLD CATALOG

Your source for factory prime, professional quality equipment. Computers, add-on boards, IC's, sockets, resistors, supplies, tools, test equipment, books, and more. Shop your buy list at Hobby World. You'll find what you want, and at a solid savings. For example, look at this month's specials:

NEW FROM CALIFORNIA COMPUTER SYSTEMS!
16K STATIC RAM KIT, MODEL XVI.
IEEE S-100 compatible, requires only +5 Volts, 450 ns, fully buffered. Bank switching capability, Phantom Line, wait state, addressable in 4K blocks.
HOBBY WORLD PRICE ONLY $265 KIT, $27 BARE BOARD

16K MEMORY ADD-ON FOR APPLE, TRS-80 OR EXIDY SORCERER
HOBBY WORLD PRICE ONLY $98 (specify when ordering)

C-10 DATA CASSETTES - PERFECT FOR TRS-80
PRICE ONLY $2 EACH! 10 for $17.50

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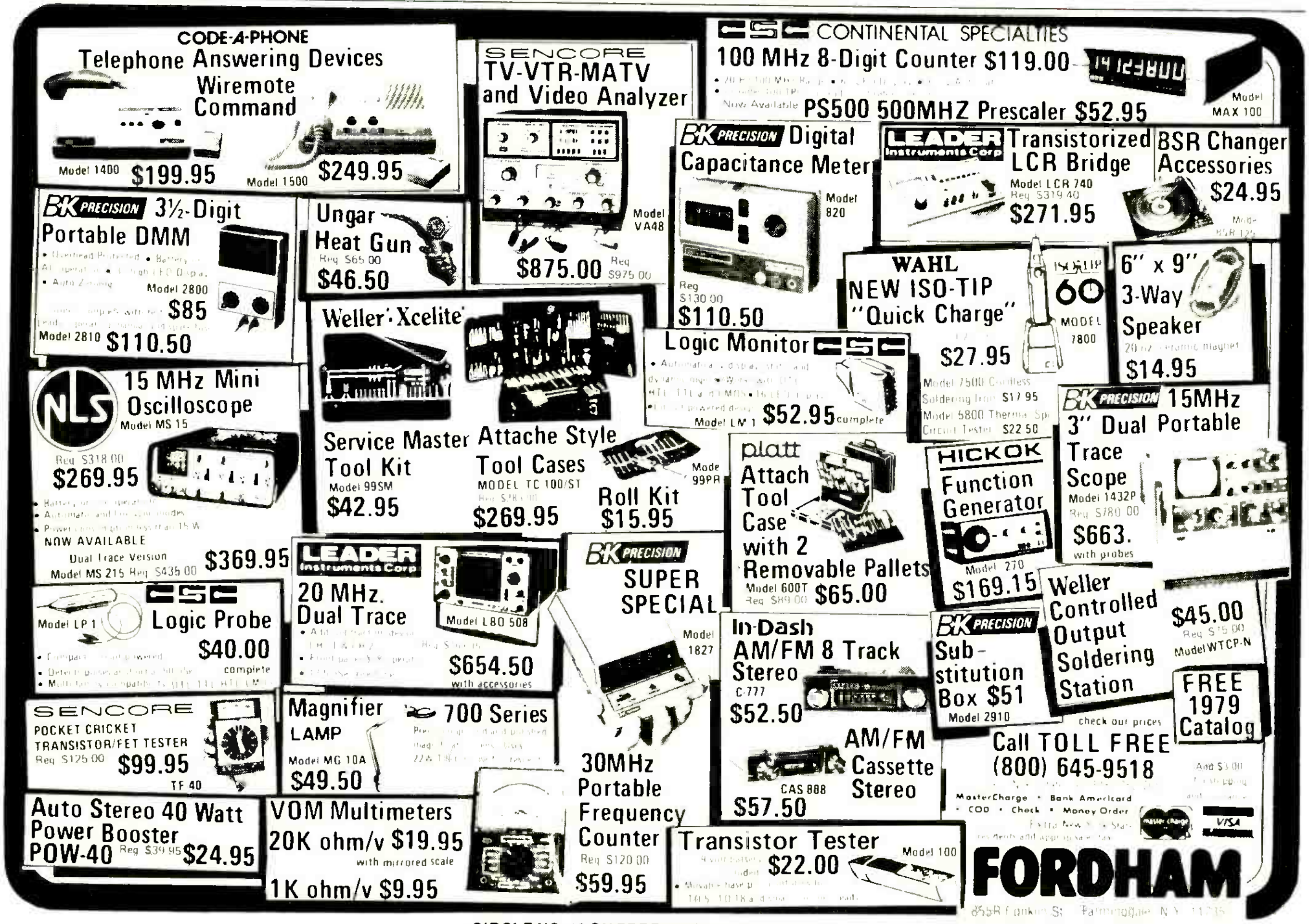

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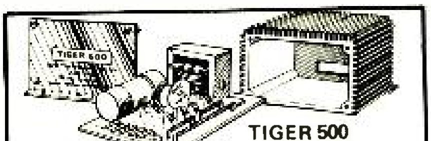

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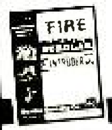

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ENJOY THE NEW YEAR with Science Fiction Films: Frankenstein; Creature With An Atom Brain. Thrillers: Marlon Brando, On The Waterfront; Strait-Jacket — each 400' S-8 B&W Snd. Our price, $34.95 ea (reg. price $43.95), add $1 ea for shipping. Sports Specials: Old Man Par (The Bobby Jones Story) & King of Diamonds (all about Lou Gehrig) — 300' S-8 B&W Snd. $19.95 ea (save $4), add 90¢ ea for shipping. Fabulous Harlem Globetrotters, $29.95 PPD 200' Color Snd (reg $32); The Queen Boxer (female Bruce Lee) S-8 Color 400. Columbia Sound Feature, $44.95 (save $10); Penny Pinchers 79 Olympic Films, XXth Olympiad Gymnastics (Olga Korbut) Aquatics (Mark Spitz) Track & Field (Jim Ryun); Competitive Sports (incl. USA USSR basketball), boxing, wrestling, volleyball, each 200' St 8 Color, only $8.95 ea while they last (can be shown on dual 8 projector). Universal 64-pg catalog, $1.10 (foreign $2.20). Columbia, Sportlite Films, Universal Ring Classics order forms 40¢ ea with flyers. SPORTLITE FILMS, Elect-2 79, Box 24-500, Speedway, IN 46224.

MISCELLANEOUS

MPG INCREASED! Bypass Pollution Devices easily REVERSIBLY!! Free details — Posco GEE2, 453 W. 256, NYC 10471

POEMS, SONGS WANTED. Songs recorded — published. Radio released. Broadway Music Productions, Box 7438-CM, Sarasota, FL 33578.

MAGNETS. All types. Specials-20 disc, or 10 bar, or 2 stick or 8 assorted magnets, $1.00. Magnets, Box 192-H, Randallstown, Maryland 21133.

Popular Electronics

ADVERTISERS INDEX

Instant In-Store Audio Comparison

An audio salon in Kansas City (David Beatty Stereo) provides its customers with a real opportunity to compare live music with the same music recorded and played back on components the dealer has. A live music concert—the premier performance was by a jazz trio—is given in a central store area. Surrounding this area are

acoustically isolated sound rooms, to which the music is fed and heard from various speaker systems. The performance is also taped on an 8-channel recorder, using four different pairs of microphones, so that recorded comparisons can be made later on playback equipment. It is hoped that the comparison experience will give customers a first-hand feel for the problems of recording and aid them in decision making when purchasing audio equipment.

Prerecorded VCR Movies

An RCA survey revealed that approximately one of five owners of video cassette recorders purchase prerecorded cassettes, most of them being feature movies. It is estimated that 85 percent of the owners of preprogrammed cassettes have bought feature movies, with "adult" movies a distant second at 12 percent.

Editing Digital Tape Recordings

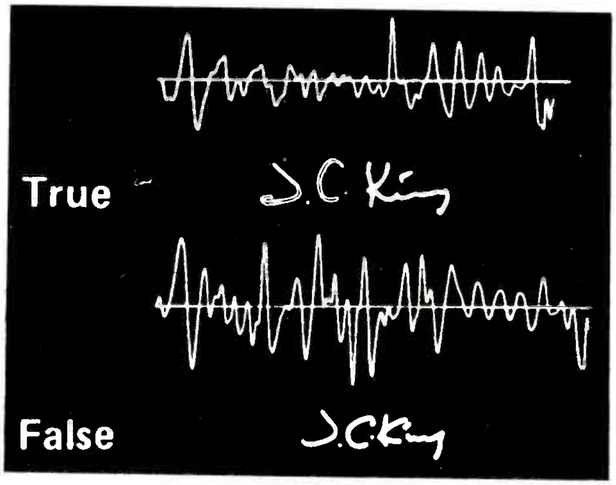
An electronic editing system has been designed to complement tape recordings made on the 3M Digital Mastering System. Rather than physically joining pieces of tape, the system copies the electronic digital signals in selected sequences to create a master. While esthetic selection is under control of a record producer, execution of the actual copying is controlled by a microprocessor. The operator listens for appropriate edit points, stops the tape, and views a graphic representation of the sound on a video screen. After satisfactory matching of sound and graphic representations, the time-encoded points on the tape are registered in the microprocessor for later automatic synchronism when the copying sequence occurs. Edit capabilities include the insertion of live music on a previously recorded multi-track tape and assembly editing of 32 tracks onto a four- or two-track master. Development of the system has been a joint effort of 3M and Inter-Technology Exchange, Ltd.

For Robot Enthusiasts

"Robotics Newsletter," a monthly periodical for amateur and professional robot enthusiasts, presents articles on microprocessors, batteries, motors, sensory devices, automata theory, bio-physical analogs, etc. Yearly subscriptions are $8 from International Institute for Robotics, Box 615, Pelahatchie, MS 39145.

Signature Verification

An experimental signature verification system developed at IBM's Research Division may someday be used to control access to sensitive data, devices or locations. The system does not "read" handwriting as such, but compares data obtained from a pen's acceleration



(changes in speed and direction) and pressure with similar information stored by a computer. Studies have shown that rapid handwriting patterns are consistent and beyond deliberate control. In a field test of the system, 2907 of 2948 verification attempts were accepted and 490 of 492 forgery attempts were rejected.

Car Audio Sales

It is reported that the U. S. Justice Department is looking into the practice of automobile manufacturers' offering car radios, tape players, and other audio components as standard equipment. By providing the audio systems as standard equipment, officials said that the buyer is deprived of an opportunity to choose what he wants for a new car. It's alleged by some radio and tape-machine industry spokesmen that auto dealers price car sound equipment far higher than sold by retail outlets. The investigation on whether the Sherman Act or Clayton Act is being violated is expected to last several months.

How to buy a personal computer.

Suddenly everyone is talking about personal computers. Are you ready for one? The best way to find out is to read Apple Computer's "Consumer Guide to Personal Computing." It will answer your unanswered questions and show you how useful and how much fun personal computers can be. And it will help you choose a computer that meets your personal needs.

Who uses personal computers.

Thousands of people have already discovered the Apple computer—businessmen, students, hobbyists. They're using their Apples for financial management, complex problem solving—and just plain fun. You can use your Apple to analyze the stock market, manage your personal finances, control your home environment, and to invent an unlimited number of sound and action video games. That's just the beginning.

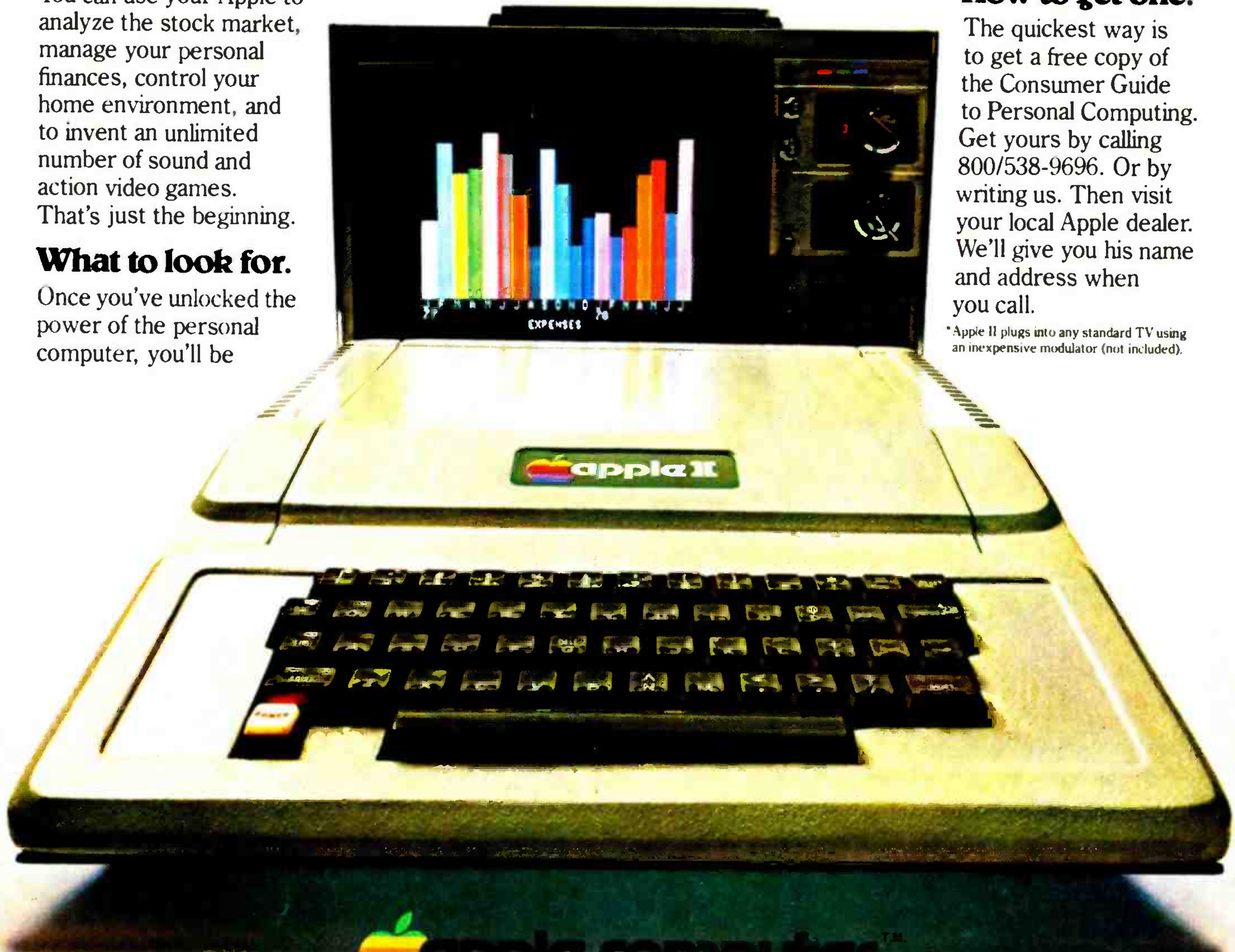
What to look for.

Once you've unlocked the power of the personal computer, you'll be using your Apple in ways you never dreamed of. That's when the capabilities of the computer you buy will really count. You don't want to be limited by the availability of pre-programmed cartridges. You'll want a computer, like Apple, that you can also program yourself. You don't want to settle for a black and white display. You'll want a computer, like Apple, that can turn any color tv into a dazzling array of color graphics.* The more you learn about computers, the more your imagination will demand. So you'll want a computer that can grow with you as your skill and experience with computers grows. Apple's the one.

How to get one.

The quickest way is to get a free copy of the Consumer Guide to Personal Computing. Get yours by calling 800/538-9696. Or by writing us. Then visit your local Apple dealer. We'll give you his name and address when you call.

*Apple II plugs into any standard TV using an inexpensive modulator (not included).



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