

The WHAT'S NEW magazine

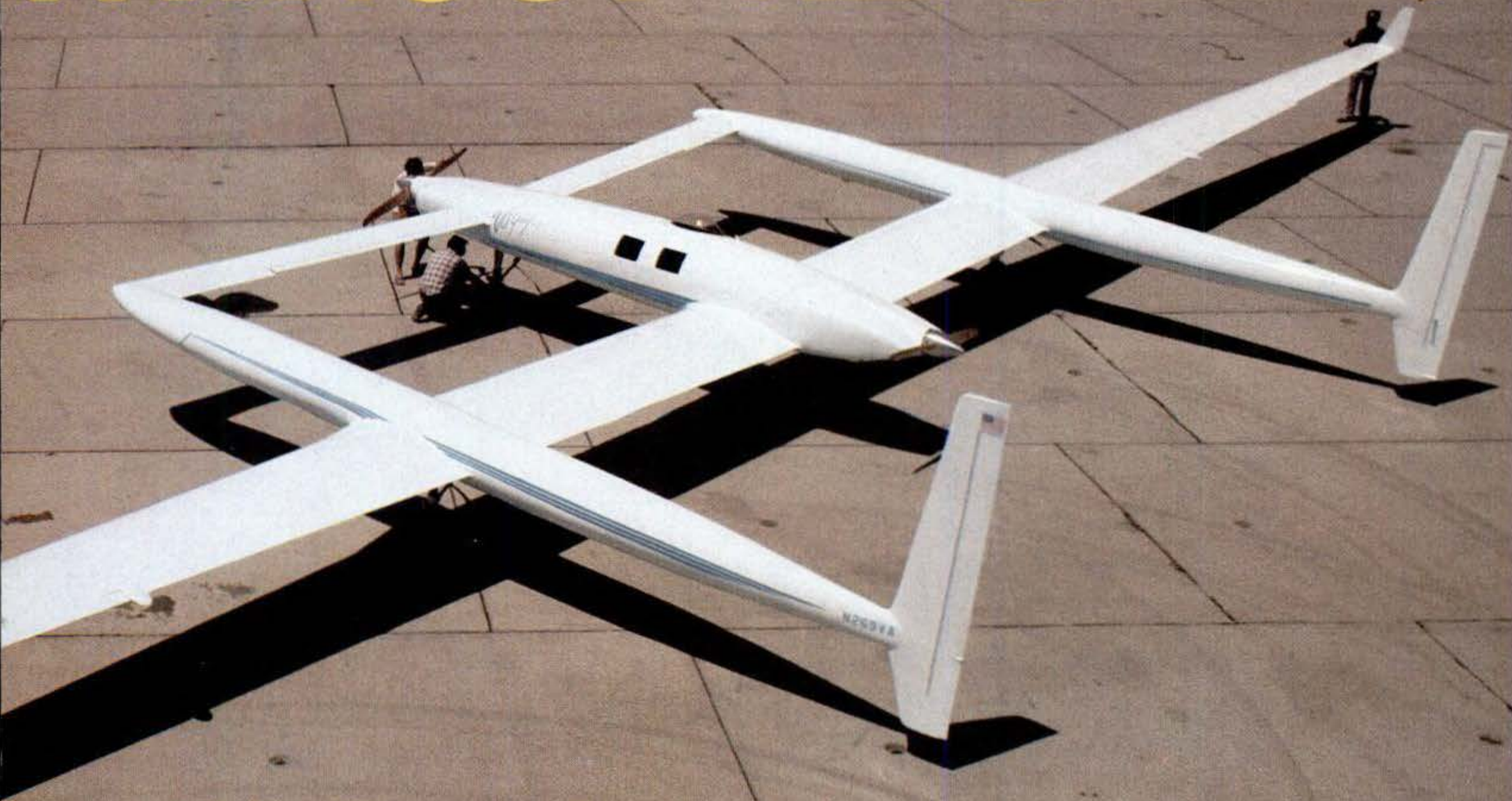
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Popular Science

Rutan's ultimate flyer— can it go nonstop?

AROUND THE WORLD WITHOUT REFUELING



PS guide to **74 portable computers**



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This One



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Cover photograph by Ben Kocivar

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Science and "Star Wars"

Just as the real purpose of the lunar-landing project of the 1960s and '70s was not to walk on the moon, the real purpose of the space-weapons projects ["Space Weapons—The Science behind the Big Debate," July] is not to build the ultimate deterrents against ballistic-missile attack but rather to justify the allocation of money for development of appropriate technologies.

The spinoff technologies of the space race kept America on the cutting edge of technological innovation and industrial development. Effective deterrence against attack may or may not result from the space-weapons projects, but what we learn about near space and the management of new sources of energy will be worth the investment—no matter how we label the projects.

It is lamentable that most of our scientific advances in this century have been made in preparation for war. But in our tight economy the military may be the only way to keep scientific research going.

Wayne S. Koski, Rose Hill, N.C.

Thanks for your coverage of space weapons—the debate has been woefully overweighted with opinion instead of fact. But I thought you could have paid more attention to anti-missile and rail-gun technologies and less to lasers and particle beams. If President Reagan's proposal is ever to become a reality, those technologies will be available more quickly than will the exotic ones.

James H. Hughes, Englewood, Colo.

The U. S. government funds "Star Wars" preparations in order to maintain a growing economy and a high gross national product. Though the development of new technology will no doubt help economic growth, I wonder how effective it will be as a defensive measure. It seems to me that any country that can produce a nuclear device could probably smuggle a radio-controlled version into any city in the world. Besides, there's little reason to believe that a "Star Wars" defense will remain defensive.

Dan Robinson, San Francisco, Calif.

There's a benefit to space weapons that

I've never heard mentioned. Space weapons can prevent a possible nuclear war by shooting down an accidentally launched nuclear missile. There are enough ways for an accident to happen—computer malfunction being chief among possible causes—to merit concern. A space-weapons system could stop an accident from turning into a disaster.

Ronald L. Charbonneau
Cheshire, Mass.

Rocket worries

Your article "How They Build High-Tech Rockets on the Cheap" [May] has given me cause to worry. I hope that the entrepreneurs launching rockets are supplying the Soviet Union and the U.S. government with advance notice of the times and places of their rocket launches. A nuclear war could be started by a trigger-happy government that sees a satellite readout of a rocket being launched from the ocean. The private rocket would look very much like a missile from a nuclear submarine, and the consequences of a mistaken identity are staggering. Does NASA give out warnings to other nations when a private rocket is being launched? I think advance notice should be required by law throughout the world.

Thomas Becher, Stratford, Wis.

Jim Schefter replies: "There are two safeguards to ensure that the launch of a private rocket will not be taken as threatening. First, advance warning is broadcast, as required by law, in Notices to Airmen and Mariners. Second, the companies notify the FAA, which turns the information over to the State Department, which in turn disseminates the information to all countries, not just those with nuclear weapons. In addition, as a Defense Department spokesperson pointed out, a single system in a non-threatening trajectory would not be interpreted by Soviet sensors as a precursor to nuclear attack."

New wings, old wings

May's "Science Newsfront" seems to discount past successes in manufacturing aircraft with forward-swept wings. Such aircraft were certainly

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Readers Talk Back

possible before space-age composite materials were available. The HFB 330 Hansa Fan Jet, a forward-swept-wing executive aircraft fabricated from conventional aluminum, was in production for a number of years. It is still being used by the West German air force as a VIP liaison aircraft, and in the United States as well.

R. Harvey Anselm
Geneva, Switzerland

Arthur Fisher replies: "Our April '80 cover story, 'Wrong-Way Wings Aid Maneuverability of Supersonic Planes,' delved into the history of this fascinating design. In addition to the Hansa Fan Jet reader Anselm mentions, there were several other planes that featured forward-swept wings. A Junkers JU-287 four-engine jet bomber was flown by Germany in 1944. The plane had a 15-degree forward-wing sweep, a conventional tail, and jet engines mounted

under the wings and along the fuselage. Incidentally, members of the German design team responsible for the JU-287 went on to build the Hansa Fan Jet. There are also a two-seater Saab MF 115 and a German powered glider that feature this design."

CVTs revisited

I enjoyed David Scott's enthusiastic article on continuously variable transmissions ["At Last: Mass-Production Stepless Transmission," March], but I think he's a little hazy on the transmission's history. The Fiat Uno-matic isn't the first car to feature a CVT. DAF, a Dutch manufacturer, introduced the CVT in the 1950s. Volvo bought the production rights to DAF cars in 1975, and those cars have featured CVTs ever since.

Jerry Argetsinger, Okinawa, Japan

David Scott replies: "Readers Argetsinger and Kortebach [RTB, August] are correct in saying that the Volvo 66DL preceded the Fiat Uno-matic as a production CVT, but my sin is one of omission rather than poor research. In fact, I reported on the Volvo 343, similar to the 66DL, in the January '77 issue of PS and have written several other articles on Volvo's Variomatic CVT, which is still available in the firm's Dutch-built 340 series. However, the Variomatic has a rubber belt in tension rather than a steel belt in compression, which is employed in the current van Dorne CVT used by Fiat (and soon to be used by Ford of Europe, General Motors, and others). So the Uno-matic could rightly be described as the first production car with a modern CVT."

Spare-tire solution

In "Coming Your Way: Revolutionary New Tires" [May], you made no mention of the possibility that dual-tire wheels could solve the spare-tire problem. If one tire were to go flat, you would still have a good tire.

John A. Robertson, Sarasota, Fla.

Tilting at windmills

Laurent Lynch's dissatisfaction with a Bergey windmill ["Alternate-Energy Answers," July] deserves an update. As it turns out, Mr. Lynch's installation was satisfactory, but there was a stuck brush in the yaw axis of the machine. When the brush was replaced, the machine operated smoothly. Mr. Lynch has told us that he is now satisfied.

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ness for five years and has produced nearly 600 wind-power generators. We pride ourselves on the quality of our engineering and our responsiveness to our customers.

Karl H. Bergey, President
Bergey Windpower, Norman, Okla.

Turbo checks out

In "Little Turbos" [July] you said that the EXP's turbocharger suffered a seal failure and quit working. We disassembled the turbocharger and found nothing wrong with it. The oil seals were in good condition.

Wayne Ikle, Account Manager
Warner-Ishi, Troy, Mich.

Correction: In the response to the Attic Ventilation letter in "Alternate-Energy Answers" [May], the equation for Q should have read as follows:
 $Q = (A/R) (T_{attic} - T_{duct})/3413.$ **PS**

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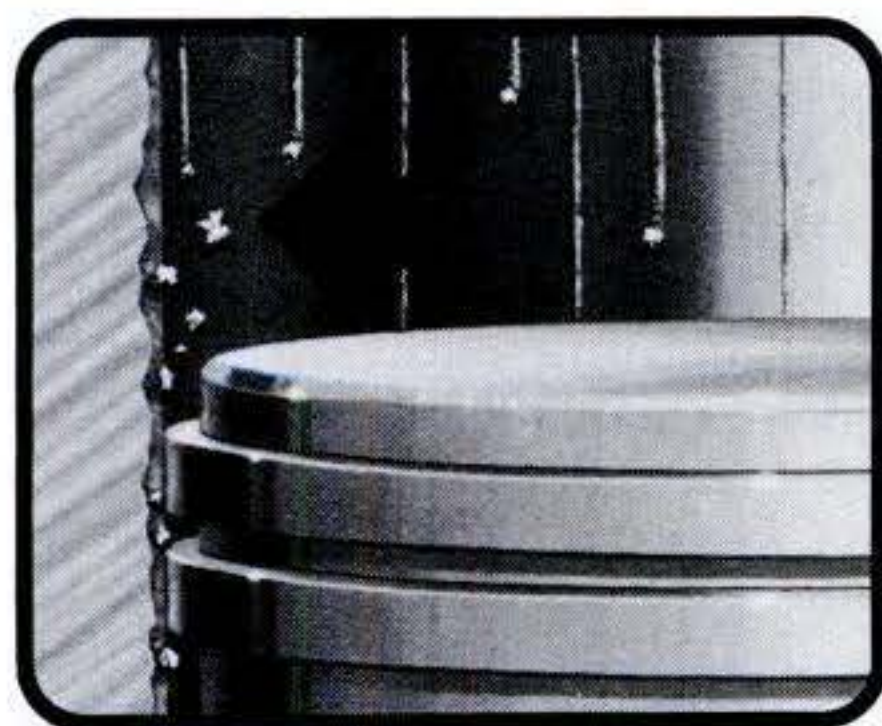
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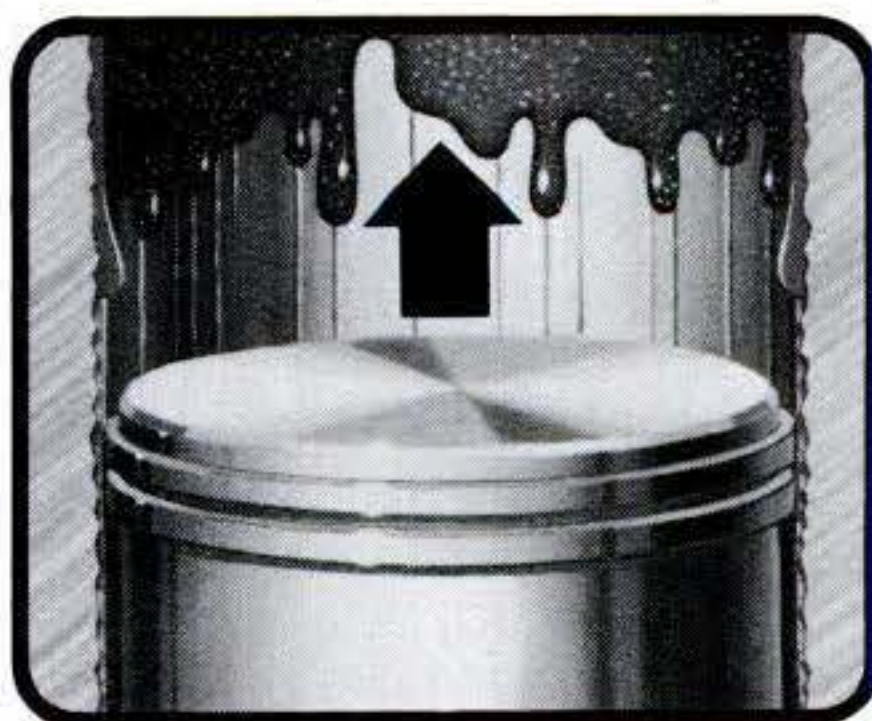


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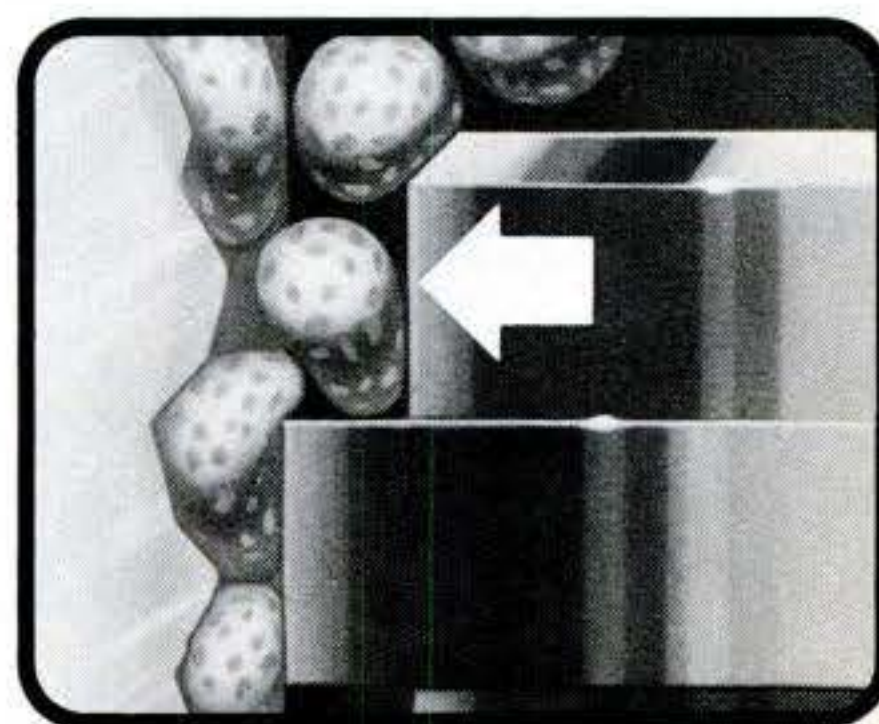
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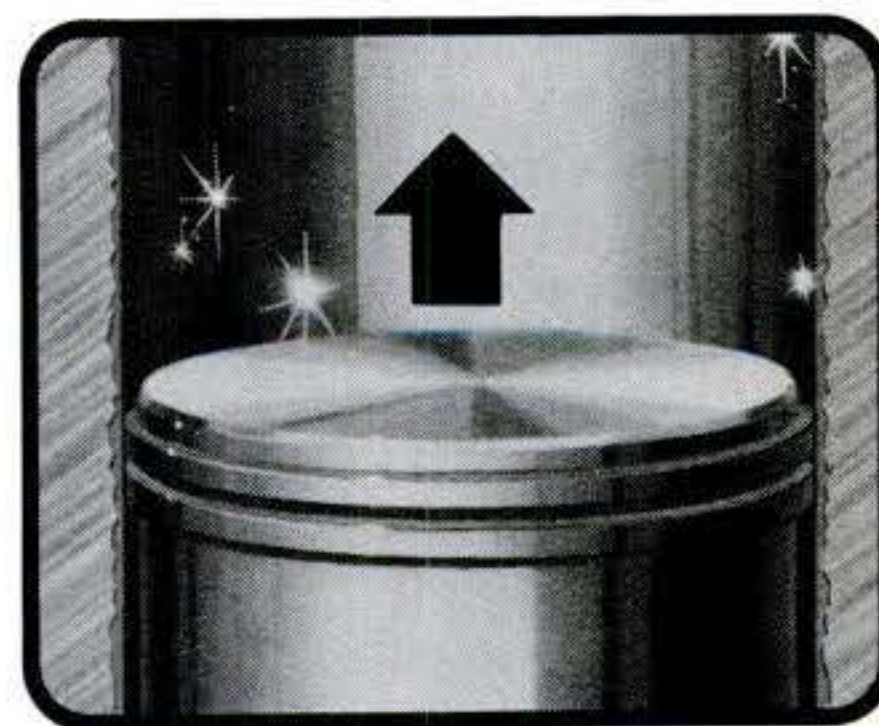


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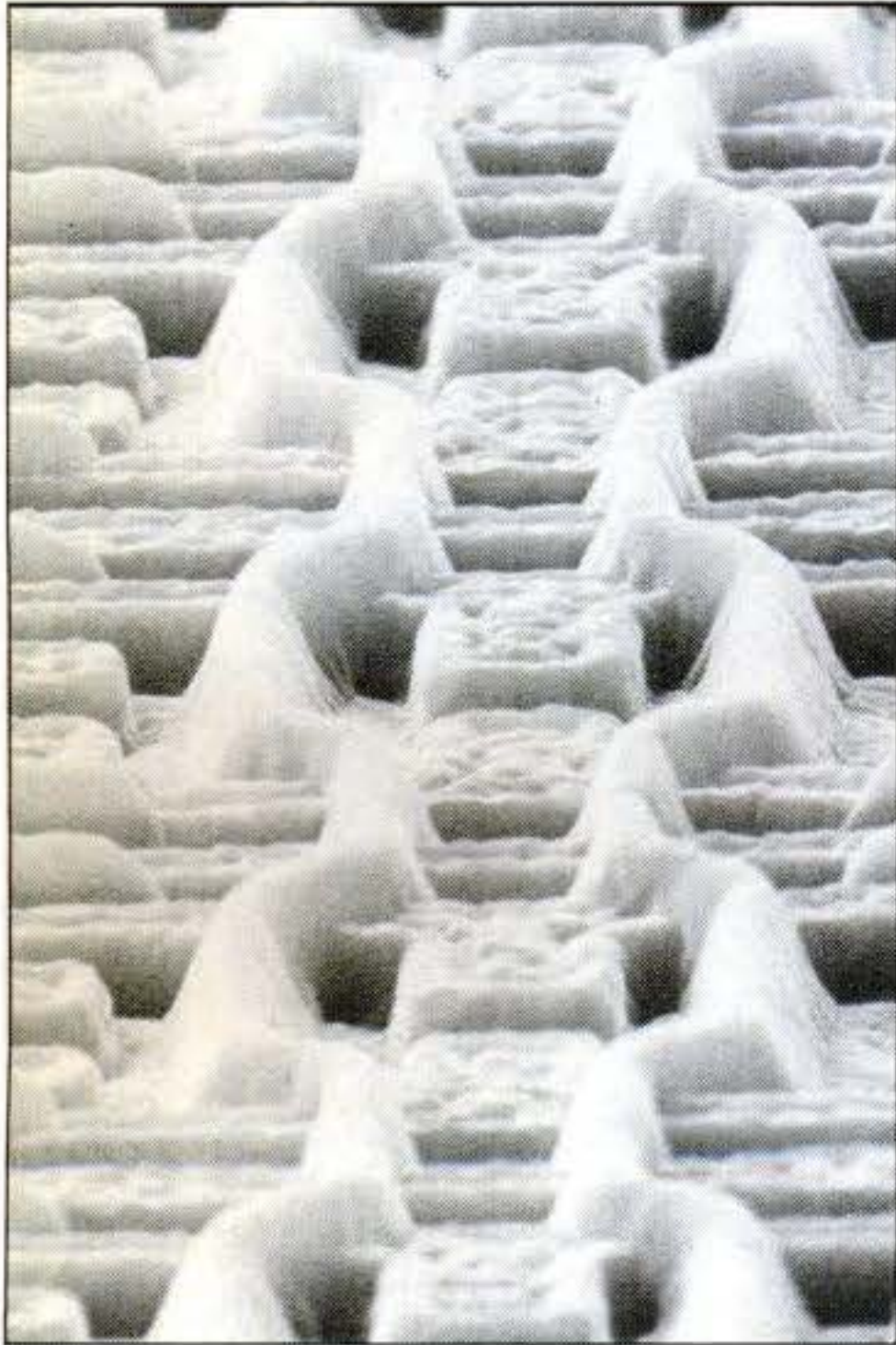
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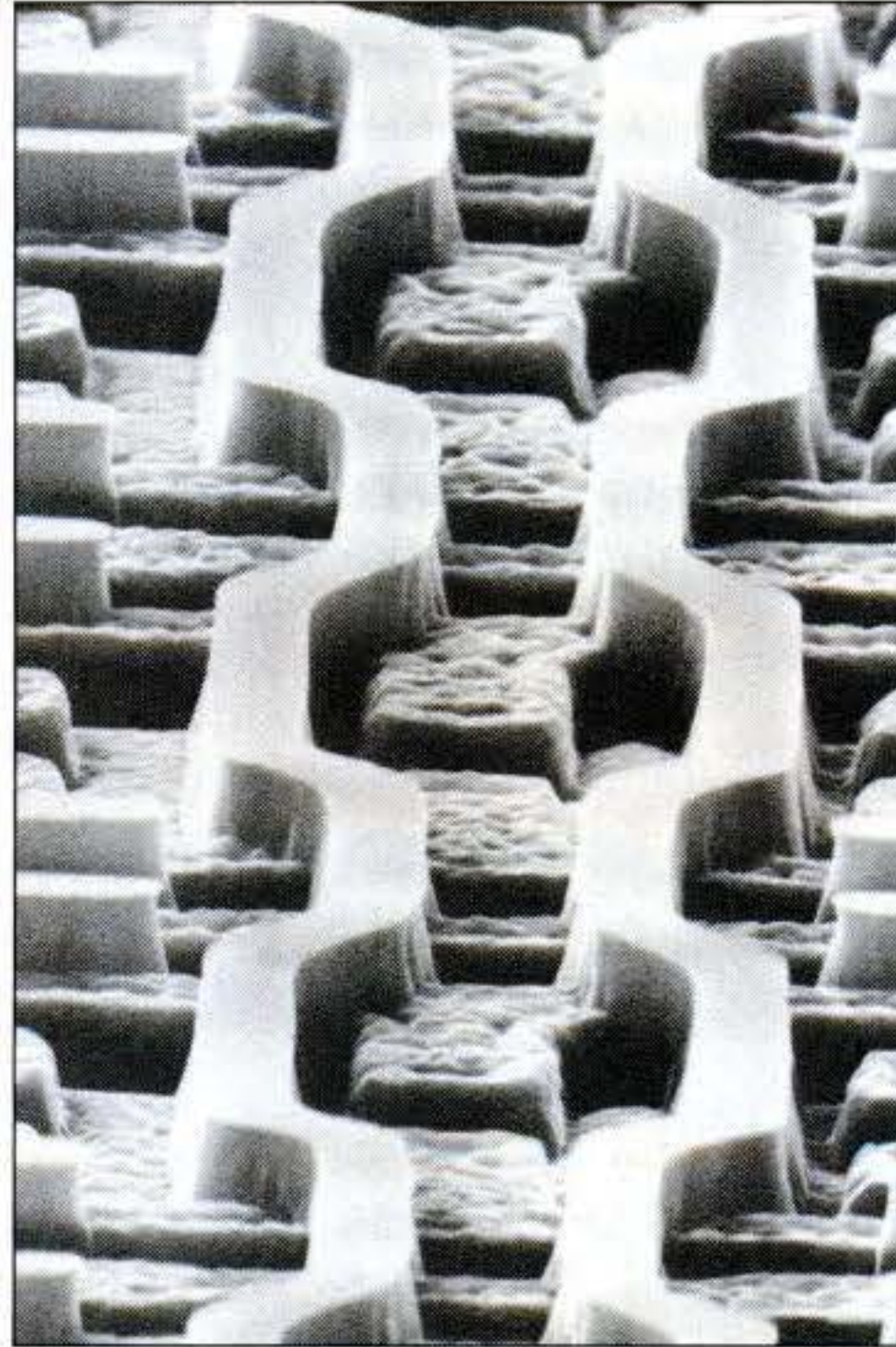
By ARTHUR FISHER



New microchip process

The photos above are scanning electron micrographs of two identical microcircuits produced with (right) and without (left) a new contrast-enhancement process developed at General Electric's Research and Development Center. Scientists there claim the technique will make it possible to achieve next-generation chips with existing equipment—chips with circuit elements as small as 0.4 micron (0.000016 in.). (The experimental circuits above contain elements about two microns wide.) It is possible to achieve the sharply defined pattern exhibited in the right-hand photo, according to GE, even when the projected mask image lacks contrast because of ultra-small dimensions.

The enhancement technique, developed by Drs. Bruce Griffing and Paul West, relies on a special photo-bleachable material that is spin-coated onto the photoresist in a thin layer. The material bleaches through most rapidly in the areas where the intensity of light shining through the mask is greatest—in other words, in the middle of the open areas between the circuit lines. By halting the exposure at precisely the right time, an area of unbleached material in the shape of the desired circuitry is created in the



contrast-enhancement layer. This unbleached material acts as an in-situ mask with ultra-sharp edges that clearly define the circuit.

Plastic light pipes

The technician in the photo below is demonstrating the light-carrying ability of a plastic ribbon being tested at Argonne National Laboratory. One thousand of these light pipes will be used to transmit faint pulses of light to detectors at the new Collider De-



tector Facility being built at Fermi National Laboratory. The flashes result from the impact of elementary subatomic particles created in high-energy collisions. Argonne and 30 other scientific institutions are cooperating in the design and construction of the new detector.

Magnetic drug therapy

A medical scientist at the University of Texas Health Science Center in Dallas has reported success in animal experiments that target drugs to specific parts of the body via a magnetic assist. Dr. David Ranney, assistant professor of pathology and director of the Laboratory of Targeted Diagnosis and Therapy, injected tiny spheres of protein one-twentieth the size of a red blood cell into the bloodstream of rats. The microspheres contained human albumin; a peptide that attracts circulating neutrophils (white blood cells); and magnetite, a naturally occurring magnetic oxide of iron found in many animals. An external magnet drew the microspheres to the lungs, where they dissolved to release the peptide. Because the peptide attracted white blood cells, the lung tissue's resistance to infection was enhanced.

The external magnet needs to stop the microspheres in the capillaries only long enough for them to pass through the capillary walls into the tissue, about five minutes.

The technique may prove particularly valuable when the drugs used have toxic side effects, as in many forms of chemotherapy for cancer. Targeting could reduce the impact of the drug on other than the tumorous tissues. "Fighting a tumor with a freely circulating drug is like waxing your kitchen floor by standing at the front door and dumping a tub of wax into the house," says Ranney. "Most of the wax will end up on the carpet, but some of it will probably get to the kitchen and wax it. In this case the carpet is the liver, the gastrointestinal tract, the hair that falls out..." He cautions, however, that the technique is still at least two years away from human experimentation.

Pinhole space camera

The artist's concept on the following page represents NASA's version of an orbiting instrument that would examine the sun by using, in part, the basic principle of an old-fashioned pinhole camera. Under study at the Marshall Space Flight Center in Huntsville, Ala., the Pinhole/Occluder Facility

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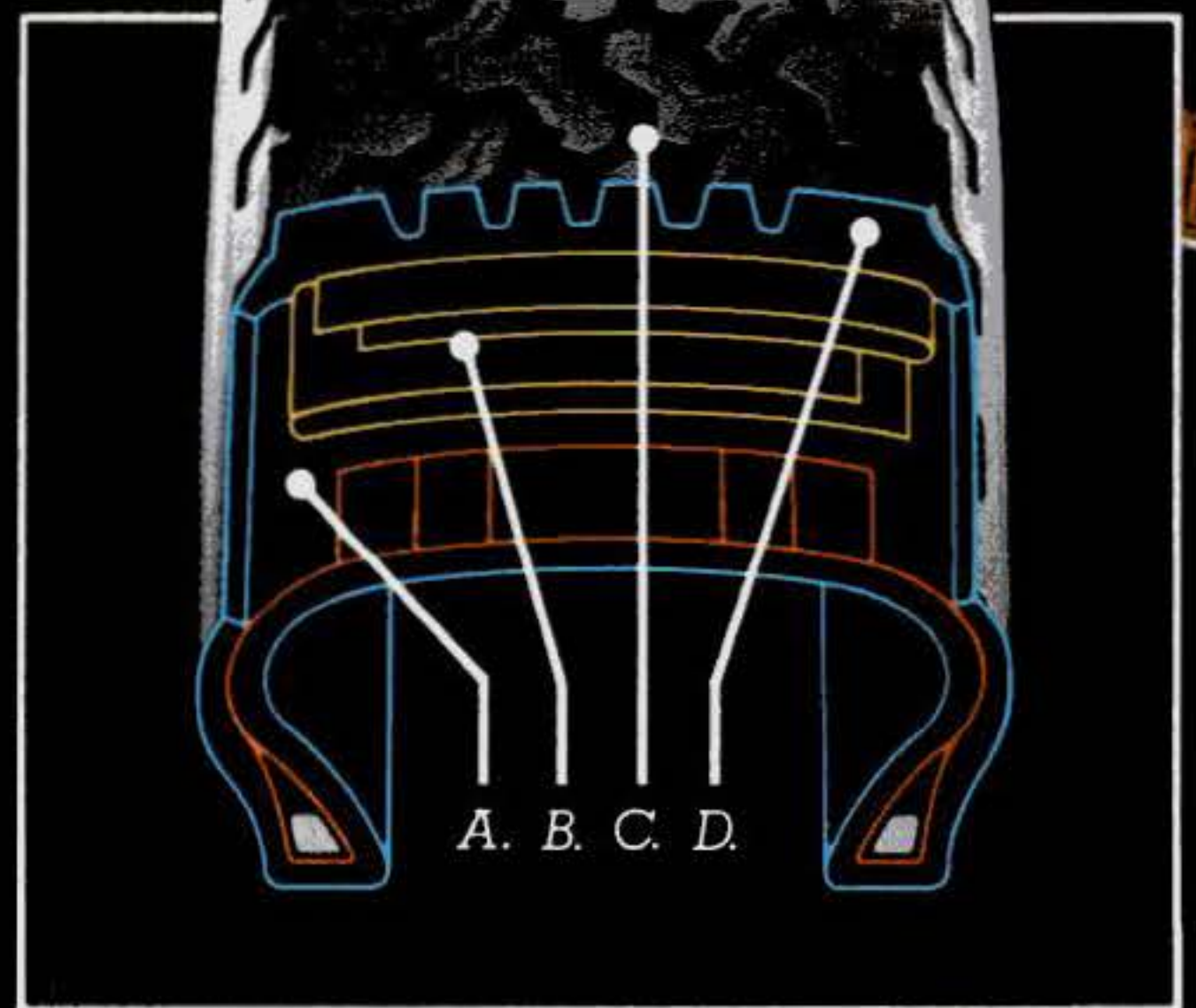
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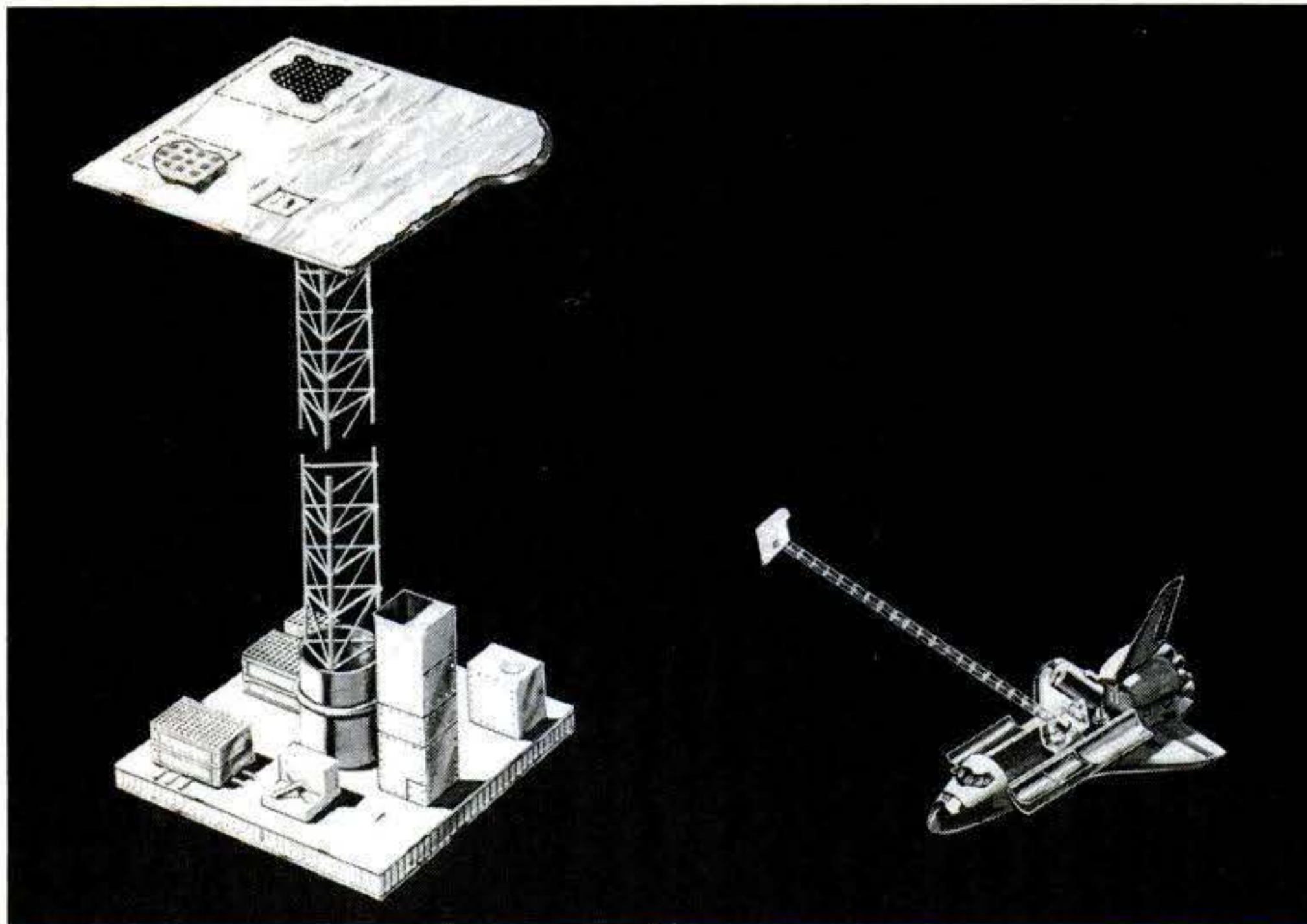
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would be a component of the Advanced Solar Observatory. This, in turn, is a planned combination of instruments on an unmanned orbiting platform, perhaps flying in formation with the future Space Station, that would scrutinize the whole range of the sun's electromagnetic radiation in the mid-1990s. But according to Joe Dabbs, study manager of the Pinhole/Occluder, the facility could be shuttle-launched as part of the Spacelab mission series, to orbit in 1989 or 1990. "The year 1990 would be especially appropriate," Dabbs says, "because that's the peak of the 11-year solar cycle."

The instrument would study the sun in two ways: with X-ray detectors mounted behind a plate pierced with thousands of microscopic holes through which X-rays would pass ("a high-tech approach to a child's cardboard pinhole camera," says Dabbs); and with a mask that would occult the bright disc of the sun so that the corona could be examined.

The multiple-pinhole technique ensures an X-ray image that is both bright and clear enough (when assembled by a computer) to provide fine details of the sun's activity.

Metal-fracture theory

Murray Daw (left in the photo at right) and Mike Baskes, both of Sandia National Laboratories in Livermore, Calif., have devised a theoretical model that may help predict how hydrogen invades metals and alloys, disrupts the crystalline lattice structure, and starts the formation of cracks that can lead to fracture—a process called hydrogen embrittlement. The subject is of great

importance to materials scientists and engineers because failure from embrittlement—in a pressure vessel or nuclear-reactor container, for example—could have serious consequences.

The model was developed into a program for the laboratory's Cray super-computer; a plot of hydrogen embrittlement in nickel, drawn by the Cray, appears behind the researchers in the photo. The model incorporates the fundamental properties of the elements involved and describes the bonds between metal atoms and between other atoms within the metal lattice.

Technology-resource directory

The Center for the Utilization of Federal Technology (CUFT), a special program at the National Technical Information Service (NTIS) of the U.S. Department of Commerce, has just



published a truly fascinating volume called "Directory of Federal Technology Resources." The directory is part of CUFT's mission to promote technology transfer between the federal government and private industry. It lists and describes hundreds of federal laboratories, research and engineering centers, and testing facilities that can provide expert advice, specialized equipment, and other services to help nongovernmental inventors, technicians, researchers, and others. The publication details the particular capabilities of each center and supplies the name and telephone number of a liaison officer at each.

To make things easier there is a separate detailed subject index, from "Accident prevention" (Army Aero-medical Research Laboratory) to "Zinc" (Rolla Research Center), and a geographic index listing resources by state.

The NTIS order number and title: PB84-100015/TCY, Directory of Federal Technology Resources 1984. The cost is \$25. For more information call (703) 487-4650.

Evaporating comet

A spacecraft in orbit around Venus has made a startling observation of Comet Encke as it streaked between Earth and Venus. Planetologists at NASA's Ames Research Center report that the comet is shedding water at a rate some three times greater than anticipated for its distance from the sun.

The Pioneer Venus Orbiter, launched in 1978, has been steadily observing atmospheric and other phenomena on Venus. But in April, mission controllers at Ames tilted the craft so that it could peer at the passing comet. The Orbiter's ultraviolet spectrometer provided the surprising data. Astronomers speculate that the larger-than-expected water loss could be due to an uneven distribution of the comet's supposed "dusty snowball" components, or to the crumbling of "mesas and hills" that may cover the surface of Encke's 1.2-mile-diameter mass.

Synthetic garlic

Chemists at the University of Minnesota have succeeded in synthesizing the active ingredient in garlic, allyl methyl trisulfide. The substance could be medically useful: It is known to inhibit blood clotting, and it may lower cholesterol levels. It may also be used as an agent to kill some bacteria and fungi, and may even be used as an insecticide. **PS**



Casio brings space-age technology to spaceship earth.

Casio's solar-powered scientific calculators put space-age technology easily within your reach.

Our FX-910 is the logical choice for students and engineers alike. At only \$24.95, it gives you algebraic logic, 48 functions and an 8-digit + 2-digit exponent display—in a size that will fit as easily in your pocket as its price will suit your pocketbook.

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by Casio's innovative sheet key technology, this handy feature makes complicated scientific equations easier to solve because the major function keys are displayed oversized on their own keyboard.

Like our FX-90, our FX-450 (\$34.95) has a 10 + 2-digit LCD display and a keyboard with touch-sensitive keys. But the keys are double size and the number of functions increases to 68. Most importantly, it lets you calculate with the speed of light—and eight other commonly used physical constants, including

Planck's constant and atomic mass. It also makes computer math calculations and conversions in binary, octal and hex equally easy to use.

Casio has more space-age instruments at down-to-earth prices than there is space for here. However your Casio dealer will gladly let you get your hands on technology that, until now, only the future held.

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Where miracles never cease

It's times like this you've got a Wagner

3 mins.

*We painted a shutter
in 3 minutes
with a Wagner
Power Painter.*

*It took us
22 minutes
with a brush.*

4½ mins.

*We painted this wicker
chair in 4½ minutes
with a Wagner Power
Painter. It took us 1
hour with a brush.*

6½ hrs.

*We painted this house in 6½ hours
with a Wagner Power Painter.
It took us 17 hours with a brush.
Both were done excluding trim.*

21 mins.

*We painted an eight-foot
section of this fence
in 21 minutes with a
Wagner Power Painter.
It took us 1 hour and
20 minutes with a brush.*



That'll make you glad Power Painter.®

Every once in a while you come across a product that offers significant advantages over a tried-and-true method of doing things.

In the case of painting, consider a Wagner Power Painter instead of a brush.

A Wagner Power Painter's speed should quickly make a believer out of you. Just among the examples we've shown, the time saved is astonishing.

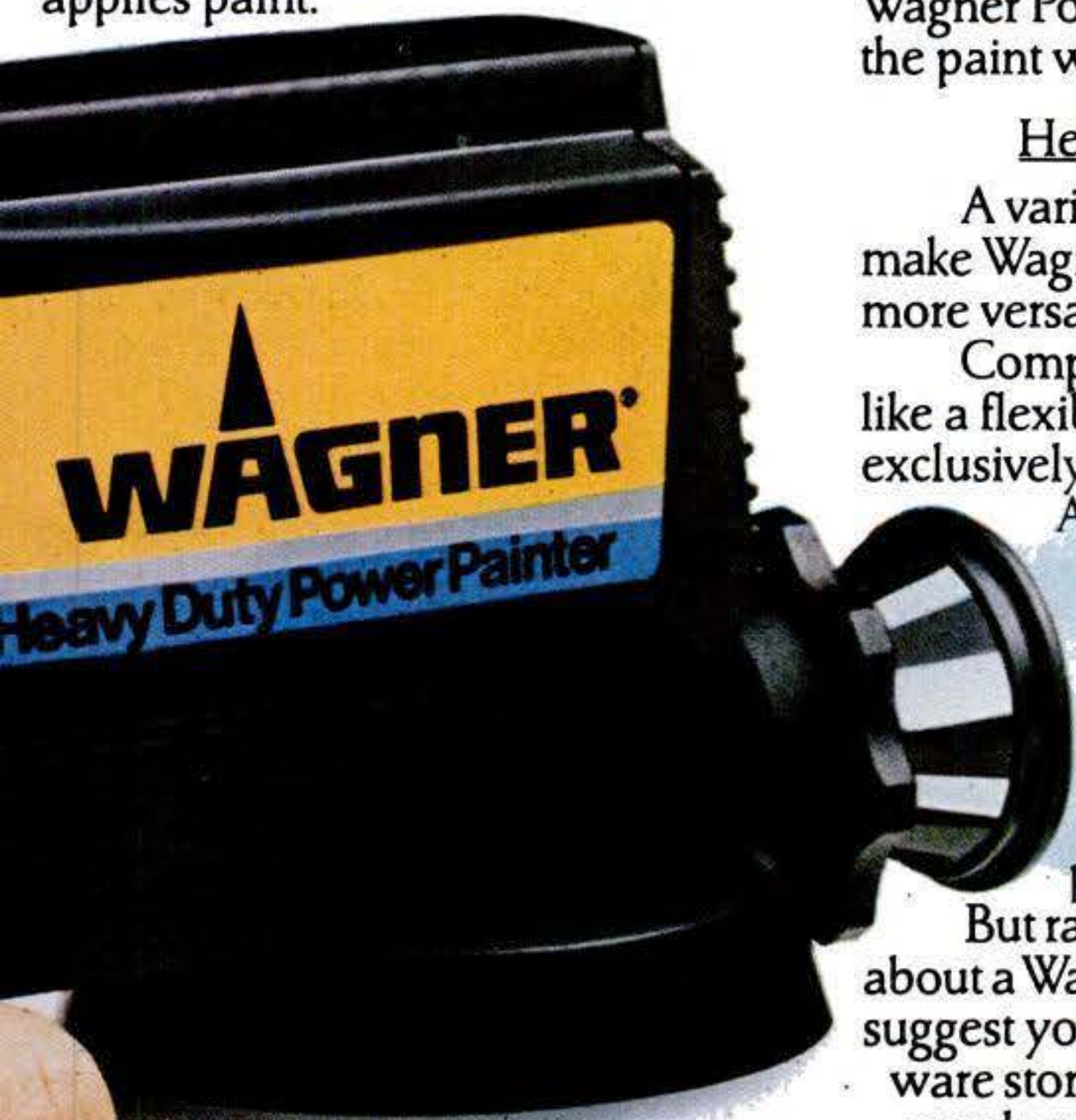
And a Wagner Power Painter is ideal for dozens of other painting chores around the house.

Professional-looking results made easier

Of course, speed isn't a Wagner Power Painter's only long suit.

A Wagner Power Painter also makes it remarkably easy to achieve professional-looking results—the spray lays down a smooth, even finish with no brush marks.

And when it comes to intricate painting jobs like wrought iron railings, louvered doors and bicycles, it's amazing the way a Wagner Power Painter reaches into crevices and applies paint.



That's also why a Wagner Power Painter is so effective on rough, textured surfaces like shake shingles.

Spray paints, lacquers, stains, varnishes, and more

Virtually any kind of latex or oil-based paint is compatible with a Wagner Power Painter.

It can also apply stains, varnishes and lacquers. Or spray almost any other liquid, even pesticides.

So a Wagner Power Painter is a lot more than just a "one project" tool.

And cleanup is simple—just run the appropriate solvent through until it's clean.

No air compressor

The secret to a Wagner Power Painter is a precision electric, piston-driven pump.

It creates a pressure that propels liquid out through the tip, which then forms the spray.

There's no bulky air compressor to lug around. And significantly reduced "fogging" that usually accompanies painting with compressor-powered sprayers because a Wagner Power Painter doesn't mix the paint with air.

Helpful attachments

A variety of helpful attachments make Wagner Power Painters even more versatile.

Complete outfits include things like a flexible spray tip designed exclusively for floors and ceilings.

And a tube that replaces the reservoir, so you can draw paint right from the can.

You can even get an optional spray tip that narrows the spray for precision painting.

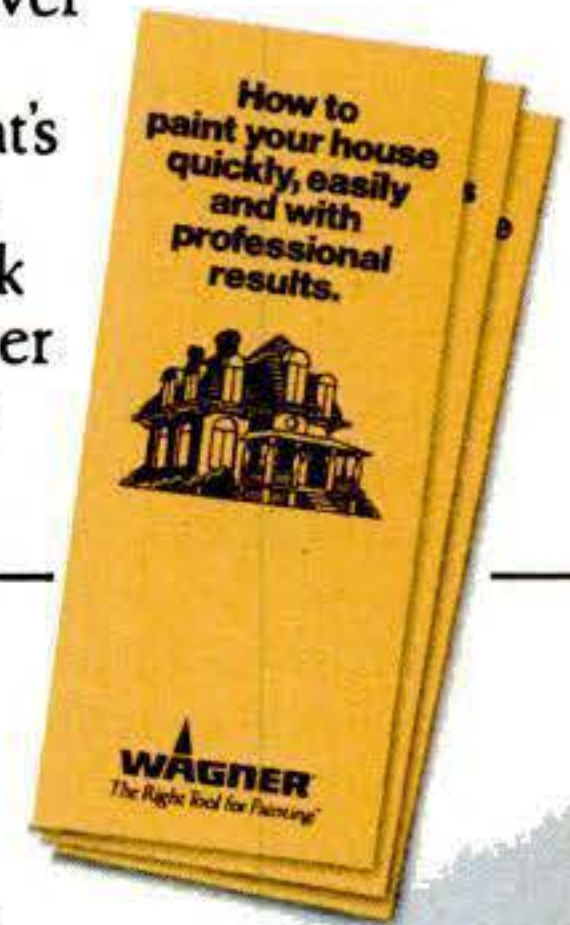
But rather than simply reading about a Wagner Power Painter, we suggest you visit your local hardware store, paint store, home center or wherever quality paints are sold.



Then ask to examine a Wagner Power Painter first-hand.

Whether you're painting your '57 Chevy or the broad side of a barn, you'll discover there's a Wagner Power Painter that's just right for you.

And we think you'll also discover it's high time you owned one.



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Please send your free "How to..." brochures to help me learn more about painting with a Wagner Power Painter.

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Address _____

City _____

State _____ Zip _____

Allow 4-6 weeks for delivery.

WAGNER
The Right Tool for Painting.™

Alternate-Energy Answers

By JAN F. KREIDER

Jan F. Kreider is a consulting engineer specializing in the design and economic analysis of solar-energy and energy-conservation systems. He is the author of several books on solar technology and a lecturer at the University of Colorado.

Choosing a heat source

I have a 35-year-old 250,000-Btu furnace that will need replacing soon. It uses natural gas. I have read in POPULAR SCIENCE of many new alternatives including high-efficiency heat-recovery furnaces, pulsed combination furnaces, geothermal heat pumps, etc. Can you tell me how to compare the initial installation costs with the savings in operating costs so I can decide what system is best?

Vilray Blair III, St. Louis, Mo.

This type of comparison involves two types of costs: initial-purchase or installation costs, and annual costs for fuel. Here's how to compare life-cycle costs: First, convert the one-time initial cost to an equivalent annual cost by multiplying it by the capital recovery factor (CRF), which equals $i/[1 - (1 + i)^{-N}]$; i is the interest rate (the rate of return on money borrowed to purchase the new furnace. If money is not borrowed, i is the rate of return on your other investments, such as stocks and bonds), and N is the expected life of your new furnace. For example, if you earn 12 percent with an alternative investment and expect the furnace to last for 20 years, the CRF is 0.134.

Next, compare the annual cost with the expected annual saving as follows: Suppose that a high-efficiency furnace costs you \$1,500 more than a standard one but saves you \$300 per year. The annual extra cost of the better unit is \$201 per year ($\$1,500 \times 0.134$). This is about \$100 less than the energy saving; therefore the investment is a sound one.

You can use this technique to compare various other furnace, heat-pump, and heat-recovery systems to find the one with the largest benefit to you. The method can be expanded to include tax credits, maintenance-cost differences, and many other factors.

Problem paneling

I paneled my attic and put three-inch insulation between the panels and roof. When it's cold, it's damp; my sheeting boards are warping; and the shingles seem to curl. What's wrong?

Donald Evans, Washington, Pa.

If your roof membrane is intact, the

source of your problem is probably the lack of a vapor barrier and lack of a means for water vapor to escape from the outer surface of the insulation. The more important of these two is the lack of a vapor barrier. It should be installed between the paneling and the insulation with a minimal number of punctures and tears. The second problem can't be fixed without redoing all your work; therefore I'd only install a very good vapor barrier and reinstall the paneling.

Solar add-on

I am planning to build a solar add-on similar to the one in your January 1983 issue. According to the article the solar room is 15 by 18 feet with a rock bed six feet deep. This yields 1,620 cubic feet. Isn't this too much thermal mass? Will it ever heat up enough to help supply heat to the rest of the house?

Robert Wrenn, Raleigh, N.C.

The rule for rock-bed volume in a fan-forced loop operated by a sun space is two cubic feet of gravel per net square foot of south-facing glazing. Therefore if your sun space is 18 feet long with 6½-foot-high vertical glazing, you need about 210 cubic feet ($[18 \times 6.5 \times 2] \times 0.9$) of clean, dry gravel in an insulated enclosure. (The factor 0.9 is the ratio of net-to-gross area for the south-facing windows.) But the add-on to which you refer had three walls of glass plus skylights, and the thermal mass was designed to stabilize temperatures year-round—the reason for its depth.

Newspaper logs

Please tell me about using rolled newspaper as a substitute for wood, or let me know which issues of POPULAR SCIENCE to check.

Robert Lommel, Wayne, N.J.

In the September 1974 issue ["What's New in Home Improvement"] a device called the Paper-Log Roller was described. It rolls newspapers into tight rolls that can substitute for wood logs. Write Cristen, Inc., 59 Branch St., St. Louis, Mo. 63147. "What's New in Home Improvement" in the February

1974 issue introduced Kindelit. It uses five horizontal half-cylinders located beneath the andirons in a fireplace. A roll of newspaper is inserted into each tube to start a conventional wood fire. Contact Kindelabra Co., Box 253, Wellesley, Mass. 02181.

Massive heat storage

I've read that 1,000 gallons of hot water will heat a house for three cold, cloudy days, so wouldn't 50,000 gallons heat it for 150 days, or clear through the winter? That way one wouldn't need to operate the solar collector at all in winter or worry about cloudy days, snow on the collector, or frozen pipes inside it.

Robert D. Smith
Swisher, Iowa

Assuming that your 1,000-gallon rule is correct, you would need 60,000 gallons or so for a typical heating season in Iowa. This amount of water will fill the basement of a 1,500-square-foot house to a depth of 5½ feet. As you can see, the problem would be the cost of the storage tank, which you would "fill" with heat and then deplete only once a year. The usual tank of several hundred gallons is thermally filled and depleted many times per year, but the tank's economics are much improved. However if many residences used one large common tank, the seasonal-storage idea that you propose would appear to have merit because of the economics of scale.

Better furnace performance

I have been approached by a company that offers a furnace add-on. It uses a fan to pull the hot flue gas through a water spray, cooling the flue temperature from 500 degrees F down to 150 degrees F or less. The warmed air is then circulated through a heat exchanger in the cold-air duct.

Harley B. Coon, Portland, Ore.

According to scientists at the University of California's Lawrence Berkeley Laboratory, this device offers one of the most cost-effective methods of improving the performance of an existing furnace. It's worthwhile to contact several suppliers of this heat extractor because prices vary.

Got a question on an alternate energy such as solar, wind, water, or wood? Wondering about energy-conservation techniques for home heating or cooling? Every other month, alternating with "Adventures in Alternate Energy," Jan Kreider answers selected questions from readers. Send yours to Energy Questions, POPULAR SCIENCE, 380 Madison Ave., New York, N.Y. 10017. Queries can't be answered by mail.



AIM HIGH!

Reach for new horizons.

It's never easy. But reaching for new horizons is what aiming high is all about. Because to reach for new horizons you must have the vision to see things not only as they are, but as they could be. You must have the dedication to give the best you have. And you must have the courage to accept new challenges.

The history of the Air Force is a history of men and women reaching for new horizons, dedicating their vision and courage to make our nation great.

You can join us in our quest for new horizons. Our pay and benefits are better than ever, with opportunities for growth and challenge.

Aim High! Find out more. See your Air Force recruiter today or call toll free 1-800-423-USAF (in California 1-800-232-USAF). Better yet, mail in the card.

AIR FORCE

A great way of life.

Detroit Report

By JIM DUNNE



GM's '87 $\frac{1}{2}$ sports coupe

Planned as a Chevrolet exclusive for at least one year, the 1987 $\frac{1}{2}$ L-special (shown above in sneak photographs) will be built on the Citation III chassis but will share little in styling. For comparison, the L-special has a 103-inch wheelbase and an overall length of about 180 inches; the Monte Carlo has a 108-inch wheelbase and is just over 200 inches long.

Base engine will be a 2.2-liter (134-cu.-in.) four-cylinder based on the two-liter (122-cu.-in.) engine Chevy now builds for the Cavalier. As an option, a 3.2-liter (195-cu.-in.) overhead-camshaft V6 will also be offered. This is an upgraded version of Chevy's 2.8-liter (171-cu.-in.) V6.

The smaller car will weigh at least 500 pounds less than the 3,200-pound Monte Carlo. With the lighter weight, small engines, and a five-speed transmission, fuel mileage should be dramatically improved. Look for EPA city numbers in the high 20s. Currently, Monte Carlo gets an EPA city rating of 20 mpg with the most economical engine and transmission.

Sleek aerodynamic body tuning is readily apparent on this model. Note

the sharp rake of both the windshield and hood, which should enable the car to slip through the air with little resistance. The side-window area closely resembles that of the BMW 633CSi coupe. At the rear, wind-tunnel engineers have added a tall hunched-up rear deck to minimize drag. That aero tweak also adds trunk space.

A close look at the car reveals a Pontiac-style grille and hideaway headlights. Insiders believe that Pontiac will be the next General Motors division to get the L-special. The car seems to be primarily Chevy from the A-pillar back, with engineers trying the Pontiac nose on the Chevy prototype. Note the different shapes of the front and rear wheel arches, which is normally considered a design no-no on new models.

Four-cylinder fixes

Two problems with four-cylinder engines have slowed their acceptance in passenger sedans. One is their inherently poor harmonics at certain engine speeds, which causes vibration. The other is their need to operate at high rpm to develop adequate levels of power.

But changes in design may help eliminate these problems. Chrysler is already committed to the Mitsubishi-type Silent Shafts for its new 2.5-liter (153-cu.-in.) and 2.2-liter (134-cu.-in.) engines for 1986. Oldsmobile is planning similar balance shafts for its proposed 4-83 four-cylinder engine. Four-valve-per-cylinder-head designs and further refinement of the turbocharger may mean increased power for the fours. No doubt, greater acceptance will follow closely on the heels of these developments.

Keeping cool

Engineers are taking a micro-close look at how engine cooling systems work.

One study suggests putting a special coating on certain sections of the water passages in the engine to eliminate or produce "hot spots" to aid combustion. The coating would take the place of thick- and thin-wall coolant passages that affect temperatures in current engines.

A second area of research involves a special sealed coolant that doesn't need a radiator. This would also eliminate hoses and a water pump. Altogether, that could mean as much as 100 pounds in weight savings.

Why not, like Porsche, go to air cooling? Experts say that although it's a good idea for small engines, it's difficult and expensive to meet emissions standards with larger-displacement air-cooled engines.

Breathing better

"The key to more power is getting more air into and out of the engine," says Oldsmobile chief engineer Bob Dorshimer. "And there's more than one way to do that."

Although most auto makers are turning to turbos for better performance from their low-power engines, others are looking at tuned induction and multiple intake and exhaust valves to get the job done. Latest to show interest in a four-valve-per-cylinder head is Volkswagen, which hints that a 16-valve four is in the cards for Scirocco. VW wants to beef up the power in its performance leader and is evidently leaving turbocharged gasoline engines to its sister company, Audi.

For Olds, Dorshimer has eschewed the turbo and instead will have a tuned-induction version of the V6 diesel. Olds is also planning a new double-overhead-cam four for introduction within two years. PS

What gives Indy's winningest chief mechanic extra performance and protection in this?



This.

George Bignotti, a legend in automobile racing, has 7 Indianapolis 500 victories under his belt. In fact, he has more first place finishes on the Indy car circuit than you can wave a checkered flag at—87 overall, that's more than any other chief mechanic in history.

George switched to special racing formula Mobil 1[®] for the Bignotti/Cotter Indy cars. He also switched to regular Mobil 1 in his family car. And for some very good reasons.

"I can't give my car better engine protection. Mobil 1 lubricates even better than conventional premium oil. It protects better against friction and wear so my engine stays

cleaner, runs smoother and performs better even under the most extreme temperature conditions."

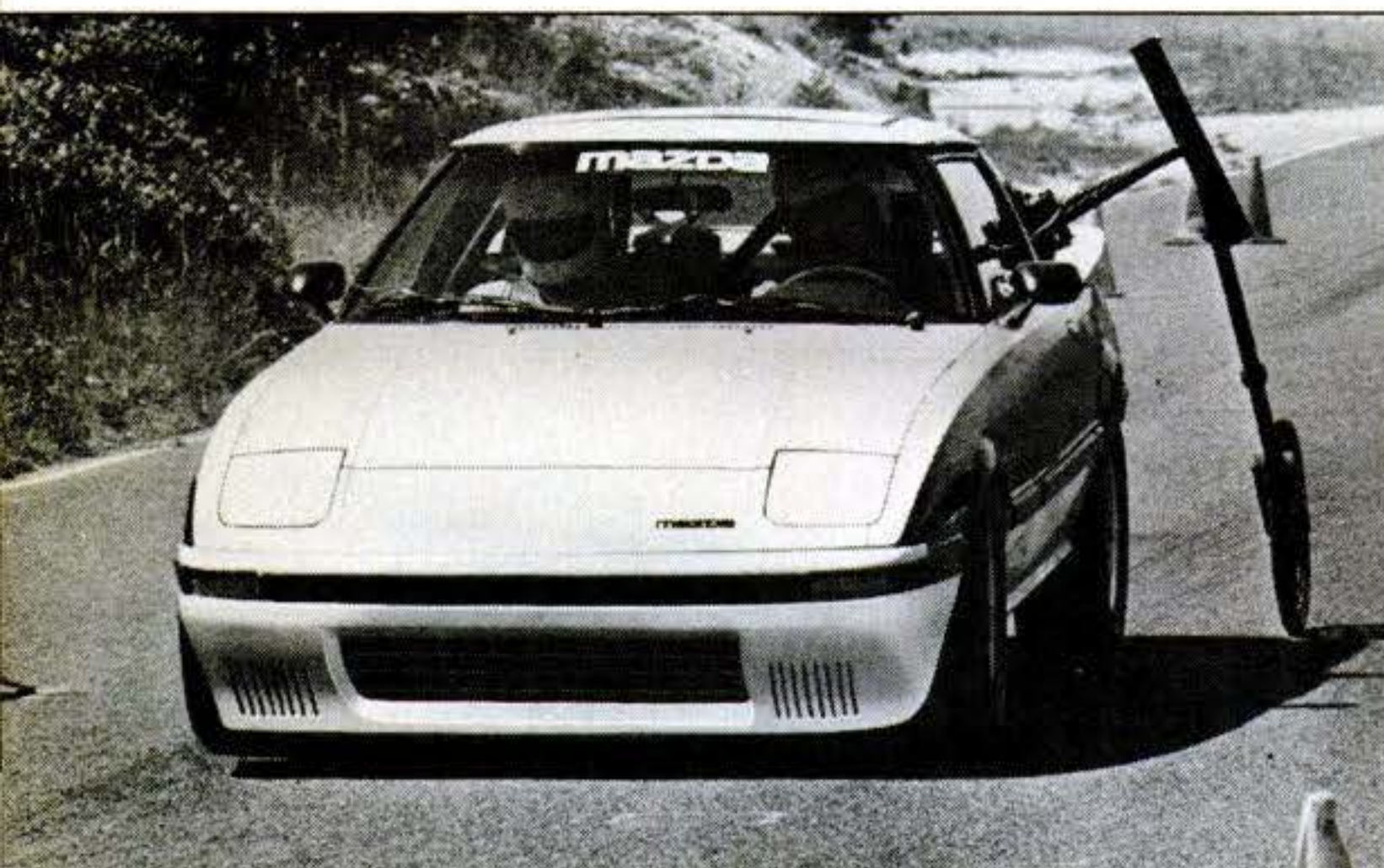
While Mobil 1 is proving itself in cars like yours, special racing formula Mobil 1 is proving itself in the Bignotti/Cotter Indy cars, by reducing friction, boosting performance and increasing horsepower.

If you want better engine protection for your car, do what George Bignotti has done.

Change your oil to Mobil 1. Because when it comes to extra performance and engine protection, Mobil 1 leaves ordinary oil in the dust.

Mobil 1.
You can't give your car better engine protection.

100% Synthetic Motor Oil
#1 in Performance and Protection*



Quick-lane quartet (clockwise from top left): Chevrolet Corvette rockets through high-speed grid;

Porsche 944 snakes through low-speed grid; Nissan 300ZX turbo launches zero-to-60-mph run; Mazda RX-7 noses into brake lane.

Sports-car showdown

—Corvette, Porsche 944, Mazda RX-7, and Nissan 300ZX turbo

PS testers roll out America's fastest sports car at Bridgehampton Race Circuit for an all-out performance showdown with three of the world's quickest fast-lane challengers.

By JIM DUNNE and JACK KEEBLER
Photos by Greg Sharko

Every year they go faster, stop shorter, handle better, and—of course—cost more. We captured four of the most desirable sports cars on the American scene for our comparison test: Chevrolet Corvette, Mazda RX-7, Nissan 300ZX turbo, and Porsche 944. Each of these vehicles is noted for its outstanding acceleration and above-average braking, maneuverability, and handling. But we also found some features that sports-car drivers often forget to mention, such as high interior sound levels, poor ride quality, and difficult entry and exit.

Another problem is the high cost of these fun-to-drive models. Prices range from a "low" of about \$16,850 for the GSL-SE version of the RX-7 to almost \$26,000 for the Corvette. But for the money, buyers can also expect some of the best driving equipment available on any production automobile.

These features include four-wheel disc brakes, low-profile tires, highly refined engines, and heavy-duty manual transmissions for the driver who

[\[Continued on page 26\]](#)

Turn page for test results and specs

Two-Line Breakthrough

Here's the latest innovation in installation-free two-line phones. You'll have Tone/Pulse switching, a real hold button, and you'll even have conferencing between the two lines.

You're on the phone. You're talking to two of your oldest friends. The three of you haven't chatted together for ages.

While you're busy reminiscing about old times and catching up on the latest gossip, you give your new two-line conference phone an appreciative little pat.

Across the street or across the country, with standard phone lines or discount services, this phone will let you make great use of your two phone lines.

And best of all, there are no monthly rental charges. And, it simply plugs into your existing modular phone line(s).

So, if you now have two separate phones or an expensive two-line Phone Company Phone, just unplug the modular plugs from your existing phone(s), plug in and start talking.

LIGHTS, CAMERA, ACTION

Push the Line 1 or Line 2 button and lift the receiver. A red LED will light to show which line is in use. And, you won't ever pick up the phone when someone is using another extension because the LED lights any time the line is in use.

If you want to change phones or if the other line rings, push Hold. The in use LED will change from red to green. You can now pick up any extension in your home and continue your conversation. This phone has true hold.

The phone is tone/pulse switchable. Just switch it to fit your area. Or, dial in pulse to access your Sprint or MCI number, then switch to tone for dialing.

In addition to the selectable high/low or off ringer, there are LEDs that show which line is ringing. Just push the button next to the blinking LED to answer the phone. It's a great convenience at night. Plus, the LEDs light even when you have the ringer off.

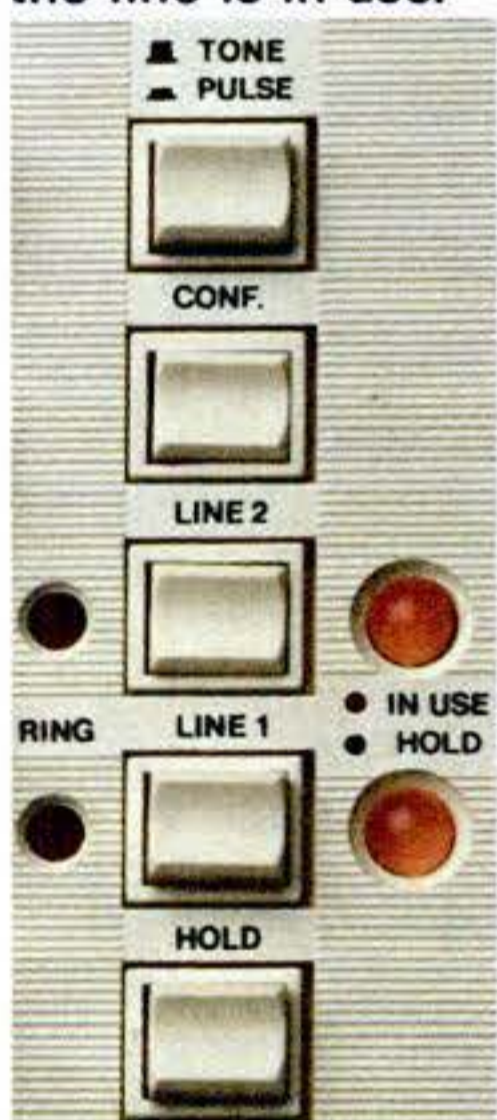
The conference feature is incredibly easy to use. You don't have to hang up, call out, or do anything special. Whenever you push the conference button, your two lines are connected.

Look what you can do. While you are talking on one line, you might want to add a third person to your conversation.

You can put whichever line you are using on hold, and use the other line to call out. Then just push Conference and both calls will be joined.

If you are talking on the phone and your other phone rings, you can either put the first call on hold, or simply push Conference and you'll both answer the second call.

And finally, if you are in a tone area and you're talking on the phone, you don't even have to put your first call on hold if you want to call out.



Just push Conference, listen for the dial tone, and dial your number. It's easy, it's fast, and group conversations can be really productive for work and fun with friends and family.

EVERYTHING YOU'D EXPECT

And, you'll love the feel of this phone. It's the perfect combination of familiar Phone Company fit and feel with the addition of super electronic convenience features.

You'll be able to laugh at local power failures because it is line powered and requires no AC. Plus, its LEDs are powered by 2 9V batteries (included). It's made by TeleConcepts and backed by their standard limited warranty.

TWO LINES--TWO CHOICES

All the convenience features described

above are available in your choice of the standard desk model or the super elegant Thinfone™. Every convenience feature of these ivory beauties is identical.

But, the Thinfone™ has some extras. At night you'll really appreciate the soft green illumination of its buttons. Wow, you can dial in total darkness.

The Thinfone™ may be desk or wall mounted. And finally, it has a Hook Switch (hang up button) on the handset.

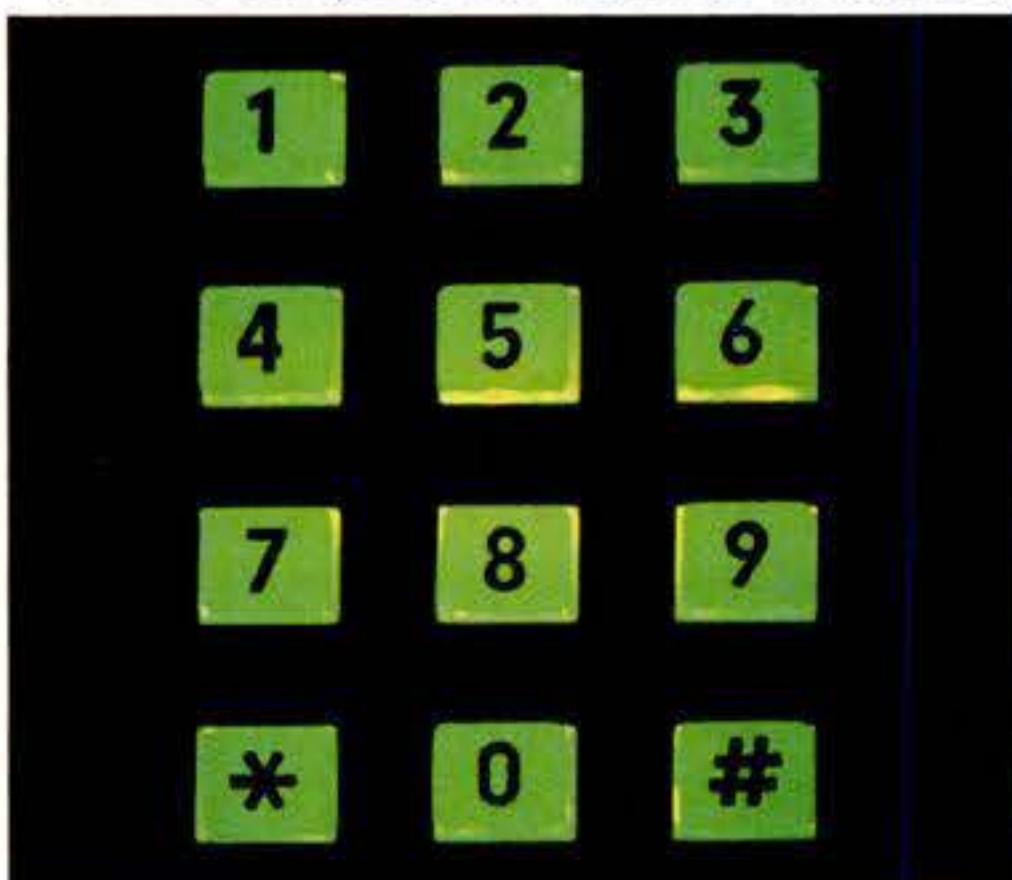
A TWO LINE WONDER RISK FREE

Call your friends. Feel and hear the quality of this phone for yourself. Then try out the conference feature.

If you're not 100% satisfied, simply return the phone to DAK within 30 days in its original box for a courteous refund.

To order your TeleConcepts Two-Line Phone with Hold, Conference and Tone/Pulse Switching risk free with your credit card, call toll free or send your check, not for the up to \$129 we have seen the Thinfone™ selling for.

Send just \$59 for the Desk Model (\$4 P&H) Order No. 9848. Or just \$69 (\$4 P&H) for the Thinfone™. Order No. 9849.



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INDUSTRIES INCORPORATED

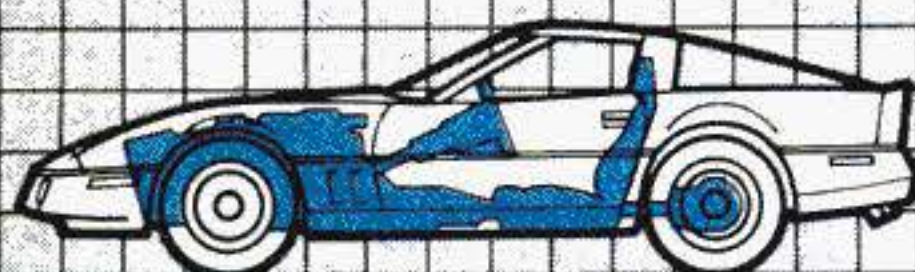
11015

TOLL-FREE ORDER LINE

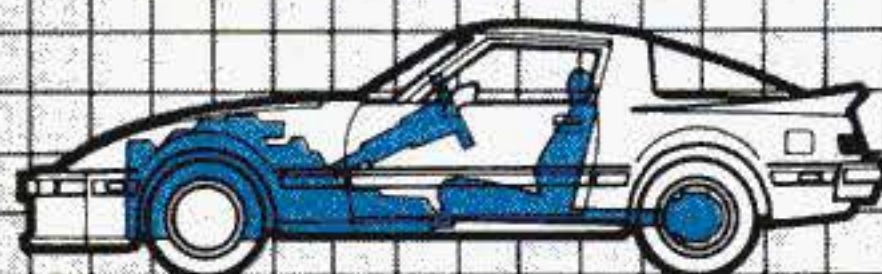
For credit card orders call 24 hours a day 7 days a week
CALL TOLL-FREE. . . 1-800-325-0800
10845 Vanowen St., N. Hollywood CA 91605

Sports-car showdown

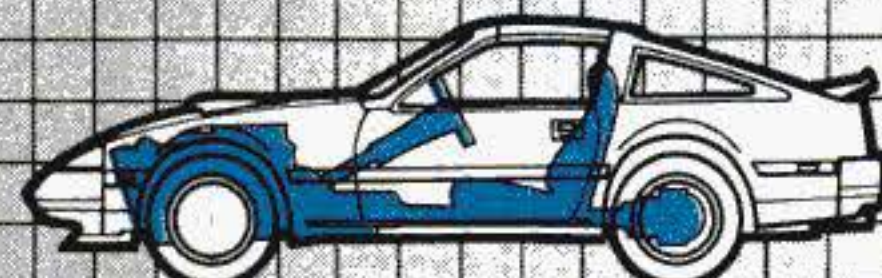
CHEVROLET CORVETTE



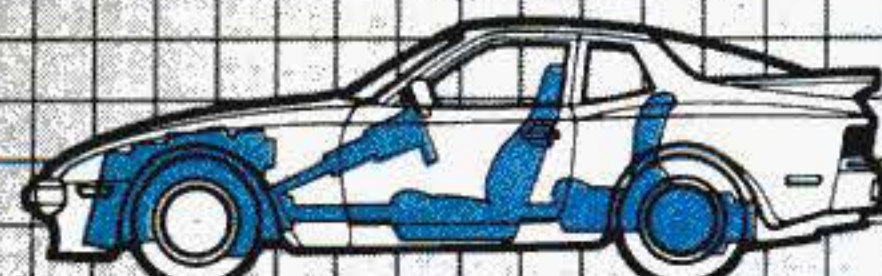
MAZDA RX-7



NISSAN 300ZX TURBO



PORSCHE 944



ILLUSTRATIONS BY RUSSELL VON SAUERS

PS serviceability ratings

How easy is it to service these cars? To give you an approximation of how difficult it is for a typical person to perform various service operations, we examine each test vehicle. The numbers mean: 1, very difficult; 2, difficult; 3, average degree of difficulty; 4, easy; 5, very easy.

	Chevrolet Corvette	Mazda RX-7	Nissan 300ZX turbo	Porsche 944
Checking fluid levels				
Battery	5	5	5	5
Master cylinder	5	5	5	5
Windshield washer	5	5	5	5
Engine oil	5	3	3	5
Coolant	5	5	3	5
Checking the engine				
Spark plugs	3	3	2	5
Distributor	3	5	4	5
Carb adjustment	F.I.	F.I.	F.I.	F.I.
Oil filter	3	4	4	5
Oil fill	3	3	4	5
Replacing hoses				
Upper radiator hose	2	5	3	2
Lower radiator hose	4	4	2	3
Heater hoses	2	3	2	2
Changing bulbs				
Headlights	5	3	3	3
Taillights	3	3	3	4
Front running lights	5	3	3	3
Front parking lights	5	3	3	3
Front directionals	5	3	3	3
Rear directionals	5	3	3	4
Rear running lights	n.a.	3	3	4
Checking fuses				
Spare-tire accessibility	2	3	3	3
Changing belts	5	4	2	3

Test results, dimensions, and specs

	Chevrolet Corvette	Mazda RX-7	Nissan 300ZX turbo	Porsche 944
TEST RESULTS				
Acceleration (sec.) 0-60 mph....	6.9	8.6	8.9	9.6
Brake test (cool) 60-0 mph				
Stopping distance (ft.).....	141	158	135	146
Pedal pressure (lbs.).....	60	120	50	90
Brake test (hot) 60-0 mph				
Stopping distance (ft.).....	145	148	170	153
Pedal pressure (lbs.).....	40	124	120	86
Interior noise @ 60 mph (dBA) ..	75	72	74	72
Handling test (mph)	65.5	60.7	65.0	64.7
Maneuverability test (mph).....	29.1	29.2	29.6	30.3

EPA FUEL MILEAGE (mpg)				
Highway	28	29	30	35
City	16	19	20	22
Calif. city	16	19	20	21

PS FUEL-MILEAGE TESTS (steady-state mpg)				
35 mph	26.8	30.7	33.8	—
55 mph	23.7	25.3	29.9	—

NOTE: POPULAR SCIENCE fuel-economy results are derived by driving the test vehicle over a flat, measured mile at sea level. Fuel consumption is measured using Pierburg PLU-116 liquid flowmeters with an accuracy of plus or minus 1.0 percent of actual flow rate. To eliminate the effects of wind, we average consumption after two north and two south runs.

TEST CONDITIONS Ambient temperature, 80°F; relative humidity, 70 percent; barometric pressure, 30.0 inches Hg

DIMENSIONS (inches)				
Wheelbase	96.2	95.3	91.3	94.5
Overall length.....	176.5	169.0	170.7	170.0
Overall height.....	46.7	49.6	51.0	50.2
Overall width	71.0	66.0	67.9	68.3
Track, F/R	59.6/60.4	55.9/55.1	55.7/56.5	58.2/57.1
Ground clearance	5.0	5.7	5.9	4.9
Front head room	36.4	37.2	34.0	37.0
Front hip room.....	49.3	40.0	40.0	42.0
Front leg room	42.6	41.5	46.5	47.0
Rear head room.....	—	—	—	32.0
Rear hip room	—	—	—	32.0
Rear leg room (min.).....	—	—	—	14.0
Rear knee room (min.)	—	—	—	-4.0
Couple distance.....	—	—	—	22.0

SPECIFICATIONS				
Engine type	V8	Rotary 2	V6	In-line 4
Displacement (cu. in./L).....	350.0/5.7	80/1.3	180.6/3.0	151.0/2.5
Compression ratio	9.0:1	9.4:1	7.8:1	9.5:1
Carburetion	F.I.	F.I.	F.I.	F.I.
Net hp @ rpm	205 @ 4,200	135 @ 6,000	200 @ 5,200	143 @ 5,500
Net torque (ft.-lbs.) @ rpm.....	290 @ 2,800	133 @ 2,750	227 @ 3,600	137 @ 3,000
Transmission	4-speed manual	5-speed manual	5-speed manual	5-speed manual
Axle ratio	3.310:1	4.076:1	3.545:1	3.890:1
Tire make	Goodyear	B. F. Goodrich	Goodyear	Dunlop
Tire type	Eagle VR 50 radial	Radial TA 60H	Eagle GT radial	SP Sport
Tire size	225/50VR16	215/60HR14	215/60R15	Super D4 radial
Steering	Rack and pinion	Rack and pinion	Rack and pinion	205/60VR15
Overall steering ratio	13.0:1	17.0-20.0:1	17.0:1	Rack and pinion
Turns, lock to lock.....	1.96	3.40	2.80	22.4:1
Turn diameter (ft.).....	40.1	31.5	32.2	31.2
Front suspension.....	Independent, single lower arm, fiberglass-plastic transverse leaf springs	Independent, strut-type, coil springs	Independent, MacPherson struts, coil springs	Independent, MacPherson struts, coil springs
Rear suspension	Independent, five-link type, mono-leaf plastic springs	Watt linkage, four-link type, coil springs	Independent, trailing arms, coil springs	Independent, diag. arms, transverse torsion bars
Front stabilizer-bar diameter (in.).....	1.0	0.91	0.87	0.85
Rear stabilizer-bar diameter (in.).....	0.79	0.59	0.86	0.55
Brakes	Disc-disc	Disc-disc	Disc-disc	Disc-disc
Brake swept area (sq. in.)	329.9	296.0	n.a.	n.a.
Fuel tank (gal.)	20.0	16.6	19.0	16.4
Trunk space (cu. ft.)	17.90	13.80	15.25	24.0*
Liftover height (in.)	35.7	33.0	32.6	37.0
Curb weight (lbs.)	3,117	2,380	3,029	2,778
F/R weight distribution (%)	51/49	52/48	51/49	49/51
Basic price.....	\$23,346	\$15,295	\$18,669	\$21,440
Price as tested.....	\$25,944 ¹	\$16,843 ²	\$21,399 ³	\$24,035 ⁴

Major options (over \$100): ¹ Electronic radio \$153, engine-oil cooler \$158, power door locks \$170, speed control \$185, Bilstein shock absorbers \$189, six-way power seats \$215, leather seats \$400, transparent roof \$595, ² air dam \$199, spoiler \$199, rollbar \$210, radial tires \$432, Momo wheels \$450; ³ delivery \$195, T-bar roof \$800, leather-digital package \$1,900; ⁴ side moldings \$155, alarm \$200, rear-window wiper \$240, sport seats \$250, cruise control \$295, AM-FM stereo \$600, forged-alloy wheels \$725, stabilizer bar \$1,300

*With rear seat folded

Phone Company's Revenge

Gone are the cheap one-piece phones. But, memory dialing, tone/pulse switching, speaker-phones and comfortable phone company design handsets are the legacy of the fight.

It was a battle. Last year, with millions of cheap one-piece phones around, the Phone Company was under siege.

But revenge is sweet. Because, as fast as they appeared, most of the cheap manufacturers have gone.

One-piece phones that didn't feel like our familiar American phones are gone. And, millions of Americans have simply kept renting their old phones.

So, the Phone Company's revenge is complete. Its great feeling handsets, reliability and America's complacency, have won the Phone Company a major round.

But, with 70 million American homes at stake, you can bet that the real war is just beginning. So, while the Phone Company relaxes after the battle, a second wave of 'smart phones' is arriving.

INDEPENDENT'S REVENGE

Everyone's learned a lot. The Phone Company is offering features and the Independents have gotten the license of a regular Phone Company handset.

But, this time the Independents are way ahead. Now you can have a standard phone with a standard feeling handset just like you've had for years.

Plus, look at this. You can have 10 memory dialing, tone/pulse switching and you'll even get a great sounding speakerphone, all for just \$59.

LOADED

Imagine the convenience of having a phone that dials for you in either Tone or Pulse at the touch of a switch. It will remember and dial any 10 numbers, including last number redial.

And, best of all, you can dial your numbers without ever lifting the receiver. Just push the hands free button and you'll be using your all new, super clear, totally automatic speakerphone.

If you do decide to lift the receiver, you'll find it cradles right on your shoulder just like a Phone Company phone.

So, using this phone is like finding an old friend who's been educated since the last time you saw one another.

PERFECT MARRIAGE

The real claim to fame of this phone is its marriage of Phone Company fit and feel with super convenience features.

Imagine walking around the room, taking notes or even washing the dishes while you talk on the phone.

And, with a speakerphone, anyone else in the room can join in too. You'll be heard loud and clear whether you are nearby or across the room, because this phone has a built-in condenser mike.

This speakerphone uses a new lightning fast auto-simplex design. It's one of the reasons that it sounds so good. You see, instead of talking and listening at the same time and sometimes getting feedback and hollow sound, this phone only does one at a time.

But, don't be misled. You won't even know it's happening. The computer brain in this speakerphone switches back and forth automatically with such lightning



speed, it took us about 10 minutes of conversation to be sure.

Of course, there are no push-to-talk buttons. Everything is automatic. And, you're in full control. You'll have a full range volume control, and you can switch to the comfortable handset at any time.

The handset has its own condenser microphone and a headphone quality speaker in the earpiece to let you hear and be heard with astonishing clarity.

THERE'S MORE

You'll love dialing with this phone. There are no cheap flat buttons. You'll have sculptured keys that fit your finger and feel solid. But, the best part of this phone is not dialing at all.

You'll have a super fast 10 number automatic dialer that works with both the handset and the speakerphone.

Dialing with the speakerphone is really nice because you don't have to lift the receiver unless you reach the person you want to talk to.



Each number you store may have up to 16 digits and you can switch from Pulse to Tone at any time. So, if you live in a Pulse area and want to use Sprint or MCI, just dial your local access code in Pulse, then switch to Tone.

Don't worry about this memory dialer forgetting. When you put in 3 standard AA batteries, all your memory is protected. And, because this phone is totally telephone line powered, it doesn't require an AC plug. So, local power failures won't affect your ability to use your phone.

THE FINAL FACTS

This phone is loaded with all the latest phone features. Its electronic ringer has high, low and 'off for privacy' settings.

Both its handset and phone line cords are disconnecting modular cords. So, just plug it in and start talking.

The phone is slanted toward you for ease of use. A stand flips out to give you a comfortable dialing angle for desk or counter use.

The phone also mounts easily on the wall with two screws. There's a mute button for privacy and LED indicators show various operations.

It's made by Unitech, the large personal stereo and telephone manufacturer. You can be sure that the circuitry and sound quality are state of the art. It's backed by their limited warranty.

UNITECH'S REVENGE RISK FREE

Wait till you hear the sound. Wait till you feel the handset against your ear or cradled on your shoulder. Talk on the speakerphone and use the automatic dialer risk free.

If you're not 100% satisfied, simply return the phone in its original box within 30 days for a courteous refund.

To order your Unitech Automatic Dialing SpeakerPhone risk free with your credit card, call toll free or send your check for DAK's incredible breakthrough price of just \$59 plus \$3.50 for postage and handling. Use Order Number 9801. CA res add Sales Tax.

Well, the Phone Company has had its revenge against the cheap one-piece manufacturers. But, with the marriage of fit, feel and technology, the real winner is going to be you, the phone user.



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When a car needs a tune-up, the symptoms are much like those of a dirty fuel system: Hard to start, rough running, stalling, loss of power.

But before you spend a small fortune on a tune-up, try Gumout Carburetor and Fuel Injector Cleaner. Pour Gumout in the gas tank. It's easy to do,

inexpensive too. Gumout works as you drive. And Gumout aerosol Jet Spray cleans outside the carburetor.

Gumout Liquid and Jet Spray— together they help engines run smooth. Help save gas, too. So when your car starts acting like it needs a tune-up, try Gumout first. It might just save you a bundle.

THE BETWEEN TUNEUPS TUNEUP.

Gumout is a division of the Pennzoil Company.

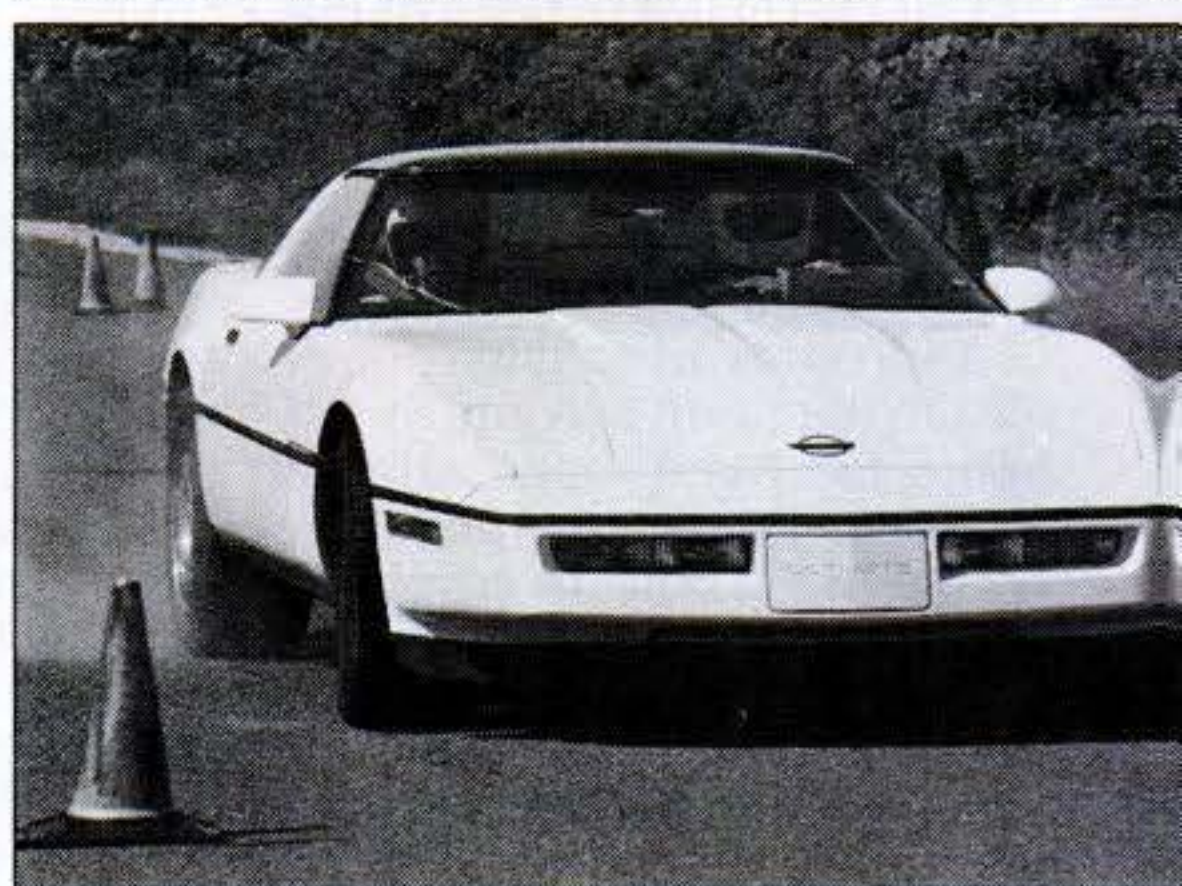
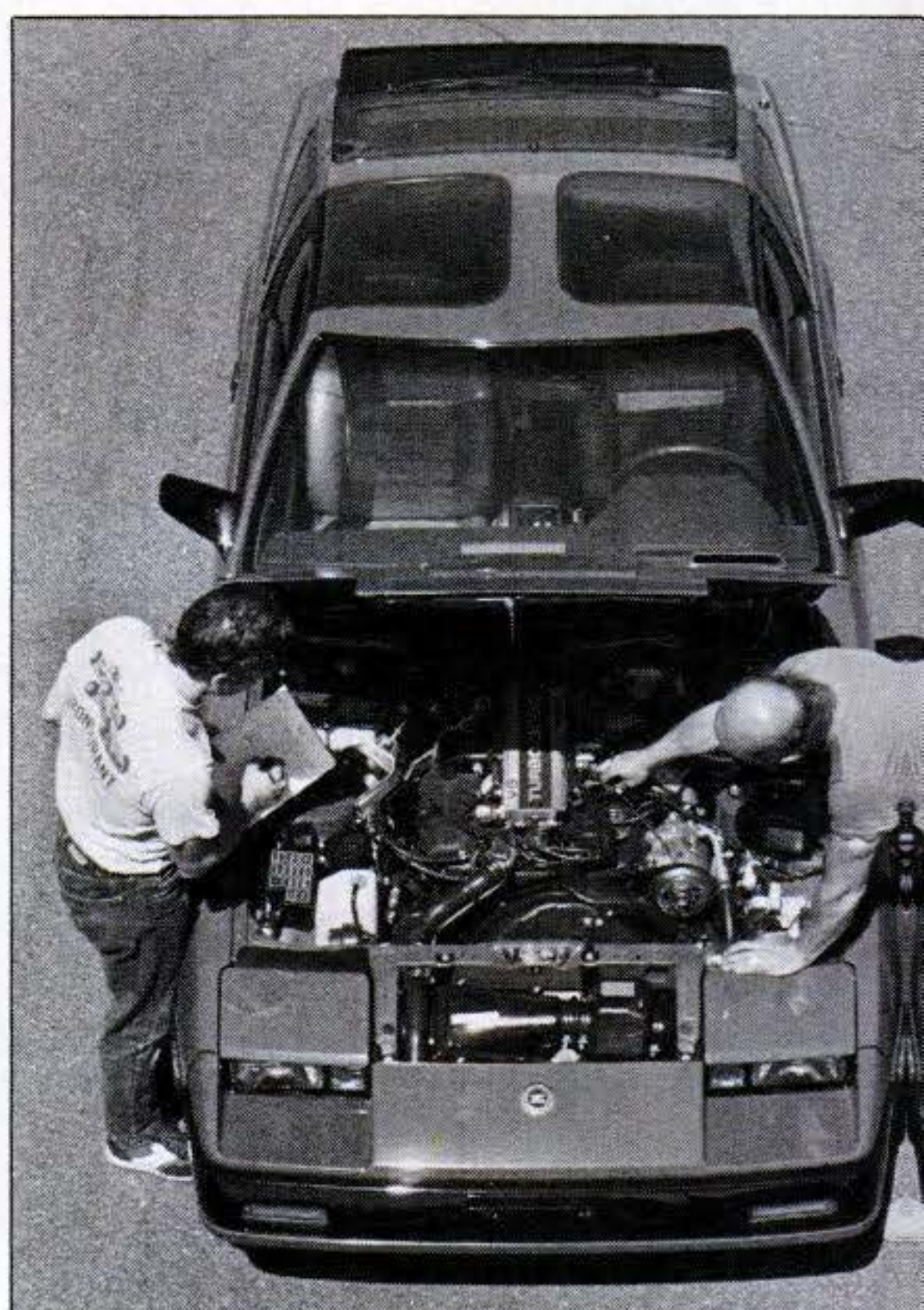


Sports-car showdown

wants optimum control over the engine's power delivery. In addition, some of the more unusual special features include unidirectional tires on the Corvette, twin counterrotating balance shafts in the Porsche's four-cylinder engine, an electrically adjustable suspension system in the 300ZX turbo, and a fuel-injection-equipped rotary engine in the RX-7.

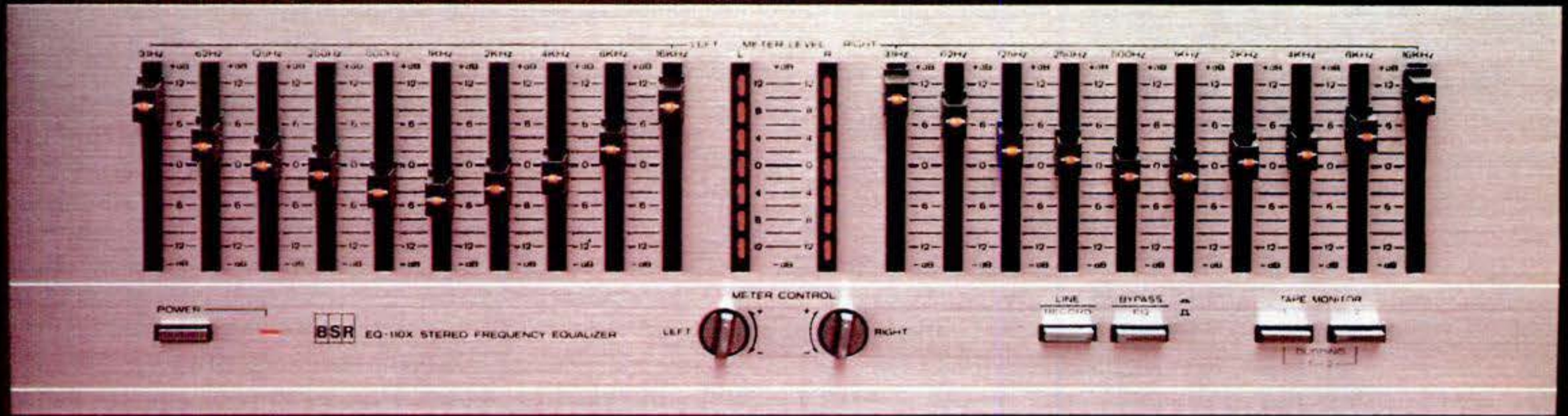
Line up the engines in this high-output bunch, and you find an amazing diversity of approaches to top performance. Corvette has the oldest and most familiar engine. It's a proven 350-cu.-in. small-block V8 with dual-throttle-body fuel injection. The 350 is teamed with a four-speed manual transmission with overdrive. This combination grabbed top honors in the zero-to-60-mph acceleration tests. In fact it's the fastest production car we've

Continued



Tom Marriott (top photo, right), fuel-economy technician, points out multi-point fuel-injection system on 300ZX to Keebler. Corvette (above) posted shortest hot-stop distance for the four vehicles despite its 3,117-lb. weight.

\$89 CLOSE-OUT



Sound Detonator Plus

Make your stereo system's sound explode with life. Improve the sound quality by 30 to 50%. Plus, you'll add tape dubbing too with this limited BSR \$89 close-out.

It's like night and day. Crashing cymbals, the depth of a string bass, more trumpets or more voice will come bursting forth from your stereo at your command.

You'll make your music so vibrant that it will virtually knock your socks off when you use this professional quality 10 band stereo Sound Detonator Plus Equalizer.

It has a frequency response from 5hz to 100,000hz \pm 1 db. BSR, the ADC equalizer people, make this super equalizer and back it with a 2 year limited warranty. Our \$89 close-out price is just a fraction of its true \$249 retail value.

CAN YOUR STEREO SOUND BETTER?

Incredibly better. Equalizers are different from regular bass and treble controls. And, 10 band EQs are the best.

Bass controls turn up the entire low end as well as the low mid-range, making the sound muddy and heavy. With an equalizer, you simply pick the exact frequencies you want to enhance.

You can boost the low-bass at 31 hz, 62hz and/or 125hz, and the mid-bass at 250hz and 500hz to animate specific areas of the musical spectrum.

And, when you boost the part of the bass you like, you don't disturb the mid-range frequencies and make your favorite singer sound like he has a sore throat.

The high frequencies really determine the clarity and brilliance of your music.

You can boost the mid-range and highs at 1,000hz, 2,000hz, 4,000hz, 8,000hz and 16,000hz. So, you can bring crashing cymbals to life at 16,000hz while at the same time you cut tape hiss or annoying record scratches at 8000hz.

You can also boost or cut specific mid-range frequency areas to add or subtract vocal, trumpets, guitars or whatever instrument ranges you prefer.

GREAT FOR 2 TAPE DECKS

You can push a button and transfer all the equalization power to the inputs of two tape decks. So, if you have a cassette deck in your car or a personal stereo that you wear, now you can pre-equalize your cassettes as you record them.

Now you can get all the dramatically enhanced sound wherever you are. This

is an especially great feature for bass starved portables and high-end starved car stereos to make them come alive.



And, look at this. There are two tape inputs and outputs, so you can dub from tape deck A to B, or make two tapes at once with or without equalization.

EASY HOOK UP

Use your tape monitor circuit, but don't lose it. Now your one tape monitor circuit lets you connect two tape decks.

Just plug the equalizer into the tape 'in' and 'out' jacks on your receiver. We even supply the cables.

As you listen to your records, FM or 'aux', any time you push the tape monitor switch on your receiver you'll hear your music jump to life.

The output from your receiver is always fed directly to your tape decks for recording, and with the touch of a button, you can choose to send equalized or non-equalized signal to your recorders.

When you want to listen to a tape deck, just press a tape monitor button on the equalizer and your tape deck will work exactly as it did before. Except, that now you can choose to listen with or without equalization and you can dub.

You won't be listening to any distortion or hum. The Sound Detonator Plus has a 95db signal to noise ratio and total harmonic distortion of just 0.018%

Once you've set your equalizer controls, switch it in and out of the system. You'll hear such an explosive improvement in sound, you'll think you've added thousands of dollars of new equipment.

WHY A CLOSE-OUT?

Last year DAK closed out over 18,000 of BSR's 7 band equalizers because BSR had decided to only sell equalizers under their ADC name and they still had some left with the BSR name on them.

Well, as Detroit comes out with new cars each year, ADC comes out with new equalizers. We got them to supply us

with just 15,000 of last year's model before they shut down for the new one.

They had already paid for all the tooling, all the research and design, so we were able to buy these for less than half the normal price, for cold hard cash.

So, you can go to any HiFi store and buy this year's design in an ADC equalizer made by the parent company BSR, or you can get this \$249 value BSR equalizer while our limited supply lasts, for \$89.

THE FINAL FACTS

There are 20 slide controls, each with a bright LED to clearly show its position. Each control will add or subtract up to 12db. (That's a 24db range!)

There are separate sound detonation slide controls for each channel at 31 hz, 62hz, 125hz, 250hz, 500hz, 1,000hz, 2000hz, 4000hz, 8000hz, and 16,000hz.

LED VU meters with \pm 0.5db accuracy show levels for each channel. It is 17" wide, 6½" deep and 4½" tall.

PUT LIFE INTO YOUR MUSIC RISK FREE

Prepare for a shock the first time you switch in this equalizer. Instruments you never heard in your music will emerge and bring a lifelike sound that will envelop you and revolutionize your stereo system.

If your system doesn't spring to life, simply return the equalizer within 30 days in its original box for a refund.

To order your Sound Detonator Plus Tape Dubbing BSR 110X 10 Band Stereo Frequency Equalizer risk free with your credit card, call toll free or send your check not for ADC's \$249 value, but for only \$89 plus \$7 for postage and handling. Order No. 9724. CA res add 6% tax.

Wake up the sound in your stereo. Your sound will explode with life as you detonate each frequency band with new musical life. And now you'll be in control of two tape decks as an added plus.

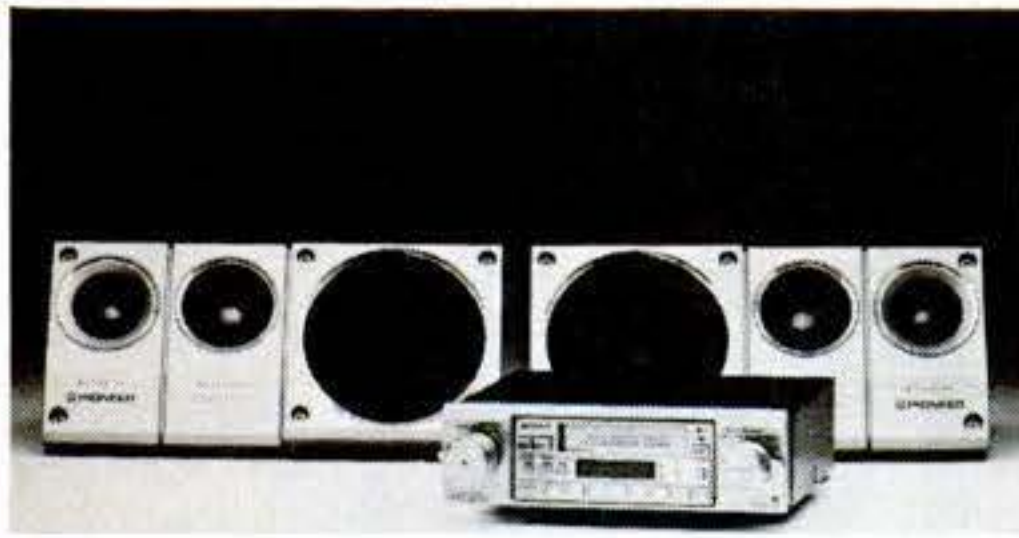


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Sports-car showdown

tested in more than a decade, with an average of 6.9 seconds. That's with an observer and our test equipment aboard. (Unofficial tests with only a driver netted a sub-six-second time.) The V8's behavior at low speeds and idle was smooth and quiet except for the snarl from the large-diameter, low-restriction exhaust. As might be expected the Corvette's fuel economy was the poorest in the group, averaging about 20 mpg.

Mazda leaves no doubt about its commitment to the rotary engine. The latest version has 34 more horsepower than its predecessor, thanks to fuel injection and a tuned intake manifold. Total output is now 135 horses. This test model finished second in our acceleration runs with an average of 8.6 seconds. That's the best we've ever recorded for the RX-7. A few rough edges that remain are the deceleration pop in the exhaust and a momentary shake as engine speed nears idle after revving to high rpm levels.

Nissan's V6 turbo engine is new this year. It replaces the venerable in-line six of the earlier Z models. Though the new engine is no smoother than the in-line six, it's more powerful by 20 horsepower in the turbo version. Less-obvious benefits of the new engine are the eight-inch-shorter block and 15-percent-lighter weight. Zero-

to-60 time for the new car is a fairly impressive 8.9 seconds. That puts the 300ZX behind the Corvette and RX-7 but well ahead of the 944. We might have recorded faster times on the 300ZX, but high ambient temperatures during our noontime acceleration runs (the temperature was 80 degrees F) seemed to have a power-sapping effect on the turbocharged engine. One of the best things about the three-liter (180.6-cu.-in.) power plant is the lack of attention it draws. It's quiet, smooth, and does not over-rev during all-out acceleration or when downshifted for power.

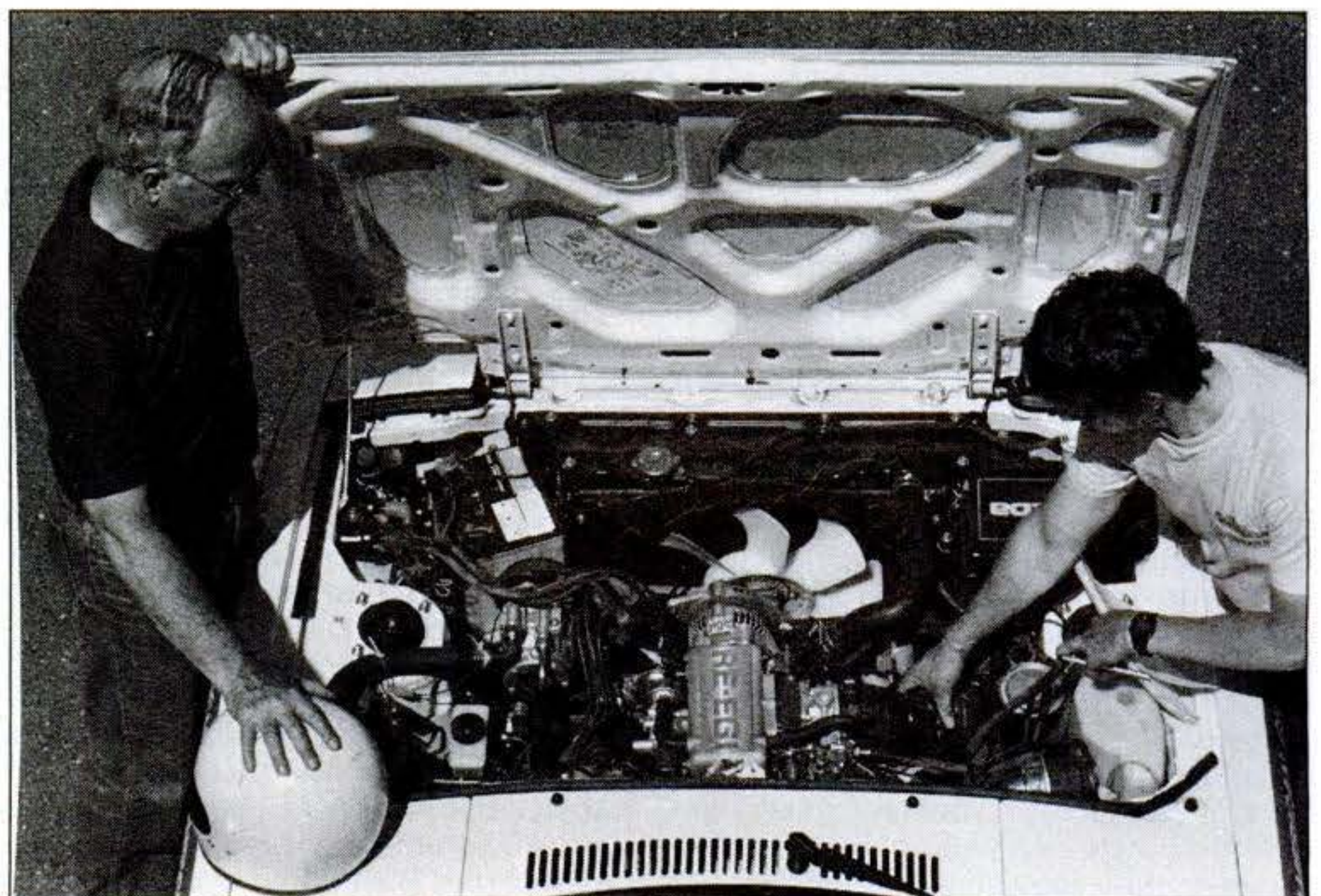
Finally there's the 2.5-liter (151-cu.-in.) Porsche four-cylinder. It's an engine that's convinced us that smooth, vibration-free running is not exclusive to large-displacement reciprocating engines. The trick: Mitsubishi-designed counterrotating balance shafts buried in the block. They spin at twice the speed of the engine to cancel out the vertical and horizontal vibrations present in all four-cylinder engines but more noticeable in big fours.

Stoplight blastoffs are not part of the 944's bag of tricks, however. This drive train is set up for European-style driving. And that means that the engine actually gets up to the higher output range of its power curve best in second and third gear. We also noted

Continued

Performance comparison with selected models

	Mpg (city driving)	Acceleration 0-60 mph (sec.)	Brakes 60-0 mph (hot) (ft.)	Handling (mph)	Maneuverability (mph)	Noise @ 60 mph (dBA)
1984 Chevrolet Corvette V8	16	8.4	157	65.4	27.6	73
1983 Porsche 944 in-line 4	23	9.8	167	66.0	28.0	72
1983 Datsun 280ZX turbo in-line 6	19	8.6	174	64.0	27.6	72



Dunne (left) and Keebler examine the RX-7's engine. Initially the car would

not accelerate cleanly to 60 mph. Keebler checks suspicious air-intake hose.

Thunder Lizard Mistake Plus

Earlier this year we offered a 15" BSR speaker system with the wrong tweeter at a close-out price. Now, here's a super improved version of the same speaker for the exact same close-out price.

It was a mistake. Somebody goofed and put the wrong tweeter in 3500 of BSR's best 15" 3-way speaker systems.

THUNDER LIZARDS

BSR's salesman referred to the speakers as Thunder Lizards because the 15" acoustic suspension bass driver is so powerfully dramatic that it can literally recreate the power of an earthquake or explosion in your living room.

Unfortunately, without the brilliant and powerful exponential horn tweeter, the bass simply overwhelmed the highs and so the name Thunder Lizard was born.

But, DAK came to the rescue. We not only bought all 3500 of the speakers, we bought the exponential horn tweeters that BSR had left out and let our customers install the correct tweeter themselves. The highs and lows this system created were nothing short of awesome.

BUT, THERE'S A PROBLEM

We thought we'd have enough speakers for the rest of the year, but we sold over 3300 in just our Spring Catalogs. So, we went back to BSR and tried to buy more of the speakers. But, they only sold us the first batch at a close-out price because they had put in the wrong tweeters and didn't know what to do with them.

BSR said that luckily they didn't make mistakes very often and the only other 'problem' they had was an inventory of 6000 too many super tweak 8" midrange drivers with an exotic polypropylene cone they used for an expensive BSR tower system.

LOOK NO FURTHER

Well, to make a long story short, we got BSR to replace the plain paper 5" midrange in the Thunder Lizard Mistake with the new exotic 8" polypropylene midrange driver. And, they put the correct tweeter in for us too.

So, for exactly the same close-out price, we have 6000 speaker systems that produce a kaleidoscopic panorama of sound that is nothing sort of incredible. You're in for an earthshaking, bone jarring musical experience.

The exponential horn tweeter gives you startling dramatic highs to 20Khz. You won't just hear cymbal crashes, you will experience them. The highs are simply brilliant. Plus, a brilliance control lets you decide just how powerful you want the highs to be.

The bass, all the way down to 20hz is reproduced with thundering accuracy by



the pride of the BSR line, a 15" acoustic suspension bass driver. The lows seem to have life of their own.

You'll hear string basses emerge that you never knew were in your recordings. Just a bass drum is an experience.

And finally, the midrange from 1000hz to 4000hz is flawlessly reproduced by the newest development in high-tech speakers. Instead of using paper, polypropylene is used.

Its characteristics give incredible purity to the entire midrange. It's much more accurate than a paper midrange.

And, it's a perfect match for the dramatic thundering bass and startling highs these speaker systems produce. There's a presence control that lets you adjust the midrange level to suit your taste.

GREAT LOOKS AND GREAT SOUND

The beautifully crafted wood-grain appearance cabinet is 29" tall, 18" wide and 10½" deep. It comes with a beautiful removable real cloth speaker grill.

BSR backs this system with a 2 year limited warranty, and speaking of protection, the tweeter is fuse protected. The system can handle 180 watts peak, 90 watts continuous and requires 15 watts.

NEVER AGAIN?

BSR says that this is it. When these 6000 speakers are gone, there'll be no more. They say they have no more mistakes and no more extra speakers.

Well, we're delighted they make mistakes. And, we know once you've heard these 15" three-way speaker systems you'll be delighted too.

**'THUNDER LIZARDS NO MORE'
RISK FREE**

Soft listening will give you a fullness and realism of sound not possible with conventional 10" and 12" speaker systems.

And, wait till you (and your neighbors) hear the thundering realism of high volume listening with these incredibly pure audiophile speaker systems.

Normally, only the most sophisticated audiophile can afford the ultimate, a 15" 3-way system. But now, due to BSR's errors, anyone can experience the incredible realism of a truly great speaker.

If for any reason you're not 100% overwhelmed by these speaker systems, simply return them to DAK in their original boxes within 30 days for a refund.

To order your BSR top of the line 15" 3-way loudspeaker system with the exponential horn tweeter and the new 8" polypropylene midrange already installed by BSR risk free with your credit card, call toll free, or send a check not for the suggested retail price of \$199 for the system with the 5" midrange but for only \$119 each plus \$12.50 each for postage and handling. Order Number 9717. CA res add 6% sales tax.

Now, without even having to install your own tweeter, you'll experience dramatic earthshaking musical sound that's so startlingly alive, it'll send shivers through your body for years to come.



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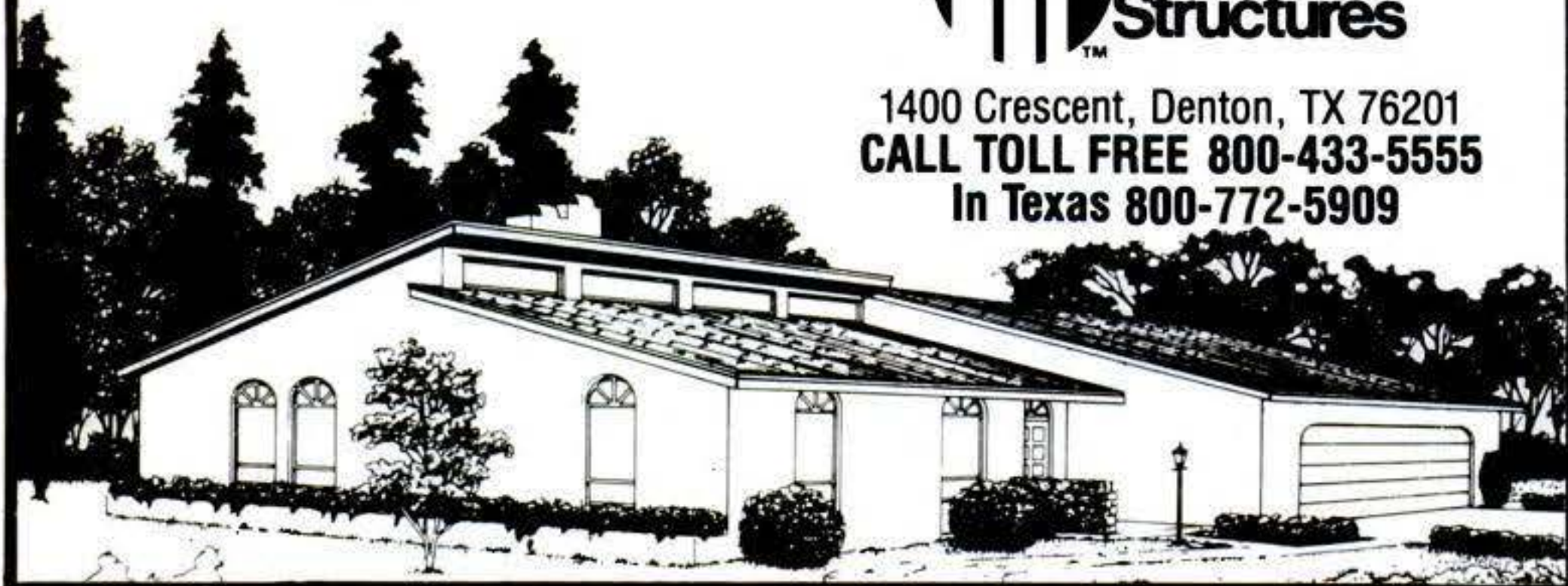
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Sports-car showdown

that the Porsche gearing is set up to require a third shift before the car reaches 60 mph. The other cars were able to hit 60 in second gear. Making the third shift probably compromised the zero-to-60 time in the 944 (9.6 seconds).

It's interesting to note that all four of these cars are rear-drives. It's a design decision that does not make them outmoded despite the general switch in passenger vehicles to front drive. Clearly, the advantages in high-speed steering control and traction that rear drive offers are more important to the sports driver than the loss in interior volume and slight weight gain. We felt that the particular demands of high-speed driving fully justify the use of a rear-drive chassis, though front-drives of modern design are not greatly handicapped.

Here's how the cars looked in detail:

Chevrolet Corvette

If there's a prizewinning category for worst-riding car of the year, the Corvette equipped with the Z51 suspension system would be the hands-down winner. Chevy explains that this is as close to a full-race suspension as it will put on a passenger car. The hard ride, so crucial to good track performance, is the penalty that must be paid this year. Chevy engineers promise to soften the ride next year to make the car more civilized for street driving.

The Corvette's instrument-panel layout gives two different impressions. At night, engine information from at least 10 sources splashes itself dramatically across the panel. But in bright sunlight the plastic dash looks lightweight, and those same electronically generated numbers and graphs are tough to read.

Though Corvette is the lowest car
Continued

PS ratings— test report in a nutshell

The ratings are based on test results and measurements. Results should be read with the understanding that they reflect tests only on our sample cars. An excellent rating is 5 points; very good, 4; good, 3; fair, 2; poor, 1; very poor, 0.

	Chevrolet Corvette	Mazda RX-7	Nissan 300ZX turbo	Porsche 944
Acceleration	5	5	5	5
Braking	4	3	4	4
Handling	5	3	5	4
Maneuverability	5	5	5	5
Quietness	0	1	1	0
Roominess	0**	0**	0**	0
Vision	3	5	4	5
Entry/exit ease	0	0	0	0
EPA economy	2	3	3	4
Ride comfort*	0	2	3	1

*Authors' opinion

**No rear seat

\$49.50 BREAKTHROUGH!

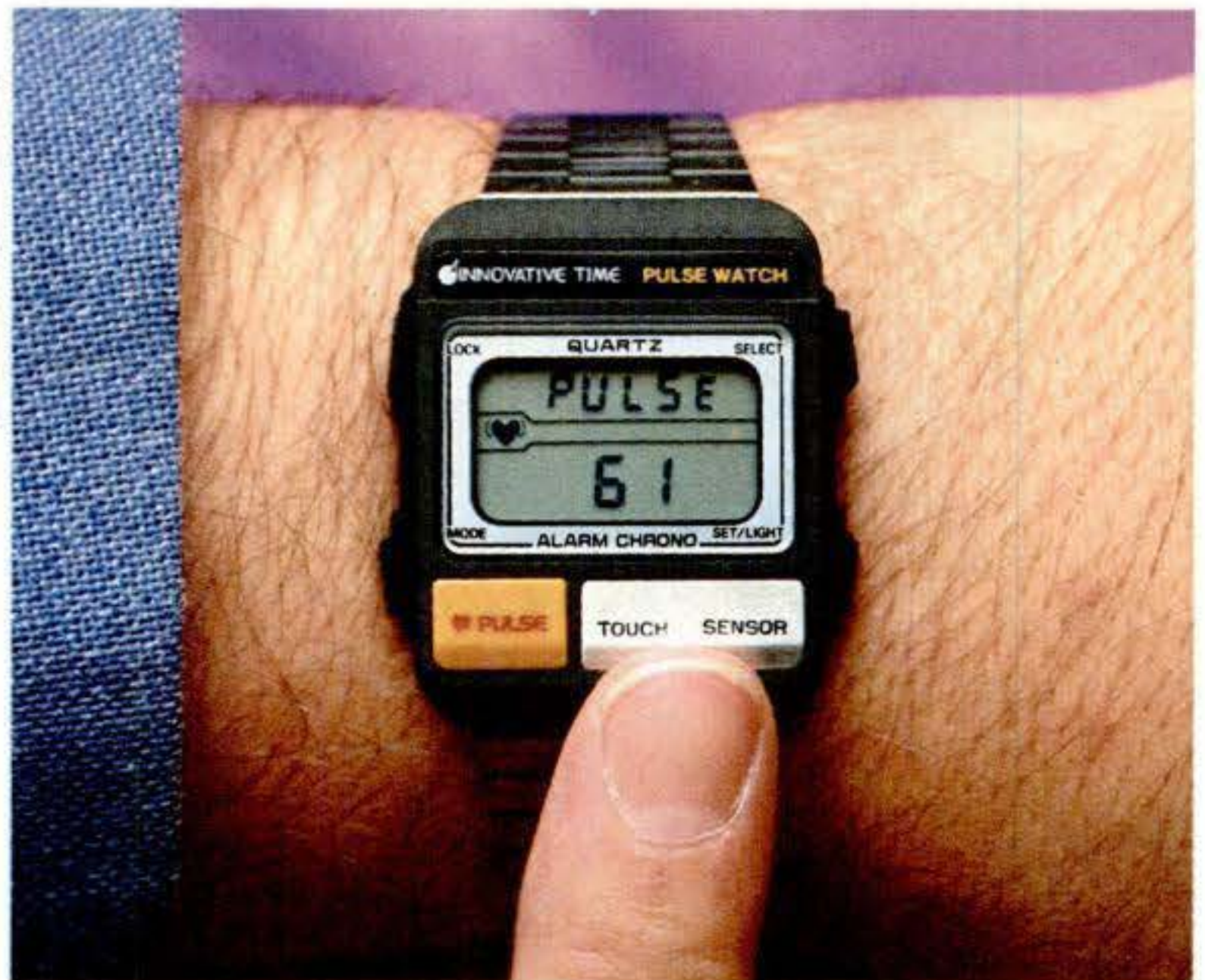


When you are at rest, so is your heart. A low resting heart rate usually means you're in good condition. Have you checked yours?



When you exercise, you should reach your heart's target zone. But, have I reached my exercise target zone, or just had too much coffee?

Heart Window



Now you can exercise, rest, swim or go out to dinner wearing the latest in computer pulse takers on your wrist. Plus, it's a talented sports watch and a formal dress watch too.

By Drew Kaplan

It's a fact. You can tell a lot about yourself from your heart rate. You can evaluate the condition you are in, how much stress you are under, and how hard you should be exercising.

Think about it. How fast does your heart beat when you climb a flight of stairs? And how long does it take for your heart rate to return to normal?

Well, if you're at all like me, you may be a little out of shape. While I'm only 37, several friends of my own age have recently had heart attacks. And frankly, I'm getting just a bit worried.

You see, I am getting past the point where I can simply say, "I'll get back into shape next year."

So, whether you're a long distance runner (this is the ultimate jogging companion), or just a few pounds overweight like I am, your heart rate will give you a picture of your heart and body's condition.

Now you can take your heart rate anytime, anywhere with the newest in sophisticated electronic pulse takers.

And best of all, this heart computer is contained in a beautiful 24 hour alarm, 24 hour chronograph, LCD watch, that you will be as proud to wear with a coat and tie as you are when you're running.



YOUR HEART'S TARGET ZONE

Your heart, just like any other muscle in your body, requires exercise. Unfortunately, unlike your arms, you can't see your heart's condition just by looking.

The type of exercise called aerobic exercise is specifically designed to exercise your heart. The purpose of aerobics is to reach your heart's target zone.

So what is your target zone? Your target exercise zone is between 60 and 80% of your maximum heart rate. And here's an easy way to figure it out.

Simply subtract your age from 220 beats per minute. So, for me at 37, my maximum heart rate is (220-37) or 183.

So when I exercise I should get my

heart rate up to at least (183 X 60%) or 110 beats per minute, and no higher than (183 X 80%) or 146 beats per minute.

With the Heart Window to help me, I can be sure that my workouts are valuable for my heart and neither dangerous escapades or total wastes of time. Of course, **before beginning any exercise program you should consult your own doctor.** Note: The Heart Window is designed to indicate your pulse rate and aid your exercise, not to make medical diagnoses. **BUT ISN'T EVERYONE DIFFERENT?**

Here's the really exciting part. The worse shape you're in, the faster you'll reach the target zone and the less work you'll have to do to stay in the zone.

You see, as you get in shape, your heart doesn't have to beat as hard to do the same amount of exercise. Just as when you work out with weights your arms become stronger, your heart becomes stronger with aerobic exercise.

So the Heart Window is safe for the beginner or the athlete. And, you'll really see your improvement as you exercise.

But you don't have to exercise. Just wearing the Heart Window and using it at the office when you're under stress, after you've walked up some stairs or around the block, will make and keep you aware of your body's physical condition.

And look at this. Sit down at your desk and take your pulse. Then drink a couple of cups of coffee and take your pulse again. You'll see just what your morning 'pickup' actually picks up, and if, God forbid, you smoke, take your pulse before and after a cigarette. Wow!

ALL ELECTRONIC

With Innovative's new Pulsemeter watch, you'll have supreme accuracy. It's like a direct electronic line to your heart.

You see, unlike other pulseimeters that use a light shining through your finger, or a microphone to take your pulse, this instrument actually measures the electrical impulses that cause your heart to beat.

The back of the watch is one receptor, and the metal touch sensor on the front of the watch acts as the other sensor. Just touch the sensor, and you'll see your pulse on the large LCD Display.

IS IT A DRESS OR SPORTS WATCH?

Innovative Time thinks that everyone interested in their pulse must be a pro-

fessional athlete. So, they've built this watch with all the athletic extras.

It's not only water resistant, it's guaranteed to 60 feet (although you can't actually take your pulse underwater). It has a stopwatch, a lap timer, and dual finish mode. Its band is made of very tough polymers. So, it's a sports watch.

But wait, I don't like black watches for dress. So, I've gotten Innovative to add a deluxe matching stainless bracelet to the watch. It's rendered in stainless and black and is a perfect high fashion choice. So, it's a dress watch.

Plus, there's a 24 hour alarm and an hourly chirp. The stainless band is great for sports or dress. So, you'll get the watch with the black band on it and the high fashion band packed with it, compliments of Innovative Time's superb engineering and DAK's good taste.

The Heart Window is backed by Innovative Time's 1 year limited warranty and comes with a 1 year battery in place.

TRY THE HEART WINDOW RISK FREE

Now you can look at your heart as easily as the time. You'll see how you react to stress, foods and exercise. Don't let DAK's low price confuse you. Take this pulse watch to your own doctor and have him test it.

Try the Heart Window risk free. Try exercising and then check your cardiac recovery rate. If you don't like what you see, you'd better keep the watch. But if you just don't like the pulse watch, simply return it within 30 days in its original box for a courteous refund.

To order your Heart Window, Pulse Sports/Fashion Watch, complete with 2 bands risk free with your credit card, call toll free or send your check for just **\$49.50** plus **\$3** for postage and handling to DAK. Order No. 9844. CA res add sales tax.

In the gym, at the track or at the office, you'll have a direct connection to the condition of your heart.



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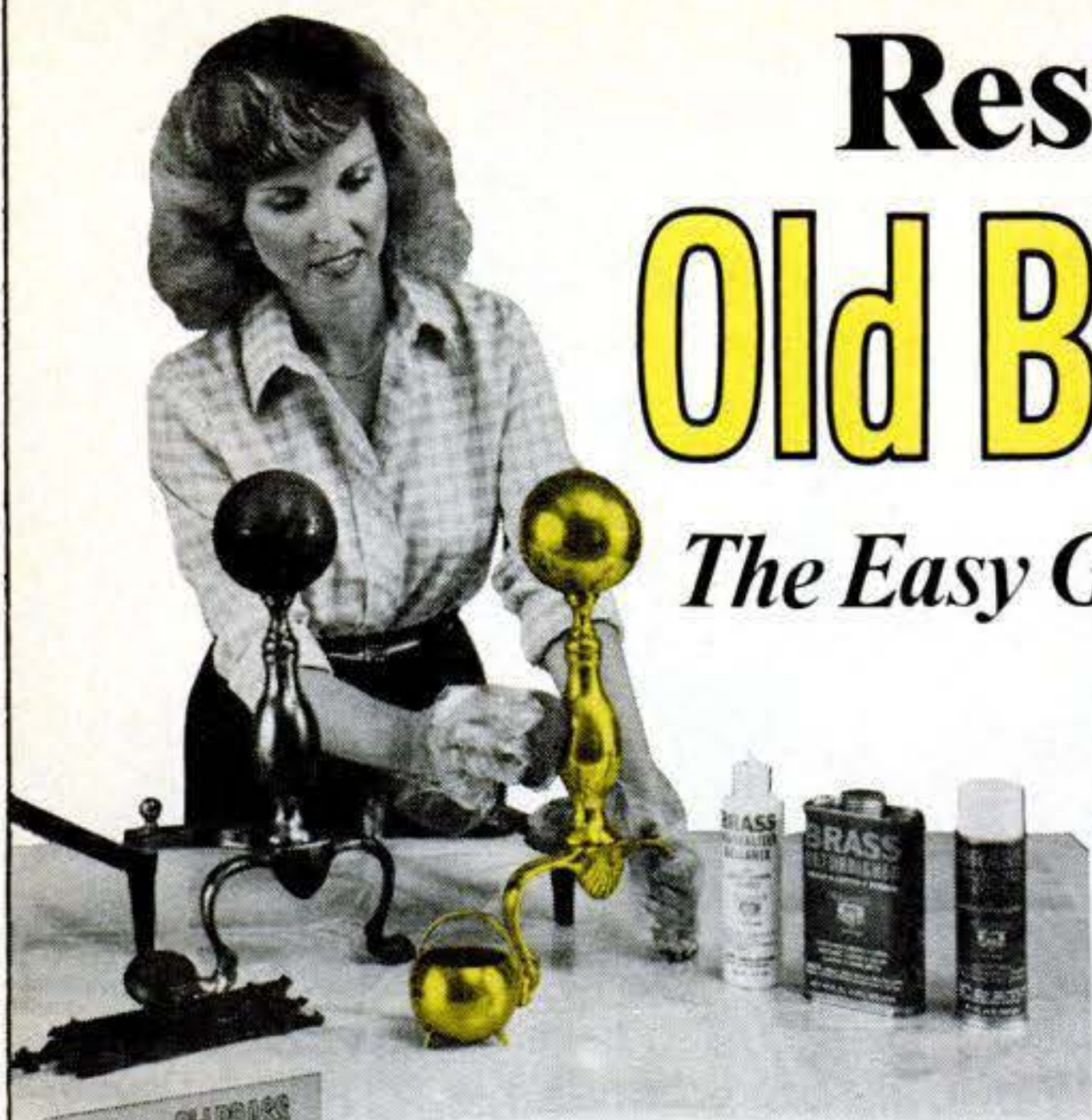
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Sports-car showdown

by a couple of inches, room inside is not cramped. Sure it's difficult to get in and out, but head room and leg room are good. In addition, the soft, deeply contoured seats make the ride almost tolerable and do an excellent job of holding passengers in place.

One big improvement over previous Corvettes is the luggage space under the rear-window hatch. Now you can pack a couple of suitcases and not worry about stacking them on your passenger's lap. Like the Camaro, Corvette has no glove box. Instead Chevy offers a center-console storage compartment for cassette tapes and vehicle credentials. And in the luggage bay behind the rear seats there are two lockable bins for larger items.

Chevy gets top grades for engine access. The massive clamshell hood hinges at the front and swings open to expose engine, front suspension, and brakes. At night two lights illuminate the carefully styled engine bay.

Mazda RX-7

Mazda moves up in the sports-car ranks with its more powerful fuel-injection rotary engine. Faster than ever, the new GSL-SE version of the RX-7 feels just as smooth as earlier rotaries but is now 34 horsepower stronger than its lesser RX-7 brothers. In fact the engine is so smooth that Mazda has fitted a warning buzzer that sounds when you exceed 7,000 rpm.

An unusual problem cropped up during our acceleration tests. The rubber air-intake tube between the intake manifold and the airflow sensor collapsed during hard acceleration, robbing the engine of power. Apparently the rubber got soft from the engine heat and high ambient temperature. When the Mazda was driven hard, engine vacuum was great enough to cave the rubber walls inward. After the engine cooled down on the shoulder for a few minutes, the rubber regained its backbone. We then ran our tests without a hitch.

One area in which the RX-7 fell short was handling. Its high-speed work earned only a "3" despite its special wide-tread tires.

The familiar body and chassis have been in production for almost a decade and long ago stopped looking fresh. Given the changes being made by the competition, it's long overdue for a face lift. Still, the current RX-7 remains one of the roomiest two-seaters available, with controls that fall easily to hand and work well.

Nissan 300ZX turbo

Pride of the Nissan fleet, the 300ZX mixes a heavy dose of luxury into its

Continued

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Identity Crisis

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Plus, wouldn't you like to see the Space Shuttle Lift off, the 9th inning of the World Series, and the news as it happens?

OR

You're lying in bed. Your mate's asleep. You're watching the late late movie. An earphone gives you total privacy, and if you fall asleep, you know that the TV will turn itself off within the hour.

In the morning, you can wake to TV, FM, AM or alarm. If you wake at night, you'll see the time on the extra large LED display with high/low brightness.

And, you won't have to worry about losing the time if there's a power failure once you install the standard 9V battery (not included) for protection.

OR

You're in your car or camper (not driving). You've plugged this entertainment center into your cigarette lighter, using the optional cable. And, you're watching the last quarter of the Super Bowl.

Now, no matter where you are, you can have great sounding AM and FM radio, or VHF and UHF TV.

FITS ANYWHERE

This beautiful micro-entertainer measures a mere 9½" wide. Its space-age silver and black styling adds a stunning look to any room at home or at the office.

While it's certainly the ideal bedside companion, think of the late nights you've spent at the office. Don't you deserve to have a companion that's a direct link to the outside world on your desk, credenza, or even a bookshelf?

HAS EVERYTHING

First the alarm. You'll enjoy every stan-

dard feature. There're fast and slow time and alarm settings. A sleep switch that lets you have up to an hour of AM, FM or TV before it shuts down for the night.

A snooze bar lets you have 9 minutes of extra sleep in the morning before the TV, radio, or alarm attacks you again.

And look at this. 59 minutes after the alarm turns on the radio or the TV, it will automatically shut itself off. In 24 hours, the cycle will repeat itself, so there's no need to reset this clock radio TV.

GREAT SOUND SAYS IT ALL

You'll enjoy the full rich sound you'd expect from an Emerson clock radio when you switch to either AM or FM.

The FM tuner really pulls in the stations. And the full range speaker has a very pleasing and full rich sound.

Of course, with the touch of a button, you can also tune in your favorite AM stations. You can keep up with the latest news or music on AM.

In the dark, linear volume and tone controls are a real luxury. So whether you're listening to the built-in speaker or the included earphone, you'll be in easy control of your music or TV.

BUT IT'S THE TV

Imagine a 4½" black and white TV that's incredibly sharp and clear. While it's certainly not for a crowd, it's perfect for viewing on your desk or night stand.

A rod antenna really pulls in the stations, or you can connect your own antenna. An adjustable flip up stand (as pictured) lets you set the angle for desk viewing (up) or bed viewing (down).

You'll have full control of brightness and contrast as you'd expect. But it's particularly important with this TV, because you may be in a very bright office or a very dark bedroom.

Just choose any station 2-13 VHF or 14-83 UHF and enjoy your TV. It's made by Emerson and backed by their standard limited warranty.

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I've been moving my sample TV between my office and night stand for about a week. I seem to use the radio more during the day and the TV more at night.

But, it sure is nice to have a TV handy when world events happen. This ad is being written on April 24, and I've been keeping up with the news on the San Jose earthquake all day. (My wife's parents live in San Jose and they're OK).

So, try it where you like. If you're not 100% satisfied, simply return it to DAK within 30 days in its original box for a courteous refund.

To order your beautiful Emerson AM/FM Clock Radio TV risk free with your credit card, call toll free or send your check for just \$99 plus \$7 for postage and handling. Order No. 9846. You can order a 12V adaptor cable that plugs into your car's cigarette lighter for just \$6.50 (\$1 P&H) Order No. 9847. CA residents add sales tax.

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Sports-car showdown

sports-car chassis. This is apparent in the noticeably soft ride, electronic instrument panel, six-way adjustable leather seats, wood-grain trim, and extras such as an electronic compass and thermometer.

An adjustable chassis should add something extra to this high-performance package, but we couldn't discover what it is. There didn't seem to be any discernible difference in either handling or ride no matter what position the center-console-mounted switch was in—soft, normal, or hard.

The test team agreed that this is the plushest, most luxurious of the sports coupes. Its ride is smooth, the seats are soft, the drive train is quiet, and the air-conditioning-and-heating system whispers perfectly controlled air into the cabin. Even in the new 300-series guise the Nissan retains the flavor that makes it the most civilized of the group.

Porsche 944

Keep it simple. That's what the folks in Stuttgart did. The 944, even when not compared with the over-equipped 300ZX, is a simple machine that presents the basics of recreational driving in their most unvarnished form. Frills are kept to a minimum, though we did note the air conditioning and power windows in this model. The steering is tight, with plenty of feedback coming through the wheel. In the dash, traditional gauges fill the stark instrument panel. All are easy to read without interference from the steering-wheel rim.

Despite the 944's small size, Porsche makes provisions for rear-seat passengers. But the seats are really too small for even average-size adults. In fact some children's car seats may be too wide to fit into the tiny rear buckets. Pull down the back of the rear seats, and the 944 has the same kind of luggage space as that of the competition, however.

Our choices

Give me the Corvette for all-out sports-car fun and driving excitement. Yes, the ride is too harsh, and getting in and out is difficult. Yes, the fuel economy is terrible. But powerful engine performance and taut handling are what I look for here, and that's what I find.—J. D.

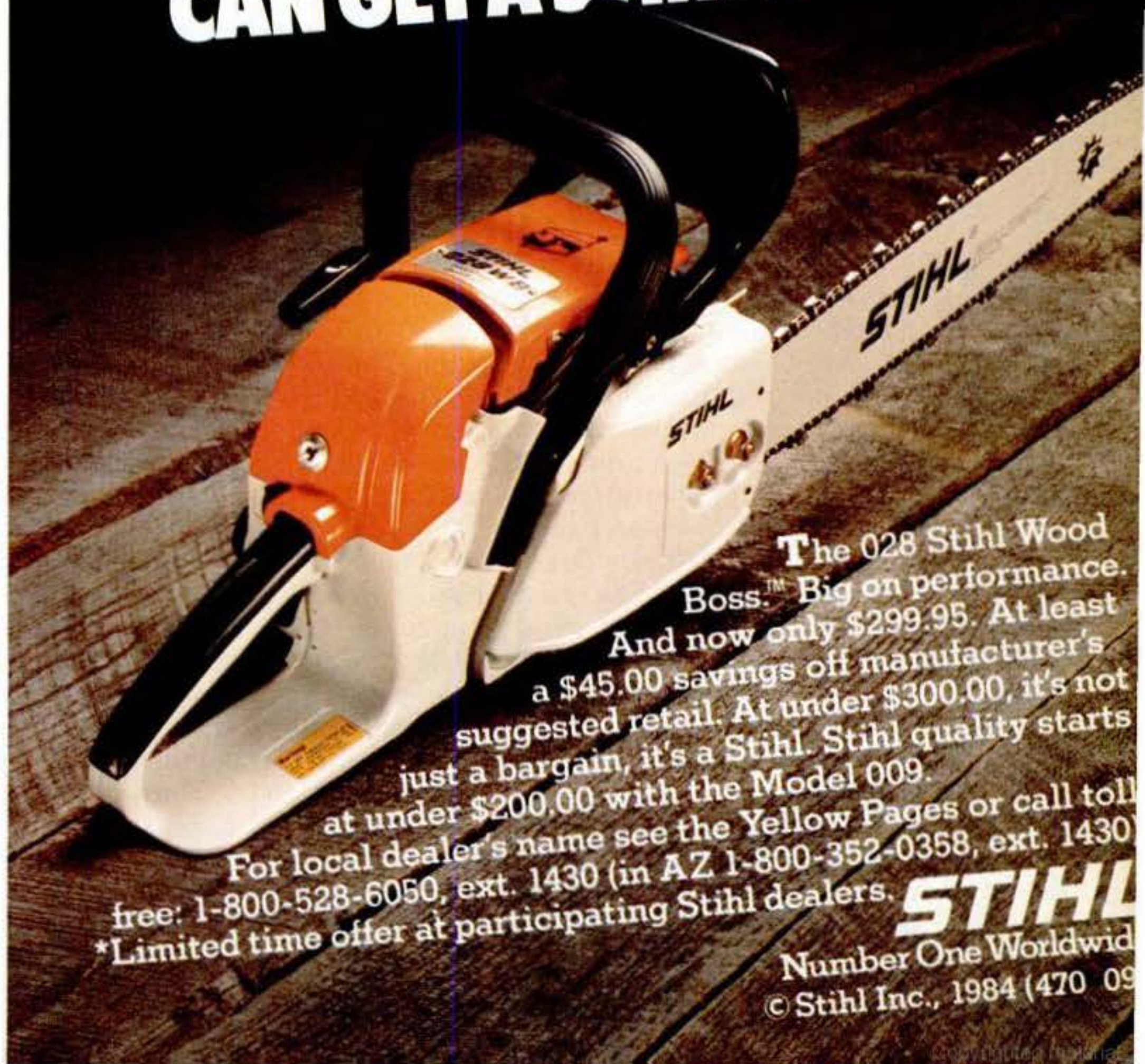
If every road were as smooth as a race track, I'd pick the Corvette in a second. But faced with the reality of rough roads and expensive fuel, I'll take the 300ZX turbo and install an after-market intercooler to cure its heat sensitivity.—J. K.

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World's biggest solar pond

Eighty 200-foot-long solar modules provide hot water for 6,500 people at Fort Benning, Ga. It took two years, 3.6 miles of pipe, and \$4 million, but it's expected to save up to \$10 million over a 20-year period.

By WILLIAM J. HAWKINS

We had to supply hot water to a population that's equivalent in size to a small town," says Ronald Sibold, area engineer of the U.S. Army Corps of Engineers' West Georgia Office. "The system had to be highly efficient and relatively low in cost." The result is the world's biggest solar pond. Stretching over an enormous 11-acre area at Fort Benning, Ga., it now supplies 26 barracks and the laundry operation for some 6,500 troops with 500,000 gallons of hot water daily.

The pond consists of 80 individual solar modules arranged in four rows, 20 to a row. Each module is huge: 15.5 feet wide and 200 feet long, with 18-inch-high concrete walls. At its base is a graded sand bed covered with 1.5-inch glass-foam insulation board. Above it, resembling a large water bed, is a black plastic (chlorosulfonated polyethylene) bag filled with 3.5 inches of water for thermal-energy storage.

To physically protect the bag and to prevent cooling from the wind or reradiation, each module is covered with a fiberglass-reinforced-polyester corrugated panel. The panel, originally designed for greenhouses, is rated to pass 89 percent of available solar energy, allowing the water-filled

bag to reach approximately 140 to 160 degrees F on most sunny afternoons.

The bags in each module are interconnected by 3.6 miles of underground piping made of insulated cement asbestos with an epoxy liner. At peak temperatures, determined by a computer monitoring system, three 50-hp pumps force the hot water out of the system and into a 500,000-gallon storage tank. Later, during the night or the next day, three 75-hp pumps distribute the water to the barracks and laundry as needed. Fresh water is then returned to the bags from a 50,000-gallon sump tank.

The site for the pond was selected for its proximity to the barracks and to catch the maximum heat from the sun. Each module is designed for easy access if repairs are needed. Removable straps hold the top panels in place, and isolation valves allow individual bags to be removed without affecting the entire pond. "Punctures can be repaired as easily as bicycle tires," says Sibold.

The system has been in operation for over a year without any major technical problems. However, the sheer size of the project has caused some unforeseen trouble. "A frightened deer once wandered into the complex," Sibold says. "Before it left, nearly a dozen panels had to be replaced."

Barring such extraordinary repairs, the solar-pond project will save money. "Heating 500,000 gallons of water a day using conventional methods is, needless to say, expensive," adds Sibold. "But by using the sun, the Army is saving energy equivalent to 11,300 barrels of oil a year."

The project, a collaboration between Lawrence Livermore Laboratories and the Savannah District of the Army Corps of Engineers, took two years to complete at a cost of approximately \$4 million. That investment, according to Sibold, "is expected to save \$8 million to \$10 million over the next 20-year period." PS

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Teletext decoder for network-TV "magazine"

On the TV screen a smiling announcer tells commuters the bad news: Repairs are starting on a major artery, and city traffic will be snarled for weeks.

At the bottom of the screen a message appears: "WBTV Extravision viewers see page 74." Two taps on the

remote control, and a screenful of text replaces the smiling face. The text lists the timetables for street repairs. Another tap, and the screen fills with a multicolored map showing detours and alternative routes.

Fascinating—except I've seen too

many teletext demonstrations like this. They all promise to deliver digitally coded, TV-text "pages" of local news, weather, and traffic. But despite the fact that both CBS and NBC have been transmitting teletext magazines (with pages of national news and weather, movie reviews, and educational games) since mid-1983, I've never seen anything but taped demonstrations. Nor have most people. The reason? No one is manufacturing the decoders needed to convert the digital signals into text.

Until now. In April a Panasonic decoder went on sale in Charlotte, N.C. Not only can Charlotte citizens pick up WBTV's locally enriched version of CBS's Extravision, but they can also read NBC Teletext pages carried by the local affiliate, WPCQ-TV.

Panasonic is the first to offer a decoder for signals using the North American Broadcast Teletext Specification standard adopted by CBS, NBC, Group W, and Canadian TV. (Zenith makes decoders for another version of teletext, but no TV network has adopted the technology.)

First developed in Britain in the late '70s [PS, May '78], teletext is still poorly understood. "Think of it as an electronic slide show," says CBS vice-president Albert Crane III. Like slides in a carousel, the digitally coded teletext pages are broadcast in an endless loop. (The signals are sent on the vertical blanking interval, the black bar between screens of a TV picture.)

Like slides, new pages can be exchanged for old. But unlike slides, teletext pages can also have new data inserted in the seconds between cycles. (The 100-page magazines are broadcast at a rate of four pages a second, 24 hours a day.)

This means that news, weather, and traffic can be constantly updated. And the information is available on demand—the viewer simply chooses the pages he wants to see. The decoder's microprocessor captures the requested pages as you'd lift a slide from a carousel. The text then appears on the screen, superseding the video image of the TV program. (When teletext signals are used to subtitle, or "caption," programs for the hearing-impaired, then, of course, the video image remains on the screen.)

Teletext is free once you have a decoder (though you will also need a new TV set if yours doesn't have a red-green-blue jack). Since WBTV's teletext service began in April, at least four other CBS network affiliates—in Buffalo, Los Angeles, Seattle, and Salt Lake City—have announced plans to broadcast local versions of Extravision.—*Susan Renner-Smith*

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You're never lost with this **dashboard navigator**

Moving a light pen across a road map enters the coordinates of your location; moving it again enters your destination. Citypilot, a computerized pathfinder, then plots your course. As you drive, a compass points the way through a maze of roads.



By DAVID SCOTT

Bar codes—those shaded stripes printed on groceries and magazines to electronically identify an item and its price—speed your supermarket checkouts. Now they're being tried on road maps to speed your drive through unfamiliar streets and highways.

The bar codes are part of a computer-controlled navigation system called Citypilot, which was developed by VDO of Schwalbach, West Germany, for experimental tests being conducted in Frankfurt. Using a light pen to "read" the bar codes printed on a conventional map, you enter your present location and up to 99 destinations. From then on, the system plans your route, indicating each turn on a dash-mounted display.

Before you start

Maps of different areas are bound together as pages in a book, and each page is identified by a bar code along the top. Before driving off you enter

your present location by first stroking the light pen across the bar code of the local map to enter its number. Then you enter the exact coordinates of your location. That's done with a special card you place over the map. The card has code strips along its right and bottom edges. You square up the two edges over the starting point and make a vertical and horizontal swipe over the strips. The coordinates for that spot are now entered.

Next you enter your first destination. (The system can store up to 99 destinations, and you assign each a number by pressing a rocker switch and watching a digital display on the dash-mounted navigation panel.) The coordinates of the destination are entered as before. They may be on another map, but the identifying map number tells the computer the general area and the scale of the new map.

Once all the coordinates have been entered, Citypilot becomes your pathfinder. A second digital display on the dash panel shows the "crow-flight" dis-

tance to the selected destination in kilometers. Above it is a compass rose that responds to the earth's magnetic field. Fed with computer-calculated data, the compass always points toward the destination, with the car's heading aligned with the due-north axis of the compass.

Staying on track

As you drive you'll naturally have to deviate slightly from the exact direction shown because of the road's twists and turns. But at major intersections and junctions Citypilot will show you the general turns to make to stay on course.

As you approach your destination, a countdown on the digital display shows how close you're getting. This indicates point-to-point and not road distance; the system integrates data to show crow-flight distance, ignoring normal road zigzags. If the reading starts going up, however, you quickly know you're traveling in the wrong direction. A zero reading shows you're within 40 meters (131 feet) of your destination.

Each of the possible 99 destinations can be reached from any starting point, which itself may be one of the preselected destinations. All stops along a doctor's or salesman's planned route, for example, could be programmed before starting a trip. As each destination is reached, the next is displayed. And if the last destination is the starting point, Citypilot will bring you home, too.

As an additional navigational aid, the display can also show a true compass at the touch of a button. The arrow then points to the car's actual magnetic heading. This could be helpful when driving in uncharted, wooded areas. In this mode, the N-S-E-W compass points appear around the rose. For areas without bar-coded maps, it's possible to program the computer roughly for any destination using a push-button pad. **ES**

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THE AFRICA-ARCTIC CHALLENGE

Rear-projection TV folds to book size

Projection-TV firms have been shrinking screen sizes. Smaller rear-projection sets cost less to make, fit most homes better, and deliver brighter, apparently sharper pictures. Typical size for compact sets: 40 inches diagonally. Japan's Matsushita, parent firm of Panasonic and Quasar here, has pushed shrinkage almost to its limits, announcing a new portable 6.3-

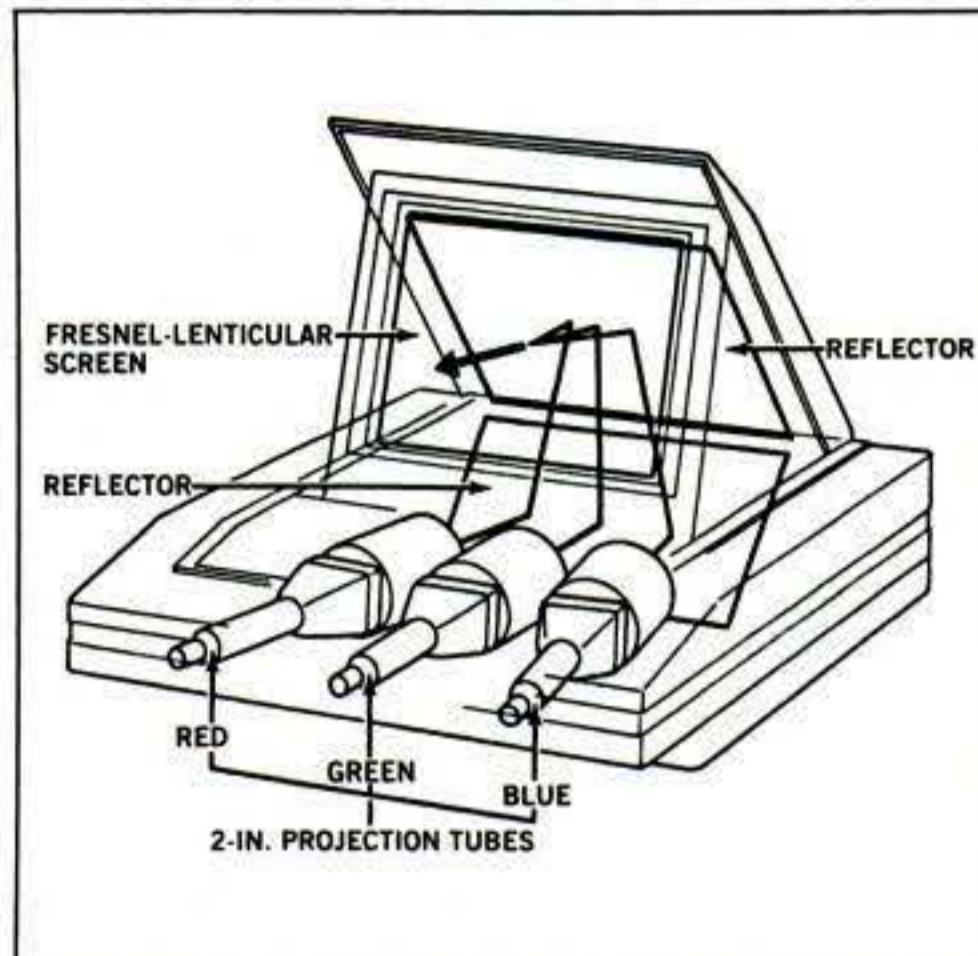
inch rear-projection color-TV model. The new projection TV could be used as a display terminal for broadcast data services (teletext), says Matsushita, or two-way phone and cable videotex. No marketing plans have been announced for the desk-top video terminal, which might also use new digital-processing chips. These computer-like circuits simplify display-

ing one color picture inside another (photo), enabling you to monitor one program while viewing information from another source.

Despite its remarkable compactness (9.8 by 3.3 by 12.2 inches), the portable works just like larger rear-projection models. Three projection tubes, each slightly less than two inches long, beam separate red, green, and blue images onto mirrors. The individual color images merge on one side of a Fresnel-lenticular screen, creating a conventional color picture.

Major advantages in projection technology are weight and size reduction. A seven-inch set with a CRT, says Matsushita, weighs almost twice as much as its 6.6-pound (minus batteries) portable and is almost twice the size. Also, the projection tubes cut power requirements: The new portable draws 12 watts; a seven-inch-CRT set uses 27 watts on DC.

The screen displays pictures with a brightness of 50 footlamberts—less than a CRT's screen but adequate with reduced ambient light. Maximum viewing angle is 30 degrees to either side of center.—*John Free*



Collapsible rear-projection screen in Matsushita's prototype folds into a carrying case. Miniature optics (above) are arranged as in much larger sets.



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Anova's astonishing Communications Center gives you every imaginable state-of-the-art phone convenience—in one powerful console. Its voice-activated answering machine provides not one, but 7 outgoing message channels—and crisp, pause-free playback on dual microcassettes. LCD displays the exact time and date of each message as you listen. At home or away (with remote) you can skip, erase or repeat messages.

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At any time, you can integrate your Communications Center with the Protection Center (below) to get undreamed-of security for your home. Call today, to discover the phone center that breaks every barrier to communication.

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The Anova Protection Center. Total home security—without wires.

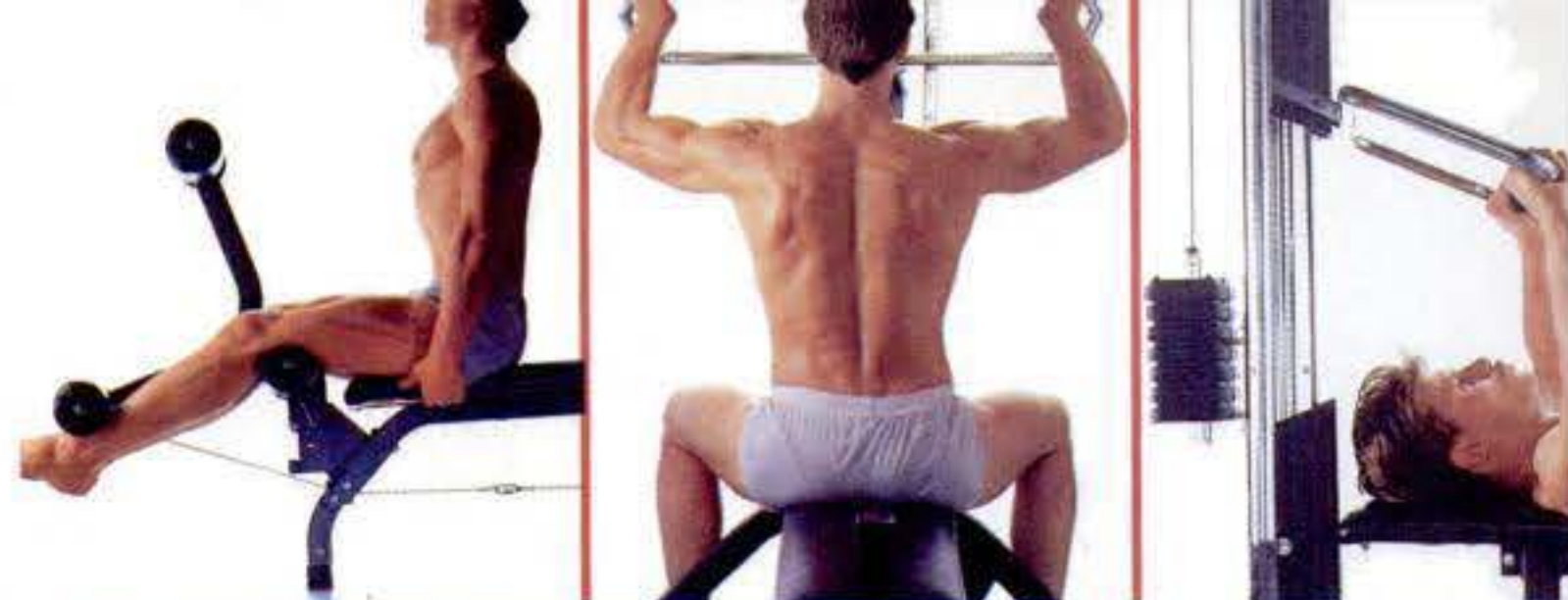
Now the astonishing Anova Protection Center gives you ultra-vigilant security—at less than 1/10th the cost of hard-wired systems. The sophisticated microprocessor console communicates with Anova's exclusive family of remote detection sensors via radio waves—for easily-installed, *totally wireless* security.

Mount intrusion sensors on doors and windows, and any illegal entry will trigger a piercing alarm. Carry the included emergency transmitter with you to instantly notify family members of personal or medical emergencies. Optional smoke and water sensors protect you from fire and flooding. A different alarm sound pinpoints each type of trouble, and the console display tells exactly where it is.



The Protection Center is only one of the components in the revolutionary Anova Master System. Integrate it with the Communications Center (above) to autodial taped emergency messages to police/fire department, doctor or neighbor. Includes 2 intrusion sensors (others available from manufacturer) and 185 dB alarm. 6½ x 5½ x 3". 3 lbs. One year warranty.

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Body Tech. One machine challenges you to 60 exercises.

Some exercise machines build specific muscles. Others provide overall body toning. Now the Body Tech Fitness Center provides *both* vital workouts—in one space-saving home system for weight lifting, resistance conditioning, and sports training.

Quick-change cables and simple pull-pin height adjustments make Body Tech the most versatile home gym ever created. Attach cables to hand-grips for a full range of variable resistance exercises. Or use ankle strap to tone individual leg muscles. Padded leg developer/exercise bench (included) connects in seconds to condition thighs and hamstrings. Or strengthen your entire upper body with challenging lat bar pull-downs. The chrome lift bar expands your arms and chest with lifts and presses.

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The ultra-soft exercise bench is padded with 2" of high density foam. Body Tech is so comfortable that it tempts you to exercise. And so efficient, you can build a trim, fit body in just half an hour, three days a week.

Made in the U.S. of heavy gauge steel, all metal parts (except cables) are backed by a *lifetime warranty*. Carriage stands 90" high and attaches to any wall stud in your home—extends only 12" from wall with bar and bench detached. Weighs 136 lbs. Bench measures 73 x 32 x 23", weighs 58 lbs. Or order the optional free-standing frame (70 lbs.) and use anywhere without attaching to wall.

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- Five additional 10-lb. nesting weights #MXC102 \$69 (18.50)



\$499 challenger takes on IBM.®

Snap any IBM typing ball into this new heavy-duty office typewriter from Japan, and you'll get the same beautifully sharp, even printing as a Selectric II.™ Even the *lift-off correction key* is in the same place. But Avanti has less than half the parts for improved reliability and easier servicing.

Like the Selectric II, Avanti gives you a stationary 13" carriage (11" writing line), power shift key and return, automatic repeat keys, and one touch tabulation key. You also get easy glide margins, vertical half space, and adjustable impression for typing carbons. Key stroke memory permits 30% faster typing than IBM. The snap-in carbon-quality correctable ribbon (included) prints in excess of 120,000 characters. (Order more ribbons below; IBM ribbons not compatible).

Avanti measures 19 × 15 × 5½", weighs only 23 lbs. Plugs into AC outlet. Comes with 12 pitch elite typing ball and 90 day warranty.

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- 12 Lift-Off Tape Ribbons #MAV152 \$9.95 (2.50)



In independent tests, this rugged Avanti typewriter performed 11 million operations (equal to 3 years hard use) without failure. Cost is less than half as much as a comparable IBM.

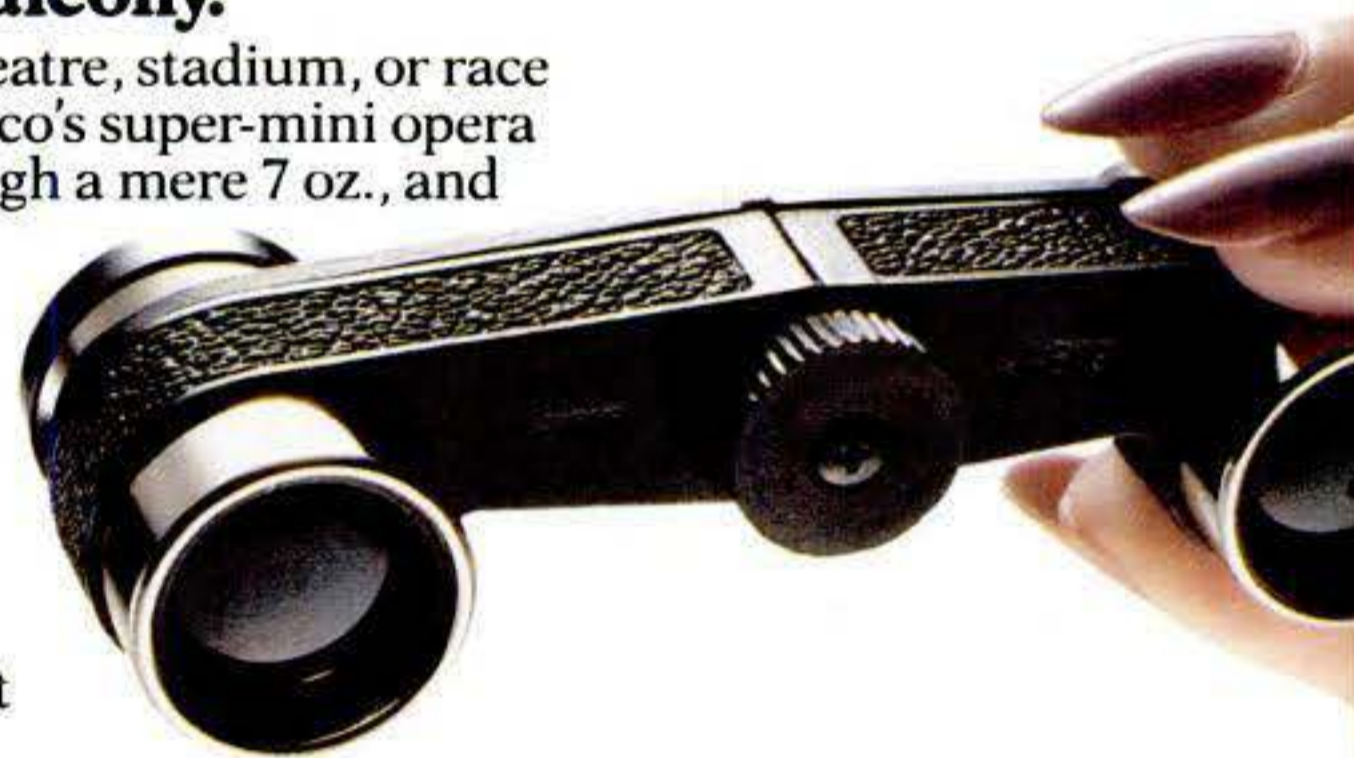
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The gold-tone trim adds an elegant touch to these versatile glasses. Sturdy frame protects the fully-coated lenses. Measures 6 × 5 × 2". Case included. *Lifetime* warranty.

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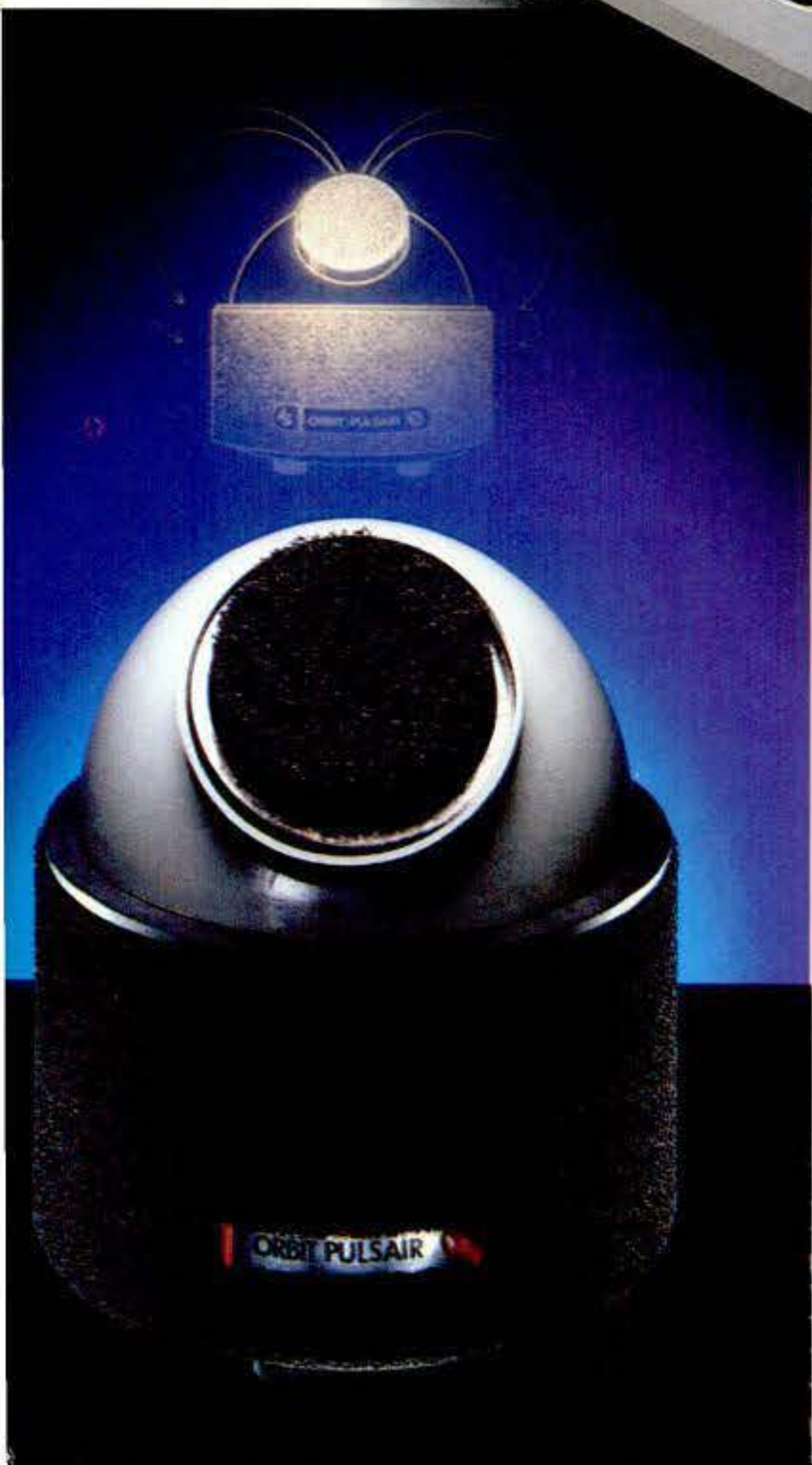
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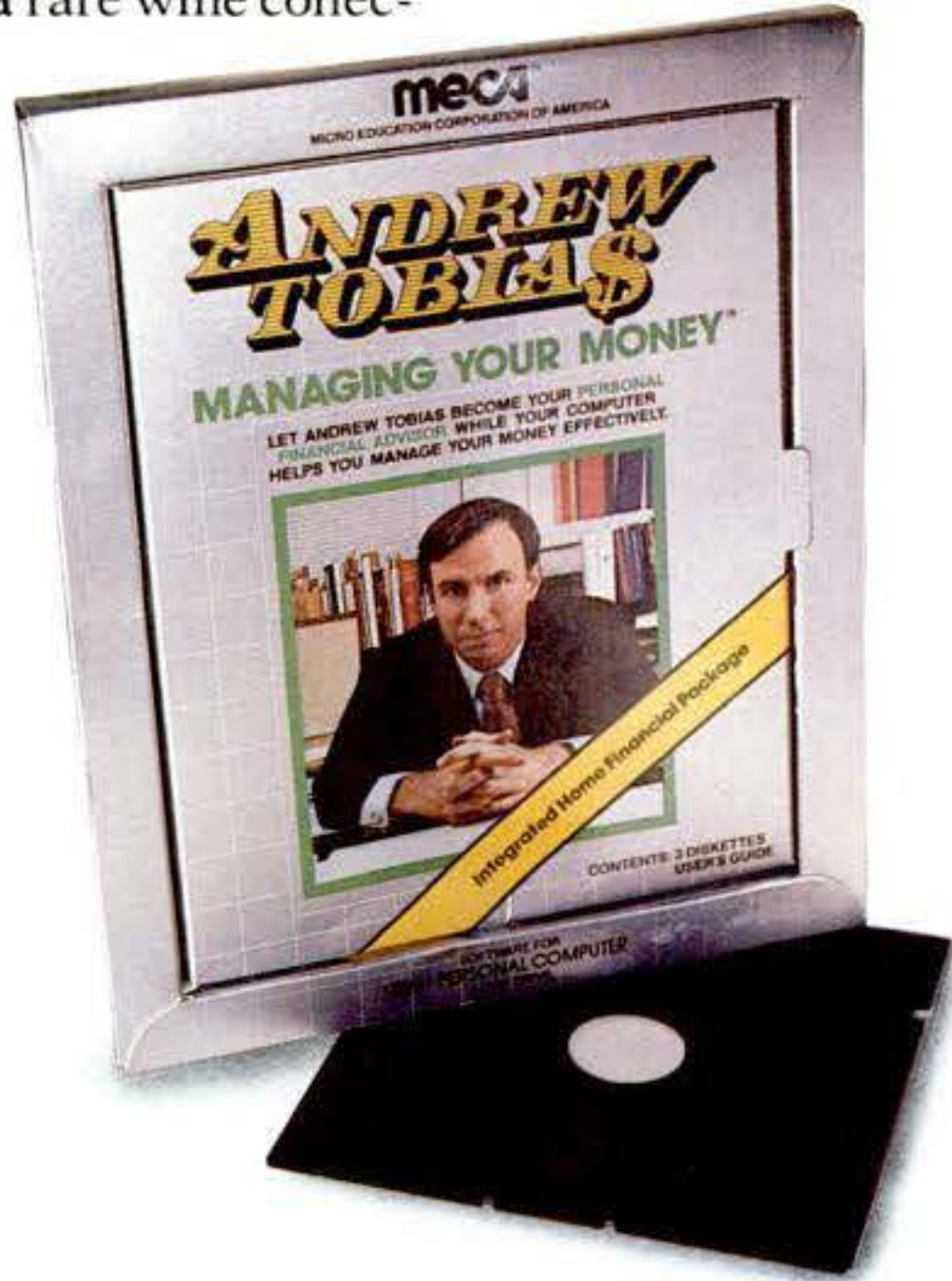
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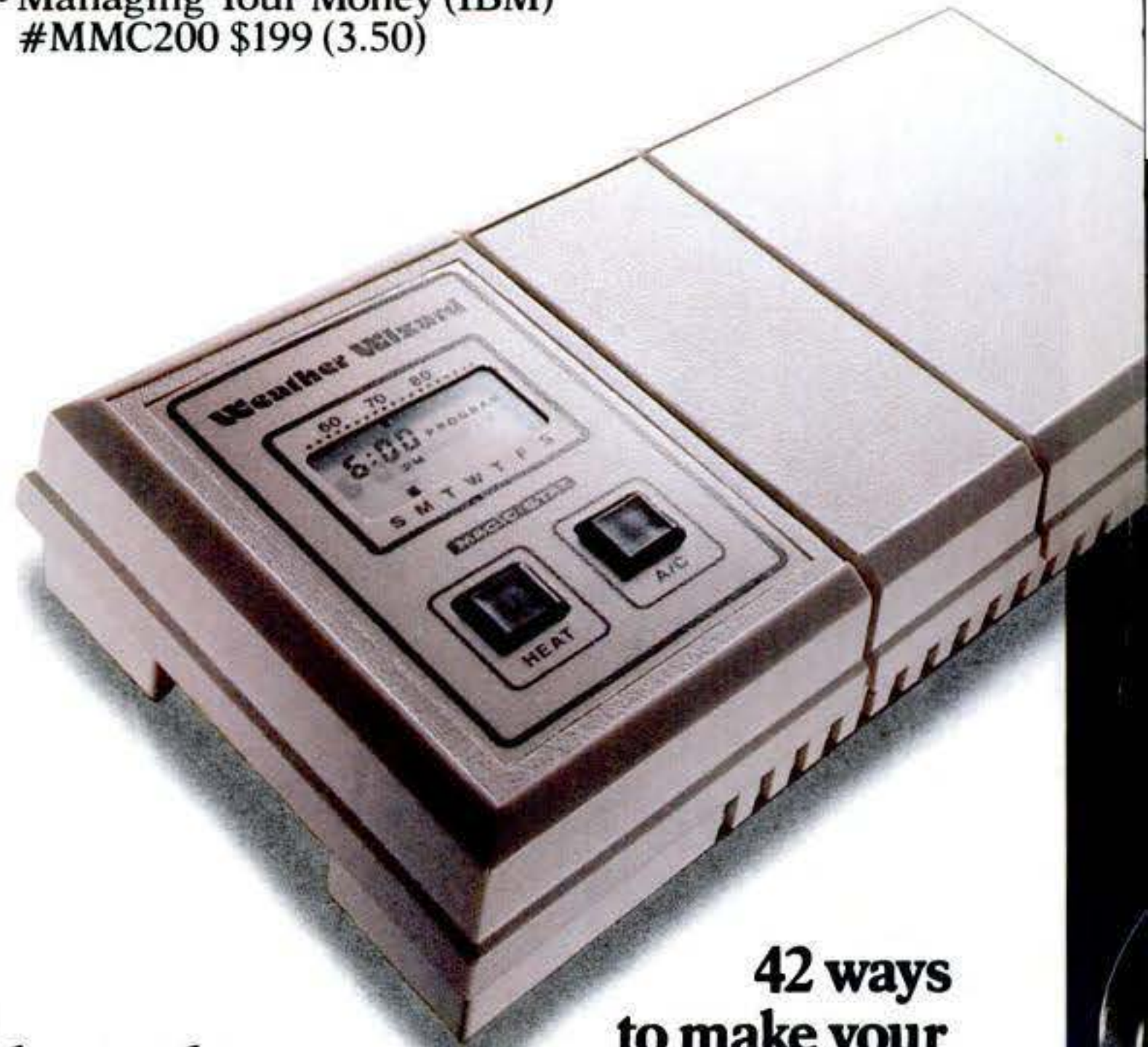


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Programming takes just 10 minutes. And you can store different temperatures for summer and winter, so you don't have to reprogram when the seasons change. Switches automatically between heat and air conditioning. When you're away it keeps the house economically cool. And warms it up for your return. Takes 9V back-up battery (not included). Replaces present thermostat (requires screwdriver). 1¼ × 3¼ × 7", 1 lb. 5 year warranty.

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- Weather Wizard Thermostat
#MQS101 \$89 (3.50)

Rich home stereo recorder takes to the road.

Aiwa's newest and most advanced personal stereo is the world's smallest recorder/player with AM/FM stereo and Auto Reverse. Just 4½ × 3¼ × 1¼", it slips into your shirt pocket. You can listen to both sides without turning over the tape. Record directly from the built-in AM/FM tuner or from another audio component. Or use the detachable one-point microphone to capture live performances in stereo.

Aiwa's Music Sensor automatically skips over undesired songs with the press of a button. Anti-roll mechanism prevents distortion during active exercise. Lightweight stereo headphones have wide 18–22,000 Hz. range for superb sound. Comes with belt hook, carrying case and shoulder strap. Weighs only 10 oz. Operates on 2 "AA" batteries (not included). 1 year warranty. Order today and start taking stereo sound everywhere you go.

- Aiwa Personal Stereo
#MAI400 \$159 (3.50)



Bring home the convenience of two-line conference calling.

If you have two phone lines, this new Webcor ZIP is the perfect choice to eliminate the clutter of duplicate phones. It's great for keeping in touch, because you can merge *both lines* for a three way conversation.

As with expensive business telephones, you get a convenient Hold button for call transferring, a built-in memory for effortless speed dialing of 12 numbers (up to 16 digits each), and Auto Redial. ZIP also has switchable Pulse/Tone dialing and programmable Pause for memory dialing to your economy long distance service. Hi/Lo/Off adjustable ringer. Built of rugged black ABS; can be wall mounted. Measures 9 x 6½ x 2", 2 lbs. Modular cord plugs into phone jack. Battery powered memory saver. 90 day warranty.

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• Webcor 2-line ZIP #MWE829 \$99 (4.50)



The Bausch & Lomb Criterion 4000. Your portable, personal observatory.

This new Criterion 4000 telescope brings more than a billion miles of space within your view. Its compound



Schmidt-Cassegrain optical system (once limited to large observatories) combines exceptional sharpness and high magnification (up to 240x) in a surprisingly compact design.

Most remarkable for an instrument in this price range, Criterion 4000 incorporates a precision electric clock drive. Now you can take time-lapse astro-photographs. Your exposures will be razor sharp, because the clock drive continuously adjusts for the earth's rotation.

180 times more light gathering ability than the human eye.

Criterion's short barrel lens system and polished 4" mirror produce sharper images over a wider, flatter field than any other design. Magnesium fluoride lens coatings (accurate to 1/250 of a wavelength) increase light transmission for astonishingly vivid images.

For terrestrial viewing, Criterion is a professional quality 1200mm F/11 telephoto lens (focuses as close as 15'). Use it to observe birds, animals and flowers—rightside up and in extreme close-up. For photography, an inexpensive T-mount available in camera stores adapts any 35mm reflex camera.

Criterion travels securely in a foam-lined fitted case (included). Comes with 4x finderscope and two 1¼" eyepieces—30mm (40x) and 18mm (67x). (Other eyepieces available from manufacturer.) Measures 7 x 7 x 14", weighs only 10 lbs. Clock drive plugs into AC outlet. The complete system also includes an informative manual, visual back and star diagonal prism. Lifetime limited warranty.

With the Criterion 4000, says Isaac Asimov "the night sky is yours, with wonder and beauty invisible to the eyes alone." Order today risk-free, and reach out to a fascinating new world.

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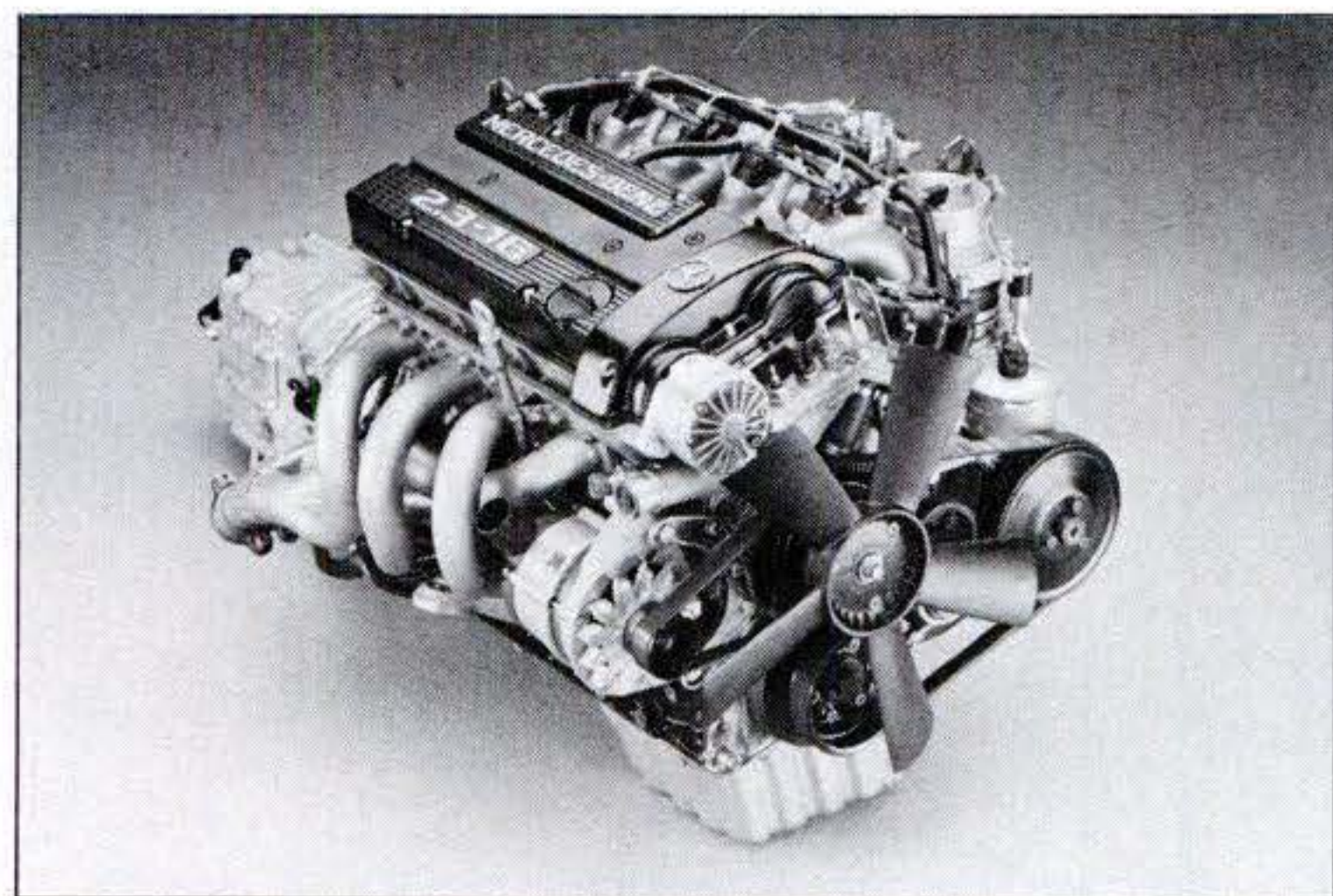
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16-valve, 4-cylinder power for speedy Mercedes

KOBLENZ, WEST GERMANY

The new Mercedes 190 E 2.3-16 sedan is as close to a four-door sports car as anything I've ever driven. It has lots of muscle, handles extremely well, has powerful brakes, and yet remains a surprisingly sedate and luxurious sedan.

The heart of this factory-built hot rod is a 2.3-liter (140-cu.-in.) four-cylinder engine with a Cosworth-designed aluminum cylinder head. Inside the cross-flow double-overhead-cam head each combustion chamber inhales and exhales with two intake and two exhaust valves. How does



this work, and why didn't Mercedes turbocharge the engine? Engineers told me that the four-valve arrangement provides better reliability and higher volumetric efficiency at various engine speeds. And the central location of the spark plug provides a combustion-chamber shape conducive to efficient burning and low pollution. Mercedes rates the engine at a crisp 185 horsepower at 6,200 rpm.

This provides some impressive performance figures: Zero to 100 km/h (62 mph) is reached in a scant 7.5 seconds, according to Mercedes, and top speed is pegged at 230 km/h (143 mph). The model I track-tested on Germany's world-famous Nürburgring race circuit topped out in fifth at "only" 210 km/h (130 mph).

To put all this power to the ground, Mercedes shod the E 2.3-16 with wider 205/55VR15 tires, beefed up the standard suspension and brakes, lowered the body by 0.6 inch, installed special aerodynamic body work, and bolted in a heavy-duty Getrag transmission.

When can we expect to see these sporty sedans cruising U.S. highways? No firm date has been established, but the company says it intends to introduce the car into the U.S. market.—*Jack Keebler*



Four-valve engine (far left) of 190 E 2.3-16 provides increased power with a broad torque curve, good fuel consumption, and low emissions. The car was heavily modified to handle the four-valve's bonus power.

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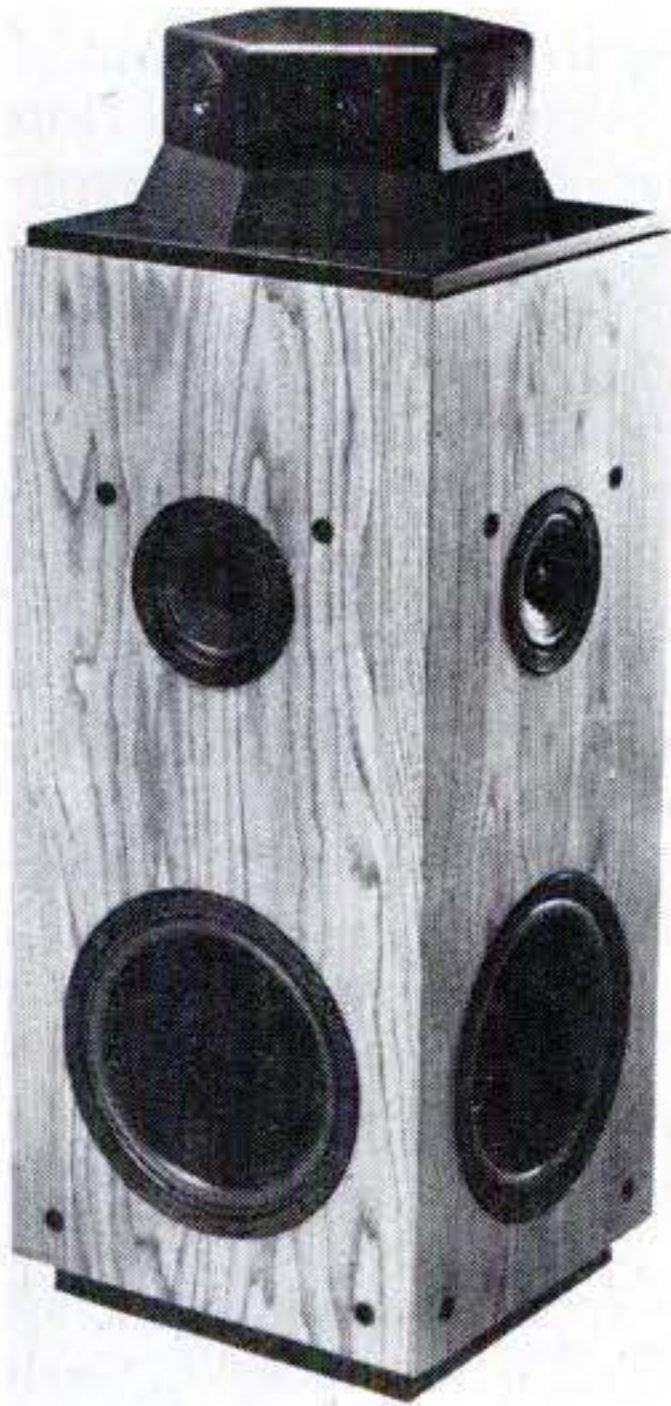
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Look and Listen

By WILLIAM J. HAWKINS



1.5 MHz of chroma (color) information. But most TVs only use 0.5 MHz of the information because processing the higher frequencies causes detail interference: a rainbow effect on complex patterns or slight movements—crawls—on the edges of figures. The ColorTrak sets use all 1.5 MHz of the signal—without the problems—for better color and color detail. I could see faces in a crowd, not just smears of color.

The detail interference is eliminated with a comb filter, and the higher, noisy frequencies that cause graininess noticeable in dark sections of the picture are reduced by a video-noise-reduction circuit. This means better performance from broadcast TV, tape, videodiscs, and even home computers—the TVs have a red-green-blue input for computer use.

All-in-one and more

A video switcher, an enhancer, a noise reducer—they're all in one Detailer III unit (photo above right) I tried. It has stereo audio and video switching for four functions plus controls for picture detail, sharpness, and noise (snow) elimination. Detailer III also has one other clever feature: split screen for comparing a standard image with one that has been enhanced. Press a button, and you see the non-enhanced half of the image on the left side of the screen and the enhanced half of the image on the right. It's made by Vidicraft, 0704 S.W. Bancroft St., Portland, Ore. 97201. Price: \$349.

Coming soon

Thousands of exhibits were shown at the recent Consumer Electronics
Continued

LAS VEGAS, NEV. "And here's... Johnny!" It was the familiar sound of Ed McMahon introducing the mainstay of midnight monologue, Johnny Carson. But this was different. It was my first taste of stereo TV and of something called "Full Spectrum" television.

McMahon's voice came from the left side of the 45-inch picture I was watching; Carson entered center stage and so did his voice. And Doc Severinsen, explaining how cleverly placed ink splashes decorated his newest tie, spoke from the right of the screen.

I was watching a demo tape of "The Tonight Show" on one of RCA's new ColorTrak 2000 projection sets. (It has been taped in stereo for the past 10 months, and broadcasts are due to begin soon.) The TV, like 17 other models in the new line, is equipped with the Zenith/dbx decoder for stereo sound reproduction.

How did it sound? I heard high-quality audio with good stereo separation (50-Hz-15-kHz frequency response, 35-dB separation). In addition to the dbx noise reduction, a National Semiconductor DNR (Dynamic Noise Reduction) circuit further eliminated the annoying background hiss heard on low—or no—audio. And the picture was of high quality, too.

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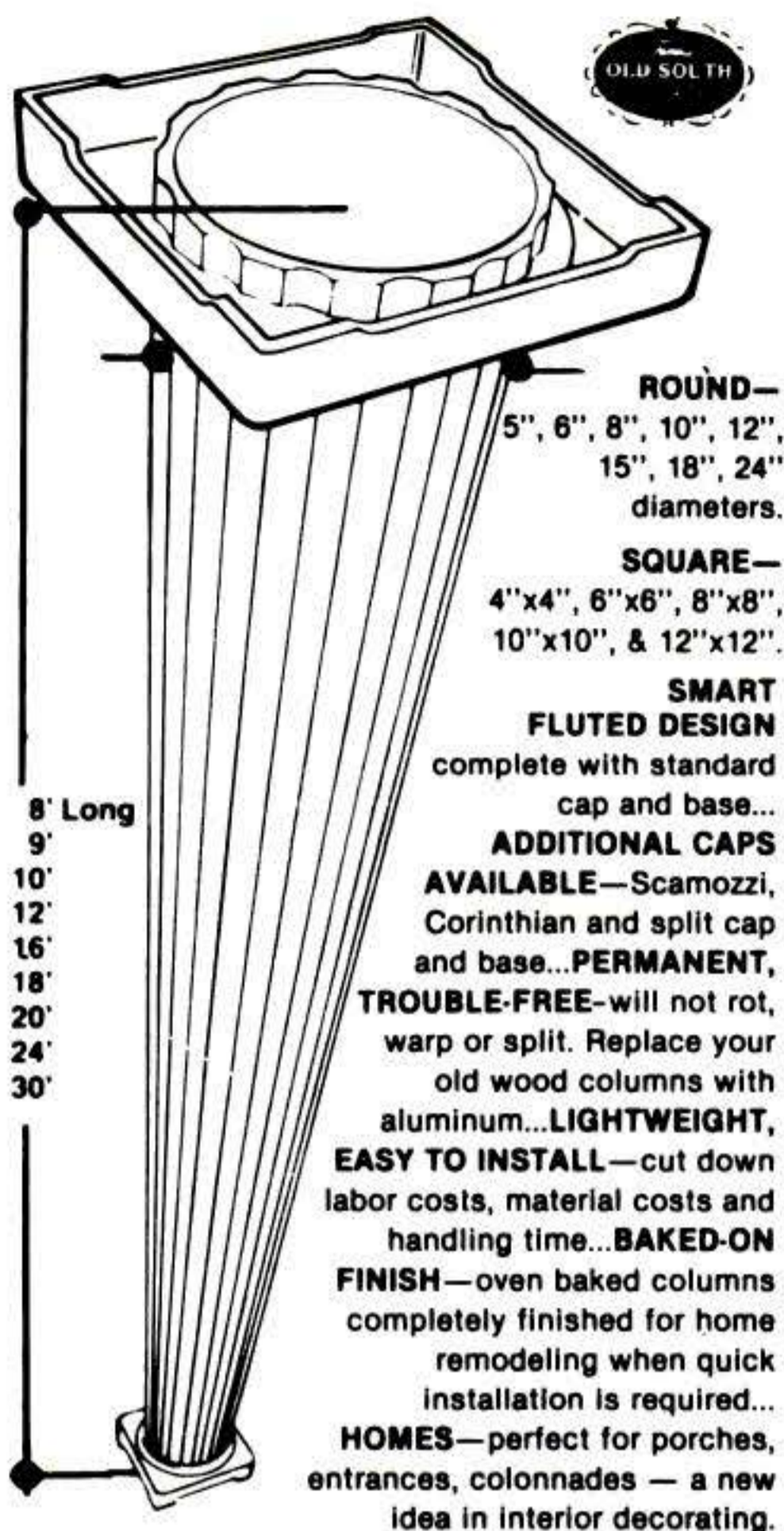
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Look and Listen

Show in Chicago. Here are some of the show's highlights:

- You hear good stereo separation from anywhere in a room if, according to dbx (71 Chapel St., Newton, Mass. 02158), you use its new Soundfield One speaker system (photo above left). The trick: Each speaker column contains 14 drivers arranged around all four of its sides. The output of each column is controlled by an "imaging controller" box. The box samples the audio signal to electronically control ambience, volume, and the radiation pattern from each column. The system costs \$2,500.

- Pioneer introduced eight-inch videodiscs. They contain up to five "music videos" that can be played on a home LaserVision player or on the company's new \$7,000 commercial video jukebox.

- Atari's "Mindlink" is a band that goes around your head and connects with the company's new 7800 video game. Result: no joy stick. Just *think* about where your player should be on the screen, and it goes there (eventually). It takes practice.

- An interactive videodisc system from RDI (2261 Cosmos Ct., Carlsbad, Calif. 92008) uses speech recognition. Speak into a microphone, and you control the movements of cartoon characters in a visual adventure game. The \$1,300 system attaches to any laser videodisc player.

- A home digital audio recorder made by CompuSonics (1 Arnold Cir., Cambridge, Mass. 02139) uses 5 1/4-inch floppy disks for storage. Price: \$1,200.

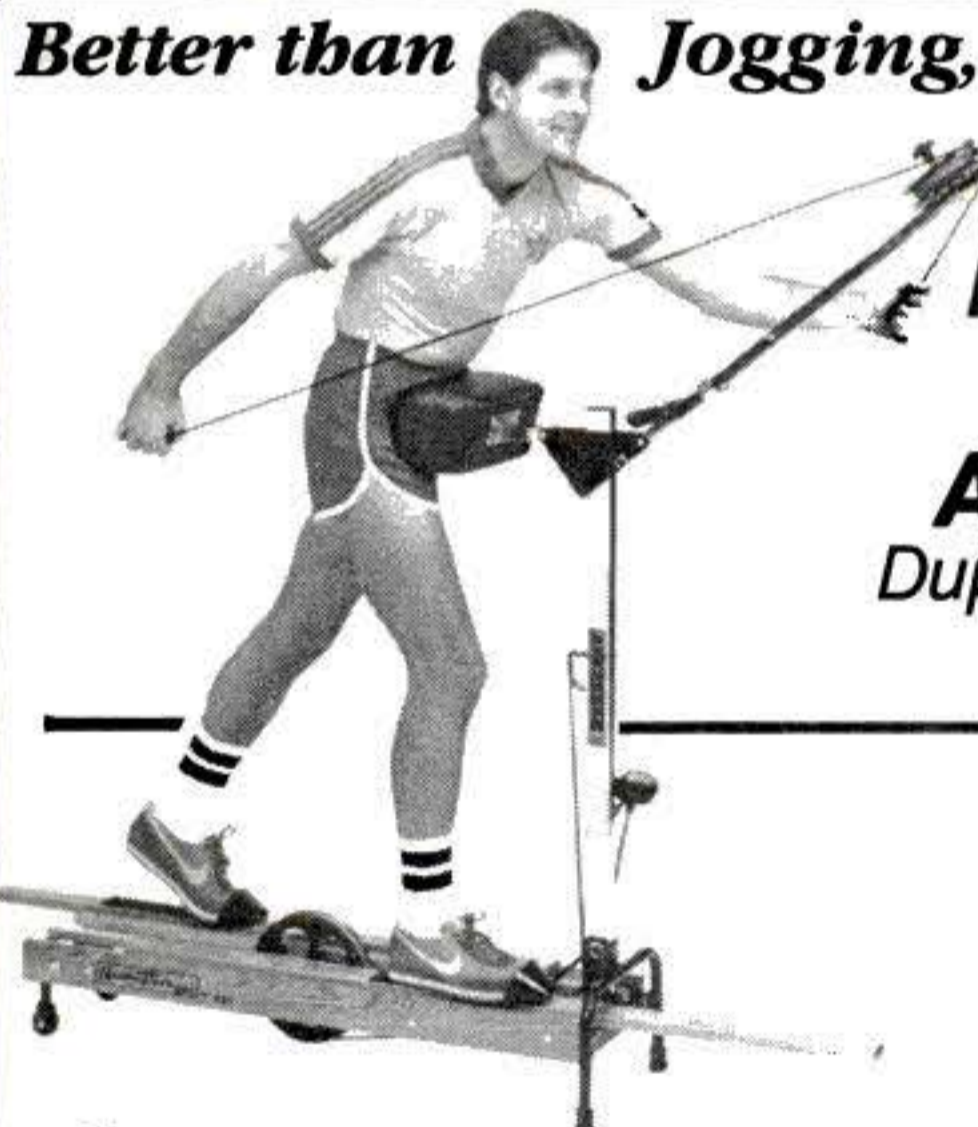
- Pocket color TVs from Hattori Seiko (Seiko and Epson brands) and Citizen have acceptable images. (They are both covered elsewhere in this issue.)

- Finally, a Sansui linear-tracking turntable allows you to pre-program any selection. A second arm plays the underside record tracks. The unit is presently a prototype.

A PS P.S.

The National Coalition on Television Violence has cited a specific cable channel as "quite troubling." After a two-week monitoring period the watchdog committee found 18 acts of violence an hour on one program, and that, it claims, can be harmful to children. Was it a shoot-'em-up? A thriller? Nope, it was the Disney Channel's Donald Duck and Mickey Mouse cartoon program. Mickey Mouse reportedly blasted the findings with an "Aw, shucks." PS

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Motor Trend, August 1983: "The Whistler® Spectrum™ resides at the top of the list. A world-class radar detector."

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BMW Roundel, July 1983: "Road testing places it (Spectrum) only about 50 feet behind the Escort in highway use, an impressive feat. City use is another matter altogether. Whistler has developed a truly useable circuit that outperforms any other detector, including the Escort."

331,000 Truckers: More American truckers and other professional drivers choose Whistler over all other speed radar detectors. Why? Consistent performance.

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High performance means sensitivity to radar signal level strengths below -90 dBm/cm². Quadradyne® (patent #4315261) circuitry puts Whistler Spectrum well beyond high performance. It's sensitive to radar levels of -103 dBm/cm² in the K Band. And an alert -111 dBm/cm² in the all-important X Band (the frequency used by about 80% of the speed radar systems operating in the U.S. today).

What does that mean? Spectrum *conclusively detects* all police radar. Stationary, moving, trigger—even pulsed radar. On the straightaway—from behind—over hills and around curves. If there's police radar in the area, Spectrum lets you know—long before the radar can sense you.

EXCLUSIVE FILTER MODE™

Sensitive receivers also detect microwave intrusion alarms, which are particularly frequent and annoying in urban areas.

Most receivers solve this problem with a "City" switch, which reduces the sensitivity by as much as 15 to 20 dB. (So a two-mile range is reduced to less than ¼ mile. You might as well turn it off!)

Spectrum's exclusive Filter Mode™ maintains *full sensitivity*. The filter simply changes the way Spectrum alerts you. Spectrum flashes amber and emits a single tone once every ten seconds, until the signal strength exceeds -95 dBm/cm². Then the system *automatically overrides the filter*. Displaying a flashing red light and giving off an urgent, geiger-effect, high-frequency tone.

POLLUTION SOLUTION™

Several imported radar detectors generate a signal on the X Band and K Band frequencies. They cause most radar detectors to "false"—but not Spectrum.

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The *Dash/Visor Model Spectrum*, measuring 1.5" × 3.75" × 4.5", is portable and compact. It plugs into the cigarette lighter socket, and mounts on dash or visor. It's quickly removed for use in another car, or to prevent theft.

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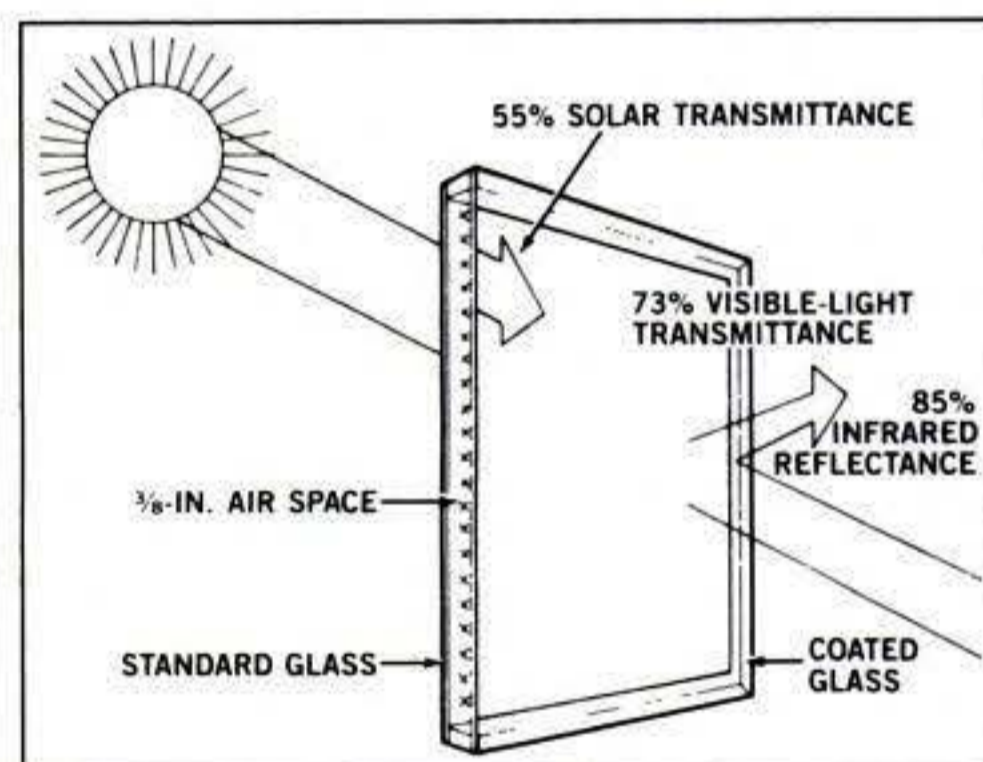
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947-094

PPG's superinsulated glass

Long-wave infrared energy, emitted by people and room-temperature objects, may account for one-half to two-thirds of the heat loss through your windows. In 1982 I wrote about two new glazings that look transparent but greatly reduce that heat loss, Heat Mirror film and Low-E glass ["Wonder Windows," PS, April '82]. Now PPG, which claims to be the world's largest manufacturer of flat glass, has introduced a similar glazing called Sungate 100.

Performance of Sungate 100 is comparable to that of the others: It reflects 85 percent of the long-wave infrared energy yet transmits 73 percent of the visible light and 55 percent of the



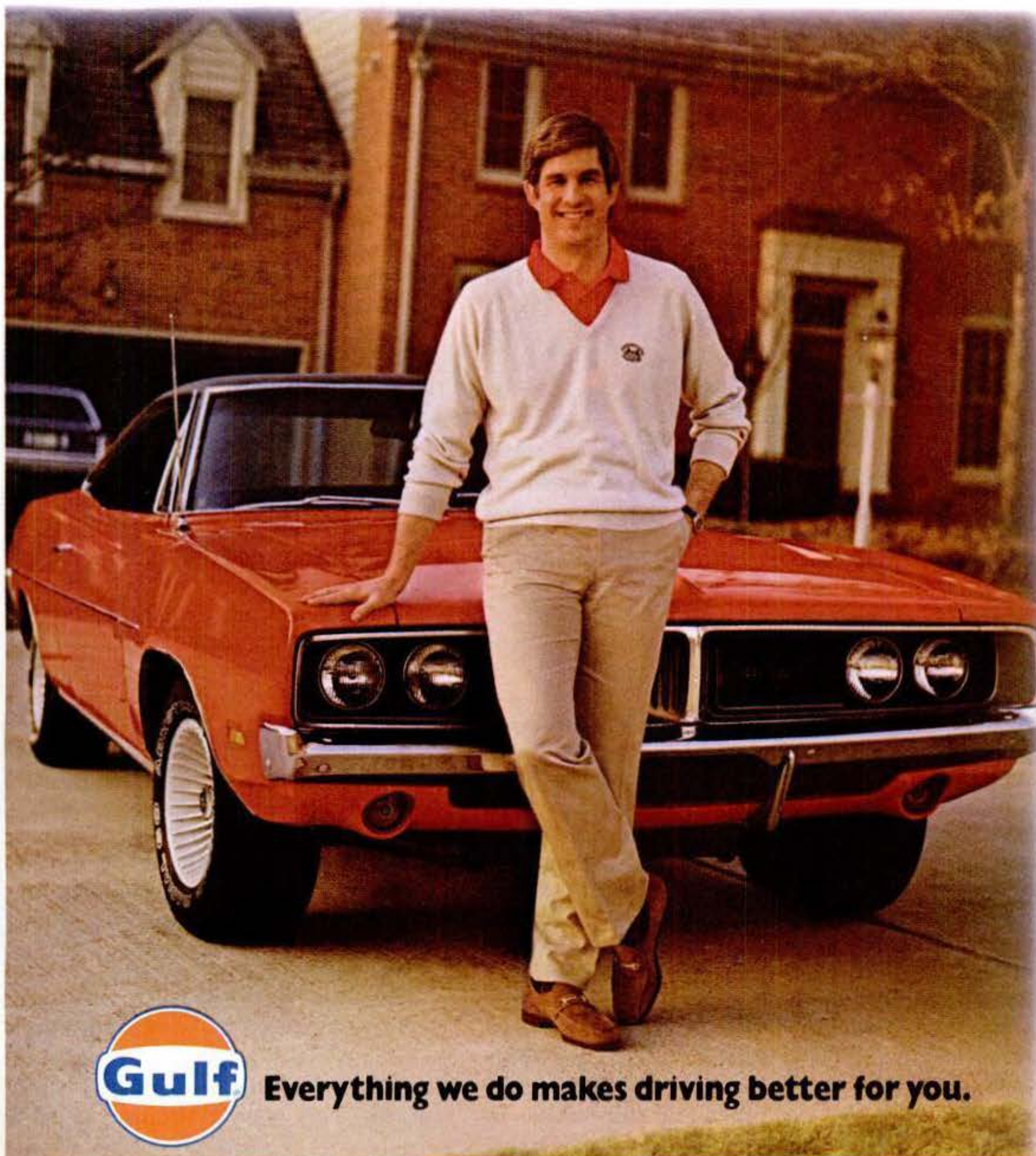
available solar energy. "The result," says Kears Pollock, PPG's director of research and development, "is a window that looks conventional, lets in light and solar heat, yet saves fuel and improves comfort." A double-glazed window with Sungate 100 as one panel insulates almost as well as standard triple glazing but without the bulk and weight.

Sungate 100 technology was developed by PPG but is similar to that used for Heat Mirror and Low-E glass. The IR reflectivity is achieved by an ultra-thin metallic film that is vacuum-deposited on the glass.

PPG will manufacture Sungate 100 windows for commercial buildings and will certify window and door makers to use the glass in residential windows. They will be available in the transparent version described and in Sungate 100 bronze, which transmits only 43 percent of the available solar energy and thus helps reduce air-conditioning costs. PPG estimates that double-glazed windows with Sungate 100 will be about equal in cost to standard triple glazing—16 to 20 percent higher than standard double-glazed windows.—V. Elaine Smay

Senior year, Dad lent me the money for this car.

I had to work construction all summer to pay him back. Do you think I'd use just any motor oil?



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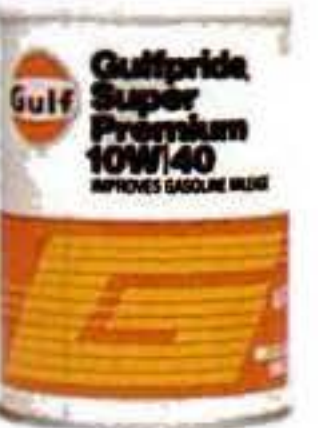
I put a lot of sweat into buying it. You better believe I treat it right.

I think Dad liked the car right off. He taught me to take care of it. To change the oil frequently. To use Gulfpride.

Of course, the car didn't get to be fifteen years old without a few things wearing out. Like the speedometer. The light switch. The driver's seat.

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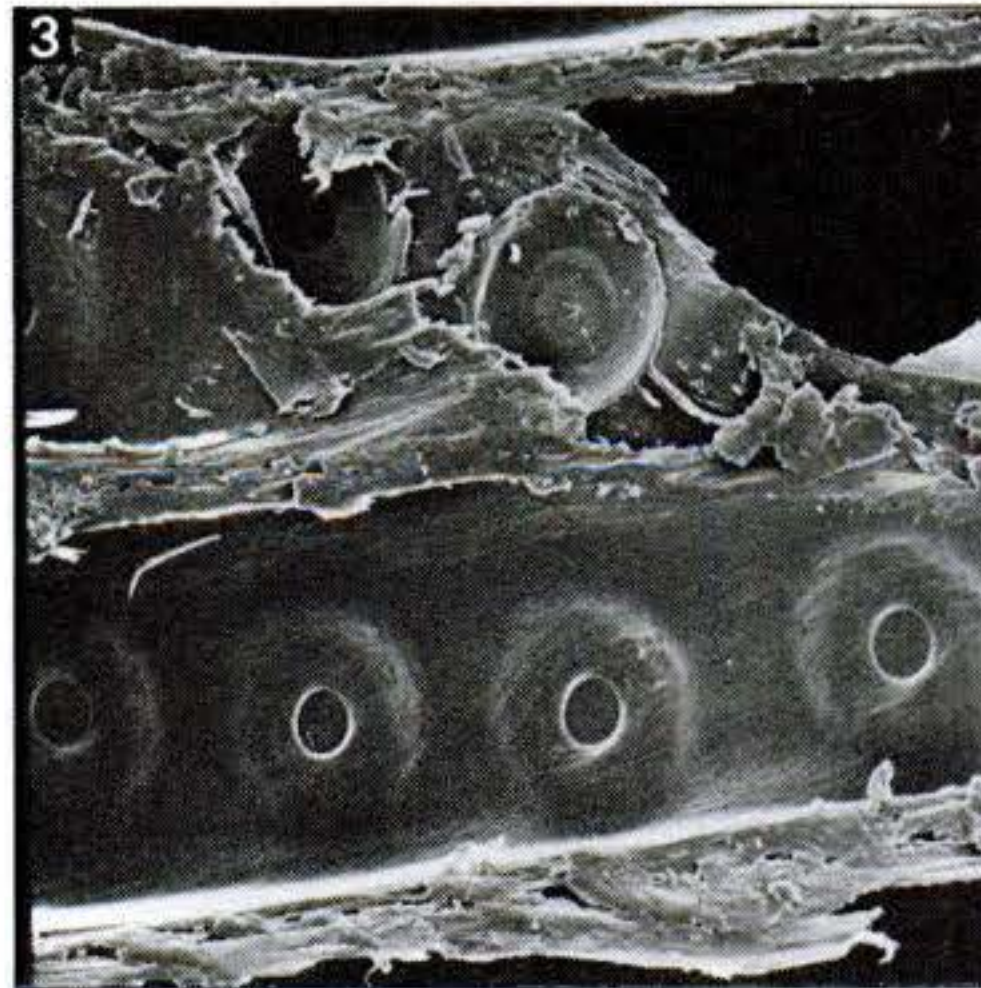
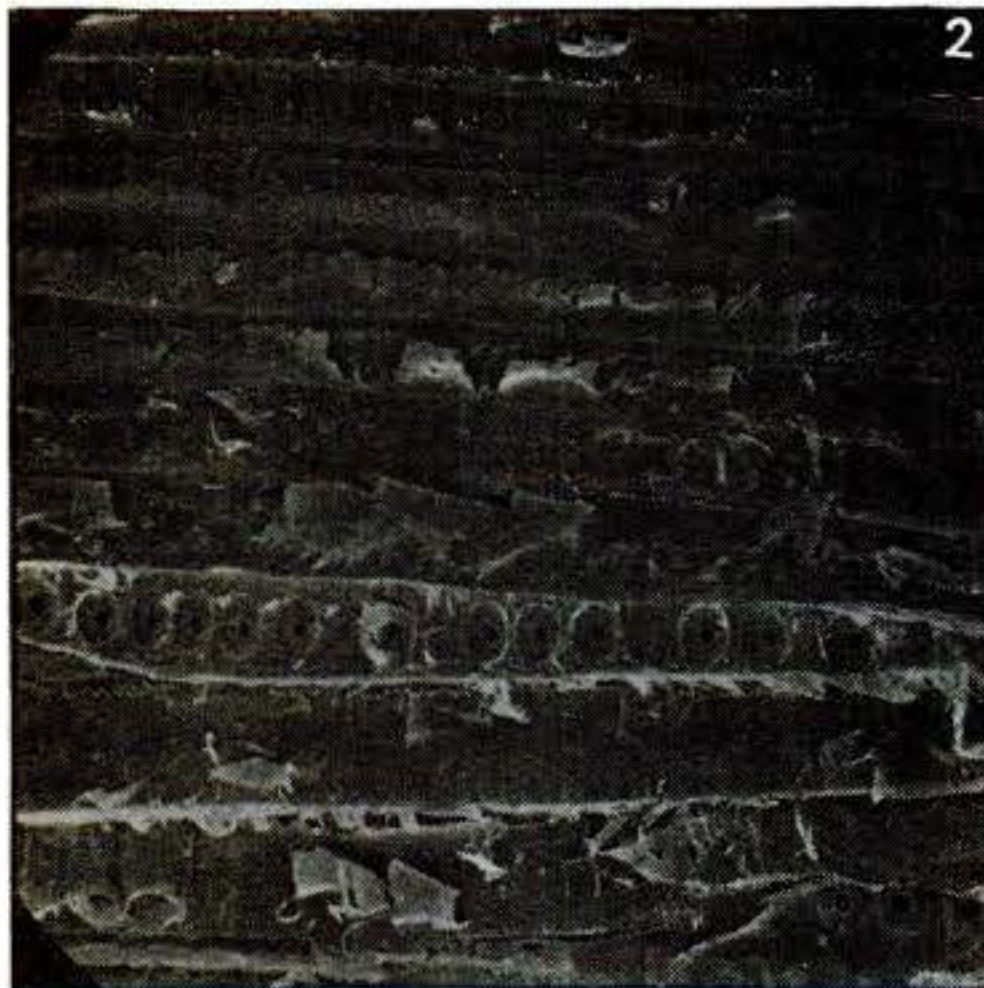
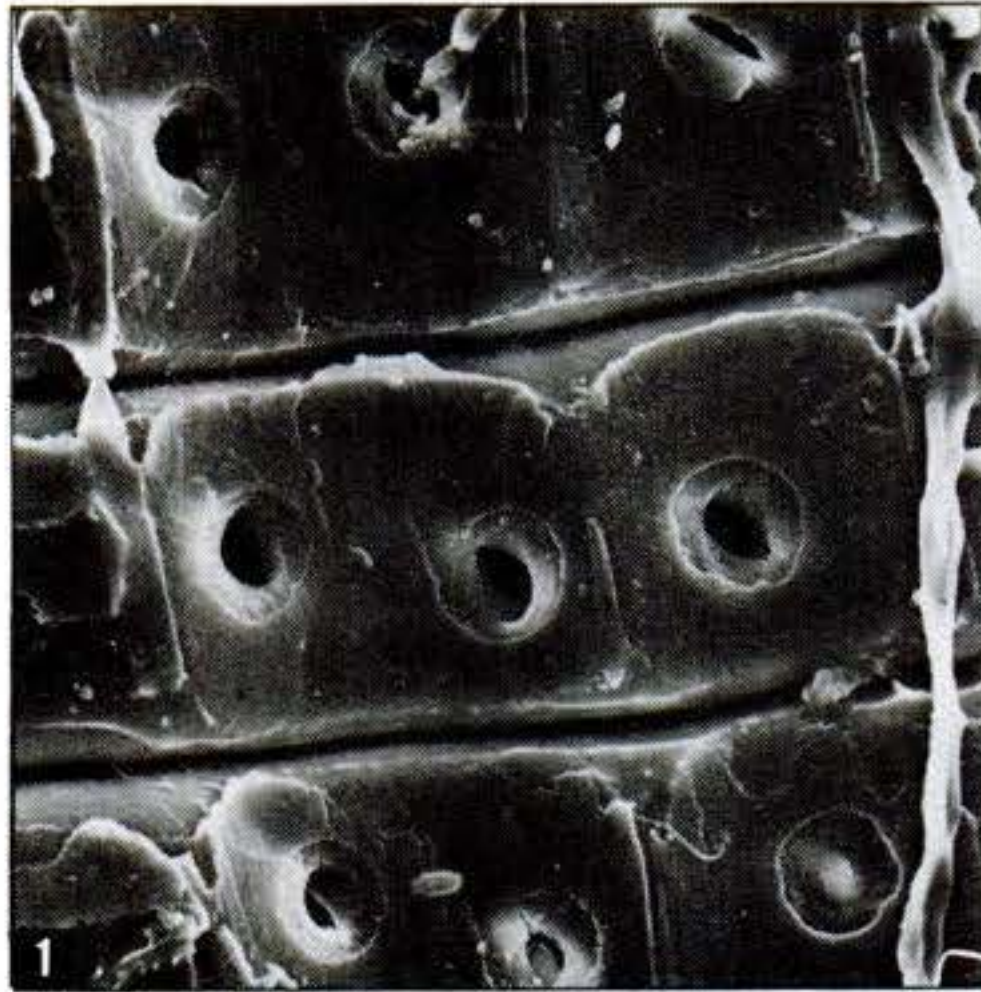
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Secrets of the Strad

A biochemist and amateur violin maker is aiming an electron microscope at tiny wood and varnish chips from Stradivari, Guarneri, and Amati violins, and he thinks he's found the secret to their sweet sound. Now he's trying to duplicate that sound in his own instruments.



Professor Nagyvary (top left) applies lessons he's learned from studying classic violins to instruments he makes. Electron micrographs show: (1) open-

ings in cells of wood treated with his process; (2) openings in wood cells from rare Guarneri cello; (3) closed cells in normal, untreated wood.

By DAVID LAMPE

Two centuries ago, annoyed that their successors' apprenticeships were much shorter than their own had been, northern Italian violin makers "forgot" the formulas for the wood treatment and varnish that had helped give the early Stradivari, Guarneri, and Amati instruments their clear, sweet tone.

At least that's one story told to explain why those formulas didn't get passed along. They seemed irretrievably lost until a biochemistry professor at Texas A&M University in College Station began applying an electron

microscope and the latest analytical tests to the quest.

The professor, Hungarian-born Joseph Nagyvary, himself an amateur violinist and violin maker, has found (among other things) traces of gold in a varnish chip from a 1660 Guarneri cello. "Not a massive amount," Nagyvary admits, "but at least a thousand times what you'd find in the wood naturally. Clearly, for their formulas the violin makers went to the leading scientists of their time," he explains, "the alchemists."

Nagyvary's electron microscope has also revealed that the cells of the wood, at least in the samples he has tested, are nearly all open. He thinks that is

critical to the instrument's tone. Any note played on a stringed instrument actually consists of that note plus several others of higher frequency, called harmonics, or overtones. "In a new instrument," Nagyvary says, "the wood cells are predominantly and randomly closed, which means you get too many overtones of the wrong nature. You can liken the effect to playing thousands of flutes all together. With all their holes open, they play one note. But close some of the holes randomly in some of the flutes and all of them in others, and you get a discord."

Nagyvary's studies have revealed that the wood used in the classic violins was pickled, or mineralized, by soaking in water. The soaking helped dissolve the natural pectic (jelly-like) substances in the wood, he believes. "That results in a certain 'looseness' of the wood cells," he says, "creating ideal noise filters." Left in, those substances can cap the wood cells, closing them and causing the harsher sound of modern instruments.

The varnishes used on modern violins are another problem, according to the biochemist. They are rubbery and dampen the vibration. The finish used on the classic violins, he believes, contains chitin, the hard material of insect skeletons and wings. It forms a stiff finish that does not dampen the sound.

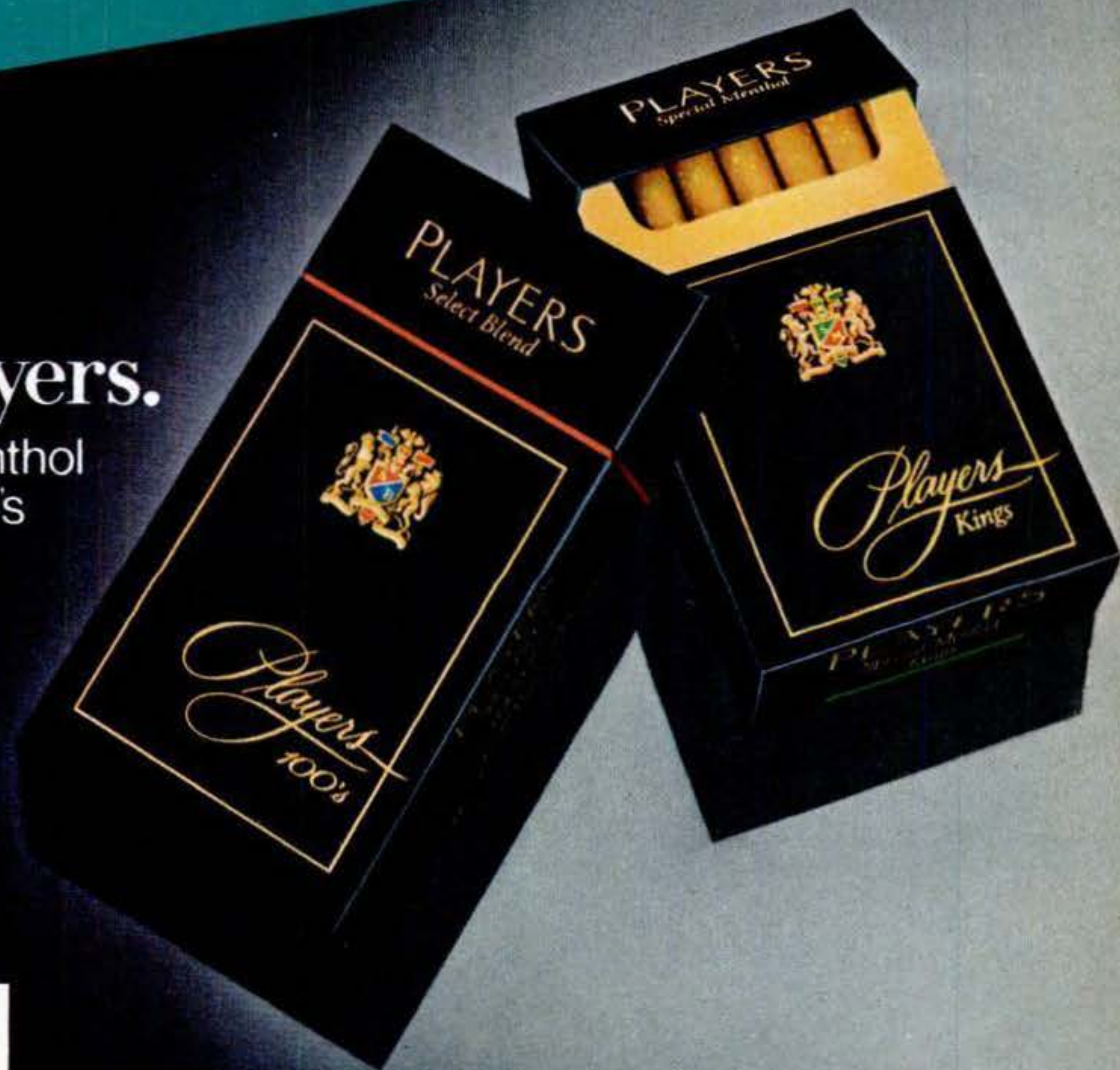
Though scientific investigations of the classic violins have been going on for more than a century, Nagyvary thinks he is on to something with his electron-microscope studies. And he is already using his discoveries to make violins that are impressing some people. According to Stradivari expert Isidor Saslav, a Peabody Conservatory professor, a Nagyvary violin sounds more like one of the Italian vintage instruments than any other modern violin he has encountered. And recently concertmasters Glenn Dicterow of the New York Philharmonic, Victor Aitay of the Chicago Symphony, and Kyla Bynum of the Houston Symphony have played—and praised—Nagyvary's violins. **PS**



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Magnesium, anyone?



Prince, the company that brought you the tennis racket with the oversize head ["Super Racket," PS, March '77], has come up with yet another innovation. Just added to a racket lineup that includes frames of aluminum, graphite, and boron (and a price range of \$49 to a stunning \$420): the Prince Magnesium Pro, priced at a relatively modest \$109.

The racket's frame is fashioned from a magnesium extrusion. Its claimed advantages: stiffer than aluminum for greater control and power; lighter than aluminum (about 12½ ounces) for better maneuverability; and stronger than graphite for durability. Also, magnesium is less expensive than graphite.

As with all Prince rackets, the Magnesium Pro has a 110-sq.-in. head, which is 50 percent larger than those of conventional rackets. The major claimed advantage is a "sweet spot" (best place on the strings to hit a ball) 350 percent larger than those of ordinary rackets.

How does the magnesium racket play? As an intermediate player, I found that I could sustain longer, more-satisfying volleys with it. Control was much improved over my conventional racket. My overall impression: a firm racket that put more power in my game.—*R. L. Stepler*

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Science education gets a computer boost from Atarilab

The scientific demonstration was a little unusual. First, the site was not a collegiate hall but a New York office. Second, the audience was composed of journalists. Third, the lecturer was a junior-high-school student.

"If we place the temperature sen-

sor in a glass of cold water, ask the computer to record the water temperature every second for five minutes, and then ask it to show a graph of the data as it's gathered," the lecturer said, "we can see on the screen a classic Newtonian cooling curve."

Our lecturer was not so much concerned with filling us in on Newton as he was with demonstrating Atari's new Atarilab Temperature Module, a computer program capable of tabulating and graphing data obtained from a temperature sensor.

The temperature module is the first in a series of Atarilabs—others include pH and biofeedback—that Atari believes will change the way science is taught in junior and senior high schools. Each Atarilab, which consists of a 16-kilobyte cassette, a sensor, and an experimenter's guide, will sell for \$89.95.

Plans are to make Atarilabs compatible with other popular personal computers. But the greatest selling point of Atarilab, according to the manufacturer, is that it solves a basic problem in science education.

"Doing science is more important than learning science from a book," explains Priscilla W. Laws, professor of physics at Dickinson College in Carlisle, Pa., and developer of Atarilab. "But students spend too much time putting data on forms. Atarilab creates tables and graphs at the push of a button, freeing students to do real science—that is, to run experiments and wonder 'what if.'"

Because the commands are simple and few, class time won't be devoted to hours of computer lessons, says Atari. To test just how easily Atarilab can be mastered, I asked the programmer of the temperature module, 15-year-old David Egolf, for a lesson.

We decided to reenact the earlier demonstration of Newton's law of cooling. Into a glass of ice water went the sensor. At his prompting I hit a cursor button for the bulb option, which brought to the screen a representation of a thermometer with the current temperature. I recorded that temperature by hitting "start."

I learned quickly that cursors are the way to enter commands. I chose the "set-up-experiment" option by hitting a cursor button. Then I ran the cursor down a column of numbers to set a time interval at which the computer will record readings and the total time of the experiment. I picked a temperature system in which to display data by moving another cursor. (Atarilab is at home in both Celsius and Fahrenheit.) The demo option told the computer to graph incoming data. After a 15-minute lesson, I was ready to solo.

I stole glances at my watch as I sat and watched the line of the graph advance. But there was no reason to keep track of the time, Egolf told me. Atarilab beeps when the experiment is over.—Richard Layne

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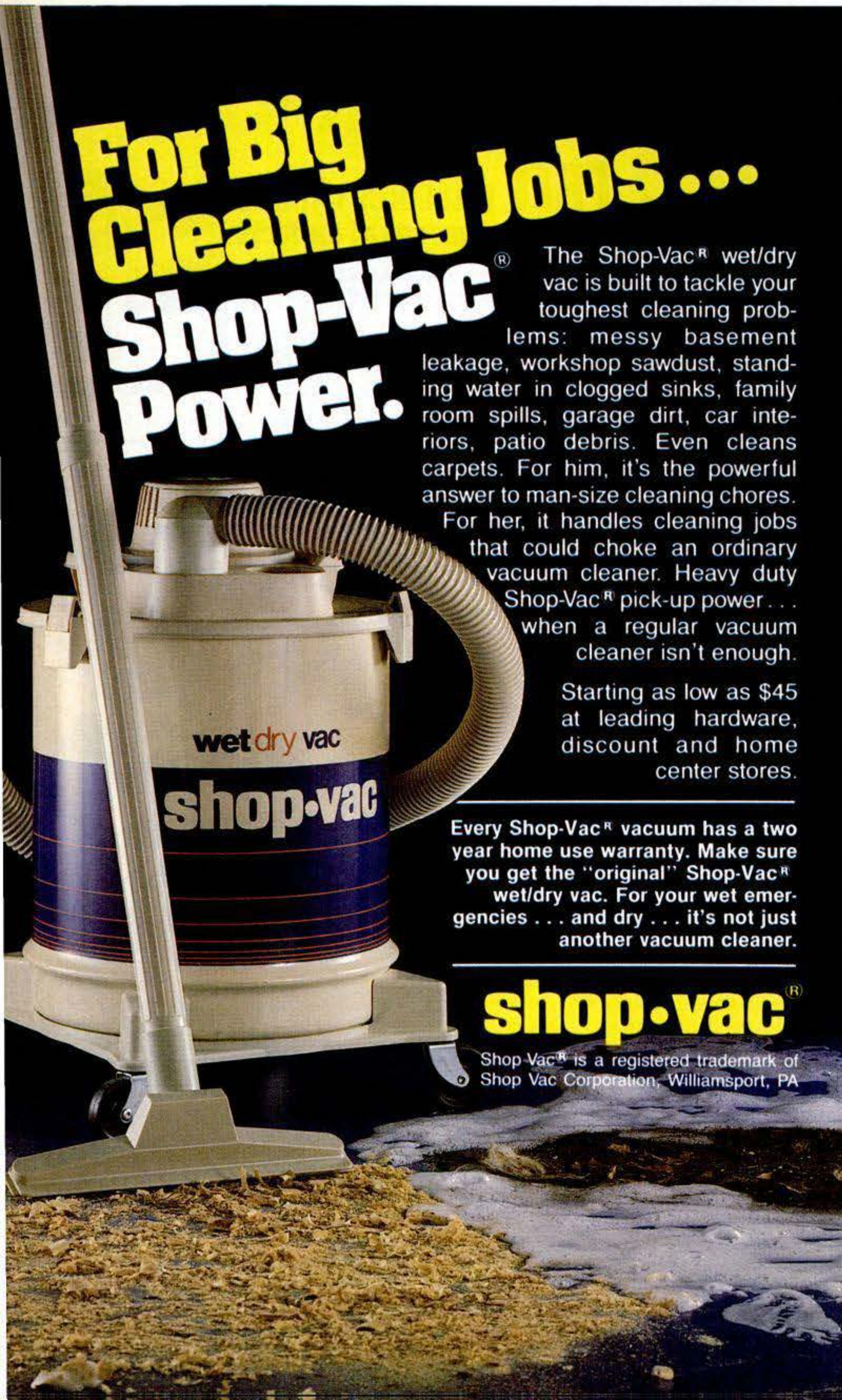
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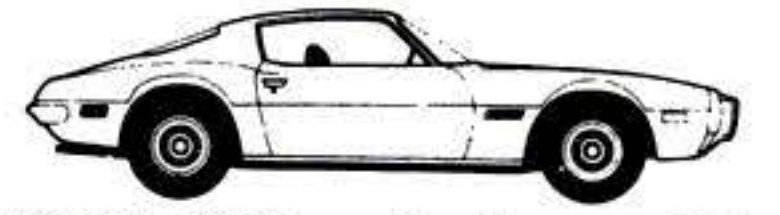
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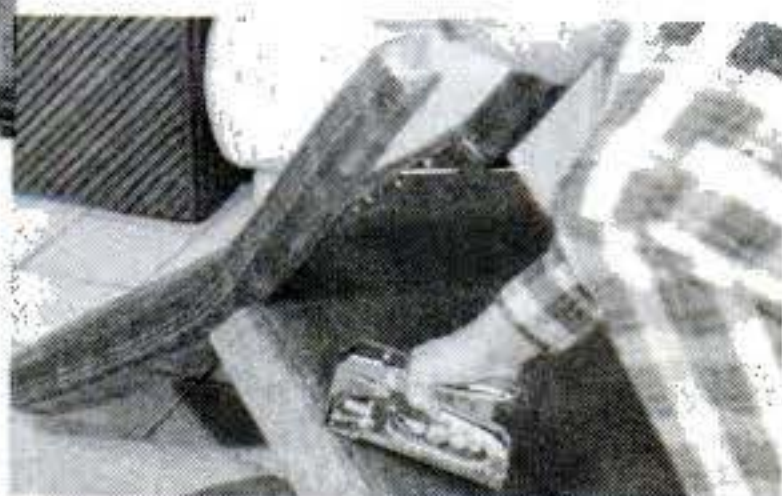
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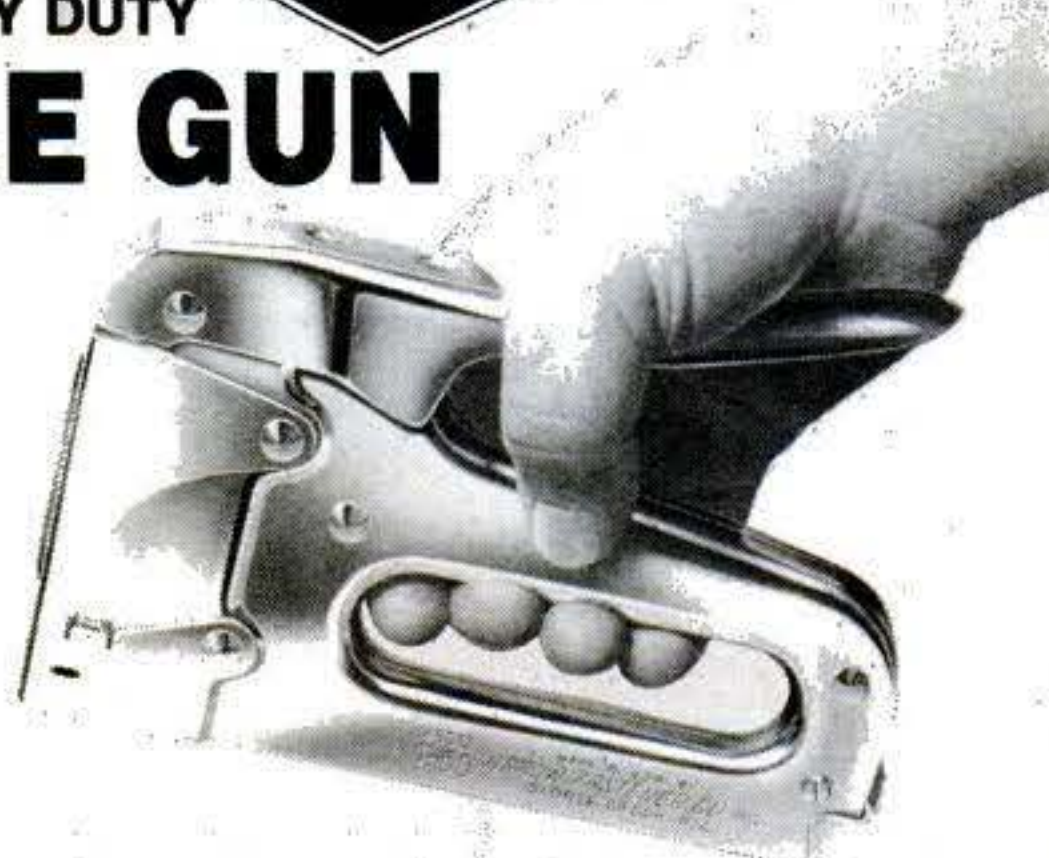
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PS 3,000-mile test: Buick Park Avenue



The Buick Electra Park Avenue is a sedan suspended in General Motors' automotive equivalent of limbo. On the one hand, it must appeal to new buyers interested in fuel injection, precise handling, and the space efficiency of front drive. On the other, it must not upset the older traditional buyers of this type of soft-riding, quiet, commodious land yacht.

Thanks to the taller, formal roof line, there's plenty of head room in this rolling living room. The new car is only 0.3 inch shy of the head room in the old model. Adding to the sitting-room ambiance is lots of wood-grain plastic trim on the instrument panel and doors.

The Buick is remarkably quiet, except for some wind noise around the mirrors and some odd suspension drumming over rough roads. Front seating consists of soft yet supportive leather-covered six-way adjustable power seats. The 60-40 arrangement of the front seat and the wide bench in the rear provide uncompromised seating for six. In comparison with most new cars, the Park Avenue is a big car at 196.2 inches. But that's still more than two feet shorter than the old model. It weighs about 3,276 pounds.

At about 1,500 miles the driver's side window stopped working. I pulled the door's trim panel off and jiggled the wires. The window started working but quit again about 500 miles later. Another problem was more difficult to diagnose. Initially the car seemed much too softly sprung. After it encountered potholes, the chassis would continue to rebound, taking what seemed like forever to recover. It also rolled heavily to the outside of even low-speed turns. Investigation revealed a loose wire at the sensor for the electronic leveling system. Once I reconnected the wire, the car took on a much improved ride character.

Easily the sweetest part of this new package is the drive line. Rumors were that further refinement of the C-body's four-speed transmission is what delayed this car's introduction. If so, the wait was worth it. Shifts are textbook clean and crisp. The 3.8-liter (231-cu.-in.) fuel-injection V6 rivals the smoothness and power of small V8s at everything but idle. (Strangely, all of the new Electras I've driven with this V6 vibrate strongly at idle.) On the economy side, the 3.8 averaged just less than 19 mpg over the 3,000-mile test period, and one long highway cruise netted 24 mpg. Our heavily equipped test model listed at \$19,300.—*Jack Keebler*



In Japan, where high-tech electronics are a way of life, they pay \$714.93 for an American-made radar detector

(You can get the same one for considerably less)

Even we were a little surprised. All we did was build the best radar detector we knew how. We shipped our first ESCORT in 1978, and since then we've shipped over 600,000. Along the way the ESCORT has earned quite a reputation—among its owners, and also in several automotive magazines.

Credentials

Over the past five years, *Car and Driver* magazine has performed four radar detector comparison tests. Escort has been rated number one in each. Their most recent test concluded "The Escort radar detector is clearly the leader in the field in value, customer service, and performance..." We think that's quite an endorsement.

Our Responsibility

One of the reasons for our reputation is our attention to detail. If we don't feel we can do something very well, we simply won't do it. That's why we sell Escorts direct from the factory to you. Not only can we assure the quality of the ESCORT, but we can also make sure that the salesperson you speak to is knowledgeable. And if an ESCORT ever needs service, it will be done quickly. And it will be done right.

50 States Only

And that's the reason we don't presently sell ESCORTs outside of the United States. Even in the countries that use identical radar (Japan and Australia, to name two) we know that we couldn't provide the kind of customer service that ESCORT owners expect. So we pass up the additional sales rather than risk our reputation.

"Dear Sir..."

So we'll admit we were surprised when a letter from one of our customers included an advertisement from a Japanese automotive magazine. The ad pictured an ESCORT, and the price was 158,000 yen. Our customer was kind enough to convert that to U.S. dollars. Using that day's rate of exchange, an American-made ESCORT was worth \$714.93 in Japan. Further translation revealed the phrase "The real thing is here!" and warned against imitations.



This 1/2 page ad was a total surprise.

Econ 101

Needless to say, we were flattered. We knew that ESCORT had an impressive reputation, but we never expected to see it "bootlegged" into other countries and sold at such a premium. But the laws of supply and demand are not so easy to ignore. When there is a strong need for a product, there is an equally strong incentive for an enterprising capitalist to fill that need. And apparently, that's just what happened.

The Moral

We still don't sell out of the country. And the price in this country is still \$245. The price we've had for the last five years.

Quite a deal for what the Japanese must think is the best radar detector in the world.

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Warning: The Surgeon General Has Determined
That Cigarette Smoking Is Dangerous to Your Health.

17 mg "tar," 1.1 mg nicotine av. per cigarette, FTC Report Mar. '84

What's News

Why take on the challenge to fly around the world nonstop without refueling? I suppose for the same reason people climb mountains: "Because it's there." To put that another way, it's because human beings seem to like to test themselves against great odds—just to see if they can prevail. That's why we climb mountains, run marathons, work as though our lives depended on it to learn to play par golf or ski like an expert, and do a thousand other things that have no inherent value but give us great satisfaction in accomplishing them.

That's why Burt Rutan's new plane is exciting. This most innovative of aircraft designers has used every trick he knows to build a plane that can achieve an unimaginably difficult goal. The result—as the cover photo by Ben Kocivar shows—is a startlingly different-looking plane. And it *is* different. Just two examples: It is a floating fuel tank, weighing when fully loaded almost 11 times its empty weight. And its skin is so delicate that Rutan lets no one get close: He fears someone may poke holes in it with their fingers.

Whether or not this strange airplane achieves its goal, it is clear that Rutan is a seemingly inexhaustible source of exciting new ideas. He is, in fact, single-handedly changing the way airplanes are built. One bit of evidence: This is the fourth POPULAR SCIENCE cover devoted to his designs. If you'd like to refresh yourself on some of his other pace-setting designs, the covers (and articles) appear in November 1978, August '81, and May '82. In addition, two other planes that appeared on the December '83 and June '84 covers incorporated Rutan trademark features.

Underground debate

In May, Everett Ortner, writing in this space, summarized the conclusions reached by a team at Oak Ridge National Laboratory. They had compared life-cycle costs of earth-sheltered passive-solar houses in five U.S. cities

with those of an energy-efficient above-ground house. They concluded that the aboveground house was a better buy in all five cities over the course of a 30-year mortgage.

Charles A. Lane, an expert on earth-sheltered construction and author of our November 1982 piece "Underground Basics" objected. Lane has impressive credentials: He is a general partner in Terra Builders, Inc., Denver, Colo. He is also a research scientist in energy-conservation development for the Minnesota Department of Energy and Economic Development and was formerly the assistant director of the Underground Space Center at the University of Minnesota. Here are his comments:

"The Oak Ridge report presented some sweeping answers to some difficult questions. I have many reservations about the authors' methodology and hence their conclusions.

"1. The ORNL researchers selected seven parameters to use in dividing the country into 15 regions. These included annual heating degree-days, length of cooling period, precipitation, annual mean relative humidity, and mean solar energy received. The study compares the energy efficiency of earth-sheltered and above-grade houses based, in part, on those parameters. It is implied in the report that the ORNL researchers fully understand how these factors correlate with energy efficiency in houses. Meanwhile, other research organizations, including Lawrence Berkeley Laboratory, Princeton University, the Minnesota Building Energy Research Center, and the Minnesota Energy Division, are actively investigating that correlation.

"2. The researchers used two completely different computer programs to predict the energy usage of the aboveground and earth-sheltered houses. As a table in the report indicates, the results for the same house in the same location are different with the two programs. This results in an apples-to-oranges comparison.

"3. In the study, all houses in all locations are assumed to use an electric air-to-air heat pump for heating and cooling. That may not be the best choice for all locations and all design loads. In most other respects the researchers consider prevailing local practices. I wonder why they did not consider local practices in this critical area.

"4. The life-cycle-cost analysis is, of course, dependent upon the data input, some of which I have already questioned. In addition, how does one accurately predict such volatile variables as discount rate, income-tax rate, property-tax rate, inflation, maintenance cost, and replacement cost over the time period of a 30-year mortgage? And finally, who holds a home mortgage for 30 years anymore?

"In summary, I contend that we have a long way to go in answering the important questions identified in the ORNL report. Computer models are a valuable tool in research; however, they are only that—a tool. If the input is inaccurate, the output is also. Remember the first law of computer modeling: 'Garbage in; garbage out.'"

The many facets of a new technology—including differences of opinion—make watching the development of a field endlessly fascinating. Want to find out how this one comes out? Stay tuned to this magazine.

74 vs. 75

Why do we have "74 portable computers" on our cover this month—but 75 inside? Because covers have an earlier printer's deadline than the magazine's innards, and the 75th new computer appeared on the market in time for the inside of PS but not the outside.



Editor-in-Chief

Engineering the new breed of walking machines

Teaching a machine to walk is tricky. For years research engineers' attempts produced ill-coordinated, multi-legged mistakes. Now, however, several teams have created machines that walk well. The key? Miniature on-board computers that control each leg.

By **PETER BRITTON**

Photos by Jim West and the author

Odex was hunkered down in the back of a small Dodge pickup truck when I arrived at the Odetics laboratories in Anaheim, Calif. I had come to see the most advanced of a new breed of robot. I found a creature with a fishbowl head perched atop six spindly legs—an integrated whimsy of mechanics and electronics and software. But this deceptively simple-looking device is highly skilled; it can walk.

Walking, a natural act for a person, is a formidable task for a robot. Replace wheels with legs, and you compel the machine to wrestle with several demanding tasks at once. A legged robot must learn to keep its balance as it chooses among a vast array of possible leg movements. The robot must coordinate these movements while checking whether each leg has landed in the proper spot. Without sensors a robot could place one leg in a pothole and one up a tree, and never know it.

Researchers, aided by the advent of microprocessors, are close to solving these problems. The design strategies vary, but each of the several ground-walking robots now under development will be more than mobile. They will be strong, agile, and—directed by advanced software—virtually independent of human operators.

Though still laboratory-bound, Odex I is the most accomplished of the new breed. The collection of metal and plastic squatting in the truck bed looked more amusing than impressive, but I knew the robot had outperformed both its ancestors and its contemporary competition.

Patents for walking machines—as opposed to tracked or wheeled vehicles—have been around for about 100 years. Machines that actually do walk have been few. One of them was Space General's radio-controlled eight-legged walker. In 1963 the Army briefly considered this walker for further development. But it was little more than a windup breadbox that scuttled, demonstrating that something could “walk” on irregular terrain.

A General Electric walking machine of a few years later had the size and look of a besotted elephant. The Quadraped Transporter's two front legs were controlled by the on-board operator's arms, its hind legs by the operator's legs. The hydraulically powered machine was said to be capable of felling trees, but the mental and physical stamina needed to run it quickly exhausted the driver inside. Still it did, for a while, walk.

By contrast Odex I can gather itself up like a giant daddy-longlegs to dance elegantly on tiptoe. The nimble robot can also squat down and sidle crabwise across the floor, carrying a heavy load. The key to Odex's agility is

an on-board computer—something earlier walking machines lacked. Among other things the computer dictates speed, provides algorithms that keep legs from hitting each other, and correlates information to avoid obstacles.

As I watched technicians ready Odex for action, Odetics director of engineering and research Marvin Russell described the robot's design. Odex moves three legs at once, using a “tripod gait.” This provides, according to Russell, optimal balance and speed.

Information for each movement or sequence of movements is stored in the master control computer, which is housed just below Odex's fishbowl. The computer sends commands to six lower-level microprocessors, each responsible for telling one leg exactly what to do.

While Russell filled me in, attendants lowered the tailgate of the pickup truck, and an engineer readied the small electronics panel that would control the robot's movements by radio signal from the far corner. Soon Odex stirred and slowly rose to nearly its full height of six feet, six inches. Its legs were splayed out in a rough circle measuring 72 inches in circumference, 33 less than the maximum. “These legs extend themselves in strides up to 44 inches in length at a rate of 18 inches per second,” Russell said.

It's alive!

While I watched, Odex I gently trembled and whirred and prepared to take its first step for me under the guidance of senior staff engineer Stephen Slykhous. Then, with a suddenly smooth motion, two of the robot's feet moved onto the lip of the tailgate.

Slykhous then initiated a pre-programmed series of actions by pushing the button on the control panel that says, in effect, “Get out of the truck.” With a barely perceptible stop in forward motion, a spindly forward leg reached forward and down as two rear ones moved an equal distance forward and under the body.

Then, in a scene reminiscent of both the lunar landing and “E.T.,” a single aluminum shaft touched down and planted its rubber tip firmly on the linoleum. It was a spooky moment, watching this first “functionoid” (as the robotics experts call it) find firm footing.

As the single front leg moved, the two rear legs also simultaneously moved forward. Finally the front two legs on the edge of the tailgate lowered themselves to the floor, and the single remaining rear leg brought the afterpart of Odex forward. Now Odex hit the ground articulating, all legs on the floor, its 24-volt, 25-ampere-hour aircraft battery providing the power.

To take this one impressive step Odex had carried out a complicated set of activities. First a leg computer told a servo driver to move that leg. Controlled by transistors,



Versatile Odex I hefts a 275-lb. weight (above) and squats low to the floor (below right). A command radioed from a separate control board (right) triggers pre-programmed sequences stored in the master computer in the robot's "neck."

power was applied to motors inside each leg: vertical motors to lift the leg, extension motors to move it out.

In this closed-loop servo, information is fed into the computer on each leg and then to the upper-level master control computer, telling it how far out each leg has gone—in effect, where it is in space. When a predetermined distance is reached the main computer tells the leg to stop and put its foot down on the surface—completing the step. Then, depending on the program, the computer either initiates another step or signals the operator, "You now have control," telling the operator to start the next program.

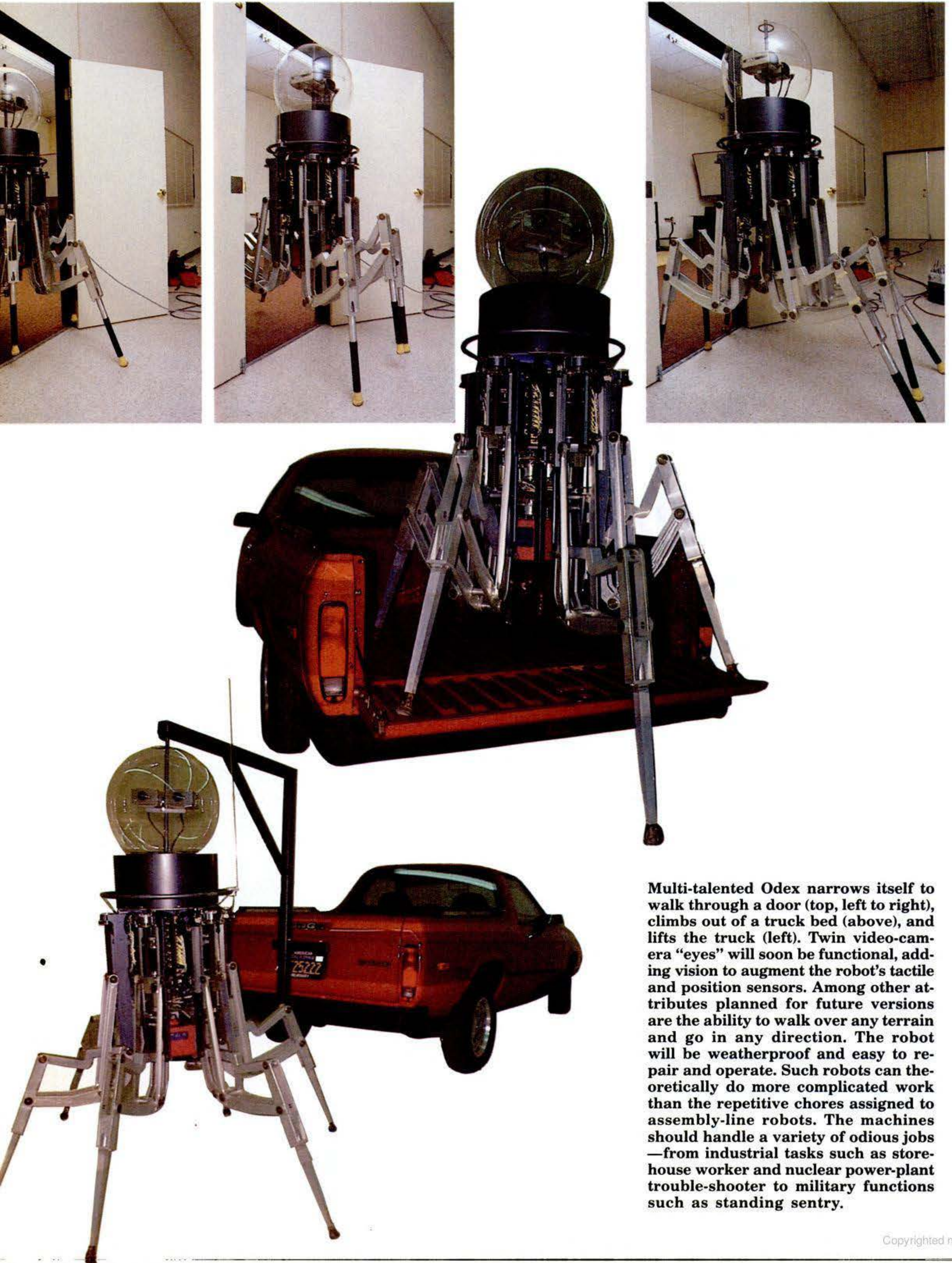
Slykhous paused as he punched in a set of commands for Odex. "We're just now installing sensors for the feet," he told me. "These will tell Odex that the floor is somehow not as we have described it in the program. This can be considered the very first step toward true autonomy."

Then—to demonstrate the potential that has interested both private industry and the military—Slykhous put Odex through a series of tricks. As I watched, the truck's tailgate was raised and a frame was attached to the rear. Odex squatted and walked beneath the frame, fitting its metal center rod into a slot in the frame. Then the func-

Continued



“Adding ‘intelligence’ is the



Multi-talented Odex narrows itself to walk through a door (top, left to right), climbs out of a truck bed (above), and lifts the truck (left). Twin video-camera “eyes” will soon be functional, adding vision to augment the robot’s tactile and position sensors. Among other attributes planned for future versions are the ability to walk over any terrain and go in any direction. The robot will be weatherproof and easy to repair and operate. Such robots can theoretically do more complicated work than the repetitive chores assigned to assembly-line robots. The machines should handle a variety of odious jobs—from industrial tasks such as storehouse worker and nuclear power-plant trouble-shooter to military functions such as standing sentry.

challenge; autonomy is the goal”

tionoid proceeded to pick up the pickup and, walking sideways, carry it through 90 degrees, lifting with apparent ease some six times its own 375-pound weight.

Odex next demonstrated an impressive agility. It approached a 40-pound circular pedestal with a ring on top, positioned itself alongside, and lifted the pedestal with one leg. Then it lowered the pedestal and nimbly climbed on top, contracting itself into a tuck position with a smart metallic thunk.

Now, dismounting, Odex started across the room at a 45-degree angle to me. In an extraordinarily smooth motion it suddenly swiveled in mid-stride and aimed directly at me, approaching at a fast walk. It gained on me all too quickly and I backed through a handy doorway, much too narrow for the advancing functionoid. Odex came to a halt and did an amazing thing: It narrowed itself to a mere 21 inches wide from its former 105 inches and walked through the doorway, right at me.

As I found myself backed against the wall, Odex stopped. Then a leg was extended in an obvious offering of peace. I accepted it and shook it heartily, knowing full well that here in this storeroom in Anaheim I was witness to the future.

Further challenges

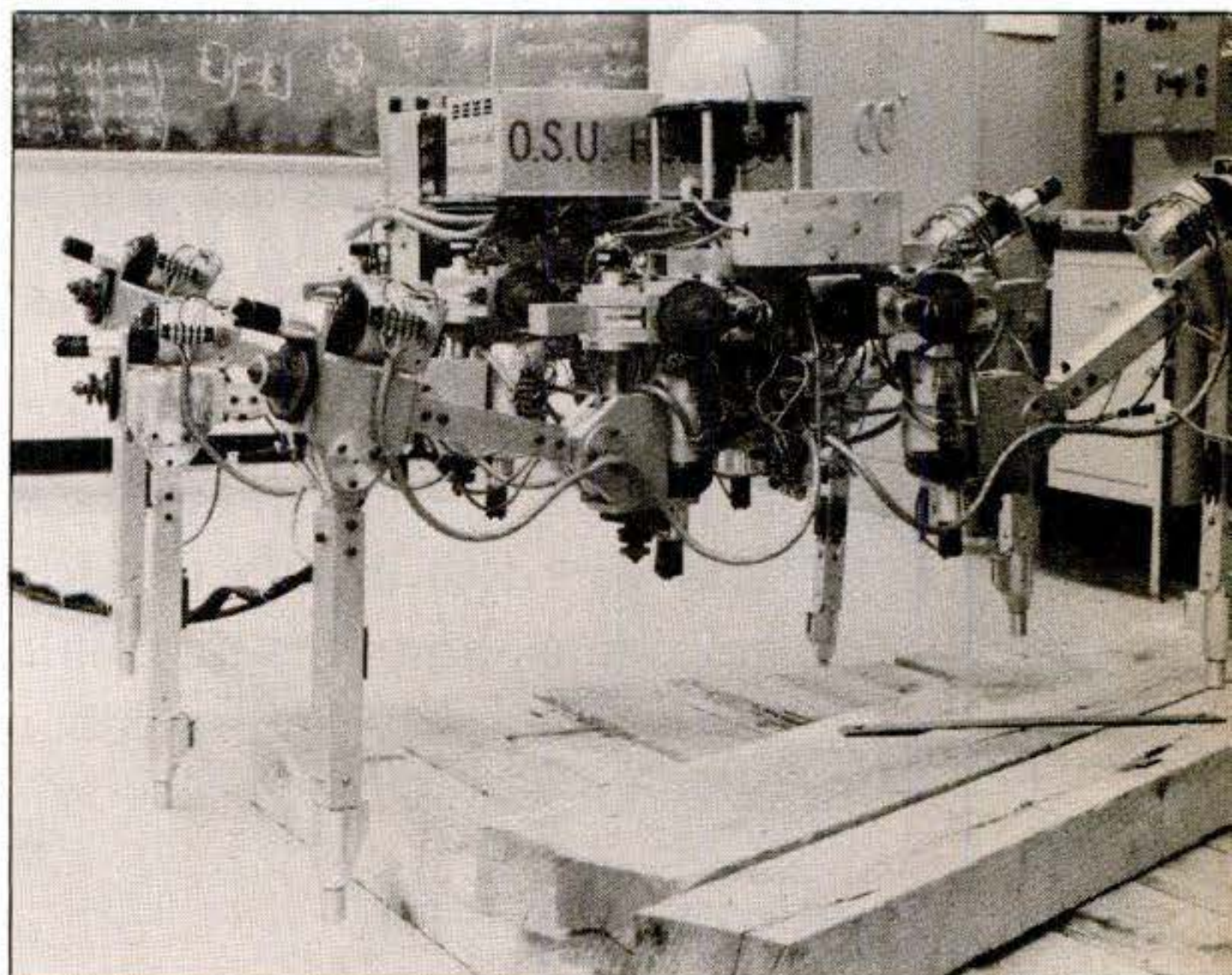
Dubbed a “capability model” by Odetics, this breakthrough robot is not quite ready to hit the road despite its formidable achievements. “As with other robots in the same boat, adding ‘intelligence’ is the challenge,” Russell said. “And autonomy’s the goal.”

How far has this research advanced? Carnegie-Mellon University has developed a single-legged device that can hop and run in three dimensions like a kangaroo. Its role is to help researchers investigate the problems of balance, which some say is the key to successful walking machines. The U.S. Department of Defense’s Defense Advanced Research Projects Agency partially funded this “pogo stick” project. The agency is also involved in another, quite different walking machine, the Adaptive Suspension Vehicle. This machine, developed under the direction of Drs. Robert B. McGhee and Kenneth J. Waldron, engineers at Ohio State University, is scheduled to take its first walk later this year. In the beginning the vehicle will use an on-board operator who will use aircraft-like controls and displays and who will steer and control speed. An on-board computer will automatically select footholds using terrain data from a cab-mounted, laser-scanning vision system.

McGhee claims that the machine will be able to walk at about eight miles an hour, take six-foot strides, step over six-foot-wide ditches, scramble over six-foot-high walls, and climb 60-percent slopes. The power will come from an 80-horsepower internal-combustion engine; a high-energy-density flywheel will smooth power demands to the engine. Each of 18 joints will be powered by a lightweight hydrostatic transmission.

The current generation of this and other walking machines, according to McGhee, “is operated mainly in a ‘supervisory control’ mode in which a human operator, either on board or remotely situated, controls vehicle speed and direction. But thanks to recent advances in sensors and in image understanding, we are now beginning to consider fully autonomous operation.

“In this mode the operator sets only high-level goals. The machine navigates independently to an assigned location and performs the designated task without human intervention.”



Hexapod (top), an early walking machine developed by OSU’s McGhee, was controlled via a cable link. OSU’s 2.5-ton Adaptive Suspension Vehicle (above) has six-ft. double-jointed legs with “ankle” sensors to handle rough terrain.

There is a world of assignments awaiting these and other robots now under development. SRI International has found, in the Army alone, over 100 potential applications for mobile robots—including sentry duty and hazardous duties such as mine disposal and exploration of hostile or inaccessible areas.

In a separate report the Army’s Training and Doctrine Command envisions a future battle scenario called Air-Land Battle 2000, which assumes the use of robot combatants with qualitatively superior systems for autonomous decision making—especially in remote-mobility sensing, organizing, and responding operations.

Odetics recently signed an agreement with RCA’s Government Systems Division to share technology in developing a mobile robotic system to perform such military assignments. RCA will develop sensory modules that will enable the robotic system to perform multi-task functions, including vision. RCA will also provide expertise in artificial intelligence.

The agreement includes RCA funding for Odetics to further develop Odex—and RCA has an option to purchase significant numbers of a second-generation model, called Odex II, over the next 10 years.

Electronic carburetor challenges fuel injection

Replacing mechanical parts with sensors and electric actuators wired to an electronic control boosts economy, cuts emissions, and aids drivability—performance comparable to that of costly fuel injection, claims a German firm.

By **DAVID SCOTT**

Illustration by Russell von Sauers

Fuel injection offers big pluses in engine economy, performance, and emissions. But West Germany's Bosch & Pierburg, a joint-venture firm, believes there's still a real future for the simpler, cheaper, humble carburetor.

To prove it, B & P has introduced an electronically controlled carburetor claimed to give up to a 15-percent fuel saving over conventional types, cut emissions by 20 percent, and improve drivability.

The new carburetor costs about 40 percent more than a normal carb. That's still one-third less than putting a fuel injector at each cylinder port—yet with comparable advantages, claims B & P. One high-end car maker, BMW, has used the new carburetor in two models.

Standard carburetors are mostly mechanical devices. The accelerator pedal controls all throttle-valve movements and thus the fuel mixture sent to the cylinders. Manual chokes have a similar linkage. Automatic designs are regulated only by engine temperature. On constant-depression units, such as Ford's variable venturi and the Stromberg CD, a tapered needle varies effective-jet size according to throttle opening and inlet-manifold suction.

At best, these merely approximate an engine's fuel needs for maximum economy under different driving conditions. Often these mechanical designs feed in too much fuel. This is particularly true for cold starts or during idling and deceleration, when lots of gas can be wasted.

Some carburetor manufacturers have given their old faithfuls slight economy gains with electronic add-ons to replace some mechanical operations, but these are compromise jobs. General Motors, Ford, and Chrysler have introduced electronically controlled carburetors ["Throttle-Body Injection," PS, Feb. '82], combining the best features of the carburetor and fuel injection.

B & P started with a clean sheet of paper. First they stripped a standard fixed-choke carburetor down to bare essentials, eliminating all the usual external levers, links, and other mechanical parts. These were replaced by electric actuators for the choke and throttle valves, and a few switches and sensors were added. These devices are wired to an electronic control unit (ECU) that continuously fine-tunes all carburetor functions for peak engine economy. Result: the Ecotronic carburetor.

Ecotronic's ECU gets messages from six sources. A puls-

ing tachometer feeds in engine speed, and there are sensors for water temperature and pollutants in the exhaust gas. Other inputs register the exact open position of the throttle valve as determined by the accelerator pedal, whether the valve is fully closed for idling, and the position of the valve actuator that controls idling speed. The ECU digests this information and issues commands.

Here's how the system works. Cold starting is fully automatic. When you first switch on, with your foot off the accelerator, the ECU's clever circuits note the temperature, the cranking speed, and the closed throttle. Using this data, it instructs the two actuators to set the choke and throttle valves at angles for the precise amount and richness of fuel-air mixture needed for starting.

As the engine fires and slowly warms up, the ECU gradually opens the choke valve to weaken the mixture. It also adjusts the throttle for a fuel-efficient idling speed at the prevailing water temperature.

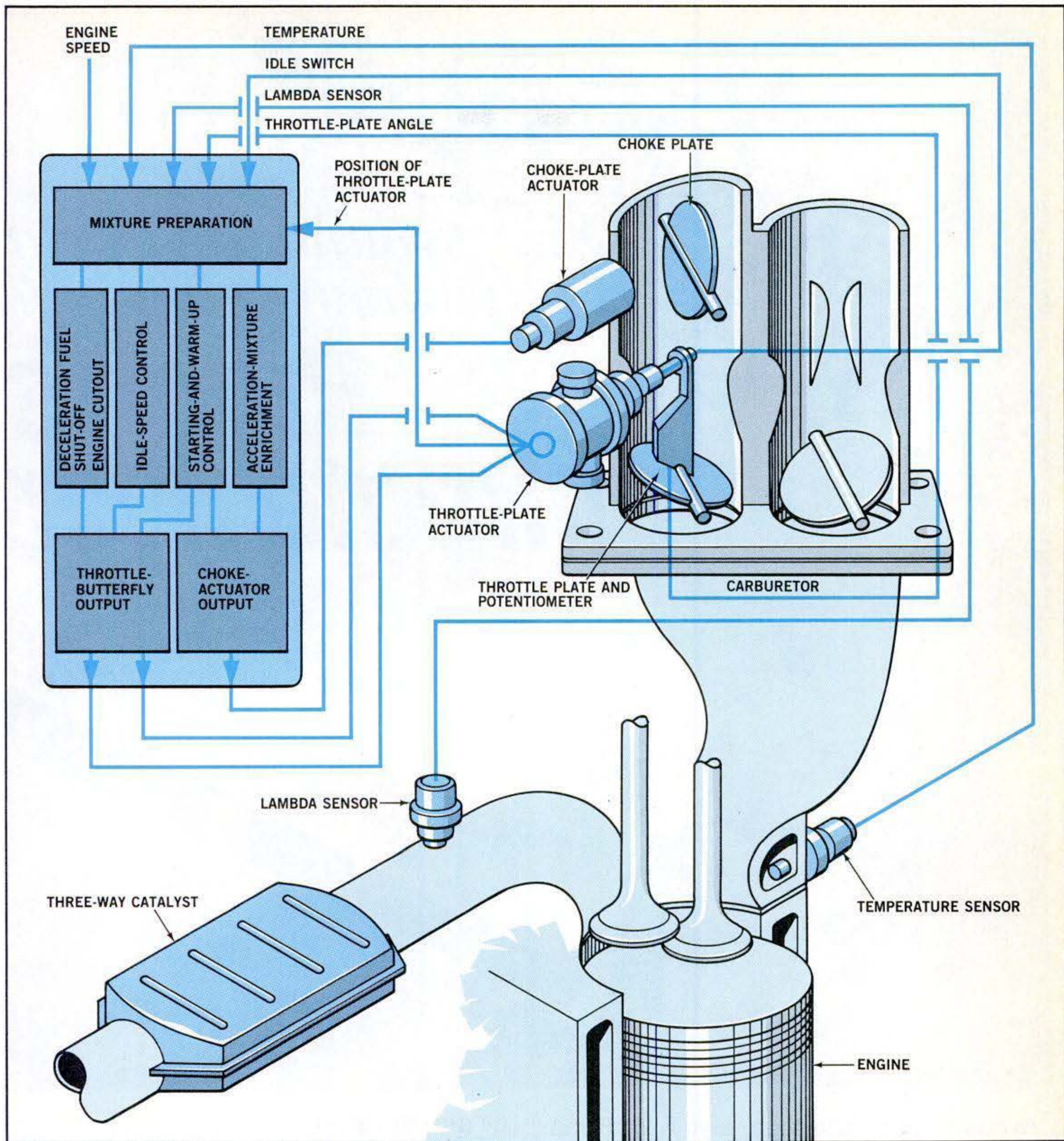
As you drive off, your foot controls the valve by mechanical linkage in the usual way. That's because the Ecotronic actuator functions only when it's in physical contact with the throttle-valve lever, as sensed by a pressure switch on the plunger tip. This contact is broken when you open the throttle to move off.

The throttle actuator is an electropneumatic device and responds to both intake-manifold depression and control signals. The position of its plunger is sensed by the ECU through a potentiometer with a fixed wiper contact. There's also feedback of the throttle-valve opening from a rotary potentiometer on its spindle.

Accelerated fuel savings

Fuel cutoff during deceleration and while coasting is another clever throttle twist. When you lift your foot off the accelerator, the actuator comes to life because it senses the closed throttle. It flips the valve slightly past its normal idle position, where it moves just below the lower-jet outlet in the carburetor throat. The outlet is thus isolated from inlet depression, so no fuel mixture is sucked in. As the car slows and engine revolution drops to around 1,400 rpm, the valve is nudged open to the idle position to prevent stalling.

Operation of the choke valve is also ingenious. This butterfly does double duty because the B & P carb doesn't have the usual accelerator pump that wastefully squirts raw gasoline into the cylinders when the pedal is depressed. Here the choke closes slightly to enrich the mixture for a



Ecotronic carburetor made by Bosch & Pierburg in West Germany has one of its twin barrels (top right) equipped with fast-acting electric actuators for the throttle and choke. Actuators receive signals from an electronic control (top left) that monitors engine

and carburetor parameters. Electronic carburetor control saves fuel on cold starts and during idling and deceleration. The control unit is fed signals indicating exhaust-gas composition (lambda), water temperature, engine speed, throttle-plate angle, and posi-

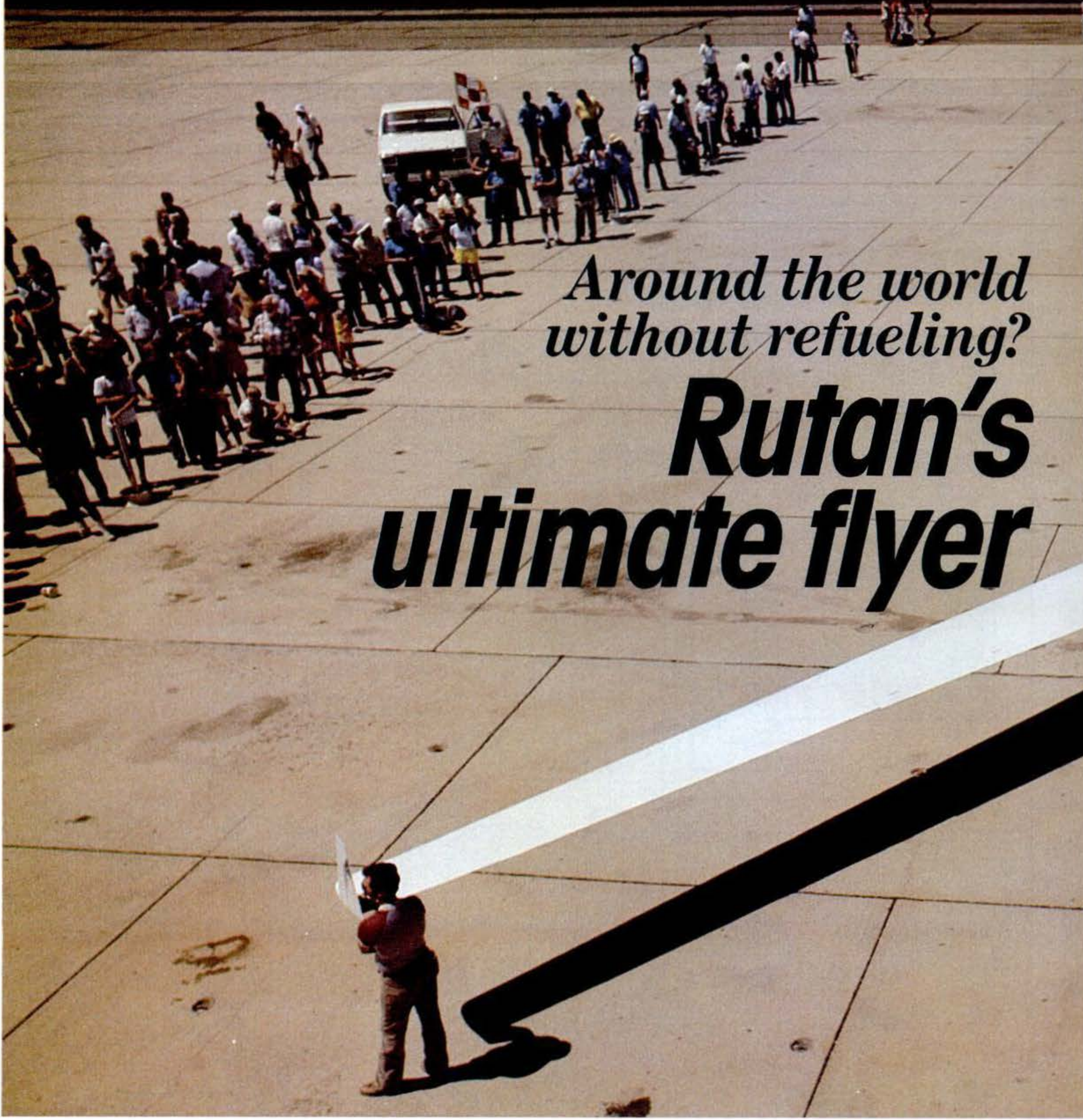
tions of the idle switch and throttle-plate actuator. Conventional mechanical linkage from the accelerator pedal bypasses electric operation of the throttle when the vehicle is driven off. A cam linkage to the second carburetor barrel actuates it at moderate speeds.

quick burst of power. The actuator is a specially rigged electric motor controlled by another ECU signal that's processed to give the optimal fuel-air balance.

This carburetor is actually a two-choke unit, but only the first part has electronic controls. The second barrel, with its own float chamber, jets, and throttle valves, is purely conventional. It comes in automatically at moderate cruising speed. When the first throttle is about two-

thirds open, a rotary cam on its spindle engages a linkage to the second, and you've got full power.

The Ecotronic is a joint venture of two leading German auto-components firms who linked up in 1978 to develop and produce it. Pierburg contributed the carburetor know-how and the manufacturing facilities, and Bosch the electronics. BMW recently adopted the born-again carb for its 316 and 518 models.



*Around the world
without refueling?*

Rutan's ultimate flyer

Aviation's last milestone, says Burt Rutan, one of our most innovative aircraft designers, is an around-the-world, nonstop, non-refueled flight. He plans to reach that goal with Voyager, an all-composite plane with a wingspan of 111 feet that is designed to carry two crew members 25,000 miles.

By **BEN KOCIVAR**

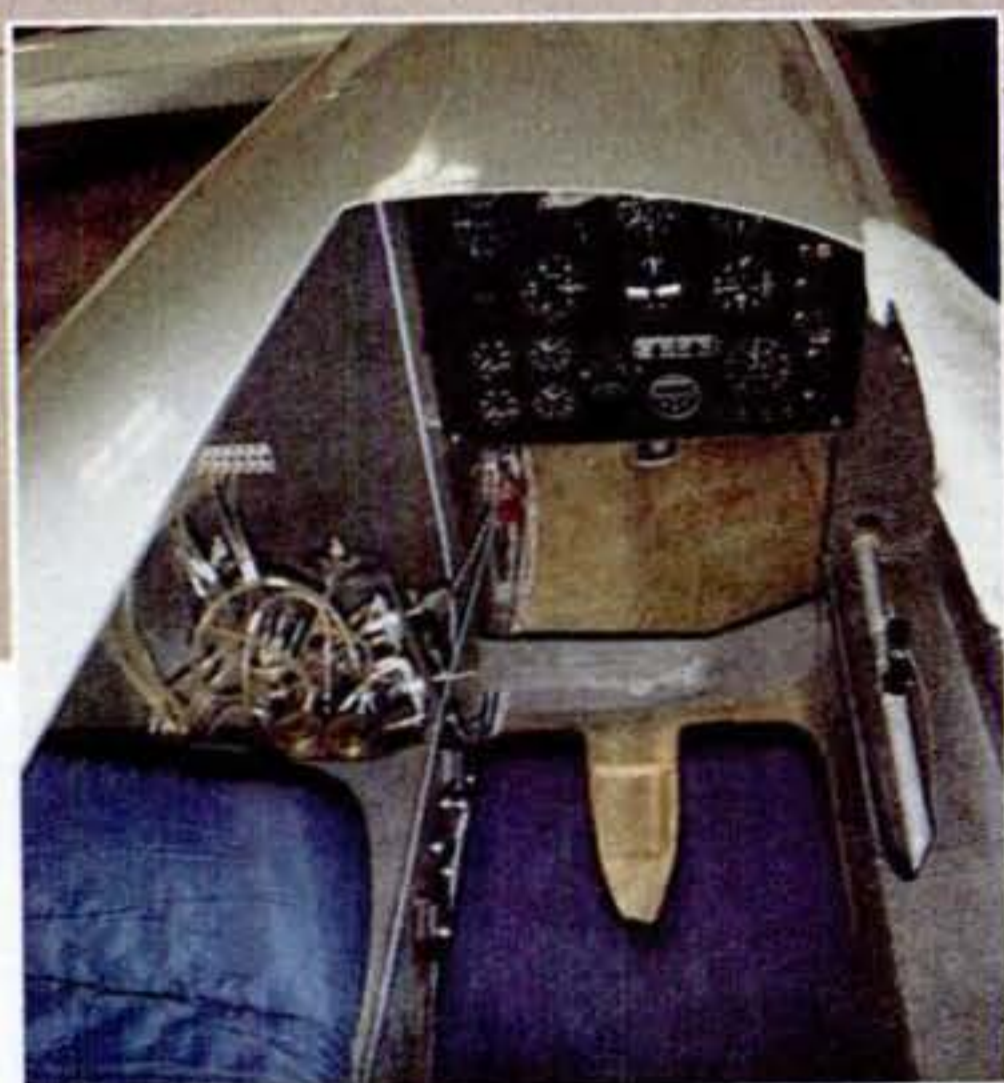
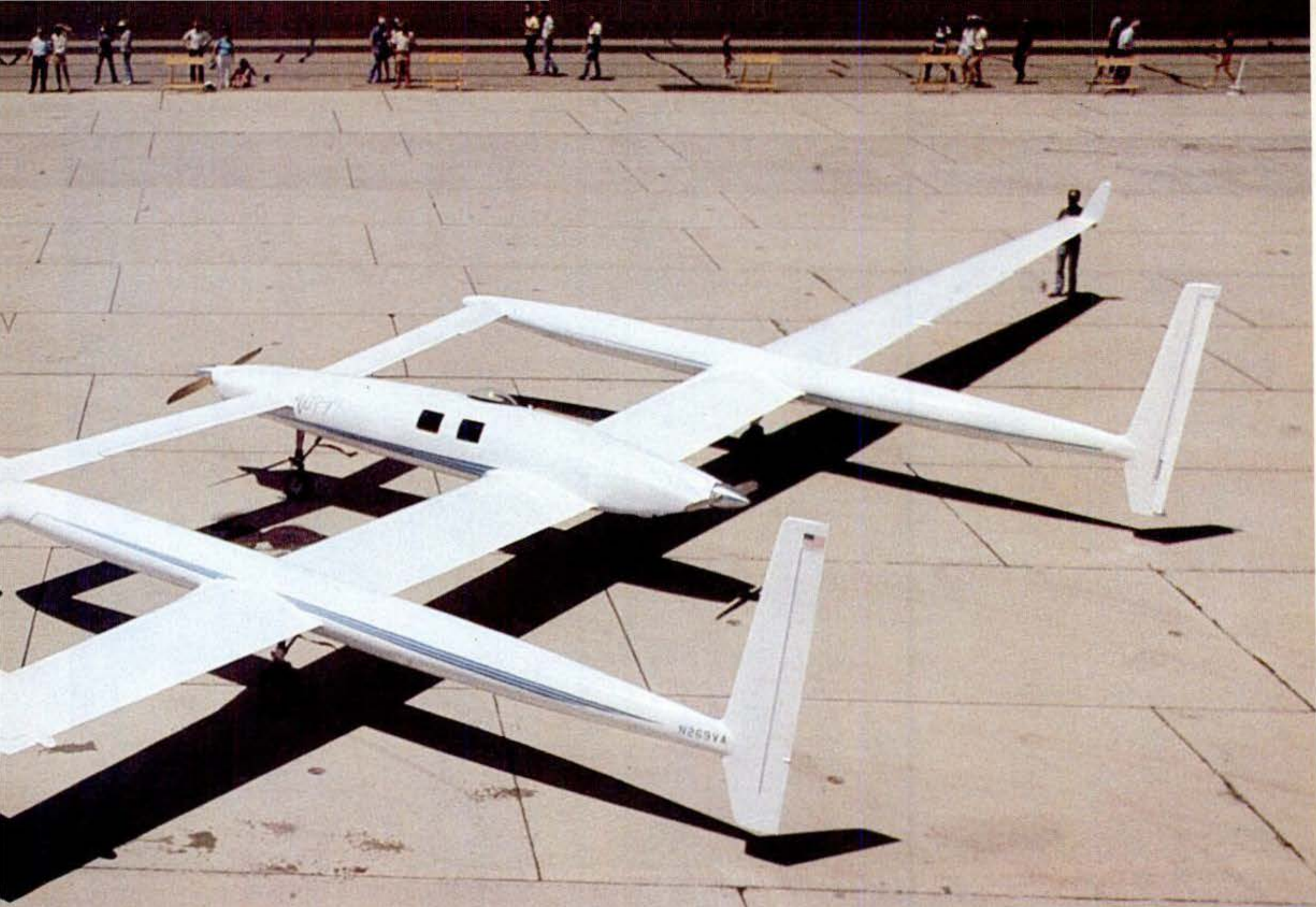
MOJAVE, CALIF.

Winds gusting to 40 knots were blowing unhindered through the Mojave Airport. A handpicked crowd of aviation enthusiasts were squinting in the sun as dust swirled, trying to keep their eyes fixed on the doors of the hangar where Burt Rutan's latest aircraft, Voyager, sat hidden.

Would Voyager appear? A member of its construction team raised my apprehension level when he told me: "Burt spent three years designing and building this lightweight to just about float around the world. He's not going to let it get tossed over during a roll-out ceremony. You may be snapping your photos inside the hangar."

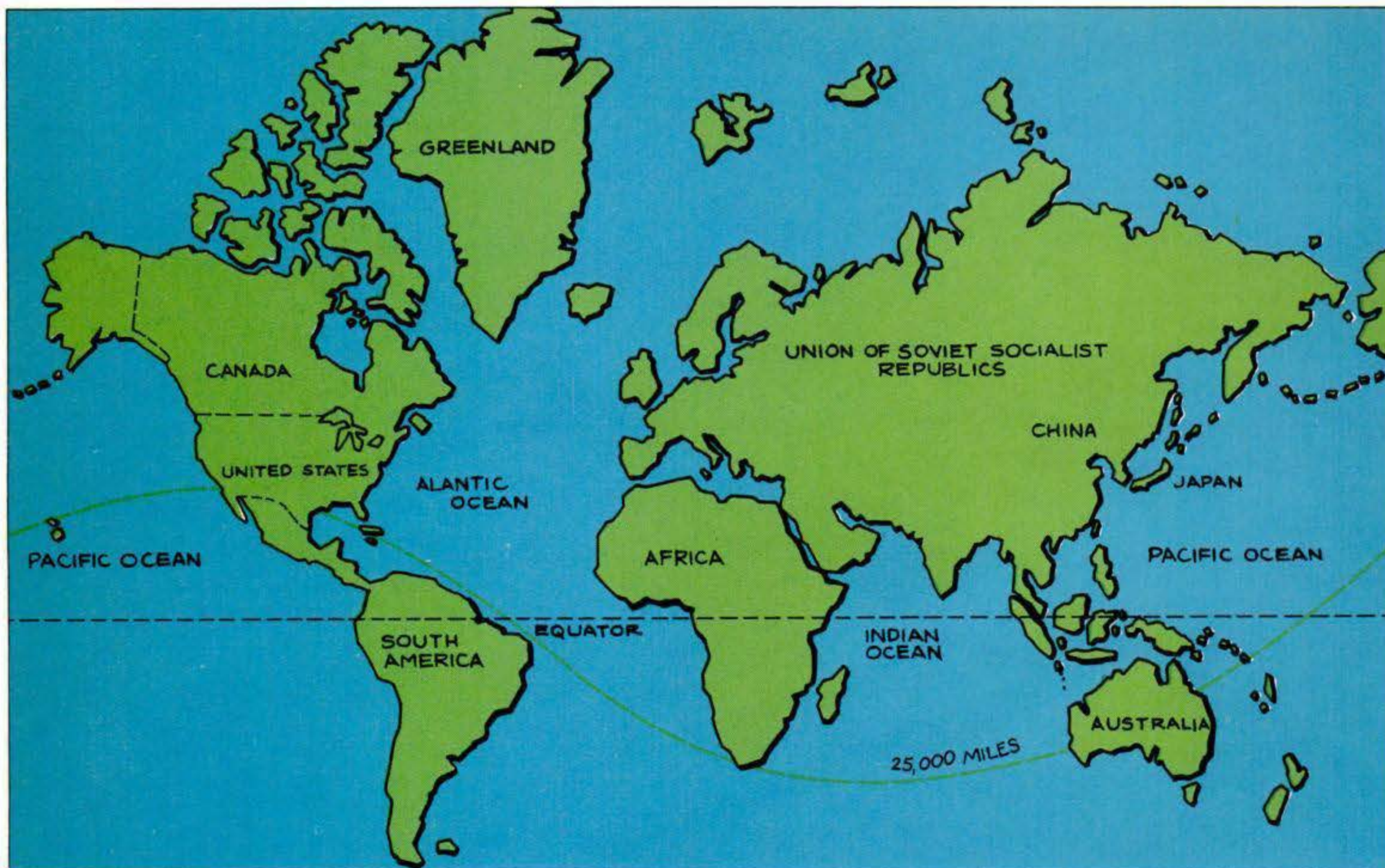
But the winds abated, the hangar doors peeled open, and

Continued



Voyager's 111-ft. wingspan seemed endless to the crowd at roll-out. By contrast, two-ft.-wide cockpit (above) and two-by-7½-ft. cabin, shown in full-scale wooden model (right), are all too finite. Dick Rutan and Jeana Yeager (above right) will sleep in turns to combat fatigue and jet lag. Forward canard, fuselage, and huge main-wing outriggers will store fuel. Transparent pilot bubble, used during takeoff and landing, is visible atop fuselage.





Mercator projection shows flight path crossing equator twice to achieve true 25,000-mile around-the-world record distance.

we watched goggle-eyed as a most unorthodox flying machine was wheeled out, with one man tenderly holding each wing tip.

"If this were designed by anyone but Burt Rutan, I wouldn't believe it," said Dan Mortenson, a veteran race pilot who has flown Rutan-designed aircraft. "But if Burt did it, well, I've got to believe."

Skepticism seems to evaporate around Burt Rutan, one of the most innovative aeronautical engineers working today [PS, May '82]. Among other achievements, he has conceived composite demonstrators for NASA and the military and was instrumental in the revival of the canard wing, which was used by the Wright brothers. With Voyager, he has again extended the frontiers of aeronautical engineering.

Unusual shape

Voyager is an all-composite, trimaran-like plane with a 25-foot fuselage, two outrigger pods, a bathtub-size cockpit, a canard wing, and a 111-foot main wing. With it, Rutan will attempt to reach a milestone in aviation: a nonstop, non-refueled flight of 25,000 miles around Earth's true circumference—a flight that will take some 12 days of skillful piloting.

Burt Rutan is quite matter-of-fact about the route to this goal: "The Breguet range formula tells the designer what is required," he said. "Stringent weight control, low drag, and efficient propulsion."

But like a man juggling apples, watermelons, and pineapples, Rutan had to manage a delicate balance of these three factors. One aspect of design could not be solved without reference to the other two. And in few planes before Voyager were these factors more critical. Where to start?

"The toughest enemy," Rutan said, "is weight."

The structural weight of Voyager—without engines and landing gear—is only 938 pounds, considerably less than a Volkswagen Beetle. When the 16 fuel tanks (distributed

throughout the craft) are full, the plane will weigh 11,300 pounds—8,400 pounds for fuel alone. Rutan estimates that the weight on landing will be 2,300 pounds.

To keep weight at a minimum yet maintain sufficient strength, Rutan used composite materials, the hallmark of all his designs. Voyager is twice the size of any other all-composite plane. The details of how he managed this engineering feat are proprietary. There are no secrets, however, about the composition of the composite: Oven-cured Nomex nylon paper provides a honeycomb core, over which is laid Kevlar (Du Pont's aramid fiber), fiberglass, and a carbon-graphite skin.

The skin looked invitingly smooth, but Rutan warned off would-be touchers. "You can poke a hole in it with very little effort," he said, which showed just how thin and delicate Voyager's covering is.

Advanced composite materials are not solely responsible for the low structural weight. Borrowing a page from the model-builder's kit, Rutan used balsa wood and fabric for the trailing edge of the wing.

Voyager's wing, which is about the span of a Boeing 727's, resembles that of a high-performance sailplane. The aspect ratio, the length of the wing compared with its chord, is high—33.8:1. Lightweight carbon-graphite spars provide some structured support, but not enough. So to support the wing, Rutan uses a trimaran design, with a fuselage and two fuel outriggers. The design also allows fuel to be shifted constantly to maintain the optimum trim for lowest drag.

Flexible wings have the advantage of acting as aerial shock absorbers. But wings that flex easily will droop under the added weight of fuel. In most Rutan designs, winglets improve wing efficiency and act as rudders. In Voyager, their sole purpose is to provide fuel vent holes at the upper tips so that fuel will not gush out when the wings droop. (Vents are normally needed on aircraft to allow for fuel expansion.)

Unlike normal planes that rotate nose up for takeoff and land nose high, Voyager will take off and land in a level attitude. The all-composite tricycle landing gear is unique: Voyager's weight is evenly distributed on the three wheels instead of being borne mostly by the two rear ones. To save weight, the crew will raise and lower each of the 17-pound landing wheels manually with a small cockpit winch.

The airfoils, Rutan says, were designed to cut drag to a minimum. When I looked closely, though, I realized that only the leading third of the two wings and the fuselage was polished. Polishing optimizes laminar flow, the smooth boundary-layer flow of air over the wing. But you can't polish the easily damaged composite unless you add filler to it—and that means adding weight. The benefits from a fully polished wing, Rutan says, aren't worth the extra weight.

Slow but efficient

Although Voyager looks sleek and fast, it is actually a very slow airplane. For optimal power efficiency, Rutan uses two small engines—all that's needed to maintain the plane's cruising speed of 130 knots (150 mph) at full weight. After the second day of flight, as fuel burns off, the lightened plane will slow to about 70 knots (80 mph). At this speed and weight, the plane flies at less than 25 horsepower and will burn only a couple of gallons of fuel an hour.

At roll-out, Voyager had two standard production engines and fixed-pitch wooden propellers, one at each end of the fuselage. Later Rutan said that the plane will have two supercharged reciprocating production engines with two controllable-pitch feathering props. The front engine will stop, and its propeller will be feathered as the power requirement drops to 25 hp. It will be turned on again to help with the landing. When I asked Rutan whether he planned to feed the engines an exotic, more-volatile fuel to squeeze every fraction of a mile possible out of the fuel weight, he replied, "Probably, but that's a proprietary item."

Breaking the existing record of 12,532 miles, set in 1962 by an Air Force B-52H on a run from Okinawa to Spain, will take more than innovative design. The world cheered Lindbergh's stamina and bravery after his 33½-hour, 3,610-mile transatlantic flight. But Voyager's flight will last 12 days—that's the challenge facing pilots Dick Rutan and Jeana Yeager.

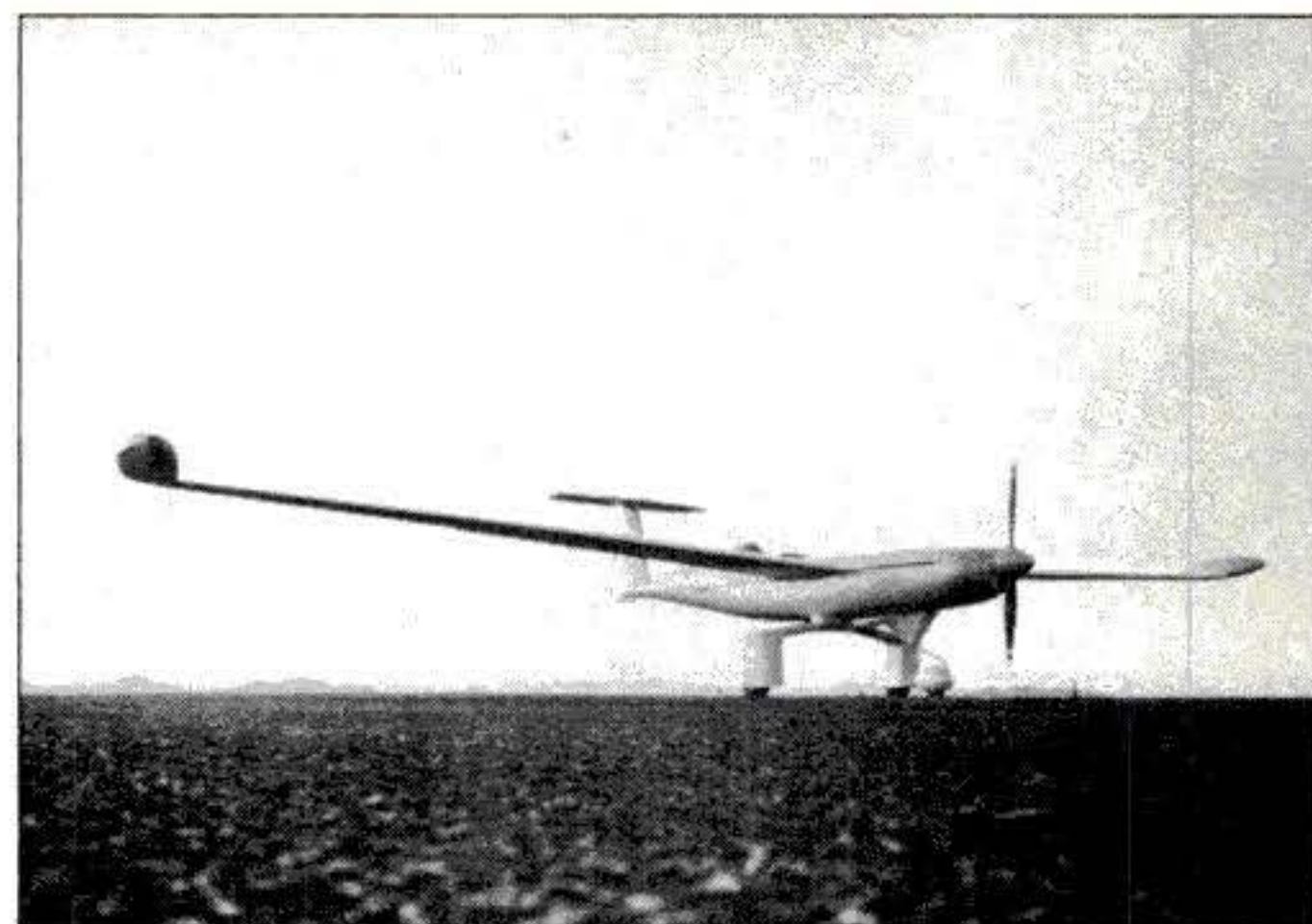
Dick, Burt's brother, is a former Air Force fighter pilot with an endurance record already to his credit. Yeager (no relation to Chuck of *The Right Stuff* fame) is an experienced pilot who has been with the Voyager project since its inception. She also weighs only 98 pounds, a boon.

Unlike most planes, which are designed to be aerodynamically stable, Voyager sacrifices stability to save weight and drag. Therefore, Voyager will have to be piloted constantly. "Flying the plane will be unique and time consuming," Dick remarked cheerfully. "If Voyager is easy to fly, Burt didn't do his job right."

Making the job more difficult is the fact that Voyager isn't pressurized—a pressurized cabin would weigh more. The average altitude of the flight will be around 12,000 feet, which means Voyager will not climb over stormy weather but fly around it. Fuel is available for a two-week flight, just in case. Radar for storm detection may be installed in the nose of the right outrigger, which projects slightly ahead of the canard, but right now the extra 18 pounds is a source of contention between designer and crew.

The pilot must also constantly monitor the fuel weight distribution. "Fuel flow and balance must be checked every few minutes to make sure the fuel is evenly distributed," Dick told us. Unevenly distributed fuel will cause trim changes and increased drag. To remedy that, the pilot controls pumps that transfer fuel from one tank to another.

The flight that failed



Preparation for a competing around-the-world flight ended in tragedy when Tom Jewett, president of Quickie Aircraft, died in a crash at Mojave Airport during a test flight of his Free Enterprise, which resembled a conventional sailplane and had a 52-foot bonded-aluminum high-aspect-ratio wing and one 130-hp piston engine. Jewett planned a 23,000-mile solo flight, cruising at about 24,000 feet and 175 knots (200 mph). He planned to sleep 10 hours during flight while the autopilot held course.

Burt's obsession with weight saving has resulted in crew quarters that looked punishingly small to me. There is only one seat—for the pilot—and a coffin-like lie-down area that measures two by 7½ feet. "The cabin really isn't as uncomfortable as it looks," Dick said optimistically. I tried out the cabin, and if it isn't uncomfortable, it sure is close.

Fighting fatigue

Physiology experts from NASA's Ames Research Laboratory in California told me a flight of this duration will have disturbing and fatiguing effects on the crew. To lessen these effects, Yeager said, "We're going to plan ahead to establish sleep cycles out of phase with each other. When one crew member is ready to sleep, the other will be programmed to be awake." An autopilot will be used occasionally.

Voyager will take off on its epic flight sometime next spring. Within a month after its initial roll-out, the plane had already made five test flights, including one of 11½ hours, to allow the crew to accommodate themselves to the craft and to verify handling and performance.

Although Voyager's route equals Earth's true circumference—25,000 miles—it doesn't trace the equator. "For security and political reasons," Burt explained, "we decided to avoid flying over the Middle East, Russia, and China."

The route will be challenging, Yeager said: "Though winds in the northern latitudes typically blow from west to east, this is not true of the equatorial region where Voyager will spend much of its time in its great-circle route. Flying west would mean less jet lag, too." Thus, Yeager points out, there may be rationale in the final analysis to make the flight east to west.

Most of the time Voyager will be over water—95 percent of the time, in fact. So even though survival suits add weight, the crew will have them on board—just in case.

Takeoff and landing will take place at a 15,000-foot runway at Edwards Air Force Base in the Mojave Desert. Voyager, with its modest power, will need every foot it can get to take off and land. But there's another reason for choosing Edwards: It isn't far from hangar 77 at the Mojave Airport, where three years ago Burt Rutan decided that this challenging aviation milestone had been around too long.

PS guide to 75

Powerful, efficient, and affordable, a new family of suitcase- and briefcase-size portable computers is replacing the small but weak pocket portables. These larger take-along models feature new microprocessors, displays, and disk drives, and lots of memory. The result of these improvements: greater capacity, higher speed, and easier operation.

By **GORDON MC COMB**
Color photo by Greg Sharko

There I was, perched on top of a cardboard box, madly tapping away on one of the new breed of advanced battery-powered portable computers: a Teleram T-5000. In front of me, at a recent computer show in Las Vegas, were 1,000 people swaying back and forth to the nostalgic sound of the Beach Boys.

The Beach Boys were singing "Fun, Fun, Fun," but I was having it. Before I left my hotel for the concert, I had loaded in WordStar, the program now playing out through this compact computer no larger than a notebook. As I wrote, my words flashed on the Teleram's large 80-column-by-16-line liquid-crystal display. Erase or add a word? No problem. I worked the same keys I use on my desk-top computer back home when I'm using WordStar with it. There's no difference. I liked that.

I got into a more comfortable position, gazed out toward the stage, and realized that the box in my hand represented *the* personal computer of the 1980s. Compact, affordable, and efficient—that's the definition of the new family of portable computers now being introduced.

And don't forget popular: You can now choose from more than 70 totable computers—a 275-percent increase since just a year ago, when I first reported on portables in the March and June 1983 issues of *POPULAR SCIENCE*. That's a rate of about four new models a month. Future Computing, a Texas-based consulting firm, feels that this popularity is only the beginning. By 1987, the firm says, we'll buy \$5.7 billion worth of portables, about a six-fold increase from this year's \$900 million.

Why such optimism? Manufacturers of portable computers are still pricing their machines lower than compa-

rably decked desk-top models. And at the same time they've been adding power and new features and making design changes. For example:

- The small and weak pocket portables are out. Instead, the latest models, such as the Kaypro and Compaq, are in the 20-to-35-pound, suitcase-size class, or they weigh in at under 15 pounds and fall into the briefcase-size category (also called lap-held or notebook). Briefcase computers include the Gavilan, Radio Shack 100, and Sharp PC-5000.

- Portables now come with, or are able to accept, much more memory than their ancestors—in some models upward of half a megabyte (½M) of random-access memory (RAM). They also have faster and more powerful microprocessors, making them quick, nimble, and smart.

- The built-in video displays are larger and easier to read in both suitcase and briefcase-size portables. Gone are the one-line-by-20-character liquid-crystal displays (LCDs), for example. They've been replaced by state-of-the-art 80-column by, typically, 16-line LCDs, and full-page electroluminescent and plasma panels.

- To pack in more data and programs many portables now come with higher-density disk drives; some even come with Winchester hard disks [PS, Oct. '82]. Still other portables use the latest floppy-microdisk drives or solid-state memory packs for long-term data storage.

- Many portables use the conventional MS-DOS or CP/M operating system. That means I can use programs such as WordStar on both my desk-top machine and on my portable. I don't have to learn how to use two word processors. That saves time, and I can transfer files from one computer to the other. (Many computers use disks that are compatible with disks used on other machines—you transfer files from one computer to another

by simply popping in the disk of text. Incompatible computers, however, can be wired together to electronically swap text files).

So there's proof. Portable computers have changed. But is the change enough? Are portables ready to tackle today's most demanding computer jobs? The answer is yes.

And no.

Portables *can* do much of the same work expected from full-featured desk-top models. But most still suffer from one or more limitations that make them less than ideal. These include power-gobbling electronics and, with models that offer full-feature design, a high price. One-hundred-percent "true" portability at an affordable price is still a year or two away. Here's the whole story.

Speedier processors

"Many people have the wrong idea of what a portable computer is," says Manny Fernandez, president of Gavilan Computer. "A true portable computer is not a souped-up calculator; it's exactly the same machine you use on a desk—only smaller. That means, among other things, it must have the most powerful microprocessor and random-access memory technically and economically feasible."

Critical to the speed and efficiency of any computer, Fernandez adds, is the microprocessor, that spidery-looking hunk of plastic and metal that crunches numbers and directs traffic within the machine. The early portables used the slow Zilog Z80 chip, which gulped down data eight bits at a time and had a speed of only two to four megahertz (MHz). Z80-based portables are still around, of course, mostly because they operate under CP/M, which allows them to use some 10,000 off-the-shelf programs.

But the success of CP/M is waning, I'm told. At a recent computer show I saw evidence supporting this: There

new portables



Typical of new take-along computers are Texas Instruments' portable (top), Eagle PC (left), and Sequa Chameleon (right).

were only a few new programs written for CP/M or eight-bit computers. It's likely that in time—perhaps in two to three years—eight-bit machines will be obsolete, like the original four-bit models that were in vogue 10 years ago.

Taking the place of the old chips is a newer generation of 16-bit processors such as the Intel 8088, a chip made popular by IBM's PC, PCjr, and portable PC (in the IBM machines the chip runs at about five MHz, neither slow nor fast). Many portable-computer makers have endorsed the 8088, which helps enable their machines to run much of the software designed for the IBM machines—a big plus.

But the design of the 8088 leaves much to be desired. Although the 8088 is internally a 16-bit chip, it accepts data only eight bits at a time. That slows down its operation. Rumors are that manufacturers are looking to put the newer generation of true 16-bit chips inside their wares—chips such as the Intel 8086, Zilog Z8000, and others. All are much faster than the chips in common use today, but the holdup is higher cost.

On the horizon—providing high speeds and small packaging—is the latest line of “computer-on-a-chip” processors such as the Intel 80186 and 80286 and the Motorola MC68020. Chips such as the 80186, a 16-bit de-

vice that can run at speeds of up to 10 MHz, are ideal for portables because they eliminate several integrated circuits (ICs) at a crack. That considerably reduces the size of the computer and makes it less expensive. They can even be used with most of the programs written under the popular MS-DOS operating system used by the IBM PC.

More speed, more power

So much for the good news. Now for the bad: Eight bits, 16 bits—all of it is academic where portables are concerned. The reason? Electronics capable of processing data at high speeds

Continued



Keyboard of IBM's portable PC snaps out for work, snaps in to cover the nine-in. amber CRT display and disk drive when computer is transported.



All in one: STM portable has built-in modem, speaker-phone, thermal printer, 25-line display, and two disk drives.

eat power. Lots of it. I didn't believe this until I put my finger inside a CompuPro 8/16 and touched its processor. (The CompuPro is not a portable, but it uses the big 80286 chip.)

I heard it first, then felt it. The skin on my finger burned white from the heat. If the heat dissipated by the power drain of the 80286 winding out at 10 MHz is enough to burn flesh, it's enough to quickly drain a conventional battery.

Statistics show that the majority of portable-computer owners place portability third on their list of priorities. (Cost and full-featured design come before.) But at one time or another just about every portable user wants to use the machine when an AC outlet isn't nearby.

The processor and most other chips used in battery-operated portables must be the lower-power CMOS (complementary metal oxide semiconductor) type. That's because the power drain from a CMOS processor is only about five percent of that of the NMOS (n-channel metal oxide semiconductor) chip.

Many popular processors are available in CMOS versions (at least in the prototype stage), but they are more expensive, slower, and 15 to 20 percent larger than their full-power cousins. (CMOS circuitry takes up more space because of its design.) Mainly because of the higher cost, few portables today use CMOS processors, a clear indication why most run on AC power only.

"But the processor isn't the only kind of chip that uses lots of power," says Gavilan's Fernandez. "The other major concern is RAM. Most people



Disk drives on top of Zenith Z-160 PC pop up for work, push down safely out

of the way for toting. The detachable keyboard covers the front panel.

don't see that not only is the amount of RAM important—64K is a good minimum—but the type of RAM is as well. That's particularly true in the smaller lap-held, or briefcase, portables. There's a move right now toward non-volatile CMOS RAM, which not only uses much less power than regular NMOS RAM but retains its memory when the power is shut off." (Standard RAM loses its memory when the power is disconnected.)

The importance of nonvolatile CMOS RAM for portable computers became clear to me after I spent three hours on the first draft of this article. I use my desk-top computer much like

any other person would: Type a few notes, stop for a while to do something else, write some more, stop again, and so on. I left for lunch, and when I returned I saw that my story had been wiped clean by a momentary power glitch. I hadn't saved my work on disk, so I lost everything.

I sat down again to pound out the first draft, but this time I used a Gavilan, which has CMOS RAM. I completed the article and even closed the computer down for two days. When I returned the text was still there, frozen in silicon inside the RAM chips.

The great advantage of a CMOS RAM-based machine like the Gavilan

is that I can use it on the go. I don't always have the time to finish my work, file everything away, and shut the computer down. Sometimes I just have time to close the lid and dash off. With static CMOS RAM I can close up the machine at any time. A day, a week, or a month later I can open the machine and start where I left off.

Like CMOS microprocessors, CMOS RAM is costly. As a result, few portables use it as main memory (though some, such as the Gavilan and the MicroOffice RoadRunner, use CMOS RAM for long-term data storage). But its application is on the rise. Look for it as standard equipment in next year's models.

Getting smaller?

Technology has managed to pack the power of a mainframe computer the size of an apartment into a box that fits comfortably in an attaché case. But what are the size limits of portable computers? Will the machines continue to shrink?

"I don't think they'll get much smaller than they already are," claims Fred Keane of Teleram, maker of the Teleram lap-held computer. He picked up his company's latest top-of-the-line T-5000 and plopped it into my lap. "Not that the electronics won't get smaller—they probably will. But as you can see, the minimum size of any computer is governed by the display and keyboard. Too small a keyboard, and you can't type; too small a display, and you can't read what's going on."

He's right. Most keyboards on portable computers—even those in the lap-held class—are full size, with the standard 3/4-inch spacing between keys. This makes it handy for touch-typing, even for someone like me with thick fingers.

Portables don't always use the full

complement of keys found on desktop computers, though, such as separate cursor-control or number keys. Instead, keys serve double and sometimes triple duty. When I use my Radio Shack 100, for instance, I use a portion of the alphabetic keys if I need a 10-key numeric key pad. The key pad is embedded in the standard alpha keys; I hit a key labeled NUM to switch between numbers and letters.

Another example: The Gavilan has a set of touch-sensitive pads located below the display that act as function keys. Along with the function pads is a panel that can be used to move the cursor. To use it you pass your finger over the panel in the direction you want the cursor to go: up, down, left, right.

The "solid-state mouse" (as Gavilan calls it) is adequate and does the job, but I've found that it's not very accurate. The alternative? Soon, perhaps in the next 12 to 18 months, portables may come with touch screens such as that used on the Hewlett-Packard HP-150 desk-top. To move the cursor to a particular position or to choose an item from a menu, for instance, you just touch the appropriate point on the screen, and it's done.

Big plus—big displays

And speaking of screens: Instead of getting smaller, the displays used in both suitcase-size transportables and briefcase computers are getting larger. Most suitcase models still use standard cathode-ray tubes. A handful are less than seven inches, but the vast majority are seven to nine inches in size.

Just last year the LCD panels in briefcase portables displayed no more than 80 columns by four lines, and most displayed considerably less. "Now 80-by-16-line LCDs are not uncommon," says Teleram's Keane.

The largest LCD screen is on the new STM PC—it's 80 characters by 25 lines. (Apple plans to offer a 24-line display for its IIc model shortly.) The larger display makes it easier for portables to use off-the-shelf programs because the software doesn't have to be rewritten to work with a limited screen.

The big display also makes computing much easier to use. I thought I had gotten used to the 40-by-eight-character LCD in my Radio Shack 100, but I was quickly spoiled by the 80-by-16-line displays in the Teleram and Gavilan, among others. I found that working with sophisticated programs such as WordStar and SuperCalc was much easier; I didn't have to jockey the text around the display to see what I was doing, for example.

LCD panels seem the display of choice for briefcase portables, but it may not be long until suitcase-size machines use them, too. The reason: Of all the current display technologies, LCDs use the least amount of power (see caption). The CRT in a typical transportable eats from 10 to 20 watts. By comparison an 80-by-16-line LCD uses less than half a watt.

By design, however, LCDs suffer from three major flaws: They're impossible to read in low light; they have poor contrast; and the crystals are slow to respond to changes, so images tend to fade in and out instead of flashing on and off as they do in a conventional CRT display.

The STM PC has already addressed the first problem. When I flicked the computer on I thought I was seeing things. The display lit up and took on a soft pastel-blue color. What I typed appeared on a glowing screen. With the STM's adjustable electroluminescent rear panel I could compute anywhere, even in pitch darkness if I wanted.

STM's backlight does use more power, but I was pleased to see that it had the effect of increasing contrast, a problem that most other portables solve by allowing you to vary the overall voltage to the panel. With most units the contrast knob is used to compensate for different viewing angles: LCDs wash out when viewed at any angle other than straight on; the knob lets you readjust for best contrast. Inelegant, but it works.

The third problem, image lag, is much tougher to correct because the larger the display, the slower the panel responds. But LCD manufacturers, including Seikosha, Epson, and Sharp, have faster models in the prototype stage. You should see them in the next 12 to 18 months.

Continued



Liquid-crystal display of the Hewlett-Packard portable flips up to show 16

lines of 80 characters; it swings down over the keyboard for carrying.

Electroluminescent and AC gas-plasma displays, used in the Grid Compass and Strategic Technologies PC Traveler, respectively, are immune to the problems that beset the LCD. Both give off their own light, provide extremely good contrast, and have fast response times.

Both electroluminescent and AC gas-plasma displays are not ideal for portables because they require lots of power. Both types draw about five watts. Worse, they are costly: The Compass and PC Traveler are among the most expensive portables on the market.

Up ahead: Electrophoretic displays for portables are in the testing stage. These new imaging panels, currently

under development by Exxon and Philips, are passive. They don't provide their own light, just white specks in an inky background. But they don't draw much power, and they're capable of producing high-resolution graphics. Look for them in portables, particularly the smaller briefcase models, within the next two years.

The last frontier?

The single factor that has prevented more-widespread use of portables is the storage medium. Suitcase-size portables have gotten away with using bulky 5¼-inch floppy-disk drives.

Briefcase computers have tried a variety of mass-storage schemes, including cassette tapes and pre-programmed

cartridges. "The true briefcase portable needs a stronger storage system than these," Gavilan's Fernandez insists. "I think the floppy-microdisk drives—those that use media under four inches in size—are the ideal answer for briefcase computers."

Floppy-microdisk drives are reasonably inexpensive compared with many other data-storage schemes, and they're compact and easy to use. But the best part? The medium inside the Sony 3.5-inch and Hitachi three-inch disks is encased in a hard shell, making it suitable for use in a variety of environments.

To try this claim out I stuffed a 3.5-inch microdisk in my back pocket and went outside to do some yard-work. After a full day of sitting down, standing up, and moving around I popped the disk back in the drive and tried it out. It worked perfectly. Then I stepped on it, threw it up in the air, and gave it to my 3½-year-old daughter. The disk won. Even *she* couldn't destroy it.

However, floppy-disk drives—standard or micro—consume lots of power (only when the disk is accessed, but the power drain is still considerable). One solution: solid-state memory. The current contenders are CMOS RAM and bubble.

Some portables, such as the Micro-Office RoadRunner, use memory packs, which are actually small cartridges filled with 16K, 32K, and 64K of static CMOS RAM and a lithium button battery. Data stored in the removable pack stay for as long as five years (the estimated life of the battery) or until you overwrite with new data. Alas, a 64K RAM pack costs about \$400, and you'll need two or three to make the system worthwhile. (CMOS read-only memory [ROM] packs are also available. These store pre-written programs, not your data.)

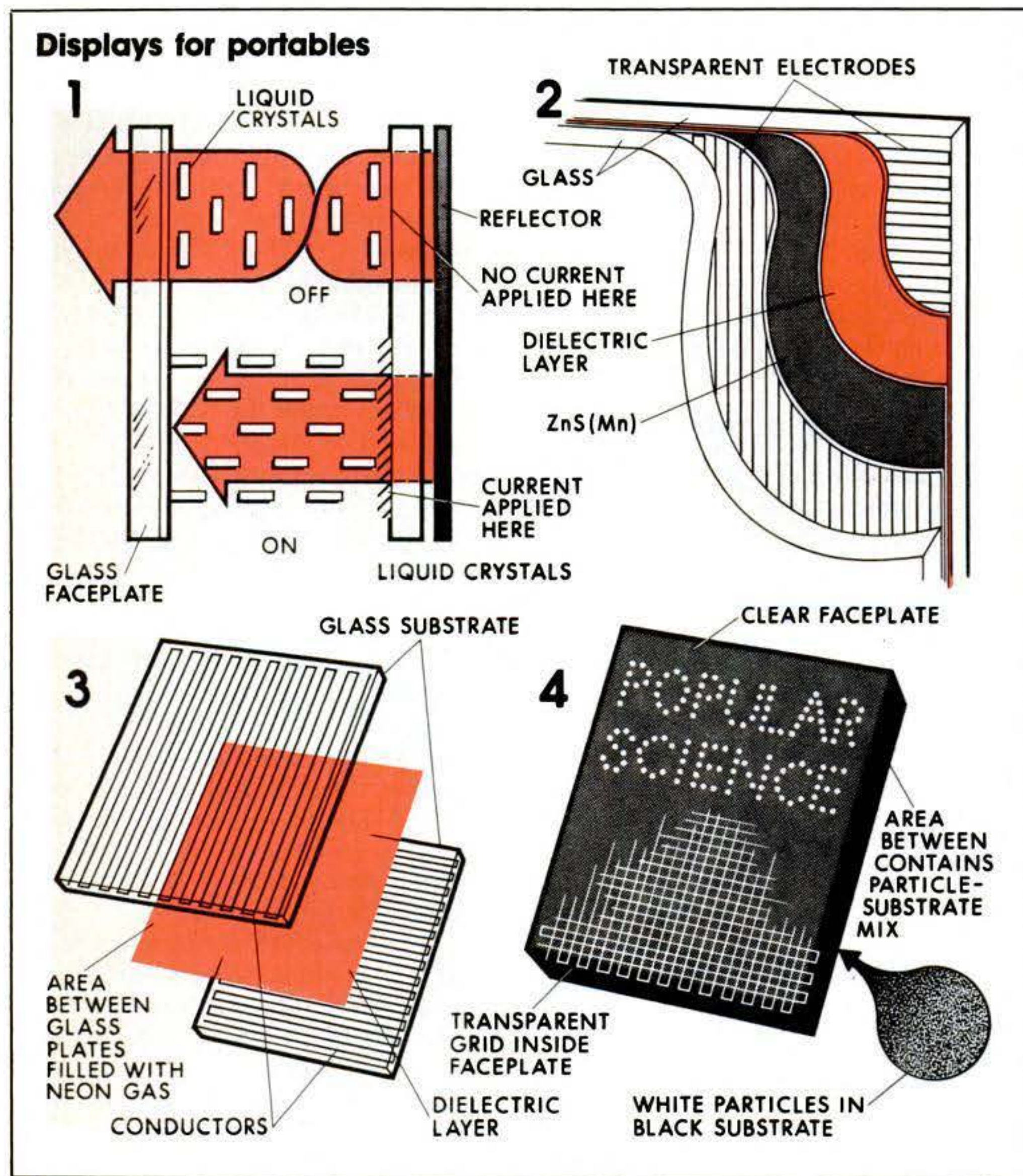
Portables with bubble memory [PS, Oct. '79] are on the upswing, particularly now that 256K and 512K bubble arrays are possible. Bubble memory works by shifting magnetic "bubbles" (hence the name) around an intricate maze. The bubbles stay put when the power is removed, making bubble memory ideal for data storage.

"Within a year," says Teleram's Keane, "bubble memories with 1M capacities will be commonplace and affordable. That'll do a lot to the power of the portable computer."

Tough Winchesters

The maximum capacity of solid-state memories and disk drives is about 1M, which used to be more than enough for many applications. But now I've

[Continued on page 134]



LCDs create images (1) when organic liquid-crystal molecules are lined up directionally to either pass or reflect light. An electric field causes the crystals to rotate, and the display area seems to turn from a dull silver to black. Remove the current, and the images disappear.

Images are produced in electroluminescent panels (2) by applying a 200-V spike voltage at the intersection of wires on a small grid. Where there's a current, there's a speck of light.

An AC plasma panel (3) uses neon

gas sandwiched between two glass panels that contain extremely thin rows of conductors. As with the electroluminescent display, images are created when a high voltage is applied to portions of the grid.

Electrophoretic panels (4) use micron-size white particles suspended in an almost-opaque colored liquid. When a charge is applied to a grid behind the face of the panel, the particles rush to the front of the screen. The result is a white image on a dark, almost black, background.

Portable computers—suitcase-size

Manufacturer	Model	Price (\$)	Dimensions			Weight (lbs.)	RAM (K)		Op sys	Display size (in.)	Storage		Interface		Software included				Comments
			W	D	H		Inc/Max	Type			Cap.	Drives	Par	Ser	WP	ES	DB	Comm	
Actrix	Act-1	2,190	17	10	11	33	64/64	CP/M	7	Flop	184K	2	X	X	X	X	X	X	Built-in printer, modem
Anderson-Jacobson	AJ Passport	3,195	18	11	9	22	256/256	MS	7	Flop	320K	2	X	X	X	X	X	X	
Bytec	Hyperion	3,195	18	11	9	22	256/256	MS	7	Flop	320K	2	X	X	X	X	X	X	
Colby Computer	PC-3	2,795	17	16	9	26	128/256	MS	9	Flop	320K	2	X	X	X	X	X	X	Also avail. with hard disk
Columbia Data	VP	2,945	18	16	8	32	128/256	MS	9	Flop	320K	2	X	X	X	X	X	X	
Commodore	SX-64	995	15	15	5	28	64/64	Prop CP/M	5	Flop	170K	1	X	X	X	X	X	X	Color display
Commuter	Commuter	1,195	18	14	8	22	128/256	MS	9	Flop	320K	1	X	X	X	X	X	X	
Compal	Briefcase	1,795	20	15	9	26	64/64	CP/M	9	Flop	320K	2	X	X	X	X	X	X	
Compaq	PC Plus	2,995	20	16	9	28	128/256	MS	9	Flop	320K	1	X	X	X	X	X	X	Second drive opt.
	Plus	4,995	20	16	9	31	128/256	MS	9	Flop/HD	320K/10M	1	X	X	X	X	X	X	Hard-disk version
Comp. Transceiver	Exec. XL	2,495	18	16	7	26	80/80	CP/M	9	Flop	400K	1	X	X	X	X	X	X	Standard CP/M
	Exec. XL Plus	3,295	18	16	7	26	208/208	MS	9	Flop	400K	1	X	X	X	X	X	X	
CompuCorp.	OmegaMite	2,995	21	10	10	25	64/266	CP/M	9	Flop	655K	2	X	X	X	X	X	X	Built-in modem
CompuSource	Abacus	2,395	15	14	8	27	64/192	CP/M, Apple	9	Flop	160K	2	X	X	X	X	X	X	Apple-compatible
Corona	Portable	2,545	20	19	10	28	128/256	MS	9	Flop	320K	2	X	X	X	X	X	X	
Digital Micro.	DMS-3/F Fox	3,995	18	15	8	30	64/64	CP/M	9	Flop	640K	2	X	X	X	X	X	X	
	DMS-15	7,495	18	15	8	36	64/64	CP/M	9	Flop/HD	640K/10M	1	X	X	X	X	X	X	HD version
Docutel/Olivetti	PC	2,795	20	19	10	28	128/256	MS	9	Flop	320K	2	X	X	X	X	X	X	
Eagle	Spirit	n.a.	20	16	19	28	128/256	MS	9	Flop	320K	2	X	X	X	X	X	X	
	Spirit XL	4,795	20	16	19	33	128/256	MS	9	Flop/HD	320K/10M	1	X	X	X	X	X	X	
IBM	Portable PC	2,795	20	17	8	30	256/512	PC	9	Flop	360K	1	X	X	X	X	X	X	Dual-drive unit \$3,220
Ivy Micro.	3001	2,995	20	14	9	24	256/256	MS	9	Flop	320K	2	X	X	X	X	X	X	
	3002	3,995	20	14	9	25	256/256	MS	9	Flop/HD	320K/10M	1	X	X	X	X	X	X	
Jonos	C2100	3,195	17	13	7	25	64/128	CP/M	9	MFlop	322K	2	X	X	X	X	X	X	3.5-in. floppies
	C2150	3,695	17	13	7	25	128/128	CP/M	9	MFlop	322K	2	X	X	X	X	X	X	3.5-in. floppies
	C2500	5,995	17	13	7	33	128/128	CP/M	9	HD	3.9M/5M	1	X	X	X	X	X	X	3.9M removable; 5M fixed
Kaypro	II	1,595	18	16	8	26	64/64	CP/M	9	Flop	191K	2	X	X	X	X	X	X	Disk-drive emulation program
	4	1,795	18	16	8	26	64/64	CP/M	9	Flop	392K	2	X	X	X	X	X	X	Same; higher-density drives
	10	2,795	18	16	8	31	64/64	CP/M	9	Flop/HD	392K/10M	1	X	X	X	X	X	X	
MicroStandard	MST3000S	2,795	14	12	7	25	64/512	CP/M	9	Flop	376K	1	X	X	X	X	X	X	
	M6000P	3,900	20	17	7	34	64/512	CP/M	9	Flop	376K	2	X	X	X	X	X	X	
Modular Micros	Zorba 2000/4	1,995	18	9	5	21	64/64	CP/M	9	Flop	400K	2	X	X	X	X	X	X	Disk-emulation program
	Zorba 2000/8	2,295	18	9	5	21	64/64	CP/M	9	Flop	800K	2	X	X	X	X	X	X	Same; high-density drives
Morrow	MD3P	1,899	19	16	7	24	64/64	CP/M	5 x 9	Flop	384K	2	X	X	X	X	X	X	Same as MD3 desk-top
Osborne	I	900	21	13	9	28	64/64	CP/M	5	Flop	200K	2	X	X	X	X	X	X	Discontinued
	Executive	2,495	21	13	9	28	128/128	CP/M	7	Flop	200K	2	X	X	X	X	X	X	Discontinued
Otrona	Attache S	2,695	14	12	6	16	64/64	CP/M	6	Flop	360K	1	X	X	X	X	X	X	
	Attache 8	2,995	14	12	6	17	64/64	CP/M	6	Flop	360K	2	X	X	X	X	X	X	Two RS-232C ports
	Attache 8:16	3,795	14	12	6	17	256/256	CP/M, MS	6	Flop/HD	360K/10M	1	X	X	X	X	X	X	Dual processors
Panasonic	Sr. Partner	2,495	19	14	8	29	128/128	MS	9	Flop	320K	2	X	X	X	X	X	X	Built-in printer; HD available
Seequa	Chameleon	1,995	18	15	8	28	128/256	CP/M, MS	9	Flop	320K	1	X	X	X	X	X	X	Dual processors
	Cham. Plus	2,895	18	15	8	28	256/256	CP/M, MS	9	Flop	320K	2	X	X	X	X	X	X	Dual processors
SKS Computer	2502 Nano	2,495	18	16	7	27	80/720	CP/M	—	Flop	400K	2	X	X	X	X	X	X	Optional board for MS-DOS
Strategic Tech.	PC Traveler	4,495	19	16	6	28	128/640	MS	9	Flop	320K	1	X	X	X	X	X	X	Built-in printer
Tandy	Model 4P	1,799	17	13	10	26	64/64	TRS, CP/M	9	Flop	194K	2	X	X	X	X	X	X	
TeleVideo	TPC-1	1,599	18	15	8	28	64/64	CP/M	9	Flop	368K	1	X	X	X	X	X	X	Graphics capability
	TPC-2	n.a.	18	15	8	28	128/256	MS	9	Flop	368K	1	X	X	X	X	X	X	
Texas Inst.	Portable Pro.	2,395	18	15	8	28	64/768	MS	9	Flop	320K	1	X	X	X	X	X	X	
Zenith	Z-160	2,799	20	19	8	33	128/640	MS	9	Flop	360K	1	X	X	X	X	X	X	Dual-drive unit \$3,199

Portable computers—briefcase-size

Manufacturer	Model	Price (\$)	Dimensions			Weight (lbs.)	RAM (K)		Op sys	Display char.	Storage		Interface		Power		Software included				Comments
			W	D	H		Inc/Max	Type			Cap. (K)	Par	Ser	AC	DC	WP	ES	DB	Comm		
ACT	Apricot xi	3,995	17	13	4	19	256/768	MS, CP/M	40 x 2	HD	5	X	X	X	X	X	X	X	X	Inc 315K	
Athena	Athena I	3,950	12	12	4	15	64/64	CP/M	80 x 16	RAM	512	X	X	X	X	X	X	X	X	CMOS processor	
Casio	FP-200	499	12	9	2	4	8/32	Prop	20 x 8	Cass	n.a.	X	X	X	X	X	X	X	X	Disk drive avail.	
Convergent Tech.	WorkSlate	895	11	9	1	3	16/16	Prop	46 x 16	MCass	n.a.	X	X	X	X	X	X	X	X	Spread sheet	
Docutel/Olivetti	M10	799	12	9	2	4	8/32	Prop	40 x 8	Cass	n.a.	X	X	X	X	X	X	X	X	Built-in modem	
DVW Microelec.	Husky	2,995	10	8	2	5	16/144	Prop	32 x 4	None	—	X	X	X	X	X	X	X	X	Bar-code interface	
Epson America	HX-20	795	12	9	2	4	16/32	Prop	20 x 4	MCass	n.a.	X	X	X	X	X	X	X	X	Built-in printer	
Exidyne	Elec. Book	3,295	14	9	2	4	48/48	Prop	40 x 2	RAM	48	X	X	X	X	X	X	X	X		
Gavilan	Mobile	3,995	12	12	3	9	32/336	MS	80 x 16	MFlop	320	X	X	X	X	X	X	X	X	Touch-pad cursor	
	SC	2,995	12	12	3	9	32/336	MS	80 x 8	MFlop	320	X	X	X	X	X	X	X	X	Same; no software	
Grid Systems	Compass	8,150	11	9	4	10	256/512	MS	53 x 24	Bubb	384	X	X	X	X	X	X	X	X	Disk drive opt.; modem inc	
Hewlett-Packard	HP-75C	995	10	5	2	2	8/32	Prop	32 x 1	Card	1.5	X	X	X	X	X	X	X	X	Wafer-tape option	
	The Portable	2,995	13	10	3	10	272/272	MS	80 x 16	MFlop	710	X	X	X	X	X	X	X	X	Drive optional; \$795	
MicroOffice	RoadRunner	1,695	12	8	3	5	48/48	CP/M	80 x 8	CRAM	64	X	X	X	X	X	X	X	X	Optional modem	
NEC Home Elec.	PC-8200	599	12	9	2	4	16/64	Prop	40 x 8	CRAM	64	X	X	X	X	X	X	X	X	Optional modem	
Radio Shack	Model 100	799	12	9	2	4	8/32	Prop	40 x 8	CRAM	64	X	X	X	X	X	X	X	X	Built-in modem	
Sarasota	Hunter	1,974	9	7	2	2	80/208	CP/M	40 x 8	RAM	—	X	X	X	X	X	X	X	X		
Sharp	PC-5000	1,995	13	12	4	11	128/256	MS	80 x 8	Bubb	128	X	X	X	X	X	X	X	X	Optional integral printer	
STM	Portable	3,449	20	11	4	17	256/512	MS	80 x 25	Flop	800	X	X	X	X	X	X	X	X	Built-in printer, modem	
Sord	IS-11	995	12	9	2	4	32/64	Prop	40 x 8	MCass	128	X	X	X	X	X	X	X	X		
Teleram	T-3000	1,595	13	10	4	9	64/64	CP/M	80 x 4	Bubb	256	X	X	X	X	X	X	X	X		
	T-4000	1,995	13	10	4	9	64/64	CP/M	80 x 8	Bubb	256	X	X	X	X	X	X	X	X	8-line version	
	T-5000	2,495	13	10	4	9	64/64	CP/M	80 x 16	Bubb	256	X	X	X	X						

Now: non-polluting

In response to the increasing concern with indoor air quality, a team at the American Gas Assn. Laboratories has developed a simple stainless-steel ring that can be placed on existing gas-range burners to cut oxides of nitrogen emissions by about 40 percent; unfortunately, carbon monoxide emissions increase. A second team at Thermo Electron has developed a new-technology range burner that cuts oxides of nitrogen *and* carbon monoxide emissions dramatically—and burns more efficiently.

By V. ELAINE SMAY

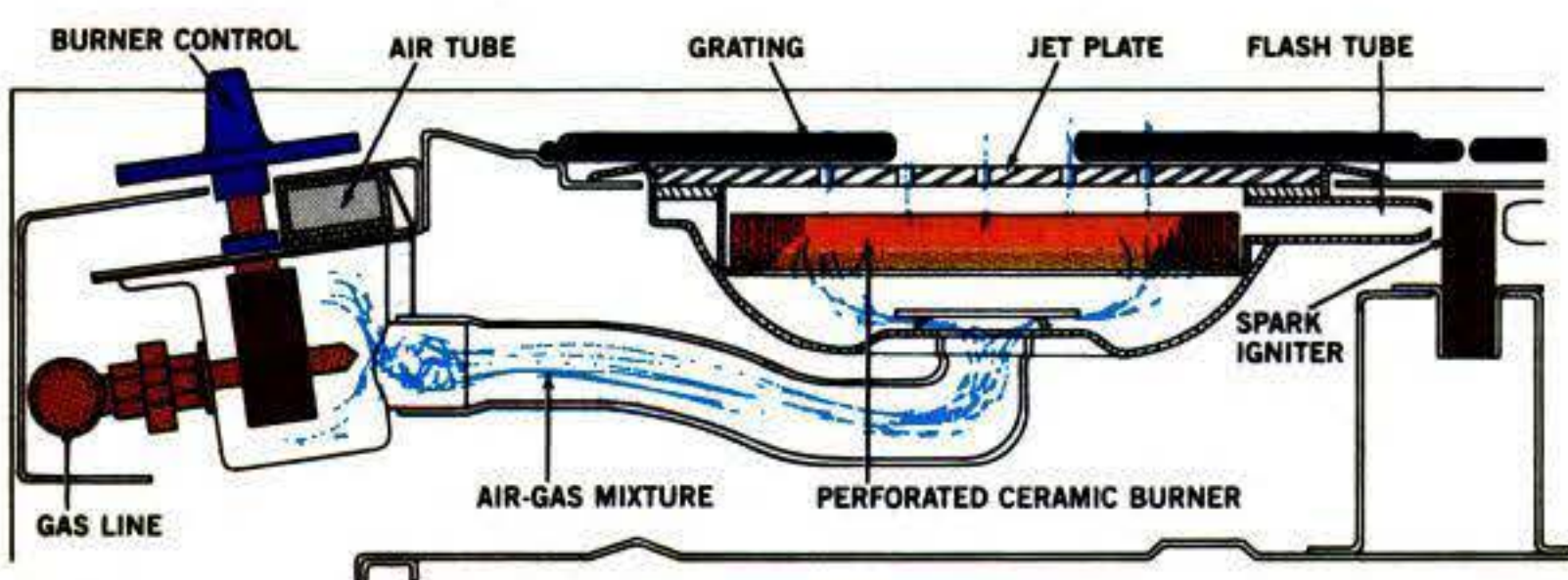
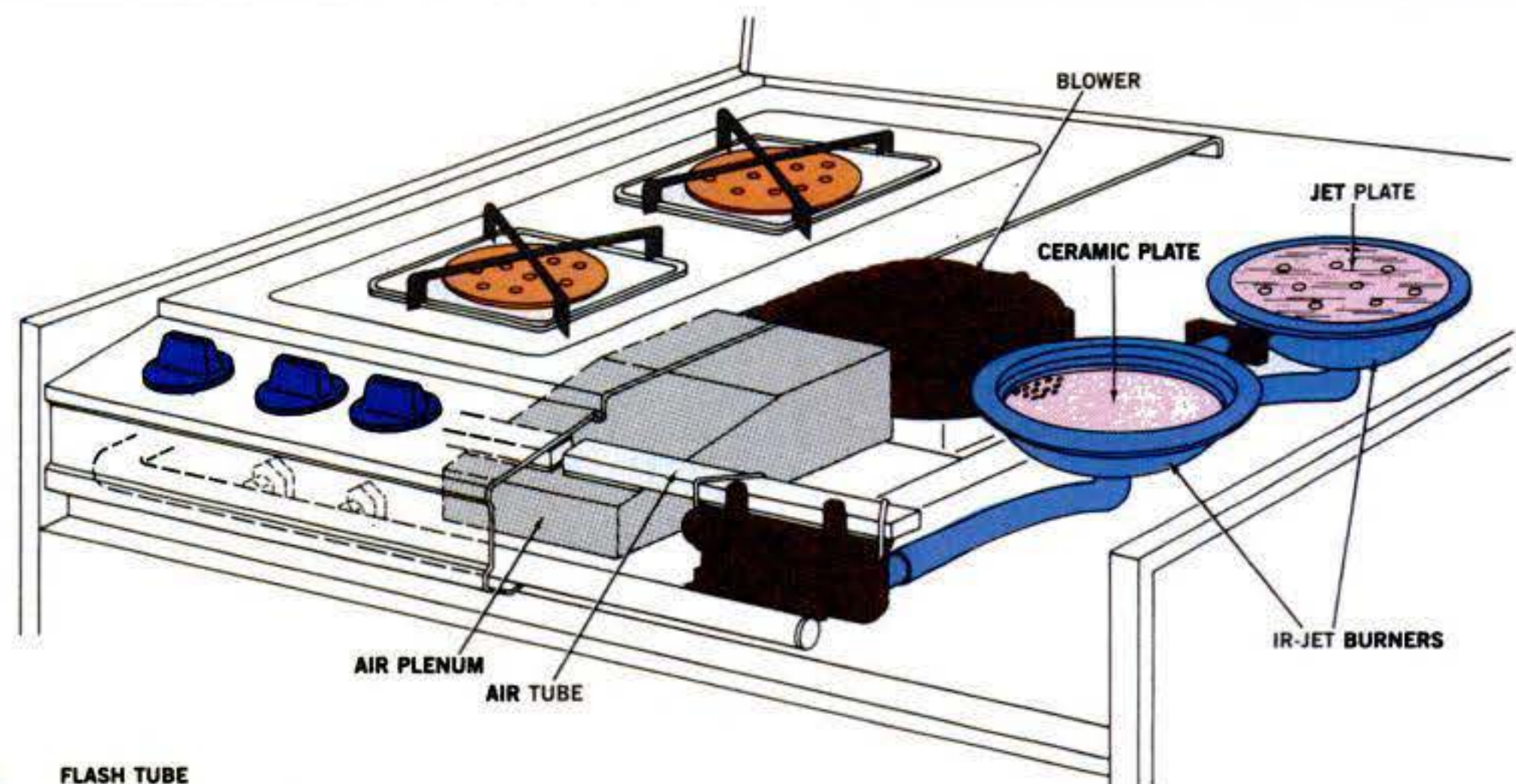
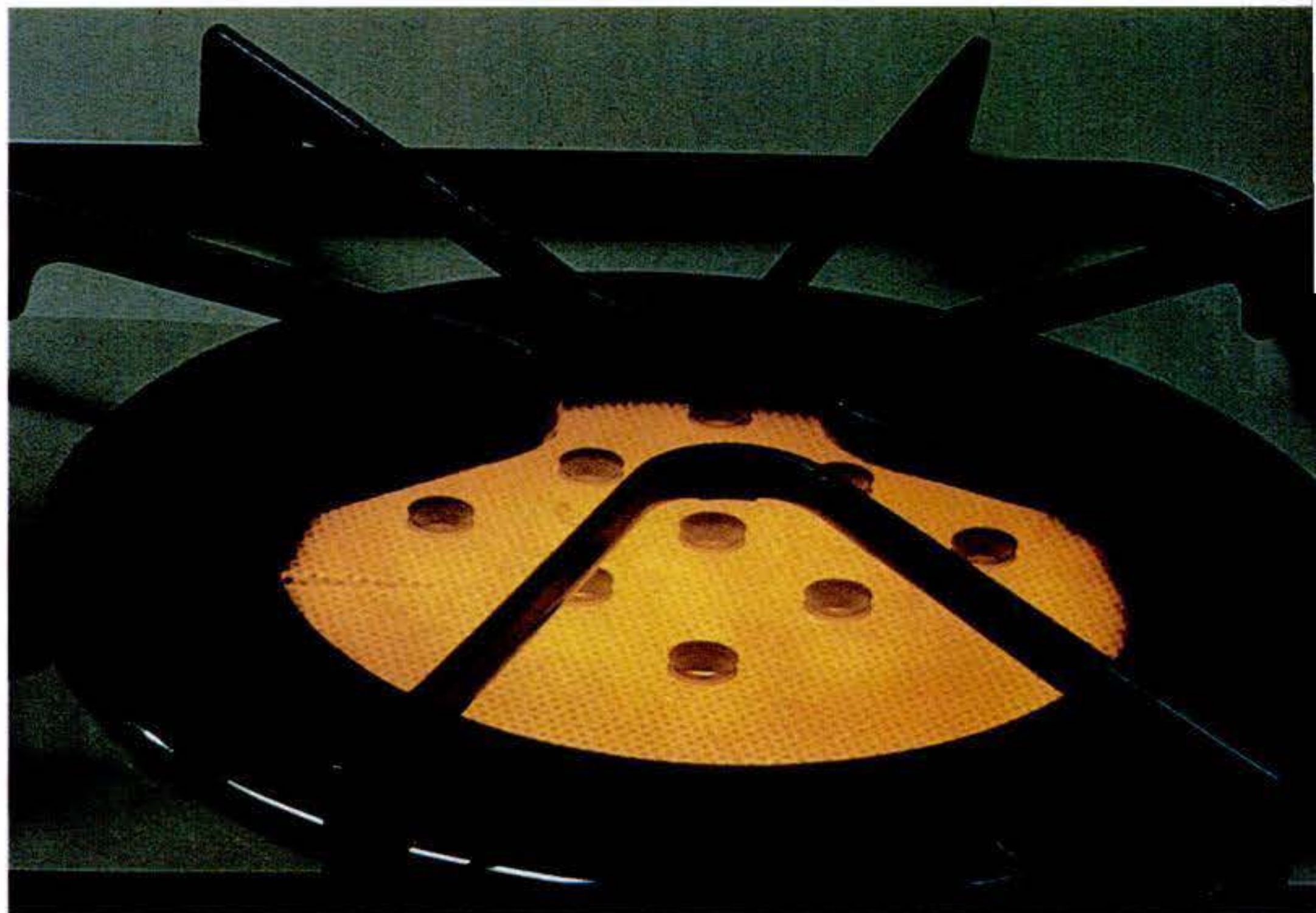
Illustrations by Ronald Carboni

In a warehouse-like lab at Thermo Electron, a research firm located along Route 128, the Boston area's high-tech highway, I saw a strange new gas range that cooks without a visible flame. Its four top burners become glowing infrared discs when the heat's on high.

Two weeks earlier, in a brand-new research house on the grounds of the American Gas Assn. Laboratories (AGA Labs) south of Cleveland, I had seen what looked like an ordinary gas range. But around its burners were doubling inserts of stainless steel. When you turn on the burner, the gas flame surrounds two glowing rings of red-hot wire.

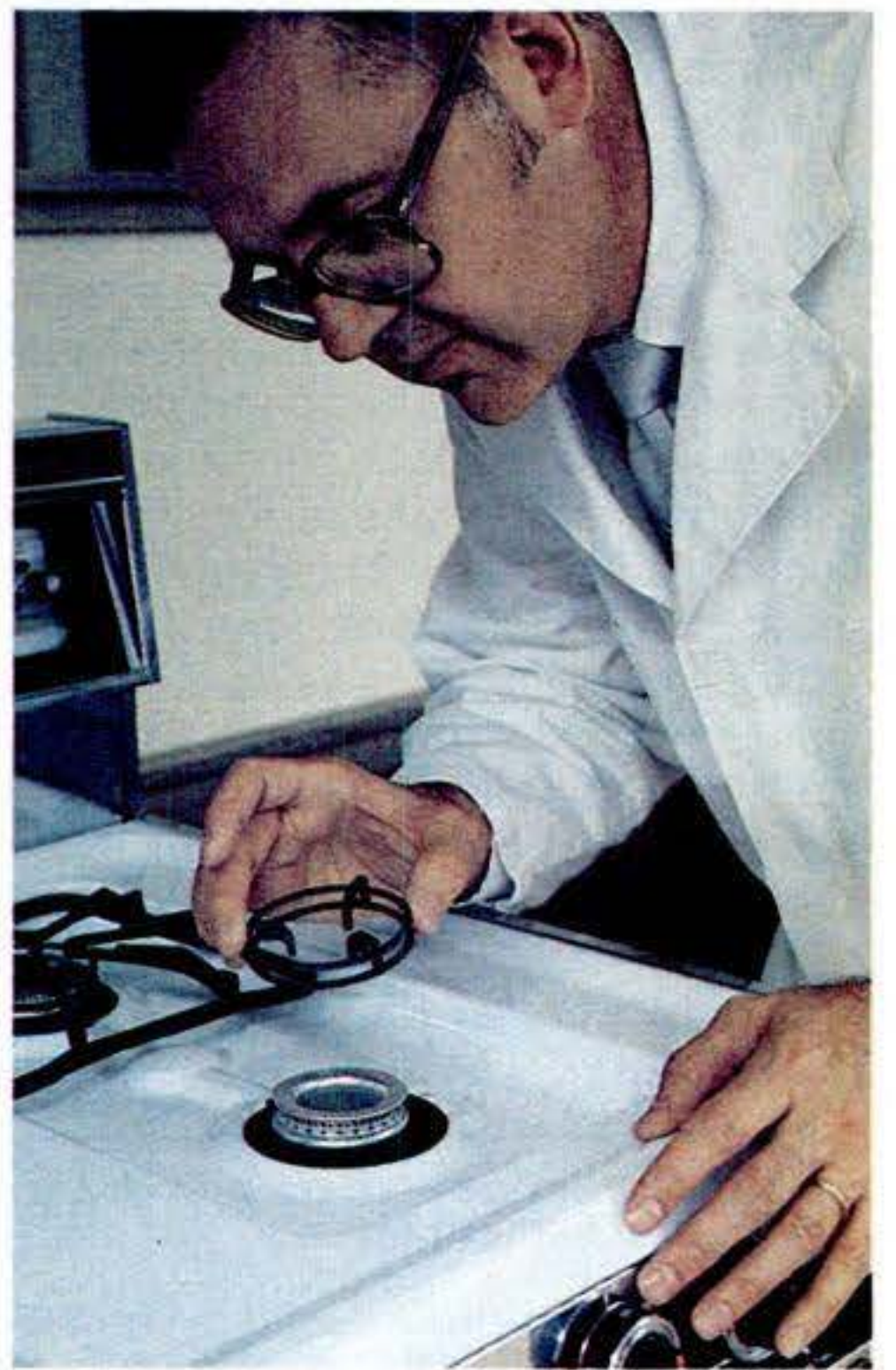
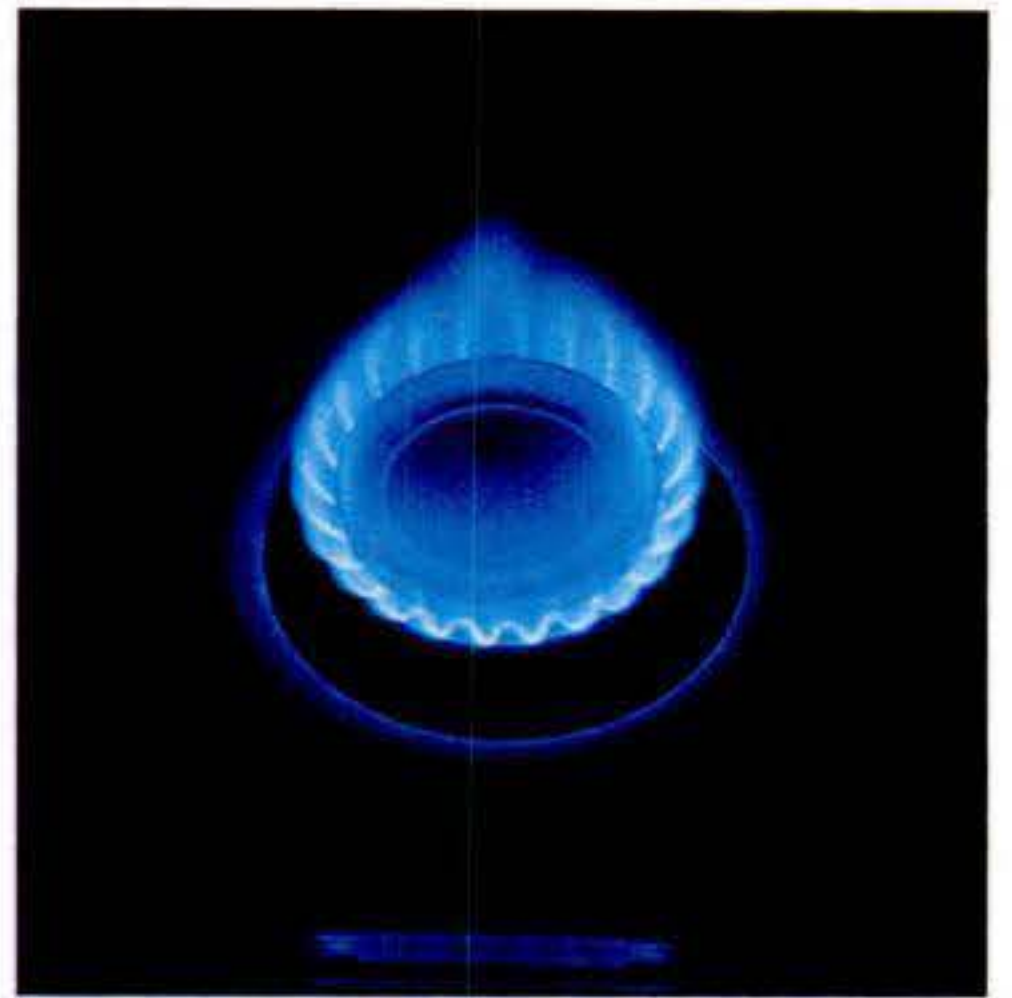
Thermo Electron's infrared burner and AGA Labs' burner insert were developed in research projects sponsored by the Gas Research Institute (GRI). The goal in both cases: to reduce emissions from gas ranges. Not that the gas range has been declared a health hazard, but as houses have been tightened to save energy, environmental-health experts have begun scrutinizing all potential sources of indoor pollution.

Gas ranges emit a number of chemicals—nitric oxide (NO), nitrogen dioxide (NO₂), carbon monoxide (CO), some aldehydes, unburned methane—that can pose a health hazard if concentrations are high enough. But no one knows for sure how high that is. Gen-



Ceramic disc of IR-jet burner (top) radiates heat through glass-ceramic jet plate above it; holes in plate enhance convective heat flow. Fan in prototype range (above) provides combustion air, which is mixed with gas and delivered to burner. Mixture flows up through perforated ceramic disc (detail, left) and into flash tube where it's lighted by a spark igniter. Combustion occurs just below the burner surface.

gas ranges



erally, the contaminant of most concern is NO_2 , a respiratory irritant that can cause lung damage ["Home Pollution," PS, Oct. '80].

"We don't currently see emissions from gas ranges as threatening," noted John Lockwood, GRI's project manager for these research contracts. "Nevertheless, we feel it is incumbent on the gas industry to see what can be done to make unvented gas appliances cleaner-burning."

Most air-quality regulations address total oxides of nitrogen (NO_x), which include NO_2 and NO , so the AGA Labs and Thermo Electron teams worked to reduce total NO_x as well as NO_2 .

Simple, inexpensive add-on

In the laboratory section of AGA's research house, Douglas DeWerth, the project manager, showed me the little double-ring insert his team developed

to reduce emissions from current range burners. He turned on a burner of the test range, and I could see that the flames were going between the two rings as they left the burner portals.

"What we're doing," DeWerth explained, "is putting a mass of something into the flame to cool it. When the oxygen and nitrogen in the combustion air meet a high-temperature body—a flame or a hot element—they react and combine. The higher the temperature, the more NO_x ." So DeWerth and his assistant William Sterbik designed the burner insert to reduce the flame temperature in the region where tests showed that the NO_x was primarily forming.

But they had another consideration: If they lowered the temperature too much, the burners would emit high levels of the toxic gas CO . DeWerth,

Continued

Double-ring insert can be placed on standard range burner to reduce some emissions, as demonstrated by Douglas DeWerth of AGA Labs (above). With insert on burner the flame is channeled between the rings (above left), which glow red when hot. Standard gas-range burner (top) is shown for comparison.

a chemical engineer, explained why: "When you burn natural gas, the primary products of combustion are carbon dioxide [CO₂] and water vapor. But an intermediate product of the reaction is CO; when you lower the temperature, the reaction tends to stop at CO.

"The burner insert we came up with is a compromise," DeWerth continued. "The average flame temperature of a standard range burner is around 2,500 degrees F. Our insert lowers it to around 2,100 degrees F. That reduces total NO_x emissions by about 40 percent and NO₂ by about 30 percent. But in doing that we have increased CO emissions [see table]. Still, they're well below the levels set by the American National Standards Institute."

A gas-range manufacturer, Magic Chef, is providing test ranges, building prototypes, and advising the research team on consumer acceptance. "When we showed the insert to Magic Chef's marketing people, they weren't sure they could sell that look," DeWerth related. "So they suggested we put a ceramic disc on top to hide it." Consequently, the insert has been outfitted with a disc made of Corning Glass Works' Vycor ceramic. The insert reduces the efficiency of the burner by one or two percentage points; the Vycor disc reduces it another point or two.

Some time soon AGA Labs and Magic Chef will field-test the inserts in a few homes. And at the AGA research house the air will be monitored for pollutants with and without inserts on the range burners. (Tests so far have sampled emissions right at the flame.) Whether Magic Chef will make the insert available is not decided. The technology may sit on the shelf until—or unless—regulations are passed that mandate lower emissions.

Emissions from gas-range burner —with and without insert

Burner	Emissions (ppm)			Efficiency (percentage)
	CO*	NO _x	NO ₂	
Standard (high heat)	560	103.3	39.9	45.1
With insert and Vycor disc (high heat)	650	59.9	28.6	40.6
Same as above (low heat)	600	38.0	23.0	n a

*ANSI standard is 800 ppm. Samples were taken in flame; numbers are averages of at least three readings taken at AGA Labs.

Emissions from prototype IR-jet burner

Heat setting	Input rate* (Btu/h)	Emissions (ppm)			Efficiency (percentage)
		CO	NO _x	NO ₂	
High	6,720	72	12	3	65
Medium	4,100	61	10	3	62
Low	2,600	58	8	2	55

*Input rate for standard range burner on high is about 9,000 Btu/h. Samples taken in flame; numbers are averages of at least 12 readings taken at Thermo Electron.

Meanwhile GRI has given DeWerth and his team a new assignment: to improve oven-burner emissions with a similarly simple, inexpensive device. Then they will look at the top burner again. "GRI has asked us to see what we can come up with if we start from scratch," said DeWerth.

Thermo Electron's new burner

That was also the assignment GRI gave Thermo Electron. The team there, directed by two mechanical engineers, James Hurley and Kailash Shukla, call their design an infrared (IR) jet burner. Combustion takes place just below the surface of a thin, perforated ceramic plate, which quickly reaches IR temperature (around 1,500 degrees F) on top. It is a powered burner: The combustion air is delivered by a blower and mixed with the gas prior to ignition. Just above the ceramic plate is what looks like a glass disc with nine holes drilled in it.

Hurley and Shukla, like the AGA Labs team, sought a design that would quench the temperature quickly to limit NO₂ and total NO_x formation. But because they were starting from scratch, they had fewer limitations.

"The formation of NO_x depends on time as well as temperature," Hurley said. "The less time the combustion products spend at high temperature, the less NO_x is produced. In a standard gas-range burner the maximum temperature is somewhere around 3,000 degrees F." And combustion products remain at high temperatures for some time. "With our burner combustion takes place at 3,000 degrees F inside the tiny cavities of the ceramic disc," Hurley continued. "But at the same time, the ceramic is transferring radiant heat rapidly, and the incoming gas-air mixture is pushing the hot combustion products up [see diagram]. Thus they immediately drop to the equilibrium temperature of the burner itself—around 1,500 degrees F. So we do not have a sustained formation of NO_x; we get about 12 parts per million." A standard burner produces about 100 parts per million.

The powered burner is another factor in reducing emissions. Theoretically a given amount of air is required to burn a given amount of fuel completely; in reality some excess air is needed, or you get smoke. A powered burner can operate with considerably less excess air than a standard atmospheric burner. And that reduces NO_x emissions. "Formation of NO_x is influenced by the amount of nitrogen and oxygen available—which depends on the amount of excess combustion air," Hurley explained.

The powered burner, since it pre-

mixes the gas and air, also speeds combustion. And that reduces CO formation. "In our burner CO is quickly converted to CO₂ during the brief time when the combustion gases are at high temperature," said Hurley. The IR-jet burner has very low CO emissions as well as low NO_x and NO₂ (see table below).

But most critical to the low emissions of the IR-jet burner is its high efficiency. "If you can make a burner twice as efficient, you can use half the amount of gas—and produce half the emissions," Hurley pointed out. The low excess air contributes to the high efficiency of the IR-jet burner. So does the transparent disc that sits above it.

The disc is called a jet plate because its nine holes jet the products of combustion, powered by the incoming gas-air mixture, up to the cooking vessel. "Those high-velocity gases break up the boundary layer of air that normally forms on the flat bottom of the utensil and diminishes heat transfer," Hurley told me. "Approximately 90 percent of the radiant energy that strikes the jet plate (made of a glass-ceramic material) is transmitted through the plate to the bottom of the cooking pot. And the products of combustion are jetted through the holes to improve convective heat transfer. The combined effect gives our burner an efficiency of approximately 65 percent," he explained. A standard gas-range burner is 40- to 45-percent efficient.

The IR-jet burner also reduces by 65 percent the amount of heat rejected into the kitchen, its developers claim. In addition the heat is uniform over the bottom of the pan. And the burner is quick to respond to temperature adjustments. "One thing we did not want to do was to design a gas version of the electric range," Hurley said with a smile.

"It takes 30 or 40 seconds for our burner to reach infrared temperatures," Hurley continued as he flickered on a burner of the prototype range. It gradually turned from the buff color of the ceramic disc to a glowing red. "But once it's at temperature, its response is as good as that of a conventional gas burner." Hurley turned down the heat as he spoke, and the red glow instantly reverted to buff.

Caloric, the manufacturer that is cooperating with Thermo Electron, is providing a half-dozen ranges to be put in homes for field testing. Two of the burners on each range will be IR-jet burners, and two will be conventional. "That will let the homeowner see the differences," said Bill Day, vice-president of engineering at Caloric. "If the burner operates the way we hope, we'll certainly commercialize it." **PS**

Piezoceramic flight sensor

Gyroscopes spinning at high speed to detect aircraft motion are not reliable. To replace them, Collins' new flight sensor uses a number of ceramic piezoelectric transducers, spun at low speed for reliability, that generate a voltage as they're continuously flexed. The system is now aboard commuter and business aircraft.

By **JOHN FREE**

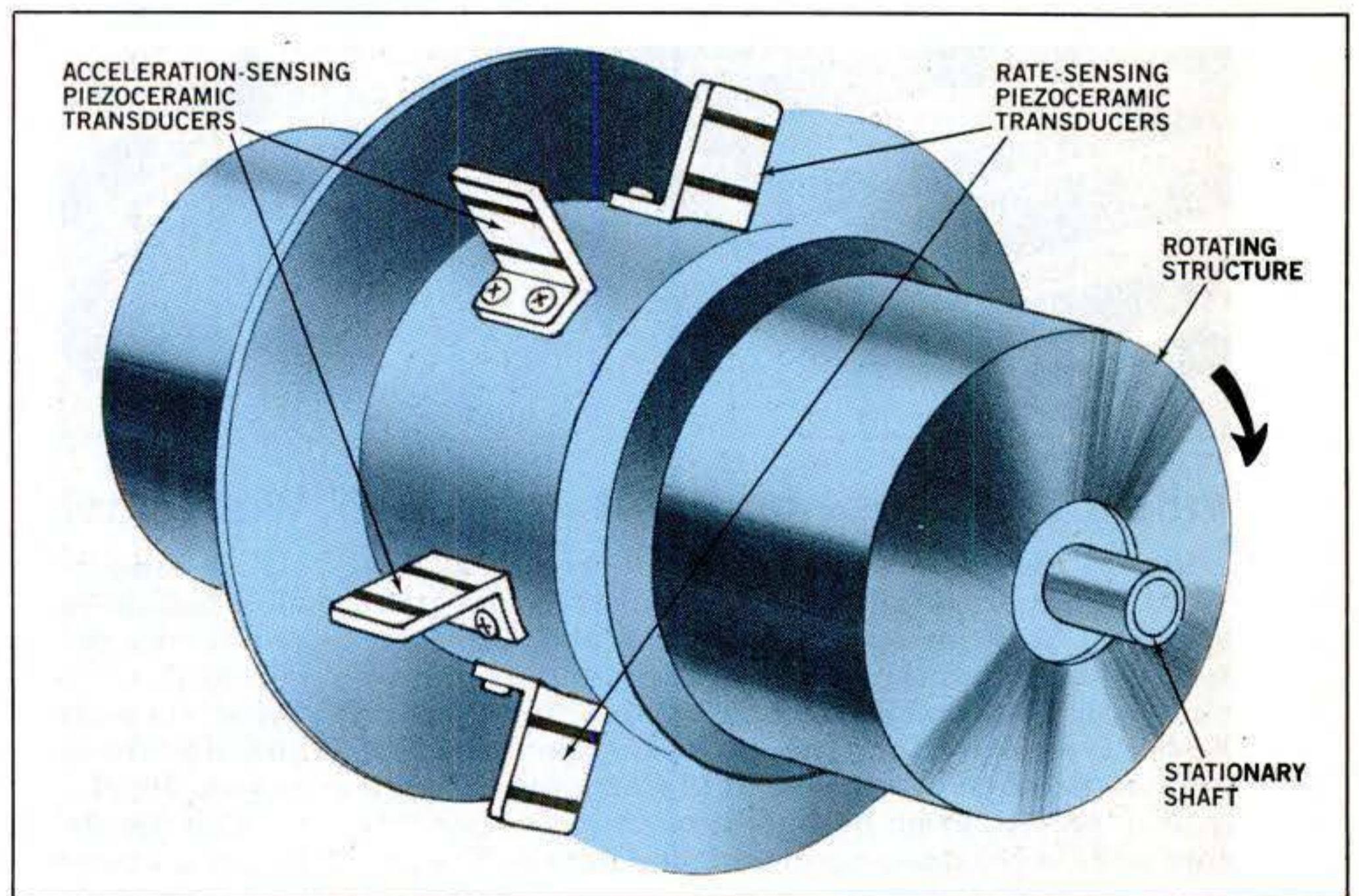
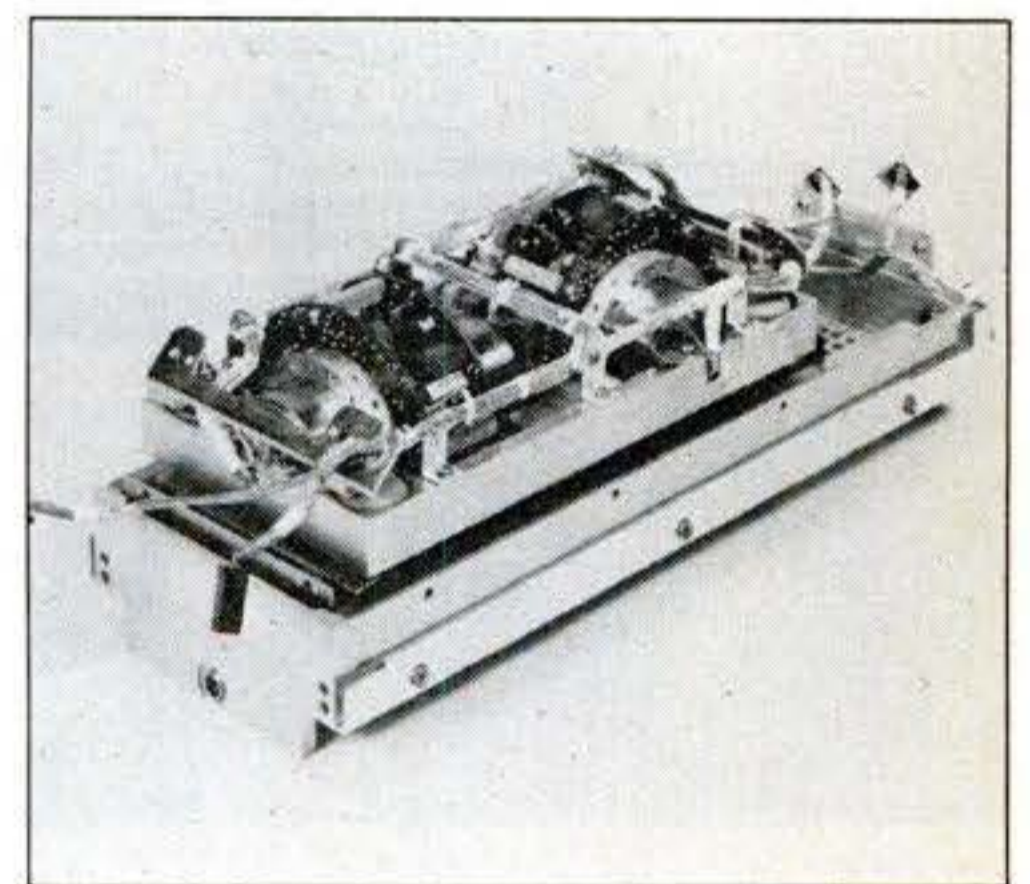
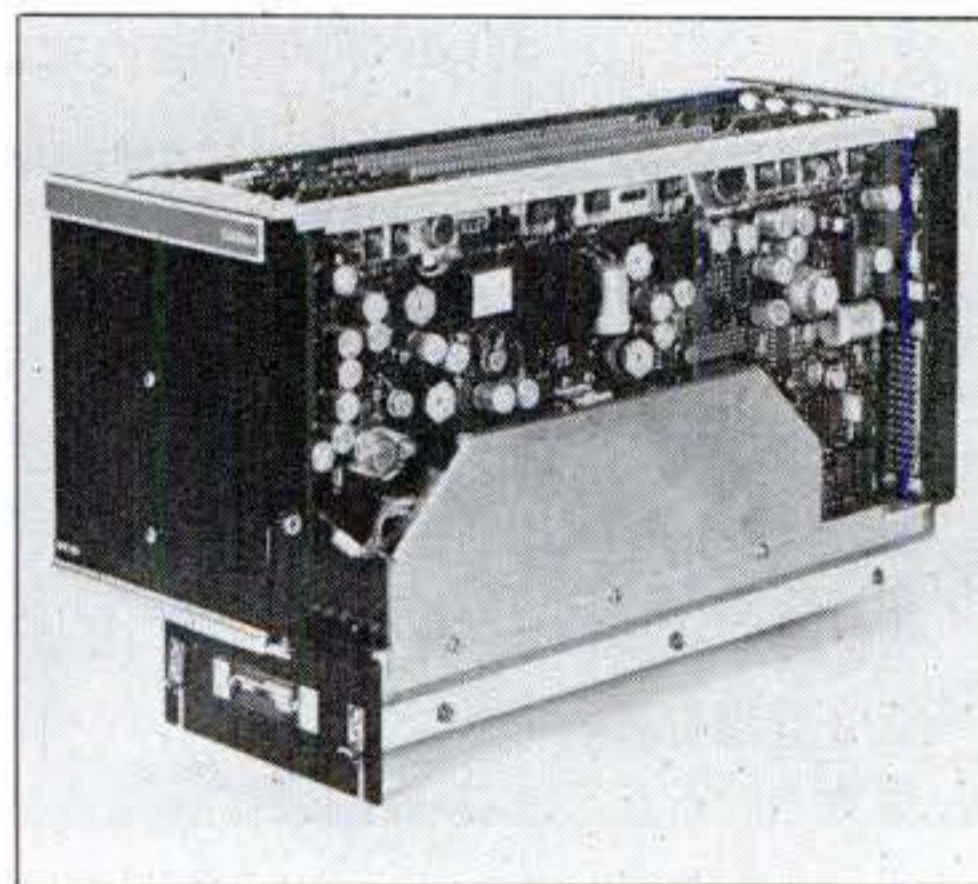
Drawing by Adolph Brotman

Most aircraft use gyroscopes as sensors to display flight attitudes and headings. But gyros create problems. "A conventional gimballed gyroscope has complex parts that are prone to failure: bearings, slip rings, brushes," said David Hemmel, an engineer with Rockwell International's Collins Avionics Group (Cedar Rapids, Iowa). "Because gyros rotate at very high speed, typically 24,000 rpm, expensive, high-quality bearings head the failure list," he said.

To solve this reliability problem, Collins developed a new type of flight sensor. Instead of gyros, the Collins AHS-85 system is based on small slabs of piezoceramic material that generate a voltage when flexed. Unlike ordinary gyro systems, with six to eight separate components, the AHS-85 has only two.

The Collins system differs in other ways. "Because our sensors spin at very low speeds—less than 3,200 rpm—there's a big jump in reliability," Hemmel told me. Spinning provides the constant flexing needed for a continuous voltage output from the piezoceramics. A stationary sensor would produce only a brief DC voltage. Also, the AHS-85 is a "strapdown" system: "The sensors are strapped to the airplane's axis," Hemmel said. As the aircraft pitches or rolls, the black box and spinning sensor also move, producing a signal that indicates the rate of movement. By contrast, with gimballed gyro sensors, the spinning wheel remains fixed in space as aircraft movement shifts the gyro container.

The AHS-85 has two rotating multi-sensor units, each with four ceramic transducers (see drawing). They pro-



duce signals, along with the magnetic detector, to compute aircraft speed, acceleration, pitch, roll, and heading. When one spinning sensor, a rate transducer, for example (see drawing), is flexed by aircraft motion, it generates a positive voltage. A split second later, rotated 180 degrees, it's bent in

(above) has four piezoceramic transducers that produce signals for an aircraft's flight instruments, autopilot, flight-data recorder, and radar gear.

the opposite direction, producing a negative voltage. A sine-wave signal results that's electrically summed with the output of a second rate transducer. An AHS-85 computer, analyzing the sensor units' signals, now helps guide commuter and business aircraft.

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What's New

products/technology



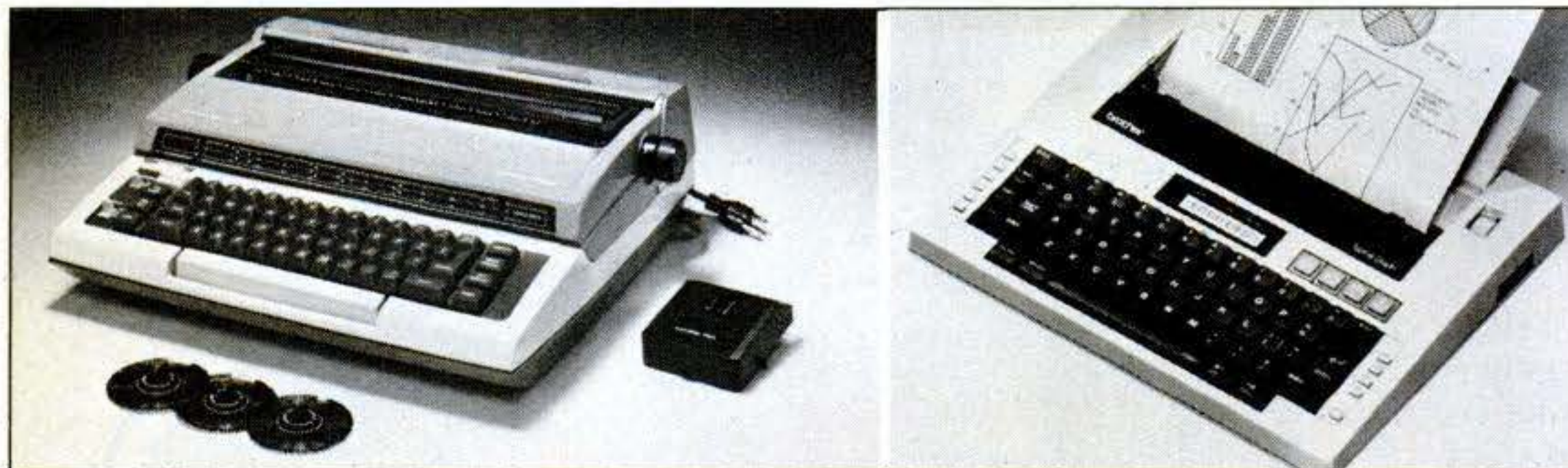
Unlooped tube

Flat bike tire? You needn't remove wheels or chain with this unlooped inner tube that has two flat overlapping ends. To remove the tube just pry one tire side loose; to replace it, overlap the closed ends. Continental Gummi-Werke AG, Box 169, 3000 Hannover 1, W. Germany.



Mobile clinic

A squat 46-in.-high tractor hauls this five-room Dutch mobile medical clinic. The 59-ft.-long van has a computer scanner, X-ray, and other gear. A 280-hp V8 diesel powers the cab. Fa. J. van Eck & Zn., Kortenhoeveneweg 75, 4128 CN Lexmond, Netherlands.



Typewriters that erase and plot

Touch a key on Smith-Corona's Memory Correct 400 Messenger (left), and it erases one word or an entire line (up to 157 characters). Add an optional module, and the daisy-wheel portable becomes a computer printer. Suggested price is \$599, says Smith-Corona (65 Locust Ave., New Canaan, Conn. 06840). Type-a-Graph (right) is a battery-powered \$350 portable from Brother International (8 Corporate Pl., Piscataway, N.J. 08854). Four ball-point cartridges "type" in four colors and three sizes—up, down, and across. The portable also plots three-color pie, line, and bar graphs.

Water tank

Hydro-Tank keeps water levels constant in pots for several weeks, enveloping plant roots above in moist air. Water seeps through a slot and fills the container to a preset level. Evaporation unseals the slot. G. R. Vatter SA, Sagerstrasse 65, 3098 Köniz, Switzerland.



Giant airship

Skyship 600, designed for aerial ads and pleasure flights, is the world's largest airship, says Airship Industries Ltd. (2 York St., London W1H 1FA, England). The 194-ft. nonrigid airship carries 24 passengers. It can take off vertically and cruise at 55 knots (63 mph).



Space rocket

A manned rocket-powered vehicle under study for military space flights could be launched from a 747, says Boeing. The proposed vehicle (topmost, cone-shaped structure), with a huge fuel tank, would be lifted from an airfield, complete a mission in space, then land.



Desk-top analyzer

Aca IV, a 44-in.-wide clinical chemistry analyzer, performs 50 different tests and will soon handle 70, says Du Pont (Wilmington, Del. 19898). The computerized machine works by mixing chemicals and body-fluid samples in clear-plastic packs. Results appear on a printer.

Mid-engine Ford

A prototype two-seater mid-engine Ford was photographed on the sly recently by an avid "Detroit Report" reader as the car underwent tests in N. Palm Beach, Fla. Ford may be planning to take advantage of all the unfilled orders for General Motors' successful Pontiac Fiero.



Child restraint

A papoose-like child enclosure fits behind a car's front seat. In a crash it cocoons the small occupant in a tough fiberglass shell. The restraint clips to a padded shield attached to the backrest. It's available from S.N.P. SA, 8 Ave. de Dallas, B.P. 40, 21019 Dijon Cedex, France.

X-wing rotorcraft

Innovative X-shaped rotor blades will enable an aircraft to take off and land vertically, hover, and, with the rotor stopped, fly like a fixed-wing aircraft at speeds up to 345 mph. The X-wing on Sikorsky's research aircraft will stop and start by a clutch.

What's New

Seesaw bike

Treadle-type pedals require less muscle power, says Alexnax Corp. (91 La Grange Ave., Rochester, N.Y. 14613). The pedal levers are linked by chain drives to a four-speed transmission that gives faster cruising and easier hill climbing than a derailleur, the maker claims.



Duplex helicopter

The pilot of the modified Sikorsky S-76 sits in a separate pod crammed with computer displays. The flights, part of the Army's helicopter research project [PS, Feb.], will test a pilot's ability to work in the highly automated environment.



Italian Corvette

Under its slick green skin, Rammaro is all Corvette. Bertone—the Italian design firm—"interpreted" the Corvette, shrinking it by 13 in. but adding five in. to its width. Rear-mounted radiators and forward-sliding doors are the major engineering changes.



Harrier tests

Hanging from a gantry, a Harrier jet is moved up and down during engine tests. Why? Its engine has advanced plenum-chamber burning for extra thrust at supersonic speeds, but when close to the ground the vertical-takeoff craft may inhale its own exhaust, weakening thrust.



Greenhouse garage

Bolt-together galvanized-steel arches frame the Ultra-Hut. Greenhouse plastic, attached with "flexible clip strips," covers the 22-by-24-ft. structure. Two people can assemble the \$895 hut in four to six hours, says Monfort Assoc., (Box 1490, Wiscasset, Maine 04578).

What's New in Photography

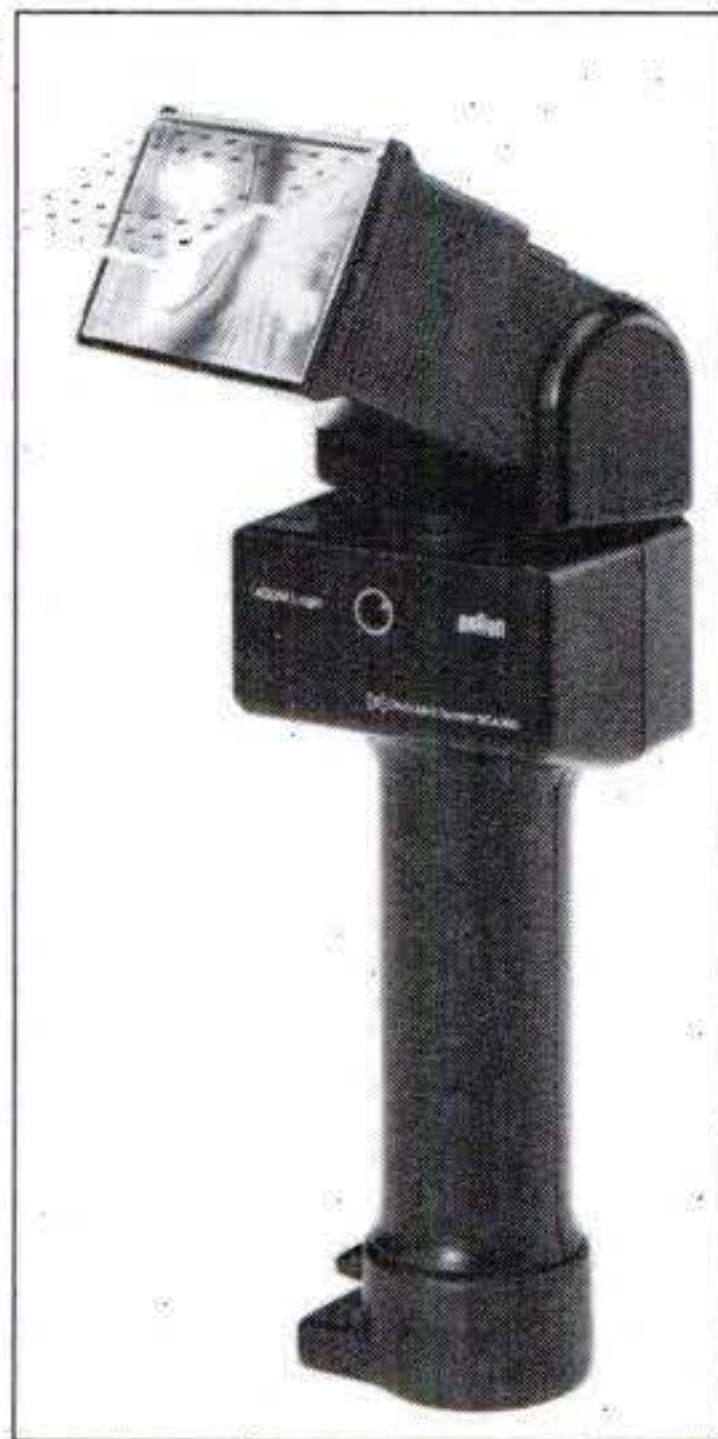
BY EVERETT H. ORTNER

Instant ID

"Simplicity" describes its new Readyprint instant ID system, says Kodak. The operator aims a light between the subject's eyebrows, sets a picture-option switch (for four same, four different, or two pairs), and fires. A die cutter and laminator complete the \$1,600 system.

Swivel flash

The Braun 400M Logic Flash swivels 120 deg. vertically for bounce and 170 deg. horizontally; can be set (with a beam splitter) for telephoto, normal, or wide-angle lenses; adjusts for full, half, or quarter power; and provides auto flash at six apertures (f/2.8-f/16). Price: \$255.



Umbrella clamp

Mount the pocket-size Stroboframe clamp on a tripod or light stand, and it grips two flash units and an umbrella for a choice of arrangements: Bounce both off the umbrella or bounce one and use one direct. The clamp is aluminum with plastic knobs. It's \$19.95.



All-auto 35

Everything's automatic in the Vivitar PS:35: exposure, focus (via an IR beam), flash, loading, winding, and re-winding. Programmed shutter speeds range from 1/30 to 1/500 second; apertures for the 35-mm lens are from f/3.8 to f/1.6. List price: \$139.95.

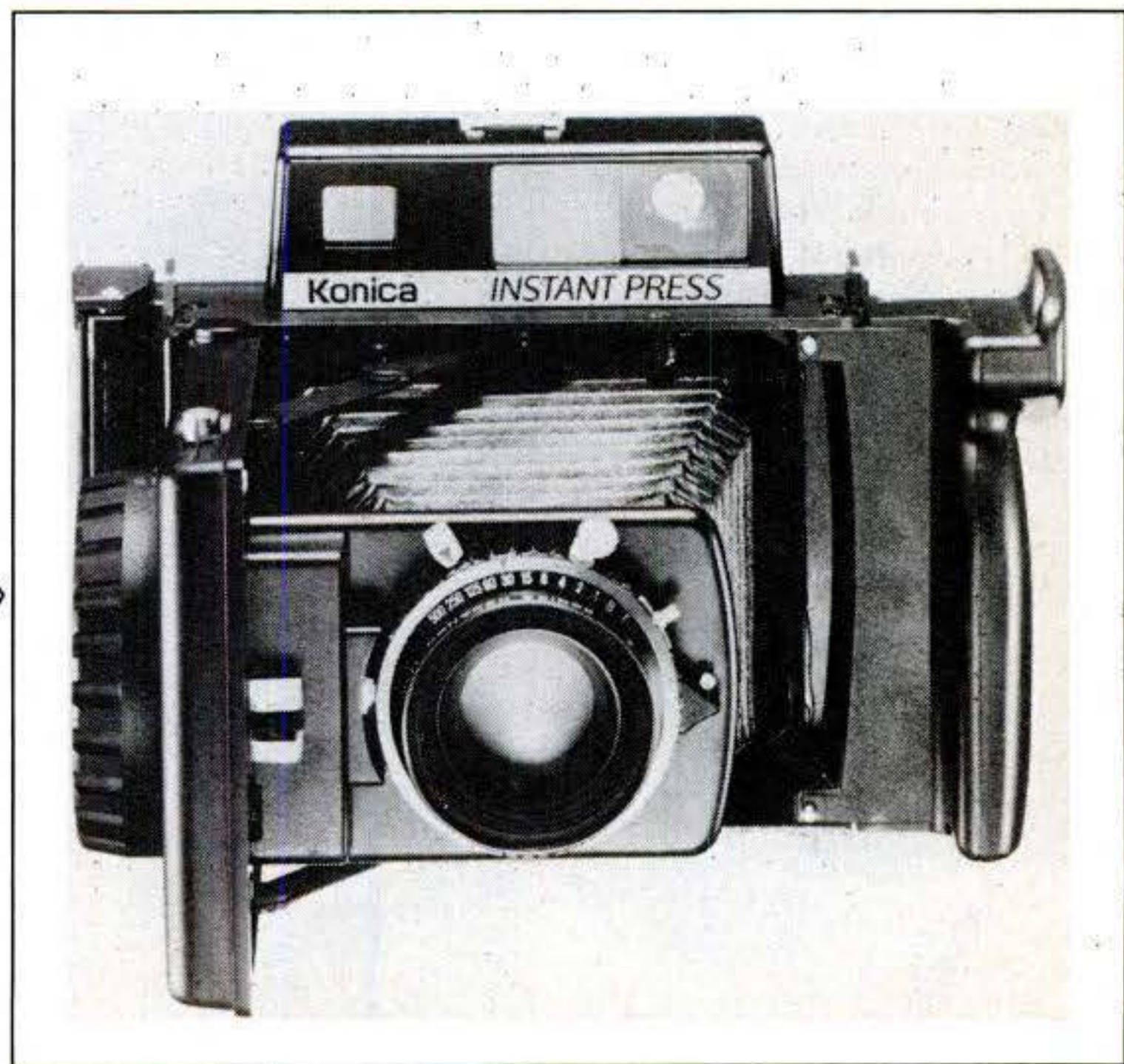


Drop-front case

One pull on the zipper handle, and the front flap of the Instant Access Case opens to give, well, instant access to your SLR with winder and lens mounted, ready to go. The 8½-by-10-in. nylon case is \$28.95 from Spiratone (135-06 Northern Blvd., Flushing, N.Y. 11354).

Basic instant

It's back to basics with the Konica Instant Press camera, designed for manual exposure—it has no light meter—using Polaroid peel-apart pack films. It has a 110-mm f/4 to f/64 lens and shutter speeds from one to 1/500 second plus T and B. \$600.



What's New in Tools

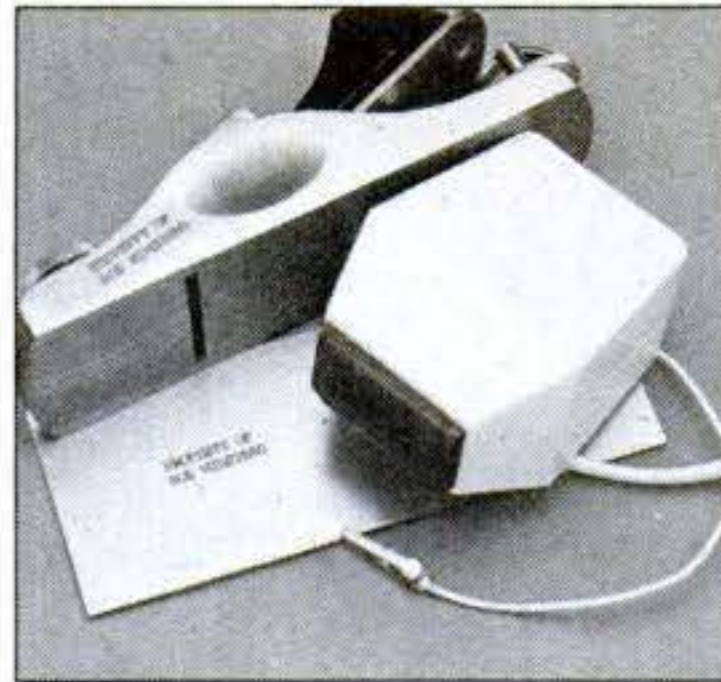
BY V. ELAINE SMAY

Smart saw

The Speedtronic 7¼-in. circular saw has a microchip that adjusts motor speed for the most efficient blade speed. Result: greater cutting ability—entering the work, cutting through knots, finishing the cut—says Porter-Cable (Box 2468, Jackson, Tenn. 38302-2468). \$199.

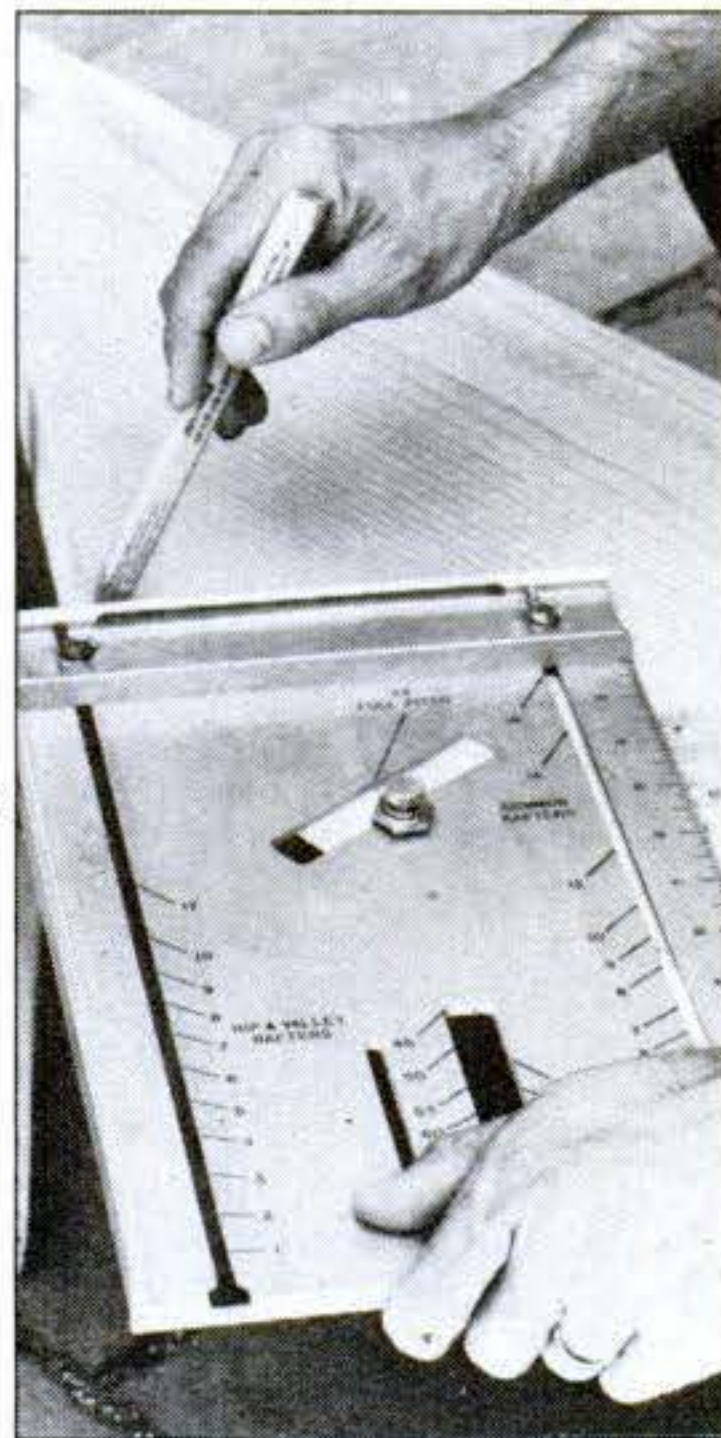
Show your etchings

... and prevent tool loss. Just type or write on the stencil, and the Etch-O-Matic marking system will etch your message into any metal, using a safe electrochemical process, according to Woodcraft Supply Corp. (41 Atlantic Ave., Woburn, Mass. 01888). Price: \$54.35 ppd.



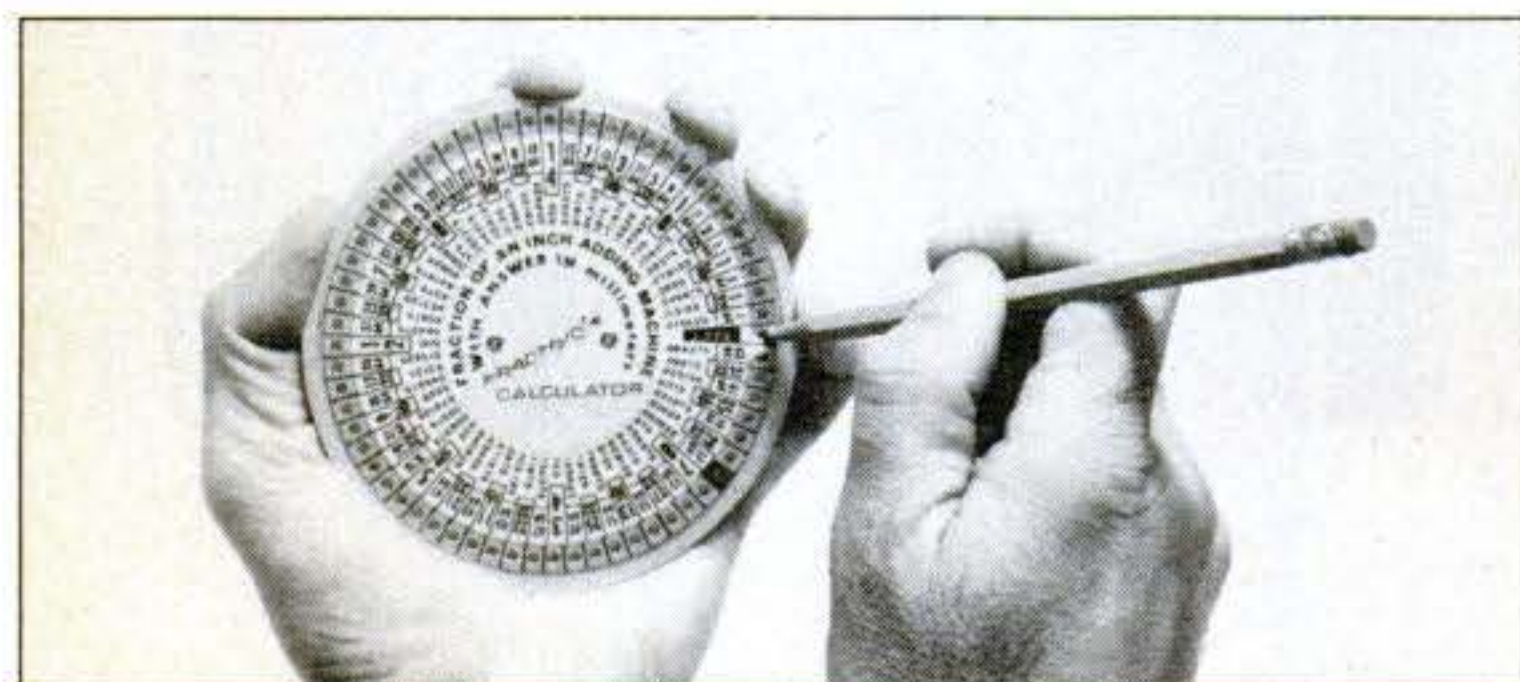
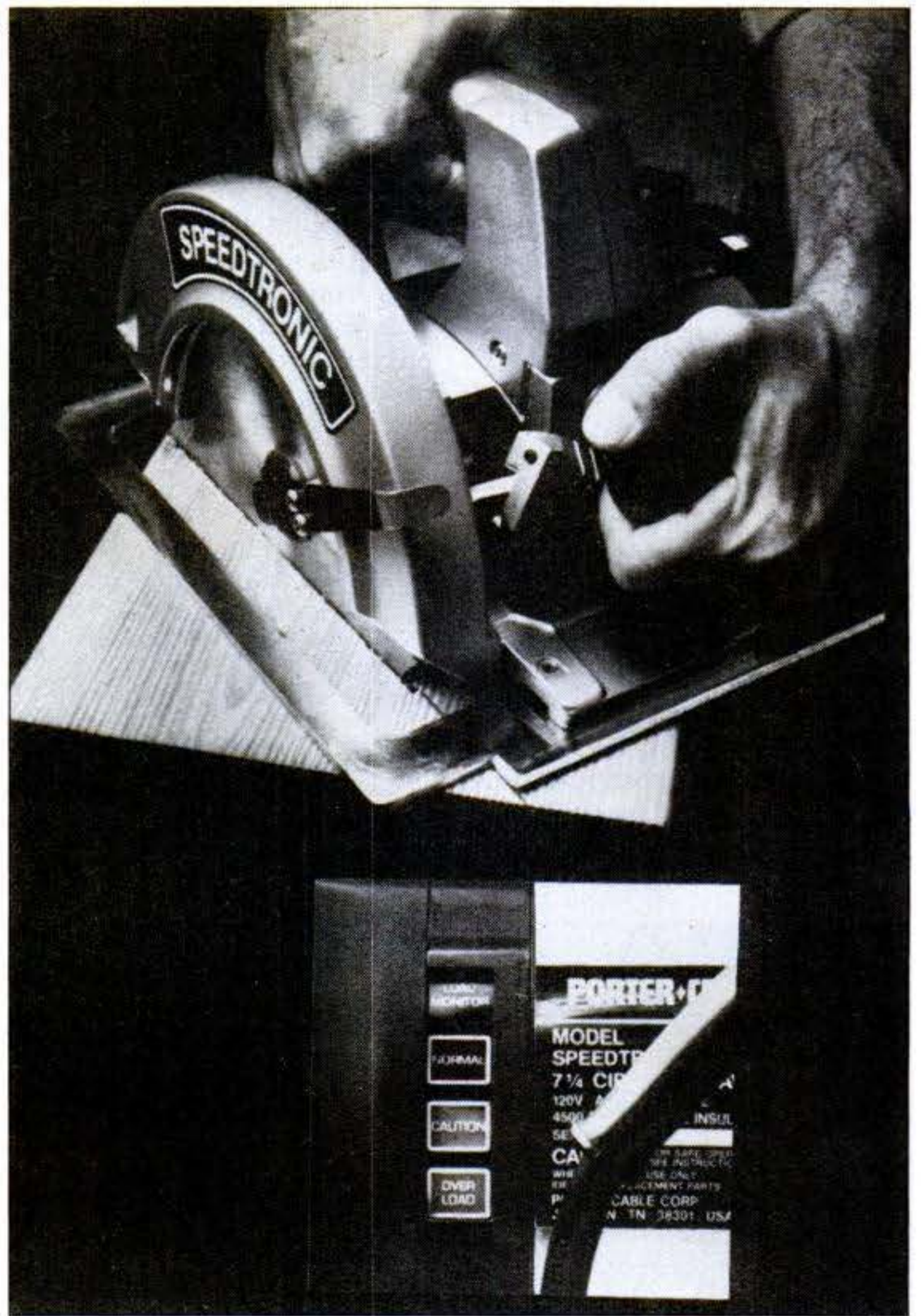
Bolt-on bolts

Jumbo nuts and bolts can't be tensioned enough with standard tools, claims Steinbock Machinery (603 Lindsay Rd., Carnegie, Pa. 15106). Superbolt nuts and bolts (shown with hex bolt, washer) can. You tighten small bolts—to a lower torque—instead of one big one.



Builder's assistant

The aluminum Speed Block Cutting Guide has all the angles and measurements you need to mark rafter cuts, ridge cuts, seat cuts, and stair stringers. As a block-cutting guide it adjusts from 14½ to 1¾ in. The Building Machine, 903 44th St., Oakland, Calif. 94608; \$25.



$$\frac{55}{64} + \frac{17}{32} - \frac{1}{8} = ?$$

You'll find the answer at the spin of a dial with the Frac-tron calculator, says Graphic Systems (Box 881, Melville, N.Y. 11747). Frac-tron adds or subtracts fractions of an inch or decimal equivalents. Frac-tric, its sibling, displays answers in millimeters. The calculators cost \$8 each.

Shop cleaners

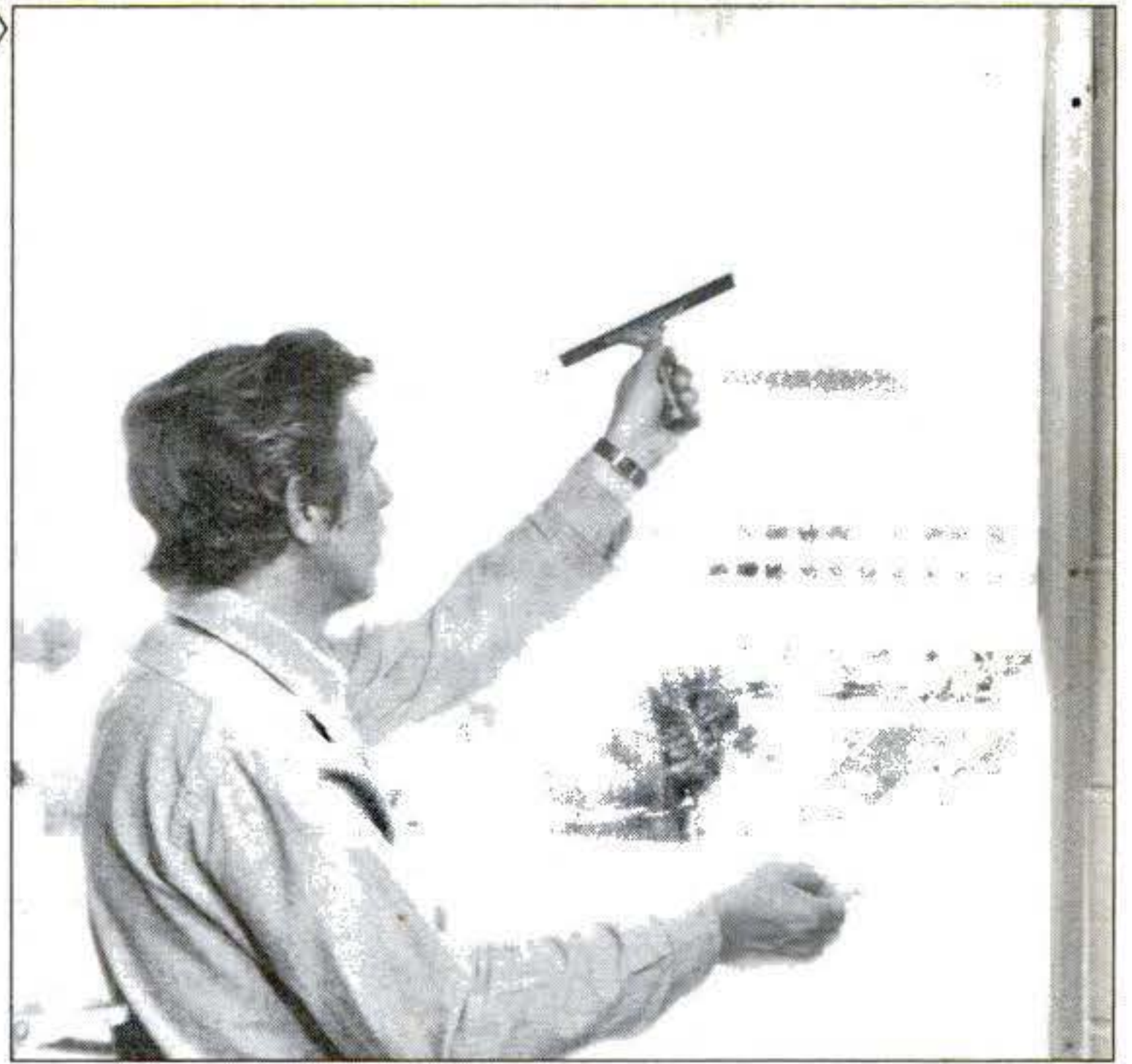
Three new portable dust collectors from Delta Intl. (formerly the Power Tool Div. of Rockwell Intl.) are made for use in the wood shop—with planers, shapers, jointers, and band saws. The one-hp model is \$443; two-hp, \$629; three-hp, \$773. (You provide the 55-gal. drum.)

What's New in Home Improvement

BY SUSAN RENNER-SMITH

Double-duty film

Scotchint Window Insulation Film IN55CL transmits 50 percent of visible light, cutting summer heat gain. The clear polyester film also reduces winter window heat loss by up to 40 percent, says 3M. The professionally installed film is available from Scotchint dealers.

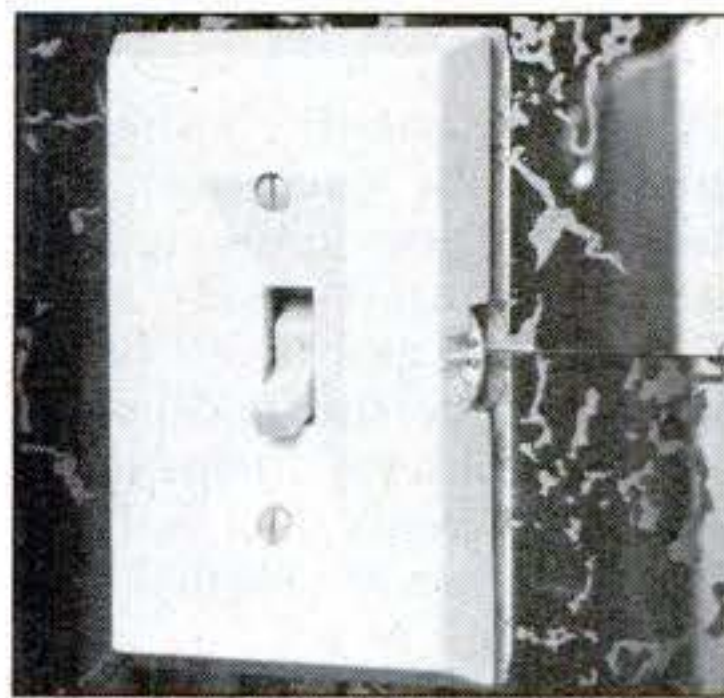


Door shutters

Movable louvers on Patio Door Covers provide privacy and ventilation. The 1 1/8-in.-thick shutters slide easily, even when the slats are fully open, says Flair-Fold (E. Farmingdale, N.Y. 11735). The five-ft.-wide unit shown is \$495; track and rollers are in the frame.

Kit room

In summer, it's a screened-in porch; in winter, a sun room. A copper roof, vertical double-pane windows, and optional skylights distinguish the All Season Room from standard add-on sun rooms, says Habitat (123 Elm St., S. Deerfield, Mass. 01373). An 84-sq.-ft. room is \$7,449.



Turn-off timer

No more lights left burning: Switch Command Electronic Light Switch replaces any single-gang switch. Turn on the light, and the switch counts down a preset interval—from five minutes to four hours—then shuts the light off. AMF, Box 28, Two Rivers, Wis. 54241; \$20.



Chimney cleaner

A child can operate this cresote remover, says Swift Chimney Cleaner (Box 2, Van Buren, Maine 04785). The hand crank pulls a brush-carrying cable up and down the chimney. A transmission reverses cable movement when the brush hits top and bottom pulleys. \$200.

Spray adapter

Stanley's screw-on aerator converts a standard faucet to a swiveling spray head. The two-way adapter pulls down for spray, pushes up for a steady stream. The \$4.20 device mounts on inside- and outside-threaded faucets. Stanley Works, 195 Lake St., New Britain, Conn. 06052.

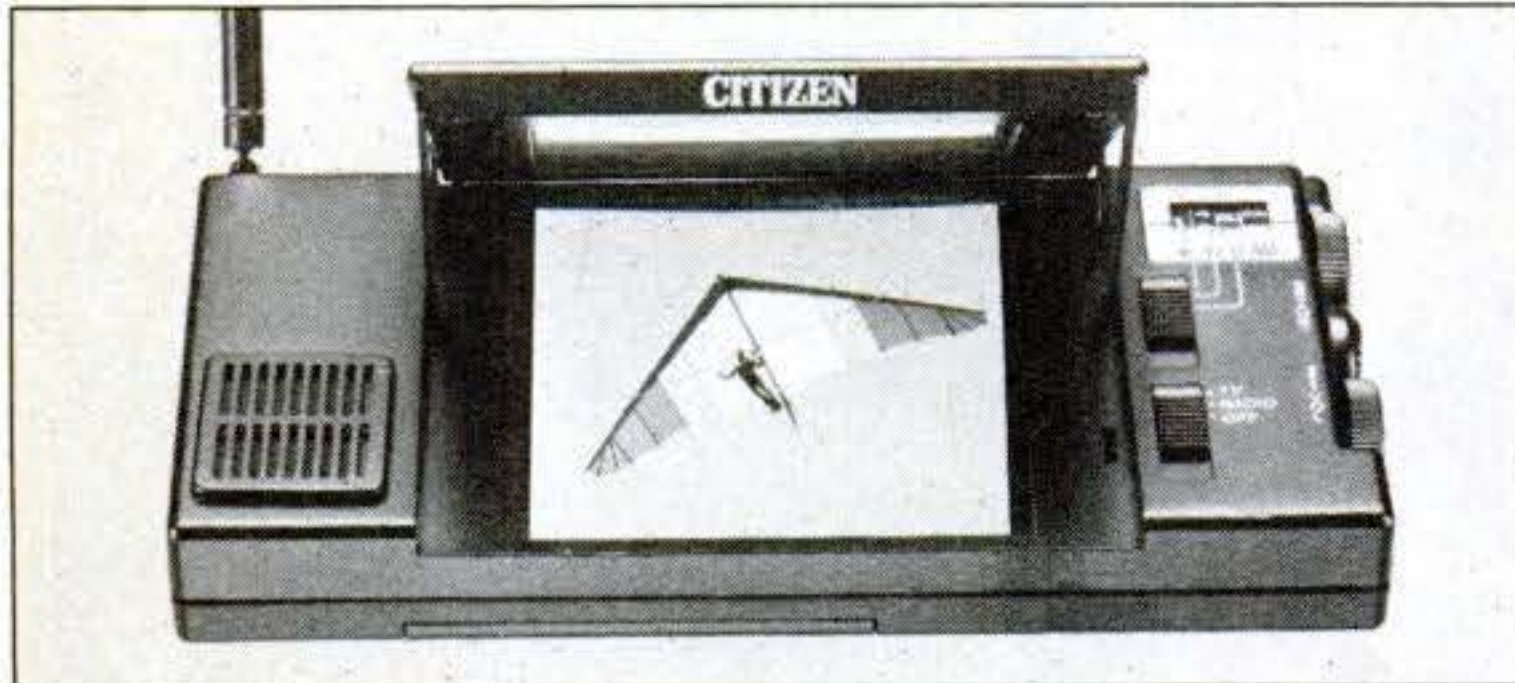


What's New in Electronics

BY WILLIAM J. HAWKINS

Tiny tape player

A cassette player as small as the cassette it plays? Not this Toshiba Walky—it's *smaller*. The trick: The cassette attaches to the outside of the player. The unit has automatic reverse, Dolby B noise reduction, and an AM-FM tuner; it weighs just 7.4 oz.



Pocket color TV

It uses multiphase highlight multiplexing. In English, that means this liquid-crystal TV is small enough to fit in your pocket, yet it delivers a bright, sharp color picture. The Citizen Watch TV (available next year) is five by three by one in. and weighs less than nine oz. \$350.

Thief stopper

Pressure-sensitive adhesive pads on the computer and table top are connected by a vinyl-coated steel cable. Result: The gear can't be removed once the padlock is in place, claims Business Security Systems (512 S. Hanley, St. Louis, Mo. 63105). The Technalock is \$25.

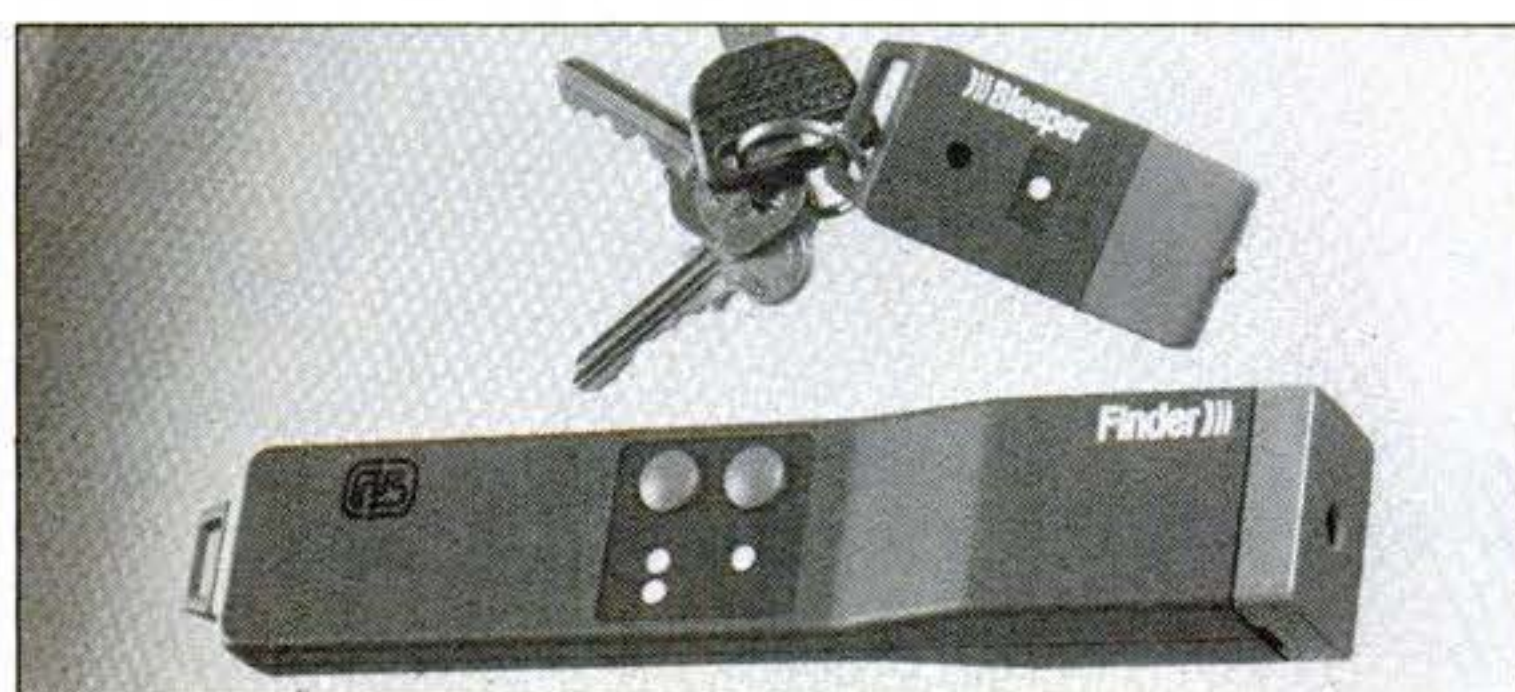
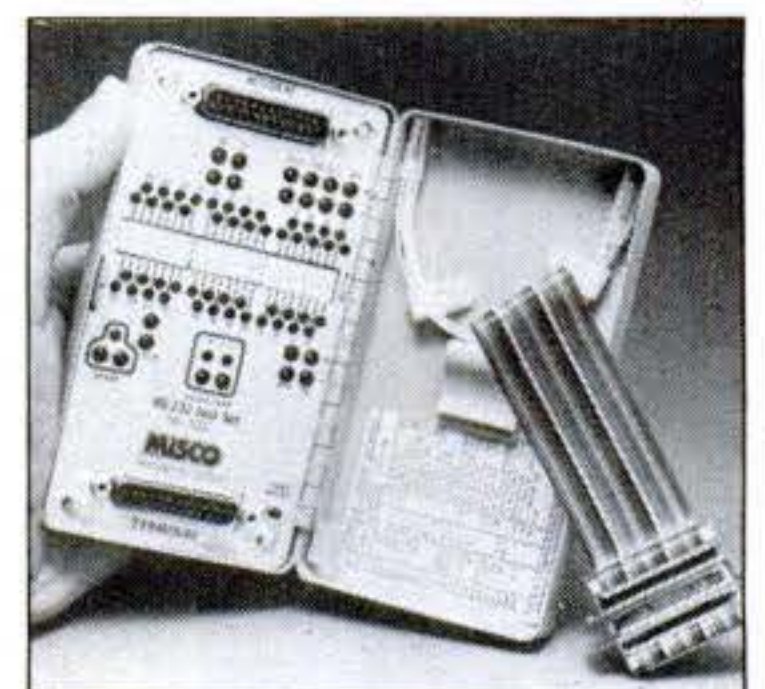


Kitchen helper

Making space on the kitchen counter is the job of this \$90 General Electric Spacemaker AM-FM radio-timer. It bolts to the bottom of a cabinet to ease the clutter and to provide timer and automatic-appliance control while you work, music while you wait.

Title-maker camera

An internal keyboard allows you to select characters (letters and numbers) or words ("Happy Birthday") from memory for instant titling of video pictures taken by the RCA CKC021 camera. The camera uses a 2/3-in. Saticon tube and a 1 1/2-in. color CRT viewfinder. \$1,295.



Key finder

Lost your keys—again? Press a button on the "Finder," and if they're within 15 ft., the key-ring "Beeper" sounds off and lights up to get your attention. (Now all you have to do is remember where you put the Finder.) Lanshaw & Co., 13085 Bodega Hwy., Freestone, Calif. 95472; \$50.

Interface tester

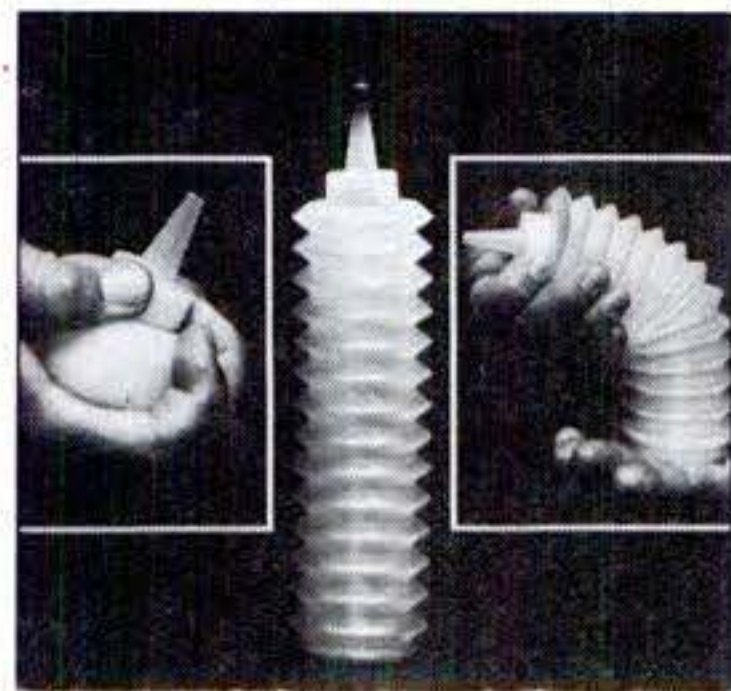
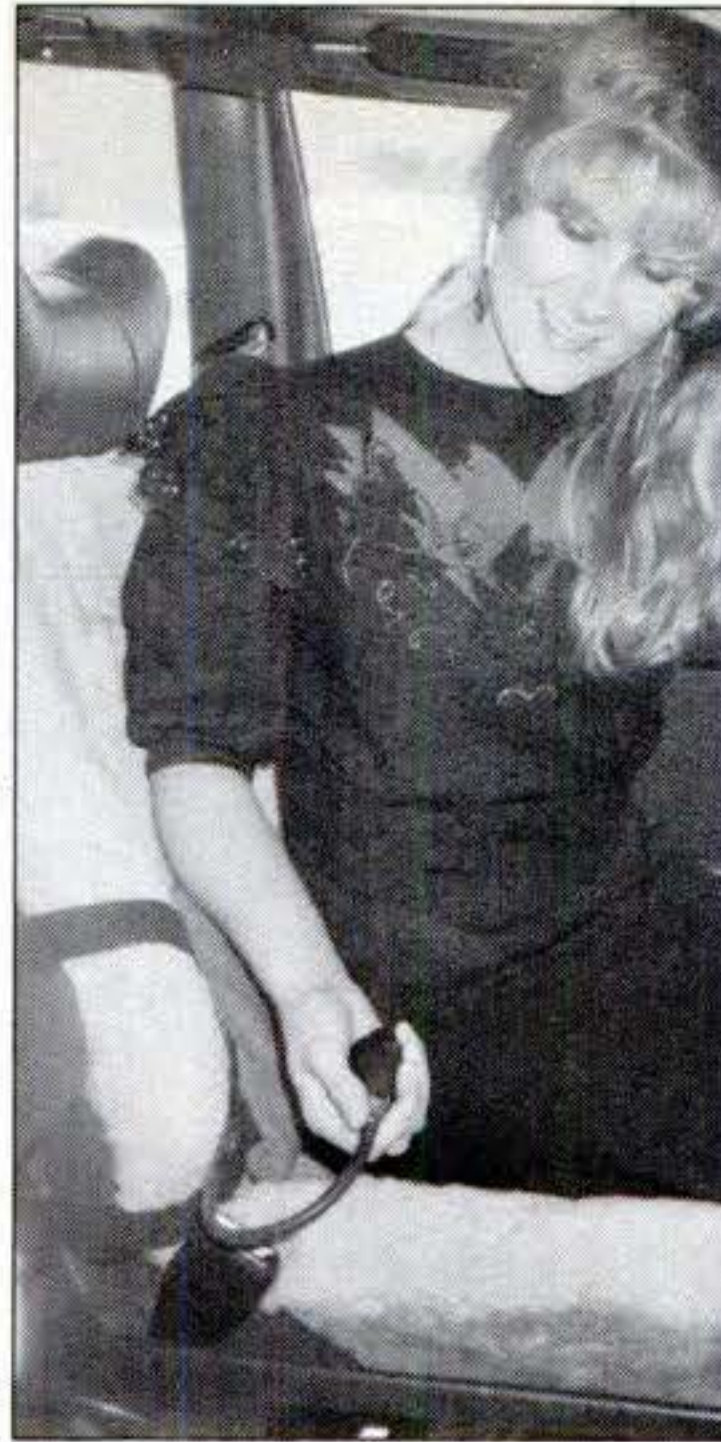
Connect the Interface Analyzer between your computer and a serial peripheral (printer, modem, etc.), and LEDs display the status of nine signal lines for troubleshooting. It's \$229 from Misco, 1 Misco Plaza, Holmdel, N.J. 07733. A \$395 parallel-port version is also available.

What's New for Your Car

BY JACK KEEBLER

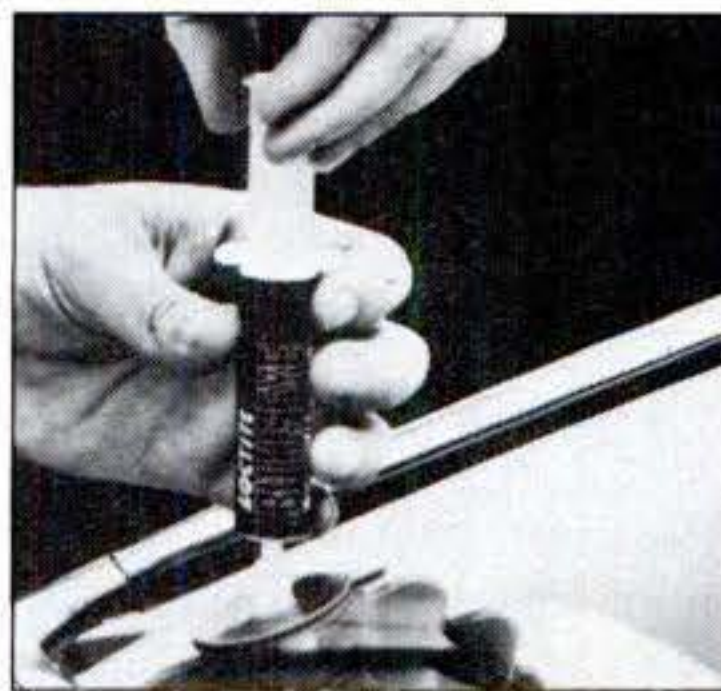
Back support

Squeezing a rubber hand pump inflates this lower-back support cushion by U.S. Fitness Inc. (790 Basin St., San Pedro, Calif. 90731). The washable polyester/cotton cover comes in red, blue, beige, and gray. The attachment straps go around the back of the seat. \$29.95.



Flexible dispenser

Poly-Lube Gear Oil & Fluid Dispenser is handy for topping off brake-fluid, gear-oil, power-steering, and transmission-fluid reservoirs with limited access, says Power Lube Co. (5654 Cahuenga Blvd., N. Hollywood, Calif. 91601). The polyethylene dispenser holds one pint. \$2.98.

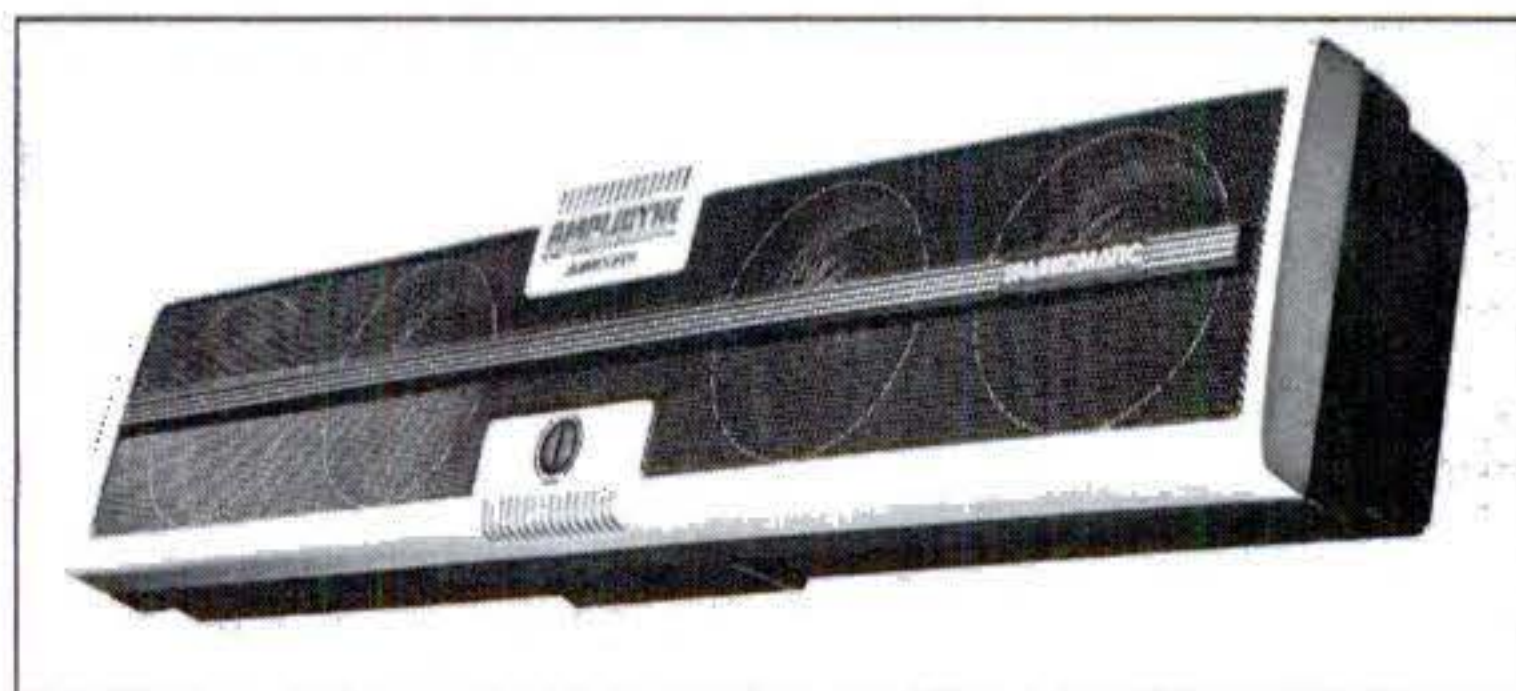


Windshield fix

Loctite's Bullseye windshield repair kit pumps an acrylic compound into bull's-eye-type windshield damage to provide a crystal-clear fix. The kit requires no mixing or pouring. An application syringe and mounting pedestal keep the compound from touching your skin. \$10.

Cassette caddy

Your tapes are organized for easy access and are protected from dirt and direct sunlight in this under-dash unit. A light inside the cover illuminates tape labels at night. Maker: Pompano Mfg. Corp. (2501 N.W. 17th Lane, Pompano Beach, Fla. 33064). Price: \$49.95.

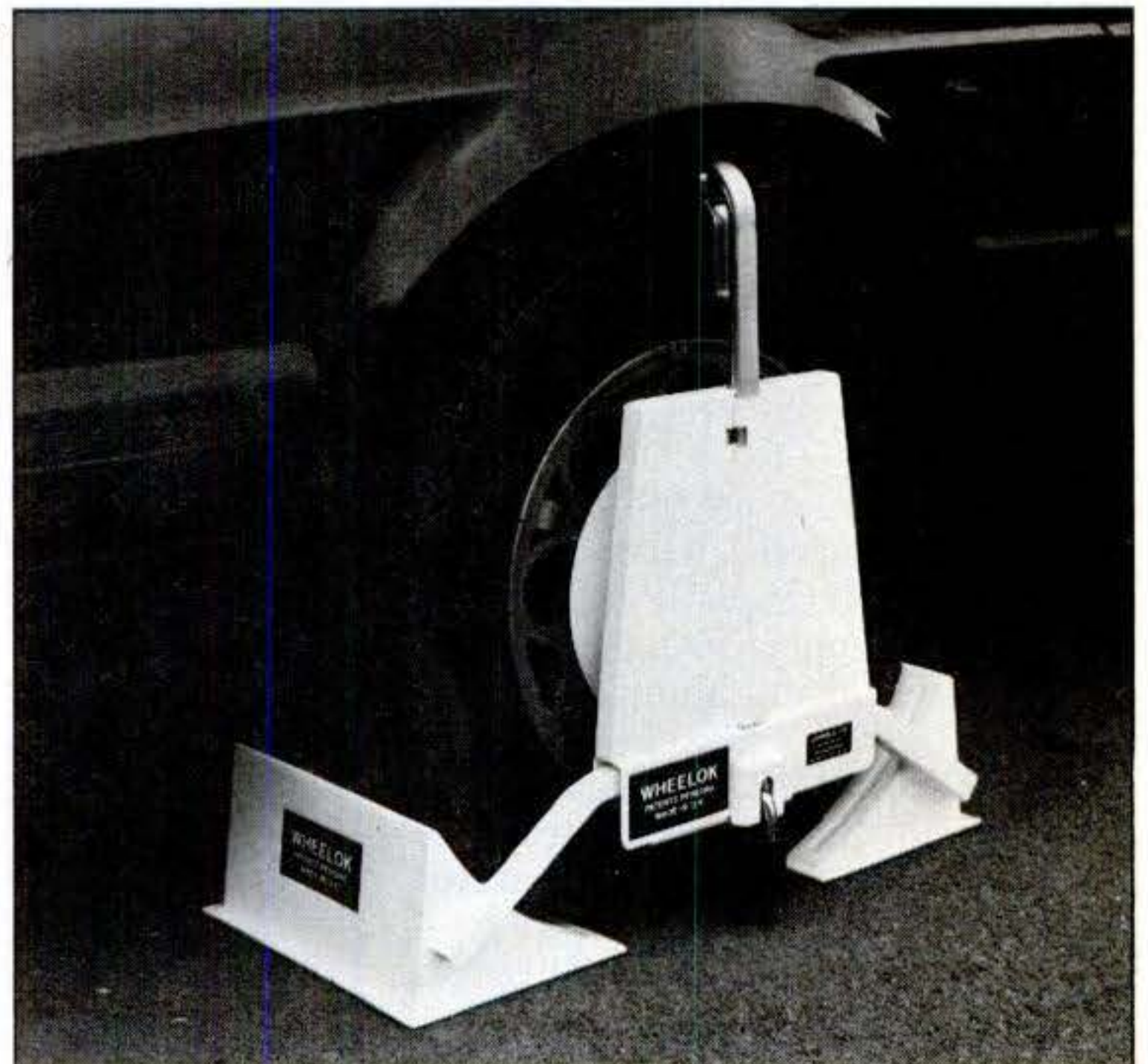


Super sound

The Amplidyne 4030 four-speaker sub-woofer extends the low frequency of automotive sound systems, says Sparkomatic. Two built-in amplifiers add up to 80 W of power. Its low silhouette enables it to be surface-mounted on the rear deck between speakers. Price: \$200.

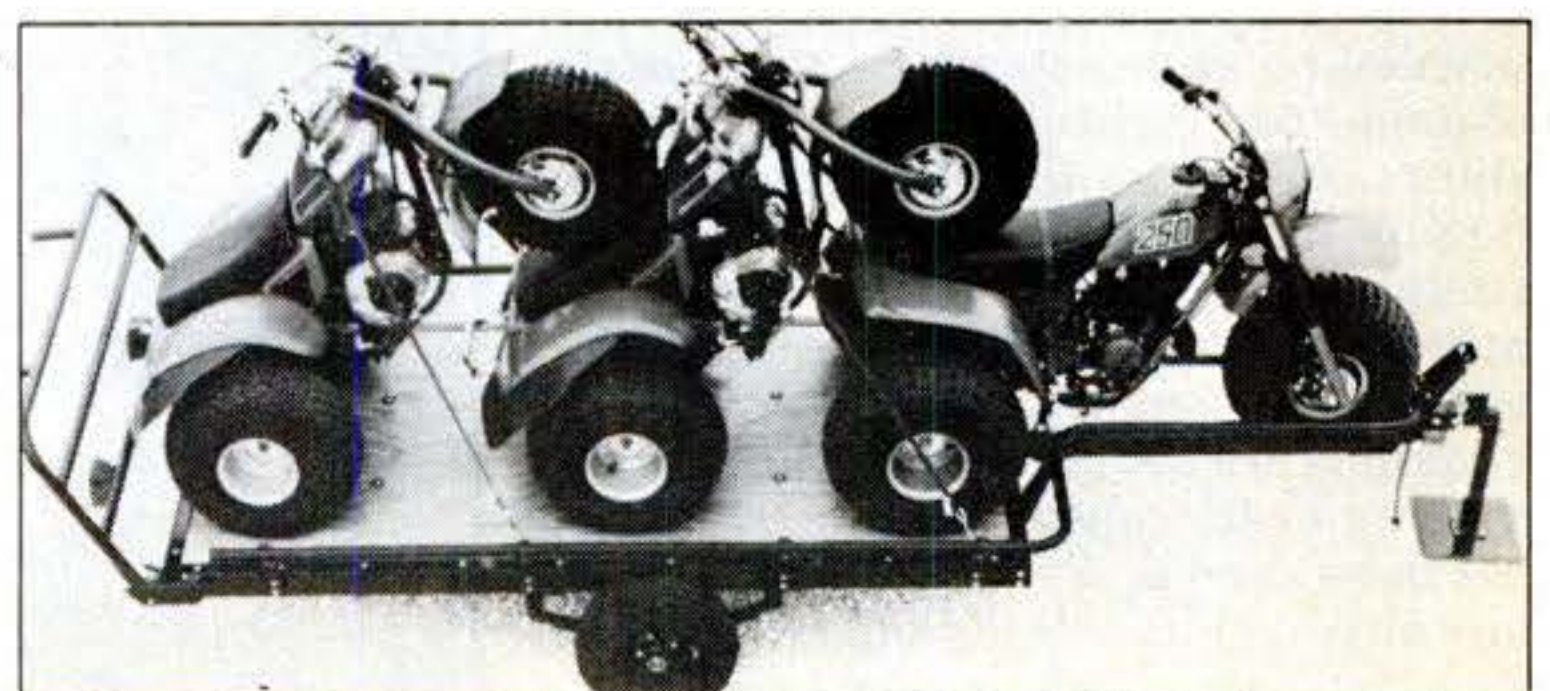
Tire-wheel lockup

Wheelok secures a car, trailer, or camper in parking lots, airports, and streets, claims Lionweld Ltd. (March Road, Middlesbrough, Cleveland TS15JS, England). Two chocks wedge under the tire; a J-bar hooks over the top. A padlock secures arms in the clamping position.



ATV hauler

Haul up to four ATVs in this four-ft.-by-eight-ft. trailer. It's so well balanced that one person can maneuver it loaded or empty, says Unique Functional Products (135 Sunshine Lane, San Marcos, Calif. 92069). Maximum load capacity is 1,150 pounds. Price: \$597.



Metal ceiling goes up with a snap

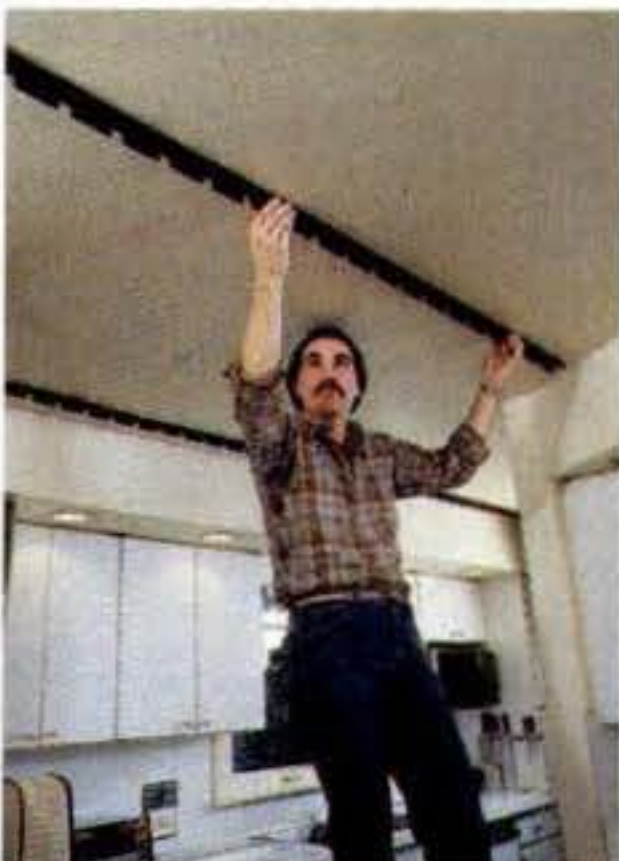
Once available only to commercial designers, these sleek aluminum channels now can be clipped to home walls and ceilings by white-gloved do-it-yourselfers. But the price is high: \$4.50 a square foot.

By RICHARD STEPLER

You've seen it on the ceilings of airport terminals, department stores, and shopping centers: The look is sleek, sophisticated, and high-tech. In fact, in its commercial form, on the market now for 12 years, more than 300 different components are available to fit recessed lighting fixtures, fire sprinklers, heating and cooling ducts, and the like.

Now, for the home do-it-yourselfer, Donn Corp. (1000 Crocker Rd., West-

A 21st-century kitchen: Polished copper ceiling channels make a dramatic change (top right), as "before" photo shows. Installation of Prestige system begins by screwing carrier strips to ceiling (right). (Strips must be firmly attached; screwed to joists or anchored with expansion-type fasteners.) Next, channels are snapped into place. By installing every other row first, then filling in as shown, it's possible to remove one or two channels if you need access.



lake, Ohio 44145) has simplified and repackaged its Prestige linear metal-ceiling system. There are only two components in the DIY version: carrier strips, which are attached to ceiling or walls; and the polished aluminum channels, available in polished copper, brass, or aluminum finishes.

I asked Joe Bauer, Donn's retail-sales manager, about the durability of the material. "We start with bright

aluminum channels," he told me, "and apply a tinted lacquer, which is then polished. Then we put a clear acrylic coating over that, which is also polished." Bauer said that the channels can be cleaned with any nonabrasive liquid cleaner and could even be used outdoors. "Just treat them as you would a mirror," he added.

The four-inch-wide channels are sold in packages of two eight-foot

lengths. The price range at home centers and hardware stores, says Bauer, is \$20 to \$24 per package. The carrier is sold separately at \$1.75 a foot. It works out to an installed cost of approximately \$4.50 a square foot.

For installation you'll need soft cotton work gloves to protect your hands and the polished finish of the channels, plus a fine-tooth (32-teeth-per-inch) hacksaw to cut the channels and carrier strips.

To determine the number of rows of channels you'll need to cover a room, divide the smallest ceiling width by four inches (the width of one channel). For a 10-by-12-foot room, for example, with channels parallel to the 12-foot wall, it's 120 inches divided by four inches, or 30 rows. The total number of channels needed for this room is 45. Channels can be spliced anywhere using splice plates for a tight joint.

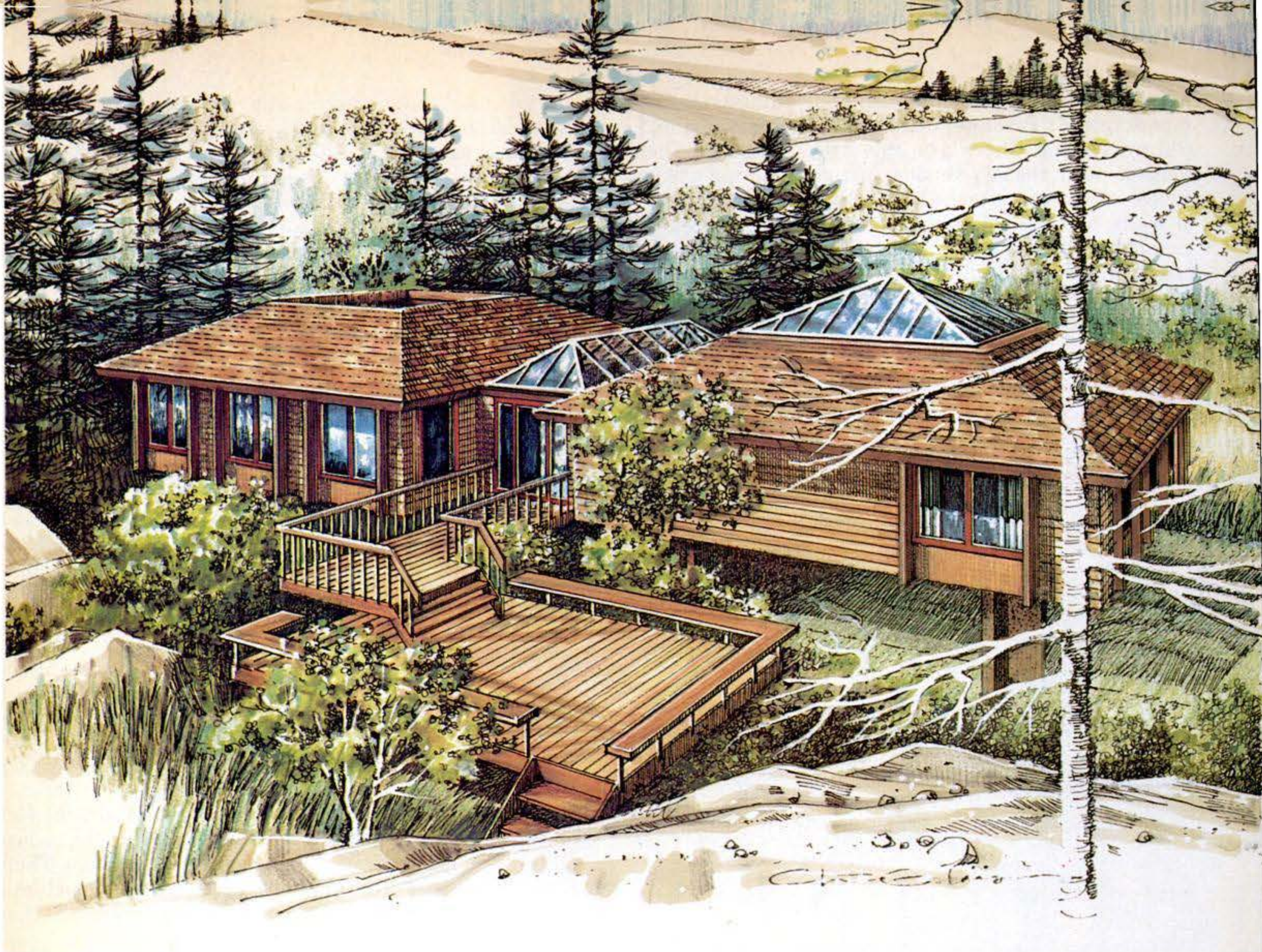
To cut a channel, mark and align a square over the cut location; then cut through the face of the channel with the hacksaw. A wood block that just fits the channel cavity makes cutting easier and more accurate.

Carrier strips are first attached to the ceiling, starting about six inches from a wall on four-foot centers. Then the channels are simply snapped into place (see photos for more installation techniques).

You should be able to find the Prestige ceiling system at most home centers, according to Bauer. **PS**

Carrier strips are flexible enough to permit wrapping channels around room, from ceiling to wall (left). Below left: An entry gains dramatic height. Below: a cool, shimmering living room.





Popular Science leisure-home plan

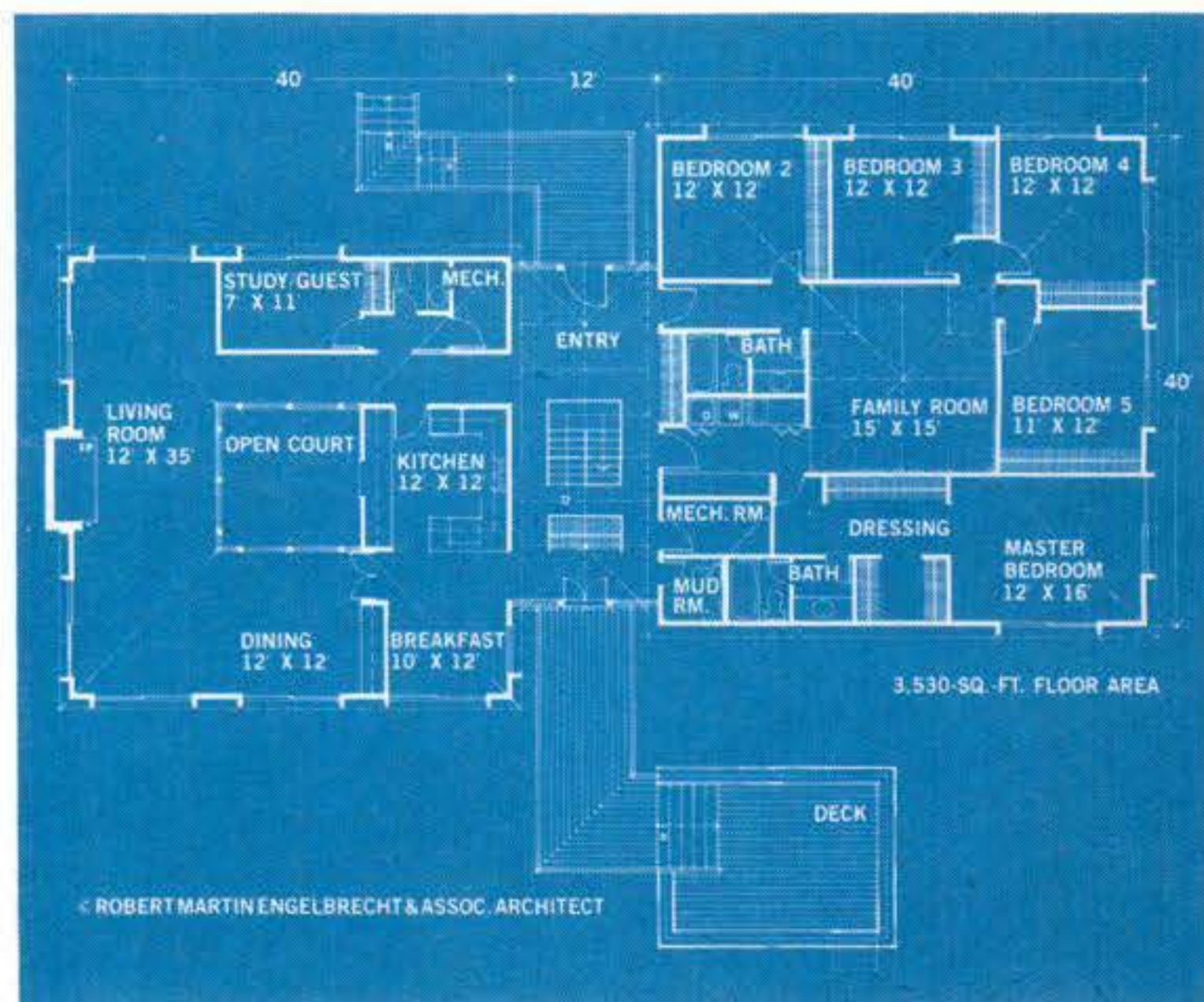
Dual atrium

Both sections of this large country house sit on concrete piers for minimal site disruption—and to float above uneven terrain.

The floor plan shows how the two 40-foot-square sections of this house are offset, joined by a glass-roofed entry and built around central courts. In the left section the court is a true atrium, open to the sky, with three glass walls to flood surrounding living areas with light. In the right section the larger central square is glass-roofed like the entry, with access from adjacent bedrooms. It becomes a common activity area for all kinds of weather.

Counting the study that converts to a guest room (isolated from family traffic), this house boasts six bedrooms—ideal for a large family or for a country site likely to draw many visitors. And it all sits up on concrete piers, so it can be built in flood-hazard areas or where deep, massive foundations would disrupt the landscape or divert ground-water flow.

The construction plans include details for the glazing strips that permit do-it-yourself assembly of the two glass roofs—which, of course, can function as passive solar collectors if you add insulating shades.—*Al Lees*



How to order your V-PAC plans

Construction plans for this house are \$75 a set or \$105 for three, plus a postage-and-handling charge of \$3 in the continental United States, \$5 elsewhere. A catalog of V-PAC plans is \$5. Send your check (U.S. funds only) to Princeton Plans Press, Box 622, Princeton, N.J. 08540. For MasterCard or Visa orders call (609) 924-9655. V-PAC Council, a group of building-materials manufacturers, includes Andersen Corp. (windows and patio doors), Benjamin Moore (paints and stains), Broan Mfg. Co. (ventilation), Formica Corp. (laminates), Georgia-Pacific Corp. (roofing and paneling), Heil-Quaker Corp. (heating and cooling), F. E. Myers Co. (pumps), Owens-Corning Fiberglas Corp. (insulation), Simpson Timber Co. (siding and doors), Tarkett (vinyl flooring), Universal-Rundle Corp. (baths), and Whirlpool Corp. (appliances).

High-tech farm —in New York City

On the left bank of the East River in New York City stands a one-acre greenhouse that is warmed by waste heat from a nearby power plant. There, vegetables are grown using a new soilless system developed in Israel.

By V. ELAINE SMAY

A few hundred feet from the Charles Poletti Power Project—a massive, windowless building where the New York Power Authority generates electricity—a plastic greenhouse covers an acre of ground. Inside, lettuce, tomatoes, and cucumbers grow year-round in hydroponic (soilless) beds [PS, March '78].

A power plant and a greenhouse may seem like strange neighbors—but not when you consider that it takes a great deal of heat to maintain a greenhouse through a northern winter, and a power plant produces a great deal of heat that is normally wasted.

"The whole thing began a few years ago when we started looking for ways to get more out of the fuel we burn," explains Power Authority spokesman Michael Saltzman. Heating a greenhouse seemed like a good way to take advantage of low-grade waste heat from the Poletti plant, which is in the Astoria section of Queens, New York City's largest borough. A study by

Cornell University confirmed the feasibility of the concept, and private investors formed a partnership called Aqua Farms to build and operate the greenhouse. Construction began in March 1983; the first crops were planted in August.

The waste heat that warms the greenhouse comes from the generating turbine's lubricating oil. Water from the adjacent East River is pumped through a heat exchanger, where it picks up heat from the oil. Previously the water was dumped back into the river—at 95 to 100 degrees F. Now it's pumped to the greenhouse through 1,200 feet of insulated six-inch pipe. There it passes through a heat exchanger, heating water in a closed loop. Huge fan-coil units distribute warm air throughout the greenhouse. Steam from the generating plant's boiler is available as backup heat. "Using waste heat saves about 42,000 gallons of fuel oil—and \$50,000—annually," says Saltzman.

The hydroponic growing system is the first of its kind in this country. It is an integrated system developed

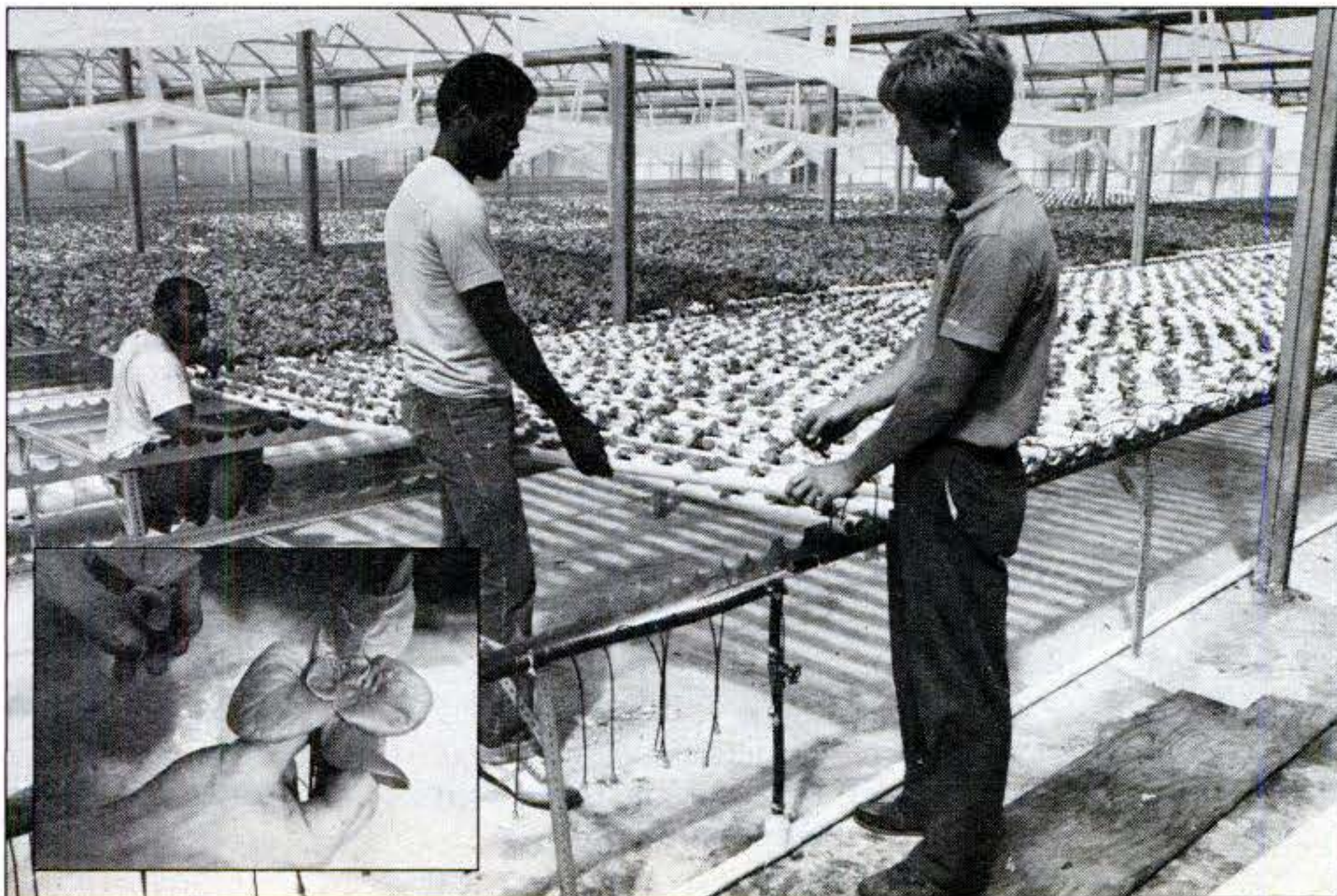
on the En-gedi Kibbutz in Israel. "The goal is to get maximum production from each square foot of space," says Fred H. Harned, vice-president of Aqua Farms and manager of the greenhouse.

In the lettuce bay, the plants sit in C-shape tubes (see photo), their roots anchored in only a tiny cube of inert foam. The hydroponic nutrient solution, which contains all the elements the plants need, constantly circulates through the tubes. As the lettuce plants grow, they are moved farther apart within each tube and the tubes themselves are spaced out. When the heads are mature, harvesters carefully remove the roots from the foam cube and pop the plant—roots and all—into a plastic bag. "Living Lettuce," says the legend on the bag. Indeed it is.

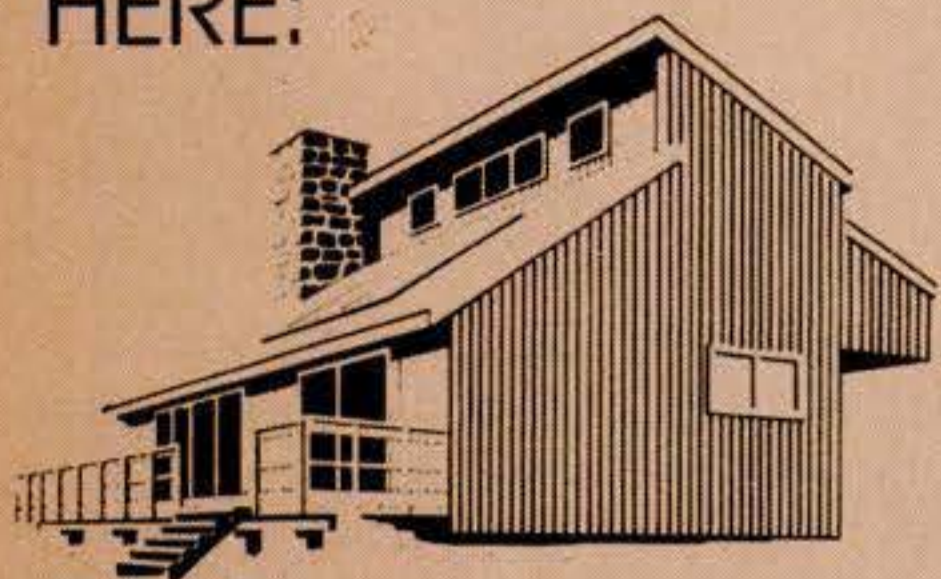
Tomato and cucumber plants grow out of enclosed canals of black twin-wall polypropylene. Harned opens one to show me the inside. "The factor that limits growth in most hydroponic operations is getting enough oxygen to the roots," he explains. "But the En-gedi system constantly oxygenates the nutrient." The method is simple: A small-diameter tube runs the length of each canal. The nutrient is pumped through the tubes at high pressure and spurts out of small holes into the air inside the canal. The solution absorbs oxygen from the air as it falls to the bottom of the canal, where the plants' roots grow.

Aqua Farms expects to grow 150,000 pounds of tomatoes, 100,000 pounds of cucumbers, and 1,000,000 heads of lettuce annually. The premium vegetables are sold (at a premium price) to supermarkets and greengrocers in the area. "They're on the shelves a day—or at the most two days—after we harvest them," says Harned. If enough heat is produced by the Poletti plant, the greenhouse may be expanded to three acres. **PS**

Lettuce plants grow in C-shape tubes. Manager Fred Harned (foreground) and staff move tubes to new locations as others are harvested. Plants have all nutritional needs satisfied, so they grow rapidly; the two lettuce plants (inset) are only a week apart in age. Growth rate depends mostly on light; artificial light is used only in winter and only for lettuce seedlings.



BEGINNING
HERE:



Fall Home Improvement

Traditionally, each September issue of *POPULAR SCIENCE* has sported a special section on interior improvements for our readers' homes. But this year we're reluctant to bid summer farewell, so we present two projects that will let you extend your outdoor-living season well into fall. Both involve new products that are fast to install (deck tile and whirlpool spas). These aren't long-term projects: Get started today, and you can enjoy the benefits before the leaves turn.

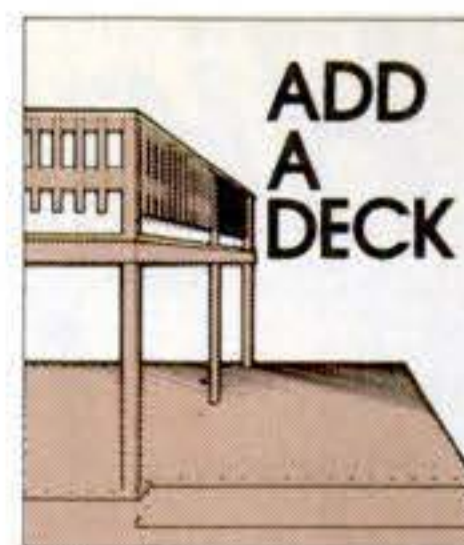
The deck-tile feature is the last in the summer-long series of add-on decks we began in May's spring home-improvement section. And our article on organizing your garage with inexpensive waferboard is the latest in our ongoing "Storage-from-Scratch" series. Your response to both these series has led us to hunt up more such projects for future issues.

Meanwhile, this year, we're offering a bonus to all homeowners. We'd worked up so large a portfolio of fresh, practical fall improvements that we lacked room for them all in this issue. So we'll be running another special section in October, following up this month's build-it-yourself version of a fold-down bed with a novel installation of the original commercial Murphy bed—in a specially designed wardrobe cabinet that doubles as a room divider. We'll also be showing how to work with new products for paving floors and mirroring walls—and much more.

And if you have specific ideas for home improvements you'd like to see in *PS*—or if you want to show us recent projects from your own home—we'll be happy to hear from you.

We've even created a special contest around one specific type of home improvement, and you'll find details in this issue on how to submit your project toward winning big cash.

New hardwood tiles make a



parquet deck

Preassembled mahogany tiles ease the tedious task of laying decking. The versatile two-foot-square tiles also form walkways and skirting. Split, they serve as stair treads.

By **GENE and
KATIE HAMILTON**

These new deck tiles are ideal for the do-it-yourselfer," says Chicago architect Tom Hood. "Each tile is finished, so no cutting or sanding is required."

Hood designed his 16-by-24-foot deck around the two-foot-square Moore-Tile. The mahogany tiles are approximately one inch thick and consist of eight slats stapled to three backer slats. Because South American mahogany is such a dense wood, there is no splintering problem, and the tiles resist rot and insect damage.

At \$12 to \$14 a tile (at most home centers), this decking material costs about the same as redwood or pressure-treated lumber. But because of their size, the tiles are faster to install than standard decking. A Moore-Tile deck requires about 25 percent fewer fasteners than an equivalent-size plank deck. And it's easier to align two-ft.-sq. modules than it is to work with six-ft.-long planks.

The square tile has other advantages, according to Hood. He first planned his deck on graph paper, using two-ft. squares as basic building blocks. He found uses for the versatile tiles as stair treads, vertical skirting, and walkways.

"If you lay out your deck in two-ft. increments and use standard-size lumber, you have a minimum of cutting and waste," Hood says. He framed his deck in No. 2 pressure-treated lumber and used cedar rails and posts for trim.

The framework is the most difficult part of any deck. With Moore-Tile you can hire a carpenter to erect the framework (especially if your location is on

a sloping site), but you can save money by laying the decking yourself. (Of course, before beginning any deck installation you should also check local building codes.)

Crafting the checkerboard

Building the deck frame to support these tiles is done the same way you'd construct a standard lumber deck—except for joist spacing. The ½-in. tile slats require a joist every 12 in. for support instead of the more common 16-in.-on-center spacing. (This means you need about 30 percent more lumber for the joists. But as a bonus you get a sturdier deck.)

If you want the tiles flush with the deck edge, allow 9¼ in. instead of 10½ in. between outer joists and the next joist. This adjustment will put the tile edge flush with the outside edge of the joist.

Installing the tiles is much like laying a tile floor except that you start along the outside edges of the deck instead of an inner wall. "Alternating tile direction creates a basket-weave pattern that hides minor errors," Hood says.

Lay the first tile at an outside corner, using a framing square. Then rough-lay the tiles along both edges of the deck. Trim tiles to fit when necessary. You can cut as much as needed when trimming the slats—but if you cut more than three in. across the slats, you'll cut off the backer slat. To keep slats in place while cutting, install a new backer slat inside the old one before you cut.

Moore-Tile can be nailed or screwed. "I found No. 8 1¼-in. brass flathead screws, bought in bulk at a hardware supplier, the most economical," says

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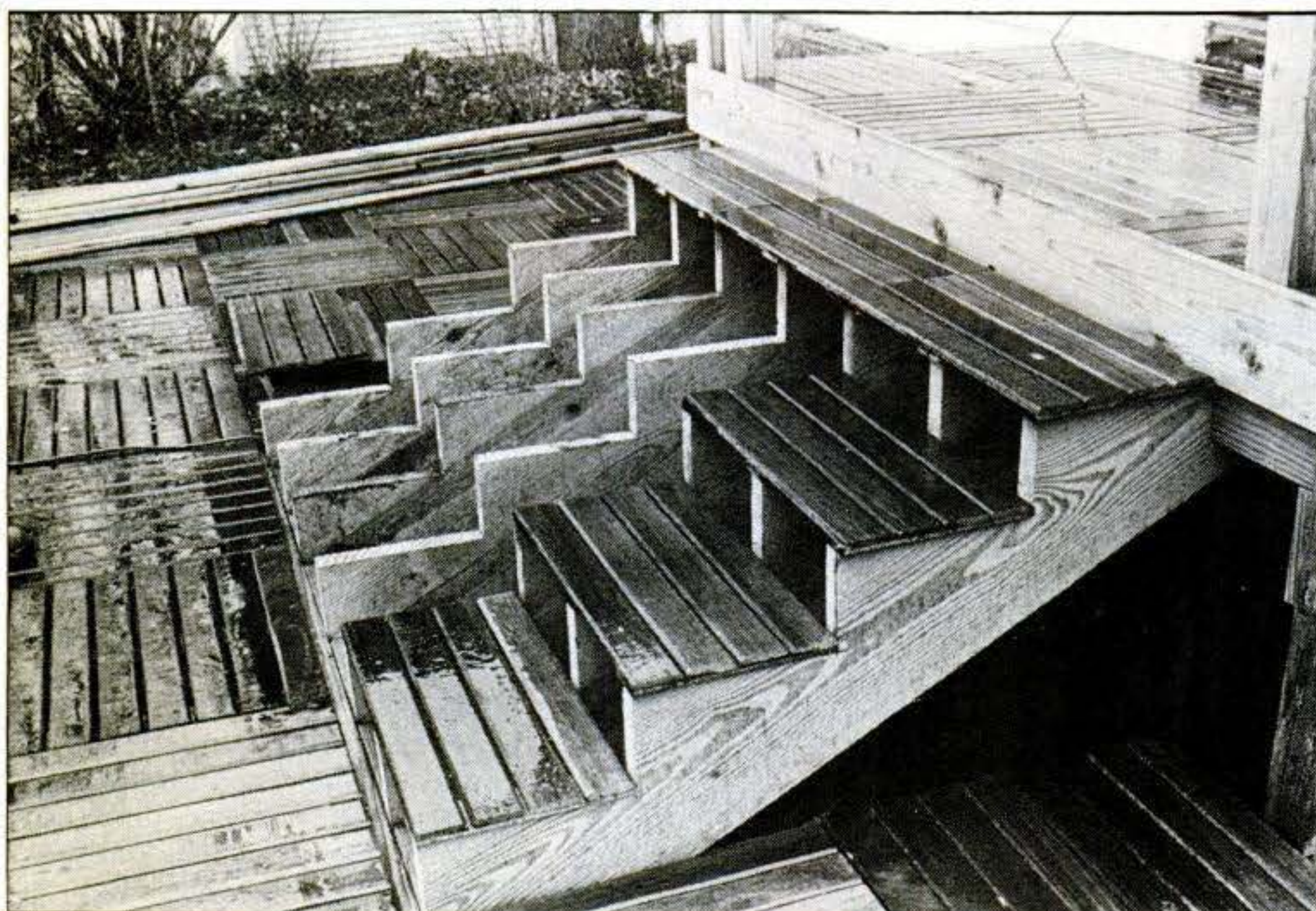


A striking basket-weave-pattern deck is formed by laying mahogany tiles in alternating directions. The square tiles are especially suited for building rectangular-shaped decks. For contrast the builder used cedar for risers and edge trim. This deck sits on four-by-four-in. poured-concrete posts, but pressure-treated wood posts can also be used. Sheet-metal framing anchors secure the posts to the pressure-treated beams that support the 2x8 joists. These joists must be spaced 12 in. on center instead of the more common 16-in. spacing.

Parquet deck



Fastening holes must be pre-drilled (above). Cedar shims can be wedged under tiles if joist surfaces are irregular. Tiles require a screw per corner, but only two screws per tile are needed to mount for skirting (right). Cedar trim hides exposed edges of tile.



Match tiles for color after cutting to make stair treads. Pre-drill to prevent

splitting. Though cedar was used for risers here, tiles may be used instead.



For walkways in low-traffic areas, such as alongside house (right), tiles can be laid right atop gravel bed contained in frame of pressure-treated wood (above). For heavy-traffic areas excavate shallow trench to hold frame.



Hood. "We used 500 screws that cost around \$50." The brass quickly tarnishes and blends in with the wood. Stainless-steel screws are a bit more expensive but will not tarnish with age like the brass.

Screw holes must be pre-drilled through the dense hardwood tile. Using two electric drills speeds the job. Keep a countersinking bit (Screwmate is a good one) in one for drilling the pilot holes, and a screwdriver bit in the other for quick installation of the four screws per tile.

Hood gave the deck tiles two coats of Thompson's Water Sealer, using a long-nap paint roller. One coat was applied before the tiles were laid, and the final coat was applied after the deck was completed.

What about maintenance? "If a deck is located under shade or sap trees, it's a good idea to remove leaves before winter to avoid discoloration," Hood says. "This happens on any type of decking but can be easily avoided."

Beyond decking

The versatile tiles are suited for more than decking. Cut in half, they make stair treads. Stringer spacing is the same 12-in.-on-center as that of the joists. Tiles also can be laid vertically to make a deck skirting.

Moore-Tile is also suited for creating walkways and even small patios. Because the mahogany tiles are rot resistant, they can be laid over a gravel bed or directly onto a plastic sheet if the walkway is not a high-traffic area.

For a walkway built on grade, use pressure-treated 2x4s—laid parallel and 24 in. apart—as a walkway frame. Hold the frame in place with wood stakes driven into the ground on the inside.

Nail two-ft. lengths of 2x4 across the frame at four-ft. intervals to hold the side rails parallel. Then place plastic between the 2x4s to hold back weeds. Fill with gravel, smoothing it to about one in. from the top of the 2x4s. Finally, insert the tiles, and backfill against the form if necessary.

The deck tiles have a variety of other uses, according to the importer (William G. Moore & Son Inc. of Delaware, 4 World Trade Center, Suite 6166, New York, N.Y. 10048). The tiles can transform an urban "tar beach" into a handsome roof deck simply by applying flashing adhesive to the backer slats and pressing in place. The tiles can be screwed directly into a run-down existing deck once loose and broken slats are nailed in place. Finally, the tiles can be glued atop an existing concrete or flagstone patio. Or they can be fitted into a perimeter frame attached to the patio. **PS**

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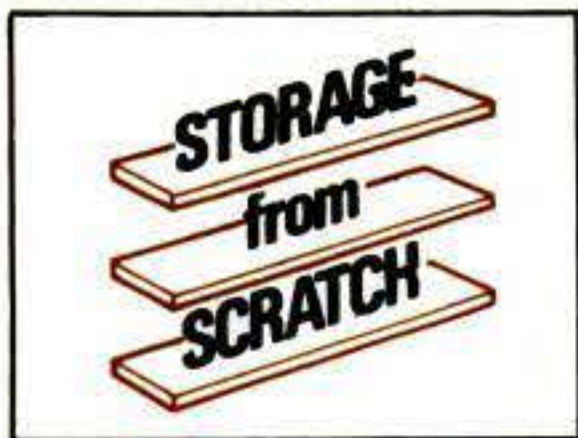


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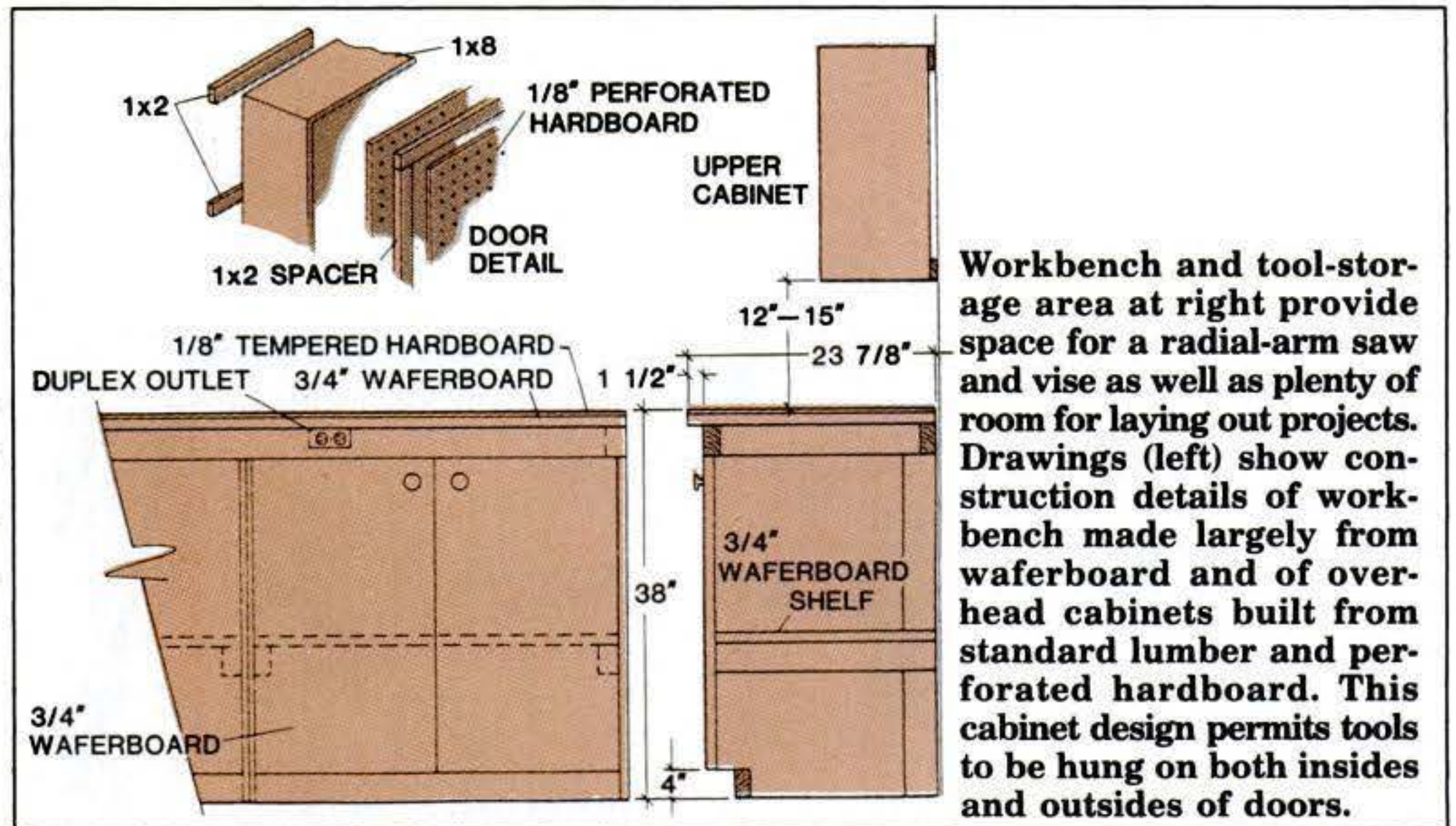


IMPROVE YOUR HOME

Organize your garage—with waferboard

Low-cost waferboard is useful not only for sheathing garage walls after you've insulated them but, in a thicker version, to create a workshop with ample storage space. Or, if you're leaving the open stud walls, you can cut a surprising number of brackets and storage shelves for them from a single panel.

By **STUART F. BROWN**



Workbench and tool-storage area at right provide space for a radial-arm saw and vise as well as plenty of room for laying out projects. Drawings (left) show construction details of workbench made largely from waferboard and of overhead cabinets built from standard lumber and perforated hardboard. This cabinet design permits tools to be hung on both insides and outsides of doors.

DRAWINGS BY GERHARD RICHTER

Insulating your garage can provide a warm place to work in the winter while holding down heating costs. If you've already undertaken or are contemplating insulating your garage, why not expand the project to include the work and storage areas you'll need?

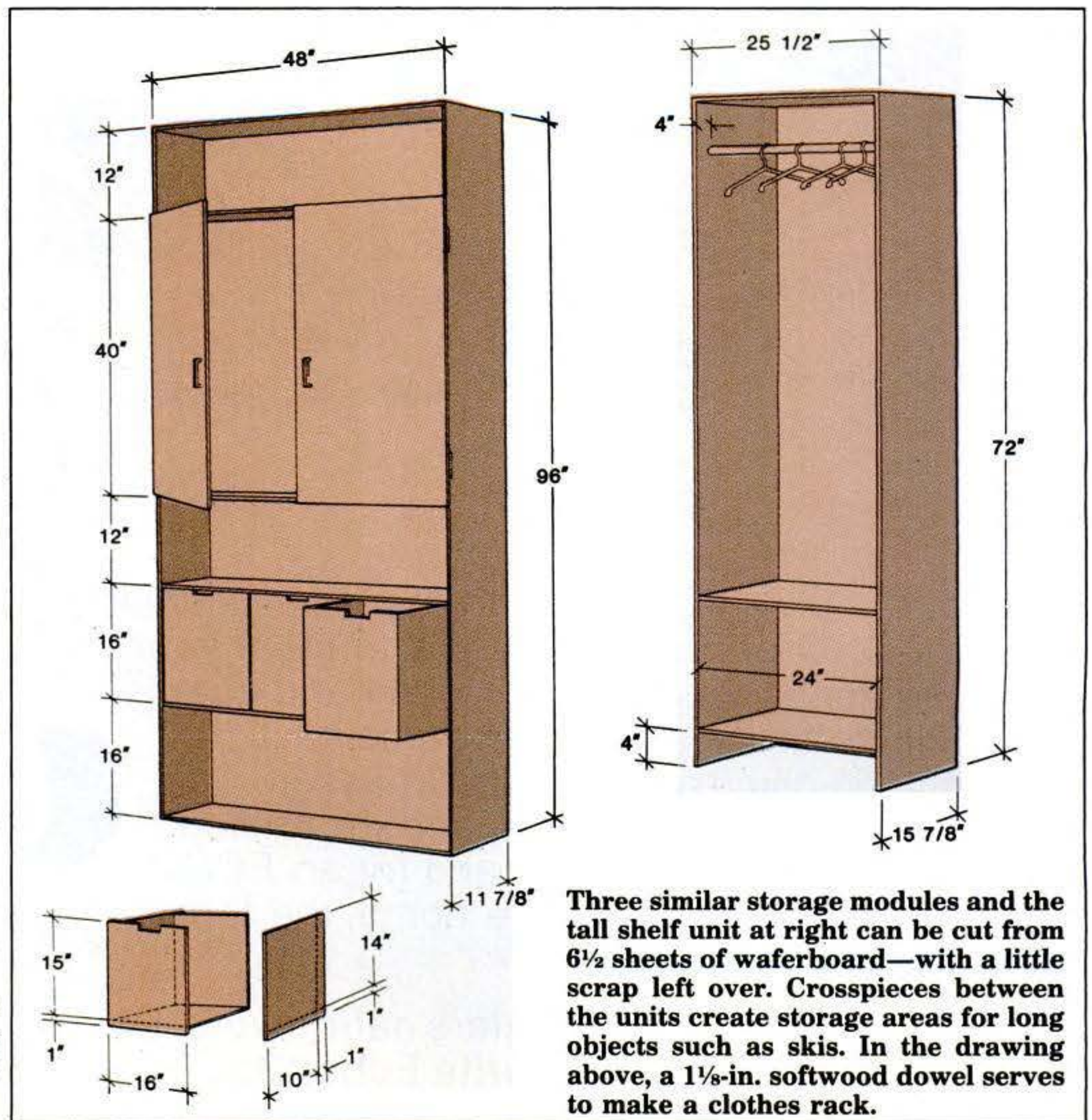
You can build a workbench, cabinets, and shelves in your garage with the same inexpensive waferboard panels used to sheathe the interior walls after glass-fiber or other insulation has been installed. These plans show how you can use waferboard as the primary building material to transform your garage into more than just a shelter for your car.

The projects call for 3/4-inch-thick sheets of waferboard to build the storage and work areas. Thinner panels, 1/4 or 7/16 inch, are normally specified for interior sheathing work such as covering insulated walls. White glue and four-penny nails are used in the simple butt-joint construction employed throughout.

The upper cabinets are fastened to the wall above the workbench by driving screws into the wall studs through 1x2 strips at top and bottom.

The shelves and cabinets shown were finished with primer followed by a coat of semi-gloss acrylic latex paint. The

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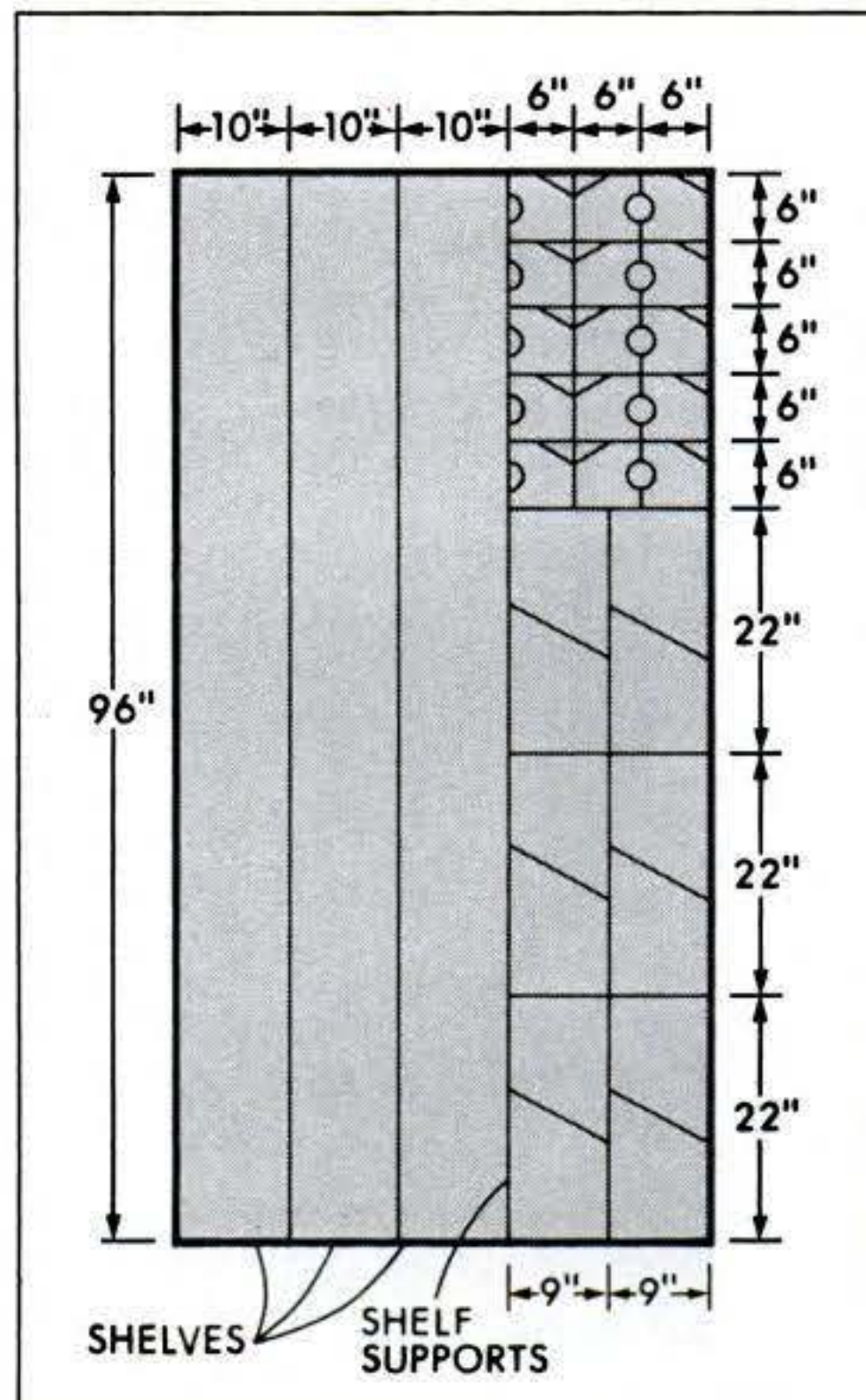
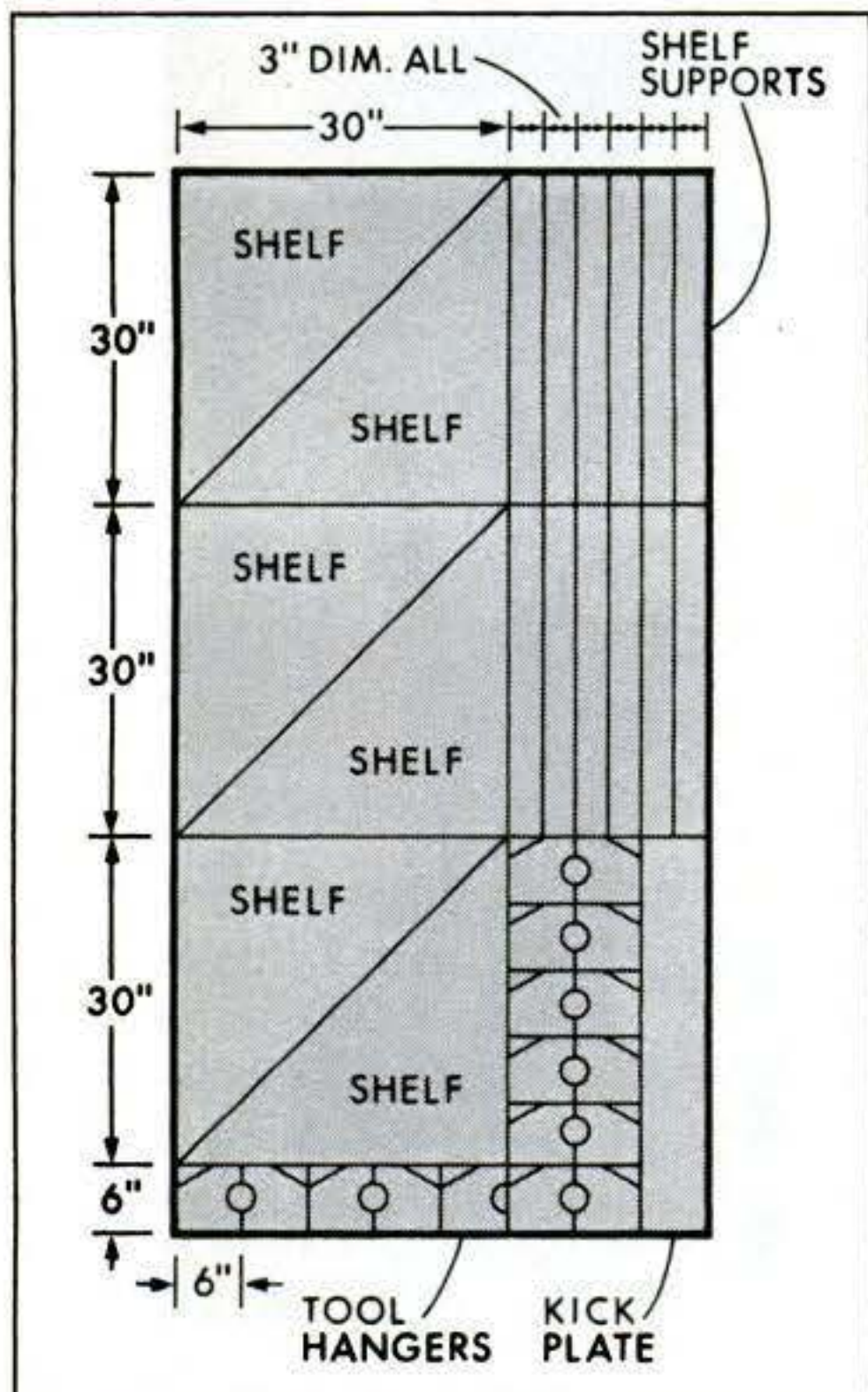


Three similar storage modules and the tall shelf unit at right can be cut from 6 1/2 sheets of waferboard—with a little scrap left over. Crosspieces between the units create storage areas for long objects such as skis. In the drawing above, a 1 1/8-in. softwood dowel serves to make a clothes rack.



PHOTOS FROM LOUISIANA PACIFIC CORP.





Corner of garage wall with exposed studs was transformed into a space-saving storage area with shelves (photo

above), supports, and garden-tool-storage brackets cut from only two sheets of waferboard (see diagrams).

exposed waferboard surfaces of the workbench and sheathed garage walls can, if you like, be finished with shellac, varnish, or urethane for a natural effect as well as protection. You can also apply an undercoat of stain to highlight the waferboard's chaotic grain patterns, which some people find pleasing.

Designers at Louisiana-Pacific Corp. (111 S.W. Fifth Ave., Portland, Ore. 97204), manufacturers of waferboard under the Waferwood brand name, have proved ingenious at designing simple stud-wall storage projects and figuring out how many pieces can be cut from a panel of the factory-sanded material. They worked out the accompanying cleverly nested cutting diagrams, which show how you can cut out the semicircular notches in 13 pairs of tool-hanger brackets by using a 1½-inch spade bit in a power drill. The remaining six unpaired notches are cut with a saber saw. This virtually no-scrap layout even provides a kick plate for the bottommost angled corner shelf. **PS**

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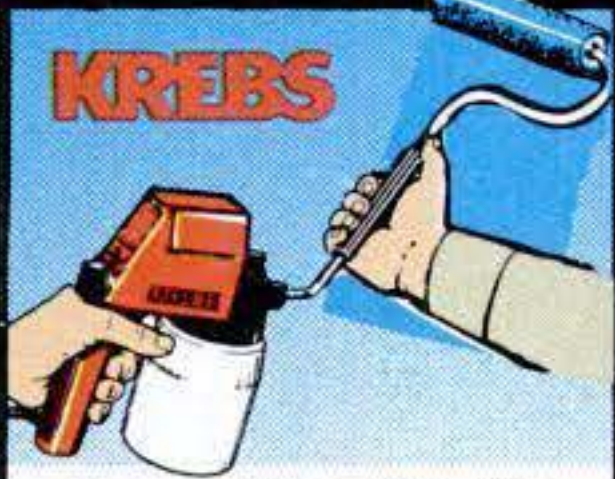
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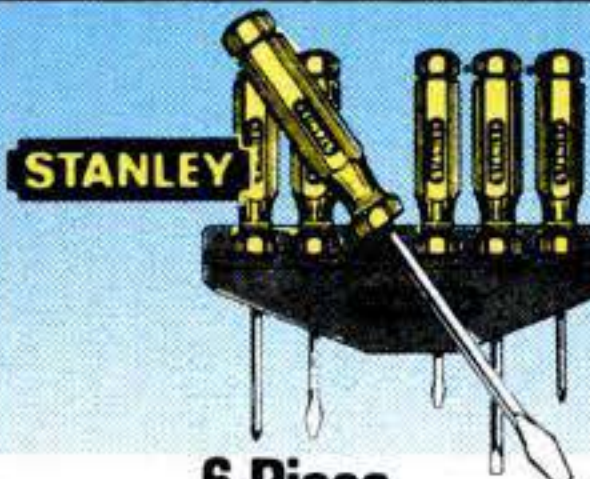


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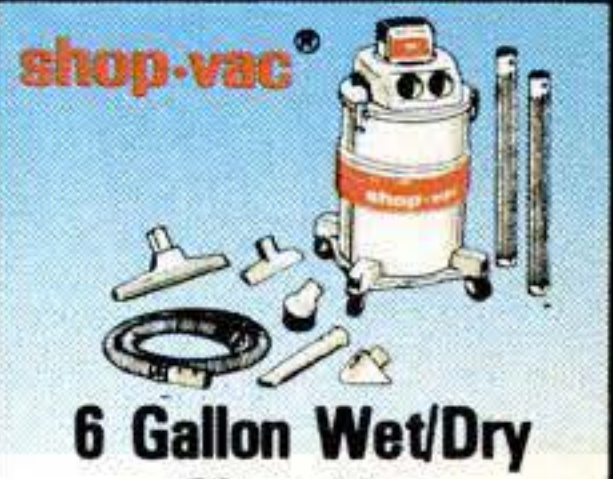
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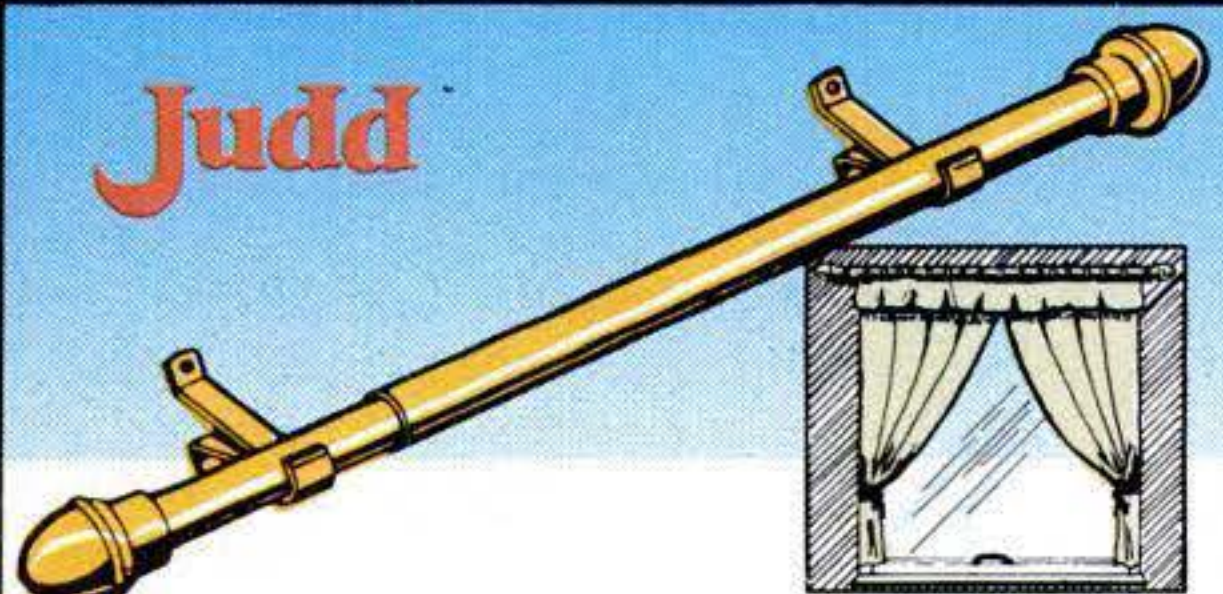
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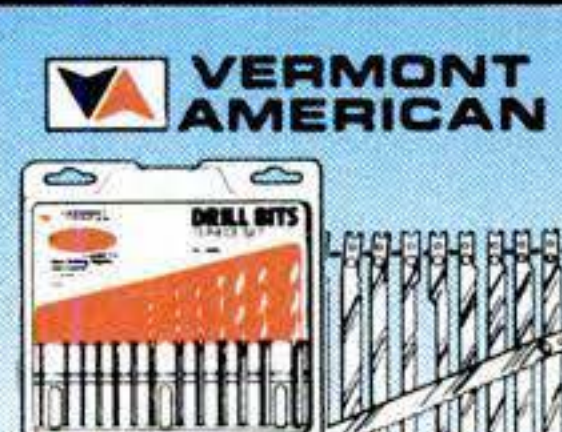
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1/2" rod with a brass colored finish. 16-6101

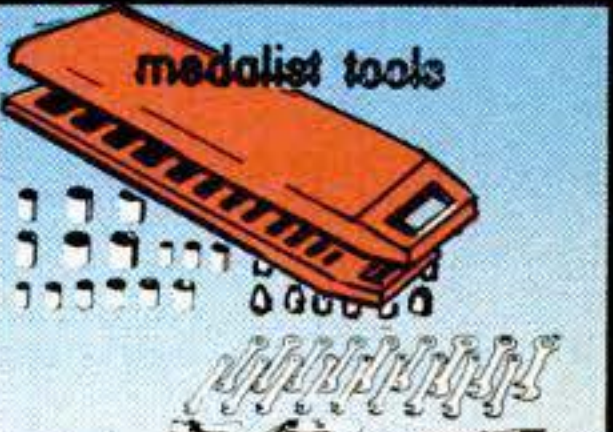


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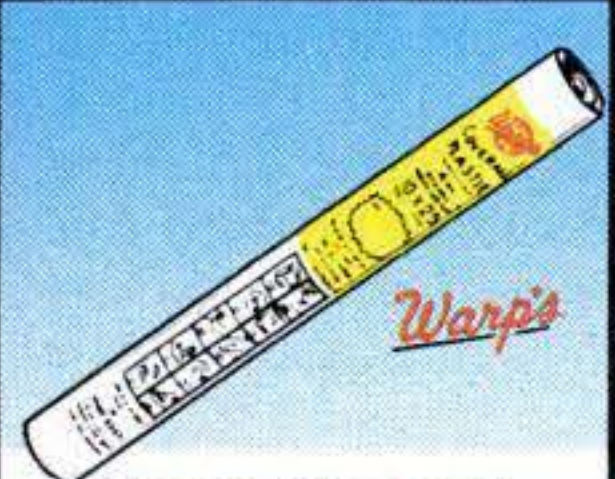
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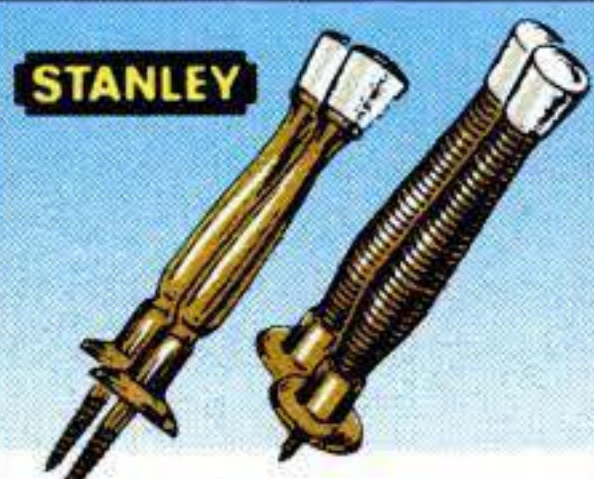


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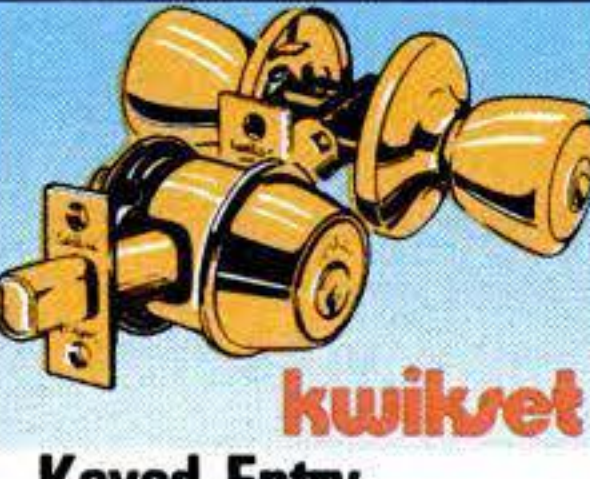
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Tile your entry area

Foot traffic from outdoors quickly soils and wears out foyer carpets. But a ceramic-tiled entry is durable, attractive, and easy to clean.

By LEE RENNER

Has the carpeting in your entry area been made old and worn before its time by your family's comings and goings? You've probably tried, over the years, the two common protective measures for carpets in heavily traveled areas: plastic mats and area rugs. But mats are unsightly, and rugs catch when the door opens. Frequent cleaning may remove dirt, but it increases wear. And new carpeting, which won't solve the problem, is expensive.

For a fraction of the cost of re-carpeting, you can tile your entry area and say goodbye to ugly mats and unfriendly rugs. Glazed ceramic tile is durable, comes clean with soapy water, and is easy to install.

The possibilities for your entry are almost endless with ceramic tile. It comes in a wide selection of patterns, shapes, and sizes. And colors range from electric blue through all the pas-



A sweep of ceramic tile delineates an entry area that will enhance the room,

stand up to tramping feet, and survive the winter's inclement weather.

tels to various shades of white. Tiled floors can look like a brick walkway or can form an abstract pattern of colors and shades. Sizes range from an inch-square (or diameter) up to one square foot.

This wide range of sizes comes in handy. If the area you plan to tile is small, narrow, or unevenly shaped, penny tiles (round tiles an inch or less in diameter) or one-inch squares make cutting and laying easy. If the area is basically square and there's room to maneuver, larger tile will fit and entail less labor. For my area, I chose tiles eight inches square.

Tile is sold by the square foot, so the first step is to measure the area you plan to redo. Buy at least one extra square foot of tile. Cutting tile takes a certain touch, and you might have to sacrifice several of them before hitting your stride. A square foot usually costs two to seven dollars, so buying extra won't overload your budget. Be sure to get glazed ceramic floor tiles; the types designed for bathroom-

wall decoration won't hold up under foot traffic.

My front door opens directly into the living room, so I chose a light-almond tile to complement existing furnishings. I decided to tackle a 56-by-68-inch area, which is big enough for two people carrying packages. To enhance both the look and practicality of the area, I gave it a curve and extended the tiles into an adjacent closet. Running tile behind closed doors also saves you from having to put an edging in an awkward area.

Use dressmaker's chalk, which is soft and comes in colors, to mark the tile area. Cut away the carpet and the mat underneath. Tape a plastic tarp to the adjacent carpet. (In the step-by-step shots I didn't bother with a drop cloth because the carpeting was soon to be replaced.)

The floor beneath the carpet is bound to have some imperfections—unevenness or abrasions—that might lead to cracked tiles. For a secure, workable surface, cut a base from ¼-

inch exterior-grade plywood (it won't delaminate) to the exact dimensions of the tile area, then nail it down. Any minor imperfections in the plywood surface will be filled or smoothed over when the adhesive is applied.

Place the tiles down to establish the width of the grout lines and to get a count of the number of tiles that will need cutting. If you're using tile that comes in sheets, such as penny tile, the grout lines between tiles are set, so you're one step ahead here.

If you're cutting tile to fit a curve or an irregular shape, use a tile nipper. Mark the cut line with a pencil, and nibble away small areas at a time. Don't try to cut off large chunks, as tiles crack easily. And wear safety glasses for protection from flying ceramic fragments. A tile cutter—which you can rent from a tile dealer for a nominal fee—can be used to cut along a straight edge. Rough edges can be smoothed out with a whetstone and a little water.

Spread the tile adhesive over an area that you can comfortably tile before the epoxy sets (it sets fairly quickly). I recommend Latacreek liquid floor mix, which is a mild epoxy and, therefore, has more give than the conventional rigid adhesives, which can

eventually lead to cracked tiles.

Set each tile in place with a gentle twisting motion. Lay one at a time, and check the alignment each time. If you don't feel confident enough to space by eye, use plastic spacers available from a hardware store, or make them out of uniform wood scrap.

You can bed the tile in a number of ways. I recommend wrapping a piece of wood in carpet, placing it on the tile, and tapping it with a hammer. A rubber-head hammer will also work, as will a fist. The extra pressure creates a better bond with the adhesive and ensures an even level.

Floor grout comes in a variety of colors. White grout, however, shows dirt quickly—which would defeat the purpose of this project. I chose an almond color to blend with the tile.

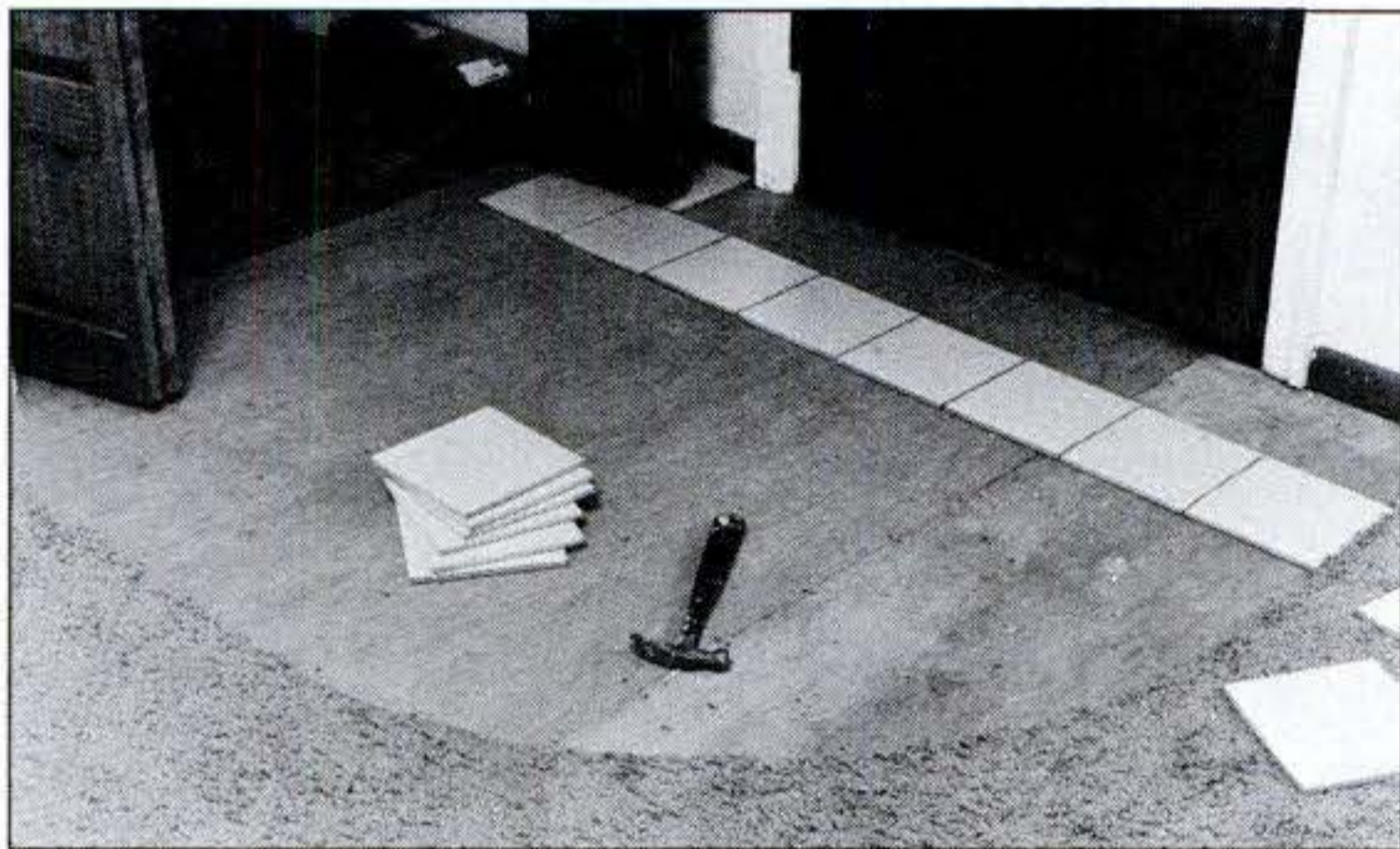
Prepare for grouting by wiping the adhesive off the tile and removing the spacers, if any. Then use a rubber-faced float to spread the grout along the tiles and into the joints. Smooth over air bubbles, and scrape off excess grout with the float. Apply a damp sponge in a circular motion to clean the tile, and smooth and set the joints even with the level of the tile. Use a jointer tool to compact and smooth out the grout lines.

Let the tiles sit for an hour or so before you start removing the haze of grout and whatever adhesive is left. Clean and polish the tiles with a soft cloth or a sponge.

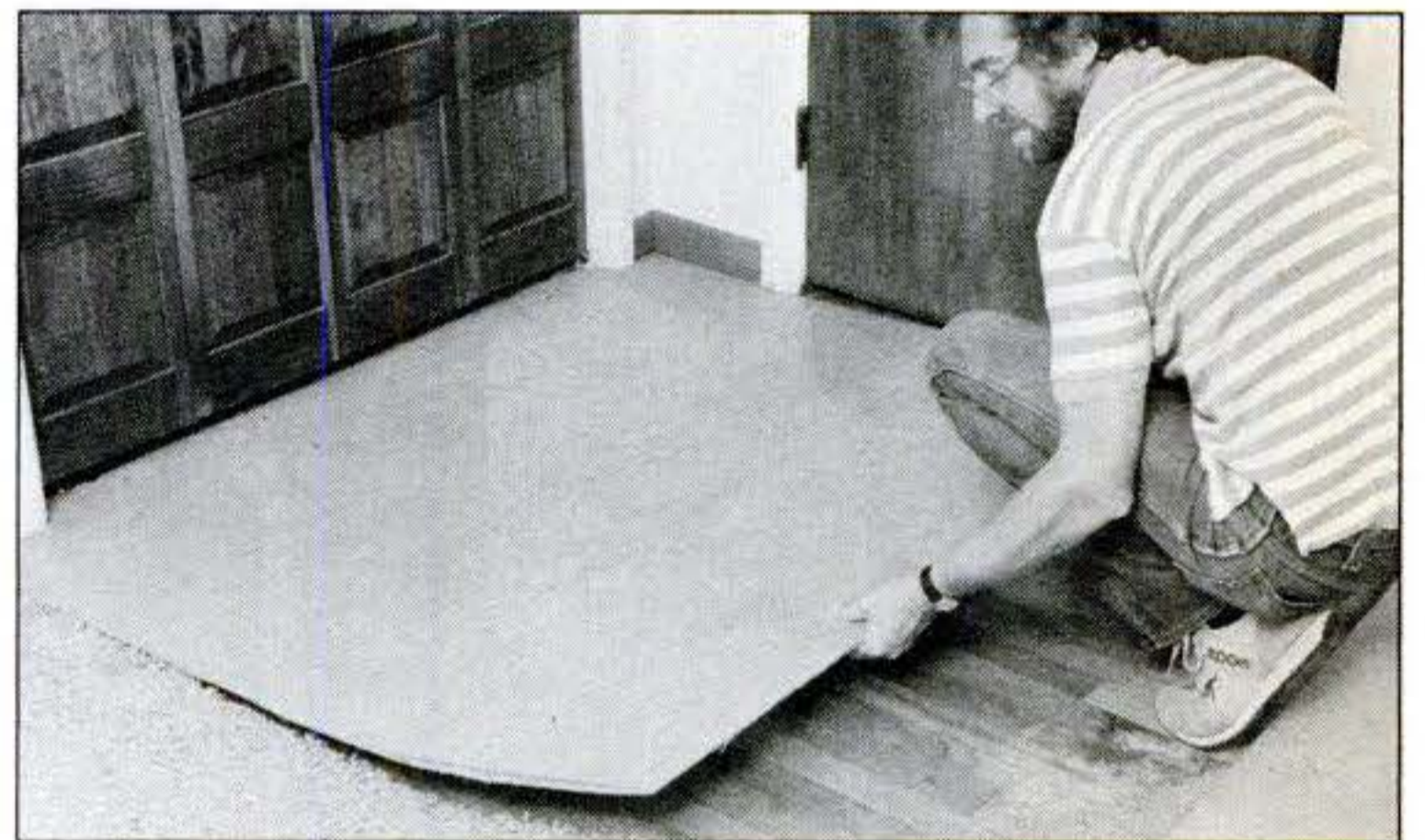
Try to stay off the tiles for about a day, until the adhesive and grout dry. To be on the safe side, keep foot traffic light through the entry for the next several days. PS



Heavy-duty knife is all that's needed to cut away the carpet and mat.



Lay the tiles out (above) to determine the grout lines and the number of tiles you'll have to cut to fit. Joint width should be roughly equal to the thickness of the tile. Cut



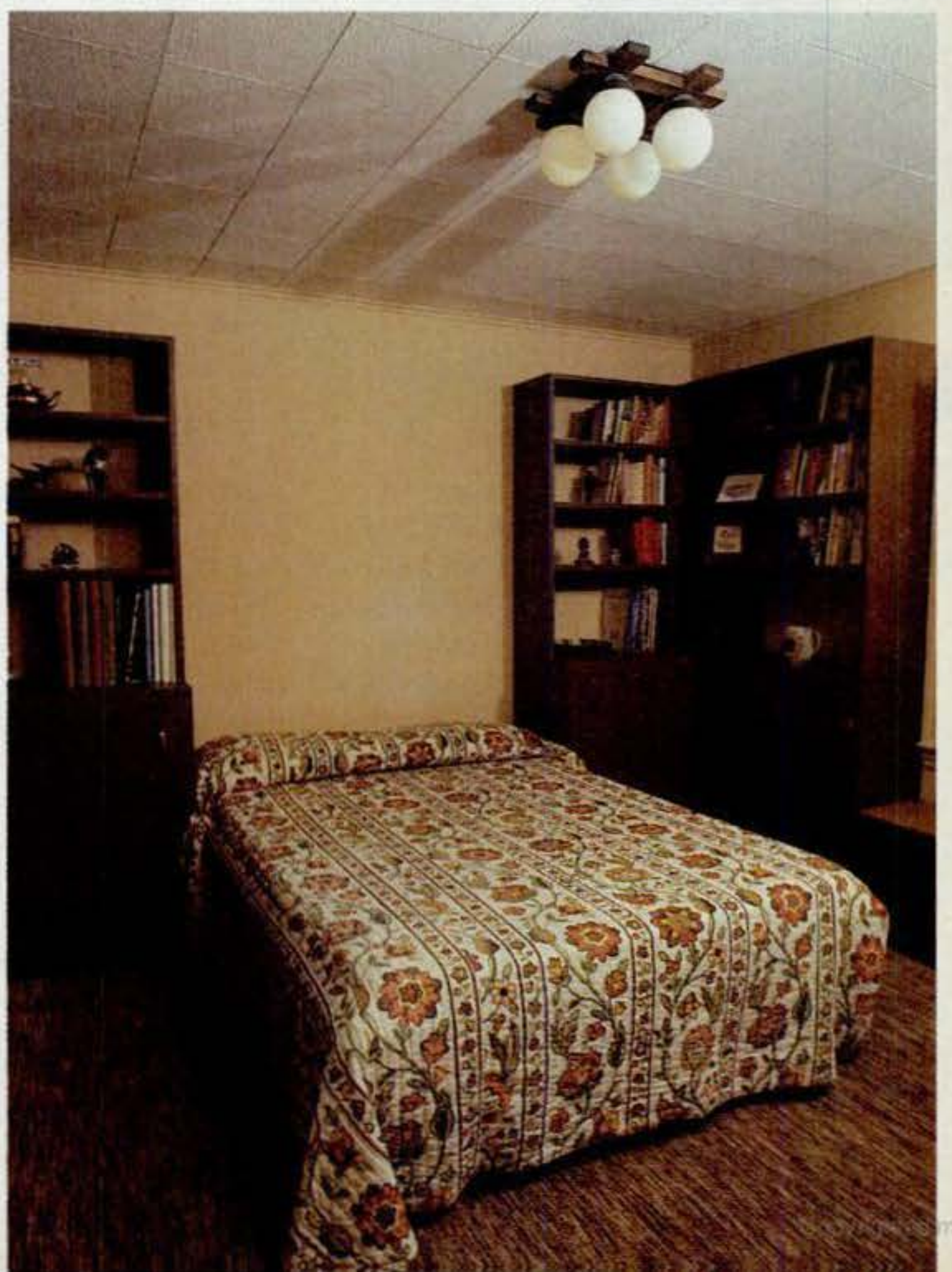
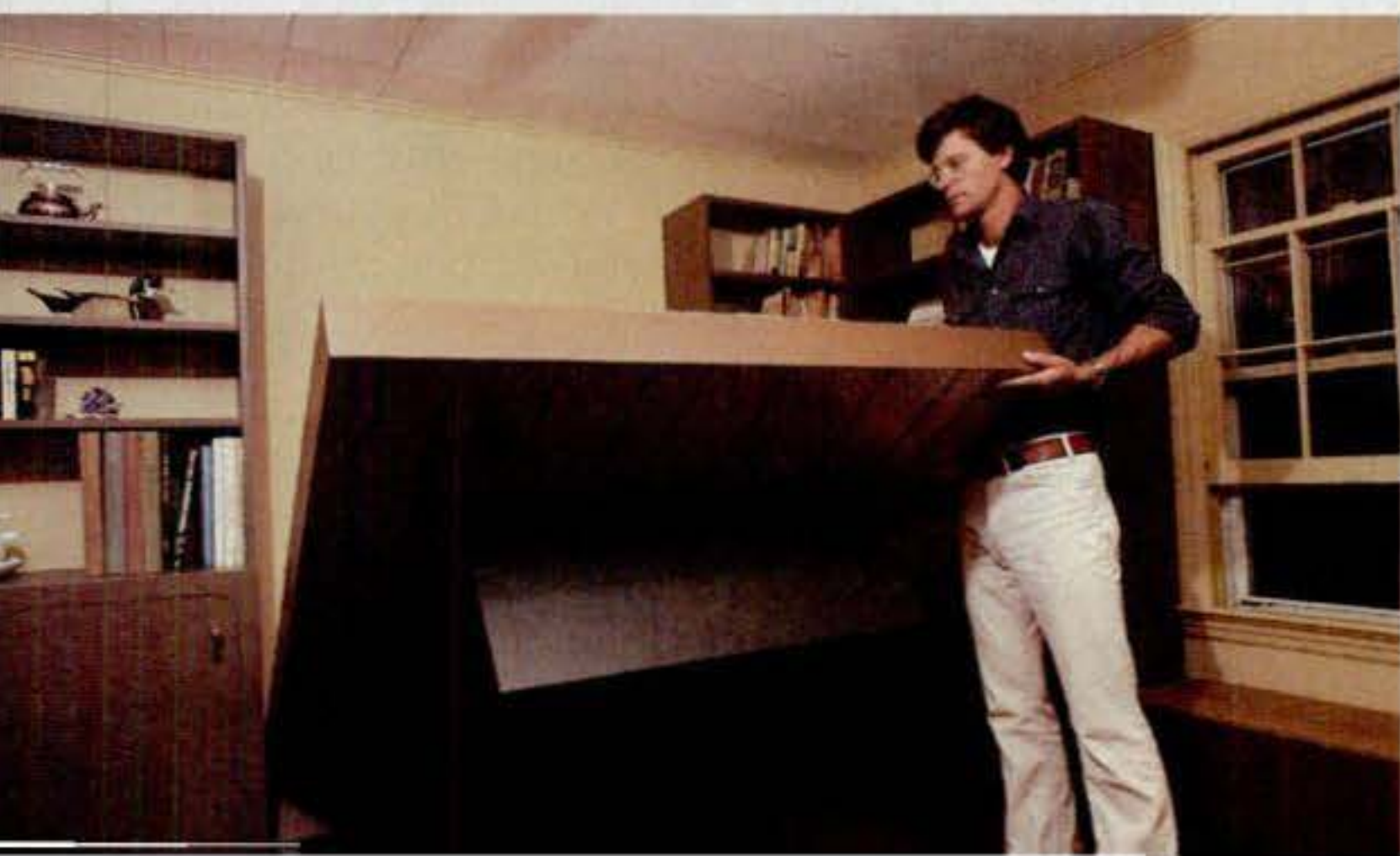
and fit the plywood form as shown in the photo (above right). Place tile down firmly (below left), and use a rubber-faced float to spread grout into joints (below right).

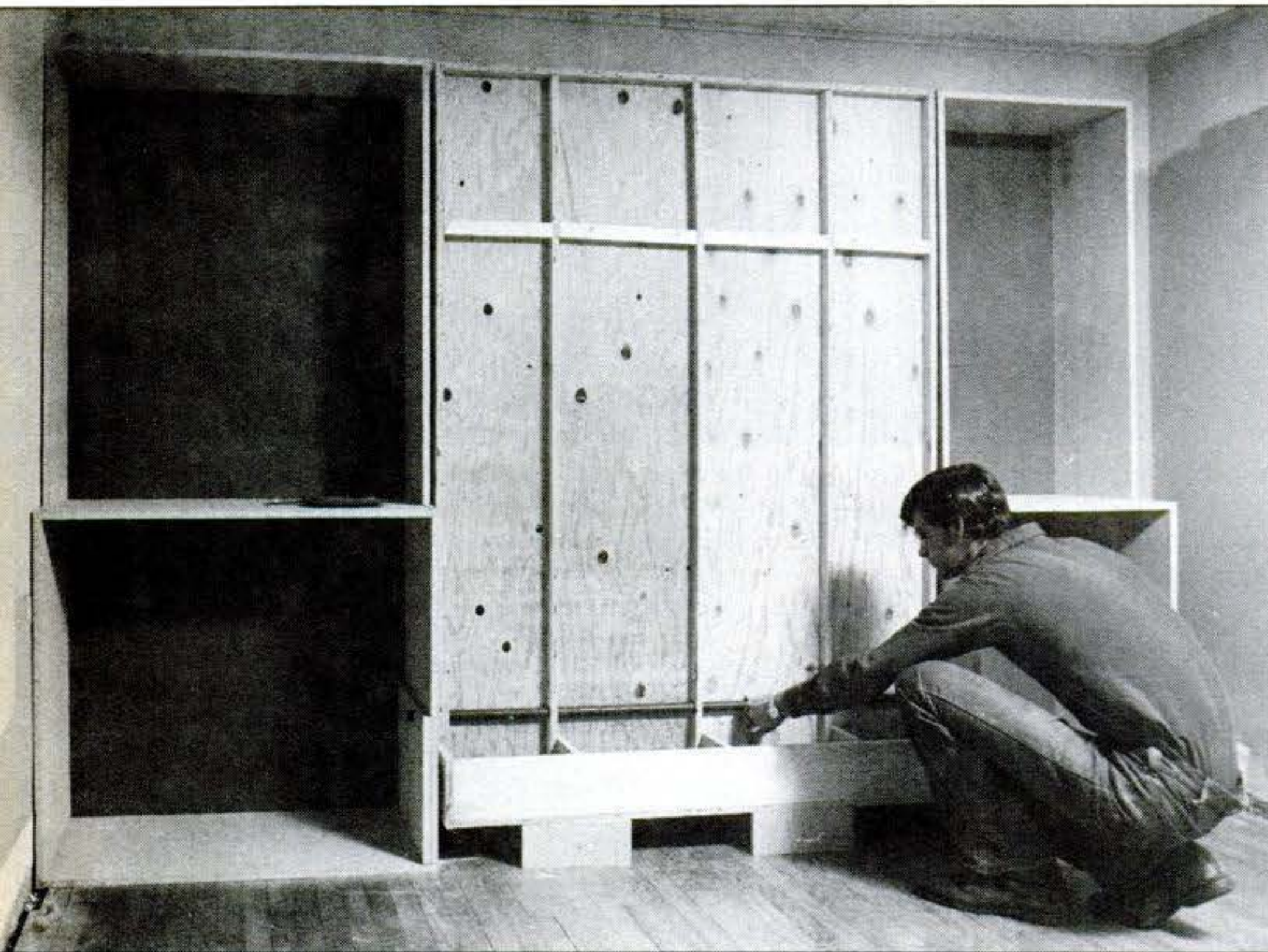
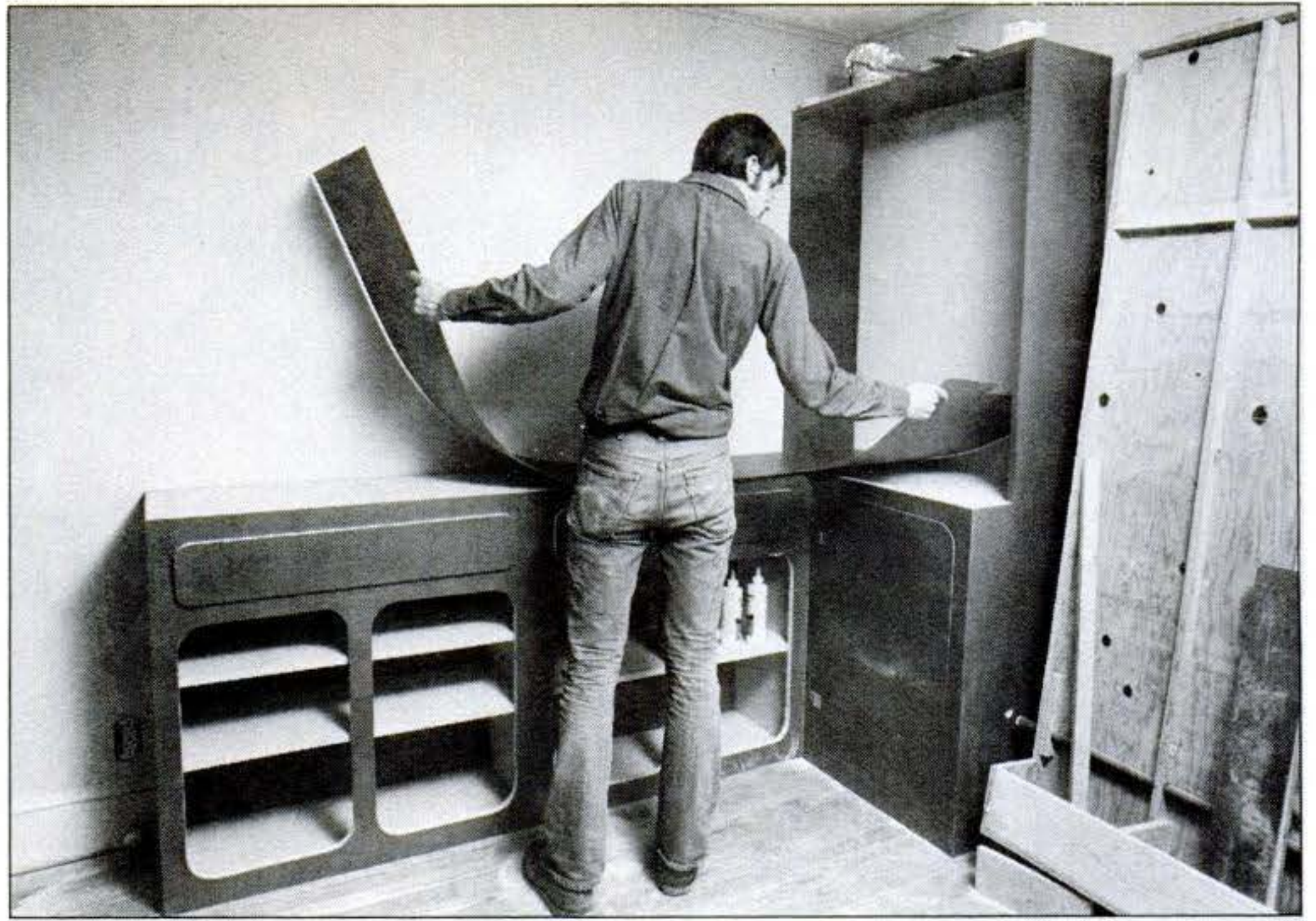
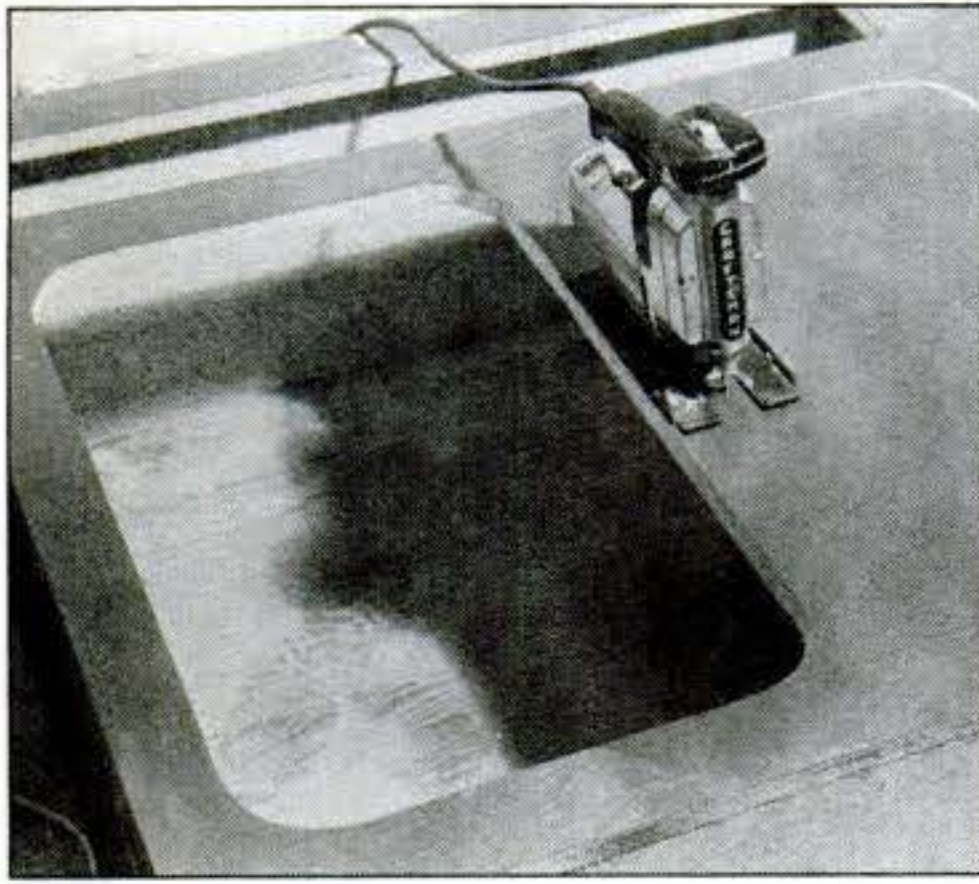




In the dining-room mode (above), circular table in the center of the room provides seating space for up to eight. Bed is folded against the wall between the two cabinets in the

background, its underside covered with prefinished oak paneling. Table hangs out of the way, and bed folds down (below left), making room (below right) into sleeping space.





Door openings (above left) for buffet and cabinets are cut after laminate is applied, using a super-fine blade such as a Trojan X-FS to prevent chipping. To cut the openings accurately, draw their outlines on laminate, and drill starting hole for jigsaw behind where one hinge will mount. Tilt saw shoe five deg. to bevel door edges for clearance. First, saw only hinge edge of door, then face-mount hinges and finish cut. Door will be perfectly hung with kerf-wide clearances all around. Laminate for both the buffet top and the left-hand cabinet top (above) is applied in one piece to eliminate need for tricky joint. Carefully cut and dry-fit the piece as shown here before cementing in place. Use slip sheets to ensure proper positioning. The counterweight box beneath pivot pipe (left) makes the pivoting bed easier to raise and lower. Box is filled with rocks "battered" in place with concrete so they don't rattle.

bine them both. Now, what used to be a little-used guest room is a dining room—with built-in buffets and cabinets for china, tablecloths, silver, and so on—that also contains a disappearing bed. Most of the time we leave it set up as a dining room, using the table year-round for sewing, crafts projects, or updating household accounts.

But if we have overnight guests, the table top goes up on the wall, and the bed pops down from between two cabinets. Pillows and blankets come out of the closet, and we have a comfortable place for friends and relatives to sleep.

All this fits neatly into a 12-by-12-foot room, with space left over to

store a sewing machine, ironing board, crafts, and games, plus eight folding chairs to go with the dining table.

Best of all, the room was inexpensive and easy to convert. Although the drawings and photos on these pages may make the project look complicated at first, nothing could be simpler. With the exception of cutting a dado in the bed frame, everything else is basic butt-joint, glue-and-screw construction. Even the cabinet doors hang themselves automatically and fit perfectly. If you can cut particleboard accurately, you can build a room like this.

Despite the simplicity, everything looks good. The reason? All those basic butt joints and screw heads are cov-

ered with a plastic laminate. If you have never worked with these laminates, I suggest you give them a try. They are by far the fastest, easiest way to put a professional finish on a project. With a little practice, you can cover a piece like one of these cabinets in an hour or two. A first-class paint job could take four or five days and might not look as good or last as long as laminate does.

So if you have a room in your home that's not earning its keep, consider giving it a double life. [In next month's issue POPULAR SCIENCE will offer plans for another type of bed cabinet, one that partitions space and uses a disappearing bed.—Ed.]



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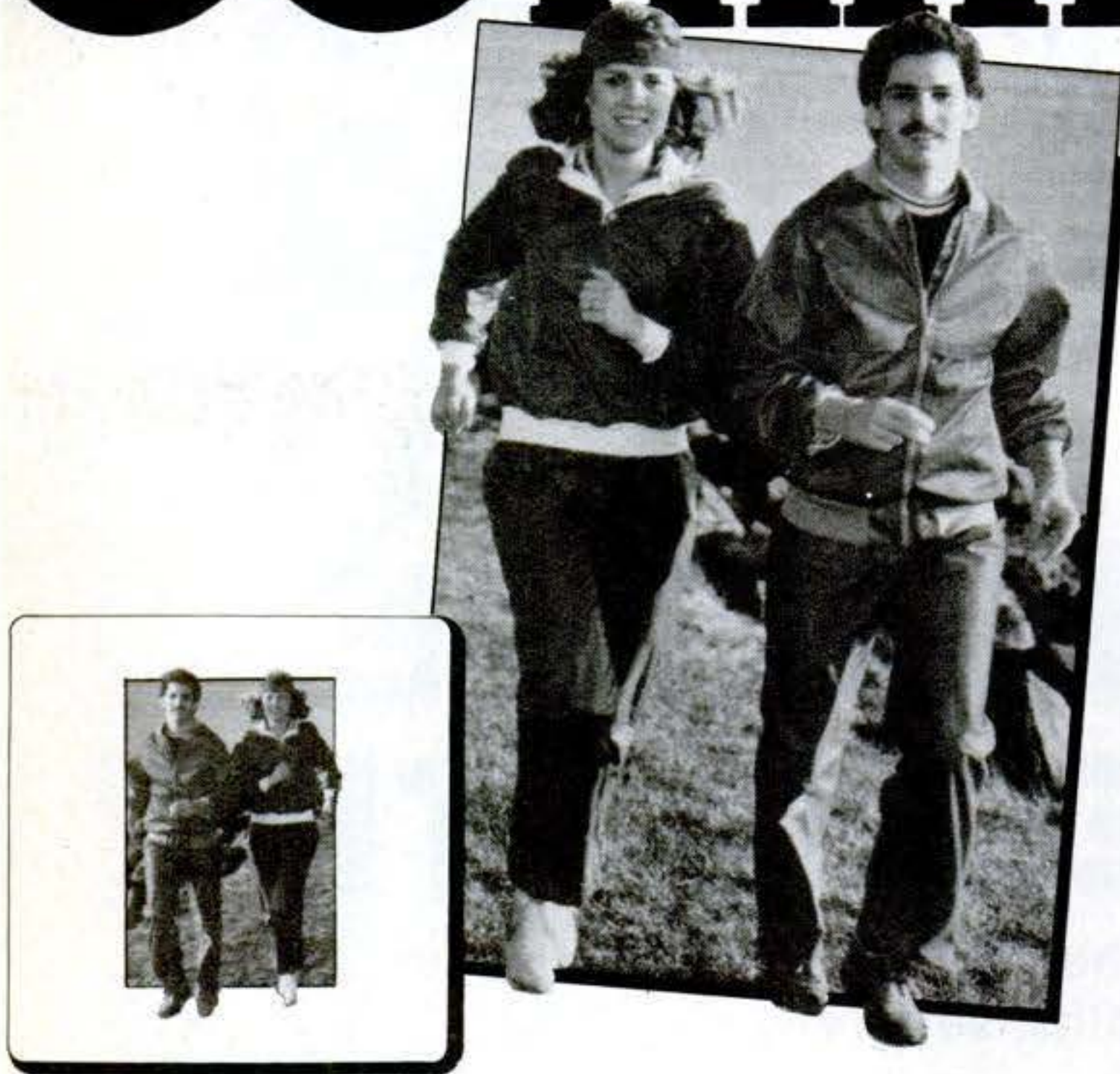
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*Hate to see summer leave?
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**spa you
install yourself**



Install your own spa, and you may cut the final cost substantially. Tips from a pro help you speed the job and ensure a professional setup.

By RICHARD DAY

The Valley Spa Warehouse in Westminster, Calif., was filled to capacity as Stu Robertson conducted a weeknight class. While Tom Miller and I worked on readying his new spa for installation, we literally had to climb over the other students.

At least 120,000 molded-fiberglass spas are installed yearly. Why the growing popularity? These heated whirlpool spas are basically mini-pools that extend the outdoor bathing season well into the autumn months. Many people who found the earlier, barrel-based hot tubs too intimate enjoy the resort-style congeniality of a spa.

Spas can be either portable (see box) or permanently installed. Although some makers, notably Jacuzzi, ship spas already set up, most spas come as shells. Before delivery the dealer must install jets, skimmer (water strainer), submerged light, drain, and air and waterlines (see diagram).

You can save roughly one-third the cost of your unit by setting it up yourself—about an eight-hour job. A few dealers such as Robertson offer setup classes where you can do the job using the shop's facilities and tools. The on-

Continued

Newlyweds Jon and Cheri Miller relax in the spa they helped install (above right). In-deck valves control bubbles in the spa, made by Catalina (1130 W. Trenton St., Orange, Calif. 92667). For silent running, pump and heater are mounted 50 ft. away. With its self-contained support systems the Hot Spring Spa (right) from Watkins Mfg. (6225A El Camino Real, Carlsbad, Calif. 92008) can be set up in minutes wherever there's a source of electricity.



ly unusual tools needed are a heat box or gun and a five-inch hole saw. A squeeze-type plastic-pipe cutter is useful.

Two jobs involved in setting up a spa can't be described as fun: drilling through the spa's fiberglass sidewalls and working with the silicone sealant. The prickly glass fibers get on your skin and clothing when drilling. The silicone-rubber adhesive, which is used inside and outside every fitting to prevent leaks, sticks all over you. But the glass fibers eventually wash off and the silicone can be peeled off once it has cured.

Starting the setup

First drill holes for the whirlpool jets, submerged light, bottom drain, and skimmer. Locate jets at different levels so that every seat has one nearby. Place the skimmer away from the main traffic pattern.

Before drilling, check the outer shell to ensure that the holes don't penetrate any vital parts. Center the holes on the molded-in depressions or on flat spots, not on curves, which might be tough to seal. To prevent drill drift, make center-line marks before drilling. To keep from spalling the edges of your holes, first drill from inside then outside, meeting in the center.

Use a hole saw to make the cutout for the underwater light.

Next install jets, light, and skimmer. Coat fitting faces with silicone rubber, slip on a rubber gasket, and insert through the wall from inside. Add another gasket and a silicone-sealed jam nut on the outside. Hand-tighten the nuts to the point at which the gaskets just begin to squeeze out. If too tight, they'll slip out like watermelon seeds between your fingers. If that happens, the fitting is a do-over, and an extra-messy job. (Wait until the end of the setup job to install the bottom drain. Once it's in, the shell needs careful propping to avoid cracking the drain.)

Now solvent-weld a venturi tee to the back of each jet where air bubbles are wanted (see diagram). When solvent-welding use a cleaner-primer for complete two-step welding—and use a high-quality solvent cement designed for use with PVC. Hold all fittings together until the joints stop trying to squeeze apart.

Pipe bending

To supply the venturis with air you'll need a manifold—basically a one-inch PVC pipe to connect the branches of all venturi tees. Assemble this pipe along with the water-

lines, which carry water from the pump to the jets and back (see diagram). Pipes must connect all water jets, and the run must be fitted with a single supply pipe that will connect to the pump line when installed. To minimize surging, Robertson advises installing eight-inch-long vertical capped air chambers just beyond the last two jets on each side (see diagram).

Although many spas are plumbed with flexible-rubber spa tubing, we chose less-costly PVC pipe. One reason: It ensures a leak-free bond to the PVC fittings, which don't bond well to the rubber. (We still used the flexible-rubber hose for above-the-waterline portions of the venturi-air and blower lines.)

There's another advantage to PVC pipe, Robertson says. You can use two-inch supply pipe (instead of the 1½-inch pipe normally used) to ensure full water flow from the jets.

PVC has one disadvantage—you must heat-soften the pipes so you can bend them to fit between fittings. This is the trickiest part of setting up the tub, and a two-person job. You can heat the cut-to-length pipe in a heat box with a calrod element and rotating rollers to keep the heat even all around. Complete heating takes about five minutes. *Continued*



Wood 'n Energy Magazine
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The clean, simple design of Kent stoves complement any room decor. And the Tile Fire adds even more flexibility with easily interchangeable tile sides.

Each model also offers a large view of the fire, through a ceramic glass door that really does stay clean.

When you look at a Kent stove, it's obvious to see the design advantages it has over its competitors.

But equally important is what is inside Kent stoves — how they work. It's that engineering expertise that really makes Kent the flame of the future.

Shopping for your spa

Although spas and hot tubs are used for much the same purpose, there are important differences between them. The original round, straight-sided hot tubs can be uncomfortable. The uninsulated wooden tubs are also energy wasters and are prone to leaks.

Most spas are molded fiberglass, though some are metal or molded-in-place shotcrete. Spas come with multilevel contoured seating and built-in insulation. The molded shells, available in many shapes and colors, are intrinsically watertight.

A wooden tub with a vinyl liner, dubbed the spa-tub, combines the smoothness of a spa with the natural beauty of a hot tub. This recent innovation has built-in insulation to minimize heat loss and provides a cushioned interior. Unlike a hot tub this version won't leak, even when freshly filled.

But the hottest thing in today's spa market is the portable. One industry survey indicates that a surprising 70 percent of future spa sales will be portables. Portables are aboveground pools usually mounted in a wooden enclosure. All of the support equipment and connecting piping fit beneath the spa. The buyer just fills the portable with water and plugs it in.

Portables use the same fiberglass tubs as other spas, from small to fairly large (six to seven feet long with a 300-gallon-or-more average fill). But a portable can be drained and moved indoors for use during the off season—provided your floor is able to support the

75-pound-per-square-foot typical loading.

There are two drawbacks to a portable. One is the muffled sound of the pump running right beneath you. The other? A portable won't enhance property values as will a sunken pool.

Portables cost from \$900 up to nearly \$5,000 depending on size, quality, features, insulation, and accessories. Many portables sell for just under \$3,000. Prices for both hot tubs and spas are in the same range—from about \$2,500 to \$4,500. This includes the necessary support equipment but not installation, which can add \$1,000 to \$2,500 unless you do it yourself.

When shopping for a fiberglass spa, the National Spa and Pool Institute (NSPI) recommends checking for uniform thickness along the edges and for absence of cracks and creases. Inside you want a blemish-free finish without scratches or pockmarks. An exterior shell that is reinforced around the seats and plumbing outlets is desirable. Either gel-coat or acrylic linings are suitable. Gel coat is slightly less costly though more susceptible to chemical and solar-radiation damage; it therefore requires more maintenance.

If you opt for a non-portable spa, you'll need to buy at least three support accessories: pump, filter, and heater. A blower, a submerged light, and timers are nice-to-have options.

The pump circulates water through the filter, heater, and tub. It also powers the jet action

at each inlet. The filter keeps the water sparkling clean. The pump should be correctly sized. Noncorroding plastic pumps are popular but they vary in both durability and price. Consider purchasing a 24-hour timer to run the filter pump—this option is really a necessity for completely automatic filtration.

The heater—usually gas-fired but can be electric—maintains the desired water temperature automatically. Make sure the heater you select is sized right. It needs to be large enough to heat the water quickly and maintain the desired temperature yet small enough to be energy efficient. A minute timer for the heater control is an easy addition, one that will burn your dollars only when you want them burned.

Though some bubbling is produced by the venturi-air system (see diagram) a blower heightens the bubbling effect. And this is a big help in stirring up the water to let the filter get it clean. A drawback: Cold air bubbling beneath you in warm water feels considerably colder than it is. Thus the blower is often not operated in cool weather.

You care for your spa as you would a mini swimming pool. The monthly operating cost varies according to climate. Figure on at least \$20 a month.

For more information contact NSPI, 2111 Eisenhower Ave., Alexandria, Va. 22314 (703-838-0083) for a free copy of its booklet, "Planning Your Spa or Hot Tub."—R. D.

What sets a Kent stove apart from others is a scientific combustion system that redirects carbon rich gases, normally lost up the chimney as smoke, down through the firebed and up into a secondary combustion chamber where complete combustion occurs.

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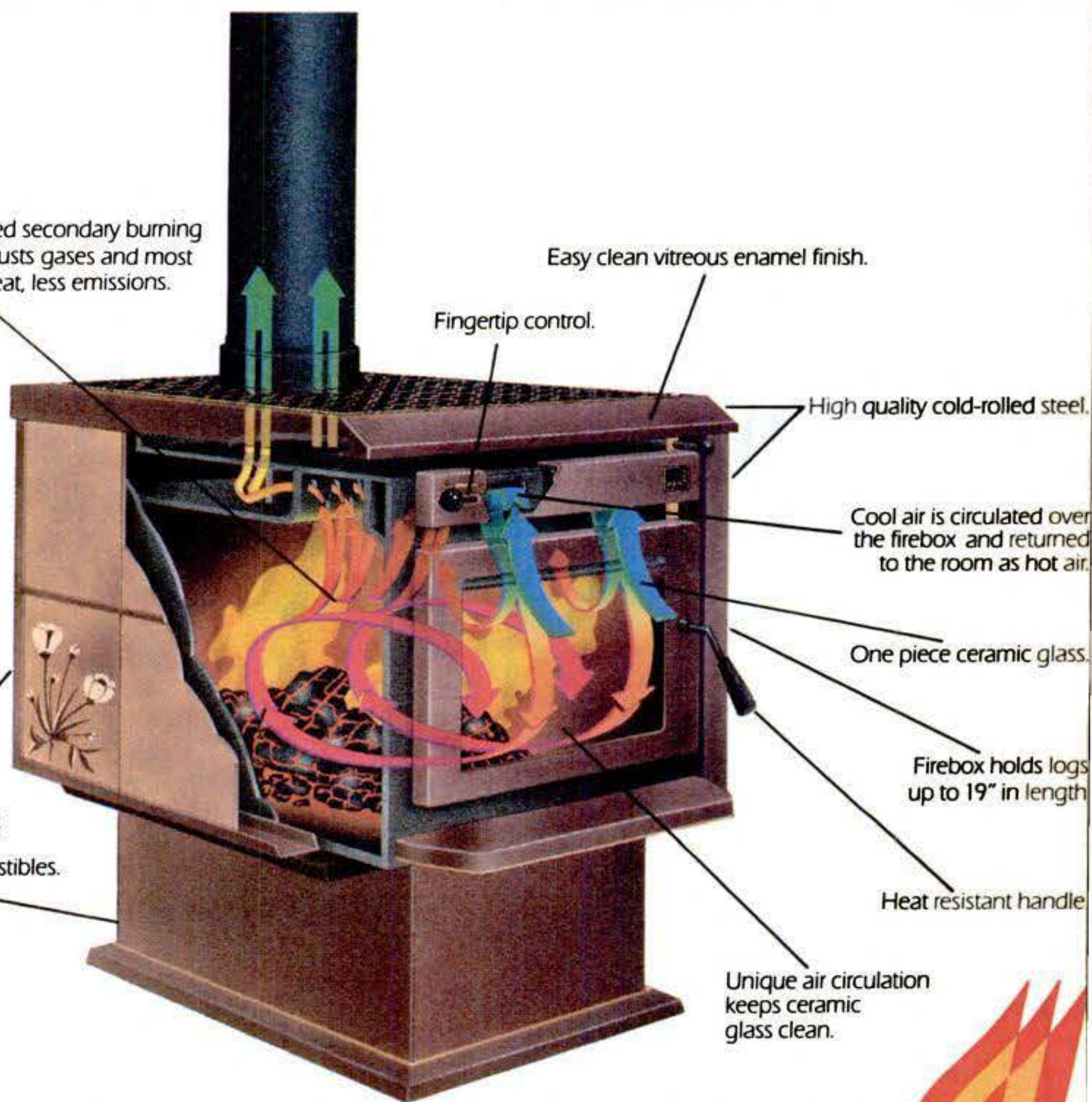
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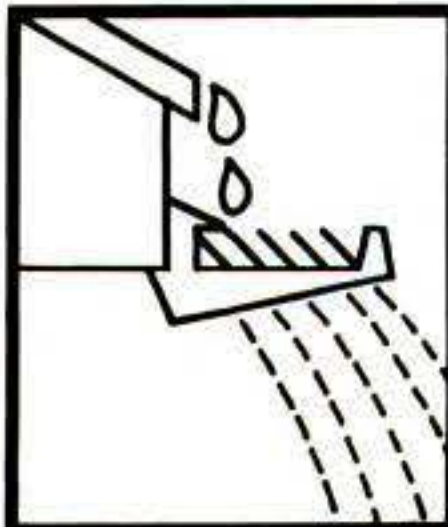
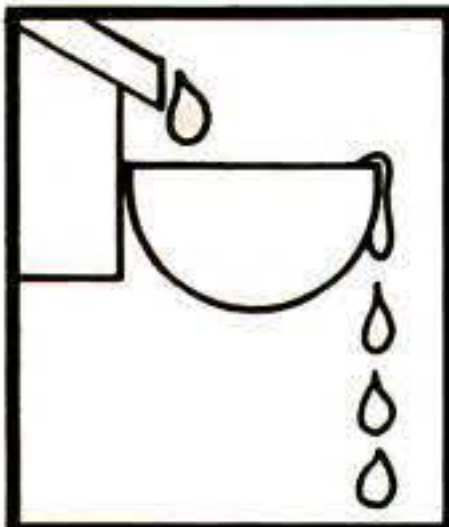
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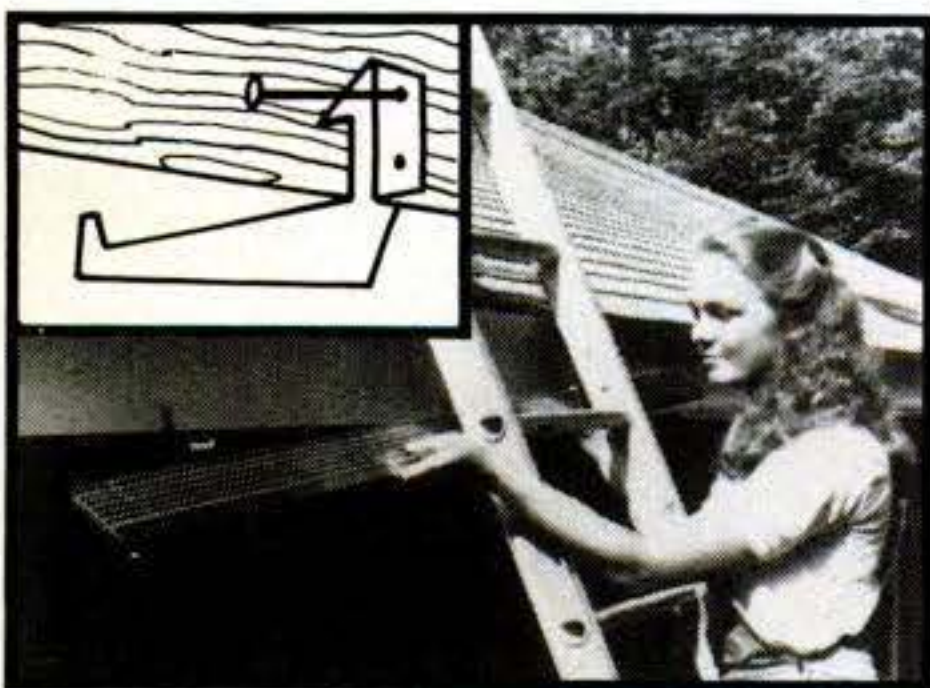
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A slightly slower method is to insert the nozzle of a heavy-duty 20-ampere heat gun inside the pipe and rotate the pipe while heating. Wear leather or cloth gloves, or hold the pipe with dry cloths. Heat only until the pipe becomes rubbery.

Insert the hot pipe into its fittings without solvent cement. If it starts to kink, quickly rotate 90 degrees or turn it end for end. Work the kink out with dry cloths to protect your hands. Once the pipe has been smoothed and pushed into place, it can be cooled off quickly by rubbing with a wet cloth. After cooling, remove the pipe and solvent-weld it into its fittings.

Once you've solvent-welded all water pipes and air manifolds in place, your spa is ready to install. But though you can set up your spa in one day, installing and plumbing it and building a deck or other surround will take several weekends or more—and you'll welcome all the help you can get. When choosing a spot for your spa be sure to check local building regulations. Also check whether any inspections are required. And choose a spot at least 12 feet away from any overhead wires or electrical outlets.

As you install the spa, support all parts of it, not just the rim. For uniform support, pack sand beneath. If you don't install the spa in the ground, fashion wood supports for it. (Have a qualified electrician wire the pump, blower, and light, and have a plumber run the gas piping to the heater.)

Locating the pump, blower, heater, and filter on a concrete slab some distance from the spa makes for quiet spa enjoyment. It's worth the extra below-ground piping, which you can lay yourself. If the runs are long, use two-inch pipe for the pressure, return, and blower runs. But install a 10-foot length of 1½-inch copper pipe in the line from the heater. This keeps PVC pipe, which is intended for carrying cold water only, at least 10 feet away from the hottest water.

After connecting all the water runs (see diagram for sequence), install venturi-air-control valves (one per air manifold) in the deck next to the tub. Connect these valves, via a flexible hose, to the manifold mounted on the spa's underside. Also install a blower switch next to the spa. (A pneumatically operated switch linked via air hose to a remote relay is safest.)

Once you get it working, you can use your spa for healthy unwinding and for socializing. You may not sit around the television set again until the snow starts falling. At that time you might want to empty the spa, or you'll have to run the heater to prevent freeze-up. **PS**

Turn page for installation photos



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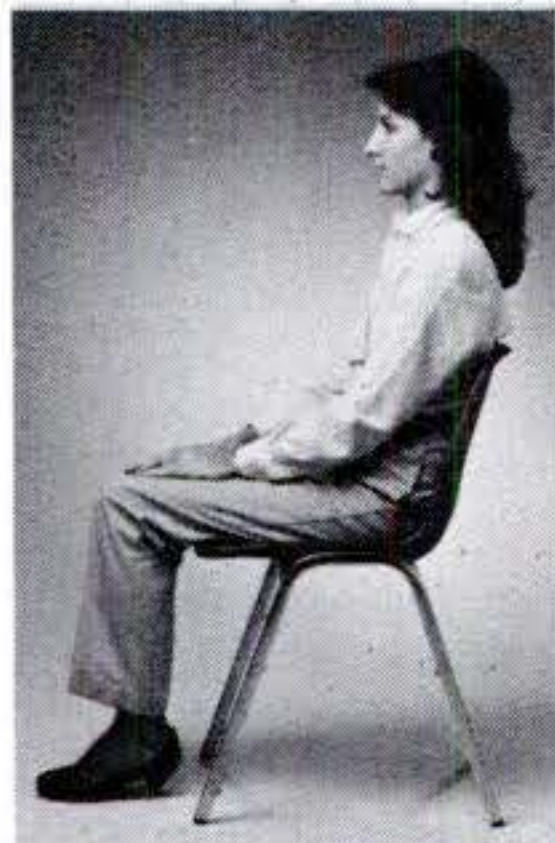
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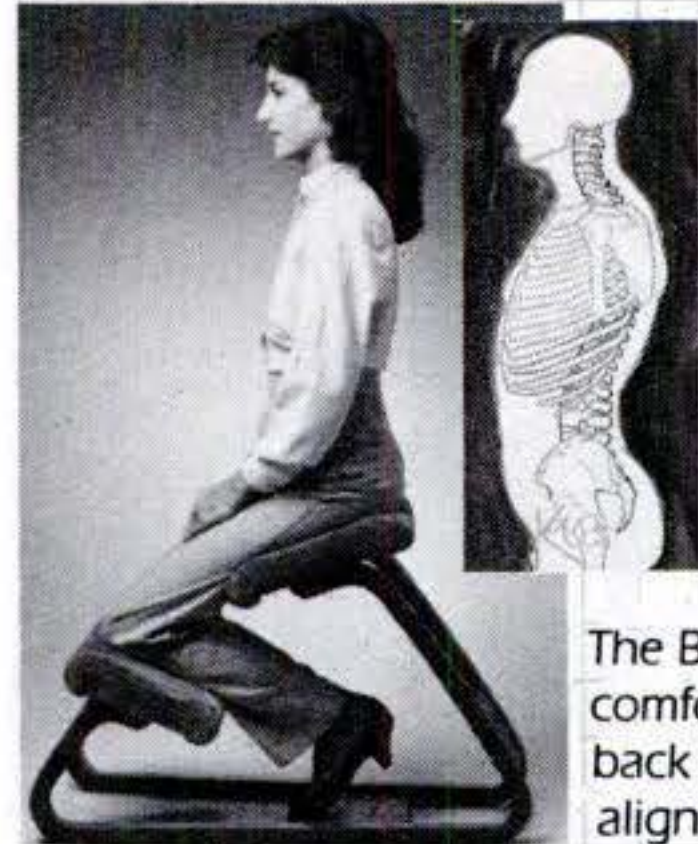


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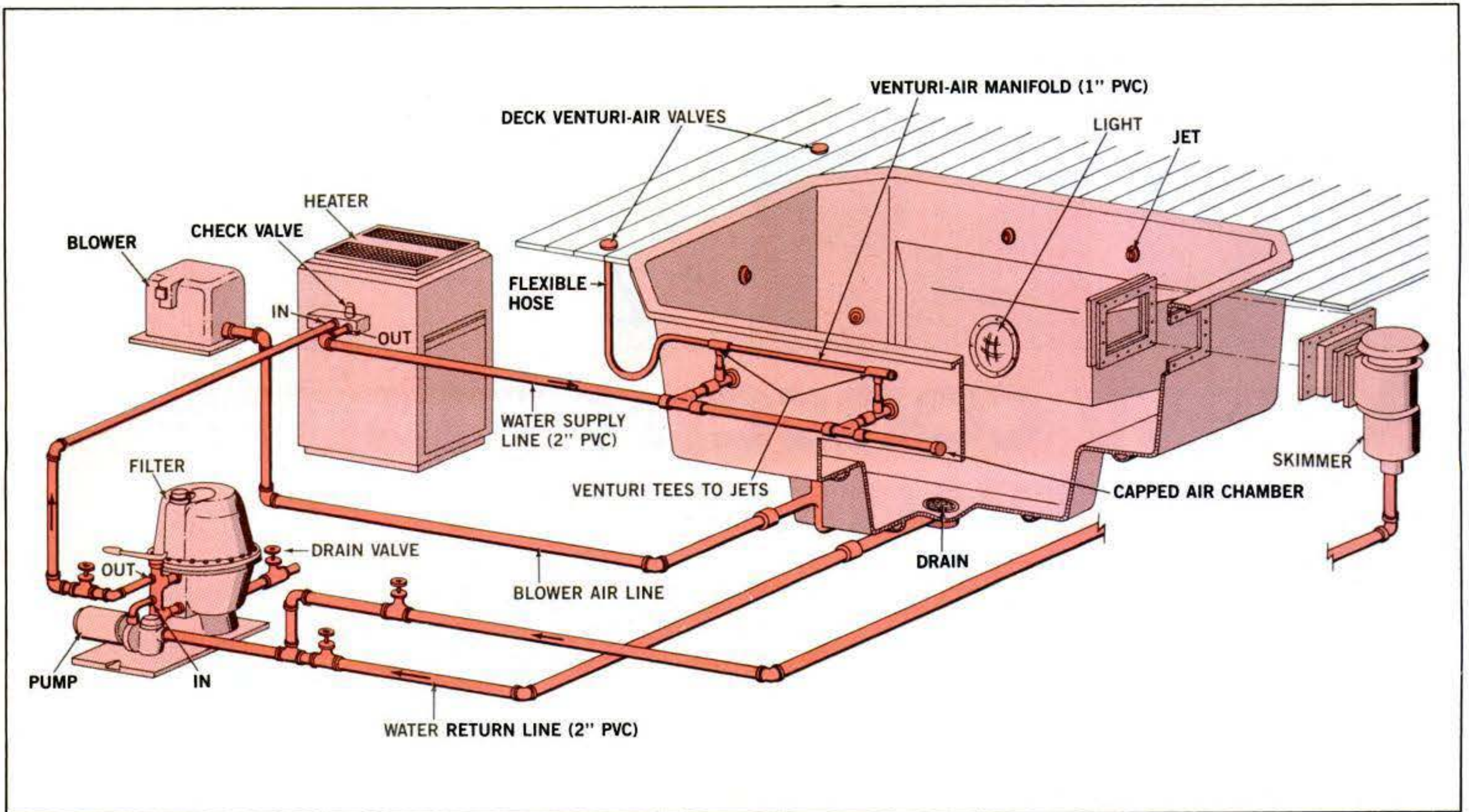
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Pipe loops (above) carry water from the spa drain via the return line to the pump, then, via the supply line, through the filter and heater and back to the jets. Suction created by the moving

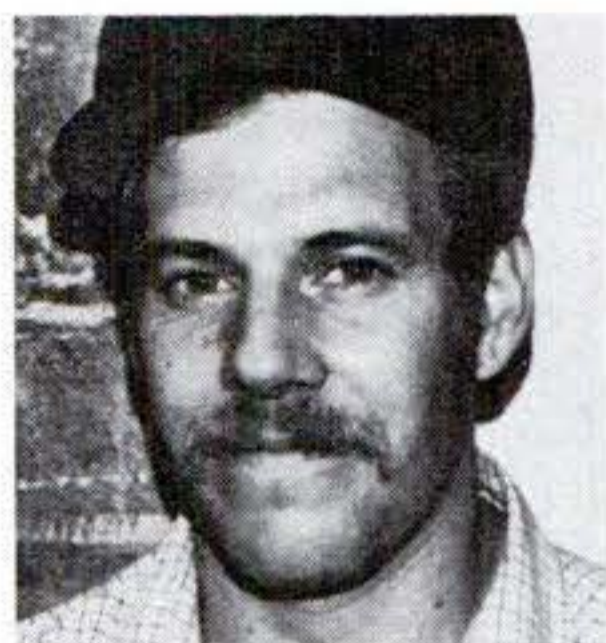
water draws venturi air in through a separate manifold. A tee feeds air to the flowing water before it enters the jet, creating bubbles as water shoots from the jet. An optional blower forces

air through a separate pipe run to create extra foam. The drain valve in the supply line has a fitting for connecting a garden hose to backwash the filter and drain the spa.



After spa fittings were sealed with silicone (above left) and supply lines were welded into place, the inverted spa was lifted into the backyard (above). Once set in place with plumbing and electrical runs connected, the unit was framed in for decking (left).

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1st person story by Tedd Mainwaring

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"About that time I got injured and ended up having to move my family to a different area to take a job as a maintenance mechanic. That idea of controlling my own destiny kept gnawing at me. By now I had five children with extra expense of about \$2,400 a year sending the oldest one to a speech and hearing center.

"How could a guy like me save up enough money to start my own business? To get into most businesses you have to own a corner of Fort Knox. If I could only ease into a business without giving up the regular salary I had to count on to put food on the table. And without making any investment. As long as I was dreaming, wouldn't it be great to find something where every single spare time order could bring in *really big* extra money.

"Sound like the impossible dream? Well, I had seen a Pace Products story about a man who earned \$4,154.65 on just one Seamless Spray order. And he didn't have to invest a penny. I sent for the free information. Believe me, when I received their literature and saw how easy their field-tested sales kit made everything—I knew it could all be more than just a dream. I decided to become a Pace distributor. And it was the best decision I ever made.

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"Pace ships the Pace Seamless Spray equipment on Free Loan. The customer pays only for the roofing products from Pace. His own men apply it. And the clincher—I would get my big commissions up front. Paid in advance. Weekly.

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"Quite frankly, my first prospect didn't buy. But I made a call for a school building with a roof the size of a football field. They called it the "Bucket Leaker," because every time it rained they had to put out buckets—in classrooms, hallways, even the cafeteria—to catch the water. I got the job and made \$7,700 on it.

"That school building is now leak-free for the first time in 25 years, so they had me do five other roofs with Pace's Seamless Spray. I was on my way. Today my family and I are enjoying a life we never thought possible before—all thanks to my accepting Pace's invitation to return that little coupon in the ad I read."

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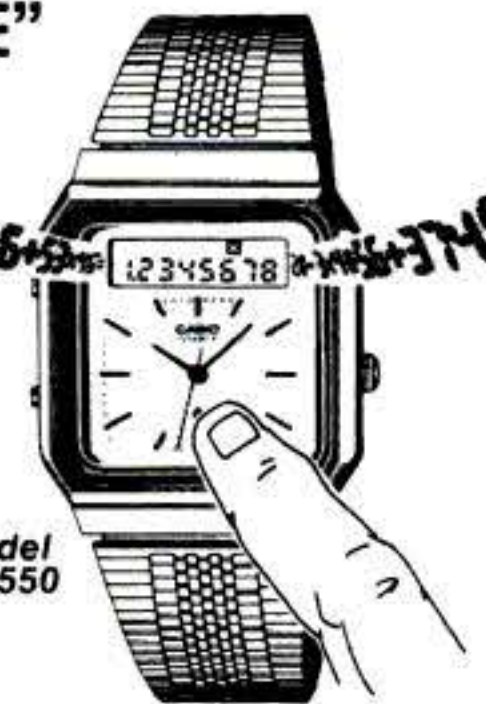
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Shop Talk

By AL LEES

Last word on underground

To conclude the debate (begun in this space last month) on the pros and cons of earth-sheltered houses, underground architect Charles Woods responds to criticisms by energy writer Bill Shurcliff:

Shurcliff: Most architects of underground homes fail to provide a protective fence at the edge of the roof or sunken patio. I'd think that three or 3½ feet would be a minimum.

Woods: Obviously this problem must be dealt with to protect children and animals. The minimum fence you propose could be well-designed—or could even be steel railings masked by bushes. Most earth-sheltered houses occupy rural acreage—like my own house, shown in last March's "Shop Talk." I've several acres separating me from neighbors and have no railings; I do have a four-foot trellis extension that would catch any creature running off the edge of the roof. No creature ever has, and my wooded property is virtually a wildlife sanctuary.

Shurcliff: The typical underground house has no basement, no attic. So to get the equivalent useful volume, the house proper may occupy 50 to 100 percent more land.

Woods: Frank Lloyd Wright argued back in the '30s that basements and attics are ugly and expensive. They don't come free in any house. To have an attic, you need a gable roof—much more costly than a flat one. All construction is now so expensive it's just no longer practical to store a collection of junk. Better to settle for a storage room—no larger than 12 by 16 feet—on the living level.

Shurcliff: Big berms exist on two or three sides of the house, almost doubling the land area preempted.

Woods: Most homes have more than enough yard space for berming. Where there's a problem, a sunken courtyard avoids the need for berms.

Shurcliff: But berms are a pain; cutting grass on them is a pain. It's no fun walking on a berm, and berms make it hard to circle the house.

Woods: It's absurd to claim that berms are inherently bad. Cutting grass on a berm can be trickier than on flat ground—as with any hilly yard—but some people enjoy doing it with

a string trimmer. If you find it a pain, choose ground cover or (as with my berms) bark mulch. I find berms are fun to walk on, and kids love rolling down them. I confess I don't spend much time circling my house—do you?

Shurcliff: Undergrounds have ugly objects sticking far aboveground—for ventilation, or light, or smoke exit.

Woods: Perhaps you're less sensitive to eyesores than I, Bill, since you admit you're not a designer. I find most architecture on this planet ugly, and most roofs have vents, flues, and antennas sticking up from them. But to answer your specific objection: An earth-sheltered house need have very few objects sticking up through the roof, and they need not be high. They can even be grouped as a sculptural feature.

Shurcliff: Occupants of an underground house get a poor view to the south because their eyes are only five feet above the south terrace, whereas in a typical two-story house one's eyes are far higher and can see over nearby shrubs.

Woods: No good designer plants six-foot bushes in one's line of view.

Shurcliff: But occupants get no view at all to the east, north, or west. One can't see the sun rise or set—or the Big Dipper without going outside.

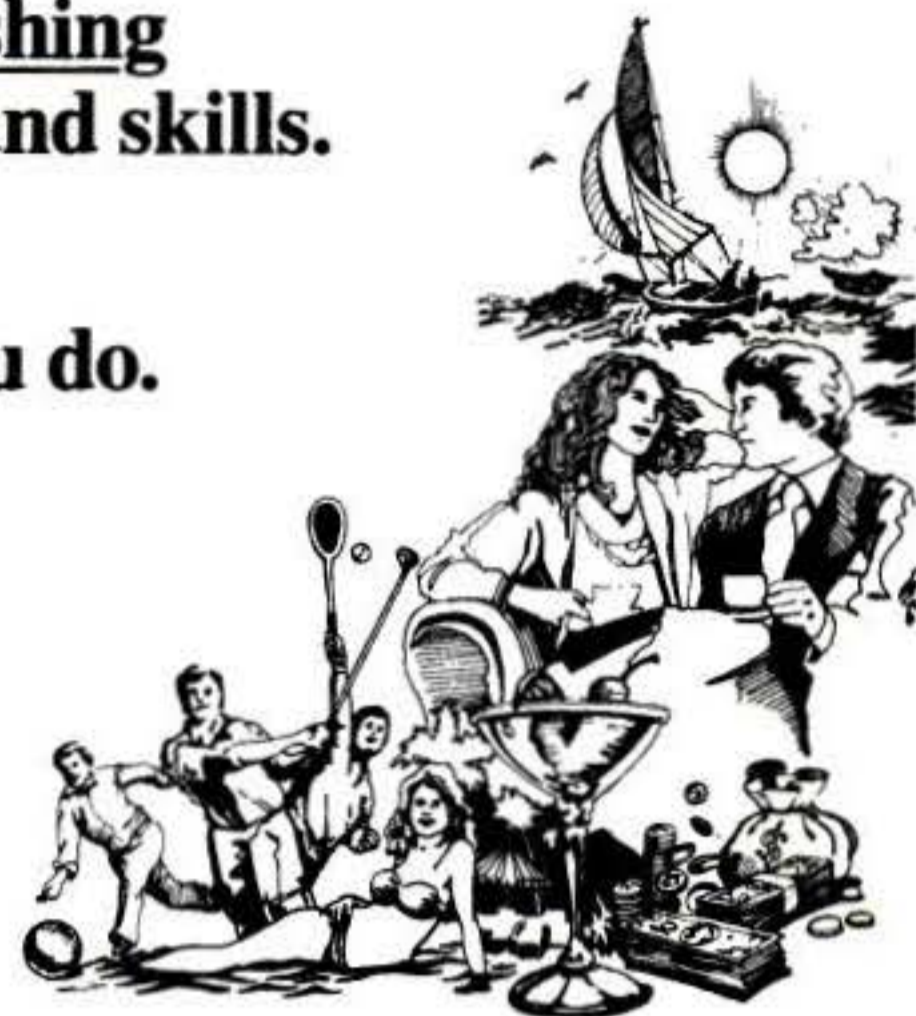
Woods: Atriums and skylights encourage stargazing. But I'm surprised to find you so interested in light and view, since you've defined superinsulated houses as having eight percent or less of floor area devoted to south windows. As with any properly sited house, the south wall would get the glass. So let's figure on the basis of 10 percent of floor area for all windows. For a modest 1,000-sq.-ft. house, that's 100 sq. ft. Now that's two windows, roughly the size of a patio door, for the whole house. Want to split them up and put one window on each wall? You can only have 25 sq. ft. per wall—two windows roughly three by four feet, and that may not give you even one per room. No big picture window for sunset watching—no skylight. Scatter them further, you're down to portholes. My first earth-sheltered house for PS [Sept. '80] had, for a 1,000-sq.-ft. floor plan, 448 sq. ft. of light—not counting two optional skylights for stargazing.

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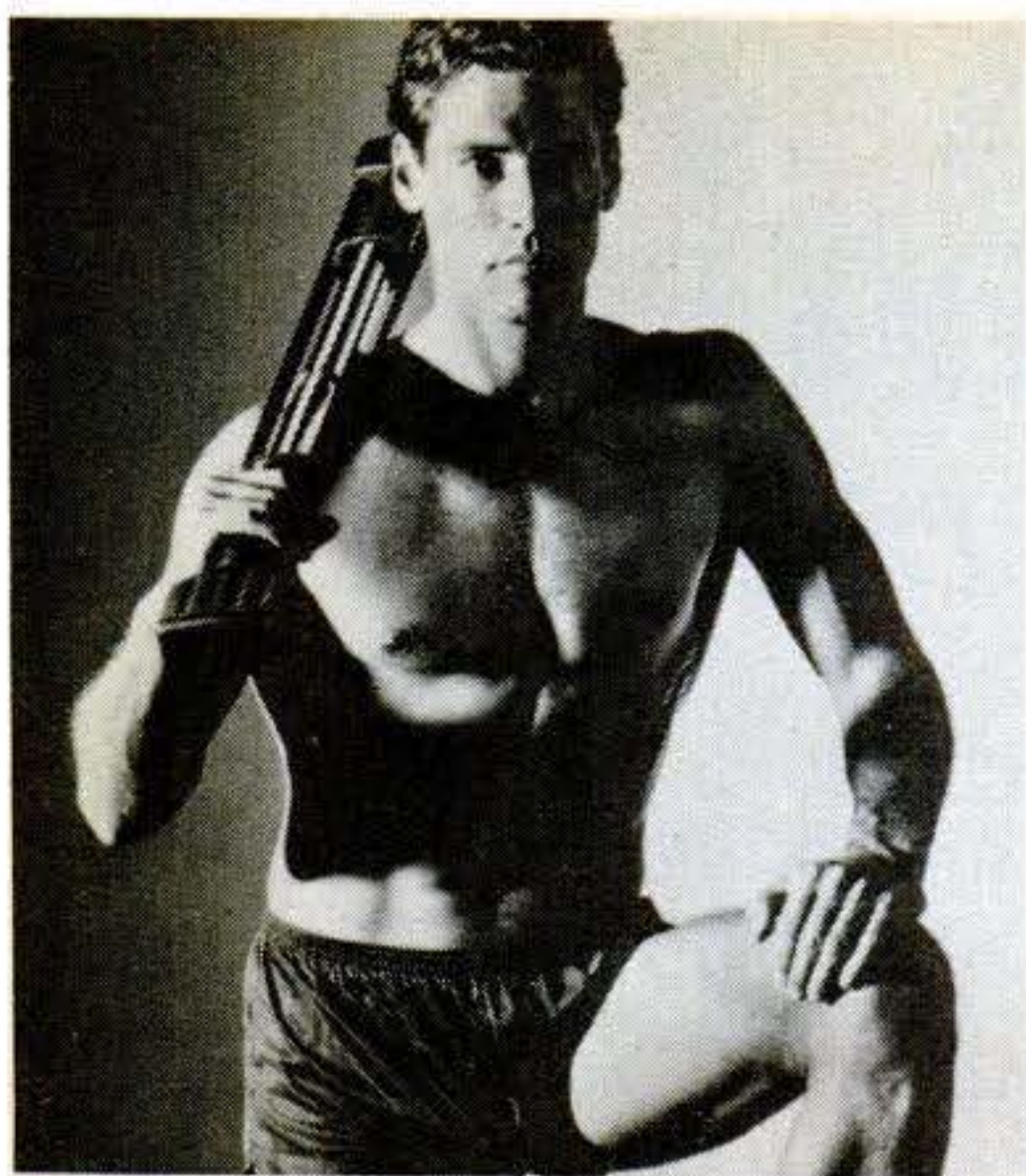
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Shop Talk

Shurcliff: The typical underground has no cross ventilation.

Woods: Earth-sheltered houses can have windows on all sides, plus ventilating skylights.

Lees: Final gong, gentlemen. Would you return to your corners?

Still time for the fair

At this writing, the Louisiana World Exposition (recommended on faith in this space last April) is struggling to keep afloat: In its first weeks this freshwater fair didn't draw the projected crowds. That's hard to fathom. I've just spent most of three days exploring the 82 riverfront acres (two days is the minimum for hitting the high spots) and am delighted to find that film is the dominant message-medium. Most pavilions offer a short, technically expert movie on freshwater ecology; here are the ones you shouldn't miss:

U.S. (in 3-D, viewed through special glasses), Canada (a lovely, wordless IMAX film), European Community and Japan (each offering a three-screen film on local rivers), petroleum industries (vertical two-screen film on the environmental impact—benign, of course—of offshore drilling), Egypt (a journey up the Nile, keyed to an immense scale model), and free-water society (a trip down the Mississippi, screened inside a replica of a stern-wheeler).

Actual rides are few and scattered at this fair (though the monorail circling the fairgrounds is useful—and free). Of most interest is a cable car that sweeps you nearly 400 feet in the air to dangle above the mighty Mississippi before swooping down to the opposite shore. The spidery support towers—a pair on each bank—are an engineering marvel.

It's a Mardi Gras of a fair, reflecting the flair of its host city, and that mild Gulf climate will let its season stretch through fall—unless financial problems shorten the run. On November 11 the fair's fanciful river-god gates will be locked so demolition can begin. The ephemeral nature of world's fairs is what lends them special magic: Each one differs from those before, and we all have only a brief chance at a unique experience.

The next fair downstream is the biggie in Vancouver, B.C., two years from now. Canada's third-largest city seems determined to equal Montreal's memorable Expo '67. Technology already runs rampant in Vancouver as computers design the grounds. Should be a must-see. **PS**

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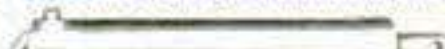


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"A super-slick oil additive that works!"

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Put simply, TUFOIL is a blend of synthetic and mineral oils with friction modifiers and particles of the slipperiest substance known to man held in permanent suspension. The particles are so small they pass right through your oil filter and form a coating over all your engine parts. It **cuts friction to the lowest level of any known lubricant.**

The particles are polytetrafluoroethylene (PTFE). You know them as TEFLON® or FLUON®. To put them in permanent suspension in oil took 14 years of laboratory research. **The process and chemistry is so unique that it is covered by six U.S. patents.**

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A big chunk of the power your engine develops is lost just overcoming its own internal friction. TUFOIL puts more of that lost power to work driving your car.

Your old engine runs smoother and recovers its lost pep. A new engine stays like new as you put on the miles.

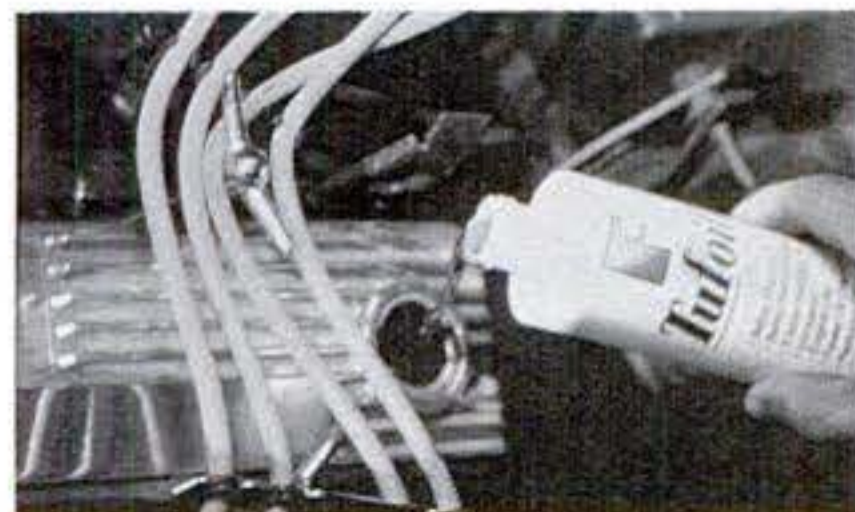
Less friction means your engine runs cooler. During hard summer driving, temperatures don't build up as high in a TUFOIL-protected engine. When you shutdown and try to restart, TUFOIL prevents overheated parts from clamping together to give you hot-start problems.

Less friction helps in winter too. TUFOIL's slippery coating lets your engine turnover easier on sub-zero mornings. Your battery and your starter last longer.

... And, of course, with less friction eating up your engine power, TUFOIL **saves you gas.** How much depends on the condition of your car and how you drive. Some old-car owners report gas savings that even we have trouble believing. Static tests done by researchers at the University of New South Wales in Australia found TUFOIL gave fuel savings of up to 7%.

Satisfaction Guaranteed

If TUFOIL doesn't do what we say it will do for your engine, just let us know for a complete refund.



How Do We Back Up Our Claims For TUFOIL?

Well, there's those Australian tests, and they were required by the government, which looks into all product claims to protect their consumers.

But there's more.

Popular Mechanic's test team found that TUFOIL was the **"super-slick lubricant that does what it promises."** They reported fuel savings of 10.3% for one test car. **"Absolutely spectacular," they said.**

Israeli researchers at the Technion Research Institute, who were looking for a reliable lubricant for scorching desert driving, found that TUFOIL kept a test engine's heat at safe levels no matter how fast they turned it over — saved fuel, too.

Stationary engines used to pump natural gas in Texas are **lasting more than twice as long** and running cooler on hot summer days. A big toymaker now claims he produces the fastest toy cars in the world after he put a drop of one of our TUFOIL derivatives, "Lubit," on each wheel bearing. Machine tool users report vastly improved bearing life on heavy grinders with another TUFOIL derivative, "Lightning Grease," according to Design News magazine.

The most Important Group of All — Our Customers

Here is what they say: Their letters come in from all over the world. From Cinnaminson, N.J., a father reports that the engine of his son's 1979 Maverick "performs as good or better than when it was new." A salesman who covers the upper Midwest says he first started using TUFOIL in his 1976 Cordoba at 40,000 miles. He now is up to 110,000 miles and says **"it starts without any trouble at 20 below zero."** A Texas truck operator states "TUFOIL in his Kenworth and Freightliner added 100 RPMs to both, gas mileage was up 8%."

How To Use TUFOIL

Just add TUFOIL to your crankcase. You will see results in less than 1,000 miles. Once your engine is broken in on TUFOIL, you add



small amounts with each oil change to keep your new performance levels. Don't be afraid to use TUFOIL repeatedly over the life of your engine. There is, by the way, no scientific basis for claims that one-time treatment by any lubricant will last the life of an engine.

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"Say, Smokey—"

**A clinic on cars by Smokey Yunick,
America's most famous mechanic**

Leaky diesel

I'm content with the performance and economy of the 5.7-liter diesel engine in my 1979 Oldsmobile 98; however, it uses a quart of oil every 500 miles. The dealer says it's due to leakage past the rope-type rear-main-bearing seal and that replacing the seal would be a short-lived repair.

Steve Hammond, McMillan, Mich.

I don't know of a better seal for that engine, and I doubt that thing's going to be around much longer. But there is a replacement main bearing that works very well. It has a groove to ease the rear-main-bearing seal's load. Contact Michael Mfg. (555 W. 2nd Ave., Bldg. A18-19, Mesa, Ariz. 85202) to find out where to buy it in your area.

Squealing wheel

I hear a loud squealing noise coming from the left front wheel of my 1980 Subaru. The noise happens most often during side-street driving or when coasting, but I also hear it at high speeds.

Michael Williams, Brooklyn, N.Y.

The noise is probably caused by your brakes. You can fix them by getting the discs back to spec. If the discs are worn, rough, or thin, you'll need new ones because the old ones would be too flimsy for much stock removal. Use the correct brake lining; it doesn't have to be Subaru's, but it must have the correct coefficient of friction. All parts must be snug in their fastenings. Too much clearance will let them resonate; too tight or dragging is also bad.

Overeager engine

My 1978 Datsun pickup has a slight but frustrating surge at all speeds from curb idle to 70 mph; it doesn't matter whether the vehicle is hot or cold. I've checked the compression, adjusted the valves, put in new spark plugs, and checked for fuel and vacuum leaks. The local Datsun dealer installed a new reluctor and overhauled the carb; he finally gave up.

M. M. Horton, Sequim, Wash.

The surge is caused by either leanness

or ignition misfiring. See whether you can find a chassis dynamometer, and check the ignition under load on a 'scope. If it's OK, put in a five-percent richer main jet. The problem could also be a plugged exhaust, the fuel system starving the engine, improper fuel-tank venting, low fuel pressure due to a weak pump, a plugged fuel line, a hot fuel-pickup line, or insufficient voltage to the primary side of the coil.

Getting clipped

The distributor-cap clips on my 1977 AMC Gremlin six keep stretching and breaking. I think heat causes the clips to lose their temper.

Eric G. Belrose, Swanton, Vt.

It seems to me that vapor in the cap, triggered by the point spark, is exploding and causing the clips to break. Drill a 1/4-inch hole in the cap or distributor area where it won't admit water or cause an electrical ground, and I'll bet it won't happen again. I believe that your engine is worn and needs the oil and gas fumes vented out.

Wants better mileage

I'm only getting 12 to 16 mpg in my four-cylinder 1979 Dodge Challenger. A CTK 35 carburetor kit installed at 19,500 miles did not help.

Nils A. Thiebaud
Santa Barbara, Calif.

First, check the automatic spark advance and static setting. Next, set the idle fuel-air-mixture ratio; this must be done with a CO meter. Also, the thermostat may not be working, causing the engine to run too cold and keep the choke on. And how about the possibility of the brakes dragging? Jack the car up and check.

Water injection—good or bad?

What's the advisability of putting an Edelbrock water-injection system on my 1981 Datsun 200SX? Even premium gasoline does not completely eliminate the knock. My dealer says no way, and the area rep claims that water mixing with the sulfur in the fuel would form sulfuric acid that would damage the aluminum head

and steel valve seats. I don't believe this.

John Stein, Oak Ridge, N.J.

As I've said many times before, water injection can significantly reduce detonation when done correctly, but over a long period of time, except in specially controlled operating and maintenance plans, water added to the combustion process in a four-cycle engine will end up as a very expensive Band-Aid. The metals and lubricants used in Otto-cycle engines have little tolerance for water or water vapor. Rapid oxidation, chemical reactions, and some loss of lubrication protection are byproducts of this situation. I will qualify my statement, though: If the engine were designed from a clean sheet of paper, these negatives could be reduced.

Chattering clutch

My 1983 Chevrolet S-10 Blazer with a V6 engine and five-speed manual transmission has been plagued by clutch chatter from the beginning. The dealer has replaced the clutch disc and throwout bearing four times and the flywheel once. The zone rep admits that a problem exists but hasn't come up with a reliable repair.

Tom Watts, Austin, Texas

Chevrolet has a clutch-chatter fix for '82 and '83 Blazers with your specs. Your dealer should have gotten a service bulletin last November.

Black smoker

My 1978 Pontiac Sunbird with a 151-cu.-in. four-cylinder engine runs fine most of the time. However, when I start it after it's been sitting for about 10 minutes, black smoke comes through the tailpipe and the car runs rough for a few minutes. The choke is working properly. Do you think the carburetor needs work?

Gene Bovino, Johnstown, Pa.

I believe your trouble is caused by heat soak of the carburetor and fuel lines. Your options include: better needle-and-seat control; changing to a brand of fuel with a higher vapor pressure; isolating the fuel-bowl area with a thermal barrier; replacing the metal fuel lines with rubber-and-fabric lines; and ducting or blowing air from the fan onto the carburetor bowl.

Balky engine

I own a 1979 Honda Accord with a 1,750-cc engine and a three-barrel

Klein carburetor. The engine sometimes stops completely after running for a quarter-mile or so. Also, after the car has run for a while it can't get past 40 to 50 mph. I've talked with other Accord owners, and they have the same problem. I'm told that the charcoal canister should be replaced or that a Holley or Weber carburetor will cure the problem.

Jerry Lanier, Lakeland, Fla.

You don't say whether this happens hot or cold; I assume it's after the car has been warmed up. If so, the fan kit mentioned in Service Bulletin 82-014 can help cure it—the 1979 Accord is the same as the 1980 model. If the charcoal canister is bad, you can check it by disconnecting the vacuum line that runs from the carburetor to the canister. Plug the line to do the test. I believe that a replacement canister is needed at 30,000 miles.

Tube in a tubeless tire

My new Firestone 721 tire had a slow leak in the sidewall from a small nail hole. It was repaired with a hot patch and a tube. I have doubts about the safety of using a tube in a tubeless tire.

Ray Krukar, Milwaukee, Wis.

I wouldn't be afraid to use a tire with the repair you describe. A tube is a fine fix, but there are some good plug-type fixes. The tire to walk away from is one with cord rupture, tread separation, or bead distress or damage. A nail hole is no big problem.

Stiff ride

The Toyota short-bed pickup I recently purchased has a very stiff ride. Is there a way to improve it by changing the rear springs? Would different shocks help? I've tried reducing the tire pressure without any success. I don't plan to carry more than a 300-pound payload.

Leo U. Florane, Metairie, La.

Springs, shocks, and tires are all involved in ride characteristics. Whatever route you choose—changing one or all three—do both the front and the rear equally. Don't attempt to soften only one end because you'll upset front-to-rear balance and get under- or oversteer, possibly to a dangerous level.

Got a car problem? Send it to: "Say, Smokey—," POPULAR SCIENCE, 380 Madison Ave., New York, N.Y. 10017. All letters are read, and those of widest interest are answered in this column. Due to the large volume of mail, Smokey cannot reply to letters not selected for publication.



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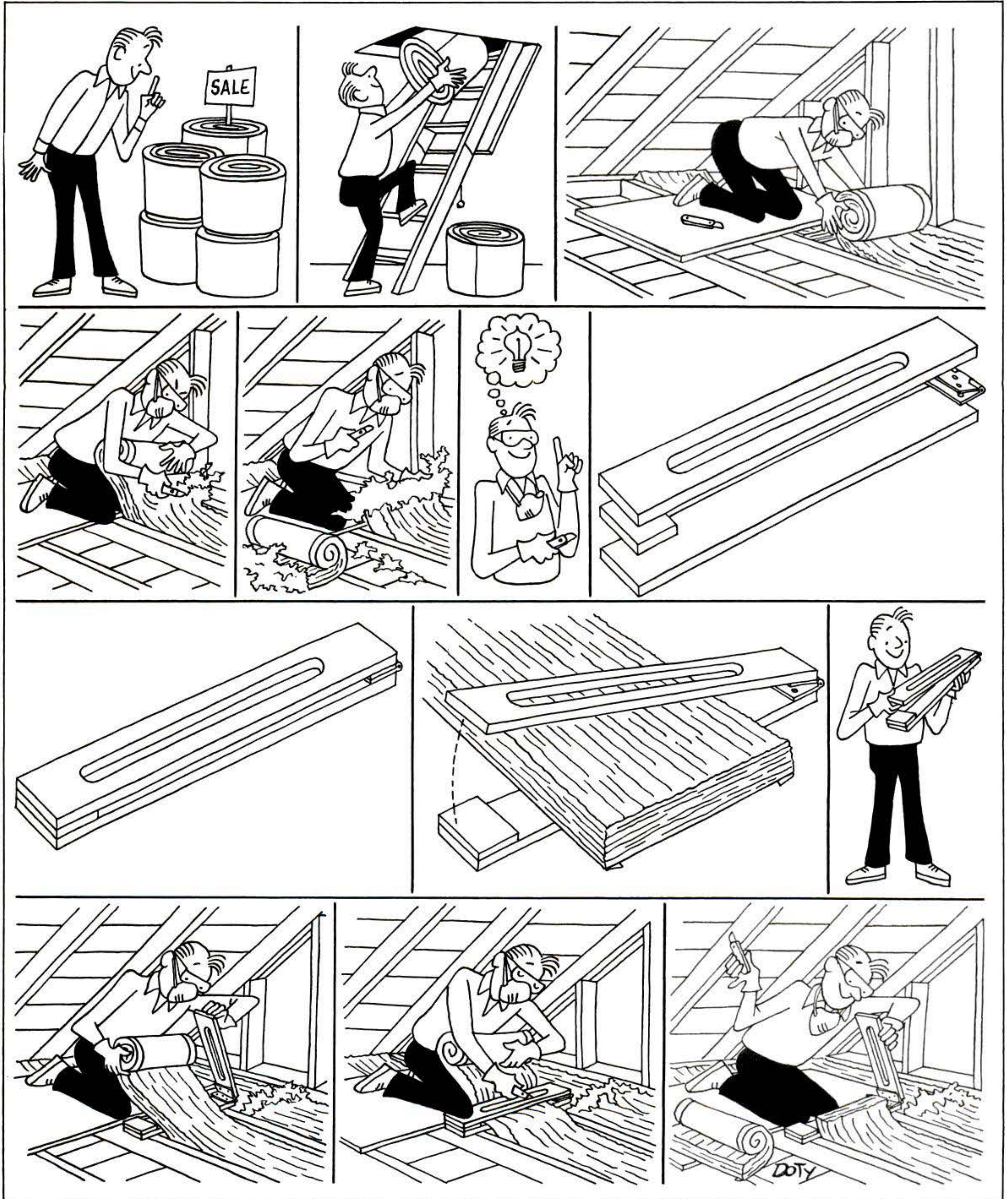
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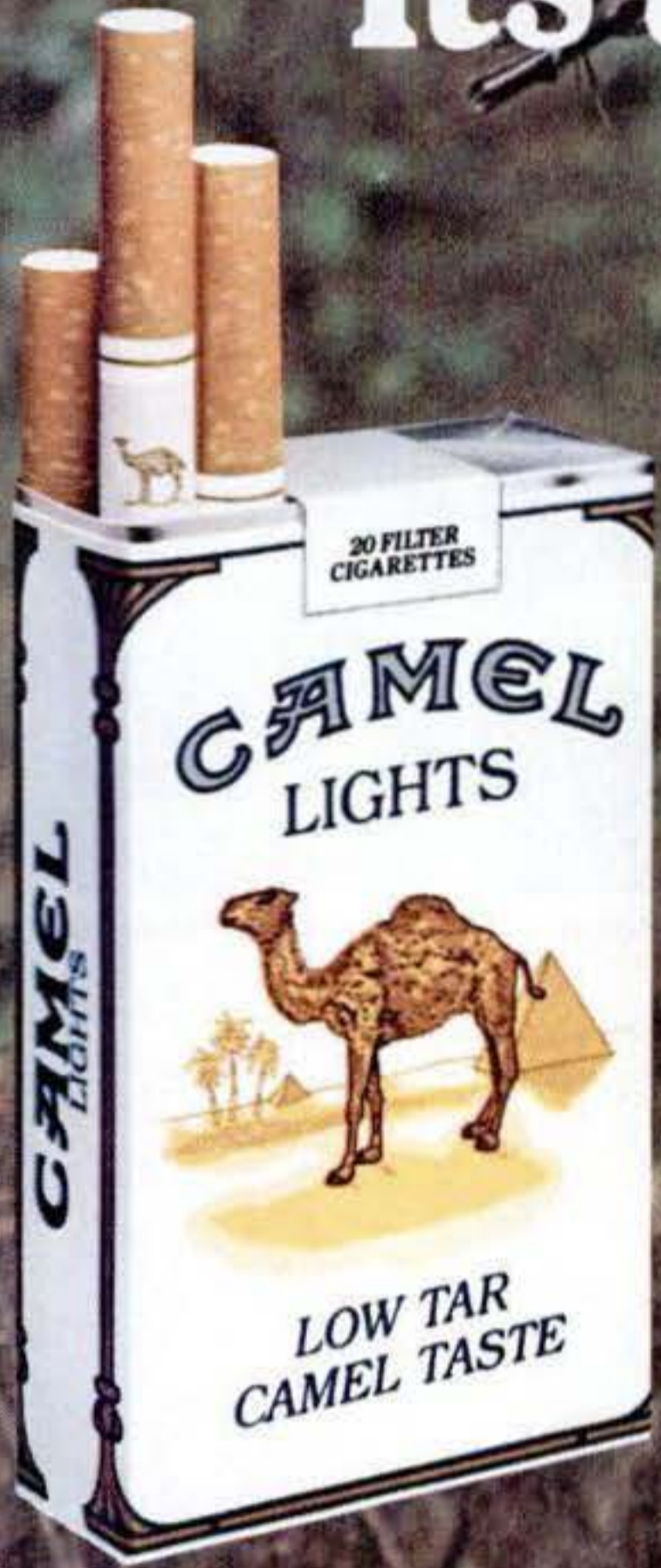
By ROY DOTY

\$50 to Steve Alford of Carmel, N.Y., for this idea. Send yours (with Social Security No.) to Wordless, POPULAR SCIENCE, 380 Madison Ave., New York, N.Y. 10017. Only purchased ideas are acknowledged.



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Warning: The Surgeon General Has Determined
That Cigarette Smoking Is Dangerous to Your Health.



Telephone calls placed from your car would use a low-cost removable transceiver that could rest on the front floorboard.

Coming— **\$400 car phone**

In General Electric's proposed "personal radio communications service," transceivers for car and home transmit calls through your home telephone. Calls from your car are placed automatically. Competitors for the channels required say the new service wastes radio frequencies. The FCC will decide.

By **LEE GREATHOUSE**

SYRACUSE, N.Y.

It could have been a hobbyist's paradise: four bays of workbenches littered with oscilloscopes, RF-signal generators, vises holding parts, and circuit boards bristling with electronic components.

Instead I was at the birthplace of what General Electric hopes will be the first mobile telephone simple and cheap enough for widespread appeal.

Here in its Syracuse labs, GE is de-

veloping what it calls "personal radio communications service," or PRCS. The mobile service, not approved by the Federal Communications Commission (FCC) at this writing, is based on a low-power radio transceiver in your car and an install-it-yourself base-station transceiver at home that transmits calls through your telephone. But new radio frequencies required for PRCS are in strong demand by other two-way radio services. And competition for scarce radio frequencies delayed the introduction of the new

cellular mobile-telephone service [PS, Oct. '83] for many years.

Beyond CB

PRCS is GE's answer to the FCC's call for something better than CB radio. When CB became a fad in the 1970s, the channels rapidly filled with chatter. The service became nearly useless. FCC studies have recommended establishing such a "citizens-band land-mobile private-radio communications service," and most of the hun-

Continued

\$400 car phone

dreds of individuals and organizations that filed comments with the agency favor the idea.

To explain how PRCS would work, John V. Kese, manager of GE's Communication and Information Systems and Services, showed me a device that looked like a slim-line telephone nestled on a rather large phone-answering machine. This was the PRCS base station for the home. The other half of the system, a unit about the size of a cigar box, goes in a car, truck, boat, or even a farm tractor.

"It's a very simple system, easy to set up," Kese told me. "You interconnect it to your home phone, and it works very much like a telephone."

You can picture PRCS as a cordless phone with a range of miles instead of feet. Both base and mobile units place calls automatically. No operator is needed to patch into the local telephone network, nor is there a central, computerized switching exchange. (Both are used in present radiotelephone systems.)

You could call another PRCS mobile unit directly from your car, or you could dial a regular telephone number from your car and the base station would place the call through your home phone. If an outside caller wanted to reach your mobile unit, the base station would forward the call.

According to GE, calls will be interference-free and private. Unlike CB radio, you'll have the channel to your-

self while you're on the air. To prevent a "ratchet jaw" from tying up channels, built-in timers will cut off conversations after about 90 seconds during busy periods. Callers would not have access to the timers.

Range between mobile units is about three miles; between mobile and base, about five miles. Range can be extended to about 15 miles with a repeater, a separate commercial transmitter that boosts the signal (see drawing). A vehicle 15 miles from a repeater could thus communicate with one 15 miles on the other side of the repeater.

GE will build repeaters in 20 large cities if PRCS goes on the market, but anyone is eligible to build and operate one, and competition to provide service is expected to be keen. Repeaters won't be linked; they will not automatically transfer calls. You can, however, subscribe to more than one service.

Lower cost

The price tag? About \$400 for both base unit and mobile unit, plus a flat \$10-a-month fee if you want repeater service. By comparison, current mobile phones, including the new cellular phones, cost about \$2,500. Cellular's monthly calling charges are expected to average more than \$100.

Jack Farrell, PRCS product manager, showed me a prototype base station. It consisted of a handset in a cradle, which is placed on the transceiver (the latter resembles a phone-

answering machine). The transceiver should be located in an upstairs room or attic for good reception, but the cradle and handset can be downstairs, connected by coaxial cable. An antenna is located near the transceiver.

As with other line-of-sight radio receivers, calling distances are affected by terrain and other factors. An antenna mounted in an apartment-building window may provide good reception for only a mile in a direction through the building. What if your base station is in a house on a hill? "That's a perfect location," said Kese.

Mobile calls are simple. "The touch pad is similar to that of a home phone," Farrell explained. To call another PRCS base or mobile unit you dial the unit's "address," a seven-digit telephone number plus one digit. To reach a regular telephone number you punch in the numbers, then push DIAL.

When a call is placed, the two radios exchange digital information, agree on a clear channel, then permit conversation.

The FCC proposes to place PRCS within an eight-megahertz-wide band of frequencies distributed between 898 and 941 megahertz. That would yield 133 channels. Five would be control channels used by the radios; 30 would be "local talk" channels for conversations between stations close enough for direct contact; and 97 channels would be reserved for repeater service. The two frequencies in the final channel allow party-line, CB-type operation in push-to-talk fashion but will not be linked to repeaters.

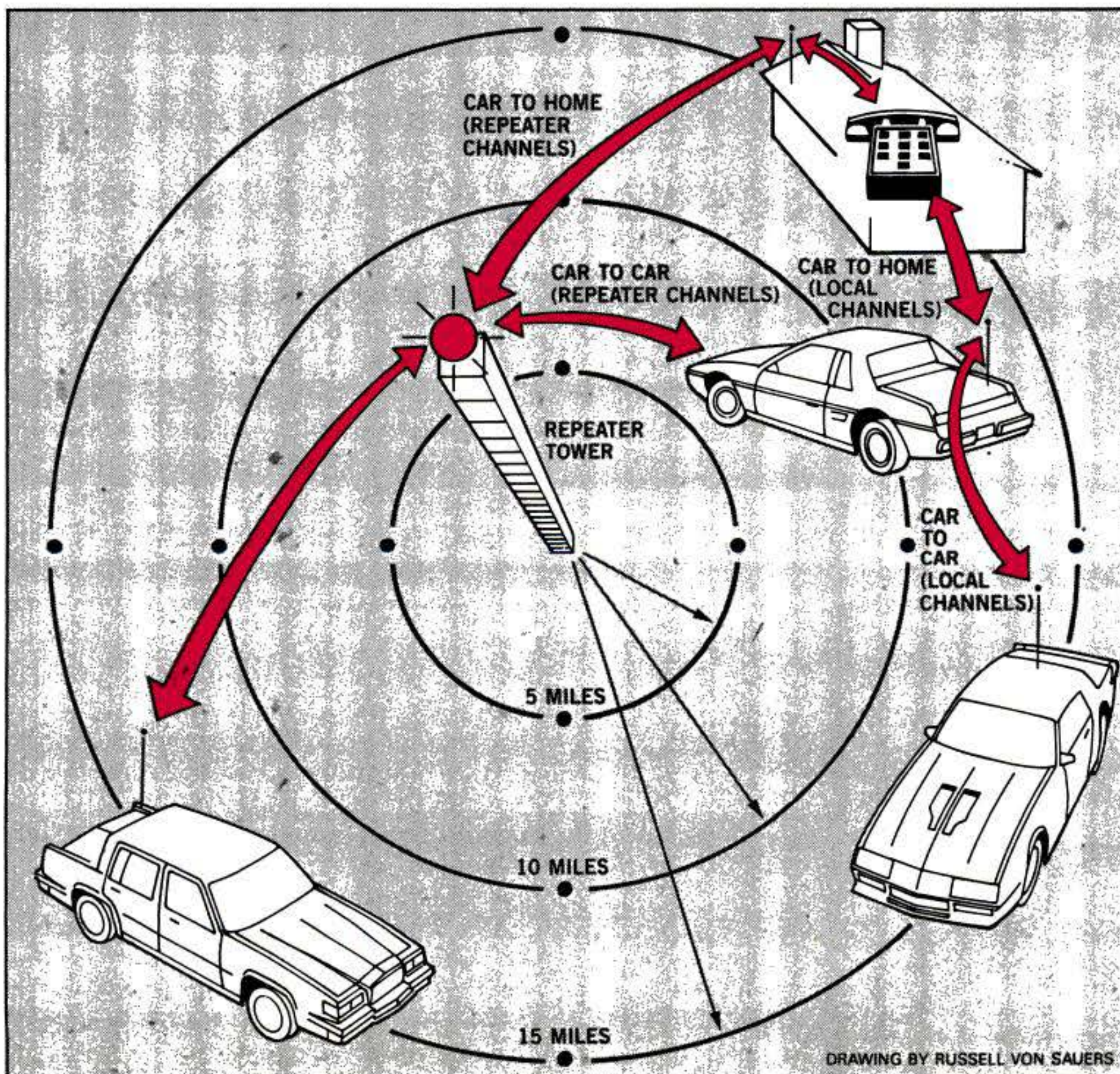
The biggest obstacle to PRCS may be competition for the scarce radio frequencies. Opponents say that PRCS is a waste of radio spectrum and that the public good could be better served by services such as cellular telephone systems, which have longer range and the capacity to handle more conversations at a time than PRCS.

An FCC decision, expected about the time you read this, will resolve the dispute. GE studies show that some 12 million people are interested in buying PRCS units, and the company expects to sell more than one million units a year for the first few years.

Use of the radio spectrum will be a political decision, but if the FCC gives the go-ahead, having a phone in your car could be almost as easy as having a phone in your home.

In its public comments, American Telephone & Telegraph said: "... [PRCS] will probably be relegated to a hobby or gadget status. . . ."

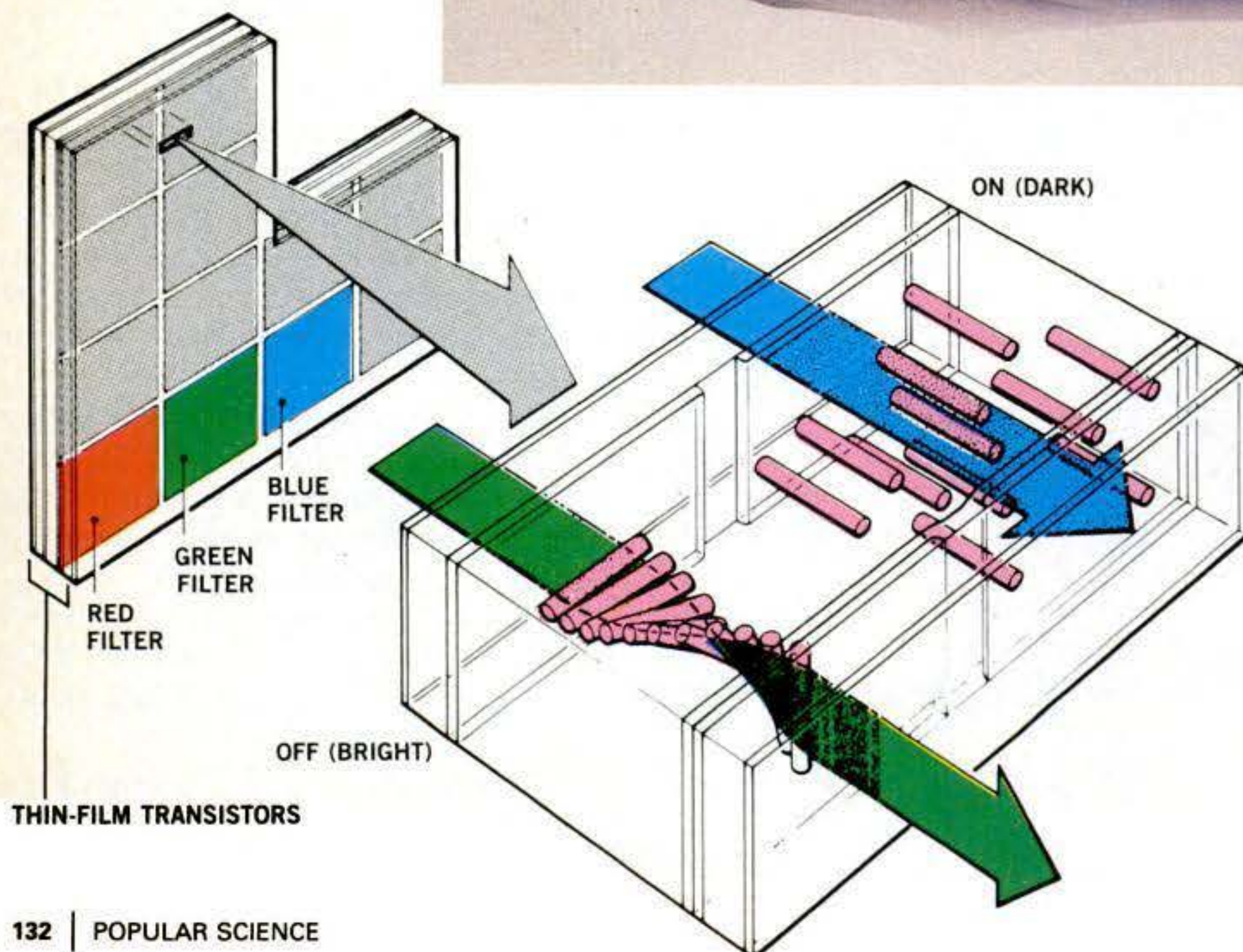
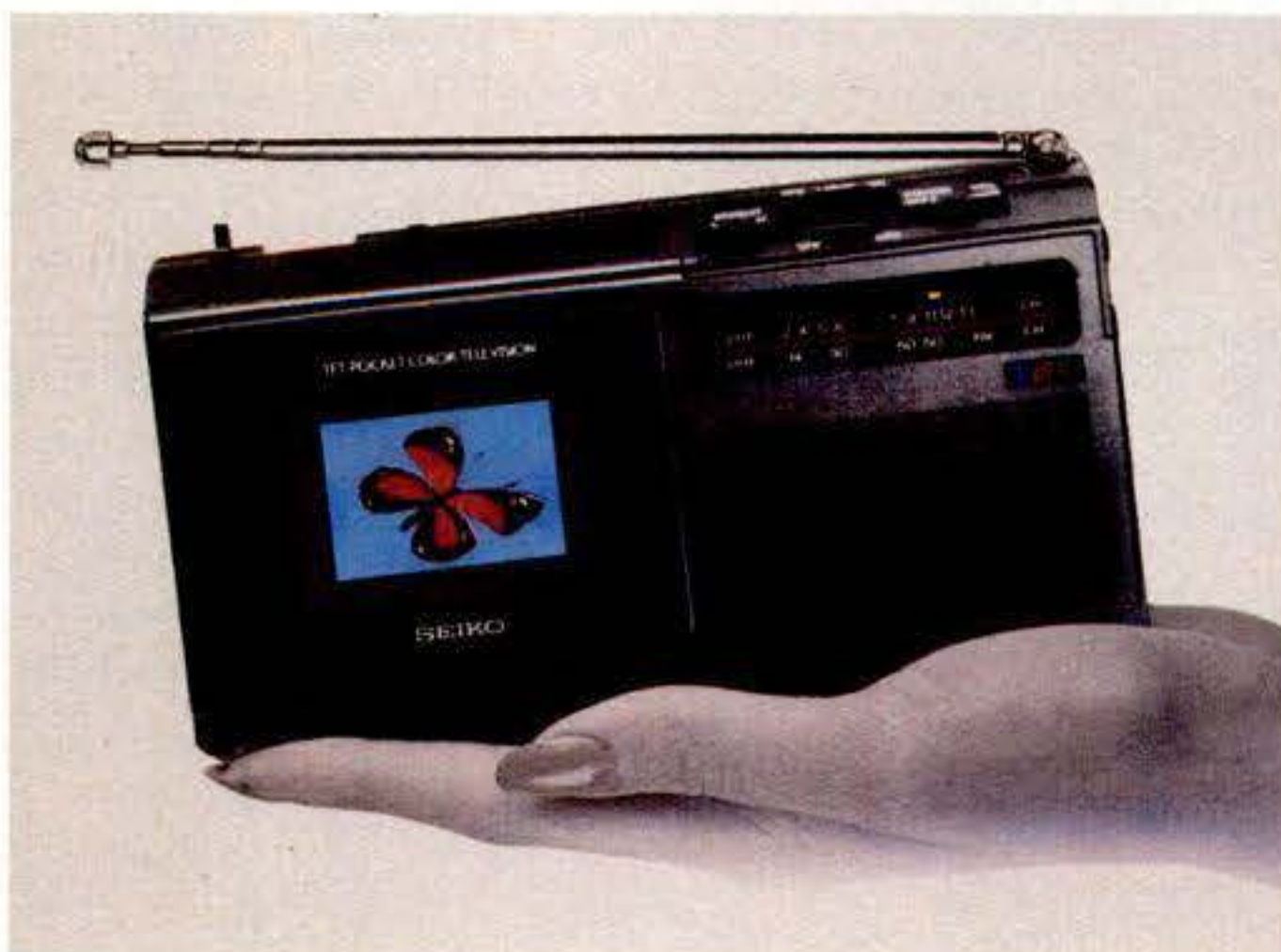
"If the telephone is a gadget," retorted Kese, "then you can call PRCS a gadget."



Now: flat-screen
**LCD pocket
 color TVs**



New Epson Elf (above) and Seiko pocket TVs were introduced recently as first color LCD sets. Identical except for their labels, they have a two-in. screen and weigh less than a pound. Because LCD screens can't be viewed in dim light, the TV set has a fluorescent backlight. A back panel opens to permit backlighting during the day without fluorescent.



A revolutionary new color-television system is finally launched in the marketplace. Its screen is a wafer-thin LCD instead of a cathode-ray tube.

By **HERBERT SHULDINER**

Recently I sat in my backyard and watched a baseball game on a pocket-sized TV set. But it wasn't like the experience I had a year ago [PS, Nov. '83], when I watched the tape of a Japanese baseball game on a prototype of this TV set while on a visit to Seiko's research-and-development department in Suwa, Japan. This was a live broadcast of a New York Yankees game on a set that's about to go on sale in the U.S.

The tiny Epson Elf TV I tested is a giant technological achievement. Instead of squeezing a cathode-ray tube into the tiny chassis, Seiko engineers have created an ultra-thin flat-screen color TV that uses liquid crystals instead of phosphors to create the colors. To achieve this, Seiko engineers created new fast-acting liquid crystals unlike the conventional LCs used in calculators and watches. The reason? Conventional LCDs react very slowly. That's fine for watches and calculators but not good enough for color TV. Slow LCDs blur fast action such as a thrown baseball or a fast runner.

The tiny TV I tested reveals that Seiko's engineers have largely succeeded. There was no blurred action as I watched the Yankees on the two-inch screen. Colors were also acceptable although not as crisp as those on a CRT.

Watching a ball game, however, on a two-inch screen wasn't very satisfying. The images appeared awfully small, and I really had to squint to follow what was going on. The little screen was more appropriate for viewing scenes that focused tightly on persons.

The Seiko pocket TV will be sold under its own label and as the Epson Elf. Price: about \$550. **PS**

Transparent thin-film transistors in color-TV panel are coated with red, green, and blue filters (enlargement, far left). TV signals actuating appropriate transistor electrodes control liquid-crystal molecules on front panel (left). When an electrode is off, light passing through filter is twisted by molecules and passes through front polarizer sheet (bottom arrow). With an electrode on (top arrow), molecules align; because light isn't twisted, it is blocked by the polarizer sheet.

Money Heist

Man with a dream grabs uncirculated one dollar bills before they are cut. Has gold mine.

Some mistakes make money. Take the famous upside down airplane stamp that today sells for thousands of dollars.

It seems that the government mistakenly printed an airmail stamp with the airplane upside down. When they found their mistake, they destroyed the stamps. A few, however, were mixed in with the good stamps and were sold. Today, they're worth a fortune.

Mr. Bernard Gittelsohn, a successful author and collector, had a similar idea. Would there be a market for uncut one dollar bills as they come off the presses at the Bureau of Engraving and Printing?

SECURITY VERY TIGHT

But history discouraged him. Nobody has ever robbed the facility that prints US money, and security there is so tight that it is doubtful if sheets could mistakenly slip out. But he continued to dream.

Then one day he made his move. In October, 1981, armed with nothing but his wallet, he managed to do what nobody else before him was ever able to accomplish. He got his hands on several hundred sheets of uncirculated, uncut, freshly-printed one dollar bills printed 32 to a sheet.

How did he do it? What secret plot? Who did he pay off? We're sorry to disappoint you, but all he did was read the newspaper. It seems that the government announced that it would issue these uncirculated 32-bill sheets to any collector who showed up at their printing plant in Washington.

HE SHOWED UP

He showed up, purchased hundreds of sheets and then stored them in a vault. "Someday," he predicted, "these sheets will be worth a small fortune."

It may be many years before these sheets grow in value. If the treasury department changes the design of its currency as they are exploring right now, then these sheets may indeed become collector items.

Mr. Gittelsohn also purchased a number of sheets of 1976 \$2 bills (16 to a sheet). Do you remember that bill? It bombed. It seemed that nobody wanted to use them. Retailers had no room for them in cash registers, many refused to accept them, and consumers didn't like them either. The bill is practically out of circulation.

DEVELOPS FRAME

It is now 1984 and Mr. Gittelsohn would like to sell his 1981 and 1976 bills. He has developed a beautiful glass frame that can display the 32 or 16 bill sheets. A black mat surrounds the bills. The mat and adhesive are of archival quality—designed to last for many generations.

The imported metal frame has a burnished German silver finish and is held together by a locking mechanism that requires a



Mr. Gittelsohn showing his loot to reporters in his New York office.

special key to open. This insures the security of your collection. In fact, the frame is worth over \$100. Each frame is shipped in a large heavily-protected container with plenty of foam and is guaranteed to arrive safely. The one dollar bills are placed in a frame that measures 26" high x 28" wide while the \$2 bills are in a frame 14" wide x 27" high.

This is truly a limited edition. There are just so many sheets left, and obviously we can't go back to the presses and print more. Each bill has been numbered in a special sequence especially for this edition.

PROFIT-ORIENTED

Picture a beautiful frame filled with one or two dollar bills. It's a great gift for the very profit-oriented company, an interesting incentive for your top sales producer, or a great decoration for the chief financial officer's wall.

As a conversation piece, it's perfect. The sample on our wall has drawn a great deal of comment. And because it's so unusual and limited, it's the perfect gift for the person who indeed has everything.

The United States is probably the only country that has issued its currency in an uncut format. So a sheet also makes a great gift

for someone overseas such as a diplomat or a foreign businessman.

We also have a 4 \$2-bill frame that is available if you'd like a small frame for your wall and it measures 8½" wide x 15½" deep and is made of the same German silver finish.

Will this series appreciate in value? Will it become as rare as many of the rare coins or stamps of our time? Honestly, we don't know. But even if it never becomes rare and even if it never appreciates a single penny, if times ever get tough, all you need is a scissors.

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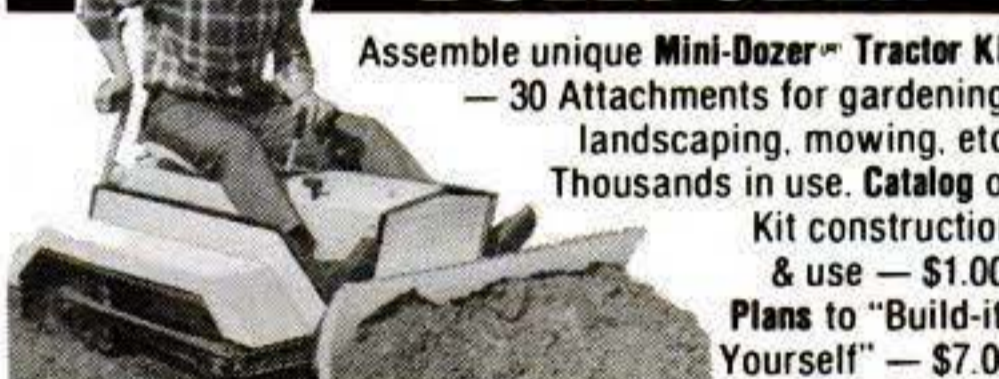


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Assemble unique Mini-Dozer™ Tractor Kit — 30 Attachments for gardening, landscaping, mowing, etc. Thousands in use. Catalog of Kit construction & use — \$1.00. Plans to "Build-it-Yourself" — \$7.00

STRUCK-KIT Dept. PS94D Cedarburg, WI 53012
 Name _____
 Address _____

FINALLY, YOUR SPRINKLER SYSTEM WILL KNOW ENOUGH TO TURN ITSELF OFF IN THE RAIN

SAVE WATER AND MONEY

Now, have your automatic sprinkler system turn itself off whenever it rains. Maintenance-free RAIN GUARD uses solid state logic to automatically prevent watering once it has detected a measurable rainfall. Then, after the storm passes and excess rainwater evaporates, RAIN GUARD will return your system to normal operation.

HOW IT WORKS

RAIN GUARD connects to any automatic sprinkler system (except for those few which are battery powered or hydraulically operated). When it rains, RAIN GUARD automatically prevents watering by electronically breaking off power to all your sprinkler valves — it does not shut off your control clock. Therefore, clock time settings and programs are not affected in any way. Also, RAIN GUARD is not damaged by heat, freezing or electrical disturbances in the atmosphere, nor is it affected by the accumulation of debris in its rain collector cup.

PROVEN BY PROFESSIONALS

Since 1975 RAIN GUARD has been used by professional landscape managers to conserve valuable water and to help guard against rain damage. Now, for the first time, this same professional protection can be yours at home — and at a price you can afford — only \$69.50 complete.

COMES COMPLETE AND INSTALLATION IS EASY

Your RAIN GUARD comes complete with its own installation kit and easy to follow instructions. There is nothing else to buy. RAIN GUARD can be remotely mounted anywhere that is exposed to receive rainfall and which is out of reach of sprinkler spray. Operating power is provided by the existing low voltage (24 to 30 volt A.C.) current your present control clock uses to operate the sprinkler valves. After mounting, a simple three wire connection to your control clock is all that is required (50 feet of compatible extension wire is provided). Installation usually takes only about thirty minutes and requires no special tools.



RAIN GUARD™

Solid State Rain Detection System (Pat. Pend.)

NO RISK UNCONDITIONAL ONE YEAR GUARANTEE

RAIN GUARD is a professional electronic rain detection instrument — not a mechanically actuated device. RAIN GUARD is unconditionally guaranteed for one year from the date of purchase — and if for any reason you are not satisfied — simply return the unit for an immediate free replacement or full refund.

NO EXTRA CHARGES

We pay shipping and handling anywhere in the continental U.S.A. Orders are shipped via United Parcel unless Parcel Post delivery is requested by you.

IMMEDIATE SERVICE

We make every effort to ship each order on the same day it is received.

HOW TO ORDER:

Please complete the order form below and mail with check or money order to WCS Inc., 141 S. Spring St., Claremont, CA 91711.

Please send _____ RAIN GUARDS at \$69.50 each.
 Enclosed please find \$ _____ CHECK MONEY ORDER
 Please ship via UNITED PARCEL U.S. PARCEL POST
 (California residents please add 6% sales tax (in Los Angeles County 6½%).

Name _____
 Street _____
 City _____ St. _____ Zip _____

WCS WATER CONSERVATION SYSTEMS, Inc.
 141 S. Spring St. Claremont, CA 91711 • (714) 621-5805

75 new portables

[Continued from page 80]

found I need nothing less than a Winchester hard-disk drive to use window programs such as MS-Windows, DesQ, and VisiOn. For example, I tried to run DesQ in a Compaq suitcase portable and found that the standard floppy-disk drives weren't enough. I needed the Compaq Plus, with its 10M Winchester hard disk. But do hard-disk drives and portables mix? Winchesters are extremely fragile and can be damaged by shock or mishandling.

"When we first came out with our hard-disk-based portable, people were skeptical," confesses Andy Kay, president of Kaypro, the leading maker of suitcase-size portable computers. "But now I can name about a dozen other companies that have followed our lead; the public and the industry realized hard-disk drives and portables can coexist."

Hard-disk drives can be just as durable as floppy-disk drives, I learned. Some models, such as those used in the Eagle Spirit XL, are rated for 40 G's, which is the same as for a conventional floppy drive. Further, the better-designed Winchesters use a metal coating rather than the standard oxide coating found in the majority of desk-bound hard-disk systems. Metal coatings resist damage caused by head "crashes."

According to Kay, portables with a built-in 10M hard-disk system are common today, but he predicts that hard-disk drives with capacities of 40M and beyond are just around the corner. "It's going to take a little longer than most people realize for 40M drives to become commonplace, but not because of any reliability problems. It'll be because the drive manufacturers can't keep up with the demand."

William Roland of Eagle Computer, another company manufacturing hard-disk-based portables, agrees: "I even see the wide acceptance of hard-disk drives for lap-held computers."

Lastly, I was surprised to find that the one technology that has prevented the maturity of portable computers is one that's decades old. "It all boils down to battery power," says Gavilan's Fernandez. "Portables aren't really portable unless they can run off their own power and be used without worrying about finding a wall plug." Unfortunately for the computer industry, battery technology hasn't advanced as fast as electronics.

"I have a feeling that batteries won't improve much," adds Fernandez, "so it's up to us to design better power circuits and lower-drain electronics. And that's exactly what we intend to do. When that happens, portable computers will never be the same. You just watch."

PS



Robot Helper

Here's a product that found its way into our hands in a very unusual way.

He threatened to turn in his Batman Credit Card.

What a pleasant surprise. With everybody selling robots, we discovered a device that could really help a robot. Or even us humans.

But before I explain the product, here's an actual letter I received from Mr. Theo Heller, the Vice President of a company trying to entice me into carrying their product. It started out quite innocently:

Dear Mr. Sugarman:

We both approve of wordy copy, so I do hope you will read this, (after all, I read and enjoy yours).

I have an item for your catalog and I will not tell you the name of it unless you write and ask me.

It is an upright vacuum cleaner, but wait, read on. It is totally different from any other vacuum anywhere. For example:

1. Until now, this machine has not been available to the general public, although it has been manufactured for 20 years. It has been sold almost entirely to commercial users.

2. Just about every other vacuum weighs between 18 and 32 pounds. This vacuum weighs only eight pounds, and it is more efficient than virtually any other vacuum made.

3. Even though it weighs just 8 pounds, thousands of the finest hotels throughout the United States use this vacuum every day. Why? Because it is so light in weight and because it is so extremely powerful. Its light weight is important to hotels. A maid is much more likely to take it off her rolling cart and use it than if it were a heavy, cumbersome vacuum. Hotels that use our vacuum have more clean rooms. A maid is not likely to wheel her cart blithely by a room and "forget" to vacuum it.

4. Quality? The finest hotels choose this vacuum. U.S. Embassies around the world have used it for years, and through several administrations. Republicans and Democrats both like it. So do hospitals, office buildings, airports, school districts, aircraft carriers, etc. It's light, it's strong and it's very dependable.

5. How can it be so light and yet so strong? A good question. I'm glad you asked: Well, just about every other vacuum fills its dustbag from the bottom. As the bag starts to fill, a large part of the motor's energy is needed to push the old dirt up the bag to make room

for the new dirt which it must force under it. It's about as efficient as filling a silo from the bottom. And as the bag gets more dirt in it, the efficiency of the vacuum diminishes proportionately. Sounds silly, doesn't it? It is. Our vacuum works entirely different. It propels the dirt up its handle and drops it into the top of the bag. Obviously our unit is equally as powerful and efficient when the bag is full as when it's empty. No energy from our motor is wasted pushing up old dirt.

Also, our bags hold much more. To do what we do, instead of a heavy, powerful ponderous motor, we use a specially built



I couldn't wait to open the box.

high-speed, lightweight motor. This results in more power and a much lighter weight vacuum. So, why push a heavy one when our light one works better? I should add that the quality of our motor is such that we give a five-year guarantee. This is at least five times as long as just about any other in the industry.

Of course our vacuum has all the other goodies: headlights; it drops very low to get under beds and sofas; all the edge brushes and bumpers that others have, and its appearance is outstanding; so outstanding that it would fit perfectly with the other state-of-the-art, top quality products that JS&A offers. Also, I would love to see the copy you'd write when you saw how remarkable the..... (whoops, I almost said it) vacuum really is.

Now, to find out more about this unit, you're going to have to write me, and so it won't cost too much, I am enclosing a stamp. Incidentally, Mr. Sugarman, I have long admired your great catalogs and your style. If anyone would respond to this letter (you are the only one I've written it to), you will. And if you don't, I'm turning in my Batman Credit Card.

Kindest regards, Theo Heller

Well. I took the bait and ordered one. When the box arrived I quickly opened it to discover the name of the manufacturer. Then I brought it home for the ultimate test.

I suppose you're expecting me to tell you that my wife loved it, that the house is cleaner and that this product is the next best thing to motherhood and apple pie. But I'm not.

Instead I'm going to insist that you fall for Theo Heller's pitch and try one out yourself. You go through the mental anguish and curiosity that I went through. You wait for the box to arrive and you decide if it's really worth everything Theo Heller thinks it's worth.

And you've got 45 days to decide. Then either you send it back for a full refund including your postage and handling or you don't send it back and keep it.

I'll also send you as an extra bonus a package of 11 bags with each unit. That should be a year's supply. Replacement bags are available directly from the manufacturer or from JS&A.

Robots are the hot new product this year. But with a little stretch of the imagination, we've come up with a novel accessory. Order one at no obligation, today.

To order, credit card holders ask for product number (shown in parentheses) or send a check plus \$4.00 for delivery.

Theo. Heller's Vacuum (0067P) \$269
11 Bags (0068P) 7

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THAT THINK

One JS&A Plaza

Northbrook, Illinois 60062

CALL TOLL FREE 800 228-5000

IL residents add 7% sales tax. ©JS&A Group, Inc., 1984

Design a prizewinning home electronic entertainment center

Good news for any reader planning to tackle some home improvement this winter: We're looking for projects to publish, and if yours is selected, it could win you far more than you invested in it. Your project needn't be elaborate to qualify for this competition—and you can win \$3,000 plus free ceiling panels. Just send us a snapshot with a brief description of what you did.

In cooperation with Owens-Corning Fiberglas, POPULAR SCIENCE seeks fresh

ideas for designing and installing a home center for electronic entertainment or work gear: home computers, VCRs, stereo, TV, and projection equipment—anything that generates sounds, from mere clicks to hi-fi blasts, sounds that need dampening or confining, or even enhancement.

That's where Owens-Corning's acoustical panels come in. Use them in any practical or imaginative way in your home improvement. If your project wins, you'll not only collect the prize

money, you'll be reimbursed the full price you paid for your O-C panels. Check out these panels at your home center or building-supply store. They're surface-coated Fiberglas, so they're lightweight and flexible—you can bow them to snap into tight spots, and they spring back flat. They come in various textured surface patterns, and some of them absorb up to 75 percent of the noise that strikes them. They vary in thickness from 5/8 inch to three inches (the latter boasts an insulat-

Continued

• **PRIZES:** A \$3,000 check plus reimbursement for the Owens-Corning Fiberglas acoustical panels used in the project will go to the grand prizewinner. There will be three secondary awards of \$500 each plus Owens-Corning product reimbursement for the next-best projects in the competition. And POPULAR SCIENCE will award two honorable-mention winners a library of home-improvement books from the PS Book Division. Your entry has six chances to win.

• **HOW TO QUALIFY:** For your project to be eligible, it must include Owens-Corning Fiberglas acoustical panels somewhere in its design. Your home electronic entertainment center can be a whole room, a corner of a room, or a single wall in which you have clustered such equipment as hi-fi, VCRs, and home computers. It can also include TV (standard or projection) or facilities to screen conventional movies and slides. Just what equipment you include

is up to you, as long as you have used acoustical panels in an innovative or practical way to control sound (to enhance sound quality, to confine sound to the general area, or to quiet such noise as a computer's printer).

• **HOW TO ENTER:** Fill out our entry coupon (or list all information the coupon calls for on a separate sheet of paper), and mail it with at least one clear photograph (black-and-white or color print preferred, but color slide is acceptable) plus a dimensioned floor plan or diagram of all elements of your project. A pencil sketch will suffice if it's thoroughly and accurately labeled with critical dimensions. Please don't submit scale models or plans sheets larger than 18 by 24 inches. Also include a list of all materials used and the sales receipt for the purchase of your acoustical panels. All this material must be mailed to the address shown in the coupon no later than February 1, 1985. Owens-Corning Fiberglas will arrange photography of the grand-prizewinning project for publication. All secondary-award projects will also be shown in POPULAR SCIENCE in photographs or sketches.

• **JUDGING** (by Bob Vila and PS Reader Activities Editor Al Lees) will be completed by February 15, 1985, with winners notified by that date. Prizewinning projects will be published in a subsequent issue of POPULAR SCIENCE. No entries can be otherwise acknowledged, and none will be returned unless accompanied by a written request and a self-addressed, stamped envelope.

Clip and attach coupon to your entry

Mail entry to:
Acoustics Contest
 Box 7812
 F.D.R. Station
 New York, N.Y. 10022

To qualify, entry must be
 postmarked on or before
 Feb. 1, 1985

YOUR NAME (print or type) _____

ADDRESS _____ Daytime Phone No. _____

CITY _____ STATE _____ ZIP _____

Description of project _____

Pattern name of Owens-Corning acoustical panel used _____

How much of this product did you purchase? _____

How much did you spend for it? (Please attach sales receipt) _____

Sign here (My signature certifies that this project is of my own design) _____



If you own a VHS video cassette recorder, here's some explosive news that may just save you lots of money.

Big Tape Deal

All ten tapes shown here are part of this unique video offer.

It's really amazing. If you own a video cassette recorder or VCR, chances are you have no idea what a vast difference there can be in video tape. So here are a few totally unnecessary facts before we get into some really exciting news.

VHS stands for Video Home System while Beta stands for the Greek letter beta. Beta is similar to the shape of the letter "B" or the way tape is transported through the recorder of the Beta system which Sony invented several years ago.

THE ADVANTAGES

Both VHS and Beta formats have advantages. The VHS cassette can play for up to six hours on the slow speed of practically all VHS recorders whereas the most you get out of the Beta system is 4½ hours on the longest playing cassette currently made. The Beta system has a better transport system than the VHS recorder, but most people prefer the advantage of the 6-hour recording time on the VHS system. VHS outsells Beta by a ratio of five to one.

Now you've almost become real experts on video tape. But if you'll learn two more fancy words and one term, you'll really sound like experts.

There are two problems with most video tape. One is called high "chroma noise." This happens when your picture has bright saturated colors that seem to bleed into each other, appear fuzzy or are simply not clear.

The second is called high "luminance noise" which relates also to the clarity of the picture or the presence of snow. This snow is really the absence of a signal often caused by uneven or badly-coated video tape.

DROP-OUT RATE

The last term to learn is called "drop-out rate" which is caused by the lack of magnetic oxide on the tape. Magnetic oxide is the substance that "holds" the signal, and often in the coating process, this one material will "drop out" of the mixture for an instant. On most recorders, you don't notice this because it appears for only an instant. But on a bad tape, it will appear in the form of black lines across your screen.

So there you have it. You're an expert. You now know more than 99% of those people who own VCR's or buy video cassettes. Now

get ready for the exciting news or what we simply call our "big pitch."

BIG PITCH

JS&A wanted to offer video tape in bulk to our customers. We saw the video tape market exploding and, quite frankly, saw an opportunity.

In selecting what we offer in this magazine, we like to become experts on the technology. This helps us select the best products available and we can often pass our expertise onto our customers.

When we investigated video cassettes, we found that European companies produced the best tape. In Europe, their TV system is different than ours. They have, for example, 625 lines of resolution on their screens versus 525 on the American TV sets. European VTR's also operate more slowly than American VTR's. This means that the video tape must be higher quality than American tape to be able to capture the higher resolution picture on a slower moving tape.

TAPE LENGTH LONGER

To get the best video cassette, therefore, meant getting one from Europe. But we discovered something else. Because the European VTR speeds are slower, their tape length is longer than ours. For example, on the popular VHS T-120 videocassette, the time of 120 minutes on the American videocassette turns out to be 129 minutes if the European videocassette was used on the American machines.

So here's what we did. We checked out all the major European brands of videocassettes and found that the best one was produced by Agfa, the German film manufacturer. We then arranged to import, in bulk, the best quality videotape they make in the same cassette they use in Germany and offer that cassette here under our name—all at a price at or below the best formulated tape you can get here in the US.

The tape has an extremely low chroma and luminance noise characteristic with the lowest drop-out rate of any of the European cassettes we tested. And Agfa's coating technology was derived from their extensive film-making experience, so their tape is made under film-making standards which are more exacting than those used for video tape.

But the nice part about our tape is that you get an extra nine minutes recording time on the normal two-hour cassette. This gives you that extra edge when recording something longer than standard broadcast time periods.

We are so convinced that the new JS&A brand video tape will compare noticeably better than your current brand that we are offering you an incentive to purchase our tape right now.

BULK PACKAGED

Our suggested list price for these tapes is \$14 each. We will offer them for only \$8.50 each if you buy a box of 10 for \$85.00.

We have kept the price this low because it does not come in a conventional sleeve, but rather it is bulk-packaged in boxes of 10 video cassettes. We also have handsome plastic cassette holders which come packaged in a set of 10 for only \$10.

Give the JS&A-brand cassette a test. When you receive your box of 10, take out one cassette and compare it to your current brand. If the JS&A tape is not noticeably better, then return your shipment for a full refund.

We only ask that you record on one tape when making your comparison as we can't accept more than one used tape if you are not absolutely satisfied.

JS&A has a real blockbuster video tape that really makes sense if you want the best tape in the world for a very reasonable price. And it's only time before it will really explode on the American scene. Order a test box at no obligation, today.

To order, credit card holders ask for product by number (shown in parentheses) or send a check plus \$4.00 for delivery.

10 VHS T-120 (5058P) **\$85**
10 Cassette Boxes (5062P) **10**

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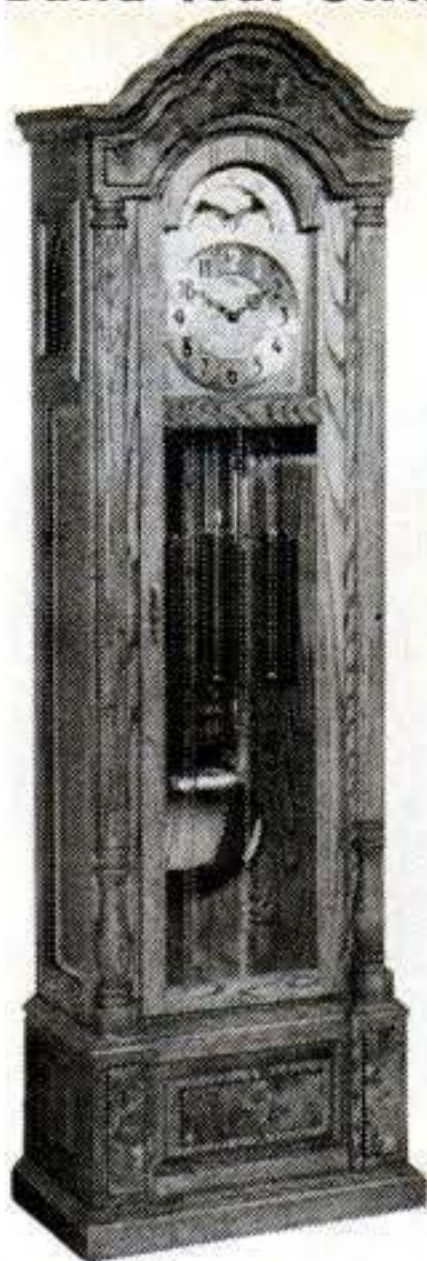
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Entertainment center



ing value of R-12, which might be an attractive bonus). Most of the panels come in two-by-four-foot sizes, but a couple of types are four feet wide and up to 16 feet in length. You can choose any of these panels and use them in any way you wish to achieve sound control in your electronic center.

Joining me in judging this competition will be the well-known professional remodeling expert (and host of the PBS series *This Old House*) Bob Vila. That's Bob in the photo above, demonstrating one method of installing the O-C panels—as a suspended ceiling to mask overhead eyesores, perhaps in an unfinished basement. But if your project doesn't call for this type of frame (made of wire-hung T-channels with L-shaped support angles nailed around the perimeter), use any other method of installation that serves your purpose. And don't feel that the panels can only be applied to ceilings; if you prefer to mount them on a vertical surface, feel free.

Original uses of the panels is only one thing that Vila and I will be looking for as we study your entries. We'll also hope to find clever construction ideas to house the electronic gear you choose to install on shelves or in cabinets. You may also want to provide built-in seating and storage.

Just what you include is up to you: Design the center for your own needs, and locate it in the most convenient spot in your home. Make it as large or as compact as its purpose and contents dictate. We've left the entry rules as flexible as we could to qualify as many readers as possible. Read the rules over carefully before you do your preliminary sketches and head for your lumberyard or home center. We'll be looking forward to seeing what you can accomplish in the next few months. Just remember that February 1, 1985, is the deadline.—Al Lees

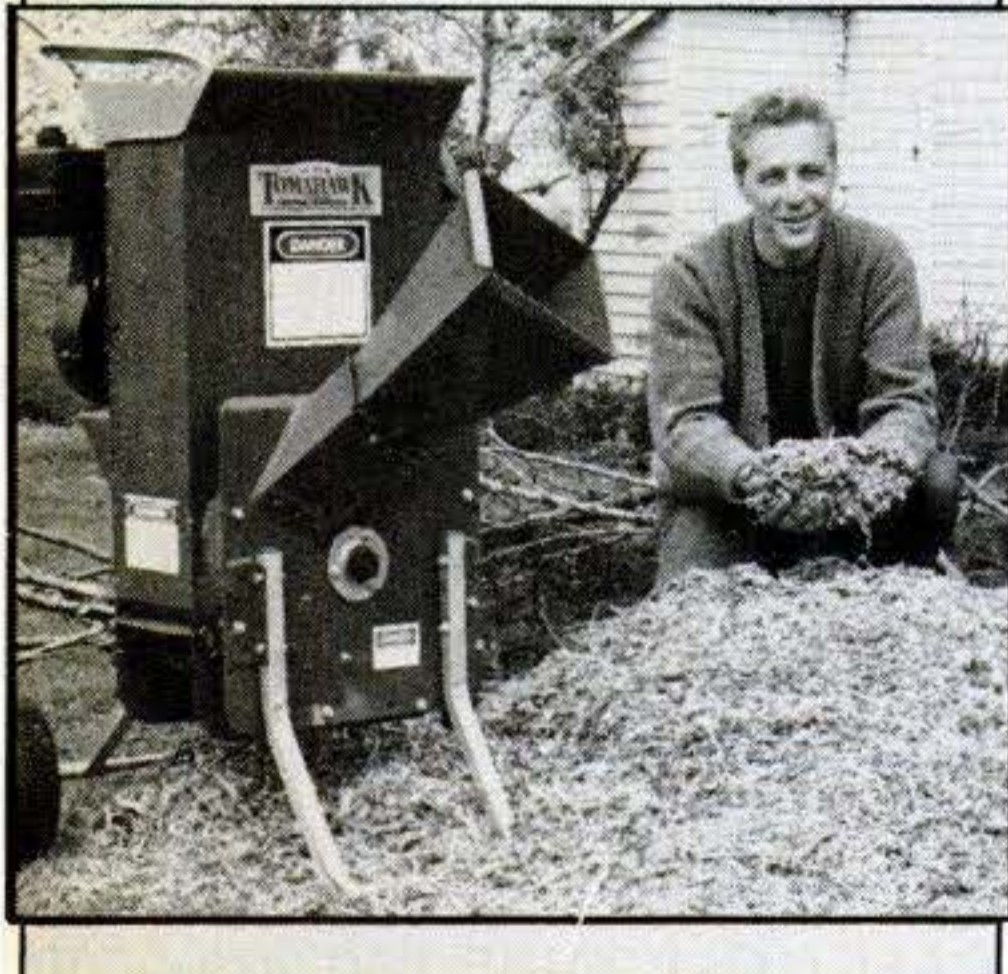
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102nd St. & 9th Ave., Troy, N.Y. 12180 3 13

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Name _____
Address _____
City _____
State _____ Zip _____



Free Ad Splash

Here's how to take advantage of a new advertising medium.

The message panel is flat and looks good on a desk or any sales counter.

It's amazing how people hate to wait. But here's how a few clever ideas can make a wait almost enjoyable.

At one building, people were complaining about the wait for the elevator until management installed mirrors on each floor. The complaints stopped.

At one company, the frequency of complaints from callers who were left on hold dropped after a music-on-hold device was installed in the company's phone system.

Elevator riders were entertained by looking at themselves in mirrors and callers didn't mind the wait when there was music. But there's a new waiting problem that concerns many offices and can't be solved by mirrors or music.

THE WAITING ROOM

JS&A has been using a clever device called the Imtech Message Panel. In our reception room is a small panel that flashes a message.

Let's say we expect an important supplier, client or customer to visit us. First, the person enters and has a seat. On the display the message says "Welcome, Mr. Smith." But then the message starts to scroll to the left, "Welcome to the offices of JS&A—America's leading electronics marketing organization!"

ONE PAGE OF SELL

We can store up to 1650 characters or almost one page of fascinating information designed to sell our products or our company, create an image or just plain entertain.

But what about other uses? A progressive dentist can inform patients of the latest dental news. A doctor can advertise his services or a barber can sell hair grooming supplies. Not only will it entertain the person waiting, but it will be a unique source of free advertising.

Did we say free? We shouldn't have. Obviously the device costs something to purchase but the payback is quick, the benefits

obvious and you own the ad medium.

Small retailers love the unit. Major department stores use them now on countertops and as part of displays. With the new wave of complicated products, these displays can often sell just like a trained sales clerk.



The standard typewriter-style keyboard below the display lets you enter your messages and special effects quickly.

The unit can be programmed with nine separate messages that can be recalled at various times. This is perfect for restaurants or stores with daily or hourly specials.

The messages can also be displayed in a pre-programmed sequence. For example, set it to go on in the morning with one message, automatically switch to another at lunch—up to nine times with nine different messages. In addition, it shuts itself off at night and turns itself on again in the morning. This is perfect for a storefront window or for any application where automatic message changing is more convenient.

You can program the unit quite easily through a built-in keyboard just below the display which is covered by a removable Plexiglass® panel.

The Imtech Message Panel also has a built-in 5-year lithium rechargeable back-up battery that will hold the current messages in

memory for up to three months after you unplug the unit from an AC outlet. This means that you can move the unit to a new location or use it as part of a traveling sales presentation without having to re-enter your message.

40-YEAR LIFE

The size of the Message Panel is only 7¾ x 10 x 1½" thick. Its bright fluorescent display has an average continuous-use life of nearly 40 years. It will display both capital and lower case characters and a full range of special effects. The unit weighs less than 3 pounds and folds flat—perfect for travel.

We urge you to test the effect of the device in your own business. Order one from JS&A. When you receive it, enter a sales message and a greeting for your next guest. Use it to entertain, inform or educate. If you own a small retail store, see how your customers are captivated by the display and how they stand there reading the entire message.

If for any reason you are not convinced of the value or the benefits of the Message Panel, return the unit within 45 days for a prompt and courteous refund.

There are other systems that have moving messages but none are as easy to carry, set up, or program and as inexpensive. Sparkle up your waiting room or sales presentation and turn a long wait into a great opportunity. Order an Imtech Message Panel, today.

To order, credit card holders ask for product number 4033P or send a check for **\$395** plus \$4.00 for delivery.

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Shipping weight 16#.



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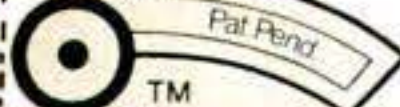
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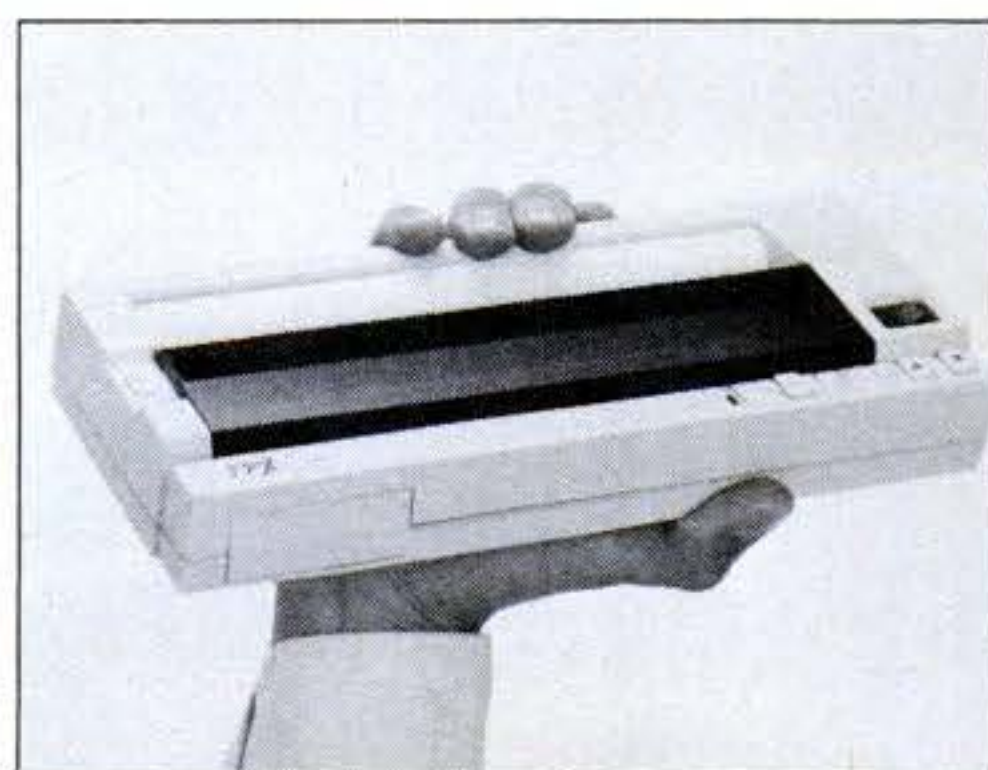
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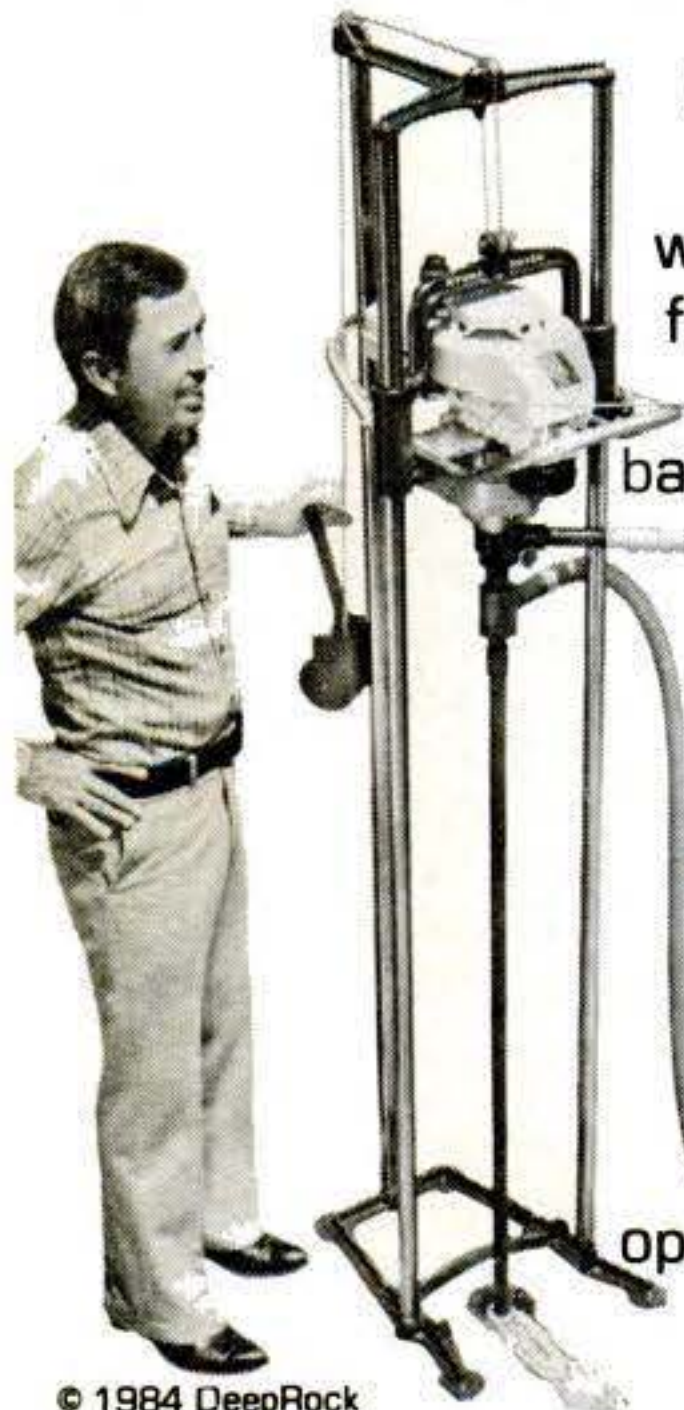
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Bits & Bytes

By JOHN FREE



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Shhh... new printers

New personal-computer printers usually appear with a noisy clatter. But with updated printer technology, that's changed. Observed—but barely heard—at recent electronics trade shows in Chicago and Atlanta were:

- A low-cost seven-color printer, the Okimate 10 (top left) from Okidata (532 Fellowship Rd., Mount Laurel, N.J. 08054) comes with interface modules for Commodore and Atari home computers. A tutorial program is included plus "screen-dump" software that copies a color CRT image. The seven-pound \$239 Okimate 10 uses thermal-transfer dot-matrix printing: Wax-based ribbon ink transfers to any paper or clear plastic (for projection) when heated by the print head. More than 40 colors can be created by mixing primary colors.

- A go-anywhere 80-to-160-column printer, the TTXpress (top right) from TTX Inc. (3420 E. 3rd Ave., Foster City, Calif. 94404) is designed to operate with portable computers. The \$229 thermal printer weighs only 2.2 pounds

and works with four C cells or an AC adapter. This model requires ordinary sheet or roll thermal paper. Print speed is 40 to 50 cps.

- A laser-based printer, the LaserJet from Hewlett-Packard (1820 Embarcadero Rd., Palo Alto, Calif. 94303) is in a different price (\$3,495) and performance class. The LaserJet (above photo, right) delivers letter-quality output (300-by-300-dots-per-inch resolution) and phenomenal printing speed. I stood next to a LaserJet at the Atlanta Comdex show and watched it quietly churn out eight pages a minute. H-P's new model is among the first to use Canon's "printer engine," based on its popular disposable-cartridge copier machines ["Bits & Bytes," June]. LaserJet works with any computer and handles graphics with the touch-screen H-P 150 (left in photo) or the IBM PC and compatibles.

Integrated computer

A variation of Commodore's top-selling model 64 home computer features

Continued



New Fresh Air Bubble™

Surround your body or your work place with ion-controlled fresh air in America's finest bipolar electrostatic home precipitator.

The new Fresh Air Bubble measures 3 1/4" in diameter and approximately 8 1/2" high and its wood grain styling will fit into most decor.

There's a real danger. And this invisible menace will affect nearly everybody reading this ad.

The danger is pollution—but not the ordinary kind. In fact, ten years ago, we didn't have this new kind of pollution.

Ten years ago, cars didn't have catalytic converters. Today, these devices "grind up" the car exhaust into particles so small they form micron soot, and micron soot is so fine, it can be easily absorbed into your lungs. Even the EPA has stated, "Because it is so fine, such soot particles stay longer and cause more damage in the respiratory tract."

Ten years ago, homes were able to "breathe" or exchange air between the outdoors and indoors four or five times a day. Today our well-insulated energy-conscious buildings and homes create and trap pollution that we breathe unwittingly.

OTHER PROBLEMS

There are other problems too. Add the daily soot, dust, smoke and other impurities in the air and you've created pollution problems even worse than they were ten years ago—so bad that environmental groups are especially concerned over this new "time bomb" lurking in our environment.

But American ingenuity hasn't been sitting still. A rash of small devices containing charcoal filters with fans and selling for around \$30 have flooded the market. But these devices only remove particles 5 microns or larger. Today's micron soot is one micron or smaller. Cigarette smoke for example is 2 to 3 microns or smaller.

70,000 UNITS SOLD

In 1978, JS&A introduced the negative ion generator in a national advertising campaign and sold over 70,000 units. It was a device that cleaned the air by electrostatically removing particles even smaller than one micron. Hospital burn centers soon began using commercial versions of the negative ion generator.

Removing sub micron particles from the air was very important, but there was also a sur-

prising second benefit. The unit added negatively charged ions to the air.

We've all felt the effects of negative ions after a thunderstorm. When you take a deep breath, the air smells good and you feel good.

The opposite is true of positive ions which can be found in polluted environments, air conditioned office buildings and in automobiles. Many scientists believe that positive ions make you feel moody, depressed, irritable and restless. A negative ion generator cancels out the positive ions and fills the air with negative ions.

AN EXPERIMENT

When you blow smoke into an inverted glass bowl and put it over an ion generator, the smoke immediately vanishes. Or if you place the ion generator in an odor-filled room, the room soon smells fresh.

It was these experiments that really convinced the public that the JS&A ion generator was a valuable new home appliance. Soon the market was flooded with competitive units. Many were not as efficient as JS&A's first model. Some emitted very few ions and one actually emitted dangerous levels of ozone. JS&A conducted independent laboratory tests which showed that JS&A's unit was indeed the best.

DON'T BE FOOLED

Even today, ion generators are being sold that supposedly produce tremendous amounts of negative ions. But there's a problem. These units create electrostatic discharges which can be uncomfortable when touching a doorknob or someone else. And they often deposit the micron soot on walls and rugs too.

JS&A had American scientists create an ion generator with a bipolar emitter which emits a balanced amount of negative ions to create a controlled ion environment. One emitter produces negative ions and the other controls and shapes the ions to create an ion bubble.

The end result is a unit which leaves just the right amount of negative ions in a large

room, attracts the pollution particles and deposits them on a beautiful wooden collector while keeping your floors and walls free of dirt. You're actually placed in a fresh air bubble while you work, sleep or relax and with no uncomfortable electrostatic charge. It's the best unit and we'll prove it.

We'll enclose a white paper filter which you can place over the wooden collector. If the white paper is not blackened with micron soot after only ten days, please send your unit back for a full refund and we'll also refund your \$3 postage and handling. And you can make that test anytime within 45 days after you receive your unit.

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We urge you to try the Fresh Air Bubble in your home or office. Put one on your desk or in any smoke-filled room. Notice the refreshing difference in your work environment. Take it home and plug it in next to your bed. Chances are, you'll want to buy another one before our 45-day trial period ends.

When you order the unit, we'll send you the Fresh Air Bubble complete with instructions and a one year limited warranty. Then plug it in and leave it run all day and night. It costs only a few cents per day.

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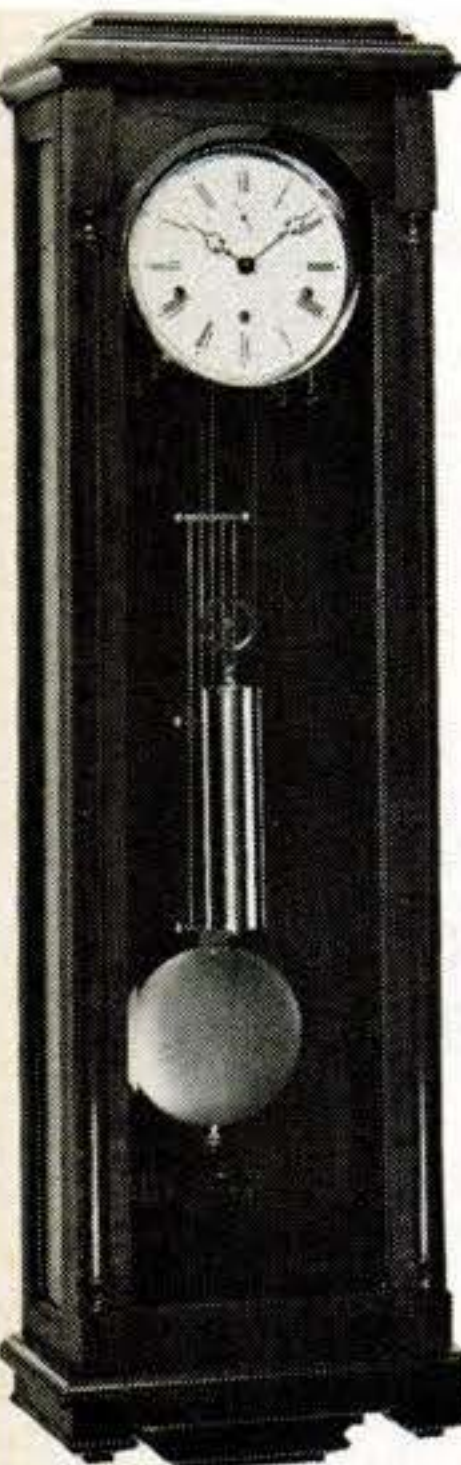
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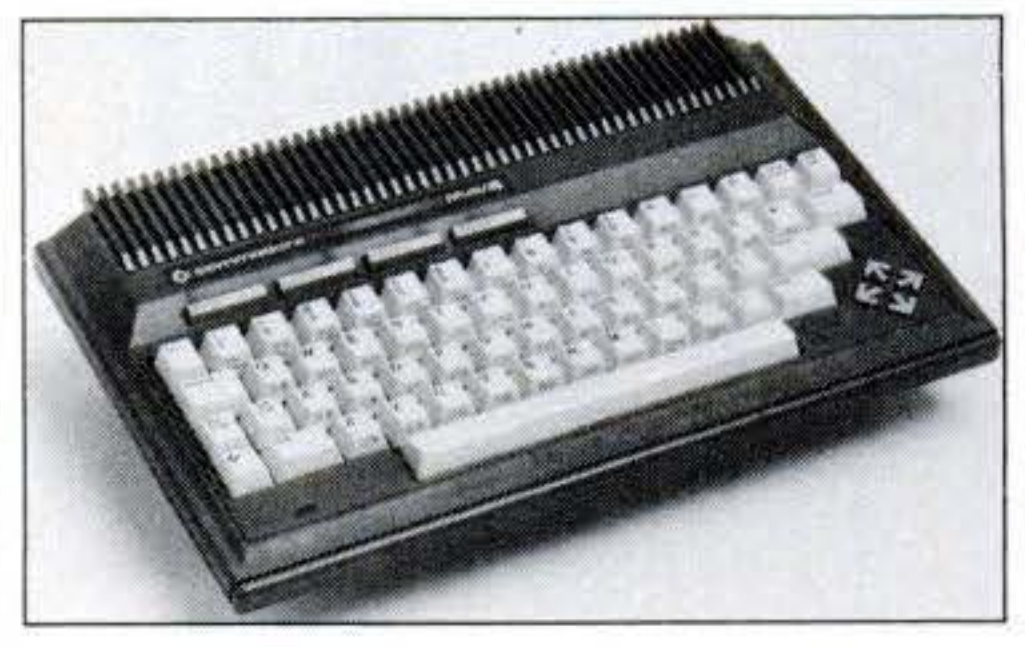
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Bits & Bytes

built-in programs. The Plus 4 (below) has permanent-memory chips that store word-processing, file-management, spread-sheet, and graphics programs. An enhanced BASIC is also built in. The less-than-\$300 Plus 4 has 60K of RAM available compared with 39K in the less-than-\$200 model 64. Described as a home and small-business "productivity tool," the Plus 4 was introduced this summer along



with new Commodore printers and other peripherals. Integrated software ["Do-Everything Software," PS, Jan.] was first developed for the IBM PC and its imitators with 16-bit microprocessors. Many of these disk-based programs require more memory than eight-bit computers such as the Plus 4 can address. The 16-bit-oriented software provides more-powerful and more-flexible programs than the budget-model Plus 4.

Shrinking drives

Microdisks such as Sony's 3.5-inch shirt-pocket-size design ["War of the Microdisks," PS, Dec. '83] are going into more and more microcomputers. Flexible disks are sealed in rigid plastic for protection, and a metal hub accurately centers disks to permit higher track densities. Last year a Sony official told me that 3.5-inch microdisk drives were already miniaturized—not candidates for further shrinkage such as the half-height 5¼-inch floppy-disk drives going into most personal computers these days. (Two half-height 5¼-inch drives can occupy the same space as one ordinary 5¼-inch drive.)

But as you might have guessed, there's no end to miniaturization. I spotted new half-height 3.5-inch drives at the Atlanta computer show. Made by Citizen Watch (2501 Colorado Ave., Santa Monica, Calif. 90404) for computer manufacturers, these floppy-microdisk drives, in both front-loading and flip-up top-loading configurations, are just one inch high and 3.9 inches wide.

Meanwhile, as smaller, more-sophisticated personal computers with larger memories are introduced for business-

Continued

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Run Fun

It's called a precision runner but the Precor power assist treadmill will amaze you with its computer electronics.

By: Joseph Sugarman, President
JS&A Group, Inc.

People often ask me, "Since JS&A sells all of these neat electronic products, which ones are your favorites?" The product above ranks as one of my all-time favorites—one that I personally use every day.

I used to run outside—a few miles a day. There were times when I've fallen, hurt a knee and braved all kinds of weather, dogs and cars. But what I didn't realize was that as much as I enjoyed jogging, I was really doing damage to my knees, ankles and hips. Then I got a sample of the Precision Runner made by Precor.

On the Precision Runner I noticed that my knees never bothered me, and the running surface cushioned my stride so I actually did not experience some of the stress from running on cement or on uneven terrain. And then there was the convenience.

PRETTY ROUGH WEATHER

Here in Northbrook, Illinois (just outside of Chicago), we have some pretty rough weather. Obviously, running indoors sure beats snow, wind, rain, bitter cold or those record summer heat waves. But I found myself preferring to run on my Runner even in perfect weather, and I've all but given up running outdoors. Here's why.

Aside from feeling safer without a single sore knee or ankle and aside from having the convenience of running indoors, I finally have precision control over my speed, how far I've run and the time that I run. I set the speed for 6 mph and comfortably run for 20 minutes. I run exactly two miles every day, produce a good sweat and comfortably stay in my target zone (the heart rate that provides the maximum benefit to your circulatory and respiratory systems).

I also watch the morning news on TV so I'm entertained, informed and often educated while I'm exercising.

POWERFUL MOTOR

The Runner incorporates a powerful motor and a heavy flywheel that rotates at a high speed. A photo optic cell looks at every revolution of the flywheel and breaks the revolution into 80 separate segments or approximately 100 each second.

Each time you step on the treadmill belt, the entire system senses that step through its photo optic sensor and transfers that information to the unit's microprocessor which then adds just the right amount of power to the motor. And it happens so quickly that you don't perceive anything. This system will ride just as smoothly for an eight-year old as it will for a 300-pound football player. And its speed and distance readings are as accurate as a stopwatch.

The plate underneath the running surface stays cool. It was developed especially for Precor by the aerospace industry and its

composition is so confidential that for competitive reasons, Precor doesn't want it publicized. Even the special running belt is imported from Switzerland.

With all its electronics and moving parts you'd expect service to be a problem. Once again here's where Precor really shines. Their first production model produced over one year ago is still running in an exercise salon where it has been used almost daily for a total of over 2,700 miles without a service problem. They are designed to be service-free. But it's their quality control system that really deserves mention.

ACTUAL FEET

Precor realized that it would be difficult to inspect or test a Precision Runner with simple machines like they could use on a bicycle. A treadmill required human interaction—actual feet hitting the surface. So after each unit is completed, tested and certified perfect, somebody from top management runs two miles on the unit as their final quality control procedure.

And there is no compromise. The Precor Runners have to be perfect before they leave the factory. This makes for very satisfied customers and the healthiest top management team in America.

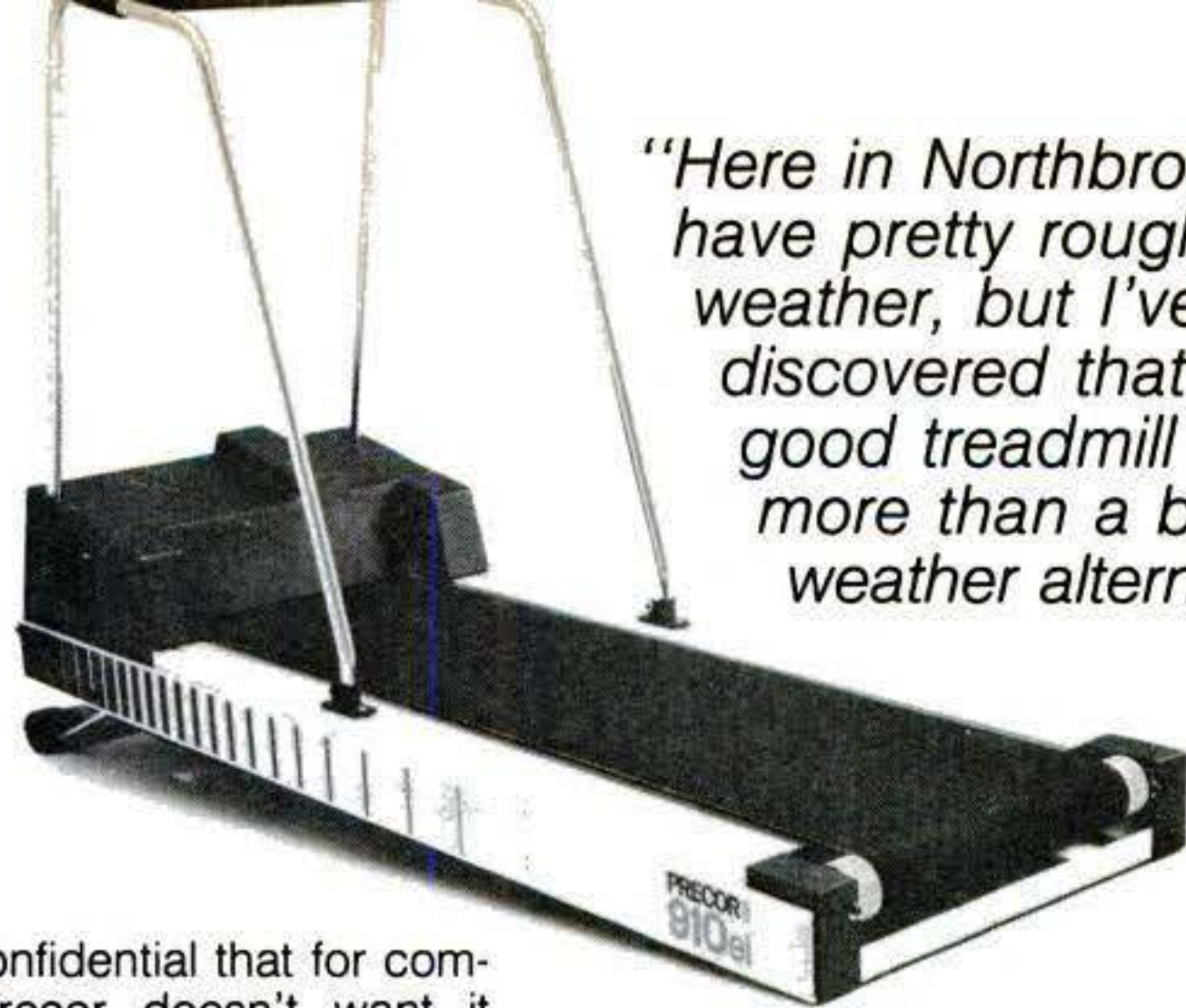
The Precor Precision Runners are built of anodized aircraft aluminum with a running surface that allows a slight give to cushion each stride. It feels like a latex track used by professional athletes.

The speed can be adjusted from one to eight miles per hour and an optional mechanism lets you tilt the track up to 15 degrees on one of the models to simulate a hill. This is a great feature for people who like to walk yet want a real workout. Walking uphill gets your heart pumping and your lungs working and your body perspiring just as if you're jogging at eight miles per hour. A combination of jogging and a track tilt can give even the best athlete a real challenge.

RUN LONGER

I have found that I can run longer on the Precision Runner than I do outside. With the Precor, there's none of the spikings, jarring, or pounding my body experiences from cement sidewalks. There are no wind resistance and temperature extremes. I'm actually encouraged to use the Runner because first, I feel great after I use it, but also because of its accuracy. I know exactly how far I've run and at exactly what speed. The only thing that has varied in the year I've used it is my pulse rate and weight. I've watched both drop.

The display on all Runners shows either the elapsed time, speed in miles per hour or the actual distance run. You can automatically cycle between all three readings or hold one of the three on the display.



"Here in Northbrook we have pretty rough weather, but I've discovered that a good treadmill is more than a bad weather alternative."

The Precor model has a running surface of 17 x 54" and takes up a floor space of 26 x 72." There are actually two versions of the Precor—one with elevation, the other without. The unit with elevation weighs 155 pounds while the one without weighs 145 pounds.

The Precor travels at a top speed of 8 mph. Which one to choose? Both models are made by Precor so you get the same quality and advanced electronics. I preferred the Precor 910ei with elevation as did most of our staff who tested it and practically all our customers.

Elevation gives you many more advantages over a flat surface. On the 910ei, you can swivel in as much elevation as you want with just a slight touch of the power-assist elevation system. It's so easy that my ten-year old daughter can do it. The angle is displayed on an easy-to-read scale.

Whichever model you choose, we'll pay all the freight charges to your location. (There's a surcharge to Alaska and Hawaii.) You'll have 45 days to test one and decide.

LONG ENOUGH

45 days is a long time for you to use it every day and notice the improvement in your physical condition. It's a long enough time for you to test the unit's quality, and to see how it holds up against the pounding you're going to give it. And finally, if you normally jog outdoors, it will demonstrate the advantages of jogging on a better, more secure surface without any of the disadvantages of jogging outdoors. Then, at the end of the 45 days, make your decision.

If you're not absolutely pleased with your unit, return it within a few days for a prompt refund. We pay the freight to your place and you pay the freight back to ours.

I can't express enough enthusiasm for the Precor Runners without sounding like a Madison Avenue pitchman. I just plain like the system. It has changed my life and given me full value in just the first year I've used one. I'm encouraged to use it every day, I feel healthier and I keep my weight in check. I urge you to try one, too.

To order, credit card holders call and ask for product by number (shown in parentheses) or send a check to address below.

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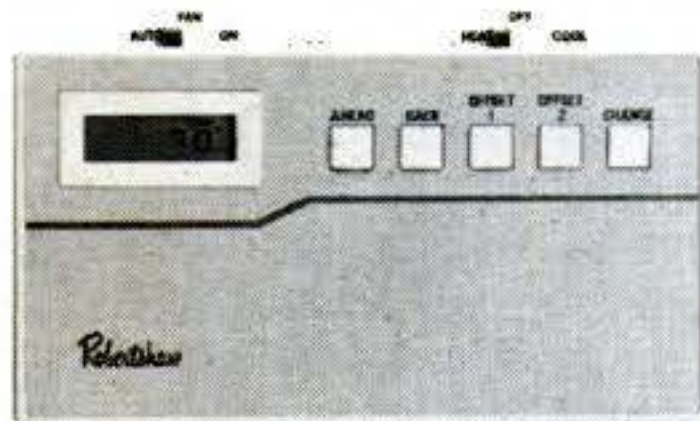
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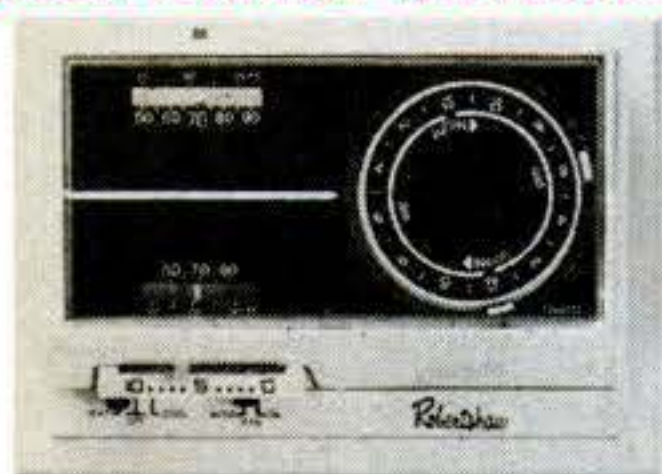
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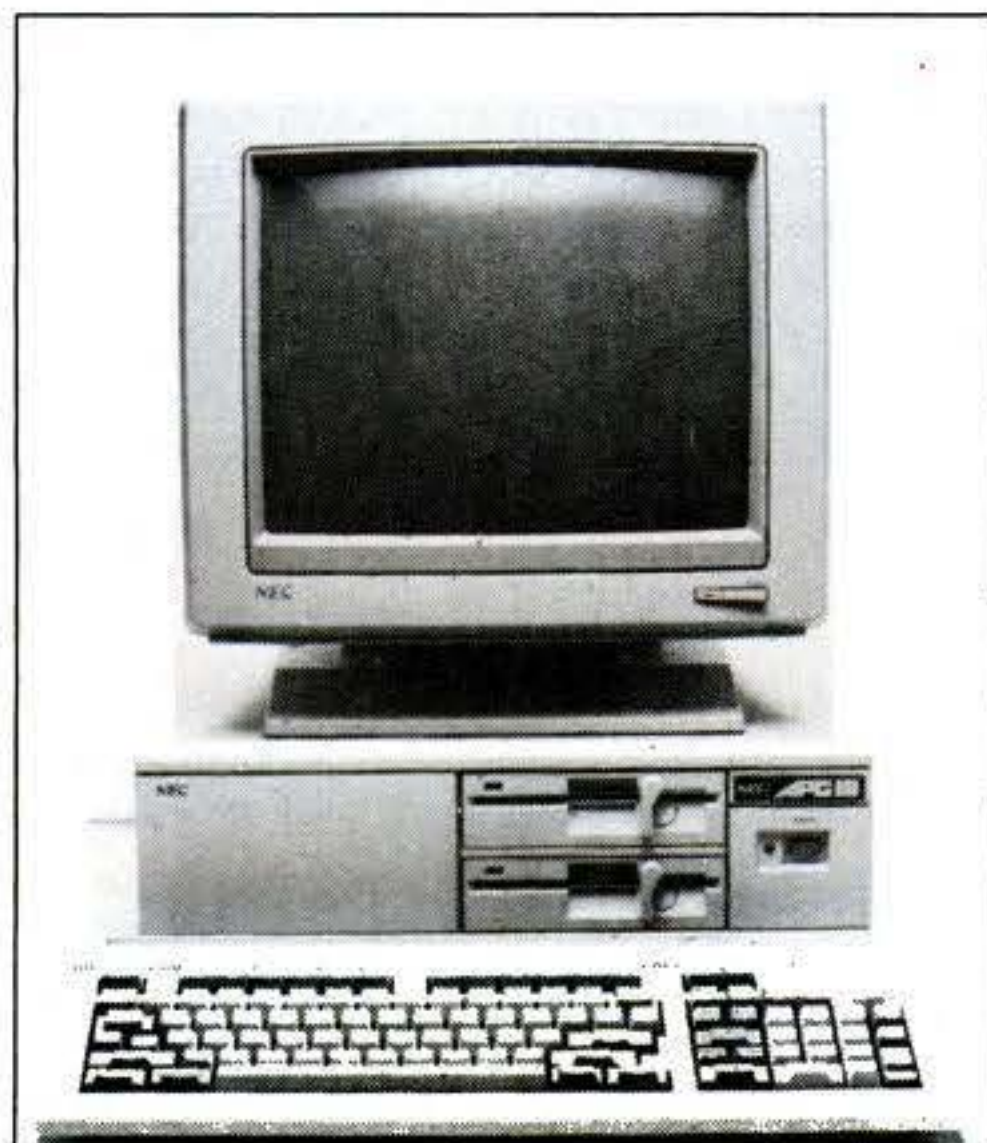
*Based on \$1,000 in heating bills. ASHRAE Journal Study shows savings up to 30% with a 10° setback for two 8-hour periods.

Bits & Bytes

es, Winchester-type hard-disk systems are also shrinking. Half-height 5¼-inch Winchester drives with super-fast access to 10M or more are now made by several firms. In addition, 3.5-inch hard-disk systems plus other sub-5¼-inch sizes are appearing.

APC versus PC

A 16-bit personal computer from NEC (1414 Massachusetts Ave., Boxborough, Mass. 01719) priced under \$2,000 is partially compatible with the more-expensive IBM PC. NEC rolled out its



new APC III (above) at about the same time that IBM slashed prices on its best-selling PC models. The basic APC III has a 14-inch monitor, one 5¼-inch disk drive, and 128K of RAM. NEC also claims superior optional graphics, and upgraded models can use the UNIX operating system as well as MS-DOS.

IBM trimmed its basic PC-model price about 23 percent, down to \$2,520. But IBM also boosted the memory in its standard models to 256K—adequate for the newest integrated-soft-



ware packages such as Ashton-Tate's Framework ["Bits & Bytes," Aug.].

Graphic scanner

Need to blend images with words and display or print them with a personal computer? A package for IBM's hard-disk PC contains a graphic scanner (bottom photo, preceding col.) plus a plug-in board and software to create documents with both pictures and words. The scanner systems, from Datacopy Corp. (1215 Terra Bella Ave., Mountain View, Calif. 94043), cost in the \$9,000-to-\$10,000 range and work with several popular word-processing and data-base programs. The scanner converts pictures—or actual objects—into digital signals for video display or printout. Wang recently introduced a similar system for one of its personal computers.

Look, no keys

In one booth at the Comdex show I spotted someone behind an IBM PC who was busily entering numbers with Lotus 1-2-3 data-management software. But here's a new twist: No key-



board was present. Instead, numbers were being "written" into the PC on a Penpad, a special graphics tablet from Pencept, Inc. (39 Green St., Waltham, Mass. 02154).

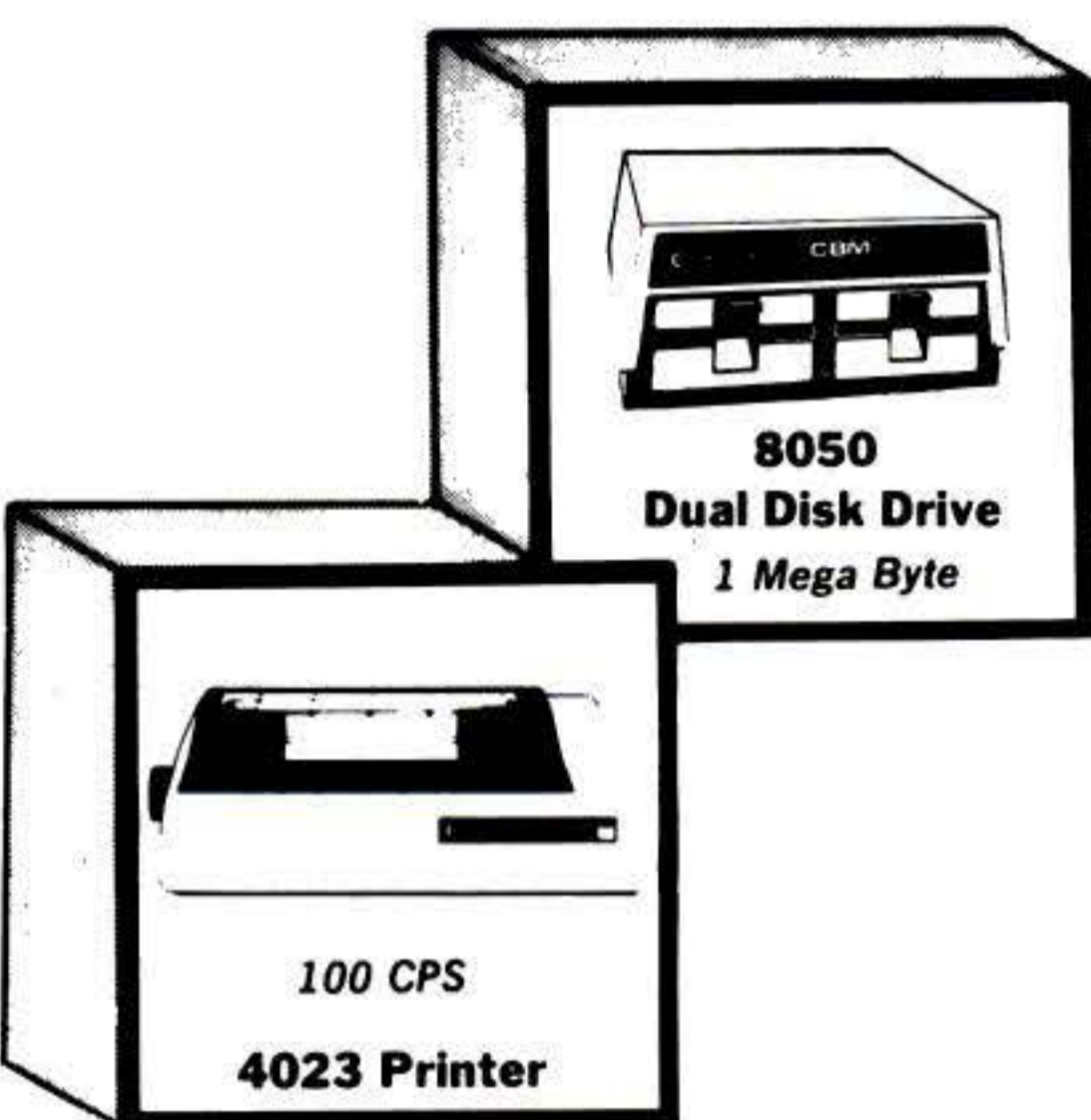
The \$995 Penpad 320 (above) combines the functions of a mouse, keyboard, and graphics tablet. Programs on a plug-in PC card enable Penpad to "recognize" hand printing from its electronic pen and to translate the printing into ordinary alphanumeric characters on the screen. This, plus fast cursor movements with the pen, speed things up: Instead of 15 keyboard entries to change a value in a 1-2-3 spreadsheet, only three steps are necessary with Penpad. Similarly, Penpad graphs a spreadsheet in 15 steps versus 48 with a keyboard. Software for the tablet helps you create custom business forms for simplified data entry, graphics for slide presentations, and other functions.

PS

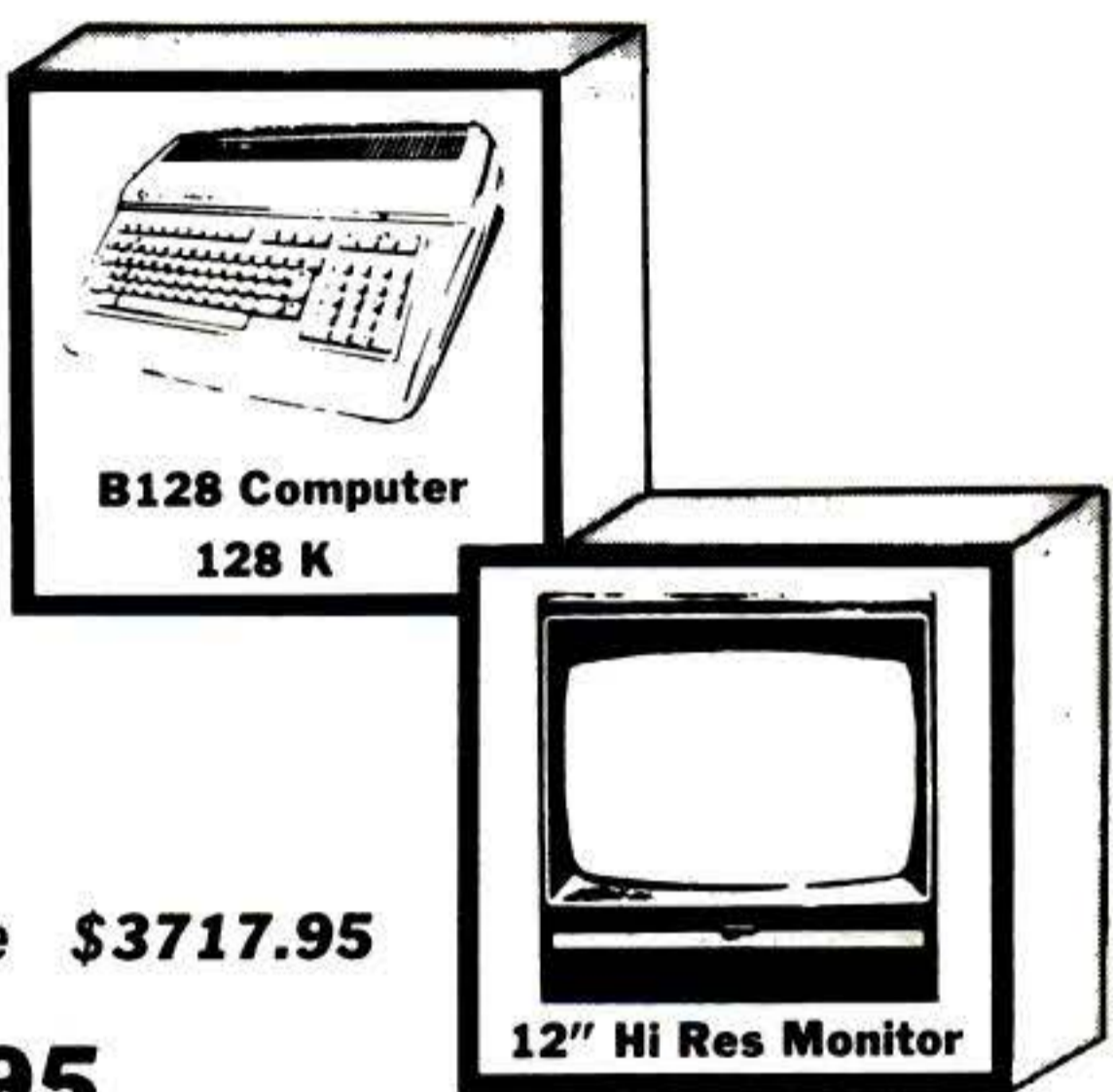
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Computer Adventures

Readers share their offbeat experiences in home computing

By WARREN L. KAFITZ

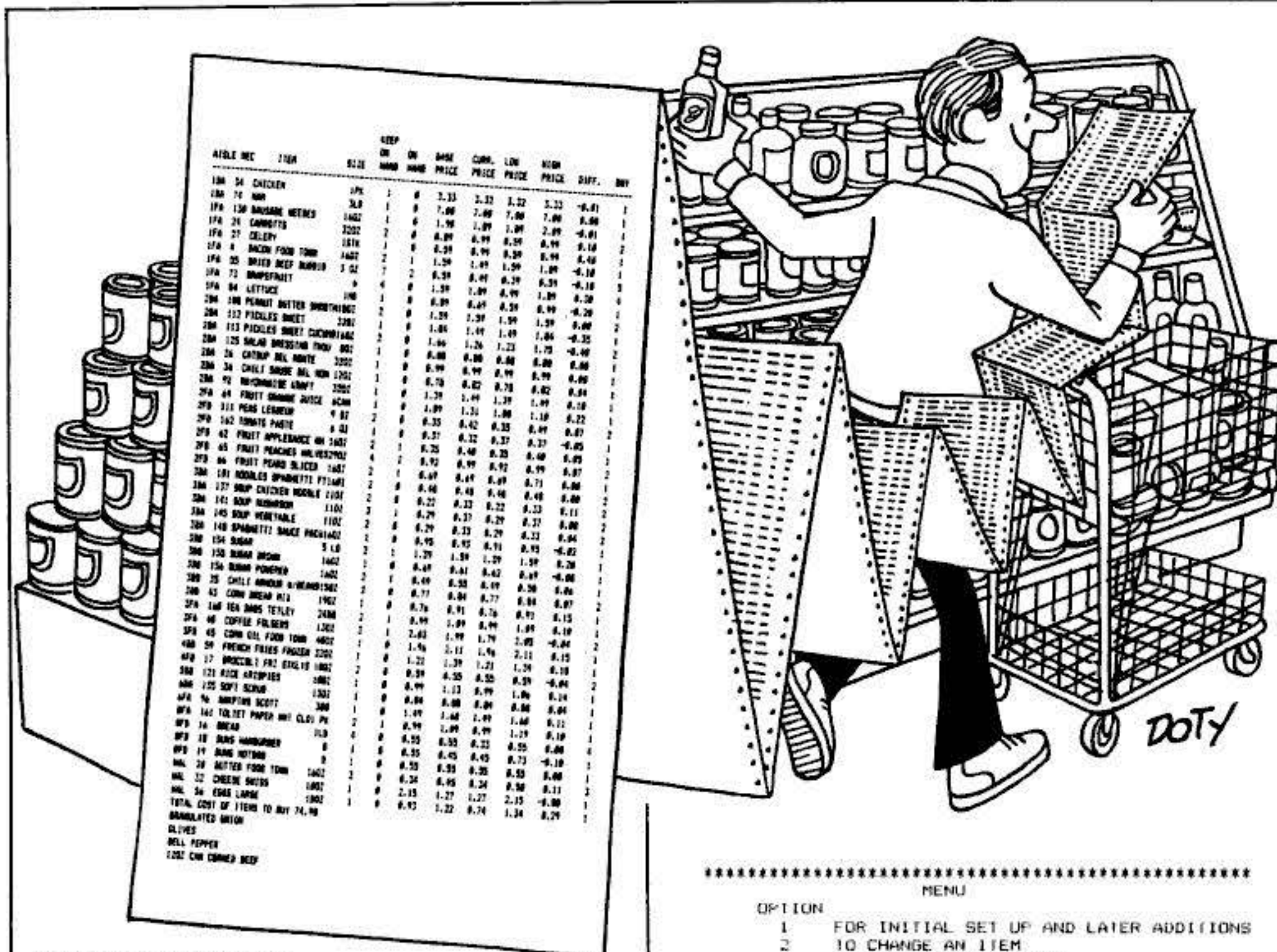


ILLUSTRATION BY ROY DOTY

BASIC shopping

When it comes to grocery shopping I'm known as the "pusher" in my family. No, that doesn't mean I push for junk food or rush the family to the car to get it done. It means that while my wife picks items from the store shelves, I push the cart.

I push it up the aisle for this, down the aisle for that, up the aisle again for something she forgot, and maybe back down once more for another item she can't find. Over here for a sale, over there for a special, three times around the same corner, twice to the bakery section—and all while a voice on the P.A. system welcomes shoppers to "the store with the biggest selection in town." My legs are not thrilled.

I knew there must be a better, more logical way to buy groceries. The answer? You guessed it: a computer program for my Radio Shack TRS-80 Model III to help organize our shopping. We've been using the program for nearly 18 months, and it not only saves shopping time but helps save money as well.

Armed with a list of groceries to buy, I do the chore in one pass; no more backtracking. Our shopping time has been cut in half, and because the com-

```

*****
MENU
*****
OPTION
1 FOR INITIAL SET UP AND LATER ADDITIONS
2 TO CHANGE AN ITEM
3 LIST ALL ITEMS ON CRT
4 LIST ALL ITEMS ON PRINTER
5 LIST ITEMS TO BUY ON CRT
6 LIST ITEMS TO BUY ON PRINTER
7 TO ADD EXTRA ITEMS TO BUY
8 TO CHANGE SEVERAL ITEMS (ON HAND ONLY)
9 ON HAND = 1 KEEP ON HAND
A END PROGRAM
*****
ENTER OPTION
    
```

puter also keeps track of the prices, we're able to watch for bargains.

The program, written in BASIC, is simply a data-entry-and-retrieval system. It can be designed in a variety of ways depending on the information you'd like included. But be sure it includes everything: My final program uses menus to enter data and lists every grocery item by aisle, size, number to keep on hand (desired inventory), number on hand (actual inventory), base price, current price, lowest price, highest price, and the difference (base price minus current price). The data are stored using random data files.

To start the program you must first make a list of all the items you normally purchase at the grocery store. This is the hard part, but bite the bullet—or a saltine—and empty the pantry. As you return everything to the shelves, enter the list into the computer.

The price and location (aisle) of each item are recorded on your first trip to the store. Mark them on your new grocery list and enter the infor-

mation into the computer later. The first price you enter will become the base, current, lowest, and highest price. From these the computer will automatically calculate any future price changes in the lowest, highest, and difference categories.

Once done, hang the master grocery list in a convenient place in the kitchen or pantry, and check off items as you use them. The night before going to the store, the items checked are entered into the computer and a list of "what to buy" is printed. The printed list is automatically sorted by aisle number and contains all the information on each item plus the quantity and total cost based on the current price.

After returning from the store, any price changes or new additions must be entered. This is made quick and easy by the use of the random data files. Only the record number for each used item and the quantity on hand need be entered to update the list. The program will adjust the low- and high-price categories and make the on-hand category equal the keep-on-hand. A new alphabetical master list is printed for use next week.

A lot of work? Not really. After a few times the list becomes very much routine—about as routine as pushing a shopping cart. And besides the time you'll save at the store, there is always money: Our master grocery list contains 169 different items, and the total price—carefully computer-controlled—has increased just 8.6 percent since May 1982. PS

Out of the mouths...

As a computer scientist, I often give talks to local schools. During a demonstration for my daughter's first-grade class I continued to emphasize that "computers can only do what you teach them to do," to stress the importance of programming.

A few weeks later I brought home a personal computer. As my daughter watched me work she said, "Daddy, computers can only do what you teach them to do."

Enthusiastically, I told her she was right. And as I swelled up with great pride in her intelligence—and my teaching ability—she added, "But at night they can do whatever they want."—David Conner

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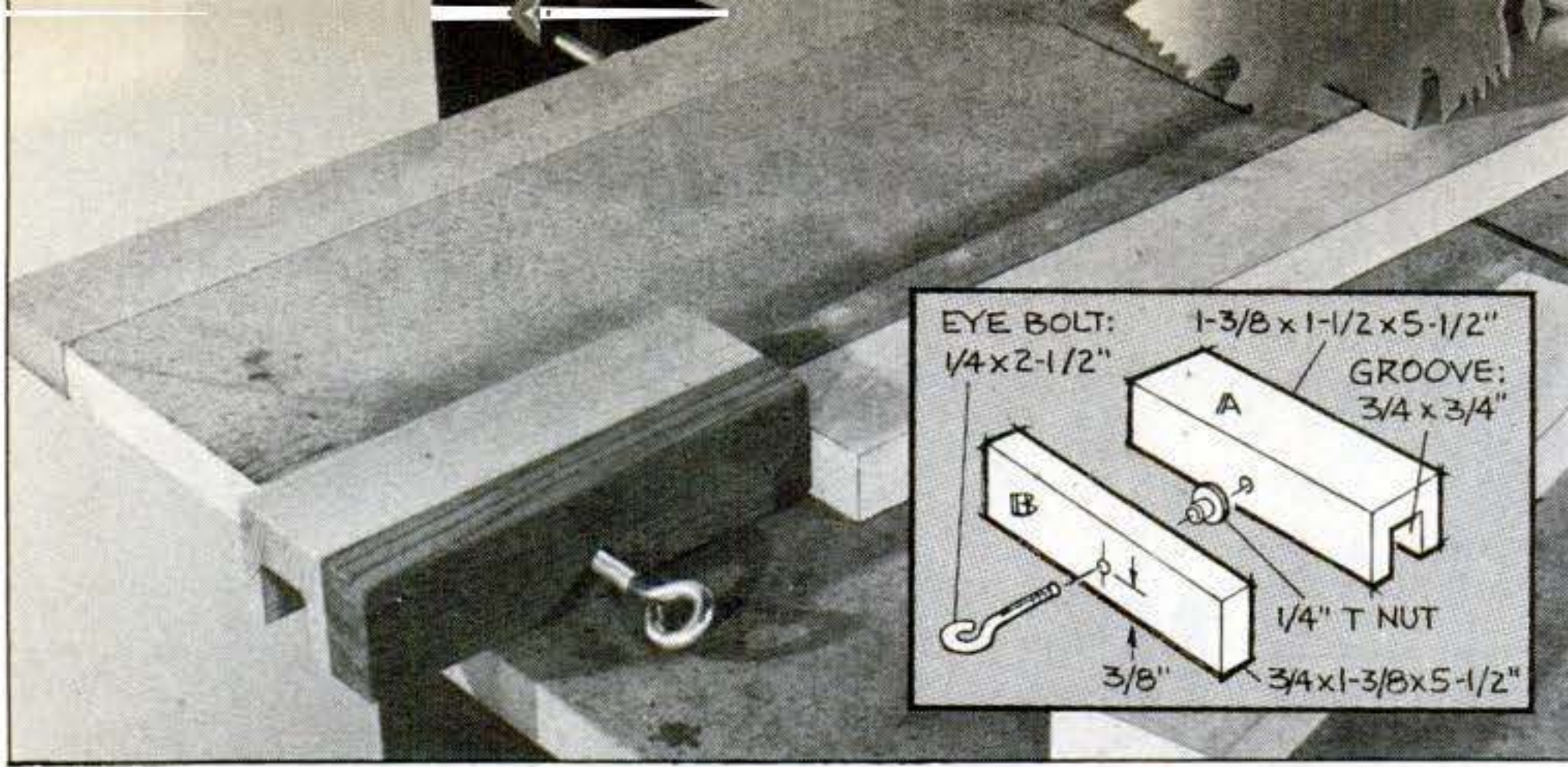
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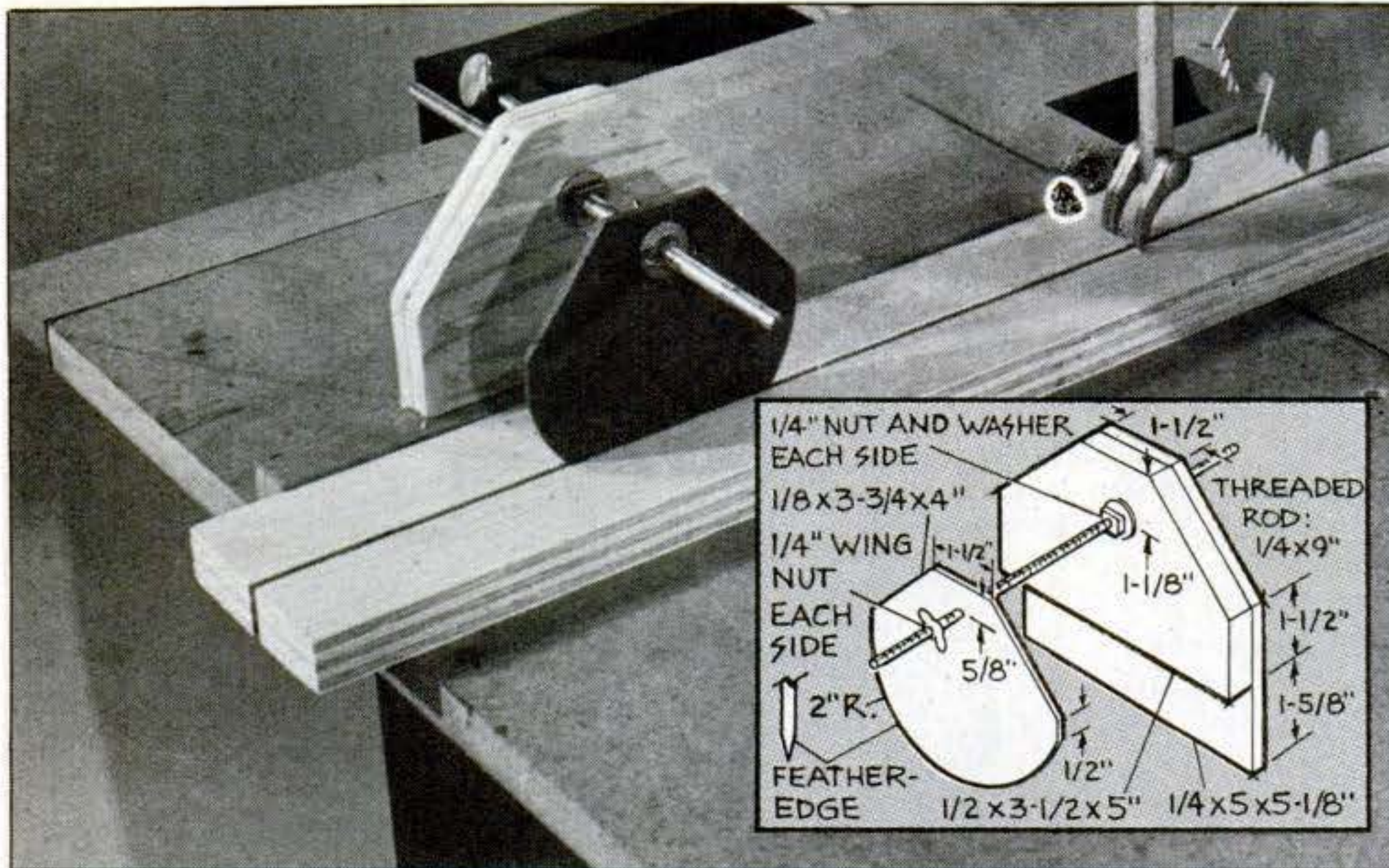
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Stop block and splitter

You've probably clamped a stop block to the table of your radial-arm saw when you needed to cut several identical lengths. My version is more versatile: It slips on and off the fence easily for use on either side of the blade. Install the T-nut before face-gluing the two blocks.

The splitter shown at bottom right keeps the kerf open (on rip cuts) after the work has passed the blade. It locks between the fence and rear table board—secured at any point. And it adjusts to various widths of cuts, because the splitter blade is on a threaded rod. (Use 1/4-in. plywood as a spacer between the rest of the rear table board and fence so the table clamps provide pressure against the fence along its entire length.)—*R. J. De Cristoforo*



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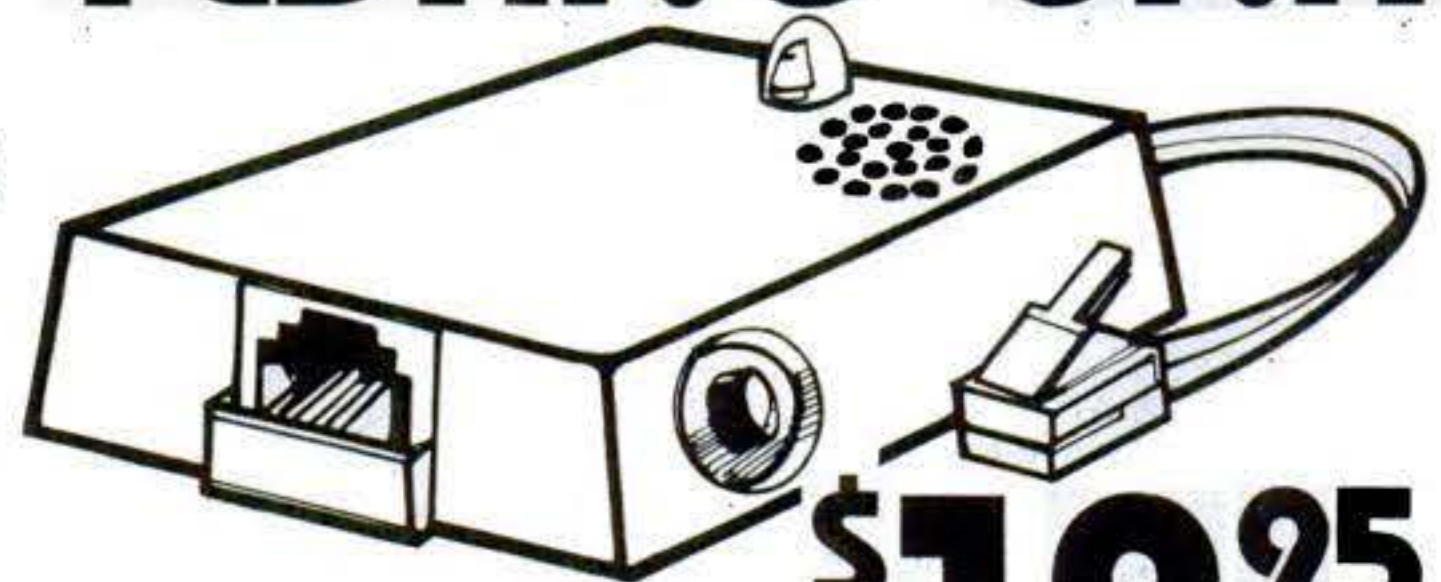
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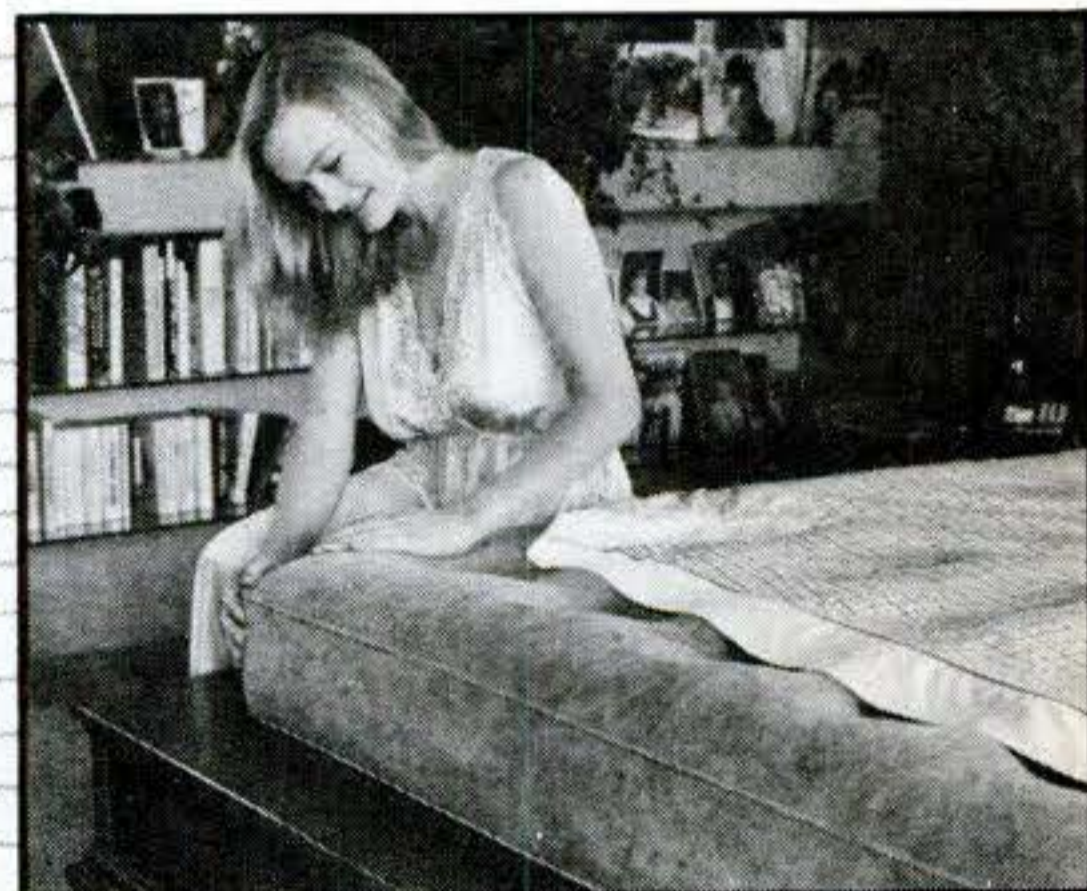


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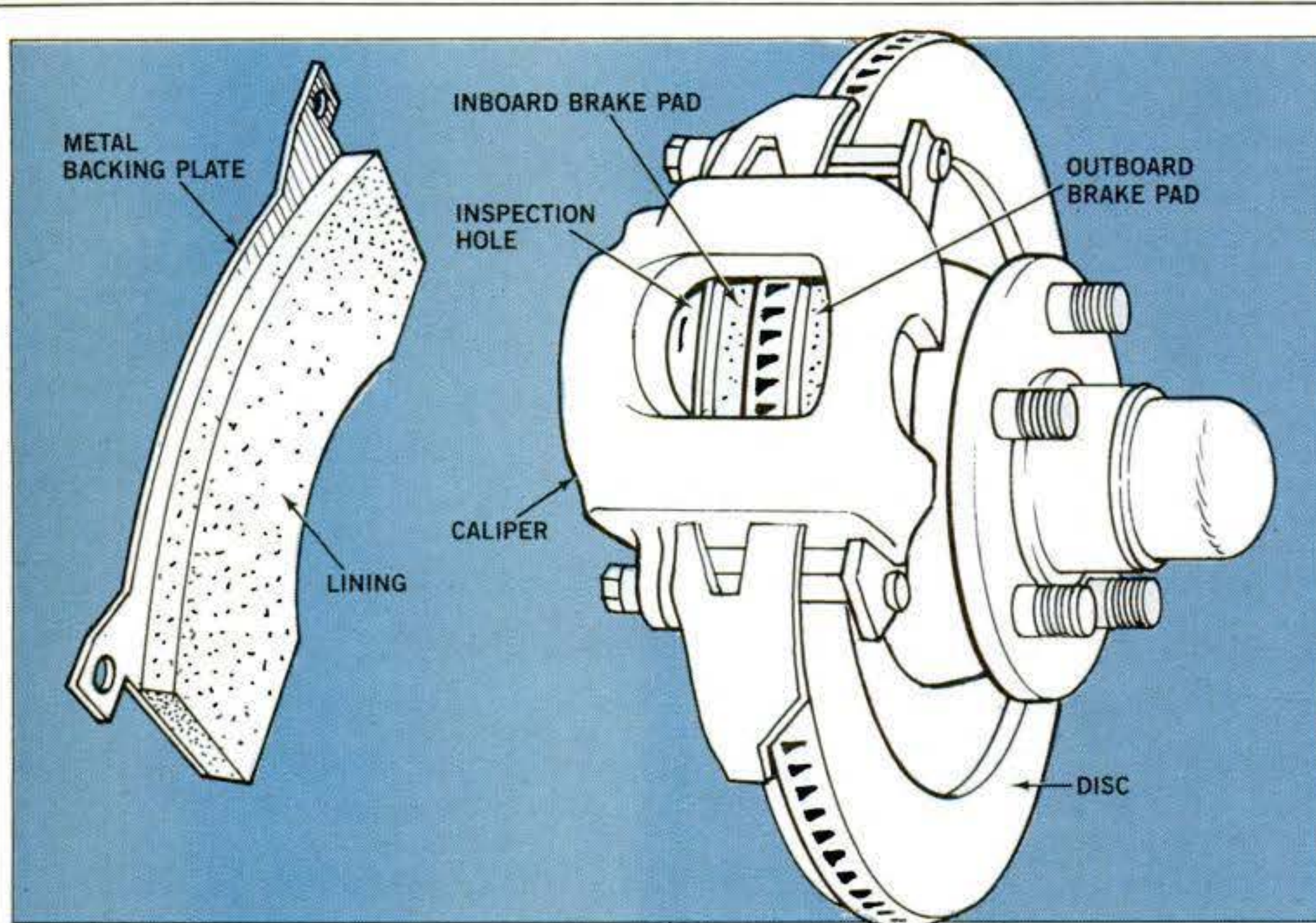
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Taking Care of Your Car

By STEVE MERCALDO

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Brake-pad checkup

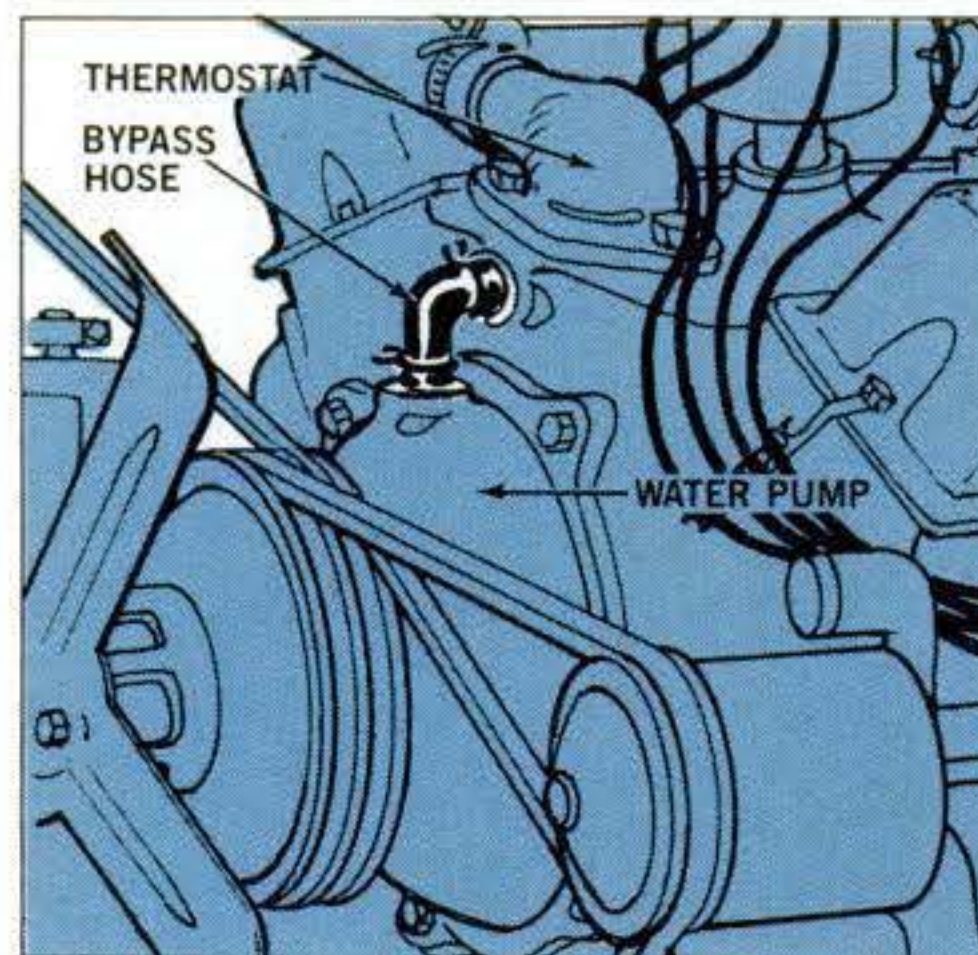
Routine brake-pad inspections reveal unsafe conditions and minimize repair costs. First inspect the pad-lining thickness. It should be no less than the manufacturer's minimum thickness specification or at least the thickness of the metal part of the pad. Also look for cracked or loose lining mate-

rial. Probe with a screwdriver, and condemn any pads where there is movement between the lining and metal part of the pad. It's also good practice to look for grease or brake-fluid leakage on the lining material. Finally, look for any foreign matter that might cause the pads to grab.



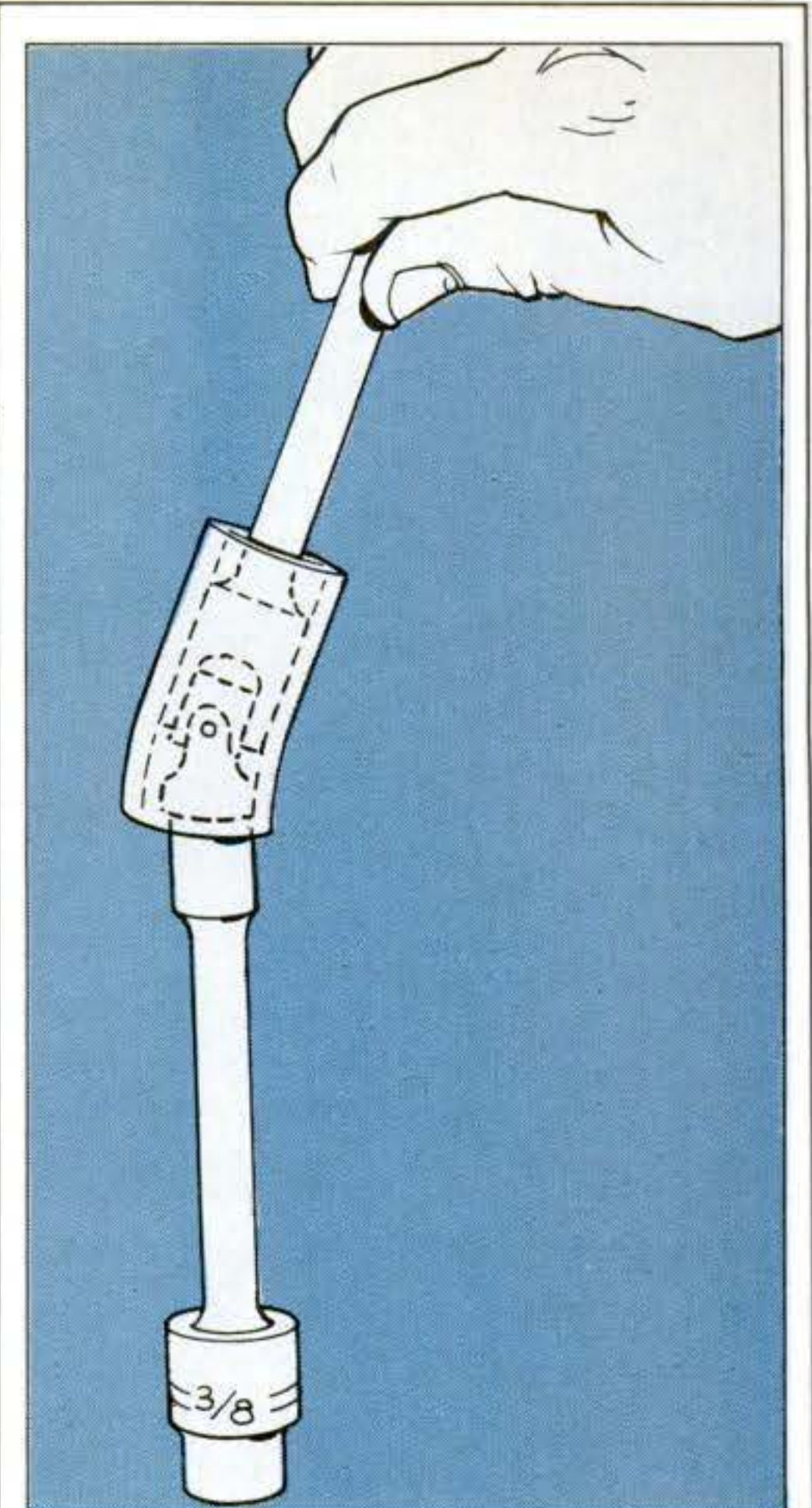
Wax enthusiastic

Paste wax hand-applied once a year at springtime is still one of the best ways to protect your car's finish. To make it easier: Apply the wax over a two-foot-square area, then sprinkle it lightly with corn starch and buff with cheesecloth; the corn starch provides "tooth" for a high gloss without streaking or smearing.



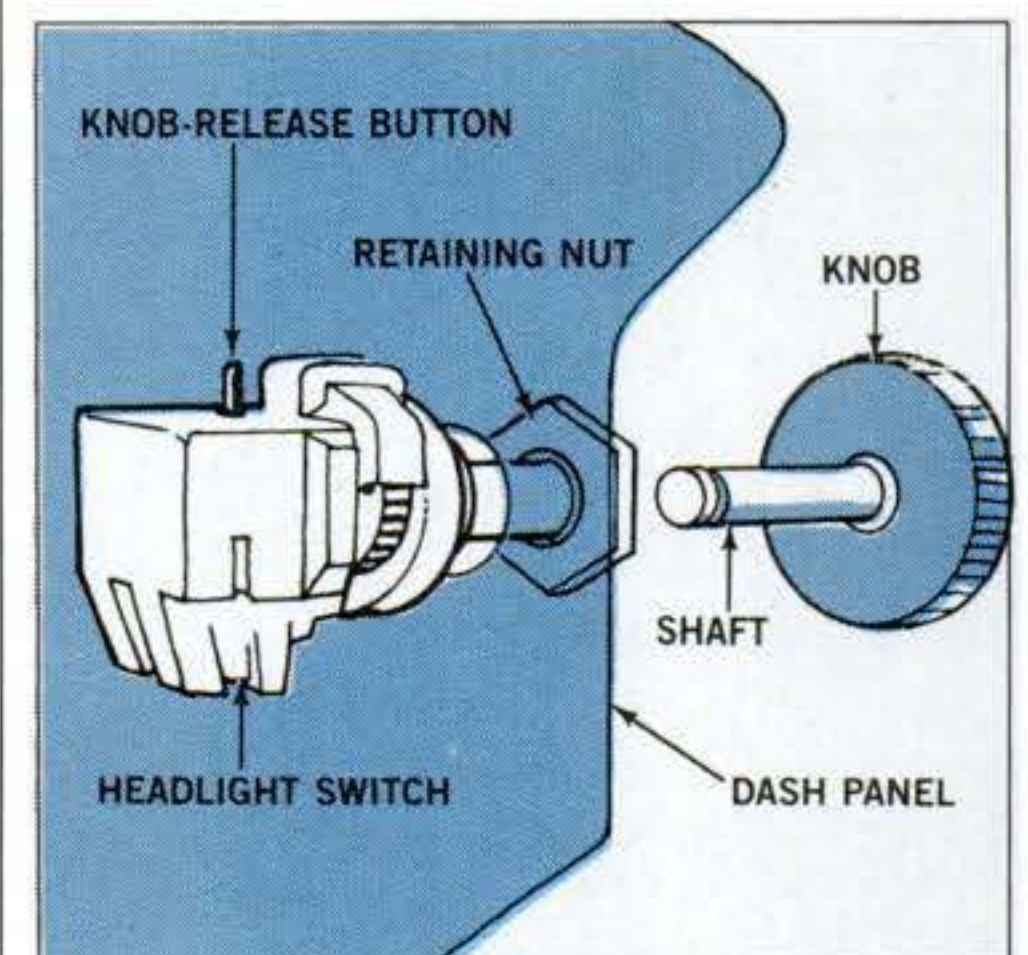
Overlooked hose

An often-overlooked part of the cooling system is the bypass hose. Its job is to allow coolant to circulate in the block when the engine is cold and the thermostat is closed. A failed bypass hose could result in a complete loss of coolant. Periodically check this small but important part of your automobile's cooling system.



Universal solution

If you've ever used a universal joint with a socket wrench and extensions, you know how difficult it can be to hold the joint at the desired angle. A solution: Insert the joint into a piece of hose or a flexible spring. This should ensure a smooth angle of rotation for your socket setup.



Switch removal

To replace a dash-mounted headlight switch you must usually remove the knob and shaft assembly to get to the switch-retaining nut. Try this: First remove the negative battery cable and pull the switch to the "on" position. Then simply depress the release button on the switch, and pull the knob out of the headlight switch.

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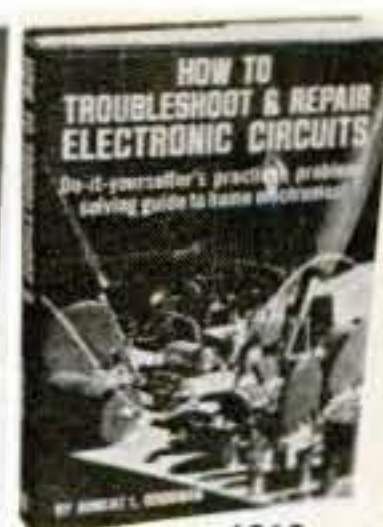
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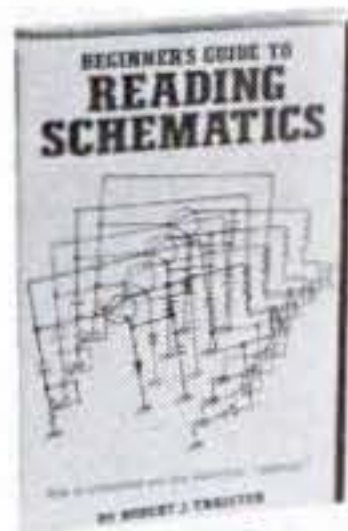
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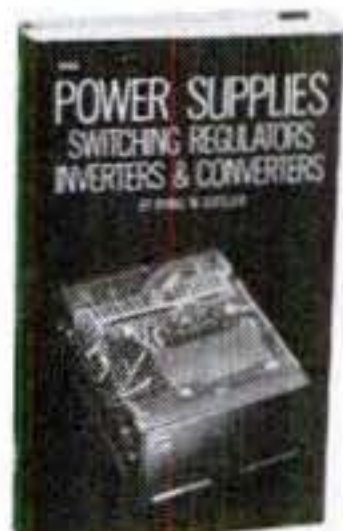
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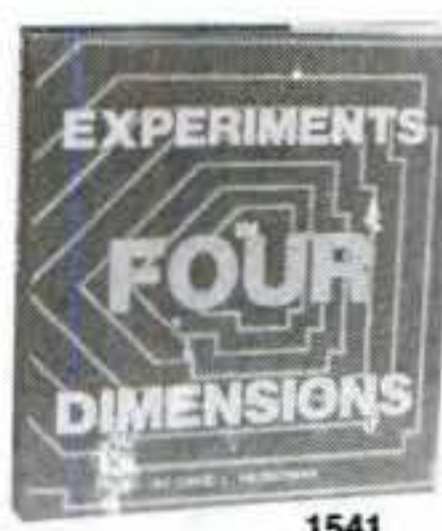
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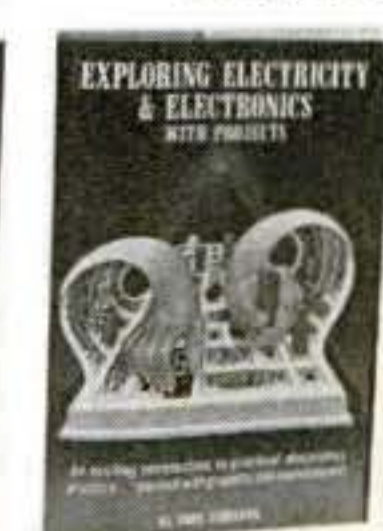
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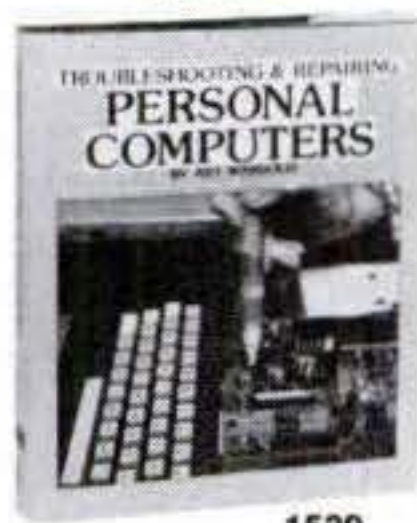
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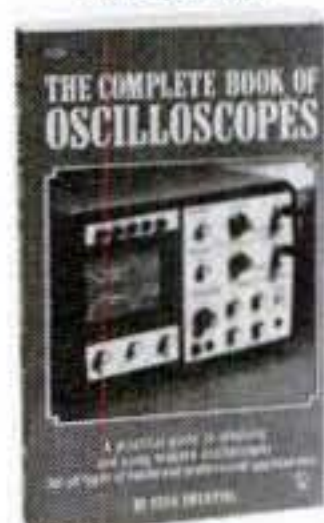
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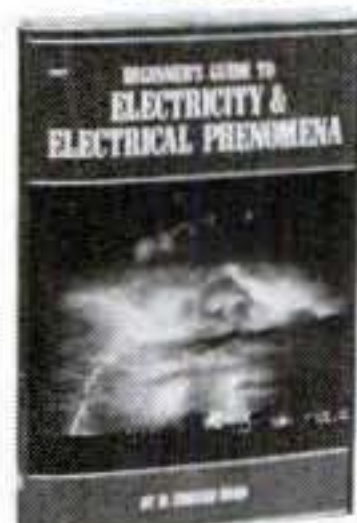
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Selective switcher for emergency generators



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All transfer switches isolate the house circuits from the utility line and connect them instead to the generator. But because most home generators can’t handle big loads, you have to turn off unnecessary appliances, which involves flipping circuit breakers, pulling fuses, or scurrying through the house in the dark. But you needn’t have to anymore.

GenTrac mounts on the wall next to your circuit-breaker box. The generator plugs into the front connector; power lines from only the appliances you’ll need during an emergency are wired in the rear.

Result: In an emergency all normal house circuits remain off, but up to six critical appliances may be individually switched to the generator with the front-mounted switches. Each switch is a separate miniature transfer switch providing instant, pre-selected emergency power. Also, you can test-run your generator without cutting off utility power.

GenTrac is made by Clymar (Box 25322, Milwaukee, Wis. 53225). A four-circuit model is \$199; a six-circuit one is \$255.—E. F. Lindsley

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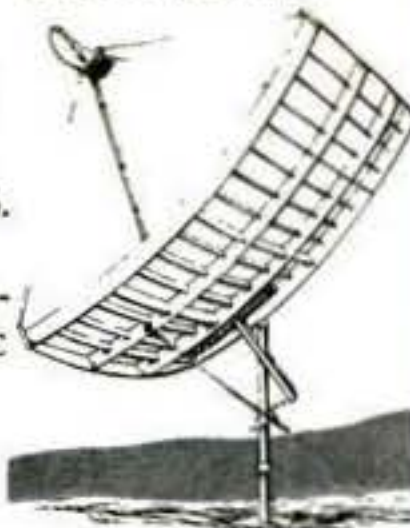
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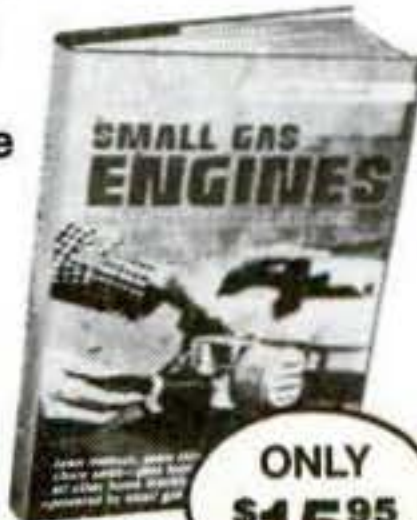
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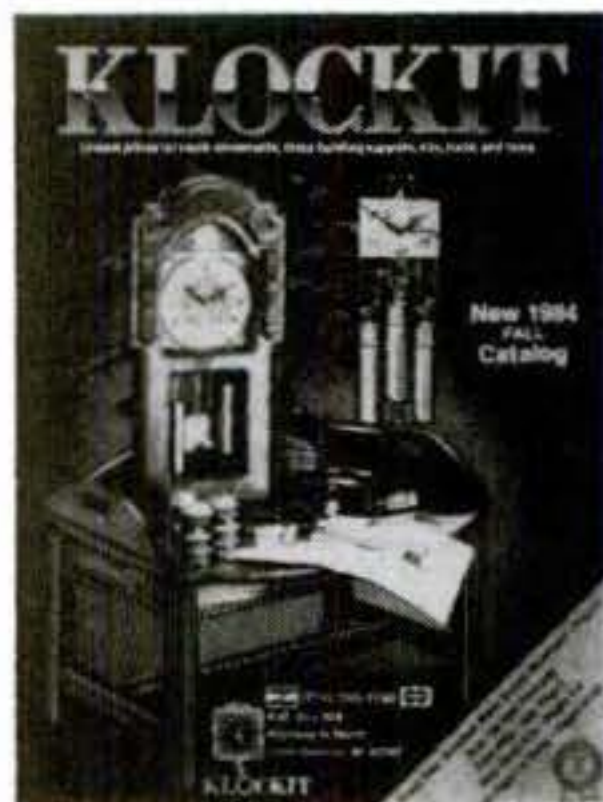


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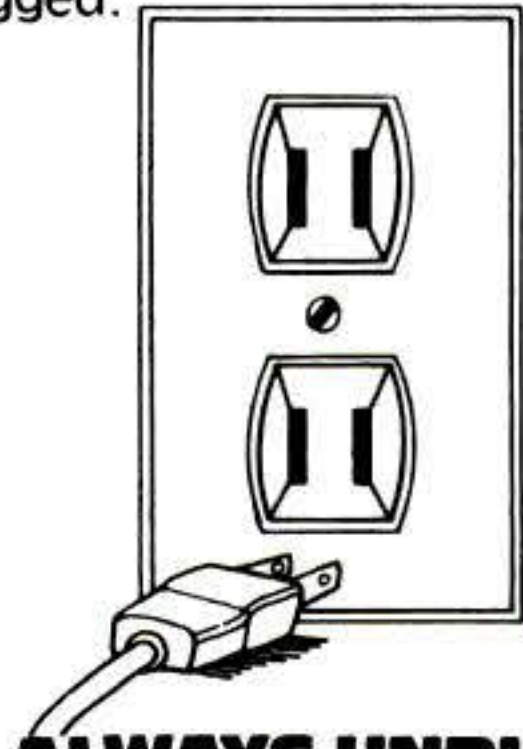
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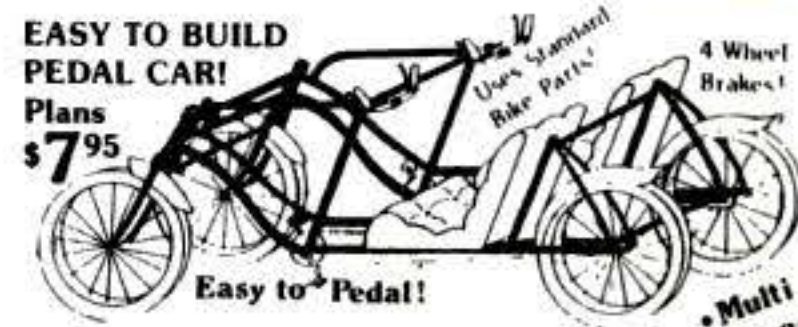
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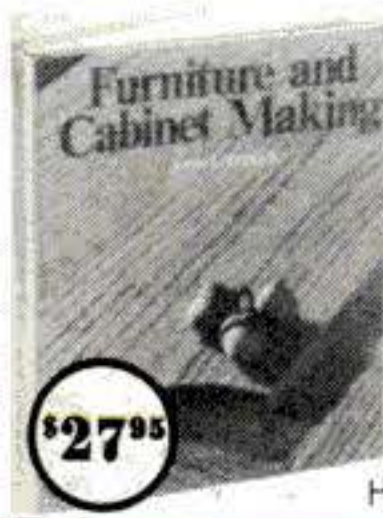
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Product Information

Booklets, catalogs, and folders listed below provide reliable information, illustrations, and specifications to help you in planning the purchase of a variety of products or services offered by these dependable companies. The convenient order form will save you time and postage.

901 High-Security Safe Here's a booklet on Cannon Safe products, a range of high-security, good-looking safes that are at home in your office, home, or workshop. Free

902 Repair Guides You name it, and this catalog from Carbooks has a book to tune it or fix it. It contains manuals and technical books for cars, trucks, boats, planes, motorcycles, and more. \$1

903 Engine-Knock Stopper A brochure from the Carter Automotive Division of ACF Industries describes the theory and operation of the Engine Knock Eliminator. One model works on all cars and light trucks and can be adjusted for proper knock sensitivity. Free

904 Energy-Efficient Building System This 40-page four-color catalog, which includes a 16-page plan-book insert featuring numerous photographs of Cathedralite homes, gives information on Cathedralite's building system and customer services. \$6

905 Garage-Door Openers Chamberlain's full-color pocket booklet gives all the facts on garage-door openers. A handy comparison chart identifies 15 features and matches them to six Chamberlain models. Free

906 Carbide Blade Sanblade, a unique carbide-tip blade, saves time, money, and energy by sanding while cutting. It's designed with oversize carbide tips to ensure long life. Get the word from Clemson Group. Free

907 Get the Most from Your Computer This detailed color brochure from CompuServe, America's largest information service for personal-computer users, tells you how to access its vast data banks for reference material, news wires, an encyclopedia, financial and travel information, electronic mail, fantastic games, and lots more. Free

908 The Stove Solution This full-color 20-page catalog features Earth Stove's full product line, including free-standing models, fireplace inserts, mobile-home-approved models, and the newest addition to the line: the Earth Stove Catalytic. Free

909 Calculators and Computers Find out about the innovative HP ThinkJet printer, HP-41CX, HP-71B, TI-66, and NEC 8201. The illustrated EduCALC catalog tells you just what these machines can do. It also shows you how to use them, with books, software, and accessories from EduCALC Publications. Free

910 Wood-Finishing Tips Minwax's 22-page booklet contains many tips that can save time and trouble for do-it-yourselfers. Also included are charts showing a full range of interior and exterior finish colors available, plus the name of the nearest Minwax dealer. Free

911 Doors and Elegant Woodwork A complete set of full-color folders from Morgan Products Ltd. describes how to use exterior and interior doors, patio doors, stair parts, entrance trim, and mantels to decorate and insulate your home with the warmth and beauty of wood. 25¢

912 Radio Intercoms The 1984 catalog from NuTone Housing Group shows its entire line of radio-intercom and stereo systems for home and office. It also gives complete details on individual system features and accessories. \$1

913 Microcomputer Software Peachtree software is available for many different microcomputers, and Peachtree offers software for business, home, and school. The firm's full-color magazine, *Peachtree Quarterly*, provides product information and interesting articles for users. \$3

914 Wall-Banger's Pocket Guide A new 20-page step-by-step guide from Red Cedar Shingle & Handsplit Shake Bureau details the application of cedar shakes and shingles. You can save up to 60 percent on labor alone. 50¢

915 Cleaner Air Information on in-the-home air-pollution control is provided in a booklet called "Cleaner Air." It describes air filters and air cleaners, and presents efficiency data on the removal of house dust, tobacco smoke, pollen, and spores by a new type of air cleaner that uses no electricity. The booklet is from Research Products Corp. Free

916 Sportsman's Catalog No matter what the outdoor sport, Bass Pro Shops has the equipment for all your needs. The 400-page catalog details more than 12,000 items—rods, reels, lures, bows, arrows, and more. \$2

917 Wonderful Wood Finishes This eight-page four-color booklet from Watco-Dennis shows how to create professional finishes the first time with all types of wood. Watco Danish Oil seals, primes, finishes, hardens, protects, and penetrates in one application. Free

918 Hot Spring Spa A six-page full-color brochure from Watkins Mfg. Corp. includes its product's benefits, features, operating costs, and specifications. Free

919 Money-Saving Plumbing This booklet from World Plumbing Supply describes the advantages of the full-flow solderless Studer-Valve Line, outlining time and money savings for the do-it-yourselfer or professional. Free

920 Recreational Vehicles A color brochure from Yellowstone describes the company's products and models of RVs. It features travel trailers from 18 to 38 feet long, fifth-wheels from 24 to 39 feet, and mini motor homes from 24 to 27 feet. Free

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POPULAR SCIENCE SEPTEMBER 1984

If you've got something really heavy to carry, let the Toyota SR5 Sport Truck carry it. There's a

1400 lbs.

standard 1400 lb. payload,* so stack those logs. The sturdy, full box frame with double wall bed construction can take whatever you dish out. But this truck isn't just made strong, it's made right. There's a wind-cheating front-end design and a new, soft-ride rear suspension system with staggered mount shock absorbers for car-like ride, handling, and confident control.

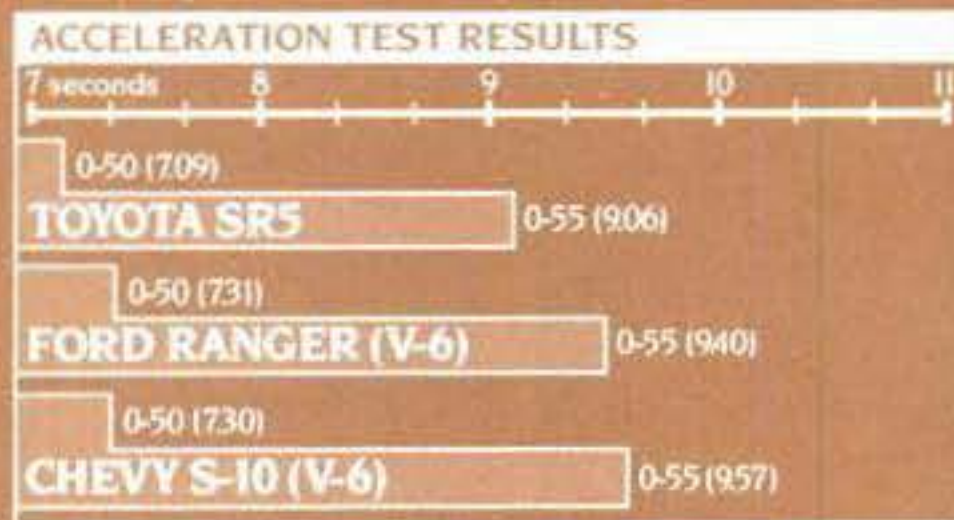
You won't believe you're driving a truck after you drive this baby. One look at the inside and you'll be amazed at just how much comfort there is. Sit down and stretch out. There's 41.5 inches of legroom. More than ever before. There's luxuriant carpeting, AM/FM/MPX stereo, full instrumentation.



You can even get a 7-way adjustable driver's sport seat. And if you're hungry for power, there's a standard state-of-the-art electronic fuel injection system which gives the already potent 2.4 liter engine

OH WHAT A FEELING! TOYOTA

even more muscle. So much power in fact, that it out-accelerates the competition's V6s.** The Toyota SR5 Sport Truck. Now you can get beauty and brawn, all in one truck.



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THE TOYOTA SR5 SPORT TRUCK. MIGHT MADE RIGHT!



BRAWN!

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**Extra Mild!
Low Tar!
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0.7 mg. nic.*

Warning: The Surgeon General Has Determined That Cigarette Smoking Is Dangerous to Your Health.

Lights: 8 mg. "tar", 0.7 mg. nicotine; 100's: 9 mg. "tar", 0.8 mg. nicotine av. per cigarette by FTC method.