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The **What's New** magazine

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**NEW
AIR SPRINGS**
—smoother ride
—automatic leveling

On the track of
**DEADLY
WIND SHEAR**

Computerized personal robots

—they move, talk, think,
and teach you
robotics

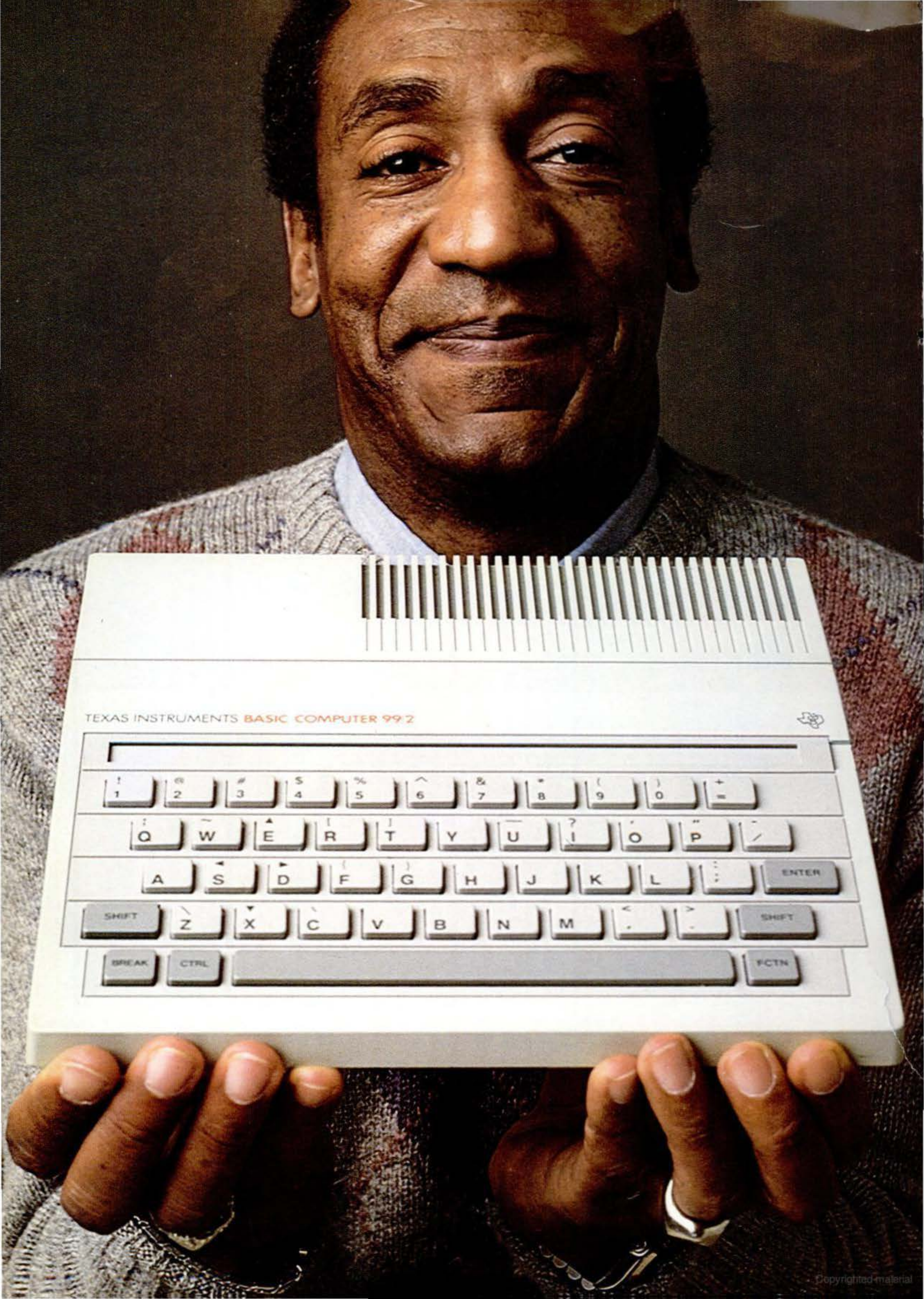


NUCLEAR WASTE
A better way
to bury it?

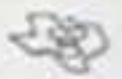
**SPECIAL HOME AND
SHOP SECTION**

- porches and decks
- emergency plumbing
- home security systems
- table-saw jigs





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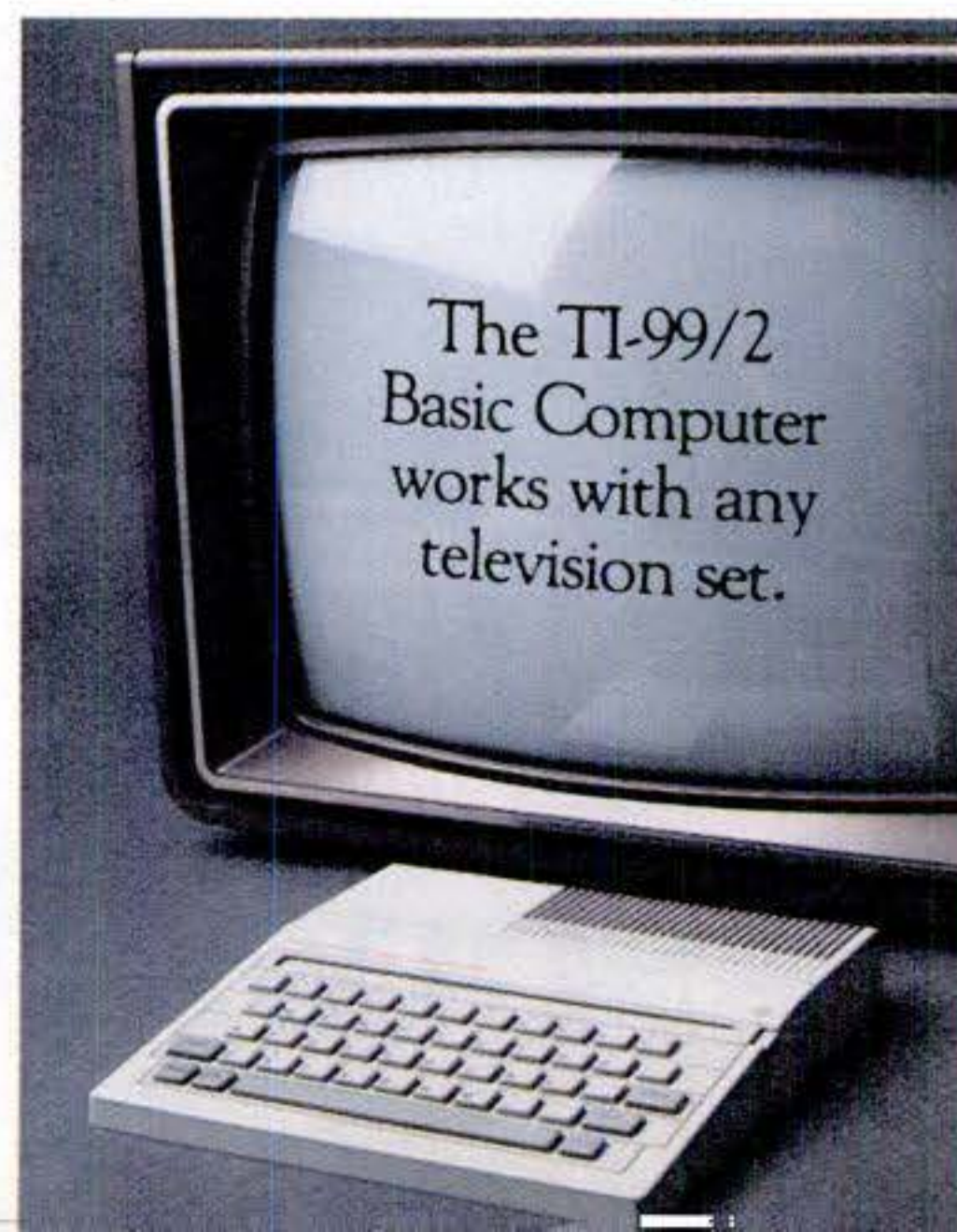
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Architect: Wendell Lovett, FAIA, Seattle, Washington

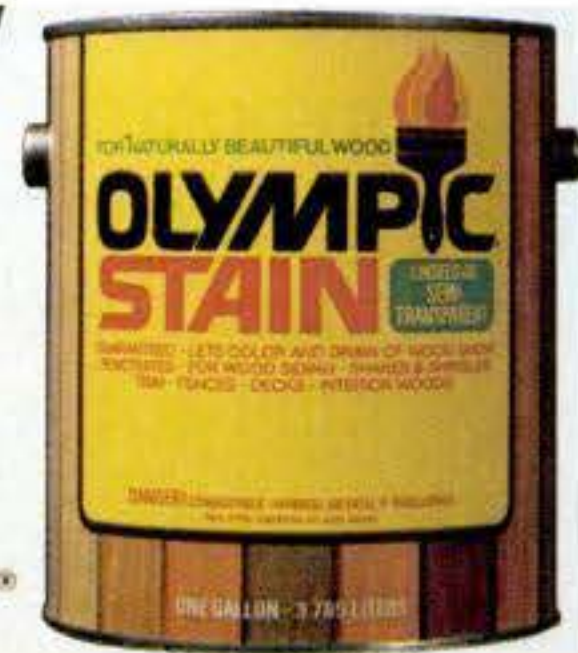


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**HIGHLIGHTS
OF
THIS
ISSUE**

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A machine to do household drudgery is one promise of a budding industry. PAGE 98
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COVER CONCEPT BY W. DAVID HOUSER
PHOTO BY GREG SHARKO

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PS READERS TALK BACK

Address letters for this column to: Readers Talk Back, POPULAR SCIENCE, 380 Madison Ave., New York, N.Y. 10017. Because of the large volume of mail, we are unable to acknowledge unpublished letters.

Friendly stealth?

Although the Lear Fan 2100 is constructed almost entirely of carbon-fiber composites, it is by no means a "stealth aircraft" ["Invisible Bomber," PS, Feb.]. It is important when operating an aircraft in today's civilian market that air-traffic control be able to identify and track each aircraft. One of the earliest demonstrations performed with the Lear Fan 2100 was to show that it could be adequately "skin painted" by radar in the event of transponder failure. Low-radar-cross-section technology is not synonymous with composite construction.

R. A. Jacobsen, Chief Engineer
 Lear Fan Limited, Reno, Nev.

Flyaway credits

The relatively small size of the Las Vegas Flyaway ["Flight Chamber," PS, March] is not indicative of the architectural and engineering complexities involved. Without the dedicated efforts of William Bettes (wind-tunnel engineer), Martin and Associates (structural engineers), and Line Systems (mechanical and electrical engineers), the Flyaway complex would still be a design dream and not a reality.

Alan L. Blum (Flyaway architect)
 Las Vegas, Nev.

Iridium connection

I certainly agree with the theory of Luis Alvarez: that a huge hunk of rock hit Earth to bring the Cretaceous Period to a close ["Killer Asteroid," PS, Feb.]. Logic shouts cataclysm, not egg-sucking mammals or constipated dinosaurs. But I think the theory can be carried one step further. Fissures in Earth's crust, coupled with other geological and biological evidence, indicate the point of impact was Antarctica.

J. W. Howland, Carthage, Texas

The article makes me wonder if we humans will learn from history rather than repeat it. If the killer asteroid's dust cloud was 1,000 times greater than that produced by the Krakatoa eruption, what would be the worldwide climatic effects of debris from a given kilotonnage of nuclear explosions?

Jeanne Lamsam, Monona, Wis.

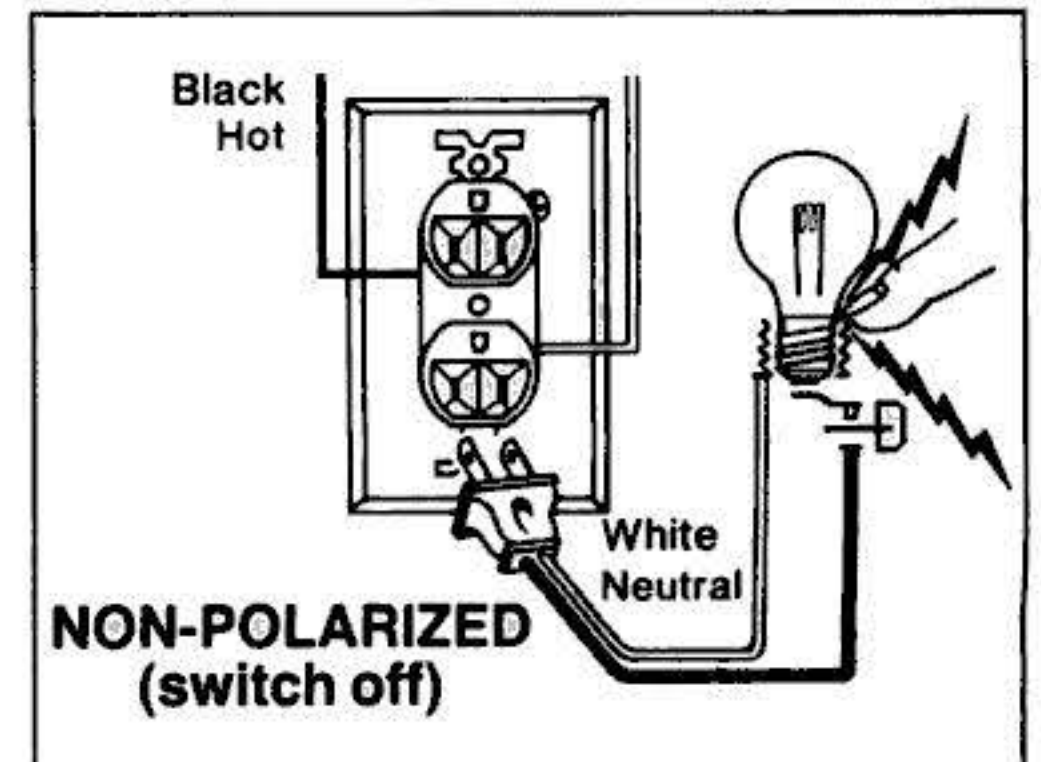
An experience I had more than 40 years ago may have some connection with your good article. When the Shasta Dam was being built near Redding, Calif., in 1940, I operated the assay offices for the prime contractors. The aggregate for the concrete came out of the Sacramento River at Redding, then was transported on a nine-

mile conveyor to the dam site. My job was to run gold "cleanups" on the aggregate before it was sent. Over a period of months, our crude gold-recovery plant extracted practical values of lead, copper, mercury, gold, silver, platinum, and palladium, but there was still a leftover residue I couldn't identify. I sent off a sample of this material to a company in New York for analysis, which reported that the residue was osmiridium [an alloy of osmium and iridium] and offered to purchase what I had for about \$700. I didn't delve deeper into the subject at the time because the concentrations were too low to be economically produced.

Thomas W. Ward, Oroville, Calif.

Shocking illustration

If a non-polarized cord is plugged in as shown in the drawing in "Polarization" [PS, Feb.], the live current will flow



through the white (neutral) wire and be stopped at the open switch. You would not receive a shock from touching the socket unless the plug were reversed.

I hope the person at General Electric who drew that diagram is not the same one who wired my clock radio.

Ken Hoover, Warminster, Pa.

Reader Hoover was among many readers who caught us and GE in this "shocking" error. GE supplied the corrected diagram.

Shell game

I was intrigued by your article on Robert Mastin's hybrid envelope design ["Double-Shell Houses," PS, Feb.]. It's good to see that some designers are willing to learn from their experience and are taking a more balanced approach to energy-efficient design instead of being dogmatic purists about any one system. How can I get more information about Mastin's work?

Jack Felloney, Silver Spring, Md.

Researchers have learned a lot about
Continued

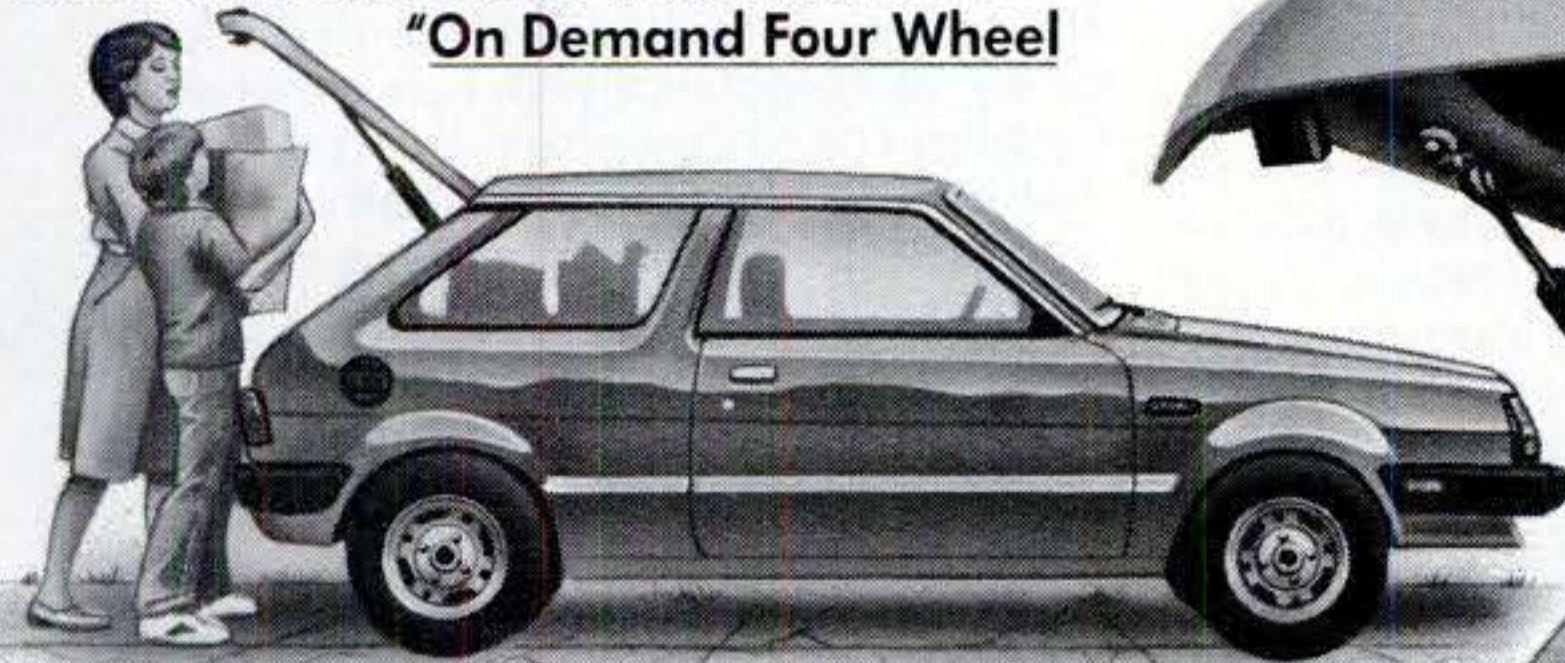
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PS readers talk back

[Continued]

Mastin's house in Middletown, R.I., but one house is not all houses. For example, air flows in a Midwest copy of the Mastin house are stronger at night than in daytime—the opposite of Mastin's case. The functional elements of double-shell houses can be combined in a great many ways. My company's new book *Building for Energy Independence with Sun/Earth Buffering and Superinsulation* (\$17.95, Community Builders, Canterbury, N.H. 03224) includes a survey of 100 such homes, showing how they reduce energy costs without reducing benefits.

Don Booth, Canterbury, N.H.

V. Elaine Smay replies: "Mr. Booth is certainly correct in pointing out that houses built following the same design will often vary considerably in performance due to such influences as the tightness of the shell, local climate, and occupant life style. However, the double-shell houses that have been monitored—from Canada to Georgia—have this in common: Where measurable air flow was found to exist in the envelope (and it wasn't always), it was too slow to distribute heat throughout the house and prevent stratification. Thus the general conclusions of the Brookhaven study are supported by other studies, suggesting they have broad validity.

"For a color brochure illustrating Mastin's designs (free) or a detailed information-and-design portfolio (\$4.75), write Robert Mastin, Natural Energy Design, Inc., 1355 Green End Ave., Middletown, R.I. 02840."

Water in the flue

Reduction in stack-gas temperature is a poor measure of performance of the Heat Extractor ["Flue-Heat Retriever," PS, Feb.]. Much of the temperature reduction is due to the evaporation of part of the water spray. This evaporated water goes up the stack carrying with it much of the expected energy savings in the form of latent heat.

Paul N. Walker, Associate Professor
 Department of Agricultural Engineering
 Pennsylvania State University
 University Park, Pa.

The article states that the stack temperature in the main chimney was 150 to 180 deg. F after installation of the device. That is low enough to cause a severe corrosion problem in the chimney due to condensation of acids in the stack.

Mark A. Schuetz, Granville, Ohio

Evan Powell replies: "The tests we did were not intended to measure efficiency but to find out what it's like to live with the unit. However, since about 85 percent of furnace exhaust passes through the unit and out a special exit duct that is slanted to promote condensation of water vapor, very little energy is lost as latent heat. The efficiency ratings cited in the article take this into account. The volume of exhaust that still exits through the chimney is too small to cause any corrosion problems."

PS apologizes to Heat Extractor inven-

tor Dan Ben-Shmuel for misidentifying him in the original article. Also, the Heat Extractor is now widely available from heating-equipment suppliers, not just Sears. For more information, write Heat Extractor Corp., Box 268, St. Johnsville, N.Y. 13452.

Research cutbacks

PS authors are falling for the bellyaching that interviewees express over the loss of government funding. E. F. Lindsley's "Stirling Auto Engine" [PS, Jan.] was a very informative article, but his last paragraph soured the entire story. The same goes for Jim Scheffer's "Energy from Wind Farms" [same issue]. The last paragraph weakens the impact of a very good write-up.

If federal seed money has pointed to achievable results, these projects can surely be completed with less expensive funding. The 17 cents from each tax dollar that actually gets to the researcher after he has created tons of paperwork in securing the seed grant is a costly way to go.

As an English teacher once told me: "When you are finished, put a period."

Joseph H. Marion, Elko, Nev.

Space-based economy

The space program did not "enrich the industrial giants," as claimed by Jesse L. Taggart [RTB, PS, Jan.]. Rather, it provided useful employment for hundreds of thousands of people ranging from pure scientists at the top down to janitors and service-station attendants at the bottom. In addition to all the jobs directly related to the space program were the benefits to everyone else of the active economy of the time. Many of the people now standing in unemployment lines are there due to the severe cuts in the space program.

Gerald L. Brady, Oxnard, Calif.

Oil glut?

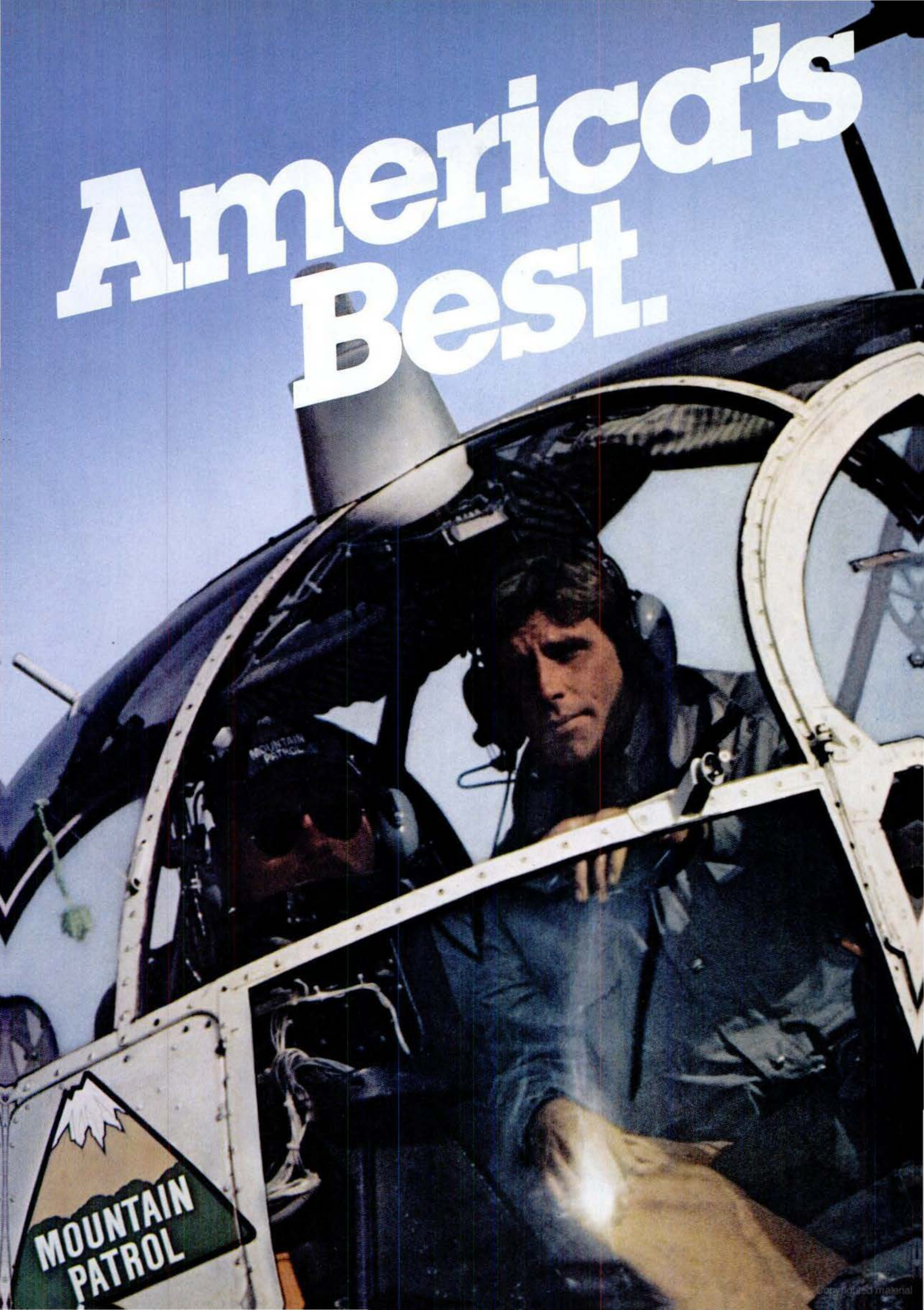
Your mini-editorial "Energy Crisis Over?" ["PS/What's News," PS, Feb.] should be read morning and night by every member of Congress and the executive branch until they know it by heart. It is clear, concise, and to the point: The energy problems of the U.S. are far from over.

Sidney Harris, Alexandria, Va.

Corrections: Here's some updated information about publications on Jeffrey Milstein's list of solar-energy books [PS, Jan.]: *Passive Solar Construction Handbook* is no longer available from the Southern Solar Energy Center; Rodale Press (Emmaus, Pa.) will bring out a new edition in the fall. Also, *Solar Engineering* magazine is now published by Business News Publishing Co. (Troy, Mich.) and has been renamed *Solar Engineering and Contracting*.

The cost and compressibility values given for polystyrene insulation in "Alternate-Energy Answers" [PS, Jan.] were for expanded, not extruded, foam. 5

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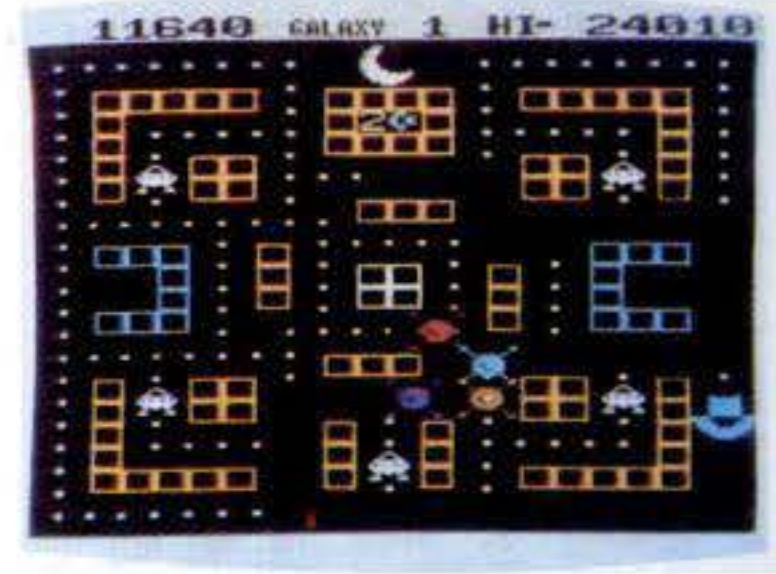
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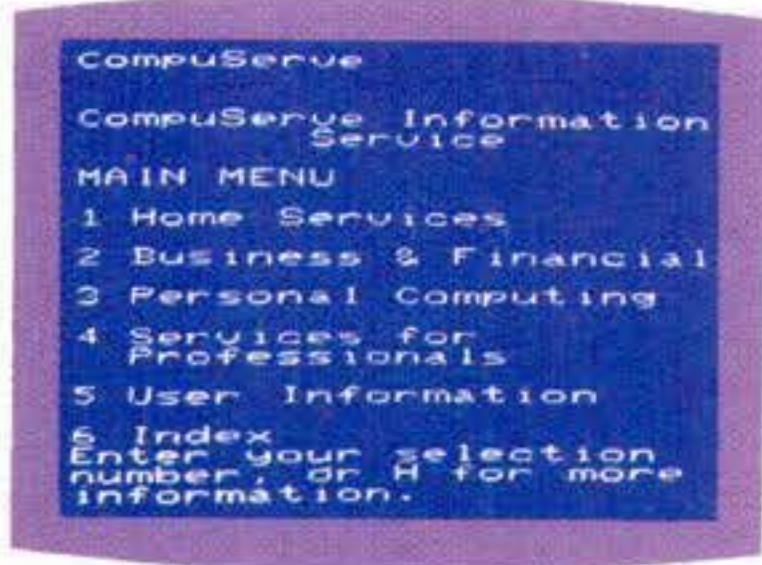


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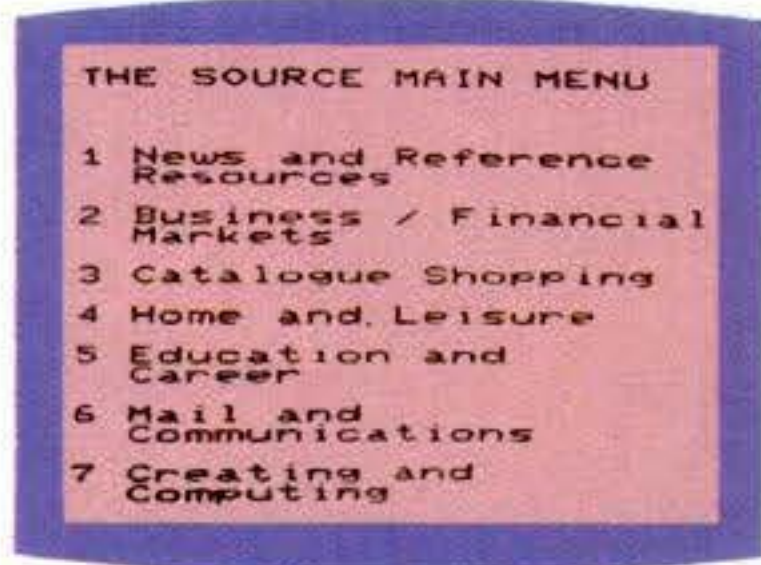


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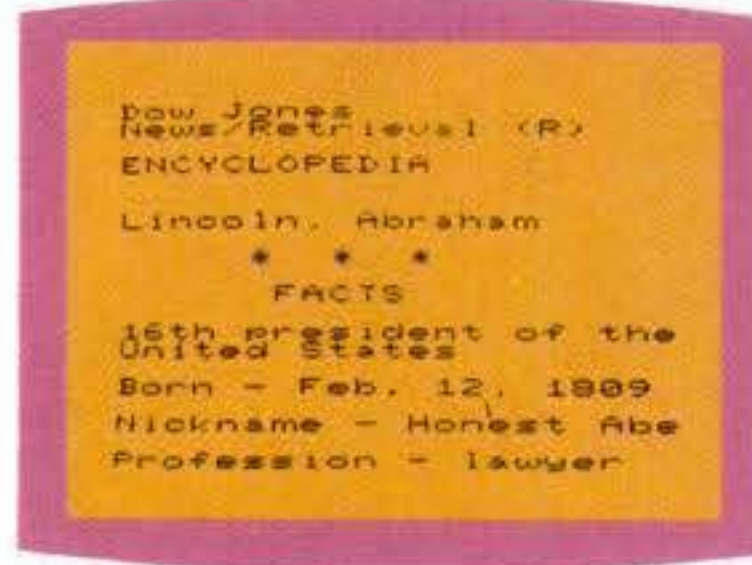
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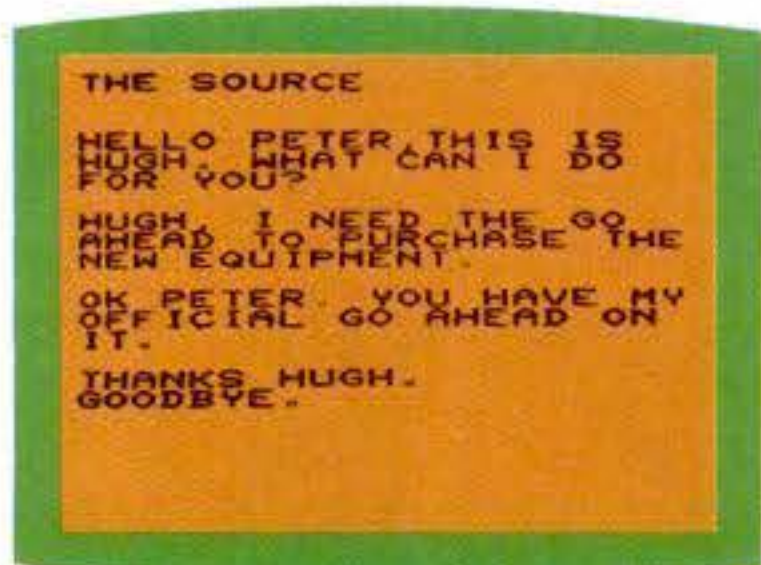
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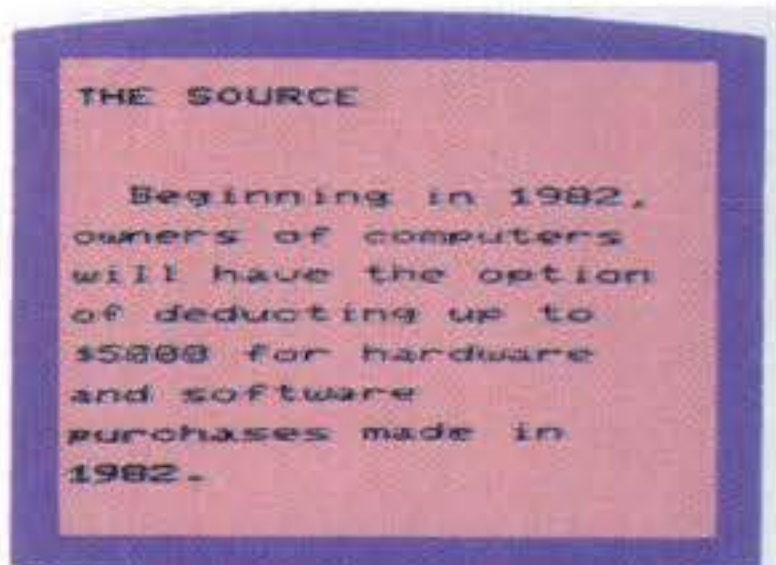
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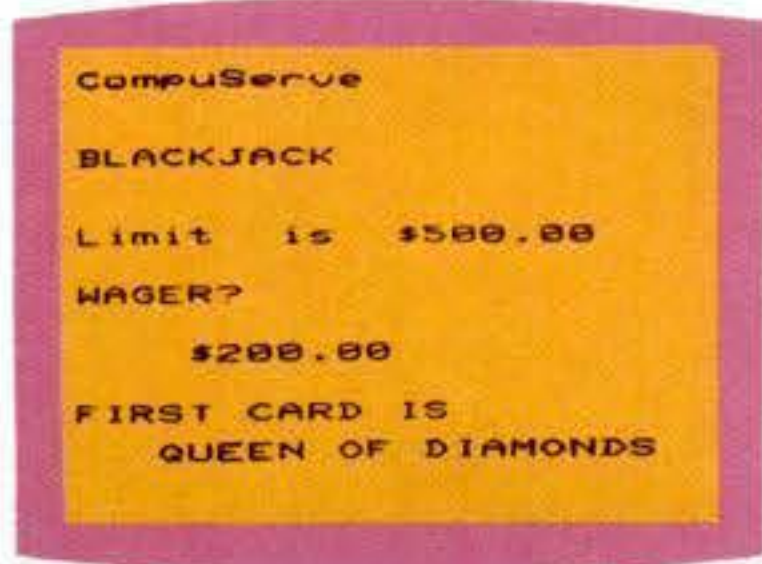
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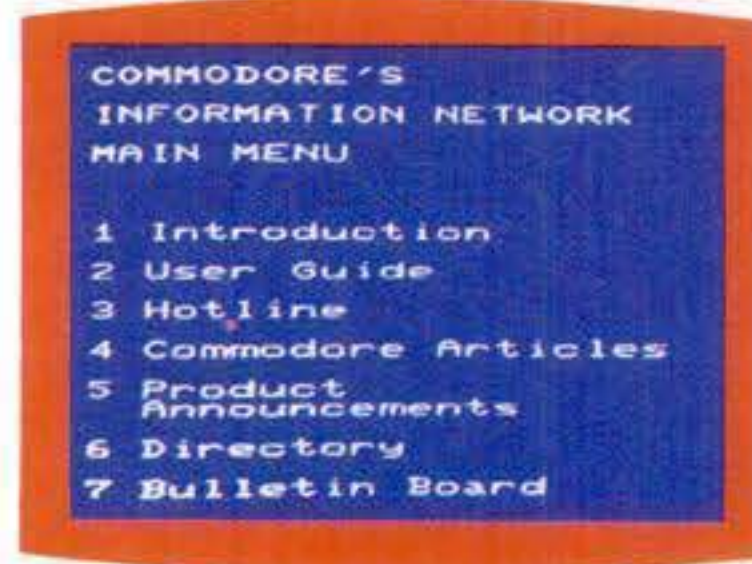
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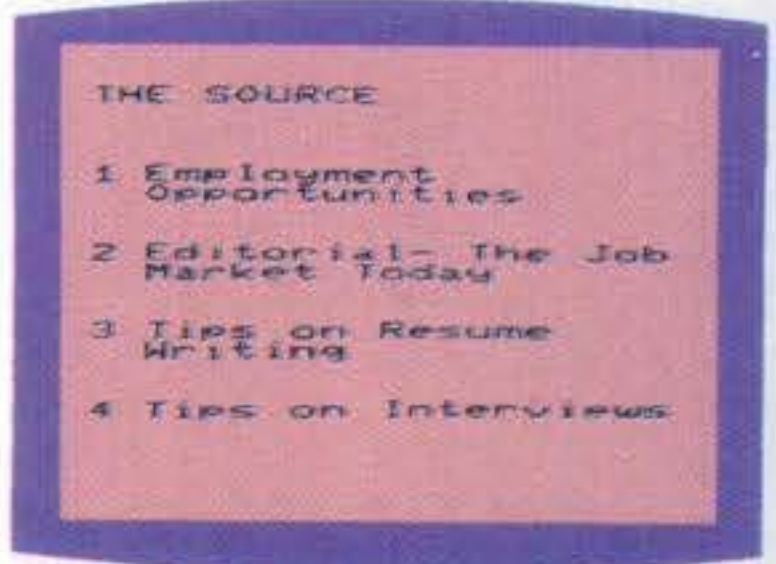
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Air lift for cars

—high-tech springs are
lighter, quieter, smoother

They adjust vehicle height to give big-car ride to lightweight cars

By E. F. LINDSLEY

DRAWINGS BY RUSSELL VON SAUERS

Twenty-five years ago air springs nose-dived into Detroit's technological graveyard. The original systems leaked and malfunctioned. And air suspension, at least temporarily, sagged into auto-design oblivion.

Today, Ford and Goodyear are on the leading edge of a push to put the air ride back into cars. In a bold move, Ford will use the springs as standard equipment on its 1984 prestige models, Mark VII and Continental.

Why didn't air springs work back in 1957, and why will the technology work now? To get the answer to those questions and others, I visited Goodyear's engineering center in Akron, Ohio. There I tested a Continental prototype equipped with the latest version of the special suspension and spoke with the engineers from both Ford and Goodyear who designed and built the air-ride system.

What advantages do air springs offer?

- Plusher rides for lightweight cars.

- Constant headlight aim.
- No spring fatigue.
- Lighter weight.
- Easier, faster maintenance.
- Sound isolation.

Why did Ford give the air springs a second chance? To understand that, let's take a small detour into the nature of springs.

Spring rate is the weight in pounds necessary to deflect a spring one inch.

The higher the spring rate, the stiffer the spring and the heavier the load it can support. But increasing the rate decreases flexibility and increases ride harshness. This makes it tough to engineer a single spring rate for a vehicle where the gross weight varies greatly with load and the number of passengers.

In the past, with 5,000-pound cars, the problem wasn't serious. Passenger weight and even a loaded trunk weren't a significant portion of the vehicle's gross weight. But today's cars with lower curb weights are profoundly affected, since passengers and loading represent a greater part of the car's total weight.

How do you preserve the car's ride characteristics without compromising load capacity? Most steel springs have only one rate. Make them soft enough for a good ride and you have no load capacity. Make them stiff enough to handle a large load, and a lightly loaded car—say, a driver alone—gets a rough ride. The answer, of course, is air springs. Their rate can be varied by simply changing internal pressure and air-spring-piston contour. My test ride convinced me that these Continental lightweights will ride with the same smooth plushness of older, heavier vehicles.

How is headlight aim maintained and spring sag from fatigue eliminated? Three sensors, one at each front wheel and one at the rear, monitor what Buddy Chance, Ford's supervisor of rear suspension and air suspension, calls the "S" and "D" dimensions.

"The S dimension at the front is the correct position of the lower suspension arm in relation to the body," Chance explains. "The D dimension at the rear is the correct position

of the axle in relation to the frame rail."

When the sensors signal the microprocessor that a change is needed, air is either added or released to make the necessary height compensation. Air that must be added comes from an electrically powered, oil-less, single-piston compressor.

It all sounded good, but I had a mental picture of the car jacking itself up and down at every railroad crossing and bump in the road.

How is that prevented? By two things, Chance says. First, the sensors have a 1/4-inch "dead" band through which they can move without stirring the compressor to action. Second, the reaction to inputs is not instantaneous. The microprocessor uses a Fourier sine wave that sums up the ups and downs to determine what action to take. If the sum of the ups is greater than that of the downs, for example, air is released from the system. That way, braking or a sudden stop isn't misinterpreted as a signal requiring a response.

There are strong reasons why Ford and Goodyear expect the system to finally fulfill its promise. Air-spring suspensions will travel over two million miles before they ever see the underbelly of a production auto.

"By the time the cars start rolling off the production line, we'll have built about 250 or 300 prototypes," Chance figures. There are already about 32 prototypes being field-tested, he says. Some are being run in the frigid -50-degree-F temperatures of Northern Canada; others are rolling through the blazing 125-degree temperatures of Death Valley. Several already have up to 55,000 miles on them. And one has actually topped

Continued

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*We painted this house in 6½ hours
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Of course, speed isn't a Wagner Power Painter's only long suit.

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

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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.

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

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

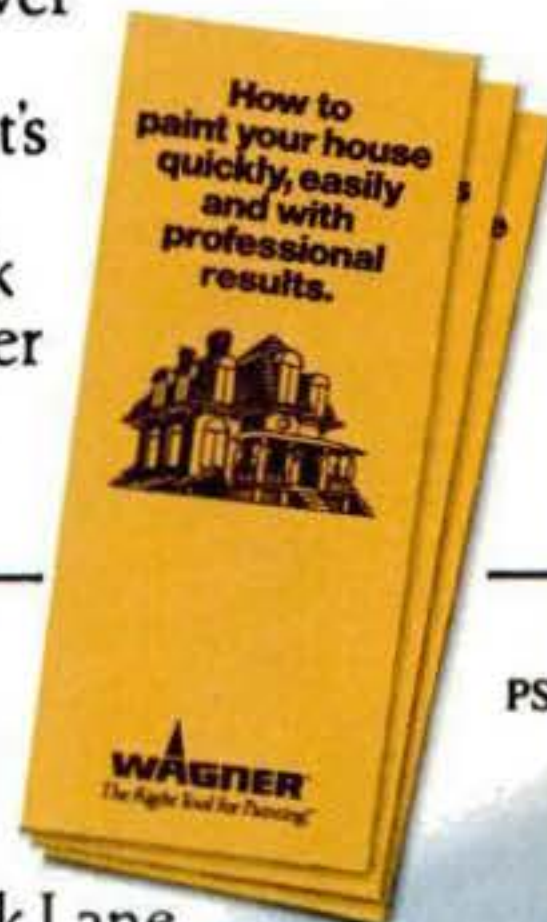
But rather than simply reading about a Wagner Power Painter, we suggest you visit your local hardware store, paint store, home center or wherever quality paints are sold.



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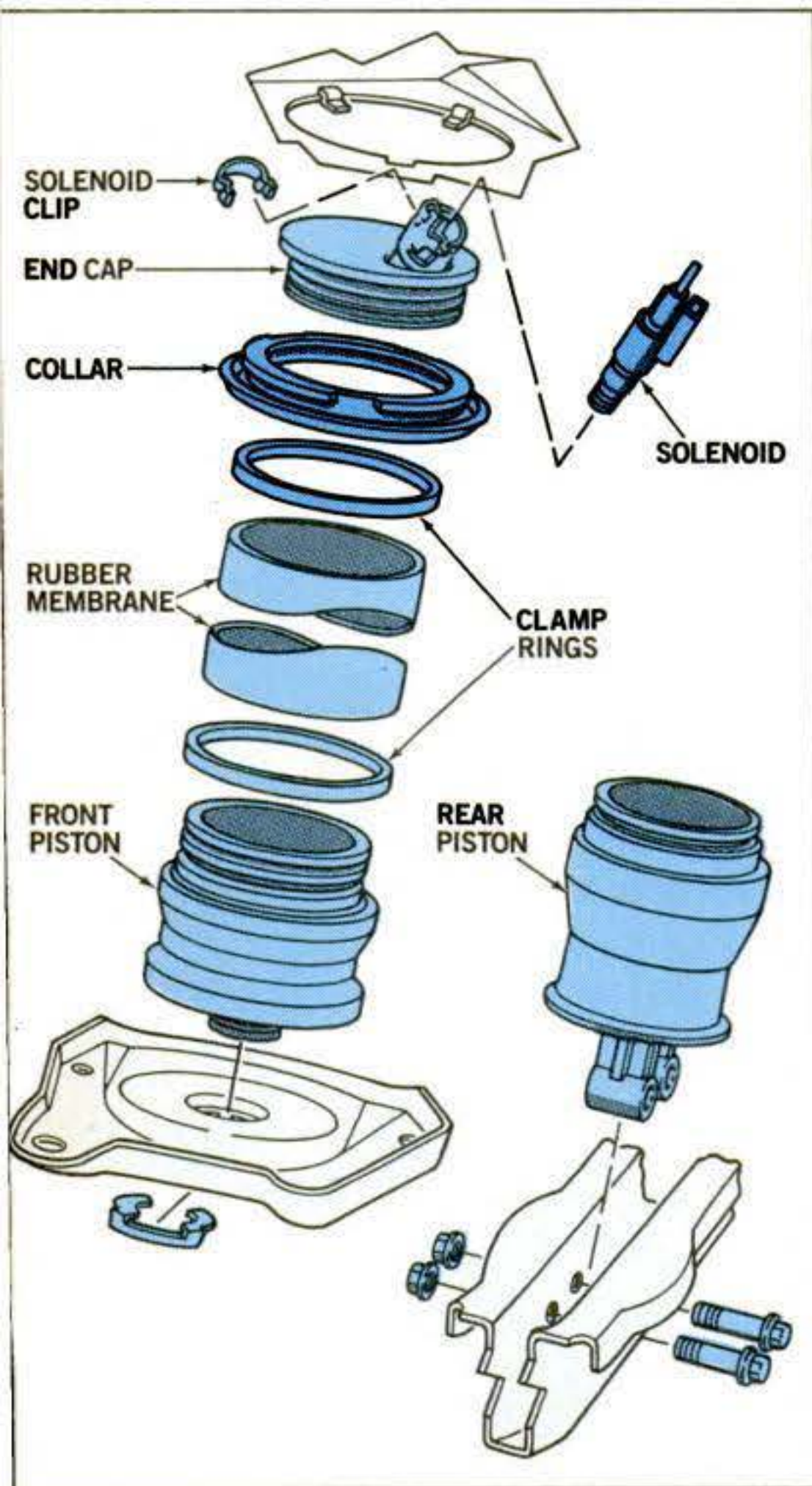
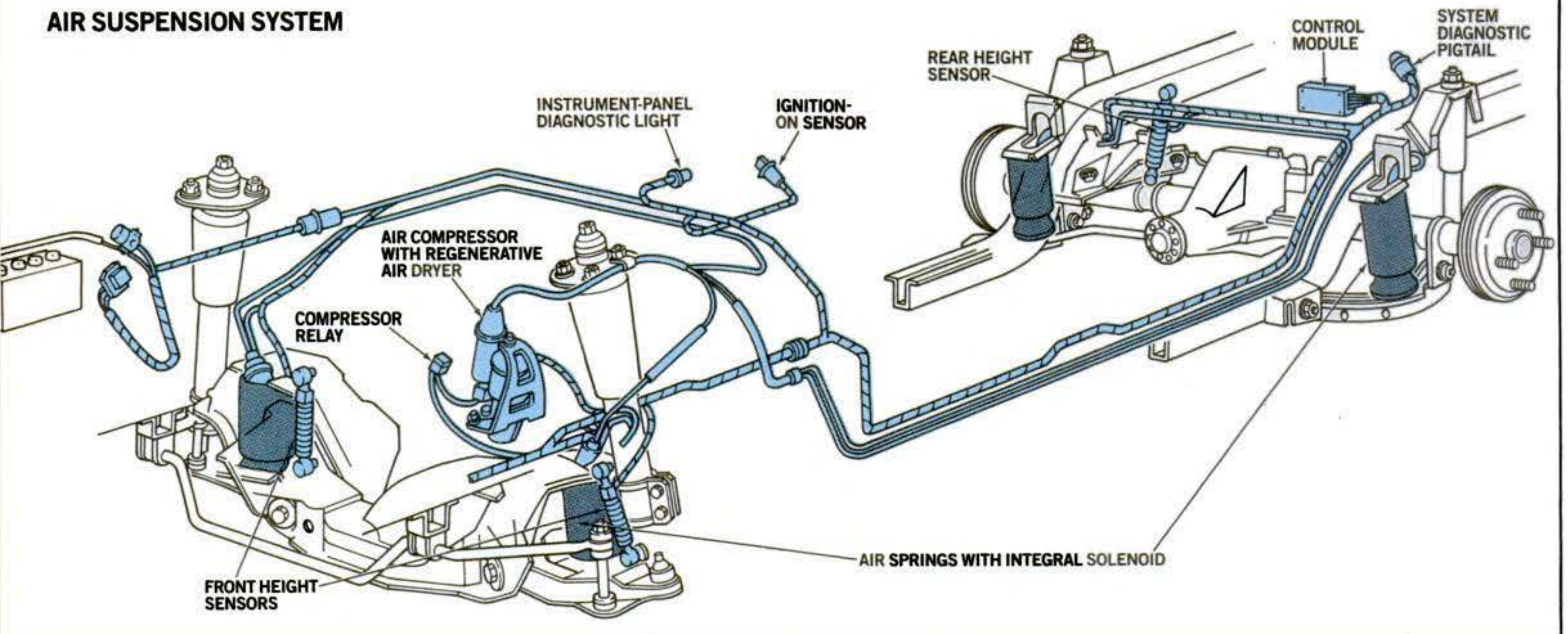
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AIR SUSPENSION SYSTEM



Air-ride components (top) are shown in their chassis locations on the new unit-body Lincoln. There are no complicated mechanical linkages. Two sensors at the front and one at the rear signal the microprocessor when adjustments are needed in vehicle ride height. The illustration (far left) reveals the simplicity and scant number of parts in the spring. Front (left) and rear springs are shown in the photo above. Internal pressures range from 65 to 100 psi.

185,000 without a single failure.

Modern materials were also cited as a reason for confidence in the new technology. Today's leak-proof compression fittings and less-permeable plastic tubing are two examples. Another is the spring's piston and end cap, made of composite plastic instead of cast aluminum. It's lightweight, less permeable, cost-effective, and more than strong enough, Ford and Goodyear claim.

The new air-suspension system has the added benefit of actually being

mechanically less complicated than the original late-'50s setup. That means, despite the electronics, easier maintenance and service.

The springs themselves are simply pressurized rubber cylinders. However, they are quite unlike a balloon. Tom Burkley, Goodyear's chief engineer for air springs, compared their construction to that of a two-ply tire. "They can take a heck of a lot of impingement from the road and are extremely resilient. Sharp stones just bounce off."

If they are damaged, however, they cannot be repaired. Fortunately, replacement is a snap. "An experienced guy in a garage could change one in about 10 to 15 minutes," claims Ford's Chance. Changing a steel coil spring is a lengthy and possibly dangerous procedure.

The Ford-designed microprocessor is probably the most complicated part of the system and, like any other component, could fail. We're all aware that computers aren't the type of thing you trouble-shoot with a screwdriver and wrench. Hank Fresch, the Goodyear engineer who coordinated the air-spring program with Ford, explained the computer's self-diagnostic system. "There's a diagnostic procedure programmed into the processor. The garage mechanic simply grounds a pigtail in the computer's wiring harness located in the trunk. By counting the flashes of a dash-mounted light, he can check the function of each height sensor and the solenoids or even check for blocked or pinched air lines."

An advantage that surprised me was the suspension's ability to provide sound isolation from the road. Sound isolation is a major problem for unit-body cars. During my test ride, I tape-recorded the car's 60-mph passes over sections of badly broken concrete. When I played the tape back later, I expected to hear the thunder of the car's suspension as it jounced and rebounded over the rough surface. Instead, there was silence, except for quiet conversation with the test driver and the sound of the seat belts creaking as we shot through the pylons on the handling course.

Come 1984, Ford will make "It's like riding on air" a reality and not just a tired advertising slogan. **ES**

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Camera-recorder uses standard Beta cassettes



Aim-and-shoot BetaMovie camera-VCR combination eliminates connecting-cable and shoulder-strap snarls. Prototype portable records but does not play back.

I spotted a BetaMovie as I approached Sony's booth at an electronics trade show. It looks like a slightly bulky eight-mm movie camera. But the Japanese firm's newest marvel is bad news for film-camera makers.

The 5.5-pound BetaMovie is a combination color-TV camera and VCR. Snap a standard L-830 Beta video cassette into it and you can record three hours and 20 minutes at Beta II speed. (A battery charge lasts one hour.)

Sound good? There's a slight twist. You'll need a Beta-format VCR at home to play back BetaMovie tapes. Sony—and other firms introducing the one-piece camera-recorder—designed it for camera recording only.

Sony's announcement of the BetaMovie stresses that no special playback adapters are required and that the portable was designed without changing the Beta cassette's size. That's a swipe at its nearest competitor, the VHS-C format ["The New VCRs," PS, Nov. '82].

VHS-C, being sold by a few firms, is a cigar-box-size deck that uses a special card-deck-size, 20-minute cassette. VHS-C cassettes need an adapter for playback in home VHS decks. A shoulder mount lets you combine a camera and VHS-C deck in one package. Stay tuned: The all-in-one camera-VCR war is just beginning.—
John Free

DETROIT REPORT

By JIM DUNNE



Concept 100

That's what Ford is calling this new show vehicle. Two of its more interesting features are sonar-detection and satellite-navigation systems. In the detection system, lights inside the car tell the driver how close the front and rear bumpers are to an obstruction, an assist that makes parking, among other things, easier. Sonar beams, emitted from and received in the bumper face, detect all solid objects, including pedestrians. The series of colored lights informs the driver of the approximate distance between the object and the bumper—red for close, yellow for a few feet, white for farther away—and on which side the obstruction lies.

The satellite-navigation system is called Trip-monitor. It uses a nine-inch-diagonal, eight-color TV screen in the center of the instrument panel. The driver calls up map displays on it that pinpoint the car's location to within 400 meters (1,312 ft.), anywhere in the world. A car-location indicator on the screen moves as the car is driven, enabling the driver to plot a route on the map.

Pontiac aluminum V6

Already supplying General Motors with its highest-volume four-cylinder—the 2.5-liter (152.6 cu. in.) "Iron Duke"—Pontiac has embarked on a new project that may provide its sibling divisions with a V6. It's an all-aluminum type that displaces 2.8 liters (171 cu. in.) and can be used across the line in compact and full-size GM sedans. The block is a die casting. It doesn't use iron liners for the cylinder walls. The aluminum is silicone-impregnated Reynolds 390, the same material used in Vega and Porsche engines. Prototypes of the engine have been tested for more than three years. If Pontiac gets the okay from GM management, it could be in production within 18 months. Look for this engine to be featured exclusively in Ponti-

ac's sporty STE and Fiero before it's available to Chevy, Buick, and Oldsmobile.

New Z

One of the most interesting new models due from Japan is the Datsun/Nissan sports car that will replace the popular 280-ZX. It's reported to be a completely new sheet-metal design powered by a V6 displacing three liters (183.1 cu. in.). The new power plant replaces the in-line six that helped establish Datsun's reputation more than a decade ago.

Riding on air

Although the Lincoln will be the first production model to have the new air springs ["Air Lift for Cars," this issue], GM and Chrysler are also moving toward this type of suspension. Like Ford, the two makers will install them on big cars first. Later, they could show up on smaller models. Smaller cars with lower curb weights will probably benefit more since air-adjustable springs can restore the design height of even an overloaded subcompact. Look for auto makers to install them at all four corners where possible. (In some small cars with front drive, space restrictions under the hood will limit air springs to the rear.) Spring for spring, the air-inflatable costs about a third of the cost of the metal-coil or torsion-bar types. But compressors, sensing devices, and microprocessors boost final costs higher.

High swirl

It's the latest trend for combustion-chamber designers. High-swirl combustion—Ford calls it HSC—is a technique that speeds up the movement of the air-fuel mixture inside the combustion chamber. Ford uses it in the Tempo/Topaz four. Pontiac is planning to use a similar technique in the 1984 2.5-liter (152.6 cu. in.) four it builds for GM's compacts and mid-

size cars. Chrysler will adopt the system for its 1.8-liter (109.8 cu. in.) four set for 1985. High-speed induction of the air-fuel charge results in better distribution of exhaust gases that are reintroduced into the engine. It also enhances mixing—and therefore burning—of the air-fuel mixture. In addition, this allows the use of a higher compression ratio for greater power output and fuel economy. Pontiac will raise the compression in the 2.5 from 8.2:1 to 9:1—a significant difference.

Bigger front-drives

Ford's next major project will be a complete overhaul of its full-size sedan lines. Front-wheel drive will take over completely in 1985. The V6 engine will probably be the only engine offered in these models. That's because the company's current V8 may be too long to fit crosswise under the hood, and a four would be too small to furnish the performance big-car buyers prefer.

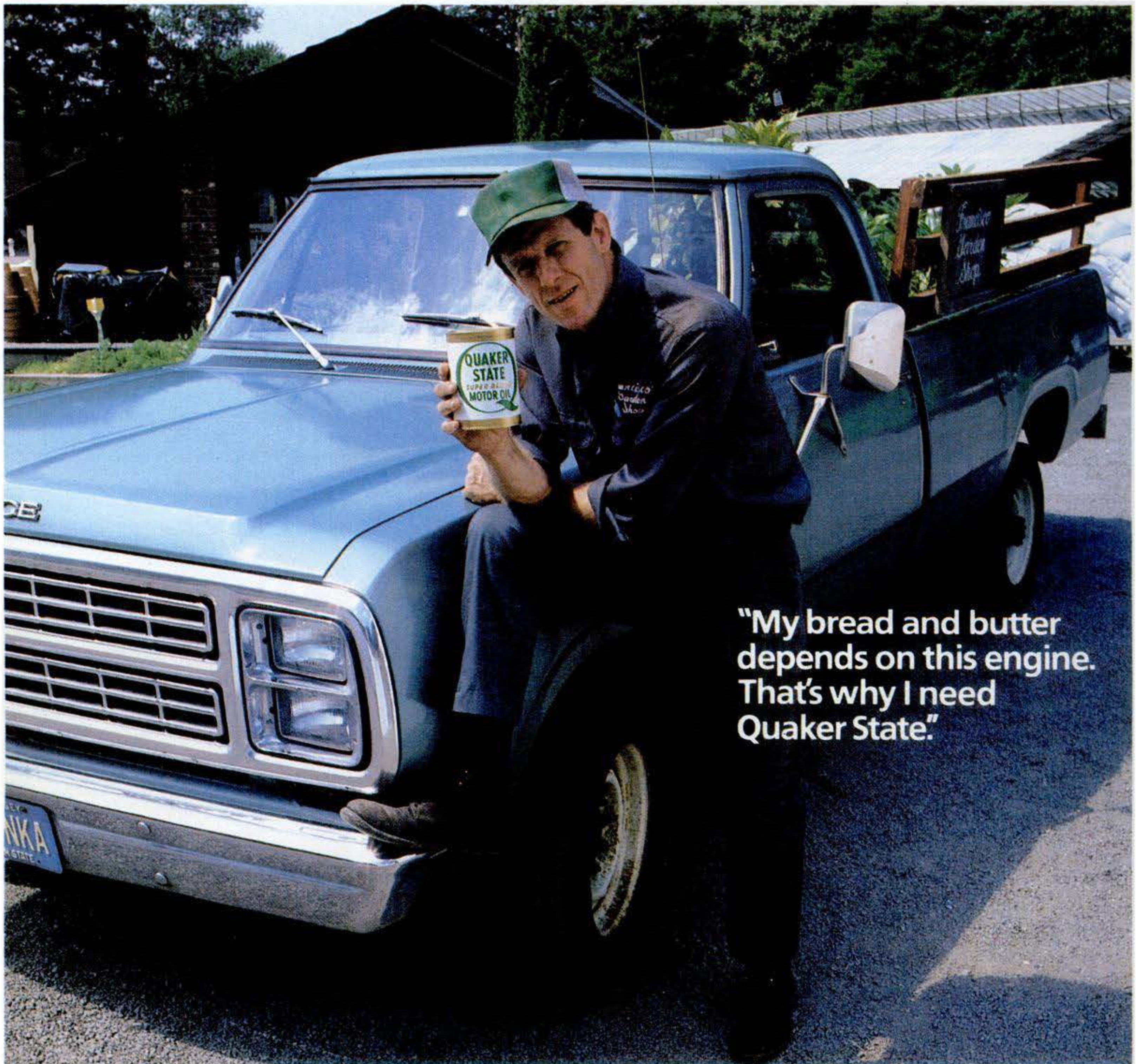
Details about the cars are scant, but it is known that six-passenger capacity and luxury appointments will be carried over. Though the big sedans will join Escort and Tempo as front-drives, sporty models, such as Mustang and Thunderbird, will retain the rear-drive layout. Chassis experts and the racing set tend to agree that rear drive offers handling advantages during aggressive driving. For example, the weight transfer to the rear of a car during hard acceleration provides greater traction for rear-drive cars.



Pressure's on

Firestone is currently testing its own version of a rubber-and-fabric spring that may be used in cars and trucks of the future. They look like long rubber barrels and stand as high as coil springs (photo above). They are also about the same diameter as coil units. Long life and precise tensioning are the major benefits; however, noise absorption, ease of handling, and lighter weight are also some of their prime features. 13

"Today, you need an oil this good."



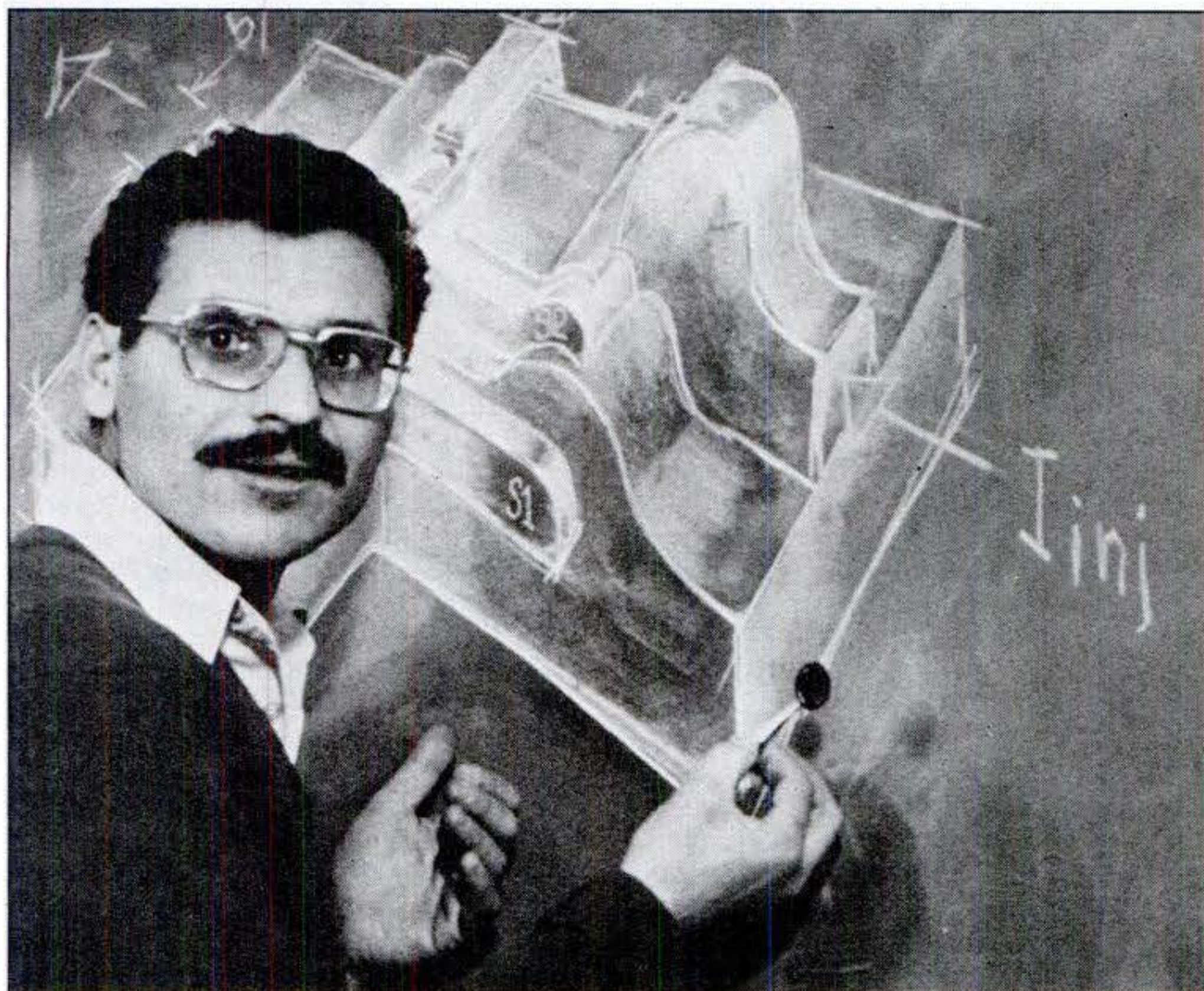
"My bread and butter depends on this engine. That's why I need Quaker State."

When you make a living with your vehicle, a costly breakdown can put you out of business. To keep your engine and business running smoothly, you need Quaker State quality. These Quaker State motor oils are made exclusively from Pennsylvania Grade Crude Oil. They offer quality protection for your vehicle. Quaker State: so good, it's America's best selling motor oil.

Quaker State



By ARTHUR FISHER



Superconducting quiteron

A new cryogenic device that acts like a semiconductor transistor but operates on entirely different physical principles has been invented at the IBM Thomas J. Watson Research Center by Sadeg M. Faris, shown in the photo above holding a wafer of experimental samples. Like a conventional transistor, the quiteron can amplify and invert incoming signals and switch rapidly. But it works at much lower power-dissipation levels, about a hundredth that of state-of-the-art high-speed semiconductor transistors. This makes it a natural for highly integrated high-speed circuits, where elements must be packed very tightly together and heat dissipation becomes a problem. In addition, it could be scaled down to a dimension of only a millionth of a meter on a side.

Quiterons make use of the phenomenon of superconductivity, in which various metals lose all resistance to a flow of electric current at temperatures near absolute zero, -273 degrees C (-459.4 F). The device consists of two tunnel junctions formed by three thin films of superconducting materials separated from one another by two even thinner films of insulating materials. Its operation depends on a non-equilibrium superconductivity phenomenon called, unfortunately, the heavy-quasiparticle-injection-tunneling effect, from which the name quiteron was

somehow derived. Incidentally, all this is quite different from another superconducting device that IBM, among others, is developing: the Josephson tunnel-junction switching device.

A first for einsteinium

Few people know that the chemical symbol Es stands for einsteinium, element number 99. Fewer still have ever seen any. Named for the great physicist, einsteinium was discovered in 1952 in the remains of a hydrogen-bomb explosion by workers in the various laboratories of the U.S. Atomic Energy Commission. One of the elements in the actinide series of the periodic table, it does not exist naturally and can only be formed by artificially transmuting the nuclei of lighter elements in nuclear reactors—and then only in very tiny quantities. Like all of the other actinides, einsteinium is radioactive and unstable: One of its principal isotopes has a half-life of only 20 days.

Because of this scarcity, the chemical and physical properties of the metal had never really been measured adequately—until now. Radiochemists at Los Alamos National Laboratory used a vaporization technique to deposit minute samples on targets for analysis. They used less than 100 micrograms, then the Western World's entire supply.

"Los Alamos has the ability to work

with very tiny quantities of materials," says John Ward of the Lab's Materials Science Technology Division and head of the project. "We have obtained precise data on our targets from as little as one-trillionth of a gram of material.

"Two of the fascinating things we discovered," says Ward, "are that einsteinium is clearly a divalent metal . . . and also that it is more volatile . . . than barium or calcium. We had considered those to be the most volatile divalent elements."

The transplutonium actinides (those that come after plutonium in the periodic table) may someday be used as power sources to replace bulkier plutonium sources in remote power stations, as radiation and neutron sources, and as diagnostic tools for medical treatment.

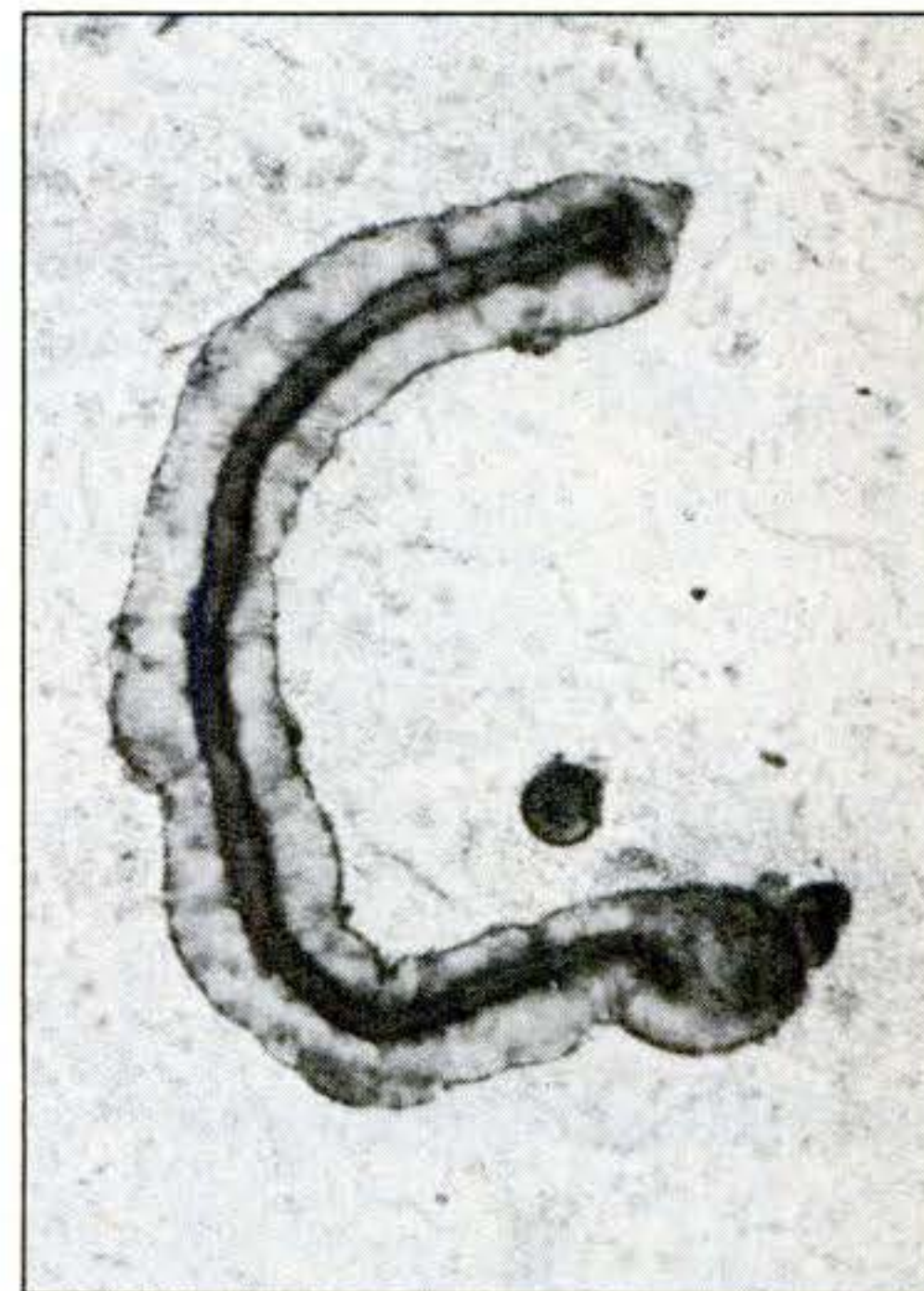
World's smallest holes

Researchers in the University of Illinois Materials Research Laboratory have used the focused electron beam of a scanning-transmission electron microscope to drill the smallest permanent holes ever in crystalline specimens. The holes are only 20 times the diameter of a hydrogen atom, which is one angstrom.

Toxemia cause found?

The 100-year-old mystery of toxemia of pregnancy may have been solved with the discovery of a previously unknown wormlike microorganism, shown in the photo below. The disease is the second most important cause of maternal and fetal death, after hemorrhage, affecting 300,000 women with 24,000 deaths in the U.S. alone. It may cause as many as five million deaths worldwide each year. Two medical researchers at Loyola University Medical Center, Dr. Silvio Aladjem and Dr. Judith Lueck, now believe they have isolated the causative organism, which they have named *Hydatoxi lualba*. Dr. Lueck first observed the organism in the placental tissue of toxemic mothers and later in the circulating blood of toxemic patients. When she and Dr. Aladjem injected preg-

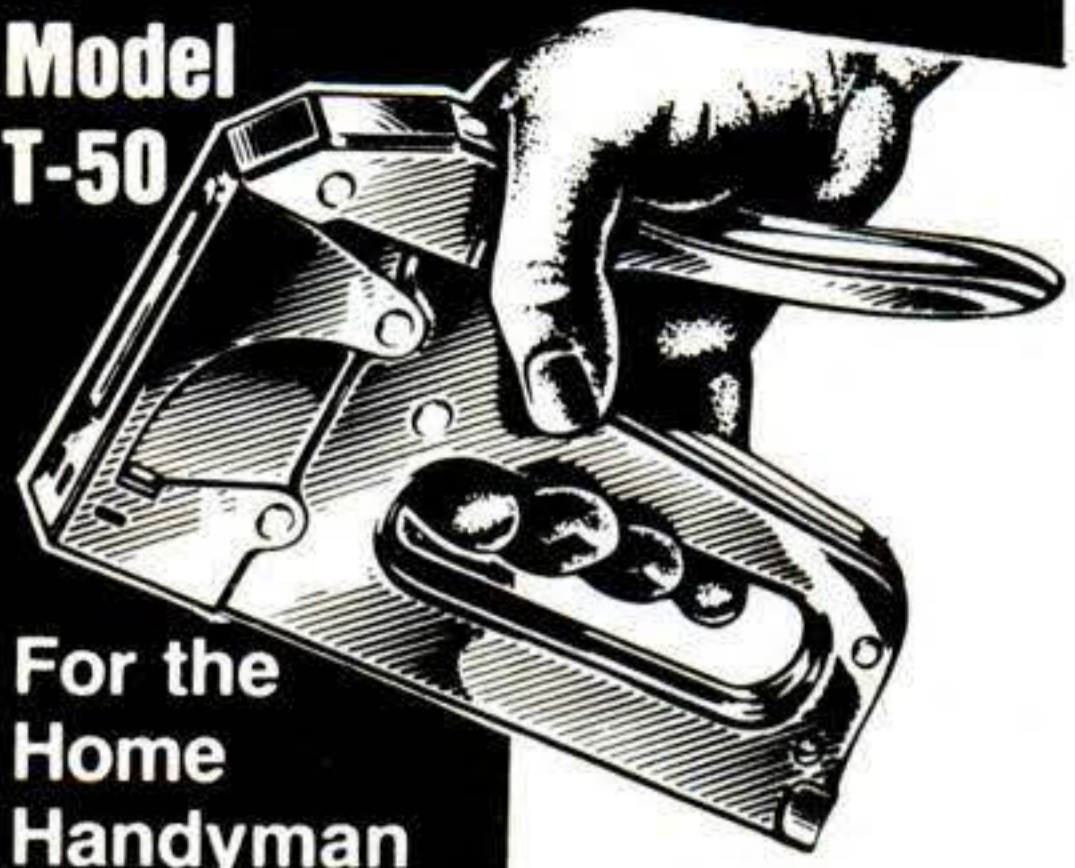
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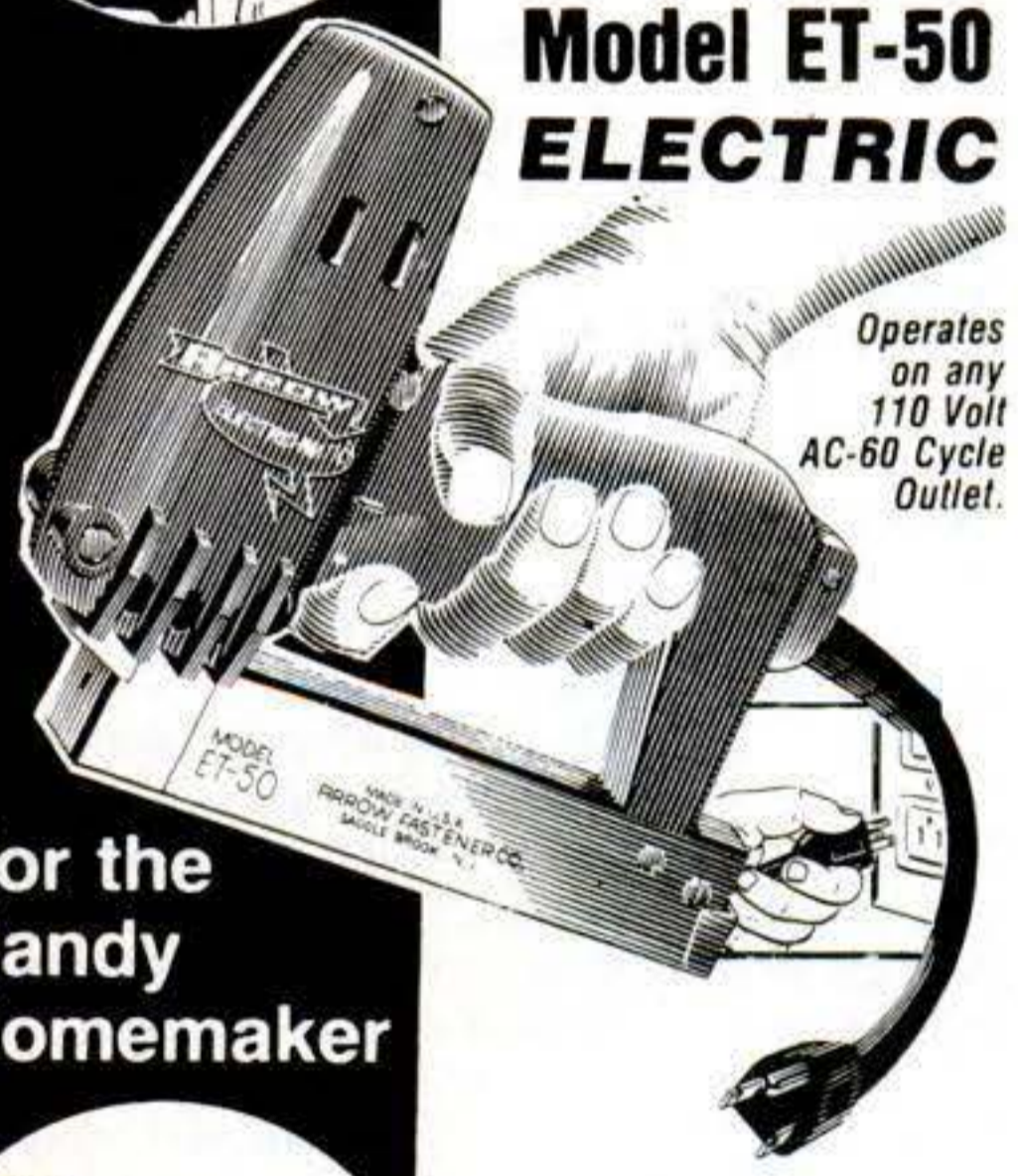


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nant animals with material containing *Hydatoxi*, the animals developed toxemic symptoms. Other experts caution, however, that these results require further checking for confirmation.

King Tut in the desert

Colonel Mohey Hussein, chief designer of the King Tut solar-power project, checks an array of solar-collector tubes (above left) to be used in an ambitious plan to irrigate a patch of the Egyptian desert using heat from the sun. The system uses 1,000 such tubes in a structure 55 meters (180 ft.) long. Sunlight is focused by an internal curved aluminum reflector onto a heat pipe, and the heat is used to vaporize Freon. The expanding vapor drives a modified multivane compressor, which in turn drives an irrigation pump. The new solar generator was designed at England's Cranfield Institute of Technology.

Tevatron magnet

Designers at the Department of Energy's Argonne National Laboratory have built a new kind of magnet that will be used to guide beams of particles at the Tevatron, which will be one of the world's most powerful atom smashers when it is completed in the mid-1980s.

The new magnet weighs three tons and is about 10 feet long. Its peak magnetic-field strength is five tesla—about 150,000 times stronger than Earth's but not by any means the strongest ever built. The principle of the magnet is that the field along the central axis of its cylindrical cavity is zero. The charged particles in an accelerator beam that do not travel along the axis encounter an ever-increasing magnetic field that repels them back toward the center, like so many frisky sheep being herded in the desired direction. The magnet conductor is a coil of superconducting niobium-titanium alloy. When cooled to near absolute zero, the coil loses all resistance to electric current. Thus intense magnetic fields can be sustained at low electric-power costs.



The Tevatron, being built at Fermi National Accelerator Laboratory near Argonne, will generate beams of particles with collision energies of one TeV, or one trillion electron-volts. It will be used to study the fundamental forces in nature [see "Cosmic Order," this issue].

Welsh wind power

This 200-kilowatt wind turbine in South Wales (above right) is Britain's first to generate electricity for the national grid. Built for the Central Electricity Generating Board by James Howden, a Scottish engineering firm, it will generate about 380,000 kW a year, enough to satisfy the electricity demands of a small village. The Board plans to order a larger, four-MW turbine this year.

The computer-operated turbine is 80 feet high. Special drag flaps on the blade tips shut it down automatically in storm winds or if vibration develops.

More solar water splitting

Two physicists at Bell Laboratories in Murray Hill, N.J., have developed an unusually efficient solar electrochemical system for splitting water into hydrogen and oxygen. Adam Heller and E. Aharon-Shalom use two electrodes immersed in a bath of perchloric-acid solution. The anode is made of titanium coated with ruthenium dioxide. The cathode is made of indium phosphide coated with a 10-angstrom-thick layer of rhodium.

This is one of the large breed of water-splitting "batteries" in which an external voltage must be applied. When it is, hydrogen gas is given off at the cathode and oxygen at the anode. But when sunlight shines on the system, a lower voltage can be supplied.

In the latest guise of the system, the rhodium film on the cathode is allowed to become saturated with hydrogen. This produces an alloy that passes a flow of electrons into the indium phosphide layer beneath it. And that, in turn, increases the system's efficiency to 16.2 percent. **ES**

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And comforts Skyhawk has aplenty. Its surprisingly spacious interior environment is enhanced with amenities in the best Buick tradition.

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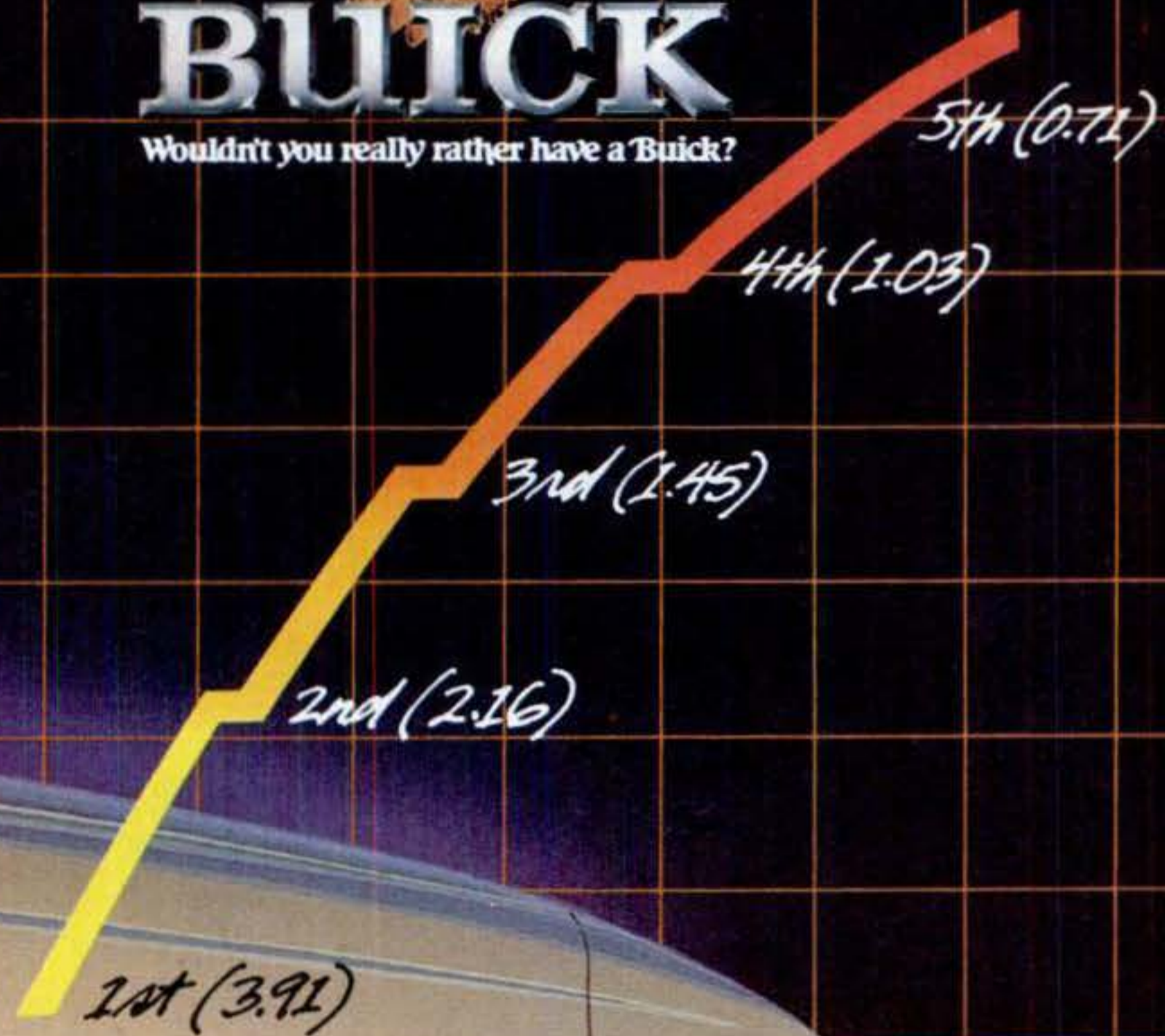
To sample how this remarkable Skyhawk flies, we suggest a visit to your Buick dealer. Some Buicks are equipped with engines produced by other GM divisions, subsidiaries, or affiliated companies worldwide. See your Buick dealer for details.

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BUICK

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SkyHawk



By **JIM DUNNE**
and **JACK KEEBLER**
PHOTOS BY GREG SHARKO

Detroit's performance coupes

—stylish and fast,
plus mileage in the 20s

One prominent trend in today's auto market is the boom in muscle-car sales. While demand has not matched that of the early '70s, the resurgence is a clear sign that buyers still yearn for excitement.

We selected three samples of this trend—Chevrolet Camaro Z28, Pontiac Firebird Trans Am, and Mercury Capri RS (a Mustang GT twin)—for this month's comparison test. Each of the cars was equipped with the biggest engine available—identical 305-cu.-in. V8s in the GM cousins and a 302 V8 in the Capri—and each had a five-speed manual transmission.

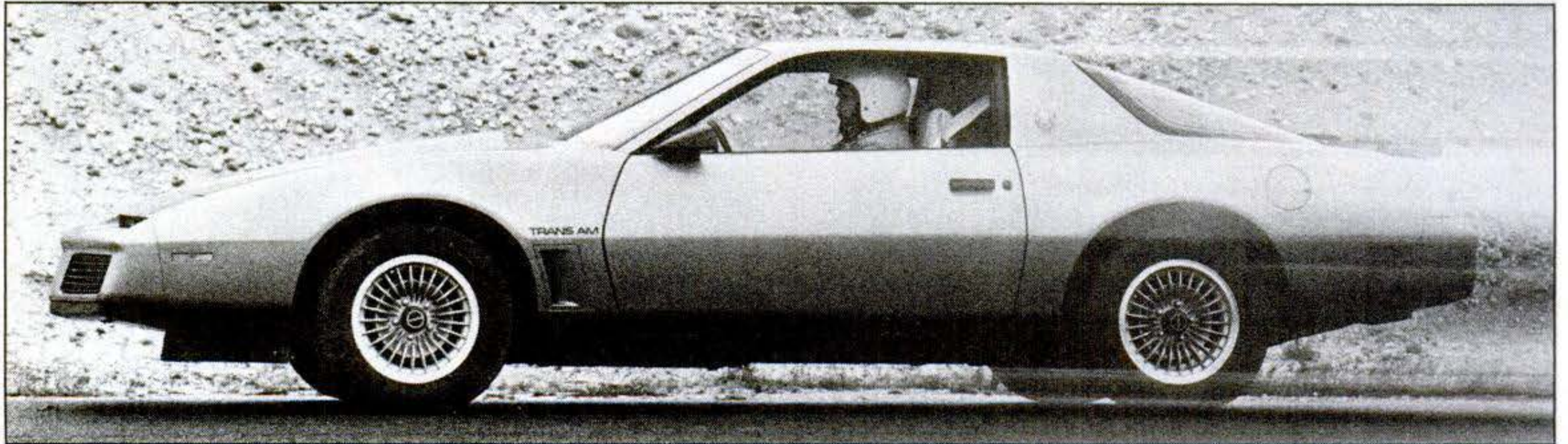
The results: There's a big difference
[\[Text continued on page 28\]](#)

For specs and test results, see page 26

Three old rivals were tested by PS. For a long time, emission and fuel-economy re-

quirements made performance vehicles shadows of their former selves. Now,

sporting quality returns (from top): Firebird Trans Am, Camaro Z28, Capri RS.





35 KILO

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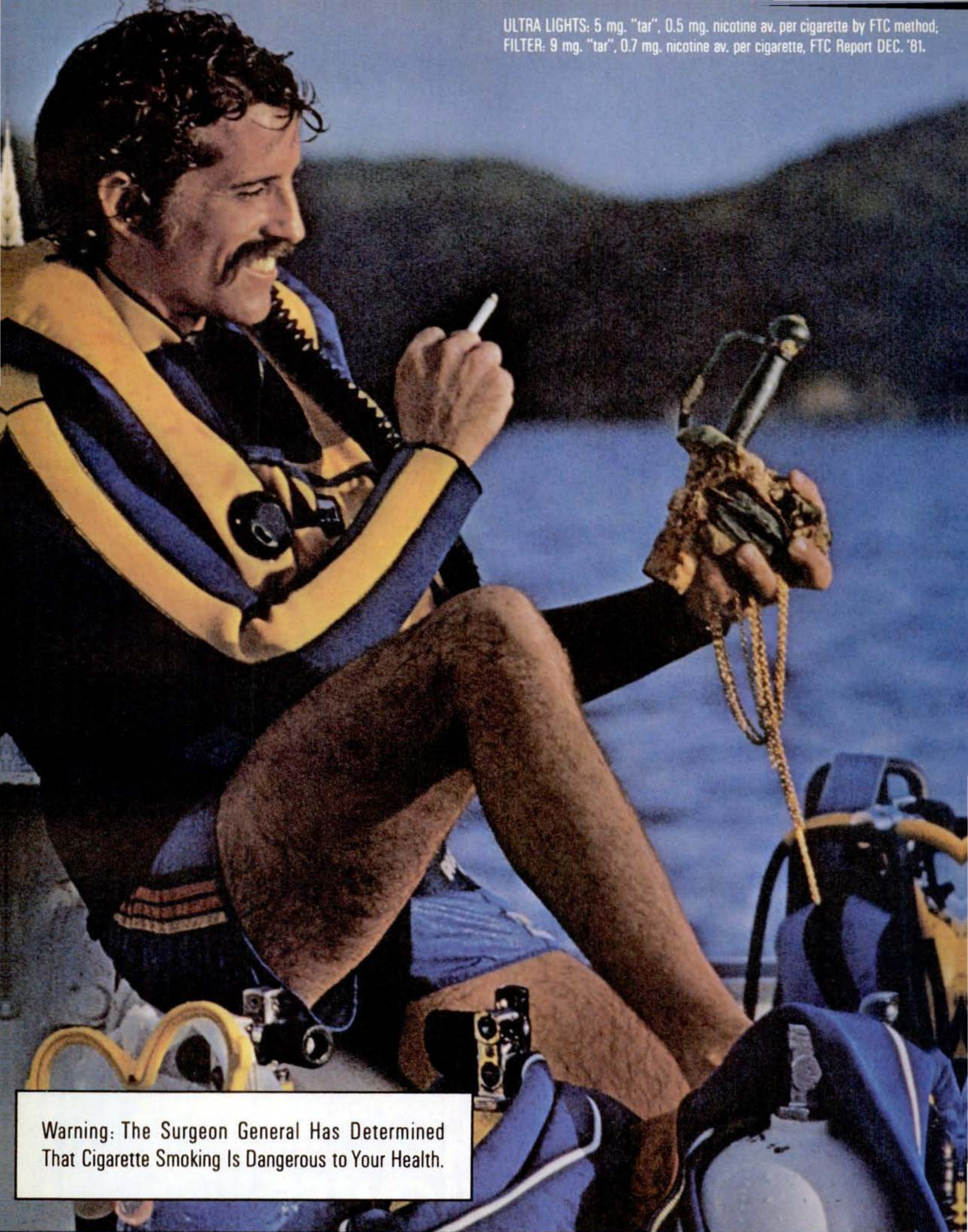
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BE ALL YOU CAN BE.**

*Military Police

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A rich reward.

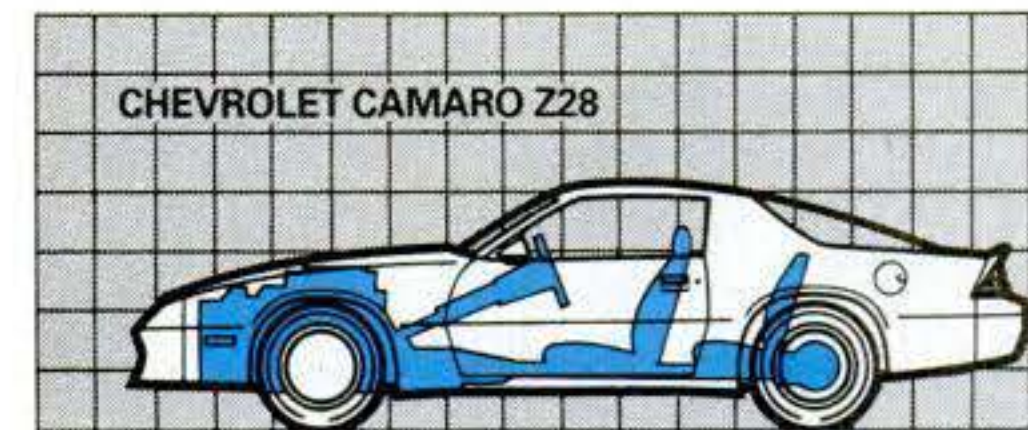
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You're tasting success and it sure tastes good.

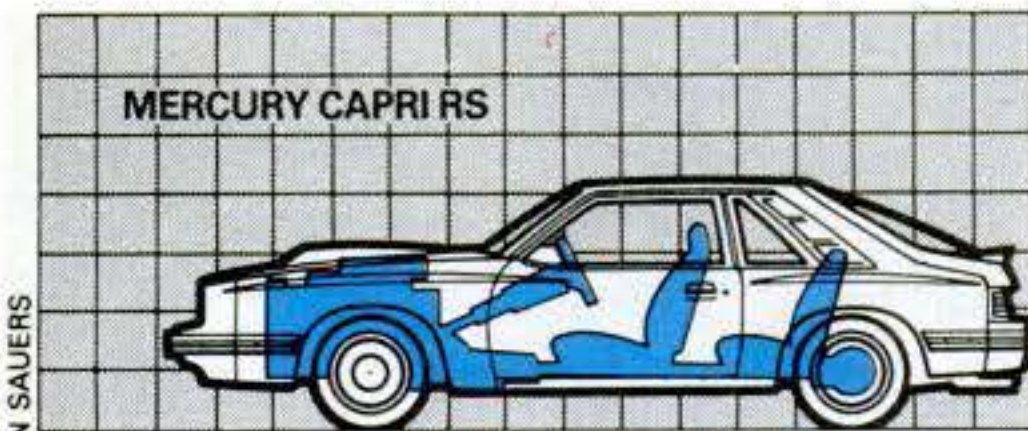
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THE TASTE OF SUCCESS.*



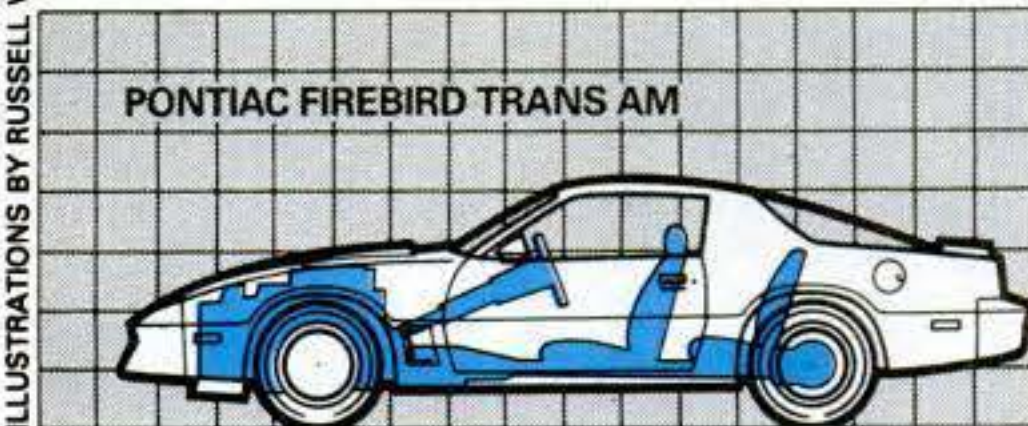
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CHEVROLET CAMARO Z28



MERCURY CAPRI RS



PONTIAC FIREBIRD TRANS AM

ILLUSTRATIONS BY RUSSELL VON SAUERS

Sleek side views don't reveal the fact that Capri has a significantly larger rear seating area than the GM models. The big V8s upset the front-to-rear weight ratio, but the efficient, reliable, and powerful engines are a welcome relief from overtaxed sixes and buzzy fours.

PS serviceability ratings

How easy is it to service our test cars? For example, is that heater hose clamp out in the open where it can be reached easily? To give you an approximation of how difficult it is for a typical person to perform various service operations on the cars, we examine each vehicle. Here's what the numbers mean: 1, very difficult; 2, difficult; 3, average degree of difficulty, no worse or better than most other cars; 4, easy; 5, very easy.

	Camaro Z28	Capri RS	Firebird Trans Am
Checking fluid levels			
Battery	4	5	4
Master cylinder	5	4	5
Windshield washer	5	5	5
Engine oil	3	1	3
Coolant	5	5	5
Checking the engine			
Spark plugs	1	1	1
Distributor	1	1	1
Oil filter	2	1	2
Oil fill	3	2	3
Replacing hoses			
Upper radiator hose	3	4	3
Lower radiator hose	1	3	1
Heater hoses	3	3	3
Changing bulbs			
Headlights	4	3	5
Taillights	2	2	2
Front running lights	3	3	3
Front parking lights	3	3	5
Front directionals	3	3	5
Rear directionals	2	2	2
Rear running lights	1	2	1
Checking fuses	3	2	3
Spare-tire accessibility	4	3	4
Changing belts	2	3	2

Performance comparison with selected 1983 and earlier models

	Mpg (city driving)	Acceleration 0-60 mph (sec.)	Brakes 60-0 mph (hot) (ft.)	Handling (mph)	Maneuverability (mph)	Noise @ 60 mph (dBA)
1982 Chevrolet Camaro Z28 V8	16	10.5	158	65.0	28.6	72
1982 Chevrolet Corvette V8	14	8.4	184	59.5	27.6+	74
1982 Datsun 280-ZX turbo 6	21	9.8	148	65+	27.6+	73
1982 Ford Mustang GT V8	18	9.7	153	59.5	27.4	73
1982 Mazda RX-7 2-rotor Wankel	21	11.8	209	65+	27.6+	75
1982 Pontiac Trans Am V8	17	10.1	188	64.7	28.1	69
1983 Dodge Charger Shelby 4	28	12.7	201	66.8	31.0	73
1983 VW Rabbit GTI 4	26	12.3	153	63.0	31.5	71

Test results, dimensions, and specs

	Camaro Z28	Capri RS	Firebird Trans Am
TEST RESULTS			
Acceleration (sec.)			
0-60 mph	10.5	8.2	10.1
Brake test (cool) 60-0 mph			
Stopping distance (ft.)	197	175	192
Pedal pressure (lbs.)	40	30	40
Brake test (hot) 60-0 mph			
Stopping distance (ft.)	192	178	200
Pedal pressure (lbs.)	25	100	45
Interior noise @ 60 mph (dBA)	71	74	72
Handling test (mph)	61.9	59	61.5
Maneuverability test (mph)	27.7	26.5	27.6
EPA FUEL MILEAGE (mpg)			
Highway	26	28	26
City	16	15	16
Calif. city	18*	17	18*
PS FUEL-MILEAGE TESTS (steady-state mpg)			
35 mph	24.7	21	24.9
55 mph	21	20.2	20.9

TEST CONDITIONS: Ambient temperature, 58° F; relative humidity, 85 percent; barometric pressure, 28.72 inches Hg

*Fuel-injection engine

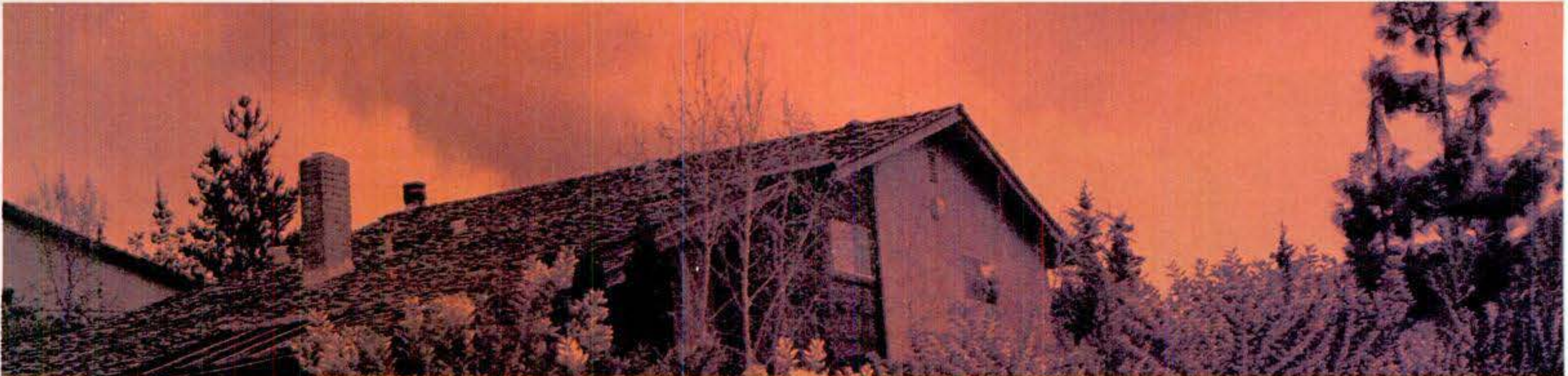
DIMENSIONS (inches)			
Wheelbase	101.0	100.4	101.0
Overall length	187.8	179.1	189.8
Overall height	49.8	51.9	49.8
Overall width	72.0	69.1	72.0
Track, F/R	60.7/61.6	56.6/57.0	60.7/61.6
Ground clearance	4.8	6.2	4.8
Front head room	37.0	37.2	37.0
Front hip room	56.3	55.9	56.3
Front leg room	43.0	41.7	43.0
Rear head room	36.1	35.5	35.6
Rear hip room	42.8	47.1	42.8
Rear leg room (min.)	28.6	29.7	28.6
Rear knee room (min.)	-0.6	-1.2	-0.6
Couple distance	26.3	27.6	26.3

SPECIFICATIONS			
Engine type	V8	V8	V8
Displacement (cu. in./L)	305/5	302/5	305/5
Compression ratio	8.6:1	8.3:1	8.6:1
Carburetion	4 bbl.	4 bbl.	4 bbl.
Net hp @ rpm	150 @ 4,000	175 @ 4,000	150 @ 4,000
Net torque (ft.-lbs.) @ rpm	240 @ 2,400	245 @ 2,400	240 @ 2,400
Transmission	5-speed manual	5-speed manual	5-speed manual
Axle ratio	3.23:1	3.08:1	3.23:1
Tire make	Goodyear	Michelin	Goodyear
Tire type	Eagle GT radial	TRX radial	Eagle GT radial
Tire size	P215/65R15	220/55R330	P215/65R15
Steering	Power, recirculating ball	Power, rack and pinion	Power, recirculating ball
Overall steering ratio	14:1	20.03-16.05:1	16.5-14.3:1
Turns, lock to lock	2.5	3.05	3.0
Turn diameter (ft.)	36.9	37.4	36.9
Front suspension	Independent, coil springs, modified MacPherson strut	Modified MacPherson strut with coil spring on lower control arm	Independent, coil springs, modified MacPherson strut
Rear suspension	Salisbury axle, coil springs	Four-link rigid axle, coil springs	Salisbury axle, coil springs
Front stabilizer-bar diameter (in.)	1.22	1.12	1.18
Rear stabilizer-bar diameter (in.)	0.82	0.55	0.47
Brakes	Power, disc/drum	Power, disc/drum	Power, disc/drum
Brake swept area (sq. in.)	307.7	275.6	307.7
Fuel tank (gal.)	16.1	15.4	16.0
Trunk space (cu. ft.)	31.2*	32.5*	31.2*
Liftover height (in.)	34.7	29.8	34.7
Curb weight (lbs.)	3,328	2,950	3,325
F/R weight distribution (%)	58/42	57/43	58/42
Basic price	\$10,336	\$9,241	\$10,396
Price as tested	\$13,271 ¹	\$10,728 ²	\$14,074 ³

Major options (over \$100) on test car

¹Power locks \$120, tinted glass \$105, power windows \$180, rear wiper \$120, rear defroster \$135, A/C \$725, speed control \$170, tilting wheel \$105, AM-FM with clock \$267, charcoal finish \$227. ²TRX tires \$327, rear defogger \$135, AM-FM stereo \$199, premium sound \$117, tinted glass \$105. ³Luggage trim \$123, rear wiper \$120, A/C \$725, cruise control \$170, tilting wheel \$105, power windows \$180, power lock \$120, power seat \$210, performance package \$229, AM-FM radio \$590.

*With rear seat folded



Haunted House

It comes through the walls. It comes through the ceiling and it comes through the floor. There's no escaping the signals.

It's eerie. As you walk through the haunted house above, you'll hear noises in the dead of night. You may hear music. You may hear voices.

And the noises don't stop when you leave the house. You'll hear them in the rose garden and by the pool. You'll hear them in bed at night while your wife is asleep. And you'll hear them while you work on your car in the garage.

If it's music you hear in the haunted house, it may sound amazingly like your favorite records, tapes or FM stereo stations. If you hear talking it may sound like an AM radio or a TV show.

GHOSTS OR POLTERGEISTS AT YOUR HOUSE TOO

Now your house can be haunted too. On the roof, in the garage or in your house, you'll hear the sounds too.

And the sounds you hear may resemble your favorite records or tapes or your TV. You can walk from room to room, lie in bed, or sit on your patio. Upstairs or downstairs, the noises are everywhere. **WHO WANTS A HAUNTED HOUSE?**

Before we determine what these supernatural noises might be, let's see if you might want your house to be haunted just like my house above.

You see, I love to listen to my stereo. But unfortunately I rarely have time to just sit down and listen. Usually, I've got a project around the house to finish.

I've got several pocket cassette players with FM. But, to be honest, I get very tired of listening to the radio station's choice of music and commercials.

Besides, I've got a large collection of open reel tapes and records that I've never copied onto cassettes. Now I can listen to **anything** hooked up to my stereo wherever I am and whatever I'm doing.

GHOST DISCOVERED

The supernatural noises I've been describing are caused by a remarkable device called the Freedom Stereo™.

It's a sophisticated VLF (Very Low Frequency) stereo transmitter that connects to your stereo, or an earphone jack on your TV, and plugs into any AC plug.

You can hear stereo transmissions anywhere in your home because VLF broadcasts pass right through walls, ceilings and floors. The left channel is broadcast at 194Khz and the right at 224Khz.

To listen to records, tapes, TV or anything else you desire, you wear a superb pair of lightweight samarium cobalt headphones with sophisticated built-in crystal locked receivers powered by 2 AA

batteries (not included) that pick up the stereo broadcasts flawlessly.

This is a professional system. It's not the kind that you use to broadcast to an FM radio. There's no competitive interference on the VLF part of the FM band. And the sound is dramatic to 14Khz.

The headphones have left and right volume controls and an on/off switch. Everything is self contained. And, there aren't even any wires.

LUXURY, SILLINESS OR NECESSITY

This system is luxury at its finest. The Samarium Cobalt headphones with mylar diaphragms produce thunderingly magnificent sound. But the real luxury is the total freedom of movement you'll enjoy.

Imagine listening to your stereo in any room in your home. I hooked up the system on a Sunday. Just the first day, I listened to my stereo while I took pictures for this catalog, then I listened while I cleaned out our pool filter.

After dinner on Sunday I usually watch 60 Minutes. But, the automatic closer on our garage door had broken and I'd promised my wife that I'd fix it.

So, I listened to 60 minutes in the garage while I installed the new closer.

the listening area. This transmitter uses what is called a loop antenna. You'll hear the dramatic broadcasts as long as you're in the loop.

I ran the wire around my house. And, I found it was really easy. On the front of the house, I just used the hooks we have for our Christmas lights and in back I ran it along the ground. The wire can be inside or out, up or down.

I also wired our back yard. It was easy too. I ran the wire along our fence on one side and down a wall on the other side. In all, I spent about an hour.

It comes with 100' of wire, which is enough to do a good size room. I want you to haunt your whole house, so I've added an additional 250' roll of wire. You can cover an even larger musical area by just adding more regular wire.

The Freedom Stereo™ is made by Cybernet which is a sister company of KLH. It is UL and FCC listed. And it's backed by Cybernet's limited warranty.

HAUNT YOUR HOUSE RISK FREE

You're free. Now you'll be able to move around while you listen to music or TV. Try the fabulous Freedom Stereo™ risk



Finally, I like to watch late night TV. My wife likes to sleep. Well, with my new Freedom Stereo™ I can listen to TV or stereo as loud as I want as late as I want without bothering anyone.

If you live with anyone who is a little hard of hearing and you're in pain from the volume level that they listen to on TV, just have them wear the headphones. They can listen as loud as they want while you listen without pain.

INSTALLATION

Just use any 'tape out' in your stereo to feed this unit. There's even a 'tape out' on this unit so you don't lose the use of your tape deck. There's also an input that matches your TV's earphone output.

OK, here's where you do some work. But, don't panic, it's not hard.

You need to run a wire (included) around

free in your own home. If you aren't 100% satisfied simply return it in its original box within 30 days for a refund.

To order your Haunted House Freedom Stereo™ risk free with your credit card, call toll free or send your check not for the discounted \$179 price that DAK originally sold it for, but because of a large cash purchase send just **\$97.50** plus **\$4** for post. and handling. Order No. 9632. CA res add 6% tax.

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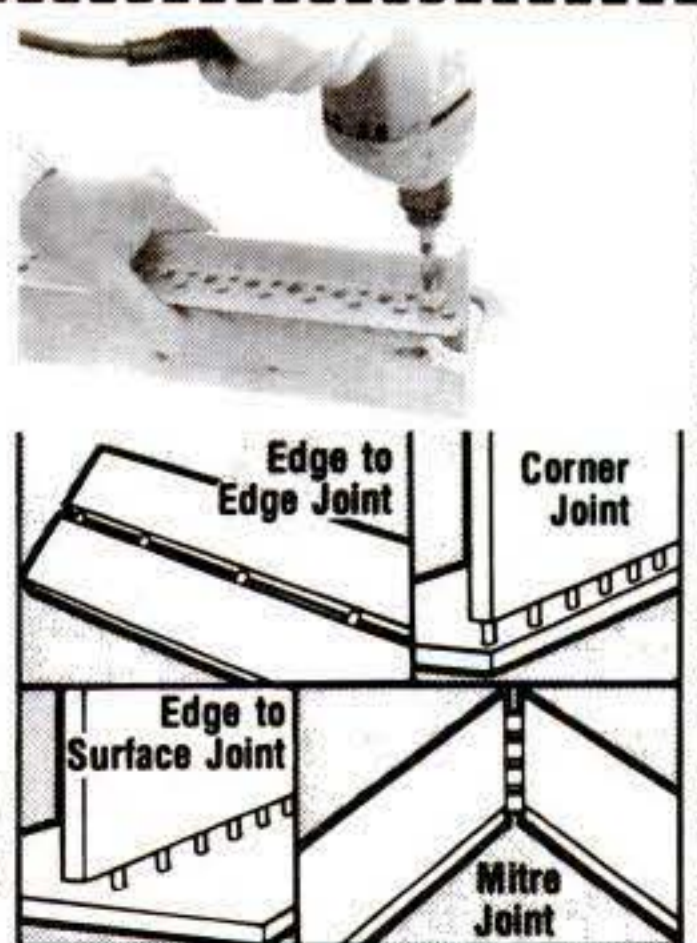
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PS car test & driving report

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.

	Camaro Z28	Capri RS	Firebird Trans Am
Acceleration	5	5	5
Braking	1	2	1
Handling	4	3	3
Maneuverability	5	4	5
Quietness	0	0	1
Roominess	3	3	3
Vision	3	4	3
Entry/exit ease	3	3	3
EPA economy	2	2	2
Ride comfort*	2	2	2

*Authors' opinion

in speed between the GM cars and the Mercury. Capri was the clear winner, zipping to 60 mph in an average of 8.2 seconds, more than a full second faster than the Mustang GT we tested last year [PS, June '82]. Firebird, with a 10.1-second average, and Camaro, with a 10.5, lagged far behind.

Closer examination of the equipment used on the test cars this year is revealing when compared with last year's models. For example, the 1982 Mustang had a two-barrel carburetor and a four-speed manual transmission. This year's four-barrel carb and the manual five-speed seem to account for the 1½-second-faster zero-to-60 time. Camaro and Firebird differ from the '82 models in using five-speed manual transmissions (instead of a four-speed manual and a three-speed automatic, respectively). Still, the zero-to-60 times were identical to those posted a year ago.

Why are the GM cars slower? We looked at three design aspects for the answer: chassis weight, real axle ratio, and engine output. Capri weighs about 300 pounds less than Camaro and Firebird. That's about 10 percent—a big advantage, admits a Pontiac engineer. But GM seems to have an advantage with a more aggressive 3.23:1 axle ratio versus Capri's 3.08:1. This is evidently offset by more-eager gearing in Capri's transmission. Finally, Ford has made some remarkable advances in engine design. The 175-horsepower output of the carb-equipped 302 is outstanding. That's in contrast to the GM 305's 150. Although GM's optional 305 with dual-throttle-body injection develops 175

Continued



Attack Phone

It's the war of the future. It's fought with all new technology. And the stakes are enormous.

It's a war. It's the Phone Company against the independents. And, your home is the battlefield.

While the independent phone manufacturers' ammunition consists of exotic new features, the Phone Company's main weapons are complacency and trust.

ASSAULT TEAM

In the forefront of the assault on the 70 million plus homes controlled by the Phone Company, is the new space age Attack Phone pictured above.

As the battle begins, let's compare the troops. You can acquire an Attack Phone in the four colors shown above. But, you can get color from the Phone Company too.

The Attack Phone has a base and a handset. And, so do the Phone Company's phones. But here's where The Attack Phone pulls ahead.

BATTLE PLAN

The Attack Phone represents the latest in electronic circuitry. It has all the latest features. One touch of its # button and this phone will automatically redial the last number you called.

There's a * button too. Hold this button, and it's like electronically putting your hand over the mouthpiece so you can talk to someone with you without the person on the telephone hearing.

But, here's the best part. The Attack Phone has a lighted hold button on its top. Touch this button and you can put the phone back in its base and leave the person you've been talking to on hold.

Then you can pick up this phone again or any phone in your house (even the Phone Company's) and just start talking.

There's more. Let's say you forgot you had someone holding or they hang up, the hold feature will drop out immediately and clear your line.

But, they aren't likely to hang up while

they're waiting, because this phone has another exciting feature. It provides the person on hold with a beautiful restful musical melody, calculated to brainwash them into being patient.

MORE EXTRAS

One of the nicest features of the Attack Phone is the push button keyboard. As you touch each key, you'll hear a beep to confirm your action. You can set its delightful electronic ring for loud, soft or off to suit your needs or mood.

The Attack Phone is a desk or counter top phone just like any other phone, but it's also a wall phone. Just screw in the two screws (included) and you've got a genuine wall phone.

It's even wired so that you can plug into an existing wall jack behind the phone or run the matched color coordinated cord to a modular jack.

You can hang up the Attack Phone by returning it to its base, touching the hang up button in the base, or the reset button on the handset.

The Attack Phone simply plugs into any standard modular jack and is totally line powered. It uses universal touch button pulse dialing that will work perfectly whether you now have rotary or push button phones.

So, how much does this incredible desk or wall phone, with hold, music and a choice of colors to match your decor, cost? Does it cost the \$3 to \$8 per month that the Phone Company charges for their dumb phones?

Not a chance. With DAK's massive cash buying power, it's yours in your choice of colors for just \$28.50.

And, you're protected. It's made by Zeta, a company you may not be familiar with by name, but a major force in cordless OEM (Private label market) phones. It's backed by their limited warranty.

And the stakes are enormous.

DAK is the largest direct selling manufacturer of magnetic products. We're proud to say we have over 240,000 customers. That's why Zeta picked DAK to introduce this phone under their name.

TRY THE ATTACK PHONE RISK FREE

Make a call. A built-in electret condenser microphone and a Mylar® diaphragm speaker let you hear and be heard with the quality of a fine stereo.

Put someone on hold. You can forget ever leaving a phone off the hook again when you go to another room. And wait till you hear the comments from your friends about the music on hold.

Try the Attack Phone in your own home risk free. 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 Zeta Attack Phone risk free with your credit card, call toll free or send your check for the incredible price of just \$28.50 plus \$2.50 for postage and handling to DAK. CA res add 6% tax. Use Order Number 9628 for Red, 9629 for Ivory, 9630 for Blue or 9631 for Gray.

Now you can match the color of your phone to your room and have a phone with the electronics of a fine stereo.

Yes, The Phone Company makes good equipment. But, there's nothing like competition to bring out innovation. The Attack Phone represents the latest in the war on the Phone Company.

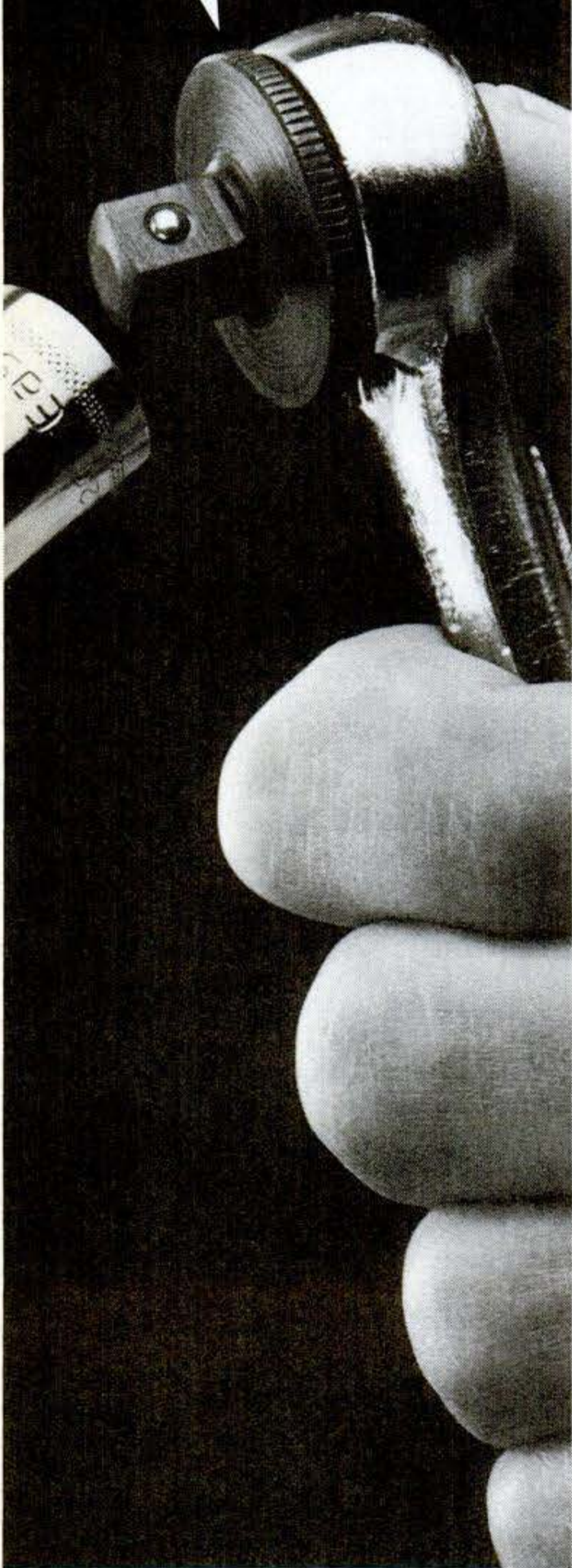


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PS car test & driving report

horses, buyers are limited to the three-speed automatic transmission. Based on tests we conducted in 1982 with a Cross-Fire Injection Z28, the best Camaro or Firebird will cut the zero-to-60-mph time by about one second—still slower than Capri.

Braking results on the three test cars were disappointing. In contrast to top marks for acceleration, the cars did not stop with comparable quickness. Stopping distances in our 60-to-zero test were below average for all three models. In measured braking, Capri ranked first with a so-so distance of 178 feet. Camaro and Firebird came in with distances of 197 and 192 feet, respectively.

Ride comfort isn't usually a top-ranked feature among sporty-car drivers. These models reflect that disregard: Road-and-engine noise is high in the passenger compartments. We suspect that this may even be "designed in" to give the driver the impression of a hard-working drive train and chassis.

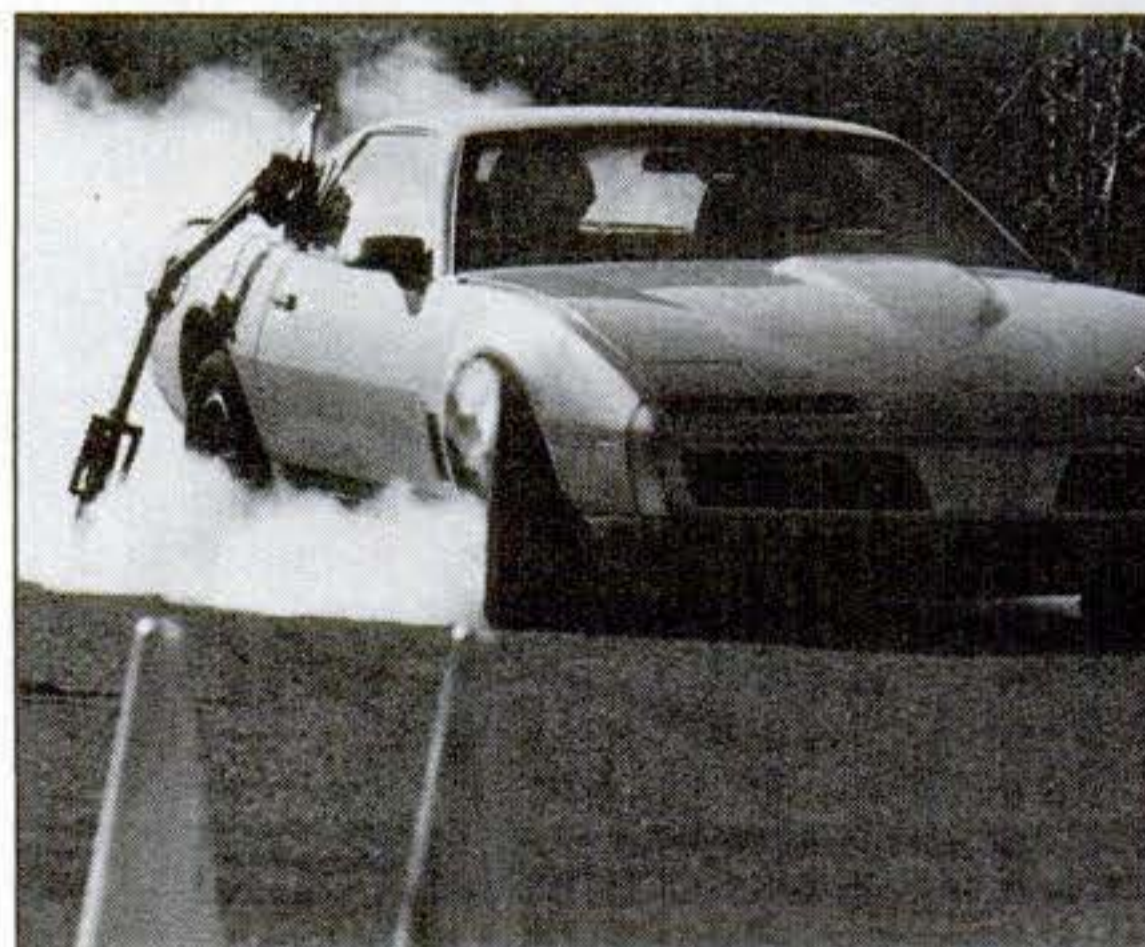
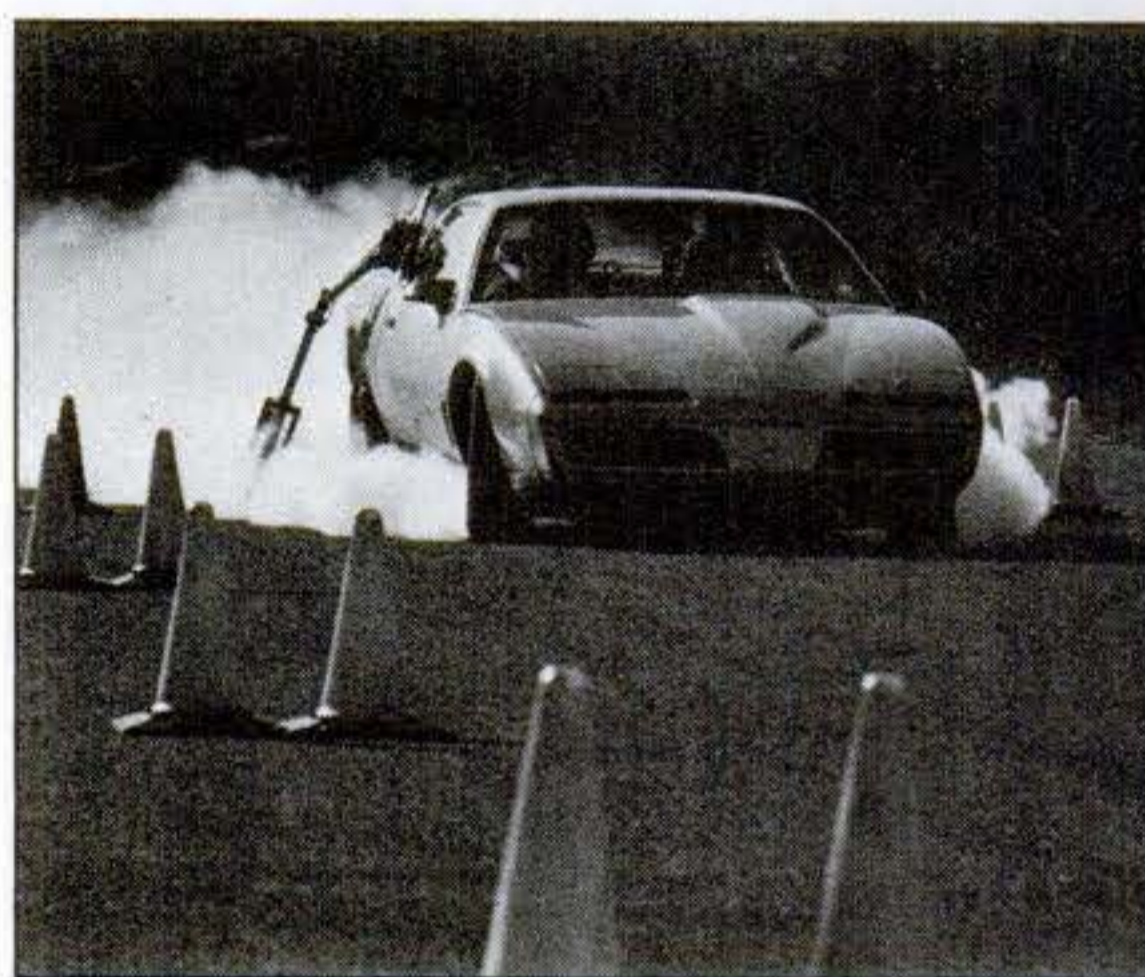
A taut chassis ride is usually a sign of good handling; however, Camaro and Firebird—and to a lesser degree, Capri—seem overly rough. On smooth surfaces, such as our test track, the ride is acceptable and handling is good to excellent. But on rougher roadways the GM bodies jolt sharply over small irregularities, and the back ends are twitchy during hard cornering. We suspect that after several thousand miles of this pounding treatment the cars may become plagued with rattles.

The fuel-economy tests were interesting. Although the 20-mpg fuel economy was a pleasant surprise, keep in mind that the economy runs are conducted on a flat, straight road with as little throttle-position variation as possible. Around-town driving consumed \$10 fill-ups as if they were salted peanuts. Here's how the cars look up close.

Camaro Z28

Camaro's relatively large size and high chassis weight go against the current trend, but GM engineered this beefy unit body to handle the power of its most muscular V8s. Inside, the front-seat area is especially wide, offering much more room than is needed for just two adults. This accounts for most of our "3" rating for roominess in the nutshell table. The rear seating area is tiny; it is *not* for adult passengers.

Continued



Firebird's rear drifts right during brake test. PS tester turns the front wheels in the same direction to keep the vehicle straight and within the brake lane.

\$49⁵⁰ 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?



It's a high fashion dress watch and a sharp looking sports watch depending on which band you use. You get two luxurious bands with this watch.

Wrist EKG



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 36, several friends 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 definitive picture of your heart and body.

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 36, my maximum heart rate is (220-36) or 184.

So when I exercise I should get my heart rate up to at least (184 X 60%) or 110 beats per minute, and no higher than (184 X 80%) or 147 beats per minute.

With the Wrist EKG to help me, I can be sure that my workouts are valuable for

my heart and neither dangerous escapades nor total wastes of time. Of course, before beginning any exercise program you should consult your own doctor.

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 Wrist EKG 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 Wrist EKG 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!

JUST LIKE A HOSPITAL EKG

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 pulsemeters that use a light shining through your finger, this instrument works just like a hospital EKG. It 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 EKG 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 professional athlete. So, they've built this watch with all the athletic extras.

It's not only waterproof, it's guaranteed down 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 Wrist EKG is backed by Innovative Time's 1 year limited warranty and comes with a 1 year battery in place.

TRY THE WRIST EKG 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 compare it with his EKG.

Why not take a copy of this ad too. Chances are that he'll also want one.

Try the Wrist EKG 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 refund.

To order your Wrist EKG, Pulse Sports/Fashion Watch, complete with two 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. 9638. CA res add 6% tax.

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



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- Protects you from the sun and rain.
- Provides a fully protected living area when combined with Coleman's screened-room option.

See this attractive, matching canopy along with all the new '83 Camping Trailers at your local Coleman Dealer today. (He's in the yellow pages.)

Offer starts April 1, 1983; only at participating dealers while promotional supplies last. Applies to all new Coleman models except Jamestown™, Jamestown™ Ltd. and Columbia™.



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"Toll-Free" calls ain't free. If you don't pay, the manufacturer *does*. Just ask Ma. Those "free" calls *must* be reflected in the selling price of the product, because there's no other way except bankruptcy.

If only 10% of those who call end up buying, a good figure, *they* pay the phone bills of the 90% who *didn't* buy. That's outrageous.

The above is from "The Book of Bugs", a free-wheeling personal statement and sales catalog written by our Head Bug. His book is outspoken, insulting, irritating, pugnacious, ascerbic, and annoyingly honest. Best of all, it's FREE.

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The five-speed-shift mechanism in Camaro is much crisper than those in past Chevrolets. Detents in the shift gate felt more certain, and gears seemed more positively engaged. However, strong muscles are still required to stir the leather-stitched shift ball.

Capri RS

Only the bubble-back window in the hatch and minor grille differences distinguish Mercury's sporty coupe from Mustang. As with the Mustang in last year's test, we found that quick starts, even on grippy, dry roads, become a matter of teasing the engine off the line, feathering the accelerator pedal, then going to full throttle once the car is rolling. Forget full-throttle takeoffs: The light rear end and plenty of torque will toast the rubber on the back rims.

Although Capri's interior looks dated compared with the high-tech decor of the other two cars, there's actually a lot more passenger room in the Mercury. This is especially apparent in the rear-seat area. All four seats also seem to be an inch or two higher than those in the GM models. This could make a big comfort difference for drivers who prefer a more upright seating position.

Firebird Trans Am

Oddly, the Pontiac's Chevy-built 305 ran smoother than the Z28's, which may be why the Trans Am proved faster than the Camaro. Other than a variation in production tolerances and possibly different divisional tuning, there's no explanation for the difference.

The driver's view is similar to that of a pilot in a cockpit, with a blackout-finished instrument panel and steering wheel. Black gauge faces with large orange and white numbers continue the aircraft theme. Our impression is that Pontiac's panel is designed to make critical information readily accessible—not as an entertainment center blinking with bright colors and flashing lights.

Our choices

I'm picking Capri this year. The hotter performance and more livable interior make a big difference. The GM's harsh ride is a turnoff.—J. D.

Although they handle well, the great looks of the GM cars promise more than they deliver. Capri's reasonable price and powerful 302 make it my favorite.—J. K.



OUTBOARDS



BIKE ENGINES




GENERATORS




PUMPS

Summer Fun Check List: ✓

sailing  motorboating


 racing cruising

star gazing fishing 

canoeing  relaxing

 water-skiing scuba

diving  snorkeling 

rowing  picnicking

exploring sailboarding

This summer, extend your family fun with a boat. Boats let you uncover new pleasures, discover new places and gain new perspectives. Boats are adaptable. You and every member of your family can do "your own thing" in a boat.

On the next few pages, you'll see a colorful variety of what's available at your local marine dealers.

Look in the Yellow Pages under "BOATS", or visit a boat show. You'll be

delighted with the choices available — in your price range.

The investment costs less than you think — and you can pay for your boat while enjoying it. What's more, unlike most things you buy, today's easy-to-maintain boats retain their values for years.



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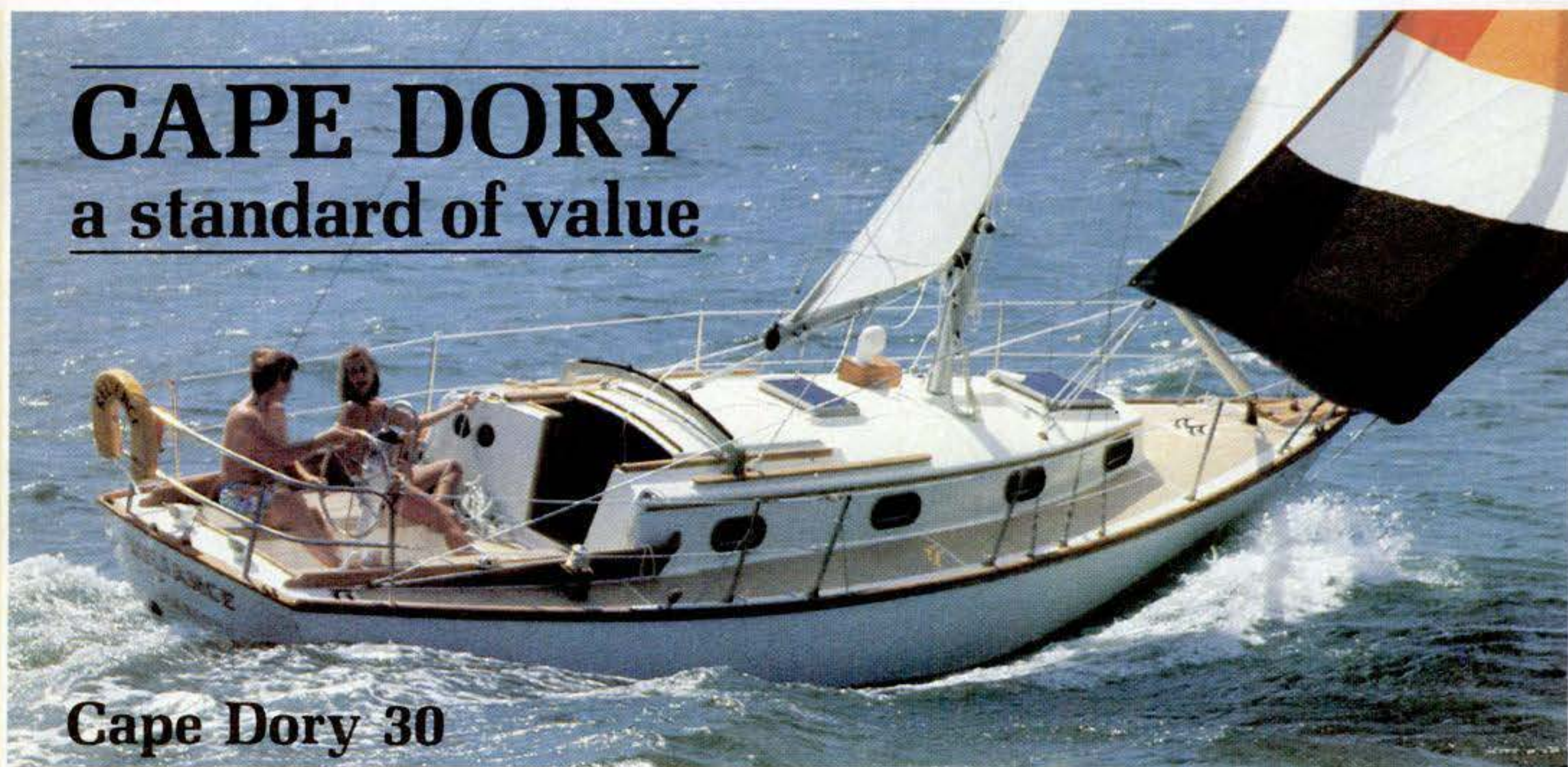
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\$6395 *Factory Authorized Special**

1600 CAPRI:
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From now until May 15 your Bayliner dealer is having a factory-authorized sale on the all-new 1600 Capri package, like the one you see here.

It's a fully-integrated package with boat, 85 hp motor and custom trailer, each engineered to work perfectly with the other, on the road and on the water.

The boat — a sister to the 19' Capri which won "Boat of the Year" honors for 1982 — seats six, features convertible top, sun-lounge sleeper seats, safety glass windshield, built-in ski storage and Bayliner's exclusive Sequential Lift™ hull for easy planing, quick performance. From the padded LeMans-style steering wheel to the custom instrumentation and flush-mounted shifter, every detail for your comfort and convenience has been thought out and installed at the factory.

The engine, our Force 85 model, is American-built with electric start and enough power to easily snap up slalom skiers in deep water starts.

The Escort Trailer, the result of state-of-the-art computer design, is precision engineered for this Capri with full hull support and self-centering loading features.

All together, it's the perfect package at the perfect price.

To get your new Capri package at this special introductory price, see your Bayliner dealer today. The only thing you'll gain by waiting is a higher price.

* Manufacturer's suggested special price in effect through May 15, 1983. Actual price set by dealer. Taxes, license, freight, options and dealer delivery charges extra. Prices may change without notice.


Bayliner

Plants in Arlington, WA; Spokane, WA; Pipestone, MN;
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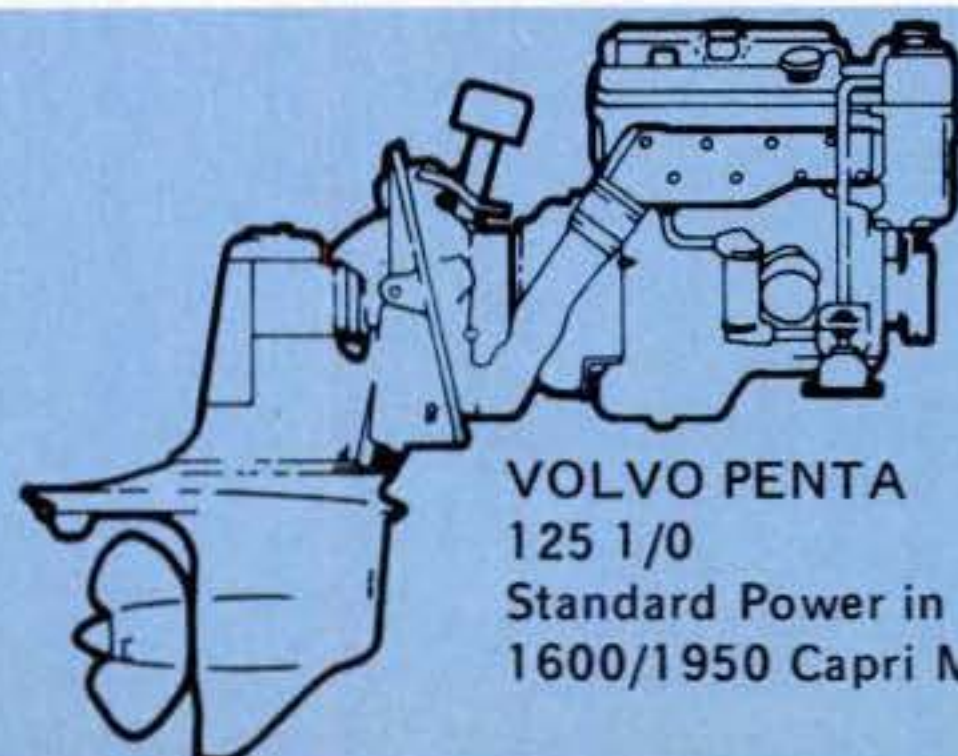


1950 CAPRI

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Standard Power in
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It's a hull of a difference!



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Bass Attacker™ by Sea Nymph® is the first tournament bass boat that slashes weight and prices without sacrificing strength.



JB 164 STANDARD FEATURES

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- Fore & aft raised casting deck
- Forward casting deck storage
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- Basspirator™ aeration system
- Rod holders
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- Bow deck storage
- Removable fore & aft plug-in pedestal seats
- Motor splash well
- Divided 36" aerated livewell with valve control
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- Bilge pump
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- Optional windshield
- Aluminum shift and throttle control mount
- The "Attacker" is designed for easy rigging and access to rigging areas

Bass ATTACKER™

Centerline — 16'4"
 Seats — 4
 Beam — 72"
 Bottom Width — 50"
 Side Depth — 23"
 Transom Width — 72"
 Transom Height — 21"
 Persons Cap. — 650 lbs.

Weight Cap. — 1000 lbs.
 Horsepower — 60
 Bottom Ga. — .072
 Approx. Wt. — 590 lbs.

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23'



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25'



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26'2"



Formula 402 SC1

40'2"



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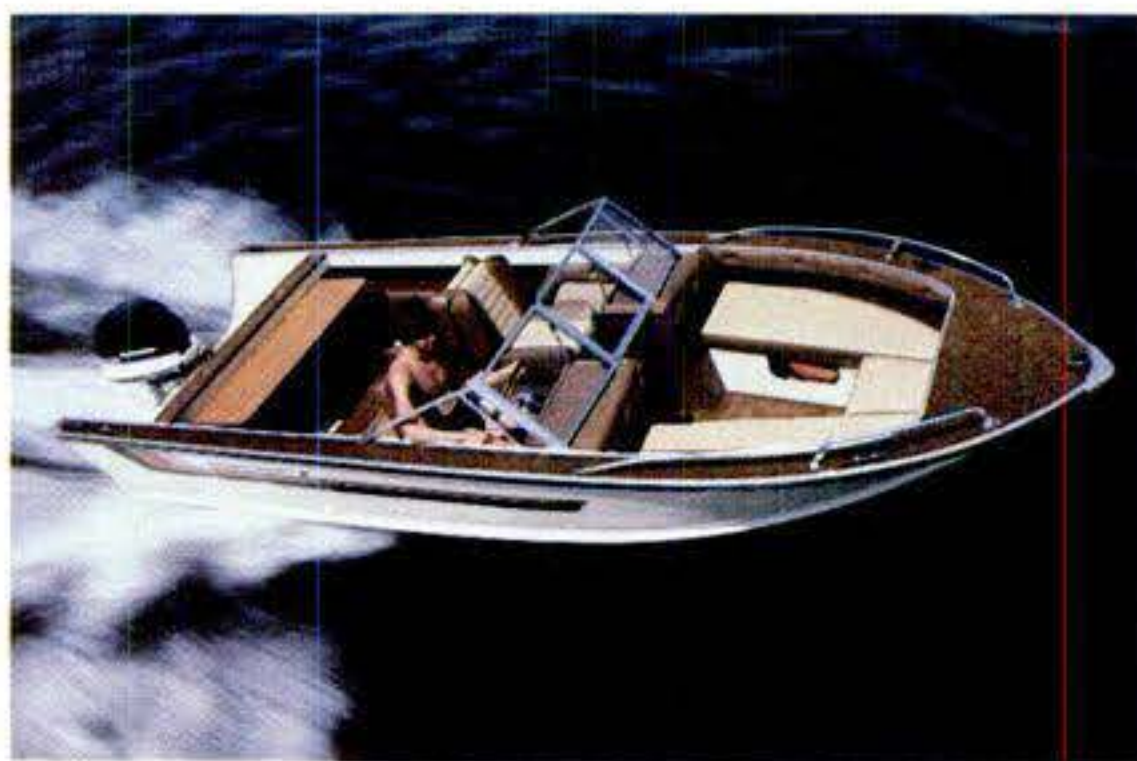
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At first glance, you'd never guess that Starcraft aluminum boats are among the most practical, sensible, and economical boats on the water today.

Their sporty graphics and clean, flowing lines make them look fast even when they're sitting still. Their plush, finely-featured interiors compare with boats priced much higher. And the quality features found in every Starcraft would lead you to believe that they're more expensive than they really are.

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MODEL 678... MIGHTY HANDFUL!

78 VHF/FM CHANNELS FOR THE MOST VERSATILE RADIO AFLOAT. RUNABOUTS: All the security and convenience of VHF/FM, without the bulk and weight. SAIL: Perfect for use where battery power is limited. FISHING: Two way communication; channels enough for clutter free fish talk. CRUISER: Make it your prime radio or back-up; inexpensive and handy either way.

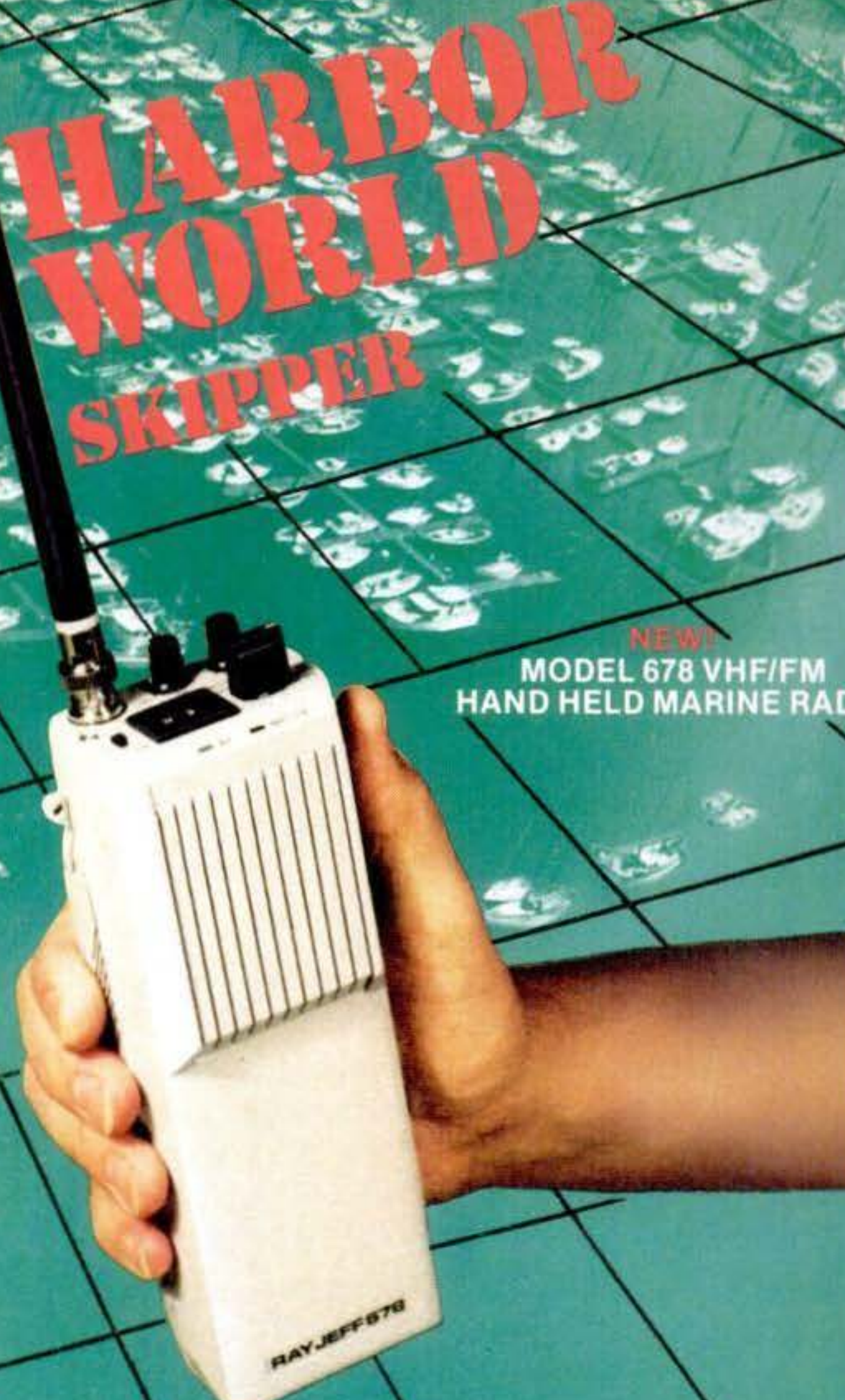
This little beauty packs all 78 domestic and international channels plus four weather channels. Full 3 watts of power for ship to ship, ship to shore and land use.

HAND CARRY IT AND USE IT EVERYWHERE!

Compact, light weight, rugged heavy duty, corrosion proof housing. Fully synthesized circuitry—no channel crystals needed. Hours of continuous talk power from its rechargeable Nicad battery!

Features? All the important ones you'll find on large, expensive permanent mount radios. An optional antenna adapter allows you to use the boats antenna for even greater range!

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MODEL 550... NEVER MISS A MESSAGE!

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NEW BOATING AREA: The "550" will pick up and establish the major locally used channels immediately... AUTOMATICALLY.

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The "550" is automatic, fully synthesized and incorporates the latest microprocessor circuitry. No channel crystals needed. Install it yourself! Comes complete with Microphone and Gimbal Mounting Bracket.

FOUR POWER PACKED MODELS

Ray Jefferson offers world travelers the Model "7800"—a 78 channel synthesized pretuned radio which includes every available domestic and international channel plus four weather channels. Boats L.E.D. digital readout and channel 16 override. Install it yourself.

GREAT VALUE is Ray Jeff's Model 5000 synthesized VHF/FM radio. All U.S. channels, four weather, full watt output, L.E.D. readout, pretuned, channel override push button. Install it yourself!

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Pay-phone monitor checks collection

Too much money. That's a problem? It is to British Telecom, with London's 10,800 public phones to empty. Every day some 400 get jammed with coins, making would-be callers seethe and would-be moneymakers inoperable.

But the city's collection system is in for an overhaul with a computerized monitoring system called All Change. It determines the use trend of every pay phone and prepares an individual money-collection schedule for each one. British Telecom figures the extra income from unclogged phones will reach \$5 million a year.

To collect the data about the phones, each coin box is numbered. When the box is removed and the coins are counted (by a machine that handles 500 coins a minute), the computer knows how much money a phone makes over a specific length of time. After processing the information, it creates a servicing program for that phone. Collection intervals may be from several times daily to months apart, and the schedules are constantly updated to account for changing trends or special crowd-gathering public events in an area.

The system works with all types of pay phones—including the newer microprocessor-controlled models (right) that signal the telephone office when three-quarters full. The All Change system is from Chapman Cash Processing, Shropshire, England.—David Scott



Computer sets collection schedule depending upon actual use.

Yanmar Shuttle Power Shift... Your lawn will never feel the same.

The big tractor features that Yanmar builds into all their tractors make a world of difference. A world of operating ease and convenience. A world of dependable diesel power and performance.



Shuttle Power Shift.

The shift is mounted right on the steering column for easy fingertip control. Lets you shift on the go without clutching. You get the ease of automatic without the 25 or 30% power loss of hydrostatic type transmissions.

You save time. You save effort. Your lawn work becomes more productive. More rewarding.

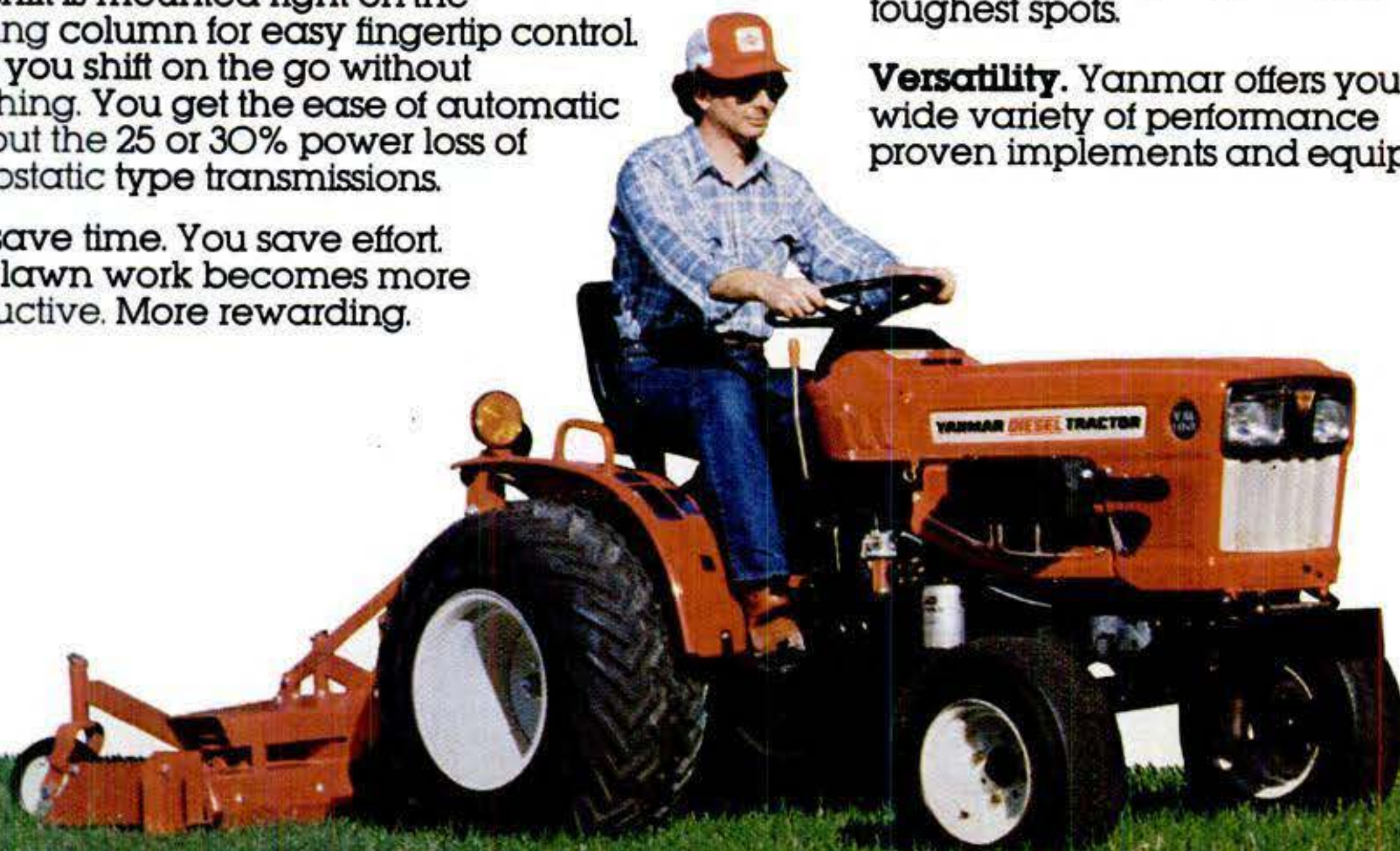
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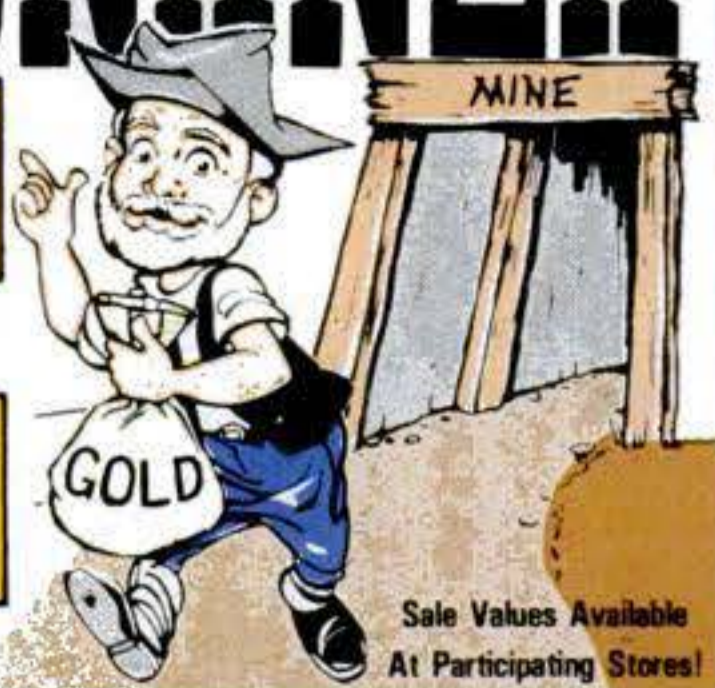
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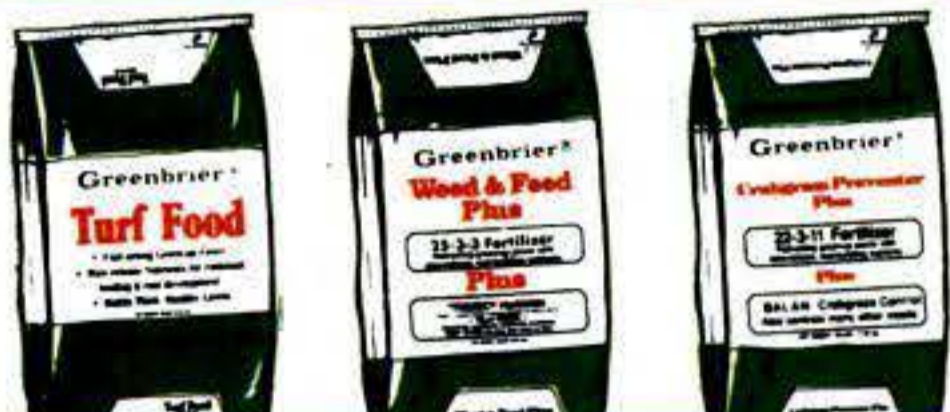


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20 lb. bags—5,000 square foot coverage.

TURF FOOD **5⁸⁸**
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Jackson
4 Cubic Foot WHEELBARROW
44⁸⁸

Features varnished hardwood handles and self lubricating bearings. 5W



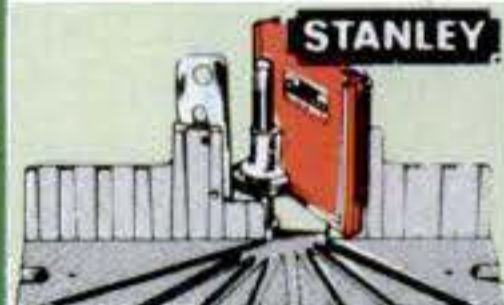
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25-Ft. POWER TAPE
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1" blade with toggle lock, shock absorber cushioned return. 8425



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Flexible garden hose with heavy gauge crush-resistant couplings. 10-58050



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Long lasting aluminum construction. Locks at 8 common cutting angles. 19-114



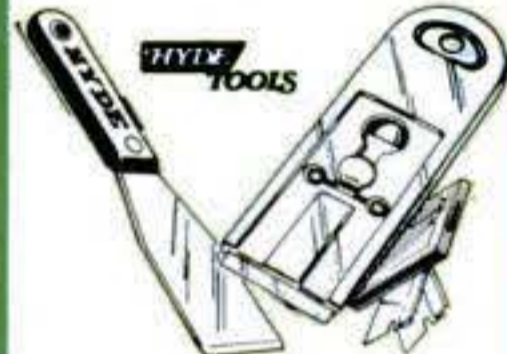
Faultless
Decorative Hooded BALL CASTERS
2 FOR 6⁹⁹

2" easy-roll rubber tire with brass hood. Choice of plate or stem mounting.



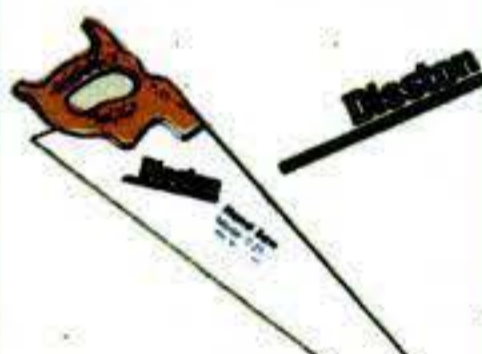
3M
9" x 11" Production SANDPAPER
Pkg. 99¢

Four sheets of coarse; or five sheets of X-tra fine, fine, medium or assorted.



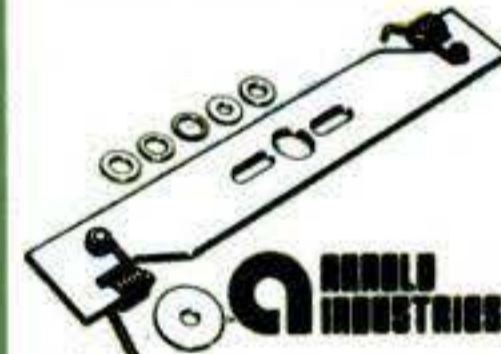
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Razor Blade SCRAPER
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1 1/2" Putty Knife... 1⁹⁹



26" HANDSAW
12⁹⁹

All purpose handsaw with chrome alloy steel blade and hardwood handle. D-23



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4⁸⁸

Loosens and removes dead grass. Fits virtually any mower hub. UPR-16



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129⁸⁸

All purpose sprayer for acrylic and latex paints, stains, enamels, etc. 350

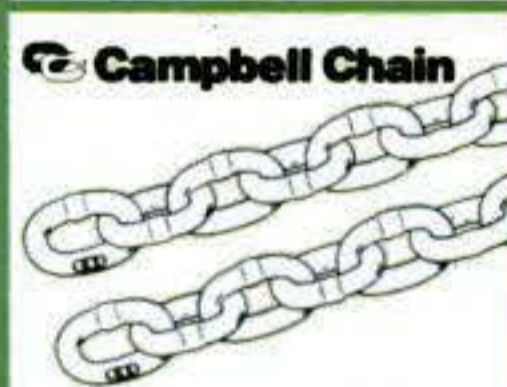


Genova RINGO
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10' GUTTER **3⁹⁹**
RW100



Decor Bathware™
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Chrome plated with square, polished stainless steel bar. Easy to install. D-1424



Campbell Chain
UTILITY CHAIN
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1/4" proof coil, plated for extra protection. For all outdoor uses. 0725127



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Fastens permanently from one side with a snap. Assorted rivets included. K110



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Double grid housing traps flying bugs from all directions. Six way mounting.



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With FREE Attachments
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4 extra attachments at no additional cost. 700-02-1



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20' x 4 3/4" heavy duty plastic. IND-20
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Holds 200' of 5/8" garden hose. 7" wheels and 3' connector hose. HRC200

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Fingertip convenience for storm and screen doors 1" to 1 1/4" thick. V333



shepherd
2 1/2" Planet® CASTERS
2 FOR 5⁹⁹
Bright brass finish. Choice of plate or stem mounting. 9303-BB 9304-BB



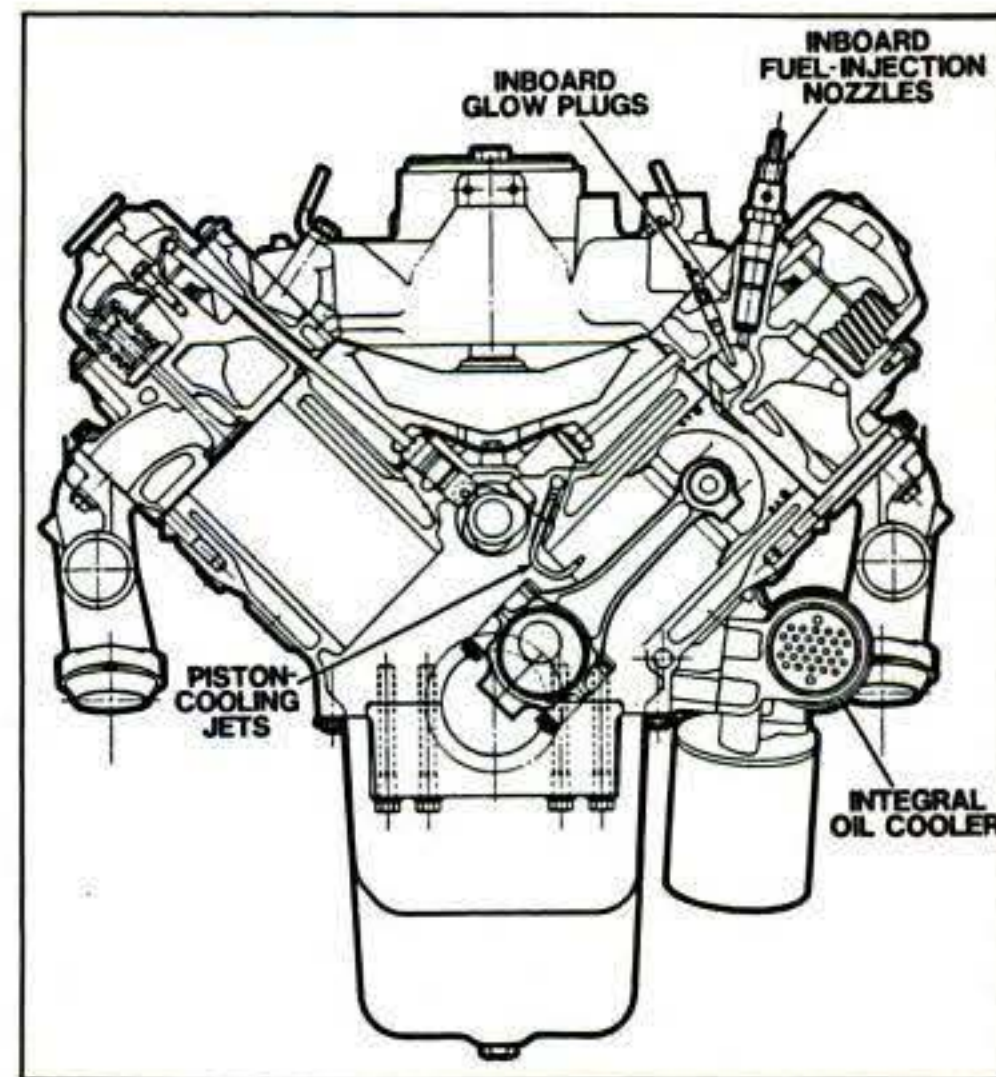
TRUE TEMPER
Quality Lawn & Garden Tools
14-TOOTH BOW RAKE
or ROUND POINT SHOVEL
YOUR CHOICE **5⁸⁸** ea.

UNION AMES

CHECK THE YELLOW PAGES FOR THE TRUSTWORTHY STORE NEAREST YOU!

RECREATION ROUNDUP

By HERBERT SHULDINER



Diesel fever wanes

It's ironic that just when reasonably priced, good-performing diesels have become available for motor homes, prospective buyers seem to have lost interest in the oil-burning engines. Gas-powered motor homes remain the top choice in a surprisingly bullish RV market, despite the introduction of a whole new fleet of diesel-powered motor homes such as the Pace Arrow 620 SD (top) and Coachmen Ambassador for 1983. Virtually all of the new diesel motor homes are built on a Chevrolet chassis with a 6.2-liter (378 cu. in.) engine. The diesel improves fuel economy by up to 50 percent over Chevy's 454-cu.-in. gas engine.

"This is the first time a motor-home manufacturer ever designed a coach around an engine," says Gary Smith, a spokesman for Fleetwood Industries, speaking of the new Pace Arrow. "The body shape and low weight were designed to maximize the capabilities of the 6.2-liter diesel," Smith adds. Weight-sav-

ing aluminum stringers and ribs were used in the motor-home walls, and a streamlined front end provides a 29 percent drag reduction over the previous flat front.

Motor homes that use the Chevrolet chassis—as both the Pace Arrow and Coachmen do—are giving the giant car company one of the few bright spots in its otherwise dismal sales slump. Chevrolet claims 86 percent of chassis sales in the RV market.

Ford's challenge

Although it still won't offer a standard motor-home chassis for 1983, Ford is planning to give Chevrolet a stiffer fight for mini-motor-home chassis sales this year, according to David Tarrant, the company's RV sales manager. One new weapon for Ford in this sales war is a longer-wheelbase (176 in.) van chassis on which such RVs as the 25-ft. Diamond Maxi-home (at top of page) are built. The new chassis will allow RV makers to build mini-

motor homes up to 30 feet long (that's mini?). And by the middle of this year, the chassis will come with an optional 6.9-liter (421 cu. in.) diesel (see drawing above), which Tarrant claims is lighter and more powerful than Chevy's 6.2-liter. The Ford diesel is actually built by International Harvester and weighs 50 pounds less than the Chevrolet engine. The Ford/IH engine turns out 161 hp at 3,300 rpm vs. 135 hp at 3,500 rpm for the Chevy. Torque is 307 foot-pounds at 1,800 rpm for the Ford vs. 240 foot-pounds at 2,000 rpm for the Chevy. The new Ford diesel is rated for vehicles of 8,500 pounds GVW and up, Tarrant says.

Tarrant predicts the new mini-motor-home chassis and diesel will help Ford gain a 25 percent share of the overall RV market this year.

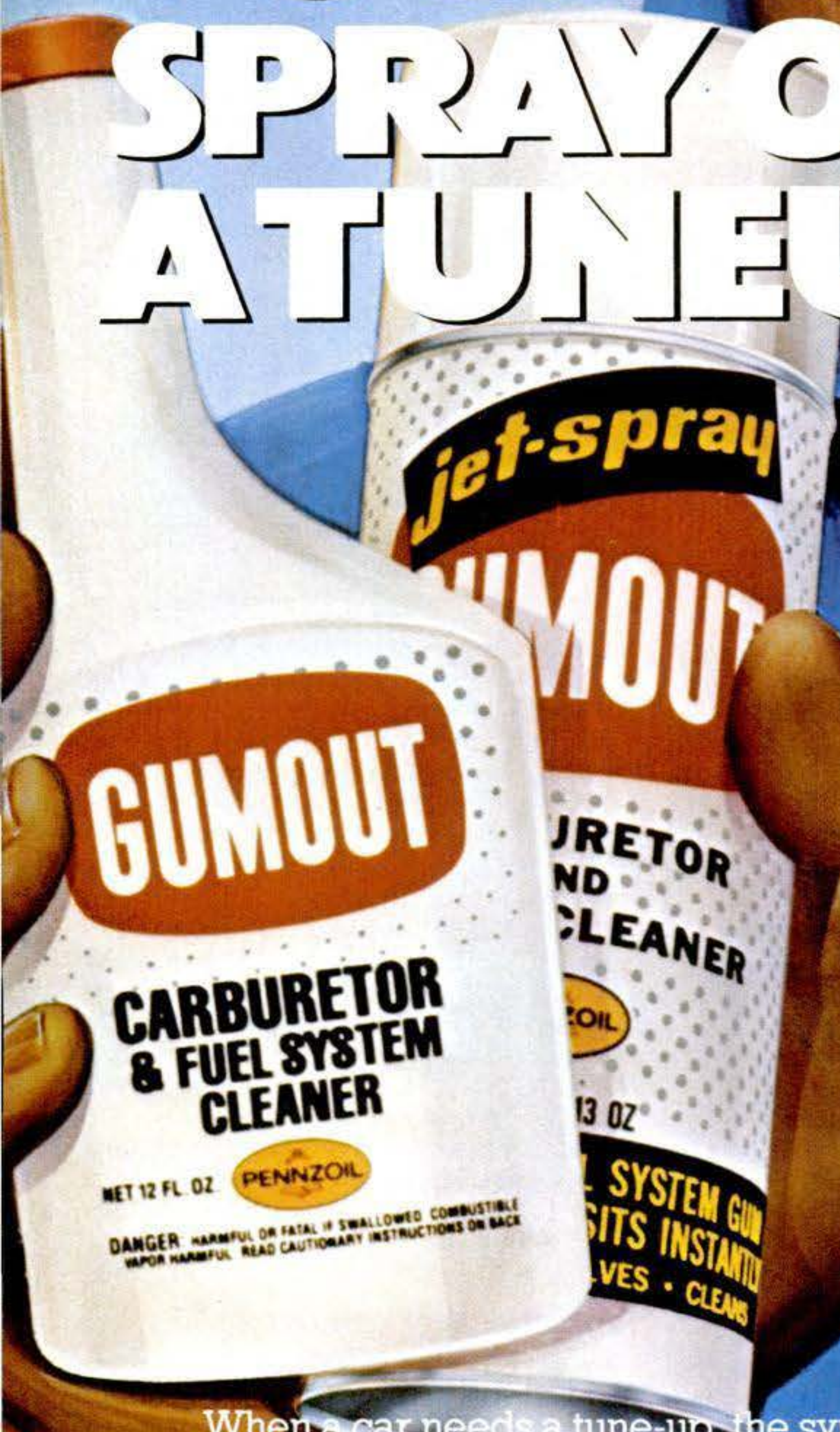
Versatile tent camper

The MTT Truck Tenter comes in a briefcase-size case, yet quickly assembles into a neat little shelter that fits on the bed of a pickup. The entire outfit weighs a mere 22 pounds and is small enough to store behind the truck seat. A shower, sink, and table are available as options. The Truck Tenter is made by MTT Corp., 2621 Daimler St., Santa Ana, Calif. 92705. Price of the basic unit is \$395. **13**



BIG DAN,
THE GUMOUT MAN,
SAYS,

**"POUR IN
SPRAY ON
A TUNEUP"**



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.

So before you spend a small fortune on a tune-up, try Gumout. Gumout Liquid in the gas tank cleans deep into carbs, down into manifolds, keeps valves clean, too. And Gumout Jet Spray cleans linkages, carb throat, throttle plate and more.

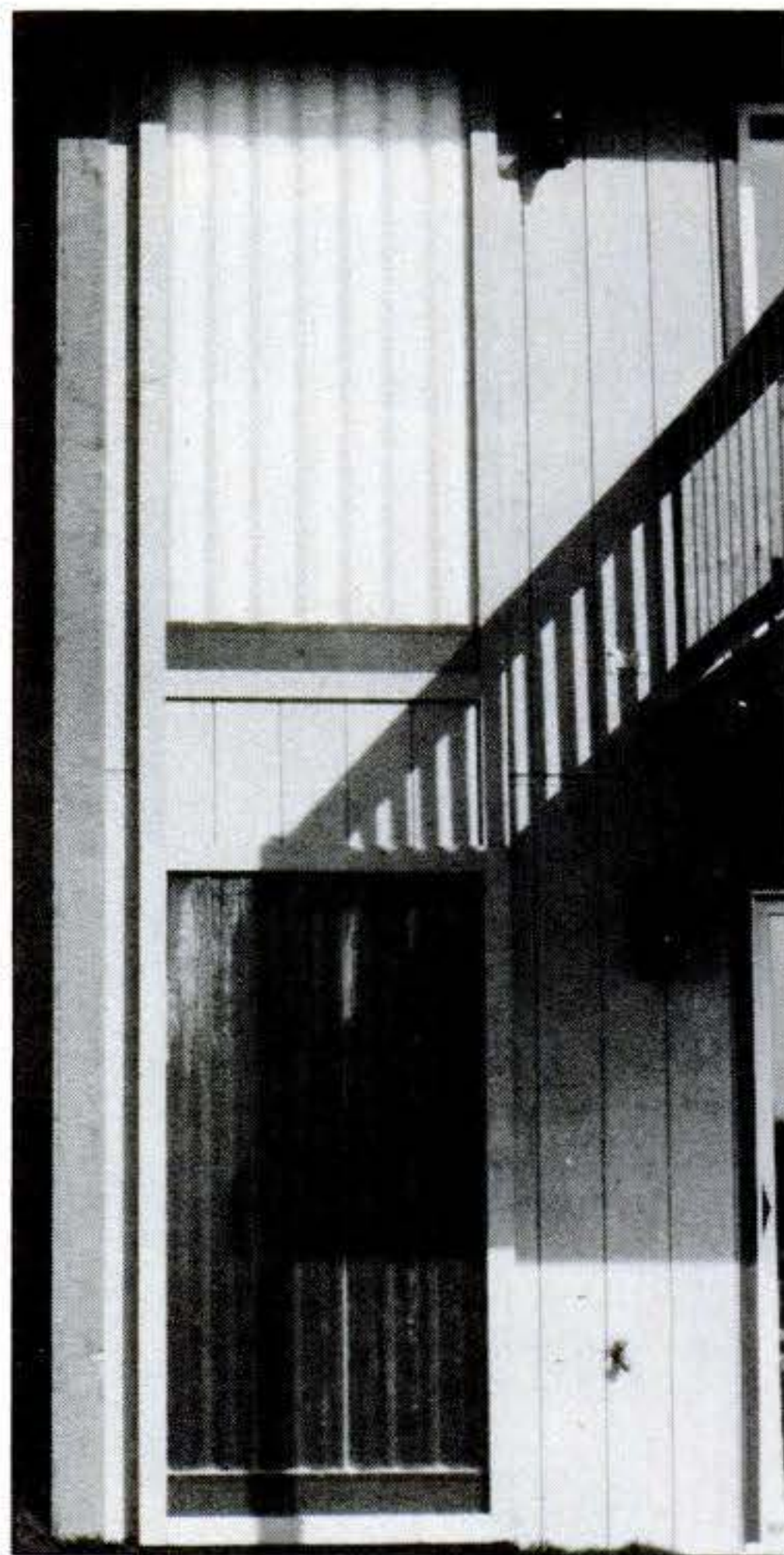
Gumout Liquid and Jet Spray—together they help engines run smooth. Help save gas, too. So when your car starts acting like it needs a tune-up, try Gumout first. It might just save you a bundle.

THE BETWEEN TUNEUPS TUNEUP.

Gumout is a division of the Pennzoil Company.



Two-faced solar wall



This solar collector turns its back on clouds. Rodwall has seven polyethylene tubes filled with a phase-change compound and shielded by insulated louvers. Mounted through the wall, the eight-inch-thick modular unit is concealed behind drywall, inset with two small registers. A fan circulates room air through the wall plenum.

When the sun shines, a heat sensor starts an electric motor to face the dark-colored rods outward (lower unit in photo), absorbing energy and causing the phase-change material to melt. When there's no sun, the reflective louvers pivot around (top module in photo). Then the phase-change material solidifies, giving off stored heat to the room.

One Rodwall module, 82.5 inches high and 42.5 inches wide, can be retrofitted in place of an existing door or window.

The \$1,275 unit meets requirements for energy tax credits. The Dow Chemical phase-change compound is guaranteed for 10 years, according to the maker, Sunwood Energy Products (Box 248, Harrisonburg, Va. 22801).—S. Renner-Smith

Copyrighted material



The \$7 AM/FM Digital Clock Radio

Now you can have a decorator styled highly automated AM/FM digital clock radio with all the extras including battery backup for just \$7. But there's a catch.

Be independent. If you're like me, you've only had one clock radio in your bedroom, let alone another clock radio in your kitchen, den or office.

Now for only \$7, not only can you have a great sounding AM/FM radio, but you'll get battery back up, am/pm indicators, and a digital timing system that would make a computer blush.

Now you can have a clock radio on each nightstand in your bedroom so you can easily see the clock on your own side of the bed, and get up when you want in the morning. It even has bright and dim settings for the LED display.

If you haven't acquired an all electronic clock radio recently, you're in for a pleasant surprise. And, for just \$7, you'll

hear. Both the AM and FM tuners are very sensitive and each has a separate built-in antenna for best reception.

You'll easily tune in your favorite stations even in the dark with the lighted full size slide rule tuning dial. The heavy magnet full range speaker produces extremely deep rich sound.

The rich walnut look will be a handsome addition to any room. This sophisticated full sized digital clock radio is 10" wide, 5½" deep and 2½" high. It is both UL listed and FCC approved.

And finally, don't be misled by the name. Bardo is a trade name for Groupman, a very substantial electronics company. The radio is backed by a standard manufacturer's limited warranty.

If they win, we'll not only give you back your money, we'll give you a free gift for your trouble. DAK's come with a deluxe hard plastic box, an index insert card and a limited 1 year warranty.

WHY, YOU MAY BE ASKING?

You're very valuable to us in the form of future business. Over 240,000 customers have responded to bonuses like this. We find most of you keep buying once you've tried our cassettes and our prices; and that's a worthwhile gamble.

NOT A BAD CATCH

DAK manufactures a cassette with no problems and great sound. We've been hot on the heels of the frequency responses of Maxell and TDK. The tape we made last year had a great frequency response up to 14,000hz.

Now our new Gold Label MLX is second to none. We have a frequency response to 19,500hz and we'll go head to head against any tape on the market.

TRY NEW DAK MLX90 CASSETTES RISK FREE

To get the automated clock radio for \$7, try 10 MLX high energy cassettes. If you aren't 100% satisfied, return only 9 of the 10 cassettes and the radio in its original box within 30 days for a refund. The 10th cassette is a gift for your time.

To order your 10 Gold Label DAK MLX 90 minute cassettes and get the automated clock radio for only \$7 with your credit card, call toll free or send your check for only \$24.90 for the tapes, plus \$7 for the radio and \$4 for postage and handling for each group. Order Number 9627. CA residents add 6% sales tax.

An automated radio for \$7 and DAK's new improved MLX. Time to stock up.



You're in complete command with your choice of music, 3 clock timers and even time display brightness.

THE CATCH

Frankly we are losing our shirts on this clock radio, but we're looking for audiophiles who use audio cassettes.

If you buy top name TDK and Maxell cassettes, you probably pay \$3.50 to \$4.50 each for a 90 minute cassette.

We want you to try DAK's new Gold Label MLX ultra high energy, normal bias cassettes. Not at \$4.50 or even at \$3.50 each, but at a factory direct price of just \$2.49 for a 90 minute cassette.

We challenge you to compare the frequency response, dynamic range and signal to noise ratio of our new Gold Label MLX to Maxell UDXL or TDK SA.



ELECTRONIC PROGRAMMING

You'll be amazed at the versatility of the clock computer section of this radio. Setting the 24 hour clock is a breeze with both fast and slow set buttons.

And, there are two other clock systems. One is the 24 hour alarm which let's you wake to radio or alarm. Or, just hit snooze for a few extra winks.

Finally, there's a count down timer to lull you to sleep with music, shut the radio off and still have the alarm get you up on time in the morning.

Best of all, you can laugh at power failures while you're asleep. Just put in a standard 9V battery (not included) and even if there's been a power failure, when the power's restored, the correct time and all programmed functions will still be on schedule.

BEAUTIFUL MUSIC

No, it's not stereo. But wait till you experience the beautiful FM music you'll

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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.

Boiler equation

My house has gas-fired baseboard hot-water heat and is divided into three zones, each having a setback thermostat. The water temperature can be set at the boiler. What is the optimal temperature setting for my system?

Roy Newton, West Orange, N.J.

The optimal water-temperature setting for a baseboard heating system depends on the outdoor temperature. Logically, as the outdoor temperature rises, the boiler-output temperature should drop. The specific set point is determined by the amount of heat loss from the building for a specific temperature difference between indoors and out. The following equation gives the proper boiler-outlet water temperature for typical single-pipe, 3/4-in.-dia. baseboards:

$$T_{\text{water}} = (UA)/6L \times (T_{\text{indoors}} - T_{\text{outdoors}}) + T_{\text{indoors}}$$

The five quantities in the equation are defined as follows:

T_{water} is the water-outlet temperature from the boiler.

T_{indoors} is the indoor-thermostat set point.

T_{outdoors} is the outside temperature.

L is the length of baseboard in feet.

UA is the overall building heat-loss coefficient in Btu/h/degree F.

The last quantity is the only one that's difficult to analyze. A rule of thumb says that for each square foot of heated floor area, UA is between 0.2 and 0.3. So for a 2,000-sq.-ft. house, the UA value will likely be between 400 and 600.

As an illustration of the use of this equation, consider a house with a unit heat load of 500 Btu/h/deg. F that is heated by 150 feet of baseboard. Find the water temperature required to heat the interior of the building to 70 degrees on a zero-degree day. Substituting the given values into the equation gives:

$$T_{\text{water}} = 500/(6 \times 150) \times (70 - 0) + 70 = 109$$

Therefore, water entering the baseboard units at 109 degrees will maintain the specified building at 70 degrees on a zero-degree day. The equation shows that the longer the baseboard, the lower the required water temperature, an important consideration in designing solar-heating systems since they normally produce water temperatures below those produced in a boiler.

There is a lower limit to the temperature setting on a boiler. If set too low, boiler exhaust gases may condense and corrode the exhaust stack. Refer to the boiler manufacturer's literature for the suggested minimum setting.

Solar software

I have an F-Chart solar-heating analysis program that runs on my Apple II Plus under CP/M. The program is for flat-plate solar systems. Do you know where I can get an F-Chart program for a parabolic concentrator system that will run on my Apple computer?

Charles T. Blanchard, Camden, N.C.

F-Chart is a method for calculating the energy delivery of common solar space- and water-heating systems. The F-Chart was originally developed at the University of Wisconsin. I am not aware of any micro-computer version of F-Chart that can handle parabolic concentrators. However, an F-Chart version (4.0) is capable of handling concentrators, but that has been prepared for large main-frame computers. For the most current information on F-Chart availability, contact F-Chart Software, Box 5562, Madison, Wis. 53705.

Super-insulation options

I am planning to build a super-insulated home using passive solar. The house will face north with a walkout basement facing south. Should the basement walls be insulated, and to what extent? Also, which is preferable and most cost-effective: 2x6-on-24-inch framing or double 2x4-on-24-inch framing?

Robert L. Burke, Louisville, Ky.

All exposed vertical surfaces of a super-insulated house should be insulated to approximately the same level. Below-grade walls should be insulated to provide roughly the same heat-loss rate as that of the rest of the building. However, since the ground temperature is well above the ambient temperature in the winter, the insulation R-value required can be scaled down accordingly.

By itself, 2x6 framing is less expensive than double 2x4 framing. But the double wall accommodates several more inches of insulation, so for a given R-value level that kind of construction can turn out to be less costly.

For example, a double 2x4 wall with an additional two-inch gap yields a nine-inch-thick cavity and an R-value of 30 if batts are used. A 2x6 wall allows an R-value of 19 using batts. To bring that up to R-30, an additional 1 1/2 inches of polyisocyanurate rigid board would have to be attached to the outside face of the studs. Compared with the high cost of board insulation, the saving for single-wall framing is minimal.

A circular (#PM-1051, June 1982) from the Cooperative Service of Iowa State University (Ames, Iowa 50011) analyzes

the cost-per-unit installed R-value of seven types of wood-frame walls. The first copy is free.

Solar cells: Is it time?

What is your opinion about installing an array of photovoltaic cells on my roof to generate electricity to serve an air conditioner? The cells would produce power during the same hot daytime periods when the air conditioner would need it.

Lester A. Shea, Los Alamitos, Calif.

At the present time, the cost of electricity produced by photovoltaic cells is considerably higher than that produced by utilities in the United States. The only cost-effective application is at remote sites where installing a power line would make utility power prohibitively expensive.

Future reductions in cost per installed watt are expected, so it is prudent to wait a few years before investing in a photovoltaic system. Keep in mind that federal tax credits for energy installations will expire in 1985, however. That saving should be factored into your decision about when to buy.

Acetylene for energy?

Has anybody thought about or investigated the use of calcium carbide and water as an energy source? The acetylene gas generated burns very cleanly.

Arthur Porges, Pacific Grove, Calif.

Acetylene is a widely used but very expensive energy source. It cannot compete with natural gas or fuel oil at the present time because of the high price of the raw material, calcium carbide. Acetylene is used, as you know, in gas welding because of the high temperatures produced when burned with pure oxygen. However, as an automotive or space-heating fuel, it is presently uneconomical.

Easy-does-it collector

Does it make sense to route cold water through a water pipe or hose on my roof to collect solar heat before it enters my water heater? There would be no additional holding tank, just that roof pipe.

Harry O. Whited, Panorama City, Calif.

Water in a hose on the roof will get hot, but it is a very small amount of water and will be at a useful temperature only on the sunniest and warmest of days. A 100-foot length of 1/2-inch garden hose contains only one gallon of water. Most people use about 20 gallons of hot water a day. Another difficulty with the approach is the potential for freezing in winter.

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. Individual queries can't be answered by mail.

HANDLING HIGH-ENERGY EXPERIMENTS IS NO TASK FOR A WEAK SPARK PLUG.



Motorcraft

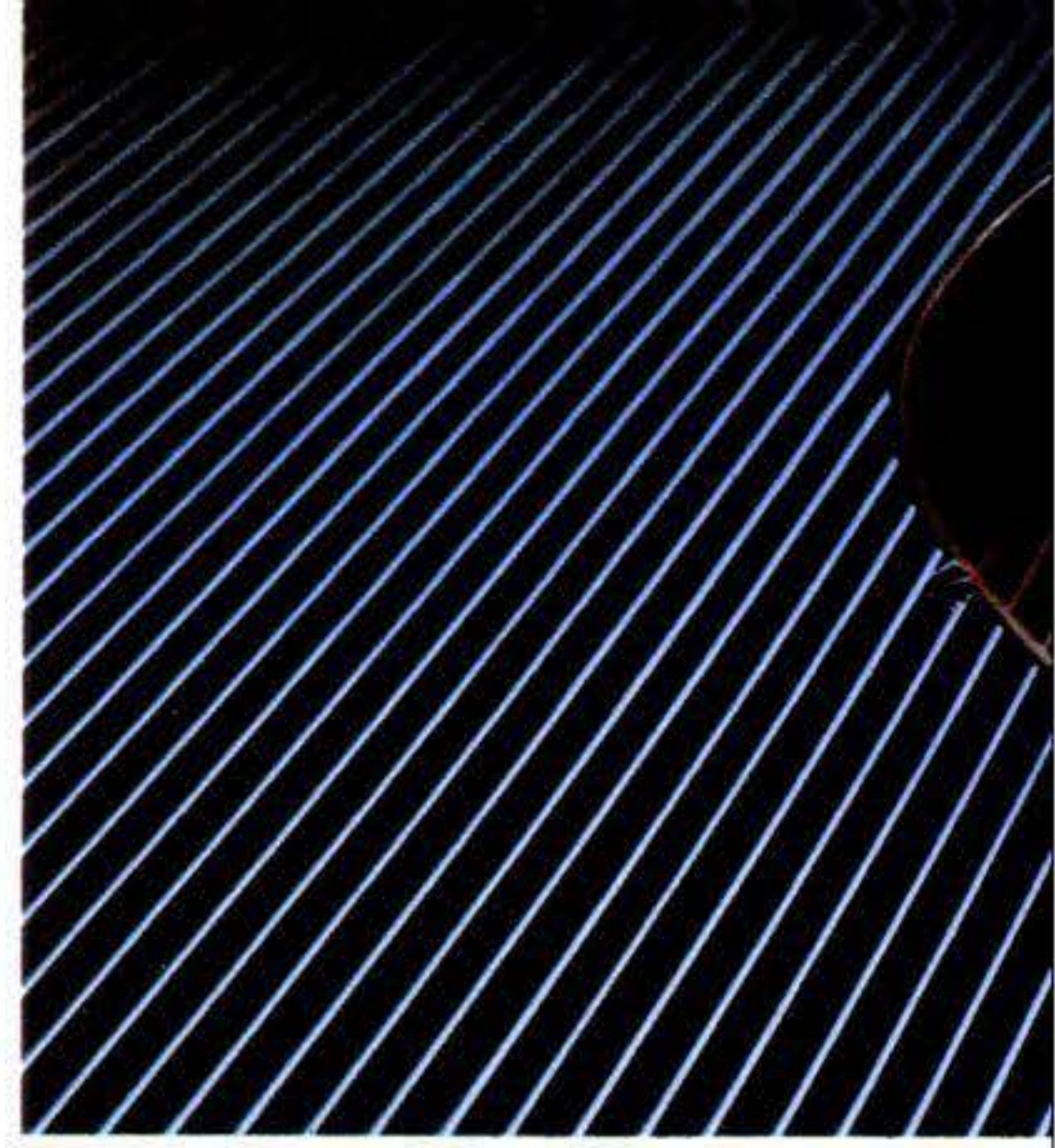
EXCEEDS THE NEED

Ironically, this experimental performance car uses a standard Motorcraft spark plug dedicated to fuel efficiency. But to remain frugal, these plugs must survive surges that could reach twice the voltage normally produced by conventional engines—including yours. Plugs capable of surviving surges to 38,000 volts: Motorcraft Extended Tip. As you drive, Motorcraft Extended Tip plugs relentlessly burn away power-blocking carbon deposits



from their electrodes. Thus allowing a cleaner path for the spark to ignite precious fuel mixtures. That means less wasted gasoline in any properly tuned normally driven automobile—no matter how advanced. Motorcraft Extended Tip Spark Plugs. Engineered to eliminate fuel-thieving sooty carbon, without eliminating themselves in the process. Motorcraft. Quality parts for all makes of cars. *Get it together—buckle up.*





ESCORT

By now, just about everyone knows a radar detector needs *lots* of warning distance to be truly effective. And ESCORT® delivers. Over hills, around corners, and from behind. *Car and Driver* magazine, in their 1982 test, went so far as to say: "The ESCORT, a perennial favorite of these black-box comparisons, is still the best radar detector money can buy." But there's more to the story.

The Plot Thickens

About a year ago, *all* radar detectors began picking up a new type of radar signal that was as strong as some police radars. The rest of the radar detector industry dismissed these signals as unmarked patrol cars, radar intrusion alarms, or even overactive imaginations. But something didn't add up. There were just too many of these new signals. And we had another clue. ESCORT's audio warning distinguishes between the two police radar bands: it "beeps" for X band, and "braps" for K band. These new radar signals simultaneously triggered *both* warnings, and that told us the signals couldn't be police radar. Tracking down a car emitting this signal revealed the actual source—a new type of imported radar detector had the side-effect of *transmitting* radar signals in both police radar bands. Hard to believe, but true.



Our first step was to inform ESCORT owners of the situation. We composed a "Radar Bulletin" explaining the source of this new radar pollution and sent out 200,000 by first class mail. But this was only the beginning.

Mission Impossible?

On the surface, the problem seems unsolvable. The signals transmitted by these "radar polluters" are in the same bands as police radar, so it's impossible to detect one and ignore the other, right?

FOR ESCORT OWNERS ONLY:

As our ad above states, we've made another improvement. The new ST/O/P circuitry is a standard part of every ESCORT starting with serial number 400,000.

Q. Why do some other radar detectors *transmit* radar signals? Aren't they just receivers?

A. All superheterodyne radar detectors have a signal generator (called a Gunn oscillator) as part of their circuitry. Responsible manufacturers design their detectors in a way that lets them keep the signal inside the detector. Unfortunately, some manufacturers use a design that makes it impractical to keep the signal inside, and their detectors actually *transmit* a strong signal in the police radar band! ("Superheterodyne" doesn't always mean a good design.)

Q. If these "polluting detectors" transmit in the same band as police radar, how can it be possible to ignore their signals and still detect police radar?

A. It's not easy. To understand how ESCORT's new **ST/O/P** circuitry does this, let's take a closer look at the signals (the "polluting detectors" actually transmit in both police bands, but we'll only show their X band signal).

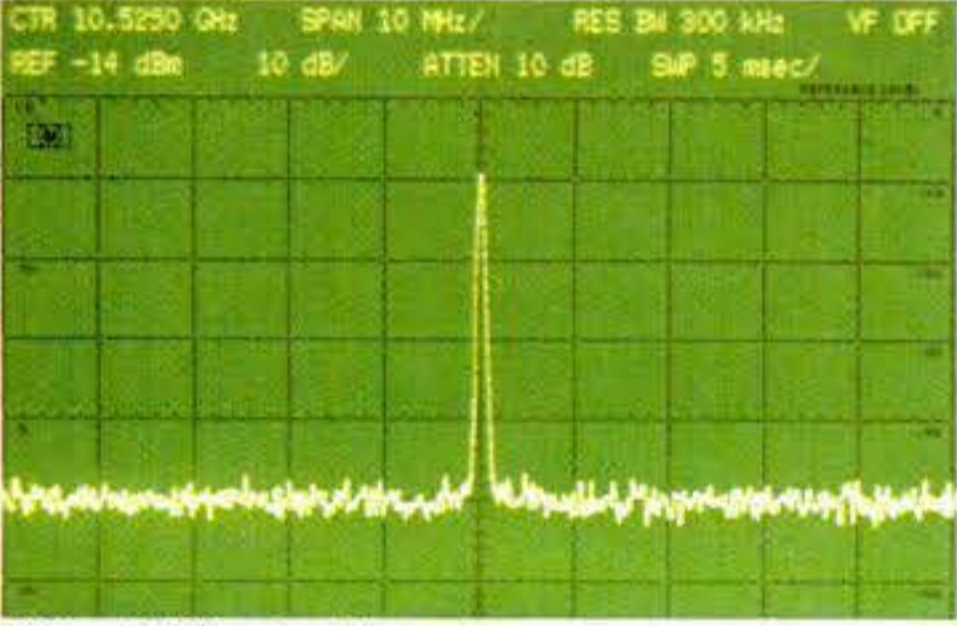


Figure 1. X band police radar.

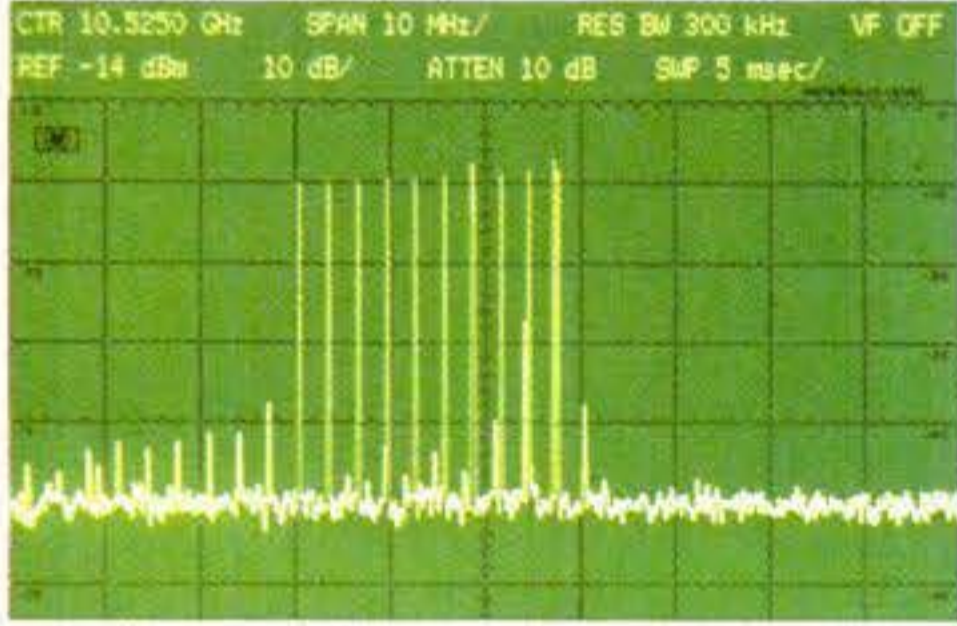


Figure 2. "Polluting detector."

1. Figure 1 is an X band police radar as viewed on a digital spectrum analyzer. (A spectrum analyzer displays signals as vertical lines—the stronger the signal, the taller the line on the screen. The frequency of the signal is shown by the side-to-side location of the line, just like the scale of your FM radio.) The analyzer used was set up so 10.525 GHz was at the center of the screen, with 10.475 at the left border, and 10.575 at the right border.

Figure 1 shows the police radar has a *steady* signal at about 10.525 GHz (The legal band for X band police radar is 10.500 GHz to 10.550 GHz).

2. Figure 2 shows the signal from one of these "polluting detectors" to be quite a bit different. It shows that instead of having a signal on one steady frequency, the signal is rapidly moving through the police radar band. Needless to say, all fast-responding superheterodyne radar detectors detect this signal. Until now.

■ ESCORT's new **ST/O/P** circuitry digitally analyzes all X and K band radar signals received, and can "recognize" certain patterns which are exclusive to each type of signal. Your eyes can tell the difference between figures 1 and 2, and so can **ST/O/P**. Other radar detectors are just too simple-minded to see the difference.

■ With the introduction of **ST/O/P**, ESCORT is redefining radar detection. **Again.**



The Radar Defense Kit

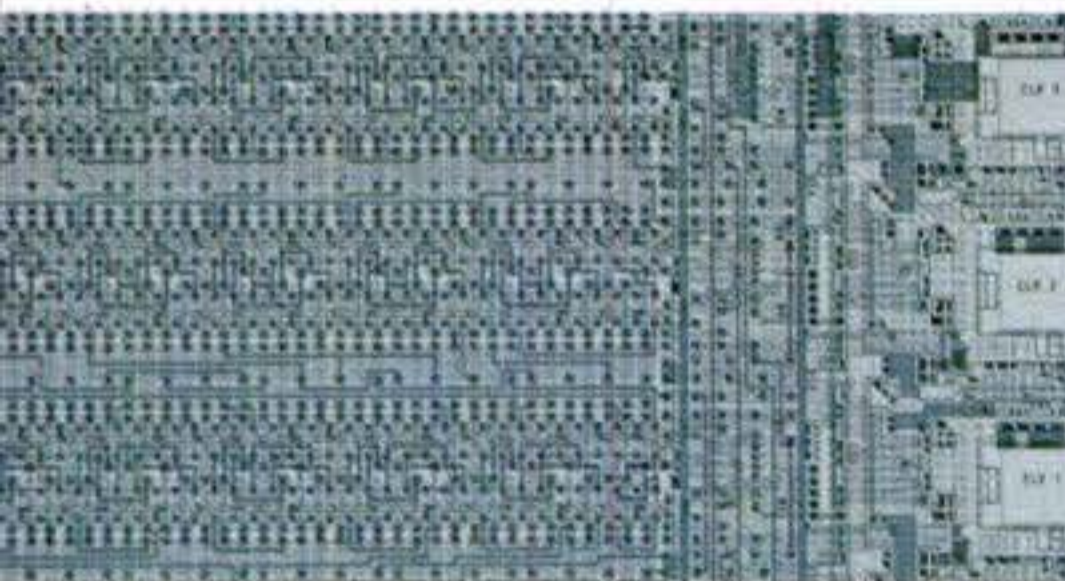
Radar Warning, No Riddles.

Not necessarily. Let's look at another type of technology to make a point. You can now buy an inexpensive device that will turn on the lights in your living room whenever you clap your hands. Or shout. Or drop a book. Or make *any* loud sound. At the other extreme, there are computerized devices available that don't merely sense sound, but can actually recognize sound patterns unique to specific spoken words. Some can even tell your voice from any other.

Why not apply this principle to radar detection? Instead of merely acknowledging the presence of *any* radar signal, a detector could look for a pattern in the signal and distinguish between "radar polluters" and actual police radar. And now ESCORT does just that.

Nothing But The Truth

The result of months of extensive engineering, ESCORT's new ST/O/P™ circuitry reduces alarms from "radar polluters" by over 95%. ST/O/P (Statistical Operations Processor) consists of a CMOS digital processor with built-in memory. When ESCORT receives an X or K band radar signal, ST/O/P recognizes patterns in the signal's amplitude/frequency/time characteristics, and uses these patterns to determine the signal's identity. All in 1/64 of a second.



If the signal is from a "polluting detector," ESCORT keeps quiet while maintaining its lookout for police radar. If the signal is police radar, ESCORT immediately alerts you. And unlike other detectors that keep you guessing, ESCORT's amber warning lamp, signal strength meter, and geiger-counter-like pulsing sounds ("beeps" or "braps") tell you *everything* you need to know. ESCORT has a lot to say, and we include a 33 1/3 RPM Radar Disc to make getting acquainted easier than ever. Play it on your stereo turntable and take a "test drive" with ESCORT as soon as you open the box.

Fully Equipped

ST/O/P digital circuitry is just the latest example of the continuous development of the ESCORT. We won't compromise on performance *or* features. Here's proof:

- Patented Digital Signal Processor
- Different Audio Alerts for X or K Band Radar
- Varactor-Tuned Gunn Oscillator tunes out false alarms
- Alert Lamp dims photoelectrically after dark
- 1/64 Second Response Time covers all radar
- City/Highway Switch filters out distractions
- Audio Pulse Rate accurately relates radar intensity
- Fully Adjustable Audio Volume
- Softly illuminated Signal Strength Meter
- L.E.D. Power-On Indicator
- Sturdy Extruded Aluminum Housing
- Inconspicuous size (1.5H x 5.25W x 5D)
- Power Cord Quick-Disconnect from back of unit
- Convenient Visor Clip or Hook and Loop Mounting
- Protective Molded Carrying Case
- Handy Cigar Lighter Power Connection
- Spare Fuse and Alert Lamp Bulb.



Take a stereo "test drive."

Critics' Corner

Car and Driver: "...All things considered, the ESCORT is the best piece of electronic protection on the market."

BMWCCA Roundel: "...The ESCORT is a highly sophisticated and sensitive detector that has been steadily improved over the years without changing those features that made it a success in the first place... In terms of what all it does, nothing else comes close."

Playboy: "...ESCORT radar detectors... (are) generally acknowledged to be the finest, most sensitive, most uncompromising effort at high technology in the field."

Autoweek: "...the consistent quality is remarkable."

Made In Cincinnati

If you want the best, there's no reason to look anywhere else. ESCORT is designed and manufactured under one roof, and sold to you factory direct.

Knowledgeable support and professional service are only a phone call or parcel delivery away. And you can try ESCORT at *no risk*. Open the box, play the Radar Disc, and install your ESCORT. Take 30 days to test it. If you're not absolutely satisfied, we'll refund your purchase *and* pay for the postage costs to return it. You can't lose. We also back ESCORT with a full one year limited warranty on both parts and labor. ESCORT will change radar for you forever. So order today.

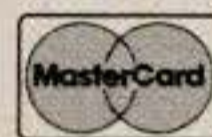
Do It Today

Ordering an ESCORT is simple, by mail *or* by phone.

By Phone: Call us toll free. A member of our sales staff will be glad to answer any questions and take your order. (Please have your Visa or MasterCard at hand when you call).

CALL TOLL FREE . . . 800-543-1608
IN OHIO CALL 800-582-2696

By Mail: We'll need to know your name and street address, daytime phone number, and how many ESCORTs you want. Please enclose a check, money order, or the card number and expiration date from your Visa or MasterCard.



ESCORT (Includes Everything) . . . \$245.00
Ohio residents add \$13.48 sales tax.

Speedy Delivery

If you order with a bank check, money order, credit card, or wire transfer, your order is processed for shipment immediately. Personal or company checks require an additional 18 days.

ESCORT®

RADAR WARNING RECEIVER

Cincinnati Microwave
Department 516
One Microwave Plaza
Cincinnati, Ohio 45242

Is ST/O/P adaptable to your present ESCORT? Well, yes and no. At S.N. 200,000, there was an internal redesign of ESCORT incorporating custom integrated circuitry, a precision quartz timebase, and a new integrated microwave mixer/antenna/Gunn oscillator. The new ST/O/P technology builds on this by signifi-

cantly expanding the digital logic and adding memory. As a result, older units (serial numbers less than 200,000) cannot be modified to incorporate ST/O/P technology.

For those of you with ESCORTs from S.N. 200,000 to 399,999 we are presently developing procedures and

facilities to make adding the ST/O/P circuitry to your unit possible. The cost will be \$75, and details and special shipping instructions will be in our advertisement in the August '83 issue of this magazine. Sorry, but we won't be able to convert your unit until that announcement.



Which do you think is the more sophisticated computer?

Epson.

The big differences between the Epson HX-20 Notebook Computer (on the left) and the Apple Computer (on the right) are: 1) the HX-20 doesn't need a power cord, 2) the HX-20 weighs only about four pounds, and 3) the HX-20 costs a lot less money.

The Epson HX-20 Notebook Computer has a full-size keyboard, a built-in LCD screen, a built-in printer, 48K of combined RAM and ROM memory, and an internal power supply that will keep it running for over 50 hours. So you can do computing and word processing virtually anywhere you happen to be. Whereas, with the Apple Computer, you can only go as far as an extension cord will take you.

And on the HX-20, you get communications interfaces, upper and lower case letters, five program areas, a full 68 keys including an integrated numeric key pad, an internal clock/calendar, and the screen and printer. Standard. On the Apple, you pay something extra for each feature — if you

can get them at all.

All of which makes the take-it-anywhere HX-20 perfect for business executives, salespeople, students, kids — anyone who's looking for an affordable, practical way into computing.

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AUTO
MAINTENANCE

Automotive trouble- shooting quiz

By STEVE MERCALDO

Questions

1. A grinding noise

Along with her customary hello kiss, your wife greets you with, "My car is making a funny sound." She explains that there is a grinding noise that can be heard when the car exceeds 20 mph.

After supper you take the car out to the expressway for a test drive. Her initial report is correct: The grinding noise increases with vehicle speed. You also feel a slight roughness in the steering wheel whenever the grinding is heard. You aim the car at the next exit ramp. Suddenly, the noise decreases and the sensation in the steering wheel disappears. Curious as to why the sound changed with a change in direction, you continue testing on the service road. When you steer right or left, the sound diminishes and the sensation in the wheel disappears.

Could the noise be coming from a faulty drive-line component? A defective rear-end assembly bearing can cause a grinding. You shift the car into neutral as you coast down the service road. The noise remains the same with the transmission in drive or neutral. What's causing it?

2. Weak battery

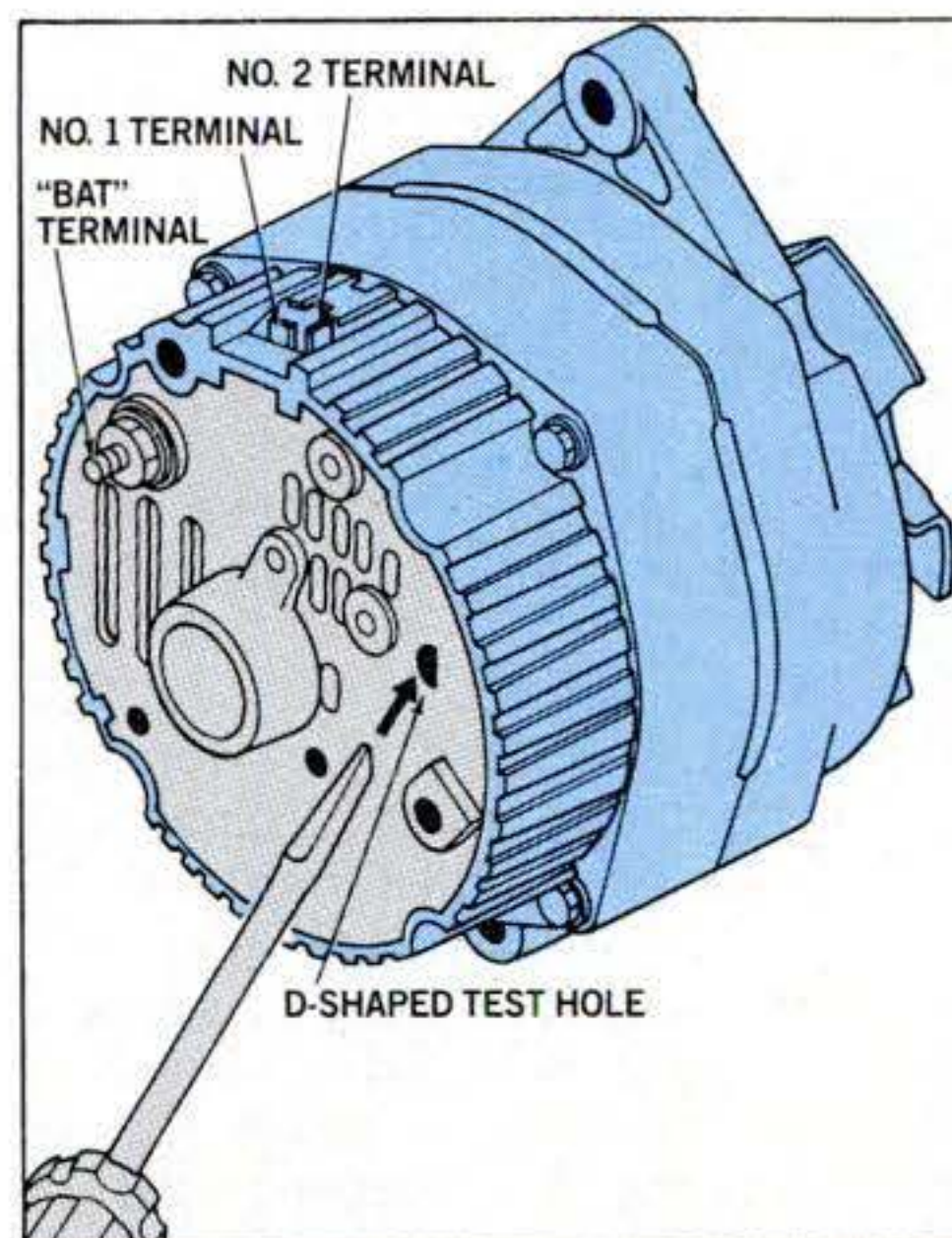
Your GM pickup's battery won't hold a charge. A recharge seems to give new life to the battery, but within a

few weeks it fails again and you're unable to start the engine. Prior to the battery's death, you notice something unusual. At idle speed, the directionals flash very slowly. Since the battery is three years old, you replace it. A month later the symptoms mysteriously reappear.

Now you're confused. The dash lamp doesn't show a charging problem. It goes out as soon as the engine fires up. You decide to trouble-shoot. The alternator belt is neither loose nor worn. You check for an electrical short by connecting a 12-volt test light between the disconnected posi-

tor, and engine ground strap. Finding nothing wrong, you turn the problem over to a repair shop.

The mechanic also checks belts, wires, and connections. All check out perfectly. He recharges the battery and connects a volt-amp tester (VAT) to check alternator output. Output is below spec. He decides to check the wiring going to the alternator, too. With the ignition key off, he connects a 12-volt test lamp to a good ground, then touches the probe of the tester to the BAT terminal of the alternator. The tester lights. Next, the number-one and -two slip connectors are removed. The key is turned to the on position. When the probe touches each terminal, it lights. Finally, the output test is repeated. But this time, the mechanic slips a small screwdriver into a D-shaped hole in the back of the alternator. The VAT's meter shows the alternator is now delivering the proper output. Why is the battery undercharged?



tive battery cable and its post. With the doors closed and the key off, it doesn't light. This rules out the possibility of a battery drain or short.

You continue your inspection by examining the wires for defects. All connectors are tight and clean, including the connections at the alternator, engine-compartment cowl, starter mo-

3. Engine knocks

The knock from your import's four-cylinder began as a slight tap. Within 100 miles, the tapping had increased to a loud knock. A knock is usually a sign of a serious engine problem. The crankcase is full of oil; you checked it as soon as the knocking started. And the lubrication system was serviced within the last year.

It seems logical that the knock could be coming from one of the components that is driven by a V belt. You know from experience that a faulty water-pump bearing can make some strange sounds. To check the belt-driven components, you remove

Continued

[Continued]

their belts and restart the engine. The knock remains.

You listen to the engine with the aid of a mechanic's stethoscope. The noise seems to come from the low end of the engine. A piston rod hitting an oil-pan dent could cause a knock. With the car raised and safely supported you examine the pan—there are no dents. You check the torque converter's tightness. The converter inspection cover is removed. You examine the flex plate for cracks or breaks where the plate connects to the engine or torque converter. Each bolt is snug, so you replace the inspection plate and lower the car.

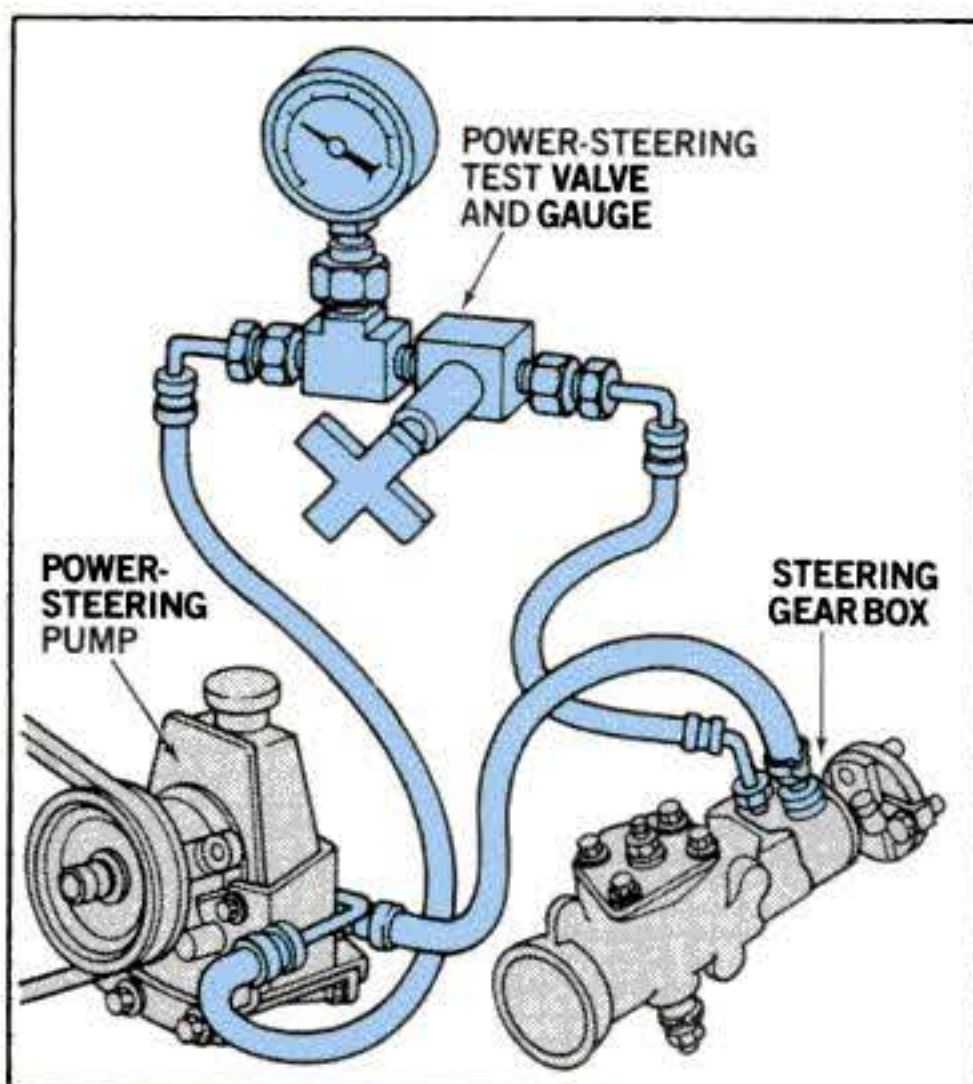
Finally, you do a power-balance test. One plug wire at a time is removed while the engine is running. When cylinders one, two, and three are killed, the knocking is still audible. But when number four is killed, the noise changes and almost disappears. What's causing the knock?

4. Hard steering

It's probably easier to maneuver a tractor in a muddy field than to turn your car out of a tight parking space. This is odd for a car with power steering. Tire pressures check out at the recommended 26 psi. An inspection reveals no unusual tread wear. The power-steering belt is neither loose nor glazed. The pump reservoir is full, and the pump brackets are tight.

You give the suspension and steering linkages a shot of lube. Steering improves slightly but still requires extra effort. You check for binding in the steering column and steering shaft. None exists.

Convinced that the tight steering is caused by a stiff linkage or suspension

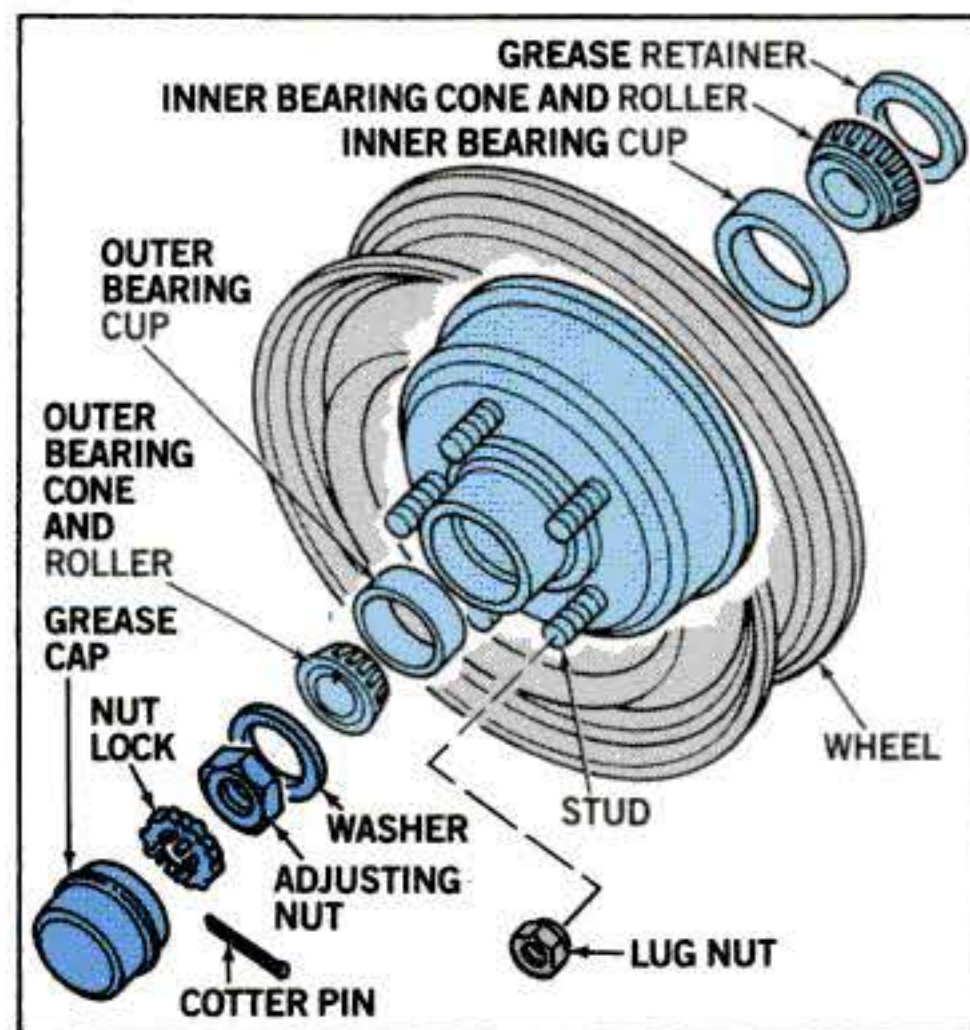


joint, you remove the pitman arm from the steering gearbox. This effectively separates the linkage from the box. You grasp a front wheel and move it through a full turn. To your surprise, it rotates freely.

You decide to take your puzzle to a pro. He listens to your tale of woe, then hooks up the gauge setup in the diagram. With the engine operating, he looks at the gauge and then closes the hand valve. He explains that the gauge pressure is below specification. What's causing the hard steering?

Answers

1. One or both front wheel bearings are defective and must be replaced. The clue to this problem surfaced when the driver turned the steering



wheel to exit the expressway and there was a decrease in the grinding noise.

Whenever a vehicle makes a turn, its body reacts to centrifugal force and the weight shifts from one side to the other. Since each wheel rotates on one or more bearings, there is a corresponding load change on each bearing. Bearing load increases or decreases depending on which way the vehicle turns. The varying load will change the noise you hear. Roughness felt in the steering wheel pointed to a front-wheel bearing. Maintenance guards against premature failure. Service your car's bearings every 5,000 miles or according to the recommendations in the owner's manual.

2. The voltage regulator is defective

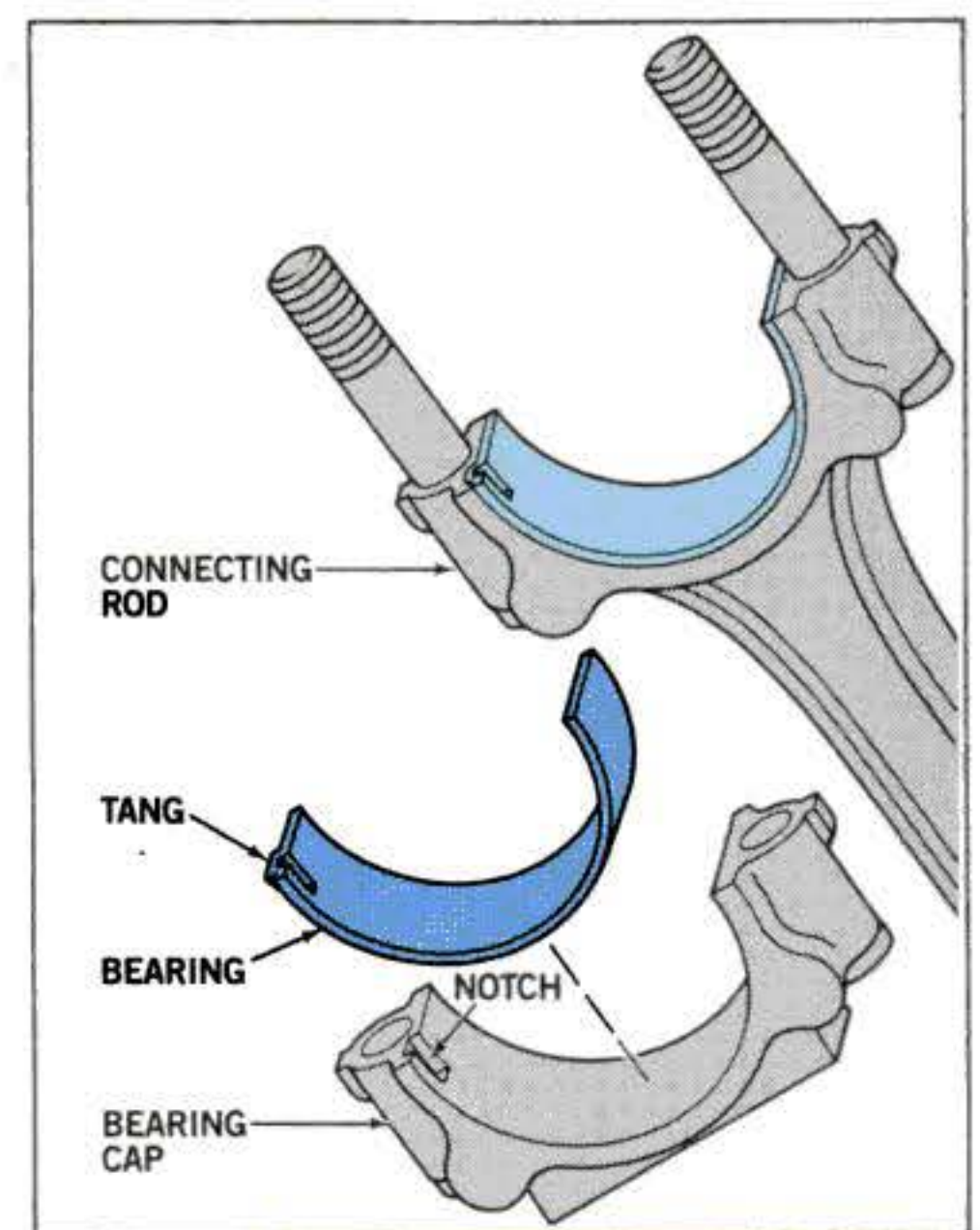
and must be replaced. One clue to the charge problem was the slow signal flash at low speeds. A low charging rate will cause slow flashing and dim lights—particularly at idle. Increased engine speed will brighten the lights and speed the flasher.

On late-model GM cars and light trucks the regulator is housed in the alternator. To check that the regulator is functioning properly, it's necessary to bypass the regulator from the circuit. To test: Position your volt-amp tester in the circuit, and operate the engine at the proper test speed. Insert a small screwdriver into the D-shaped hole. This grounds out a tab in the alternator. (Note: Insert the screwdriver no more than an inch [25 mm] into the hole. Deeper insertion will damage the alternator.) If the alternator begins to deliver a full charge, the regulator is defective. However, if the alternator fails to deliver a full charge, it is defective.

Why didn't the dash warning indicator light up and alert the driver to the low charge rate? Because it only shows that a charge is being delivered, not the amount. If your car or truck is equipped with an "idiot" light, have the charge rate tested at least once a year.

3. The connecting-rod bearings are worn out in number-four cylinder. The engine will have to be disassembled to make an accurate estimate of the damage. To locate a bad bearing, simply perform a power-balance test as described in this problem. Set the engine speed to the rpm where the knock is loudest and then remove one

Continued



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[Continued]

spark-plug wire at a time. When the faulty cylinder loses its spark, the knock will lessen or disappear completely.

It's a good practice to follow the manufacturer's procedure when performing a power-balance test. Some auto makers don't recommend removing a plug wire while the engine is operating. Damage to the electronic ig-

niton can result. If in doubt, first ground the plug wire with a jumper wire, then start the engine and listen for changes in the knock.

Why does killing the spark to a cylinder with a loose (worn) bearing change the noise? Each time the air-fuel mixture ignites in the combustion chamber, the piston assembly is placed under a heavy load. A loose set

of connecting-rod bearings will send out a knock as the piston reacts to combustion-chamber pressure. When the wire is removed from the plug, ignition is halted. This, in turn, reduces the force or load on the connecting-rod bearings.

The most common causes of a worn bearing are: lack of sufficient lubrication due to insufficient oil in the crankcase, dirty oil and filter, or a faulty oil pump. Regular oil and filter changes are good insurance against bearing knock.

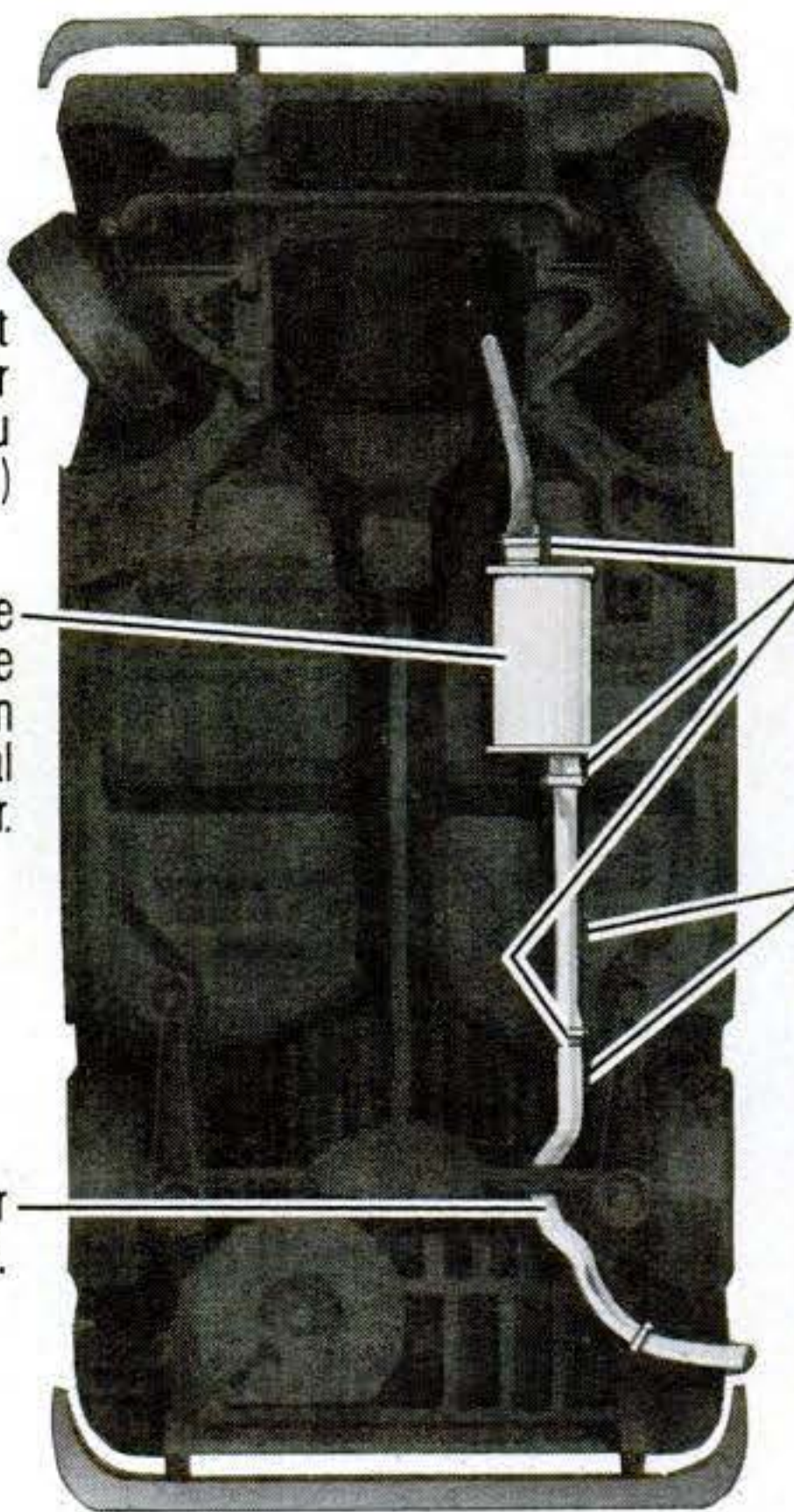
4. The hard steering is caused by a faulty power-steering pump. You took the right approach by first eliminating several routine checks. Tire air pressure is critical for normal steering. A loose power-steering-pump drive belt or a low oil level in the reservoir can also be a problem. Lubricating the steering linkage and suspension parts was also a step in the right direction. When the possibility of interference between the linkage and another component was eliminated, it was time to do some serious trouble-shooting.

One of the best ways to locate a problem is by process of elimination. By disconnecting the pitman arm from the gearbox, the steering linkage was isolated from the power-steering components.

The clue came when you were able to turn the front wheels manually with a minimum of effort. At that point, the linkage was eliminated as a possible cause. The problem was narrowed down to either the steering gearbox or the pump.

The mechanic used a special high-pressure gauge and valve set to pinpoint the problem in the power-steering system. The gauge and valve are connected into the pressure hose between the gearbox and the pump. System pressure is recorded as the engine operates. If the pressure is below specifications, the hand valve is closed for five seconds and the pressure is read. This is repeated several times. The test pressures are then compared with the manufacturer's specs. This pump must be replaced or overhauled. There's a good chance that the problem is either the pump's flow-control or pressure valve sticking in the open position. After the pump is removed from the vehicle, the valves can be removed, cleaned, and carefully polished with crocus paper. Avoid rounding the edges of the valves. **PS**

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Solar power for remote phones



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Banks of 66 photovoltaic cells charge 12-V batteries that can store enough power to keep five nights ahead of needs. The cells should last indefinitely, say the inventors at Gladwin Inc., Oakwood, Ga., and the batteries have a life expectancy of seven to 10 years. The components add \$300 to the cost of an installation, but to the Bell System, now putting cells to work, it's worth it in some areas: The phone shown here is in Bedford, Texas, and stringing electrical lines would have meant expensive trenching across a vast concrete parking lot.

Many of the solar-lighted pay phones will replace ones that used to draw power from nearby advertising signs, which, because of the high cost of electricity, are no longer left on at night. When their power was switched off, so was the pay phones'. Still other installations are only temporary—such as the 25 pay phones that were dotted around the Knoxville World's Fair grounds. Future solar systems for phones will eliminate all wiring. The phones will work like cordless phones but be capable of sending and receiving calls over greater distances to a central station.—

David Lampe

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*Based on R.L. Polk & Co. registrations, May 1982.

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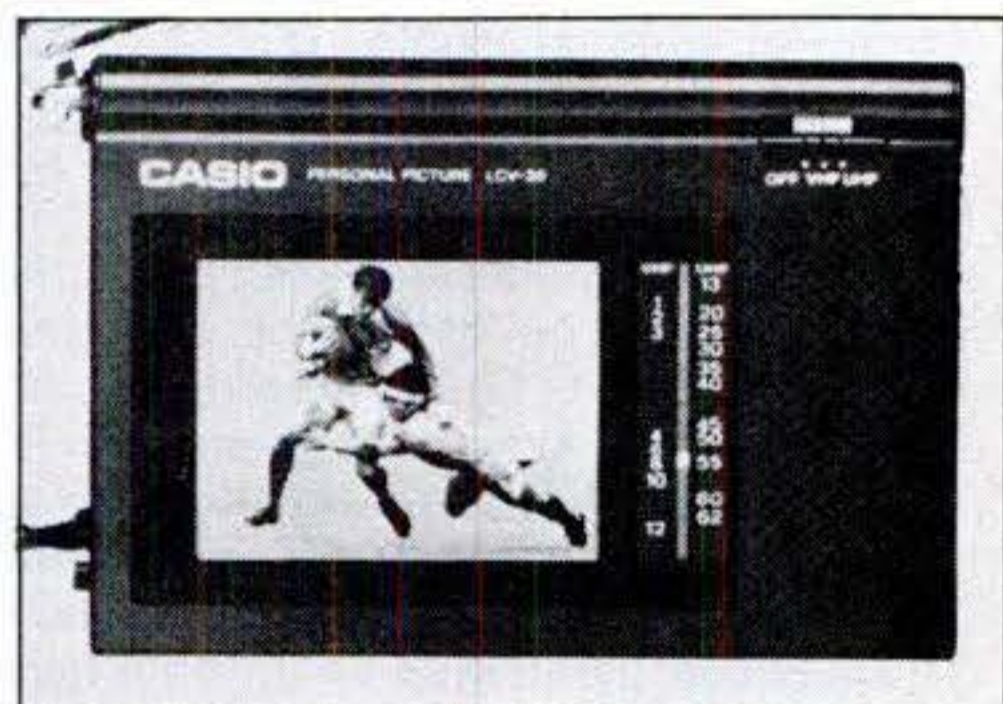


AMERICA'S TRUCK

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LOOK AND LISTEN

By JOHN FREE



Liquid-crystal TV

Now there are two pocket-sized flat-screen TVs.

Last year Sony introduced Watchman, a black-and-white model with a two-inch CRT ["Go-anywhere TV," PS, Nov. '82]. Sony's \$350 Watchman measures eight by 3½ by 1¼ inches. Picture quality is fair, and contrast on the tiny picture tube isn't bad either.

Casio's new monochrome 2¾-inch flat-screen set (photos above) uses both liquid crystals and solid-state electroluminescent (EL) material for display. The liquid-crystal elements are arranged in a 160 (horizontal) by 128 (vertical) array, providing 20,480 pixels for TV images. The EL material can backlight the display for viewing in poor light or darkness. The models I saw inside a display case at a brightly lighted electronics show had poor picture contrast—both with ambient light and EL backlighting. Casio's first TV product takes the prize for compactness—

it's about the size of a deck of cards—but Sony's CRT model has a better display. Casio will sell its flat-screen Casiovision for about \$250. Next year there may be a color Casiovision model, as well.

Beta versus VHS hi-fi

Piping high-fidelity audio from a VCR's audio-out jack into your hi-fi system hasn't been possible until now. That's because this audio is recorded on a very narrow path along the edge of videotape. There's lots of tape hiss, made worse when the narrow audio track is halved for stereo. And the tape moves so slowly that the fixed audio head—like those in pocket tape recorders—can't capture the higher frequencies.

But 11 firms marketing Beta VCRs will offer stereo models this year that eliminate VCR audio-fidelity problems. These new decks have a feature called Beta Hi-Fi. The sound it produces—enhanced in realism by video imagery—is fantastic. To achieve this, audio for Beta Hi-Fi cassettes is frequency modulated and added to the video track—the slanted magnetized path created by the video heads. New stereo decks will have special circuits to separate this audio from the video and send it to audio-out jacks.

Demonstrations I heard at a Las Vegas electronics show made it obvious that the new Beta audio technique easily surpasses the fidelity of ordinary music sources. Beta Hi-Fi has an 80-dB dynamic range (the difference between loud and soft passages). That compares with 60 to 70 dB for the best tapes, LP records, and FM broadcasts. Conventional VCRs offer only 40 dB of dynamic range, with Dolby noise reduction boosting it to 46 dB. Beta Hi-Fi frequency response is 20 Hz to 20 kHz, and wow and flutter are less than 0.005 percent. Only the digital tapes and discs ["Digital Discs," PS, Nov. '81] I've heard exceed Beta Hi-Fi's sonic wallop.

The Beta group is introducing about 70 new cassettes recorded with the technique, but they may be slow arriving in stores until duplicator machines can be upgraded to handle Beta Hi-Fi. The cassettes include recent blockbuster movies, a variety of rock concerts, and a so-called video LP from Sony: "Vladimir Horowitz in London." Sony, apparently hoping to tap the growing audience of videophiles hooked on 24-hour cable-TV music channels, is also offering Video 45 cassettes. Video 45s may carry about 15 minutes of popular music and cost \$15 to \$20.

Manufacturers of the competing VHS format have been marketing stereo machines with lower-fidelity fixed-head au-

dio tracks for some time. But they have also been privately demonstrating prototype VCRs with the new super-fidelity FM-audio tracks. It's likely that VHS firms will offer upgraded stereo VCRs later this year.

New look in TV

Color-TV picture tubes with completely flat screen surfaces have been introduced by Toshiba. The Japanese company says its flat square screen has several advantages over cylindrical screens (Sony's Trinitron) and spherical screens (most CRTs on the market). Square-corner tubes don't need the masks used to cover the corners of ordinary tubes. As a result, you can see more of the picture: Only 0.3 percent is missing with flat tubes, compared with 1.7 percent for cylindricals and three percent for sphericals, says Toshiba. The firm also says that the new tubes provide a wider viewing area and that their light-absorbing phosphors deliver 10 percent better contrast and a wider color range than ordinary CRTs. Sears will join Toshiba in marketing sets with flat faces this year. Other tube makers are likely to introduce similar flat-surface picture tubes. Comparing a grid pattern on all three types of tubes side by side, I noticed the new device had less distortion at the picture edges and, overall, a more pleasing picturelike display.

A few years from now the inside of Toshiba's TV receivers will look different, too. Toshiba, like several firms, is developing a set of semiconductor chips for digital processing of the TV signal ["Digital TV," PS, July '82]. The TV chips promise a sharp reduction in the components required for a set plus special features such as enhanced resolution, ghost cancellation, and reception of pictures in any country.

Miniature CCD camera

A palm-sized TV camera (photo) that can capture TV images in a completely darkened room has been introduced by Sony for security and surveillance. The charge-coupled-device (CCD) sensor in the monochrome camera is sensitive to infra-



red and works with about 0.1 foot-candle of illumination. Its camera is immune to strong magnetic fields and is rugged enough to record underground boring, says Sony. The 3.4-ounce camera has 280-line horizontal resolution and vertical resolution exceeding 350 lines.

Continued

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Look and listen

[Continued]

Quick looks

- CBS and AT&T's American Bell have added at-home banking, TV listings, shopping guides, stock-portfolio listings, and date reminders to a videotex test at homes in suburban New Jersey. Videotex provides access to computerized data over phone or cable lines. Both CBS and NBC are planning commercial teletext service this year—regular broadcasts carrying "magazines" of information encoded into unused TV scan lines. Adapters to extract the text might cost \$250.

- Videodisc notes: A third type of videodisc system called VHD ["Videodisc Players," PS, July '80] didn't make its scheduled U.S. introduction. It is now slated to go on sale in Japan about the time you read this. Some 200 albums will be available for the \$625 player, which has random-access capabilities (accessing TV frames by number) . . . RCA says it will introduce a CED player later this year with random-access features, too . . . Interactive optical discs (using random-access and other player features) are slowly growing in numbers: MysteryDisc, a detective plot with a variety of solutions is a new addition. Also, arcade-game-maker Sega Enterprises is readying a disc-based game offering spectacular space-war action with realistic movielike scenes instead of computer graphics. And MCA Video Disc is marketing Action Adventure Games, an interactive disc that lets players guide "real" images (actors), not computer-graphic symbols, through action scenes.

- Recording techniques that align magnetic regions vertically instead of horizontally for greater density on tape or disc are barely out of the labs. But already so-called perpendicular recording is turning up in prototype consumer hardware. Toshiba has shown a magnetic-disc still-picture camera similar to Sony's Mavica [PS, Dec. '81] that captures 70 color-TV frames compared with 50 on the Mavica. Discs from these 35-mm-like cameras can be played back on any TV or printed on special paper. A videotape coated for this high-density recording has also been demonstrated by Toshiba. The tape could double the recording time (to four hours) of combination VCR-cameras based on 1/4-inch-wide tape ["The New VCRs," PS, Nov. '82]. These ultra-compact machines are being readied as the next generation of portables. But the extended playing time would make them suitable as home recorders, too.

- Plug-in boards for future color-TV sets may take the hassle out of attaching them to various cable-TV systems and hardware such as computers and videodisc players. Groups in cable and electronic industries are jointly trying to establish a standard "port" on TV receivers. You'd buy or rent a plug-in circuit board instead of the usual black-box converter. That would enable you to use the remote control for your TV to change cable channels. Today, cable-ready TVs and VCRs may not work on all systems. **ES**

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Toyota's EX-11

—an electronics showcase

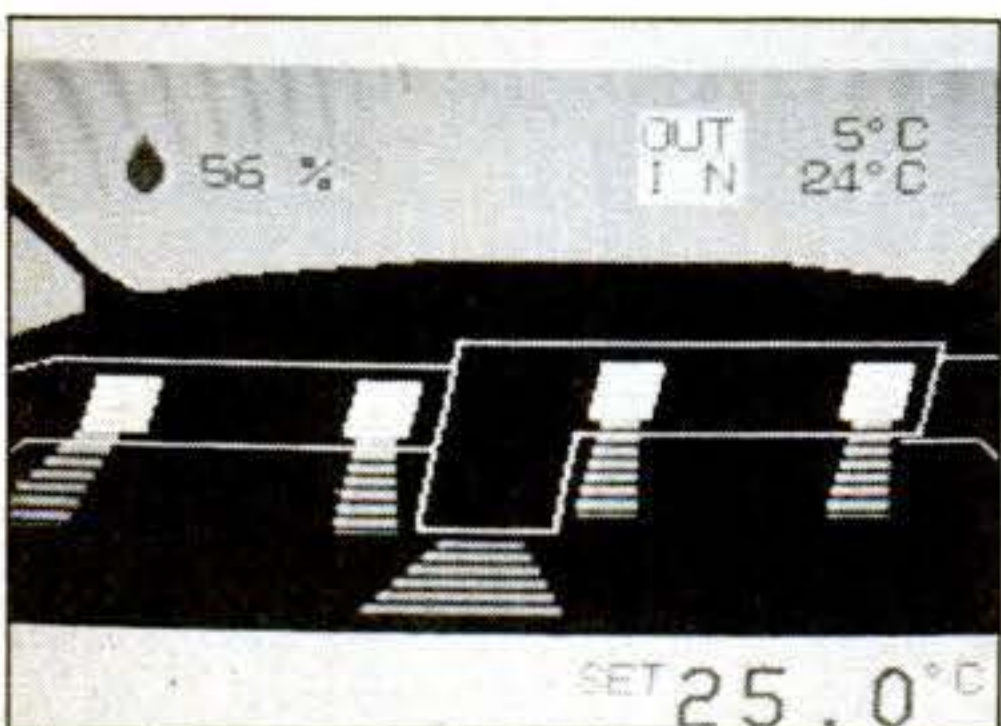


By DOUG GARR

TOYOTASHI, JAPAN
From the outside it's just another boxy sedan. It's when you slip into the driver's seat that you notice that the EX-11 is no ordinary car. Packed into the interior is Toyota's testament to an electronic future. The dash bristles with information from 18 microprocessors, which control everything from the power-adjustable headrests to the car's radar and sonar safety and navigation systems.

According to Yutaka Goto, one of the firm's top electronics experts, many of the sophisticated features in the EX-11 today will be in Toyota's production models tomorrow.

The car is keyless. To unlock it, you press a combination of buttons on a nine-button grid panel on the door. There are 300,000 combinations, and you'd better be sober, because you get



Multi-information display shows the car's route on a map. The map is provided by a cassette, which the operator inserts in the monitor system. The lower display shows ventilation and air-conditioning information. The screen can also be switched to a regular TV channel by voice command or by a hand-held remote-control unit. Audio, A/C, and other controls are integrated through a speech-recognition device that responds to your voice and replies to your commands through a speech synthesizer.

only three tries. After that, the lock deactivates for a short time. To start the engine, you must push the buttons of a similar grid on the dash.

A sonar indicator above the rear seat beeps and flashes when you back up if you're within two meters of an object.

A radar system built into the front bumpers maintains a preset distance between you and the vehicle ahead. Even if the car ahead slows, a safe distance will be maintained.

A microprocessor-controlled suspension system provides a smooth, fuel-efficient ride. The suspension adjusts to maintain proper vehicle ride height despite the load. On rough roads, the car sits higher for additional clearance. At highway speeds the vehicle is programmed to tip itself forward for better aerodynamics.

The windshield wipers and lights turn on automatically. A drizzle puts the wipers in an intermittent mode. When the rain comes down harder, wiper speed increases automatically. At dusk, a sensor turns on the parking lights. Later, the oncoming lights of traffic will trigger a fender sensor to adjust headlight beams to high, medium, or low. A computer-controlled anti-skid system keeps the brakes from locking during panic stops.

How much would an EX-11 cost? Even the Japanese rolled their eyes skyward. [5]

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"SAY, SMOKEY—"

A clinic on cars by Smokey Yunick, America's most famous mechanic

Better propane performance

I have a 1979 Dodge D150 with a 318-cu.-in. engine equipped with a dual propane-gasoline conversion. When I switch from gasoline to propane, I drop from 13 mpg to 10 mpg and lose power. What can I do to get better propane performance?

Richard R. Schnabel, Gold Hill, N.C.

You need more compression, more ignition advance, more air (port and cam), and more fuel. The Btu content of propane is lower than gasoline, so you have to load the cylinders harder and work on a slower reaction that is less sensitive to knock.

Wants to update Buick

I have a 1973 Buick with 455-cu.-in. engine, and I wonder if it's possible to retrofit it with throttle-body injection and computerized ignition. I intend to keep the car a long time.

James W. Read, Beaverton, Ore.

Unless you're a genius, forget it. The injector is a closed-loop, computer-controlled feedback system. An oxygen sensor establishes an electrical signal, depending on hydrocarbon content, and relays it to a computer, which is programmed for the engine, car, and drive train. The computer controls fuel, fuel temperature, air and water temperature, and power demand. The wiring is very complex, and the controls must be sized to the vehicle. These are only some of the complications.

The ignition connection

My new Ford Escort ran well on short trips, but I couldn't travel more than 50 miles before it quit—as if the ignition were shut off. A mechanic replaced the coil, and I then went 100 miles before the problem reappeared. Also, the car doesn't idle very well.

Roland Whitwer, Omaha, Neb.

It could be a bad connection between the ignition module and the harness. Clean it and coat it lightly with silicone grease.

Plugged EGR, high pressure

Most of the driving we do with our cars is at low speed, maybe two or three miles at a time. The EGR [exhaust-gas recirculation] plates have either clogged or burned through, and a white powder builds up on them and has to be scraped off. Also, I notice that when I stop for fuel after driving for a few hours, there is high pressure in the tank when I remove the cap. I

checked pressure with a gauge at the fuel pump and found it to be high: 10 lbs.

Charles Dixon, Wichita Falls, Texas

The white-powder deposit in the EGR is from fuel additives. Changing your fuel vendor will affect it. The fuel-tank vent is a pressure system with a valve to prevent

backflow. It's supposed to open at two psi. If the cap isn't working properly, a plugged hose will cause trouble.

Laid-up lifter

While checking the hydraulic-lifter adjustment on my 1977 Chevrolet Monte Carlo with 305-cu.-in. engine, I heard a clacking noise. I found that the rocker arm on number-five intake was still loose after I adjusted it three-quarters of a turn past zero lash. If this is caused by a worn cam lobe, why would it occur on one lobe only, and why after only 45,000 miles?

James Peck, Sussex, Wis.

A worn cam lobe wears on the lift side of the cam, but lash is established off the base circle and doesn't wear. Your trouble sounds like a bad lifter: You probably

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adjusted one that was collapsed. Pull it out for inspection; expect that the cam lobe will be gone when you look down the lifter bore.

Why grease terminals?

The instruction book for my 1975 Lincoln says to use silicone grease on spark-plug-coil and distributor-wire terminals, and to coat the brass electrode surfaces when installing a new rotor or cap. Why?

Gus Canela, San Bernardino, Calif.

The grease prevents oxidation and maintains good electrical conductance.

Car fires back

My 1980 Datsun 280-ZX, 2+2 automatic backfires under low revs when driving

away. The problem disappears under high acceleration and normal cruise.

John C. Tobin, New York, N.Y.

There are three probable causes of back-fire—the exhaust valve is open or leaking when the engine fires; oxygen is getting drawn into the exhaust system through a leak; air is being pumped in at high vacuum because of defective air-pump cycle control.

Shroud that fan

My 1975 V6 Ford Mustang II with factory air conditioning and standard transmission shows a slightly above normal temperature on the road and climbs toward the danger zone at idle. I've checked the radiator, thermostat, coolant mix, and temperature gauge, and I've made sure

the system holds pressure. I believe these symptoms started after a water pump was replaced. Another water pump and thermostat have been installed since then.

Carlie Luck, Chapel Hill, N.C.

The fan shroud could have been damaged or left off at the time of the water-pump change. A fan shroud is necessary for adequate cooling.

Lean machine

My 1981 V6 Buick Skylark hesitates and sometimes stalls after a stop. Pumping the accelerator helps if the engine is still turning. The car has only 4,000 miles on it, and the problem is both hazardous and annoying.

Orley Johnson, Manhattan, Kan.

The hesitation and stalling are caused by lean mixture, but how it gets lean is the question. Whether the engine is hot or cold makes a difference as to where the trouble is. Unless you understand fuel-spark and emissions systems, you're shooting in the dark. You need to find a dealer or very-up-to-date shop. The trouble is probably minor, but an amateur could make an expensive three-ring circus out of it.

Fluttering diesel

My 1981 Pontiac Bonneville diesel has developed a flutter at idle. If I step on the throttle a little, it smooths out. The dealer checked over the fuel pump and injectors; it didn't make any difference.

Don H. Fleury, Raynham, Mass.

The flutter is in the pump itself—an air leak, for example. It can also be caused by improper internal timing or a defective metering assembly. You can't fix it. The pump needs to be removed and flow checked; the trouble will then show up.

Opposite results

How can a compression gauge and a leak-down tester give opposite readings? On my 1976 400-cu.-in. Chevy, all cylinders show 150 to 160 lbs. The leak-down tester shows 70 percent leakage in all but number-one (30 percent). All leakage is past the rings.

Barry O. Williams, Clearfield, Pa.

Go by the leak-down tester and note that right at TDC, a little crank movement will raise or lower the readings. The problem is that the ring can leak at the top or bottom of the ring land. Make the check with a warm engine; oil in ring lands gives a tighter reading.

Each month, Smokey Yunick answers questions on cars—family cars, high-performance models, and racing vehicles. Got a 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 that are not selected for publication.

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BITS & BYTES

By WILLIAM J. HAWKINS



Smart computers

"Draw a circle," my demonstrator said in a normal voice. Blip. A circle appeared on the video screen. "Ah, let's see..." (WORDS IGNORED showed on the screen as he thought out loud.) "Make it red." Lines of bright color instantly filled the shape.

I was watching over his shoulder. I could see the microphone he held rather casually and the CRT screen of Texas Instruments' new personal computer called The Answer.

"Move the circle to the right," he continued. Whoosh—it scurried to the right of the display. "Now draw me a triangle." A three-sided figure instantly appeared. "Make it larger," came his next command, and the triangle suddenly doubled in size. "Oh, and color it yellow." Streaks of yellow painted its surface.

Impressive? You bet, but voice recognition (*usable* voice recognition, that is) is just one trick of what promises to be many from a new generation of personal computers: smart computers.

They're just starting to appear from manufacturers, and at the moment the two standouts are this TI (above) and Apple's Lisa (photo at right). What makes them so smart?

It's not the jobs they do—you'd expect those from any computer worth its weight in silicon chips. Instead, it's the way these



machines communicate with humans—we no longer have to learn special programming codes or commands to make them do something.

While the TI can use voice recognition, Lisa (which stands for Local Integrated Software Architecture) relies on its superb screen graphics and a hand-held gizmo, called a mouse, that you slide around the table top. The screen shows pictures of things you can do: type a letter, file it away, print something, or do calculations. But to choose one, you don't type a command on the keyboard—instead, you move the mouse around on the table in front of you.

As you do, the screen cursor moves, too: Move the mouse up, the cursor goes

up; move it in a circle, the cursor duplicates your movement on the screen. For work, move the cursor to the picture you want and press a button on the mouse, and you have issued a command that would ordinarily require several typed words and a working knowledge of the computer system. Then, once you've selected a program, you can use the clever control for other things: to edit a document, for example, or create graphics.

But working with humans isn't easy—it takes a bit more than just knowing what to do when a command is given. Since much of our work overlaps into different areas, the software included with these machines must overlap, as well.

For example, Lisa's word processor allows you to type the main body of a letter. But the computer creates the final document you send out. It gets the proper address from a data-handling program, numbers from a spread-sheet program, and drawings from a graphics package. The result is: "Dear Mr. Hawkins, you still owe us \$..." complete with color charts of my past paying habits.

TI's computer works similarly, but all of its software will be able to use the voice-control option. Reason: The software is standard—voice control comes from a circuit board that fools any program into thinking the command it just got was punched in at the keyboard. Now that's clever.

TI has also created programs and hardware that integrate the computer with other office devices: It answers the phone, for example, speaks to the caller, and takes the message by digitizing the incoming voice and recording it on a hard disc for playback later.

Both The Answer and Lisa are capable of using CP/M. (The Answer can also use MS-DOS.) That means lots of programs are available from other sources, too. Lisa comes complete for under \$10,000. The Answer begins at \$2,595 and is \$6,185 with all options but speech and voice recognition. The prices for those have not yet been set.

Home file system

There is only one problem with a home computer: Despite everyone's efforts, there are still very few real jobs it can do around the house. (How many times can you compute your mortgage?) But there is an exception: filing. Everybody has something to file—from recipes to phone numbers to the Christmas-card list. And a new program from Atari takes all the fuss out of using an elaborate data-base management system.

The program, called The Home Filing Manager, makes it all easy by using the screen graphics to create a filing cabinet and the three-by-five cards we're all used to scribbling on. Pick out a card, type in the information you want it to contain, and place it in the file.

Later, you can easily retrieve it again by looking at cards in file order (like thumbing through the box) or by asking the computer to search for a card by its title or a specific phrase it contains.

Continued

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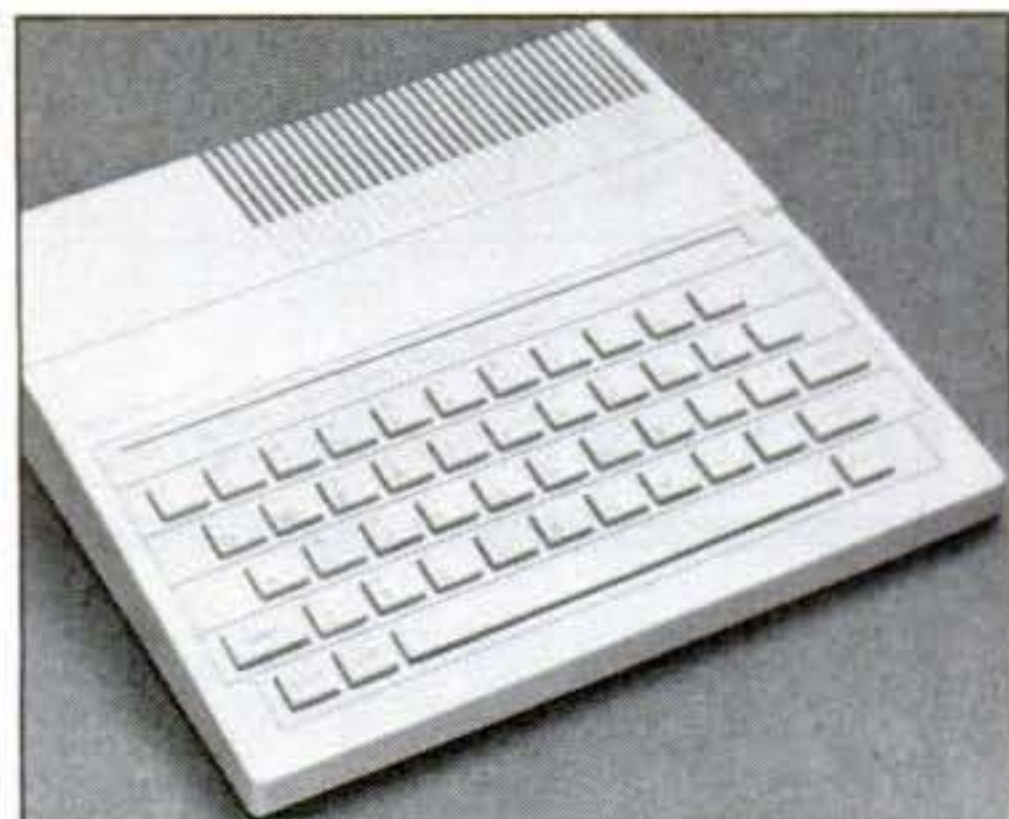
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Bits & bytes

[Continued]



Up to 700 cards can be held on one disc—that's a lot of recipes. For Atari computers, it's \$50.

No end in sight?

The way things are going, I expect Kellogg's to soon be in the computer business: With two box tops, you get your choice of a signet ring or a 16K personal computer (and your kids will come to you to find out what a signet ring is). Prices are dropping, while, at the same time, machines are becoming more sophisticated—and they're available everywhere. Take a look:

Above is the Texas Instruments 99/2 home computer. It's a 16-bit machine that works in BASIC and accepts tape or cartridge programs. Price: \$100.

Below is a Sharp PC-1250. It looks like a calculator, but it is a complete computer that's programmed using BASIC. The price is basic, too: just \$110.

Dynasty Computers are \$1,500, but you can't buy them in a store. The company intends to sell them door-to-door through private representatives. ("Avon calling.")



And what do an ice bucket, a computer, and the Bible have in common? By 1985, they'll all be standard in TravelHost motel rooms. The company has ordered 500,000 terminals and intends to have them work through an IBM main-frame computer.

The last word

Radio Shack is now offering two other operating systems for its Model II and 16: CP/M Plus from Digital Research and Xenix (a form of AT&T's UNIX system) from Microsoft. Both are powerful systems allowing the Model II or 16 to use literally thousands of off-the-shelf business programs. All this is a good idea, but it comes as a surprise: Radio Shack has always insisted on using only its own TRSDOS operating system.

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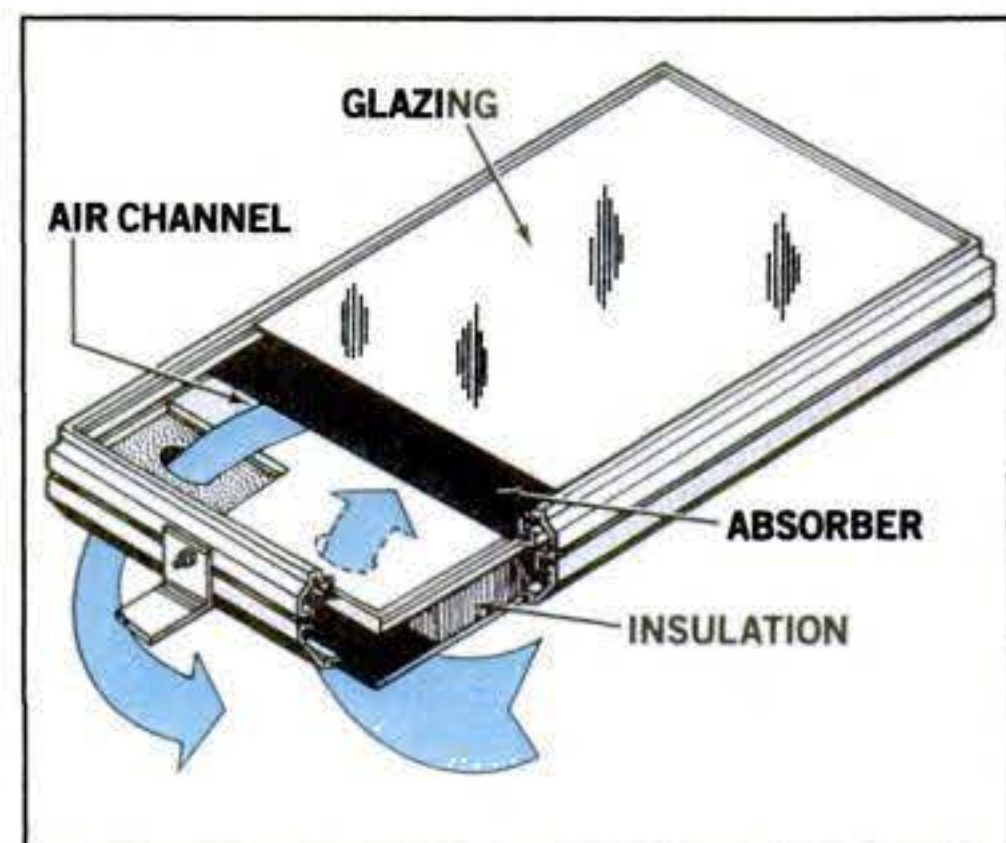
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14 DAY MONEY BACK GUARANTEE

Low-cost solar collector in a kit



Air enters collector, passes through air chamber and under absorber panel, then exits through duct. Components of the \$300 kit are shown in the photo.

Part of the expense of installing a solar heating system can be offset by doing some of the work yourself. You can save on the cost of a collector, for instance, by building your own from a kit such as the Series 4000 kit air collector manufactured by the Colorado Rural Housing Development Corporation (CRHDC).

The kit costs \$300 and includes an extruded-aluminum frame, low-iron glazing, electroplated black-chrome collector panel, sealant, insulation, internal support, and other materials needed for construction. CRHDC estimates that an experienced do-it-yourselfer can build a collector in three hours. The kit requires no soldering.

In operation, air drawn into the collector passes over 72 square feet of heating surface. It can be used for daytime-heating or rock-storage systems. CRHDC (4140 Tejon St., Denver, Colo. 80211) also offers blowers and controls, along with other components for building a complete system.—Charles A. Miller

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Around spun the head of the little robot. And with it went the robot's steel hand, clutching a little red book that said *Robotics* and placing it, at the end of a 270-degree circuit, in a human hand. It took about 10 seconds—start to finish—to deliver the book, and approximately every second POPULAR SCIENCE Staff Photographer Greg Sharko punched the button of his Norman studio flash to put a separate exposure on film, each exposure marking a stage in the movement of the steel hand. That, at any rate, was roughly how we started out to take this month's cover photograph, using Polaroid film at first so we could see immediately what the picture would be like.

What it was like was terrible.

Was our original concept at fault? HERO 1, the Heath Company's contraction of *Heath Robot*, is not intended to be a cute little android that will shine your shoes and roll off to the kitchen on command for a six-pack. Instead, HERO is a teacher. Its (his? her?) subject is robotics. And we wanted to show it in a complex movement: its hand grasping a textbook on robotics, swinging around in an angled plane, and releasing the book at the end of the swing. How to do it? Obviously in a multiple-exposure picture with the lens of our studio camera open and our flash units pulsing on and off as HERO swung its book around. Now the problems:

- Our white seamless-paper background reflected off the arm so strongly at each flash pulse that it tended to wipe out the successive images.

- The features of HERO's top, spinning around, merged with each other in the successive exposures, making them almost impossible to distinguish. "No good," said Art Director Dave Houser. "You can't make out the key pad."

- The human hand reaching out (and appended to Senior Editor Richard Stepler) was badly overexposed.

The picture we wanted to take would have been impossible but for the existence of one of the most ingenious machines electronics has given us: the Israeli-made Sci-Tex. It is a machine that makes the impossible visible. Would you like the pyramids moved a little closer to each other in a photograph (as one magazine did)? Sci-Tex can do it. Would you like to show HERO's arm in motion, but show its top still so the key pad will be seen clearly? Would you like to have a

sharp final picture of HERO handing over the robotics textbook to Stepler's hand? Sci-Tex can do all of those things.

The solution to our problem was to take three separate photos. One was that multiple-exposure picture with HERO's arm swinging around. A second, with the robot unmoving, was of its top. A third, with its arm in front, showed it passing the book along.

Then into the electronic brain of a Sci-Tex Response 350 went the millions of picture elements—pixels—scanned, separated into colors, and digitized for storage. At the Sci-Tex color console, Roger Crain of Nashville Electrographics merged the three pictures. A zoom button let him enlarge any portion of the picture or move back to see the whole picture at once. Other controls let him "airbrush" any section in any color with a stylus or take any element of the picture and move it anywhere he chose.

When he was done, with Dave Houser looking over his shoulder, we had the picture you see on the cover. In a way that no camera alone ever could, it shows what HERO is like and what it can do.

While all this was going on, Associate Editor Daniel Ruby was writing the article in this issue "Computerized Personal Robots"—with time out for programming HERO so its top and arm would swivel between preset start and stop points. This was done by entering a series of instructions on the robot's alphanumeric key pad to put it in the "learn" mode and to make some memory available. The desired motion was then performed under the control of a hand-held "teach" pendant. After that, with the pendant disconnected, HERO would play back that series of motions whenever photographer Sharko called up the program on the key pad.

Are personal robots about to take over? Ruby recalls one special scene centered around a futuristic bundle of motors and microchips called B.O.B. "Okay, so where ya hiding?" B.O.B. called out as its head spun excitedly in search of a sassy and very elusive five-year-old boy. But wherever B.O.B. looked, the boy moved out of range, playing hide-and-seek.

Witnessing that scene, Ruby felt reassured: If machines are going to take over, it won't be for some time yet. Later, as he visited five other robot manufacturers in California, Colorado, and Michigan, his sense of superiority turned to wonder.

In the last half-dozen years, we've seen computers turn from expensive office machines into personal tools. Now we seem to be at the beginning of the age of the personal robot. Where will that have led us by 1990?

Superconductor

First large-scale utility application of superconductivity [PS, May '81]? That's the claim for a \$1.5 million, 11-foot-diameter superconducting magnet scheduled to stabilize power transmission between the Pacific Northwest and Southern California. Its job: to act like an electrical "surge tank," periodically storing and returning electrical energy. In tests, it was charged to its full operating current of 5,000 amps on the first try.

Grand unification at last?

Physicist Sidney Drell put it neatly: "We know that there exist simple general laws that explain the rich diversity of nature; that is our fundamental faith as scientists." This belief, basic to modern science, drives the ongoing search to unify the four fundamental forces of nature under one theoretical umbrella. It's been going on for more than a century and has tantalized—and baffled—many of the greatest minds in physics. Science & Engineering Editor Arthur Fisher has been tracking the progress of theorists and experimenters across the nation from Harvard to Stanford in recent years, on the understanding that he would write a story on "grand unification" when some appropriate event made it timely. That event occurred in late January when physicist Carlo Rubbia broke the news that what he called "the most prized trophy in physics" had been found in the high-energy proton-antiproton collider at CERN, in Switzerland. For a report of that discovery and its significance to what Fisher terms "the great intellectual adventure we call science," read his absorbing account of the search for "Cosmic Order."



Editor

Nuclear waste

—a better way to bury it?

A new process traps radioactive debris within synthetic rock's structure

By **TOM JOHNSON**

PHOTOS BY ROBERT KOLLAR AND PETER KELLY

With the passage of the Nuclear Waste Policy Act of 1982, the country has at last made a start toward solving the problem of what to do with radioactive waste. The act does not specify how the waste should be packaged. It merely directs the Secretary of Energy to select a method.

Research has been going on for years [PS, Dec. '78], and a number of alternatives have been suggested. At the moment, those charged with the selection process seem to be moving toward mixing radioactive waste with molten glass as the first step in keeping it isolated for thousands of years.

But researchers working on another approach claim theirs is better. It was developed in Australia and further worked on in this country. Reporter Tom Johnson recently visited the Australian project to learn what investigators there have done and what claims they are making for the alternative technology. Here is his report.

CANBERRA, AUSTRALIA

The ebony-black disc in the palm of geochemist Ted Ringwood's hand appeared utterly insignificant—perhaps a souvenir paperweight from some long-forgotten job in a machine shop. But that disc was synthetic rock, or Synroc. It's the latest and, according to its inventor, perhaps most promising system for storing nuclear waste.

Synroc, says Dr. Ringwood, could

play a vital role in the nuclear-waste-disposal scheme now being worked out under the provisions of the Nuclear Waste Policy Act. At the moment, however, majority opinion seems to be going in favor of another substance—borosilicate glass. Still, some authorities side with Ringwood. Now, with a decision on this critically important matter due to be made within the next year, Ringwood makes a series of impressive claims for Synroc. Among them:

- It is safer than glass.
- It is no more costly than glass, though many claim it is.
- It can be made by thoroughly tested processes.
- It would be far easier and cheaper to bury and would not need the large, politically unpopular national waste repositories now planned.

I went to Australia to visit with Ringwood and find out what backing he has for these strong claims.

To see how Synroc would fit into the overall scheme, it is necessary to understand the broad program of nuclear-waste disposal now envisioned. First, the general scheme: Since some materials in nuclear waste remain dangerously radioactive for thousands of years, the waste must be kept isolated from the environment for that long. For several decades researchers have pondered possible ways of doing this, from burying the waste in the deep sea bed to using rockets to fire it into the sun.

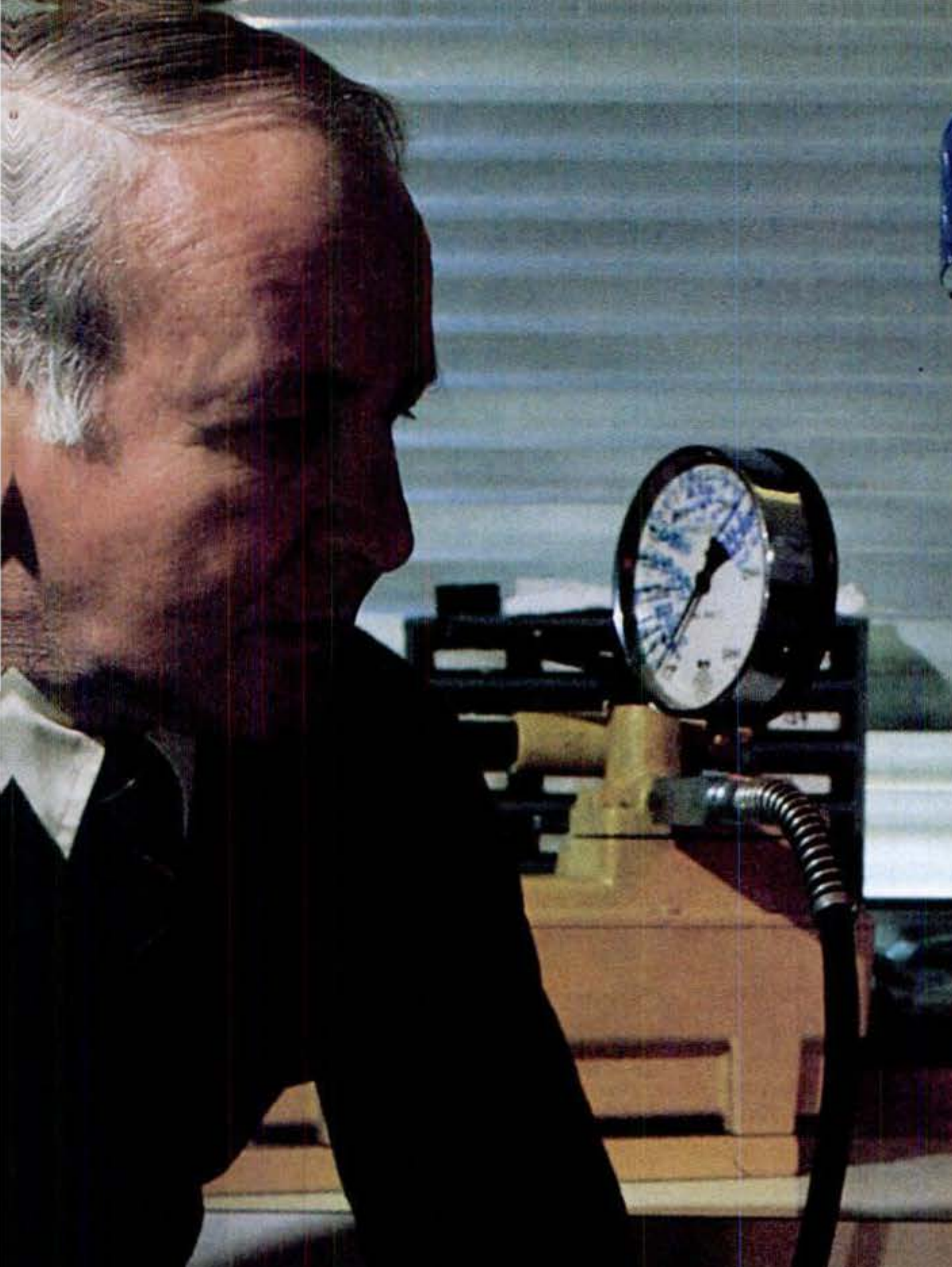
The method now generally agreed upon is to bury the waste in caverns carved out of salt or granite perhaps 2,000 feet below Earth's surface. To protect the environment, the radioactive refuse must first be incorporated into some insoluble material, creating what's known as a "waste-form."

"Ideally, the waste-form itself should function as an immobilization barrier, fully capable of preventing any significant release of radionuclides into the biosphere for 100,000 to one million years," Ringwood told me in his office at the Australian National University, where he's head of the Research School of Earth Science. "The waste-form should be sealed into canisters made of highly corrosion-resistant alloys. This will create a second, independent engineered barrier," he said.

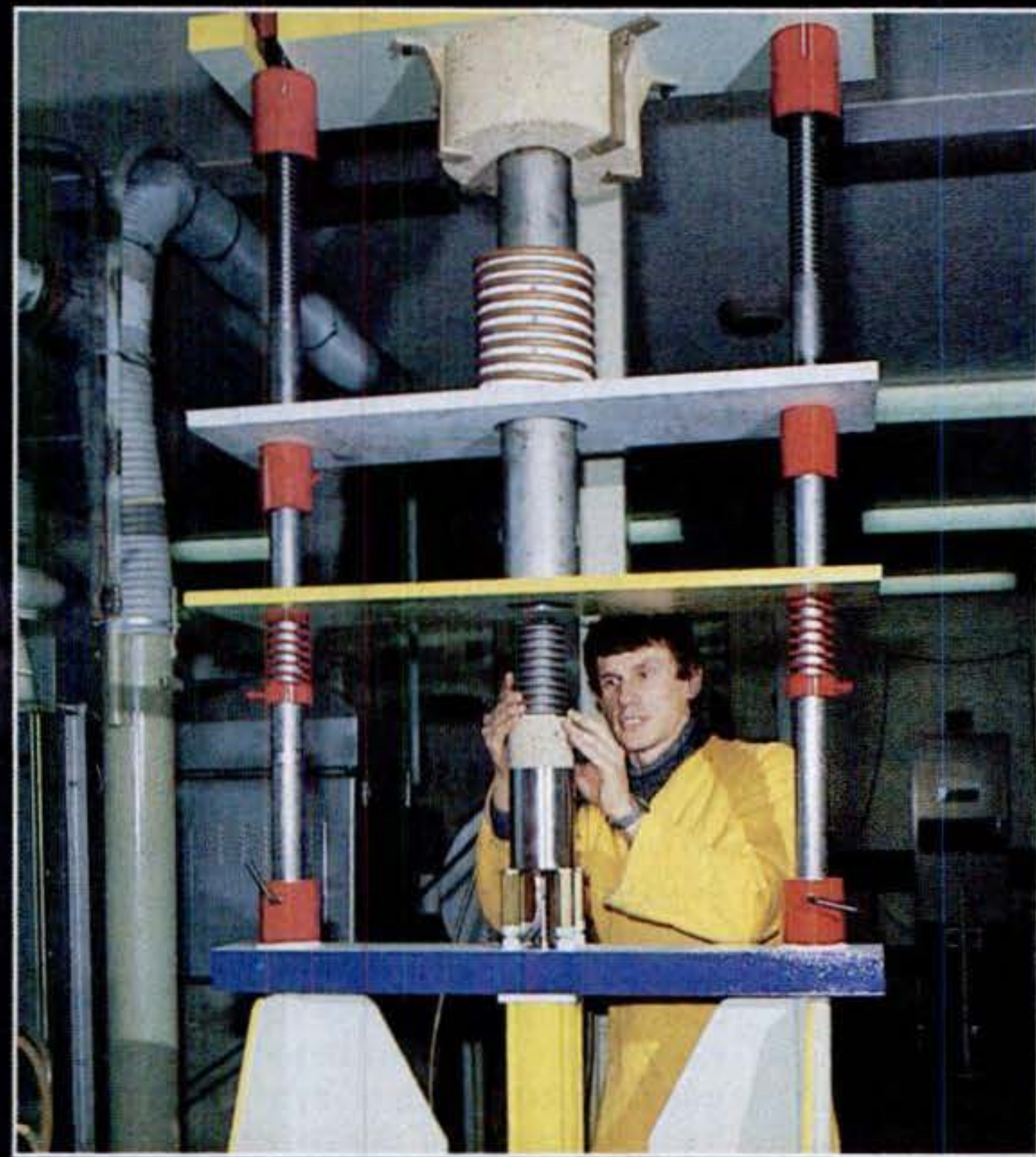
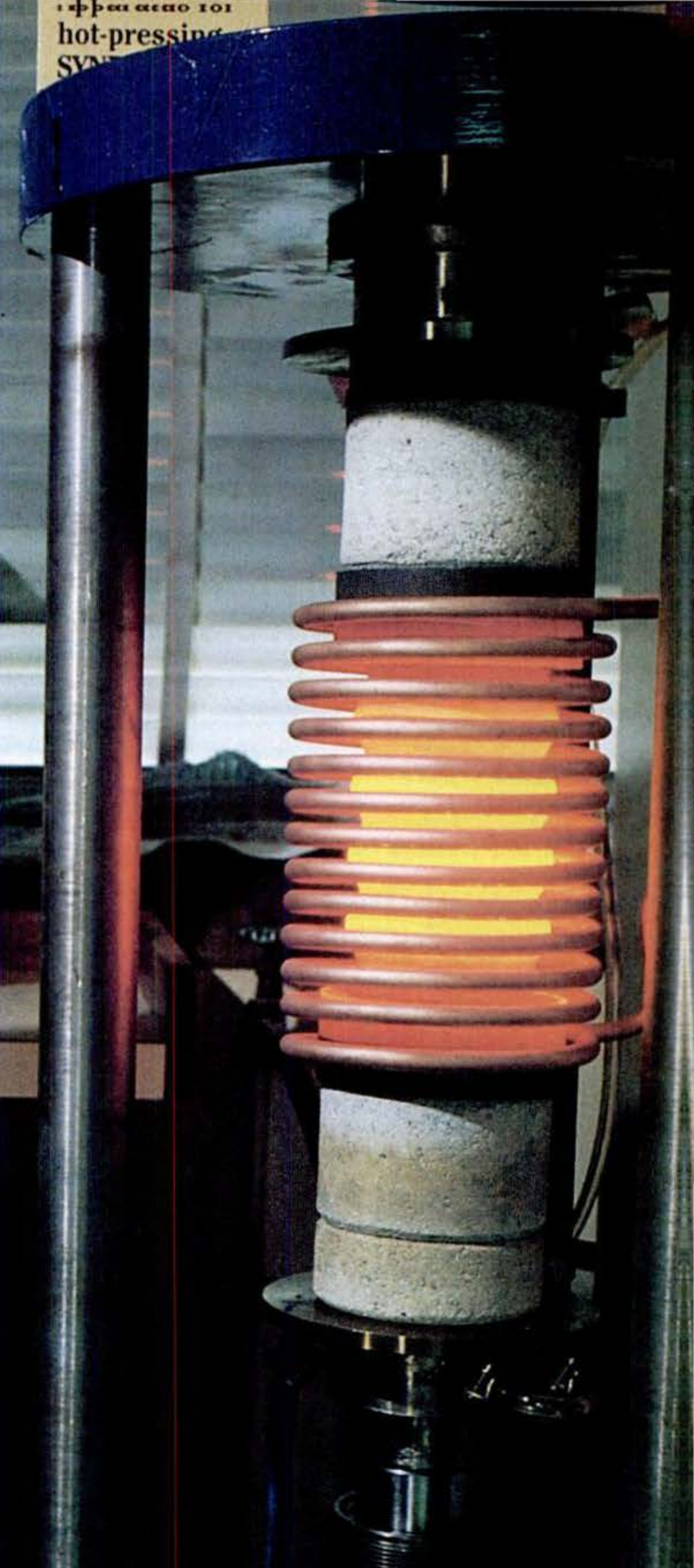
Such a multiple-barrier system should effectively neutralize the waste. First of all, since the burial site is a deep, stable geologic formation that has not changed in millions of years, it presumably should be stable for millions of years into the future. But if by mischance ground water should get in, the waste would be protected by its stainless-steel canister. If that failed, the waste should be protected by the insoluble substance it

Continued






Developer of Synroc process, Ted Ringwood, monitors a bench test of a scaled-down Synroc container. The bellows-shaped can contains a mixture of minerals that can immobilize radioactive waste. When heated, then compressed by the piston, the can collapses uniformly. The result is a disc of dense ceramic completely contained by the flattened bellows can. An Australian technician (inset, near right) experiments with compressing the Synroc bellows as it sits within a straight outer container. If this process works, it will simplify the remote-control engineering needed for a full-scale Synroc waste-processing plant. Shiny black Synroc samples (inset, far right—upper row) are barely affected by high heat and leaching in water. Given the same treatment, the glass samples (lower row) crumble.



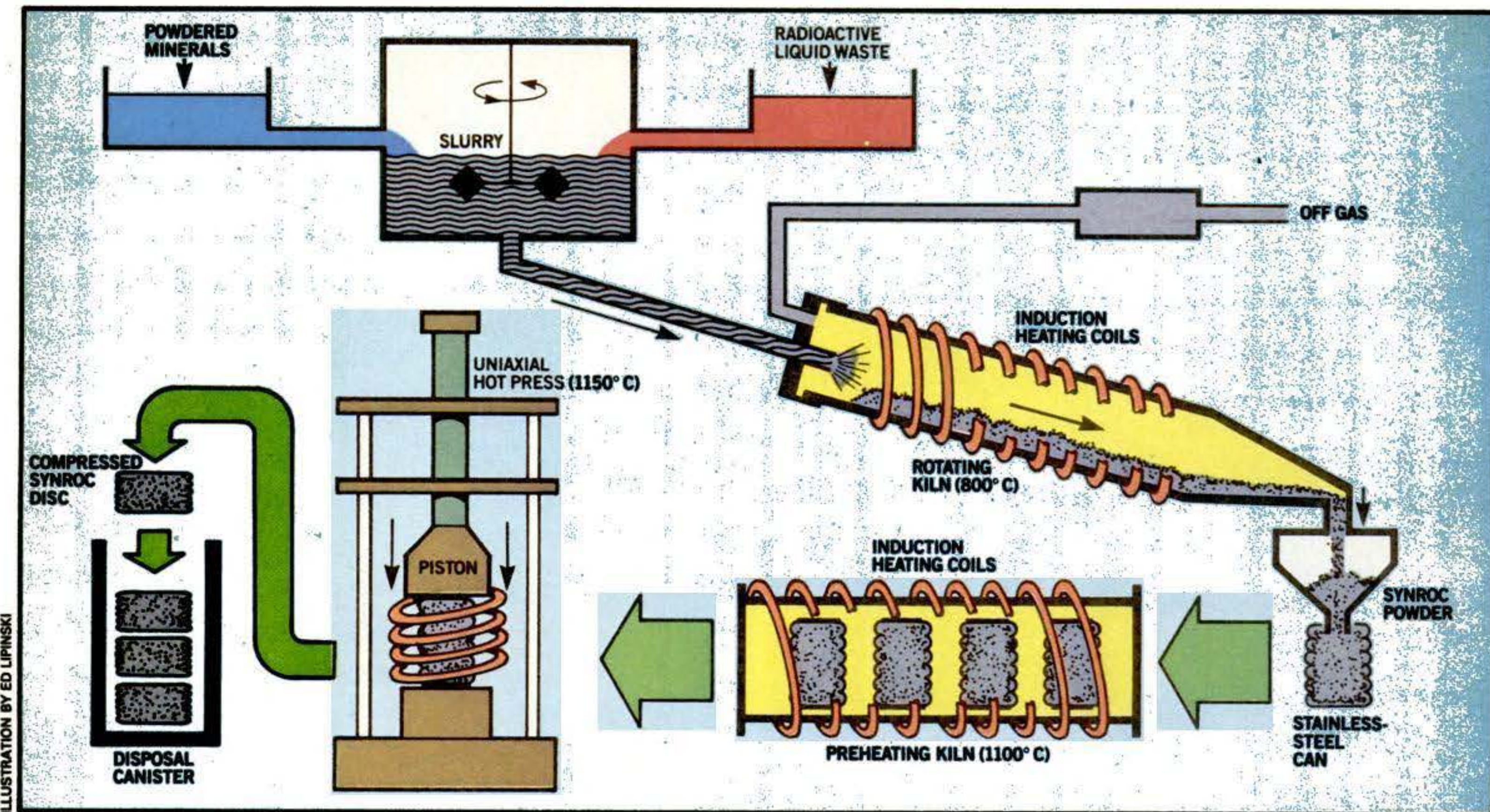
hot-pressing
SYNROC



High temperature tests are also necessary because nuclear wastes generate their own heat.

BEFORE LEACHING	AFTER LEACHING IN WATER	
	 39C 7 days	 57C 4 days
		

Unlike glass, SYNROC displays excellent leach resistance at high underground temperatures.



High heat and pressure transform dangerously radioactive slurry into ceramic that's similar to naturally radioactive rocks.

has been enclosed in. This is basically a box-within-a-box security system. What those "boxes" will be has not yet been determined.

Today, the U.S. Department of Energy has about 8,000 metric tons of used fuel assemblies from commercial power plants, plus 10 million cubic feet of radioactive waste from weapons contractors in temporary storage—so-called defense waste. After years of debate, Congress has finally adopted a plan to dispose of this waste. The new act sets a timetable for selecting and preparing a burial site for nuclear waste. The first site must be chosen by 1987, with waste burial to be under way before the year 2000. (The law applies only to commercial waste but mandates the President to decide by 1985 whether to bury defense waste at these sites.)

The new law also charges the DOE to decide by April 1984 on the process for packaging radioactive waste. Most experts favor vitrification—locking the waste in a matrix of borosilicate glass. This process has been under development for at least 15 years. By contrast, Synroc is an upstart.

Since 1978, Dr. Ringwood has worked on Synroc along with his university colleagues in Canberra and with researchers at the Australian Atomic Energy Commission and at Lawrence Livermore National Laboratory in California. Together, they have developed a process that binds radioactive components into atom-sized spaces within rock crystals.

Because there are chemical differ-

ences between commercial and defense waste, there are two versions of the Synroc system. But the basic process begins with a nonradioactive powder containing titanium and zirconium oxides. Mixed with a solution of radioactive waste, it becomes a slurry. It then passes through a rotating kiln, or calciner, that's heated to 1,470 degrees F to drive off volatile components such as water.

The resulting powder is funneled into a bellows-shaped, stainless-steel container, which looks much like a corrugated pipe used for highway culverts. After air is evacuated from the 12-inch canister, it's sealed, heated to at least 1,830 degrees F, and mechanically compressed to a height of four inches. What's left is a stack of four-inch-by-14-inch discs that looks like a pile of Paul Bunyan's pancakes. The "pancakes" can then be stacked in yet another canister for transport and burial.

The mechanics are simple except for a major hitch: Because of the extreme radioactivity involved, everything has to be done by remote control. (Remote control is also necessary with the glass process.)

Easier, cheaper operation

"Originally, the Synroc-C [for commercial waste] process called for 'isostatic hot pressing,'" Ringwood told me as we walked down the hall to one of his labs. "That meant the powder in the bellows was consolidated into a dense monolith by heating it to 2,200 degrees F and simultaneously subjec-

ting it to a pressure of 1,500 atmospheres [22,000 psi].

"Hot pressing is widely used on a commercial scale for manufacturing specialized ceramics and alloy steels," Ringwood noted. But it's a complex, costly process. "We recently discovered that we can achieve the same results we get with hot pressing by simply heating the bellows canister and mechanically pressing it flat," he said. "This new development promises greater ease of operation by remote control. It is much simpler, so it will reduce the cost of a processing plant."

The borosilicate-glass process is basically similar to the Synroc process, except for the materials used and the final hot-pressing step. And both glass and Synroc trap the radioactivity, immobilizing it so that it doesn't contaminate the biosphere at an unnatural rate. But the Synroc ceramic—or synthetic rock—more closely resembles naturally radioactive rocks. What's the advantage of this?

"These minerals are extremely resistant to attack by hydrothermal solutions [ground water]," Ringwood told me when we entered his lab. "In nature these minerals have survived in a wide range of geochemical and geological environments for up to two billion years," he added.

Tests of the Synroc-C system show it to be much more stable than glass and, perhaps, easier to handle, Ringwood says. "We evaluated the leaching characteristics of Synroc-C under both flowing- and nonflowing-ground-

water conditions," he told me. "Synroc-C has been placed in 1,470-degree-F water at 1,000 atmospheres [14,700 psi], and it survived without destruction. It is literally 1,000 to 10,000 times more resistant to leaching than glass."

Tests show Synroc-D (for defense wastes) holds up 1,000 times better than glass for the leaching of most radioactive elements, says Ringwood.

By contrast, some research shows that borosilicate glass might not be able to withstand ground water if—in a "worst-case" scenario—it seeped into a burial site while the capsules were still hot. When first made, borosilicate-glass canisters are hot—perhaps as hot as 390 degrees F. They can stay at that temperature for decades, heating any ground water leaking into the burial site. In 1978, Gregory McCarthy and his colleagues at Pennsylvania State University discovered that borosilicate glass disintegrated in superheated water. When exposed to a brine solution at 572 degrees F, the glass fell apart, creating more surface area to release (leach) radioactive elements.

"Since then, the Australian Atomic Energy Commission has found that glass deteriorates in water at 300 degrees F," Dr. Sue Kesson, one of Ringwood's research associates, told me.

To some experts, the sensitivity of glass to heated water is of little concern. Says Ron Likilla, manager of the Nuclear Fuel-Cycle Program at Battelle Memorial Institute in Richland, Wash., "We really don't think this will be much of a problem, because we will be working with wastes that have been in storage pools for at least 10 to 15 years. These old fuels are cooler than fresh ones in terms of radiation and temperature," he said.

As new wastes are generated, they could also be stored in cooling pools for several decades before submitting them to permanent underground storage. But that solution could be politically unpopular—and would require costly extra handling of the waste materials.

Synroc-canister economy

Synroc's proponents claim still other advantages for the process. A greater amount of radioactive waste can be loaded into a given volume of Synroc than can be incorporated into the same amount of glass, according to Ringwood: "In general, the higher the waste loading, the fewer waste canisters will have to be produced, transported, and, ultimately, stored.

"Typically, borosilicate glass will accept only about 25 to 30 percent of its weight in waste material. But Syn-

roc-D can be typically loaded at levels of 60 to 70 percent," Ringwood said. "Also, Synroc is 35 percent more dense than glass, so the actual waste concentration is about three and a half times greater," he added.

Another cost-saving advantage is claimed: Because Synroc resists the effects of heat and ground water, it doesn't have to be buried in a massive underground cavern. Instead, Ringwood proposes to bury the Synroc canisters as deep as possible. They could be packed down a shaft two miles deep, down to the region of relatively dry, impermeable rock.

"There are a few advantages to be gained here," Ringwood said, pulling out a diagram of a drill hole. "First, such a drill hole could be located just about anywhere in the states—it could be close to the processing plant to minimize handling of the canisters. Second, the canisters would not have to spend time cooling before permanent burial. Third, one such hole could accept all the waste generated by 80 large nuclear-power stations in a single year. Finally, the holes could be drilled when and where needed—there'd be no need to excavate a cavern massive enough to handle all future waste. We think disposal in drill holes could be 50 percent cheaper than disposal in a mined repository."

Despite its claimed advantages, however, it seems that Synroc may not be chosen to solidify U.S. nuclear wastes. Because of a lack of funding, the research at Lawrence Livermore Labs was essentially shut down in the summer of 1982. And after weighing the merits of borosilicate glass and Synroc, the DOE has chosen the glass process to deal with some defense-plant waste—that now sitting in tanks at the Savannah River plant in Aiken, S.C.

According to Tom Hindman, office director of DOE's defense-waste-processing facility at Savannah River, the DOE expects to seek authorization to begin construction in 1984 of a \$970 million borosilicate-glass plant there. The plant should be operating five years after ground is broken.

"We could find no appreciable difference in the quality of the products [glass and Synroc]," Hindman told me. "We picked glass because of less complexity in the actual fabrication process."

Hindman and other DOE officials also believe that the Synroc process was still an infant in its development and engineering. That critique was echoed by a spokesman for the Atomic Industrial Forum, an industry association: "We've been making and testing large quantities of glass for years,

but Synroc is still a lab phenomenon—they've just made sample pellets."

Dr. Jack Campbell, leader of the Synroc-research effort at Lawrence Livermore, generally agrees with the Savannah River decision, but with qualifications. "The worst place to have the defense waste is in the tanks, and they're trying to get it away," he told me. "I think glass now is a good idea because we need to get the cycle closed.

"But it's a mistake to cut off research into alternatives," he added.

The debate continues

The DOE had yet another problem with Synroc, according to Stephen V. Topp of the Savannah River laboratory. "Defense wastes are not uniform," Topp said. "A lot of different fuel has gone into those reactors over the years. Ceramics [Synroc] must be precisely tailored to the exact waste-form. . . . That's why glass shines."

Livermore's Jack Campbell claims that charge is no longer true. "We've found that components in the waste sludge can vary by as much as 50 percent without affecting either the quantity of Synroc additives needed or the quality of the final product," he told a symposium in West Berlin in June 1982.

Critics of Synroc argue further that its waste-processing plant would be too complicated to engineer and will, therefore, drive up the cost of the plan vis-à-vis borosilicate glass. "No one questions that Synroc might be a better material," said an industry spokesman. "But from a cost-benefit standpoint, it just isn't in the ballpark."

Nonsense, says Ringwood. "Except for the final hot-pressing step," he explained, "the production of Synroc uses only process technology that has already been developed and applied in the fabrication of borosilicate glasses under fully radioactive conditions."

To prove their point, the Australians are going one step further. The Australian Atomic Energy Commission announced late last summer that it would spend \$1 million this year (and eventually \$8 million during the next three years) to build a non-radioactive pilot plant designed to demonstrate all steps in the production of full-scale Synroc canisters.

Curiously, that nation has absolutely no immediate need for such a plant: It has no nuclear reactors, save a couple of small experimental reactors for research. But Australia is potentially the world's largest exporter of uranium. And if that resource is to be sold as a fuel, its leftovers must be disposed of safely. E 5

Dramatic new evidence in the century-old search for **cosmic order**

Discovery of the W particle in the world's most powerful atom smasher brings physicists closer to the long-sought grand unification theory

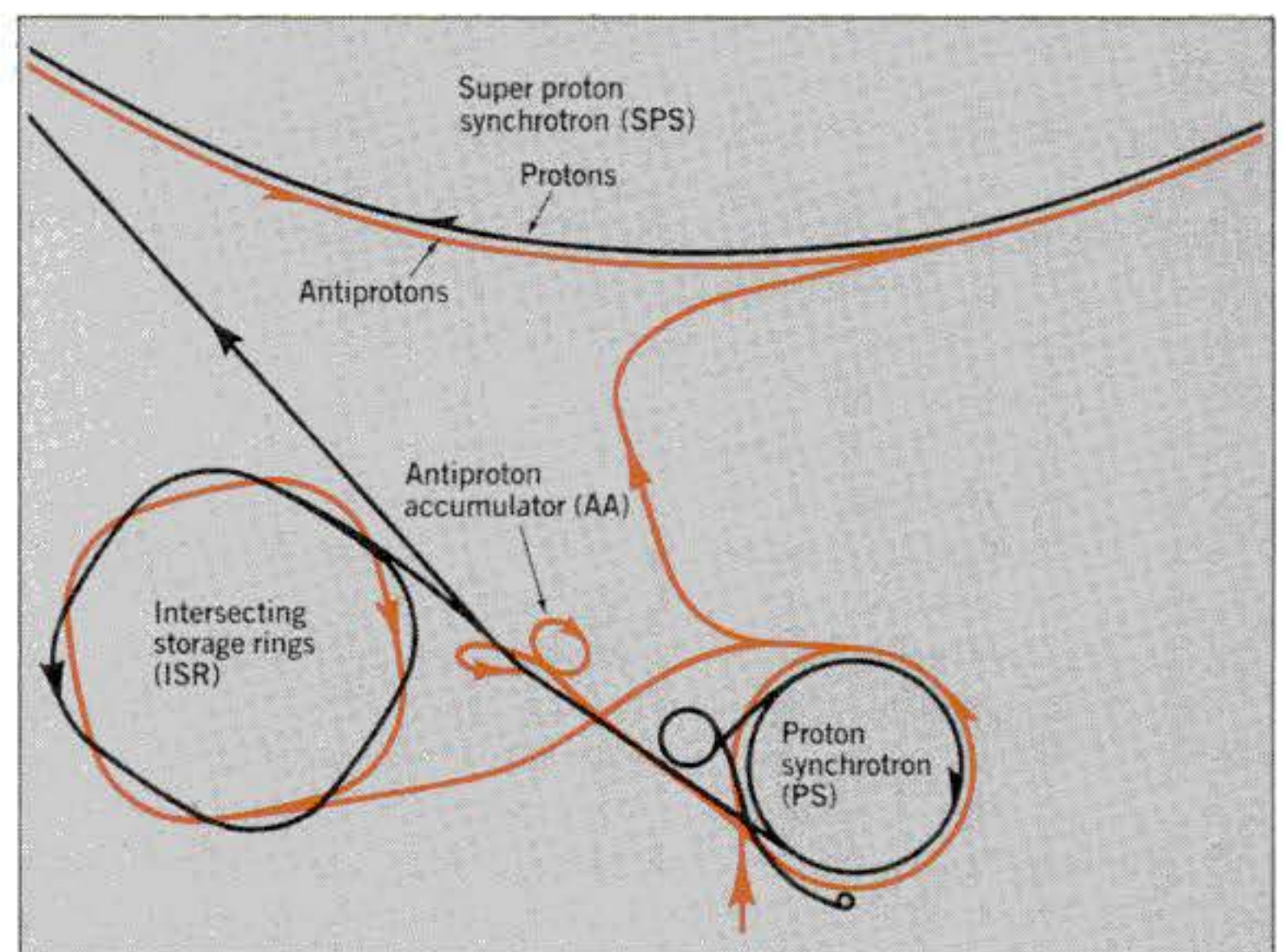
By **ARTHUR FISHER**

The call came one night last November as Carlo Rubbia was having dinner. It was from CERN, the European Organization for Nuclear Research, a conglomerate of laboratories and particle accelerators headquartered in Geneva. And it is at CERN that Dr. Rubbia, on leave from Harvard University, has been leading 126 researchers in a particle-physics experiment known as UA 1.

"Carlo, you'd better get over here quick, we have a very interesting event for you to look at," said a voice at the other end. The event proved to be clear-cut evidence for the existence of a long-sought subatomic particle called the W. It electrified physicists all over the world and made Rubbia an instant candidate for a Nobel Prize. For the discovery of the W is probably the most important step of the decade in a quest that began more than a century ago. That is the attempt to unify the four basic forces in nature—gravity, electromagnetism, and the strong and weak nuclear forces—into one graspable mathematical structure, a so-called grand unification theory.

This grand unification would be the most stunning triumph of the great intellectual adventure we call science. It would yield a single set of rules so powerful as to predict and explain all phenomena everywhere in the universe, on scales from the inconceivably small to the inconceivably large: the decay of atoms and the swirl of galaxies; the sun's thermonuclear furnace and the nothingness of black holes; the flight of eagles and the mind of man. Both energy and matter would be bound by its decrees, and the identity of basic particles resolved—order out of chaos.

The discovery of the W particle is momentous because it provides the strongest confirmation yet of a unification theory that binds two of the four basic forces—electromagnetism and the weak nuclear force. It is also a key step in lending authority to grand unification theories. But an understanding of why the W was predicted some 40 years ago, how it was discovered, and why it is so significant, demands tracing the devious twists and turns of physics that led up to it. The year 1865 is a good place to start threading that maze.



How to make an intermediate vector boson: All of CERN's particle devices were enlisted to create colliding beams of protons and antiprotons (stored in accumulator) with an energy of 540 GeV, high enough to create the very massive W particles.

The physical world seemed, in 1865, a reasonably well-ordered and comprehensible place. The various categories of phenomena in nature—heat, light, mechanical forces, electricity, magnetism, chemical action—were well analyzed. The idea of a basic particle of matter, the atom, originating with the Greeks, had been elaborated in the 19th century by John Dalton and others and was accepted without quibble. Isaac Newton had penetrated the meaning of gravitation and motion. And the 19th century saw the gradual unification of two forces that had once seemed entirely separate—electricity and magnetism—by the Scottish physicist James Clerk Maxwell. In a brilliant leap of the mind, Maxwell proved mathematically that electricity and magnetism are two linked manifestations of the same force. The simple, symmetrical, and elegant equations he wrote also made a remarkable prediction: that an electromagnetic field could travel through empty space. They also predicted the speed of this radiation. Amazingly, that speed turned out to be 300,000 kilometers a second—the known speed of light! Maxwell concluded that light was a form of electromagnetic radiation. That bold claim was confirmed experimentally in 1888 when Heinrich Hertz used an electric spark to generate what were then called Hertzian waves, what we now know as radio waves. Thus

Maxwell had, for the first time, unified two of nature's fundamental forces.

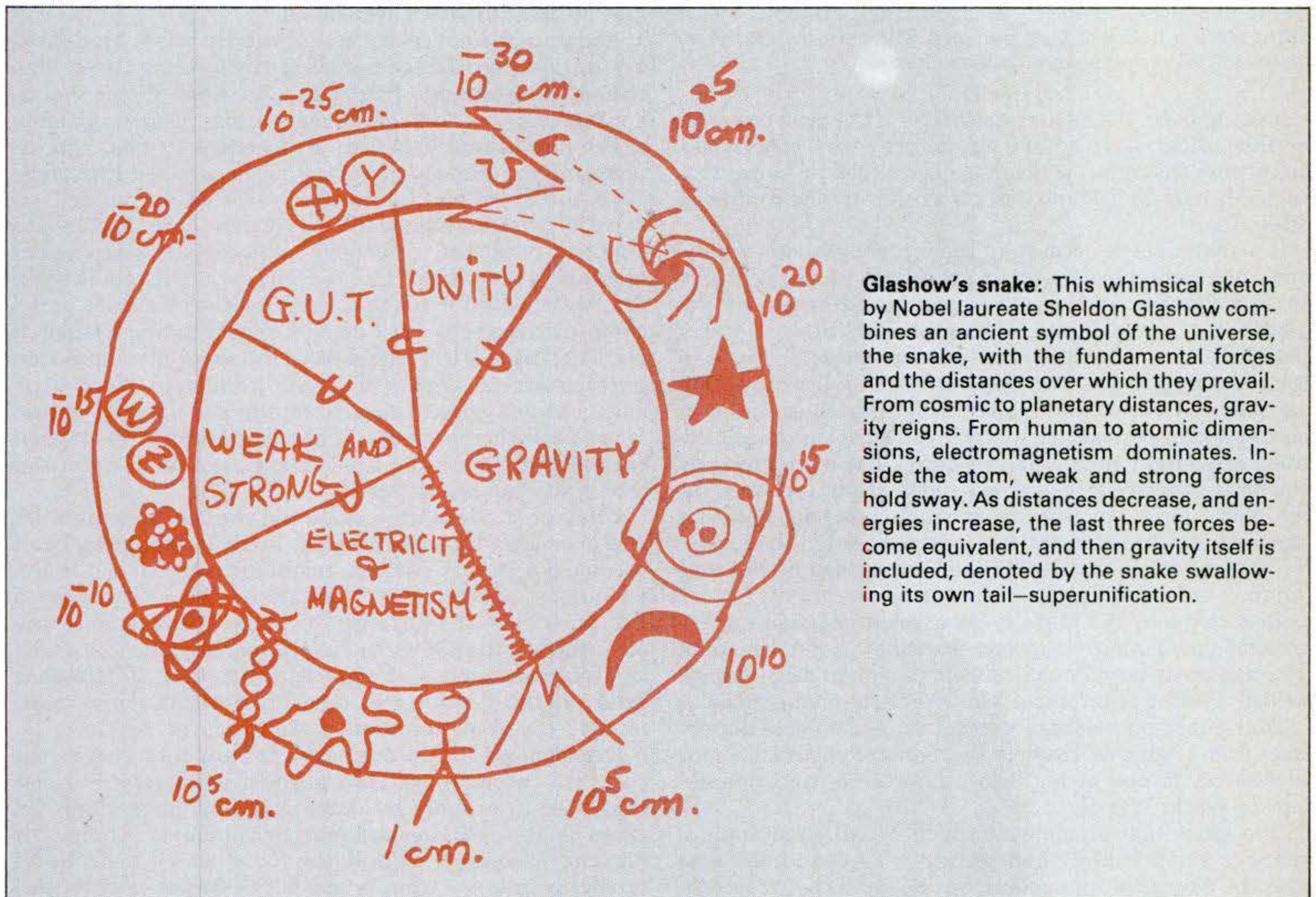
It is impossible to exaggerate the importance of this contribution and the influence it had on all physics to come. Einstein kept a photo of Maxwell in his office and wrote at one point that the whole 19th-century mechanistic view of the world had been turned topsy-turvy by "the great revolution forever linked with the names Faraday, Maxwell, and Hertz. The lion's share in this revolution was Maxwell's. . . ." In 1865, then, with electricity and magnetism unified, gravitation understood, and the fundamental particle—the atom—identified, physicists could relax. Some were even led to declare, with a kind of Victorian smugness, that there was simply nothing left for physical science to do. But the end of the 19th century saw that cozy state violently disturbed.

In 1896, Antoine Henri Becquerel discovered radioactiv-

ments. Rutherford and others had already hypothesized that atoms must contain some positively charged particles, to balance the negatively charged electrons.

Rutherford bombarded a sheet of thin gold foil with alpha particles and devised a way to trace their motions. He expected that because they were positively charged, the alpha particles would be repelled by the positively charged nucleus he believed dwelt at the core of the atom and therefore scattered at various angles, depending on how close to the nucleus they came. By measuring these paths and applying all that was then known about the laws of motion and the electric force, Rutherford would be able to deduce the size, mass, and charge of the particles.

What Rutherford learned astounded him, and his conclusion, published in 1911, proved the coup de grâce for the old, solid-ball model of the atom. The experiment showed that the atom was in fact mostly empty space; most of the



Glashow's snake: This whimsical sketch by Nobel laureate Sheldon Glashow combines an ancient symbol of the universe, the snake, with the fundamental forces and the distances over which they prevail. From cosmic to planetary distances, gravity reigns. From human to atomic dimensions, electromagnetism dominates. Inside the atom, weak and strong forces hold sway. As distances decrease, and energies increase, the last three forces become equivalent, and then gravity itself is included, denoted by the snake swallowing its own tail—superunification.

ity, a process in which something seemed to be emanating from within the atom. But if the atom was fundamental, if there was nothing smaller inside it, how could this be? A year later, in 1897, a researcher dealt another blow to the idea of the indissoluble atom. Joseph John Thomson, at Cambridge University, succeeded in identifying a negatively charged particle that was an unbelievable 1,800 times lighter than the hydrogen atom.

"There is no escape from the conclusion that we are here dealing with particles that are far, far lighter than atoms," Thomson wrote. This unwanted imp was the electron.

That was just the beginning. In the first decade of the 20th century, Ernest Rutherford, Thomson's successor at Cambridge, developed a method of aiming high-energy particles at atoms to investigate their structure. The "bullets" he used were alpha particles—later known to be helium nuclei—that were emitted by some radioactive ele-

"bullets" had gone right through the foil without being deflected. Some were deflected to differing degrees, and some had bounced straight back as if they had hit something unyielding head on. That was almost as incredible, Rutherford wrote later on, "as if you fired a 15-inch shell at a piece of tissue paper and it came back and hit you." The calculations proved that the nucleus occupied only about a million-millionth of the volume of the gold atom yet contained about 99.9 percent of its mass. The electrons revolved in a kind of shell around the nucleus.

Further experimentation convinced Rutherford that single positive charges were borne by particles identical to the nucleus of a hydrogen atom, each some 1,936 times the mass of an electron. Rutherford called these particles protons (from the Greek for "first").

At about the same time, another revolution in physics

Continued

Fundamental forces in nature

Name	Strong nuclear force	Electromagnetic force	Weak nuclear force	Gravity
Range of action	10 ⁻¹³ cm	Infinite	Less than 10 ⁻¹⁵ cm	Infinite
Relative strength	1	10 ⁻³	10 ⁻⁵	10 ⁻³⁸
Particles acted on	Hadrons (protons, neutrons, mesons, etc.)	All charged particles	Hadrons and leptons (electrons, muons, neutrinos)	All particles and energy
Carrier (mediator) of force	Gluon	Photon	Intermediate vector bosons (W [±] , Z ⁰)	Graviton
Where seen in nature	Nuclear binding forces, energy of thermonuclear fusion	Atomic forces, electricity and magnetism, light, radio waves, etc.	Radioactive beta decay	Astronomical bodies, tides

The bewildering array of fundamental forces: Gluons (eight of them), photons, W particles, Z-noughts, and gravitons (never seen) are the force-carrying particles. The electroweak theory unites the weak and electromagnetic forces.

was being born. It was to result in one of the most powerful mathematical descriptions of nature ever conceived—quantum mechanics, which has been called by Nobel laureate Murray Gell-Mann “that magnificent and confusing discipline.”

It is magnificent because in the bizarre realm of atomic and subatomic physics, where the laws of classical mechanics founder, it works. It is confusing because it replaced the rigid order of Newton’s world with a slippery indefiniteness, a neither-here-nor-thereness. Light can act, according to quantum mechanics, as if it were both a particle and a wave, and, more upsetting, so can a bit of matter such as an electron. Moreover, such things as electrons can simply not be pinned down. The more precisely you try to specify an electron’s momentum, for example, the more uncertain you are about its position, and vice versa. In fact, only by statistics can you predict the behavior of a group of particles; the individual member of that group is unknowable.

Most laymen, and initially some scientists, found these notions maddeningly incomprehensible. Even Einstein, who had contributed much of the theory’s underpinnings, balked, finding it incompatible with a rational cosmos.

That quantum mechanics is not intuitable does not detract from its success. Here, in the words of physicist Victor Weisskopf, is one of his “most impressive experiences” during World War II:

“We knew that an element which we called plutonium ought to exist. Nobody had seen it . . . All we knew was that the charge of its nucleus was 94—and that it had 94 electrons around it. So we sat down and calculated its properties. The fact that this calculation could be done at all shows the tremendous power of quantum mechanics. We could predict that it must be a metal; that it must be brown colored; that it had a particular spectrum; that it had a certain hardness and a certain elasticity. And when we had the first cubic inch of plutonium before us, it turned out that all of this was true.”

The idea of the quantum is one of the keystones of quantum physics. In the atomic world, energies do not occur over a continuous gamut but at definite levels like the rungs of a ladder. In 1900, Max Planck theorized that radiant energy could be emitted and absorbed only in discrete quanta. In 1905, Einstein extended the idea of quanta to light and, thus, to all electromagnetic radiation. The bundles of energy that are the quanta of light—massless and chargeless—are called photons.

By 1930, quantum mechanics had been wedded to Max-

well’s equations of electromagnetism and to the principle of relativity, developed by Einstein beginning in 1905, to form quantum electrodynamics, QED for short. The theory is a precise mathematical way of describing the way electrons and photons are governed by electromagnetism. It gave a clear and remarkably accurate picture of the chemical and physical properties of the atoms that make up everything around us.

Then things started to unravel again.

The antiparticle

In 1932, Carl D. Anderson of Caltech was photographing the tracks left by cosmic-ray particles. One of the tracks was a maverick; it showed an electron curving in the wrong direction as it passed through a magnetic field. Anderson concluded that he had identified a particle with the same mass as an electron but with an equal but opposite charge—a positive charge. Dubbed a positron, this was the first bit of antimatter ever found.

Anderson did not realize it, but shortly before his discovery, antimatter had been predicted by a young Cambridge theoretical physicist, Paul Dirac, in what Victor Weisskopf describes as “one of the most dramatic developments of the intellectual penetration of nature by man.” In attempting to reconcile quantum mechanics and Einstein’s 1905 theory of special relativity, Dirac formulated an equation that frightened him so much he at first refused to credit it, preferring to believe he had made some monumental blunder. What shocked Dirac was the implication, firmly embedded in his mathematics, that for every particle in nature there must exist a corresponding antiparticle. The antiparticle would have the same mass and spin (most residents of the subatomic world spin about their axes) but an opposite electric charge and opposite values for certain other attributes. Thus, said Dirac, if an electron existed, there must also exist an antielectron, the positron that Anderson found later.

Other predictions were made and verified, altering what had once been a simple scheme. In 1930, Wolfgang Pauli predicted a ghostly particle, massless, neutral, and therefore almost undetectable. The Italian Enrico Fermi named it the neutrino (rhymes with “bambino”); its existence was confirmed in the 1950s. In 1934, Japanese physicist Hideki Yukawa bravely said a particle more than 200 times as heavy as the electron would be found within the nucleus; in 1947 the pi meson, or pion, was discovered.

Experimental physicists began to build larger and more powerful “atom smashers”—particle accelerators. These they used in roughly the same way that Rutherford had when he aimed high-speed particles at atoms to probe the nucleus. Weisskopf calls it the Swiss-watch method: “If you want to know what is inside two Swiss watches, you bang them together as hard as you can and see what comes out.” As experimenters bashed their watches together with ever more furious energies, the trickle of new particles became an avalanche. Most of these subnuclear particles did not exist in ordinary matter but were created in the collisions. Most had extremely short lifetimes; they disappeared after an interval that is not comprehensible in human terms, on the order of 10⁻²⁴ seconds (one-trillion-trillionths of a second).

From the mid-1950s the new particles made a shambles of the “simple” house of matter. Before he died in 1954, Enrico Fermi said, “If I could remember the names of all these particles I would have been a botanist.” And when researchers found the muon, a particle identical to the electron but with a mass a baffling 200 times greater, physicist I. I. Rabi quipped, “Who ordered that?”

Today, physicists confront a menagerie of more than 200 subnuclear particles known as hadrons (from the Greek

Fundamental particles in nature

QUARKS		LEPTONS	
Charge = $-1/3$	Charge = $2/3$	Charge = -1	Charge = 0
Down quark	Up quark	Electron	Electron neutrino
Strange quark	Charmed quark	Muon	Muon neutrino
Bottom (or beauty) quark	Top (or truth) quark	Tau	Tau neutrino

Quarks and leptons seem to be the fundamental matter particles. They fall into three families, which have increasing masses. The top (truth) quark and the tau neutrino, members of the heaviest family, are still being sought in accelerators.

for thick), whose names and properties are diligently recorded in the 120-page particle bible called "Particle Properties Data Booklet." This is in addition to another class of particles known as leptons (from the Greek for light).

But it was not only the number of "fundamental" particles that had proliferated since Maxwell's time. So too had the number of fundamental forces (or interactions, as physicists prefer to call them), from two—gravitation and electromagnetism—to four. Quantum physicists dissecting the behavior of matter and energy in exquisitely small places uncovered two additional forces: One was the strong nuclear force and the other, the weak. Both operate within the confines of the nucleus.

The remarkably different properties of these four forces (see accompanying table) seemed even more daunting to those seeking unity in the cosmos than the confusing abundance of nuclear particles. The strong nuclear force acts over a range of roughly 10^{-13} centimeters, about the diameter of a single proton, and binds together the inhabitants of the nucleus. By far the strongest force in nature, 100 times more powerful than electromagnetism, its magnitude accounts for the awesome power of thermonuclear fusion. It acts on all hadrons.

Gravitation, by contrast, is the weakest by far of the four forces yet the most pervasive, holding sway over both matter and energy with an infinite range of action. It is some 38 orders of magnitude (100 trillion trillion trillion times) feebler than the strong force, another number incomprehensible in human terms. Thus its effect is perceptible only in the vicinity of very large masses such as a planet.

The range of the electromagnetic force is also infinite, but it affects only charged particles. Aside from its familiar magnetic and electrical effects, it determines the size and shape of atoms and thus fashions chemical activity.

Most enigmatic of all is the weak nuclear force, which is 100,000 times weaker than the strong force. It is responsible for one form of radioactive decay, which transmutes one particle into another, and for one energy source in stars. It works on both hadrons and leptons.

The Holy Grail of modern physics is clearly the unification of these four disparate forces under a single umbrella, a unified-field theory.

The evolving path to unification relies on two key ideas. One idea came in the 1930s from the work of Hideki Yukawa, who proposed that if two particles experience a force, they do so by exchanging between them another, intermediate, particle, which is said to mediate or carry that specific force. A basic tenet of quantum electrodynamics, for example, is that when two electrons are scattered (repelled), they are actually exchanging a photon, which is the carrier of the electromagnetic force.

The other key idea is subtler and deeper, and is intimately entwined with the effort to group the bewildering array of subnuclear particles into related families. It is a special kind of quantum field theory called gauge theory or gauge symmetry. Gauge theory is a mathematical concept that connects geometrical transformations in space and time, the symmetry of the laws of nature, and the internal symmetries that define the quantum properties of particles. It is hard to demonstrate without resort to a branch of mathematics unfamiliar to most laymen but second nature to particle physicists—group theory. There is a vital difference between ordinary symmetries and gauge symmetries, one that endows the latter with extraordinary power. Steven Weinberg, now of the University of Texas at Austin, put it this way: "A symmetry puts particles together in families, but it doesn't tell you what particles exist. A gauge symmetry, however, tells you not just about the behavior of particles if they exist; it dictates the existence of specific families of particles called the gauge particles."

Maxwell's unified theory of electromagnetism, in fact, turns out to be the oldest gauge theory. In the notation of group theory, it is a U(1) symmetry. The gauge theory, explains Weinberg, "tells you that a particular particle must exist. That particle is the photon."

The last two decades have seen physicists applying the power of gauge symmetry to bring forth a number of theories, including at least one unification theory, that have

“It was almost as incredible as if you fired a 15-inch shell at a piece of tissue paper and it came back and hit you”

been proved stunningly successful.

In 1961, Murray Gell-Mann of Caltech organized the jumble of confusing heavy and short-lived subnuclear particles into mathematical families according to a scheme he whimsically called the "eight-fold way," after a Buddhist code of right behavior. (An Israeli colonel, Yuval Ne'eman, arrived at more or less the same classification scheme independently.) The scheme predicted a particle, the omega minus, that had never been seen; it was found by Brookhaven experimenters in 1964.

Organizing the particles was certainly a help, but the nagging question of what was really elementary remained. Could there be hundreds of "fundamental" particles? Gell-Mann (and independently George Zweig, also of Caltech) said no. He proposed instead a wickedly delicious idea, a new, basic unit of matter called the quark, which came in three kinds of "flavors" that he dubbed "up," "down," and "strange."

In varying combinations they would make up every hadron. Strangest of all, to make the theory work, Gell-Mann endowed his quarks with fractional electric charges, which had never been observed in nature. All the hadrons known as baryons (the proton, neutron, and relatives) were made of three of these basic entities. The rest of the hadrons, called mesons, had one quark and one antiquark.

Although individual quarks have never been seen (and, according to some theorists, can never be liberated from inside the nucleons) there is substantial evidence that they exist. A string of experiments conducted at very high energies at the Stanford Linear Accelerator Center and other facilities showed that there were indeed small, heavy quarklike somethings inside the proton. An experi-

Continued

ment at Fermilab in 1976 saw three somethings inside the proton resting in a mass of “glue,” like raisins in a rice pudding. The grains in the pudding acted as if they were force-carrying particles. Now called gluons, they are thought to bind the quarks, and therefore all the hadrons, together—they are the carriers of the strong force. In 1979, an international team, working at the Petra storage ring in Hamburg, Germany, confirmed the existence of gluons.

The quark theory has been much elaborated, by many hands. It has been necessary to add three “colors,” which have nothing to do with real colors, and three more flavors—top, bottom, and charm. It now adds up to what virtually all physicists believe is a correct theory of the strong interaction, called quantum chromodynamics, or QCD, by analogy to quantum electrodynamics, QED. It helps to reduce the hundreds of fundamental particles to a manageable bunch of quarks and leptons, six of each (plus their antiparticles), which fall into three sets, or families. (See table of fundamental matter particles.) It is notable that QCD is a gauge theory; it has an SU(3) symmetry.

And so, it turns out, is the theory of the weak interaction—SU(2) is its symmetry group. “Gauge,” says Harvard theoretician Sheldon Lee Glashow, “is a certain highly

“The salvation of elementary particle physics is, at least for the moment, in the hands of the experimentalists”

specific kind of quantum field theory. At one time, there were all kinds of quantum theories that one could write down, in principle, to explain things. But what has become clear . . . is that nature has chosen this particular version of a quantum field theory, which happens to be called a gauge theory, and chosen it not once but three times, for the electromagnetic, the strong, and the weak force.”

As early as the 1930s Yukawa had proposed that the weak force could be carried by particles in the same way that electromagnetism was carried by the photon. These proposed carriers of the weak force came to be known, around 1957, as intermediate vector bosons (after S. N. Bose, the Indian physicist). Numbers of theorists, including Julian Schwinger and later his student Sheldon Glashow, began writing gauge theories that tried to unite the weak and electromagnetic forces. By 1960, Glashow had described important features of the present theory.

But there were two severe problems. In a strict gauge theory, the field quanta (force-carrying particles) should be massless. That was true of the photon. But quantum theory said that the intermediate vector bosons had to be very massive, as a direct result of the weak force being so weak. How could a massless photon and a massive boson be reconciled in one unified theory?

The second major problem was that the early gauge theories didn't make mathematical sense. Says Steven Weinberg, “If you calculated, let's say, the scattering of a neutrino by an electron via the weak force, you'd get meaningless results, nonsensical infinities for the strength of the force.” Similar infinities had plagued QED during its evolution but were eventually solved using a special mathematical technique called renormalization.

In 1967, Weinberg (then at Harvard)—and a year later, independently, Abdus Salam of London's Imperial College—promulgated a version of the unified theory of weak and electromagnetic interactions that seemed to solve

both problems. It specified that there were three intermediate vector bosons: two charged particles, the W-plus and W-minus, and a neutral one, the Z-nought. It connected these to the photon with a precise symmetry, while supplying a special mechanism called spontaneous symmetry breaking, to account for their masses.

This rather abstruse notion is critical to modern particle physics. It means that while the gauge equations have symmetry, their solutions do not—the bosons have mass. Weinberg offers a rough analogy: If you start out with the equations for a bunch of iron atoms and the electromagnetic field, they have no preferred direction, nothing to differentiate north from south; they have a symmetry. But when you solve those equations, one possible solution is a magnetized hunk of iron, a bar magnet with a north and south pole. That doesn't mean there's anything wrong with the symmetry of the original equations; it's just that the solution has broken that symmetry.

Weinberg and Salam were sure their theory was also renormalizable. But they had to wait for proof until a brilliant young graduate student at Utrecht University in the Netherlands, Gerard 't Hooft, found the right mathematical procedure for exorcizing the demon infinities.

This progress immediately galvanized the experimentalists into testing the by then four-year-old theory. And the new theory was testable, for it made several predictions. One was that there had to be a form of the weak interaction never previously observed. For 80 years, physicists assumed that every example of the weak interaction involved a transfer of charge. In such reactions, a charged particle has to be the vector, or force-carrying particle. And that is the role of the W-plus and W-minus bosons in the Weinberg-Salam-Glashow theory. But what about the Z-nought boson, demanded by the theory? The inclusion of a neutral intermediate vector boson inexorably required a new kind of weak interaction in which no charge was transferred, a neutral current interaction. And in 1973, experimenters at CERN and Fermilab found evidence that neutral currents did indeed exist. Later experiments confirmed other aspects of the electroweak theory.

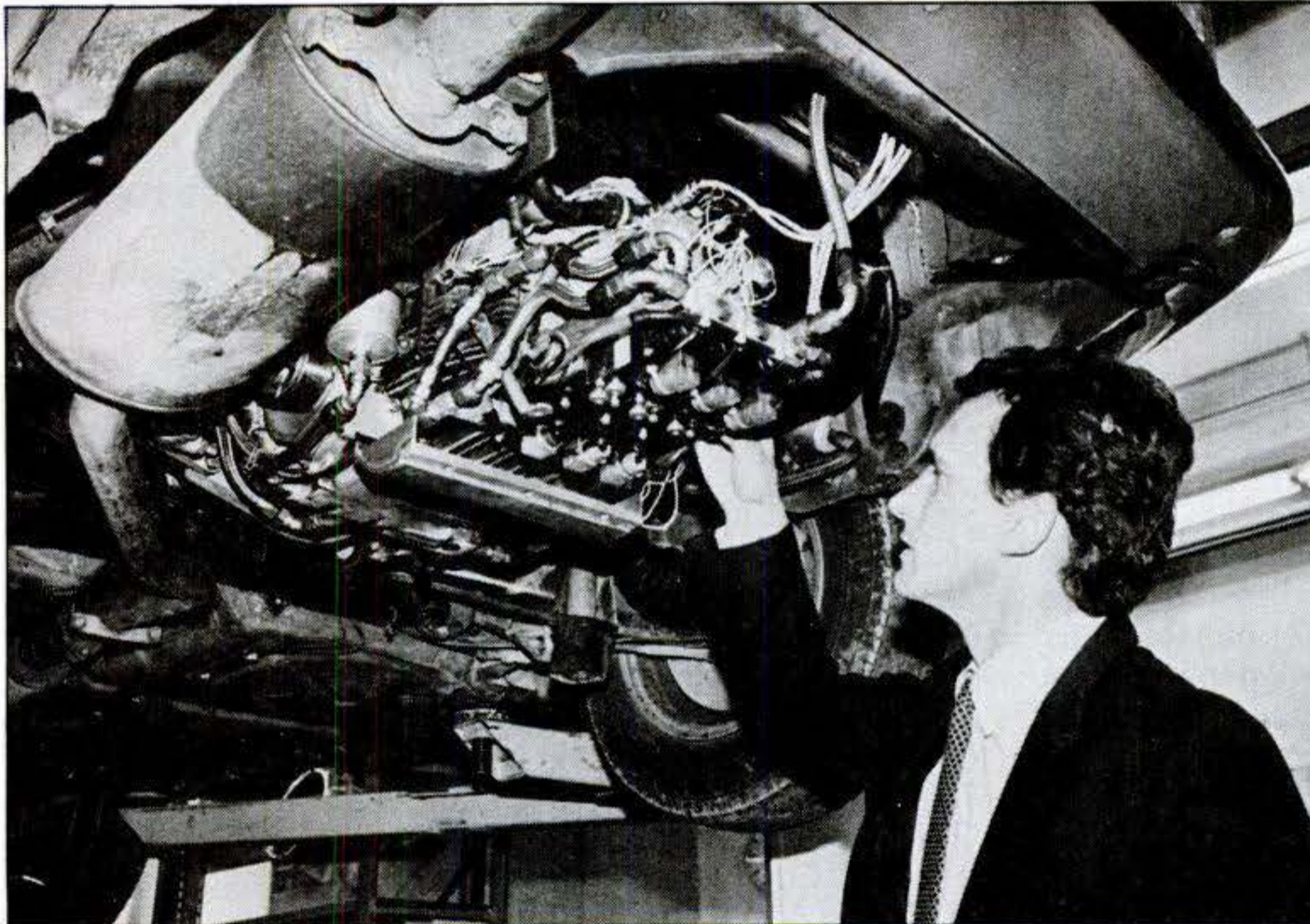
Glashow, Weinberg, and Salam received the 1979 Nobel prize for their manifold contributions to the building of a successful unification theory. “The Nobel Committee really put their reputation on the line,” says Glashow, “by awarding the prize for a theory whose principal prediction had not yet been found.”

The prediction? The existence of three intermediate vector bosons, two of which have now been found at CERN—the W-plus and W-minus. Particles that had no previously provable existence, save in the insights of daring theorists, have left brief, delicate, but indisputable traces in a detector. The discovery is the strongest support yet for the electroweak theory. Moreover, these are the first force-carrying particles with mass to be seen, and the symmetry-breaking mechanism that gives them mass is crucial to all unification theories. So the discovery encourages physicists in their conviction that more-encompassing unification theories of the gauge variety remain to be found.

Why had the Ws not been found before? They were too massive. Theorists calculated that the W mass should be around 80 GeV, the Z-nought about 93 GeV. (GeV stands for billions of electron-volts, a unit of energy; energy is equivalent to mass in particle physics.) By contrast, a proton has a mass of a little less than one GeV. To create such a massive particle using the Swiss-watch, or particle-smashing, method requires an enormous amount of energy, unavailable in any of the world's accelerators until recently. To capture this “most prized trophy in all of physics,” Carlo Rubbia and his colleagues in 1976 devised a

[\[Continued on page 140\]](#)

Porsche's hot two-clutch automatic



Modified rear transaxle of Porsche 944 is now automatic. Experimental assembly

This five-speed gives faster shifts and better economy than a manual

By DAVID SCOTT

WEISSACH, W. GERMANY

Imagine an automatic transmission that shifts faster than a race-car driver can with a manual gearbox—and is faster around the track, too. That's what engineers at Porsche claim for its new five-speed transmission. And because it has no torque converter, the device saves fuel, as well.

The basic principle is ingenious but simple. The transmission has two hydraulic clutches. The concept is similar to the constant-mesh design of Britain's Automotive Products' "split-personality" transmission [PS, Nov. '81]. The two clutches alternately couple the engine to odd- and even-numbered gears, which are grouped on separate shafts. When starting the car from rest, first gear is engaged in

bolted behind gearbox has external actuators for easy access during tests.

the usual way, and clutch number one drives. Meanwhile, second gear is pre-engaged by its synchromesh cone but is not driven, because the second clutch is open. For the upshift, clutch number one releases as number two simultaneously engages. This odd-even sequence is followed up and down the ratio range.

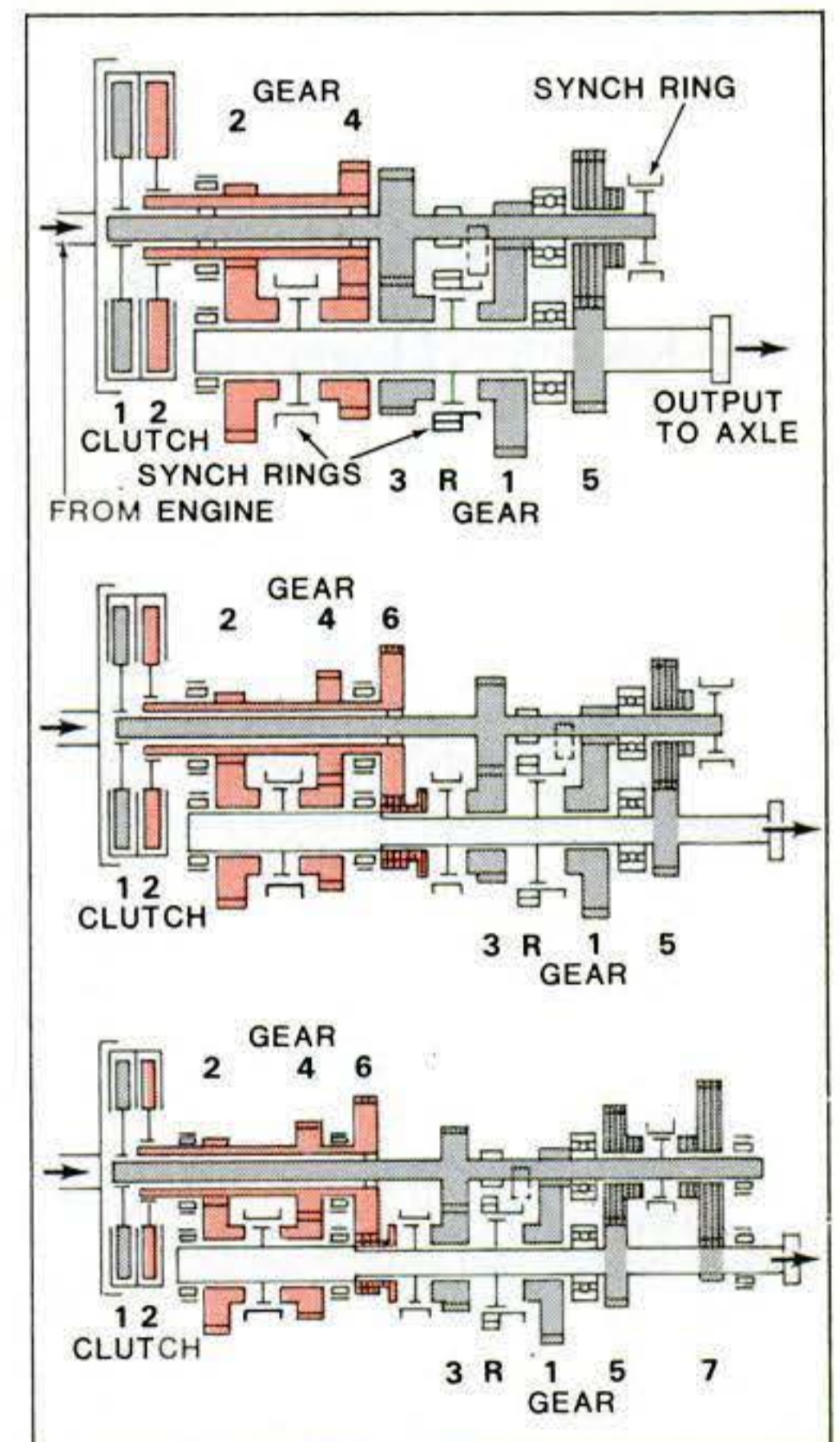
The setup gives positive drive at all times—the interruption of power to the wheels that happens when de-clutching for a manual shift doesn't occur. Hydraulic losses, such as those from the converter in a conventional automatic, are avoided too, and you still get fast shifts—changing gears without throttling back the engine. Emissions are reduced because the engine runs at near-constant speed during gear changes.

Gears are engaged and disengaged by bidirectional hydraulic actuators moving selector forks. Operation of the actuators and clutches is controlled by an electronic system programmed to shift at the most econom-

ical points, taking into account the engine and road speeds as well as throttle position.

The clutches are located at the front end of the transmission casing. Porsche engineers claim that the twin-disc arrangement is not only a simple mechanical design but is safe, too. A hydraulic interlock helps prevent the risk of double engagement, which would cause the gearbox to lock up—with disastrous consequences.

Porsche's models 944, 924, and 928, all with rear transaxles, could take the new transmission. While five speeds with overdrive naturally boost economy, there's room in the tail end of the Porsches to stretch the design lengthwise even more—to six or even seven gears for fuel efficiency approaching that of a continuously variable transmission (CVT). Production costs of the automatic would be relatively low because all mechanical parts can be made on existing production lines. PS



Conventional constant-mesh manual gearbox is basis for twin-clutch five-speed automatic. Gears are arranged so that odd- and even-numbered primary gears are grouped on separate coaxial shafts. Clutch number one drives the odd-numbered gears, shown here in gray, while clutch number two drives the even-numbered ones. Engine input alternates between clutches as shifts occur. The six- and seven-speed transmissions at bottom are future Porsche possibilities. Transmissions with a large number of ranges would give very wide ratio spreads to maintain near-constant engine speeds for optimal fuel efficiency.

On the track of deadly **wind shear**

A dramatic new look at the abrupt and dangerous shifts in the wind that can spell disaster at airports

By **BRUCE W. MOST**

At first glimpse, the series of radar patterns on the display screen was a bewildering jumble of colors: browns, whites, greens, purples, blues. But with the aid of meteorologist Cathy Kessinger, I began to decipher the color-coded images—images that in coming years may save the lives of hundreds of air travelers.

Recorded two months earlier on a pulsed-Doppler radar near Denver, Colo., these patterns were a vivid portrayal of the birth and death of a “microburst”—a strong downflow of air, usually (but not always) associated with a thunderstorm. Microbursts strike the ground and spread radially, spawning violent, low-level wind shears—sudden changes in the speed and direction of the wind over a short distance. These wind shears can strike aircraft quickly, dangerously, and without sufficient warning.

The tape I saw showed one of many microbursts observed and recorded last summer as part of the Joint Airport Weather Studies (JAWS), a \$2.2 million, three-year project conducted by the National Center for Atmospheric Research in Boulder, Colo., and the University of Chicago with principal funding from the National Science Foundation. The microbursts were recorded within a 5,000-square-mile area around Denver, which experiences one of the highest frequencies of thunderstorms in the nation.

On the replay, the colors on the screen first appeared as scattered browns, whites, and greens on a neutral field of gray. Then the colors quickly built in intensity as they formed a pattern that is characteristic of a microburst: a purple core surrounded by an irregular pattern of blues and greens, separated—by a jagged white strip—from another irregular pattern of tans and browns. A color key at the bottom of the screen enabled me to compute a peak wind differential between the purple and tan cores of 25 meters per second (50 knots), all within an area of three to four kilometers (1.9 to 2.5 miles). The microburst evolved and died in only a few minutes.

Why take such elaborate pains to study the wind? More than 100 scientists, engineers, and technicians are seeking to discover answers to questions such as: What causes microbursts? Why don't they occur in all thunderstorms?

And why do some occur even when there is no thunderstorm? The project is also taking a close look at present and potential technologies for detecting and warning against microbursts. Therein lies the major importance of the project: its potential contribution to air safety.

In the last seven years microbursts have been blamed for at least nine airliner accidents, including the downing of Eastern Airlines Flight 66 at Kennedy International Airport in 1975, an accident that killed 113 people. A microburst is also the most likely suspect in last year's crash of Pan Am Flight 759 near New Orleans, killing 154.

“There are other wind shears—gust fronts and frontals, for instance—and they're nothing to laugh about,” said John McCarthy, one of the team of scientists for JAWS. “But they're not as dangerous as microbursts.”

Why are microbursts so menacing?

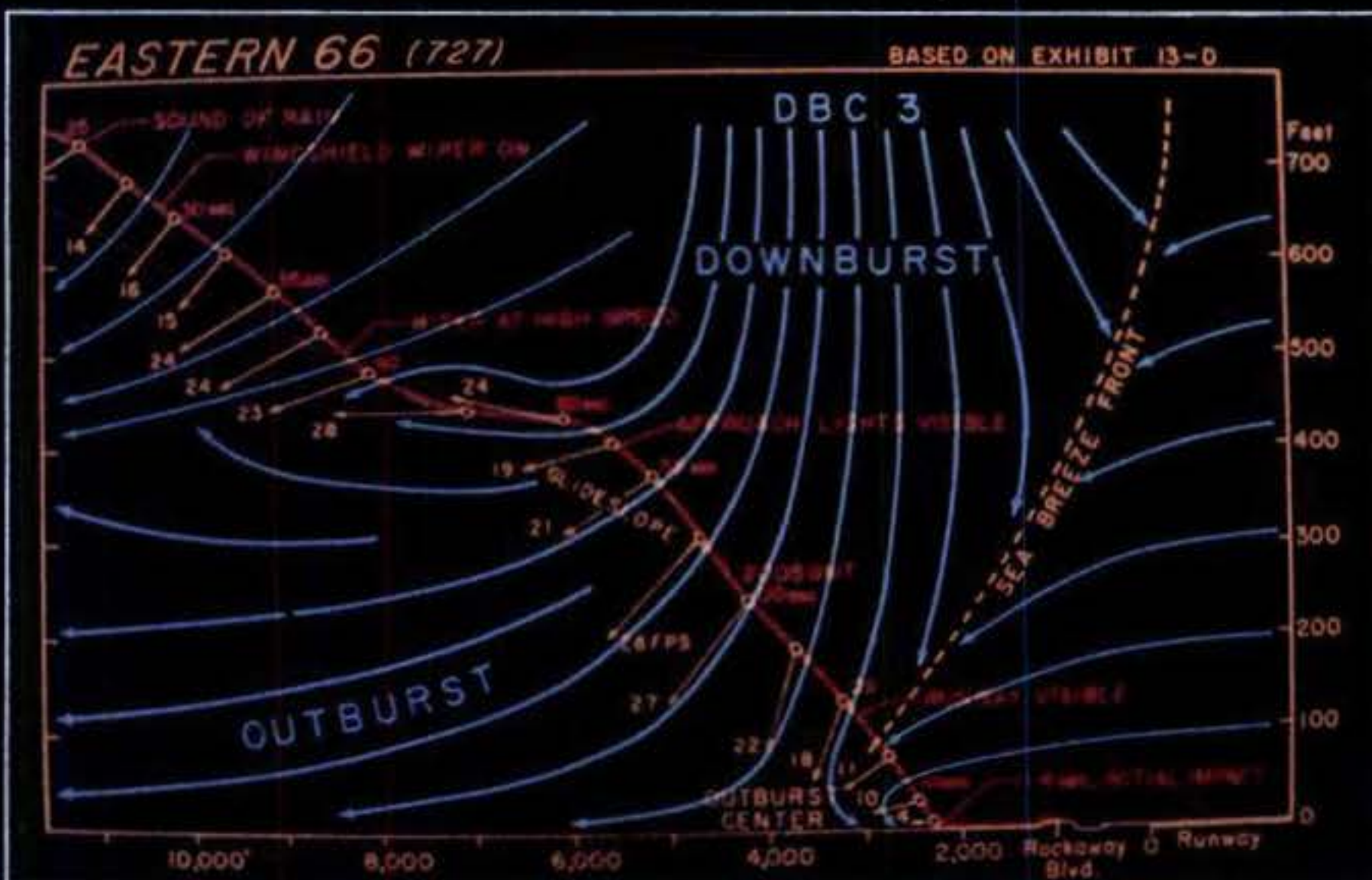
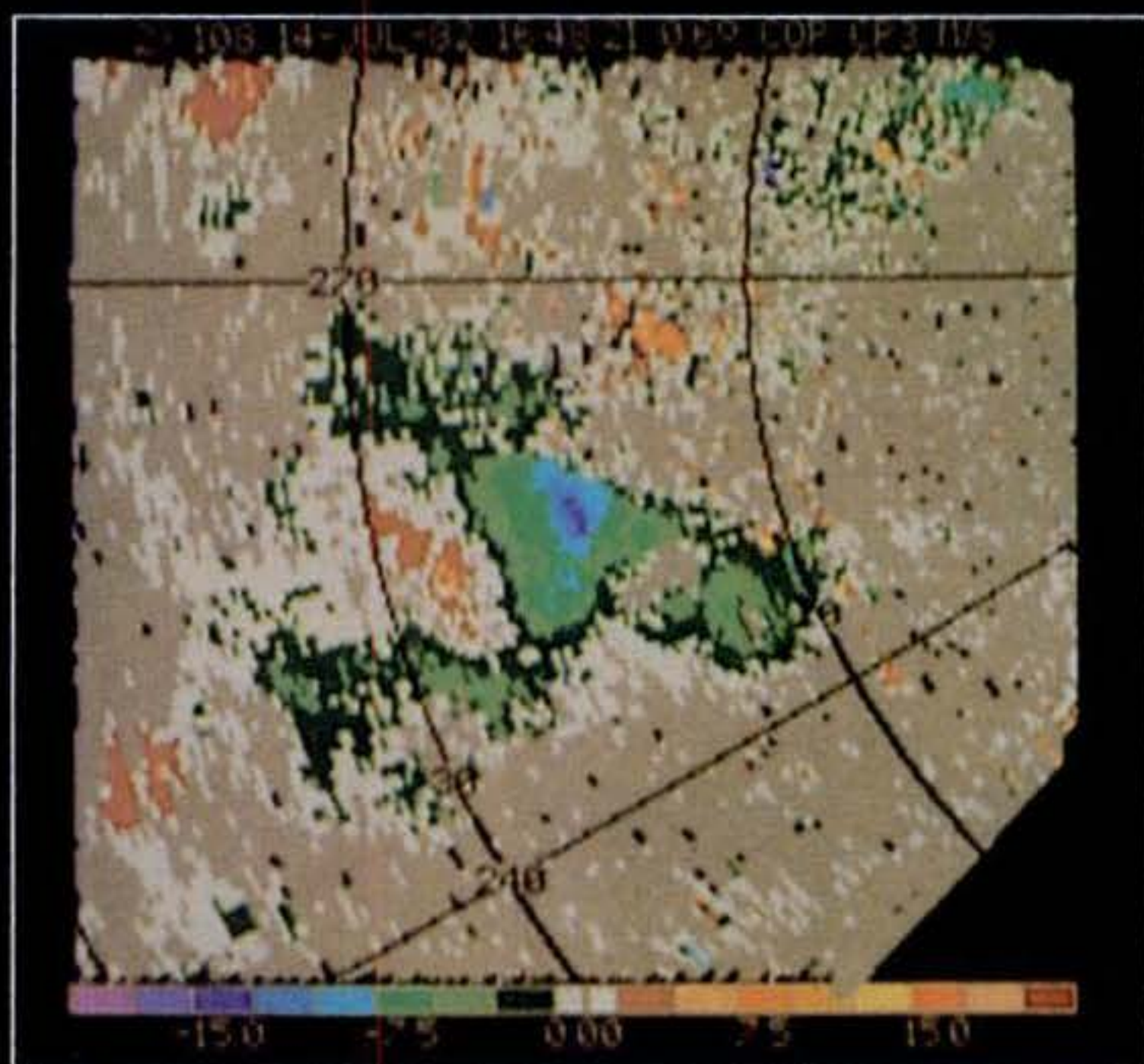
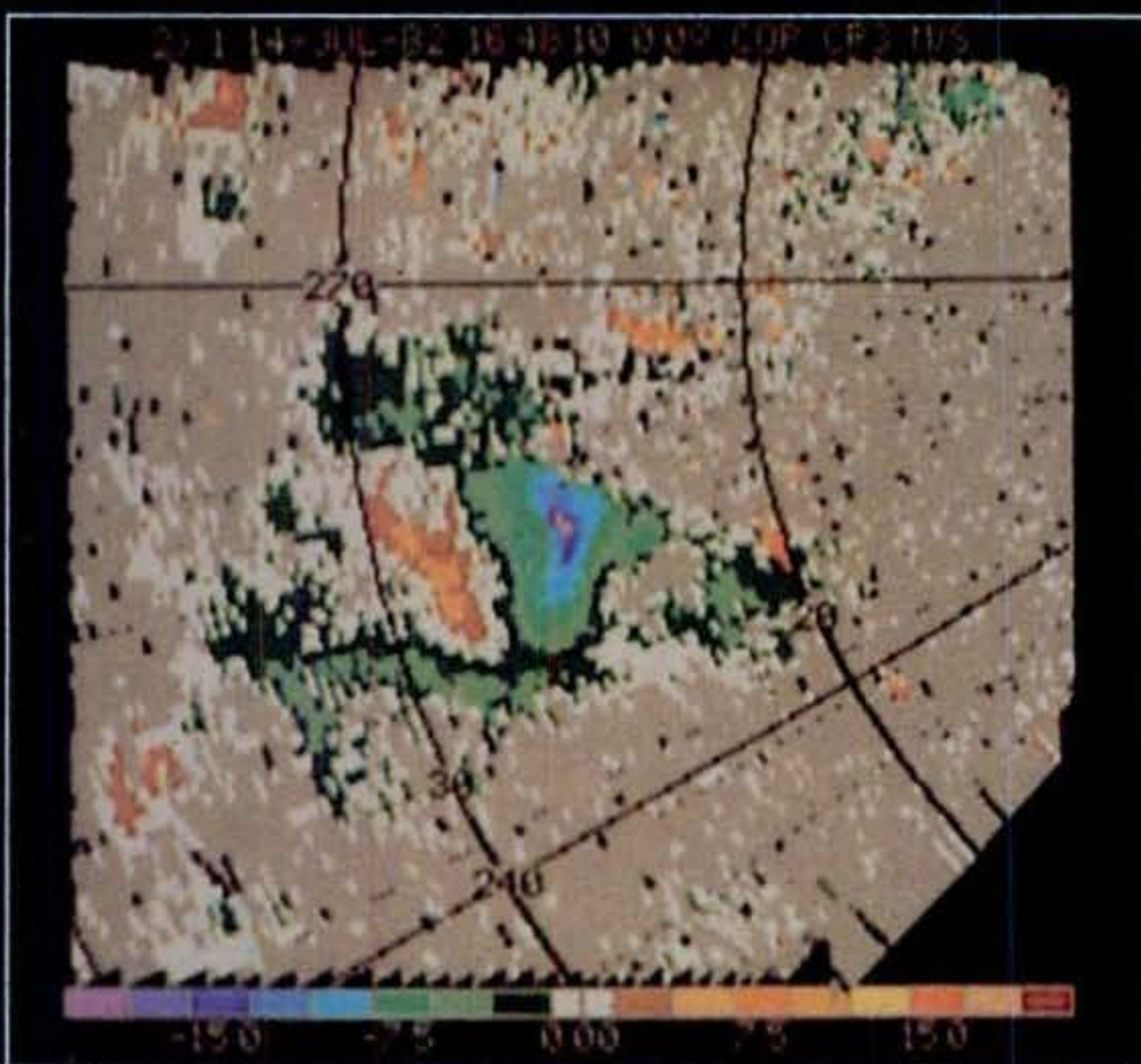
By definition, microbursts are 400 meters to four kilometers (0.25 to 2.5 miles) in diameter and two to 10 minutes in duration. Downbursts, which are somewhat larger, range from four to 20 km (12.4 miles) and last five to 20 minutes. Large-scale downdrafts, funneling out of thunderstorms to produce gust fronts, are 20 km or more across and last much longer.

It's the intensity, compactness, and short-lived nature of microbursts that make them so insidiously dangerous. An aircraft encountering a microburst first experiences a head wind, increasing lift. Yet only moments later it's caught in a tail wind, decreasing lift—sometimes to the point of stall. Small aircraft normally can respond quickly to such abrupt changes. Unfortunately, a heavily loaded airliner taking off, such as the Boeing 727 from New Orleans, or a jet making a final approach at 60 percent power has more difficulty—six to eight seconds are needed for the engines to reach full power. If the microburst strikes at 500 feet or below, there is often not enough time to respond.

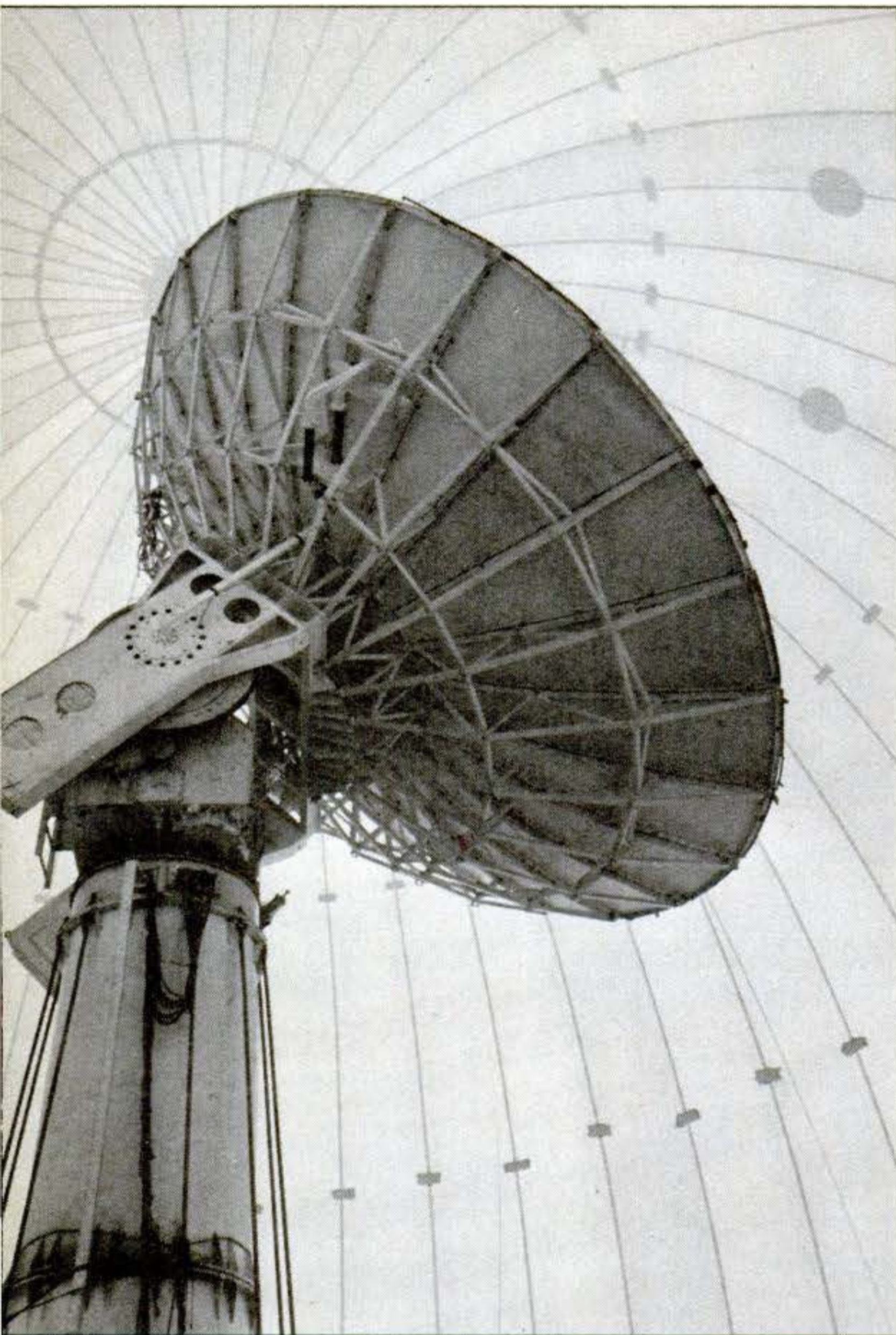
A microburst can create other kinds of havoc, too. “Loss of lift is probably most critical,” said Jim Wilson, one of the JAWS project's principal investigators. “But certainly the downdraft is a contributing factor. Also, there's the force of rainwater on the plane. Even rain beating on the wings changes the aerodynamics, adding to the decreasing lift. Everything goes wrong.”

As aircraft have grown larger and air-traffic volume heavier, microbursts have become more of a danger, says

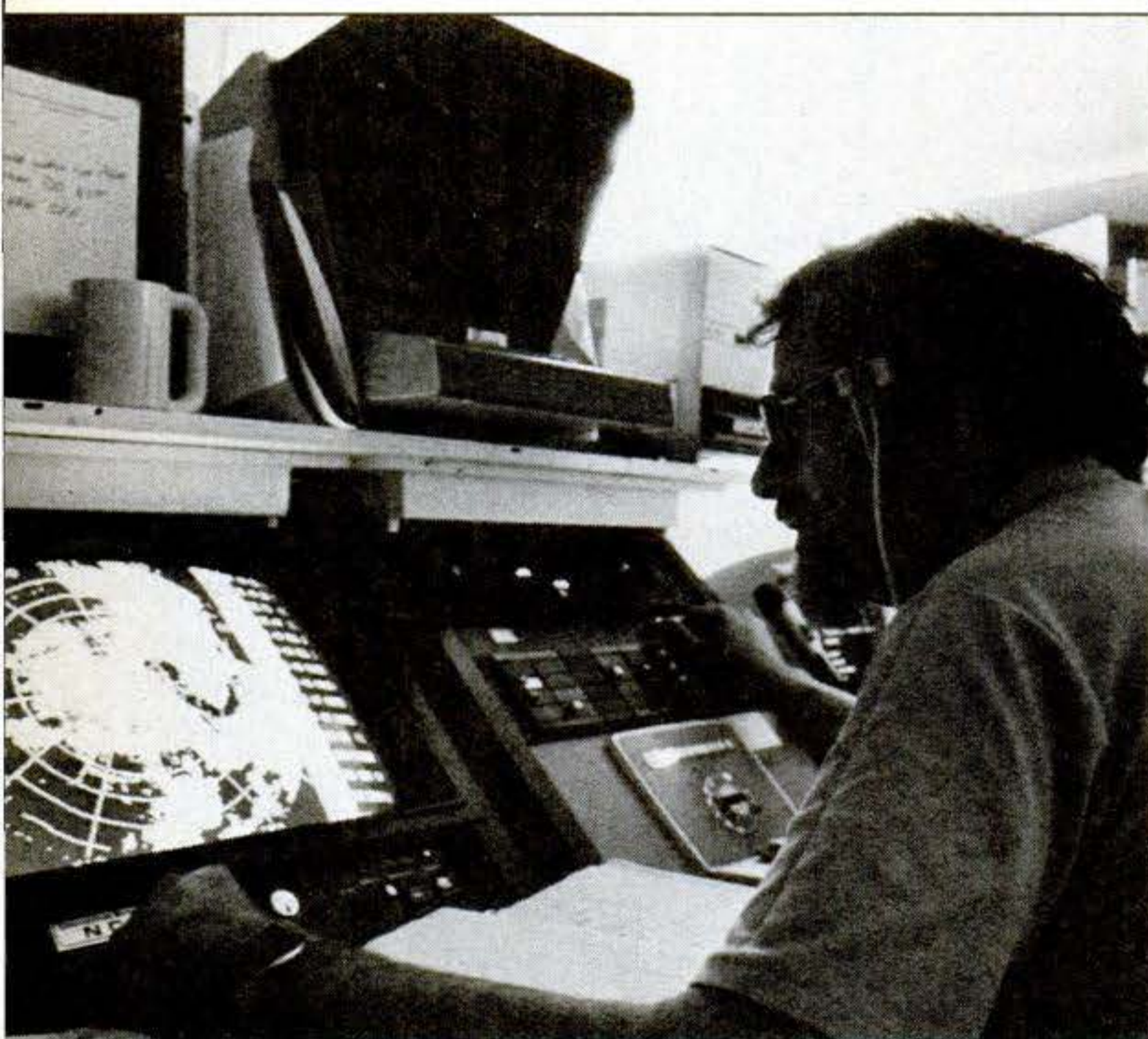
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Radome at Denver's Stapleton Airport houses gear for studying wind shear in the JAWS project. Shown at center are color-coded radar images of a microburst's peak velocities, as measured by Doppler radar. Cooler colors, ranging from greens (slow) to purples (fast), indicate winds blowing toward the radar; warm colors, ranging from browns (slow) to reds (fast), indicate winds blowing away from the radar. White indicates no wind or wind blowing across the view of the radar. Left: A profile of the landing pattern of Eastern Airlines Flight 66, which crashed at Kennedy International Airport in 1975, and of the wind shear that caused the accident.



Inside 60-ft.-dia. radome at Denver's Stapleton International Airport, system sees into clouds by measuring frequency shift of microwave signals bounced off raindrops blown about.



John McCarthy directs operations for JAWS project from one of three ground radar sites. Other kinds of equipment include an anemometer network and airborne wind-shear detectors.

the man who first identified microbursts, Tetsuya Theodore Fujita of the University of Chicago, a co-investigator at JAWS. An authority on violent storms, Fujita gained prominence for his investigation of the 1975 crash of Eastern Airlines Flight 66. At the time it was generally assumed that a gust front had brought the plane down, but Fujita was suspicious of that explanation. Gust fronts are the leading outflow of thunderstorms and, therefore, widespread. Yet some of the planes landing just prior to Flight 66 reported no difficulties, while others reported severe wind shear with head and tail winds. Fujita knew, too, that the Boeing 727 was less than 500 feet above the ground when it went down. "I felt that this meant the air was coming down from above and moving outwardly very close to the ground, like water from a garden hose going straight down on a concrete sidewalk," he said.

Initially most meteorologists did not accept his theory, but in 1978 he confirmed his suspicions by recording 10 downbursts and microbursts on Doppler radar at Chicago's O'Hare International in a study called "The Northern Illinois Meteorological Research on Downbursts."

Although this study and its successor, JAWS, have confirmed the dynamics of microbursts, Fujita and his colleagues remain stymied by the question of what happens in a cloud to cause them.

In many cases during the JAWS field studies, no microbursts were seen during thunderstorms. But when they did occur, they tended to appear in clusters. Fujita believes the downbursts form somewhere *inside* the clouds instead of at the cloud tops, and that convective heating is fundamental to the process. Beyond that, however, microbursts remain a mystery.

Building the system

The JAWS project has developed what is now the most promising detection system for wind shear: the latest in real-time Doppler radar and Doppler lidar. Unlike conventional weather radar that simply measures the overall speed and intensity of a storm, Doppler radar can see what's happening *inside* a storm, measuring the internal wind velocities and directions. Operating on the same principle as police speed-detection radar, Doppler radar measures the frequency shift of its signal bounced off raindrops being blown about in the storm's winds. The Doppler lidar sends out a laser beam to measure the movement of aerosols such as dust and salt; it can even sense insects borne by a breeze. Its effectiveness is limited in rain, but it is extremely useful when the air is clear.

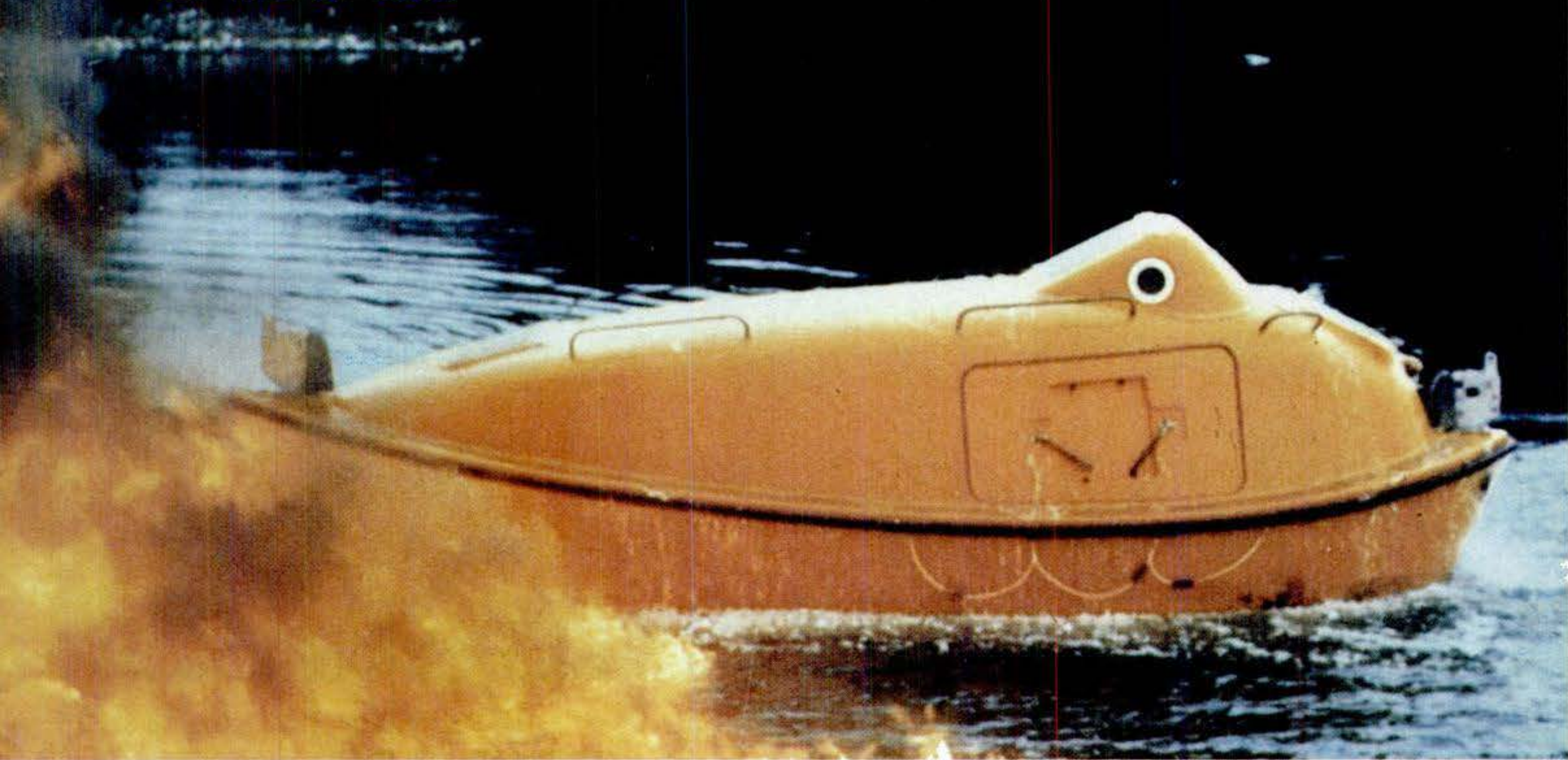
For JAWS, three Doppler radars were built: One operates with a 10-centimeter wavelength at a frequency of 3,000 megahertz, the other two with a five-cm wavelength at 5,500 MHz. They were placed in a triangular pattern. Supplementing the microwave units were two ground lidars, one built by NASA and the other by the National Oceanic and Atmospheric Administration, whose Lockheed P-3 turboprop, one of five research aircraft used to gather data on weather and flight performance, carried an airborne radar unit. Balloon soundings, as well as readings from 48 automated surface stations (27 of them solar powered), rounded out the data.

In 91 days of field operations, JAWS recorded 62 microbursts, a number that "surprised us and exceeded our fondest dreams," said McCarthy.

So, while JAWS has yet to answer all the meteorological questions, it *has* answered questions about the technology necessary for accurately detecting wind shear. "Our procedures and technologies today probably aren't adequate to address the enigma of microbursts," said John McCarthy, a pilot himself. "But we think we've identified the technologies that *can* address it adequately." ES

Airtight lifeboat

for fire at sea



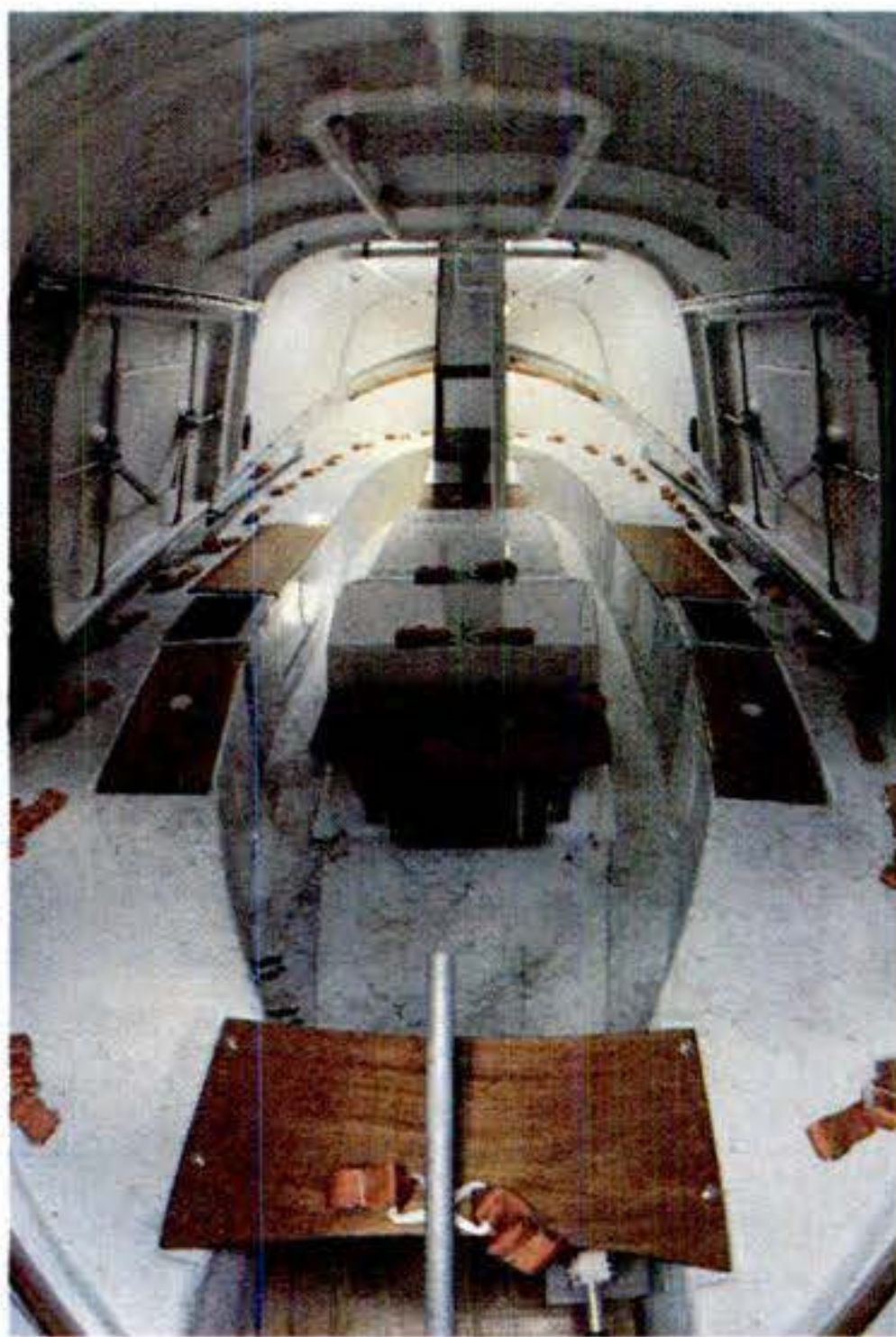
Protected by spray, this enclosed boat should run a gauntlet of fire safely

By CHARLES A. MILLER

One of the worst calamities that can befall a mariner is fire. On land you may be able to scramble to safety. At sea, especially aboard an oil tanker or drilling rig, you may get overboard only to be caught in a wall of flame from an ignited oil slick.

Fortunately, now there is an innovative way to escape an inferno at sea. Watercraft America, Inc., has designed and manufactured a lifeboat that is completely enclosed and able to withstand high temperatures—thanks to a water spray over the craft of enough duration for a fleeing crew to escape. What's more, the boat is fitted with a compressed-air system to allow crewmen to pass through toxic gases. The Watercraft lifeboat comes in five sizes, ranging from a 16-footer that carries 14 men to a 28-footer that holds 58. The Class I lifeboats are made of fire-retardant fiberglass-reinforced plastic. The hull is molded in one piece, as is the cover.

Another feature is the boat's self-righting design, which keeps the keel down no matter how it hits the water,



Rations, life jackets, and survival aids are stowed aboard boat. Hatches at either end offer access to lifting hooks, which are ordinarily released from inside.

due in part to polyurethane-foam blocks in the hull. As long as the hull stays intact, the boat is unsinkable.

The helmsman's exterior view is through a window in the dome at the top of the enclosed hull. His console includes engine controls, water-spray



Water-spray system in action: Jets are powered by the main engine. The water spray protects the cover, dome, exposed portion of the hull, and personnel.

pumps, winch brake, and hook release, as well as gauges, a compass, and, of course, the wheel.

The boat is powered by a keel-cooled marine diesel that can propel in excess of six knots. Fuel capacity is enough for 24 hours' running. **RE**

Sub suits

Latest models
plunge 2,000 feet
beneath the sea



Wasp, a legless suit with electrical thrusters for propulsion (top), is named for the insect it resembles. Conceived by Englishman Graham Hawkes, it weighs 1,100 lbs. in air but is neutral in water. Designed for mid-water tasks, the Wasp has lights and a TV camera to transmit images to the surface. The latest Wasp, the Inspector (above), hangs in its deployment cage over a test tank. Nearby is a Jim.

Pressure-proof diving suits, developed for the oil industry, are going to work for science, too

By **CHRISTOPHER SWANN**
PAINTING BY ADOLPH BROTMAN

Encased in a cast-magnesium diving suit known as Jim, I plod step by ponderous step along the bottom of the 37-foot-deep test tank at NASA's National Space Technology Labs in Mississippi. It is like learning to walk all over again. The secret, I am told, is to roll from side to side with a swinging gait. If I want to turn, I am to lean to one side, then lift the opposite foot and put it down in the direction I want to go. Invariably, I end up going

Jim has legs and is designed to walk on the ocean bottom (right). Normally it remains tethered to a support ship via lifting and communications cables. In an emergency the operator can jettison the cables, release the lead ballast, and make a buoyant ascent. Then a through-water transducer keeps the operator in touch with the ship. A flashing beacon and pinger aid in recovery. Jim's operator breathes through a mask that doubles as a microphone. Hoses channel his air through chemical scrubbers (in tanks behind his back) where carbon dioxide is removed. Makeup oxygen is fed in from external bottles. Manipulator claws are op-

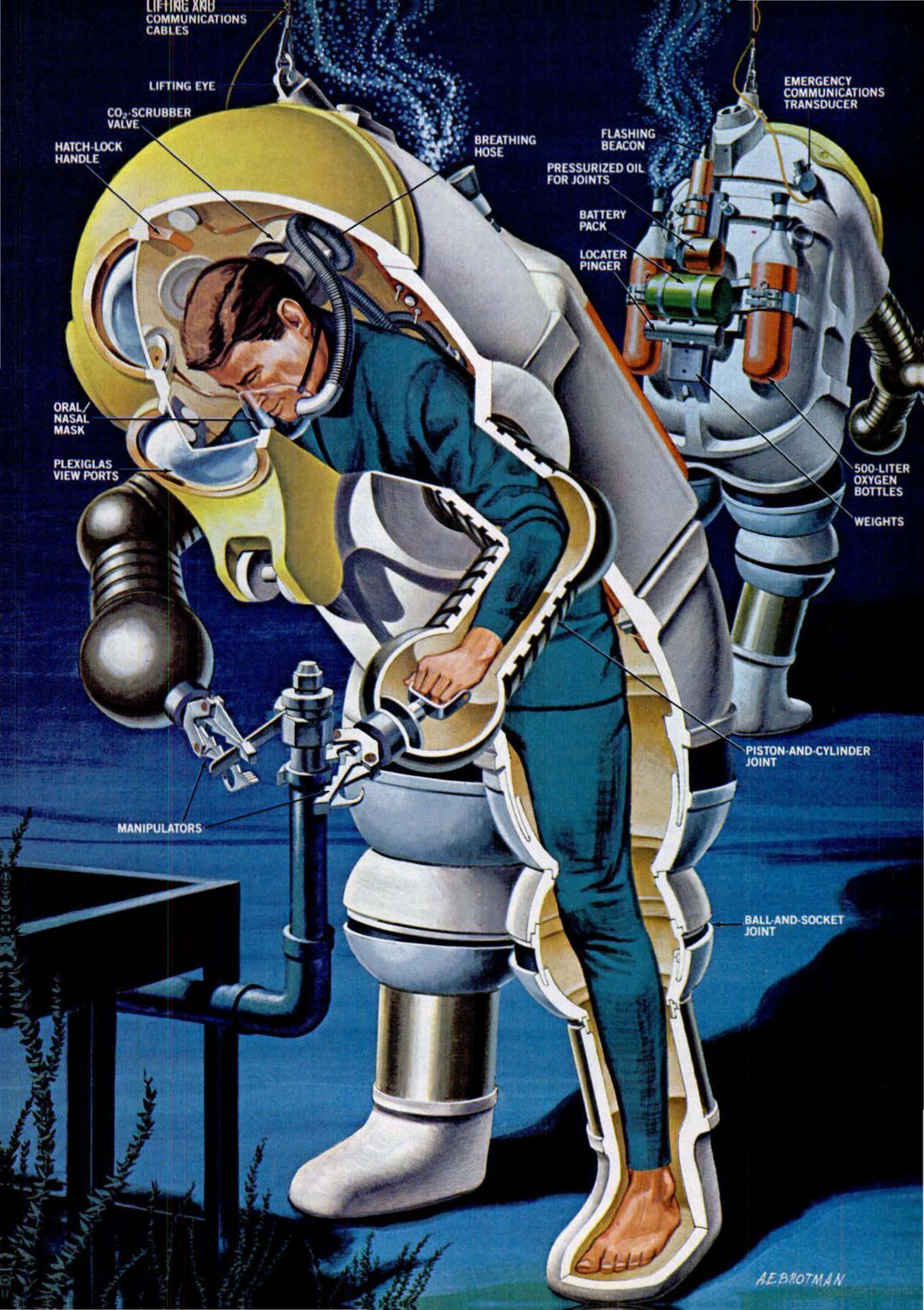
erated with a T-bar handle. Pushing or pulling the handle opens or closes the jaws, screwing it in or out adjusts the opening, and turning it rotates the claw: (Wasp uses the same manipulators.)

the wrong way. From time to time I adjust the oxygen flow into my oral-nasal mask. Becoming bolder, I lean forward—and promptly fall on my face. To get up, I lean back, arch my legs, and bring the suit upright. But holding the position too long, I fall over backward. I feel as helpless as an overturned turtle. Under instructions from the surface, piped to me through a small loudspeaker in the suit, I grab the handles of my claw-like manipulators and pull myself forward. It works. After 40 minutes in Jim, I can see why it takes 30 hours of tank time to become proficient.

Jim is what the industry calls an atmospheric diving suit, because the operator stays at sea-level atmospheric pressure—14.7 pounds per square inch—no matter how deep he dives.

Continued

Jim's namesake is Jim Jarratt, a British diver of the '30s who descended to the wreck of the Lusitania in an armored diving suit dubbed the Iron Man. Its inventor, Joseph Peress, served as a consultant on Jim. Type II Jim shown is of cast magnesium, weighs 900 lbs. in air, 60 lbs. in water, and is pressure-rated to 1,500 ft. Type III, of aluminum alloy, is rated to 1,000 ft.; and Type IV, made of fiberglass, has the deepest rating—to 2,000 ft.



LIFTING AND COMMUNICATIONS CABLES

LIFTING EYE

CO₂-SCRUBBER VALVE

HATCH-LOCK HANDLE

ORAL/NASAL MASK

PLEXIGLAS VIEW PORTS

MANIPULATORS

BREATHING HOSE

PRESSURIZED OIL FOR JOINTS

BATTERY PACK

LOCATER FINGER

EMERGENCY COMMUNICATIONS TRANSDUCER

FLASHING BEACON

500-LITER OXYGEN BOTTLES

WEIGHTS

PISTON-AND-CYLINDER JOINT

BALL-AND-SOCKET JOINT

A.E. BROTMAN

That makes diving much safer—and cheaper—beyond relatively shallow depths. Wasp, Jim's first cousin, is another atmospheric diving suit, but it has no legs. Instead, it hangs in the water, maneuvered with thrusters. Both of these diving machines are part of a worldwide fleet—15 Jims and 12 Wasps—built in Aberdeen, Scotland, and owned and operated by Oceaneering Intl., Inc., of Houston.

The first Jim became operational in 1974; the first Wasp in 1978. But a constant string of changes and improvements has made them more versatile than ever. As a result, they're finding jobs not only in offshore oil fields but in scientific exploration of the ocean. I recently had a chance to be brought up to date on these advanced machines—and try them out—on trips to the Mississippi test tank and to Oceaneering's facility in Santa Barbara, Calif.

The development of Jim and Wasp was brought about by the need of oil companies to go ever deeper into the oceans in search of oil. That requires underwater inspection, maintenance, and repair.

Traditionally, that has meant divers. But sending divers to great depths is an expensive and potentially dangerous business. The major problem: pressure. A conventional diver is subjected to the ambient pressure of the water around him. The deeper he dives, the greater it becomes. Pressure can cause serious—even fatal—physiological reactions unless proper precautions are taken. Thus a diver who descends deeper than about 200 feet must breathe a mixture of helium and oxygen instead of air. Worse, he must decompress slowly in a hyperbaric chamber when the job is done. After only 30 minutes at 500 feet, for example, he must spend 14 hours decompressing. If he is down longer, his decompression time jumps to 3½ days. At such depths, divers commute to the job in a diving bell—a chamber pressurized to equal the ambient water pressure—and generally live and work under pressure for weeks. This is called a saturation dive. The deeper they go, the longer it takes to decompress.

A diver who suits up in a Jim or a Wasp, however, can descend as deep as 2,000 feet and stay for many hours—limited only by fatigue. When he's pulled back on ship, he simply climbs out of the suit, his job done.

The opportunities these suits afford have not been lost on oceanographers. In 1979, well-known marine botanist Dr. Sylvia Earle took a pioneering step when she donned a Jim and descended 1,250 feet to explore

the ocean bottom off Oahu, Hawaii.

Last September, a team from the University of California at Santa Barbara leased a Wasp and explored mid-ocean waters down to 1,780 feet, 12 miles off the Santa Barbara coast. In the past, mid-ocean researchers could only lower nets and bottles over the side of a ship and haul up whatever they could catch. "Problem was, we could only catch animals that were not very fast or fragile," points out marine biologist Alice Alldredge, one of the divers on the National Science Foundation-sponsored expedition.

Wasp brought a new dimension to mid-ocean research, according to Alldredge. "It was as if we had spent 100 years studying the forest from hovering helicopters, then suddenly were allowed to walk among the trees."

Alldredge and Bruce Robison, another biologist at UCSB, headed a

“Experienced operators can climb a nine-inch step, lift an 80-pound weight, and tie knots with the claws”

team that for 25 days lived aboard a ship and dived repeatedly, observing, photographing, and taking samples of animals. Their most surprising discovery: a dense layer of tiny crustaceans 1,500 feet below the surface. These shrimp-like creatures, called copepods, were strangely inactive day after day. Now back in their labs, the marine biologists are trying to puzzle out why this important food source congregates at such depths.

Atmospheric diving suits are an old idea. In fact, Jim and Wasp can trace their ancestry directly to the armored diving suits of the 1930s (see captions). But they are leagues beyond their ancestors in capability and ease of use. And improved models keep coming. First-generation Jims can descend to 1,000 feet and are fitted with sealed, ball-and-socket, oil-lubricated joints. Their drawback: During long, deep dives they must be returned to the surface occasionally to get their joints topped up with oil. To get around this, an Oceaneering subsidiary developed piston-and-cylinder, O-ring-sealed joints that are automatically supplied with oil at ambient pressure by a regulator on the suit. The Jim that I tried (and the one in our painting) has piston-and-cylinder arms and ball-and-socket legs, a combination known as Type II. Jim cur-

rently comes in two other versions (for details, see caption). All contain 72-hour life-support systems.

My own attempts notwithstanding, nimbleness in Jim is far from impossible. Experienced operators can walk sideways and backward, climb a nine-inch step, crawl, and hop. They can also go up a 20-degree gradient, lift an 80-pound weight, and tie knots with their manipulators. Current Jims can work only where they can get a footing. However, a version with thrusters, called Jet Jim, is due soon. It will enable the diver to work both in mid-water and on the bottom.

For the moment, though, mid-water work is the province of Wasp. The latest model, called the Inspector, is the first in the series to use the cage-deployment system (see photo, opening page). The Inspector travels to depth in a protective cage, undocks, and motors over to the job. Its umbilical feeds from a reel behind it to a radius of 450 feet. This eliminates the long umbilical to the surface. All Wasps have cast-aluminum hulls and are certified to 2,000 feet.

In the test tank in Mississippi I also got my chance to try a Wasp Inspector. Understandably, I was confined to the cage. No one wants a green pilot crashing an expensive piece of equipment into the wall. In Wasp I didn't need to breathe through a mask. An electrically driven scrubber recirculates the air in the suit, removing the carbon dioxide.

After my trial in Wasp I watched an experienced operator pilot the machine. Once below, he eased out the bottom of the cage, then deftly juggled a ratchet, held in his manipulator claws, onto a nut. He made it look easy, but of course it wasn't. His feet were shifting between two pairs of foot pedals, coaxing the Inspector up and down, in and out, left and right with the two vertical and two horizontal thrusters.

At Oceaneering's facility in Santa Barbara, I looked at a new hydraulic thruster system which, if successful, will be fitted to the entire Wasp fleet. This new propulsion system includes a computerized depth sensor, which will signal the thrusters to hold the Wasp at any depth—an aquanaut's version of an automatic pilot.

No one pretends that atmospheric diving suits will do away with the conventional diver. But there are areas where atmospheric divers can work at lower cost in greater safety—and at greater depths. Given man's need and curiosity, it seems inevitable that still more dexterous suits, engineered to withstand still greater pressure, will be devised. ■

Ford's new off-road compact: **Bronco II**



It's 1,000 pounds lighter than the standard Bronco and a lot easier on fuel

By **JIM DUNNE**

Smaller packages can be more exciting. That's the impression I got after checking out Ford's smaller version of its Bronco utility vehicle, the Bronco II, at Ford's proving grounds in Dearborn. Steve Speth, Bronco II's development manager, rolled out a finished prototype for me to sample.

"It's our third version of the Bronco and is about the same size overall as the original that came out in the early 1960s," Speth explained. "We expect it to appeal to young, single buyers, and to women, who will make up about 20 percent of our customers."

Bronco II is the utility four-wheel-drive version of Ford's Ranger pickup. Its general dimensions, drive train, and cab details are identical to those of the compact truck. Differences show up in the cab aft of the doors. The body is covered with a permanent steel roof, and it features wrap-up

rear windows that give the package a distinctive appearance. The vehicle seats four, and the rear seat has a fold-down system that enlarges cargo-box length to more than five feet. The width between wheelhouses is almost 42 inches.

The sample I drove was powered by the standard 2.8-liter (170 cu. in.) V6 built by Ford of Germany. The V6's stop-and-go response is perky. It is matched to a high-economy five-speed manual overdrive transmission. Fuel economy is estimated at 20 mpg in the EPA city test, an improvement of 33 percent over the V8-powered full-size Bronco.

A typical Ford four-wheel-drive set-up works just fine. Use two-wheel drive for dry pavement. Then shift to four-high and back to two-wheel drive without slowing down, declutching, or stopping. To get into and out of four-low, however, the truck must be stopped. The transmission's shifter worked so easily that I had to check the instrument-panel light to be certain that all four wheels were engaged when I changed modes.


Standard transmission is a four-speed manual; a three-speed automat-

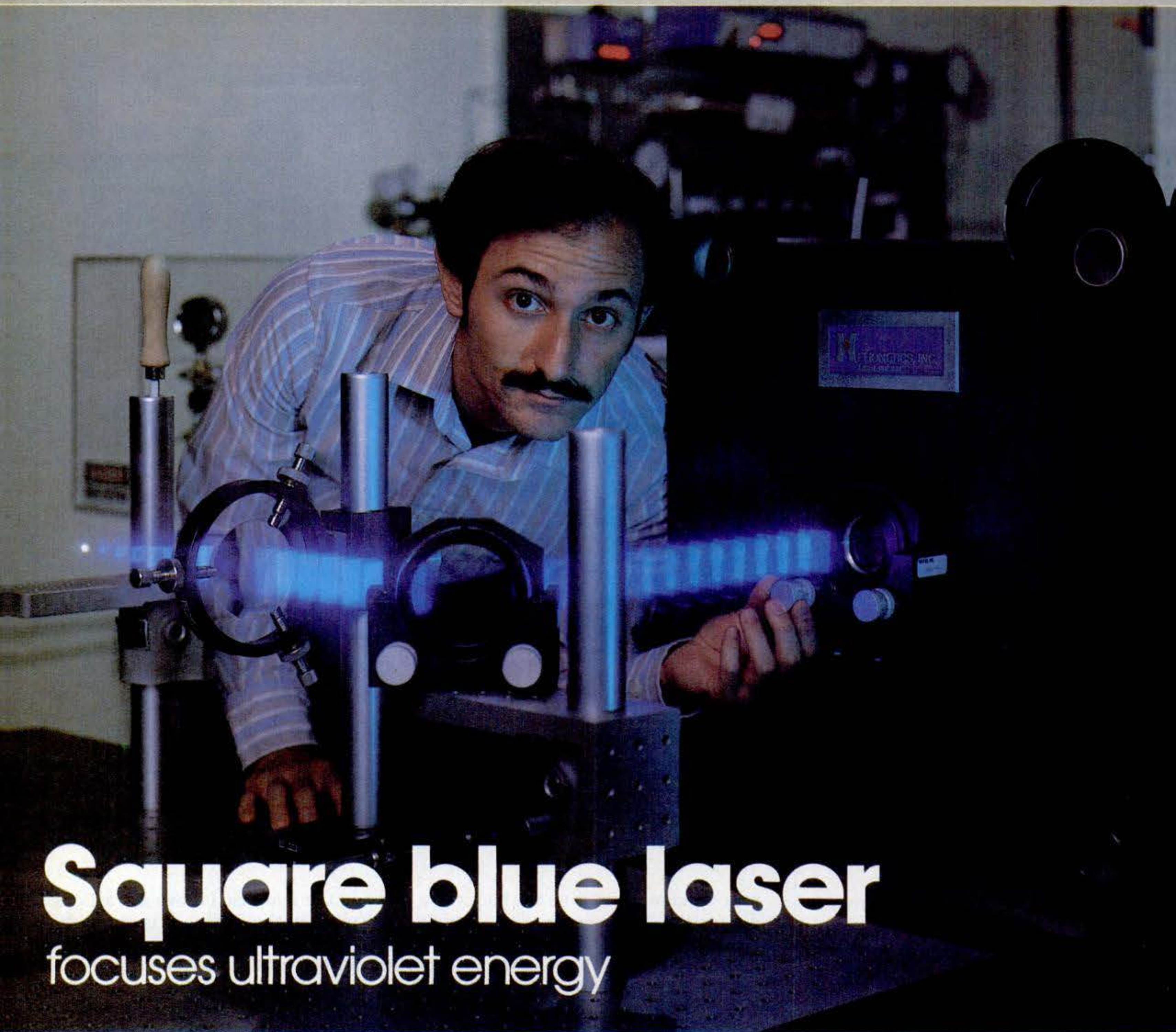
ic and the five that I drove are options.

Riding in the Bronco II is more like riding in a mid-size sedan than in a truck. The interior is relatively quiet, and the suspension is soft enough to smooth out small bumps.

Bronco II is bigger than the compact trucks from Japan, and that translates into more passenger room. Head, leg, and shoulder room are generous. Getting in and out is slightly difficult because the floor level is higher than that of a sedan.

"We have to clear the Twin I-Beam front suspension," explained Speth. "That puts our engine up higher and raises the whole body a couple of inches." Ford's I-Beam suspension runs across the chassis in the front. Competitors use more-conventional suspensions that allow the engine to be cradled lower—down between the springs.

With a 3,000–3,100-pound curb weight, Bronco II is more than 1,000 pounds lighter than the standard Bronco. However, its trailer-towing limit of 4,200 pounds is a good indicator that this smaller vehicle is no lightweight when it comes to tough pulling jobs. 



Square blue laser

focuses ultraviolet energy

The excimer laser may help lower solar-cell cost, improve nuclear-waste recycling, and much more

By **JIM SCHEFTER**
PHOTO BY VIC HUBER

SAN DIEGO

The blue laser beam pulsed with a mild click, throwing its unusual three-centimeter-square (1.2 in.) shape onto a sheet of paper held close to the aperture. "Now, watch this," said Dr. Jeffrey Levatter, pulling back the paper to let the next pulse ricochet through focusing mirrors.

Crack!

The sudden noise exploded from a point in midair.

Crack!

That time I was ready. A tiny blue

burst of energy seemed to flash away from the point where the laser beam was focused. "It's ionizing the air at that point," Levatter said. "Molecules in the air are exploding."

To demonstrate the power of his excimer laser, Levatter spent the next few minutes burning holes through paper and heavy plastic, putting pits into stainless steel, and vaporizing the surface layer of glass. But such routine laboratory tricks are not the future for this unique device. The excimer laser should find important industrial applications, beginning this year. They include materials processing, photochemistry, communications, and other fields. Levatter expects semiconductor and solar-cell manufacturers to be among the first commercial users because silicon, the raw material for both, absorbs UV wavelengths with great efficiency.

Pulsed UV beam of excimer laser is controlled with focusing mirrors. Dr. Jeffrey Levatter, whose development work made it a practical device, demonstrates.

The name excimer comes from the excited dimer, or diatomic molecule, which fluoresces in ultraviolet wavelengths as it decays. Levatter's excimer laser uses xenon and chlorine gases to form the lasing medium. The xenon chloride created is in an excited state, and it instantly decays, giving off ultraviolet light.

"Excimer lasers are the most intense source of ultraviolet energy available today," Levatter told me at his laboratory here, where the young inventor is president of the Laser Division of Helionetics, Inc. "And they emit a beam of uniform intensity. Most laser beams are circular, and, like a candle flame, 30 to 40 percent of

their power is concentrated in the center. Power gradually weakens outward to the edge of the circle."

The Helionetics laser produces a square beam; the electric discharge—the flow of electrons between two flat metal plates—has a square cross section. The plates are a meter (3.3 ft.) long and three centimeters (1.2 in.) wide and are separated by a three-centimeter gap.

It is this unique combination of characteristics—high power, a uniform square beam, and laser light in the ultraviolet band—that makes the excimer laser a promising new tool.

"We can control the power and heat generated by focusing to change the beam size," Levatter said. "A millimeter-size (0.04 in.) beam could vaporize material, but a one-centimeter (0.4 in.) beam just melts the surface."

Such beams could be used to anneal silicon. Annealing is the process of melting surface layers to heal the "scars" created when ions or impurities are implanted to give solar cells and semiconductors their unique properties. It is usually done in high-temperature ovens, a lengthy batch process requiring careful control. Inevitably, some units are ruined.

"With the excimer laser, a four-inch-diameter solar cell that produces a watt of electricity could be annealed in about one second," Levatter said. Conventional lasers can't be used for such processes because there's no way to evenly scan a surface with a round laser beam of uneven intensity. With a square, even beam, you can scan the surface with no overlap and no holes.

"A laser can fit into solar-cell production at a number of steps," Levatter said. "I can visualize assembly lines using excimer lasers to process ribbons of silicon into solar cells costing about \$1 per watt." Today, around \$6 is about the best anyone can do.

The focused beam also could be used to create positive-negative junctions in semiconductors, and for a process called "gettering," which uses heat to remove crystalline impurities, Levatter said. He plans to deliver commercial units of the laser to several semiconductor companies this year for their own testing and experimentation. (IBM, which is conducting its own excimer-laser research, sees the device as the possible key to the economical manufacture of much more densely packed integrated circuits.)

Out of the lab

Because xenon and other rare gases are inert, experts once thought it was impossible to make molecular compounds out of them. If properly excit-

ed in an electrical discharge, however, such compounds do form and become excellent lasing media. Trouble was, after about 20 nanoseconds (billionths of a second) the input electrical energy became unstable. The result was uncontrolled arcing, and all the power went into the arcing instead of into the lasing. The arcing also put a theoretical lid on power output because it started before input power had reached its peak. A further problem: The recovery period between laser pulses was too long.

Solving the problems of excimer lasers has been Levatter's specialty. As a doctoral student at the University of California at San Diego in the late '70s, he became convinced that high-power output could be achieved if high-power input occurred fast enough. The concept is comparable to that of damming a river until you capture enough water, then releasing it to power a turbine efficiently. Water, indeed, was what Levatter used to capture the power he needed. In one of those intuitive leaps that mark technological advance, he conceived of a discharge device using water as the dielectric, or insulator, between metal plates. Similar devices to drive lasers use polyethylene or similar materials.

"It's really a water capacitor," Levatter said, "a very powerful battery that delivers tremendous power." An electric charge builds up rapidly in the device, with water storing 40 times as much power as polyethylene. Just before the water ionizes and loses its insulating properties, a high-voltage discharge is released into a chamber containing neon, xenon, and hydrogen chloride. Some xenon chloride molecules are created in the resulting plasma, and they decay and fluoresce almost instantly. With extremely high input power—35,000 volts and up to 60,000 amps discharged in less than 10 nanoseconds—laser power goes up accordingly.

With that sudden zap of high power, Levatter overpowered the arcing mechanism. Result: The lasing began before the arcing could occur. The water capacitor also recharges very rapidly, so there are only milliseconds (thousandths of a second) between laser pulses. Levatter published his results, and similar but less successful devices now are used in other research labs. The excimer laser I saw will produce 20-megawatt pulses 100 times per second. Its high-voltage switch cycles in 10 nanoseconds and already has surpassed its rated lifetime of 10 million switchings.

What's ahead? Another prototype laser, incorporating a flow loop to

clean and cool the lasing gases, with blowers and heat exchangers to dissipate heat, will be ready soon. It will be as powerful as the current model—but one-third smaller—and will be used to test prolonged 100-pulse-per-second operation. An even smaller unit is scheduled for commercial introduction later this year.

Beyond solar cells and ICs

If all this goes well, the excimer laser could be used eventually for more exotic applications than the manufacture of solar cells and semiconductors. "It could open the whole field of photo-induced chemistry," Levatter said. The energy in one ultraviolet photon is about three electron-volts, nearly the same as the energy holding together a molecule. "Each molecule has a very precise absorption line, absorbing some exact wavelength of light," he noted. "We can fine-tune the laser to precisely the desired wavelength, then manipulate a chemical reaction with light."

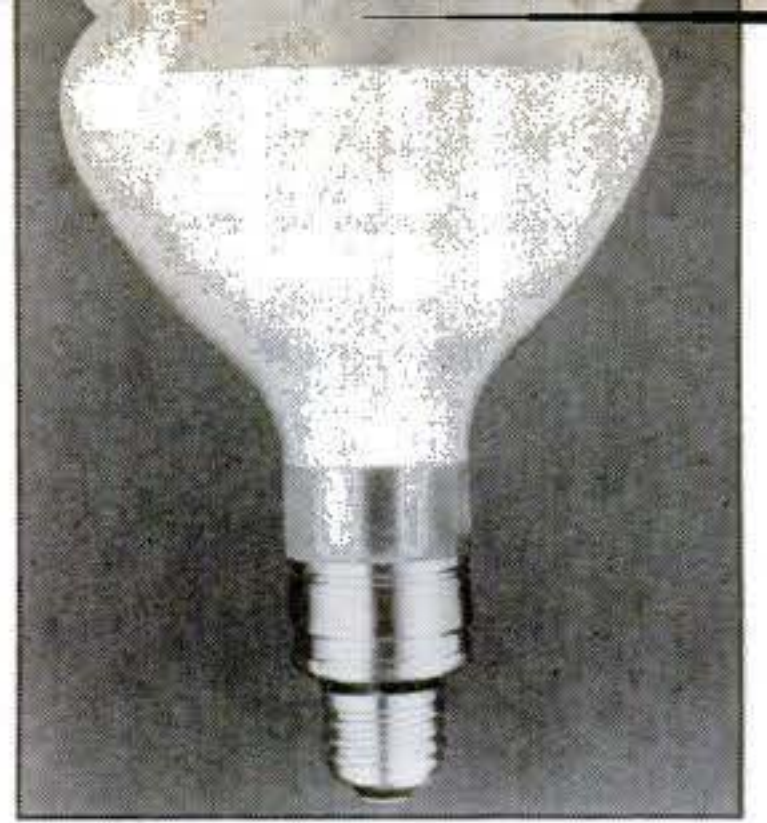
One application: Levatter believes that an excimer laser could efficiently separate uranium-235 and such rare elements as palladium, rhodium, and xenon from nuclear wastes by fine-tuning the UV output to ionize them individually. Today, they have to heat the wastes to trigger the chemical reactions that allow these elements to be recovered. With the excimer laser, recovery could be done with a lot less energy and time, which would reduce both the cost of reprocessing and the ultimate volume of waste to be stored, Levatter said [see "Nuclear Waste," this issue].

The military sees another potential use: satellite-borne excimer lasers to communicate with submerged submarines. The Department of Defense and the Navy have long sought such a system. "A blue-green laser will penetrate water," Levatter said. "A few Joules of energy will go down to several hundred meters."

But with current laser efficiencies of less than one percent, more than 40 kilowatts of power would be needed aboard a satellite. That is clearly impractical with current solar arrays in space. Instead, Helionetics is working under a contract from the Defense Advanced Research Projects Agency and the Office of Naval Research to develop an excimer laser with efficiencies above three percent. An early prototype has already reached 2.8 percent efficiency, according to Levatter. "They also want a laser that will survive through 10 billion pulses," he said. "Nobody has ever done that." Then he added cryptically: "But we think we've solved those problems." ■

What's New

A PICTURE ROUNDUP OF NEW PRODUCTS AND DEVELOPMENTS



kWh saver

Replace standard 150-watt PAR-38 and R40 lamps with Mercandescent, a 110-watt mercury-vapor lamp, and you'll reduce kWh electricity usage by 27 percent—without reducing lighting—says Public Service Lamp Corp. (410 W. 16 St., New York, N.Y. 10011). Rated bulb life is 12,000 hours. \$55.

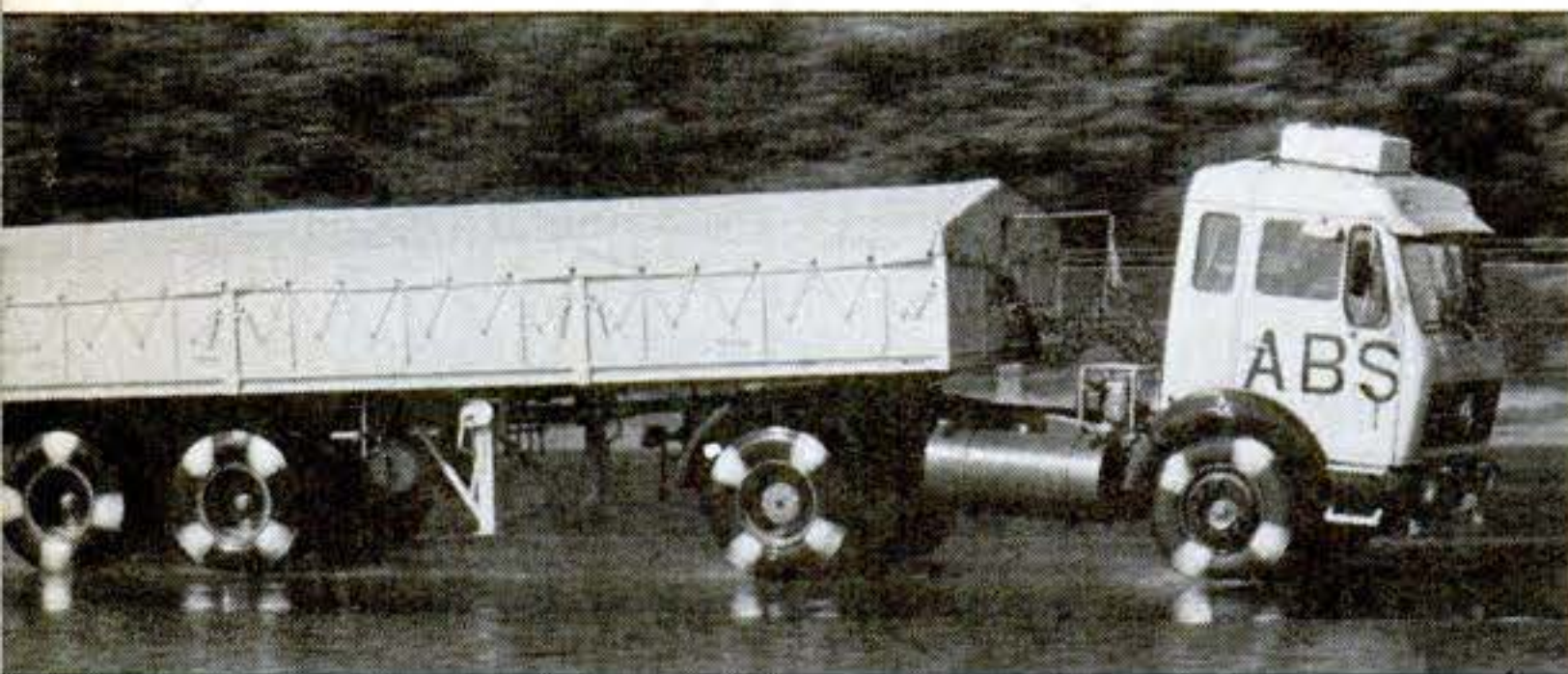
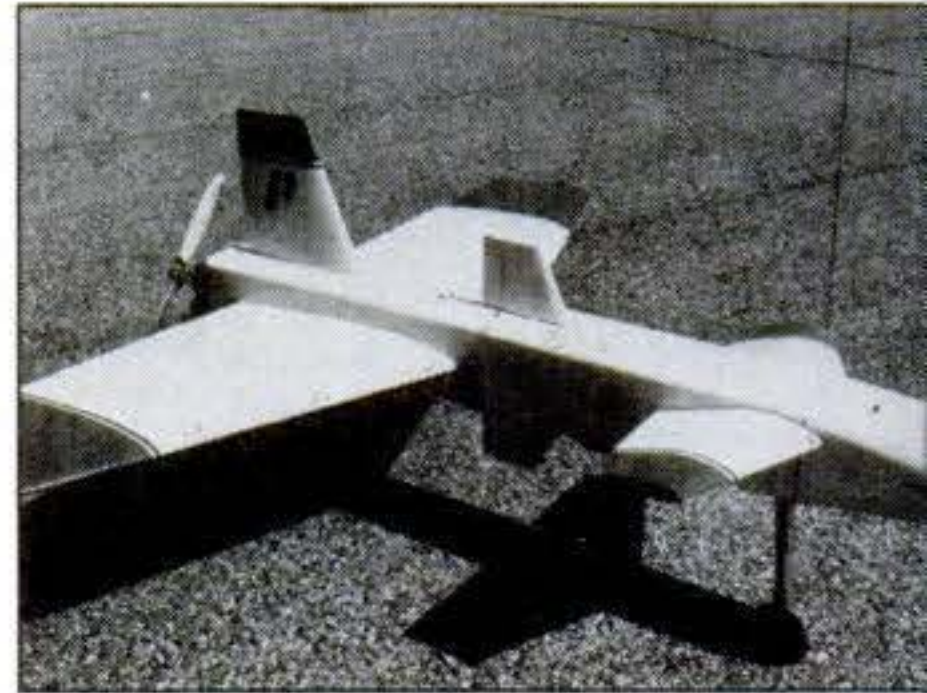


Grand tourer

Climb aboard the de Cotta Apollo touring coach for panoramic views. The Spanish-built bus has a glass-enclosed top deck for 57 passengers. The driver's compartment is below, along with a bar and toilet. A 280-hp diesel powers the 40-ft. vehicle.

Canard drone

An unusual canard-wing radio-controlled drone designed by Fairchild Republic has vertical fuselage fins that let it move sideways without banking. A future military version will weigh 170 lbs., have a seven-ft. wingspan, and be powered by an 18-hp engine and two-ft.-dia. prop.



Anti-lock brakes

Hard braking with anti-lock brakes in this Mercedes truck makes the cab nose-dive, but there's no skidding or dreaded jackknifing. An electronic device monitors wheel-rotation speed. Stopping distance is decreased, as well, claims Mercedes.

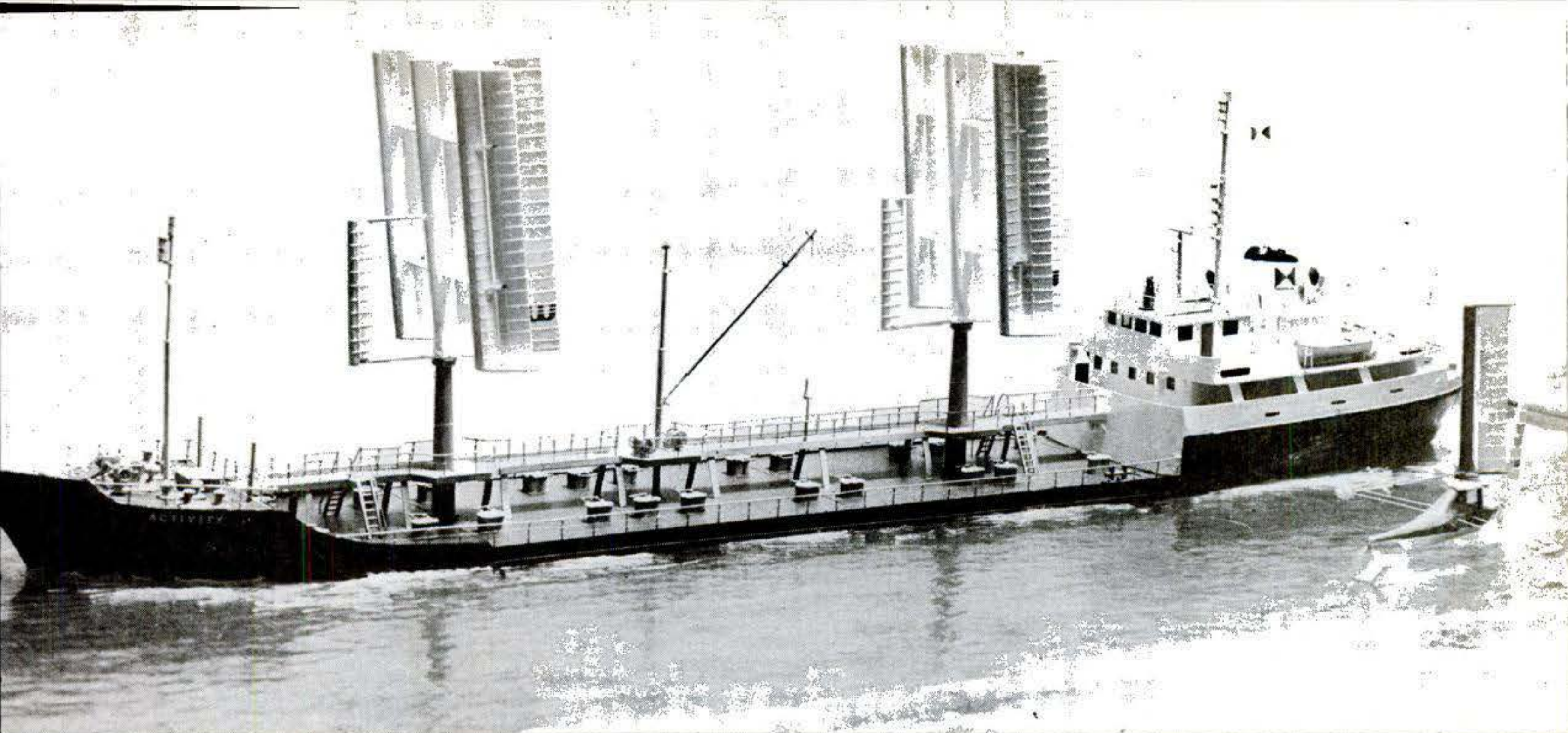
Radio chopper

Need aerial photos? The MK 1, a radio-controlled model helicopter, can carry photo, measuring, and surveying gear. Its one-cylinder, 2.2-hp engine lifts an 11-lb. payload for 20 minutes. Price: \$5,000. Ing. Dieter Schlueter, Dieselstrasse 5, D-6052 Muehlheim, W. Germany.



Super-mini

Latest contender in the mini-car arena: Fiat Uno. It replaces the Italian auto maker's 10-year-old 127, still a top seller in Europe. The front-drive Uno has a 45-, 55-, or 70-hp transverse engine. Ultralight plastic construction aids fuel economy. It won't be sold in the U.S.



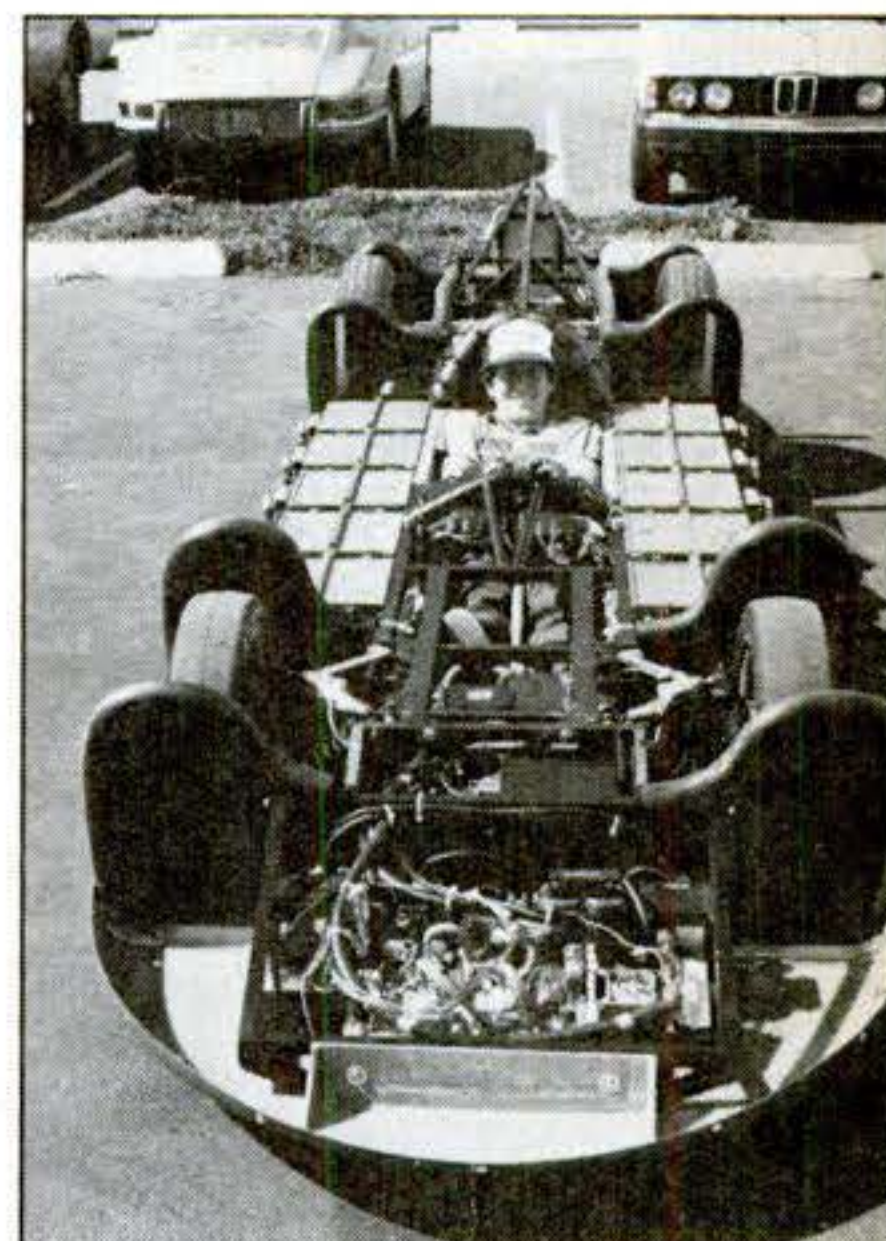
Fuel saver: self-trimming wing sails

Vertical winglike sails retrofitted on this 1,300-ton tanker will deliver twice the thrust of comparable rigid sails used by Japan's NKK [PS, Dec. '80], claims British designer Walker Wing-sail System, Ltd. (Hants, England). They could cut the tanker's fuel bill by a quarter, says the firm. The wing sails are self-trimmed by an adjustable tail plane. More thrust energy is harnessed, compared with conventional sails, because of their airfoil characteristics. Computers will sense wind speed and direction, then set the wings and engine power accordingly.



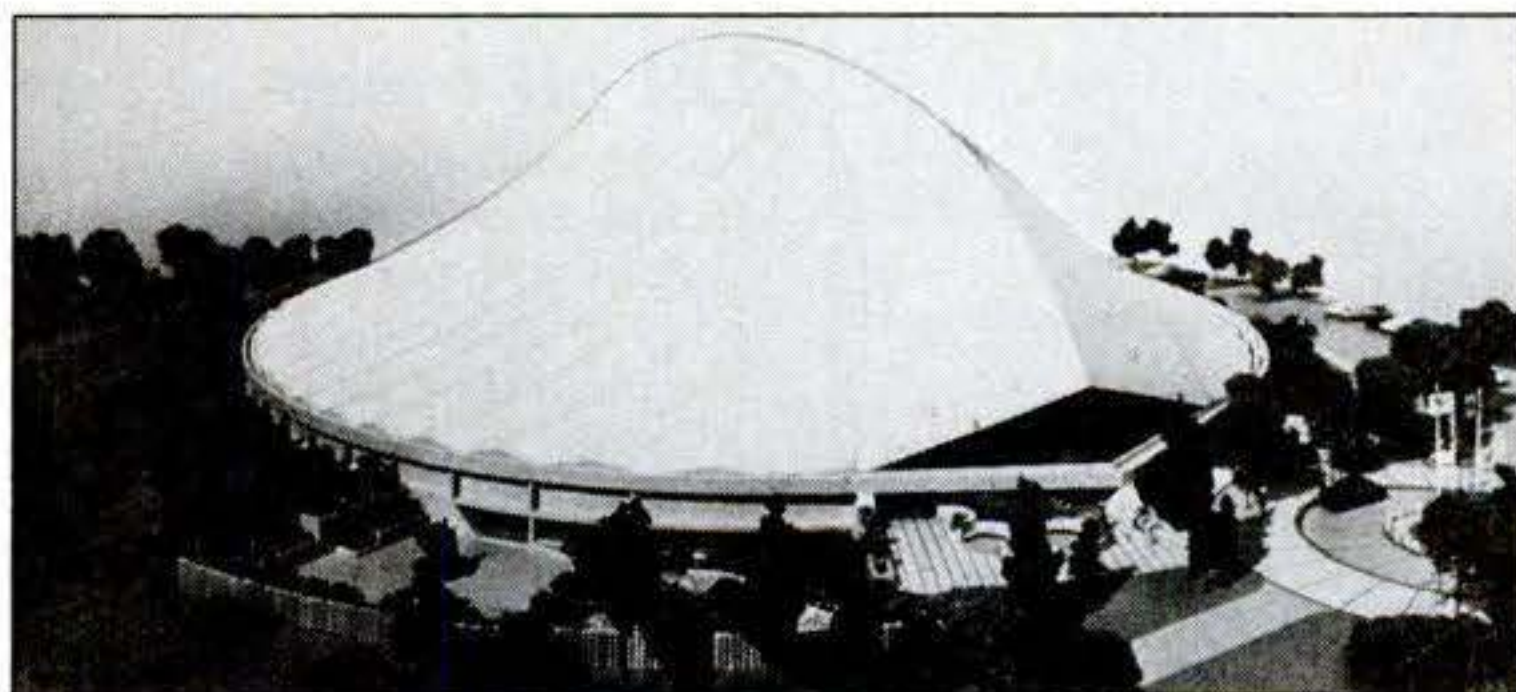
V/STOL fighter

Square jet intakes and exhaust ducts with deflectors to vector the exhaust, plus canard wings, are being studied in this twin-tail-fighter concept by Grumman Aerospace Corp. (Bethpage, N.Y.). Movable exhaust ramps aid V/STOL performance and improve maneuverability.



Giant tent

An insulated-fabric roof over a 2½-acre park in Calgary, Canada, will let light in but keep the cold out. The arch-supported roof [PS, July '81] is a Teflon-coated fiberglass fabric sandwiching R-16 fiberglass insulation. The translucent roof admits about 200 foot-candles of light.

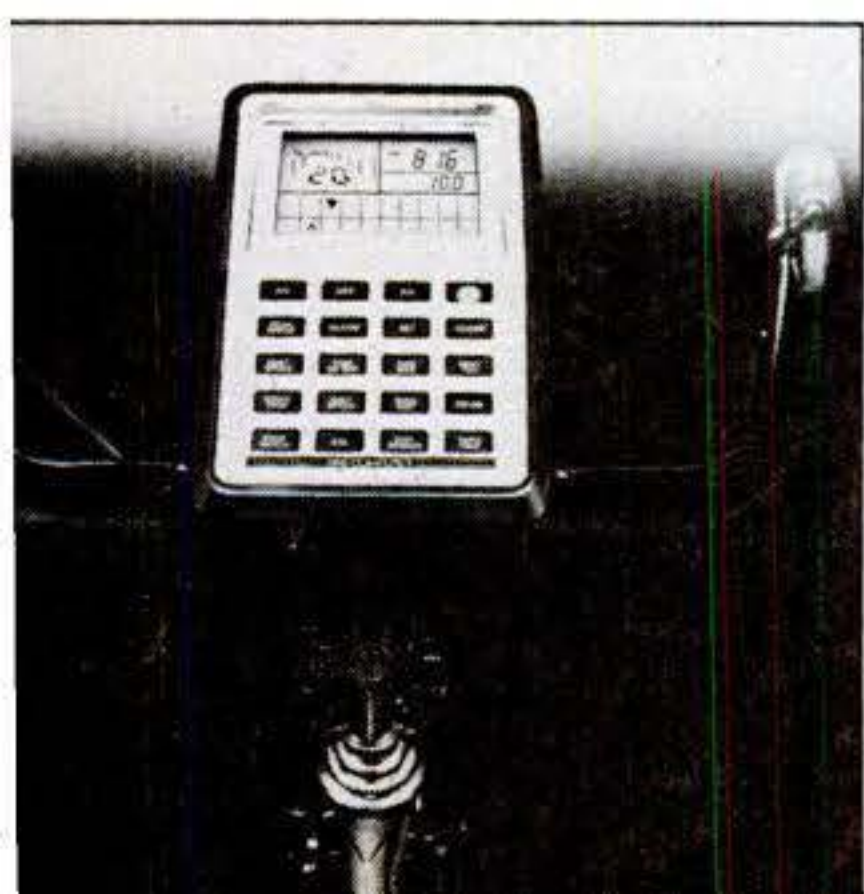
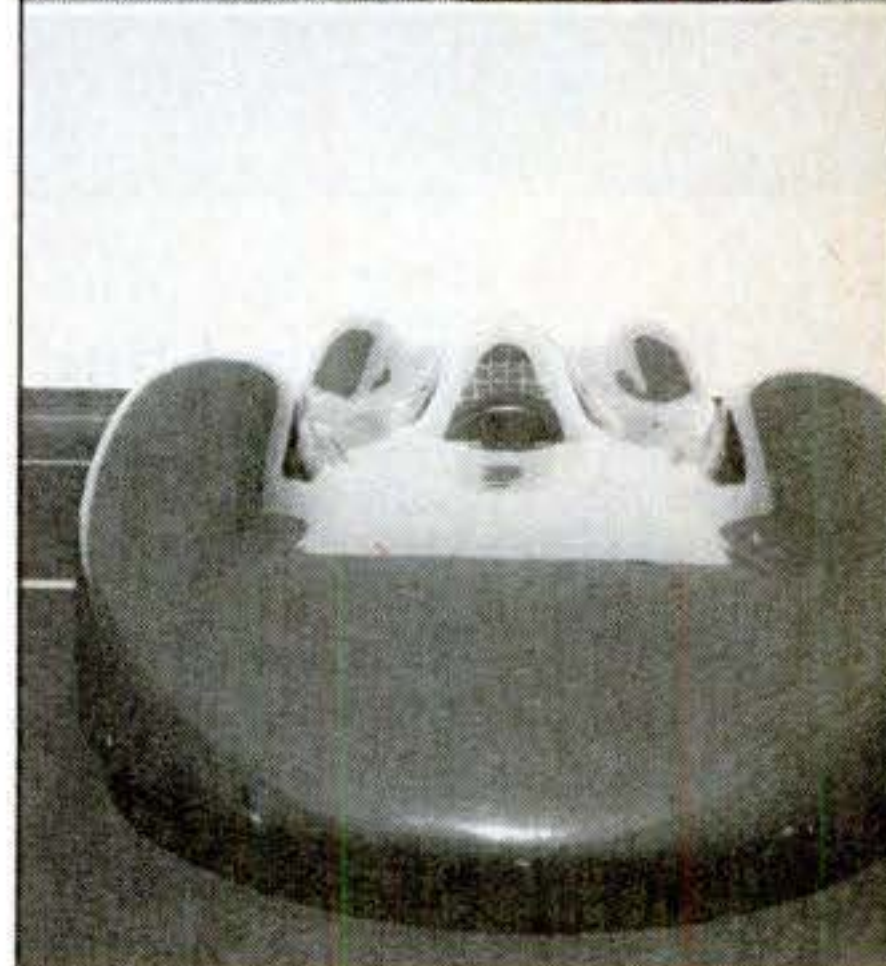


Cyclist's computer

Bike Computer gives cyclists more than a dozen categories of data, including speed, distance, time, and pace, plus a stopwatch-alarm. It installs on bicycles, mopeds, or exercise cycles with 10- to 36-in.-dia. wheels. It's \$89 from Heckendorn's, 525 W. Main St., Millville, N.J. 08332.

Electric dragster

An 800-lb. pack of ultra-high-discharge nickel-cadmium batteries in the X-1 delivers up to 180,000 watts for short periods. That's why the fiberglass-body research vehicle broke or exceeded six world speed records for electrics, says Demi (Santa Barbara, Calif.).

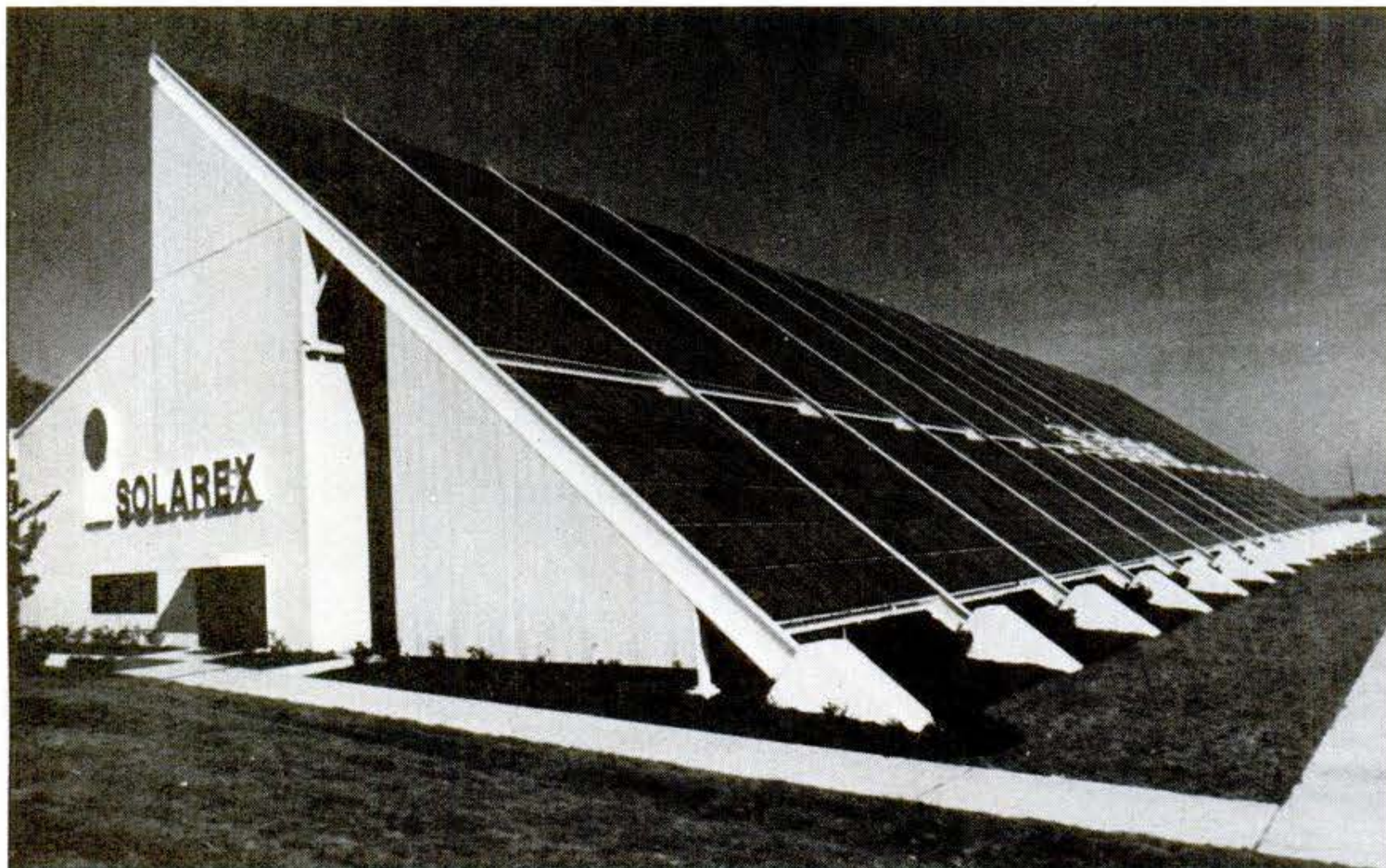


What's New



Arrow-wing F-16

Swept-back, arrow-shaped wings on the General Dynamics F-16XL have twice the area of the standard F-16 fighter. The 34.3-ft.-long wings are made of weight-cutting graphite composite. The new design lets this research plane carry 80 percent more fuel—doubling its range or payload.



Breeder update

This massive solar array covers 27,000 sq. ft. of south-facing roof. Installed on the Solarex factory in Frederick, Md. [PS, "What's New," Feb. '82], the array generates 200 kW. That power runs an assembly line that makes—you guessed it—more solar photovoltaic cells.



Lift-off trailer

No cranes needed here: A forklift truck can hoist this lightweight, plastic truck body off the chassis. The truck can then be unloaded while the chassis is serviced elsewhere. The system will save \$3 million a year, claims British Telecom (2-12 Gresham St., London, England).

Off-road go-cart

With its fat, knobby tires, the Gumball rides easily over sand, snow, and mud, says Motosonic (Bluebird Industrial Estate, Park Lane, Wolverhampton, England). The 10-hp, rear-mounted engine runs for three hours on a gallon of gas, the maker claims. It's about \$3,000.

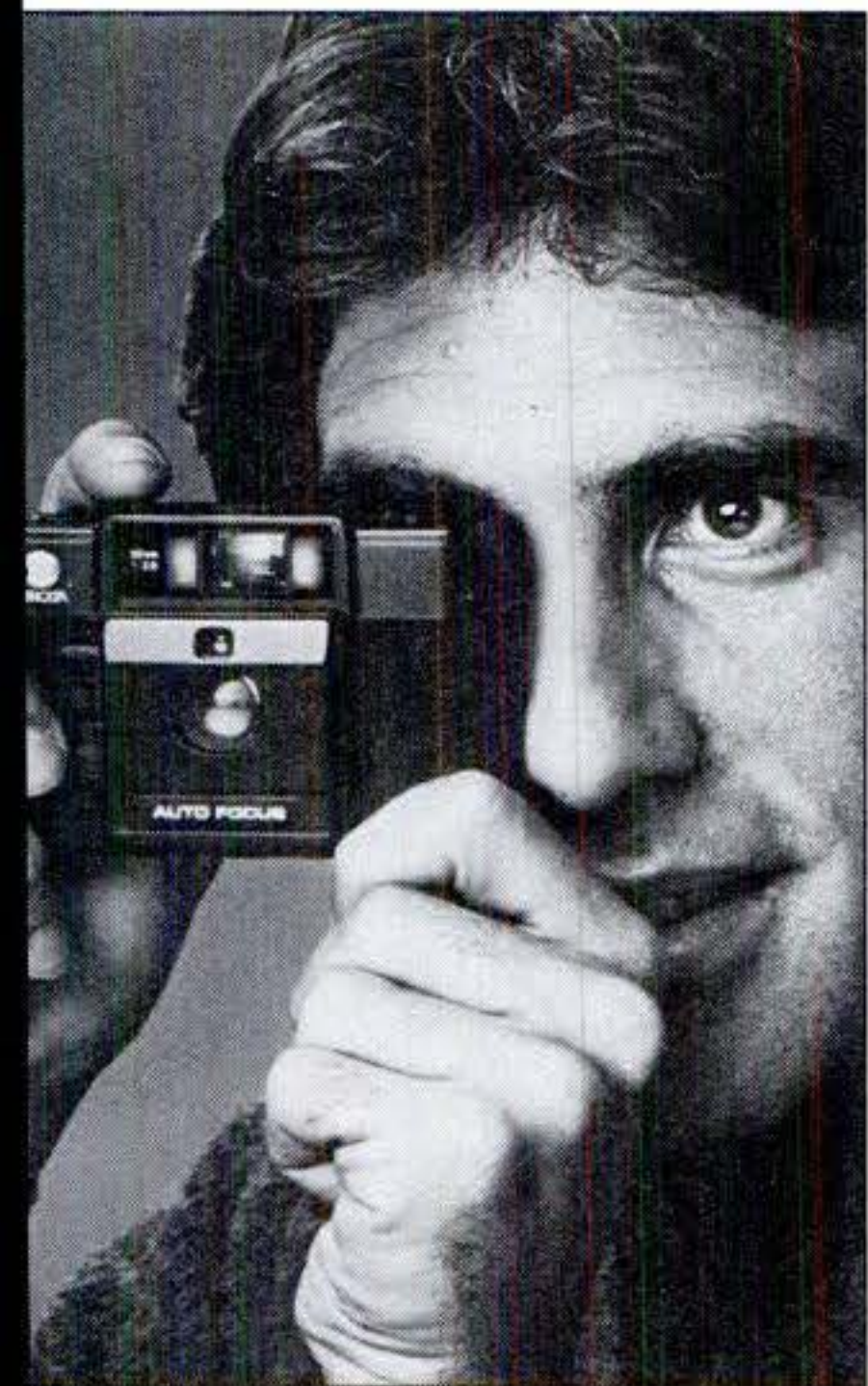
High-mpg test bed

It gets 67.5 mpg at highway speeds—yet zips from zero to 60 in 11 seconds, according to Britain's BL Technology. Built of plastic, aluminum, and special steels, the 12.5-ft.-long car weighs 1,463 lbs. It has an experimental engine—a 1.1-liter three-cylinder, with four valves per cylinder.



What's New IN PHOTOGRAPHY

BY E. H. ORTNER



For snapshoters: three new discs

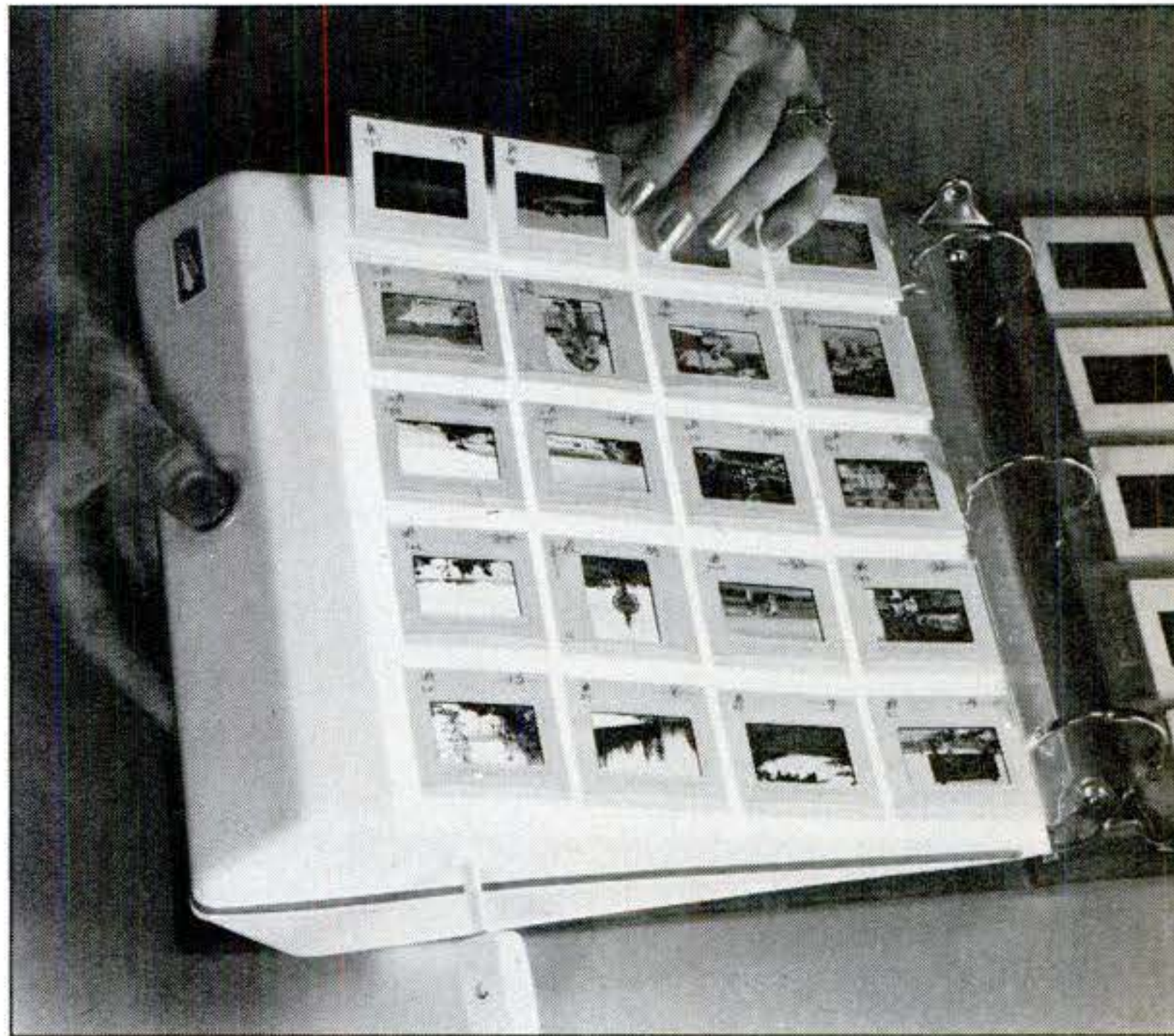
Now Minolta has disc cameras, too: Disc-5 and -7 (above, left). Both offer a two-lens system, one lens for fixed-focus shots from four ft. to infinity, the other for close-ups from 16 in. to four ft. And each has built-in flash, automatic film advance, and a five-year lithium battery. Disc-5 lists for \$96.50; Disc-7, with self-timer, is \$122.50. Kodak's new disc camera, the 3000 (above), has all the features of the company's other three discs—motor, built-in flash, four-element all-glass lens, automatic exposure—except one: the five-year lithium battery. It's powered by a nine-V alkaline. \$56.95.

Most compact 35

Lightest, smallest auto-exposure autofocus 35-mm camera—that's the new Minolta AF-C. A sliding shield in front of the all-glass 35-mm f/2.8 lens protects the camera and turns off the power when closed. \$210 (list); flash: \$35.

Easy SLR

For the amateur who hates complexity, here's Canon's new T50. It's an easy-to-use, high-quality 35-mm SLR. Features: fumble-free film loading, motorized film advance, and a programmed auto-exposure system that sets shutter speed and lens opening. List price: about \$300.



Economy 600

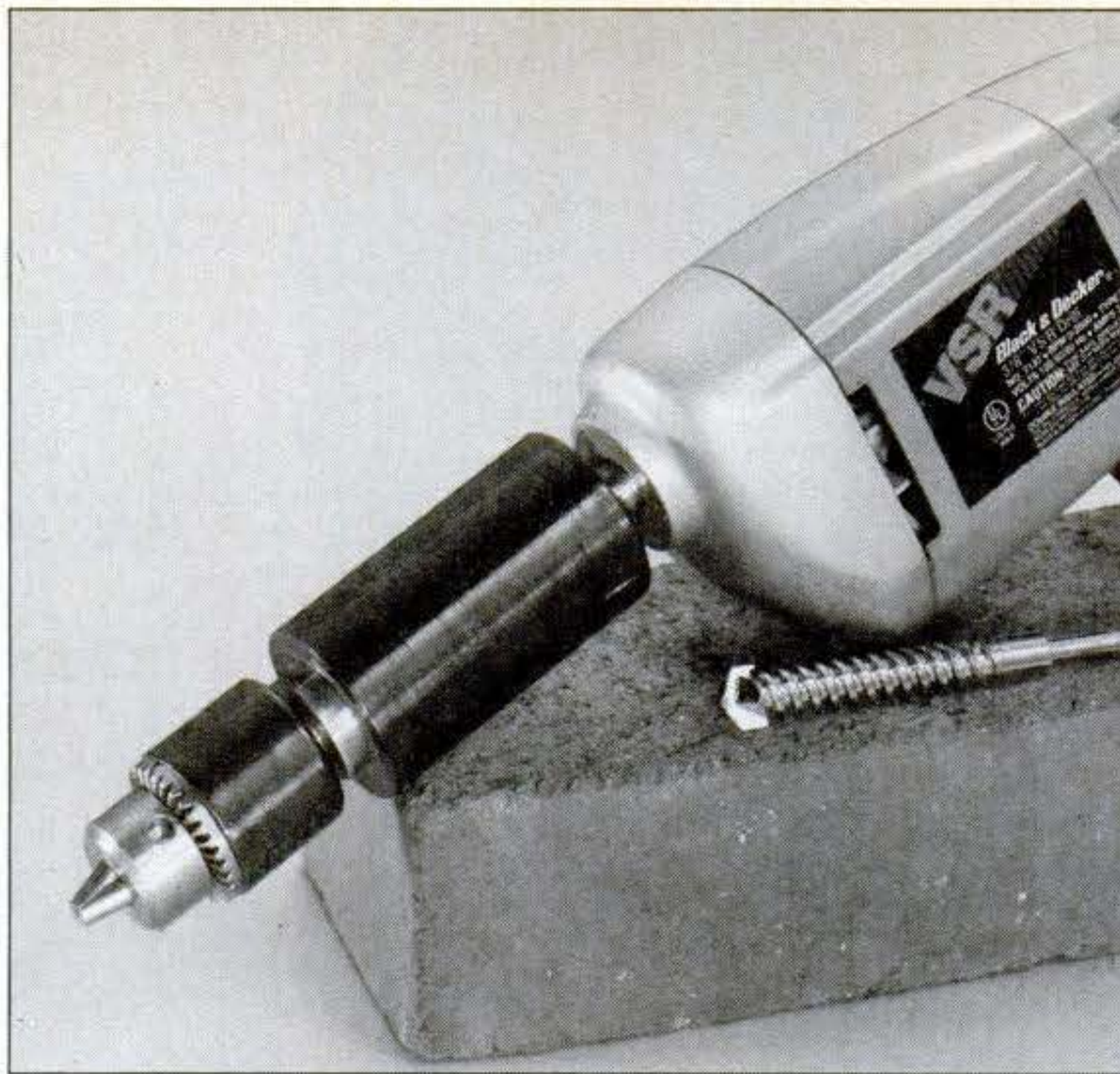
The simplicity of a fixed-focus camera is combined with a sophisticated built-in flash in the Polaroid Sun 600 LMS. The camera has programmed automatic exposure with apertures from f/14.6 to f/45, shutter speeds from 1/3 to 1/200 second. List price: \$39.95.

Slide light

Do you keep your slides in plastic sheets in a book? The Lite-A-Page from Cartwood Products (714 Highland Ave., Charlottesville, Va. 22903) makes viewing them easy—just slide it between the pages. It has a 5,500-K fluorescent light for color balance. List price: \$49.95.

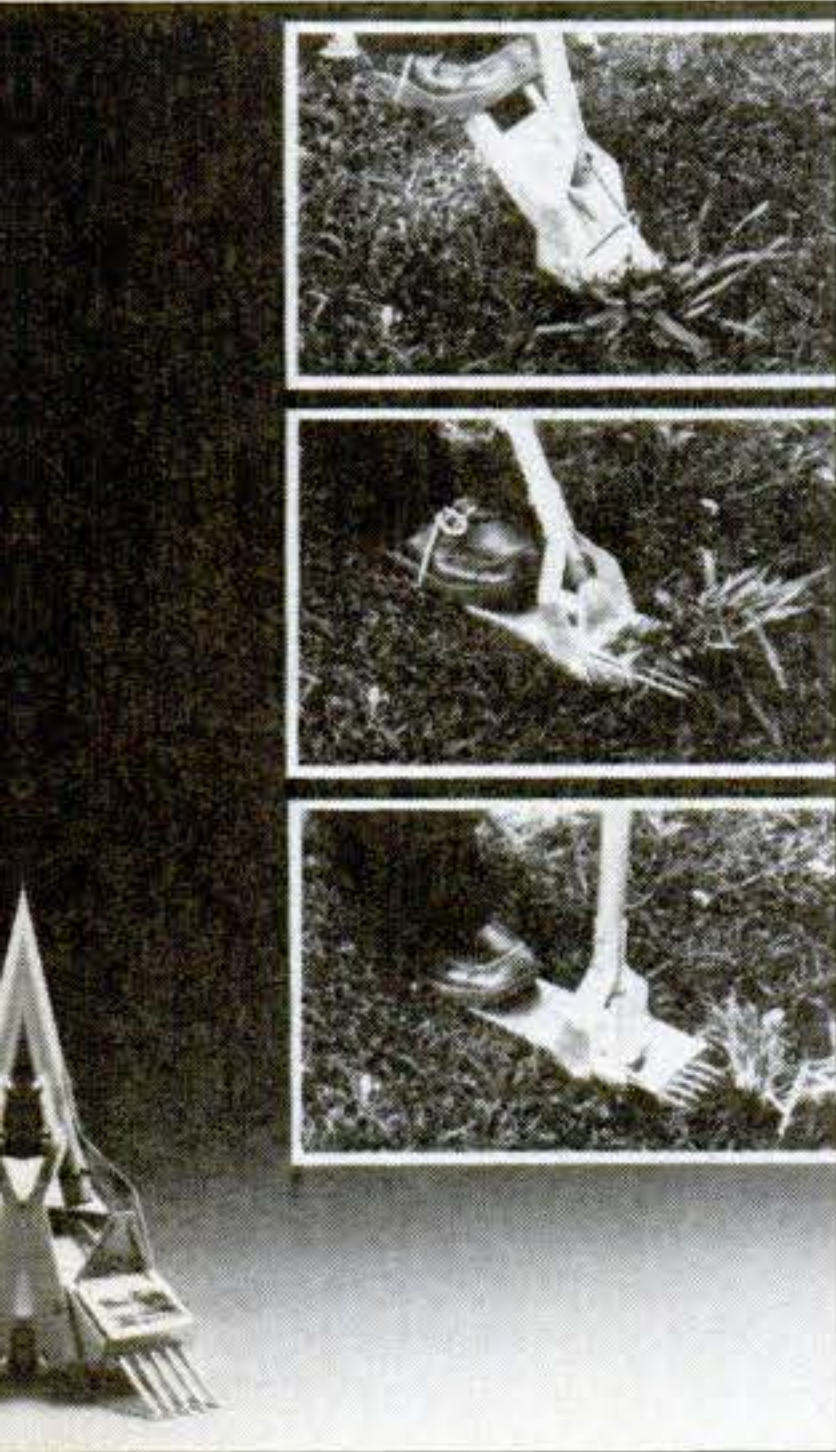
What's New IN TOOLS

BY V. ELAINE SMAY



Drill converter

Need to make holes in brick, block, or concrete? This masonry drilling attachment (\$14) will convert your 1/4- or 3/8-in. electric drill to a rotary hammer drill and punch those holes up to four times faster, says Black & Decker. It's claimed to extend the life of carbide-tipped bits.

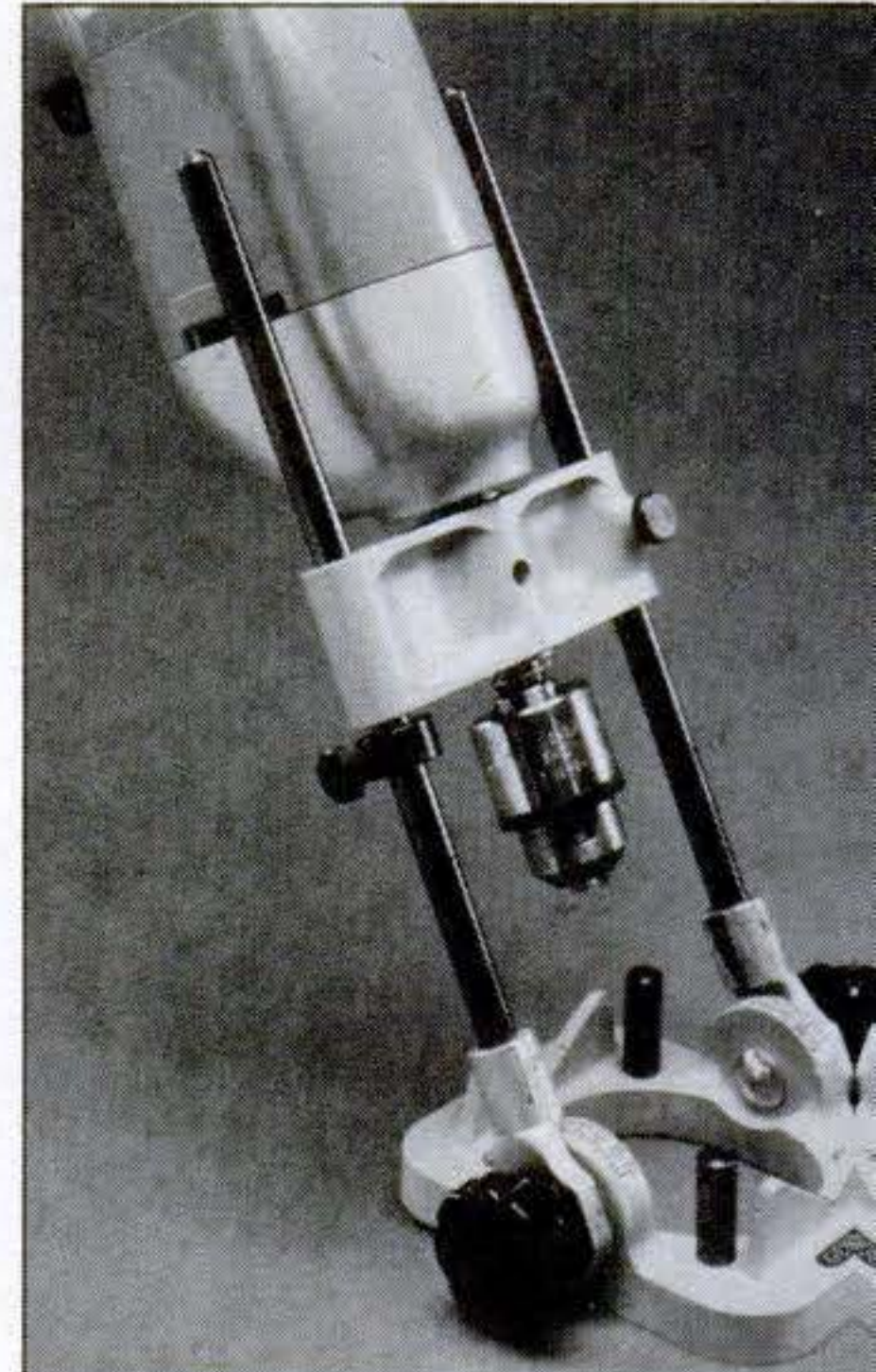


Stand-up weeder

Push the tines of the Weed-Popper into the roots of that dandelion, step on the lever, and the pesky weed pops out—roots and all—says Wonder Products Mfg. Co. (1030 Santerre Dr., Grand Prairie, Tex. 75050-1937). It's made of zinc-plated steel with a wood handle. Price: \$23.

Drill angler

You'll drill accurate holes at angles to 90 degrees (marked at five-deg. increments) when you attach your drill to the Precision Drill Guide, says General Hardware Mfg. Co. (80 White St., New York, N.Y. 10013). It fits 1/4-, 3/8-, and 1/2-in. drills, costs \$20.



Mowers

Do you like the clean-cutting action of a reel-type mower? Now you can have it in a rechargeable model from Sears (right). The Reel-1 (\$400) is powered by a 12-V battery and cuts an 18-in. swath for up to an hour per charge. Recharging takes about 30 hours. Another new Sears mower (far right) lets you ride or walk. Called (naturally) the Ride-R-Walk, it has a riding sulky that attaches (without tools) when you want to mow sitting down. For trimming, you can detach the sulky and use the mower as a walk-behind. The Ride-R-Walk (\$600) has a 197-cc engine and electronic spark ignition. Both mowers comply with Consumer Product Safety Commission rules.



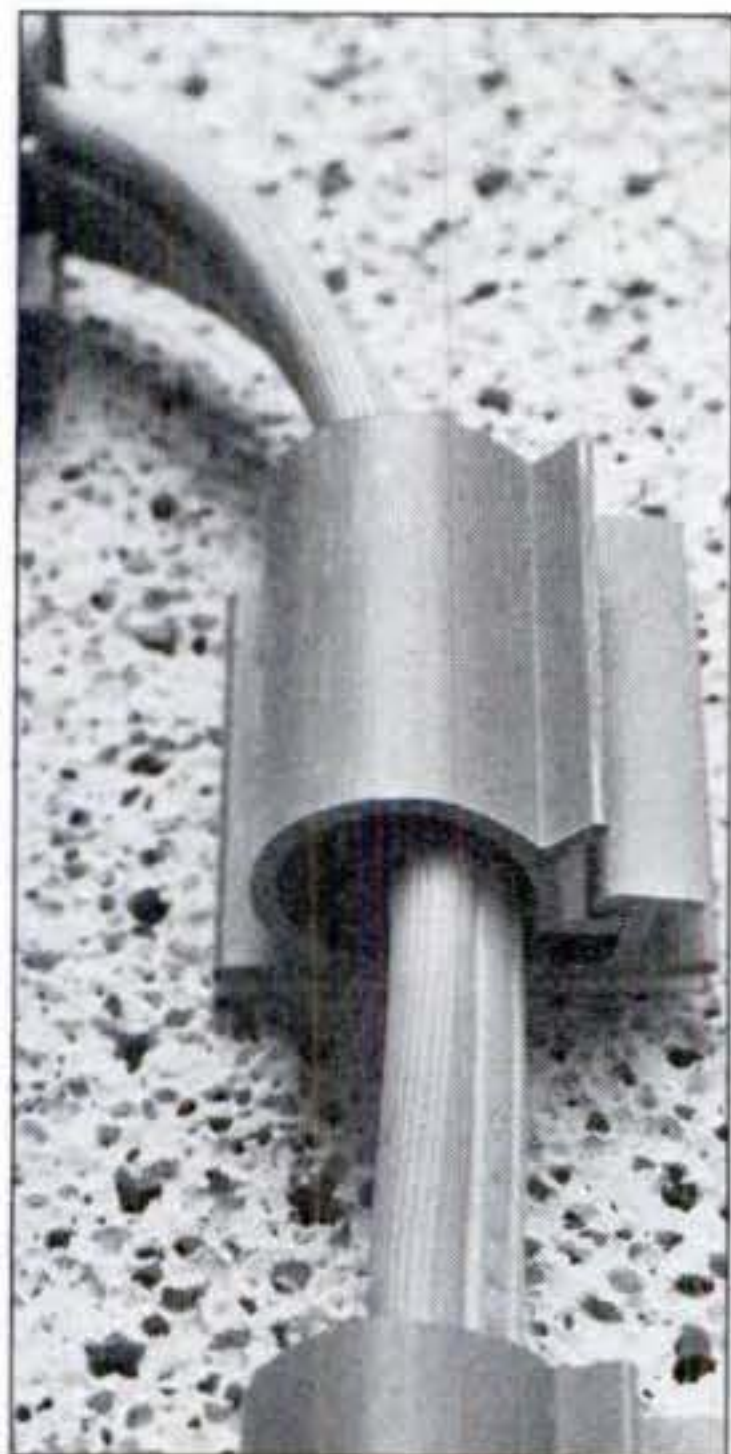
U-turn driver

This flexible screwdriver bends to your will to do those awkward jobs. A free-turning collar lets you align the tip. A palm-shaped ratchet grip slips on to give you extra torque. Lacrex Brevetti S.A., Via Eco Casa Luce, 6644 Orselina, Switzerland.

What's New

IN HOME IMPROVEMENT

BY SUSAN RENNER-SMITH



Wire straightener

Dangling, tangled wires can ruin the looks of even the sleekest components. This PVC holder accepts wires up to 1/2 in. dia. The adhesive-backed guide has a locking flange that snaps open and shut. Price: \$2.51 for three. Vaco Products, 1510 Skokie Blvd., Northbrook, Ill. 60062.

3-way fluorescent

Screw the Tri-Mizer fluorescent lamp into a three-way socket and use it on the high setting for six hours a day. You'll save from \$53 to \$107 on your electric bill over the lamp's guaranteed five-year life, claims Creators, Inc. (1642 N. Besly Ct., Chicago, Ill. 60622). Price: about \$15.



Water saver

You control the amount of water needed to flush the Seiche One tankless toilet: That can translate to about a miserly quart per flush, claims Patrick Creek (Box 135, Hinesburg, Vt. 05461). The ABS toilet fits standard plumbing, uses normal water pressure, and costs \$250.



Home heat pump

Carrier's newest—and most efficient—heat pump has a COP of 3.0. The Golden Round Heat Pump also has a solid-state defrost system that automatically de-ices the outdoor coil for best efficiency. Models of the heating-air-conditioning unit typically cost about \$3,000, installed.

Super-paint

Paint your house in '83—and forget it until '93, says Sears. New Weatherbeater 10 exterior paint covers with one coat and lasts a decade—if you apply as directed. Tough acrylic resins and a polyester modifier give the latex paint extra adhesion. Price: \$24.49 a gallon.

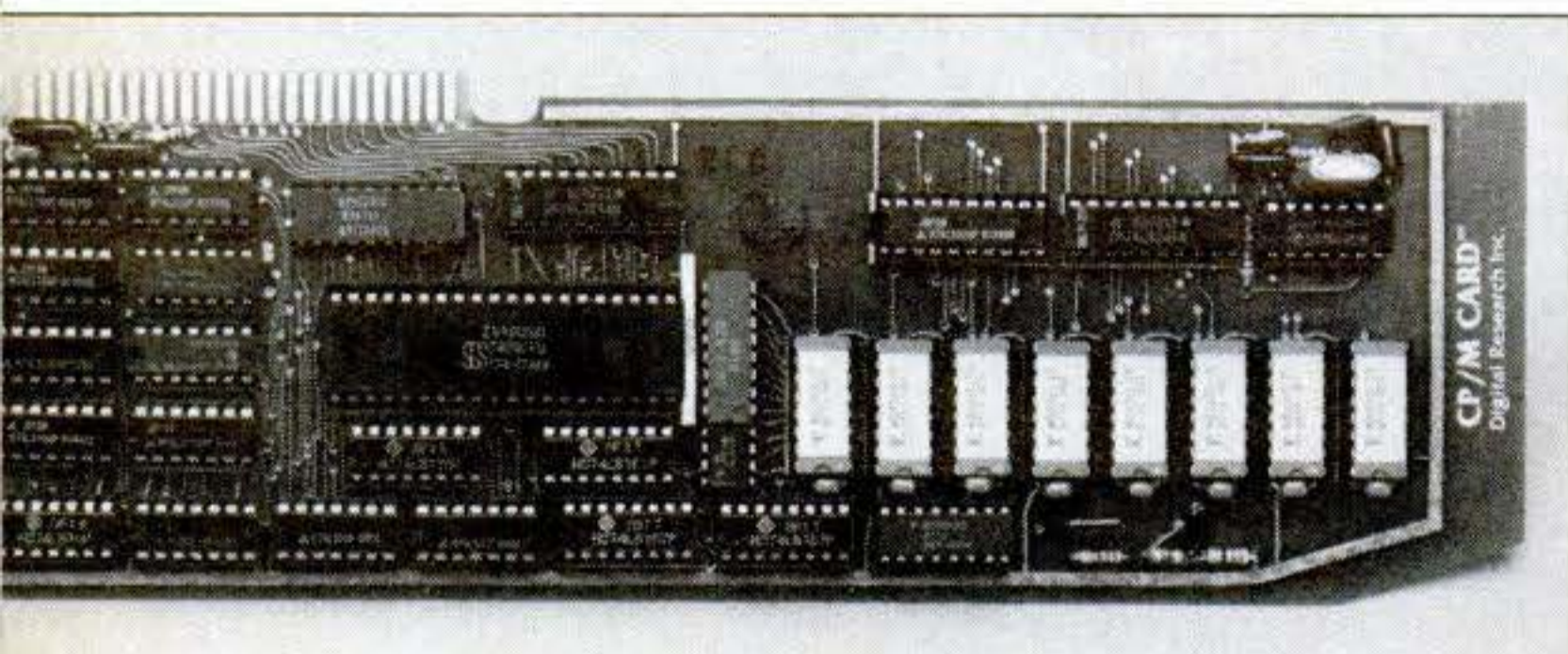
Solar screen

A solar screen you can see through, Solar Shield's finely woven fiberglass mesh blocks up to 92 percent of the sun's heat, claims Vimco (Box 8229, Richmond, Va. 23226). The tension-mounted screen rolls up for winter storage, costs \$1.50 a sq. ft.



What's New IN ELECTRONICS

BY WILLIAM J. HAWKINS

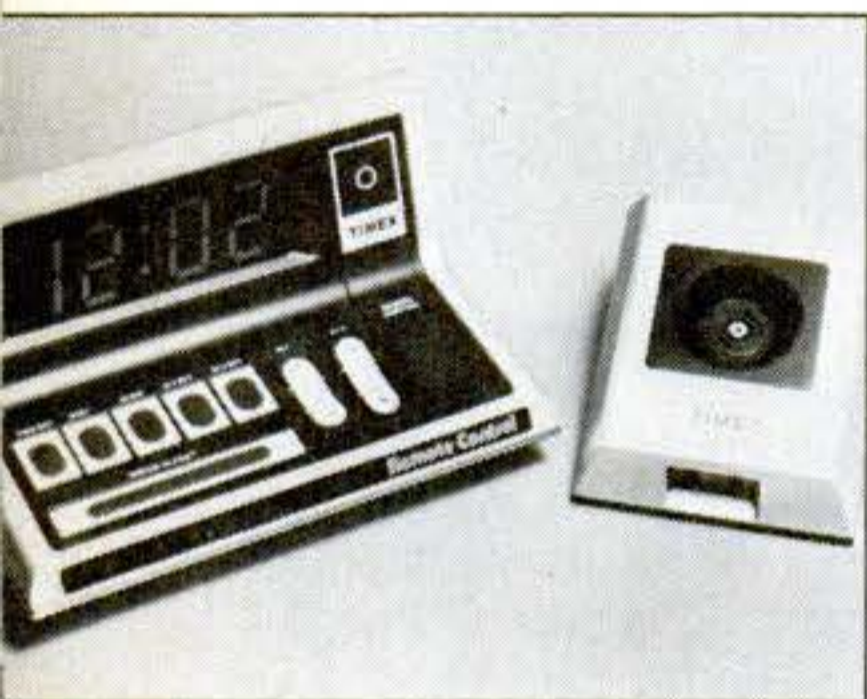


Plus for Apple

Plug this printed-circuit board into your Apple II computer, and you've converted it to the CP/M Plus disc-operating system. That's the latest version of CP/M, and it means you can use any of the 3,000 CP/M-based programs available. The Digital Research unit is \$399.

Desk-top do-all

It's a phone answerer and dialer. It's a burglar alarm and smoke detector. It automatically controls remote appliances or lets you do it with a push of a button. And even better, it's all in a modular desk-top package. It's by Anova, 3 Waters Park Dr., San Mateo, Calif. 94403.



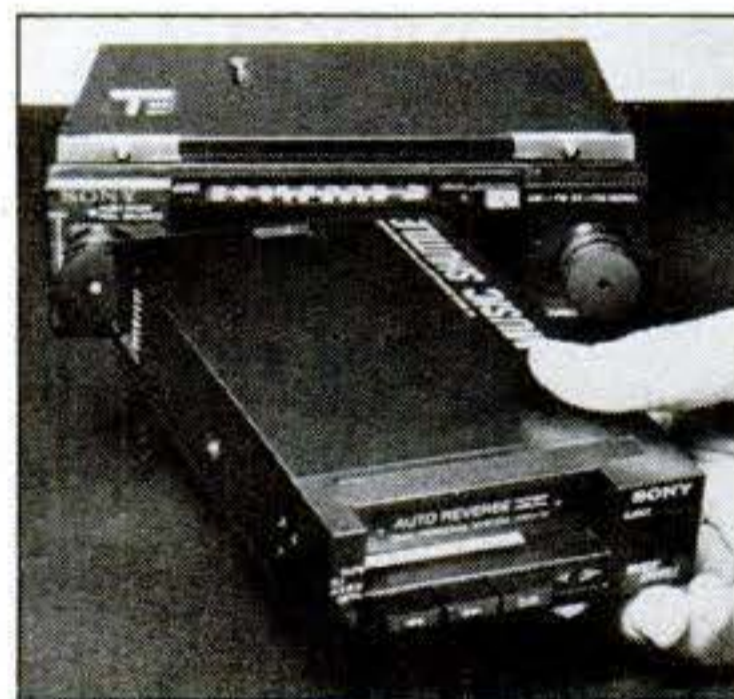
Bedside control

Sure, it's a stylish bedside clock complete with snooze alarm. But besides waking you up, it could make the coffee. The Timex remote-control clock turns on appliances in your home through small outlet modules you simply plug in—no wiring needed. It's \$60.



Tug & take player

In your car, it's a complete in-dash AM-FM receiver with cassette-tape player. But—with a quick tug—the cassette portion pulls out. That deters thieves, and it lets you take the music with you. The Sony Music Shuttle is \$380, including battery pack.



Anywhere music

Play records, tapes, AM or FM music—it's all available in this small table-top package by Bang & Olufsen. But this is not a typical stereo system: A Master Link box sends music to speakers anywhere in your home, and you can control the system remotely. The Beocenter is \$2,500.

Song maker

Use the keyboard to enter a song (from sheet music or a score you've composed), and the Sharp Music Processor plays it. That's just the start. A digital dual-cassette system lets you dub voice or full-chord accompaniment, giving your work a professional sound. \$650.

Electronic maid

The GE Home Control System (in wall) is a future product that will take care of your home—from washing the clothes to controlling the lights, TV, burglar alarm, and heat. It will call you by phone if there's a problem—or you can call home to give it instructions.



What's New FOR YOUR CAR

BY JACK KEEBLER



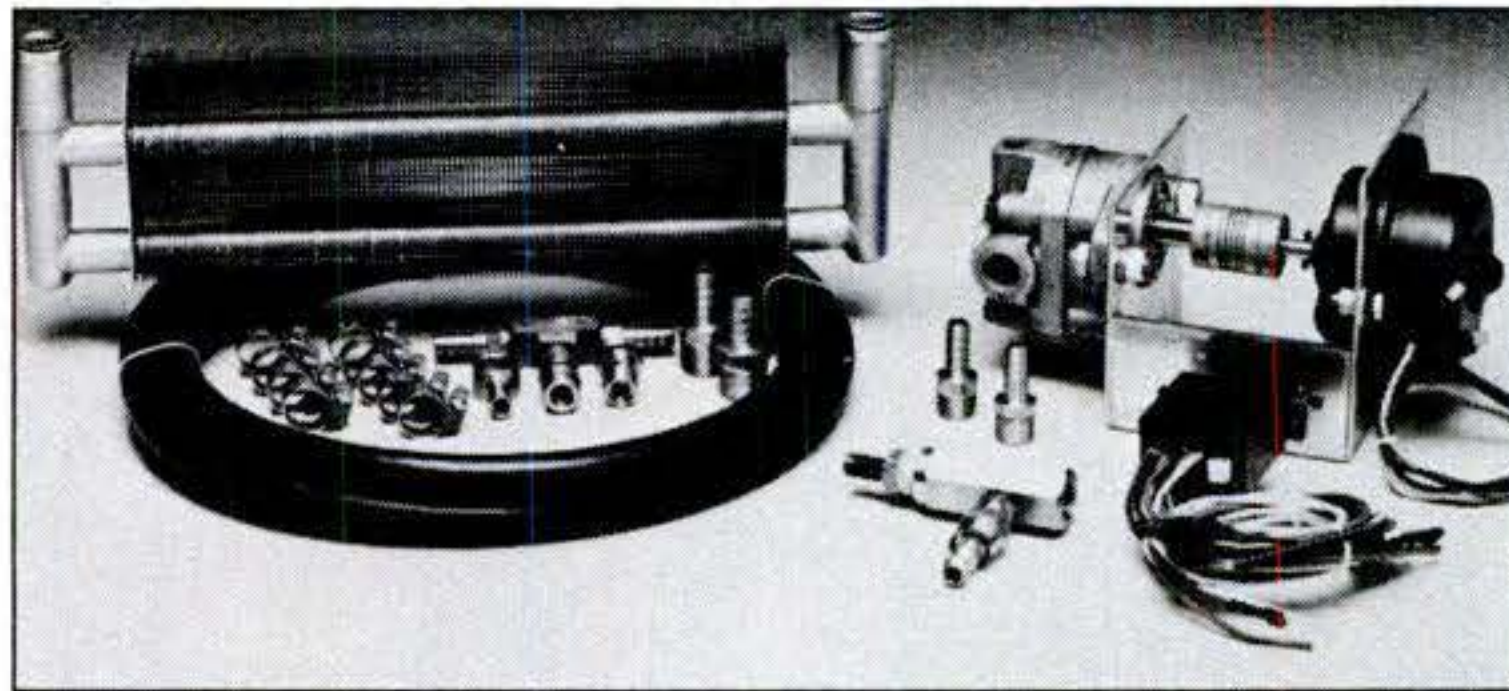
Aero rack

Roof racks create drag even when they're empty. Magik-Rak eliminates this problem with flat, permanent stainless-steel tracks and a removable attachment system for skis, bikes, and luggage, says Amco Mfg. (7425 Fulton Ave., N. Hollywood, Calif. 91605). Price: \$59.95.



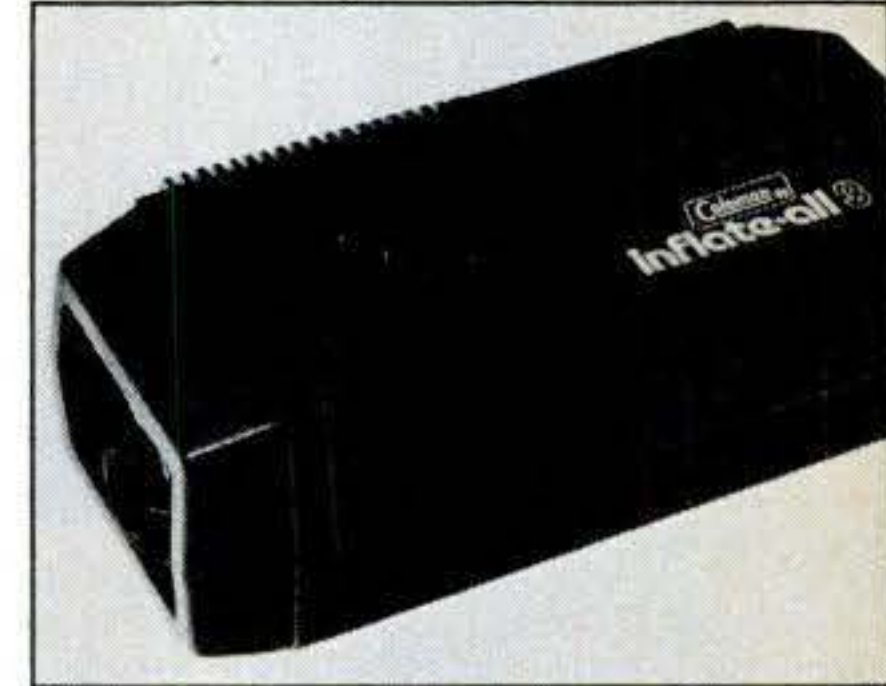
Ultimate jack

Powered by a 110- or 220-V hydraulic pump, Autolift lifts a 6,610-lb. vehicle up to 42 inches. The unit, for the enthusiast with \$3,200 to spend, combines a vehicle-frame hoist with a portable floor jack. Maker: Auto-Line Mktg., Inc., 125 N. Park St., Streator, Ill. 61364.



Powerful pump

Capable of handling inflation loads of up to 120 psi, Coleman's Inflate-All 3 weighs less than 2½ lbs. and includes adapters for air mattresses, balls, and other equipment. The 13½-ft. power cord plugs into the lighter. Price: about \$22.



Turbo cooler

Excessive oil temperature is the biggest cause of premature turbocharger-bearing failure. Hayden Inc. (Box 848, Corona, Calif. 91720) offers a kit that's said to lower oil temperature without creating flow restrictions. It costs \$289.



O₂-sensor tester

This solid-state unit checks proper operation of the oxygen sensor and the computer fuel circuit. Made by Thexton Mfg. (Box 35008, Minneapolis, Minn. 55435), it simulates rich or lean output signals and monitors oxygen-sensor voltage output. It has an LED display. Price: \$59.98.

Volt checker

The OTC voltage checker trouble-shoots DC circuits of eight to 24 volts, says OTC Tools & Equipment (927 Eisenhower Dr., Owatonna, Minn. 55060). Attach the alligator clip to ground, touch a test point with the probe, then just read the LED display. \$19.95.



Spray wash

Wet the car and spray on Instant Shine's foam. Wash with a sponge and then rinse. The car is now clean and has a protective shine equal to that of normally applied polishes and waxes, claims Star Brite Corp. (3650 Hacienda Blvd., Ft. Lauderdale, Fla. 33314). Price: \$4.



18 pick-of-the-crop
**gardening
tools**



Planting and pruning are easier, speedier, more pleasant with proper tools

By V. ELAINE SMAY
PHOTOS BY GREG SHARKO

Hardly anyone who has bought a 59-cent screwdriver would repeat the purchase. But I, for one, have been slow to carry the lesson over to the hand tools I use for gardening. I labored for years with a trowel that buckled under even moderate pressure, cursed as I tried to coil a kinky garden hose, and for many jobs in the garden simply made do with whatever tools I could scrounge from my workbench and kitchen drawer.

If this sounds like your approach to gardening, perhaps you, too, should get properly tooled up for planting, pruning, trimming, and watering. Like any other activity, gardening is easier, speedier, and much more pleasant if you have the right tools. Shown here are some of the finest we found on a recent search. **US**

MAIL-ORDER SOURCES FOR GARDENING TOOLS

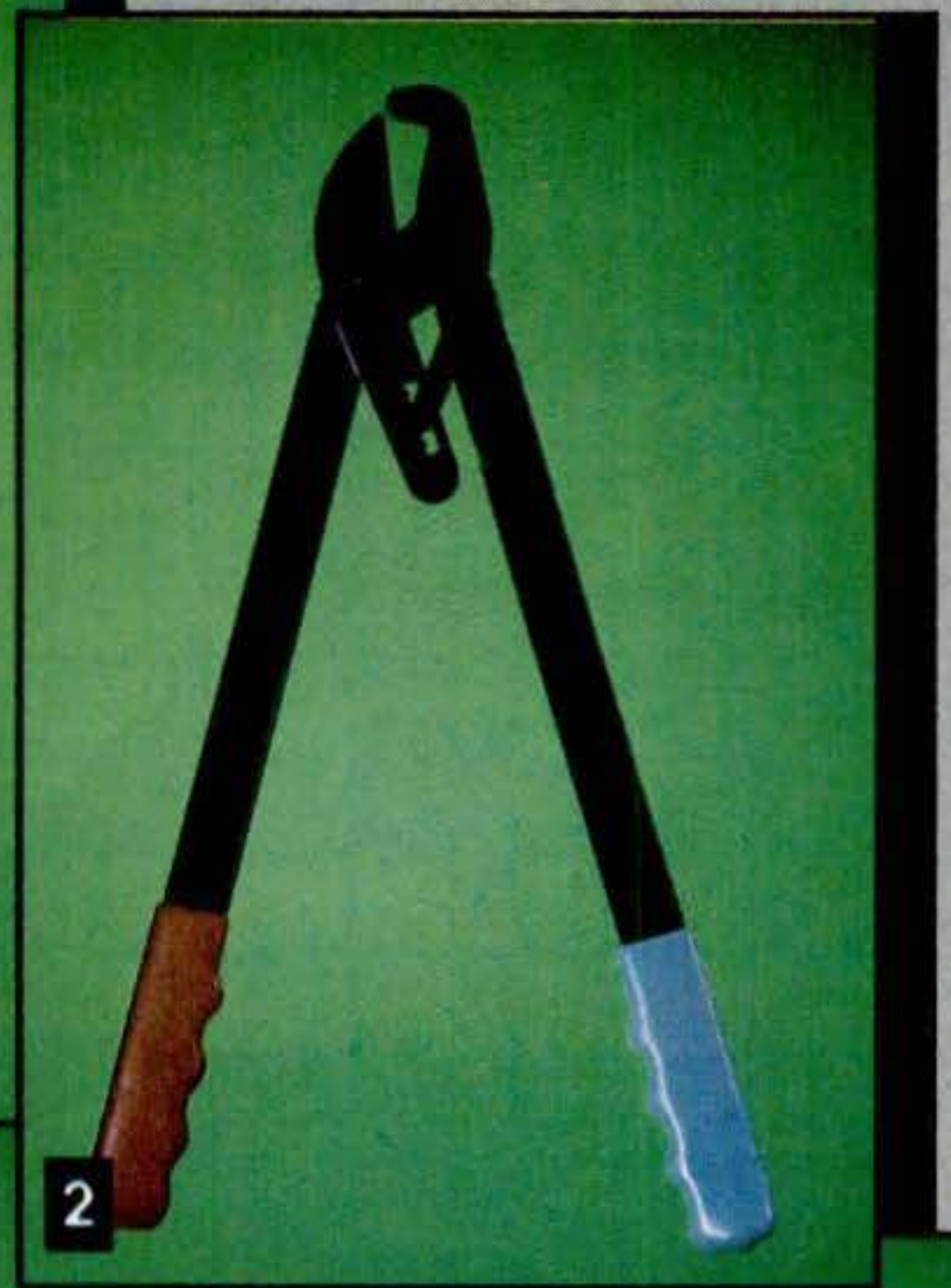
Brookstone Co., 127 Vose Farm Rd., Peterborough NH 03458; The Fine Tool Shops, Inc., 20 Backus Ave., Box 1262, Danbury CT 06810; Garrett Wade Co., Inc., 161 Ave. of the Americas, New York NY 10013; Hammacher Schlemmer, 145 E. 57th St., New York NY 10022; Leichtung, 4944 Commerce, Cleveland OH 44128-5985.

Cast-aluminum tools—transplanter (in use in photo at left), cultivator, trowel, and fork—are virtually unbreakable. Thumb and finger rests make them comfortable to use. Cultivator is sold by Brookstone for \$5. Others are sold by The Fine Tool Shops and other stores for prices from \$12 to \$22 a set (it pays to comparison-shop). Orange-handled tools on bench, made by Saboten in Japan, are from The Fine Tool Shops: Grass shears (far left) have swiveling handles that can be used parallel, perpendicular, or diagonal to blades (\$14). Professional pruners (second and third from left) can cut through 1/2-in. twigs. Both use special blade-pivot mechanism that reduces friction. One has curved bypass blades, the other has straight blade that cuts against an aluminum anvil (\$13.50 each). Pint-size pruner and trimmer (foreground), designed for smaller hands, weigh only five oz. each. Trimmer has straight blades; pruner, curved (\$10 each).

Photos on this page: Saboten hedge shears (1) have a "kicker-stick" that automatically flicks clippings away, cost \$25. All Saboten cutting tools are made of heavy-gauge steel, have Teflon-coated blades, comfortable handles, and blade locks. Pruners have wrist straps (removed in our photo). Pruning thick branches calls for the power of a ratchet lopper (2). Pull the blue handle, and the ratchet clicks up a notch to give more leverage. Mini-lopper (19 in. long) has tungsten-carbide-coated blades for easier cutting; it's \$40 from Brookstone. Japanese pruning saws (3) cut on the pull stroke so blades can be



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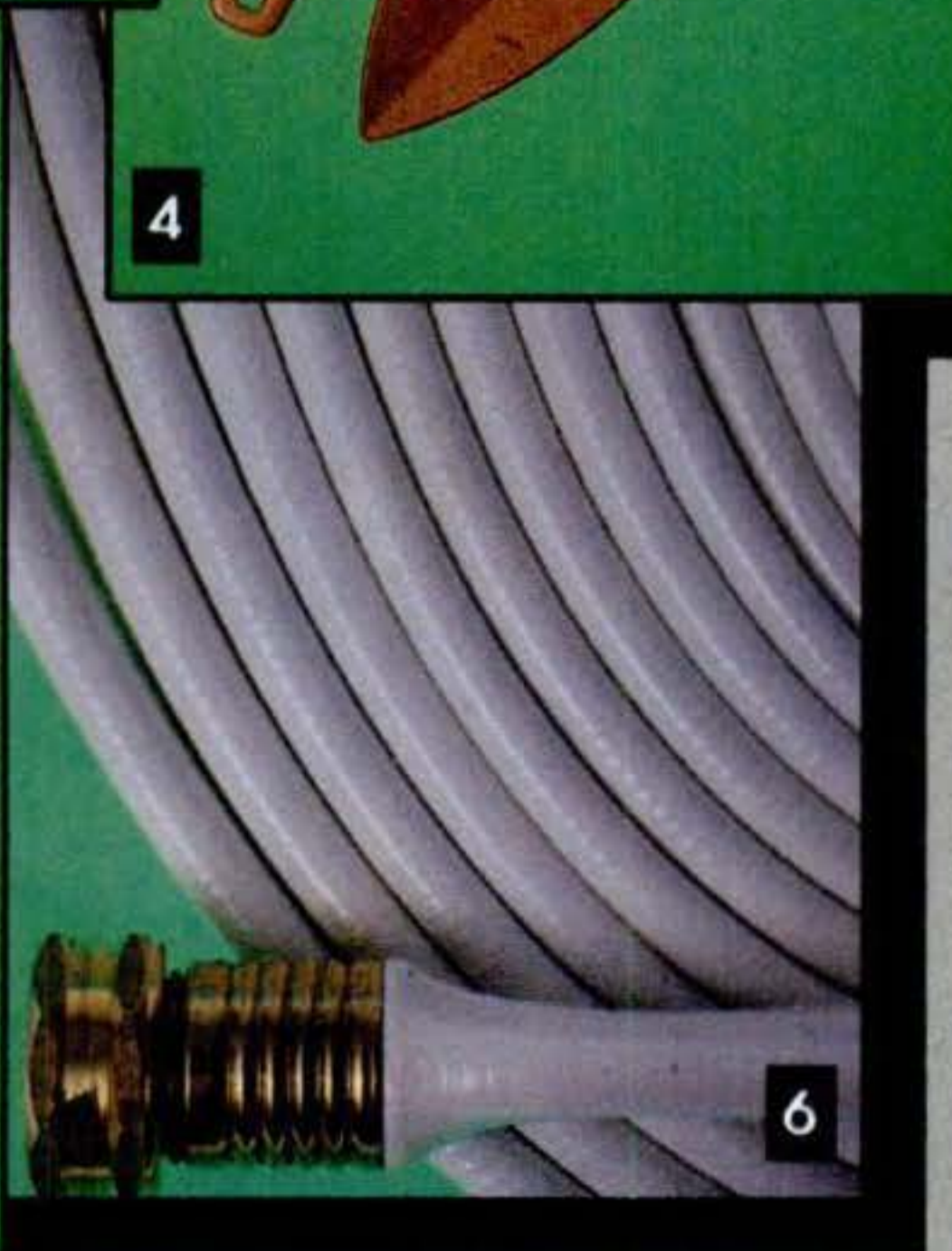
3



4



5



6

thin but tough. Holster model (\$13) has 7 1/2-in. blade; folding model (\$12), 8 1/2-in.; both from Garrett Wade. Stainless-steel hand rake (4) by Saboten adjusts from 3 1/4 to 6 1/2 in. wide, costs \$6. Use long tines to dig in deep; rounded part for gentler raking. Seed planter (beside rake) helps you space small seeds more evenly. As you turn the ratcheted wheel, the seeder vi-

brates and seeds hop off end. (If seeds cling to plastic, spray with antistatic fluid used for records.) Seeder is about \$6. Stainless-steel trowel and fork (5) have sculpted rosewood handles (Brookstone, \$9.50 each). Trowel is graduated in inches and centimeters. Flat garden hose (6) coils without kinks and drains when water is off; \$24 from Brookstone.

Computerized personal robots

—they move, talk, think, and teach you robotics



HEATH'S HERO 1



ANDROBOT'S B.O.B.



RB ROBOT'S RB5X

These androids have the talents—but not yet the programming—to do useful chores at home

By DANIEL J. RUBY

On the first day, I involuntarily flinched when a personal robot named B.O.B. came weaving on its angled wheels toward me in its maker's Sunnysvale, Calif., offices—even though I knew that he was equipped with sensors not just to recognize me but also to stop before he ran into me.

On the second day, my skepticism began to dim while I watched a squat, domed cylinder named RB5X navigate around obstacles in a room in Golden, Colo.

By the third day, when a robot named HERO 1 crooned "Happy Birthday" to me in Benton Harbor, Mich., I was quite at ease with this new species of machine.

My whirlwind introduction to these personal robots was hardly any faster than the way they burst into the world. Before last December, the only personal robots around (not including some radio-controlled show robots) were a few homemade assemblies in hobbyists' basements. Then, in rapid succession, three companies introduced real robots with on-board computers, sensing capability, and other features for the consumer market. A fourth is set to join them soon. In addition, a variety of industrial trainer robots that could also be called personal plus computer peripherals that could also be called robots are available. Suddenly, home robots—previously viewed by many as mere gimmicks—have arrived.

But what do they do? you ask. Everybody asks that. They do quite a lot: talk, move, determine distances; sense light, heat, and motion; grip objects; and much more. So far, however, none of them has been programmed to use these abilities to do the kinds of menial chores people expect from having watched robots in the movies.

Make no mistake: These are not toys. They are the earliest offspring of an industry that may grow up as fast as the personal-computer industry did. "Back in 1976," recalled Doug Bonham, director of educational systems at Heath Co., "people asked what you'd want a computer at home for, and the answer was: You could balance your checkbook."

Personal robots are at that stage now, with one difference: It took a few years for home computers to grab the public's imagination. But the re-

sponse for the first home robots has been overwhelming. Orders are coming in faster than the robots are being produced. Indeed, one company's premature listing of an \$8,000 robot in a department store's Christmas catalog brought in a dozen checks, even though no product could be demonstrated, much less shipped.

Here is the cast of characters:

- The first personal robot to be announced was RB Robot Corp.'s RB5X—a two-foot-tall, battery-powered, wheeled canister containing a microprocessor, memory, and a variety of sensing switches and instruments. It sells for \$1,500, with more memory available as an option.

- Heath Co.'s HERO 1 also costs \$1,500 (in kit form; \$2,500 assembled). It is designed as part of an educational course in robotics and has an arm and a speech synthesizer.

- Androbot Inc.'s B.O.B. (\$2,500) and Topo (\$1,000) come within the same three-foot-tall humanoid body, but the latter is radio-controlled by an external computer while B.O.B. contains a remarkable three microprocessors with three megabytes of memory on board.

- Robotics International says its Genus, scheduled for a June introduction, will be sold in a variety of configurations starting at about \$5,000.

Besides those four companies, I also visited Microbot Inc., whose stationary robot arms (used as trainers for industrial roboticists) are in the same price range as the personal robots, and Technical Micro Systems Inc., whose ITSABOX (a computer-carrying "turtle" that manipulates objects around a table top) might cost just several hundred dollars if the company decides to market it.

Autonomous creatures

As I traveled from company to company and made my acquaintance with these first personal robots, I began to feel that they differed from each other more than they were similar. So at RB Robot's offices, I asked for a definition. "A robot is really just a computer, but one that is able to sense and react to its environment," said Joe Bosworth, a computer expert at the Solar Energy Research Institute before he founded the company. "Depending on the sensors, logic, and output devices used, an unlimited variety of robots is possible," he continued, as RB5X cut a rug across Bosworth's office, using its built-in sonar and bumper switches to sense and map in its memory the placement of chairs and the desk.

"Note that none of the elements that make up the robot is unique," he

went on. "Robotics is not a discipline in its own right but a package assembled from available technologies."

But personal robots may be a case of the whole being more than the sum of the parts: With sensing, processing, and affective capabilities, the robot becomes an autonomous creature—able to make decisions based on its inputs and to take actions based on its decisions. That's new, especially let loose for the first time in homes.

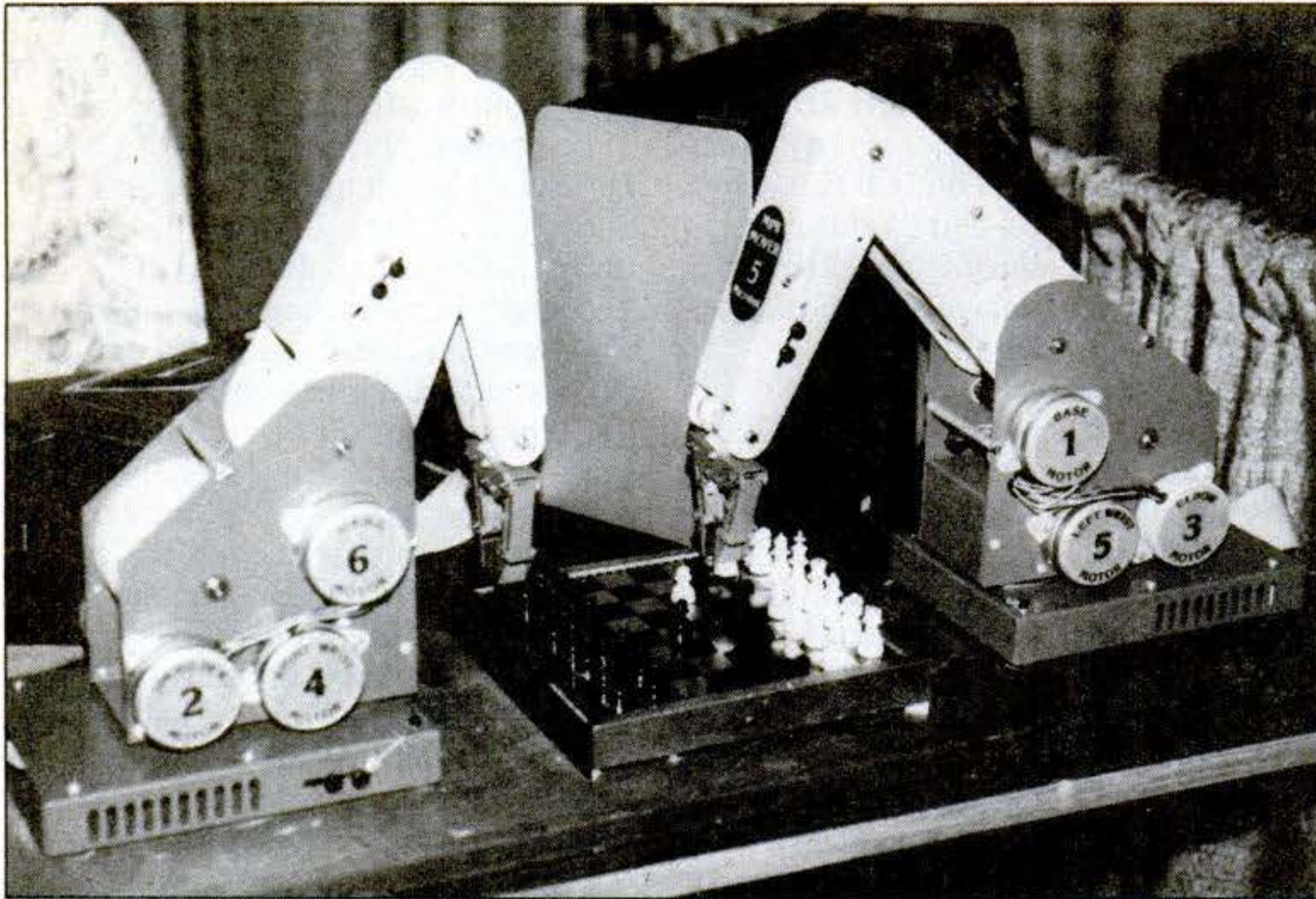
Of course, the way that a robot uses its abilities is determined by its programming. As B.O.B. told me in his human-sounding voice: "Fish swim, birds fly, Androbots follow." That is certainly true, but for a robot to carry out any complicated task—and the most trivial tasks to a human are extremely complicated to a robot—it has to remember its past experiences and make decisions based on them. That implies a mind of its own.

Consider what may be the easiest household chore robots will be called upon to do: vacuuming floors. (Genus will be available with a vacuuming attachment and RB5X is said to be getting one next fall.) It is a fairly easy matter to program a machine to come out of its closet at a certain hour every day and mindlessly cycle through a pre-established sequence of motions around a room. It is something else to have that machine be able to find its own way around an unfamiliar room. And it is something entirely more to have that machine decide that a certain area of the room needs a second pass.

Genus's vacuum attachment will be able to map a room, the company says, but it won't be smart enough to make decisions about quality. "We could probably include a vision system and the necessary processing power to make it vacuum as well as a human, but it would cost more money than you'd pay 10 maids for 10 years," Robotics International's Vic Pytko told me. And vacuuming is an easy example. If you look at the complexity of washing dishes or windows or doing other household jobs, you can appreciate the problems. "Robots can do an enormous number of things," Androbot's chief engineer, Frank Jones, told me. "But right now they can't do things that require a great deal of mechanical or cognitive ability."

That's why personal robots are beginning by doing simpler things, which is not to say they aren't useful. "Robots can combine a slew of functions people now get done individually," Jones said. Thus, the first robots are serving as talking computers on wheels for entertaining guests and

Continued



Two Microbot Minimovers recreate 41-move Fischer-Spassky chess game under

external-computer control. Board's grid permits programming of non-seeing arms.



Mock-up of Genus robot includes optional on-board computer and triple-jointed arm. Base model would include top and bottom sections only.

educating children. Linked to modems, they are acting as telephones. Equipped with sensors to detect smoke or intruders, they are mobile security systems. Most significantly, as they are programmed to do these things, they are teaching their owners robotics.

The programming is accomplished either with an integral keyboard or through a computer temporarily interfaced with the robot. The languages used vary with the robot, ranging from hexadecimal machine language for HERO to versions of BASIC, Logo, and FORTH for the others. HERO and the training arms also allow you to use a remote teaching pendant to program a series of motions, which the robot then repeats.

I got an idea just how hard it is to get a machine to do your bidding while trying out HERO's pendant. Each shift of a dial and pull of a trigger actuated one of eight stepper motors, moving the robot's wheels, head, or arm at any of its five joints. For 15 minutes I sent HERO on a herky-jerky chase around the room before I finally got it to pick up a film canister Bonham had placed on the floor.

And that is the simplest kind of programming. Nevertheless, it surely won't be long before owners will have taught their robots to fetch slippers or a can of beer. After that, the companies say, anything is possible. "We are counting on our users to come up with the software," Bosworth told me. "It will be like having hundreds of programmers on our payroll."

Because nobody knows for sure what the ultimate uses of personal robots will be, most companies are designing their products as platforms

for experimentation by users. (Only Robotics International will offer specific hardware packages for specific functions.) Each views its market differently, however, and the products are designed accordingly.

Heath's HERO was introduced not as a personal robot at all but as an industrial-robotics trainer. Therefore, the robot was designed for easy access and independence of its circuit boards, motors, batteries, and other components. It was also designed specifically *not* to look "Star Wars"-ish, although product manager Jim Lytle concedes that the company's industrial designers apparently failed in that goal. "Everyone thinks HERO looks like R2D2," Lytle told me. "That's because it definitely doesn't look like C3PO, and are there any other robots in the world?"

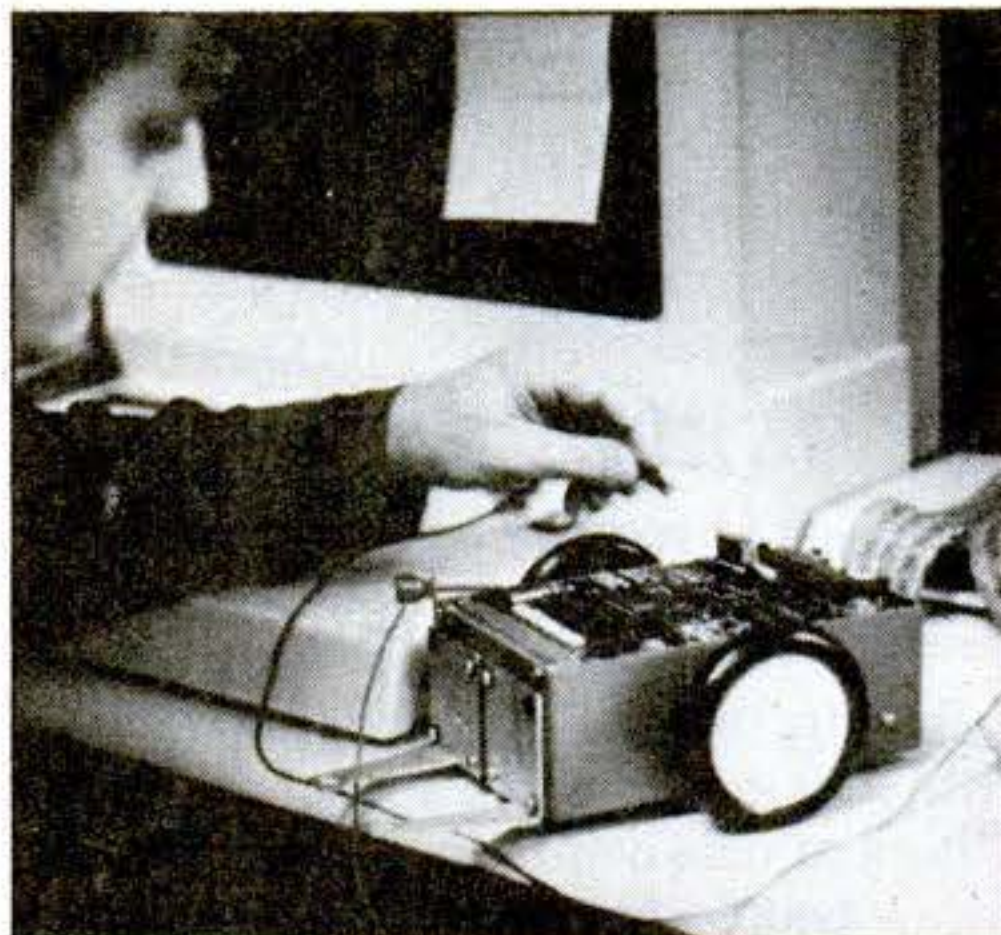
Now there are. Of the first generation of personal robots, RB5X is probably the least humanlike. "We didn't want to mimic the human form because a robot's role is not to replace humans but to extend their capabilities," Bosworth told me. Androbot's robots, on the other hand, were specifically designed to be humanlike. "We decided that what people would want in their homes is a playful companion but one that looks somewhat futuristic, as well," said company president, Tom Frisina. That distinction shows up in another way, too: Frisina always refers to B.O.B. as "him," while engineers and executives at the other companies generally say "it" of theirs.

It will be some time before anyone mistakes B.O.B. or the others for a human, however. Besides clever programming, there must be further advances in hardware. Androbot is still perfecting a beacon system that would permit B.O.B. to fetch something or let an owner summon it. Right now, using rudimentary sound recognition for that purpose, B.O.B. might show up saying, "Yes, master," every time you called the dog. Similarly, HERO is able to distinguish words of differing numbers of syllables, which might be useful, Bonham suggested, in having the robot serve either Coke or Pepsi. However, you could order vodka and still get Pepsi.

Vision systems are even more limited. Sonar and other devices are used to serve the seeing function, but several of the robots have primitive photodetectors, as well. "They are certainly not good enough to distinguish between an ashtray and a coffee cup," Frisina told me. But they can be useful in other ways.

At the time the HERO prototype

[Continued on page 136]



ITSABOX's computer is programmed from terminal, detached to explore table top autonomously. Switches prevent it from falling, fingers maneuver objects.

Zip-up, blow-up boat



Double-walled inflatable has puncture protection

By **SUSAN RENNER-SMITH**

At first glance it's just another sleek inflatable. But that sporty black stripe on the gunwale isn't a conventional fender. It's a zipper—to seal the Radhial's inner tubes snugly inside its hull.

On other inflatables, the air-filled flotation chambers *are* the boat's hull. But the Radhial's three air chambers are separate tubes encased within an outer skin. The zipper, a self-lubricating toggle closure (inset), makes a watertight seal when the unique craft is inflated.

Why this double-shell design? "You won't get the pinhole leaks caused by abrasion," says Debra Young, vice-president of Radhial (136 Charwood Circle, Rochester, N.Y. 14609).

"That's the most common cause of leaks in inflatables." The double shell also reduces the risk of direct punctures. And it protects the air chambers from stresses and pressure losses.

"But if the Radhial does need repairs, it's much easier to fix than the usual type of inflatable," says Young. "The owner can change the inner tube on the spot, if necessary—you get a spare one with the boat."

The zip-up boat has a further advantage. Hull and inner tubes can be made from the material best suited for each. Radhial's flotation tubes are light but tough PVC foil. "The foil is highly expandable, so it fills the whole space inside the hull," Young explains.

The boat's outer skin is made of Erstrom, a specially woven Trevira polyester impregnated with PVC and polyurethane. The material is highly resistant to both abrasion and ultraviolet rays, according to the inflat-

able's Italian maker, Plasteco Milano.

"It's the same material Plasteco uses for the bubble buildings it puts up over tennis courts and stadiums in Europe," says Young.

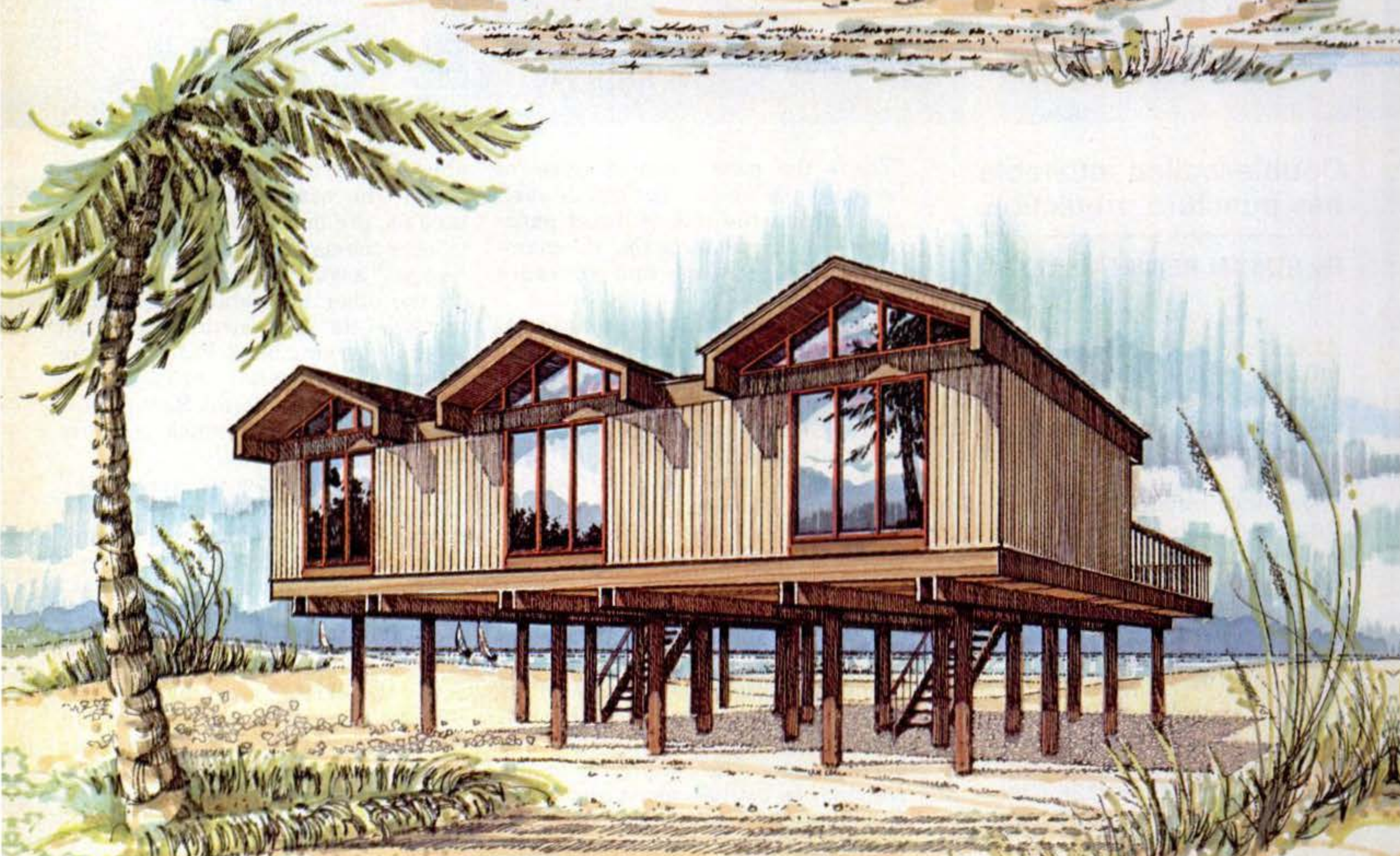
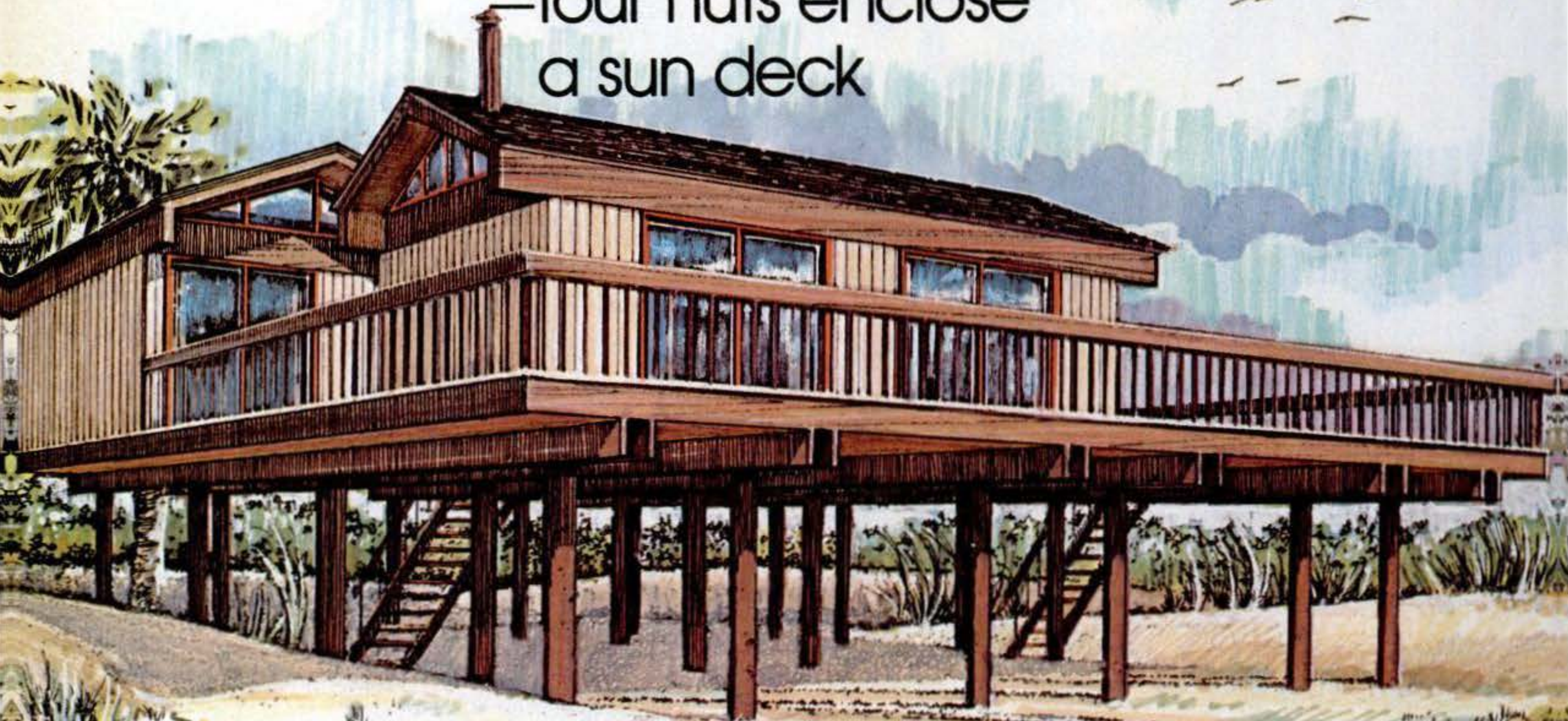
Like other inflatables, Radhial is portable—its components pack into several carrying bags. But the zip-up design makes the boat stronger than other inflatables, claims Radhial, because the boat isn't stuck together with glue.

"Glue can deteriorate over time," Young explains. "The seams can peel apart." Radhial's seams are electronically welded. And all the fittings—from wood transom to carry handles—are screwed into flanges mounted in the hull. Such through-hull mounting is impossible on conventional, single-shell inflatables, Young notes.

Radhial backs up its claims with a 10-year warranty on all six versions of the zipper boat. They range in size from 11 to 15 feet, and prices start at \$1,799. P 5

Floating quartet

—four huts enclose a sun deck



By AL LEES

With almost prophetic relevance, architect Robert Martin Engelbrecht brought us this house last January, christening it the Malibu. Riding above high water on a broad deck supported by firmly anchored dock pilings, the beach house was designed, Engelbrecht explained, for protection from pounding surf. A few days later we were all seeing on television the consequence of incautious building along that California coast—shot after shot of homes in the Malibu area with waves rolling across their floors.

While no leisure home can hope to stand unscarred through Nature's occasional rampages, any builder is well advised to ensure that his basic structure is well designed for local weather extremes.

In our February issue, PS featured an earlier V-PAC Council design intended to meet the ocean-front zoning restrictions now becoming standard, especially along the Gulf Coast—requiring that the main floor be 10 feet above normal high tide. This second approach to the same problem floats a cluster of separate huts on a docklike deck. Each hut is structurally independent, right up to its own roof. Note that three of the huts set parallel to one another across the rear of the deck, with the fourth set at a right angle in front. Since the middle hut at the back is only half-length, connecting walls and corridors create a secure and private atrium sun deck, screened from view and from gust-blown sand.

All units are single-story. The alternate floor plans at right show several possible adjustments you can make to suit your specific requirements: The complete, four-unit plan at top offers three bedrooms plus a completely separate and self-contained apartment for a permanent guest or paying tenant (sleeping, of course, would be on a convertible couch). You could even seal off the right-hand door to the master bedroom to give the apartment a private entry and its own bathroom.

If the house is to be used only by a couple who have few guests but would find a rental apartment useful, the middle floor plan shows how one hut can be eliminated. The dotted line across the 12-by-12-foot bedroom shows how this could be split into two private sleeping areas—for that occasional house guest—by closing an accordion-type folding partition.

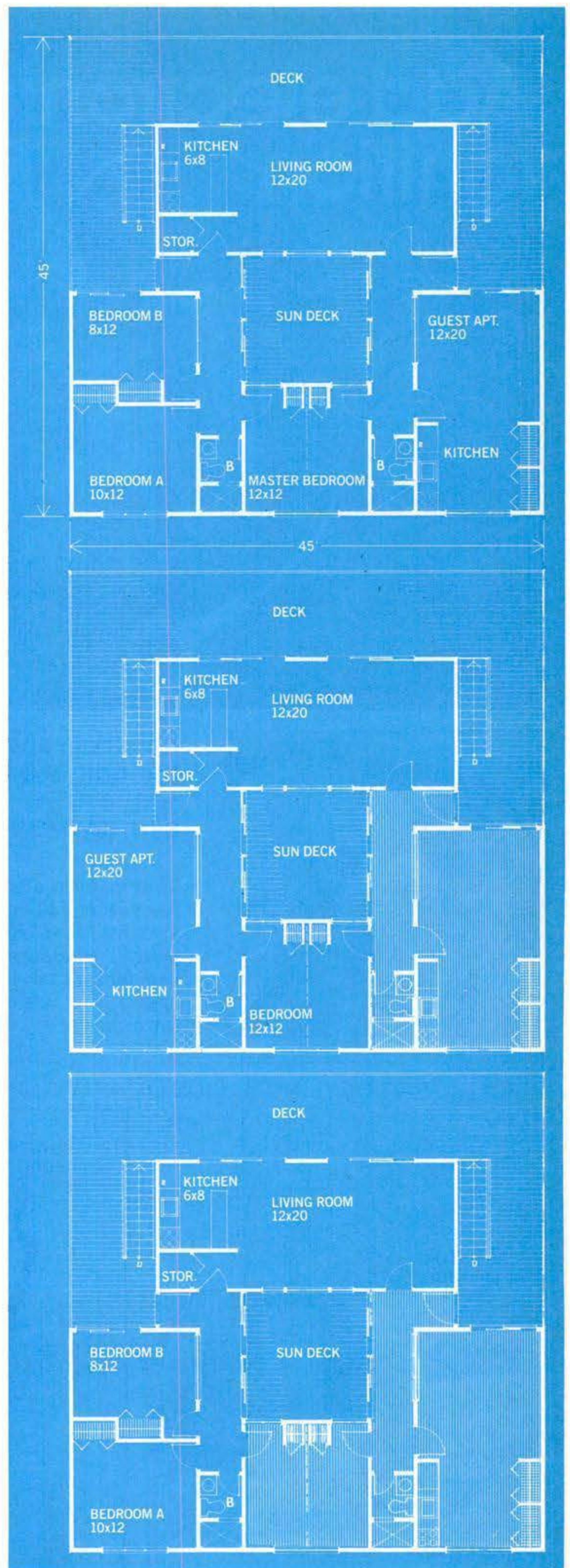
Finally, the third floor plan omits the half-hut bedroom to settle for just two buildings on the deck, with the sun deck tucked into their L. Whether you'd then retain the two nonstructural walls of the sun deck would depend on your need for a wind or privacy screen there.

Access to the deck proper is by means of an open stair at each end of the living-room hut. The stairs are kept simple and sturdy so that storm damage needn't be a major concern. There's plenty of room between the pilings for sheltered parking for several cars.

All gables are glazed for an open, airy feeling indoors, even on overcast days. In sunny weather, the spacious deck offers various activity zones—including a private area for the apartment. Incidentally, that apartment could be a great inducement for a live-in "house sitter" during your extended absences. ■

How to order your plans

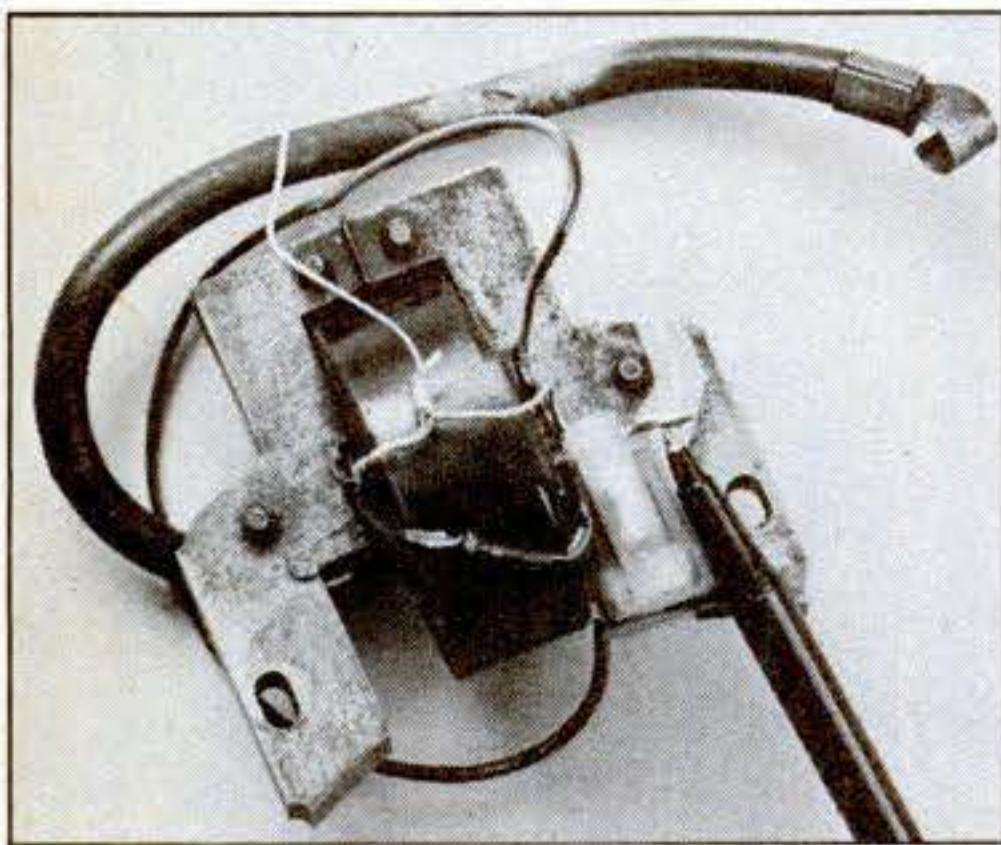
Construction drawings for the Malibu (VPS #61) are \$65 a set, \$95 for three sets, \$20 for each extra set. Add \$3 for postage in the continental U.S., \$5 elsewhere. Complete revision of V-PAC Council catalog, newly titled, "The Uncommon House Collection," will be available after May 15 for \$5. Send check (U.S. funds) to Vacation Plans Service, Box 622, Princeton, N.J. 08540. MasterCard or Visa orders: Call (609) 924-9655. V-PAC Council is an organization promoting good house design.



Build only as much as you want: Top floor plan has three bedrooms plus separate unit. Omit right-hand hut (shading on center plan) or both it and bedroom half-hut (bottom) if not needed.

Add electronic ignition

to your gas-powered tools



It works—and installing the unit is a breeze

By J. RAYMOND TRULL

They've been available for older cars for years: add-on electronic-ignition systems that replace troublesome points, condenser, and distributor cam for a fatter, hotter, more reliable spark. Now you can get one for your lawn mower.

Made by Briggs & Stratton Corp. (Box 702, Milwaukee, Wis. 53201), the new low-cost unit (\$14.95) fits virtually all models manufactured after 1963—and that must be a lot of engines since, according to the company, sales of the device are brisk.

Adding the add-on

I got to try the new add-on on my 16-year-old, 3.5-hp mower. Result: The engine fired on the first pull and runs nearly as well as it did in 1967. I've not only extended the life of the engine but gained the extra reliability and convenience of an electronic-ignition system.

The Briggs & Stratton system is contained in one rather tiny module (see photo) you add to your engine. Electrically, it replaces old components; physically, nothing is removed—all the old parts stay on the engine. I simply disconnected them and wired in the module.

The instructions with the device first guide you through a test procedure to guarantee that the engine "stop" switch works properly. This, of course, is to be sure the engine won't start accidentally. Once through the simple tests, you can begin to work.

Gaining access to the points and condenser cover is the first chore. After removing the sheet-metal housing, I used Briggs & Stratton's fly-wheel holder and a large pair of slip-joint pliers to unscrew the rewind starter clutch. The company's fly-wheel puller—a tiny bar and two bolts—provides quick and safe removal of that part and access to the points and condenser leads.

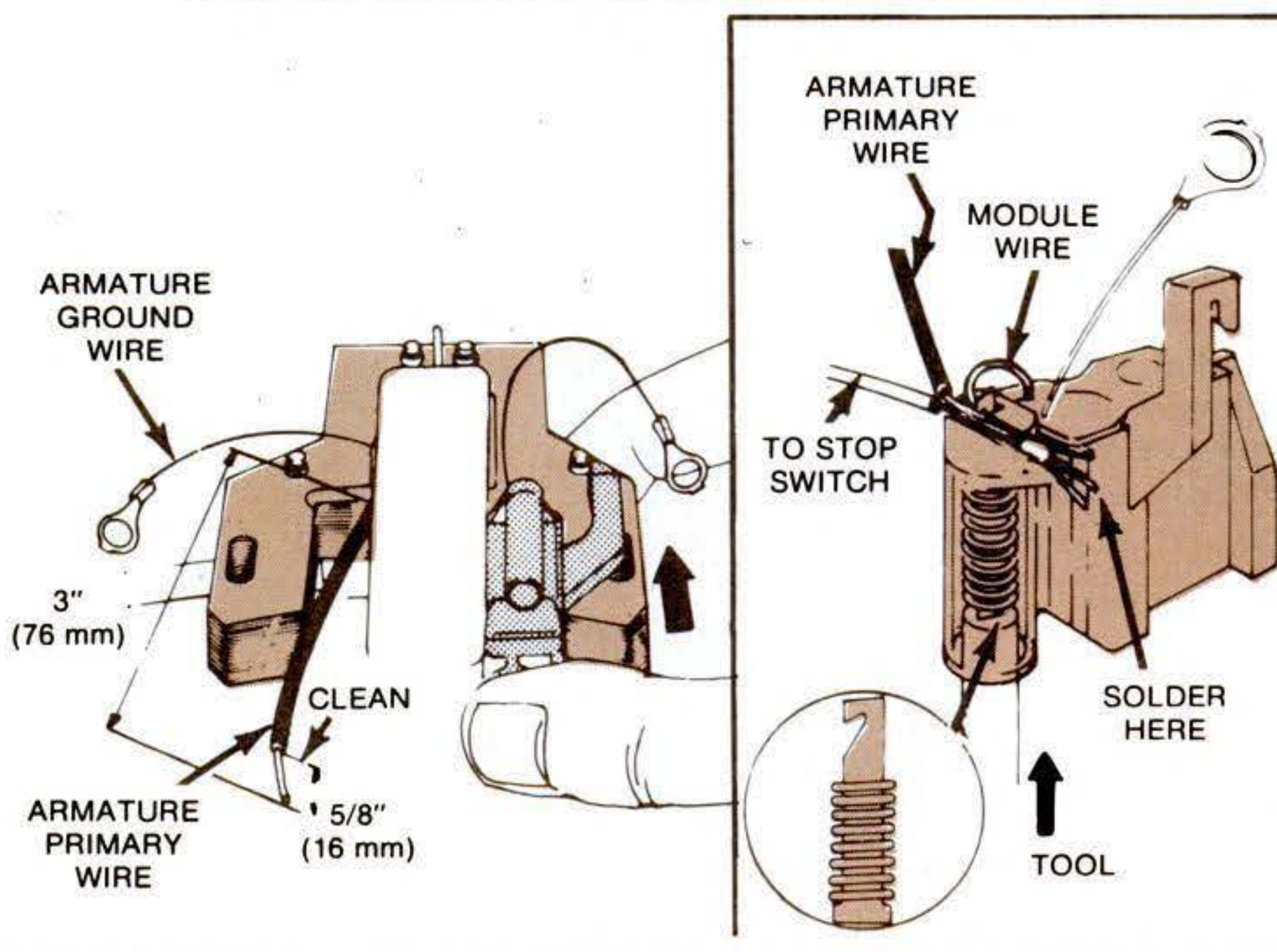
Wiring the module to the ignition system takes two steps: After installing the module on the engine armature, you first insert the armature and module primary wires (and stop-switch wire, if used) into the module terminal (see drawings). An included spring-loaded catch holds them securely in place while you solder the wire ends together.

Next you twist the long module and armature grounds together, solder the joint, and cut off the shorter end. Briggs recommends that these wires be glued to the coil with a sealer such as Permatex No. 2 for protection from vibration.

That's it. Since the module fits into formerly unused space, reassembly is a snap and trying it is just a rope-pull away.


Naturally, the module is not confined to lawn mowers. Any Briggs-powered tool—from snow blowers to garden tillers—can use it. For more information, write to Briggs & Stratton.

BACK/CYLINDER SIDE OF ARMATURE



SPECIAL SECTION

OUTDOOR UPGRADES



Your choice of

add-ons for outdoor living

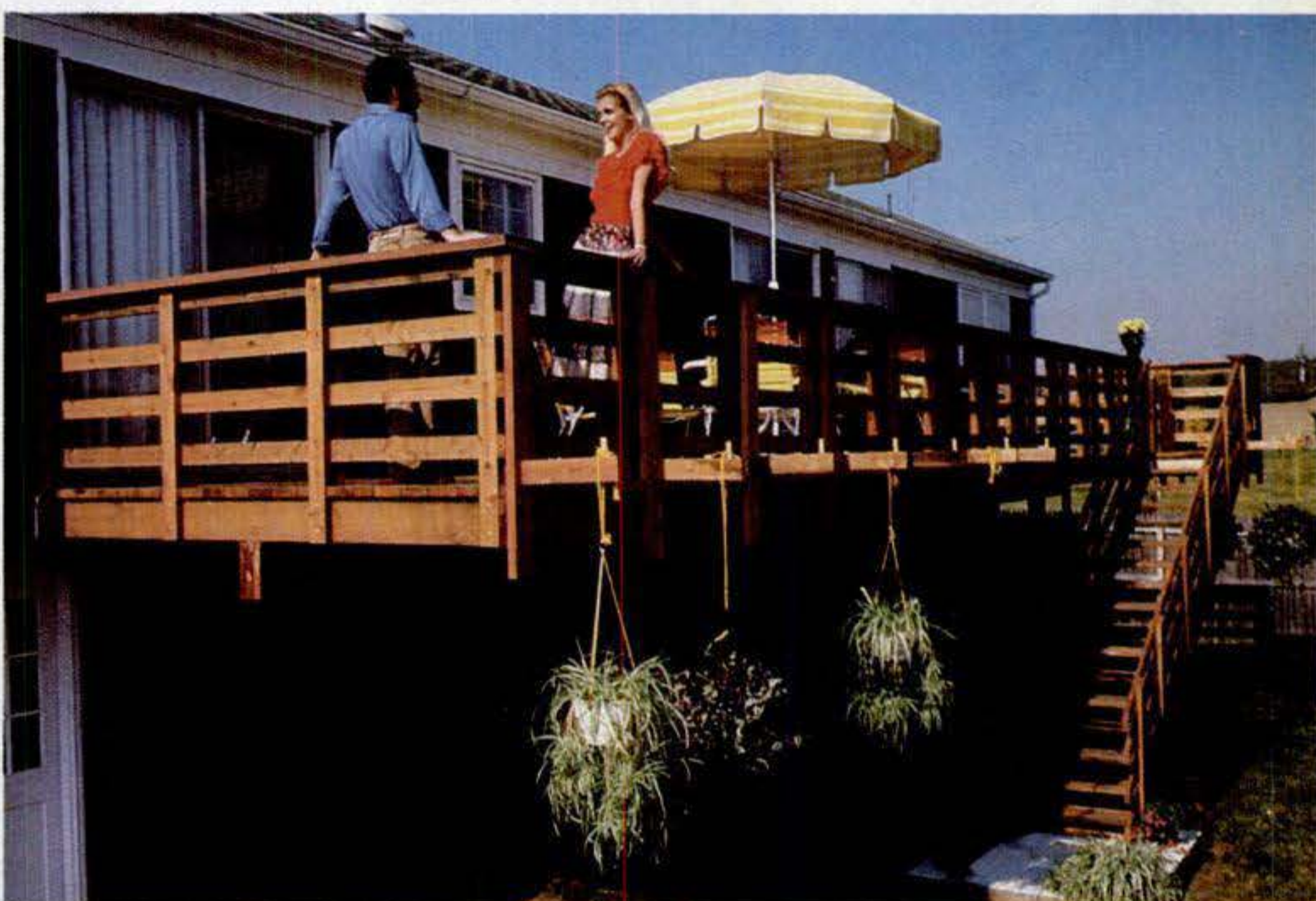
● We've made the choice as broad as possible: If you plan to expand your home this year to create space for al-fresco entertaining or family fun, you can add a porch or an upstairs deck. We commissioned two contrasting projects to present here, complete with construction details. Our first story features a sun porch of great ingenuity and versatility. Every glazed opening shown, below right, converts to summer screens.

● When you're at the rail of the floating deck at right, you feel as if you're sailing a cruise ship into the breeze. Its stairway makes the climb a breeze, too. And it's all built of easy-to-work redwood.

● The owner-built home is a growing phenomenon across the country as many prospective buyers find the only way they can afford a custom-built home is to do most of the building themselves. Special schools to teach how have mushroomed—many with summer-camp-type courses. Here's our directory.

● As a section-within-this-section, our semi-annual home-hardware roundup offers plans and instructions for a unique multi-purpose jig that will let you do jobs on your table saw you never thought possible. And to round off this special-format section, we show you how to assemble emergency kits for plumbing repairs. These easy-to-collect kits adapt to rigid pipe or tubing, and no home should be without one.

In this section: complete plans for a tile-floored all-weather porch and a second-story deck



ELEVATED DECK



CONVERTIBLE PORCH

SPECIAL SECTION
OUTDOOR UPGRADES

Porch for all seasons



A tile-floored solarium has hinged window panels that store overhead

By H. L. KIRK

DESIGN BY LEIGH MONTGOMERY

My Vermont retreat lacked one amenity: a spacious all-weather porch. What POPULAR SCIENCE, a young contractor, and I worked out together is a handsome structure that invites hospitality and relaxation.

Its flexibility of purpose—especially the overhead-storing folding window panels that transform it into a winter solarium—makes the porch adaptable to many styles of homes across the country.

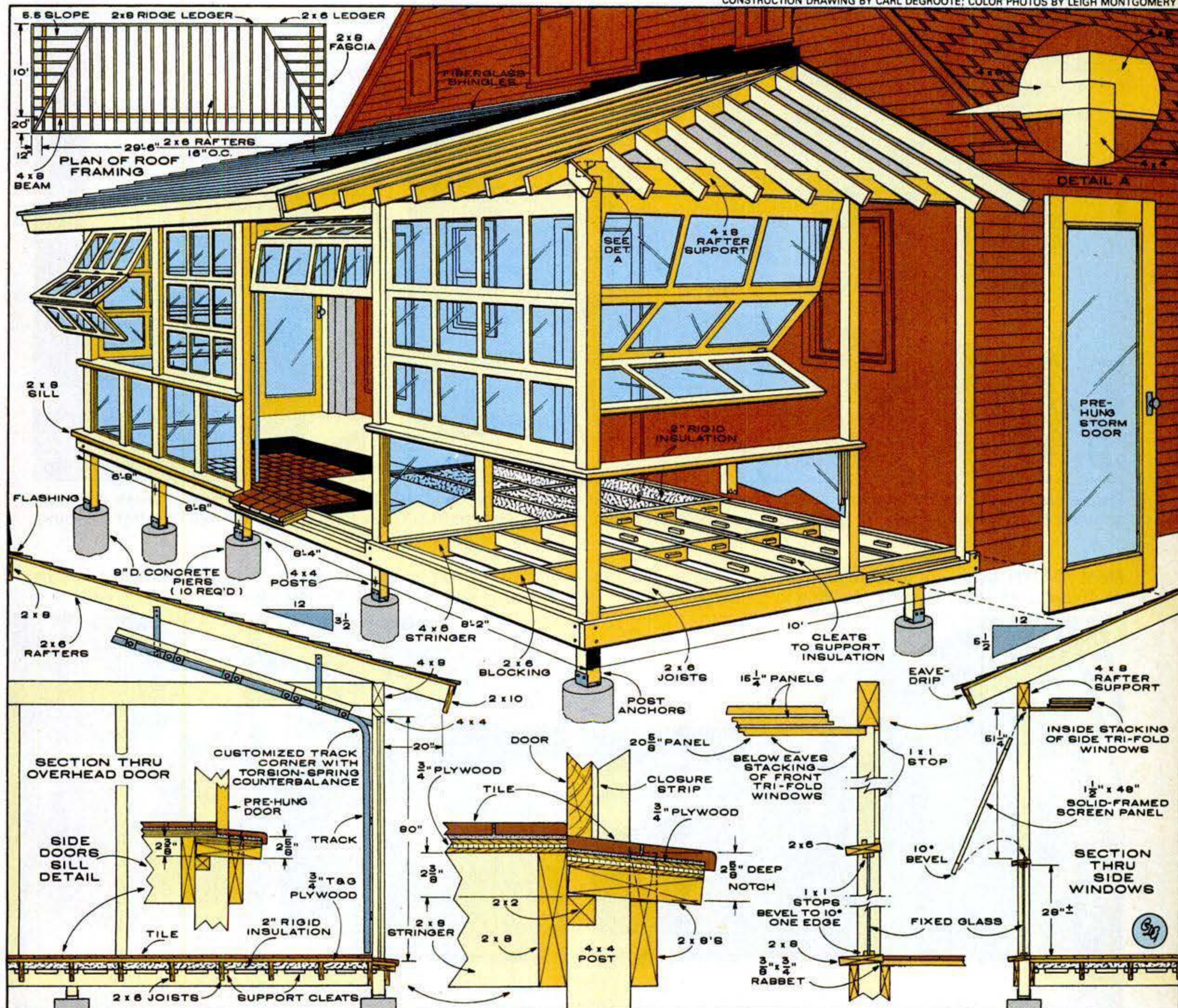
Every homeowner has individual
Continued

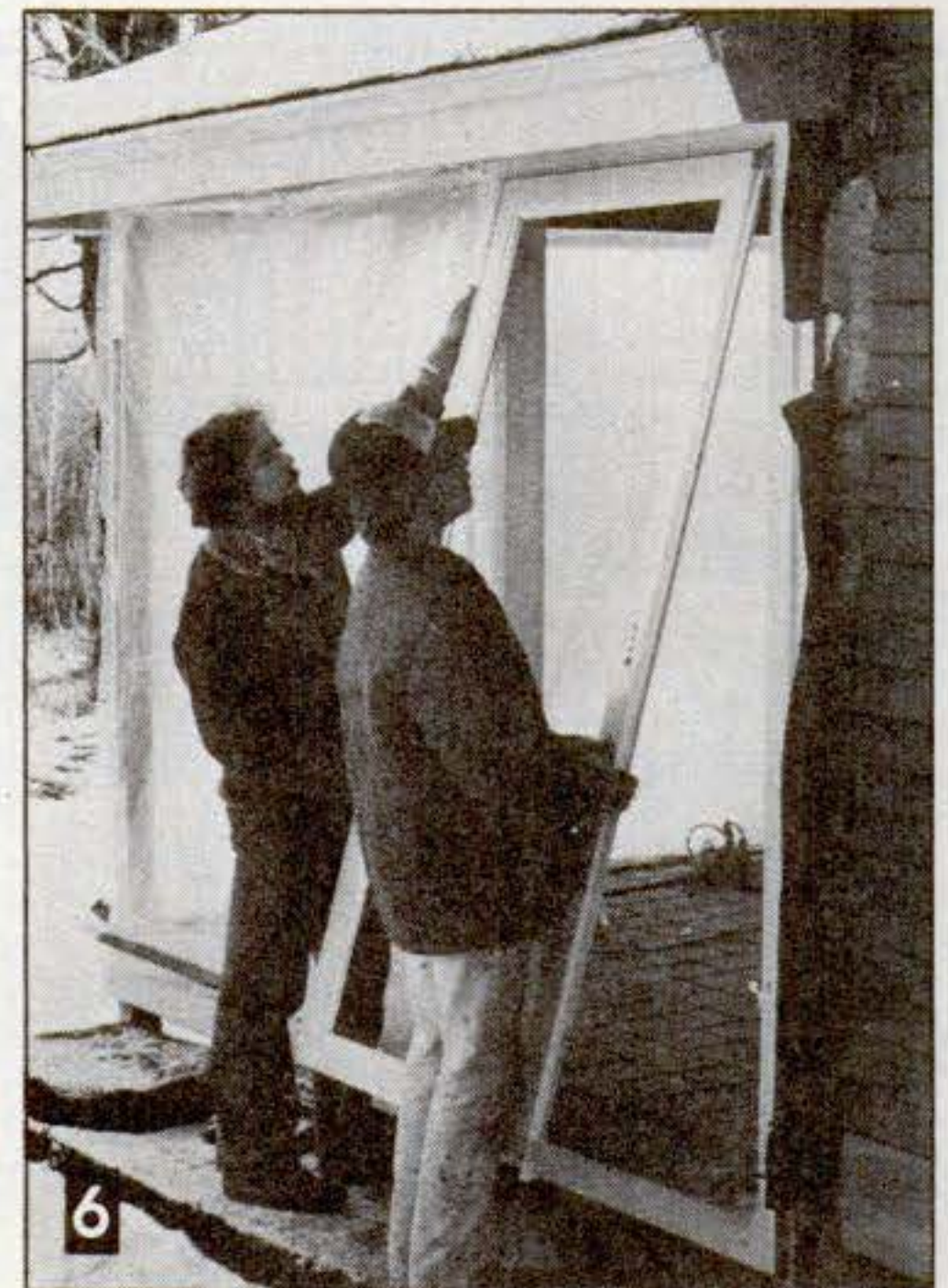
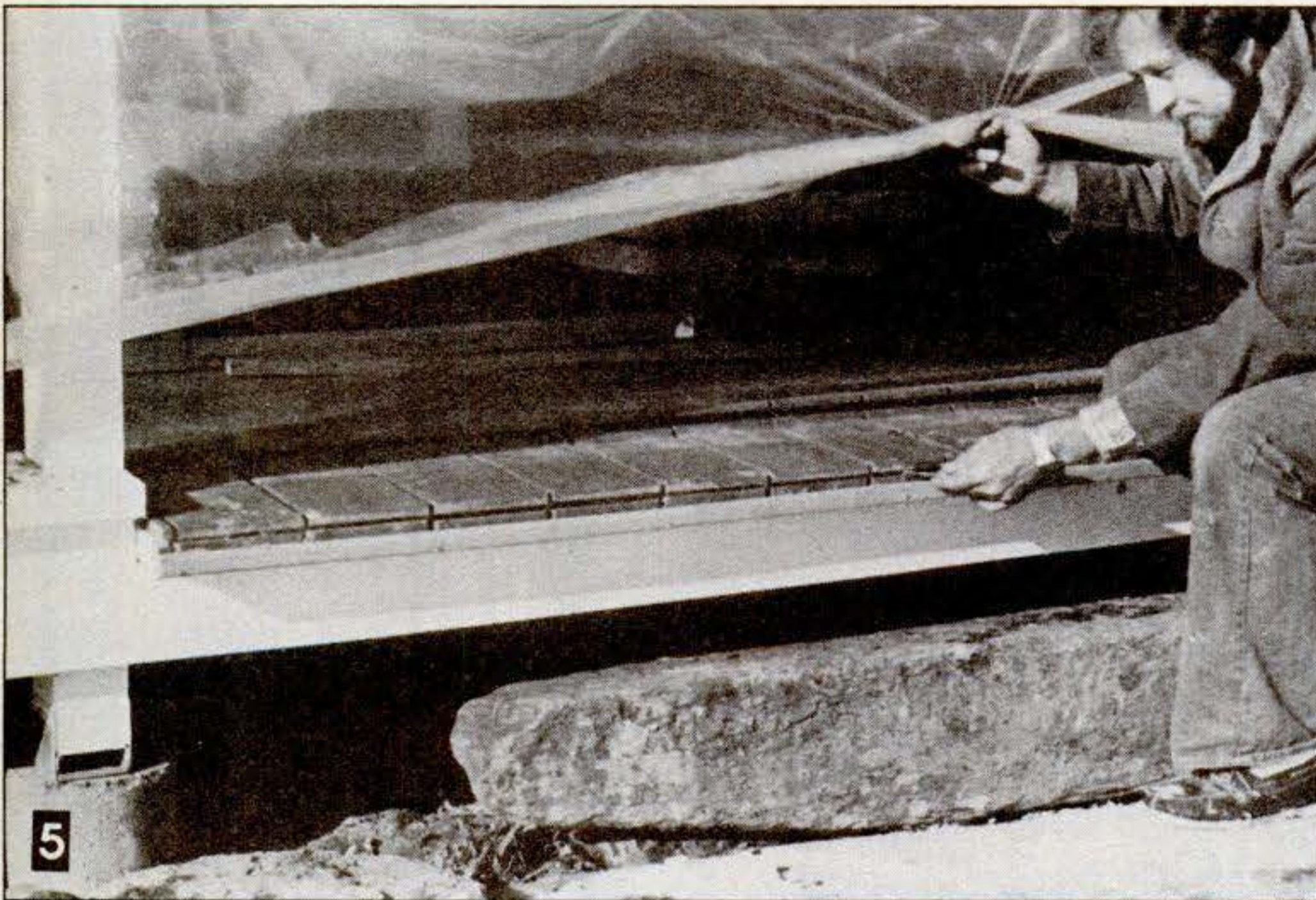
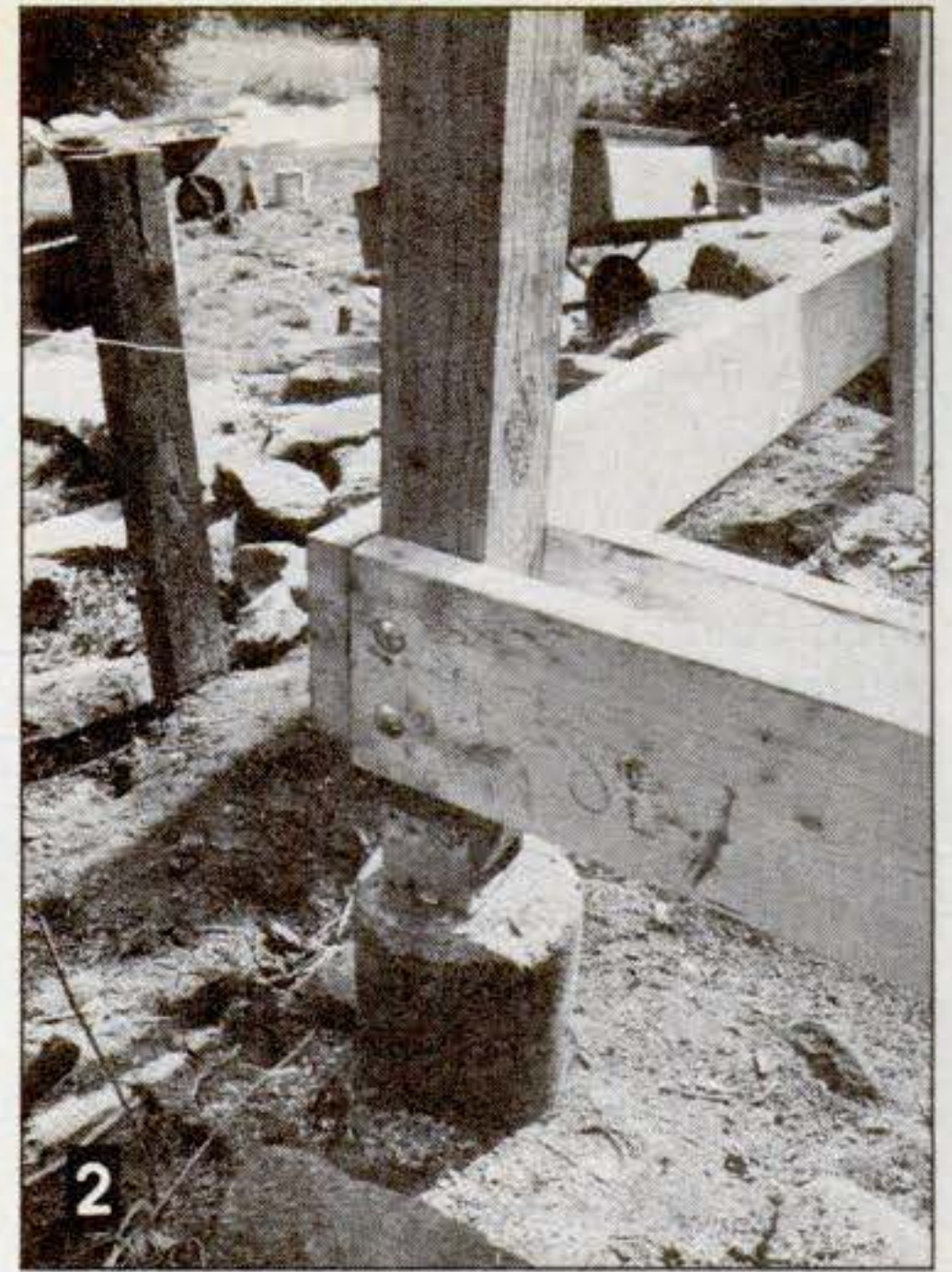
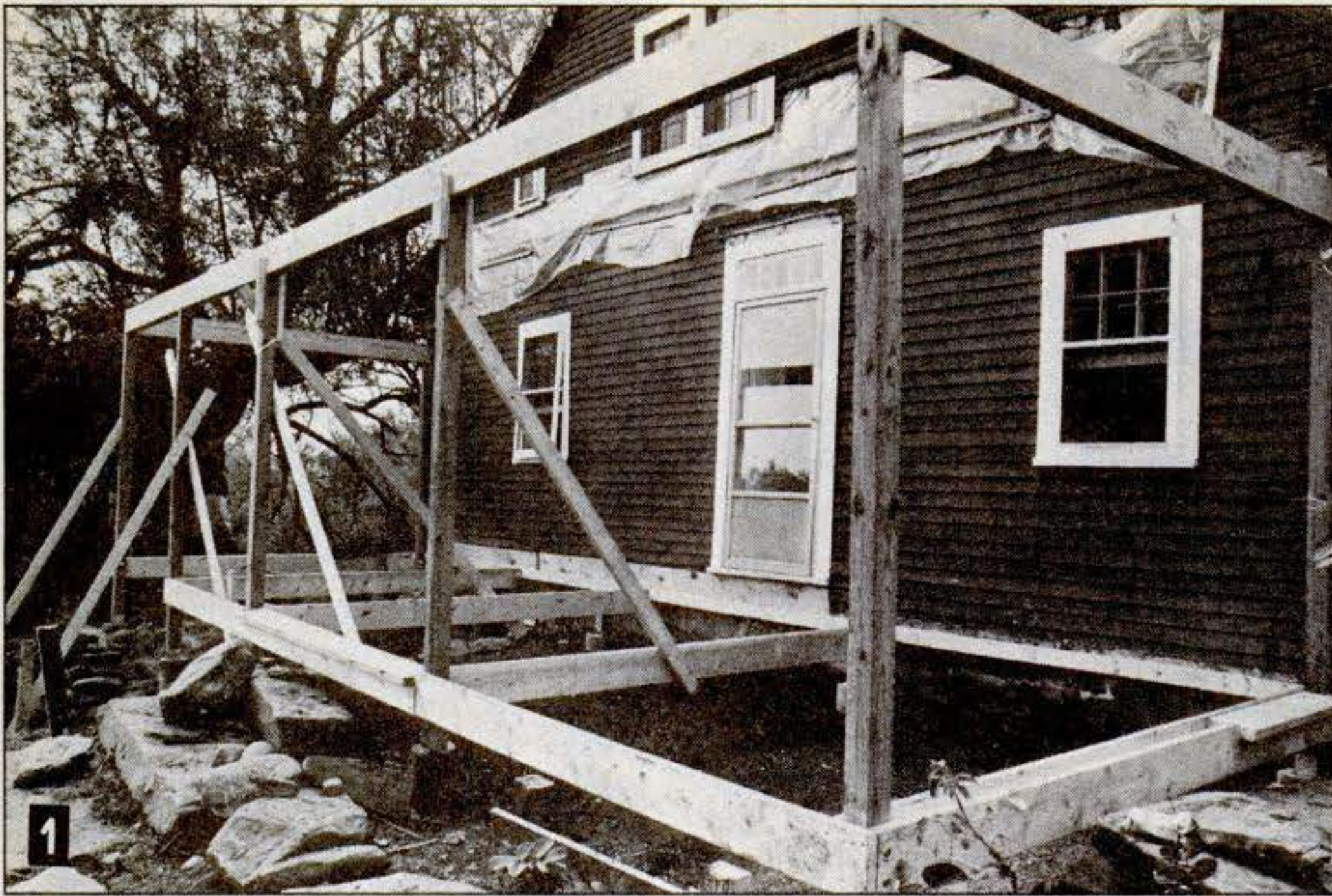


Central entry span is glazed with overhead door that tracks up under the roof. Flanking it: tri-fold windows that store along eaves (end-wall type, right).



CONSTRUCTION DRAWING BY CARL DEGROOTE; COLOR PHOTOS BY LEIGH MONTGOMERY



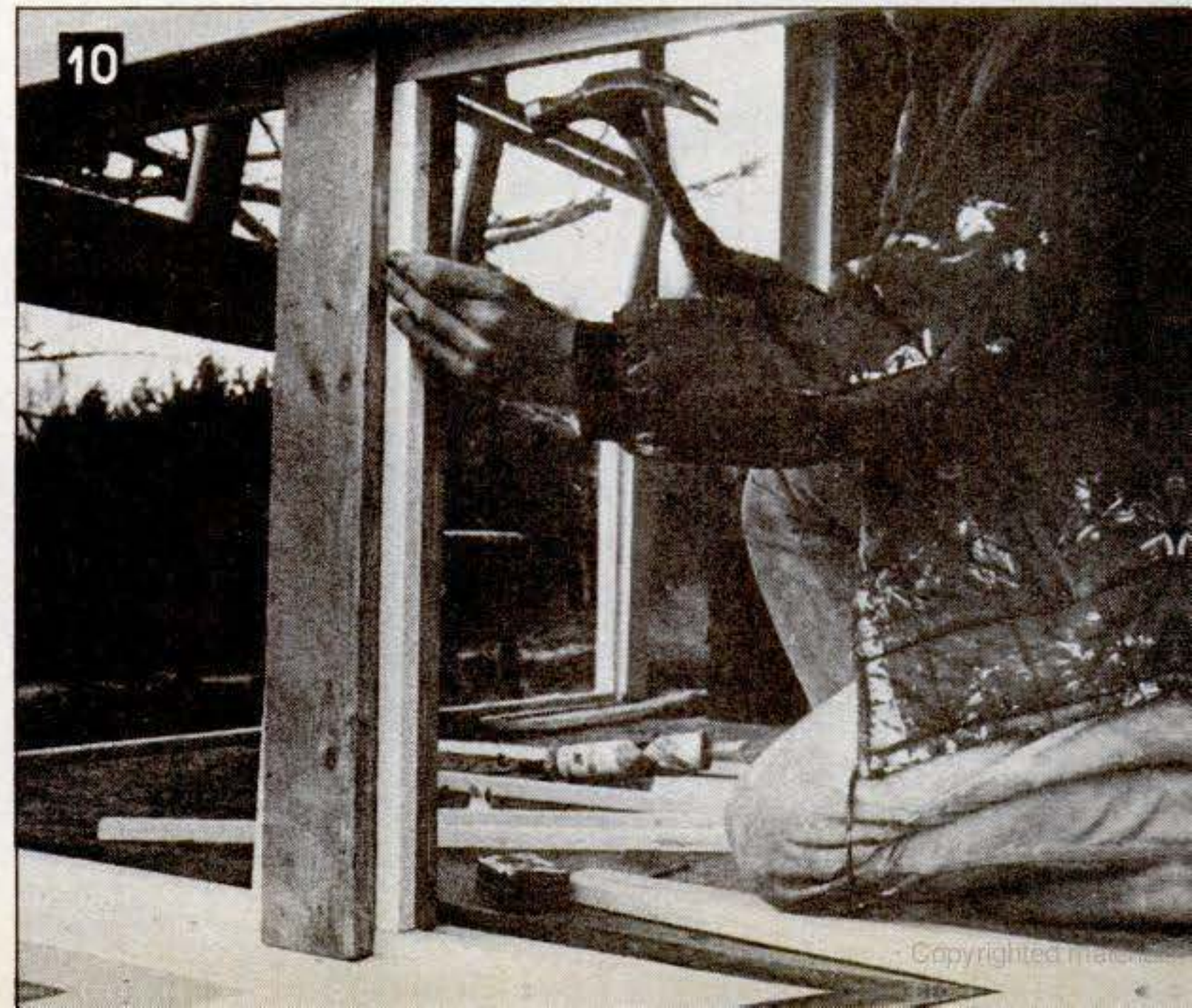
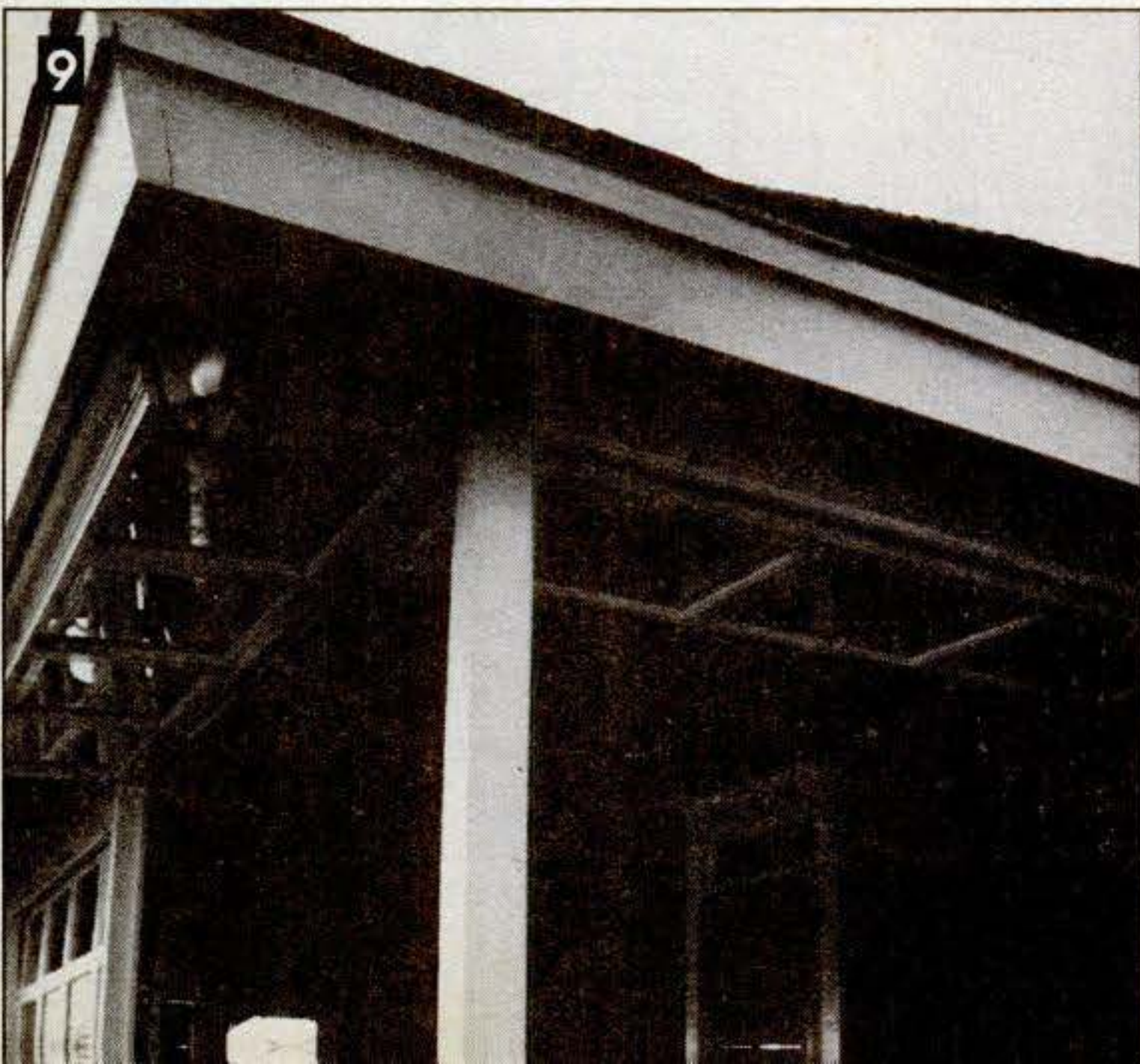


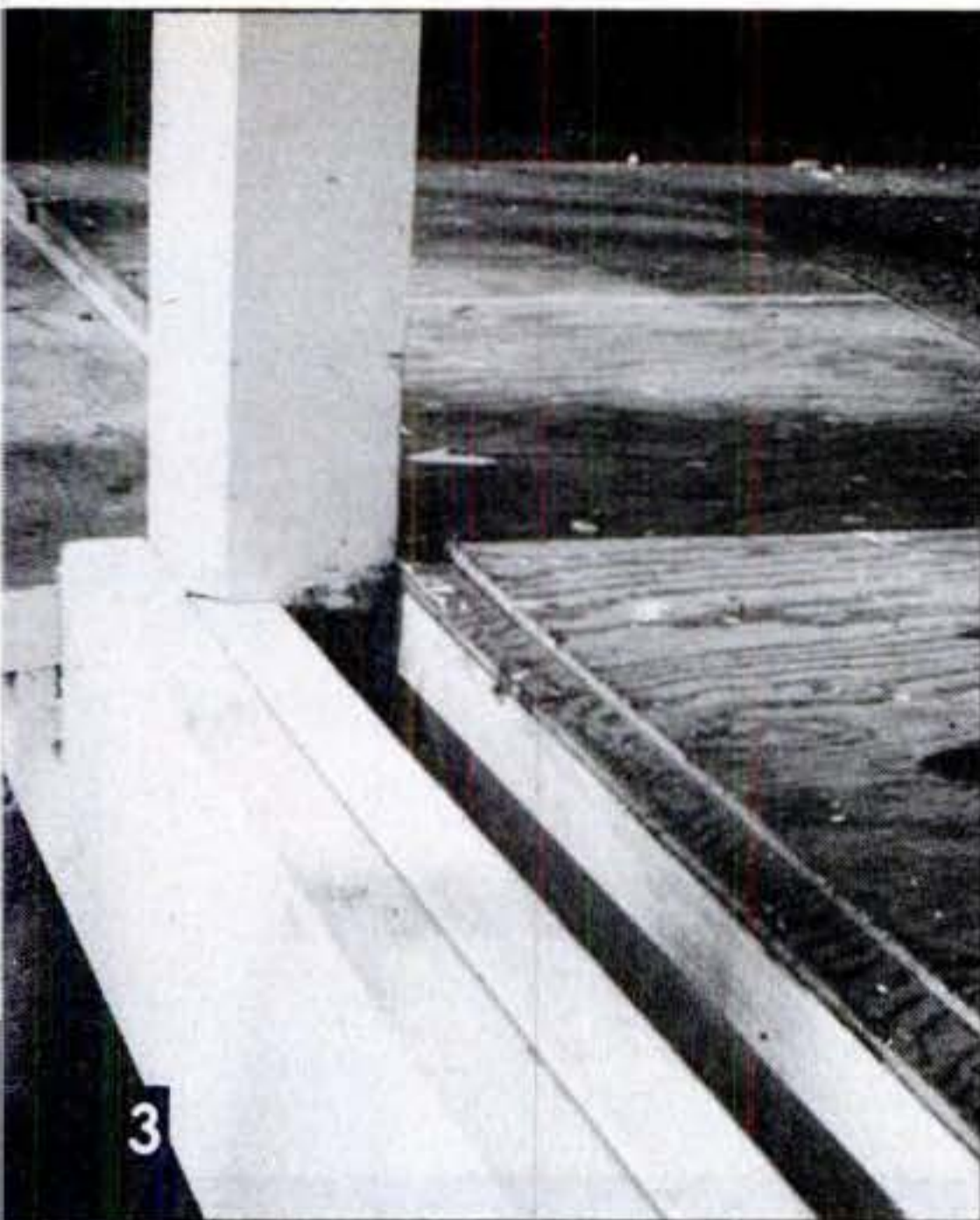
Protective wrap is lifted by builder Montgomery; he's checking space for grouting on double-bullnose recess of main-entry threshold. Ten-penny nail gives space.

Storm door (JCPenney) comes pre-hung in steel frame you nail in rough opening.

Front tri-folds swing out to store under eaves. Sharper hip-roof pitch forces end-wall tri-folds to swing in for storage, right.

Tack stop strips on inside faces of posts; you'll also need stops across sill and under rail. Mating edge is beveled to match.





Post-and-beam cage (1) ties directly to house but adds no weight: It rests on its own foundation piers—locations critical.

Anchor bases (2) keep ends of posts dry, permit some alignment adjustment on piers—which are sunk below frost line.

Plywood floor (3) sets flush with face of inner band joist. Rabbet sets sill at 10-degree slope. Beyond is center threshold.

Lay tile in thin-set mortar (4), right up to edge of sill; this last row of tile is positioned on sill, ready for laying.



7

8

Snug closure is ensured with adjustable channel that has vinyl sweep base.

End-wall tri-fold, next to door, mounts flush with inner faces of posts and header

(note top hinges). Its bottom panel rests on railing, swings up for storage.

Slide latch secures overhead door—up or down—by engaging slots in the track.

requirements for any add-on. For this project, mine were:

- A porch—not an added room—that would retain the architectural integrity of an old farmhouse of some distinction.

- An addition that would not mask the home's view of meadows, forest, and mountains—in any season.

- A structure that could bear heavy snow loads, with a sturdy deck-support framework that wouldn't shift and crack a quarry-tile facing, even at 20 degrees below zero.

- A system of overhead-storing glazed panels that could be lowered in cool or stormy weather and would latch securely in place for the winter—plus screen panels for protection against insects (and occasional bats) from spring through early autumn.

- Three-way access to my home's main entry through doors offering the same glass-to-screen convertibility.

- A capacity for taking advantage of whatever passive-solar potential the site offered. This would have been

[Continued on page 150]

PARTICIPATING MANUFACTURERS

American Olean Tile Lansdale PA 19446	Lava-red quarry tile
Asphalt Roofing Mfgs. Assn. 6288 Montrose Rd. Rockville MD 20852	Three-dimensional fiberglass-based asphalt shingles
Fimble Door Corp. Nashua NH 03060	Overhead door and tri-fold frames
General Glass Intl. Corp. New Rochelle NY 10801	Low-iron glazing, for both fixed and movable frames
JCPenney Co. 1301 Ave. of the Americas New York NY 10019	Convertible storm doors
Teco 5530 Wisconsin Ave. Chevy Chase MD 20815	Post and rafter anchors



11



Second-level deck

for outdoor living space upstairs

This big all-redwood deck is easily accessible—from both house and yard

By **CARL DeGROOTE**
PHOTOS BY GREG SHARKO

On warm summer days, it's hard to beat the ease and convenience of a deck, especially if it's located off the main living area of your house. Unfortunately, not every house has such a convenience—or if it does, it's often small and inadequate.

The deck shown on these pages graces the second-level dining and bedroom areas at the rear of a two-story tract home. Access is through sliding glass doors from the kitchen, and a window nearby serves as a pass-through for food and beverages served on the patio.

The deck is made entirely of construction heart redwood as classified by the California Redwood Assn. This lumber is naturally resistant to insects and decay and—like all redwood—is dimensionally stable and easy to work with using ordinary tools. You'll need a portable power drill and circular saw.

The deck is supported by five Lally columns, each eight feet long. The columns are set one foot deep in concrete piers, which in turn extend to below the frost line.

The deck is 40 feet long and 9½ feet wide. It has exceptionally clean lines, with the front plank of decking set between railing posts so no butt joints are exposed, and with all bolt heads located to be an element of the design.

Building the deck is a straightforward job. After installing the Lally columns, allow the concrete to cure thoroughly, then fasten the main

How many beams to a cantilever?

Ideally, a deck attached to a house should be designed for a live load of 40 lbs. per sq. ft. The redwood deck shown here weighs 10 lbs. per sq. ft. (its dead load). So the supports—the girder, Lally columns, and footings—had to be designed for a total deck load of 50 lbs. per sq. ft. (40 lbs. of live load plus 10 lbs. of dead load).

What about the cantilever, especially the long cantilever of the stair platform? When you calculate the load a cantilevered wood beam can bear, you figure it either with the load concentrated at the end of the cantilever or with the load evenly distributed along the length of the beam beyond the point of support. The distance from the girder to the ends of the joists on the stair platform is seven ft. To find the uniformly distributed load that can be supported by one joist, use the formula:

$$W = \frac{fbd^2}{36L}$$

in which W = safe load (lbs.) uniformly distributed on joist; f = fiber stress (psi); b = width of joist (in.); d^2 = square of the depth of joist; and L = length of span (ft.).

Fiber stress is a figure derived from laboratory tests. If you carefully select construction heart redwood with a close grain structure (eight rings or

more per in.) and no splits, knots, or interrupted grain, its fiber stress will be about 1,000. Based on the formula, then:

$$W = \frac{1,000 \times 1.5 \times 7.25^2}{36 \times 7} = 312.87$$

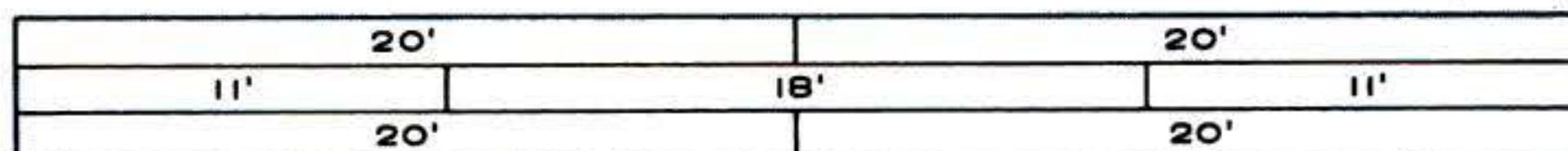
One joist can safely support roughly 313 lbs.

The uniform loading of the long cantilever is 1,307 lbs. (found by multiplying the area of the cantilevered section by the total load of 50 lbs. per sq. ft.). Add to that one-half the load of the upper half of the stairs, or 800 lbs. (calculated by multiplying an average 200-lb. load for each tread times eight treads and dividing by half). The total load, then, that must be supported by the seven-ft. cantilever is 2,108 lbs.

To determine the number of joists necessary to support the total weight, divide the total load by the capacity of each joist:

$$\frac{2,108}{313} = 6.74$$

Seven joists are needed, spaced to fit as shown, but they must be held together in such a manner that they support the entire distributed load as a unit. The girder itself is a built-up beam constructed from redwood 2×10s pieced together as shown below.—C. D.

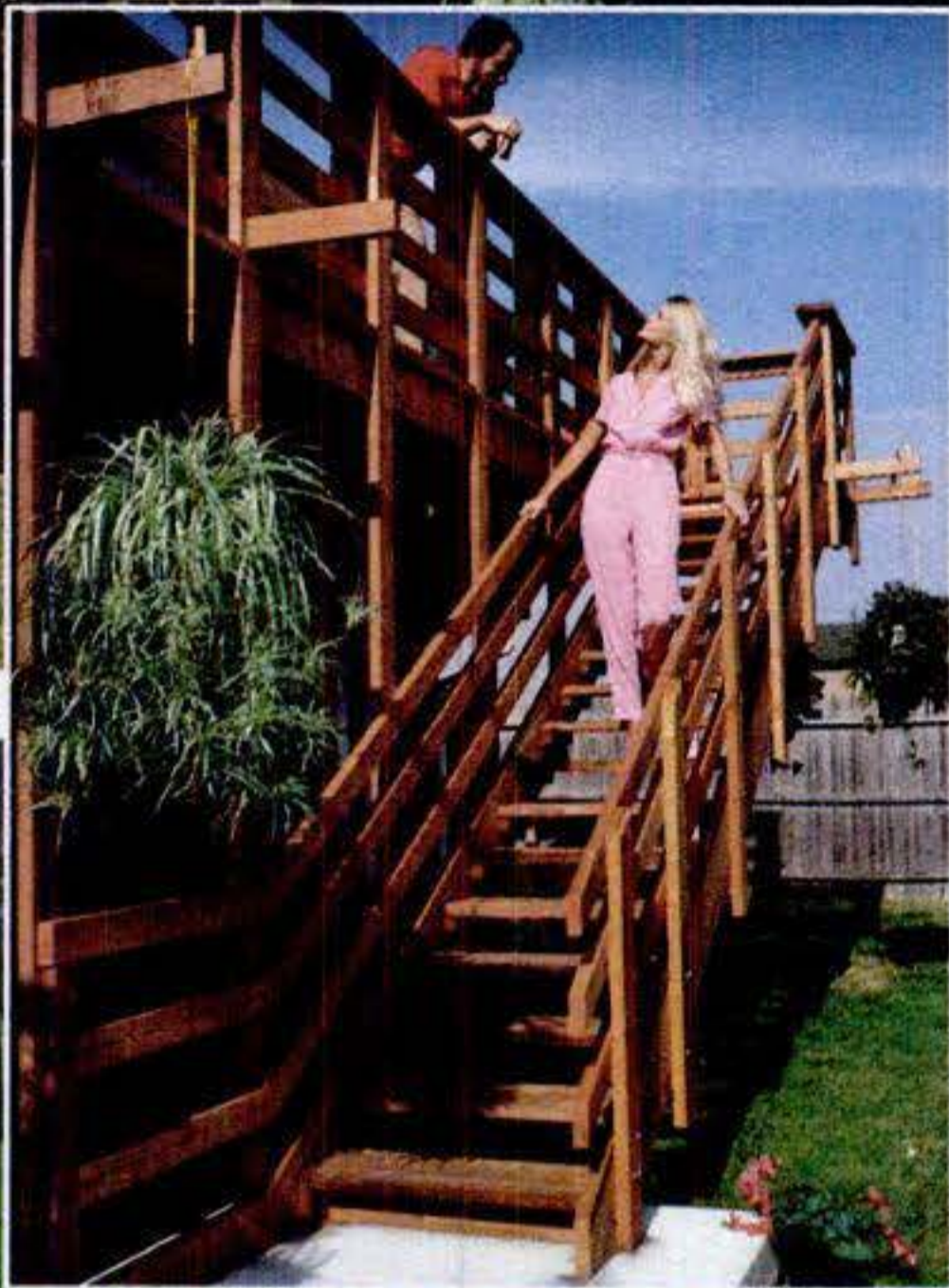


girder to the top plates. Use ¼-by-three-inch galvanized lag screws.

Fasten the 2×8 ledger board to the header at the house's second level so that its lower edge is ½ inch higher than the top of the girder—this gives a slight slope to the deck for better drainage. Use ⅜-inch galvanized lag

screws four inches long on one-foot centers.

Fasten the joists to the ledger with 2×8 joist hangers. The main deck joists are cut to nine feet 1½ inches from 10-foot lengths. The waste is used for the blocking between joists (located at the center of the girder).



Easy-to-climb stairs, wide railing, and attractive plant hangers are among features of handsome, functional elevated deck.

Fasten the joist blocking with 10d hot-dip-galvanized nails.

After placing the 2×8 deck header and the 2×4 railing posts, cut into the tops of joists for the 1×6 bracing shown on the plan and fasten securely. Now the 2×6 decking can be laid, again using 10d galvanized nails.

Assemble the railing and stair supports as shown in the drawings. Note

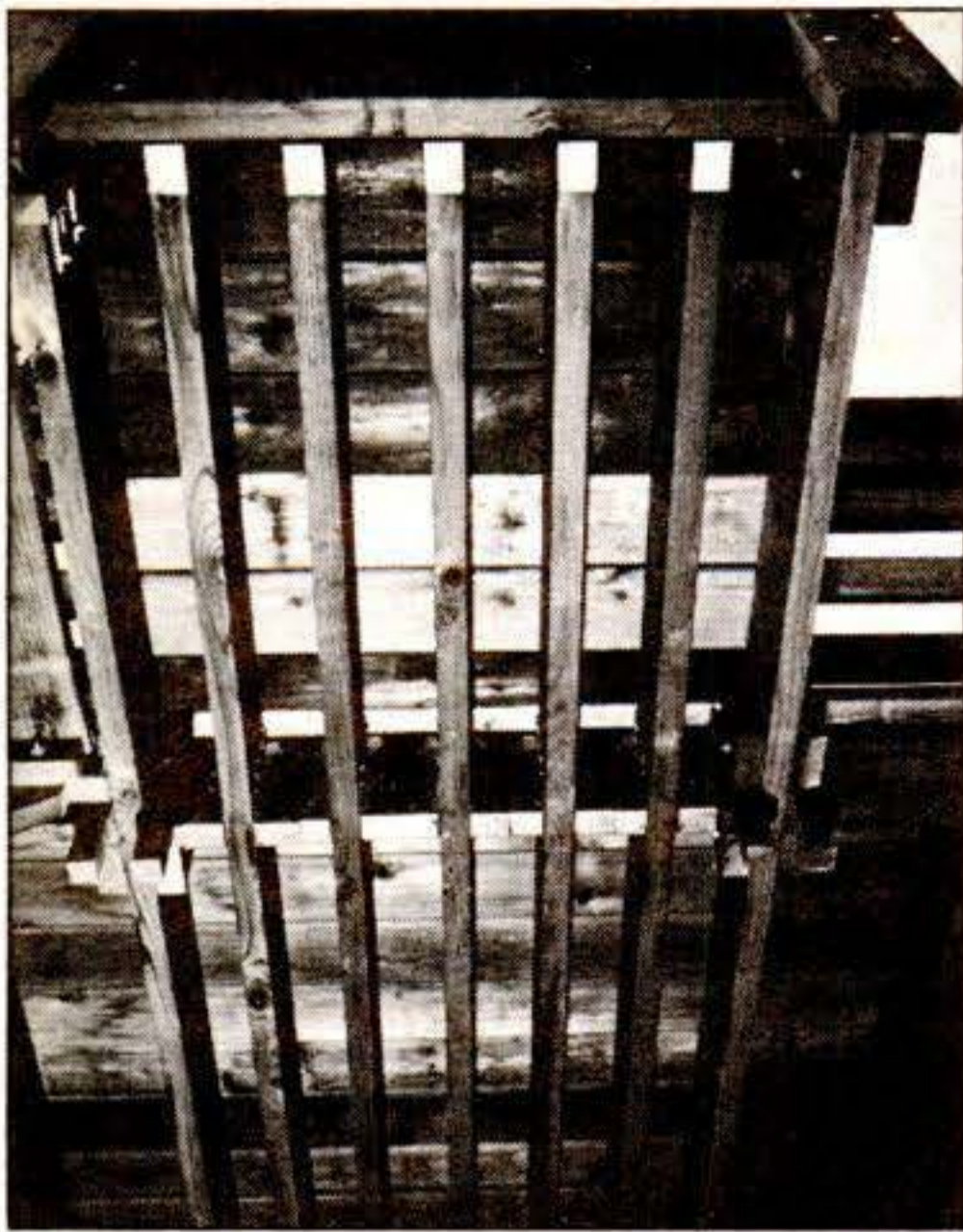
that the 2×8 railing is mitered at all corners. Where it's butted along straight lengths, it's joined with 45-degree diagonals.

The stringers and treads of the stairs are cut from 2×12s. Treads are 11¼ inches wide with a rise of 6⅝ inches. This combination makes the stairway easy to climb up and down—there's no need to negotiate high

steps. Support the treads on 2×2 cleats attached with carriage bolts.

The stair stringer located closest to the deck is supported by 2×10s ripped in two, which are attached with ¼-inch carriage bolts. Both stringers are attached to the upper platform with 2×8 joist hangers. Secure the stringers to the concrete base with a 2×4

Continued



Support joists for stair-landing platform run seven ft. past the main girder. To support the load, the joists must be narrowly spaced, properly blocked, and secured with steel hangers as shown so that the total load is transferred to and supported by *all* of the joists. Nail the hangers to the joists at the platform blocking and ends before attaching them to the house ledger: There's very little room to swing a hammer with spacing this close.

stringer stop that's anchored to the concrete.

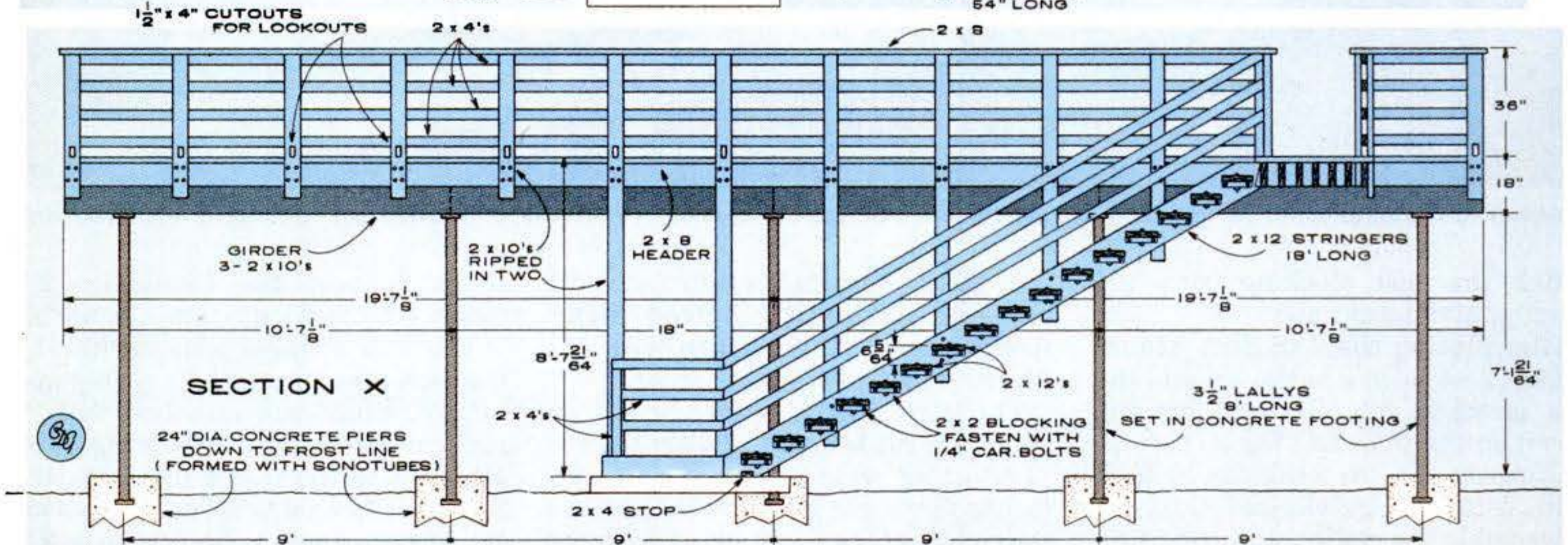
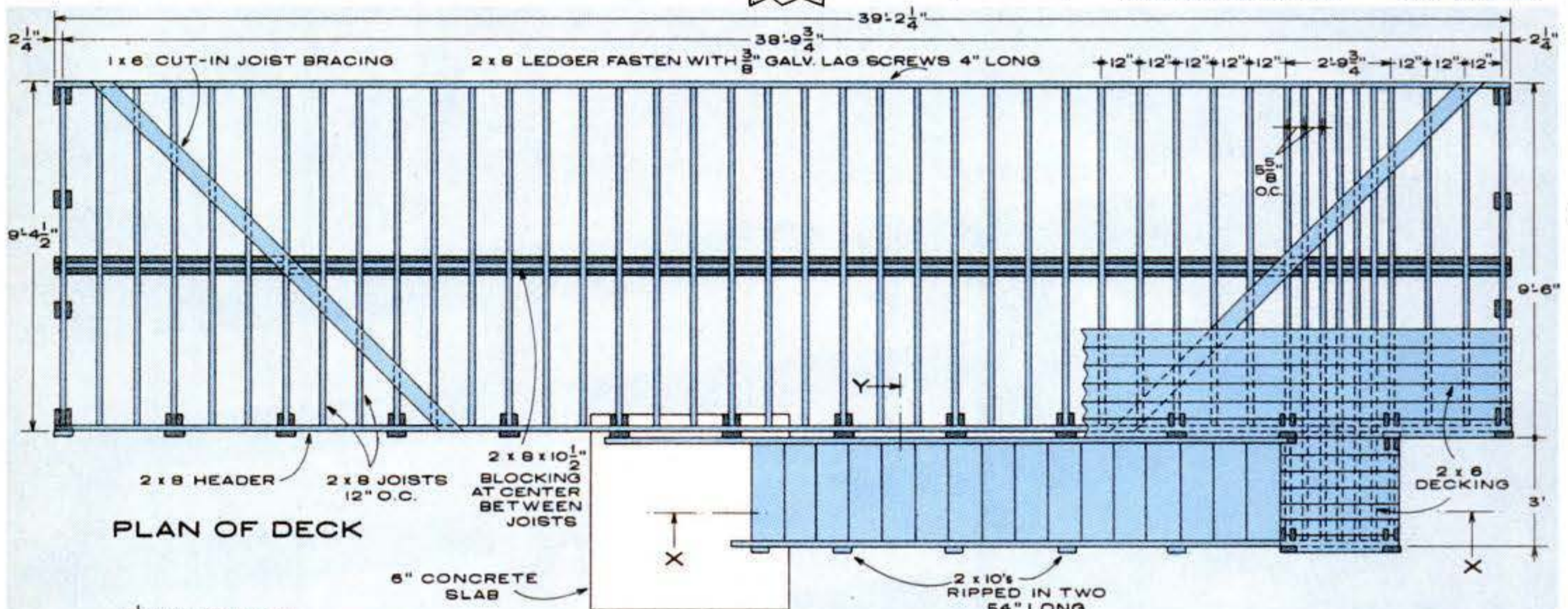
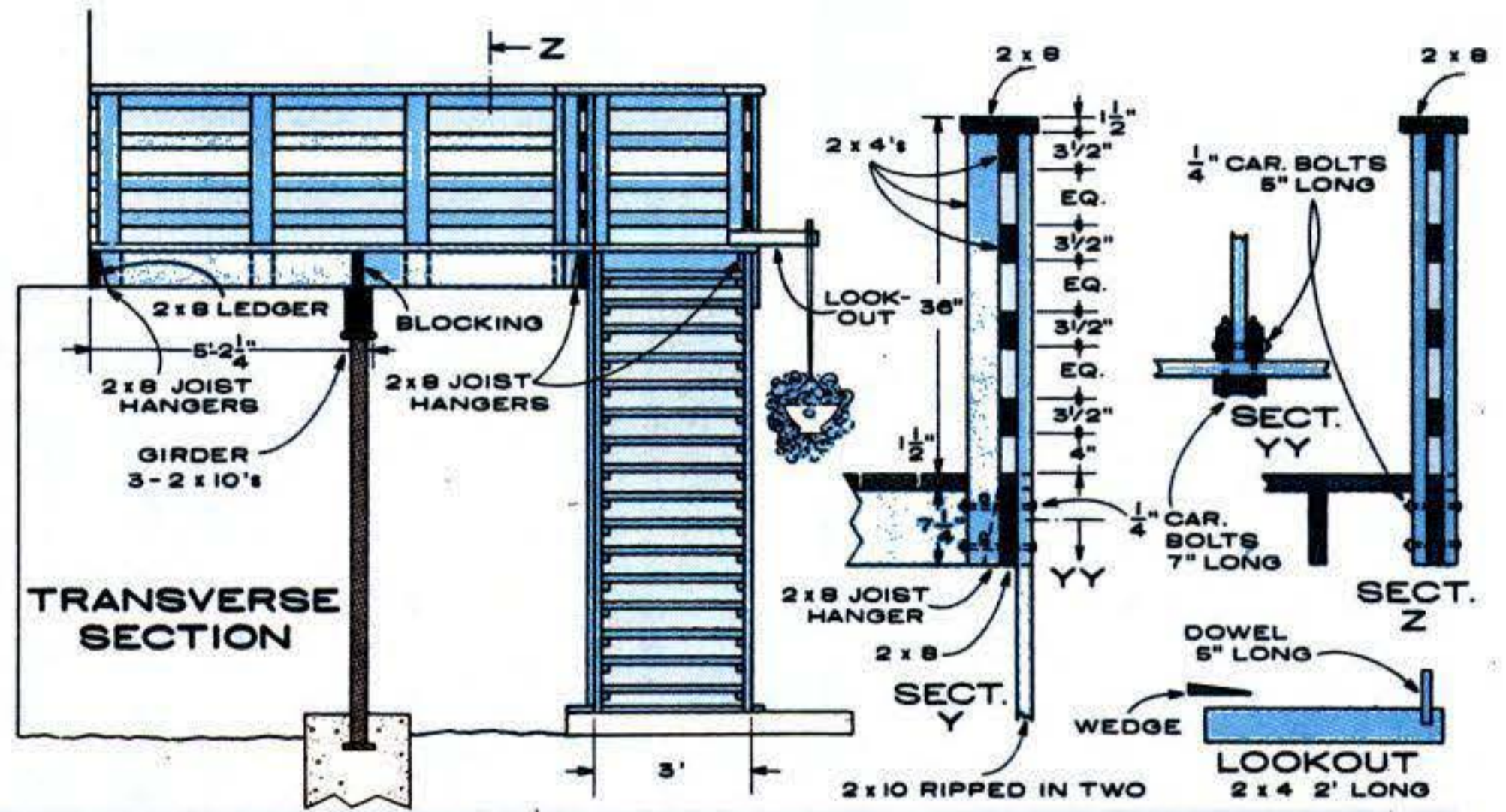
The plant hangers are made from 2x4s drilled for a one-inch-diameter dowel; they are wedged into the cutouts drilled and chiseled through the railing posts. (For a novel treatment of hanging plants, see "Shop Talk.")

The natural finish of the redwood can be maintained with clear water repellent and mildewcide applied immediately after completion and every two years thereafter. This tends to mellow the color to a shade of buckskin tan. If left unfinished, or if the water-repellent treatment is discon-

tinued, the deck will gradually weather to a driftwood gray. If you want a permanent redwood color (or some other color tone), use a lightly pigmented deck stain or bleach. **E**

MATERIALS LIST FOR DECK

- All lumber is construction-grade heart redwood.
Stringers and treads: five 2x12s, each 20 ft. long; three 2x12s, each 16 ft. long
Girder: five 2x10s, each 20 ft. long; two 2x10s, each 12 ft. long
Short joists, ledger, deck header, shelf, and railing: 28 2x8s, each 20 ft. long
Long joists: seven 2x8s, each 14 ft. long
Stringer supports and post fasciae: four 2x10s, each 20 ft. long
Posts and rails: 23 2x4s, each 20 ft. long; six 2x4s, each 18 ft. long
Decking: 42 2x6s, each 20 ft. long
Deck bracing: two 1x6s, each 20 ft. long





Build your own house

—they'll teach you how at owner-builder schools

Hands-on training teams up with classroom lessons. Here's our report

By **KENNETH LELEN**

The do-it-yourself movement that continues to sweep the country isn't restricted to home repair. Each year about 200,000 new homes are built by people who do the work themselves or act as their own general contractor. For these would-be home builders, there are now owner-builder schools that give hands-on knowledge of construction principles and skills.

Already there are more than 30 such schools in the U.S., including Shelter Institute, which was reported on in this magazine in September 1977. About 10 new schools are expected to open this year.

Owner-builder schools offer summer residency programs, weekday-evening seminars, and Saturday sessions (see our directory for details).

The courses explain local-code requirements, essential tools, and common building materials. The instructors, who are architects, builders, and contractors, also give helpful tips on estimating, financing, and managing subcontractors.

"The owner-builder-school movement began in the early 1970s as part of the back-to-the-land, self-sufficiency movement," explained Jim Hatch, director of Maine's Cornerstones School. "But today we see more middle-class people who are interested in

Continued

Raising the west wall, Cornerstones students hoist it onto the second-story deck. Students also cut and raised roof rafters during the advanced home-building course.



understanding and working on their own shelter."

To find out about this growing trend, I signed up for a typical two-week Cornerstones course this past summer.

Learning by doing

At Cornerstones, as at the other schools, students split their time between classroom instruction and actual work at job sites.

Hands-on training is by far the most exciting portion of any school's program. It typically covers rough and finish carpentry, mechanical systems, foundations, roofing, siding, and insulation, as well as the selection and use of power and hand tools.

Students can save 20 to 50 percent of conventional home-building costs, it's claimed, depending on how much they do themselves. But saving money is not the only motive for attending an owner-builder school. Many people also want the satisfaction of designing and managing their own construction projects.

"People feel the 'experts' have taken over," said Cornerstones' Hatch. "Architects and builders, like doctors, write prescriptions for housing, and people blithely write checks to pay for it. Many are fed up with professionals who don't allow them to participate in building their own homes."

But the real value of owner-builder schools may be the self-reliance and confidence that students gain rather than the construction skills that they could pick up in other ways.

"Owner-builder schools help people decide the level of participation they can handle," Hatch said. "We see many people who don't intend to drive every nail themselves but want to supervise—personally and intelligently—their home-building project. They frequently hire an experienced carpenter and act as his helper throughout the job."

Prior to last summer's course, my construction experience included remodeling two homes of my own and managing nine new-home or renovation projects for others.

At Cornerstones, my classmates included a truck driver from New Mexico, a housewife from Colorado, a mail carrier from Indiana, a father-and-son team from New Hampshire, two couples, and several single men and women. In all, we numbered 16 people. Construction know-how varied from "very little, mostly repairs around the house," as one student put it, to "experience in carpentry work on my friend's house and my own garage," according to another.

PS directory of owner-builder schools

School	Programs	Cost Per Person (\$)	Cost Per Couple (\$)
Building Resources 121 Tremont St. Hartford CT 06105 (203) 233-5165	8-week courses in new-home construction and old-house renovation	75	125
Cathedralite Dome Building Seminars 820 Bay Ave. Capitola CA 95010 (408) 462-2210	Weekend course in design and construction of geodesic domes; contact firm for schedule and prices of upcoming seminars		
Colorado Owner Builder Center Box 12061 Boulder CO 80303 (303) 449-6126	8-week course on home building Saturday seminars, various topics Weekend hands-on workshops 3-day adobe-construction workshop	300 40 95 150	490
Cornerstone School 21 Stanwood St. Brunswick ME 04011 (207) 729-6701	3-week house building 2-week advanced house building and finish carpentry House building for women 3-week renovation and energy-auditor training Timber-frame raising Energy-auditor training Passive solar design for professionals 2-week finish carpentry for women	495 350 425 675 300 450 195 325	795 700
Cosanti Foundation 6433 Doubletree Rd. Scottsdale AZ 85253 (602) 948-6145	5-week hands-on workshop in construction and community design	400	
Denver Owner Builder Center 5835 W. 6th Ave. Lakewood CO 80214 (303) 232-8709	8-week course on house building 8-week course on remodeling Saturday seminars and hands-on workshops	340 340 50	540 540 90
Dome School 5955 Otter View Circle White Bear Lake MN 55110 (612) 429-1777	Weekend course on design and construction of geodesic-dome homes	125	150
Domestic Technology Institute Box 2043 Evergreen CO 80439 (303) 674-1597	1- and 2-day workshops in passive-solar and other renewable-energy systems	40-75	
Dovetail Ltd. Box 1496 Boulder CO 80306 (303) 449-2681	Conducts timber-frame-raising courses in various locations throughout the country	175	
Durango Owner Builder Center Box 3447 Durango CO 81301 (303) 247-2417	8-week course on house building 8-session remodeling packages	295 195	445 295
Earthwood Building School Rte. 1, Box 105 West Chazy NY 12992 (518) 493-7744	Workshops in home design, earth-sheltered housing, cordwood masonry construction techniques, and wind power: 1-day 2-day 3-day	60 100 200	90 150 300
Eastfield Village Box 145 RFD East Nassau NY 12062 (518) 766-2422	Courses in historic preservation and Early American Building crafts: in 1- to 5-day classes	110 235	
Georgia Solar Coalition Box 5506 Atlanta GA 30307 (404) 525-7657	9-day course in designing and building an energy-efficient house 9-day solar building institute 6-evening solar design	250 250 80	375 375
Heartwood Owner-Builder School Johnson Rd. Washington MA 01235 (413) 623-6677	3-week summer residency program in house building 1-week remodeling course 1-week cabinetmaking course Earth-sheltered-housing workshop	475 200 200 60	800 350
Home Building Institute 6455 South Central Ave. Chicago IL 60638 (312) 735-3343	12-week courses in new-home construction and old-house renovation 6-week course on old-house wiring 10-week hands-on workshop Ongoing project: "our old house"	295 115 250 395	345 165 375 550
Lady Carpenter Institute 25 St. Mark's Pl. New York NY 10003 (212) 228-2520	6-8-week courses in home maintenance and building topics, including electrical, plumbing, carpentry, painting, masonry, and architectural moldings	250-350	
Legendary Log Home School Box 1150 Sisters OR 97759 (503) 549-7191	2-week residency course in log-home-construction techniques 1-week course on building roof structures	400 200	600 300
Mackie School of Log Building Box 1205 Prince George, B.C. Canada V2L 4V3 (604) 964-4515	4-week residency program in log-home construction 3-week residency program in piece-in-piece log-home construction 3-week residency program (for couples only) in log-home building 4-week residency course on finishing a log-home-building project	600 450 600	600
Michigan Owner Builder Center 1505 E. 11 Mile Rd. Royal Oak MI 48067 (313) 545-7033	8-week course on home building 8-week course on remodeling	275 225	400 350

School	Programs	Cost Per Person (\$)	Cost Per Couple (\$)
Minnesota Trailbound School of Log Building 3544 1/2 Grand Ave. Minneapolis MN 55408 (612) 822-5955	10-day residency course in the scribe-fit method of log-home building	300	500
New Homestead School Rte. 1 Murphy NC 28906 (704) 837-8873	5-day course on solar renovation and retrofit 5-day course on country woodcraft and chair making 3-day course on passive solar design 3-day course on organic gardening 2-week course on owner-built shelter 5-day course on log and post-and-beam construction	80 80 75 50 155 80	
Northwest Building Institute 5410 S.W. Dover La. Portland OR 97225 (503) 244-8266	3-week house-building course	295	450
Northwest Owner Builder Center 1139 34th Ave. Seattle WA 98121 (206) 324-9559	8-week house-building course 7-week remodeling course 5-week residential-design course 1-day work sessions on various topics	225 210 150 45	
Original Log House Construction School 22203 State Rte. 203 Monroe WA 98272 (206) 885-4972	Weekend courses in log-home-construction techniques	n.a.	
Owner Builder Center 1516 Fifth St. Berkeley CA 94710 (415) 526-9222 or (800) 547-5995	2-week summer residency home-building course 3-week summer residency home-building course 7-week house-building or remodeling course 2-week home-repairs and -improvement class Hands-on workshops: 1-day 2-day 1-day seminars on various home-building topics	500 600 295 95 55 105 40	750 900 445 145
Owner Builder Center of Fairfield/Westchester Counties 335 Post Rd. W. Westpoint CT 06880 (203) 726-7095	16-session home-construction course 14-session remodeling course (hands-on workshops)	320 280	495 450
Owner Builder Center at Miami-Dade Community College 11011 S.W. 104 St. Miami FL 33176 (305) 596-1018	8-week course on home building 7-week course on remodeling (hands-on workshops)	300 250 50	450 375 75
Owner Builder Center Pacific Box 10603 Honolulu HI 96816 (808) 523-8056	6-week remodeling class Home-building seminars	250 40	385 60
Owner Builder Center of Southern California 361 E. Magnolia Blvd. Burbank CA 91502 (213) 841-1942	7-week course on house building 7-week course on remodeling 2-day hands-on courses	295 295 95	450 450 150
Riverbend Timber Framing 415 East Adrian Blissfield MI 49228 (517) 486-4566	1-week program in timber-frame raising	150	
Shelter Institute 38 Center St. Bath ME 04530 (207) 442-7938	3-week house building 2-week compressed course 15-week + 2-Saturday course	400 350 350	650 550 550
Southwest Solaradobe School Box 7460 Old Albuquerque Station Albuquerque NM 87194 (505) 842-0342	Adobe-construction course; contact school for additional information		
Tree House Design 15083 Marine Dr. White Rock, B.C. Canada V4B 1C5 (604) 536-9624	The Plan Shop: house plans, books, magazines, workshops, seminars, and audio-visuals for owner-builders	n.a.	
Windstar Foundation Box 178 Snowmass CO 81654 (303) 927-4777	Summer residency workshops on appropriate technology, greenhouse construction, and gardening	n.a.	
Pat Wolfe Log Homes RR #1 McDonalds Corners, Ontario Canada K0G 1M0 (613) 278-2009	4-week course on log-home-building techniques 1-week summer course on log-home building 10-week summer course on log-home building	400 120 1,000	
Yestermorrow Box 76A Warren VT 05674 (802) 496-5545	2-week home-building course 2-week renovation course 2-week construction course for professionals	375 375 375	563 563

Most of my classmates wanted to build or remodel their own homes, and took the Cornerstones School program in order to prepare themselves for the project. Three people were seriously considering home building as an occupation, and the program was their introduction to the field.

The price of the Cornerstones School course in energy-efficient house building was \$450 per person or \$750 per couple. The course had four elements:

- Morning classes on home-building basics.
- Afternoon training in construction skills at an actual job site.
- Workshops on site selection, tool use, wall and roof framing methods, and installing plumbing and electrical systems.
- Tours of nearby owner-built homes to see how other people had solved their design, construction, and budget problems.

For an extra \$75 (\$125 per couple) the school offered six evening seminars on house design and plans drawing. About half of the class signed up for these seminars, which were conducted by architectural designer Steve Oransky.

Morning classes were led by carpenter and energy auditor Jim Young, who detailed the major structural elements and construction tasks needed to build a house.

Young described five types of foundation systems—full basement, perimeter wall, structural slab, slab with wood floor, and pier. "Your choice depends on your budget, building skills, house style, soil conditions, and available materials," he told us, going on to list the construction methods, costs, advantages, and disadvantages of each.

Owner-builders usually hire a contractor to pour the foundation, Young noted. "But if you want to save the cost of a contractor, consider digging and pouring your own pier foundation," he said. He discussed three types of pier foundations—Sonotube (cardboard concrete forms you buy ready-made), concrete, and telephone pole—then showed us two inexpensive ways to build wooden forms for concrete piers.

We learned how design decisions affect the construction process and expense of a home-building project. "For example, the location of a basement window can affect the location of a beam pocket in the foundation wall," Young said. "This decision affects the location, size, and cost of the joists that span the foundation and hold up the house."

Continued

The classroom work steered us through the maze of builder's jargon. This was handy at the job site, where we had to work with many different types of dimensional lumber ranging from the familiar stud, rafter, and joist to bridging (joist braces).

Classroom instruction also covered the evolution of structural wall systems from post-and-beam and Eastern braced frame to balloon and platform frames. We discussed the design, sizing, and cost of septic, plumbing, electrical, and heating systems; and we learned how to install insulation, vapor barriers, doors, and windows.

Building a house

While morning classes delivered information, our job-site training provided valuable hands-on experience. During 11 afternoons our class erected the second-floor deck, exterior and partition walls, rafters, and roof of a two-story house that had been started by the previous class.

The work was supervised by Lee Kuzmitski, a carpenter and former contractor, who organized us into teams. I worked with a five-person team that assembled the lumber, hauled it up to the second-story deck,

then measured and laid out the second-story south wall. Another team nailed foam insulation and exterior sheathing onto the first-floor walls. Meanwhile, a three-man team built the entire west wall on the ground. Late one afternoon everyone raised this into place.

As job-site problems cropped up, our teams solved them just as we would on our own projects. We resolved many ambiguities in the blueprints when dimensions didn't add up. We also learned to correct our own construction mistakes without tearing down entire sections of work.

We picked up lots of carpentry tricks, too. We learned how to measure and mark the bottom plate of a stud wall so other student-builders could "read" and erect the wall. When attaching partition walls to exterior walls, we allowed nailing space for drywall installation. We also left nailing space for trimmers and curtains when building a window's rough opening in a stud wall.

We learned how to build stud corners that reduced lumber use yet allowed space for insulation. We "flushed up" walls by driving nails laterally from one stud to another.

And we squared up completed frame-wall sections by pulling the diagonals with our tape measures.

Erecting an actual structure and solving its problems reinforced the classroom lessons. Lectures on heat transfer through building materials and moisture degradation of insulation were driven home the afternoon we taped joints in the south wall's vapor barrier. When we measured, cut, and raised roof rafters, we were reminded of the morning talks on building loads and rafter sizing.

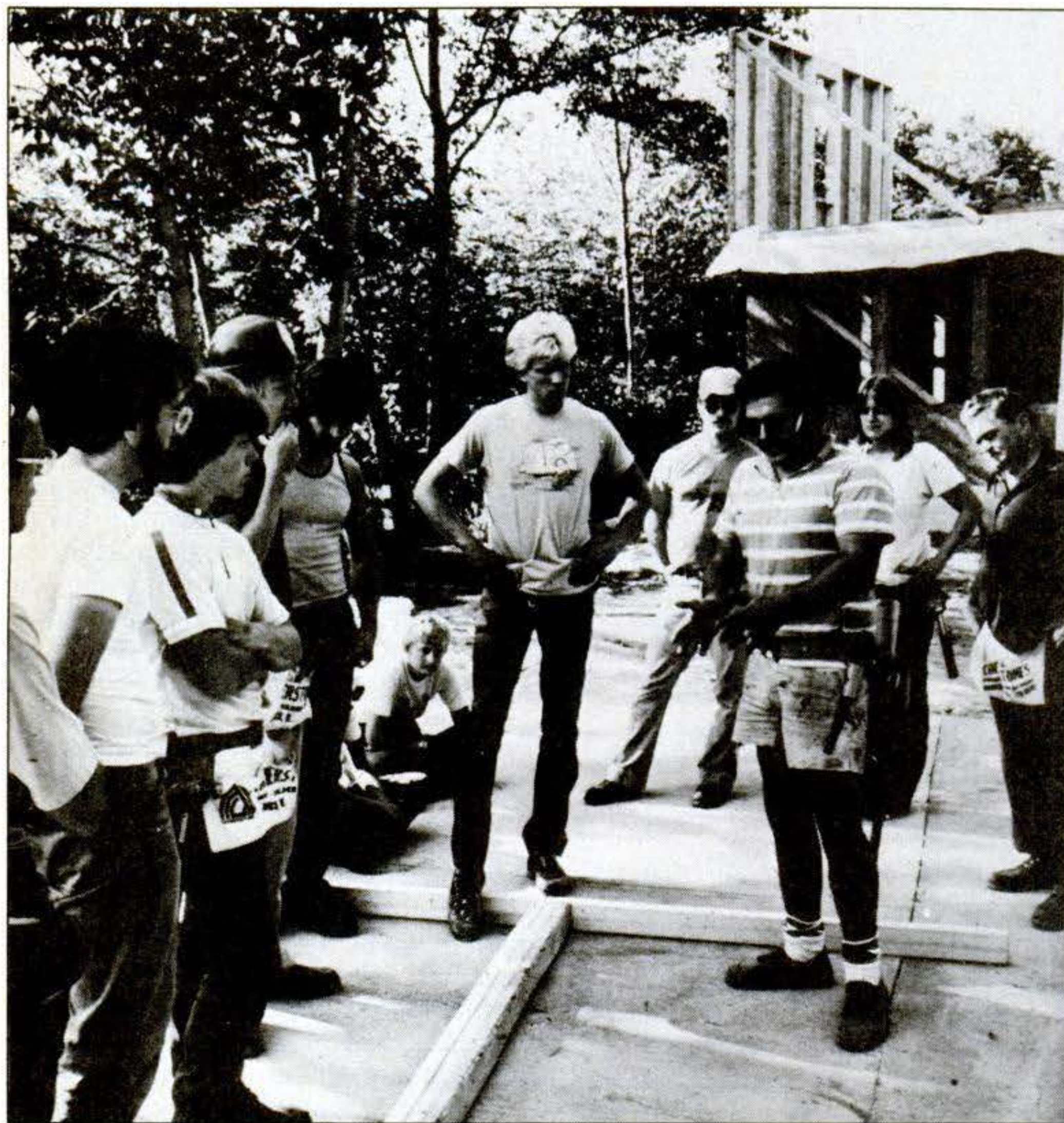
Near the end of the second week, we learned about several energy-efficient home-building systems. Classroom instruction covered super-insulated wall construction, computer programs for home energy audits, solar greenhouses for space heating, breadbox heaters for domestic hot water, and the use of heat exchangers to maintain indoor-air quality in an energy-tight home.

Now my classmates had informed opinions about these systems. They could weigh design alternatives and construction methods against anticipated budgets, climate restrictions, or building plans. Their knowledge and experience had grown enough to generate confidence in their decisions.

One criticism of the Cornerstones School program: Though it was long on technical information and building expertise, it was short on developing project-management skills. In my opinion, we received skimpy advice on obtaining and evaluating estimates, coordinating subcontractors, and managing a building budget. Developing these skills should have held a higher priority in the course.

I also think the design seminars should have been mandatory for all. These allowed people to examine their housing needs and desires and to try their hands at drawing house plans. They are important lessons for all owner-builders, whether they buy an architect's design or create their own dream-house plans.

Caveats aside, if you plan to build or remodel your own home, consider taking a course at one of the owner-builder schools listed in our directory. No two are alike, so contact several. All schools emphasize the use of energy-efficient designs and indigenous or locally available materials. But several schools offer training in the specialized techniques of historic preservation, rural homesteading, earth-sheltered housing, adobe and rammed-earth buildings, geodesic domes, log homes, or timber-framed structures. You should be able to find one that offers training to match your needs. ■



Cornerstones School instructor Lee Kuzmitski reviews the methods used to build stud walls square and flush. Students'

handiwork—a half-finished house with the second-story west wall braced in place—is visible at the rear in photo.

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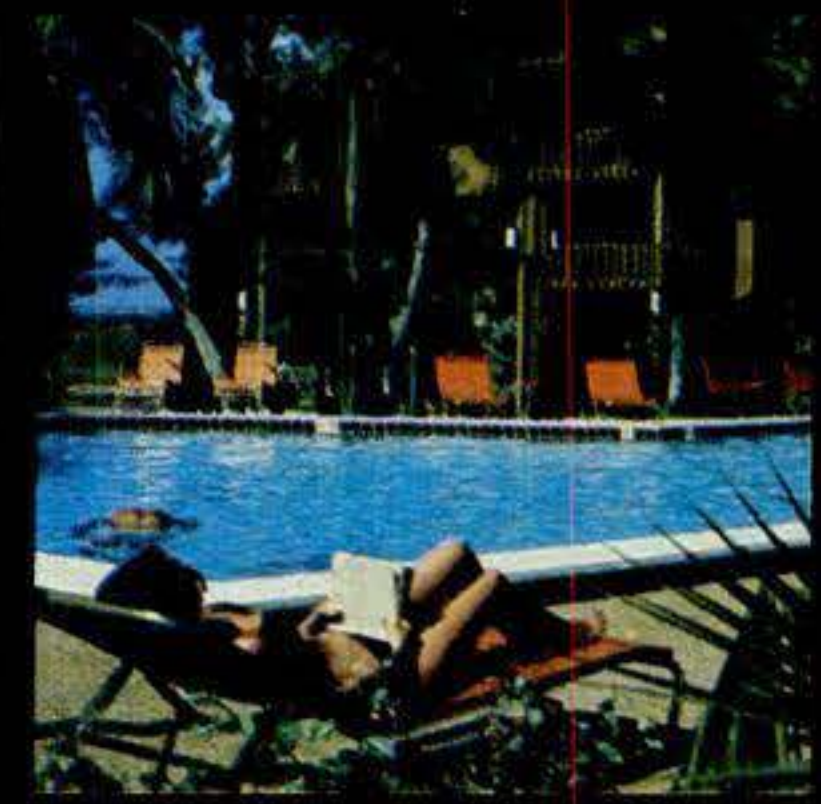
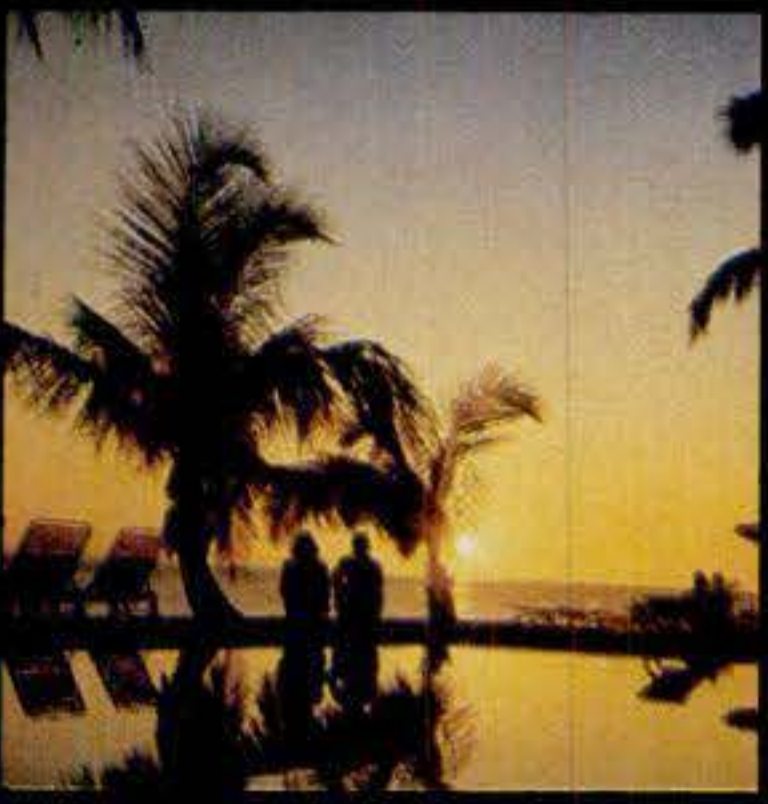
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Beginning here: Our spring hardware section groups together information on home-maintenance tools you'll find at your local home center or hardware store

For your table saw: Build this do-anything master jig

By R. J. DE CRISTOFORO

Ever wish you could make your table saw do more? With a master jig, you can. The multipurpose jig shown here turns your saw into a versatile yet precise tool. In fact, once you use it for a while, you'll wonder how you managed without it.

Its secret? Since the work and jig table move together, sawing is easier and more

accurate. And attachments for mitering, feathering, splining, tenoning, slotting, and many other standard—and not so standard—operations make it one of the most useful accessories going.

The jig is shown on a Rockwell 10-inch Unisaw, which has a 27-by-36-inch table. Many other nine- and 10-inch machines (the most popular sizes) are similar, so the dimensions in the drawings are generally

applicable. The only tailoring you need to do is on the dimensions of the bars and their placement on the main table. The bars slide in the table slots, and their positions vary from saw to saw.

The thickness of the sliding table reduces the maximum blade projection, but since projection is normally 2¾ to 3½ inches, reducing it by ½ inch isn't criti-

Continued

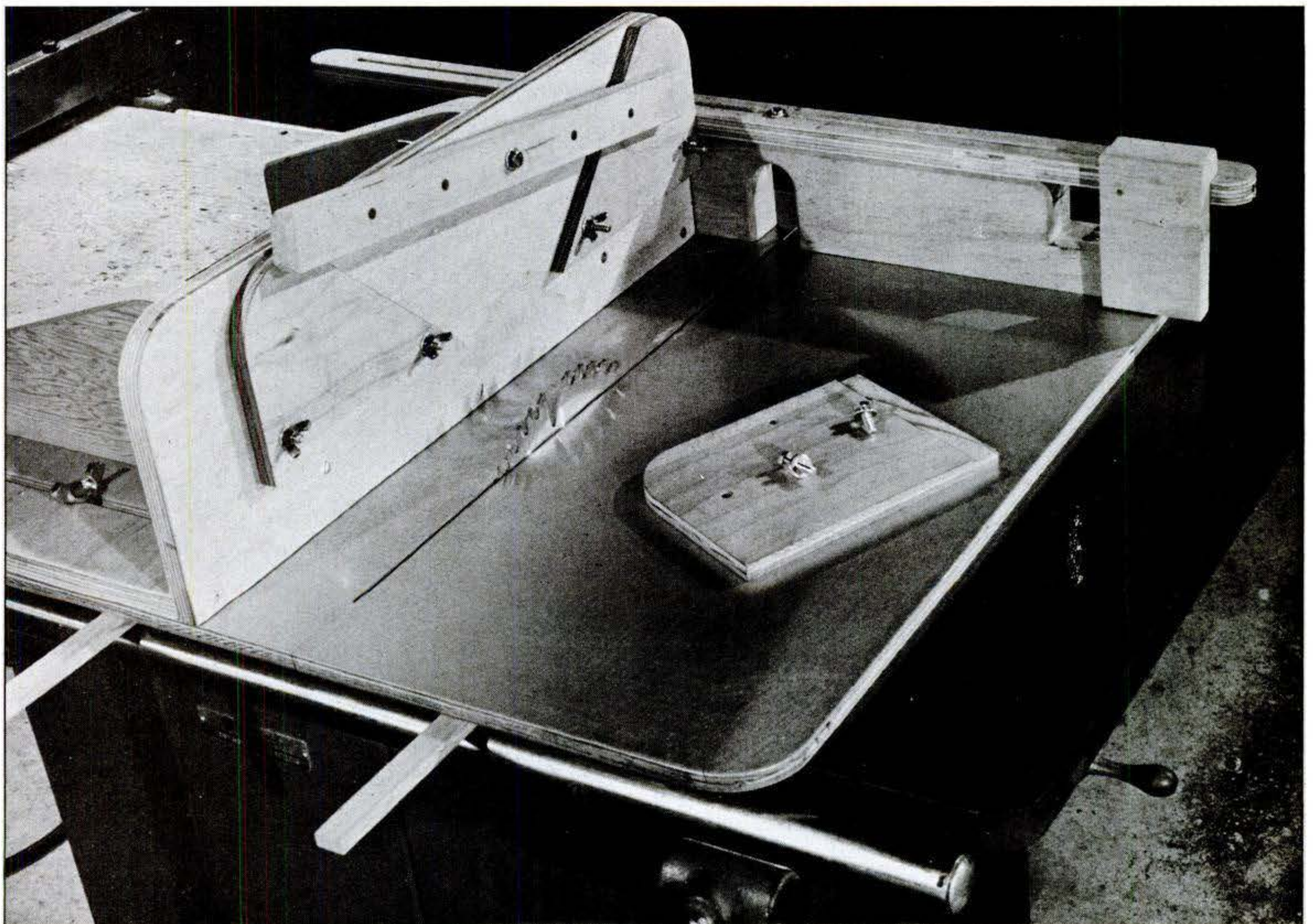


Table-saw master jig consists of an aluminum-veneered sliding table with attachments for a

variety of shop jobs. Shown above are the crosscut fence, adjustable stop, vertical work

support, vertical miter guides, hold-down, and right-angle guide (mounted on table).

Master jig

[Continued]

cal; it'll still cut most standard stock.

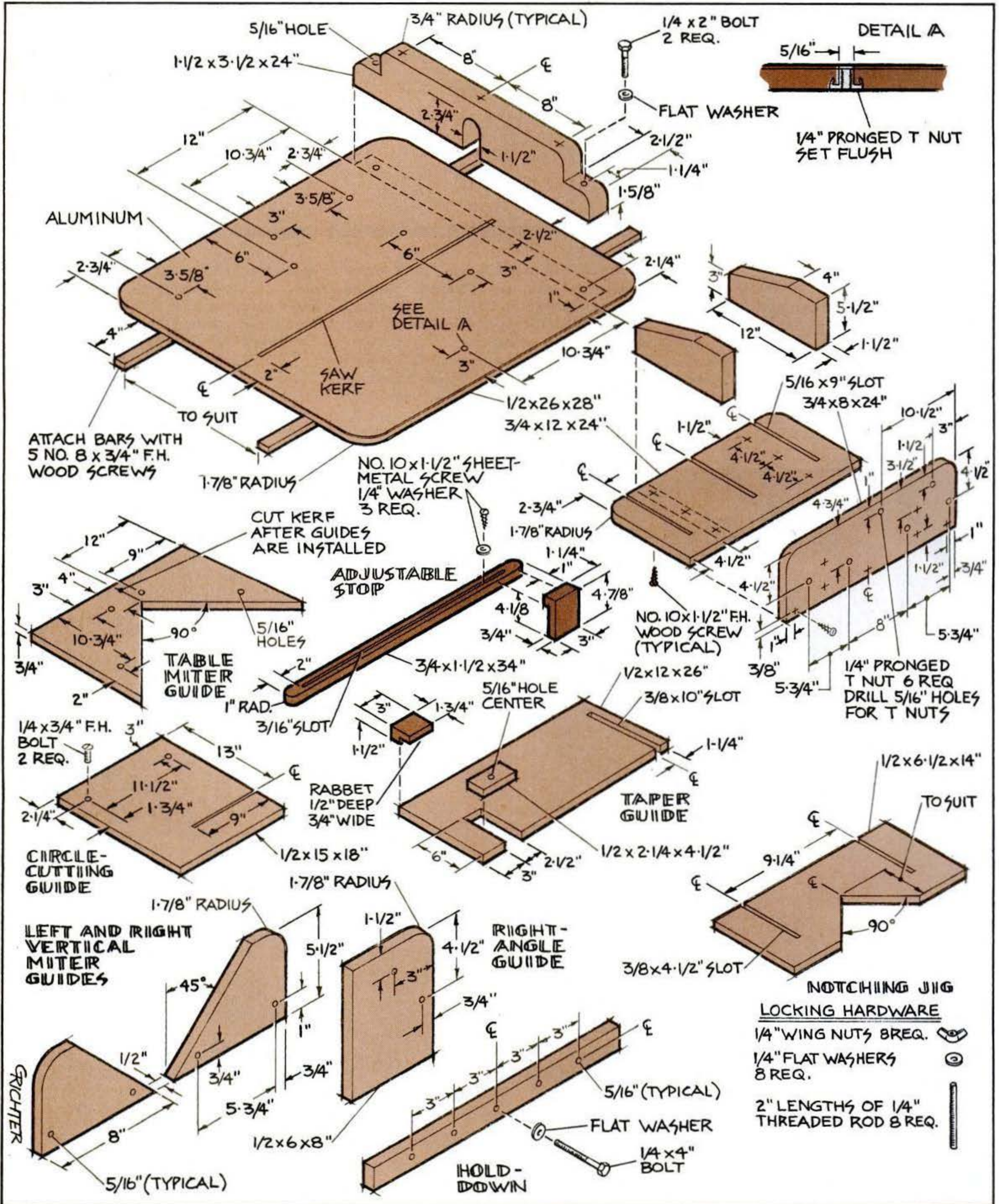
Accurate construction of the jig is important, although some tolerances are built in. For example, the fastening holes in the attachments are $\frac{5}{16}$ inch in diameter, even though they are secured with $\frac{1}{4}$ -inch locking hardware threaded into $\frac{1}{4}$ -inch T nuts. This permits $\frac{1}{16}$ -inch adjustments.

Use a good grade of maple or birch plywood. After each part has been sized and the corners rounded, use fine sandpaper to smooth surfaces and edges. For the table

top, cut a sheet of aluminum to size and bond it to the table using contact cement.

Next, shape the bars to fit your table slots. Sand the bars so that they slide easily in the table slots without wobble. Put

Continued



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For more information, or the name of your nearest dealer, call 800-447-9126 toll free (800-322-6796 in Illinois) or write John Deere, Dept. 50, Moline, Illinois 61265.



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Master jig

[Continued]

the bars in position, then place the sliding table so it's centered over the saw blade. Make sure its edges are parallel to the table slots. Use C-clamps to hold the bars to the sliding table, and drive a short brad to keep them in place. Repeat this procedure at the opposite ends of the bars, and permanently attach them with No.8-by- $\frac{3}{4}$ -inch flathead wood screws. Be sure to drill shank holes for the screws; if you don't, driving the screws may spread the bars and cause them to fit too tightly in the table slots.

Next, form the saw kerf. Work with a good saw blade, one that you will always use with the master jig. Don't use a con-

ventional hollow-ground blade—the best kind to use is a carbide-tipped combination blade.

With the machine off, set the blade to its lowest point and put the sliding table in place. Turn on the machine and slowly raise the blade until it cuts through the sliding table, then move the table to lengthen the kerf.

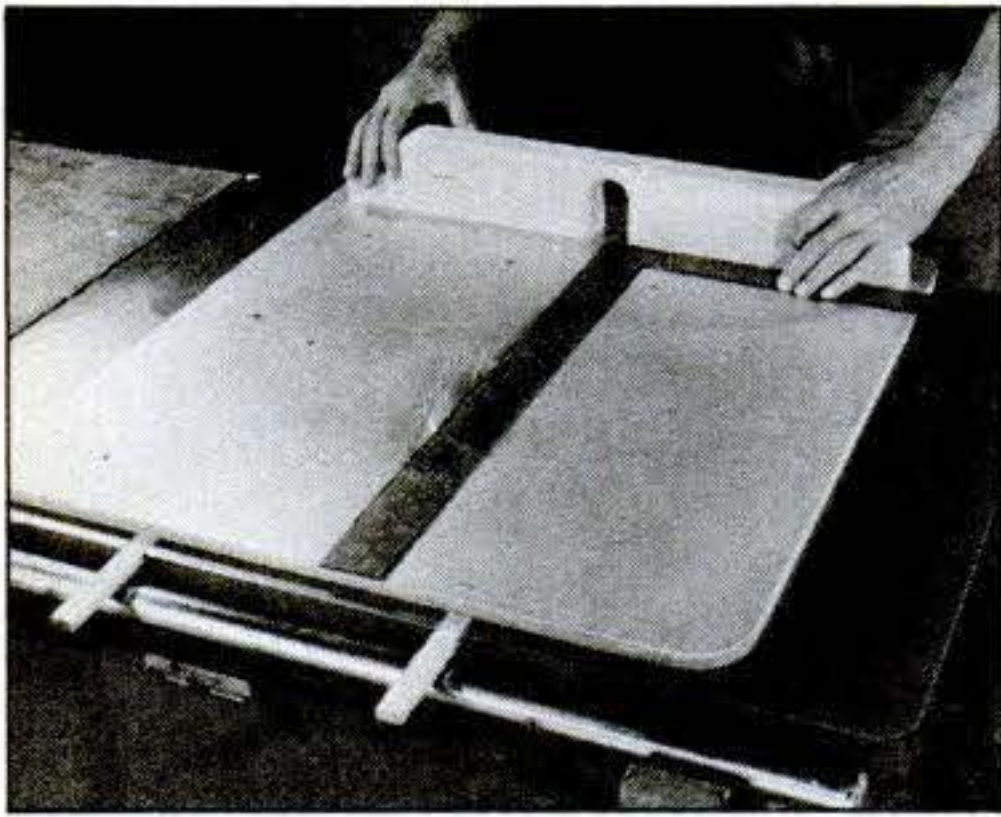
Carefully mark the locations for all the T nuts needed for the table. Work with a scribe, but mark lightly so you don't mar the aluminum. Mark the hole locations with a prick punch and then drill a $\frac{1}{16}$ -inch hole at each mark. Use a $\frac{3}{4}$ -inch brad-point bit on the underside to form a $\frac{1}{16}$ -

inch-deep counterbore and then, from the top side, open up each of the holes to $\frac{5}{16}$ inch.

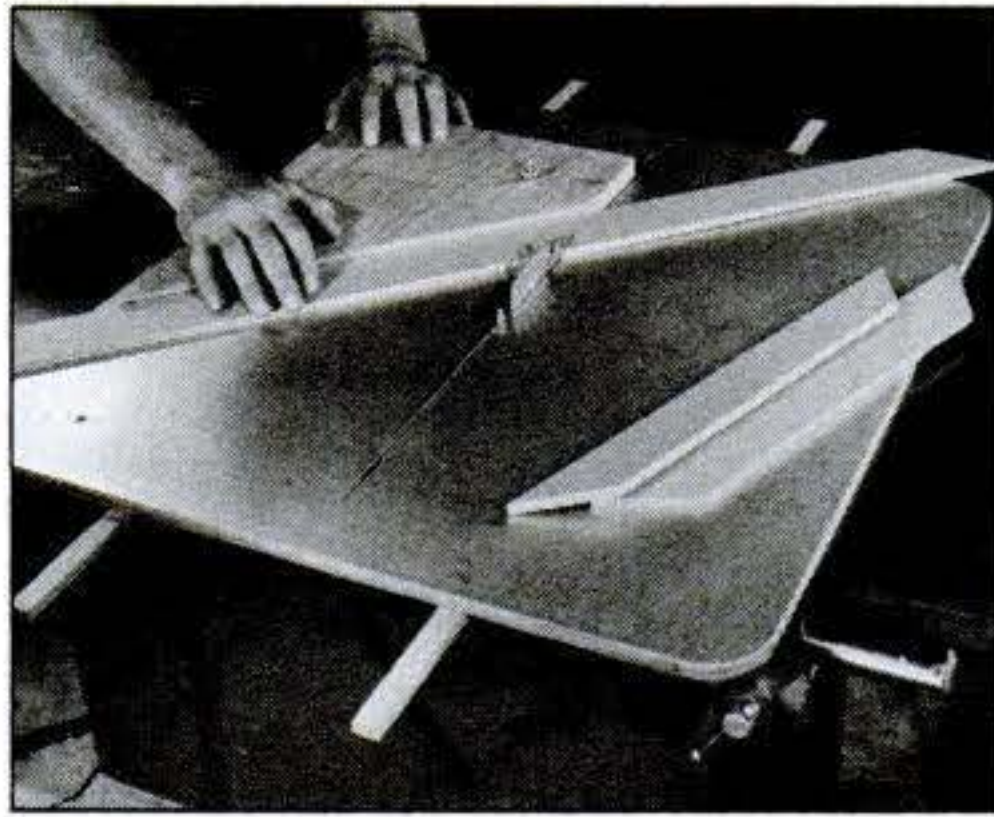
Install the $\frac{1}{4}$ -inch T nuts by tapping them into place with a hammer. They must be flush with, or slightly below, the surface of the plywood.

Shape the crosscut fence, and then drill the $\frac{5}{16}$ -inch holes for the bolts used to secure the fence to the table. The three hole locations on top of the fence are for the screws that hold the adjustable stop when it's in use.

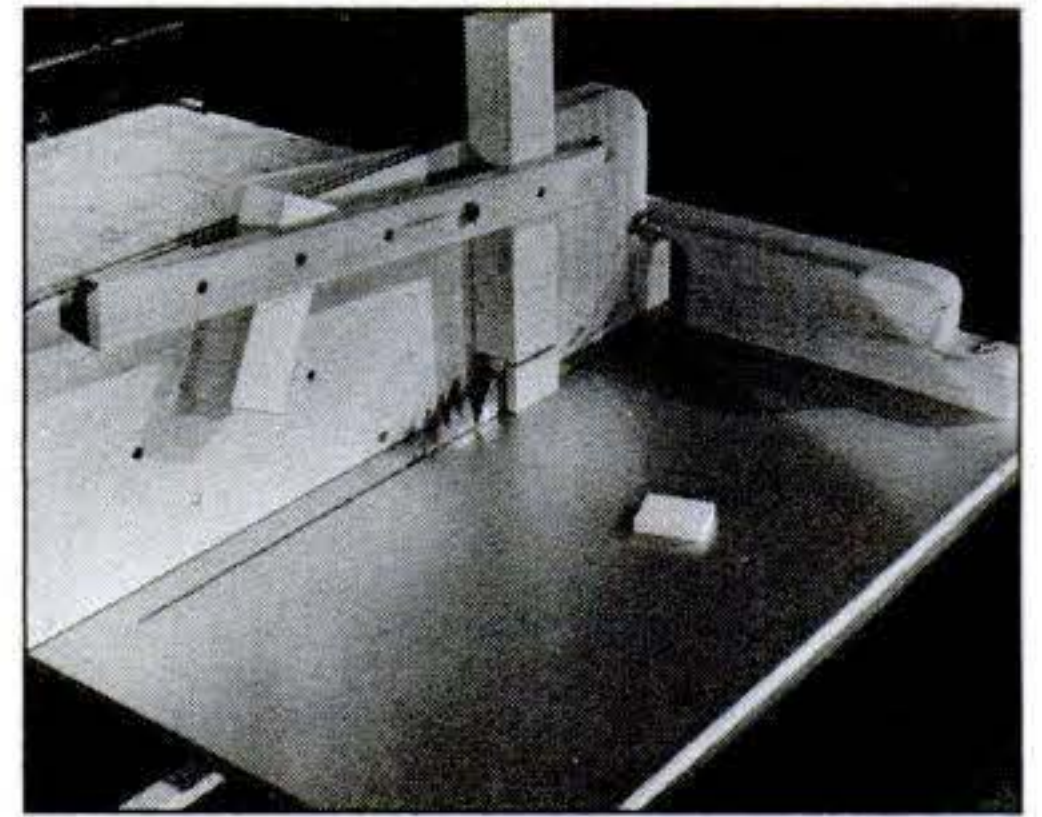
Rather than being a one-piece V-block, the miter guides are made in two pieces. You can use both pieces when mitering



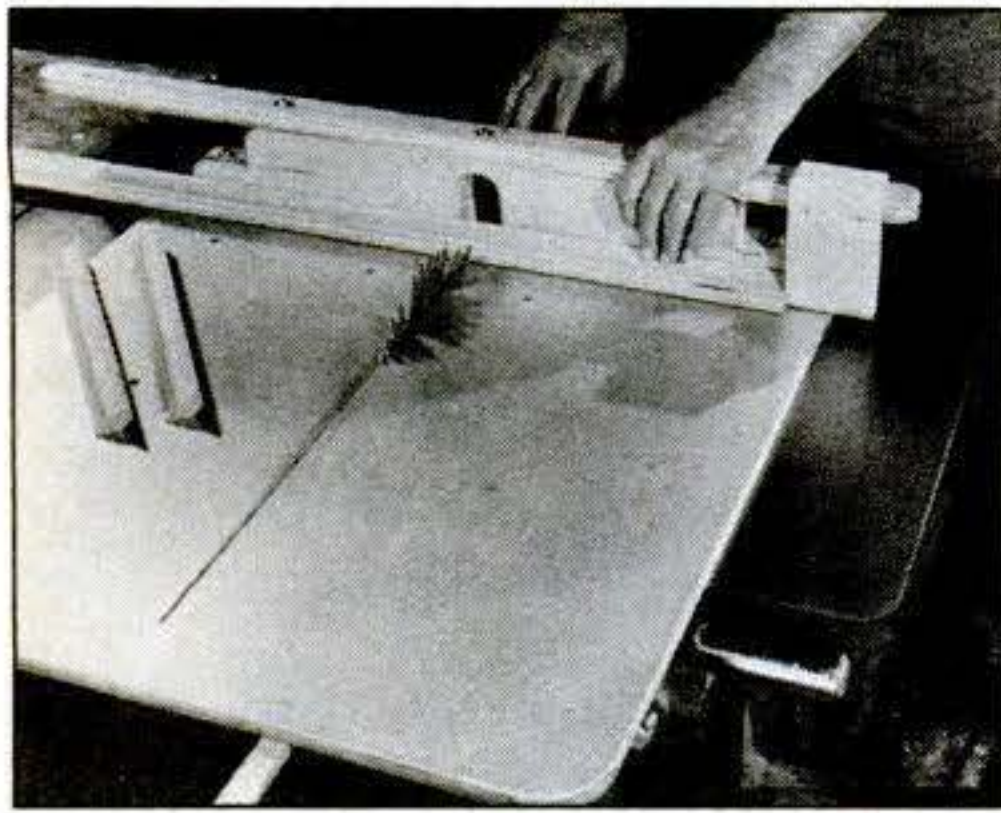
Use a square to set crosscut fence 90 degrees to the blade before tightening fence bolts. Difference between $\frac{1}{4}$ -in. locking bolt and $\frac{5}{16}$ -in. holes in fence allows for minor adjustment.



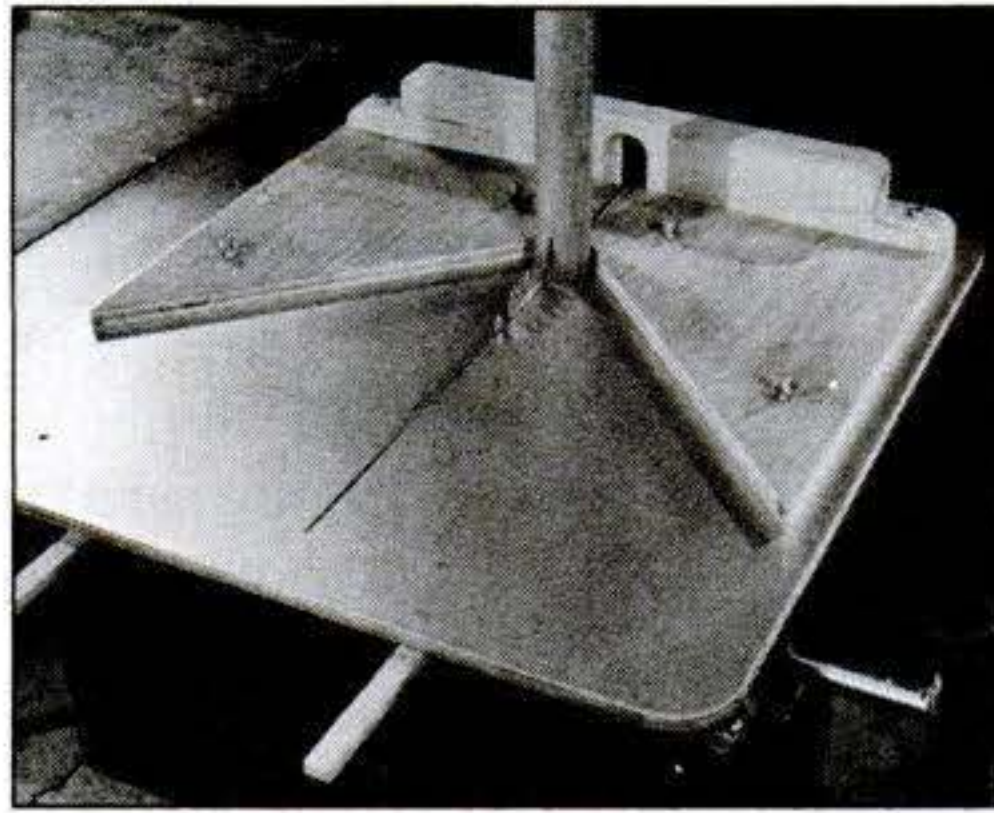
To make consecutive cuts along a single length of stock, remove the crosscut fence and work with one guide. If stock can't be turned over, you can alternate left- and right-hand guides.



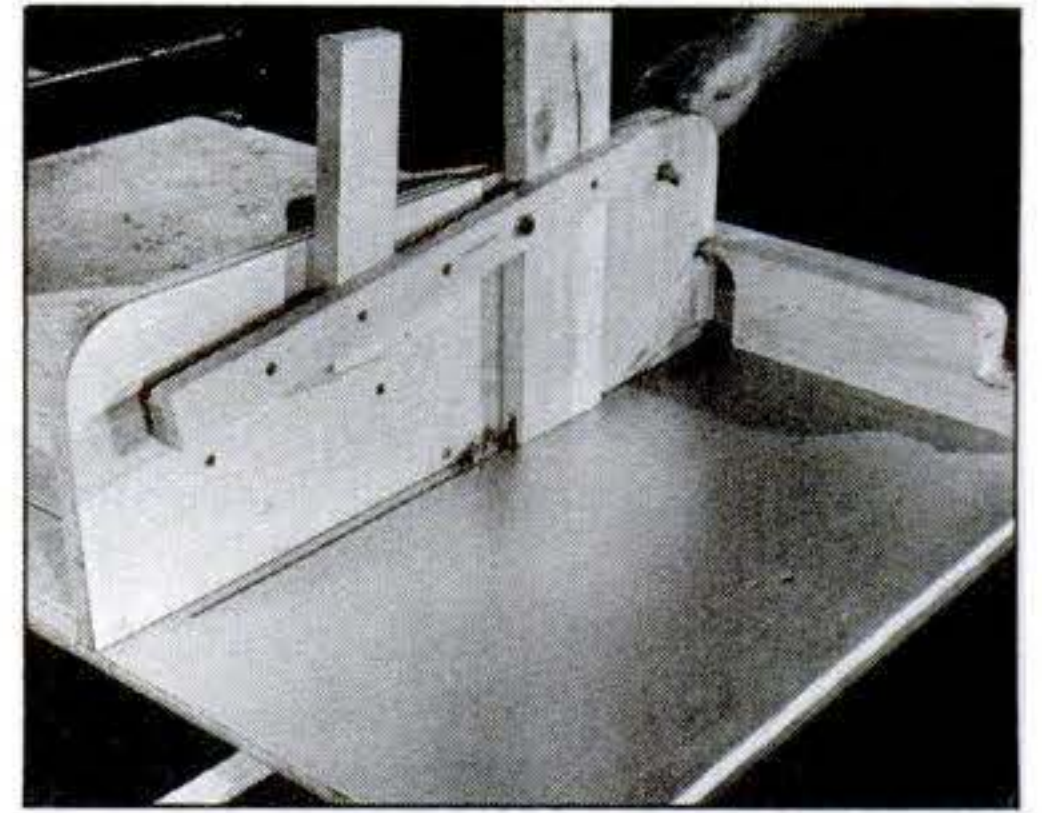
To form tenon, first make shoulder cuts and set up as shown for cheek cuts. For second cuts on each you just reverse stock's position. Use same-size scrap under free end of hold-down.



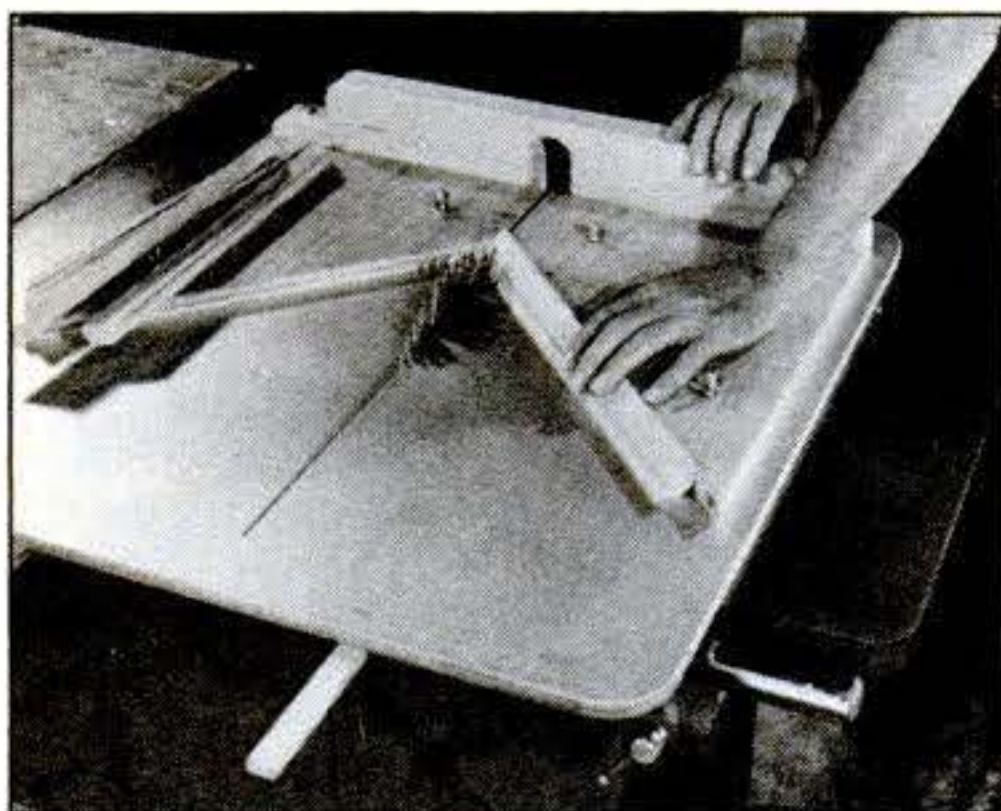
Use the adjustable stop to saw multiple pieces to the same length. This attachment permits cuts up to 28 in. long. Hold work firmly and return to starting position before removing.



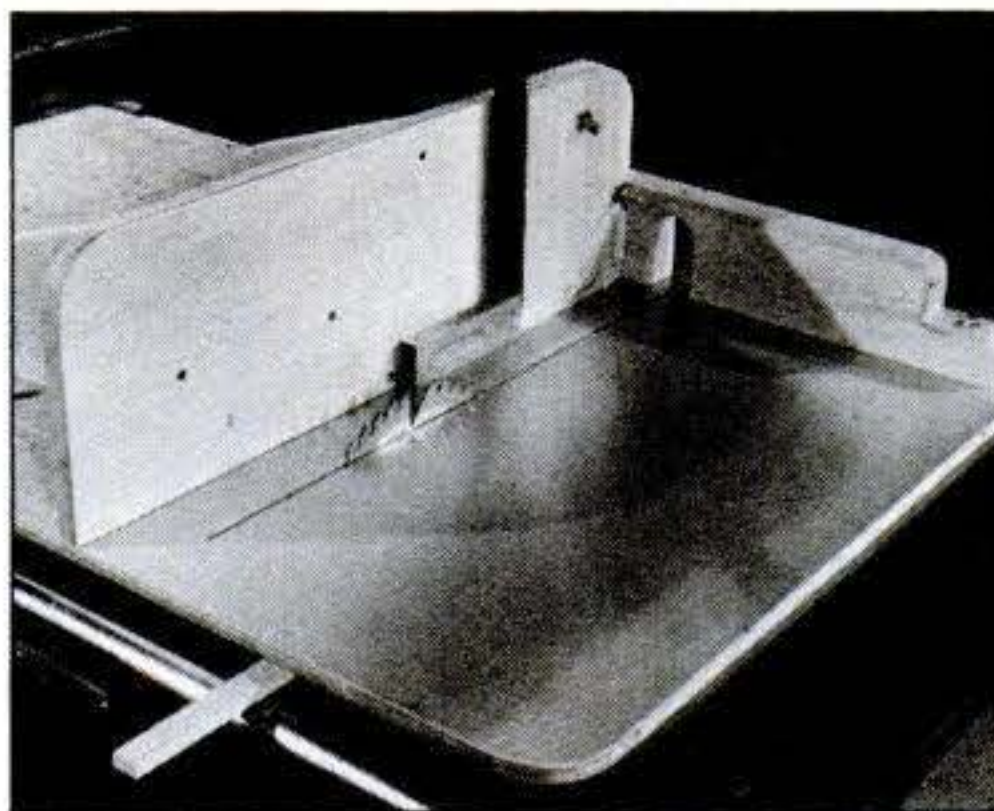
Use table miter guides to cut slots in rounds. To mark center of round or square stock, lower blade to minimum and make two cuts at right angles; center is where the kerfs intersect.



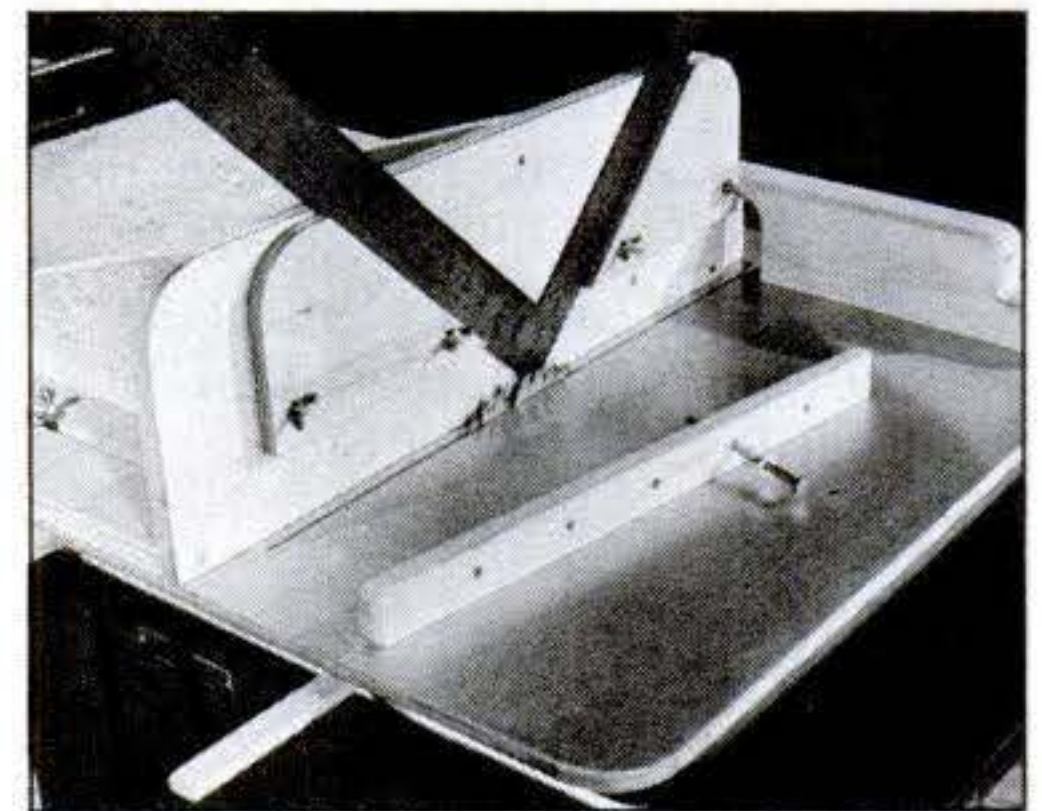
To form a slot in narrow work, set the vertical work support to the width you want the shoulder of the slot to be. Make a pass, reverse stock, and make another—the slot will be centered.



With table miter guides in place you can form accurate miters on pre-cut stock—even molding, since you can cut on either side of blade. Check position with triangle before locking.



Vertical right-angle guide is used for end cuts such as slots and tenons. Before securing in position, check with a square to be sure guide's bearing edge is 90 degrees to the table.



To set vertical miter guides, first lock one into place, checking with a triangle to be sure bearing edge is 45 degrees. Secure the other guide after checking with square as shown above.

parts that have been pre-cut to length or just one when cutting to size. You can remove the crosscut fence and use either the left- or right-hand guide when making consecutive miter cuts on a single length of stock.

Mark the 45-degree angle on each guide by using a combination square. Saw approximately to the mark and finish by sanding exactly to it. Lock the guides on the table so that the short edges abut and the joint is centered over the kerf. Then move the table so the saw blade spreads them apart. When the guides are mounted, use a triangle to be sure they are in correct alignment with the saw kerf.

To make the vertical work support, first make the base—the slots can be formed by making repeated passes with the saw blade—and then add the braces. Check with a square to be sure the front edges of the braces are 90 degrees to the base.

Shape the face and carefully lay out locations for the T nuts. Here, the T nuts do not have to be set flush. All you need to do is drill a 1/16-inch pilot hole and then enlarge it to 5/16 inch.

Mark the 45-degree angle on the vertical miter guides by using a combination square as shown in the illustration.

To form the long slot in the adjustable stop, first drill 3/16-inch end holes and then cut between them with a coping saw or jig-saw. The slots in the other attachments can be formed by repositioning the parts

and repeating passes on the table saw.

Sand all parts before assembly. Apply two to three coats of sealer, sanding between coats and after the final one. Apply paste wax to the saw table and to the bars and underside of the sliding table, then rub to a high polish. 5

MATERIALS LIST

Sliding table

Main table: 1 1/2-by-26-by-28-in. cabinet-grade ply.
Table cover: 1 26-by-28-in. aluminum sheet
Bars: 2 3/8-by-3/4-by-36-in. hardwood
Crosscut fence: 1 1 1/2-by-3 1/2-by-24-in. hardwood; 9 1/4-in. pronged T nuts; 10 No.8-by-3/4-in. flathead wood screws; 2 1/4-by-2-in. bolts; 2 1/4-in. flat washers

Vertical work support

Base: 1 3/4-by-12-by-24-in. cabinet-grade ply.
Face: 1 3/4-by-8-by-24-in. cabinet-grade ply.
Brace: 2 1 1/2-by-5 1/2-by-12-in. hardwood; 6 1/4-in. pronged T nuts; 13 No.10-by-1 1/2-in. flathead wood screws

Table miter guides

Guide: 2 3/4-by-12-by-16-in. cabinet-grade ply.

Adjustable stop

Bar: 1 3/4-by-1 1/2-by-34-in. cabinet-grade ply. or hardwood

Stop: 1 1 1/4-by-3-by-4 7/8-in. hardwood; 3 No.10-by-1 1/2-in. sheet-metal screws; 3 1/4-in. flat washers

Circle-cutting guide

Platform: 1 1/2-by-15-by-18-in. cabinet-grade ply.; 2 1/4-by-3/4-in. flathead bolts

Taper guide

Platform: 1 1/2-by-12-by-26-in. cabinet-grade ply.
Stop: 1 1 1/2-by-1 3/4-by-3-in. hardwood
Clamp pad: 1 1/2-by-2 1/4-by-4 1/2-in. hardwood or ply.

Vertical miter guides

Guides: 2 1/2-by-5 1/2-by-8-in. cabinet-grade ply.

Right-angle guide

Guide: 1 1/2-by-6-by-8-in. cabinet-grade ply.

Hold down

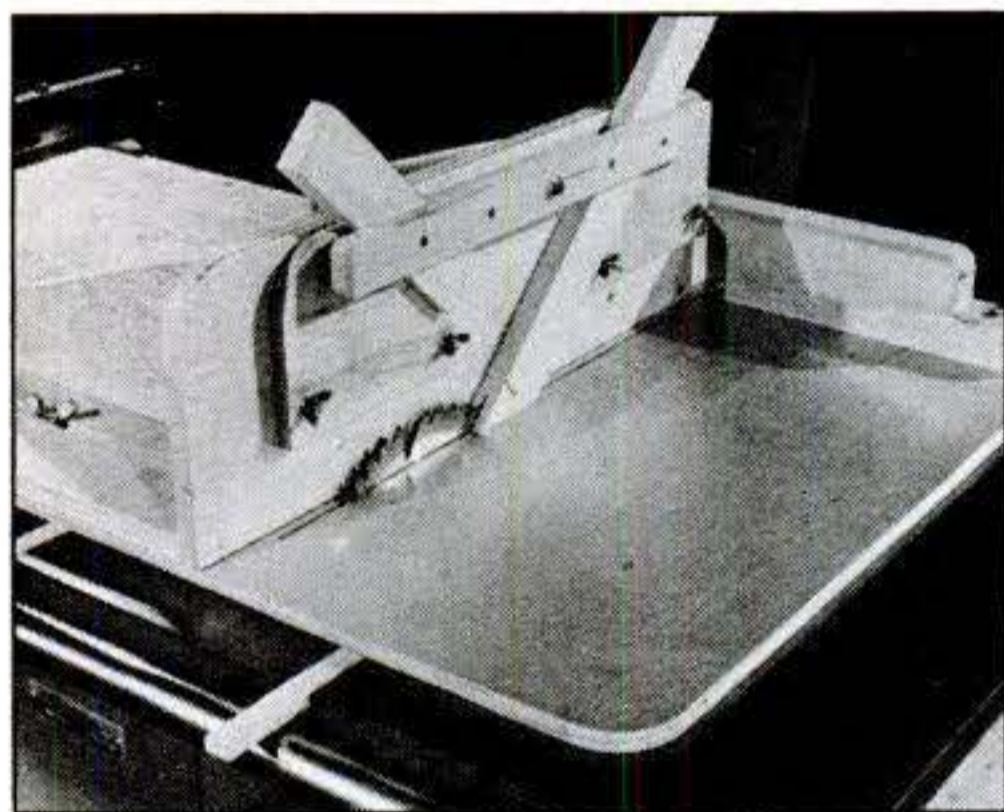
Bar: 1 5/8-by-1 1/2-by-18-in. hardwood; 1 1/4-by-4-in. bolt; 1 1/4-in. flat washer

Example notching jig

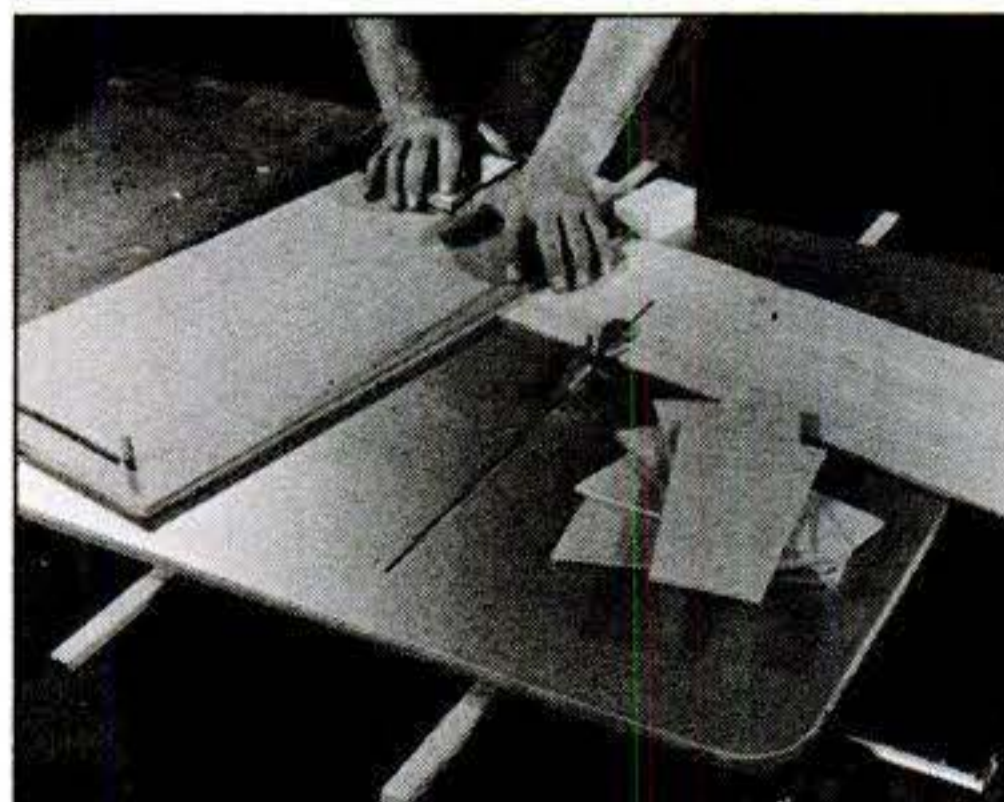
Guide: 1 1/2-by-6 1/2-by-14-in. cabinet-grade ply.

Locking hardware

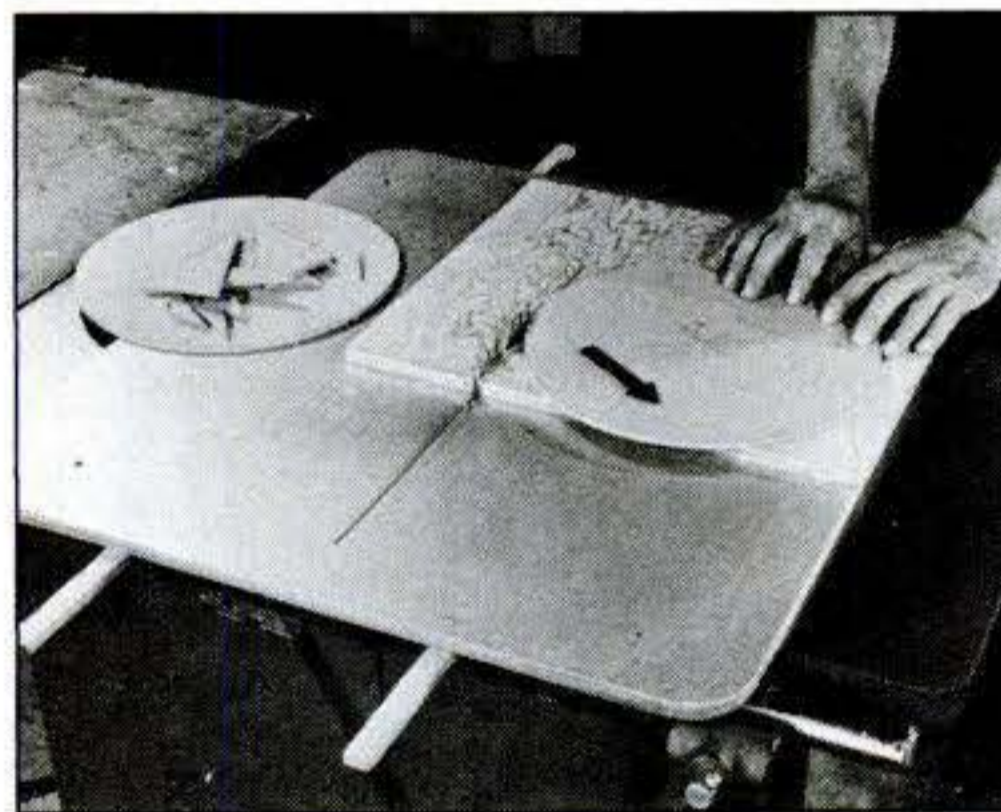
General-use pieces: 8 1/4-in. wing nuts; 8 1/4-in. flat washers; 8 1/4-by-2-in. lengths of threaded rod



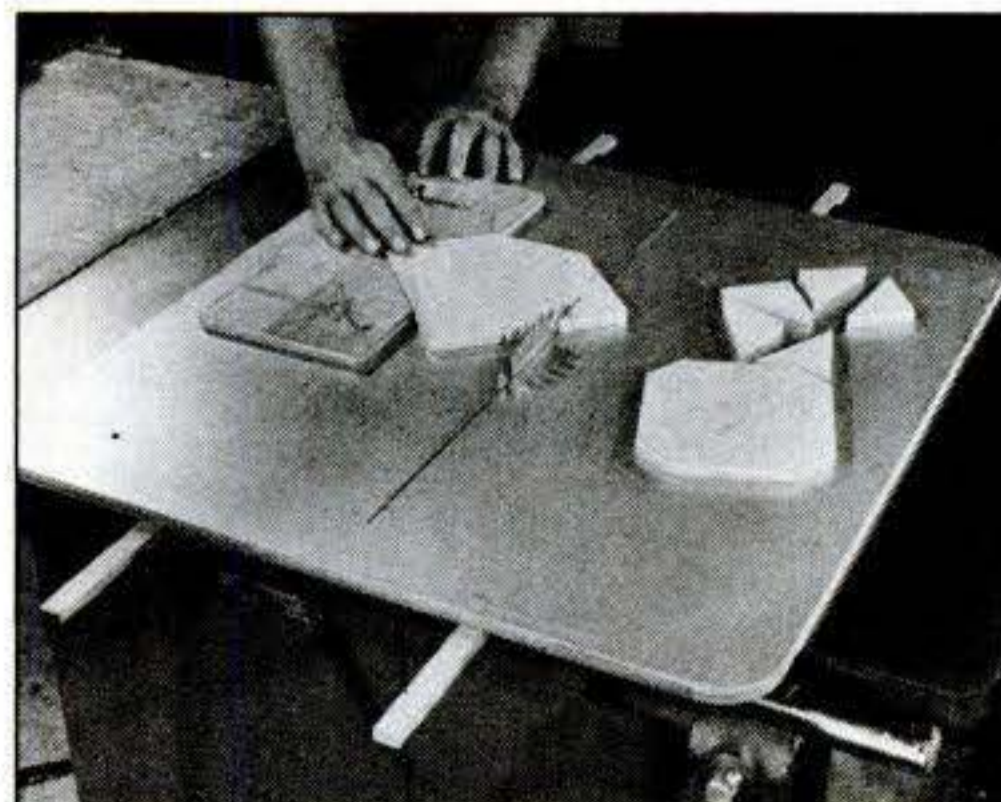
For centered spline groove, reverse stock for second cut. For off-center groove, use both guides. Face matching surfaces toward guide, cut both pieces, reset guide, and pass again.



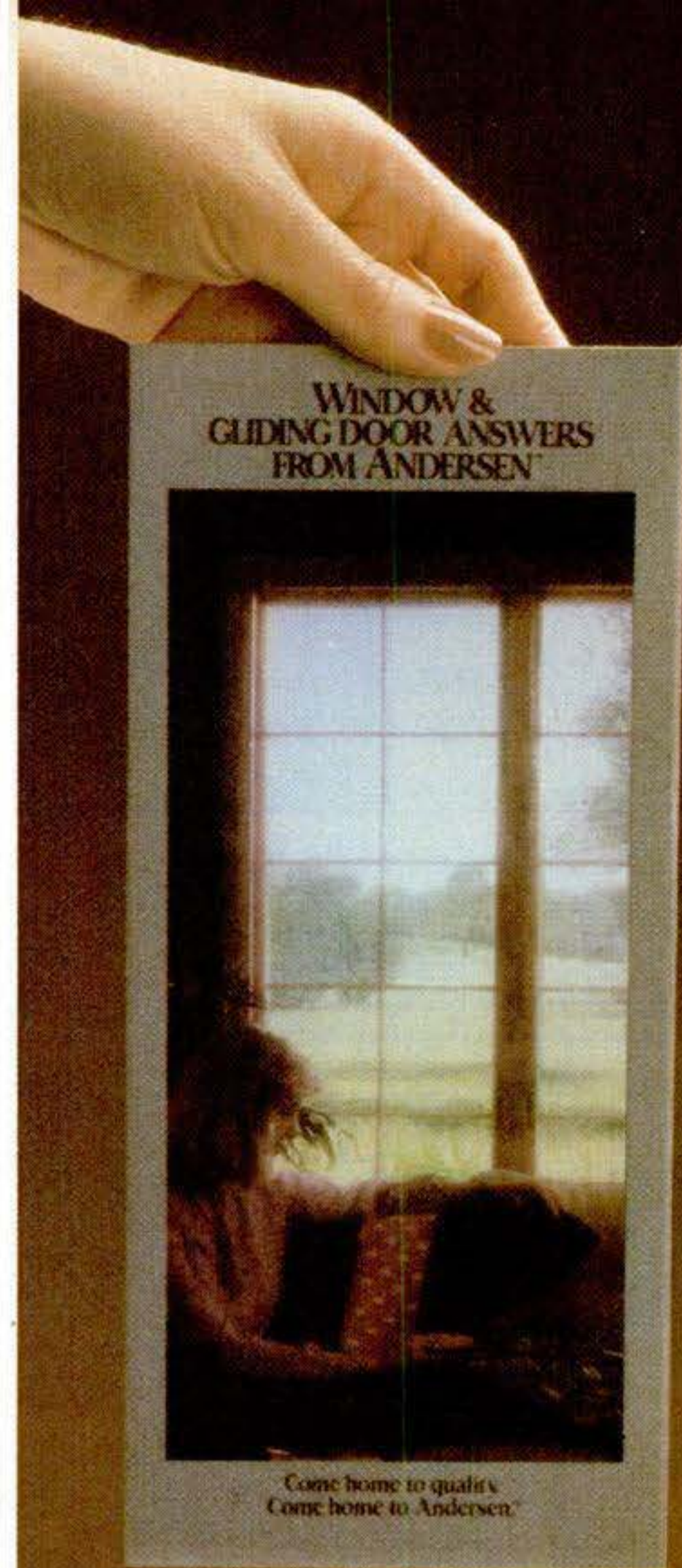
For multiple pieces that are tapered on one side, make first cut off a squared piece of stock, invert and slide it down to the guide for a second cut. All pieces will be identical.



To cut circles, nail stock to guide and make series of straight cuts, rotating work 10 degrees with each pass. Then align nail with blade front and rotate work in direction shown.



Notching jig can be used to make odd-shaped pieces that would be difficult to form with standard tools. Shape of jig varies according to what you need to make with it.



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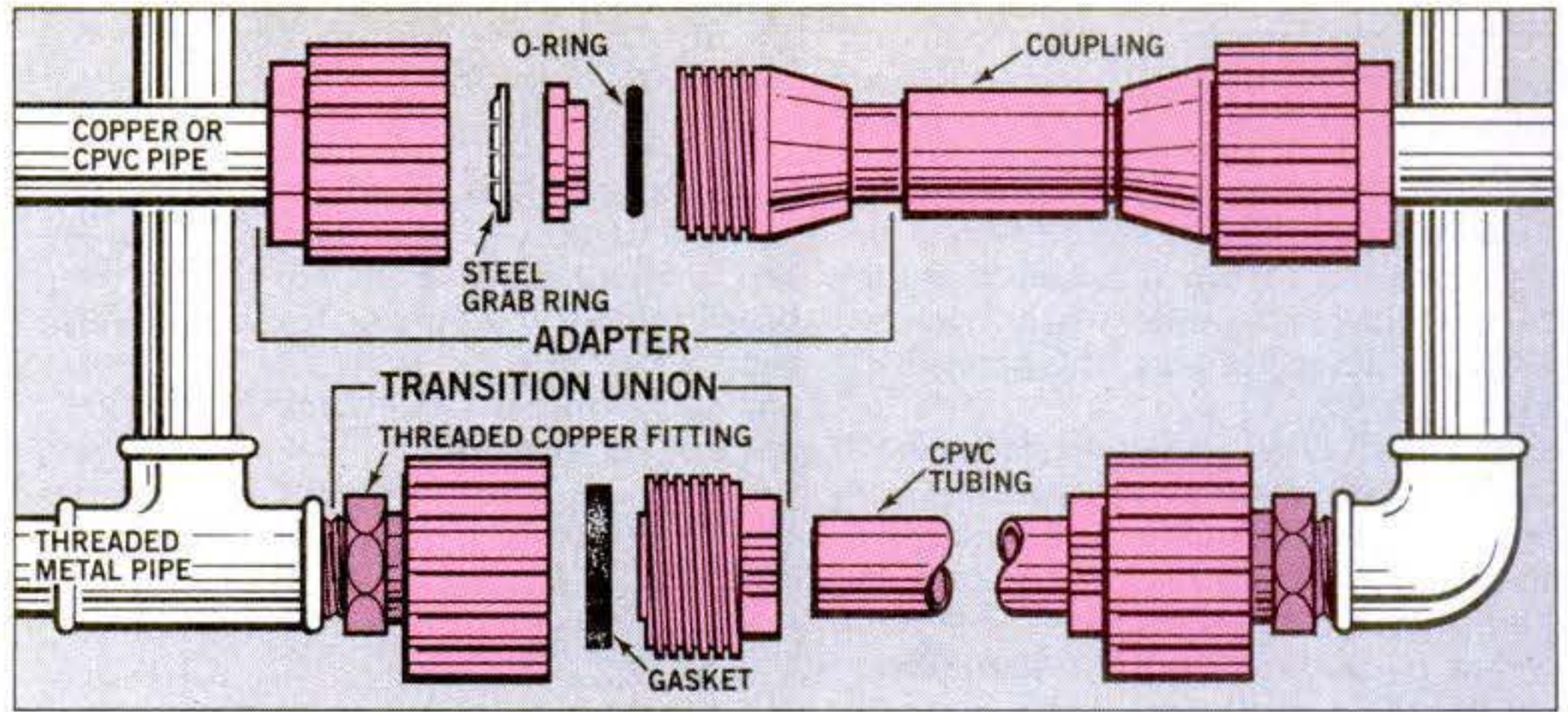
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Assemble a kit for emergency plumbing repairs

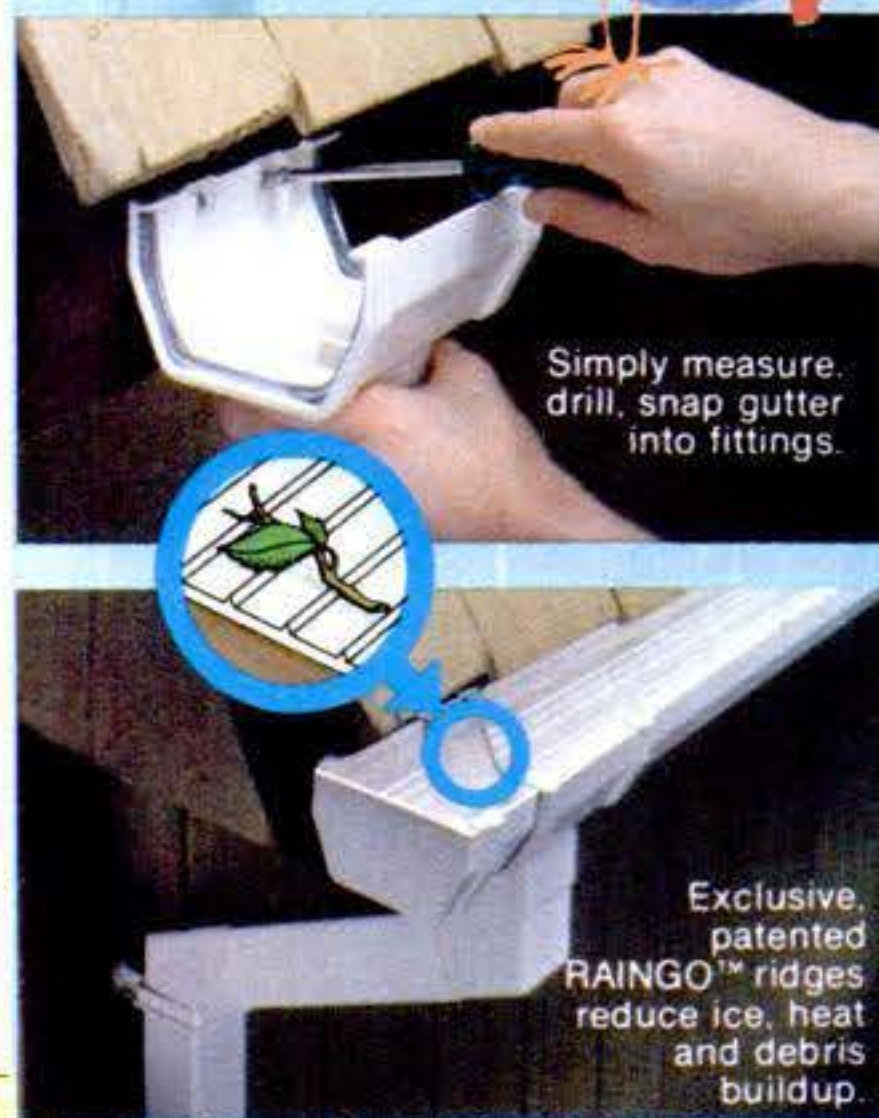


To repair copper or CPVC pipe (top) you need adapters and coupling. For longer repairs you need CPVC tubing. Transition unions for threaded pipe accept CPVC tubing directly.

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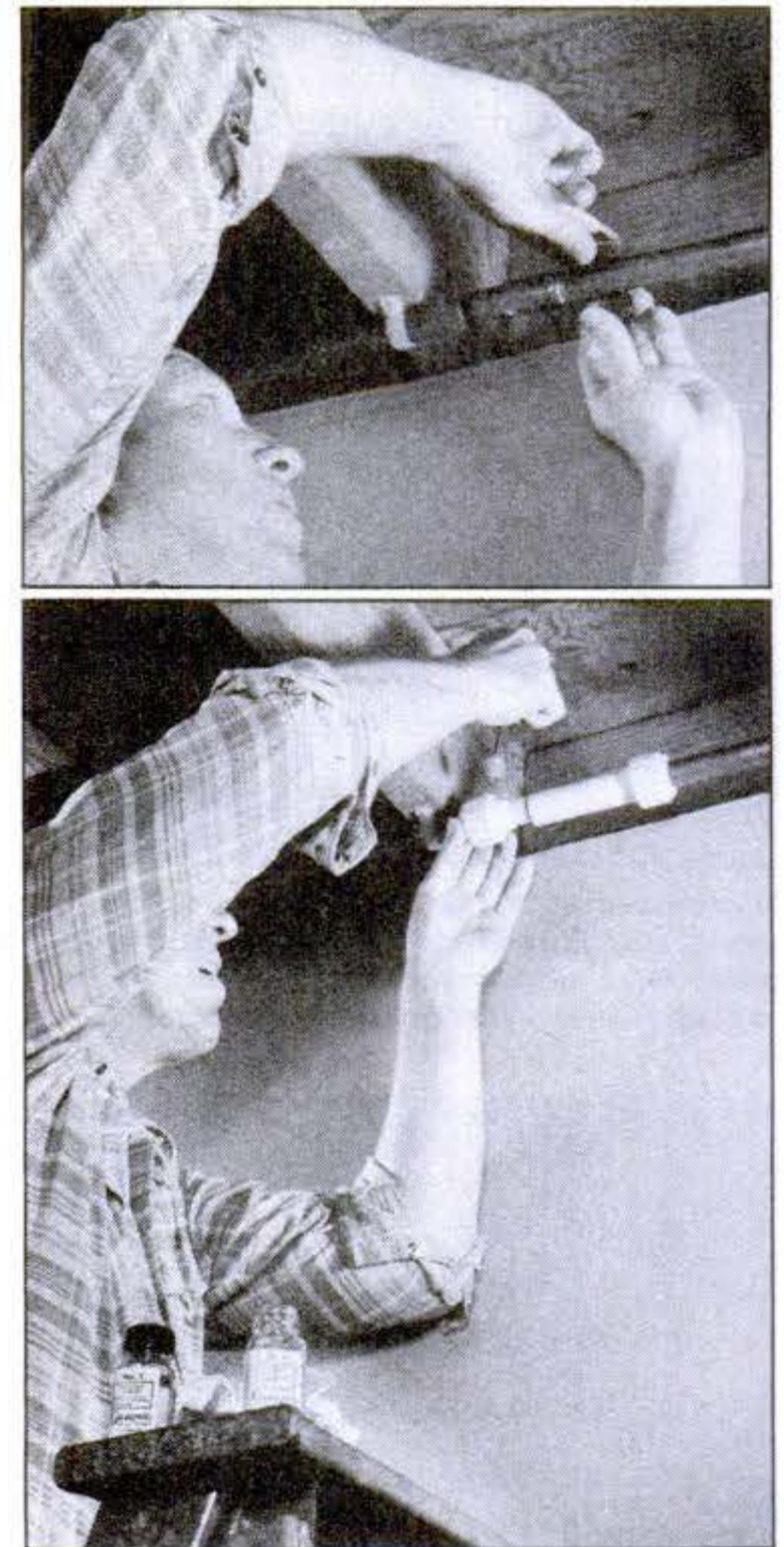
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The temperature kept dropping. By morning it had sunk to 22 below, colder than it had been in years. The Lloyds awoke, ready to spend a quiet Sunday buttoned in the bosom of their suburban home. But Cindy Lloyd soon discovered there was no water pressure anywhere in the house.

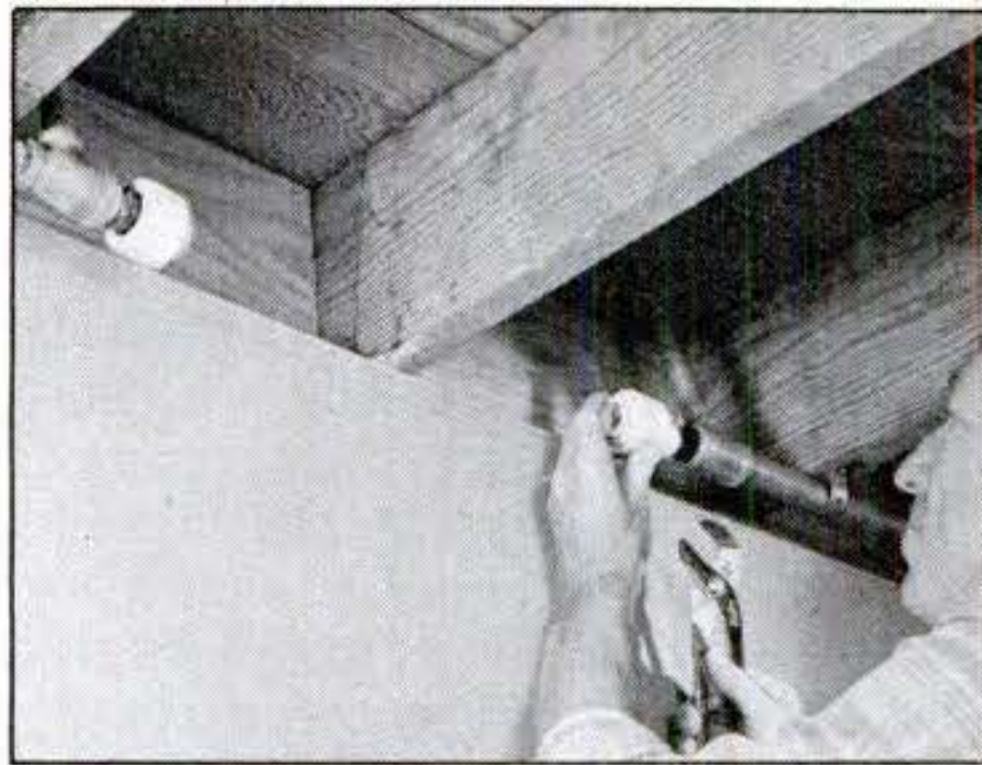
"Must be a frozen pipe," George said as he bundled up to go out and check. He was back shortly, stomping snow off his feet. "Someone unplugged my heat tape," he ac-



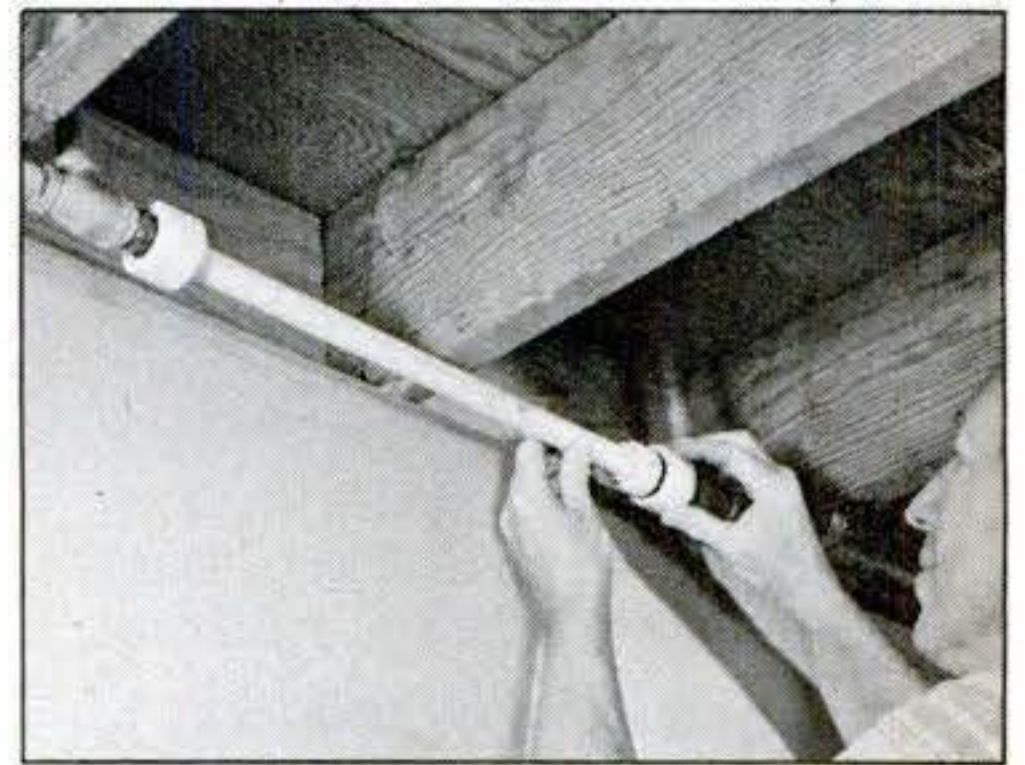
To repair a leaking copper or CPVC tube, cut out the defective portion with a hacksaw or tubing cutter (top). Next, slide an adapter onto each tube end and tighten, following package directions. Slip a coupling onto each adapter, then cut CPVC tubing to bridge the gap. Slip it into the couplings, then solvent-weld all the CPVC slip joints as shown above.



To repair a leaking threaded-metal pipe, saw through the defective pipe, then remove both ends with a pipe wrench (left). Next, thread in the transition unions, using one at each end of



the remaining metal pipe (center). Tighten with pliers or an open-end wrench. Use pipe dope or TFE tape on the male threads. Now measure the distance between the gaskets inside the



two transition unions and deduct one inch. Cut the CPVC repair tube to that length and solvent-weld it into the transition unions (right). Let the welds cure two hours.

cused. "Pipes in the crawl space are probably frozen solid. They should be thawed soon, though."

Soon, however, they heard a disheartening sound coming from the crawl space: the steady trickle of running water. "Blasted pipe's split, I'll bet. Gotta turn off the water," George muttered as he hurried outside.

"Shall I call a plumber?" Cindy shouted. "Guess you'd better," he yelled back.

But the only plumber she could reach was on his way out to a long list of emergency calls. The other plumbers were already gone. The Lloyds weren't the only ones with frozen pipes that morning.

George Lloyd ended up taking his family

to a motel, where they spent two nights before the pipes were repaired. The repairs, at overtime rates, plus the motel bill and meals cost the family \$300.

You can keep this from being your story by putting together an emergency plumbing-repair kit. We've designed one that's so simple to use you won't mind doing the repairs yourself (see table). The kits contain CPVC-plastic adapters, tubes, and couplings. These can be used to replace sections of 1/2- and 3/4-inch house piping. The parts are assembled with solvent-welding cement, which you also include in your emergency kit.

Why CPVC? First, this tough, heat-resistant thermoplastic is rated to withstand

a pressure of 100 psi at 180 degrees F. Second, solvent welding is super-simple [PS, Jan. '81]; no pipe threading or sweat soldering is required. Another advantage is that CPVC will halt the electrolytic action that transfers metals within a plumbing system, especially in hard-water areas. (Spots from which metal is transferred can get thin and leak.) Your system will be even better after the repairs than it was before.

You'll need two sizes of repair kits—1/2- and 3/4-inch—because most houses have both sizes of water-supply pipes. Choose either the kit for copper or CPVC pipes or the one for threaded-metal pipes, depending on the kind of plumbing your

Continued

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BOWHUNTING SHAFT SELECTION CHART

Bow Type	Arrow Length	30-35 lbs		35-40 lbs		40-45 lbs		45-50 lbs		Weight (lb)	Diameter (in)
		Min	Max	Min	Max	Min	Max	Min	Max		
Recurve	28-30	1.00	1.10	1.10	1.20	1.20	1.30	1.30	1.40	1.00	0.75
	30-32	1.10	1.20	1.20	1.30	1.30	1.40	1.40	1.50	1.10	0.75
Compound	28-30	1.00	1.10	1.10	1.20	1.20	1.30	1.30	1.40	1.00	0.75
	30-32	1.10	1.20	1.20	1.30	1.30	1.40	1.40	1.50	1.10	0.75

EASTON ALUMINUM
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For 1983, Chrysler increases its warranty protection to two years.

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Exciting new graphics . . . new models highlight Chrysler's '83 lineup. Chrysler Marine outboards feature attractive new graphics, designed to complement any craft. Choose from a complete lineup of 1983 performers from the 3.5 to the 140 HP, including three of the highest-thrust sailor engines designed for displacement hulls.

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See your Chrysler Marine dealer now.

*Excludes normal maintenance service and parts, and outboards that are part of boat builder packages. \$25 deductible required in second year. See dealer for details.

NOW FROM CHRYSLER MARINE: THE INDUSTRY'S LONGEST OUTBOARD WARRANTY.



CHRYSLER MARINE

Emergency plumbing repairs

[Continued]

house has. Parts for both types are shown in the drawing as well as listed in the table. The tubes and fittings can be purchased at a good hardware store or home center. The kits will cost about \$12 each to put together. (A service call from a plumber: about \$35 plus per-hour charges.)

We show parts made by Genova. If you use another brand, be sure it offers transition unions to go between the plastic and metal piping and take up differential thermal movements. Tape or wire the parts of the kit together and put them in a handy place. The kit is for repair of pipes and tubes only. If there's a faulty fitting, it will have to be replaced, of course.

The parts of the emergency kit you should use depend on the required length of your repair. A short repair in copper or CPVC—up to 1½ inches long in a ½-inch tube and up to two inches in a ¾-inch tube—can be done with just the two adapters and one CPVC coupling between them. An adapter is pushed into each cutoff end of tubing (see photos) and tightened a bit beyond hand-tight. It helps if you coat the tube ends with petroleum jelly or silicone lubricant for easier sliding. Each adapter comes with a plastic grab ring inside and a stainless-steel version on the blister card. Discard the plastic ring (it's meant for flexible tubes) and insert the steel one.

With ½-inch copper or CPVC tubing, repairs of lengths between 1½ and 2½ inches cannot be made: They fall between lengths that the parts will fit. With ¾-inch tubing, you can't make a repair between two and 3½ inches. Make your cutouts short or long enough to avoid these "blind spots." There are also minimum repair lengths for both sizes of tubing. They're listed in the table. Beyond these lengths, two CPVC couplings are used, one at each adapter. A length of CPVC tubing cut to the proper length slips into the couplings to bridge the gap (see illustrations).

A look at the table shows that the shortest repair you can make in ½-inch threaded-metal pipe is 4¾ inches; in ¾-inch threaded pipe it's 5½ inches. You make the repairs by threading a transition union into each end of the good pipe and connecting them together with a length cut from the CPVC tubing. Longer repairs simply call for a longer connecting tube.

The table also lists the sizes of repairs the kits will handle. The maximum length with each kit is just over 10 feet. By adding more CPVC tubing and couplings to link the tubes, longer repairs can be made. Because 10-foot CPVC tubes are too long for convenient storage, you'll probably want to cut them into shorter lengths. I've listed the parts in the table assuming you'll cut the tubing to 40-inch lengths. If you want shorter lengths, add more couplings—one for each saw cut you make—and you'll still be able to make a 10-foot-long repair.

By keeping the parts of the kits together where you can find them, you'll be able to fix a leaky pipe at any time. The repair should last as long as your house plumbing does. And if you clip this article to put with your emergency kits, it will remind you how to use them.—Richard Day

Emergency plumbing-repair kits

Pipe type (house)	Pipe size	Parts	Fits pipe removed (min.-max.)	Tools needed
Threaded galvanized-steel or brass	½ in.	1 ½-in.-by-10-ft. tube* 2 ½-in. CPVC couplings 2 ½-in. transition unions Solvent-welding kit	4¾ in.—10 ft. 4 in.	Pipe wrench, hacksaw, and pliers or open-end wrench
	¾ in.	1 ¾-in.-by-10-ft. CPVC tube* 2 ¾-in. CPVC couplings 2 ¾-in. CPVC transition unions	5½ in.—10 ft. 4¾ in.	
Sweat-type copper or solvent-welded CPVC	½ in.	1 ½-in.-by-10-ft. CPVC tube* 2 ½-in. Genogrip adapters (or equivalents) 4 ½-in. CPVC couplings Solvent-welding kit	1¾ in.—1½ in. (using just adapters and couplings) 2⅝ in.—10 ft. 1½ in.	Hacksaw or tubing cutter
	¾ in.	1 ¾-in.-by-10-ft. CPVC tube* 2 ¾-in. Genogrip adapters (or equivalent) 4 ¾-in. CPVC couplings	1⅞ in.—2 in. (using just adapters and couplings) 3½ in.—10 ft. 2 in.	

*Cut to convenient storage length—couplings included for 40-in. lengths



The measure of lasting quality.

When you buy a tape rule, you can be sure it will read inches and feet. But in many cases, that's all you can be sure of. Unless it's a Stanley Powerlock® tape rule.

Powerlock tapes are built with quality that lasts. They offer you features you can't find in ordinary locking tapes. A DuPont

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Stanley Powerlock tape rules are available in a wide range of lengths and widths.

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STANLEY
helps you do things right

Electronic home controllers

help keep energy in
and burglars out



Your house will blaze to life when you touch the "all-lights-on" key of any home-control system. Leviton's programmable command center (inset, foreground) is wired into your home's AC circuitry. The wire-in wall switch, receptacle, and mini command center are visible in back.

Now you can control lights and appliances remotely or at the touch of a button—or have them work automatically

By A. J. HAND

PHOTOS BY THE AUTHOR

Concerned about security and energy savings? Now you can have both. And in the process you get a healthy dose of convenience, as well. The secret: a new generation of electronic devices called home control systems. The essential components are a programmable command center and some switching modules that you attach to the lights and appliances you want to control.

After living with some of these systems for three months, I found the possibilities to be almost endless. Let me take you through a typical day with a home control system and show you what I mean.

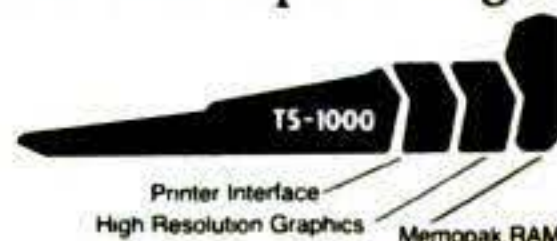
It's 7 a.m.: The TV at the foot of your bed wakes you to your favorite news show. The lights in your room switch on to half power, not so bright that they hurt your sleepy eyes. As you wash, the aroma of fresh coffee brewing automatically in the kitchen fills the air.

7:30: You head to the kitchen for a cup of that coffee, and the air conditioner in your bedroom shuts down. It won't cut in again until evening.

Next, you put the makings of a stew in your Crock-pot and plug it in. In your haste to get to work, however, you forget to turn on the Crock-pot. No problem. At work you call home; a machine answers the phone. You press a few

TIMEX MAKES THE COMPUTER, BUT WE MAKE IT TICK.

If you own a TS-1000 or ZX-81 computer and want to bring out the power within it, you'll want Memotech. From easier input to high quality output and greater memory, Memotech makes the add-ons you demand. Every Memotech peripheral comes in a black anodized aluminum case and is designed to fit together in "piggy back" fashion enabling you to continue to add on and still keep an integrated system look.



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software, enables TS-1000 users to perform complex number crunching routines with ease. With the 64K RAM a table of up to 7000 numbers with up to 250 rows or 99 columns can be specified. Quick revisions can be achieved by entering new data to your formula.

MEMOTECH KEYBOARD For ease of operation, the Memotech keyboard is a high quality standard typewriter keyboard, with TS-1000 legends. The keyboard is cable connected to a buffered interface which is housed in a standard Memopak case and plugs directly into the back of the



TS-1000 or other Memopaks. **MEMOPAK HRG** The Memopak High Resolution Graphics, with up to 192 by 248 pixel resolution, enables display of high resolution "arcade game" style graphics through its resident 2K EPROM, programmed with a full range of graphics subroutines.

CENTRONICS PARALLEL AND RS232 INTERFACES

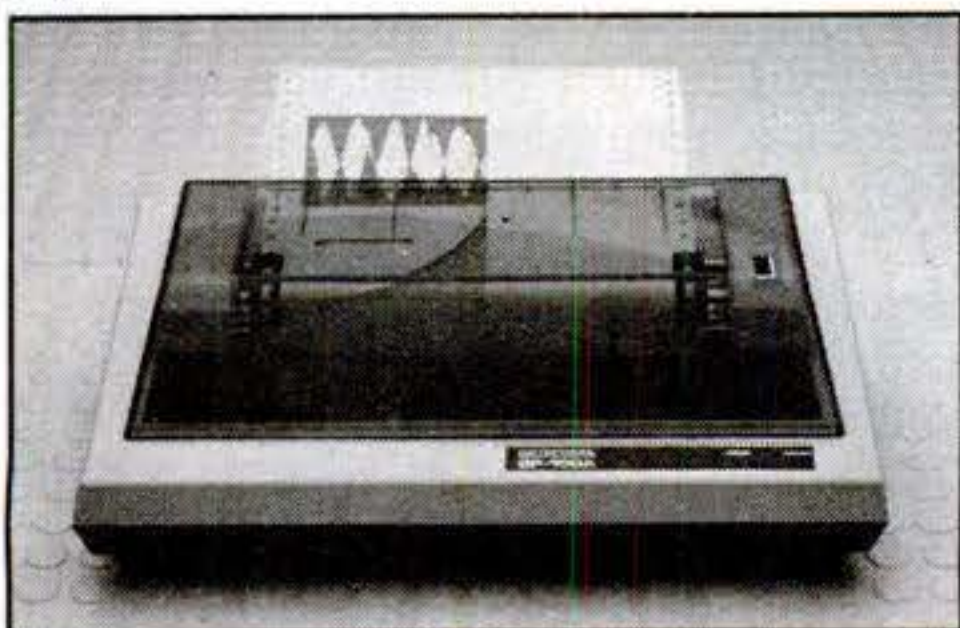
Memotech's Interfaces enable your TS-1000 to use a wide range of compatible printers. The resident software in the units gives the



complete ASCII set of characters. Both Memopak Interfaces provide lower case character capabilities and up to 80 column printing. The RS232 Interface is also compatible with modems and terminals.

SEIKOSHA GP 100A PRINTER The Seikosha GP 100A uses a 5x7 dot matrix printing format with ASCII standard upper and lower case character set. Printing speed is 30 characters/second with a

maximum width of 80 characters. The printer uses standard fanfold paper up to 9-1/2 inches wide. The GP 100A is offered as a package including cable and



interface. Other printer packages are also available through Memotech.

ORDER AT NO RISK. All Memotech products carry our 10 day money back guarantee. If you're not completely satisfied, return it within ten days and we will give you a full refund. And every Memotech product comes with a six month warranty. Should anything be

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BSR's remote transmitter lets you send orders through phone lines. You call home and punch out commands on the keyboard. A telephone responder conveys them to the target switch.

buttons on a pocket transmitter, and the Crock-pot turns on.

You work late at the office. As the sun sets, your porch and walk lights turn on, though no one's home. Lights and a radio inside the house cycle on and off periodically, giving your home a lived-in look.

Home at last, you eat your stew, relax with a book, and finally hop into bed and turn on Johnny Carson. Your outside lights turn off automatically. An hour later, your TV does the same. You fell asleep during Johnny's monologue.

1:40 a.m.: A loud crash wakes you from a deep sleep. You roll over and press a button. All the lights in your house blaze to life. You lie quietly listening for another sound, but your dog isn't even barking. You head cautiously downstairs and soon learn why. There he is, licking up the leftover stew he knocked off the kitchen table.

After cleaning up the mess, you slip back in bed and press a button, and all your lights turn off. You sleep soundly until 7 o'clock, when the whole cycle starts again.

None of the three systems I tested (BSR-System X-10, *Continued*)

Home control systems: features and accessories at a glance

Manufacturer	Command center	Capacity (unit codes)	Security key?	All-lights-on key?	All-modules-off key?	Dim-bright key?	Energy-saver key?	Sleep switch?	Once key?	Daily key?	Day-of-week keys?	Status key?	Modules available ¹	Mini command console? ¹	Ultrasonic remote control? ¹	Telephone responder? ¹
Anova Electronics Three Waters Park Dr. San Mateo CA 94403	Control Center 8000 (\$189) ²	16	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	n.a. ³	PIL, PIA, WIR, WIW	No	No	No
BSR USA, X-10 Div. Rte. 303 Blauvelt NY 10913	System X-10 (\$70)	8	Yes	Yes	No	No	No	Yes	Yes	Yes	No	No	PIL, PIA, WIR, WIW, TWW, SI	Yes (\$30)	Yes (\$15)	Yes
Leviton Mfg. Co. 59-25 Little Neck Pkwy. Little Neck NY 11362	Wall-Mount Programmer (\$215)	8	Yes	Yes	Yes	No	No	Yes	Yes	Yes	No	No	WIW, WIR, TWW, SI	Yes (\$86)	No	No
Pittway Corp. 780 McClure Ave. Aurora IL 60507	Home Command Center ⁴ (\$44)	16	No	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	PIL, PIA, WIW	No	No	No
Radio Shack 1800 One Tandy Ctr. Fort Worth TX 76102	Plug 'n Power (\$70)	8	Yes	Yes	No	No	No	Yes	Yes	Yes	No	No	PIA, PIL, WIW, SI	Yes (\$25)	No	Yes
Sears Roebuck & Co. Sears Tower Chicago IL 60684	Home Control System (\$70)	8	Yes	Yes	No	No	No	Yes	Yes	Yes	No	No	PIL, PIA	Yes (\$30)	Yes (\$15)	Can use BSR's

¹Accessory; ²price of the Anova Control Center includes two plug-in lamp modules and one plug-in appliance module, other command centers are sold without accessories, prices are approximate and may be discounted; ³not applicable, status constantly displayed; ⁴Pittway system is available through the JCPenney catalog

Features and accessories explained

Capacity: This tells how many different channels you can command with the system. You assign each switching module a number called a unit code (see text). Of course, you can set more than one module to the same unit code (all lights in your basement, for example).

Security key: Use this key when you program your lights, and they'll switch on and off at *approximately* the times you set, varying a few minutes from day to day. This avoids the clockwork precision that can alert a burglar to the fact that your lights are being run by a timer.

All-lights-on key: Push this, and all the lamp modules controlled by the console will come on.

All-modules-off key: Enables you to turn off all modules at once. Otherwise you have to do so unit code by unit code.

Dim-bright key: Activates the dimmer circuits in your lamp modules. Most programmable consoles don't have this feature, but the mini consoles do.

Energy-saver key: Enables you to turn

on a light to a preset brightness level.

Sleep switch: Push it, and an appliance or lamp will turn off in an hour.

Once key: Press it when you want a programmed procedure to be carried out only on the day you enter it.

Daily key: Use this when you want the programmed procedure to be repeated every day of the week.

Day-of-the-week keys: Allow you to program each day individually. Thus you can set your TV to wake you up at 7 a.m. Monday through Friday, for example, but let you sleep on weekends.

Status key: Press this key to check whether any lamp or appliance in your system is on or off. The Anova constantly displays the status of all 16 channels.

Modules: Abbreviations in the table tell what kinds of modules are available for each system. Here's what they mean: PIL—plug-in lamp; PIA—plug-in appliance; WIR—wire-in receptacle; WIW—wire-in incandescent wall switch; TWW—three-way wall switch; WIFW—wire-in fluorescent wall switch; SI—security inter-

face, which ties the system into your burglar alarm: If the alarm is tripped, all lights on the system come on or blink.

Mini command console: This has no clock or computer, so it can't be programmed. But it gives you remote control of your home from wherever you plug it in. (The Leviton is wall-mounted and wired in.) You can also use it in addition to a programmable console, controlling the same circuits from a different location or controlling different circuits. BSR offers a special version of the mini console that can also be activated by an ultrasonic remote control. Range is about 30 feet, but the remote control must be pointed at the console and have a clear line of sight.

Telephone responder: BSR and Radio Shack offer this feature (see text and caption). It can be used with the Sears system, as well. After the phone rings for 42 seconds, the phone responder will come on the line. You punch in your commands, and short, Morse-code-like beeps from your transmitter tell it what you want. It activates the switching modules.

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CLEAN ACE isn't just an improvement on the old ionizers or filters. It's the result of totally new technology.

This Air Cleaner uses only 14 watts of power. It's whisper-quiet. It's compact and attractive.

But under its good-looking exterior thrums a mighty, powerful, industrial-strength heart. As it gathers the dust and pollution in the room, it disinfects and cleans the air, actually replacing dirty air with ozone-clean fresh air.

Kills Air-Borne Germs and Mites

The CLEAN ACE Air Cleaner has a built-in ultraviolet light. This special lamp radiates on two separate wavelengths.

The first, lower wavelength converts the oxygen molecules in the air to ozone, destroying odors as though a hammer is smashing the offending molecules.

The second, high wavelength kills not only germs but also the tiny "mites" that can be so irritating (and socially unacceptable). You might notice an immediate **decrease** in the number of runny noses and colds. It's no accident.

Will you Actually Feel Better?

We think you'll feel better because the air will be so pleasant and refreshing to breathe. Many, many people report the disappearance of their tiredness and general irritation when the air is properly ionized.

An opinion is one thing; a fact is another. The ability of the CLEAN ACE to kill germs and airborne pests is a **fact**. The feeling of well-being you get from fresh ozone is a **fact**. The oxidizing effect ozone has on bad-smell molecules is a **fact**.

Of course the CLEAN ACE is absolutely safe. The special ultraviolet quartz-glass tube doesn't transmit the high-range rays that can redden the skin. The unit plugs into any wall outlet, and because it "creates" fresh air you don't have to open a window.

Unbelievable POWER

The home-size Model 8200 CLEAN ACE is 11" wide, 7½" high, 5" deep. It weighs only a couple of pounds. It makes no noise.



The home-size CLEAN ACE Model 8200 cleans the air in an average room in about 10 minutes.

Can you believe it will clean the air in an average room in about 10 minutes? Can you believe it works with every window shut and the heater or air conditioner on? Can you believe you'll be able to see the ugly black particles from your room the CLEAN ACE has trapped in its super-efficient filter?

You'd better believe it.

You don't assemble anything. We'll include a descriptive booklet, but there's nothing to learn: just press the "On" button and let it run.

END EMBARRASSMENT FOREVER!

If someone is bedridden, somehow odors start to accumulate. Never again!

If even two or three people smoke at a party, the air is blue with smoke. Never again!

If you have a meeting in your office or conference room, after a while the air is heavy, even foul. Never again!

If you're cooking, the aroma of fish, shrimp, lamb, and many vegetables seems to hang there forever, gradually changing from "aroma" to "smell." Never again!

Now—

A CLEAN ACE for Your Car!

The Model 1000 mounts under the dashboard or sits on the seat. Plug it into the cigarette lighter, and smog, pollution, grime, and stale air never will touch you.

What a difference clean air will make when you're driving around town or when you're stuck bumper-to-bumper in rush hour traffic, where normally you'd be inhaling the carbon monoxide from the exhaust of the car in front of you!

If someone is a smoker, instead of driving around with smarting, burning eyes, turn on your CLEAN ACE Model 1000 and forget that cigarette or cigar is lit.

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We've seen old-fashioned air cleaners which lack the space-age technology of the CLEAN ACE, selling for up to \$245. New Horizons is a direct-factory source, and you'll be able to own this **high-powered** air cleaner for far less than you'd expect to pay in a store—if they had it.

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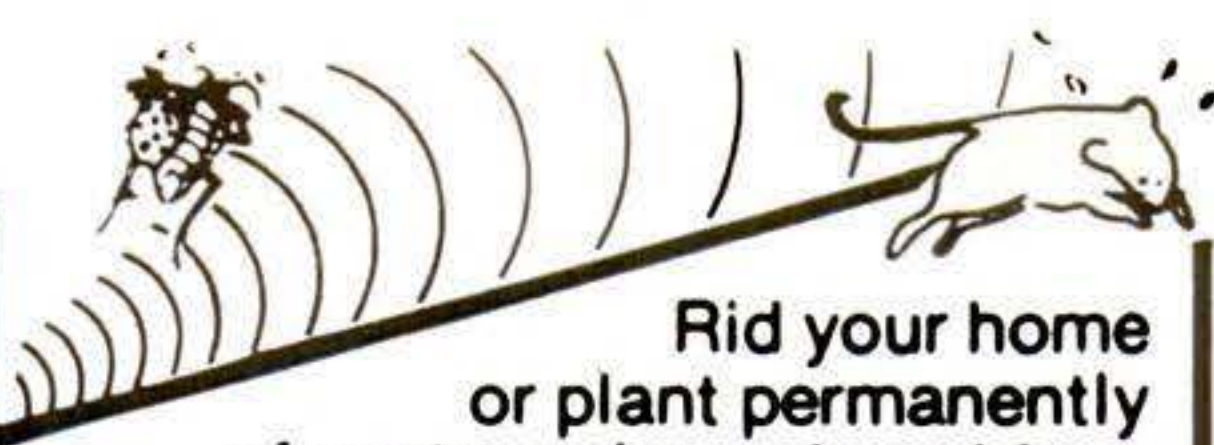
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DECIMATE

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Just plug *DeciMate* into your 110V and watch your space become totally varmint free. You have two levels of output intensity, depending on the severity of the problem. It is a humane, clean, and totally effective system to rid yourself of pests once and for all. Clean up your home or plant and order today!

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Electronic home controllers

[Continued]

Sears Home Control System, Pittway First Alert Home Command Center) will do all of the things mentioned above. Only the BSR has the telephone responder, for example, and only the Pittway can turn lights on to preset dimness levels. But all work on the same principle.

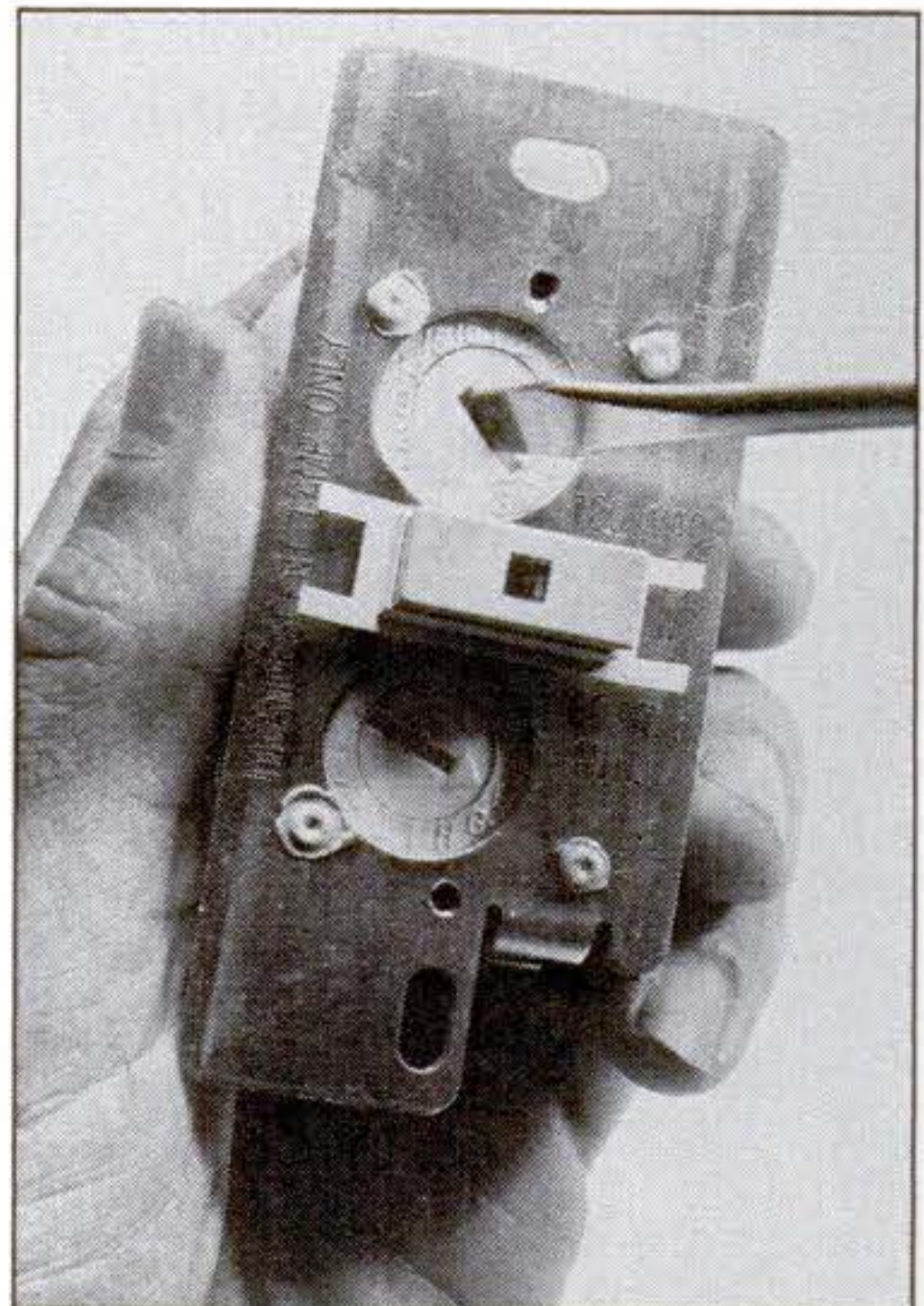
The heart of all systems is a small programmable control (or command) center. It contains a digital clock, a microprocessor, and an array of push buttons that lets you program the unit to run things automatically or use it as a remote-control center.

To install most command centers, you just plug them into an electrical outlet wherever it is most convenient. The wall-mounted programmer of the Leviton Home Control System (which I did not get a chance to test) is connected directly to the house wiring.

Once installed, any of the control centers can communicate with special switching modules through your house wiring. Switching modules come in various types. The simplest are the plug-ins, which come in two versions. One—called a lamp module—has a dimmer circuit and will control incandescent lamps only. The other will control appliances and fluorescent lamps but has no dimmer.

To use either variety, you just plug it into an outlet and plug the lamp or appliance into the module.

Continued



Each switching module is assigned its own unit code (see text) by turning a small dial to the desired number. You set all your modules to the same house code on the lettered dial below.

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- Ringer off switch. You can turn off the pleasant "chirper" (it isn't a bell) when you don't want to be disturbed. A separate ringer l.e.d. light will alert you, if you're interested.
- Access pause key. For Sprint, MCI, and other code numbers, the Pause button gives you the proper gap between the original dialing and the time the system takes to answer with a tone. The Pause has other uses, too, but we just can't list all of them here.
- Secretarial aids. Open a little door and you have a memo pad to jot notes. For the numbers stored in automatic dialing memory, slide out the Directory Card, concealed under the phone unit.
- Battery backup. Two tiny, easily replaceable batteries keep your memory intact. A power failure, even one that lasts for months, won't wipe out what's stored in the memory.

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The Everything Phone is a handsome, contemporary ivory phone with a standard modular plug, ready to go.

It's as though someone said —
"Let's think of *everything* any telephone can do, and combine them into one fantastic instrument."

Someone did say that. This is it.

We call it THE EVERYTHING PHONE because it does everything. It advances the science of phone communications by ten years, even in this age of wild changes and improvements.

For example —

This Phone Actually TALKS To You

The Everything Phone speaks to you in a warm, gentle voice. It never tells you wrong.

Touch the "Voice" switch and when you push a button, the phone tells you the number you've pushed. If you're working in dim light, you won't dial a wrong number, because your friendly phone voice repeats each digit immediately, as you dial it.

A Complete Phone Answering System

If you press the "Prefix" key, the "Clear" key, the Direct Memory Keys, or any of the other special function keys (more about these later), your Phone Voice tells you what you've pushed. If you get tired of company, you can shut off the voice; but it's like having a friend right inside your phone.

This feature takes some explaining.

In the bank of keys to the right of the dial pad are three marked M1, M2, and M3. M1 and M2 will tell a caller, when you're out, either when to call back or another number where you can be reached.

What about M3?

M3 makes *any* cassette recorder an answering device. Using the connector (supplied), your recorder can take messages up to the total length of any tape cassette. The Everything Phone turns the recorder on and off automatically when a call comes in.

So — you have your voice of 1) a message, in the phone's own voice, to call back at whatever hour you designate; 2) a message that you're out and can be reached at whatever number you designate; 3) an invitation to leave a message after the tone, with a capacity as long as the cassette — an hour or more.

Memory Keys Galore for Automatic Dialing

At the left of the numeric keypad are ten Direct Memory Keys. The key at the upper left is for MCI, Sprint, or other computer-code dialings. It holds the access number and your personal code number.

The other nine let you dial stored numbers, including long distance numbers, by pressing one key. You can inset a tab showing whose number is stored.

But you ain't see nothin' yet!

You actually can store up to 50 numbers of 20 digits each, using a two-number code. Example: if you already have 30 numbers in memory and you want to store 1-305-473-2044, punch in that number, use the "Store" key and "31", and you'll be able to dial that number in the future just by pressing "31".

Quality Speaker-Phone

Of Course The Everything Phone has one-way speaker-phone capability. Of course it's high quality sound.

Just press the "Speaker" button and you have a hands-free phone. A volume control gives you just the right amount of amplification.

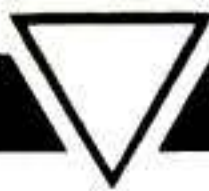
Music on Hold; "Mute" Switch

You can put a caller on hold just by pressing the "Hold" key. What a pleasant surprise! Instead of dead sound, the person on hold hears a pleasant melody. (You'll hear it too, so you won't forget he's on hold.)

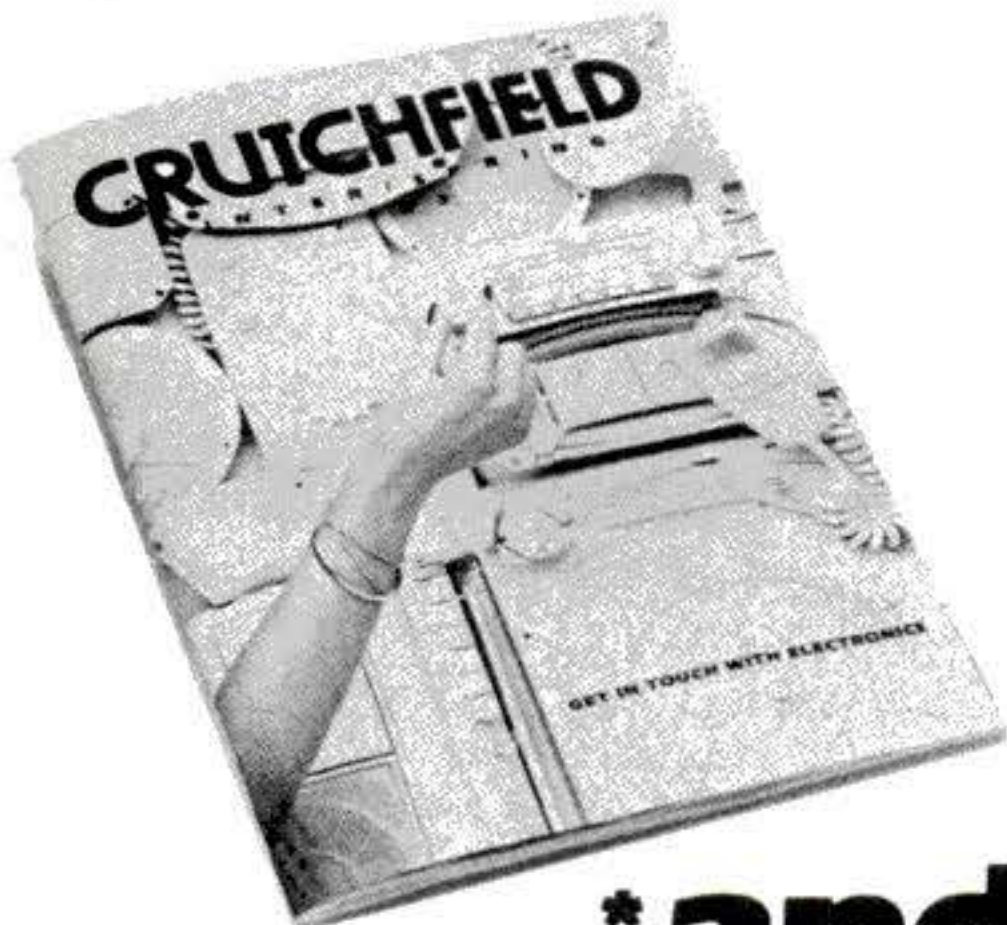
You have a "Mute" privacy button, and it couldn't be more convenient — it's right in the center of the modern hand-phone. Press that button, and although the other party won't be able to hear you, you'll still be able to hear him or her. Release the button and communications are normal again. (No tell-tale "click" when you press the Mute button.)

Here's a List of Other Built-in Benefits

Your Everything Phone is an electronic butler. It has —
— Automatic redial. Press this key and your phone will redial the last number you called either once (if the phone is off the cradle) or four times (if the phone is in the cradle).



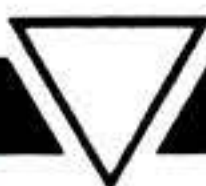
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Electronic home controllers

[Continued]

But plug-ins can't be used to control fixtures that are worked by wall switches. For these you need wall-switch modules, which you wire in to replace your standard wall switches. (Leviton has only wire-in modules.) The modules are now controlled by your command center while functioning as standard wall switches, too.

Wall-switch modules hook into your wiring with simple wire-nut connections, and they are supposed to fit standard electrical boxes. In my house, however, several boxes were just a hair too small to accept them.

Some manufacturers also offer wire-in outlets called receptacle modules. Replace your present wall receptacle with one of these, and you have a duplex receptacle with one outlet controlled by the command center, the other continuously live.

Once your command center and switching modules are in place, you're ready to set up and program. All systems I know of are set up in essentially the same way. First step is to set your command console and all modules to the same house code (see photo). House codes prevent interference between different control systems in the same area. After setting your house code, you assign a unit-code number to each module. That allows you to direct your commands to a specific module without activating the others.

The BSR, Sears, Radio Shack (all essentially the same unit), and Leviton systems are programmed similarly. Here, for example, is how you would program a room air conditioner to shut off at 7 a.m. and turn back on at 5 p.m.:

Slide the unit-code selector on your command console to the unit-code number you have assigned to your air conditioner. Slide the on-off switch to OFF, telling the center you're programming the module to switch off. Advance the digital clock to 7 a.m., your desired shut-off time. Press the DAILY key if you want the shut-off to occur every day or the ONCE key if you want the program to last for one day. Your shut-off command is entered.

To enter your turn-on command, slide the on-off switch to ON. Advance the clock to 5 p.m. Press either the ONCE or DAILY key to complete your program.

Programming the Pittway involves many more steps. To program a light to turn off Thursday morning, for example, requires 10 separate operations. This seems complicated at first,

but in practice, the Pittway is as easy and quick to program as the others. Its digital display coaches you along, leading you from one step to the next. And to enter on and off times, you just punch them in. This eliminates the tedious process of advancing the clock to the times desired.

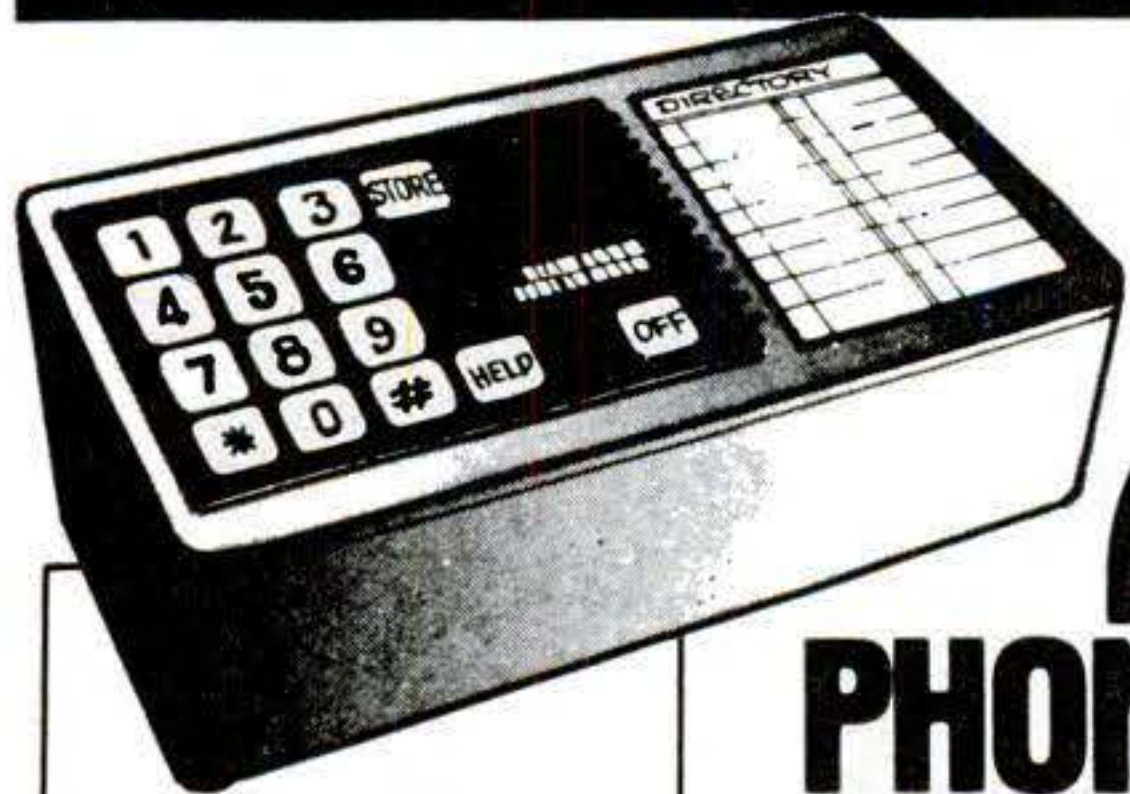
Which one of these systems you choose—or whether you need one at all—is largely dependent upon your life style. I work at home, so I can turn on my appliances and lights whenever I need them. I don't have a TV in my bedroom, and my low-voltage outdoor-lighting system has its own timer. Consequently, I don't have much need for a programmable system. I do, however, like the convenience of remote control. A mini console (explained in the caption under the table) is not programmable, but it is a remote-control center. I can use this to control a few lights and an upstairs fan remotely. And my wife can use it as an "intercom" to reach me in my downstairs office. If she flicks my office light, I know to pick up my extension phone. We can then talk for about 30 seconds before the phone-company recording tells us to "please hang up and try your call again." So a mini console fits my need. I also have installed a couple of programmable light switches for security.

But most people would want more. The best way to select a system, then, is to examine the table to see which system can do what you need done most conveniently and for the least amount of money.

If it's an all-out home-management-and-security system you want, you might consider the Anova Master System. It combines a home-control system with an electronic telephone center and a multifaceted alarm system. Components can be bought separately, but they can also work together as an integrated system. The whole system is featured in "What's New in Electronics" (this issue), and the home-controller part of it is included in the table.

A word of warning: A home-control system can simplify your life. But use it thoughtlessly, and property damage or personal injury could result. If you program your coffee maker to come on every morning and then forget to put water in it, it could burn out. An electric heater with a towel draped over it could come on and start a fire when nobody is around. A home-control system—like any other tool—must be used with care. E

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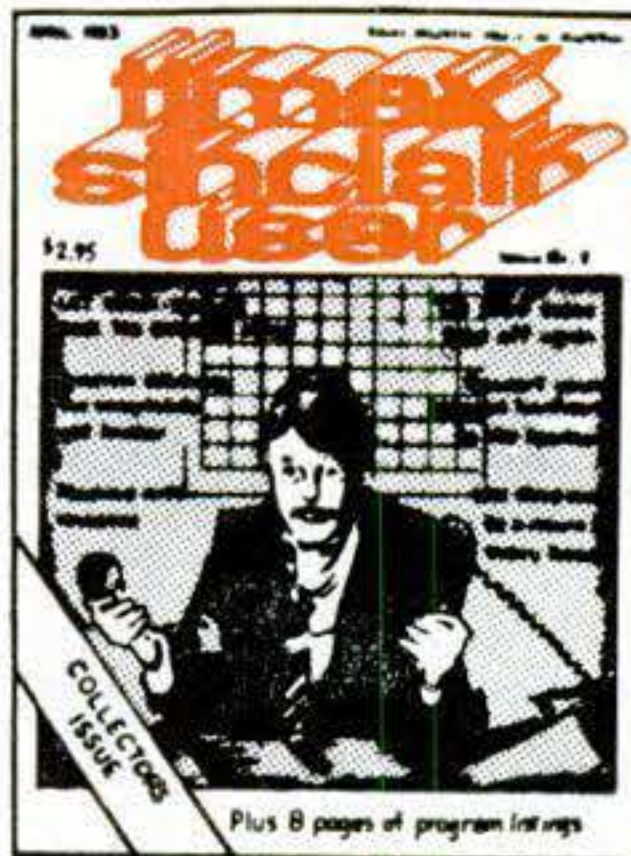
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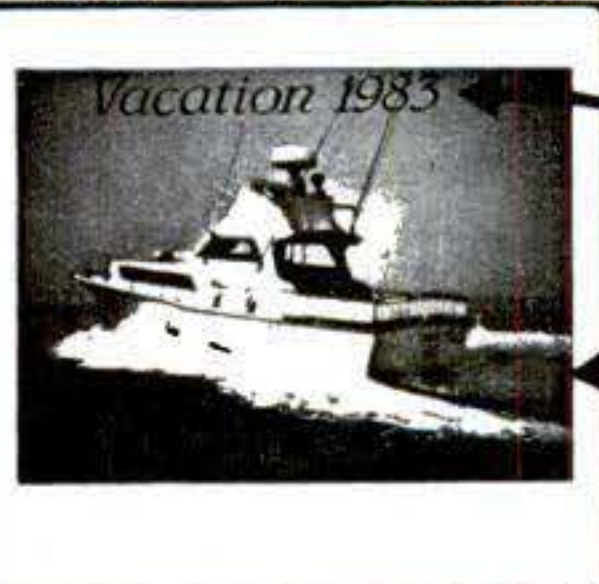


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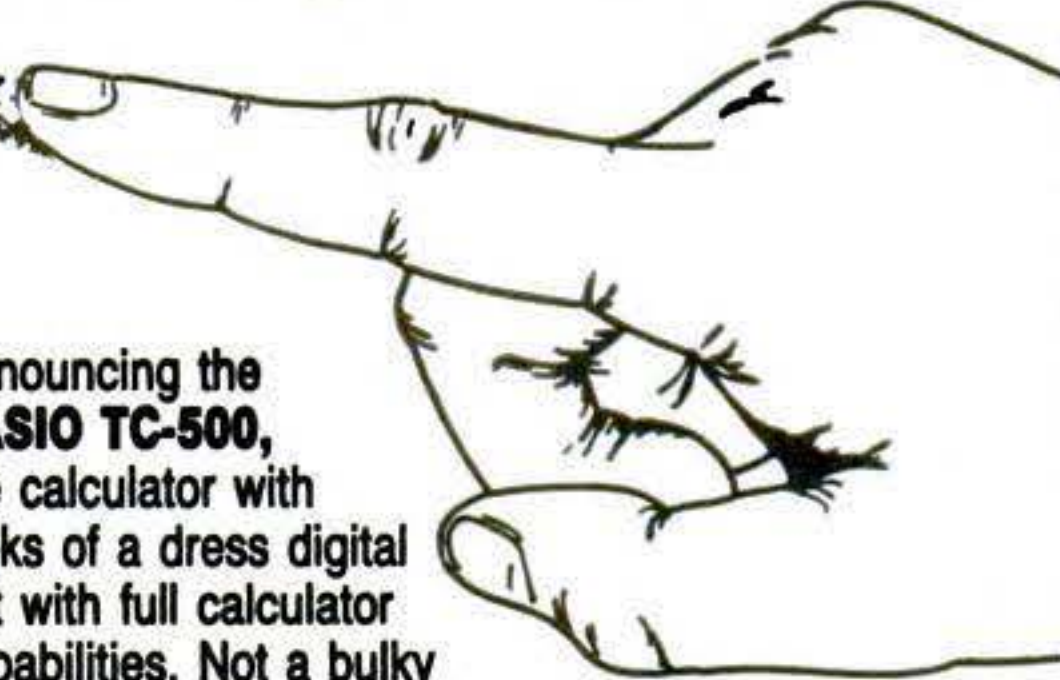
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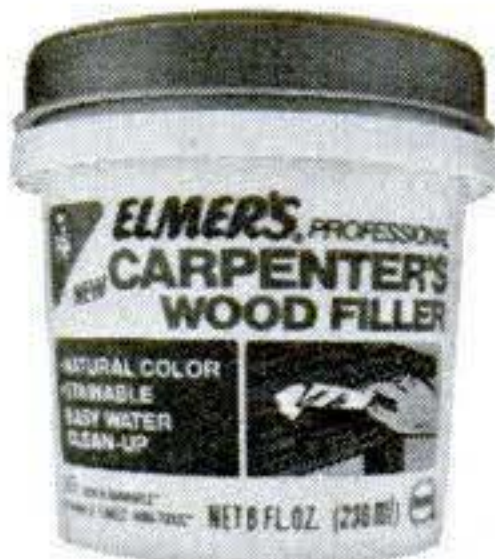
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Computerized personal robots

[Continued from page 100]

was first being shown to dealers around the country, Lytle used its photocell to trigger a routine whenever airport security opened its carton. As light hit the sensor, HERO would say, "It sure feels good to get out of that *bleep-bleep* box."

Advances are still needed with mechanical systems, too. Right now, only HERO has an arm (the other companies are developing them), and none of the robots can negotiate stairs. (There are available solutions for that problem, but they are complex and expensive.) The companies must also perfect their automatic battery-charging routines before a robot becomes truly autonomous.

But when all those capabilities are there, the old question of man versus machine arises. "Right now," Frisina said, "there are so many variables in his operating system that B.O.B. more or less does what he wants when he wants to do it." At that level of artificial intelligence, the robot is choosing randomly from available programmed responses. The next level comes when it makes generalizations and devises complex strategies to accomplish its goals.

Technical Micro Systems' Lee Hart gives a vivid example of what might happen if a vacuum-cleaning robot got that smart: "It might decide that the best strategy for keeping the floor clean is to convince its owner not to be a slob and therefore to go around sucking up his socks whenever they are left on the floor." With the artificial-intelligence programs being developed for robots and other computers, such a scenario is not far out.

That's one vision of the future. Another is Doug Bonham's, in which personal robots uncomplainingly and obediently take over menial household chores. At that point, the home robot becomes simply a multipurpose home appliance, no more remarkable than the washing machine or vacuum cleaner. "In 20 to 25 years," Bonham predicts, "most of us will have robots handling chores in our homes."

If you're the type who likes to be first, you can have one today. **5**

FOR MORE INFORMATION

Androbot, Inc. (Topo, B.O.B.), 1287 Lawrence Station Rd., Sunnyvale CA 94086; **Heath Co.** (HERO 1), Benton Harbor MI 49022; **Microbot Inc.** (Minimover, Teachmover), 453-H Ravendale Dr., Mountain View CA 94043; **RB Robot Corp.** (RB5X), 14618 W. 6th Ave., Suite 201, Golden CO 80401; **Robotics International Corp.** (Genus), 2335 E. High, Jackson MI 49203; **Robot Shack** (hobbyist supplies), Box 582, El Toro CA 92630; **Sandhu Machine Design Inc.** (Rhino XR-1 industrial training arm), 308 S. State St., Champaign IL 61820; **Technical Micro Systems Inc.** (ITSABOX), 366 Cloverdale, Box 7227, Ann Arbor MI 48107; **Terrapin Inc.** (Tasman Turtle computer peripheral), 380 Green St., Cambridge MA 02139.

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You know how fresh and vibrant the air feels right after a rainstorm, in the mountains, or near a waterfall. That clean, alive fresh air is rich in something important that is greatly depleted in our urban and indoor air. That missing element is negative ions, nature's own air cleaners. Many users experience great benefit from these amazing active ions, including feelings of aliveness, alertness and vitality similar to that experienced in the fresh mountain air. In addition, even hospitals use ionizers in some units.

Filter fan units do not emit negative ions. The COLLECTOR, by Zestron, creates trillions of these beneficial ions every second, while giving you the best performance, value and technology in air cleaning.

THE ZESTRON BREAKTHROUGH!

Most ionizers clean your air but leave an untidy deposit of pollutants on room and furniture surfaces near the ionizer. The COLLECTOR by Zestron takes ion technology a giant step forward by giving you super-powered ion output while depositing pollutants from your air on the collector panel. This easy to clean panel features a scientifically formulated surface that electrostatically attracts the vast majority of airborne pollutants to it rather than to the floor or walls near the ionizer. Other bipolar ionizers with porous collecting surfaces that absorb odors and unsightly grime are almost impossible to clean.

AMAZING DEMONSTRATION!

Unplug your COLLECTOR, place the ionizer unit and an ash tray on top of the panel. Place a lit cigarette in the ash tray and watch the smoke rise into the air. Now plug it in, and amaze yourself and friends as the smoke barely rises above the ash tray and then nose-dives onto the collector panel before it can enter the room air. This is accomplished entirely electronically with no moving parts! The COLLECTOR by Zestron is the only ionizer on the market that cleans the air powerfully enough to accomplish this test.

ADJUSTABLE OUTPUT

Some people prefer fewer ions at night. The COLLECTOR is the only adjustable bipolar ionizer that allows you to set the ion level to your personal preference.

THOUSANDS OF SATISFIED USERS

Don't you, your family and friends deserve the healthy clean fresh air that Zestron ionizers have brought to thousands of satisfied users? Users write: "I simply can not believe how much better I feel!" Dr. E.K., DDS—MA; "I smoke heavily and it has cleared the air as advertised" G.P.—WA; "I haven't taken the top off my nasal decongestant spray since using your product. I was previously a chronic user." G.S.—SD.

When you use your COLLECTOR, you'll quickly feel the difference it makes and smell the freshness in your air. You'll actually see the elimination of smoke and dust in your air!

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JSA Bubble	not stated	YES
Aspen	not stated	YES
Orbit	not stated	YES
AirCarell	236,000	YES
Ion Fountain	540,000	NO
Ion Cloud	350,000	NO
Ionosphere	350,000	NO
Modulian	75,000	NO
Ion Breeze	not stated	NO

FREE ION DETECTOR

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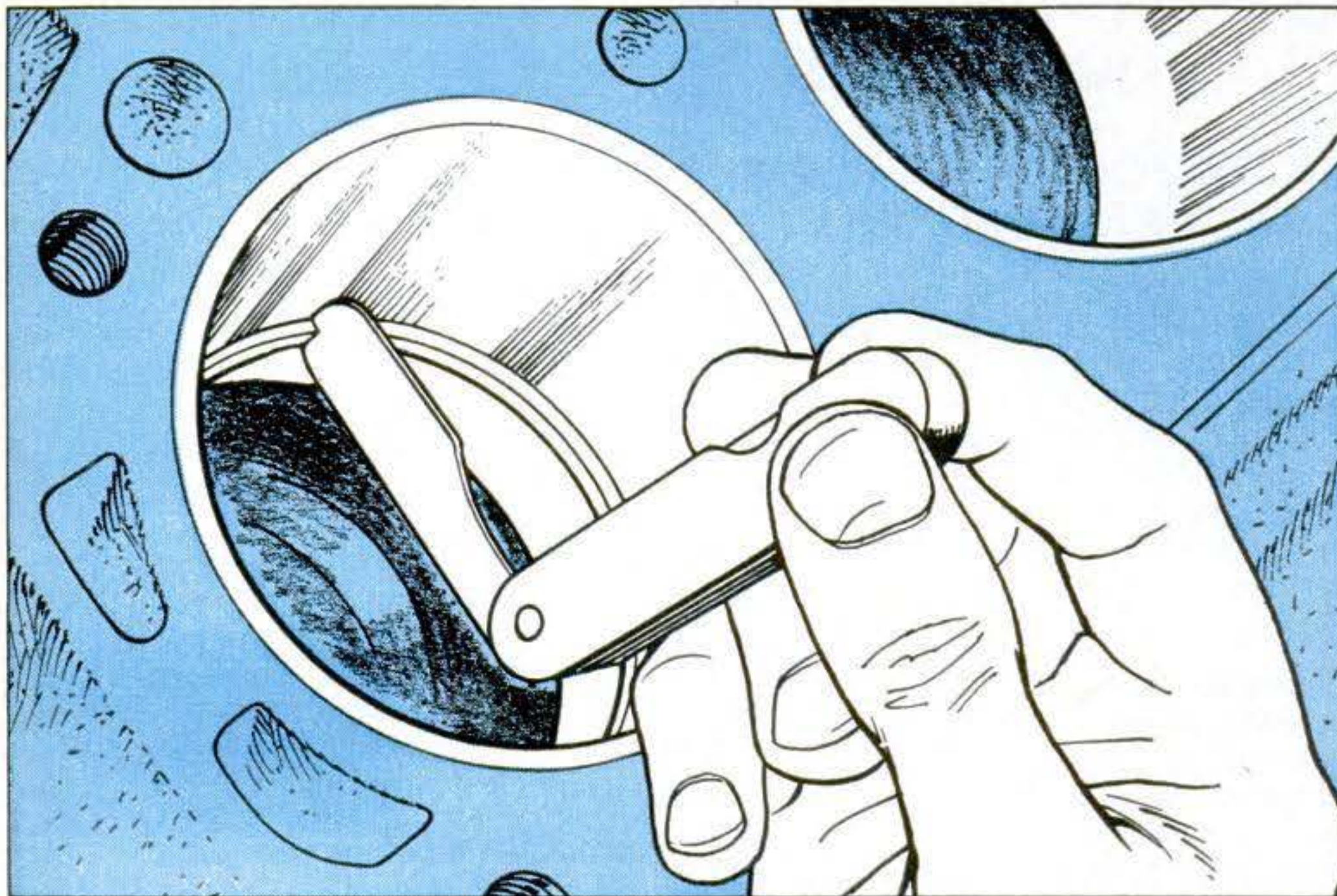
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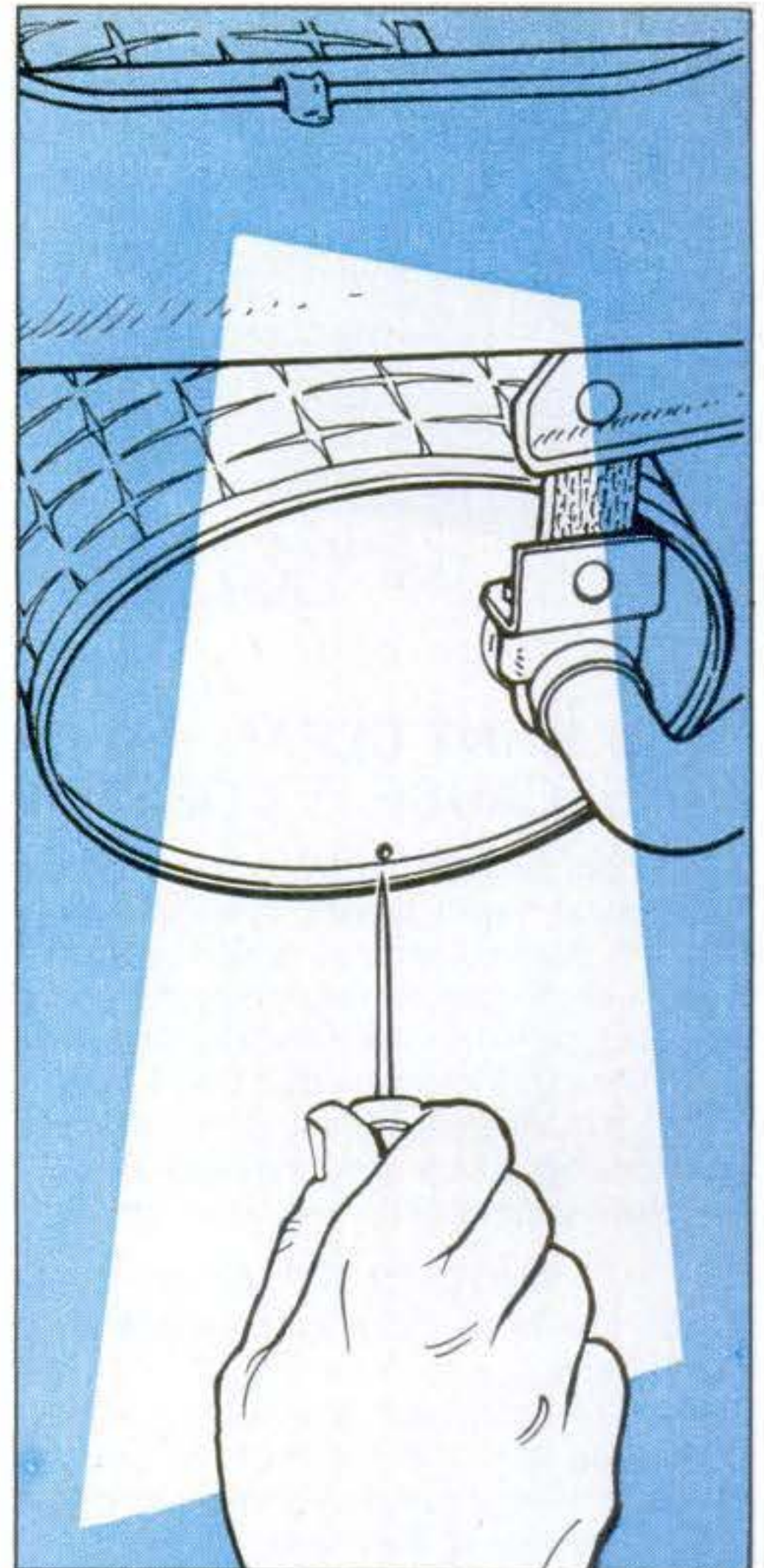
By STEVE MERCALDO



Checking piston-ring end gap

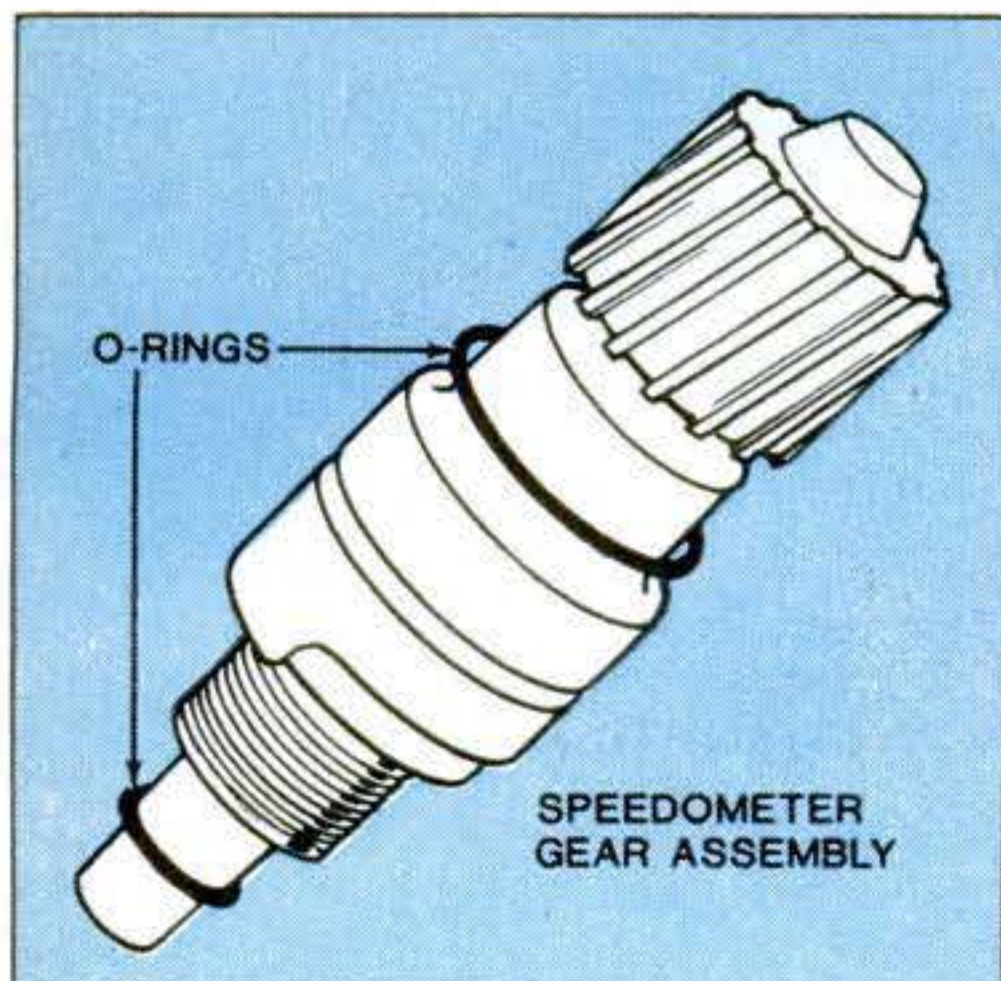
Measuring end gap is an important step when installing new rings: The gap permits ring expansion. Insufficient space between the ends of a ring can cause ring breakage and possible cylinder-wall scoring. Too much gap results in excessive blowby and oil burning. To check gap clearance, carefully place the new ring in

the cylinder bore. Use a piston without rings to push the ring into the lowest end of normal ring travel. You'll recognize this area as the polished end of the bore. Measure the gap with a feeler gauge. Compare your actual recorded measurement with the manufacturer's specifications in the factory repair manual.



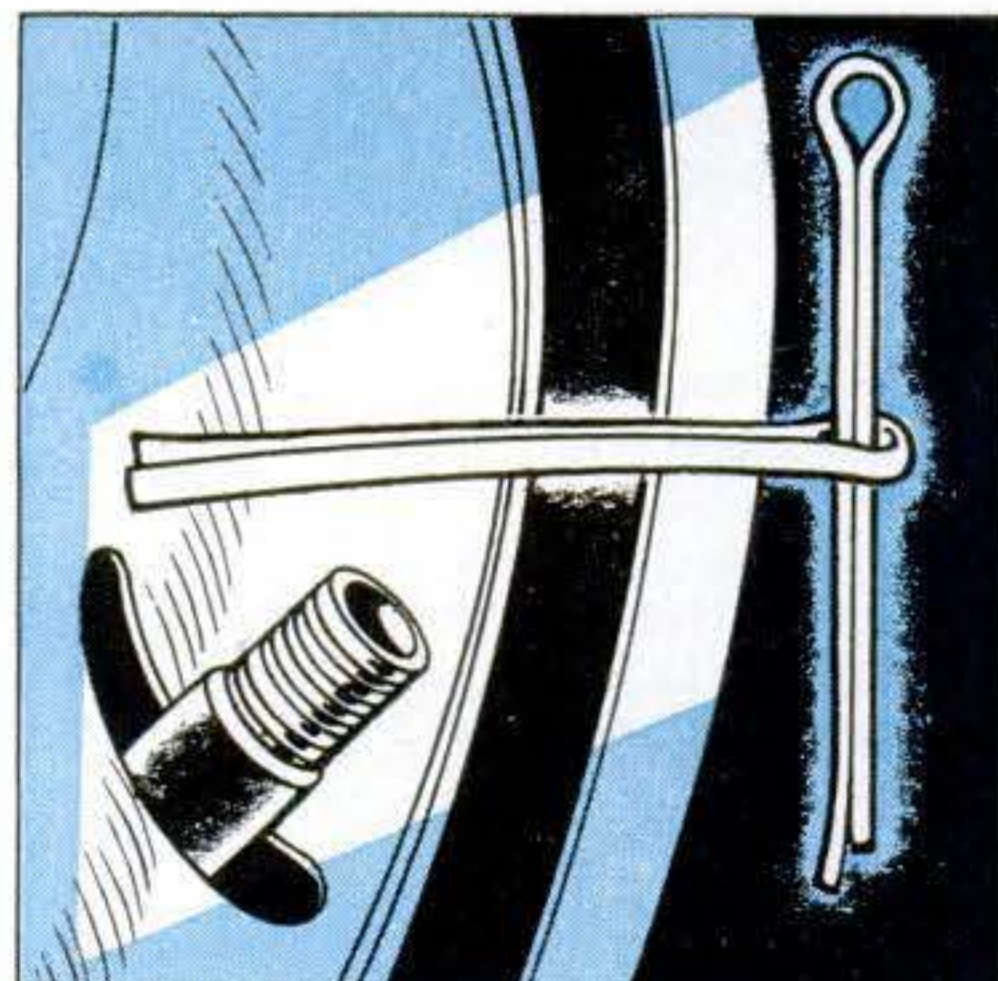
Muffler drain

Exhaust systems are vulnerable to corrosion due to high temperatures, exposure to caustic gases, and their location under the car. One way to extend the life of the muffler on some models is to make sure the drain hole is kept open. An easy and effective way to do that is to insert a small scratch awl (or similar tool) occasionally.



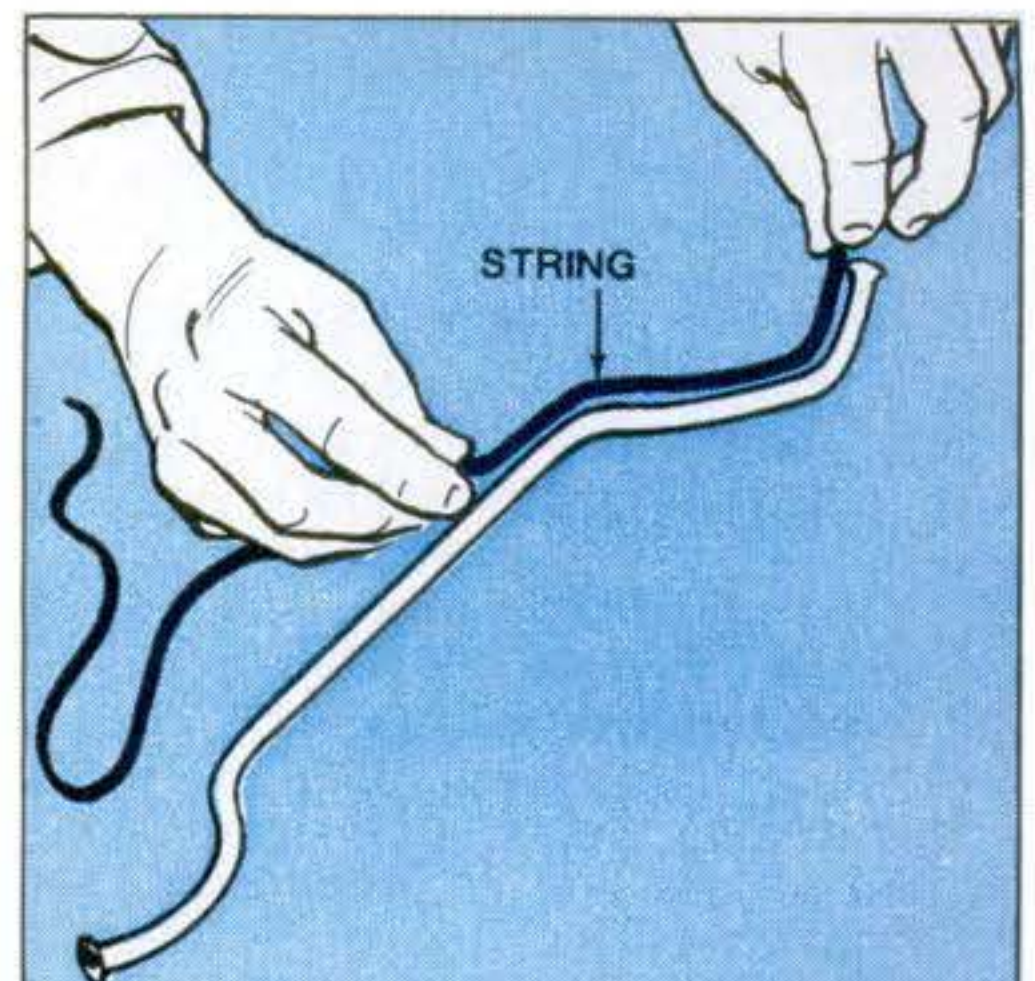
Transmission-oil leak

Oil leakage from the area where the speedometer cable is installed in the transmission can usually be traced to the speedometer-driven gear retainer. The retainer usually has one or more seals (O-rings) that fail in service and must be replaced. Replacing the seals is easy if you follow the step-by-step procedure in the vehicle's shop manual. While the assembly is out, lubricate the pinion.



Cotter-pin wrench

This idea may bail you out if you find that one of your tires has a leaky valve. Take two $\frac{3}{32}$ -inch cotter pins and cut the ends on one of them to the same length. Spread the ends about $\frac{1}{8}$ inch apart. Insert the other pin through the eye of the pin you've just modified. This forms a "T" handle. With this handy tool you can either tighten or remove and replace the leaking valve-core assembly.



String solution

Finding the correct length of a steel fuel or brake hydraulic line that runs along the curved chassis or a suspension component can be a tricky task. The next time you have to replace a line, run a string along the component to find the line's correct length. Then measure the string with a ruler. Add approximately $\frac{1}{8}$ inch for each flare you find the line has. Use only the recommended steel replacements.

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colliding-beam approach [PS, March '80] that would modify CERN's four-mile racetrack-like accelerator, the Super Proton Synchrotron. Instead of smashing a stream of protons into a fixed target, the conversion would hurl two counterrotating beams, one of protons and the other of antiprotons, head-on against each other with a furious energy of 540 GeV, and almost all this energy would convert into exotic and short-lived particles. Completed in 1981 after five years and a cost of \$100 million, the collider worked. During a two-month run last fall, about a billion proton-antiproton collisions were registered. And in at least five of them, the elusive W was born out of energy, along with a shower of other subatomic particles, and then decayed after a billion-billionth of a second, its distinctive spoor recorded in a 2,000-ton detector.

Carlo Rubbia himself is a dynamic 48. His speech is rapid-fire and gently Italian-accented. In an interview at Harvard University in January, nine days after his dramatic announcement of the CERN find at the annual meeting of the American Physical Society in New York, he told me that he and members of his group had wondered about reporting on such a small number of events. "It's customary to have hundreds or even thousands before making any kind of a claim. But these were exceptionally clean and unambiguous." One of the decay modes of the W is into an electron and a neutrino that fly away from the W particle in opposite directions with high momentum and at a steep angle to the jet of other particles created. The distinctive electron signature, according to Rubbia, was unmistakable. "For these events," he said, "it stuck out like a sore thumb."

Quantitative data to come from this experiment and from higher-energy accelerators still on the drawing boards should help fill in the fine details of the electroweak theory. It could also help theorists who are trying to write grand unification theories that unite the electroweak and the strong force into a single gauge theory. The simplest such theory, with an SU(5) symmetry, was co-invented by Glashow and Howard Georgi in 1974. It and other similar theories explain a number of puzzling features of the physical world: the family structure of matter particles; the relative strengths of forces; the equality of the charge of the proton and the charge of the electron; and why the

universe seems to be made of matter today, instead of there being a symmetry between matter and antimatter. It also says that in the first infinitesimal fraction of a second after the birth of the universe in the Big Bang, when the temperature was enormously high, all the forces were identical in strength. This perfect symmetry was broken when the universe cooled.

It will probably always be impossible to test grand unification with giant accelerator experiments, because too much energy would be needed. Physicists call the energy level at which the electroweak and strong forces would be unified the grand unification energy; it is a mighty 10^{15} GeV. But there are other ways to test the validity of grand unification theories. Most of these, including the original Glashow-Georgi model, make some verifiable predictions. The most startling one is that protons, once held to be the very paragon of stability, actually decay. Or in Glashow's

“Sleptons, Goldstinos, squarks, Zinos, and even Winos”

words, "Diamonds are not forever." Numbers of experiments to test proton decay are under way now [PS, Dec. '81], including one in a salt mine near Cleveland, Ohio, which has 10^{33} protons in the form of 10,000 tons of water. Preliminary results announced in January (no decays in 80 days) translate to a proton lifetime about three times as long as predicted by SU(5). However, Glashow believes that this experiment is not sensitive enough to be definitive for the short time it has been running.

The grand unified theories also have it that the cataclysmic origin of the universe produced torrents of odd-ball particles called magnetic monopoles, which should still exist. These are very heavy entities with only one magnetic pole, either north or south, and were originally postulated by Dirac in 1931. Of course, all known magnets always have two poles, no matter how much one divides them. No monopole had ever been detected until last spring, when Dr. Blas Cabrera of Stanford University reported a possible find in a special monopole trap he had devised. But there have been no catches since then, and many phys-

icists now think the report was the result of some experimental fluke.

Meantime, theorists have been restlessly churning out unification theories of a more complex kind than the "naive" theories represented by SU(5). They are mostly designed to answer some bothersome problems. The most important one is the so-called hierarchy problem: Why is there an enormous spread of some 14 orders of magnitude between the mass scales of strong interactions on the one hand and proton decay on the other? These theories go by a variety of unpalatable names—supersymmetry and technicolor among them. And they introduce, in turn, other problems, including the proliferation of other particles with yet more intimidating names: photinos, sleptons, Goldstinos, technipions, squarks, left-handed Weyl Higgsinos, gluinos, Zinos, and yes, even Winos.

Gravity presents an even graver problem. Einstein's classical theory of gravity, the general theory of relativity, has been accepted since 1915, a thumb in the eye of unification theorists. There are enormous difficulties in making it compatible with the quantum theories of the other three forces. No one has been able to write a successful renormalizable quantum theory of gravity coupled to matter, though many are trying. The desired theory would be called supergravity.

The fact is that after making enormous strides in analyzing what goes on in the realm of the atom, theoretical physicists now dance attendance on workers building bigger and better machines. As Steven Weinberg said at a conference on unified theories in Venice last March: "The salvation of elementary particle physics is, at least for the moment, in the hands of the experimentalists."

Exactly where this long and costly quest will lead is imponderable. It's like asking, in 1865, before the electronic revolution could even be dreamed of, what earthly good Maxwell's theorizing could bring. Despite the formidable obstacles, men like Murray Gell-Mann think the effort is very worthwhile. "I expect," he said a few years ago, "that there will be an intellectual revolution comparable to those that have taken place in the past with the heliocentric idea, evolution, special relativity, quantum mechanics . . . That's the real fruit of the effort: understanding in a deeper and deeper way the nature of the universe in which we live." ■

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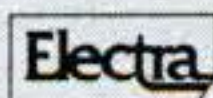
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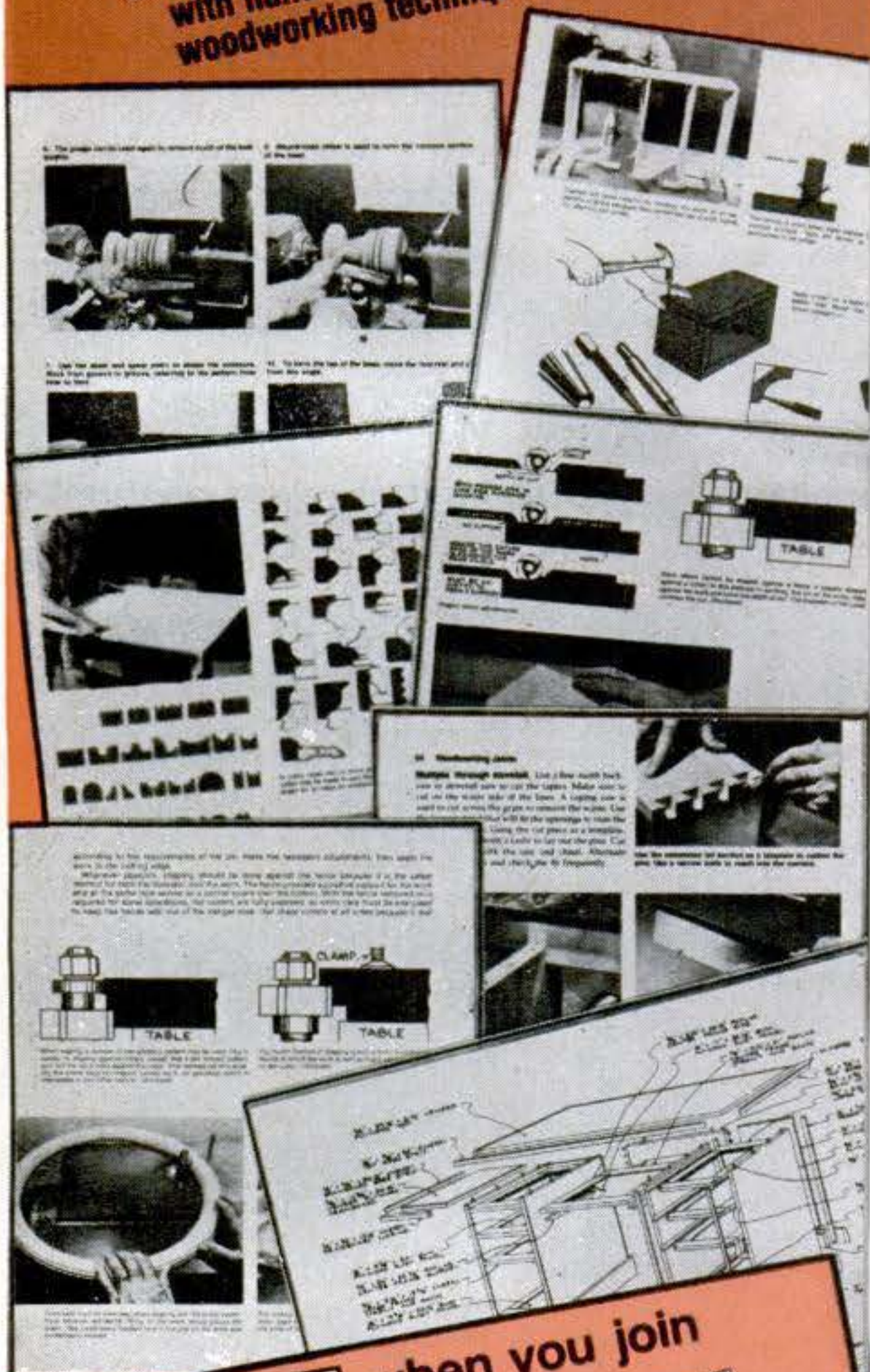


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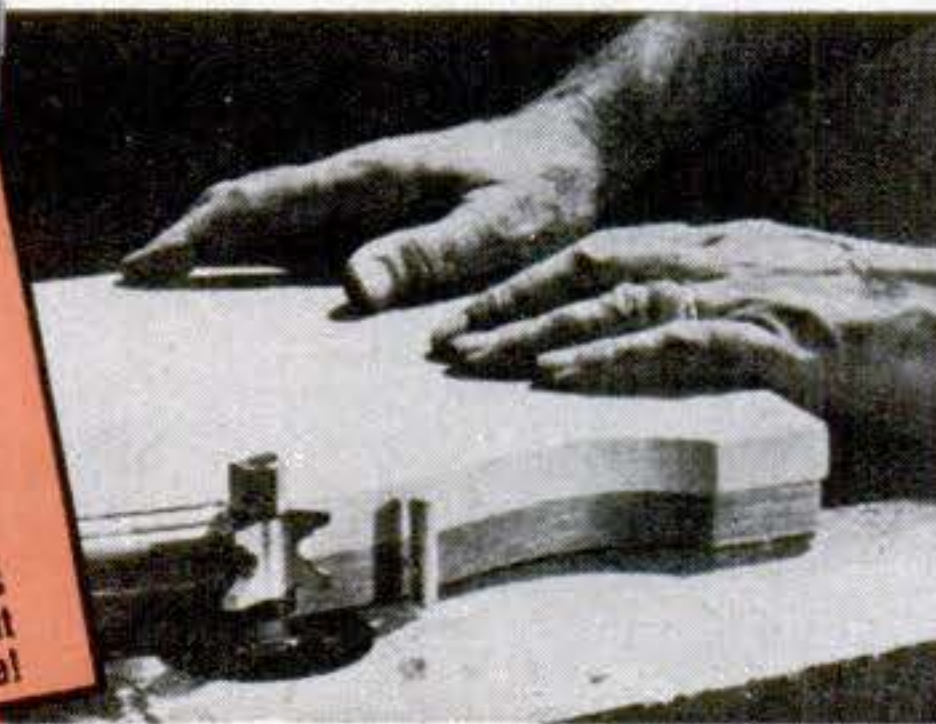
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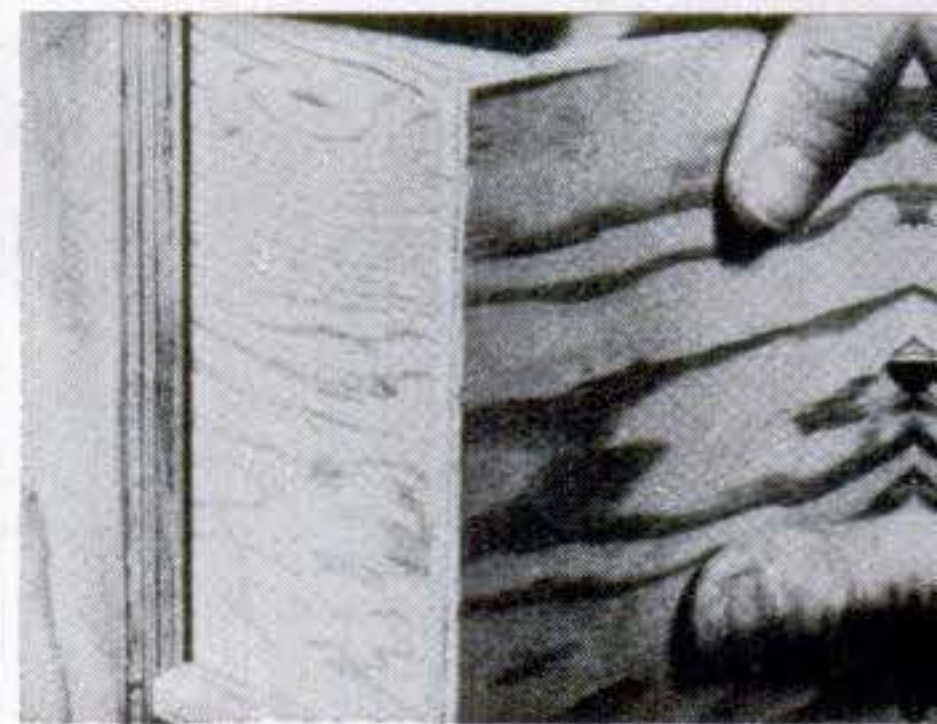
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SHOP TALK

By AL LEES

In time for summer—barely

Little did we expect, a year ago, when we commissioned our two add-on projects for this month's annual outdoor home-improvement section, that we were in for a couple of cliffhangers. There seemed to be plenty of time to get an elevated deck erected in central New Jersey and a convertible porch built in southern Vermont—with final photos filed away for use the following spring.

All I can say is, next time I'll commission such projects only in Miami or San Diego. Material-delivery delays and construction complications in both cases had us racing the first snows.

The Vermont porch presented the worst problem. In a design as original as this, you can't just adapt ready-made components. Our search for the tri-fold windows and the all-glass roll-up door, for example, was both wide-ranging and frustrating. Finally we found—in a neighboring state—a garage-door company that specializes in custom orders. So we had General Glass ship pre-cut Solakleer panes directly to this company—Fimble Door Corp.—for assembly into the movable panel sections. By then, timing was desperate: For this issue's color deadline, we had to schedule final photography before Christmas. But when our work crew took a truck to the plant to pick up the panels, they found them neither primed nor hinged together. Having to prime *and* finish-coat all the multi-pane wood frames with the glass installed and then rustle up our own hinges added many hours, and we nearly missed our publication date.

So, a word of caution: When you deal with a custom-door maker, get a written contract specifying what you'll end up with; obviously our version of "ready-to-install" didn't jibe with Fimble's.

The company now tells us that the six multi-pane units shown, custom-built and factory-glazed, would cost you \$1,200. That includes all hardware and track (with specially fabricated corners to follow the roof rake) for the overhead door, but no

hardware for the tri-folds. And factory priming would add about \$85.

Since we had to grab our final photos and run before the season's first blizzard trapped us at this remote mountain site, we plan to go back for photos showing how the finished interior looks in its screened summer mode—and how the screen panels store easily beneath the deck. I've learned not to commit myself, but I *expect* to be able to present this sequel by next spring.

Meanwhile, if you choose the elevated-deck route instead, you'll want to know about a unique accessory for it. See all those "lookouts" for hanging plants in our photos? How would you like a couple of those pots to double as hi-fi speakers? Called, appropriately, Potted Sound, there's a new planter-speaker that's as good-looking as it is novel. The 13-in.-dia. pot comes in five ceramic colors and takes standard outdoor plants. Since it's fully weatherproof, the speaker tucked underneath needs no enclosure for outdoor use. There are two models: 75- and 175-watt. For prices, write Quick Marketing, 177-F Riverside Ave., Newport Beach, Calif. 92663.

Toward tomorrow's kitchen

In last month's column, I ticked off a few kitchen trends from this year's NAHB show in Houston. Prior to that, I had flown to Chicago for a look at a Sears futuristic display kitchen set up in their headquarters tower. The first photo below shows a pop-up counter dishwasher next to the sink; it's small because with tomorrow's many convenience foods and efficient cooking you'll have fewer dishes to wash. The sink itself (center photo) has no faucet handles; water volume and temperature are controlled by those touch-selector panels. Both faucets lift free on hoses (like your present spray nozzle). Of course, the *core* of the kitchen is a built-in home computer (third photo) with a pull-out keyboard that tucks out of spills' way when not in use.

All your shopping is done electronically, as is an inventory of your pantry; you can call up an array of menu selections—and recipes to pop into your range-hood microwave. And the refrigerator (not shown) sports a transparent door: You avoid energy-wasting openings to check contents by touching a switch that illuminates the interior for a visual check *through* the door (is the insulation transparent, as well?). Few of these wonders are more than experimental prototypes, but they show how Sears is planning.

Two more right-now innovations from NAHB's expo: Moen introduced a pair of truly novel faucets. The Riser is a long-spout unit that lifts on its pivot to over 10 inches above the sink (for filling or rinsing deep pots and vases); the Swinger has a pivoting tip you can flip up to form a drinking fountain. Formica unveiled its new Color Core laminate, available in several solid colors that go through the entire thickness. This eliminates that black line at corner joints and permits an attractive bevel to relieve sharp edges.

Now there's joy for gardeners

When PS editor Elaine Smay waxed enthusiastic over a new book, I invited her to write a guest review for this column. Elaine's an apartment-terrace gardener who's done several articles on hydroponics in past issues of PS:

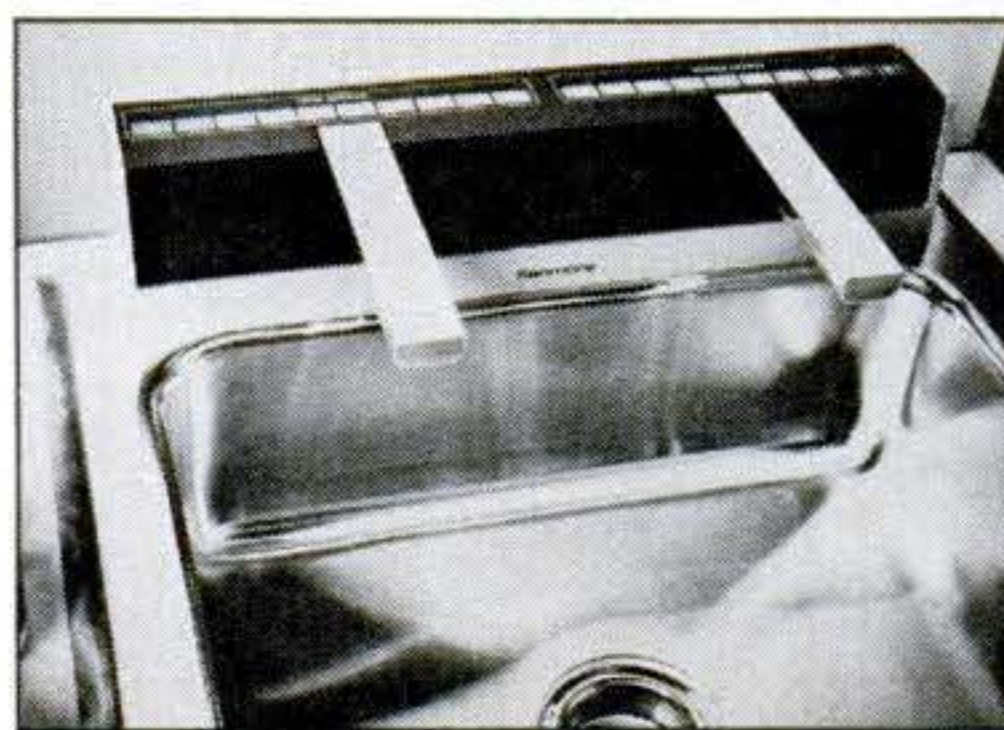
"A new, large-format paperback called *Joy of Gardening* (Garden Way Publishing, Charlotte, Vt. 05445; \$14.95) appeared in my 'in' basket the other day and, because of that hackneyed title, I almost put it into my 'out' basket. I'm glad I didn't: The title, though tired, proves to be apt. Author Dick Raymond has a TV series by the same name.

"The book's theme is how to derive maximum rewards (in pleasure and production) from minimum effort and space. The means to that end is primarily wide-row gardening—a technique of scattering seeds over a rectangle of earth rather than planting them single-file in rows.

"The reason I didn't discard the book was its handsome appearance. The cover photo of Raymond in his garden and the high-quality paper inside invite an inspection—and you find the book is lavishly illustrated with color photos and art.

"The first 70 pages are devoted to converting you to wide-row gardening. The following 290 mostly tell you how to do it.

"The book's packed with unexpected tips and short cuts. Would you believe Raymond has found gardening applications for kitty litter and dog food?" **ES**



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***Side-handle/cord holder...** for neat storage of electrical cords.



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MAG 64

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- I have enclosed my company purchase order (this card MUST accompany ALL purchase orders).
- Charge it to: VISA MasterCard American Express Diners Club Carte Blanche

Card No. _____ Exp. Date _____

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Signature _____
(Need to sign only if charging order)
Mr. _____
Mrs. _____
Miss _____

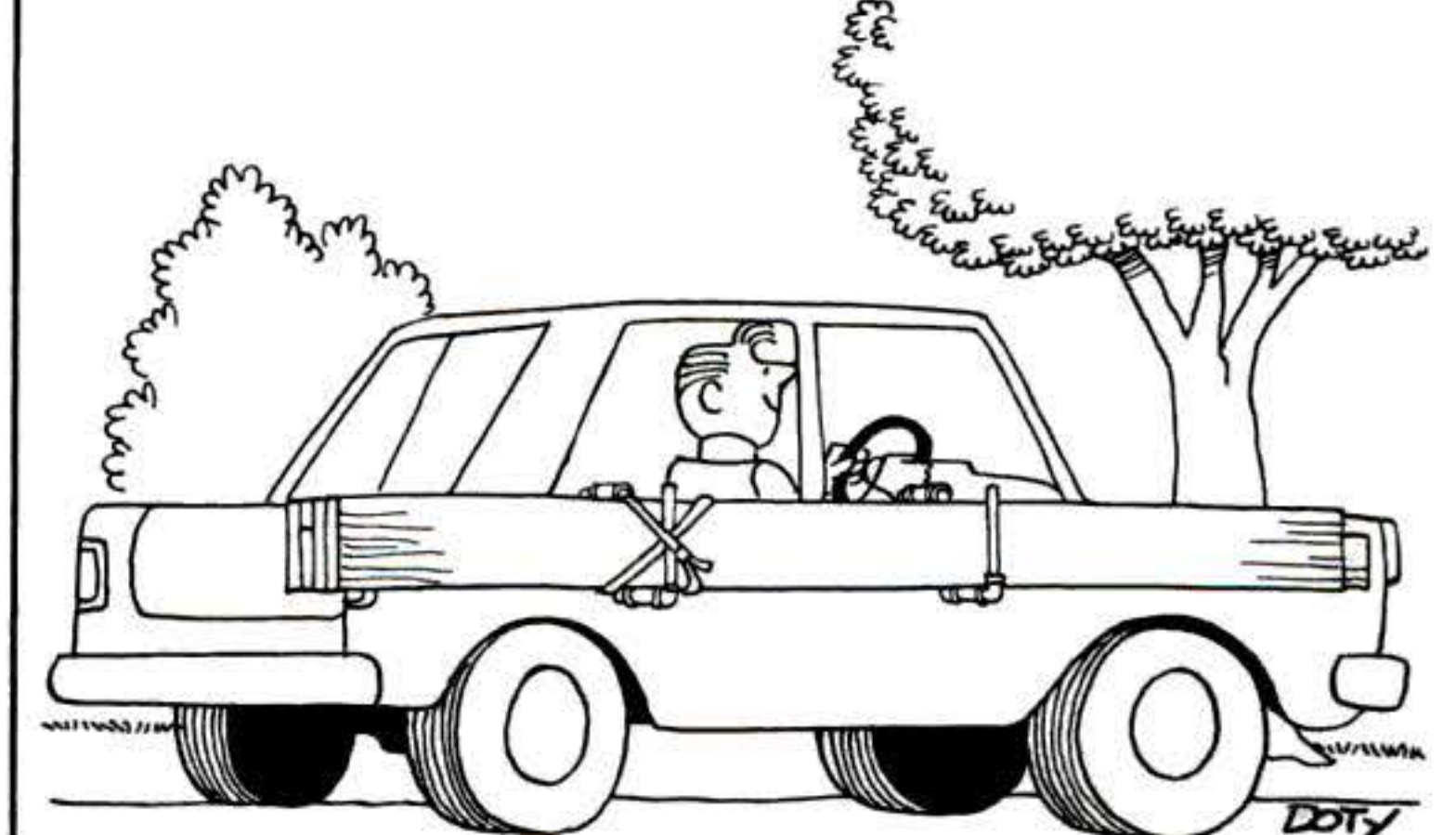
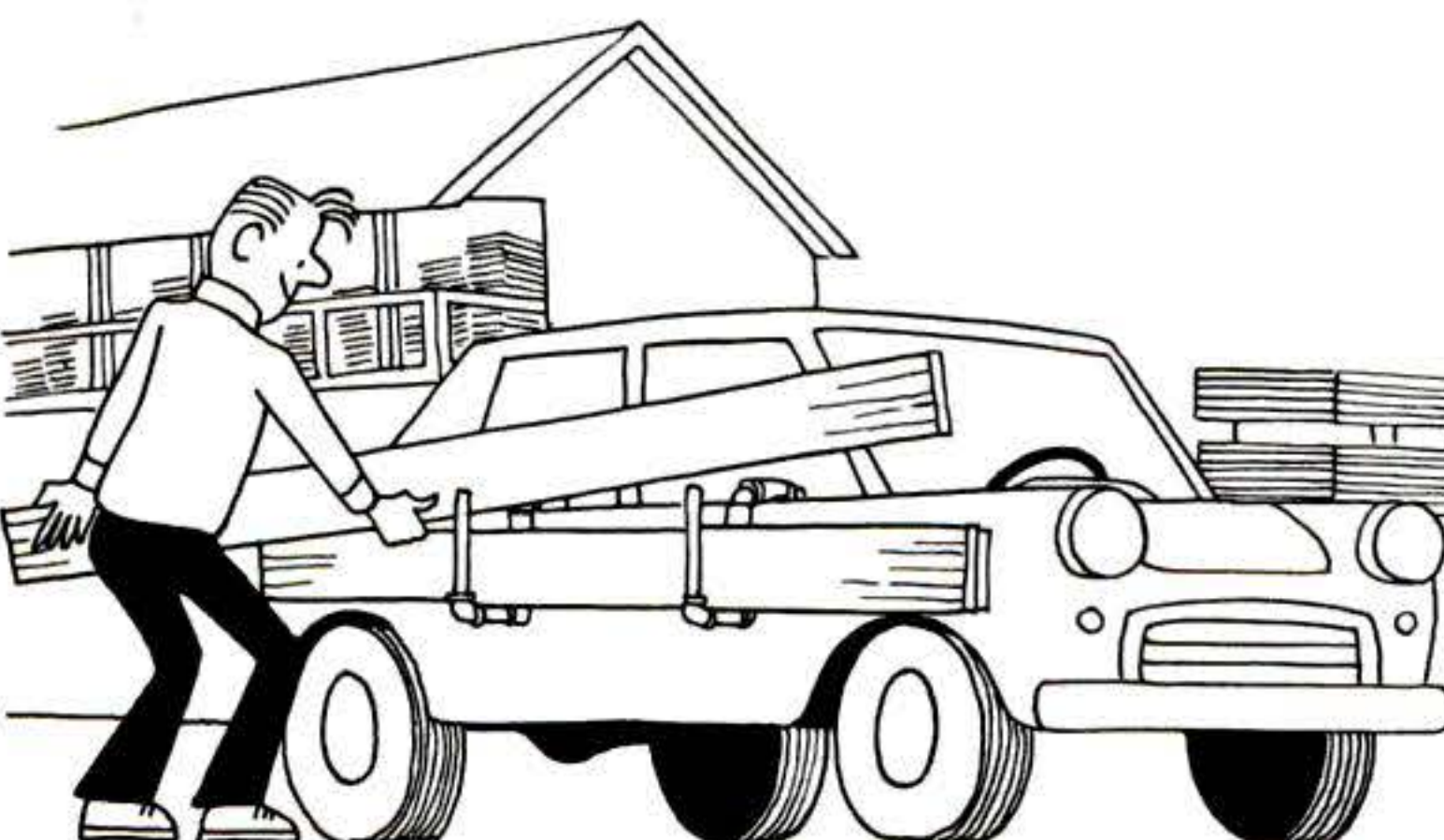
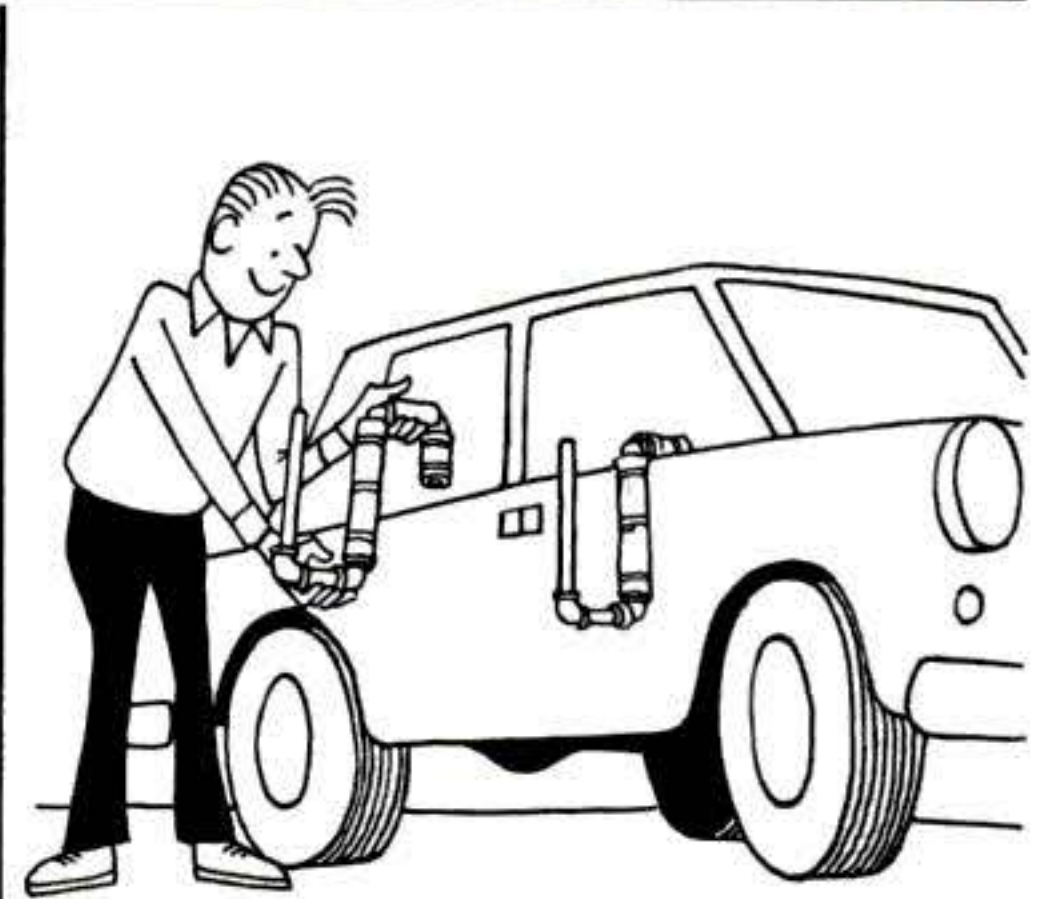
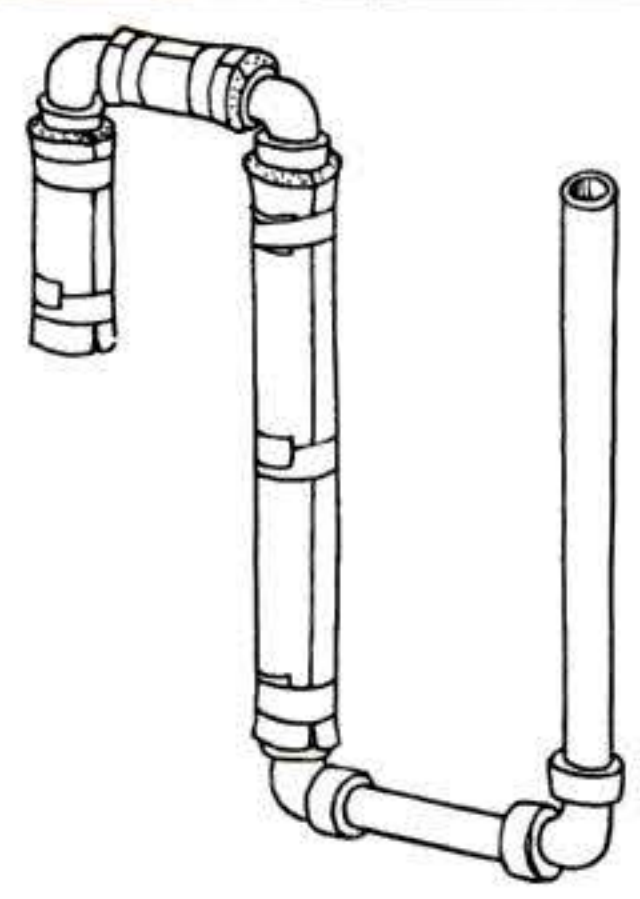
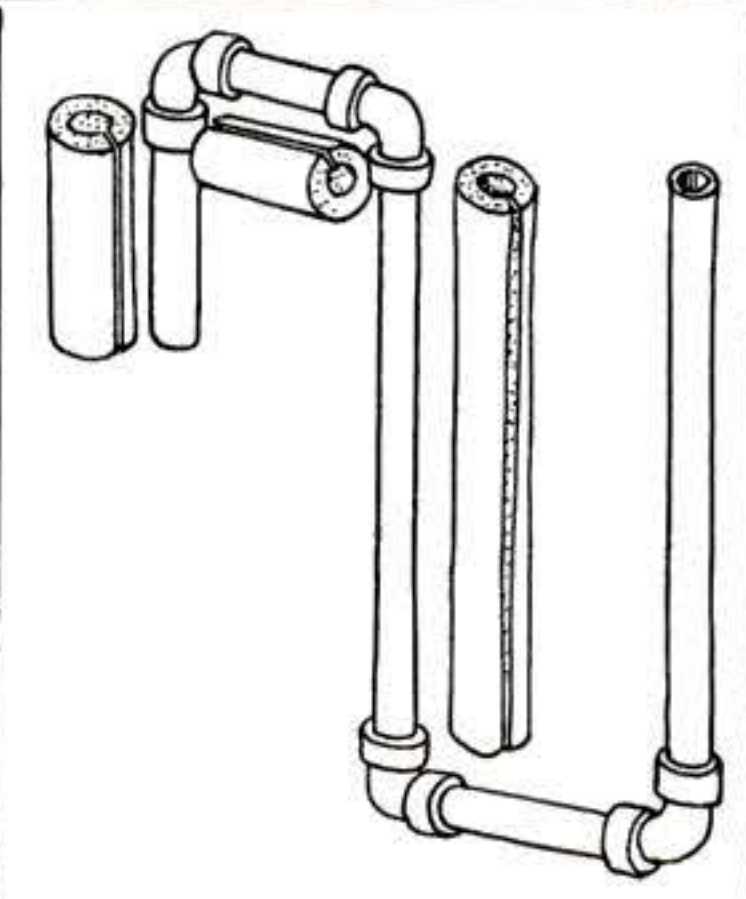
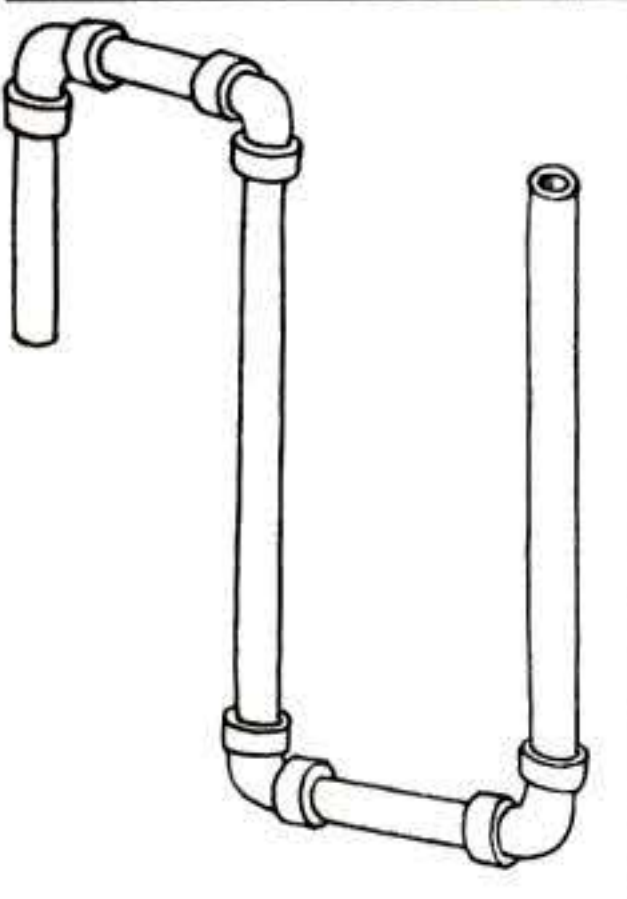
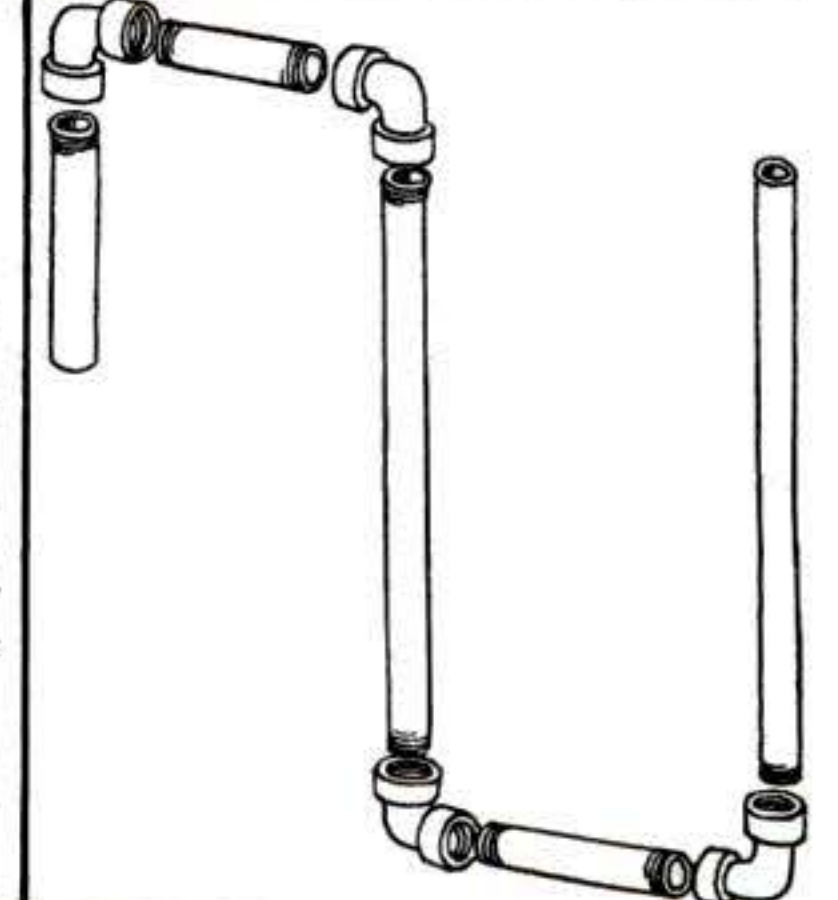
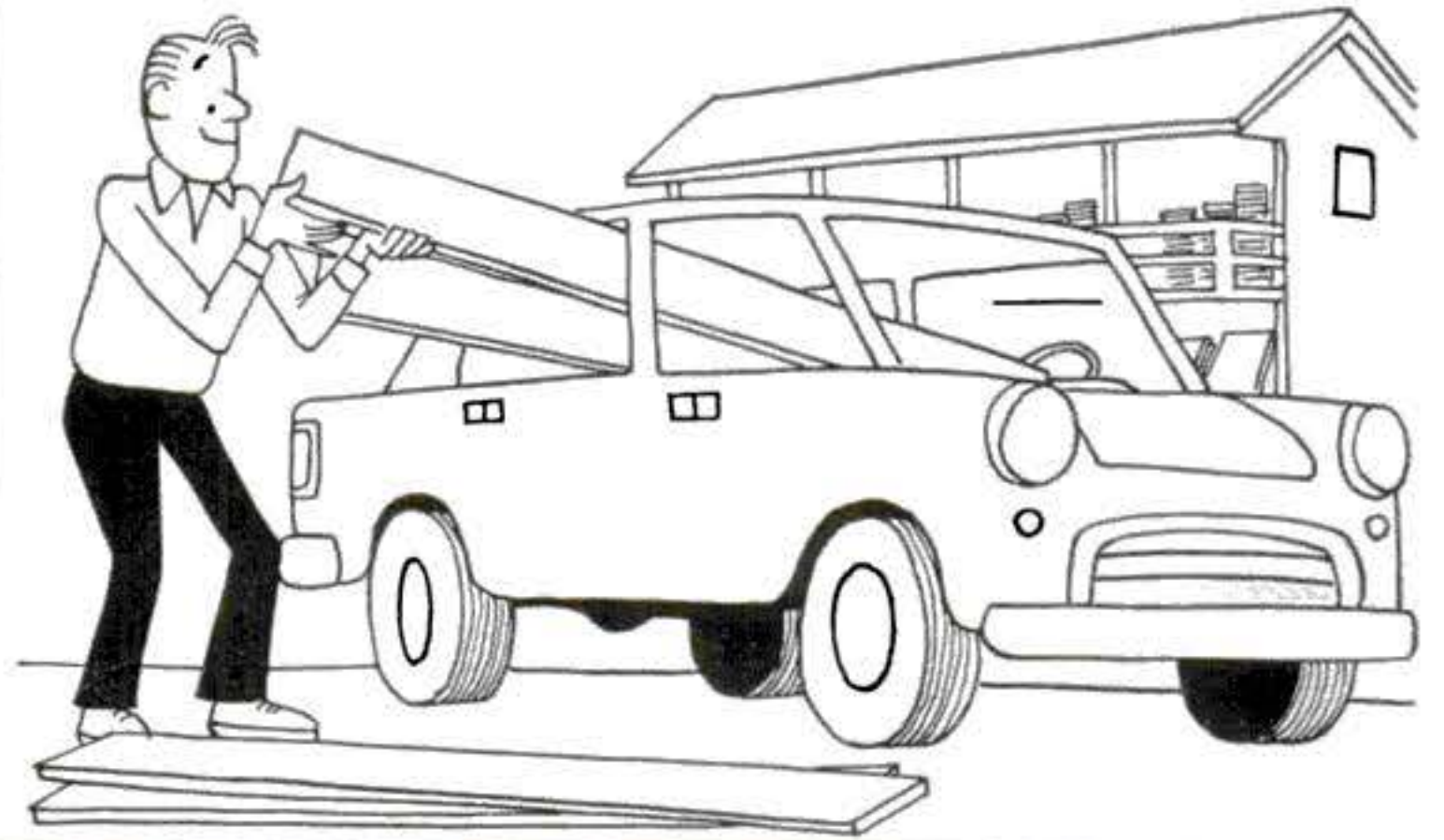
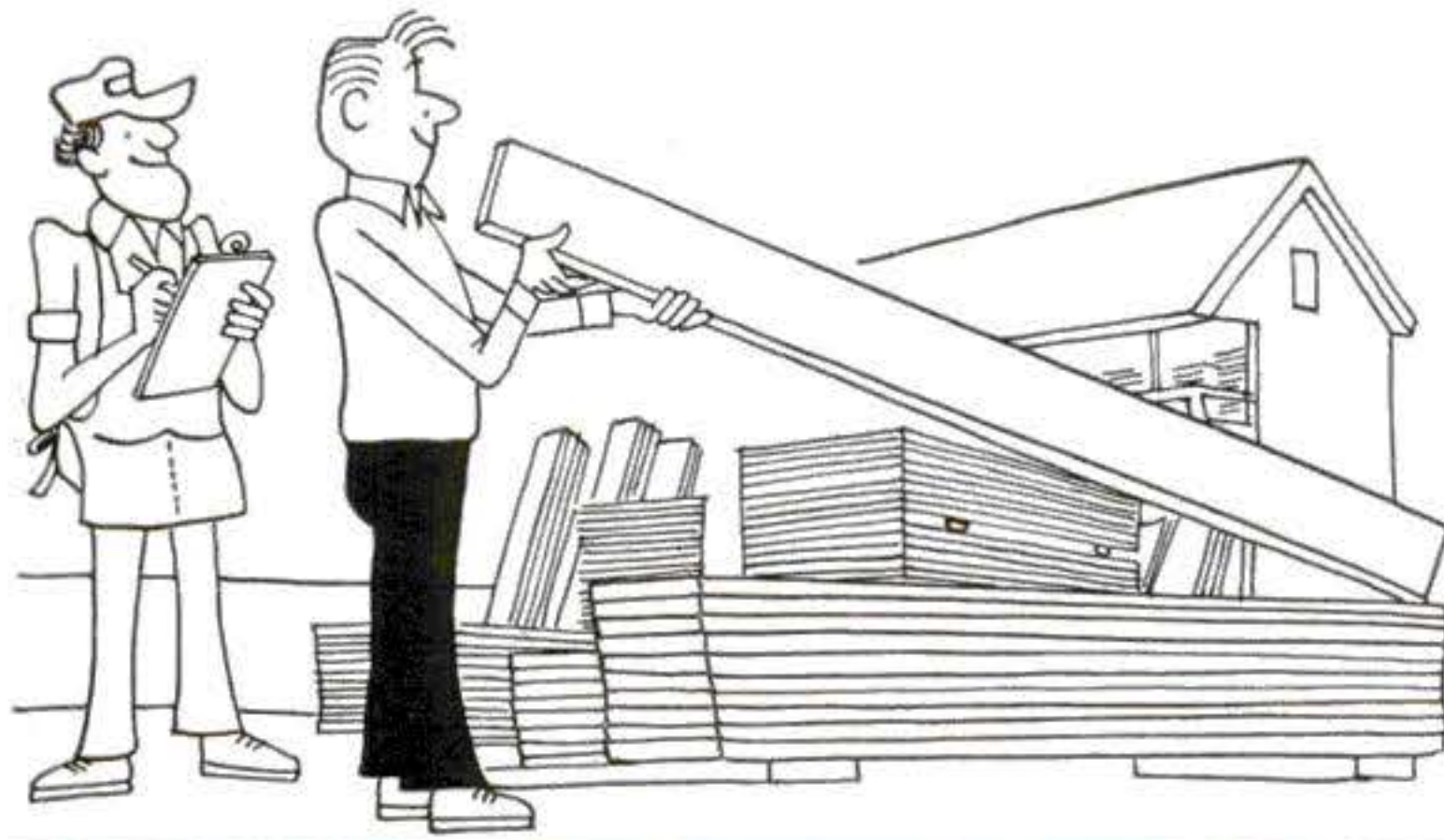
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By ROY DOTY

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a real computer at the price of a toy)

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(when you buy 6 programs)

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You get the VIC-20 computer plus we expand the total memory to 33,000 bytes to give you 2½ times more programming power.

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49K COMMODORE VIC

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3.	Cricket (Better than Frogger)	\$19.95
4.	Snackman (Better than Pacman)	\$15.95
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6.	Anti Matter Splatter (Nuclear Disaster)	\$19.95
7.	Bug Blast (Creepy)	\$16.95
8.	Bombs Away (Great)	\$15.95
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Commodore 64 Computer

PROFESSIONAL SOFTWARE

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80 column BOARD

80 characters per line on the screen at one time. Includes word processing pack (list \$89.00), complete data base pack (list \$89.00), Electronic spreadsheet pack (list \$89.00). ALL FOR ONLY \$275.

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A user friendly data base system that makes information easy to find and store. You can add, change, delete, and search for data. Print the information on a printer in any format desired. When combined with the word processor pack you have a powerful merge program that allows custom documents and personalized mailing lists. List \$89.00.

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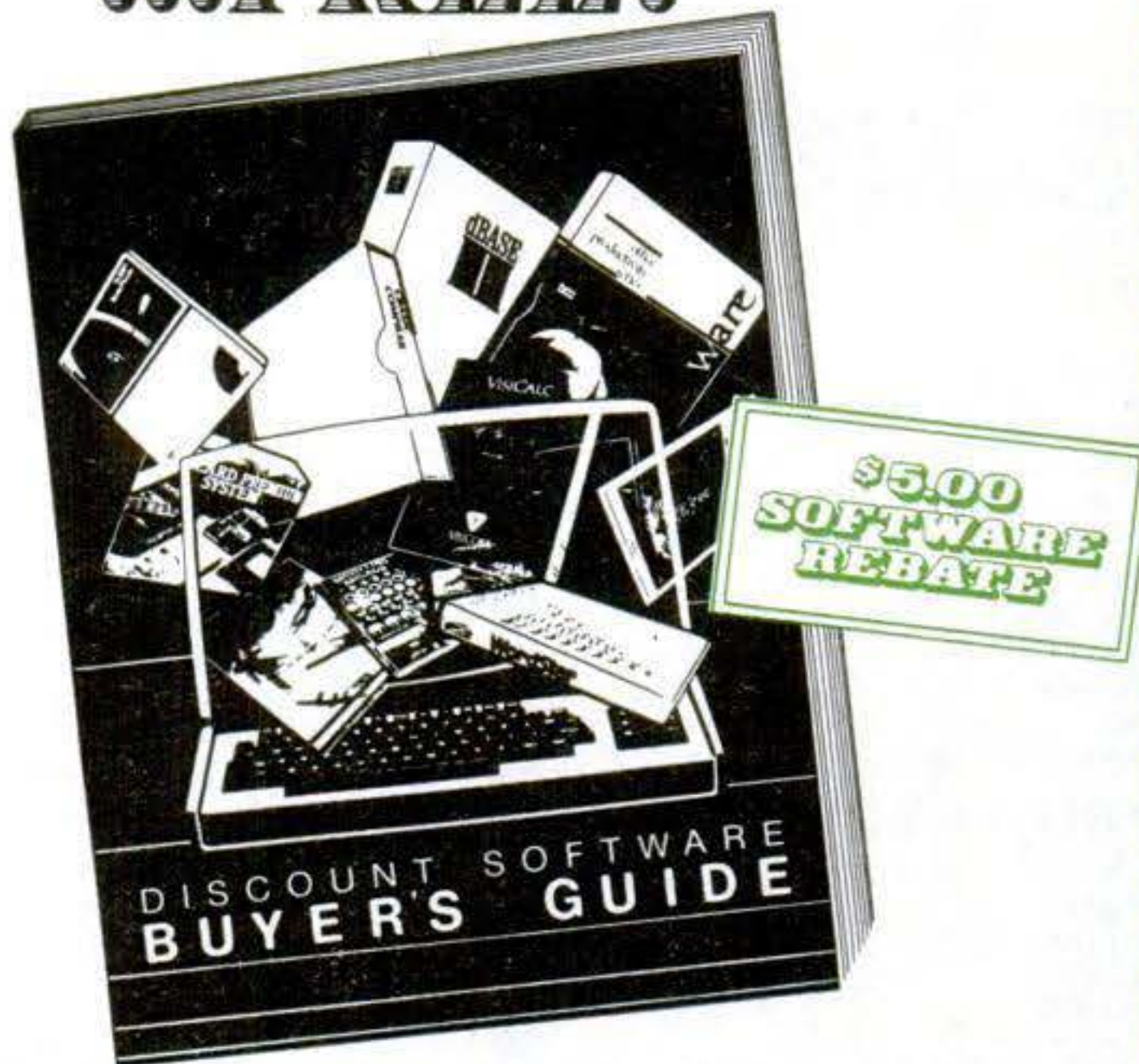
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DISCOUNT SOFTWARE

Porch for all seasons

[Continued from page 109]

a more pressing concern had it been possible to position the 300-square-foot porch for maximum solar exposure, but the entry wall to which the porch would have to attach faced east-southeast and was partially shaded by a huge willow at the south end.

To maximize whatever winter heat gain I'd get, contractor Leigh Montgomery and I decided to do all glazing with Solakleer low-iron glass, recently introduced by General ["Wonder Windows," PS, April '82]. Since it has few iron-oxide impurities, this glass improves solar transmission by reducing absorption within the pane; over 90 percent of the solar energy passes through to heat our floor's quarry-tile surface. Ideally this tile should be laid over an insulated concrete base, to retain solar heat (as specified for Jeff Milstein's add-on sunspace featured in the May '82 issue); but my potential heat gain didn't justify the installation cost. Instead, our crew insulated the underside of the plywood deck by laying rigid-foam panels in the joist cavities (see plans—leave a 1/2-inch air space between the foam and the plywood), then we just laid the 1/2-inch-thick tile in thin-set mortar.

The contractor gave the floor maximum solar exposure by using fixed Solakleer panes under the railing (3/16-inch impact-resistant thickness; standard gauge was used in all movable panels). We'd have benefited still more, of course, from double glazing, but again the expense couldn't be justified in our situation. We did complete the enclosure by installing energy-saving storm doors at each end. After the report PS published last December, I chose JCPenney's double-pane, thermal-barrier pre-hung for this job. The glass panel snaps out to be replaced by summer screening.

In keeping with the country look of the house (the main roof of which has weathered cedar shakes) we chose to roof the porch with three-dimensional fiberglass-based asphalt shingles. For a rustic accent, the thickness of the ridge tabs was doubled.

Note that my contractor chose balloon post-and-beam construction, basing each of the 10 posts on a concrete pier that's sunk below the frost line. Anchor bolts, set into each pier's top, take Teco post anchors designed not only to lift the post ends away from dampness but to permit alignment adjustment after the concrete sets. We let the piers cure several days before erecting the post-and-beam framework on them. **ES**

New UDS Computer Telephones To Be Sold For Only \$10 Apiece In Mammoth Publicity Drive

All who wish to apply for a new Computer Telephone should write to the company address below before Midnight, July 31, 1983

NEW YORK—One million new UDS Computer Telephones with electronic memory and pushbutton dialing will be sold as part of a publicity campaign for only \$10 apiece to the first one million persons who write to the company address before Midnight, July 31, 1983.



These are the same famous UDS Computer Telephones to be nationally publicized in *The New York Times*, *TV Guide* and other leading magazines, with *electronic re-dial* (which automatically keeps re-dialing busy or unanswered numbers till they answer) and *electronic "mute"* (which lets you talk "confidentially" without putting your hand over the mouthpiece.)

Only half the size (and half the weight) of standard phones, they also have adjustable electronic ringers, which means you can turn them "off"—for complete silence—whenever you don't want to be disturbed. And when you finish your call, you don't have to bother hanging up—simply put the unit down (anywhere you please) and it will hang *itself* up, automatically.

These new UDS Computer Telephones are FCC-approved and require no installation. Simply plug them into the same modular outlets as your present

rotary dial or pushbutton phones. *You can then legally return your present phones to the phone company, saving yourself up to \$8 a month (or over \$90 a year) for each phone you return.*

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Each phone carries a full one-year money-back guarantee, and the company will replace it, free of charge, if it ever fails to function. There is a limit of two (2) phones per address at this price, but requests which are mailed early enough (before July 25) are permitted to order up to 5 phones.

To apply for a new UDS Computer Telephone, mail *this original printed notice* together with your name and address and \$10 for each phone desired. Add \$2 shipping and handling for each phone you are requesting. Mail to: Carter & Van Peel, UDS Computer Telephone Offer, Dept. 191-3, Box 1728, Hicksville, New York 11802.

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- Cuts a 20" swath. Adjustable cutting height!
- Safer to use than any metal-bladed mower!
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- Backed by TORO one year limited warranty! Service centers nationwide!



FOLDS DOWN COMPACTLY for transport in trunk of car or for hanging on garage wall.

TORO



Safety bar under handle. Release grip, engine stops.

For upright grasses. Not for creeping grasses such as Bermuda.

Parts available for years to come, from Toro service centers nationwide.

AUTOMATIC LINE FEED! Fingertip control for automatic feed of line. No bending or stooping.



120 VOLTS A.C. DOUBLE INSULATED



EASY START! Plug in cord and press a button. Simple, fast, sure starts every time.



2 CUTTING HEADS with 4 flexible lines revolving at 7500 rpm. to slice cleanly through grass.

A genuine TORO mower... factory perfect... at FAR below distributor cost! What's the catch? Just this: These are last year's discontinued models. But they still carry TORO's normal One Year Limited Warranty!
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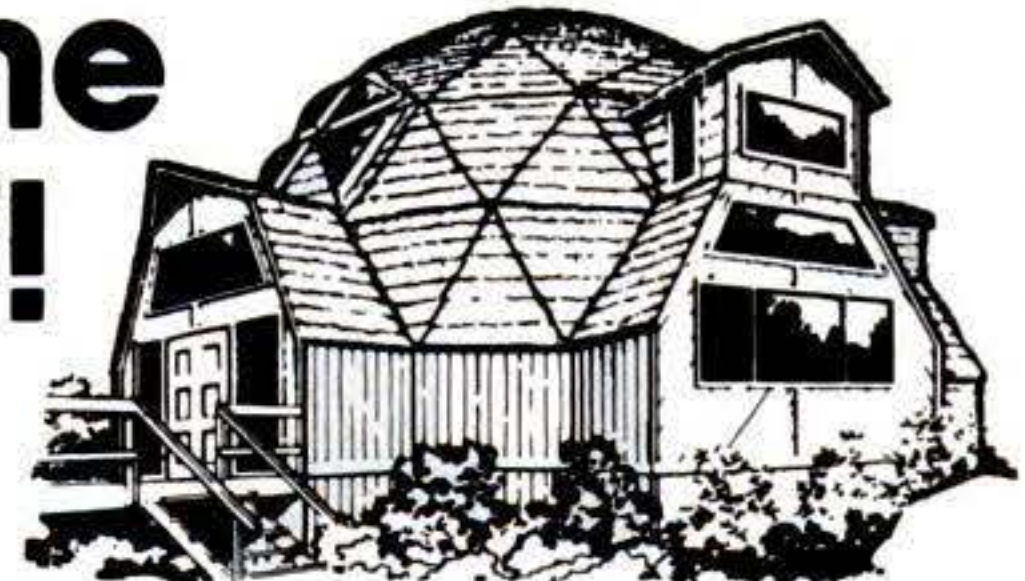


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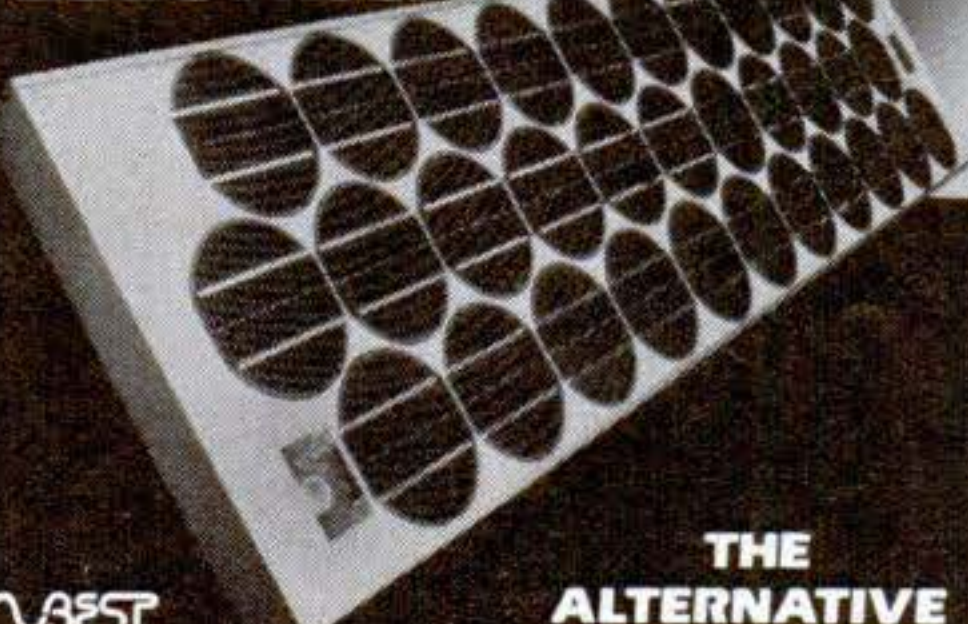
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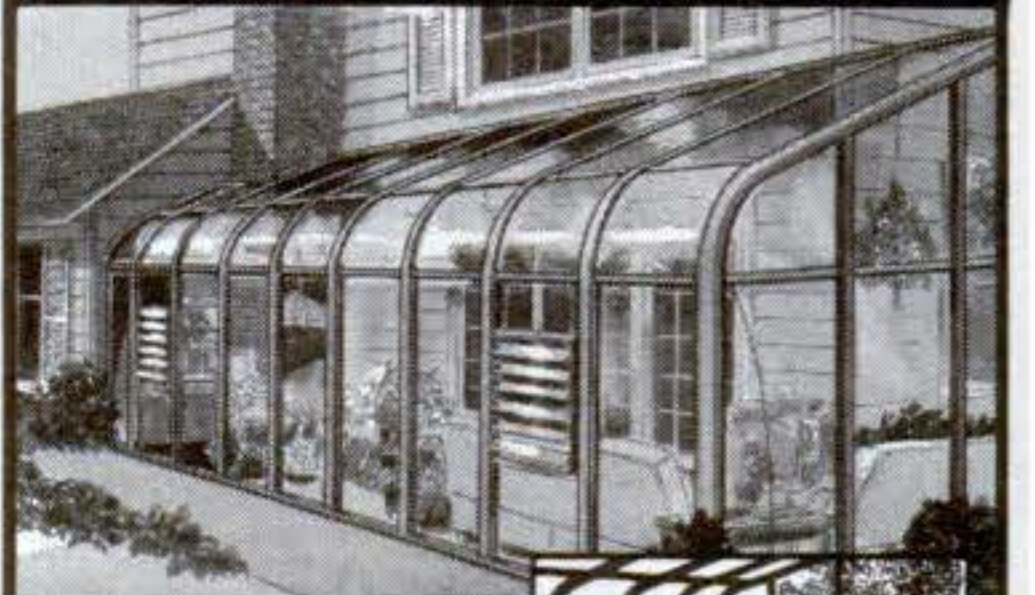
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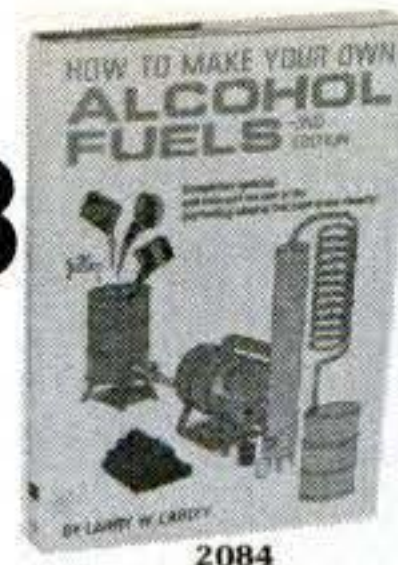


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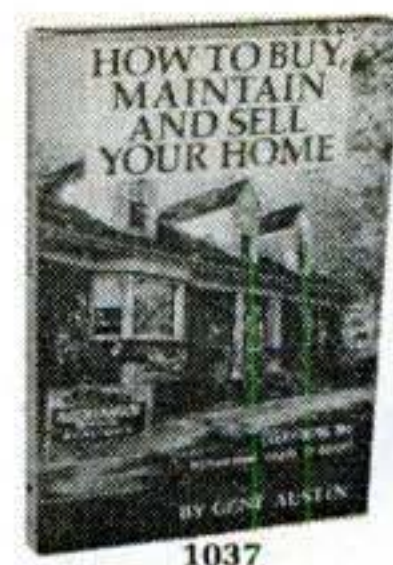
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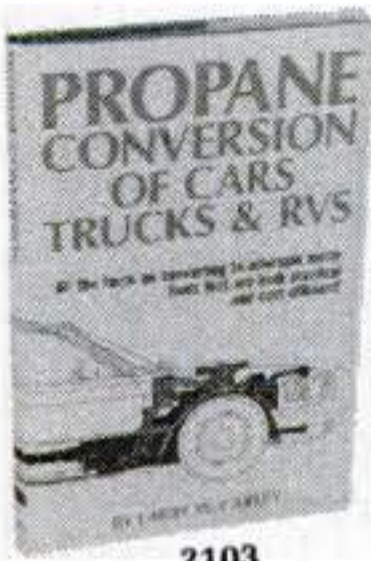
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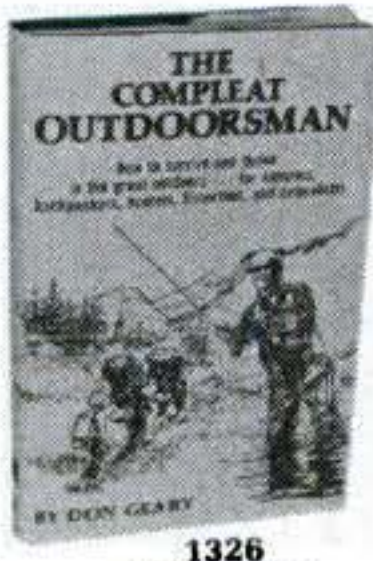
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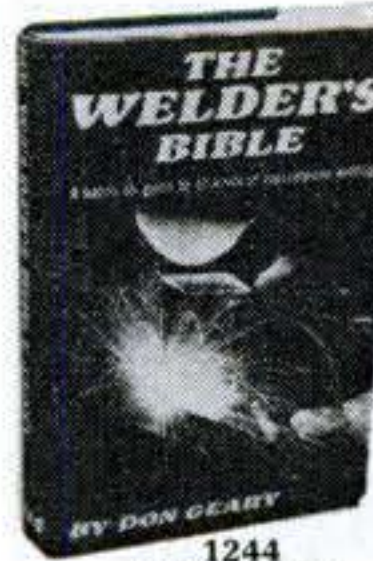
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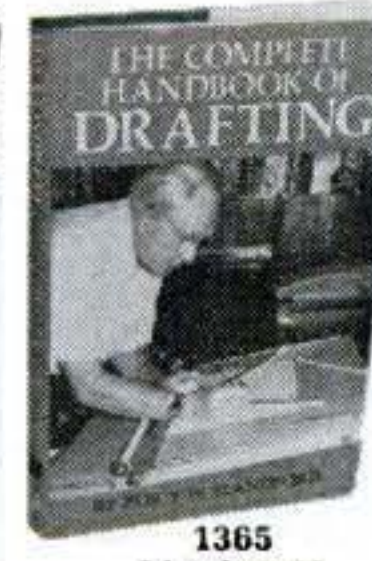
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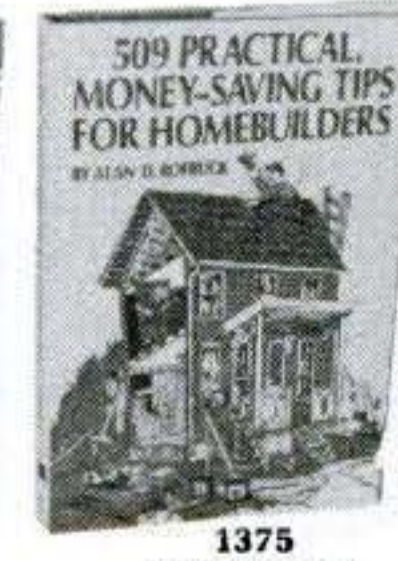
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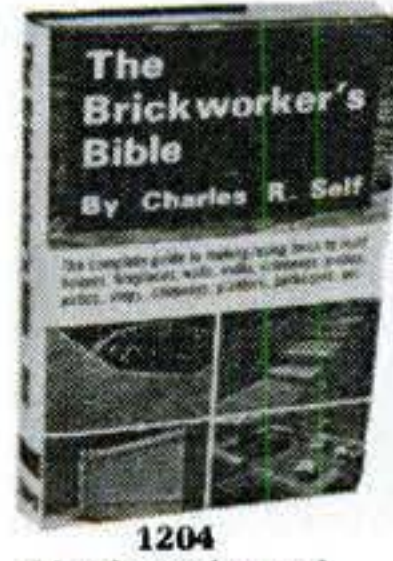
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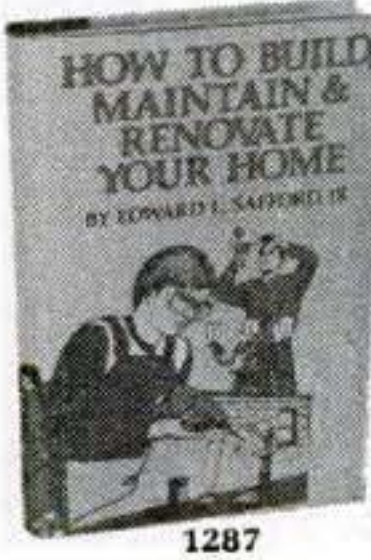
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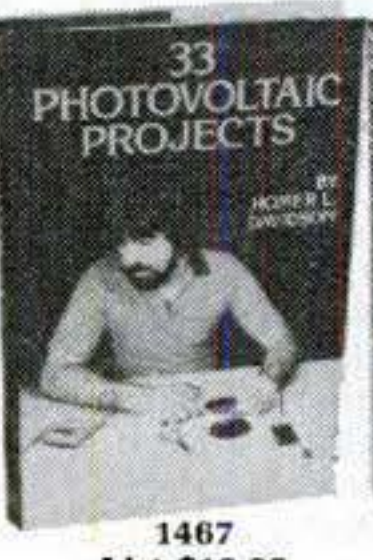
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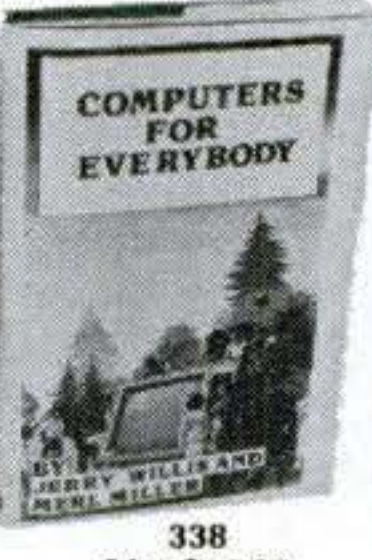
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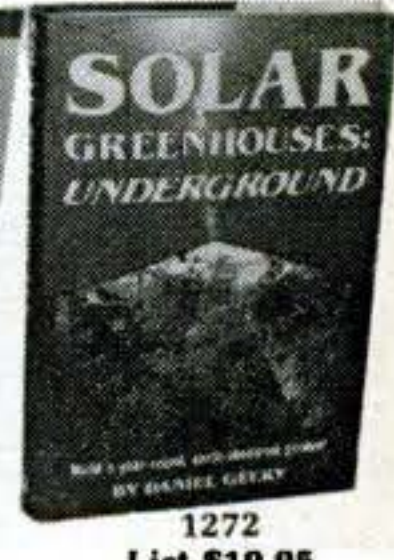
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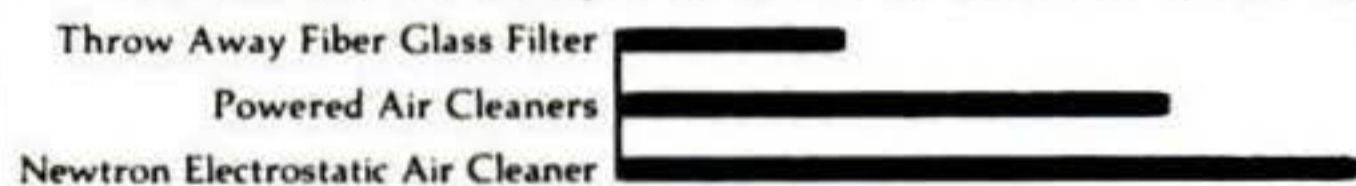
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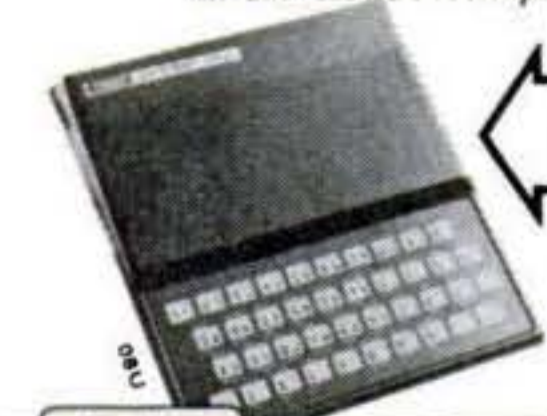
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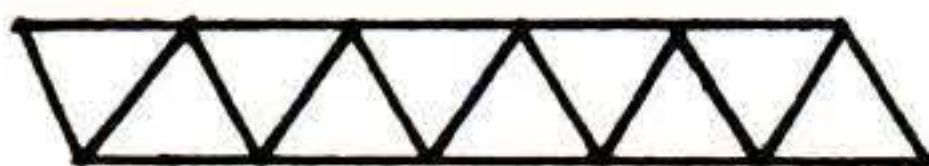
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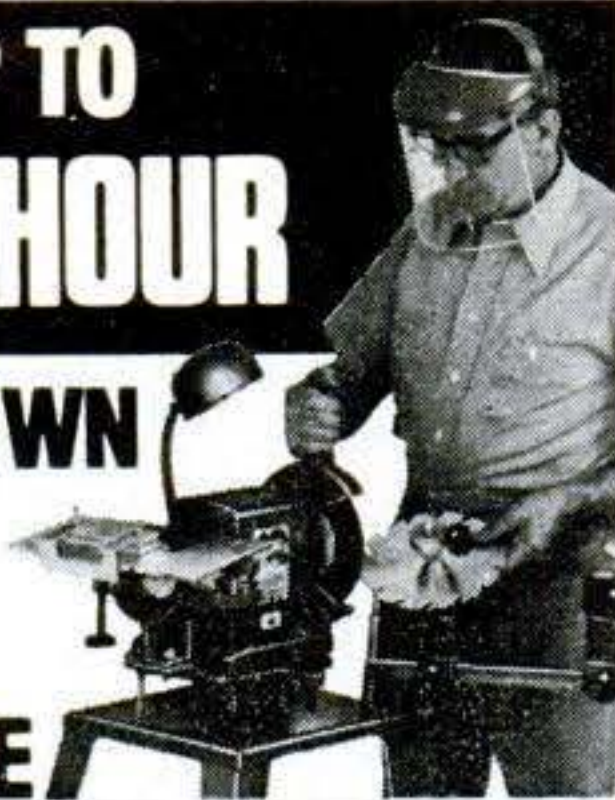
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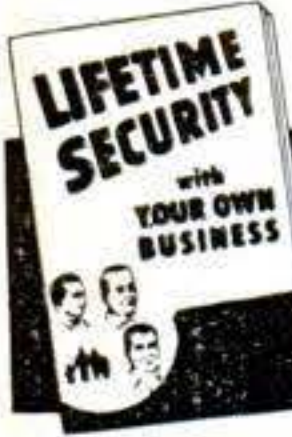
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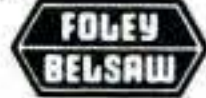
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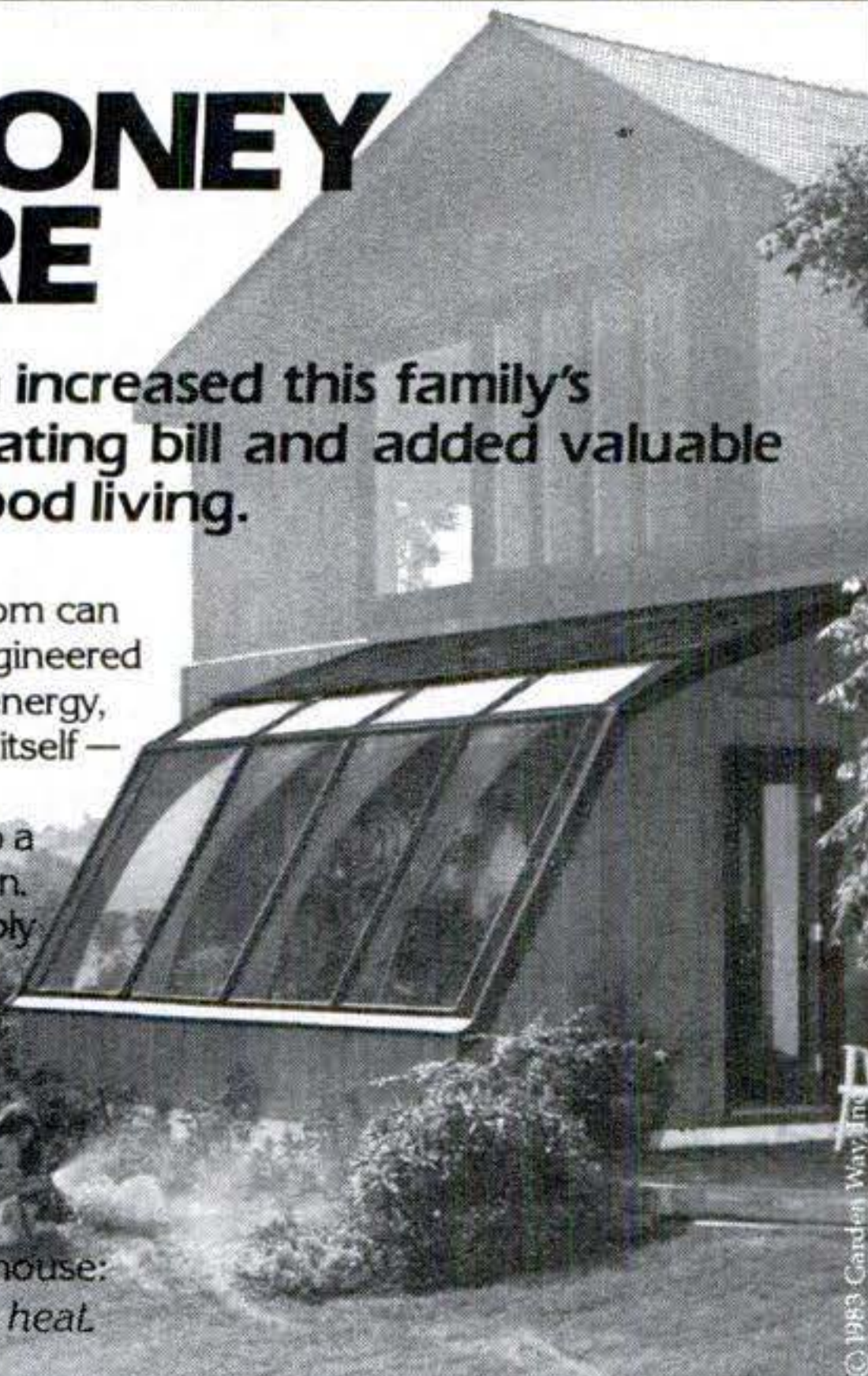
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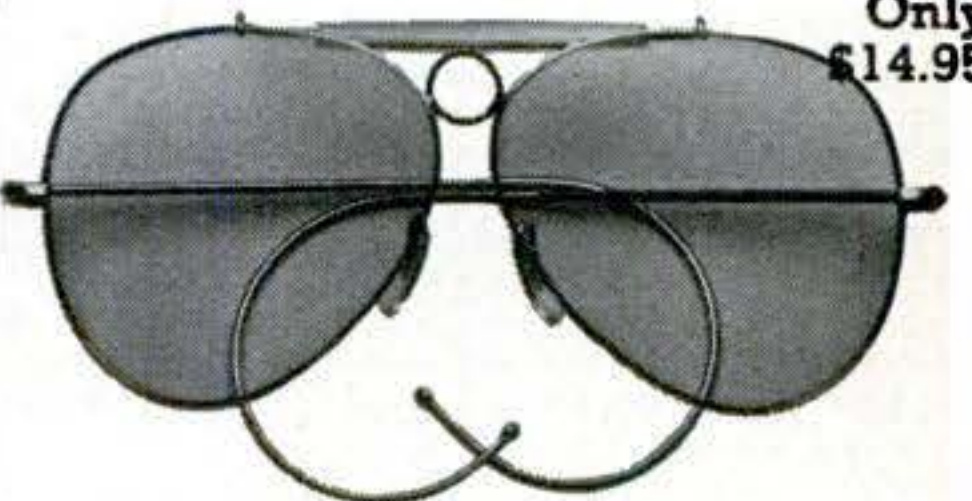
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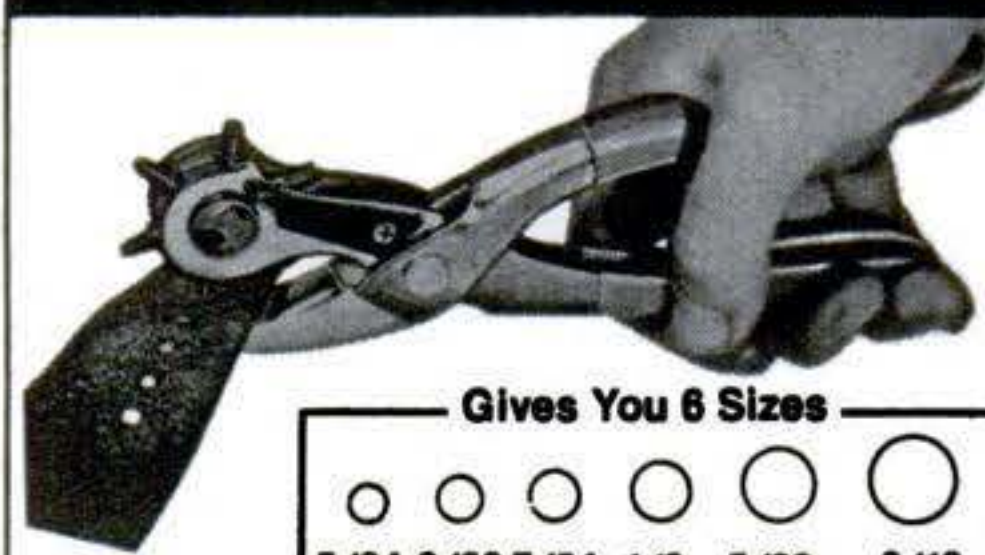
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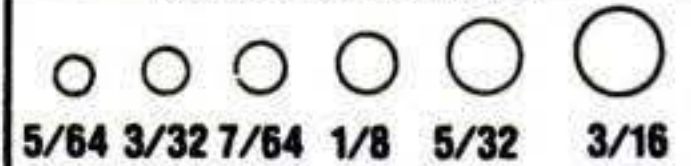
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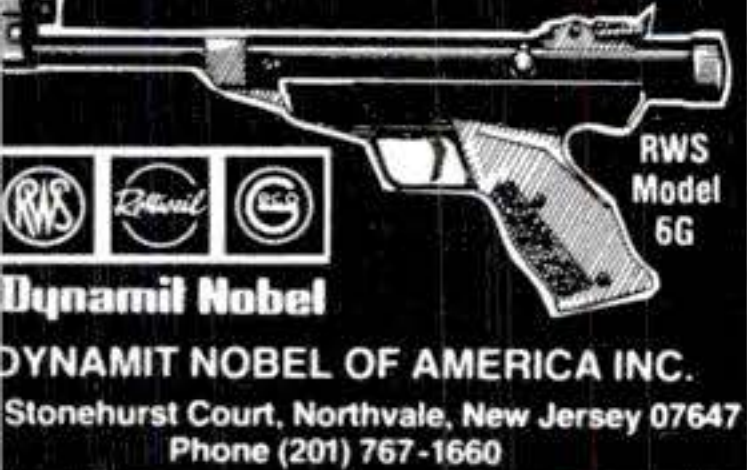
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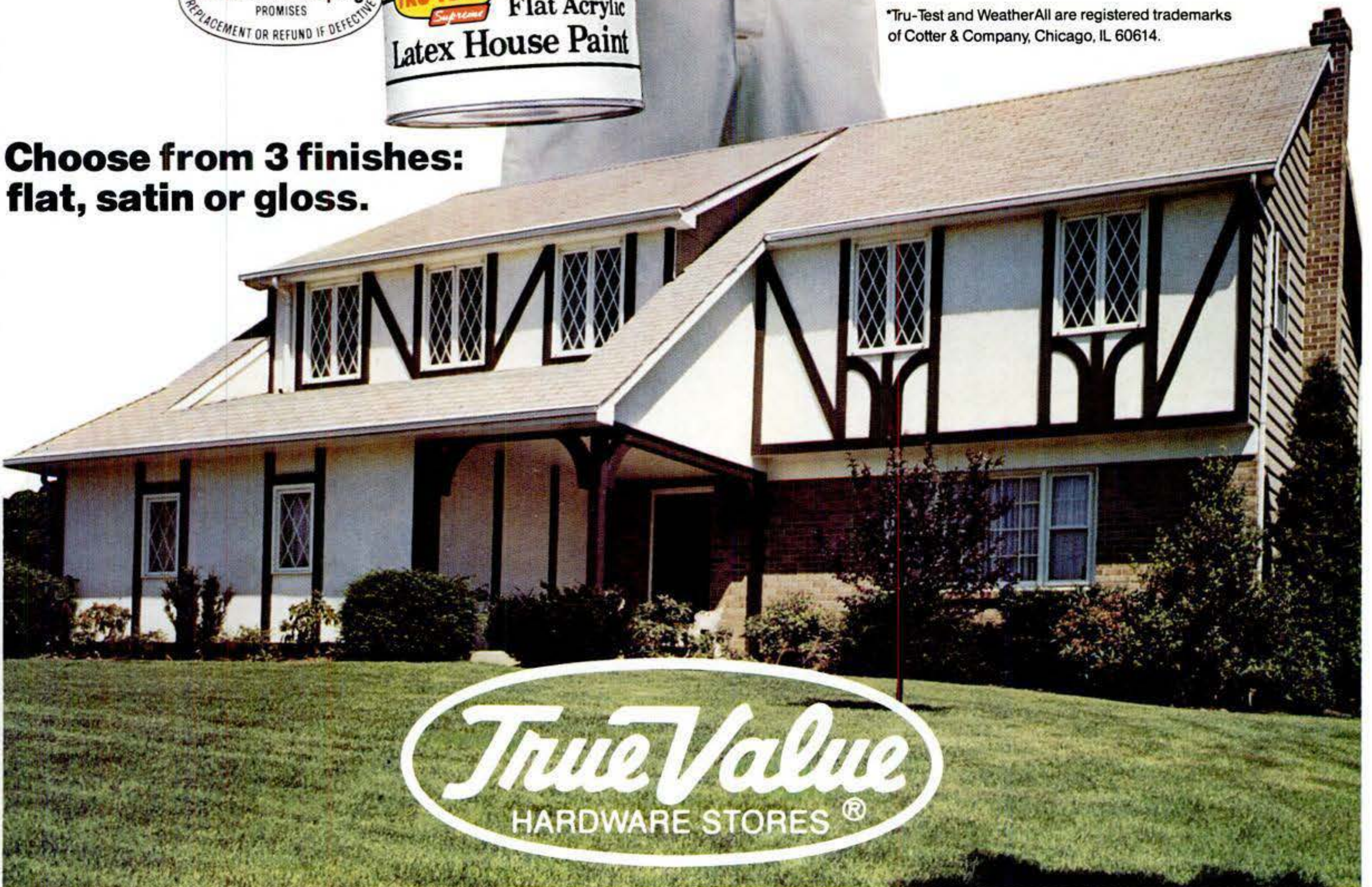
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