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Popular Mechanics

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features; but only Ranger XLT gives you all of them at no additional cost. IT'S THE BEST RANGER XLT EVER.

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DOLLAR FOR DOLLAR, CAN'T TOUCH IT.

redesigned instrument panel with tachometer — Ranger XLT even outdoes itself. Column shift automatic transmission is available as an option. And returning features from last year include a fully synchronized 5-speed manual overdrive transmission, Twin I-Beam Front Suspension and tinted glass. Competition aside, Ranger XLT is a lot of truck for the money.

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FORD RANGER XLT GIVES YOU
ALL THESE FEATURES FOR LESS MONEY
THAN EITHER

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- Tachometer
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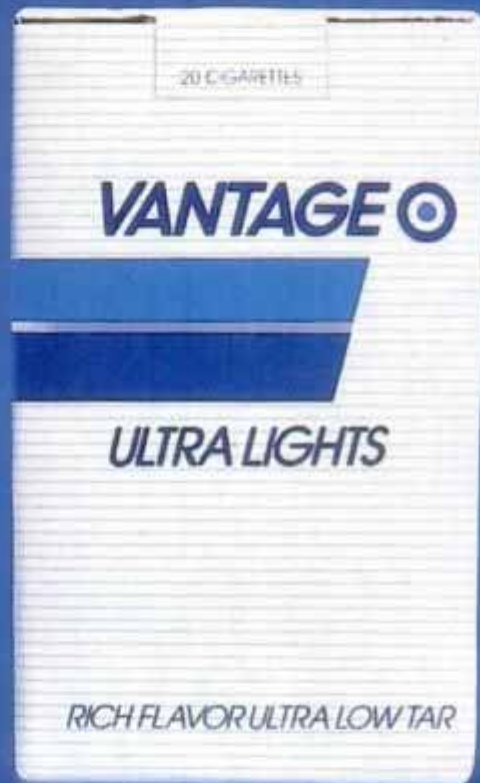


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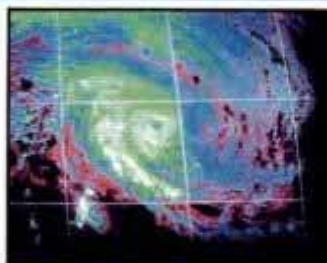
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54 COVER STORY

Constructed adjacent to open waterways, the vertiport of tomorrow might include landing pads for both tiltrotor transports and Sikorsky's Very Large Civil Transport. —PM illustration by Mike Machat

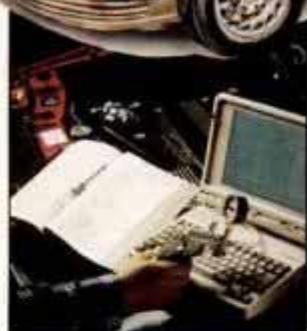


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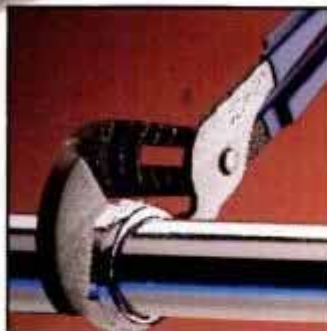


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EDITOR'S NOTES

THEY TALK about the "global marketplace." What is a global marketplace? Most of the time for most of us, it's just a phrase. It really doesn't mean anything. We can't relate to it. But when you have to send editors, writers and photographers to such exotic places as Japan, Germany, Portugal, Hawaii, Portland, Detroit, Montreal, Pasadena, White Sulphur Springs, Elkhart Lake, Watkins Glen, Toronto, Ogden and Asheville just to gather information for one story—the 1990 new cars—then the phrase global marketplace takes on new, and real, meaning. Today's automotive industry is truly international in scope and our editors have literally been combing the globe gathering information for our new car reports. You know that today's automotive marketplace is truly international when Ford announces that its all-American Crown Victoria will contain components and materials more than 25 percent of which will come from *outside the United States*. It will thus become classified as an import. That's international. Pretty soon, Chevy will be importing its hot dogs and apple pie. In traveling the world, Automotive Editor Tony Swan,



The startling Mercedes-Benz 500SL and me in Portugal.

Assistant Auto Editor Mike Allen, Detroit Editor Jim Dunne and the rest of us gathered so much material that we could not fit it all into one issue. So this month, we give you the early bloomers, the first of the 1990 crop (page 51). Next month, we'll hit you with all the domestics (including the Ford Crown Victoria—we're diehards), and you'll get all the imports in the December issue. Hope you're along for the complete ride. . . . One of the promises of vertical flight has always been convenience. Helicopters can land and take off from virtually anywhere. Even dense inner cities. Yet, helicopter travel by civilians is still in its infancy. Presently, you can't travel from one city to another by helicopter. You have to take a regular airliner. One stumbling block is helicopter size. At present, the largest helicopter can hold only 10-15 passengers. But there are plans to build 100-passenger helicopters, virtually as large as a Boeing 737 airliner. Such an aircraft just could be the answer to many of today's transportation problems. The technology to build such an aircraft exists now, as you can read in this month's cover story (page 54). When we'll be able to fly in one becomes the question. . . . As we enter the annual hurricane season, one hopes that it will be a mild one and that all the technology poised to locate and track tropical storms will have little or no use. In the old days, hurricane hunting was one of the more macho occupations you could have. Strapped into small aircraft with little more than a radio for equipment, meteorologists flew into hurricanes, located the epicenter of the eye, and calculated direction and speed of the storm. There are still unsung heroes flying aircraft to track tropical storms. But today, they're backed up with the latest computer and satellite technology to give us the time to prepare *before* major storms hit populated areas. The whole fascinating story begins on page 68 of this issue. Till next time.


Joe Oldham

Popular Mechanics

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LETTERS

This Old House

MY Victorian house turned out so well that I'd like to share a photo of it with other PM readers. Of course, if you look at it closely you'll realize that it's a dollhouse, and you'll recall that it was featured in "Two Enchanting Dollhouses You Can Build," in the Dec. '76 issue (page 116).

Since you no longer have the special plans offer, I just used the photos and the accompanying drawings in the story. There's a lot of detail in the house, so it took me about four months to build. PM makes it really easy to improvise.



Little Victorian home is the handiwork of PM reader Philip Ciulla.

PHILIP CIULLA
JAMAICA, NY

Readers who wish photocopies of the dollhouse story, or any other back stories, can write to POPULAR MECHANICS, P.O. Box 1014, Radio City Station, NY 10101 and send 75 cents per page. The 5-page dollhouse story is \$3.75.

How To Relax

I always enjoy coming home from a hard day's work and relaxing by reading POPULAR MECHANICS. I would like to personally congratulate you for carrying excellent articles on home improvement by Bob Vila. The "Old House Restoration" column is the one thing I look forward to every month. Keep up the great job.

FRANK CONFORTI
WEIRTON, WV

All-American Bikes

Thanks for a great pick-me-up in "Recycling The Classics" (page 64, July '89). I am especially enjoying the Schwinn Black Phantom pictures and facts.

I (vaguely) remember a special Phantom-type Schwinn (circa 1949) designed for the Whizzer bike motor (with fender

cutouts for the drive-belt). Also, in about '52 or '53 I remember seeing a Schwinn-Whizzer manufactured as a complete motorbike. Schwinn-Whizzer nostalgia is a definite delight. I'd love to see a Whizzer article in the future.

Thanks for the great magazine.

JULIAN C. LONG SR.
FLORENCE, SC

Quick Fix

In your July '89 The Better Home ("How To Repair Holes In Drywall," page 97), you illustrate two ways to repair holes in gypsum wall-

board. But after years of repairing such holes in apartments and other rentals, I came up with a solution to these problems that works well and is really quick. First, lay out a square, rectangular or circular cutting line that will entirely remove all broken material. Proceed to cut along the lines, but hold the drywall saw or keyhole saw at an approximate 45° to the wall—each cut angled toward the center of the opening.

Second, cut a patch from scrap gypsum board with the edges angled at the same approximate 45°—then fit and trim (I use a Stanley Surform tool or coarse sandpaper) the patch to fit the opening loosely. When in place, its surface should be about 1/8 in. below the wall surface.

Third, apply ready-mixed joint compound generously to the dampened edges of both the hole and the patch. Press the patch firmly into place, squeezing out excess compound. Be sure that the patch surface is slightly below the surface of the wall. Cover the patch and surrounding wall area with a thin coating of compound and press in strips of drywall tape to cover the entire area. When the compound has dried, sand and apply one or more thin coats to achieve an invisible repair.

WARREN H. PUTNAM
REDLANDS, CA

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Free advice.

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WHERE TO INSULATE FOR
MAXIMUM ENERGY SAVINGS.

HOW TO UPGRADE
EXISTING INSULATION.

ANSWERS TO THE MOST
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OR ATTIC CONVERSION.

INSULATION CONSIDERATIONS
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TIME MACHINE

75 YEARS AGO: SEPTEMBER 1914



Goodbye To Sail

Square-rigged ships were fast retreating from the high seas, replaced by more powerful steam engines—and an upstart that would later transform the business of heavy hauling. The diesel engine was making steady progress in maritime commerce, and a PM survey spotlighted 24 ocean-going vessels equipped with the innovative internal combustion powerplant. But reliability, as with any emerging technology, was still a distant dream.

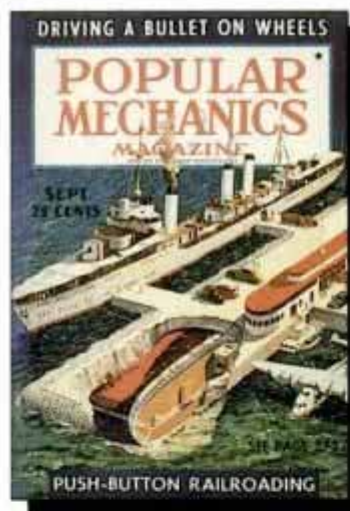


Try For The Atlantic

Glenn H. Curtiss continued his pioneering efforts in aviation at Lake Keuka, one of the glacier-formed Finger

Lakes of western New York, focusing on a prize of dramatic proportions—crossing the Atlantic. His platform: the flying boat *America*.

50 YEARS AGO: SEPTEMBER 1939



Infrastructure

Adjustments were needed in ways to manage some remarkable improvements in transportation. Larger, more centrally located airports and smoother highways to support faster cars were a crying necessity. And ships had to find ways to off-load cargo at remote locations. The French solution, as our cover showed, was to build deep-water facilities out of the hulks of abandoned vessels. The submerged ships served as foundation for rock

fill and concrete. An adjacent seaplane base served aerial travelers.

Bullet Car

Ever since Barney Oldfield—one of PM's early automotive writers—man's thirst for ever-greater speed has gone unquenched. And as Capt. George E.T. Eyston pointed out a half-century

ago, there would always be new records to break. Eyston was the driver of Thunderbolt, which established a land speed record of 357.5 mph on the windswept void of Bonneville Salt Flats. He showed PM's growing cadre of speed fanatics the critical issues in building and driving one of our early speed machines.



25 YEARS AGO: SEPTEMBER 1964



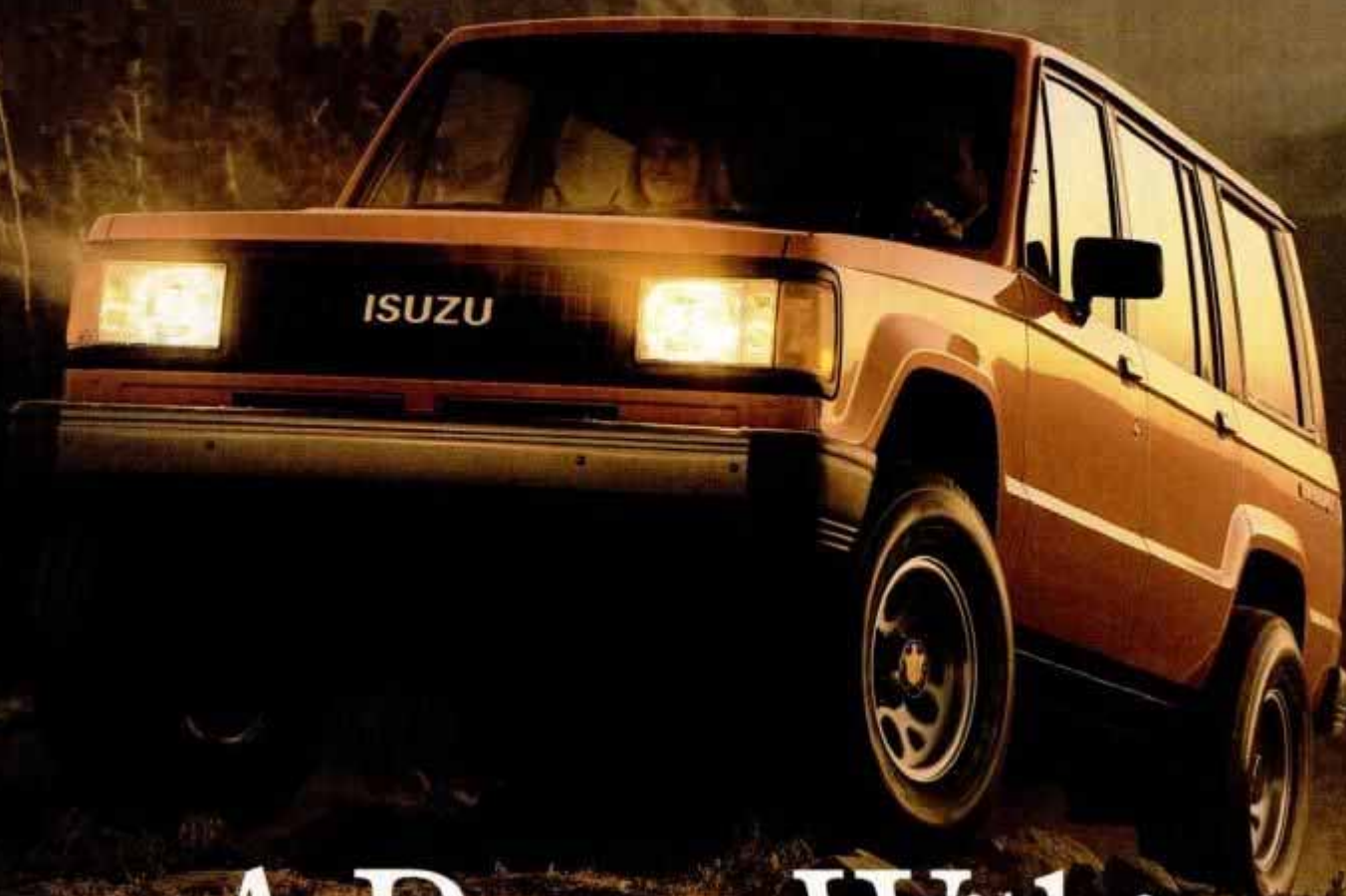
Salute To The Tinkerer

Short-field takeoff and landing was the objective a quarter-century ago. The innovative solution, developed by Willard Custer of Hagerstown, Maryland, was the channel wing, the technique of placing a pusher prop in a semiducted flying surface. The vacuum produced by this configuration literally sucked air over the wings and plucked the craft off the field. Stall speed was also reduced. But the aircraft failed to find a market.

Before Hubble

Astronomy is a never-ending effort to improve the position of the observer—either through more sophisticated instruments or by placing those instruments in more optimized locations. About 25 years ago, star gazers recognized that the best location for a telescope wasn't on Earth at all, but orbiting overhead instead. The Orbiting Astronomical Observatory (OAO) achieved that higher plane, gathering invisible ultraviolet light from distant worlds.





A Rover Within Your Range.

If you're contemplating the purchase of a 4x4 utility vehicle, consider your options. You could pay over \$35,000 for a Range Rover and impress all your friends. Or you could spend substantially less

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\$13,149*

for an Isuzu Trooper and impress someone far more important. Yourself.

Like the Range Rover, the Trooper offers high glass areas for excellent visibility and enough interior space to comfortably carry five adults.[†]

Yet unlike the Range Rover, the Trooper offers you a choice of engines. You can get an economical, fuel-injected four-cylinder or opt for a beefier V6.

And while the Range Rover comes with only one type of transmission, the Trooper offers a choice between two: a rugged five-speed manual or an optional four-speed automatic transmission.

Of course, the Range Rover does offer an impressive 70 cubic feet of cargo space with its rear seat folded down. But, once again, the Trooper offers you even more.

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The way we see it, there's only one thing keeping the Trooper from being the vehicle in vogue. It's affordable. And that's just not chic.

Isuzu Trooper



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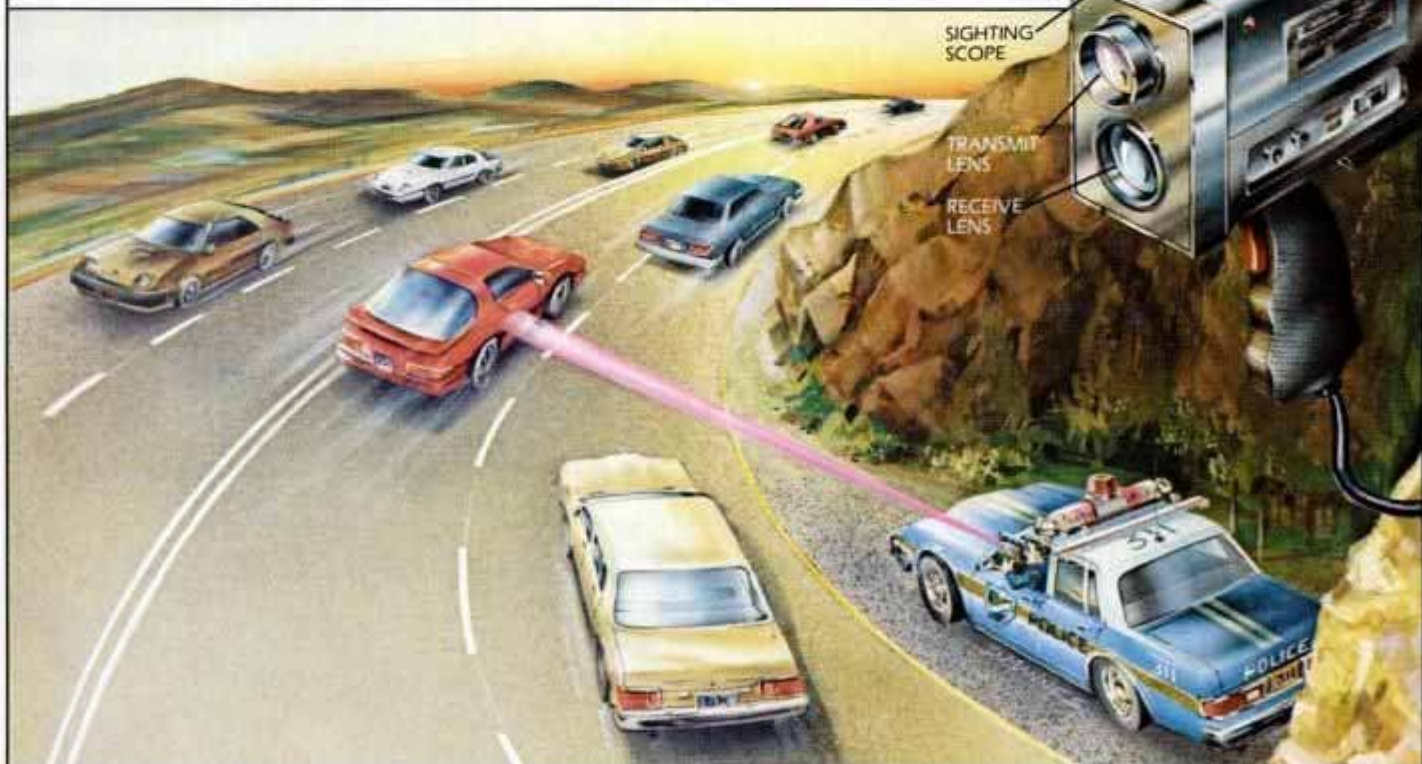
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TECH UPDATE

News Of Tomorrow's Technology Today

Laser Thwarts Auto Radar Detectors



PM ILLUSTRATIONS BY DON MANNING

Laser speed gun can clock cars coming or going. Jammer (right) would flood gun's detector with rapid-fire pulses.

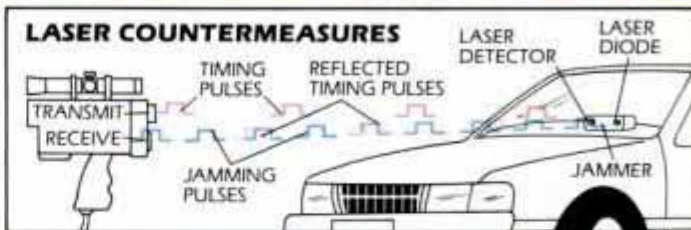
LITTLETON, CO—A new police speed gun that uses a laser beam instead of radiowaves could render automobile radar detectors useless, and set the stage for a new generation of countermeasures.

The gun, which has just gone into production, uses technology that the manufacturer, International Measurement and Control, developed for military range-finders. After being aimed with a telescopic sight at a suspected speeder, it emits a series of pulses from an infrared laser diode. The time it takes for reflections to return indicates how far away the car is from the gun. Computing the rate at which that distance changes yields a speed reading.

Since the laser is narrowly

focused, and the gun needs only a 1/2 second to take a reading, detecting a laser speed trap in time to slow down is nearly impossible. The new threat is not likely to go unanswered, however. Experts believe laser jammers would be relatively easy to develop from off-the-shelf parts. The simplest type of jammer would use an array of detectors at a few points on the front and back of the car. When illuminated, they would send out a stream of pulses, swamping the gun's detector. More expensive jammers would allow drivers to dial in whatever speed they want the speed gun to register.

Editor: Tim Cole
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Thomas G. Murphy



PM ILLUSTRATION BY RON CARBON

Highlights This Month

- **Big Booster**—NASA's answer to the Soviet Energia unveiled.
- **Autonomous Bombers**—Tiny supercomputers guide nimble attack drones.
- **Environment Tech**—Turning poisons into building materials and fuel.
- **Wargames**—Advanced battle simulator adds new combat dimension.
- **Moon And Mars In New Mexico**—Simulators provide a very small step for man.
- **High-Tech Sawbones**—CAD/CAM and robotics usher in a new age in orthopedics.

NASA ILLUSTRATION



SHUTTLE-C COMPONENTS

Shuttle-C (above) takes advantage of many existing components for considerable savings. One of its first missions (right) may be ferrying materials to Space Station Freedom, after which it will burn up on reentry. The EDU (below) at Marshall.

TYPICAL CARGO FLIGHT



PM ILLUSTRATION BY ED VALIGURSKY

Shuttle-C Prototype Completed

MARSHALL SPACE FLIGHT CENTER, AL—NASA has unveiled a full-scale Engineering Development Unit (EDU) to test designs for the Shuttle-C, an unmanned expendable variant of the Space Shuttle with

triple the payload capacity. The craft uses the same external tank, solid rocket boosters, main engines and boattail aft fuselage as the Space Shuttle, but replaces the orbiter with a cylindrical cargo element (CE) of simple

skin-and-stringer construction. Dispensing with crew compartment, heat shield, wings, tail and some avionics, gives the Shuttle-C a payload of 170,000 pounds, which approaches the payload capacity of the Soviet's previously unrivaled Energia booster.

NASA PHOTOGRAPH



Attack Drones Made To Search, Destroy, Escape

NEW YORK, NY—It sounds like a science-fiction nightmare: Descending like a swarm of insects, turbojet-powered smart missiles bob, weave and circle in search of hidden targets. Locked on, they release a deadly spawn of submunitions with inhuman precision, then wheel and depart. The eyes and brains of these supersmart stand-off weapons are now being tested by weapons manufacturers in the U.S. and Europe. At

Martin Marietta's Electronic Systems Division, researchers are using a giant 3-dimensional terrain board that mimics the colors and contours of European countryside to run navigation systems through their paces. Forward-looking infrared sensors (FLIR) and millimeter-wave radar units are mounted on a computer-controlled gantry above the board. The computer interprets sensor data, and guides the sensors to targets.



Martin Marietta AAV blasts mobile ICBMs with smart submunitions from a rotary dispenser.

MARTIN MARIETTA ILLUSTRATION



General Dynamics MSOW concept deploys parachuted penetrator submunitions to knock out an airfield runway.

Called a geometric arithmetic parallel processor (GAPP), the computer is about the size of a VCR, and can process all the information necessary to distinguish a target from background clutter in less than a second. The guidance system will go into a ground-launched AAV (autonomous aerial vehicle), giving it the ability to pick targets, attack, assess

damage and attack again if necessary. A similar vehicle, called the Modular Stand-Off Weapon (MSOW), is being developed for NATO by two competing international consortia headed by Rockwell and General Dynamics. Now in the project-definition phase, the program should culminate in an air-launched submunitions dispenser by the mid-1990s.

GENERAL DYNAMICS ILLUSTRATION

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The next time you change your oil, **REALLY** change it...into the engine treatment it could be, it should be!

TUFOIL® IS EASY TO USE!

It's easy to make your engine run better, last longer. Just change the oil and filter and add 8 ounces of Tufoil to the crankcase. After that, add 4 ounces each time you change your oil. Tufoil is so fine that you don't have to shake the container or add an engine flush. Just pour it in and drive away. You'll keep that engine purring like new!

SILKY SMOOTH ACCELERATION

Your throttle will get silky smooth...acceleration will improve. One customer said his car "takes off like a scared rabbit!" Tufoil works wonders for all known engine oils. It's actually slipperier than Teflon®. (according to a famous US government laboratory.)

FAST STARTS - HOT OR COLD

You'll get astonishingly fast starts on cold mornings with both diesel and gas engines. The Canadian government tested TUFOIL at its cold regions lab. They showed faster cranking and significant fuel savings with TUFOIL. Better on desert like hot days too.

MORE POWER - BETTER RESPONSE

Owners of very expensive German diesels call in wanting to buy stock in our company. They say their diesels are accelerating like nothing they've ever seen before. One said he doesn't have to down shift any more on an annoying hill in his area.

Your car can have more power like that too!

One customer put it nicely when he said, "You can hear it...you can feel it", after adding Tufoil to his engine!

No other lubricant even comes close.

WORLDWIDE PATENTS

Don't forget! TUFOIL is the result of over 15 years of research and development. The U.S. government has awarded us 6 patents so far...so have Germany, England, France and Canada. No other engine lubricant containing PTFE can make that claim!

TESTS: UNIVERSITIES WORLDWIDE

Reported widely in famous scientific journals...The University of South Wales (Australia), Technion University (Israel), Canadian Cold Region Lab, the US GOVERNMENTS MOST PRESTIGIOUS LAB. and many others.

ONE TIME TREATMENT!

Some products claim to be a permanent, one-time treatment or to last 50,000 miles. Ridiculous! There is no published data in any respected scientific journal to substantiate such claims!

Engines last longer with Tufoil

Our 1976- 460 T-Bird is now at 190,000 miles and purring.

Many customers' cars have passed 250,000 miles. The list grows rapidly.

Several months ago, a gentleman I'd never seen before walked into our offices, big smile on his face, sat down and said, "Would you believe 340,000 miles on a Tufoil engine?" He went on to rave about how well his engine has been running all these years. - couldn't get a word in edgewise.

Recently, a truck driver called in with over 1,000,000 miles on a diesel using TUFOIL ---- SPECTACULAR!

A customer from Vermont added 10% TUFOIL to his sticky mechanical transmission, called in and said he couldn't believe it... "Shifting is like slicing butter now!", he said.

SAAB owners are writing letters praising TUFOIL in their "NINES" magazine. They report spectacular improvements in their engines and manual transmissions!

Stay in tune with your car!



Quart

8-ounce

Gallon

PS--Our loyal customers wrote this ad for us. It's full of their comments!

Thanks!

TREAT YOUR CAR TO ONE 8 OZ BOTTLE OF TUFOIL FOR ONE OIL CHANGE.

You'll notice quieter-smoother operation, quicker starting, snappy acceleration! If you don't, just send us proof of purchase with a note describing the year and make of your car. We'll refund your money immediately.

Send for TUFOIL today and prove to yourself the amazing increase in your car's performance. Fill in the coupon today or call TOLL-FREE any time, 24 hours a day.

1-800-922-0075.
(in New Jersey, call 201-825-8110.)



FREE... Products based on TUFOIL technology. Check one with each order of 2 bottles or a quart. Check 2 for each gallon order. Values range from \$3.98 to \$9.95.

- TUFOIL Gun-Coat — Super rust inhibited, smooth action
- TUFOIL Compu-Lube — Low viscosity for computer mechanisms
- TUFOIL Lightning Grease — Easily sheared grease for instruments
- TUFOIL Lubit-8 — General purpose, household use lubricant

FREE brochures...

- 30 Questions/Answers about TUFOIL
- "Fun with Superconductors"—we're leading that field too!

See NASA Tech Briefs for technical details, 1986, 1987 and 1988.

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TUFOIL® is reg. T.M. of Fluoramics
U.S. Patent No. 4,294,518
U.S. Patent No. 4,224,173
U.S. Patent No. 3,933,606
Other U.S. Patents issued and pending.

When POPULAR MECHANICS tested TUFOIL, it reported "TUFOIL is absolutely spectacular!"

YES

rush my TUFOIL order:

- ONE 8 oz. bottle... treat one car for \$14.25 (plus \$3.50 shipping and handling). See money back guarantee.
- TWO 8 oz. bottles... treat two cars for \$25.00 (plus \$4.00 shipping and handling) **SAVE \$6.00**
- ONE Quart bottle... treat 4 cars for \$34.95 (plus \$4.00 shipping and handling)
- ONE GALLON... treat 16 cars for \$125.00 (plus \$6.00 shipping and handling.)

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Fluoramics, Inc. PM-99

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Upper Saddle River, N.J. 07458

My check or money order for \$ _____ is enclosed.

Charge my credit card:

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Card No. _____

Exp. Date _____

Phone No. _____

Name _____

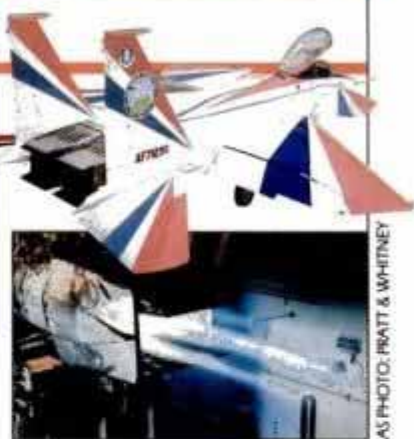
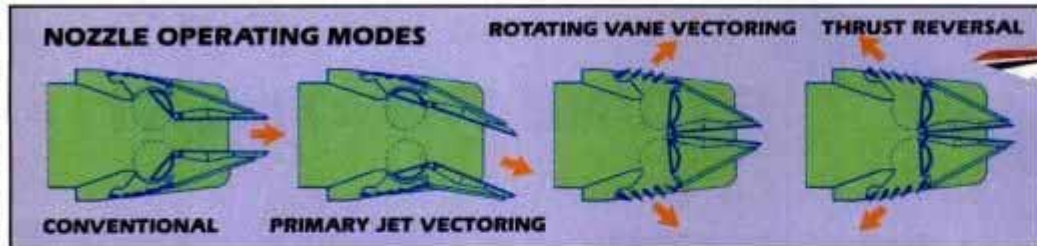
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City _____

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(N.J. residents please add 6% sales tax). Orders to Canada: Send check or money in U.S. currency. Add \$10 extra shipping charge.

PM ILLUSTRATION BY HANK IKEN



Vectored Thrust For Agile F-15

WEST PALM BEACH, FL—The F-15 Short Takeoff and Landing/Maneuver Technology Demonstrator (S/MTD) has entered its next phase of flight testing with the addition of two thrust-vectoring engine nozzles.

Capable of deflecting thrust 20° up or down, or reversing it, the nozzles enable the plane to perform radical maneuvers and land on bomb-cratered runways. An advanced fly-by-wire system automatically determines

optimum vectoring for a given maneuver, reducing pilot workload. Flight testing with the nozzles is expected to continue through early 1990, leading to a plane able to land on a 1500-ft. segment of wet, damaged runway with ½-mile visibility and 30-knot crosswinds.

Drawings (left) show nozzle configurations that give F-15 S/MTD (top) better pitch and roll performance, and a 72-percent shorter landing roll. Nozzle was tested at Pratt & Whitney (above) before installation.

TOP: MCCORMICK DOLUGAS PHOTO; PRATT & WHITNEY

Pollutant Recovery Techniques Ready For Use

NEW YORK, NY—Technology itself, long seen as the culprit behind the declining quality of our air and water, is now showing its ability to undo some of the damage. In England, where cheap and plentiful coal power has contributed to a severe acid rain problem, construction is under way on the world's largest flue gas desulfurization (FGD) plant.

The plant is sited at the 4000-megawatt Drax Power Station, source of one-tenth of England's electricity. Each year, it will capture 90 percent of Drax's SO₂ output and convert it into 1.1 million metric tons of gypsum for use in plasterboard.

The process begins when flue gases pass through a scrubber for cooling and removal of chlorides and fluorides. An absorber unit then

Drax FGD plant makes gypsum from water, sulfuric acid and limestone. Water, from nearby river, is treated before release.

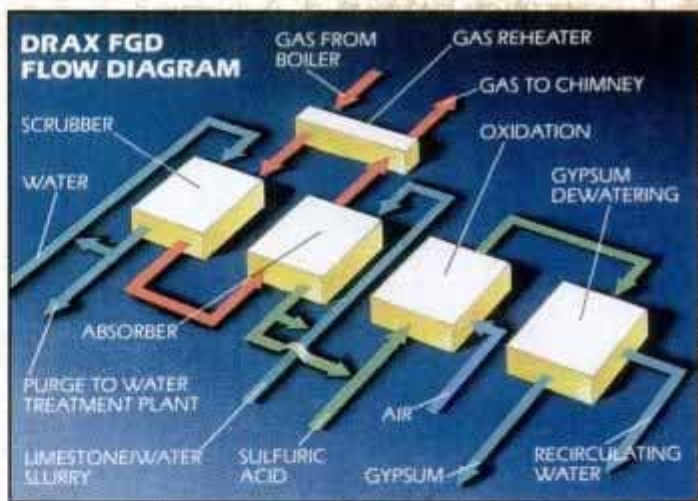


Modified photo of Drax (above) shows future FGD buildings. Canadian reactor (right) makes oil by heating sludge to 300° C.

brings the gas into contact with a limestone slurry, which reacts with SO₂ to produce calcium sulfite. Oxidizing calcium sulfite with air yields calcium sulfate (gypsum). The cleaned gases are reheated for their trip up Drax's 850-ft. chimney.

In the United States, more innovative techniques for clean coal combustion are being experimented with on a smaller scale.

Among the first to be funded was Babcock & Wilcox's Coolside process, which has now begun a full-scale com-



mercial demonstration at Ohio Edison's Edgewater Plant. Coolside begins with limestone injected into combustion gases as they leave the boiler. The resulting reaction binds sulfur pollutants into particles, which are sprayed with water, and then removed with a precipitator. The process can remove up to 80 percent of sulfur impurities. Other DOE-sponsored technologies now beginning to show results include an advanced cyclone combustor and a circu-

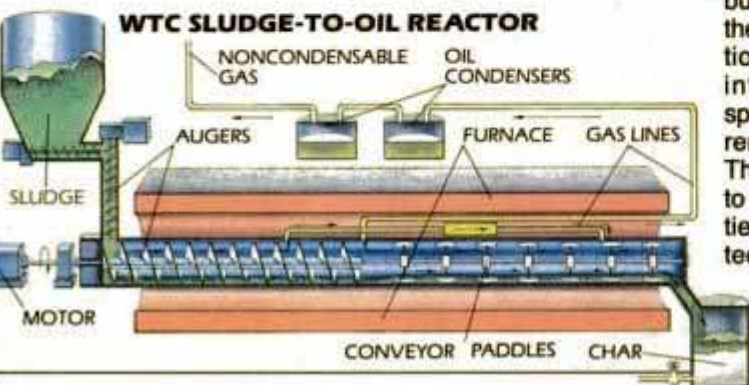
lating fluidized bed combustor, both of which could be retrofitted to existing plants for 90-percent reductions in sulfur emissions.

Another pollutant that may be susceptible to technological solutions is sewage sludge. At Canada's Wastewater Technology Center, a way has been found to convert it into fuel oil. The technique—which speeds up the million-year process by which nature produces crude oil to 30 minutes—could save Canada \$20 million a year.

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Enhanced Laser Simulator

ALBUQUERQUE, NM—Sandia labs has developed a new Tactical Engagement Simulator System (TESS) to train members of the elite Defense Nuclear Agency, which protects U.S. and NATO warheads from terrorists. Like earlier systems, TESS scores "kills" when photodetectors on clothing are activated by weapon-mounted lasers. But the new system works with a wider range of weapons, and has a

built-in memory that can be read by a handheld computer for post-exercise analysis. Extractable information includes who was shot when, and with what weapon, whether it was a near miss or a kill, and what position he was in when hit.

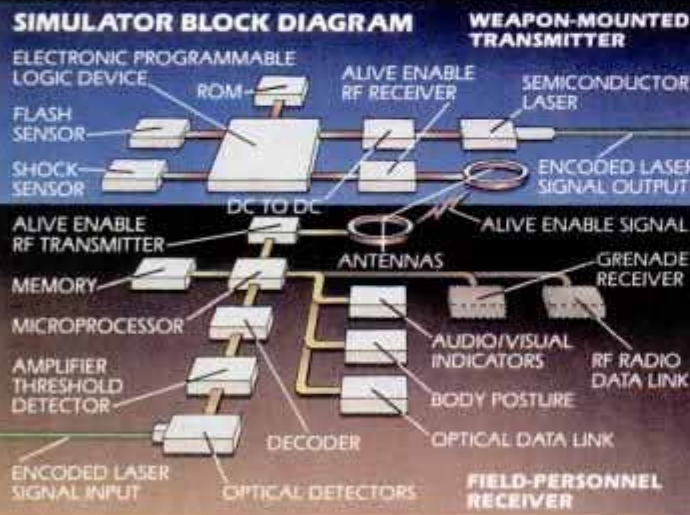
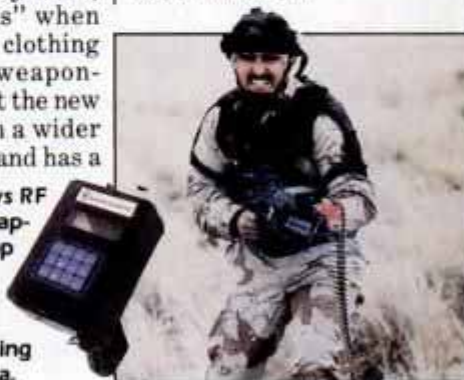


Diagram (left) shows RF link that disables weapons-mounted laser (top left, on M-16) if bearer is dead. Reader (inset right) passes over detector-equipped clothing to extract exercise data.



Superconducting Motor

PALO ALTO, CA—A motor that uses superconducting magnets to achieve increases in power and efficiency has been designed at Oak Ridge National Labs (ORNL) in cooperation with the Electric Power Research Institute (EPRI).

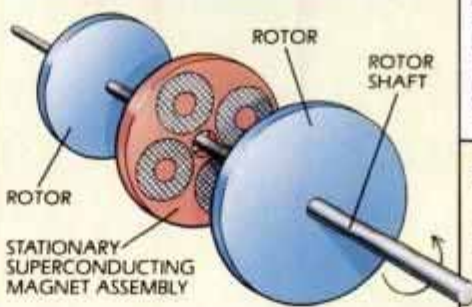
Called an axial-gap superconducting motor, the design places the superconducting elements on a stator sandwiched by two rotors fixed to an output shaft. This eliminates the need to deliver refrigerant to a moving part. Increasing output is as easy as stacking additional rotor-

stator sets on the shaft.

The design is also extremely simple, and could likely be executed even in the difficult-to-fabricate high-temperature superconducting ceramics. No brushes or commutator are needed, and the superconductor doesn't have to be formed into coils—something which is still difficult with the high-temperature materials.

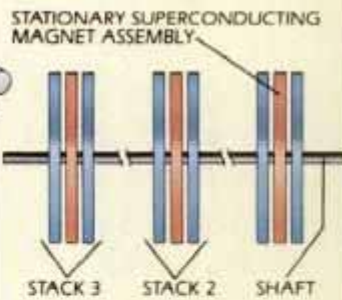
This fall, EPRI plans to

AGS MOTOR EXPLODED VIEW



Elegant EPRI/ORNL design (left) bypasses fabrication hurdles, and is the only superconducting motor with fully adjustable speed. Stacking AGS modules (below) would increase power output and efficiency.

STACKED AGS MOTORS



test a prototype version of the motor using low-temperature, niobium-titanium superconductors. It is expected to produce 180 horsepower and 535 ft.-lb. of torque at 1800 rpm.

CETEC SIMULATOR



Martian/Lunar Simulator

ALBUQUERQUE, NM—A consortium including Los Alamos National Labs and the University of New Mexico has put forward a plan to create the nation's first simulated extraterrestrial environment. The facility would enable researchers to try construction, mining and processing operations preparatory to 1992, when NASA will decide whether to recommend lunar colonization or a mission to Mars.

and Construction (CETEC), the simulator would use a set of six surplus 16-ft.-dia. x 60-ft.-long steel vacuum cylinders radiating from a newly constructed central building. A seventh cylinder will extend straight down from the hub to allow tests of drilling techniques.

Floors of the cylinders will be covered with crushed ilmenite, which closely resembles lunar soil. Solid blocks of the imported mineral could be used to simulate drilling operations.

Called the Center for Extraterrestrial Engineering

CETEC facility would build construction and exploration know-how.

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A. SPOT CHECK!™ New. Carpet cleaning attachment for Shop-Vac® wet/dry vac. For quick and easy clean up of spots, spills, high traffic areas. Requires no water hookup. Cleaning concentrate included.

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Carpet Cleaning Concentrate also sold separately.



A. MALIBU RECTANGULAR FLOODLIGHT SET. Low-voltage outdoor lighting. Includes 6 fixtures with stakes, 50 ft. low-voltage cable and plug-in power pack. SALE 32⁸⁸

B. TIER II WALK LIGHT SET. Shaded outdoor lighting. Includes 4 fixtures with stakes, 40 ft. low-voltage cable and plug-in power pack with timer. SALE 29⁸⁸



A.

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52" HUNTER CEILING FANS. Three-speed, reversible. Dual capacitors for quiet operation. Specially designed hanger system reduces vibration. Light kit adaptable. Installer's Choice™ dual mounting system. Choice of bright brass, antique brass or white and brass.

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SPRED INTERIOR PAINT. Give your rooms a bright new look with dependable Glidden paint at a low K mart price. Easy to apply, washable, and cleans up with soap and water. Choose from a wide selection of colors.

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SPRED SATIN AND SPRED ENAMEL PAINT. Glidden's famous Spred Satin interior wall paint covers most colors in one coat with a beautiful, scrubbable finish. Spred Enamel dries to a durable semi-gloss finish. Ideal for walls, trim and cabinets. Easy soap-and-water cleanup. In white and decorator colors.


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WIN One of 10 Starcraft® Camping Trailers

STARCRAFT'S LUXURIOUS NOVA: • Retail value of over \$6,000 • Huge storage capacity • Sleeping for six including a queen size bed • Indoor/outdoor gas stove • Electric and water hookups



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Glidden "Get Fall Rolling" Sweepstakes. 10 Starcraft Camping Trailers will be awarded nationally. Plus, five \$250 K mart gift certificates. **NO PURCHASE NECESSARY.** Void where prohibited by law. Must be 18 or over to enter. Details in store. Promotion ends September 9, 1989.



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Select Colors by Dutch Boy®
EXCLUSIVELY AT K MART

Martha Stewart, Entertainment and Lifestyle Consultant for K mart, and Dutch Boy have assembled a palette of 60 interior and exterior colors to help you decorate your home.



FASHION FRESH INTERIOR PAINT. Economically priced premium-quality paint with 6-year durability. Fast drying. Soap-and-water cleanup. Washable. Whites and colors. Custom-tinting available at no extra cost.

FLAT... **6⁹⁴** Gal. SEMI-GLOSS... **8⁹⁴** Gal.

FRESH LOOK INTERIOR PAINT. Our best interior latex paint. 10-year durability. Covers most colors in one coat. Easy to apply. Easy soap-and-water cleanup. Dries quickly. Whites and colors, plus a wide selection of custom colors tinted at no extra cost.

FLAT... **8⁹⁴** Gal. SATIN... **9⁹⁴** Gal. SEMI-GLOSS... **10⁹⁴** Gal.
LATEX PRIMER **8.94** Gal. OIL PRIMER **9.94** Gal.



WEATHERIGHT EXTERIOR PAINT. Stock up now for fall projects. An excellent quality paint, economically priced. Six-year durability, easy soap-and-water cleanup, chalk and fade resistant. Can be used on all surfaces. Custom tinting at no extra charge.

FLAT... **7⁹⁴** Gal. GLOSS... **9⁹⁴** Gal.

PERFORMER EXTERIOR PAINT. 10-year durability. Provides one-coat coverage. Excellent color retention. Cleans up easily with soap and water. Can be used on all surfaces. Available in whites and colors. Custom tinting at no extra charge.

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LIGHTMAKER™ GARAGE DOOR OPENER. 1/2 hp. Turn on indoor/outdoor house lights from the safety and convenience of your car. One lamp module included. Comes with easy-installation video. Buy now and receive the Home Control Bonus from Stanley with mail-in coupon. Model #6500 **SALE 158⁰⁰**

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HOME CONTROL BONUS. Controls up to eight lights and appliances with available modules. One lamp module included with opener. Mail-in coupon required.

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DELUXE GARAGE DOOR OPENER. 1/2 hp. motor drives a hardened steel chain. Has two built-in safety features. One-year manufacturer's warranty. Includes easy-installation video. Buy now and receive the Electric Keyswitch Bonus from Stanley with mail-in coupon. Model #3200 **SALE 144⁰⁰**

Garage door openers available at most K mart stores.



ELECTRIC KEYSWITCH BONUS. Easy to install. Lets you open garage door from outside without radio control transmitter. Mail-in coupon required.

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A. Miter Box with Saw	10.45	G. 100' Tape Rule	10.14
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E. Utility Knife	2.73	K. 4" Screwdriver	1.15
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PORCH & FLOOR OIL-BASE PAINT.* Durable one-coat gloss alkyd enamel. For interior or exterior. Use on stairs, porches, patios, decks and house trim. Color choice: light gray, battle gray, tile red, brown, and white.

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Gal.

PORCH & FLOOR LATEX PAINT. Helps protect masonry, concrete or wood. Dries to a low sheen in 40 minutes. Blister resistant. Choice of light gray, battle gray, tile red, brown or tile green.

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POWER ROLLER® PLUS. For walls, floors, ceilings, and trim. Automatic paint feed has fingertip control for faster, easier, neater painting. No compressor means quieter operation. Complete 10-piece outfit.

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HEAVY-DUTY POWER SPRAYER. Sprays up to one gallon of latex in 20 minutes. For painting houses, garages, decks, and fences. Complete 10-piece outfit.

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POWER STRIPPER. Heat gun removes paint and varnish fast and clean without chemicals or flame. Two heat settings: 1100°/600°F. Includes three versatile accessories. Plugs in any 120V AC outlet.

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RUST-OLEUM® STOPS RUST® SPRAY PAINT. Fights rust. Excellent chip and peel resistance. Use on metal surfaces. Choice of colors.

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52" FAN WITH LIGHT KIT. Model #9010. Antique brass. Four hi-gloss wood blades; one side light oak, one side walnut. Three-speed, high-power motor. Reversible rotation. Dual mounting system: hugger or down rod. Bulb not included. SALE **49⁹⁹**



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Normal rotation circulates cool air.



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Reverse rotation forces warm air downward.



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U24 HOUSE SYSTEM™ Whole-house water filter. Get fresh filtered water at every tap, not just one. Patented built-in bypass allows for easy 15-minute installation. No soldering necessary. 3/4" flow rate for full water pressure. **SALE 27⁰⁰**

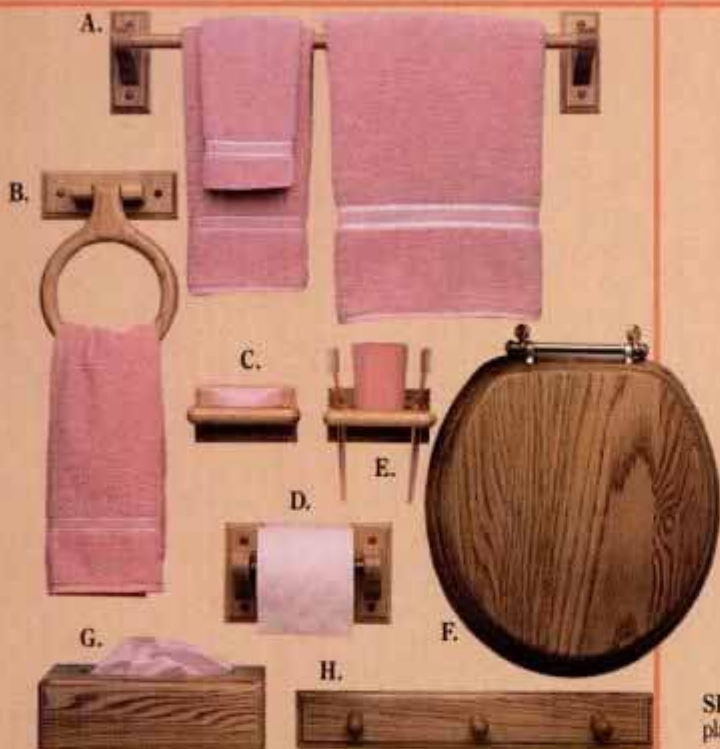
FILTER CARTRIDGES. Fit most other brands.
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90W — Has storage cabinet with sliding doors and two shelves. 91W — Has three storage shelves.

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A. AIR STATION. Model #9327. Fast, powerful, convenient, alternative to service-station air. Built-in pressure gauge. Includes three inflator nozzles.

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SALE
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E. CORDLESS SCREWDRIVER. Model #9018-2. Drives screws faster. 130 rpms, continuous charger with slotted/Phillips bit.

SALE
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F. 8-PC. BULLET™ DRILL BIT SET. Model #14-347. Excellent for metal or wood drilling. Also for plaster, plastics and other materials. Drills up to four times faster and lasts up to seven times longer than ordinary bits. Ideal for cordless drills.

SALE
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Special Report: Orthopedic Engineering

NEW YORK, NY—High-tech engineering tools developed for industry and aerospace are now being turned toward a marvel of natural engineering—the human skeletal system. A critical early step in this process is obtaining an accurate survey of the complex topography of our joints' working surfaces. At Columbia University's College of Physicians and Surgeons, Dr. Van C. Mow is performing this task with the same techniques used to map the Earth from space.

Presented at a Bristol-Myers-sponsored orthopedics symposium, the technique involves precision photography and digitizing equipment. Joints from cadavers are placed in a calibration cage made of ceramic with a very low coefficient of thermal expansion. The surfaces to be mapped are held between two vertical planes, one defined by a set of target points on the face of the cage, the other by points on studs projecting from it.

A pair of large-format Sinar cameras are aimed at 60° to each other, converging on the cage. The room is darkened, and the camera shutters opened. Then a high-intensity strobe flashes



Strobe illuminates joint surface to make the photograph that will later be digitized into computer map.

through a mesh of chrome wires, projecting a grid pattern on the bone, and exposing the film.

A high-accuracy digitizer transfers the resulting photographs to a computer, which translates the target points and grid lines into a spline function similar to those used to describe parts on CAD/CAM equipment.

Dr. Mow and his team have surveyed numerous knees, shoulders and wrists by this method, accumulating a valuable database on these hitherto unmapped surfaces. Immediate uses for the data-

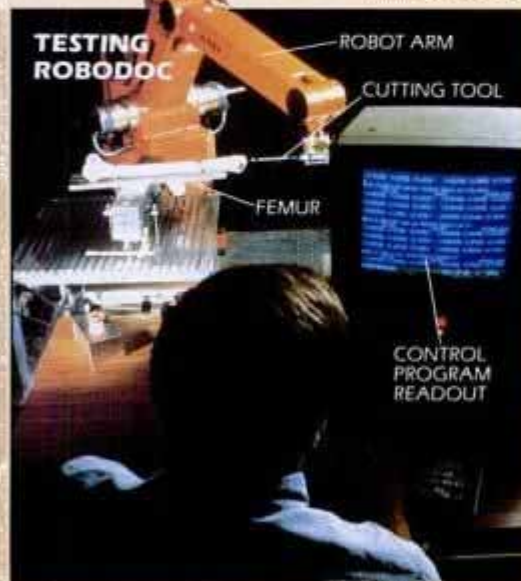
base include the development of more natural prostheses and anthropological study of human evolution. In years to come, the technology may be linked to Magnetic Resonance Imaging (MRI) or CAT scanning equipment, allowing living joints to be mapped. Computer manipulations of the maps could allow doctors to spot subtle problems, and experiment with solutions before performing surgery.

Even without this futuristic technology, ways have been found to apply CAD/CAM to joint repair. Doctors at U.C.

termines the optimal size, shape and location of the implant. During surgery, RoboDoc precisely locates each pin, and drills the implant cavity under computer control. Better fitting and longer lasting prostheses are expected to result.

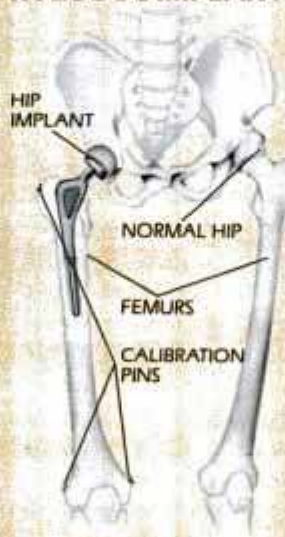
Somewhat less exotic, but startlingly effective is a technique developed by an obscure Soviet surgeon that can actually produce new bone in stunted and damaged limbs. Called the Ilizarov technique after its inventor, Gavriel A. Ilizarov, the procedure begins with a shallow incision made in the damaged bone. Thin wires are run through the bone above and below the cut, and attached to an external framework, or fixator. Turning nuts on the fixator draws the bone apart at a rate of 1 millimeter per day, giving new bone time to fill the gap.

Ilizarov external fixator can lengthen bones by as much as 1 in. every 10 weeks.



RoboDoc drills femur in experiment above. Calibration pins (right) will guide the system in actual surgery.

ROBODOC IMPLANT



Davis are experimenting with a robotic system developed in conjunction with IBM researchers that can perform artificial hip implants with 10 times the precision of hand tools.

Nicknamed RoboDoc, the system orients itself by three calibration pins placed in the femur under local anesthesia before surgery. A series of X-rays is taken to produce a 3-D computer model of the bone and pins. The computer then de-

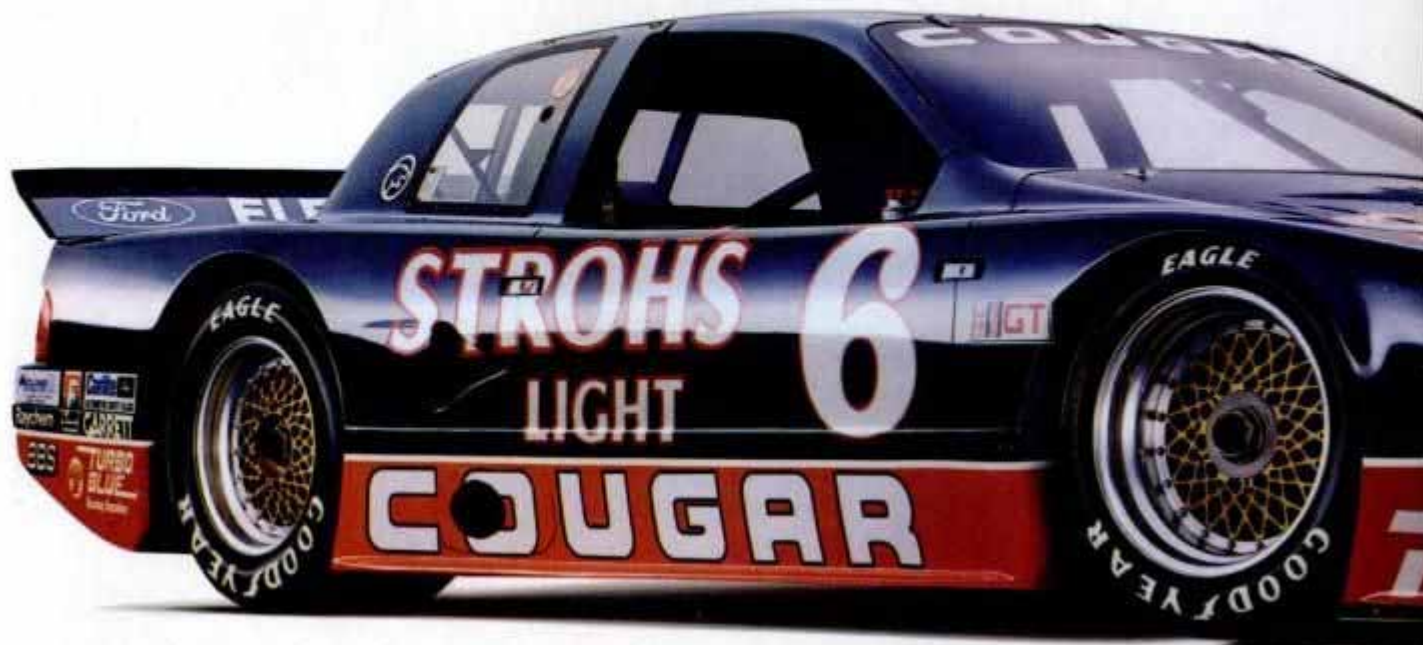


PM PHOTO BY BARRY TENN

IBM PHOTO; IBM ILLUSTRATION

UNIVERSITY OF OKLAHOMA PHOTO

O N L Y O N



*The race-winning IMSA GTO Mercury Cougar XR7.
Exclusive tires: Goodyear Eagle racing radials.*



*The 1989 supercharged Mercury Cougar XR7.
Exclusive factory-specified tires: Goodyear Eagle street radials.*

E A G L E S.



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GOODYEAR
BECAUSE THERE REALLY IS A DIFFERENCE.

ELECTRONICS

BY STEPHEN A. BOOTH

Scouting Report For 1990

WE'RE JUST back from the summer Consumer Electronics Show in Chicago, where manufacturers display their wares for the 1990 model year. Here's an overview of the highlights—many of which you'll find in local stores after the traditional Labor Day closeouts of '89 merchandise.

Based on the lineups seen in Chicago, it's clear that TV has never sounded better. Things are looking better, too: Direct-view tubes keep getting bigger, while the even larger projection sets are approaching the brightness and sharpness of cathode-ray tubes. Home video equipment now sports features usually found only in studio gear. And digital audio compact disc players are subject to yet another running change under the hood.

TV Sound

Some years ago, automobile manufacturers began beefing-up their car stereo systems through joint ventures with traditional hi-fi loudspeaker manufacturers. Now, TV makers are rushing to the same altar to obtain big sound for their even bigger sets.

Following the lead of Zenith and Bose, vows have been announced by Magnavox and JBL, Sony and Hughes, Toshiba and Carver. All three weddings are attended by Dolby Surround or a reasonable facsimile.

The top-shelf Magnavox/JBL system mounts eight speakers and three



Super Carver stereo gives Toshiba's TV sound as big as its 32-in. tube.

amps in 52- and 46-in. projection TV sets. Total power is 100 watts, distributed among front-channel drivers, two bass subwoofers and rear-channel speakers for Dolby Surround.

Toshiba, which added Carver's Sonic Holography system to its large-screen TVs last year, has renewed its vows with Super Carver.

This new, improved sound system, built into two 32-in. direct view sets, mimics the operation of Dolby Surround and adds some special effects. Ambient sounds are served up by a rear-channel speaker that you can leave attached to the back of the set, or detach and place behind your seating location. Total horsepower is 40 watts, split among the bass subwoofer and front and rear channels. In one of the big-tube sets, the speakers are motorized so you can reposition them, by remote control, for best effect.

look for RCA/SRS sometime in the near future.

The Big Picture

As for the TV image, you'll soon see Improved Definition technology in 40-in. to 60-in. projection sets from Mitsubishi, NEC and Panasonic, and in a 27-in. direct-view tube from Sony. IDTV sets use digital processing techniques to double the vertical resolution, and in doing so, eliminate the flicker, dot crawl and jagged outlines caused by the current NTSC scanning system.

In conventional NTSC sets, the finest, brightest color picture we've seen so far comes from RCA's 27-in. High Performance tube, which eventually will grow to a 31-in. model. Hitachi, meanwhile, ups the ante in non-IDTV projection with 46- and 50-in. screens that claim 800 lines of horizontal resolution, and respective brightness levels of

(Please turn to page 22)

Sony's adding SRS—for Sound Retrieval System—to 11 new sets, including seven 27- to 32-in. models. The sound system was developed by Hughes Aircraft for airline audio, and uses only two channels to create an illusion of 3-dimensional depth. Much like Carver's Sonic Holography and other so-called soundfield systems, the effect is audible from any seating position in the room. RCA already has a licensing agreement with Hughes, so



Hitachi's portable TV/VCR combo weighs 8 pounds, including battery and 5-in. LCD screen.

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So if you expect great performances out of your car, spray on the power. The power of Jet-Spray Gumout®.



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460- and 540 foot-lamberts. The projection business might see more action in the LCD segment, too. Sharp's 25- to 100-in. system, priced at about \$4000, is expected to reach the United States sometime soon.

VCR And Camcorders

The expanded roster of VCRs shows the influence of camcorders by the addition of many useful movie-editing functions—while the camcorders themselves incorporate more special-effects and post-production features than ever.

Panasonic and RCA lead the field in recognizing the growing interest in home moviemaking. Each is adding a passel of studio-type features to its camcorders and VCRs, for more sophisticated movie production. Panasonic, in fact, is the first company to incorporate pro-type functions such as chromakey and time-base correction in home video equipment.

Chromakey (pronounced KROW-mah-kee), found in Panasonic's PV-535 full-size VHS camcorder, is a special effect that superimposes a subject against a different background. You've probably seen this popular trick used in many sports broadcasts. Although the announcers appear to be standing in front of the playing field, they are actually in

the broadcast booth or studio, posed against a blank cyan-blue background. Their silhouetted images, recorded with one camera, are then superimposed on a panorama of the field that is shot with another camera.

To achieve this effect, Panasonic mounts a tiny, second camera on the PV-535. The resulting image may be inserted into the scene shot by the main camera in a picture-in-picture fashion, or superimposed onto the main-camera scene by chromakey. Other pro-type features found in Panasonic camcorders



Video to go: Sharp's VC-V540U combines a VCR and 5-in. color screen, runs on AC/DC.



Despite compact size, Sharp's XV-100Z LCD projection TV delivers 25- to 200-in. picture.

include 10-watt color enhancement lights, ear-level speakers, LCD color viewfinders and variable-speed zooms up to 12-power.

Making its home video debut in Panasonic's PV-S4990 Super VHS format VCR is time-base correction. TBC (also referred to as gen-lock) corrects any flagging and waviness in an image. This is sometimes present when a tape recorded in one machine is played back in, or dubbed over to, another.

Video To Go

Mobile moviemakers soon will be able to preview their takes on location with a portable TV/VCR combo. Sony introduced "personal video" last autumn with its 8mm Video Walkman. Now,

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Winston

FILTERS

W I N N I N G

owners of VHS and VHS-C equipment can take their shows on the road.

Sharp and Hitachi will be offering VCRs married to active matrix LCD color screens (4 and 5 in., respectively). The units weigh in around 8 pounds with battery—good for about 2 hours per charge—and use full-size VHS cassettes (or VHS-C minicassettes in full-size adapters). Panasonic, though, seems to believe the portable future is in Super VHS-C.

Since January, the company has been giving sneak previews of a compact, boombox-styled portable that boasts hi-fi stereo, an input for the tiny 2-in. color camera used for chromakey in the PV-



The new VHP tube in RCA's 27-in. G27500GB delivers a stunning color picture.



RCA's CC360 Pro-Edit Super VHS camcorder has built-in editing for home video movies.

535, and a 3-in. LCD color screen that projects a reasonably large image when connected to an optional projector module. The company seems to be saying that with 30- and 40-minute VHS-C tapes on the way, feature-length 2-hour movies will be possible using the high resolution of Super VHS-C's EP (extended play) recording mode. We'll have more on this in future columns.

Compact Disc

The first great outpouring of CD players occurred in Chicago only six years ago. These were 2- or 4-times oversampling machines with 14- or 16-bit digital-to-analog converter (DAC) circuits.

Since that time, equipment makers have tried to build DACs that reproduce

the original music waveform with increasing accuracy. To do so, a DAC must read the incoming 16-digit codes correctly. If a defect in the DAC reads a bit out of place, what's supposed to emerge as a soft murmur might sound like a loud belch.

One way to minimize decoding goofs is to use more bits. Within the past year, DACs with as many as 20 bits have come on the market. Now, get ready for 1-bit. This is how Sansui and Philips see digital audio's future.

Preliminary information on the 1-bit system indicates that instead of swallowing 16-bit codes whole—and risking the mistakes that multibit DACs are prone to—it translates them one bit at a time but at very high speed. Oversampling on the order of 32 or more times, aided by noise-reducing formulas, removes the noise inherent to a 1-bit digital conversion.

Proponents of 1-bit say it's a more efficient—and eventually less expensive—method of accurate digital-to-analog conversion. Sansui even claims that it delivers greater clarity in low-volume musical passages, but we'll have to do more listening in a home setting, away from the racket of the show floor, to learn whether this is audible.

Stay tuned.

FM

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Smoke Contains Carbon Monoxide.

17 mg. "tar", 1.1 mg. nicotine av. per cigarette by FTC method.

TASTE

by
Puritan

CAR CLINIC

BY MIKE ALLEN

Morning Sickness

MY 1977 DODGE VAN has had the same problem since I bought it new. At startup in the winter, it runs terrifically rich, with much black smoke and rough running until it warms up a little. This happens even when the choke plate is completely wide open. It then runs extremely well, getting an honest 12 mpg. I'd rather put a new engine in this van instead of buying another one, but you would make me extremely happy if you could tell me what is wrong.

HAROLD NEFF
BENECIA, CA

If the choke is open, and the engine is too rich even though it's still cold, then look at the evaporative emissions system. The charcoal canister is

designed to store gasoline vapors from the fuel tank and float bowl until the engine is running, and then meter them, slowly, into the intake manifold. Sounds like you're dumping all the fuel in right away, as fast as engine vacuum can suck it in.

There's a purge valve and a solenoid to control all of this. Try temporarily plugging the canister purge line, preventing the fuel from reaching the engine. If this improves the situation, you've isolated the problem.

There are several lines running from the canister to the engine, so be sure you've got the right one. And I strongly recommend fixing this system, rather than simply removing it altogether. For one thing, there's no sense letting all that expensive gas evapo-

rate when you can trap it and use it. Also, the gas tank isn't vented except into the canister, and you stand chances of: 1. collapsing the tank, 2. fuel starvation after only using a few gallons because of the vacuum in the tank, or 3. getting a serious case of gasoline vapors inside the van.

Oil's Well That Ends Well

I own a 1987 Cadillac DeVille with just over 20,000 miles. I change the oil and filter every 3000 miles and only get 2-3 quarts of oil when the oil is drained. There is black soot inside the tailpipe, a sign of burning oil. The dealer said that Cadillacs use a quart of oil every 1000 miles. Is this true, or do I have a lemon?

CARMEN MARCHETTI
SAFETY HARBOR, FL

Carmen, don't you ever check your oil between changes? Why are you letting your oil level get 2 quarts low? You should never let it get more than 1 quart low.

Also, don't forget that the filter holds almost a quart, and you're probably not accounting for that. So your consumption is only a quart or two in 3000 miles.

In spite of what the dealer says, Cadillacs don't use any more or less oil than any other modern car. Your oil mileage might be a little high, but probably not enough to make a case for disassembling your engine. At \$1.50/quart, over the 100,000-mile life of your car, it might cost \$50 more for oil than if it got 2000 miles per quart of oil. That's no big deal compared to the cost of an engine rebuild. Count your blessings, check your oil more often, and add a quart when you need to.

A sooty tailpipe is not a sign of burning oil. It is a sign of an over-rich engine. Have

the dealer look into the fuel injection. Blue smoke is a sign of burning oil.

Film Critic

I have a film on the windshield of my 1989 Buick Park Avenue that won't come off. It worsens even more when it rains or when I use the windshield wipers. It's so bad that driving in the rain, especially at night, is impossible. I've replaced the wipers, and cleaned the windshield with soap and water, four different glass cleaners, ammonia and water, vinegar, acetone, gasoline, alcohol, isopropanol, petroleum distillates, industrial glass cleaner, waterless hand cleaner, Spic and Span, dry newspapers and more. The dealer has no answers.

LESTER CROOM
ELIZABETHTOWN, NC

You've named enough solvents and cleaners to dissolve anything but the national debt. So something must be introducing this film anew.

What are you using for rags to clean the windshield? Try using fresh, unscented, plain white paper toweling. I'd start with commercial glass cleaner, then move to alcohol mixed with acetone. Be sure you don't let any of the solvent get under the edge of the windshield trim, and leach out anything hiding under there.

If you're still seeing the film, maybe it's redepositing itself on your windshield while you're parked. Trees and industrial pollution can leave a persistent film in only a few hours. Is it lurking in your washer bottle or hoses? Perhaps something like brake fluid or ATF was inadvertently added to your washer.

If you can find a 3M product called Rain-X, it does a

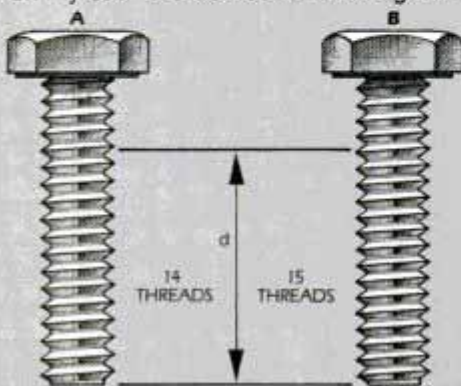
(Please turn to page 26)

Pitched Battle

Quick now—which bolt is standard thread, and which is metric? Well, bolt B on the right has slightly finer thread. But that doesn't really mean anything, as both inch-sized and metric hardware are available in different pitches for the same diameter.

Well, okay, there's (usually) a stamp on the bolthead, which, if you know how to read it, will tell you if it's metric or standard while it tells you the strength. But what about studs? Or nuts? No headstamp.

Several common sizes are so close that they'll mate for a couple of threads before they jam—just enough to sucker you into thinking it's the correct fit and let you ham-fist something expensive. But, you say, I don't have standard and metric bolts on my car—it's domestic. Look again. Domestic cars have



been carrying metric-sized parts for a generation, right next to inch-sized parts. So—be sure you know that that nut you picked up from the shop floor is the right one, and not left over from some other project.

PM HOTLINES

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CAR CLINIC (Continued from page 24)

terrific job of making rain water slide off the glass, and I've found that it keeps oily films and bug smears from adhering.

Short Takes

Everybody knows that short trips and cold weather are hard on engines. Why? I drive 1 mile to the bus in the morning, and 1 mile home at night. Aside from changing the oil every 1000 miles, what can I do to protect my engine? Should I let it warm up by idling it while waiting for the bus?

KEE DUH

CHESTERFIELD, MO

Short trips are bad because:

■ The engine's internal clearances are different, i.e., looser, when the engine is cold, and the loose-fitting parts like pistons and bearings wear faster.

■ The oil is cold and viscous, and isn't pumped around rapidly enough to maintain proper lubrication—especially in the first few seconds when all the oil has drained back into the crankcase overnight.

■ If the oil never warms up properly on a steady diet of short trips, the moisture and unburned hydrocarbons will never evaporate completely, forming yucky sludge in your crankcase and cylinder heads.

In your case, continue to change the oil

Two-Fisted Radiator Repair

Copper and plastic-bodied radiators often contain a cooler for the transmission, in the form of a loop of tubing or a small tank inside one of the end tanks. In the copper variety, the tubing is soldered in place,

while in the plastic ones, O-rings are used to seal and

hold the fittings. To remove the lines from the fittings, be sure to use two wrenches. One, obviously, to turn off the collar on the line. But be careful because it's altogether too easy to twist off the soft metal of the tank, unless you hold the flats of the fitting steady. Plastic tanks are also fragile, and may leak afterward at the O-ring unless care is exercised.

Flare nut wrenches are best, but the open-end wrenches we've shown here are usually acceptable. Stay away from pliers or Vise-Grips, which will deform the soft metal.

Put one wrench on the inner nut, and put a little elbow grease into it clockwise—but not enough to turn it tighter. Then use the second wrench to turn off the outer nut, counterclockwise, without letting the inner move at all. Do the opposite while reinstalling the lines, too.



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For quicker starts, smoother acceleration and improved fuel efficiency ask for Bosch Platinum.



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at least every 1000 miles (even in warmer weather) if you continue to drive only 1 mile at a time.

Don't warm up the engine by idling it. You'll simply accelerate the wear. Instead, treat this station car to a weekly trip long enough to warm up the oil, and keep it warm for 20-30 minutes. This will boil off any moisture, and keep sludge formation to a minimum.

The Right Stuff

Is there a difference in brake fluid? Do different cars require a different fluid? My 1980 Audi 5000 has needed three new master cylinders in three months. These were purchased at a foreign car parts store, and the mechanic who installed them used the same fluid he has used for years on Mercedes and BMW. The Audi dealer says their brand of fluid has a different consistency—at \$25 a can. When the last master cylinder was replaced, the entire system was flushed, and filled with new fluid, but after 30 days or so, the pedal began to sink down.

C.M. FEREE
HIGH POINT, NC

That \$25 can the dealer wants to sell you must be a synthetic of some sort. For an assortment of reasons, I don't recommend synthetic brake fluids for the aver-

age driver, primarily because braking systems were designed to work properly with conventional glycol fluids. There are some excellent synthetics, and for heavy-duty or racing uses, they can sometimes solve heat-related problems.

Brake fluid that meets the DOT 3 or DOT 4 standards is fine for use in any modern hydraulic brake system—that's why the DOT sets those standards. I doubt you could find any brake fluid on the market that didn't meet these standards. Audi currently doesn't recommend any DOT 5 brake fluids, because of the corrosion liability—these silicone-based fluids don't absorb any moisture, so water may settle to a low point and rust a hole in a steel brake line.

Your problem is more likely related to the replacement master cylinders you've been buying. I'm not going to blame it on the foreign car aftermarket parts industry—many of the parts they sell are the identical ones available at the dealer, and often at considerably less cost. But perhaps you've gotten some that are old or have been improperly stored. **PM**

DO YOU HAVE A CAR PROBLEM?

Just ask Mike about it. Send your question to Car Clinic, Popular Mechanics, 224 West 57th St., New York, NY 10019. While letters cannot be answered individually, problems that are of general interest will be discussed in the column.

SERVICE TIPS

■ Chrysler TSB 06-02-89 details replacing the clutch release lever with P/N 4511039, to cure a noise or growl when depressing the clutch at moderate to high engine speeds. This covers all 1988 and earlier fwd manual transaxle vehicles except L bodies.

■ '81-'84 Ford Escort, EXP, Lynx and LN7s experiencing front-end vibration may benefit from re-indexing the hub on the spline shaft 180° from the original position. TSB 83-20-12

■ Some '85-'87 Cadillacs with 5.0L engines with a persistent misfire traceable to cylinder No.5 may have a wire inside the distributor chafing against the rotor hub. TSB 87-41-6D

■ Chevrolet notes in TSB 87-5-2 that aftermarket antitheft systems that tap into Corvette hydraulic systems to prevent the car from being stolen may damage some components in the ABS braking system.

■ '85-'86 Toyota Camrys may be hard to start when facing downhill—if there is less than 1/4 tank of gas. TSB FUEL-001R recommends replacing the fuel pump, filter and a rubber cushion inside the fuel tank.

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JOHN MADDEN



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*Based on engineering estimates.

IMPORTS

BY BILL HARTFORD

Vanguard Of The 1990s

LONG AGO, around mid-century, soon after the people's car—the Beetle—began conquering the world, Volkswagen started making what came to be called the microbus, an unlikely vehicle that started a whole new trend in transportation.

And so it was that the minivan was born.

VW's van fare for the common man was a blunt-nosed, rear-engined hippie-hauler that could really pack 'em in. The emphasis was on living accommodations, and it didn't take long before we saw VW buses advertised with a photo of a baby elephant inside, happy to be going for a ride.

But today, with even the breadbox-like Vanagon ready to retire and make way for an all-new front-engine VW van, the emphasis has

Nissan Axxess for 1990: See-through accessibility with two sliding doors for the rear.



its first model to be labeled 1990. Driving the Axxess will make you feel as if the year is 2001 and you've just come out of orbit.

The Axxess will shuttle seven people around in great style, even though, compared to the competition, it's a slightly scaled-down minivan. Its smaller dimensions—wheelbase just under 103

between a family sedan and one of the larger minivans will find the Axxess a very appealing choice. And it puts only 1 gallon of burned fossil fuel into the atmosphere every 27 miles (EPA highway, 5-speed). Expect to pay somewhere between \$15,000 and \$20,000, depending on your choice of the XE version (lots of standard equipment) or SE version (even more good stuff).

Another scaled-down minivan that would help change the shape of family wheels for the 1990s could be Honda's. The Accord-based vehicle, seen at left in a concept illustration, is now under development.

No More Audi Bashing

When Audi catapults one of its cars into an immovable barrier, it's for safety testing. When owners do it because of what the National Highway Traffic Adminis-

tration has concluded is "pedal misapplication," they blame it on Audi, calling it sudden, or unintended acceleration. It seems as though, these days, no one will just fess up and say, "I goofed."

My crash testing of an Audi Coupe GT, not too long ago, was of a different sort, but the incident still revealed the failure to face the music that's so rampant today: A fellow motorist attempted to change lanes into a spot otherwise occupied by yours truly. He wrinkled the driver's side of the Coupe nicely. Okay, it happens. But then, he hangs a left and beats it down a side street. (If he had known I was in a press car on loan, he probably would have tried to sue PM and Audi!)

I hope that when we take out the new Coupe Quattro, that replaces the GT for '90, we'll return it exactly as we received it—except for a good number of test miles on the odometer. **PM**



Honda minivan: A whole new shape for the family car?

shifted to a more carlike ride. A minivan's basic shape automatically yields the volume you expect, so recent development has gone into performance, handling and all the appointments that are demanded of a comfortable family car.

Nissan Axxess

Just when we thought it was safe to declare a winner in the minivan sweepstakes and cite Mazda's MPV as our first choice in this category (see "Imports," page 30, Apr. '89), along comes Nissan with

in. and overall length 172 in.—contribute to its agility. A total of 138 hp is available from the 2.4-liter Four and aero is 0.36 C_d. Its cowcatcher nose is reminiscent of Renault's Espace, a minivan that never came here from France, but one that impressed us when we drove it in Paris in 1985 just after it was introduced.

The front-wheel-drive Axxess is also available with a 4wd drivetrain, and transmission choice is 5-speed manual or automatic.

Anyone trying to decide



Audi Coupe Quattro's new Five gets four valves per cylinder.

NEW LAB TEST REVEALS: SLICK 50 CAN CUT ENGINE WEAR IN HALF!

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The following introduces one of the most fully tested and credentialed gas saving, friction reducing engine treatments ever to reach the market!

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The makers of Slick 50 have invented a way to permanently bind "Poly" to your engine with one treatment. All you do is add one quart of Slick 50 to your oil. By reducing engine friction, Slick 50 increases gas mileage and horsepower and it reduces engine wear, defraying costly overhauls.

Slick 50's Credentials are Impressive

Just this year the premiere engine and lubricant testing lab in the U.S. tested Slick 50. This EPA approved lab conducted a strictly controlled experiment using industry standard ASTM procedures. They found that engines whose oil had been treated with Slick 50 showed 52% - 57% less engine wear than engines whose oil had not been treated with Slick 50. We know of no other Poly treatment on the market that has passed a wear reduction test conducted by an EPA approved lab using nationally accepted ASTM procedures. Watch out for those treatments that cannot back up their claims with such solid proof.

The March/April 1982, p. 35 issue of *Consumer Digest* magazine stated, "Slick 50 does reduce engine heat and ordinary wear, and our informal tests indicated that it will improve gas mileage by about 2 or 3 miles per gallon."

Researchers at a nationally respected research laboratory, after applying a powerful ultrasonic cleaning process to a Slick 50 treated engine part, were surprised at its performance. They stated, "We actually expected the Slick 50 "Poly" resin coating to also be removed, but later found it was still there."

The Federal Aviation Administration has fully accepted a similar product—Slick 50 Aircraft Treatment (F.A.R. #33.49).

TUV, a German testing laboratory with credentials every bit as prestigious as our Underwriters Laboratories, tested Slick 50 in 1986. They found substantial increases in both gas mileage and horsepower.

The power technology laboratory at a leading southwestern university stated, "Slick 50 does increase horsepower and decrease fuel consumption in tests done at the university." The Space Shuttle Columbia uses the chemical "Poly" in its gears and bearings because it is the only chemical lubricant which can withstand the heat and corrosive elements of space.

The most dramatic of all is a torture test overseen by the Automotive Services



Council for Pennsylvania. This test was shown on television station WTVE. Three cars with between 75,000 and 129,000 miles on them, were treated with Slick 50. Six months later the oil was drained from each vehicle and the cars were driven without the oil plugs for about half an hour. The water temperature never rose and the engines sustained no apparent damage.

It's Easy to Treat Your Engine

Add your FREE engine flush and idle engine for 5 minutes. Then change oil and filter and substitute one quart of Slick 50 for the last quart of oil. (Add two quarts for engines with oil capacities of seven quarts or more.)

Slick 50 gives a permanent coating so you need to treat your engine only once, and not each time you change your oil. Slick 50 is also excellent for turbocharged engines, aluminum block engines and rotary engines.

Slick 50 will work with all petroleum based oils and synthetics compatible with petroleum based oils.

What are the Benefits of Slick 50?

Since there are many factors that influence an engine including the type of driving, temperature, engine condition, oil change intervals, etc., the actual benefits in percentages will vary. However, by reducing friction, Slick 50 does all of the following:

1. Increase gas mileage
2. Increase horsepower (small economy cars and large RV's really need this)
3. Reduce operating temperatures, thus increasing the lubrication and life of the oil and engine
4. Minimize or eliminate costly overhauls by reducing engine wear
5. Easier starting (important in cold weather)
6. Since lubricating lead is being removed from gas, and unleaded gas is poor in lubricating qualities, this extra lubrication

of Slick 50 on valve systems and guides is a real bonus.

7. The drastic reduction in engine wear can delay costly overhauls. Slick 50 eliminates the "lubrication starvation" that all cars experience when you first start them, before the oil has a chance to circulate. Up to 90% of engine wear can be caused by this starvation. You receive all these benefits for less than the cost of two tanks of gas (\$39.95).

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OLD HOUSE RESTORATION

BY BOB VILA

Glazing And Marbleizing

RE-CREATING fantasy or faux finishes on the walls, ceilings and trimwork of houses is an old art that's being reborn today. Generally considered decorative painting, there are many different techniques that come under this heading.

Some of them, like stenciling and graining, have already been discussed (page 34, Nov. '88 and page 48, Dec. '88, respectively). But there are more finishes included under this decorative painting umbrella which, when used properly, can enhance the look of a period home.

The two I'd like to discuss this month are glazing and marbleizing. A look at the basic steps involved in each will give you a pretty good idea of what to expect if you decide to take on either restoration project.

Glazing: an experimental art

Glazing, in its broadest sense, means putting a finish on something to make it look like glass. A protective coating that's durable and can be cleaned easily, glazing creates an interesting translucent effect on walls. A clear finish, applied to a painted surface, is manipulated while still wet with various tools to create a pattern.

Although the ground color is still visible through it, the depth or texture that results from this movement of the top coat gives the surface a soft, mottled quality. In essence, glazed walls seem to halo a room.

Popular for centuries, glazing was used extensively in Victorian homes. Because

Contributing Editor Bob Vila is host of public television's "This Old House."



In the Victorian era, marbleizing fireplace mantels was especially popular. Often this faux finish was applied over cast iron or slate, with results that were astonishingly realistic.

of their durability, glazed walls were often found in high-traffic areas like living and dining rooms, front halls and bathrooms. This decorative art reached its peak of popularity in the post-Victorian era, namely the '20s and '30s, when it was known as Tiffany glazing.

Today, glazing may be a solution to both old-and-new-house decorating problems. A relatively easy technique to learn, there's no limit to the effects you can achieve by varying the tools used to manipulate the glaze coat. There are three basic ways to do this: stippling, striating or mottling.

The first, stippling, involves lifting off the glaze coat using a dry brush in a pouncing motion. Dragging a tool through the glaze—it could be a rag, dry brush or sponge—is called striating. Finally, mottling the glaze means to simply blot this wet top coat with a sponge or pad

of material like paper towels, cheesecloth, plastic wrap or tissue paper.

It's easy to make your own color glaze using one of the commercial glazing liquids as a base. Many of the major paint manufacturers make this glazing liquid, which is essentially a slow-drying varnish. To this, simply add artist's colors and a little thinner to retard its drying time. Adding some oil base will make the mix spread easily. This will give you a sheer enough medium so that the wall color underneath will come through nicely.

The trick to a successful glazing job is to hide the markings left by the tool you use to create the depth and texture in the surface. Before you tackle a major glazing project, it's a good idea to practice on a smaller surface first. A piece of smooth cardboard or particleboard is an ideal place to start. Not only can you experiment with dif-

ferent tools and manipulation techniques, but you can also try out different glaze colors.

Marbleizing magic

Marbleizing is a decorative technique commonly used on woodwork and trim. One of the more popular uses of this faux finish was on the fireplaces in Victorian homes. Some of you may be surprised to find that, what you thought was a real marble fireplace, is in fact cast iron or slate painted to look like the costly stone. To the average observer, it's difficult to tell the difference between the fantasy finish and the real thing.

Unfortunately, some old-house owners find this out the hard way. Perhaps, while painting the surrounding wall, some paint drips onto the mantel. If you try to get the splatters off with paint stripper and the stripper sits too long on this faux surface, it will eat right through the

GRAMMAR OF ORNAMENT PHOTO

faux finish.

As with any hand-executed finish, the secret to a successful marbling job is twofold: patience and time. The domain of the skilled craftsman for many years, marbling is something you can learn to do yourself and achieve results you'll be happy with. This includes the simple touch-up and repair of chipped or cracked surfaces.

For example, if your old marbled mantel is 99-percent intact but has a few flaws here and there,

you should be able to touch it up yourself with a small artist's brush. Since the original finish was more than likely done in oil, an oil-based paint is usually best for this work. Don't be afraid to experiment. Any mistakes can be erased easily with a cloth moistened with paint thinner.

Is there a surface in your house, old or new, you want to marble from scratch? If so, the process is similar to graining. First, the surface must be prepared for paint. If you plan to marble raw metal, start with a metal primer. If the surface is unfinished, tightly pored wood, a wood primer must be used. Applying the base coat, which is the ground coloration of the surface, comes next. The lightest highlight of the piece, it should be an enamel finish. Since your objective here is to create a base that's flat and smooth, you may need more than one coat. You don't want any brush marks to spoil the marble effect, so expect to smooth this bottom surface with steel wool or sandpaper once it dries.

A natural sponge can be used to add *cloudiness* to some areas over this smooth base coat. Lightening or thinning the background color and applying it spottily with a paint brush in a circular motion will add background variations.

Now, here's where patience really comes into play. To recreate the veins of a marble surface, some professional decorative painters carefully paint in each line over the ground coat with a small artist's brush. Others do the same thing using a turkey feather.

Another way to create the veins and drifts of real marble is to apply paint with a brush, rolled-up rag or sponge, then pull the color off using the same tool. Many times, this technique gives a more realistic look, lowering the contrast to create more of a textured rather than *spotty* or harsh look. In either case, it helps to keep a piece of the real stone handy to pattern your work after.

If reading about the basics of these decorative painting techniques has whetted your appetite to learn more, your next step should be a visit to the local library for books detailing every step.

Remember, to do these decorative arts well, you must be willing to pay attention to detail, take your time and be patient. The amount of satisfaction you'll get from either of these beautiful painted finishes is well worth the time and effort taken to create it.

FM



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Glazing is a great way to add texture to a wall surface. It creates a translucent effect that makes the wall appear to shimmer.



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NOTICE TO PM READERS

We need your help.

To commemorate the 90th anniversary of POPULAR MECHANICS, the Henry Ford Museum & Greenfield Village and PM are assembling an exhibit on the history of American mechanical ingenuity, as chronicled in the pages of POPULAR MECHANICS. PM has played an important role in bringing an understanding of the industrial revolution to its readers. The history of our magazine reflects deep and lasting American traditions of self-reliance, ingenuity and inquisitiveness. We would like to bring these same qualities to this exhibit.

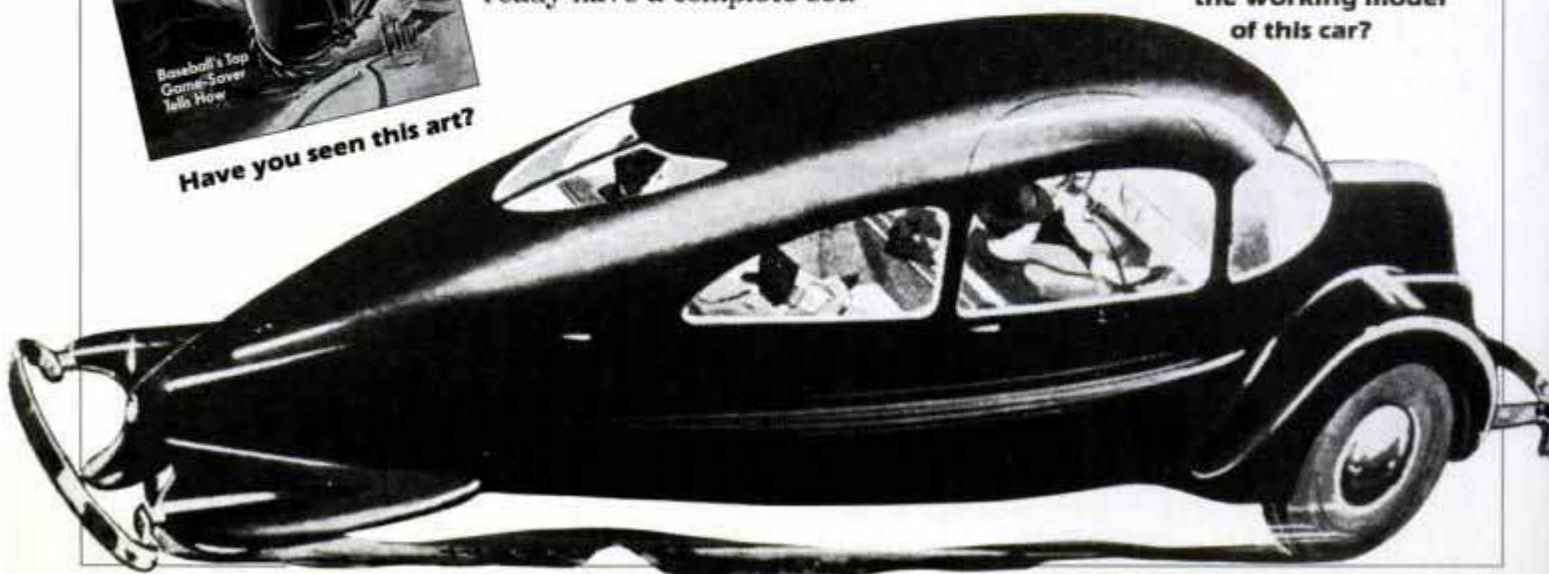
We need your help in identifying inventions, artifacts, projects, models, cover artwork and illustrations that appeared in the countless features that have filled the pages of POPULAR MECHANICS for the past 87 years. We are interested in both those things that never came to pass, and also those things which have become part of the fabric of everyday living. Please help us locate these objects, inventions and artwork so that we can create a timely and exciting historical exhibit.

Please send any information you think would be helpful to POPULAR MECHANICS Exhibit, 224 West 57 Street, New York, NY 10019.

NOTE: Thank you, but we are *not* interested in back issues of POPULAR MECHANICS. We already have a complete set.

Whatever happened to the working model of this car?

Have you seen this art?



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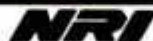
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BY TIM COLE

New Views Of Mars



A Viking shot of the red planet's Valles Marineris (left) forms the basis for the 3-D computerized animation in "Mars The Movie" (right).

PLANETARY scientists are creating new tools to extend man's vision of other worlds. "Mars The Movie," produced at the NASA/Cal Tech Jet Propulsion Laboratory in Pasadena, California, is a shining example.

The computer simulation transports viewers through Valles Marineris, an enormous canyon near the Martian equator that stretches farther than the distance between Los Angeles and New York. Relying on imagery obtained by the Viking Orbiter spacecraft, the movie was crafted during 37 days of uninterrupted computer time. A digital terrain map and photo mosaic were established that could in turn be manipulated on a computer screen. The effect is like flying through the canyon system—over actual terrain features like the Tharsis Montes volcanoes—at 600 miles per second.

Scientists in JPL's Visualization and Earth Sciences Applications branch hope "Mars The Movie" will give planetologists a more complete picture of the Martian surface.

JPL is also working on a

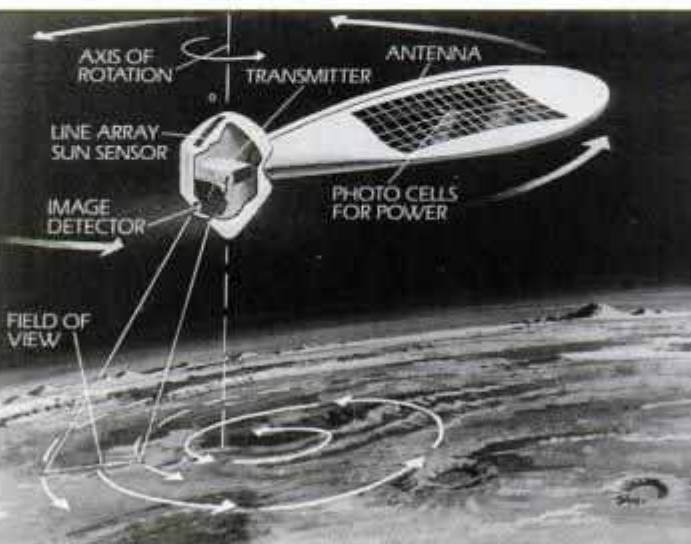
truly revolutionary means of building our knowledge of the Martian surface—forgoing large, expensive orbiting spacecraft in favor of sprinkling a greater number of simpler probes across a wider area.

The concept, developed by JPL's Spacecraft Systems Engineering section, borrows from the elegant simplicity of nature. Shaped like a seed from a maple tree, the single-wing *Samara* Probe would flutter to the surface in a circular pattern, its on-board electronics obtaining

concentric scans of the Martian surface.

JPL's Jim Burke explains: "At Mars, for example, the Probe would enter the atmosphere hypersonically like an arrow or a javelin. Then, when it decelerates to subsonic speeds, it begins to spin the way a maple seed does." Length, angle and pitch of the wing would dictate the rotation speed.

Both "Mars The Movie" and the *Samara* Probe demonstrate an innovative—and delightfully simplified—approach to exploring planets.



The *Samara* Probe flutters like a maple seed to a landing on Mars.

Baby Step Against Acid Rain

Last month's column outlined the cause of acid rain and the effect this environmental scourge has on the North American wilderness. Not to cast too much gloom on the issue, it's important to realize that the Department of Energy is also taking some tentative steps to reduce emissions at our nation's coal-fired generating plants.

A 5-year demonstration program has been awarded to the Alliance, Ohio, firm of Babcock & Wilcox Corp. to proceed with two advanced, low-cost clean coal technologies. The Coolside process removes as much as 80 percent of sulfur impurities from the combustion process by introducing a lime "sorbent" into combustion gases.

The Limestone Injection Multistage Burner Process also uses a lime sorbent to clean sulfur from combustion gases.

Both techniques will be explored to see if they can be economically applied to existing powerplants. Let's hope it does the job well enough, soon enough. **PM**

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OUTDOORS

BY JOE SKORUPA

Twin Wheels Keep On Turning

I'VE JUST come back from a lake test where a new prop delivered such head-snapping, hole-shot power that the boat climbed out of the water and rode entirely on the lower unit. I don't recommend this maneuver, but the point is that something interesting is happening on the cutting edge of prop technology.

Torque-Shift

The revolutionary Torque-Shift prop, made by Land & Sea, of North Salem, New Hampshire, shifts pitch angles like a transmission shifts gears, and offers a glimpse into the future of boating.

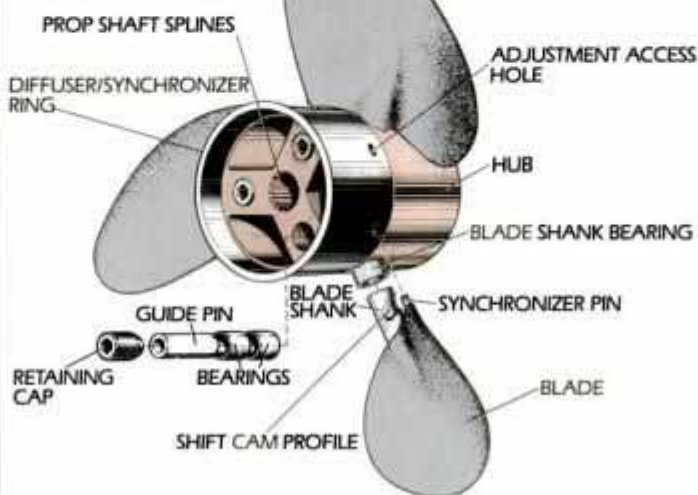
Bob Bergeron, the president of Land & Sea, Al Nolan, sales manager, and I had just finished our radar and stopwatch runs, which showed the Torque-Shift to be an impressive performer, when Nolan offered one more demonstration.

He hopped into a 17-ft. HydroStream runabout, trimmed out the 150-hp Merc outboard a few degrees and hammered the throttle. The boat accelerated with such force that it shot out of the water. Maybe 6 in. of the stern maintained water contact (maybe less). The boat was essentially riding on the lower unit. I've never seen anything like it.

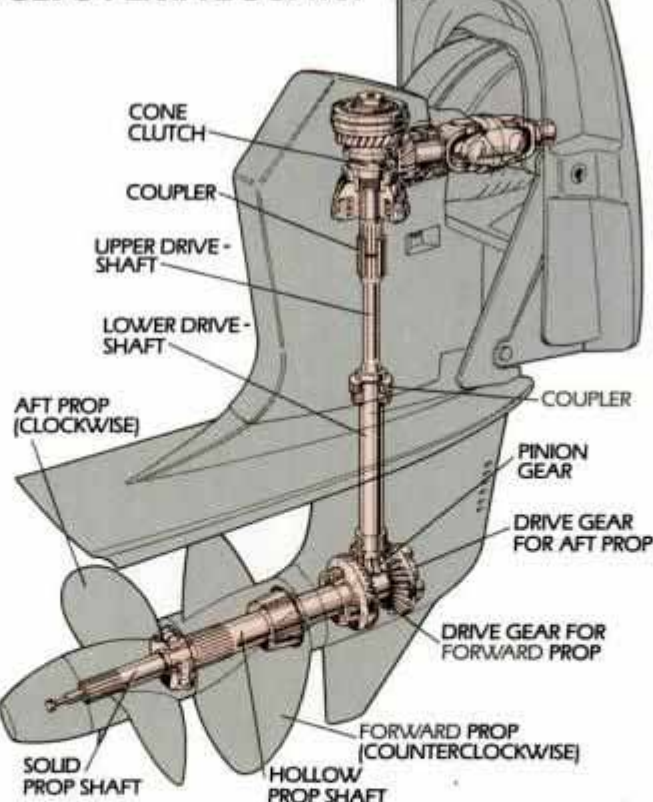
The reason the HydroStream displayed such phenomenal power is that the prop was set for a 10-in. pitch angle on the low end, about the angle used by waterski show boats to pull as many as a dozen skiers at once. With this kind of low-end power, it's not surprising the hull took off like a rocket.

Outside of waterski shows, however, boaters never run 10-in. pitch props, because they don't want to risk damaging engines by over-rev-

TORQUE-SHIFT



VOLVO PENTA DUOPROP



ving at full throttle. A correctly propped boat should allow the engine to achieve maximum recommended rpm. A prop with a pitch angle too small allows

engine over-revving. A pitch angle too large results in diminished planing ability.

This situation forces boaters to choose between a few mph on the top end or a few

seconds out of the hole. With a fixed-pitch prop you can't have both. With a two-in-one Torque-Shift you can, because at about the 35-mph plateau the prop automatically shifts into the upper setting, optimizing top-end efficiency and preventing engine over-revving.

Comparison testing

We loaded four passengers into a 220 Sport Baja equipped with a 260-hp Merc sterndrive and clocked top-end speed and acceleration times (0-40 mph) running a 22-in. pitch polished stainless-steel prop and then a Torque-Shift prop set for 11-in. and 22-in. pitch angles. (Torque-Shift props are adjustable to a wide range of pitch angles, but the recommended ratio between the upper and lower setting is two to one.)

Not surprisingly, top-end was a solid 52 mph at 3800 rpm with both props, demonstrating that the double-cupped, stainless-steel Torque-Shift blades are as efficient at full-throttle as fixed-pitch blades. The difference in hole shot, however, was stunning. The Baja with the Torque-Shift was on plane instantly (okay, maybe it took a second), then hit 40 mph in 9.34 sec. (average of three runs). With the fixed-pitch prop it took twice as long, 20.68 sec.

The Torque-Shift uses a cam system built into the hub to shift the prop while underway. At low rpm, springs keep the blades in the low-pitch position. When rpm is increased, a combination of centrifugal force and torque sensing enables the individual blade shafts to pivot and upshift while underway. The feeling is similar to that of an automatic transmission in a

(Please turn to page 41)

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car. Interestingly, the Torque-Shift is a versatile prop beyond its 2-speed capability: 1. Its limits are adjustable by using an Allen wrench, 2. A variety of interchangeable springs, shims, cam profiles and blades are available for additional tinkering, and 3. You can control shifting by use of power trim—upshift by trimming up, downshift by trimming down.

Land & Sea makes Torque-Shift hubs to fit all V6 and V8 outboards and OMC, Merc and Yamaha sterndrives. The company recommends the prop for use on 50-mph boats equipped with power trim. Price is about \$500, which makes it an affordable alternative to owning several different wheels. Bass fishermen and waterskiers should consider it standard equipment.

Volvo Duoprops

It took eight years of development before Volvo Penta, whose American division is located in Rockleigh, New Jersey, perfected the Duoprop and introduced it in 1983. It's not surprising it took this long because prop design is part science and part black art, and the Swedish engineer Lennart Brandt had two inline props to deal with plus the challenge of creating counterrotating shafts along a single axis.

But the effort paid off and a revolutionary prop and drive unit finally emerged. Unfortunately for Volvo's American division, early Duoprop technology was available only on diesel engines. As Alan Revington, president of Volvo Penta of America, observes, "Diesel engines didn't make the Duoprop a very exciting package in the U.S., contrary to Europe where it's extremely popular."

It required a few more years of R&D to adapt the technology to gas engines, but by 1986 Volvo was able to offer Duoprop on a 5.7-liter small-block V8 (the 570 DP) and ultimately, for model year 1990, a 7.4-liter big-block V8 (the 740 DP). Both are built by Chevy.

With a full line of gas V8s now available, Duoprops are genuine options to consider for any sterndrive boat buyer. Here's what to expect.

I recently took my first Duoprop ride and, although it wasn't quite as dramatic as the Torque-Shift demo, it was an eye opener. Planing was instantaneous, acceleration brisk, maneuverability sensational and noise at full-throttle incredibly soft (even during a test with the engine cover up).

The reasons for all of the above are complex but relatively easy to understand. Because the Duoprop is running two counterrotating props, it outperforms single-screw installations by taking a firmer prop bite and losing less energy through the water. The former

is the result of increased blade area, nearly double that of a single screw, and the latter the result of cavitation, ventilation and slip losses reduced by low prop rpm and the neutralization of the paddle-wheel effect (sideways torque) and the spinning motion of the water column's exit flow.

Why is Duoprop so quiet? This isn't as easy to understand, but it has to do with a vibration frequency less prone to amplification by hulls.

There are a few drawbacks with Duoprop, namely the props aren't yet available in stainless steel, and that efficien-

cy is only maintained to about 55 mph. Nevertheless, Duoprop offers a glimpse of the future of boating and now that it's available on a variety of gas V8s, we're going to see a lot more of them on the waterways. This is especially true since Duoprops cost only a few hundred dollars more than single-prop units.

Two-in-one props, like the Torque-Shift and Duoprop, easily outperform single-screw units and many marine companies, no doubt, will try to copy them. But don't look for this to happen any time soon. Current patents don't run out until the turn of the century. **PM**



Since radar displays only one number, the operator has the responsibility to decide which vehicle is being clocked.

Why radar makes mistakes. How to protect yourself.

It's hard to believe, but traffic radar does not identify which vehicle is responsible for the speed displayed. It shows only a speed number. The radar operator must decide who to blame.

How radar works

The radar gun is aimed at traffic and it transmits a beam of invisible radar waves. Moving objects reflect these waves back to the radar gun. Using the Doppler principle, the radar calculates speed from the reflected waves. But there's a problem.

The best guess

Remember, these reflections are invisible. And truck reflections can be ten times stronger than car reflections. How can the operator know for sure which vehicle is responsible for the number?

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The only way to defend yourself against these wrongful tickets is to know when radar is operating near you.



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FREEWHEELING

BY TONY SWAN

Back-Country Brute

YOU SAY the current crop of sport/utility vehicles is just too tame for your tastes? That tells us you haven't seen this one. Weighing in at a trim 6681 pounds, the Lamborghini LM002 ranks as the world heavyweight champion of utes—just the thing to convince your friends and neighbors that you've graduated from mere off-road fun into the more demanding realm of desert warfare.

Available in extremely limited numbers through Chrysler dealers, the LM002—Chrysler insiders call it "the dreaded La Moo Too" and "the Rambo Lambo"—this brooding hulk was in fact designed for desert use. The huge 345/60VR-17 Pirelli tires have a special ridge at their outer edges to help shed sand—just the thing for remote patrol duties in places like Saudi Arabia, which has a number of these brutes cruising the burning sands even as we speak.

And we do mean cruising. Despite its bulk, the LM002 can propel itself up to a brisk 110 mph in sandy terrain, even faster on hardpack and pavement. That's because there's plenty of power to go with the poundage. Nestled in the LM002's massive tube steel chassis is the same dohc 48-valve 5167-cc V12 engine that powers Lamborghini's Countach 5000S sports car. In LM002 tune, it churns out 455 hp at 6800 rpm, sending power to the wheels (either the rears or all four) through a 5-speed ZF manual gearbox. There's enough propulsion on hand to give the LM002 a top speed of 125 mph on pavement, even though this truck's aerodynamic properties are about



Lamborghini off-roader: Even at \$130,000, the LM002 gives you lots of beast for your buck.

on a par with those of a medium-sized barn.

For all its combat readiness, though, the LM002 is also a real kick to drive on the street. There's plenty of room in the short rear cargo box for a couple of picnic hampers (not to mention a matched pair of missile-launchers), and the leather-lined interior is more attuned to Dom Perignon than it is to K-rations. You'll find yourself wondering why the Saudi Border Patrol needs such

fripperies as mahogany trim on the instrument panel and an Alpine stereo system with overhead controls, but even though it's not a jungle out there, life is clearly tough on the frontier. And where does it say off-roading has to be uncomfortable to be efficient?

Other civilizing touches include power windows and door locks, and air conditioning, of course, is standard equipment. There's roomy seating for four, and four

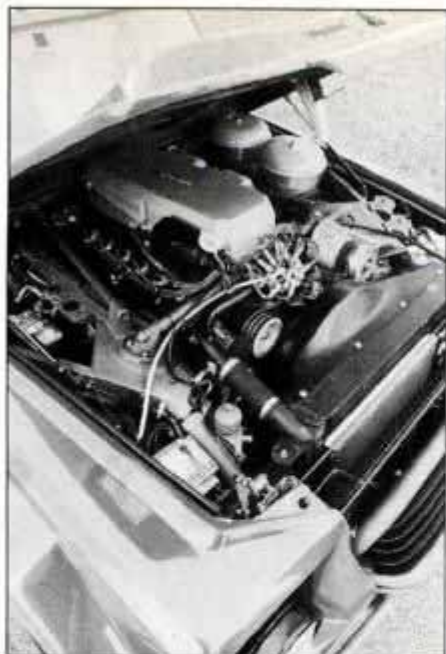
only (although you could have your bodyguards stand up in the cargo box, thus providing themselves with a good field of fire).

Amenities and performance notwithstanding, though, the thing that makes the LM002 more fun to drive than anything this side of Bigfoot is the reaction it produces in the traffic stream. On city streets this vehicle has a double-take quotient that's comparable with Jamie Lee Curtis showing up unannounced at a stag party. Even in the exotic mixture of Ferraris, Bentleys and Aston Martins that passes for everyday traffic on West Hollywood's fabled Sunset Boulevard, the LM002 stands out like a bear among beagles.

As you might expect, automotive individuality such as this doesn't come cheap. The going price for an LM002 is roughly \$130,000, which is about what you'd pay for a Countach. However, since



Glove leather interior of the LM002 belies warlike exterior.



In LM002 sport/utility trim, Lambo 5.2-liter V12 engine makes 455 horsepower.

only 50 or 60 of these machismobiles will be federalized this year, you do have the satisfaction of getting a lot more visibility per buck. And if you want a desert camouflage paint job, bring your own spray can.

Mpg-Plus

With fuel economy showing signs of re-emerging as a buying priority, you'll be pleased to know that tomorrow's automotive engineers continue to busy themselves with high-mpg projects.

A recent example is the sixth annual West Coast Supermileage Competition, sanctioned by the Society of Automotive Engineers (SAE) and the California State Automobile Assn. The teams were composed of students from a dozen universities and state colleges around California, and the starting point for each group was a 2-hp Briggs and Stratton engine.

To qualify for glory—and the \$400 first prize—each team had to complete four laps of the 1.75-mile California Highway Patrol test track at Bryte, California. And if \$400 doesn't seem like much return for the man-hours involved in building a competitive car, consider how far \$400 would take you, if you had the time and patience to travel in one of these high-mileage specials.

Figuring gas at \$1.10 per gallon, the 1989 Supermileage winner could go almost 465,000 miles, which works out to more than 58 circuits of the Earth at the equator, without resorting to credit cards or frantic calls to mom and dad. That's computed on a basis of 1278.69 mpg, which is what the Cal State Northridge team achieved with its entry, nicknamed Big Richard.

While Big Richard's achievement was 327.16 mpg better than the second place

entry, fielded by California Polytechnic of San Luis Obispo, it fell a whopping 693.08 mpg short of the mark set for this event by Cal State Sacramento two years ago. Cal State Sacramento was also the event's defending champion, winding up third this year at 888.68 mpg. Cal State Fresno finished fourth, with a mere 787.69 mpg.

The Cal State Northridge car was piloted by Hiep Nguyen. Crew members included Sunil Short, Sam Raheb, Bryan Clementson, Dave Harris, Kenny Chang, Ray Flores, Steve Rickles, Luis Izquierdo, Donald Ashcraft and Chris Gelinas. The faculty advisor was Bruce Ryan.

Our congratulations to all concerned.

Mpg Ad Infinitum

If you like cars that run on mere fumes, you've gotta positively *love* cars that don't need gasoline at all.

That's certainly the prevailing sentiment at General Motors, which recently announced its sponsorship of an 1800-mile race for solar-powered cars right here in the U.S.A.

You will recall that the General Motors Sunraycer came home first in the great Australian solar-powered race of 1987, finishing days ahead of its closest competitor.

This achievement can be ascribed in some measure to good luck—the Sunraycer got off to an early lead and escaped cloudy weather that seriously handicapped the rest of the field. But it can be ascribed mostly to thorough preparation and a serious commitment to solar power at GM—which brings us to this next chapter.

The GM Sunrayce USA will feature teams from 32 North American colleges and universities, including those mileage magicians from Cal State Northridge and Cal Poly San Luis Obispo. The field was developed from proposals submitted by would-be teams from 61 schools, and whittled down by a panel representing GM, Hughes Aircraft, Chevrolet, AeroVironment, the Department of Energy and the Society of Automotive Engineers.

The green flag will wave at the GM World of Motion Pavilion at Florida's Disney World next July, and the course will be run over secondary roads through Florida, Alabama, Tennessee, Kentucky, Indiana, Ohio and Michigan, finishing up at the GM Tech Center in Warren, Michigan.

The payoff in this event is a little more compelling than the California Supermileage competition. GM will send each of the top three Sunrayce finishers on to represent the United States in the first renewal of the World Solar Challenge race in Australia, which is set for November of 1990. May the sun shine on all the players.

Un-Paralleled Parking.



Introducing
the Mazda MX-6
with four-wheel
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INSIDE DETROIT

BY JIM DUNNE

Stealing From Ford

THE scuttlebutt in and around Detroit says that Chevy's 1991 Caprice wagon will be a larger version of the Ford Taurus, with the same aero shape and sleek appearance. First sighting of the Caprice wagon confirms much of that. While visibly larger than the Taurus, the Caprice has the same canted tailgate angle, and rounded bodywork that makes the Taurus styling unique. Like the 4-door sedan, the new Caprice wagon will use the same frame and suspension system as today's cars. Today's 5-liter V8 will be the only powerplant.

Ford Counterattack

Ford will offer a new full-size wagon of its own shortly after the 1991 Caprice wagon hits the showrooms, and it too will look much like today's Taurus wagon. However, the LTD Crown Victoria wagon will not be a Caprice clone. Major differences in the front-end styling will set the two rivals apart. Ford's front end will be similar to those seen on recent Mustangs, with little brightwork, and virtually no grillework. Plastic bumpers will wrap around to the front wheel openings in the fenders. Chevy's Caprice will stick with a chrome grille. It



Next-generation Crown Victoria, due in 1991, will feature family Ford look mated to current platform.

will have an eggcrate texture, and be attached to the hood, à la Mercedes. Look for the Caprice to use a 1-piece hatch for the rear door, while Ford sticks with a 2-piece split door. An exclusive: Chevy is testing a sunroof for rear-seat passengers in this wagon.

Saturn Sedan

First undisguised photos of the sporty Saturn show what many suspected—the passenger compartment is completely surrounded by glass, with no interruption from body posts. At least that is the impression you get when viewing the car from the outside. The posts for windshield and backlite are completely hidden behind



Though disguised, this prototype shows front of '92 Brougham.

the window glass. The Saturn's roof forms a tiny cap atop the glass. Also, the car has flipper headlights that pop up from a semirecessed position in the front of the hood, thus offering the sporty appearance of hidden headlights without being completely hidden look-alikes.

Full-Disguise Cadillac

A prototype of the 1992 Cadillac Brougham, heavily disguised, was caught off base somewhere in Michigan earlier this year. The traditional Cadillac styling is seen in the grille, headlights, door handles and wheels. But the rear end is all disguise. A phony panel covers the C-post area near the rear window, while the non-Cadillac taillights are recessed deeply in the rear.

A wraparound windshield, frameless door glass and quarter-windows in the front door are among new styling features.

Chrysler Fifth Avenue

The Fifth Avenue line will return for 1990 when Chrysler brings out a lower cost version of the new Imperial. Chrysler Fifth Avenue will be an upgrade of the current New Yorker sedan, but it will not be priced on the same level as the flagship Imperial. Fifth Avenues will have the same rectangular opera window in the sail panel as the Imperial and the front end will have an extended overhang. Trim and equipment are different between the cars, with the Imperial reassuming the role as top dog in the Chrysler line.



As 1992 launch date nears, Saturn styling readies for pilot production.

U.S. Testing Grounds

It seems that more foreign cars and trucks are using North America for prototype testing than ever. European and Japanese vehicles are taking advantage of the climate and test tracks and laboratories in the U.S. and Canada to make certain their vehicles stand up to our driving conditions. A favorite for Europeans—especially British cars like Jaguar and Austin, and German cars like Mercedes—is Arizona, where high temperatures and long highway distances are unique to the U.S. Nissan is a strong Arizona user, too. It has a full-fledged test track near Phoenix. Japanese cars and trucks travel California roads for most testing. But you also see them winter testing in northern states like Michigan and Minnesota. Volkswagen likes the northern U.S. and Canada for much of its on-the-site winter tests. One trick some Japanese use to avoid public exposure: Cars are run on public roads only at night.

Pay \$30 To The Lawyers

That's the amount per car or truck that GM spends on legal expenses each year. All told, the company pays out \$200 million in legal expenses annually, fighting or pursuing all kinds of lawsuits. That figures to an extra \$30 for each car and truck each year by the company. But it does not include awards or settlements. That money comes out of insurance coverage. Day in and day out GM has an average of 25,000 lawsuits in dispute.

Think Small

That's what the Big Three automakers are doing when it comes to engine planning. Small V8s, smaller V6s and new Fours are in the development stage, and should start coming to the streets within 18 months. Ford is working on a 2-liter V6 for the mid-1990s cars. Meanwhile a 4.6-liter V8 will be ready for installation in 1991 full-size cars and the Thunderbird/Cougar line. GM wants to get an all-new 4.0-liter V8 in production to replace the 5.0-liter V8s in its full-size lines. This engine is set for the early 1990s and will use aluminum extensively. Forget about the V10 engine for a passenger car at Chrysler if fuel economy standards are raised above the 27.5 mpg now federally mandated. To cover its bets, Chrysler is developing a small V8—probably in the 4-liter class—that will fit in its bigger fwd sedans. Why is Detroit so late in building small displacements? Smaller engines lack the low-speed torque that U.S. drivers demand in bigger cars.

Goodbye K-Car

Chrysler will not use the venerable K-car chassis for its cars of the future. Instead, the Eagle Premier will be the

base car for any new midsize Chryslers. The Premier takes the place of the so-called Liberty car Chrysler has been working on for the past few years. Liberty was to form the basis for the Chrysler cars of the future. But Chrysler had problems getting the Liberty program off and running. In the meantime, Chrysler bought AMC and came into possession of the Premier design, as up-to-date as anything in the midsize market. So the decision was made to drop Liberty and go with Premier.

Return Of The Monte Carlo SS

Chevy may revive the famous Monte Carlo SS name for a high-performance 1991 Lumina coupe. While two Lumina coupes will be on the market this fall, the high-performance version will not be ready until a year later. Its appearance is so special that Chevy insiders are hoping to give it a special name. And Monte Carlo seems to be the favorite. Engineering details are sketchy at this point, but it is possible that the hot coupe will have some kind of air-charging system for its 3.1-liter V6 engine, like the turbo system currently offered with the Pontiac Grand Prix, or possibly even a supercharger. A number of changes in appearance will set the coupe apart from standard Luminas. Most striking is a new grille panel. Cooling intake slots replace the eggcrate texture of the Luminas.

Atop the hood are two grilled openings, similar to those on the Pontiac Grand Prix Turbo. Ground-effects panels line the lower edges of the body from the front bumper to the rear, while the requisite air wing sits atop the rear of the trunk. Look for this model to challenge the Thunderbird Super Coupe for performance honors in the midsize coupe lineup.

Chevy's Thundertruck

After showing its full-size K-series pickup last fall with a 454-cu.-in. V8 option, it looks as if Chevy is really going to make this muscle truck available for 1990. Sources inside Chevrolet say the big honker will be on sale when the new Chevys roll out in October.

Chevy marketing types don't expect big volumes for the 454, but do expect this option to have a halo effect for the full line—as well as create a challenge to perennial pickup sales leader Ford.

Crowning Touch

The basket handle—a stylistic device first introduced in the '50s with the Ford Crown Victoria—is back again, showing up this time on GM's new APVs—the Chevy Lumina, Pontiac Trans Sport and Olds Silhouette.

While the APVs are new, the handle is not—it's purely decorative. **FM**

An Advanced Way to Tread Water.



Introducing the Mazda MX-6 with four-wheel steering.

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8-Millimeter Ups The Ante

BY FRANK VIZARD, Contributing Editor

ONE OF THE many things you can do with a camcorder is record events that broadcast and cable TV ignore because the potential audience is too small. An example of this situation was the recent U.S. tour by Ireland's championship football and hurling teams.

Irish football is similar to soccer except that the ball may be handled as well as kicked. Hurling is a wild, fast, highsticking game best described as hockey played on grass with a baseball and without protective gear. In both games, 3-point goals are scored by firing the ball under a crossbar, while single points are awarded for shots over the bar.

This year's tour was historic in that it was the first time in more than 20 years that an Irish National Football League final had been played in the United States. This small bit of sporting history drew an enthusiastic crowd of about 6000 to New York's Gaelic Park. We were on hand to record the highlights with a new video system whose proponents hope will be equally historic to the world of amateur video-making. The new system, called Hi8, is to 8mm what Super VHS is to VHS. The Hi stands for High-Band, which is an upgraded for-

mat designed to increase horizontal resolution, improve signal-to-noise performance and offer better color rendition than the existing 8mm system. Like Super VHS, Hi8 is only upwardly compatible with the older format. Standard 8mm tapes can be played and recorded in a Hi8 machine—but with no improvement. Hi8 recordings can't be played back in a standard 8mm machine. Blank Hi8 tapes can be recorded in a conventional machine, but will yield only conventional results.

The improvement in horizontal resolution, to 400 lines from about 240, is achieved by raising the luminance carrier to 7 MHz (megahertz) from 5 MHz. This effectively expands the video bandwidth to 5.4 MHz from the 3.4 MHz of standard 8mm. The frequency deviation range also has been increased, to 2 MHz from 1.2

MHz, to produce a better signal-to-noise ratio. The use of higher frequencies means that details in the video image are better recorded.

Another factor in Hi8's improved performance is the videotape itself. Two new formulations, called Hi8 Metal Evaporated (ME) and Hi8 Metal Particle (MP), provide the high-density magnetic storage needed to record all those details. The production of ME tape represents a major manufacturing breakthrough. The application of a vaporized metal alloy directly to the carrier film had been troublesome for years. Generally, oxidized iron particles are applied to a plastic film through a binder. This is how MP tape is made. MP tape is recommended for everyday moviemaking and time-shifting, while ME is the tape of choice when you plan to make multiple dubs of your home movie. ME tape costs \$13,

\$17 and \$22 for the 20-, 60- and 120-minute lengths. Hi8 MP tape lists for \$9.50, \$13 and \$16 respectively for each length.

The Hi8 format was introduced by Sony, but the flagship of current Hi8 camcorders is Canon's A1 (\$2299). The A1 combines the sharp performance of Hi8 with a wide range of features, innovative design, and even a remote control to facilitate its use as a second video cassette recorder.

Among the Canon A1's most notable features is hi-fi stereo sound, an attribute that preserved the authenticity of the swirling bagpipes and the singing of two national anthems at the start of the Irish football game. As the games progressed, the joys of a 10X power zoom lens became evident by bringing



Canon's remote-controlled A1 camcorder uses the new Hi8 format. It can be held like a film camera or like a conventional camcorder.



scoring attempts taken at either end of the field easily into view. The autofocus system will switch between two focusing zones depending on the relative distance of the subject, a procedure that works effectively but seems a tad slow at times.

Spectators watching the competition soon found themselves shoulder to shoulder as the small ballpark filled to capacity. In this situation, the A1's innovative use of two grips came in handy. The A1 may be held on the forward right side like any conventional camcorder. It also may be held like a still-picture camera—2-handed style—thanks to a grip at the rear of the camcorder body. Dual start/stop and zoom controls near each grip allow you to operate the A1 from either position. And since the A1 weighs only 4 pounds, it doesn't put much strain on your hand whichever way you hold it.



VCRs such as Sony's SLV-70HF offer multiple editing features for camcorder-made movies.

Regarding lens performance, swinging "hurleys" that sent a small inside-out baseball 70 yards or more in a single stroke were recorded without blurring or image-trailing thanks to a choice of four high-speed shutter modes— $1/2000$, $1/1000$, $1/500$ and $1/250$ of a second. Combine these design and technical elements together with a viewfinder that rotates 180° and you've got a camcorder that can follow a play up and down the field—and also record crowd reaction even if the same crowd prevents you from moving much more than your hands.

Our post-game analysis of the A1's High-Band tapes confirms that the 8mm format has found its answer to Super VHS. Colors were bright and details well defined, offering a very discernible improvement over standard 8mm performance. The fully-featured A1 also seems to be a winner, proving itself to be a light and maneuverable performer in a tight situation.

Editing Decks

While videotape editing features are more common on camcorders, they're also appearing on video cassette recorders more frequently. Sony, for example, has targeted camcorder owners with its SLV-70HF VHS VCR (\$1100).

Terminals for a camcorder's audio and video outputs are located on the front of the SLV-70HF for easy connection to the VCR. Once linked, the Sony SLV-70HF and the camcorder become an editing machine.

By using picture-in-picture technology, the SLV-70HF allows you to watch footage from a camcorder and a VCR simultaneously. Editing functions can be accessed by touching the front panel controls. Features such as these are liable to turn you into a video production chief long before the product warranty expires.

Beta Movies

Beta is not the big videotape format it once was but neither is it ready for the last rites. There are still a few million Beta video cassette recorders in use and their owners are hungry for prerecorded material. Unfortunately, many neighborhood video stores stock only VHS titles these days.

Fortunately, there are sources that dedicated Beta owners can tap into in their quest for new titles. The most promising source of Beta titles might be the Beta Only Store. Already a fixture in New York City, the Beta Only Store recently opened a branch in Philadelphia. Plans call for additional store openings in Washington, D.C., and on the West Coast in the near future.

If you can't get to the stores you can write for a free catalog listing 3000 titles to: Beta Only Store, 202 W. 49th St., New York, NY 10019.

Heard But Not Seen

As much pleasure as audio and video components can provide, they don't always blend aesthetically with a room's decor. You might decide, therefore, to hide the electronic components in a cabinet with wooden doors—or even a closet if one is handy.

The problem is that you have to open the doors to operate the equipment, and shelves full of components might seem a little unsightly or out of place to dinner guests.

So how do you keep the gear out of sight but still accessible? Assuming you have a remote control, Xantech Corp. has the answer. The product is called Hidden Link and it's smaller than a pack of cigarettes.

The concept behind Hidden Link is simple. The small ($1/4$ -in.-high \times 3-in.-wide) box is mounted atop the cabinet and aimed toward the seating area. As the box receives the infrared signals emitted by your handheld remote control, your instructions are transferred via normal speaker wire to two small infrared LEDs that you've installed inside the front section of the cabinet. The LEDs retransmit your instructions, and they are received by the sensor built into the components.

Hidden Link is installed easily and requires no tools. List price is \$50. **PM**



You can keep your components undercover and retain remote control with Hidden Link.

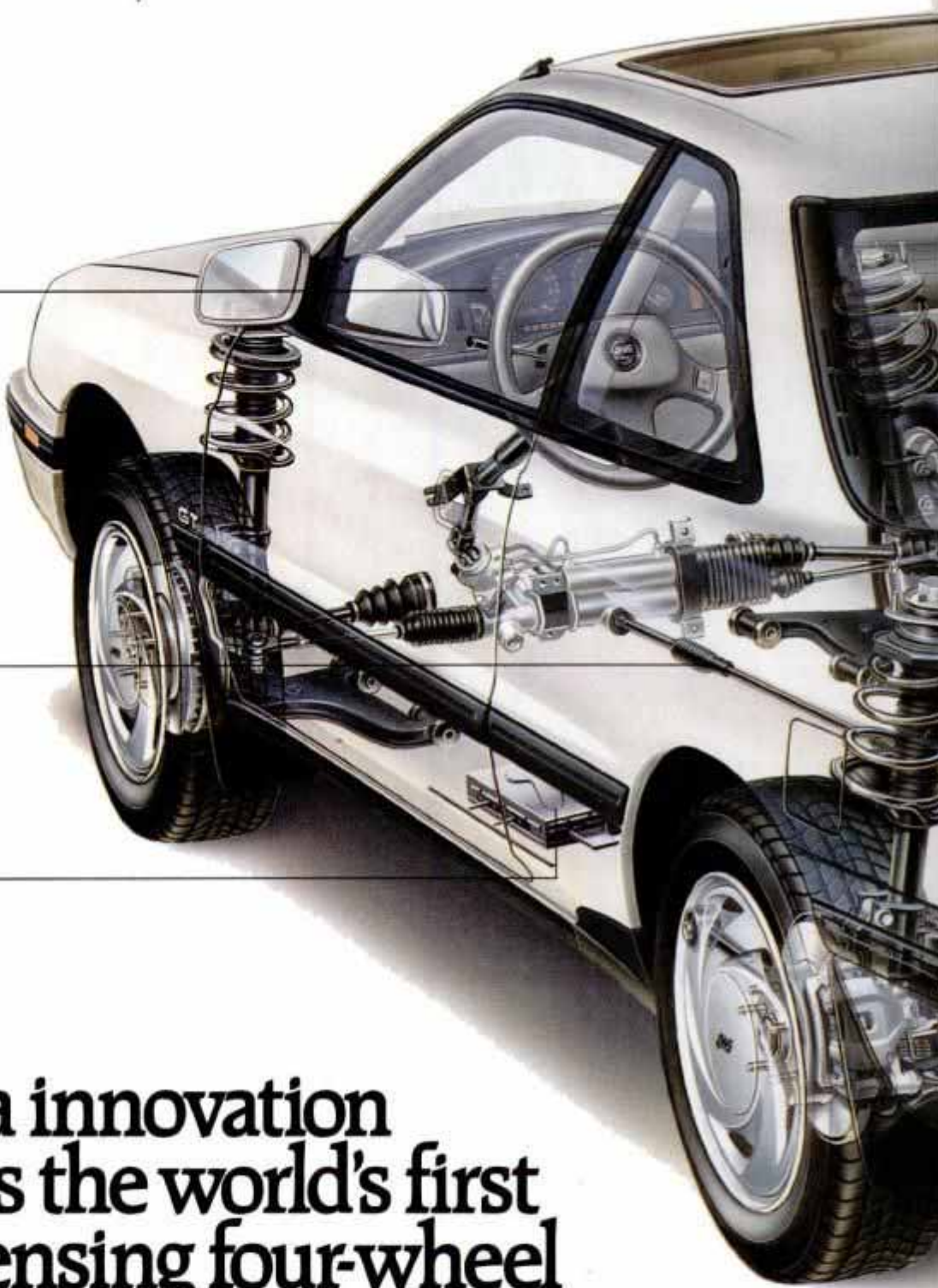
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Introducing the Mazda MX-6 with four-wheel steering.

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**STEERING ANGLE
TRANSFER SHAFT:**
rotates the gears in
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to coordinate front
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gives signals to the
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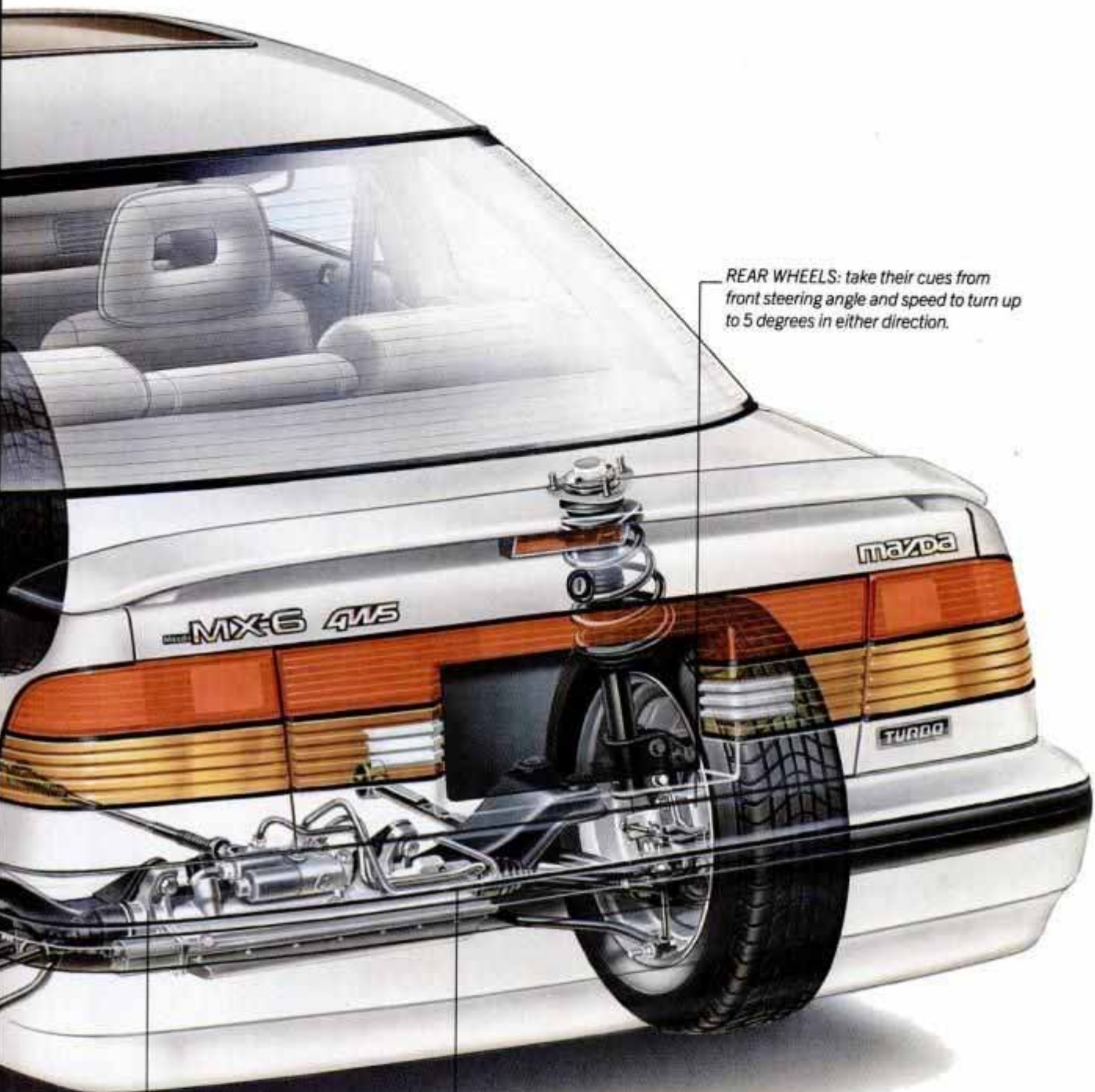
Mazda innovation produces the world's first speed-sensing four-wheel steering system.

Imagine yourself on an undulating, serpentine ribbon of road. Now imagine driving it in a car engineered with the world's first speed-sensing four-wheel steering system: the turbocharged Mazda MX-6 4WS. An automobile so advanced in its handling capabilities, you may think it's in synch with your every thought.

Simply put, the connection between you, the car, and the road is significantly heightened,

because this exclusive Mazda innovation enables all four wheels to steer. Above 22 mph, the rear wheels steer in the same direction as the front wheels for exceptionally quick response in S-curves or lane changes. And that unsettling body motion you'd normally feel during these maneuvers is reduced. In its place, a comfortable feeling of confidence and control.

Below 22 mph, the rear wheels steer in the



REAR WHEELS: take their cues from front steering angle and speed to turn up to 5 degrees in either direction.

POWER CYLINDER: moves the rear wheels with hydraulic pressure from control valve.

CONTROL VALVE: applies pressure from the power steering pump to control rear steering angle.

opposite direction of the front wheels to provide increased maneuverability for situations such as U-turns and parallel parking.

The turbocharged Mazda MX-6 4WS. It takes handling precision, control and performance to levels that can only be described as "exhilarating." And more importantly, raises your personal driving enjoyment to a level even beyond.



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HydroRunner—Taking to the water will never be the same after you blast the throttle in this 40 miles-per-hour personal watercraft. Powered by a 28-hp outboard, this sleek tri-hulled machine measures 8 1/2-ft. long with a 4 1/2-ft. beam, and weighs 200 pounds. Plans contain six blueprint sheets and a detailed photo-illustrated book. (PM-1810—\$15.95)



Doll Cradle—Watch your little girl's eyes light up when you give her a charming reproduction of an 18th-century doll cradle. With our plans, you build it of mellow pine and finish it with a durable varnish. Measures 10 3/4" x 22 1/2". (PM-1820—\$5.95)



Redwood Patio Furniture—Six durable pieces made of heartwood redwood, built to withstand exposure to heat and moisture, resist warping and fulfill specific needs. The barbecue cart has two drawers, a maple cutting board and a broiler pan on the food preparation side and a built-in ice chest and bottle storage rack on the other side. The chaise lounge can be adjusted either to a reclining position or placed flat so several people may sit. Four additional pieces are included. (PM-1013—\$6.95)



Model SS United States—The glorious, record-breaking flagship of the U.S. Merchant Marine. No passenger ship has ever matched her top speed. The professional quality model is drawn in detail on 3 full-size blueprints. Over 2-ft. long; made of wood and metal. (PM-1200—\$9.95)



Roll Top Desk—Nostalgia buffs will especially appreciate the always popular roll top desk for both home and office. It's antique style is cherished by many. Make one yourself in fine cherry and take pride in this charming heirloom. You build it as two separate units, a base and a roll top. (PM-1736—\$6.95)



Bookcase Wall—A floor-to-ceiling dream project that makes your living or family room seem larger. The shelves are 12-inches deep, and the five cabinets can be adjusted to any width. Great for storing or displaying your fine items. (PM-1008—\$5.95)



Stone-Sheathed Utility/Garden Shed—This spacious shed fills the bill for both town and country gardeners who need more room. Plans consist of four 17 x 22-in. drawing sheets, a detailed 8-page instruction manual, and a complete materials list. (PM-389—\$18.50, 1 plan; \$16.00 each additional plan)



Portable Ironing Center—Unscrews from the wall to move when you do. Plans feature a receptacle for the iron, a fluorescent light and storage space for all materials. The ironing board folds up behind louvered doors. (PM-1005—\$5.95)



Captain's Bed—Build this space-saver bed/dresser/desk for your youngster. The dresser features four drawers and bookshelves, while the desk provides room for writing, doing homework and reading. The bed, which fits securely on top of the dresser and desk, is surrounded by guardrails to protect your sleeping child. (PM-1850—\$6.95)



Toolbox—Old wood toolboxes are valuable, but it's hard to find one in good condition. Build one yourself from cherry or walnut and use it to store tools, camera equipment, hobby collections, jewelry or sewing aids. This one has brass corner caps and lock, too. Measures 20 1/8" L x 12 3/8" H x 9 1/4" D. (PM-1826—\$5.95)

FALL FIRSTS

High performance and high luxury make the first of the 1990 new cars great roadburners.

THERE'S NO GETTING AWAY from it—when it comes to new car introductions, fall is rapidly becoming a 6-month season. The traditional October rollout of shiny new cars is getting very little respect these days, especially from import manufacturers.

Early last spring, we began attending 1990 introductions and, as a consequence, found that we've got more 1990 news than we can fit into a single issue—or, for that matter, two issues. We'll still bring you our annual domestic new car spectacular in next month's issue. But in the meantime, we want to get things started with some of the more 1990 significant new cars we drove prior to Detroit's traditional fashion show.

Lexus LS 400

As the speedometer edged resolutely past 150 mph, the dignified face of Ichiro Suzuki was suddenly wreathed in a big, boyish grin. Mr. Suzuki, Chief Engineer for the new LS 400, was one of my passengers, and we were hurtling

LEXUS LS 400



FALL FIRSTS



LEXUS ES 250

Lexus ES 250 will play supporting role for new LS 400. New bodywork rides on Camry chassis.

down an open stretch of German autobahn in search of truth and maximum velocity. This turned out to be 162 mph, achieved on a gentle downhill, and when the needle moved past 150 Mr. Suzuki and his interpreter both giggled like schoolboys. Their creation had not only lived up to its advance billings, it had proved itself capable of even more.

The LS 400 is the flagship of a new marketing section of Toyota Motor Sales USA, a \$35,000 supersedan designed to challenge the upper crust of

the luxury establishment—Mercedes-Benz, BMW and Jaguar. Based on our initial encounter with this car, we expect the challenge to be successful. The hardware is certainly world class, including a 250-hp dohc port-injected all-alloy 32-valve 4.0-liter V8 *any* manufacturer would be proud to offer. It hustles this sleek 3755-pound cruiser to 60 mph in less than 8 seconds, and *never* intrudes on the car's occupants.

Sleek is certainly the right word to describe the LS 400's body. It sports a

C_d of just 0.29, which accounts for its ability to attain high cruising speeds, as well as an exemplary level of operating quiet.

Both the interior and exterior of the LS 400 could just as easily have been created in Stuttgart. Mercedes cues abound. The subdued leather-clad interior even features real wood trim. And from the rear, the car is hard to distinguish from an S-class Benz. We don't think the front-end styling is particularly successful, but it's about the only detail that misses the mark.

The LS 400 will be offered with two suspension options—a basic coil spring setup, independent at all four corners, and a variable-rate air spring system. We liked the latter for its ride quality. But for high-speed stability, the coils inspire a tad more confidence.

We'd also say that the LS 400 gives something away to its European rivals, particularly BMW and Mercedes, in terms of chassis stiffness. For all its competence, this doesn't quite feel like a German car—yet.

But with a price tag of \$35,000, literally thousands less than its intended competitors, it does have a certain feel all its own—it feels like a great buy. —Tony Swan



MERCEDES-BENZ 500SL



Long-awaited Mercedes SL roadster will be available with 6- and 8-cylinder engines initially, with V12 to follow. Pop-up roll bar is activated by vehicle attitude sensors.



INFINITI Q45



Nissan's new Infiniti sedan is due in November. Interior treatment is nicely integrated and leather-lined. New 4.5-liter V8 32-valve engine makes 278 hp.

Lexus ES 250

Lexus dealers are going to need another car in the showroom besides the LS 400, and Toyota has taken the Camry platform as the basis for the \$21,050 ES 250. Its 156-hp V6 seems a bit overrated for the actual acceleration it delivers. But perhaps that's a false impression created by driving the more powerful LS 400 back-to-back with the ES 250.

Like the LS 400, the ES 250 is an extremely quiet car, almost totally devoid of road, tire or exhaust noise

until the speedo points over toward the radio. The suspension is typically Japanese—supple and refined.

The interior, admittedly a little rough in fit-and-finish in the prototype we drove, is conservative and tasteful, replete with California maple inlays on the dash and console.

As pleasant as it is, though, with the wood, and a considerable number of standard features (cruise, a/c, stereo, power doorlocks and windows, stereo, driver's airbag, and burglar alarm), we wonder if there's sufficient



INFINITI M30



Infiniti M30 coupe is better known in Japan as the Nissan Leopard. The instrumentation is all analog. M30's 3.0-liter V6 formerly saw service in 300ZX.

reason to choose the Lexus version over the Camry—except for the privilege of driving a Lexus. —Mike Allen

Mercedes-Benz SL

Every car you drive—or we drive—leaves an impression. Some cars have such strong personalities that the memories of driving them linger for years. And we're confident that the new Mercedes-Benz SL is near the top of all-time memorables.

Here is a car that evokes every emotion and pushes every visceral button as you push it through tight, twisty mountain roads, as you power past slower traffic on 2-lane country byways or as you blast along at 140 mph on modern superhighways.

The car that it replaces, the 560SL, has become something of a classic and a tough act to follow. But the new SL is, simply, state of the art—blowing away the 560SL in every possible way. It is, by far, the most technologically advanced car on the road. Every detail has been engineered and reengineered by Daimler-Benz over the past eight years. The convertible top, for instance, operates better than any convertible top we've ever seen. One button controls everything, from the latching and unlatching to the raising and securing of the rear hatch.

Not only does the SL look all-new, it's also all-new under the smooth, flowing aerodynamic skin. U.S. SL buyers will have a choice of drive-trains for the first time—something Europeans have had for years. The 300SL-24, powered by a 24-valve inline 3-liter, 6-cylinder engine rated 228 hp, is available with either a 5-speed manual or a 5-speed automatic transmission. The 500SL packs the wallop of a 32-valve 5-liter V8-rated 332 hp, backed by a 4-speed automatic transmission. If that's not enough punch, Daimler-Benz engineers promise a 400-hp V12 for '91 or '92.

Despite the high horsepower, acceleration isn't really startling. The reason is weight. The 500SL weighs 4163 pounds. Still, the 500SL is capable of a 170-mph top speed (155 mph in U.S. tune), and the car certainly never feels wimpy. In fact, it's just the opposite. Like every Mercedes-Benz we've ever driven, the new SL gives you a feeling of solidity, stability and supreme confidence. This is a car that feels like it can take on anything and not slacken the pace.

The suspension that accomplishes all these remarkable feats is similar to the 190- and 300-series sedans in the Mercedes lineup. That is to say, shock absorber/struts up front with multi-links in the rear. But there have been

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HELIPORT 2000

It's been 50 years since Igor Sikorsky perfected vertical-lift aircraft. The next 50 will see dramatic improvements in helicopter power, control and avionics.

BY FRED MACKERODT, Contributing Editor
PM Illustration by John Berkey

NEW YORK, NY, 2020 — Back in the old days, before most major cities on the East Coast constructed waterside vertiports to speed intercity travel, flight time from Washington, D.C., to Manhattan took nearly 3 hours. About 45 minutes of that was actual flight time. The rest was travel to and from airports. Congested ground transportation and near total gridlock in our nation's air traffic control system cost travelers precious time and lost productivity.

But today, we've cut the trip to about an hour. And if you'll lean back in your ergonomically correct passenger chaise and look out the starboard side viewport of this new Sikorsky Very Large Civil Transport helicopter, you and 99 fellow passengers will see what created the enormous efficiencies of modern air travel.

We're about to land on that collection of landing pads and passenger terminals jutting into the East River — anchored safely to crowded Manhattan by passenger walkways and

auto ramps, its over-water approach pattern permitting safe, noise-reduced maneuvering for our helicopter, one of the world's largest.

The VLCT's trailing-arm main gear extends and we delicately alight. A Bell-Boeing civil tiltrotor on an adjacent flight pad advances power and sails skyward. Passengers stream to rail, auto and ground-effect craft water links. Outbound ticketholders queue for the trip back to D.C. The system, created in the throbbing heart of downtown New York, speeds people and commerce in the wheel and thunder of a nation abuilding.

We owe this effort-free travel network to the city planners of the 1990s. Back then, they decided that movement between population centers could best be achieved through an infrastructure designed to take advantage of emerging techniques for taking off and landing aircraft vertically. VTOL eliminated the need for commuter airlines that consumed landing slots best-suited to long-distance

The vertiport of tomorrow might include landing pads for both tiltrotor transports, designed for medium-distance travel, and Sikorsky's Very Large Civil Transport. Constructed adjacent to open waterways, future heliports would permit safe maneuvering while respecting noise-abatement laws. Merging infrastructure with vertical takeoff and landing technologies will relieve air traffic congestion, expected to worsen as the next century unfolds.

haulers, liberating the nation's beleaguered air traffic control system. Bringing the airport to the passengers also reduced traffic snarls and pollution.

What made it possible? The marriage of this remarkable infrastructure with technologies that were in



HELIPORT 2000

their nascent stages back in the 1980s. Tiltrotor tech was an obvious way to move people up to 600 miles. And the enormous VLCT—Sikorsky's magic carpet—linked exurban areas and nearby cities to fuel economic growth at the start of this new and exciting century.

Back to Earth

Of course, the interesting part about the foregoing fantasy is that it veers only slightly from the realm of the possible. Japan is constructing an extensive infrastructure for helicopters throughout her archipelago. The on-again, off-again tiltrotor, recently canceled by the Defense Department for budgetary reasons, has significant potential as a commercial transport. And Sikorsky's VLCT already exists—in slightly altered form.

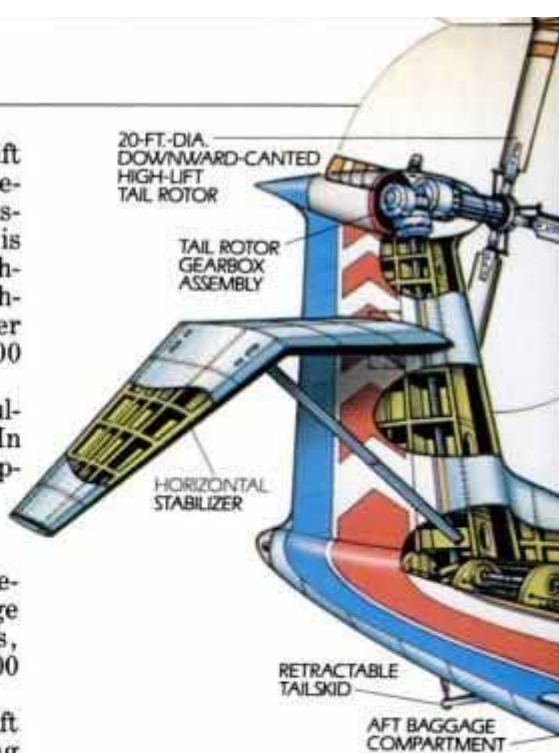
When Sikorsky Aircraft presented a drawing of its future VLCT at the Helicopter Industry Assn. meeting last January, only the drawing was futuristic. Technologically, the machine was doable with even less than state-of-the-art tooling and materials. The idea was to present a concept helicopter with passenger-hauling capabilities rivaling that of fixed-wing

commercial aircraft. The ability to lift and transport 100 passengers in a helicopter over short and medium distances at speeds more than 150 mph is simple using presently available technology. And it would only be stretching it a little to envision a helicopter capable of hauling as many as 200 passengers.

Military choppers have been hauling larger loads around for years. In fact, Sikorsky's own CH-53E helicopter now used by the Marines (*Super Stallion*) and the Navy (*Sea Dragon*) is capable of hefting loads up to 32,000 pounds. The load requirement for the VLCT, with an average passenger weighing 170 pounds, would be somewhat less than 20,000 pounds, including baggage.

The CH-53E, in fact, is the aircraft Sikorsky would use as the starting point for developing the VLCT. Like its military antecedents, the VLCT would be powered by three turbines, putting out more than 13,000 horsepower. It would also probably use a 7-blade rotor similar to that found on the present military chopper. Items like the landing gear and drivetrain would also swap over.

So if it can be done today, why

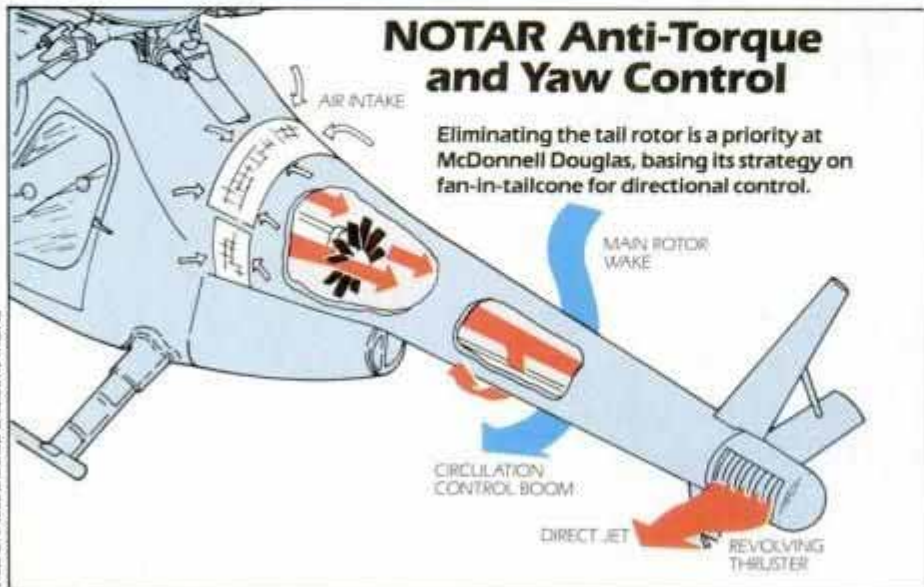


doesn't Sikorsky just go and do it? Because a lot of things have to be in place before the VLCT would be commercially feasible. First, you need the heliports for the VLCTs to fly into and out of (tiltrotor proponents prefer the term vertiports). Then, you would need a whole separate air traffic system—complete with ground navigation aids and control personnel—to get the most benefit out of vertical takeoff aircraft like the VLCT.

The present system, especially around large metropolitan areas like New York, Chicago and Los Angeles, is quickly reaching saturation. Airports are even closer to capacity. New slots are just not available, and the existing ones get gobbled up by current carriers. A lot of those slots are being used for short-haul flights, flights that would be ideal for aircraft like the VLCT.

Conventional fixed-wing aircraft have reached their size limit—about 500 passengers is tops. And whether the airplane is a 747 bound for Tokyo, or a small commuter coming in from 100 miles away, only one aircraft can fit on one runway at a time. Japan has even worse problems. The country's current intercity travel system is overloaded. That is why the Japanese are looking most seriously at a proposal to build a system of 600 heliports, with the possibility of eventually having 3300 of them.

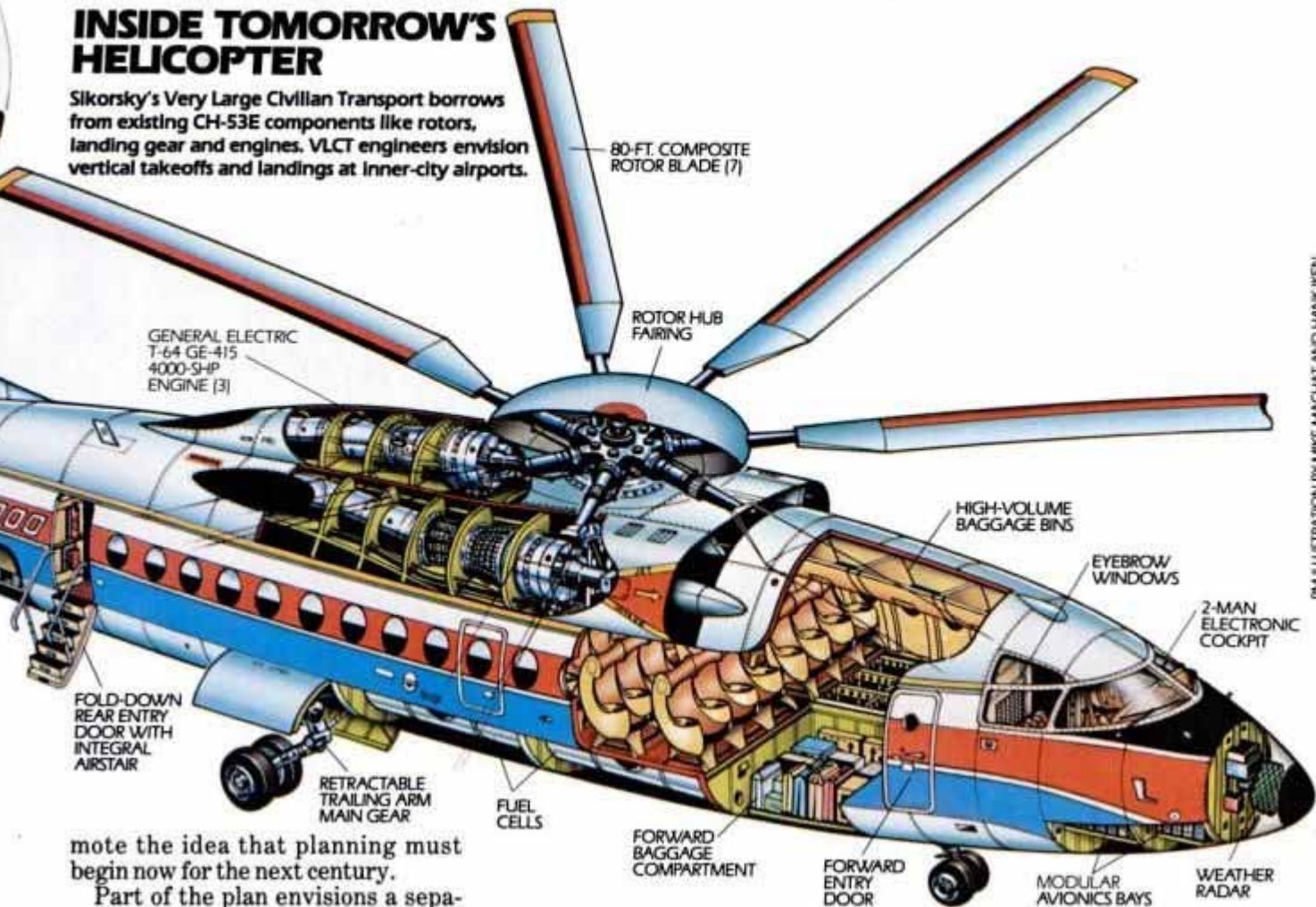
Add to this the fact that more and more people who have never flown before are climbing into commercial airplanes every day, and you have the potential for massive problems popping up around the turn of the century. A separate vertical takeoff system would be a neat solution to the air travel mess the experts forecast. In fact, that's the reason behind Sikorsky's proposal for the VLCT—to pro-



MCDONNELL DOUGLAS ILLUSTRATIONS

INSIDE TOMORROW'S HELICOPTER

Sikorsky's Very Large Civilian Transport borrows from existing CH-53E components like rotors, landing gear and engines. VLCT engineers envision vertical takeoffs and landings at inner-city airports.



PM ILLUSTRATION BY MIKE MACHAT AND HANK IREN

mote the idea that planning must begin now for the next century.

Part of the plan envisions a separate air traffic system just for vertical takeoff machines. Roy Lobosco, who is working on an FAA-funded study on the issue of heliports for the Port Authority of New York and New Jersey, points out that with the new system, helicopters would also be able to fly into and out of airports without conflicting with fixed-wing traffic, adding enormous versatility.

A new VTOL system, as some vertiport visionaries see it, would have aircraft like the VLCT handling trips from 100 to 200 miles. Tiltrotor aircraft, with twice the speed, would handle longer distances, say from 300 to 600 miles.

Key issues

While some may argue that future large-scale VTOL flight remains a distant dream, the basic systems we'll find aboard tomorrow's helicopters are taking shape right now. Military VTOL programs are closely linked to the advancement of civilian VTOL technology in general—technology directly transferable to the VLCT of the future.

For instance, the current program for the development of a new Army helicopter, dubbed LHX, is the main engine driving vertical flight technology at the present time. Two teams—McDonnell Douglas/Bell and

Boeing/Sikorsky—are currently competing to see who will build the \$38 billion worth of new Army helicopters LHX planners envision. This prize, which is supposed to be awarded in December 1990, represents 50 percent of the world's new helicopter

business over the next 20 years.

With a plum this huge ripe for the plucking, you can bet that the two teams are working at full steam to do their best to develop the world's best helicopter. And a lot of what's being

(Please turn to page 102)



Vertiport visionaries also see a future role for a commercial version of the Bell/Boeing V-22 Osprey tiltrotor.

PM ILLUSTRATION BY ED VAUGURSKY

California MUSCLE BOATS

Life begins at 100 mph in a thousand-horsepower, water-borne hot rod.

BY JOE SKORUPA, Boating/Outdoors Editor; PM Photos by Rich Cox

SOUTHERN CALIFORNIA. Birthplace of monster-cube hot rods and technicolor dream machines. And not just the 4-wheeled variety either. SoCal has long been a hotbed of hot boats. In fact, many drag racers who once got their kicks from burning rubber with hot rods switched to scorching water with hot boats. Californian Bob Teague is a good example of this hot-wheels-to-hot-props migration.

"A lot of guys loved hot rods as kids. But things changed in the 1970s," says Teague, who now operates Teague Custom Marine. "The gas crunch was a factor, but even more importantly, we grew up, had families and ended up buying sensible cars. Underneath, of course, we're still the same, so now we're into boats."

The water-rod scene to-

day is dominated by speed machines with trademark low-to-the-water, needle-nose profiles and no pretense of a cuddy cabin. In addition to gleaming engines with huge displacement, the boats are impressive for vivid, multicolor graphics that raise gelcoating to the level of a fine art.

But top priority for any speed freak, Californian or otherwise, is reserved for a scrupulously massaged, radically modified, chromed, polished and anodized Chevy big-block V8.

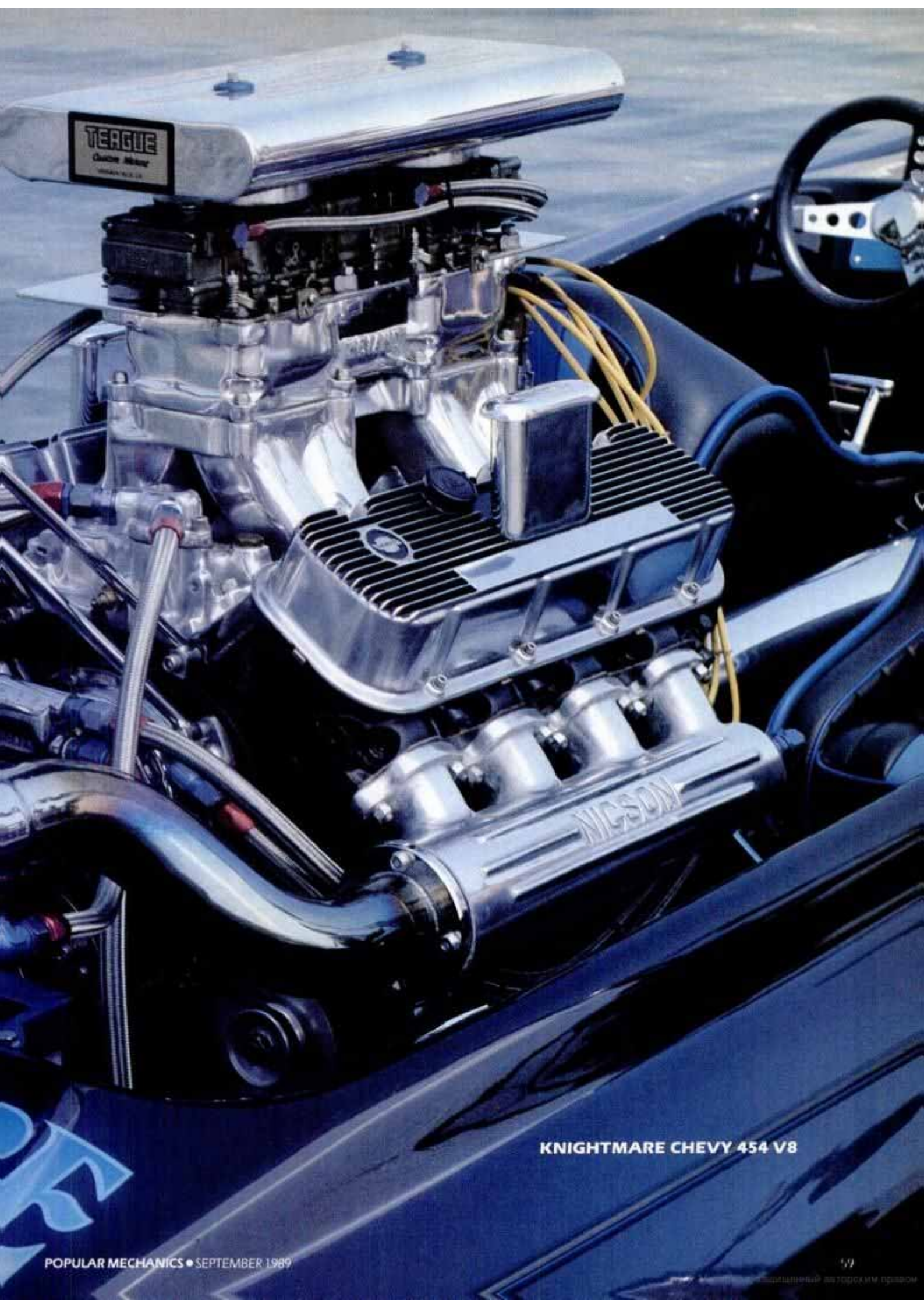
California screamin'

It took Scott Stephens, a magician with a paint gun who runs Scott's Custom Colors in Simi Valley, a full year to

complete his dream machine. With his special talents, he knew the boat would look good. But that wasn't enough. It also had to blister the water. So he contacted ace engine-builder Bob Teague and together they transformed a 19-ft. Spectra semi-V into a 700-horsepower, supercharged screamer called Water Colors.

Starting with the ubiquitous Chevrolet 454 big-block engine, Teague re-





TERGUE
Custom Marine
MILWAUKEE, WIS. U.S.A.

KNIGHTMARE CHEVY 454 V8

California MUSCLE BOATS

packed it with high-performance parts: a Kryptonite crank, Crane cam, valve springs and retainers, Manley valves, TRW pistons, Accel ignition parts, Edelbrock water-cooled exhaust manifolds, Mooneyham intake manifold, Dan Olson oil cooler, and Offenhauser valve cover breathers, to name a few.

The engine breathes through a GMC 6-71 supercharger, reworked by Mert Littlefield, that is belt driven and fed by twin 750-cfm 4-bbl. Holleys. Backing up the engine is a billet flywheel with a Borg-Warner driveplate, a Casale V-drive with 43-percent overdrive, and a GM Turbo Hydra-Matic 400 transmission. Stephens estimates he has 11 grand invested in his boat's drivetrain.

Todd Mielke, of Glendale, knew he was in trouble when a water separator exploded over his newly painted hull. More mishaps followed for three frustrating years and it became obvious that the name of his 19-ft. Hondo was destined to be Knightmare.

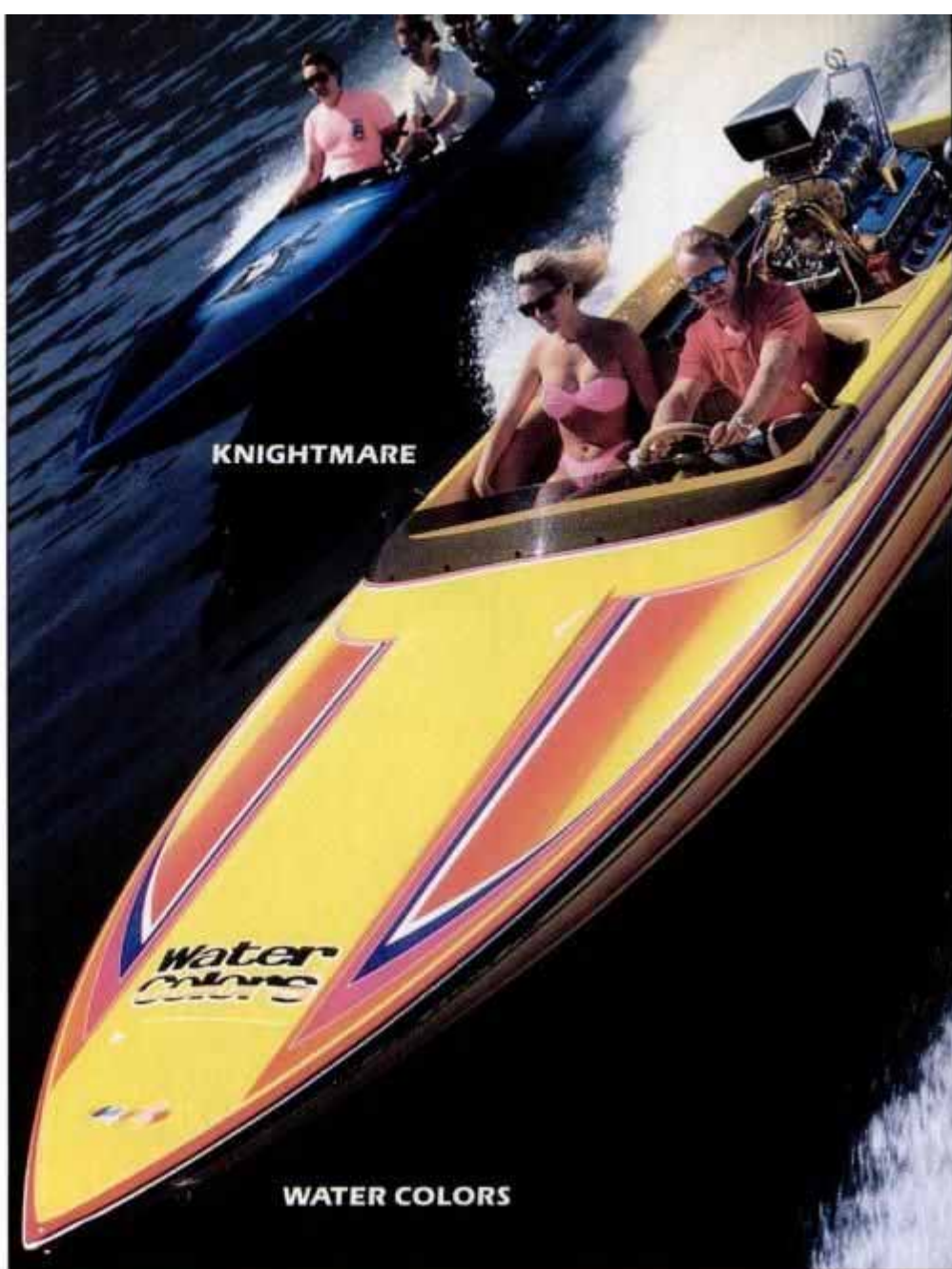
Like Stephens, Mielke called on Teague to do the engine rigging and together they came up with a 475-hp firebreather. Trick hardware on the naturally aspirated engine includes Dan Olson oil cooler, Edelbrock water-cooled exhaust manifolds, Gil exhaust pipes, Crane roller rockers, Norris lifters, billet flywheel and high-performance GM crank, cam, pushrods, springs and valves.

Tunnel-ram induction feeds the twin 4-bbl. 750-cfm Holley carbs while Accel racing parts handle the ignition. In keeping with Knightmare's speedboat approach, there's no transmission beyond the in/out linkage of the Casale V-drive, which has 29-percent overdrive.

Water turbos

If money's no object, the hot engine today is a twin turbo and A.J. Sbarounis wanted one in his Hallet Vector 21 semi-V. Price for the Paul Pfaff modified engine, which achieves 1059 dyno-rated hp is \$34,000.

The bored-out 540 Chevy V8 looks as good as it runs. All lines are braided stainless steel, including those for the bilge. All fittings and the block are anodized blue. And everything else is either polished or chromed. The modified Hallet Vector is outfitted with a pair of 4-bbl. 830-cfm Holley carbs fed by Gentry twin turbos. It delivers power through a Reuben Delgado GM Turbo 400 trans that runs into a Casale heavy-duty split-case V-drive with 50-percent overdrive. To complete the effect, Sbarounis tows the boat on a custom



KNIGHTMARE

WATER COLORS



WATER COLORS

Engine Displacement (cu. in.):	454
Bore x Stroke (in.):	4.25 x 4.00
Horsepower @ rpm:	700 @ 6000 rpm
Induction:	GMC 6-71 blower
Boat:	19-ft. Spectra semi-V
Engine Price:	\$11,000
Complete Boat:	\$30,000
Top Speed:	95 mph

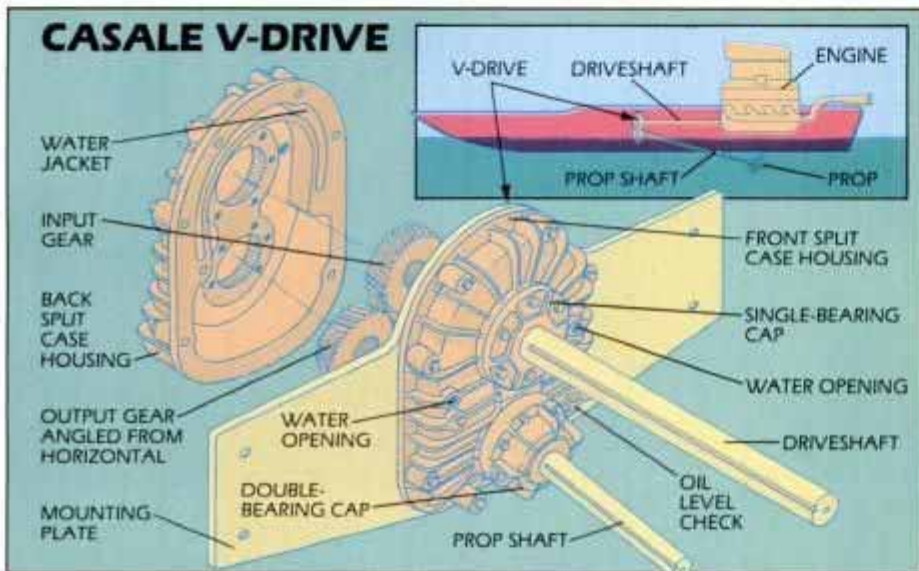
KNIGHTMARE

Engine Displacement (cu. in.):	454
Bore x Stroke (in.):	4.25 x 4.00
Horsepower @ rpm:	475 @ 6000 rpm
Induction:	tunnel ram
Boat:	19-ft. Hondo Sprint flat-bottom
Engine Price:	\$7000
Complete Boat:	\$15,000
Top Speed:	95 mph



NOTHING SHOWING

HALLET VECTOR 21



triple-axle trailer behind a 1989 Chevy Suburban 4x4 painted to match.

When a man's been inducted into the American Power Boat Assn. Hall of Champions and his garage, in Granada Hills, contains heavy-metal milling, sanding, cutting, drilling and deburring machines, plus hundreds of spare parts, you might expect him to drive a mean waterscorcher. Bob Teague doesn't disappoint.

Lift the engine cover on Teague's 21-ft. Schiada semi-V, called Nothing Showing, and you'll find one of the slickest powerplants in Southern California. Teague's perfectionism extends to X-raying and polishing valves, panagraphing head gaskets, anodizing 600 parts and hand-fabricating billet hardware.

Teague put his unique stamp on a twin-carb (4-bbl. 830-cfm Holleys), twin-turbo installation that beats the heat with an intercooler. He uses a Dan Olson oil cooler, Gentry exhaust manifolds, Patterson water-jacketed exhaust pipes, Imco watercooled turbine housing, Kryptonite crank, Manley valves, Engle cams, Norris lifters, Smith Bros. pushrods, Crane roller rocker arms, Can Am springs and retainers, TRW pistons, billet flywheel with Borg-Warner drive plate and Offenhauser valve-cover breathers. His Casale heavy-duty, split-case V-drive is set for 27-percent overdrive and gets power from an Art Carr-modified GM Turbo 400 transmission.

Teague took us for a 90-mph ride in his \$77,000 water rocket and demonstrated how the hull can turn on a dime, with the aid of ski fins fitted to the keel. In fact, we scorched the water in all four during a dawn-to-dusk day on Lake Perris, proving that these muscle machines are anything but hangar queens. As the song says, "Baby, they were born to run." **PM**



HALLET VECTOR 21

Engine Displacement (cu. in.): 540
 Bore x Stroke (in.): 4.50 x 4.25
 Horsepower @ rpm: 1059 @ 5500 rpm
 Induction: intercooled Gentry turbos
 Boat: 21-ft. Hallet Vector semi-V
 Engine Price: \$34,000
 Complete Boat: \$63,000
 Top Speed: 105 mph



NOTHING SHOWING

Engine Displacement (cu. in.): 468
 Bore x Stroke (in.): 4.31 x 4.00
 Horsepower @ rpm: 970 @ 6200 rpm
 Induction: intercooled Gentry turbos
 Boat: 21-ft. Schiada semi-V
 Engine Price: \$25,000
 Complete Boat: \$77,000
 Top Speed: 105 mph

LONG HAULERS

PM's long-term test fleet takes on some new faces—and new duties.

ONE OF THE MOST persistent questions we're asked—in the mail and on the PM Hotlines—is whether a high-performance car with a big V8 engine is still practical for everyday use. It's a question we can answer once and for all with the latest long-term test car in the PM stable.

Pontiac Trans Am GTA

The GTA is one of the fastest cars produced in America. Its big (350-cu.-in.) engine is rated at 235 hp and 330 lb.-ft. of torque, essentially the same engine you get in a Chevrolet Corvette. The Trans Am breathes through tuned aluminum ram tubes, dual exhausts and is fed by direct port injection. Backing up the engine is a 4-speed automatic transmission and a 3.27 rear axle with limited-slip differential.

That's a lot of hardware. When you put it all on the pavement, you're rewarded with a 0-60 time of just 6.5 seconds. Our testing at Raceway Park in Englishtown, New Jersey, resulted in a best quarter mile of 14.78 seconds at 95 mph.

As we said, this is one of the fastest cars you can buy. But can you live with such a beast over the long haul? That's what we'll be finding out as we use the GTA in normal daily service. So far, we can tell you that the GTA's

interior is extremely comfortable for a low, sporty car—providing you're one of the front-seat passengers.

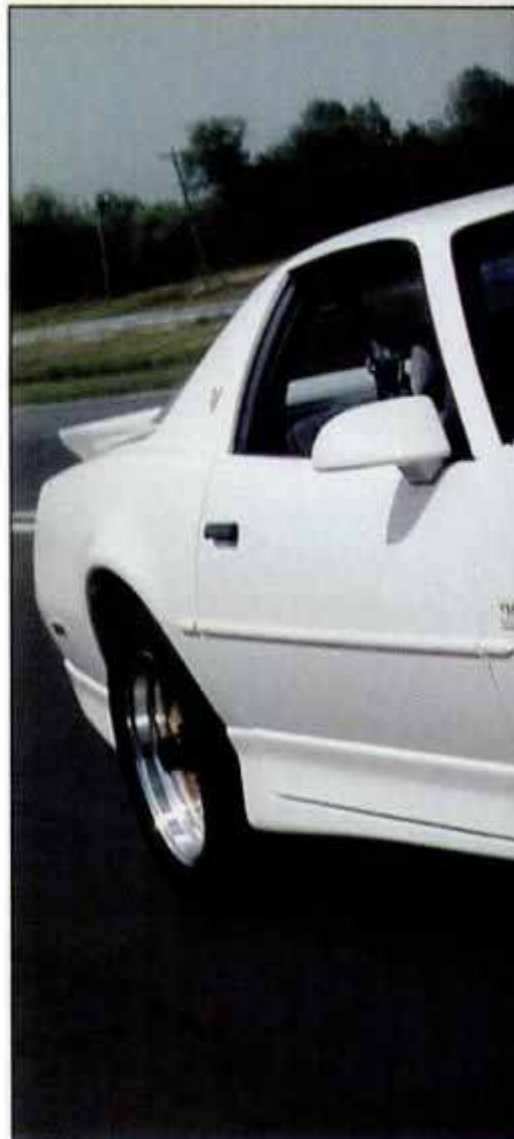
All controls are well marked, and as easy to use as those in any family sedan. In fact, this test car has steering wheel-mounted radio controls, which sounds gimmicky, but they're actually easier to use than the controls on the radio itself.

Driving the Trans Am GTA can be a real pleasure if you're a hard driver. Or it can be no more taxing than a drive around the block in a Pontiac 6000 sedan. The GTA's personality all depends on how much pressure you apply with your right foot. With a light foot, it's a docile pussycat. But punch your right foot down hard and the GTA turns into a snarling, shrieking beast, capable of devouring anything you're likely to meet.

We eagerly look forward to these encounters. —Joe Oldham

Ford Thunderbird Super Coupe

The Super Coupe differs from its lesser T-Bird nestmates by the presence of a positive-displacement supercharger bolted to the front end of its 3.8-liter V6 engine. This adds up to a 70-hp edge over the normally aspirated editions of the Thunderbird, 210 hp versus 140, as well as a number



of accompanying chassis upgrades, making the Super Coupe the most interesting entry in the hottest new car line to emerge from Detroit for the 1989 model year.

Besides the supercharged, inter-cooled engine, standard equipment includes speed-sensitive variable-assist power rack-and-pinion steering, automatically variable shock damping, limited-slip 2.73:1 rear axle, higher spring rates, front and rear antiroll bars, 4-wheel disc brakes with antilock and 225/60VR Goodyear GT+4 tires on 16-in. cast-alloy wheels.

It sounds like the sort of equipment inventory you'd expect on a real driver's car, and that's what the Super Coupe is—luxurious, but also more than capable of holding its own on a mountain road. And even though the curb weight is high at 3542 pounds, the SC's massive torque output—315 lb.-ft. at 2600 rpm—provides remarkable get up and go.

Our Super Coupe was handed over at Manhattan Ford with exactly 6 miles on the odometer, and we've run up an additional 2915 miles since then, most of them in the New York metro-



FORD THUNDERBIRD SUPER COUPE



PONTIAC TRANS AM GTA

politan area. They've been mostly trouble-free miles, although quite recently, the ABS system quit. The basic brake system functions, of course, but in wet weather we miss the security of ABS. We'll detail the problem once we've had the car in for service and get a diagnosis.

We've also recorded a couple of quirks. Engine vibrations drew comments from several drivers when we first got the car. At low speeds, there's more than a little shakin' goin' on under the hood. However, we've found that this is one of those things that becomes subliminal with familiarity, and the engine's midrange performance and response is nothing short of excellent.

It's not as easy to ignore the other quirk, which is exceptionally high clutch pedal effort, which makes stop-and-go driving a real chore.

With an EPA city cycle economy rating of 17 mpg, we didn't expect the Super Coupe to deliver much in the way of fuel mileage, and this expectation proved out. Our best tankful was almost 21 mpg, the worst 15.5, and our average to date is 18 mpg even.

Quirks and thirst notwithstanding, though, our initial impression of the Super Coupe is very positive. It's a well-made car that's rewarding to drive, and also a piece of rolling sculpture that turns heads wherever it goes.

—Tony Swan

Pontiac 6000 STE AWD

First the bad news: Pontiac isn't going to be producing any of these in the 1990 model year. The 3000 or so '89s that Pontiac did make were proof-of-

concept for the GM corporate AWD drivetrain components, and other vehicles in the GM lineup will receive the benefits next year.

Meanwhile, we continue to enjoy ours, although with the onset of warm weather the AWD system is really just dead weight. Really powerful fwd cars can benefit from AWD, but the 3.1-liter V6's 140 hp doesn't even come close to overpowering the front tires' grip on dry pavement.

The 6000 continues to get a disap-



PONTIAC 6000 STE AWD

LONG HAULERS



WINNEBAGO CHIEFTAN

pointing 16 mpg in commuting service, and about 18 on the freeway. Aside from the power steering leak we mentioned in our last long-term report, there have been no other mechanical problems of any sort with this Pontiac.

—Mike Allen

Winnebago Chieftan

Motorhomes and Manhattan are mutually exclusive, unless you're particularly fond of suffering—which explains why we rarely have an opportunity to live with one of these rolling residences. However, the 1989 PM Racing schedule gave us the perfect forum for a long-term evaluation of a motorhome. After all, one of the keys to extracting fun from endurance racing is having someplace to hang out while the enduring is in progress, and for us that means a 27-ft. Winnebago Chieftan.

Although there are much bigger units on the market, this size suits us just fine, with sleeping accommodations for four or five. Amenities include a shower, a head, a sink, a 4-burner gas stove, microwave, AM/FM/cassette sound system, auxiliary generator, retractable stairs and an air-conditioning system that's better than at least two-thirds of the apartments in New York City.

From a design point of view, the most impressive thing about the Chieftan is its storage capacity. There are lockers, bins and cupboards all over the place, inside and out. There's also quite a handful of keys, three of them indistinguishable, for the exterior lockers, and the locks are ex-

tremely balky. But this irritation aside, we're satisfied that very little opportunity to create storage space has been overlooked.

Assessed as a road-going vehicle, the Chieftan has been a pleasant surprise so far. True, its large frontal area and slab sides make it tend to be lively in breezy weather, but its handling is competent in most other respects, and inspires confidence once the driver is acclimated.

The Chieftan's substantial muscle helps the driveability impression a lot. GM's 454-cu.-in. V8 supplies the grunt—350 hp—which is enough to give 6000 pounds of motorhome a comfortable cruising speed of 60 to 70 mph. The Chieftan flattens hills like a passenger car, and is perfectly capable of towing.

Fuel economy is about what you'd expect of a rig like this—we've recorded an average of 10.2 mpg so far

—but the 45-gallon tank provides plenty of range.

As delivered, our Chieftan carried a window sticker of \$52,000. That's a hefty chunk of change for a recreational vehicle—but so far our impression is that in this application, you get a lot for your money.

—Tony Swan

Ford Club Wagon XLT

It's true—there's no substitute for cubic inches, especially when you're trying to tow a big load. Ford was anxious to show us its new 460-cu.-in. fuel-injected V8 engine, since injection is something new in the behemoth-displacement category. We figured—correctly—it would be just the ticket for towing the PM Racing Mustang.

Ford's big vans haven't changed much in years, and the design is be-

(Please turn to page 99)



FORD CLUB WAGON XLT

12 TOOLS FOR FIXING YOUR EIGHTIES CAR

No, you don't need a computer to fix the new cars.

BY MIKE ALLEN, Assistant Automotive Editor

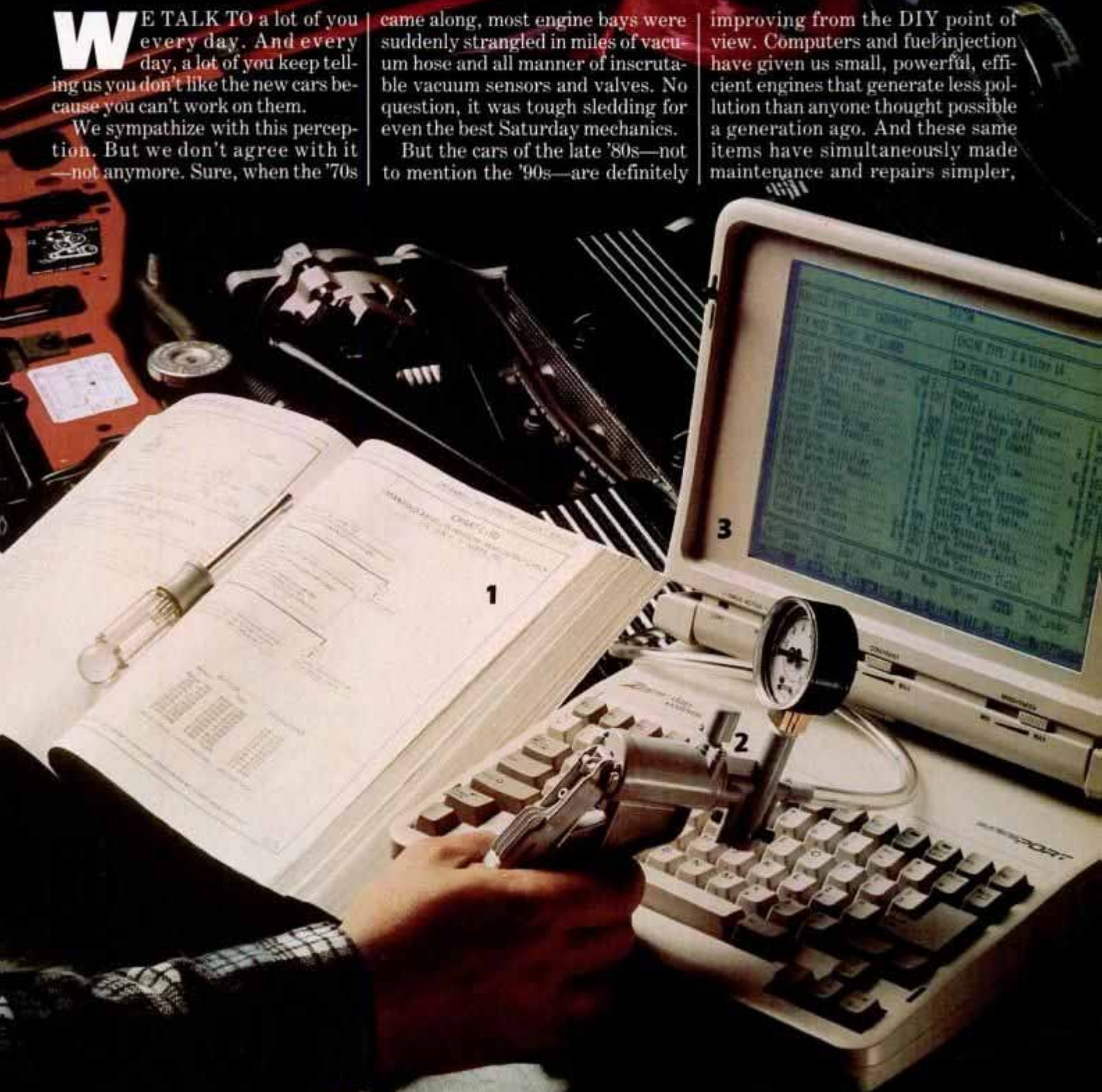
WE TALK TO a lot of you every day. And every day, a lot of you keep telling us you don't like the new cars because you can't work on them.

We sympathize with this perception. But we don't agree with it—not anymore. Sure, when the '70s

came along, most engine bays were suddenly strangled in miles of vacuum hose and all manner of inscrutable vacuum sensors and valves. No question, it was tough sledding for even the best Saturday mechanics.

But the cars of the late '80s—not to mention the '90s—are definitely

improving from the DIY point of view. Computers and fuel injection have given us small, powerful, efficient engines that generate less pollution than anyone thought possible a generation ago. And these same items have simultaneously made maintenance and repairs simpler,



12 TOOLS FOR FIXING YOUR '80s CAR



4



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by reducing component count, opening up crowded engine compartments and lengthening maintenance intervals. On-board diagnostics make fuel-injection troubleshooting possible without sophisticated tools.

But, you'll need the proper tools. You won't have to replace all of the tools you've always had and you don't have to buy all the new ones today, but here's a selection of things that will make working on today's cars either simpler or possible.

1. Documentation—Don't even *think* of troubleshooting your new car without getting the factory-authorized version of the truth. It used to be that a carburetor was a carburetor, and all you needed was a screwdriver. But today's engine-management systems are different from manufacturer to manufacturer, engine to engine and year to year. Go to the dealer, get the factory shop manual for your car.

2. Vacuum gauge/pump—Engine management systems rely on intake manifold vacuum-driven sensors for information. Troubleshooting those

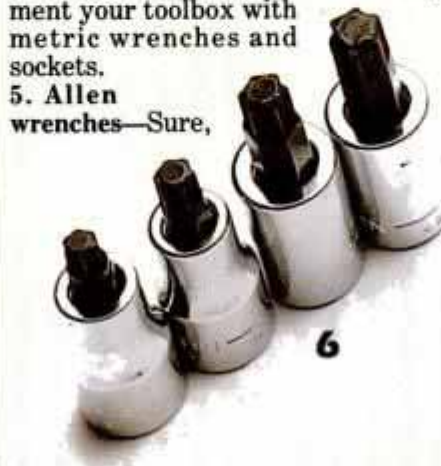


sensors requires a source of vacuum. There are several on the market, but this plastic-bodied version of the professional Mi-ty-vac is more than adequate for occasional use.

3. Software—Yes, you *can* troubleshoot your fuel-injection system with nothing more than a bent paper clip. But Diacom software from Rinda Technologies will let you plug your PC directly into your car's computer, monitoring 80 or more variables while the car is running. It even has a "snapshot" data capture mode, trapping the last 15 to 30 seconds of engine operation. This lets you back up a few seconds, and figure just where that stumble or surge originated, *after* you've pulled to the side of the road. This is admittedly a very sophisticated tool, but the next step up is a dedicated scanner tool intended for pros, and one of those will set you back considerably more than Diacom's \$299.

4. Metric wrenches—Even England has converted to the metric system. And don't look now, but so has Detroit. Everything new since the late '70s is metric. So, you'll need to augment your toolbox with metric wrenches and sockets.

5. Allen wrenches—Sure,



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everybody's got a set of Allen wrenches for tightening setscrews, but modern cars are using a lot of high-strength fasteners on things like cylinder head studs and CV joints—and they're often Allen-headed. You'll need, obviously, a metric set.

6. Torx—Those funny 6-point fasteners that none of your Allen wrenches will fit properly are called Torx. You'll need them for a variety of bolts that hold on items like headlights, seat tracks and interior panels. In the smaller sizes you might prefer the screwdriver-handled versions.

7. Torque wrench—Overkill engineering is a thing of the past. Cast-iron engines and transmissions are being replaced with aluminum. And as a

consequence, proper torquing of critical fasteners can't be done anymore without a torque wrench. This digital model from Craftsman is a luxury edition, capable of handling English and metric, though it may be more than you need. For most jobs, a simple \$15 beam-and-pointer type will suffice, and won't ever break or go out of calibration.

8. Fuel-pressure gauge—Fuel pressures on fuel-injected engines vary from 8 to 80 psi (depending on the vehicle), so you'll need a gauge capable of accurate readings in the appropriate range, and fittings to mate it with the vehicle's fuel system.

9. Spark tester—The time-honored tradition of holding a plug wire next to the block looking for a spark jumping the gap can have an unpleasant downside in today's cars. It can damage an expensive ignition box. Use this OTC tester instead, clipping it onto a convenient metal object in the engine compartment, and running the plug wire to it. Doing ignition testing this way also eliminates the possibility of running 40,000 volts up your arm.

10. Noid-Light—Here's another tool for troubleshooting the wet side of a no-start vehicle. Just unplug the harness from the fuel injector, and plug in the noid-light. Crank the engine, and if the noid-light flashes, then the injector is pulsing on and off—which means the f.i. computer is operating, and the cause lies elsewhere.

11. High-impedance meter—Digital electronics are too sensitive for old-fashioned voltmeters. Accordingly, the new generation of high-imped-



ance meters are usually digital, though not always. If you really prefer a swinging needle, there are high-impedance models available.

12. Metric taps and dies—With aluminum's tendency to gall and strip threads, you'll want a set of metric taps and dies, especially if you work on your car over the weekend, when auto parts stores are closed.

Where to find them

With the exception of the Diacom computer software, any of these tools can be found either at your nearest auto parts store, a Sears or even in the auto department at department stores. Try asking the counterperson at an auto parts store anytime you've got a problem that a special tool might solve. For Diacom, call (800) 888-4146; (312) 595-4146 in Illinois. **PM**

HURRICANE HUNTERS



Planes, satellites and high-speed computers join forces to stalk the storms that lash our coasts.

BY HANK BRANDLI; PM Illustration by Jeff Mangiat

ON A TYPICAL DAY in a typical week during hurricane season, you'll find Lt. Col. Paul McVikar of the 53rd Weather Reconnaissance Squadron strapped to a bucking Lockheed WC-130 Hercules, engaged in the perilous but vital exercise of hunting hurricanes. McVikar—joined by navigator, engineer, meteorologist and dropsonde loadmaster—flies out of Keesler Air Force Base, Mississippi, directly into the beating heart of the world's most severe tropical depressions. His team takes the pulse of these enormous bundles of destructive energy as they flail the Atlantic and threaten our coastlines.

McVikar's bird is part of an elaborate system of airplanes, satellites, meteorology buoys, ground stations

and high-speed computers operated by the National Oceanic and Atmospheric Administration's National Hurricane Center in Coral Gables, Florida. In concert with NOAA's pair of 4-engine P-3 Orions, McVikar and company monitor barometric pressure, wind speed, temperature, sea state and other critical factors, sending real-time data to weather forecasters and disaster preparation teams via the Air Force satellite communications net.

What's it like to fly in the belly of this altogether malignant beast? Listen from the cockpit:

"The turbulence ranges from a few bumps to a severe thrashing," says McVikar. "We try to reduce the effects by reducing our speed to 65 knots above stall. The most severe storms are usually located in an area 5- to 7-



NOAA P-3 Orion plunges into heavy weather, carrying radars on belly and tail, and a boom-mounted gust sensor up front. Wingtip devices measure cloud particles. In the background, an Air Force WC-130 releases a parachuted dropsonde to take the storm's temperature profile. A Soviet Meteor 2 satellite (top left) looks down from orbit. Flanking it, a NOAA geosynchronous operational environment craft transmits pictures. At NOAA's National Hurricane Center, a satellite dish captures data from orbit, and an enclosed Doppler radar probes the storm. Out at sea, a weather buoy gathers data on surface conditions.

HURRICANE HUNTERS



Clockwise from upper left: WC-130 flight deck, a satellite view of hurricane Gilbert, digitized satellite images at the National Hurricane Center, and 3-D computerized-imaging forecasting of the future.

miles thick right near the wall of the eye. It's phenomenal when you pop out into the open. You go from pitch darkness to beautiful daylight in an instant."

High-tech

So much for the human side of hurricane hunting. But McVikar and crew are hardly alone in this task of probing the inner world of intense storms. Satellites are assuming a greater role in the science of detecting and tracking these potential killers. No two hurricanes are exactly alike, and therefore, the size, characteristics, severity and centers vary, not only from storm to storm, but from geographic area to geographic area. Satellite photos can show the severity, size and exact location of approaching hurricanes.

Last summer, high-resolution images from Defense Meteorological Satellite Program (DMSP) and NOAA weather satellites tracking hurricane Gilbert revealed small vortices inside Gilbert's eye, but more importantly, showed the shrinking of the eye as the surface winds intensified to over 200 miles an hour. Gilbert turned out to be the most powerful hurricane in history.

Satellite photos see whirling clouds on storm tops spiraling out in an opposite direction to the inflow. But, more importantly, the newest polar-orbiting satellites see inside the hurricane itself—surface winds, wave heights, the structure of the eye, tops of clouds and even rainfall.

Armies of the sky

Every day and night, meteorological spacecraft of the United States, U.S.S.R., Japan, China, India and the European Space Agency (ESA) transmit imagery of our entire planet and its atmosphere—taken mostly at visible and infrared (thermal) wavelengths—to ground stations. Some of these space vehicles carry additional sensors to detect water vapor, soil moisture, wave height, rainfall, ozone, lightning, pollution, energy waste, auroras and even whether the ground is covered with ice or snow.

Around the clock, polar-orbiting meteorological satellites launched by the United States, China and U.S.S.R., take images of every area on Earth. These satellites circle the globe at altitudes ranging from 400 to 600 miles high, passing over the Earth every 100 minutes or so, ceaselessly taking pictures with resolutions of approximately 1½ miles.

The Department of Defense's military meteorological satellite is the only weather spacecraft that can make observations at night in the visual mode. Moonlit clouds, city lights, erupting volcanoes, lightning, meteors, fires, oil and gas field burnoffs, as well as the aurora borealis and aurora australis can be captured by this polar-orbiting vehicle's low-light sensor.

In June 1987, a third type of sensor on DMSP became available to provide microwave imaging capability. It is currently flying on one of two DMSP satellites in orbit, but will be installed

on all future DMSPs. Unlike an infrared radiometer, the new microwave sensor can gather information on the Earth's surface through cloud cover. It can produce an image of the eye that visible and infrared data cannot create. In fact, the sensor can plot ocean surface roughness and surface wind speed from thermal energy emitted by the Earth and atmosphere. DMSP can do this over a wide area, unlike the data collected during aircraft surveillance missions. Microwave imagery also provides land surface moisture, integrated water vapor content, rain, snow, ice and cloud water content.

Unlike their polar-orbiting cousins, geostationary weather satellites orbit the Earth above the equator at an altitude of 22,000 miles. These vehicles remain stationary with respect to the Earth's rotation, photographing one-sixth of the globe continuously. The Earth's curvature makes viewing from geostationary satellites very poor compared to polar-orbiting shots. Two geostationary satellites (GOES and METEOSAT) have water vapor or moisture sensors to complement other imagery. First developed by NASA, these images are ideal for observing upper level wind-flow patterns and cloud formation.

On board all the latest polar-orbiting and geostationary meteorological spacecraft are vertical temperature profile radiometers that can measure temperatures through clouds. This ability provides worldwide weather-

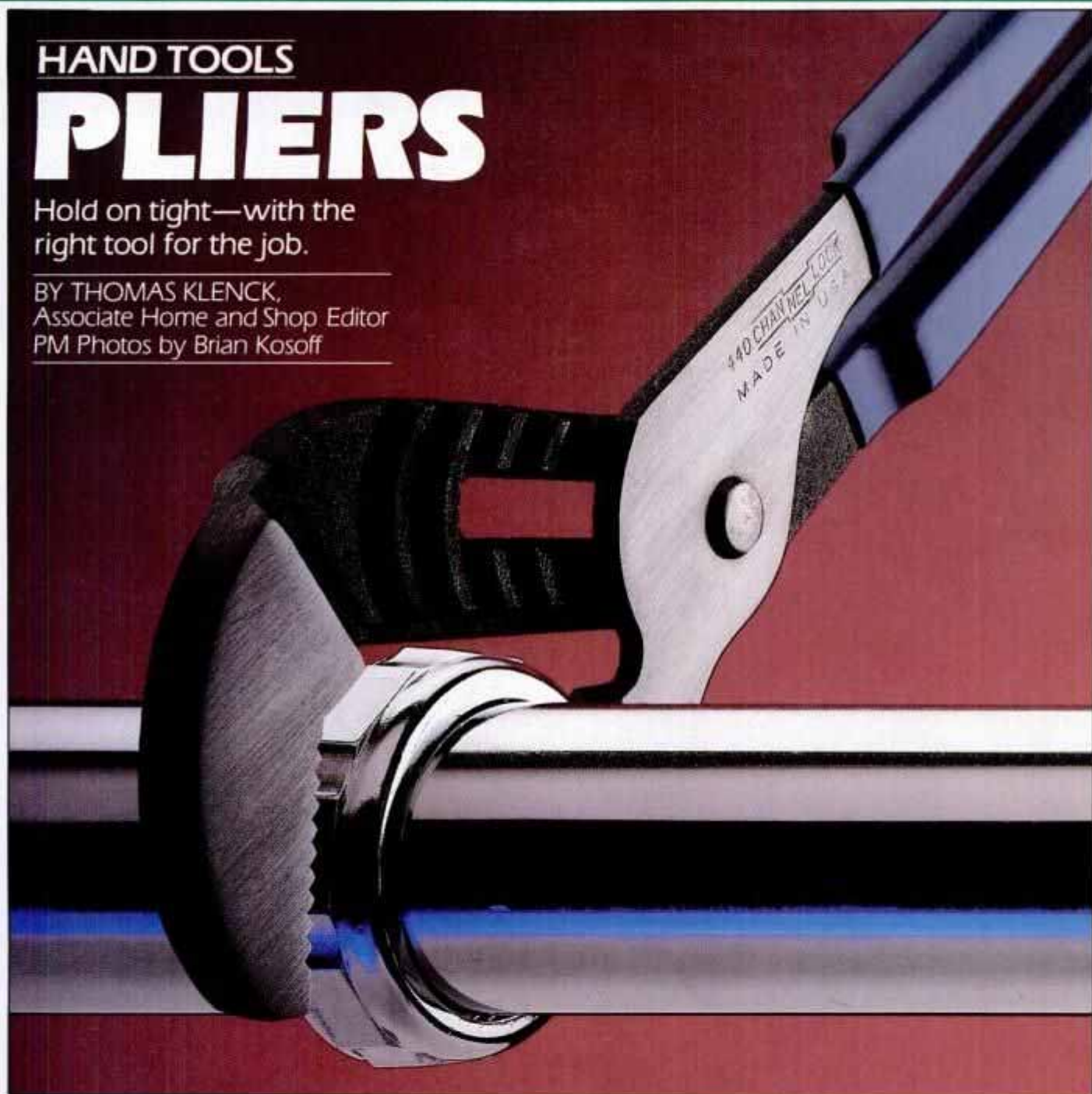
(Please turn to page 101)

HAND TOOLS

PLIERS

Hold on tight—with the right tool for the job.

BY THOMAS KLENCK,
Associate Home and Shop Editor
PM Photos by Brian Kosoff



NEXT TO the hammer, there's one tool that can be found in virtually every household and shop across the nation—a pair of pliers. Why? Because they're literally an extension of our most basic, built-in equipment for manipulating the world around us—our hands.

Gripping pliers come in a wide variety of jaw designs each suited to a particular job. Short jaws are the choice for power, and are usually connected

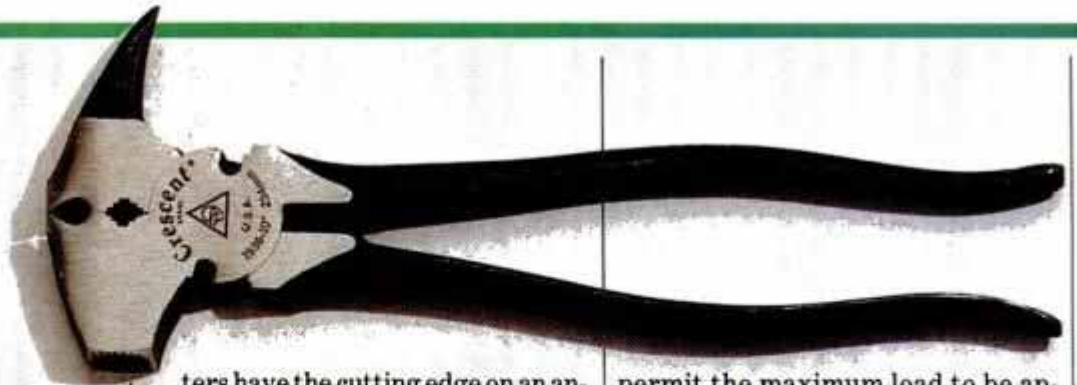
at a heavy-duty boxed joint to stand up to bending and twisting loads. Longer-jaw tools sacrifice gripping force to get into tight spaces. Jaw faces can be toothed to prevent slipping, or plain for a mar-free grip. Straight or curved jaw faces are available to suit the shape of the work.

Cutting pliers are designed primarily for wire cutting and typically have short jaws for maximum leverage. On most cutting pliers, the knife edges

are beveled from both sides to create a V shape. On other cutters, the outside face of each edge is straight for flush cutting. Although flush cutting may be an advantage in certain applications, this edge won't hold up as well as the regular V profile. Cutting pliers are available as end nippers—where the cutting edge is at the end and at right angles to the tool—and side cutters where the cutting edge is on the side of the jaws. Diagonal cut-



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ters have the cutting edge on an angled side face. While many pliers are designed solely for cutting, some types incorporate both gripping and cutting features. Common slip-joint pliers have a shearing cutter.

Pliers designed for electrical work may be available with an insulating, dielectric coating on the handles as a safeguard against shock. However, the first step in electrical work is always to shut off the power—the handle insulation is only there for an added measure of safety. Most pliers with coated handles don't offer this protection—the coating is for comfort only.

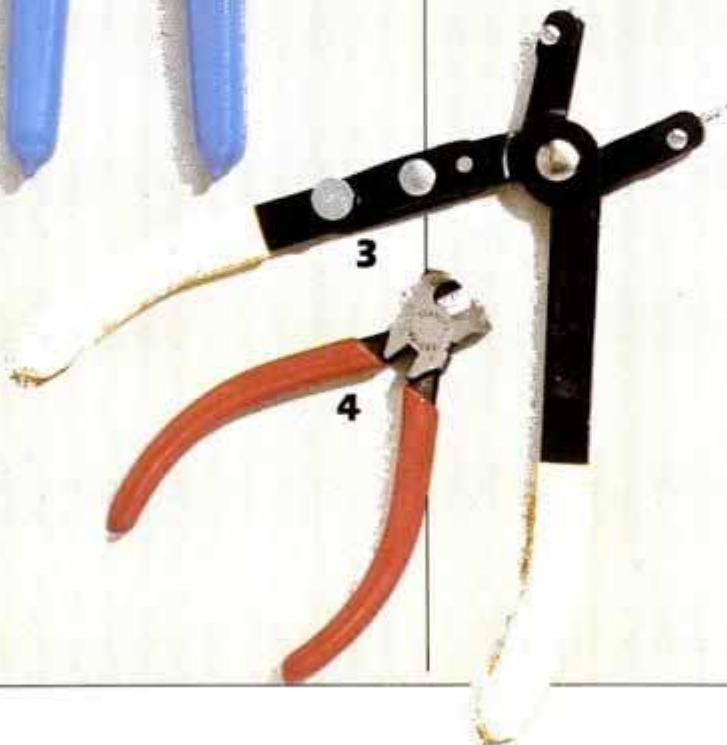
For most gripping or wire-cutting jobs, there's a unique pair of pliers designed to handle the situation. The following survey includes many of the basic types and a few of the more specialized tools available.

1. Large end nippers—The long handles of this 14-in. tool are designed for maximum leverage to create all the power you'll need when cutting through nails, small spikes and heavy wire. It features drop-forged construction, polished head and plastic-sheathed handles for comfort. Two small stops between the handles

permit the maximum load to be applied while protecting the cutting edges from being damaged. Made by Channellock, the tool costs about \$19.50 and is also available in a 10-in. size. Contact Channellock, Inc., Box 519, Meadville, PA 16335.

2. Heavy-duty fence tool—When you take off to repair the fences around the back forty, you don't want to lug your toolbox around—not when you can do just about everything with one tool. This pair of pliers features a corrugated hammer head for driving staples and a massive single prong on the other side for removing them. Around the joint are two hardened wire cutters. The toothed jaws between the handles are designed for holding the fence wire as it's pulled taut. The nose of the tool incorporates a slot that extends across the jaw opening. This permits grabbing on to both the staple and the wire at the same time. The tool is offered with either plastic-sheathed or plain handles, and costs about \$20 as shown. For more information, write to Cooper Tools, Box 728, Apex, NC 27502.

3. Snap-ring pliers—Many manufacturers offer one specific snap-ring pliers for



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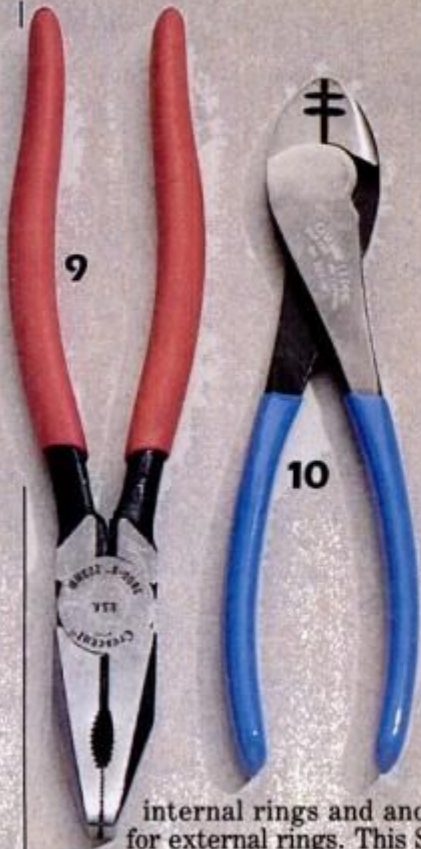
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internal rings and another for external rings. This Sears model is designed to perform both jobs. As shown, the pliers are configured for internal rings. Simply insert the pin ends into the ring holes and squeeze the handles to compress and release the ring from its groove. By disengaging a small arm on one handle and connecting it to the other handle, the pliers work in reverse for removing external rings. The tool comes with an assortment of pins for different size snap-ring holes and costs about \$9. Contact Sears, Sears Tower, Dept 703-PM, Chicago, IL 60684.

4. Small end nippers—If those large end nippers seem a little out of scale in relation to your needs, perhaps this 4-in. model will do the job. Although end nippers generally don't have the cutting capacity of comparably sized side cutters, they're indispensable when working in confined spaces. This Stanley model costs about \$8. Contact Stanley Tools, Division of Stanley Works, 600 Myrtle St., New Britain, CT 06050.

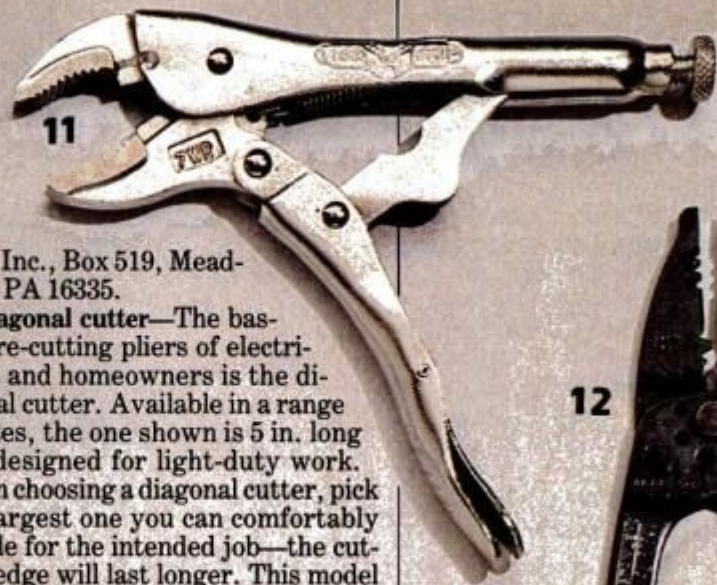
5. Round-nose pliers—Here's a pair of pliers that's expressly designed for looping, coiling and forming fine wire. Its completely round jaws are not designed for gripping tightly, but rather for holding the wire gently while it's shaped. At 4½ in. long, it's just the right size for fine electronics work. This model features plastic cushioned grips and costs about \$13.75. For more information, write Channel-

lock, Inc., Box 519, Meadville, PA 16335.

6. Diagonal cutter—The basic wire-cutting pliers of electricians and homeowners is the diagonal cutter. Available in a range of sizes, the one shown is 5 in. long and designed for light-duty work. When choosing a diagonal cutter, pick the largest one you can comfortably handle for the intended job—the cutting edge will last longer. This model is manufactured by Channellock and costs about \$13.50. Contact Channellock, Inc., Box 519, Meadville, PA 16335.

7. Extra-thin long needle-nose pliers—This tool is truly an extension of your fingers. Its long needle nose (nearly as long as the handles) makes it easy to apply gentle pressure when positioning and holding small pieces in confined spaces. This model features textured jaws for a slip-free grip. Long-nose pliers are available in a range of jaw lengths and shape variations such as flat-nose and duck-bill pliers. Some styles are offered with side-cutting capacity. For fine cutting in tight areas, needle-nose pliers are offered with the cutting edge at the tip. This 6-in.-long model without cutter is about \$17. Contact Cooper Tools, Box 728, Apex, NC 27502.

8. Curved needle-nose pliers—Curved- or bent-nose pliers may not seem like a necessity for the average toolbox, but you'll only need them once to realize their worth. The pair shown is 6 in. long and the jaw extends up about 1¼ in. This model costs about \$18. For more information, contact Cooper Tools, Box 728, Apex, NC 27502.



9. Universal lineman's pliers—

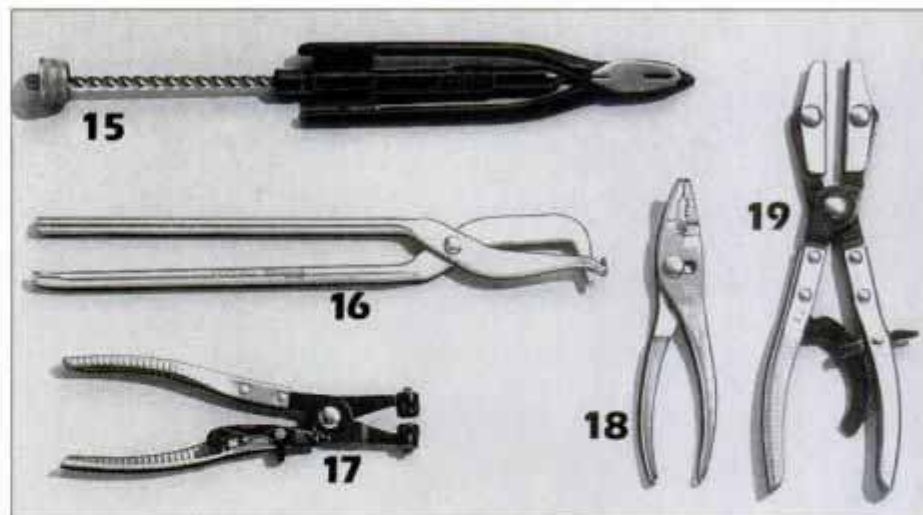
Lineman's pliers are characterized by their massive square jaws and heavy-duty construction. These tools have flat-tipped jaws with serrated faces for maximum gripping and side cutters suitable for a wide variety of wire. The heavily constructed joint makes this type ideal for bending and twisting work. The Crescent universal lineman's pliers shown also feature a rounded, toothed area behind the tip for holding round stock. This 8 $\frac{3}{8}$ -in.-long model costs about \$22. It's also available in a 6 $\frac{1}{4}$ - and 7 $\frac{1}{4}$ -in. size. Contact Cooper Tools, Box 728, Apex, NC 27502.

10. Wiring pliers—Electricians who do a lot of wire cutting and stripping can benefit from this tool. Basically a lap-joint wire cutter, it also features accurately ground notches for stripping two common sizes of wire—12 and 14 gauge. These wiring pliers (about \$16.50) are 7 in. long and have plastic comfort grips. For more information, write Channellock, Inc., Box 519, Meadville, PA 16335.

11. Locking pliers—Actually a hybrid between conventional pliers and a clamp, this tool is almost in a category by itself. Because it clamps onto the work, hand pressure normally applied to the handles is no longer necessary. A knurled knob at the handle end adjusts the jaw opening to the desired clamping pressure and a small lever inside the lower handle quickly disengages the tool. Locking pliers come in a variety of jaw designs including long, narrow jaws and straight jaws. The Vise-Grip model shown has a curved, toothed section for gripping irregular shapes and a wire cutter. Available in a range of sizes from 4 $\frac{1}{2}$ to 10 in. long, this 7-in. model costs about \$11. Contact American Tool Companies, Inc., 301 S. 13 St., Suite 600, Lincoln, NE 68508.

12. Electrical pliers—These light-duty pliers offer a host of features in one handy tool. Just below the finely serrated gripping end are a series of wire-stripping notches for 12-, 14- and 16-gauge wire. Next comes a knife edge for wire cutting followed by a crimper for splicing caps and terminals. Surrounding the central pivot are threaded holes for shearing five different small bolt sizes. Made by Stanley, this 5-in-1 tool sells for about \$15. Write to Stanley Tools, Division of Stanley Works, 600 Myrtle St., New Britain, CT 06050.

13. & 14. Tongue-and-groove pliers—For the ultimate in jaw capacity, nothing matches these pliers. The



jaws can be locked in one of several positions to suit the size of the work. The inside face of one of the tool halves has a series of grooves and the other half has a single tongue. By opening the pliers to their limit, the tongue disengages from the groove, the jaw opening size is adjusted and the tongue can be engaged in a different groove. The 12-in. model shown (about \$13) features seven positions that vary the opening from $\frac{1}{2}$ to 2 in. when the jaws are parallel. For small work, the 4 $\frac{1}{4}$ -in.-long model (about \$10) has three positions that range from $\frac{1}{8}$ to $\frac{1}{2}$ in. Tongue-and-groove pliers are available in a variety of jaw profiles. For more information, contact Channellock, Inc., Box 519, Meadville, PA 16335.

15. Wire-twisting pliers—These pliers are designed to easily and consistently twist wire that is used in safety wiring—where wire is passed through a hole in a nut or bolt head, twisted and secured to protect against loosening. Simply clamp the ends of the wires in the jaws by gripping the handles and sliding the locking collar down the central shaft, hold the tool by the knob on the end—and pull. Squeezing the handles releases the grip. We've shown the knob in its extended position so you can see the helical inner shaft that does the job. The tool also features side cutters for trimming wire to length. Although they may not find a place in everyone's toolbox, those interested can contact Milbar Corp., 530 Washington St., Chagrin Falls, OH 44022. The suggested list price is \$70.

16. Brake-spring pliers—Here's a specialized tool designed to make the auto mechanic's life easier. Sure, you can get those brake springs off if you try hard enough. This tool, however, will do the job quickly without damag-

ing the springs. Extralong handles provide the necessary leverage and the specially shaped ends fit in the springs. These 12-in.-long brake-spring pliers cost about \$13.50. Contact Old Forge Tools, 7750 King Rd., Spring Arbor, MI 49283.

17. Hose-clamp pliers—The wire-ring clamps found on automotive vacuum lines and other hoses can be a nuisance to open with ordinary pliers. These hose-clamp pliers are designed to solve the problem with special tips that engage the ends of the wire clamps. Open the clamp by squeezing down on the handles—a ratchet keeps the clamp open while you remove the hose. The tool costs about \$6.50. Contact Sears, Sears Tower, Dept 703-PM, Chicago, IL 60684.

18. Bent-nose slip-joint pliers—Although these may look like your garden-variety slip-joint pliers, they differ in one small detail—the jaws are bent at about a 30° angle from the handles. Designed to reach where normal slip-joints fear to tread, they're not only handy where access is limited, but also for gripping flush to a surface. This tool sells for about \$10. For more information, write to Cooper Tools, Box 728, Apex, NC 27502.

19. Radiator hose pinch-off pliers—There is a way to install a new thermostat or water pump on your car without completely draining all of the coolant. Simply secure these pinch-off pliers at the appropriate position on the radiator hose to block the coolant flow. This model features 2 $\frac{1}{2}$ -in.-long pivoting jaws that remain parallel at any jaw opening and a ratchet that keeps the jaws locked. A release lever is mounted on the handle. These radiator hose pinch-off pliers retail for about \$13. Contact Easco/K-D Tools, 35-75 Hempland Rd., Lancaster, PA 17604. **PM**

**WORKSHOP
PROJECT**

**HOW TO
BUILD A
ROUTER
TABLE**

BY ROSARIO CAPOTOSTO,
Contributing Editor

OUR ROUTER TABLE provides several advantages over working freehand with a router. Many times it's easier to move work over a router table than to move the router over the work. With nearly 4½ sq. ft. of work surface, our table offers more support than the router's base.

Moving the workpiece over the router table also eliminates the need for clamping the work. This is a great advantage when working with small pieces, which are difficult to clamp.

We've incorporated a pivoting fence on our router table because it's easier to adjust than a fence that slides in parallel grooves. Just pivot the fence, measure for the amount of cutter exposure and lock the fence down with a single C-clamp. Its miter gauge slot facilitates cutting half laps or tenons.

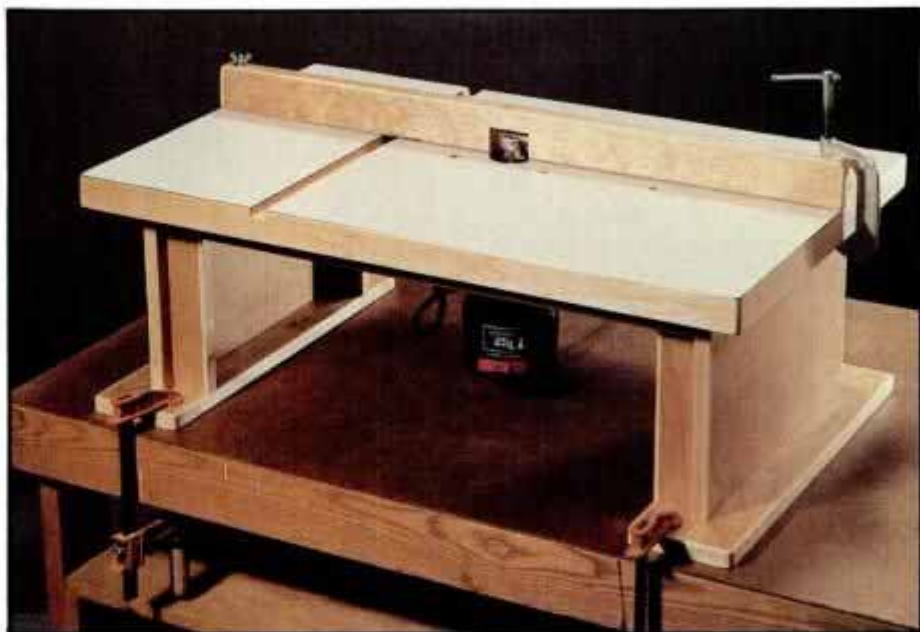
Construction

Begin construction by ripping and crosscutting the particleboard for the top (photo 1). Rip and crosscut the plywood strips attached underneath the top. Fasten these to the top with countersunk screws or nails and glue.

Next, cut a ⅜-in.-deep recess in the top for the router base. I used a straight bit guided by a template



1 Begin router table's construction by ripping and crosscutting particleboard for top. Here, the miter gauge guides the cut.



This sturdy router table features a generous 4½-sq.-ft. work surface.

(photo 2). The recess can be cut freehand, but it would not be as clean.

The template's diameter equals the diameter of the router's subbase minus the diameter of the straight bit and the template guide's offset dimension. Tack the template in place and rout the ⅜-in. groove that establishes the outside of the recess. The recess is off center to allow more support for a workpiece in front of the bit.

Once the groove has been routed, pry off the template and finish cutting the recess (photo 3). Move the router side to side, from the front of the recess toward the back. This way, the router is supported during the cut.

Now, bore the 2-in.-dia. bit clearance hole in the tabletop (photo 4). Bore the three holes for the screws that fasten the router base to the top.

Add a finished look to the top by gluing on edge strips. We used ¼-in.-thick strips ripped from ⅝ birch (actually, 1½ in. thick), but you can also resaw these strips from 1½-in.-wide stock or rip some strips from the same

plastic laminate used on the top. The edging strips should be slightly wider than the thickness of the top so they can be trimmed flush with a block plane (photo 5) or a laminate-trimming bit in a router.

Rip the plywood and hardwood parts for the base to size. Glue and nail the plywood uprights to the plywood panel sides (photo 7). Then, glue and screw the feet to the sides. Attach the hardwood cross support with glue and screws. Glue and nail on the hardwood banding, then trim flush.

Dry assemble the top and base right side up. Run a sharp pencil along the corner of the uprights to mark a guideline for the screws that attach the top and base. Bore pilot holes from underneath the top for the screws (photo 8).

Cut the plastic laminate for the top about ½ in. oversize in length and width. Apply a thin, even coat of contact cement to the top and the underside of the laminate. When the cement has dried, position the laminate over



2 Cut the outline of the recess that will seat the router's base using a template, straight bit and accessory template guide.



3 Remove template and finish cutting the recess. To ensure support for router, cut away waste moving from front to back.

the top using sticks or dowel rods (photo 10). Pull these out, one at a time and press the laminate down.

With the router table upside down, bore a hole through the laminate covering the bit clearance hole. Also bore through the three holes for the screws that attach the router base to the top. Flip up the router table, drop the flush-trim bit through the hole and trim the laminate covering the bit clearance hole. Countersink the three screwholes for the router base.

Cut the groove for the miter gauge using a straight bit (photo 11). Guide

the router using a pair of fences clamped across the top.

Bit safety guard and fence

The bit guard is designed for operations where the fence isn't used. It's installed in the rear position for general work like edge shaping shown in photo 12. It's installed to the right of the cutter when making end cuts guided by the miter gauge.

The mounting posts for the guard are hexbolts with the threaded portion cut off. Bore through the edge of the wood block, into the bolts for the

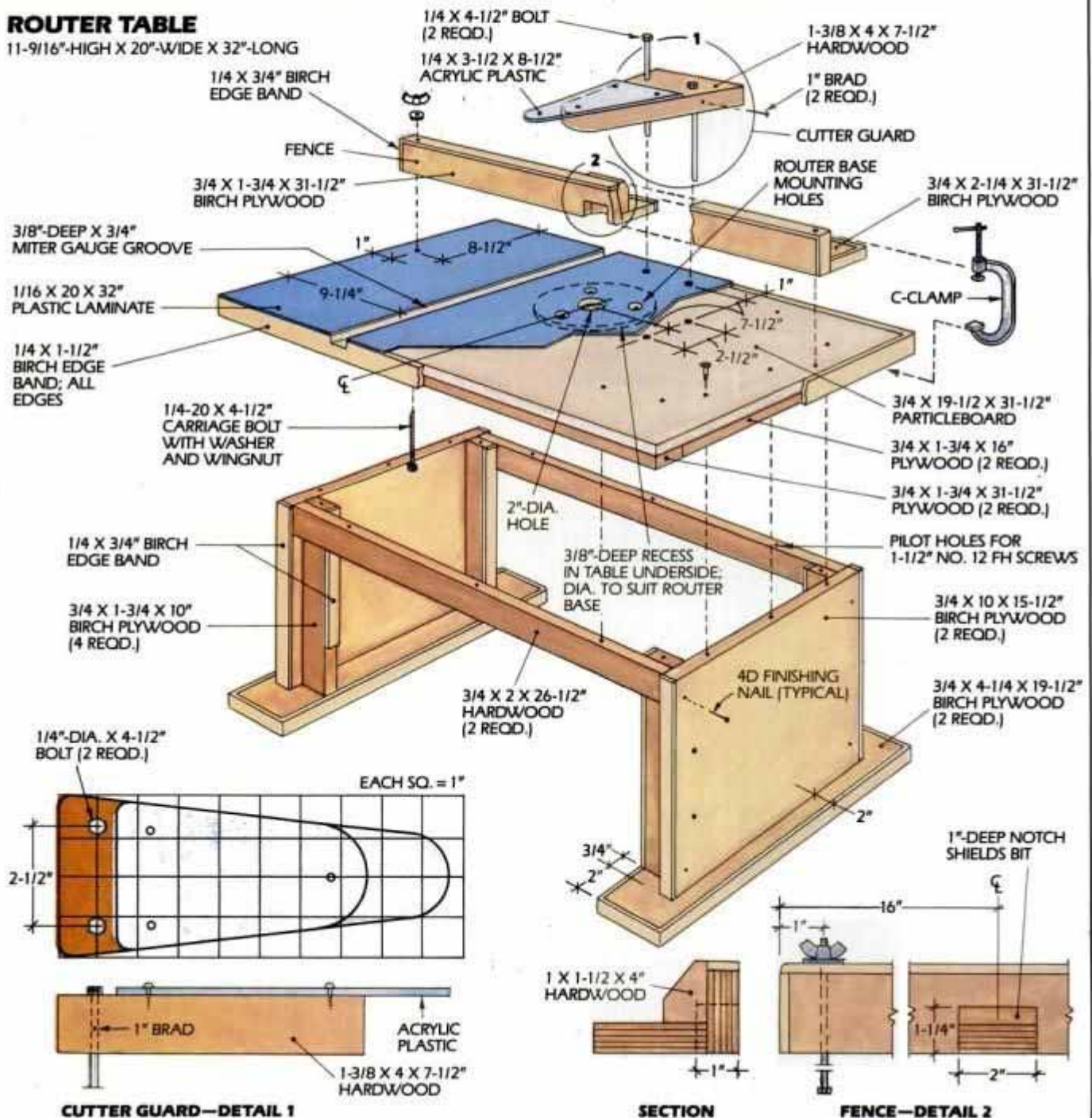
1-in. brad that keeps the posts in the guard. Bore four postholes in the top.

Rip and crosscut plywood for the fence. Attach, then trim the edging. Glue a wood block to the fence, as shown, to shield the bit from behind. Bore the stopped 2-in. clearance hole in the fence for the bit using a Forstner or spade bit. Bore the holes near both ends of the top and the fence for the bolt that the fence pivots on.

Round off the corners of the edging, sand and fill holes. Apply two coats of a brushing lacquer such as Deft Satin Finish to complete the job. **PFM**

ROUTER TABLE

11-9/16"-HIGH X 20"-WIDE X 32"-LONG

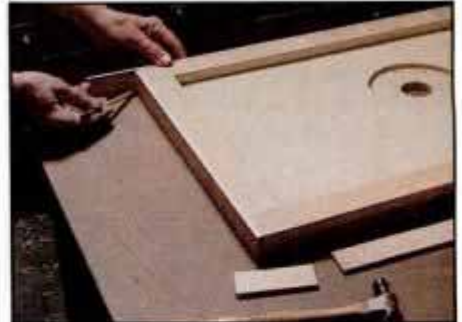




4 Bore through the center of recess for router bit clearance hole. Guide the 2-in. holesaw by boring the pilot hole first.



5 Cut wood edging strips slightly wider than thickness of top. Apply ends first, then trim flush using the block plane.



6 Apply front and back edging strips after ends are nailed and glued in place. Trim flush with ends and round off the corners.



7 To construct base, glue and nail uprights to side panels, then attach feet. Trim the base edges with hardwood edge strips.



8 Bore screw holes in top from underneath. Gain clearance in the corners for the drill guide by supporting it on wood block.



9 Countersink the screw holes in the top, and drive the screws through into the base side panels and hardwood cross supports.



10 Move laminate into place, resting it on sticks. Starting at one end, remove one stick at a time until the sheet rests on top.



11 After excess laminate is trimmed off, cut the miter gauge slot in top. Guide the router between the two fences clamped to top.



12 Bit safety shield is used during router operations with fence removed. For edge shaping, use router bit with ball-bearing pilot.

NEW TOOL

SOMETIMES IN woodworking it seems that two hands aren't enough, especially when clamping up stock. The Quick Grip clamp is a bar clamp designed for one-handed use.

Hold the clamp's pistol grip, and press the release lever on the sliding jaw. Slide the jaw against the stock and release the lever. Tighten by squeezing the pistol-grip handle.

Quick Grip comes in five jaw capacities, from 6 in. to 36 in. and costs from \$21 to \$34 (suggested list prices). It's sold at hardware stores and home centers. For more information, contact American Tool, Inc., 301 South 13th St., Suite 600, Lincoln, NE 68508. **PM**



HOW IT WORKS

MICROWAVE OVEN

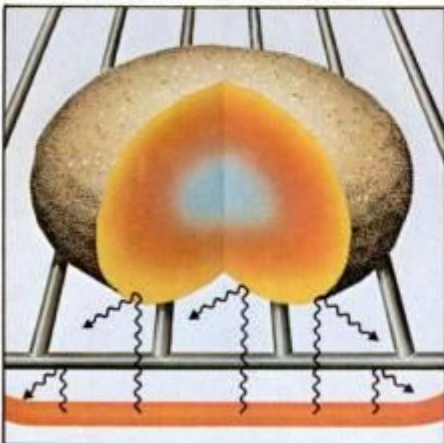
BY THOMAS KLENCK,
Associate Home
and Shop Editor
PM Illustrations
by George Retseck

THERE USED to be only one way to get food hot—you put it in a hot place. Not only did the food get hot, everything got hot—including you if you got too close. Until the early '70s, this was the only way to go. Since then, however, a revolution has occurred. We're cooking food, boiling water and defrosting dinners in a small box that plugs into an ordinary wall outlet—and it *doesn't* get hot.

The box, of course, is the microwave oven. And, although it performs differently, it's more closely related to conventional ovens than you might think. Whether you're cooking with electricity, gas, wood or microwaves, you're using a type of energy called electromagnetic radiation.

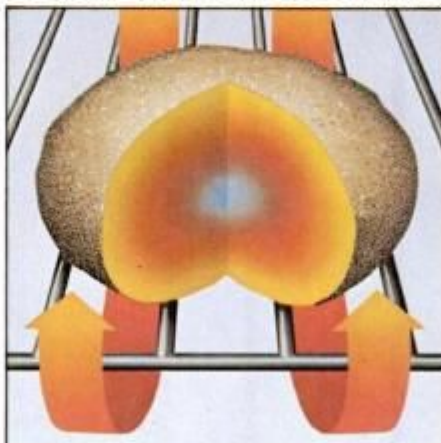
This energy is in the form of continuous oscillations or radiating waves of an electromagnetic field. Like sound waves, which can be generated at different frequencies to produce different pitches, electromagnetic radiation exists in a range of frequencies called the electromagnetic spectrum. Each frequency has a specific wavelength—as the frequency decreases, the actual length of the wave gets longer (see chart on page 79). In the

RADIANT COOKING



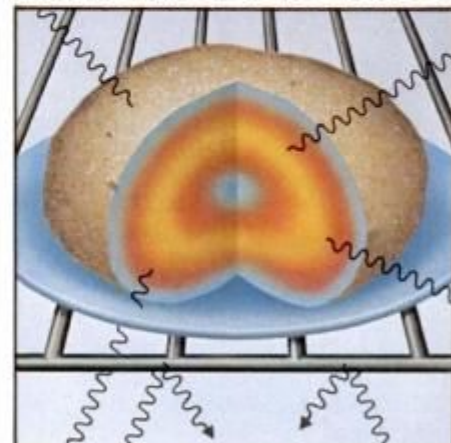
In a conventional oven, infrared radiation strikes oven surfaces and food to transmit heat. Heat moves to center by conduction.

CONVECTION COOKING

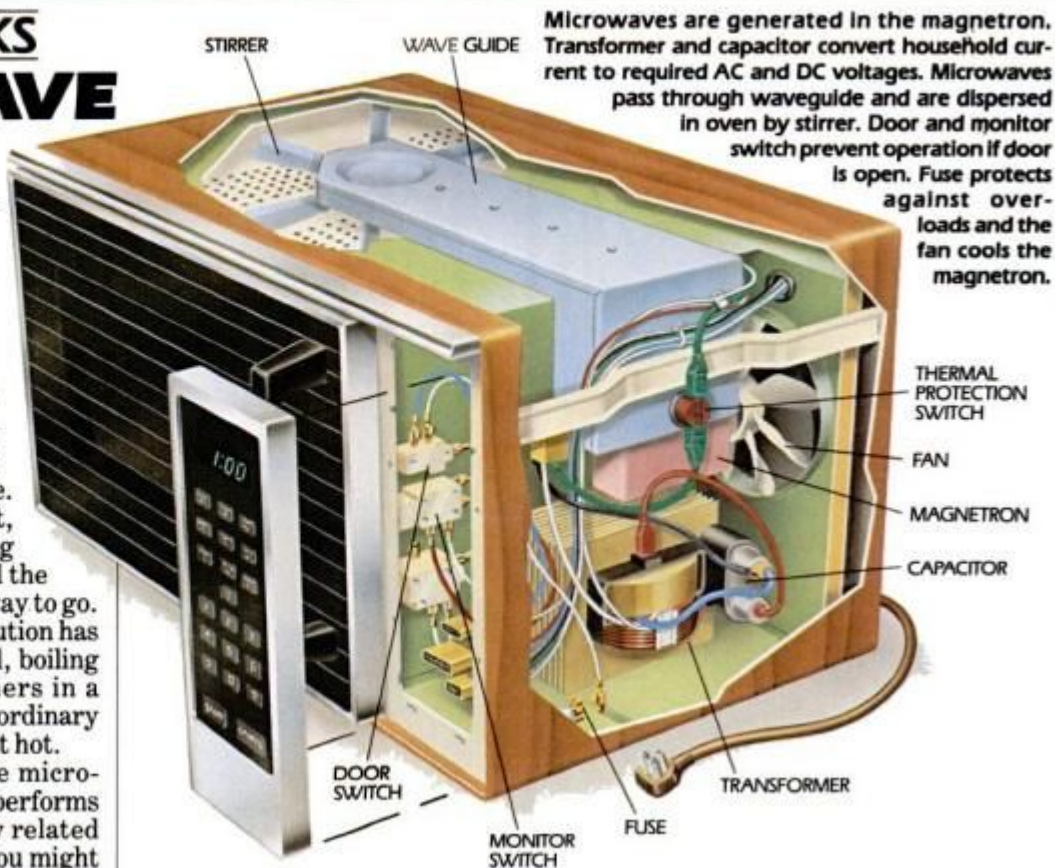


A convection oven works by circulating hot air. As in radiant cooking, all surfaces become hot and heat conducts toward center.

MICROWAVE COOKING



Microwaves heat food to a depth of 1 in. Waves bounce off metal, but pass through dishes. Unheated air cools food's surface.



Microwaves are generated in the magnetron. Transformer and capacitor convert household current to required AC and DC voltages. Microwaves pass through waveguide and are dispersed in oven by stirrer. Door and monitor switch prevent operation if door is open. Fuse protects against overloads and the fan cools the magnetron.

same way that we can only hear certain frequencies of sound, we can only see a small portion of the electromagnetic spectrum—visible light. We can also sense another portion that we can't see—heat.

The molecules that make up all things around us are moving. This activity generates low-level infrared electromagnetic radiation. When the molecules vibrate faster, as in an electric heating element of a stove or in a fire, infrared radiation increases. Objects in the path of the radiating infrared waves—oven walls, racks and

food—receive the energy and gain in heat. This is called radiant heating and is the traditional way that we cook food.

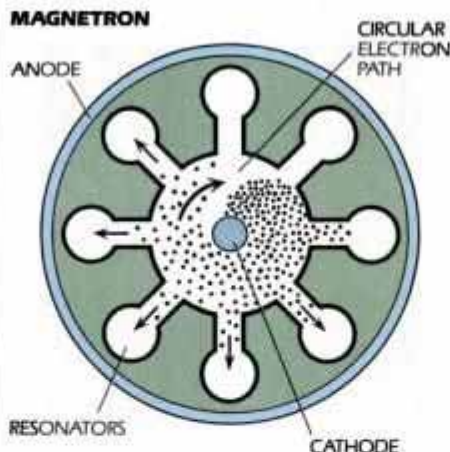
Radio waves are longer than infrared, and between the two reside wavelengths called microwaves. During the development of microwave radiation for communication purposes in the '40s, scientists accidentally discovered that these high-frequency radio waves had unique and potentially useful properties. They could generate heat in certain materials—materials with similar charac-

teristics to the food that we cook. The standard frequency that microwave ovens use is 2450 megacycles per second. Because each wave has a positive and negative component, the molecules of food being cooked in a microwave oven are being jostled back and forth at twice that rate or 4.9 billion times each second. The length of each microwave is about 4½ in.

Microwave radiation doesn't affect all materials in the same way. Just as light passes through glass, certain materials are relatively transparent to microwave radiation such as glass, paper and plastic. Metals, however, reflect microwaves similar to the way that a mirror reflects light. This is why the metal cabinet doesn't get hot. And, because the cabinet doesn't get hot, the air inside stays cool. The see-through door panel is shielded with a fine metal grid—the holes allow light to pass through, but not the longer microwaves.

Water, fat and sugar—common components of much of the food we eat—readily absorb microwaves. The radiation actually penetrates the food up to a depth of about 1 in., depending on the density of the food and the amount that's in the oven. However, because the air in the oven is relatively cool, the surface of the food loses heat giving the false impression that the food is being cooked from the inside out.

In a conventional oven, the heat applied to the surface migrates to the center of the food through conduction. If the infrared energy is too high, the surface will burn before the inside is cooked. Because a microwave oven heats a larger mass of food through direct, high-energy radiation, the food is warmed more uniformly and quick-



Inside magnetron, cathode emits electrons which move toward positive anode. Magnetic field causes circular path. Microwaves generate in resonators as electrons pass by.

ly without burning. However, the center of thicker foods may not be affected by the radiation and only become cooked as the heat conducts to the center. Controlling the energy level allows you to ensure that the outer layer of food won't be overcooked before the inside is done.

Many microwave ovens are equipped with an additional heating method that duplicates the surface-browning nature of a conventional oven—convection cooking. Here, hot air circulates throughout the oven transferring energy by direct contact. It can be used alone so the inside of the food is cooked by heat conduction, or paired with microwave radiation for faster cooking.

The magnetron

The heart of the microwave is the magnetron. This converts electrical energy to microwave radiation. To do the job, it uses low-voltage alternat-

ing current and high-voltage direct current. A transformer changes the incoming voltage to the required levels and a capacitor, in combination with a diode, filters out the high voltage and converts it to direct current.

Inside the magnetron, electrons are emitted from a central terminal called a cathode. A positively charged anode surrounding the cathode attracts the electrons. Instead of traveling in a straight line, however, permanent magnets force the electrons to take a circular path. As they pass by resonating cavities, they generate a continuous pulsating magnetic field, or electromagnetic radiation.

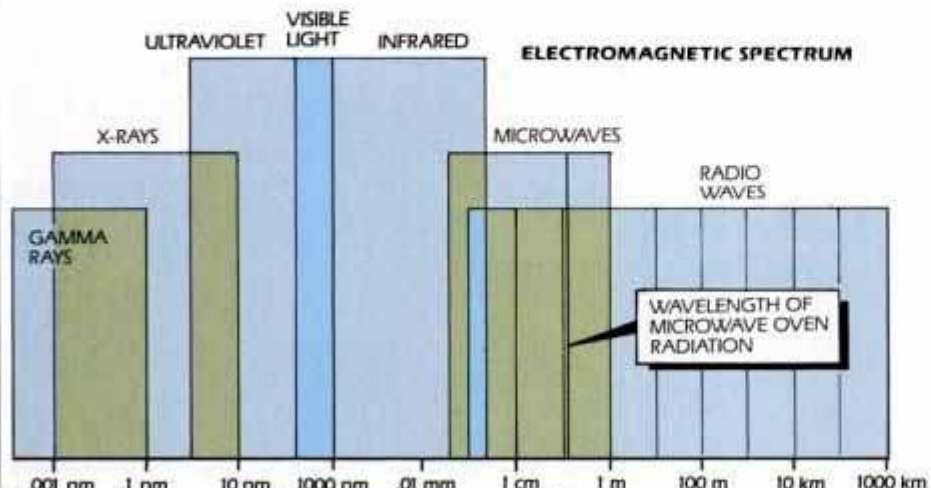
After leaving the magnetron, the microwaves are routed to the oven via a waveguide or metal channel. At the end of the waveguide, a stirrer rotates and disperses the waves within the oven cavity.

While the early microwave oven was a rather simple affair, today's unit can boast a variety of features that make high-tech cooking better and easier. Rotating trays eliminate the need to periodically turn the food so that it's uniformly exposed. And, humidity sensors are being used to determine when the cooking is complete. Some new ovens actually smell the food to determine when it's done.

Keep in mind that contrary to popular belief, metal can be used in a microwave. Most of us have seen many units that come equipped with a metal grille or shelf, and the technique of using a piece of aluminum foil to keep a certain section of the food cooler than the rest is gaining popularity. Because microwaves are reflected by metal, however, using deep metal pans will keep the radiation from reaching the food. Also, if not positioned properly, the energy bouncing from the pan to the cabinet can cause an electrical arc or spark which can, over time, damage the oven. So your best recourse is to follow precisely the manufacturer's recommendation for proper use.

If your microwave oven stops working properly, *do not* attempt to repair it yourself. Even so much as disassembling the cabinet can be dangerous. Not only is there the risk of electrical shock—the capacitor stores high-voltage current even when the unit is off and unplugged—but the cabinet seals that keep the radiation inside will be disturbed. It takes a qualified technician with specialized equipment to diagnose and repair a problem—and, to reassemble the unit so it's safe to use.

PM



Spectrum reflects range of electromagnetic wavelengths as measured in meters. One nanometer (nm) equals one-billionth of a meter. As waves lengthen, frequency (cycles per second) decreases. Microwave oven radiation frequency is 2450 megacycles per second.

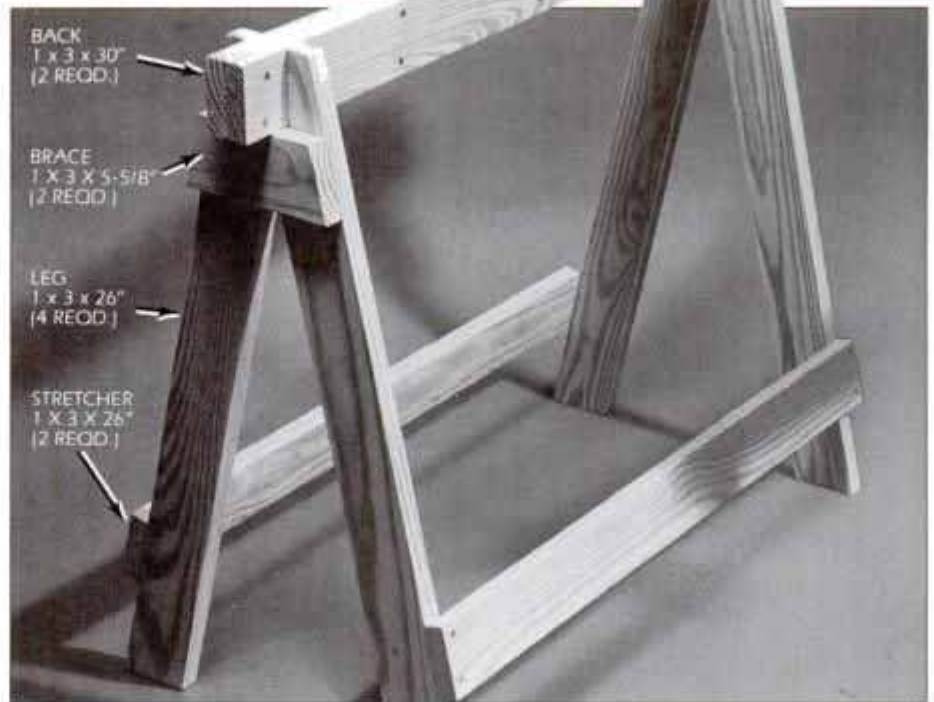
SHOP PROJECT

EASY-TO-BUILD SAWHORSES

TEXT AND PHOTOS BY ROSARIO CAPOTOSTO, Contributing Editor

NO HOME workshop is complete without a pair of sturdy sawhorses. However, most sawhorses are made of heavy 2x4s. We decided to show you how to build a pair of lightweight, yet strong, sawhorses using 1x3 stock. As an added bonus, these horses can be stacked. While these sawhorses will handle almost any job, they're not intended for scaffolding.

Begin by crosscutting the 1x3 stock for the back, stretchers, braces and legs. Then, mark the angled notch at the top of each leg, as shown. We used a jig to ensure fast, uniform notch cutting. The saw is guided by strips. The distance from each strip to the cutting line equals the distance from the edge of the sabre saw's blade to the edge of



the saw's base. To make the end cut on each leg, space the saw away from the fence by butting a small piece of plywood to the fence (photo 2).

Begin assembly by gluing and nailing a 1x3 back piece to the top of a pair of legs. Use 3d (1 1/4-in.) nails. Nail a stretcher 3 3/4 in. from the bottom of each leg. Repeat the process on a second pair of legs. Next, glue and nail the two halves together (photo 4),

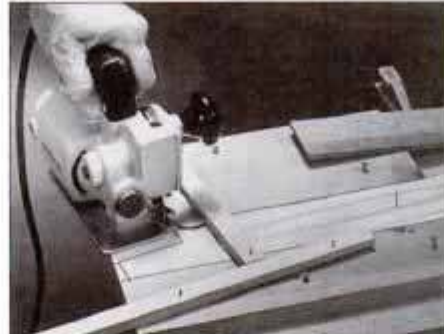
Sawhorse is simple, rugged, lightweight and easy to build. You can build it from inexpensive 1x3 softwood stock.

supporting the back on a wood block. Complete the assembly by gluing and nailing the side braces.

Stand the sawhorse on a bench and mark a cutline across each leg. Elevate the pencil by running it along a wood strip or slide the pencil along on a block of wood. Cut the legs on this line so the horses will sit flat. **PM**



View is top end of 1x3 leg with layout lines for notch. Mark angled lines using a sliding bevel gauge set with a protractor.



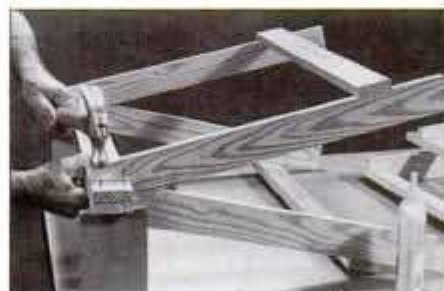
1 Guide saw with jig while cutting notch in top of leg. Sequence of cuts is not important. Hold the saw firmly against the strips.



2 Plywood filler piece butted to cross strip positions the saw to make leg top cut. Keep the saw level to avoid tipping off jig.



3 Once legs are cut, fasten one back piece to the top of the legs with 3d nails and glue. Attach stretcher in same manner.



4 Join together two halves by nailing and gluing together two back pieces. Support the back on wood block while nailing.



5 Mark legs for end trimming by standing sawhorse on flat surface and marking level line. Elevate pencil on wood strip.

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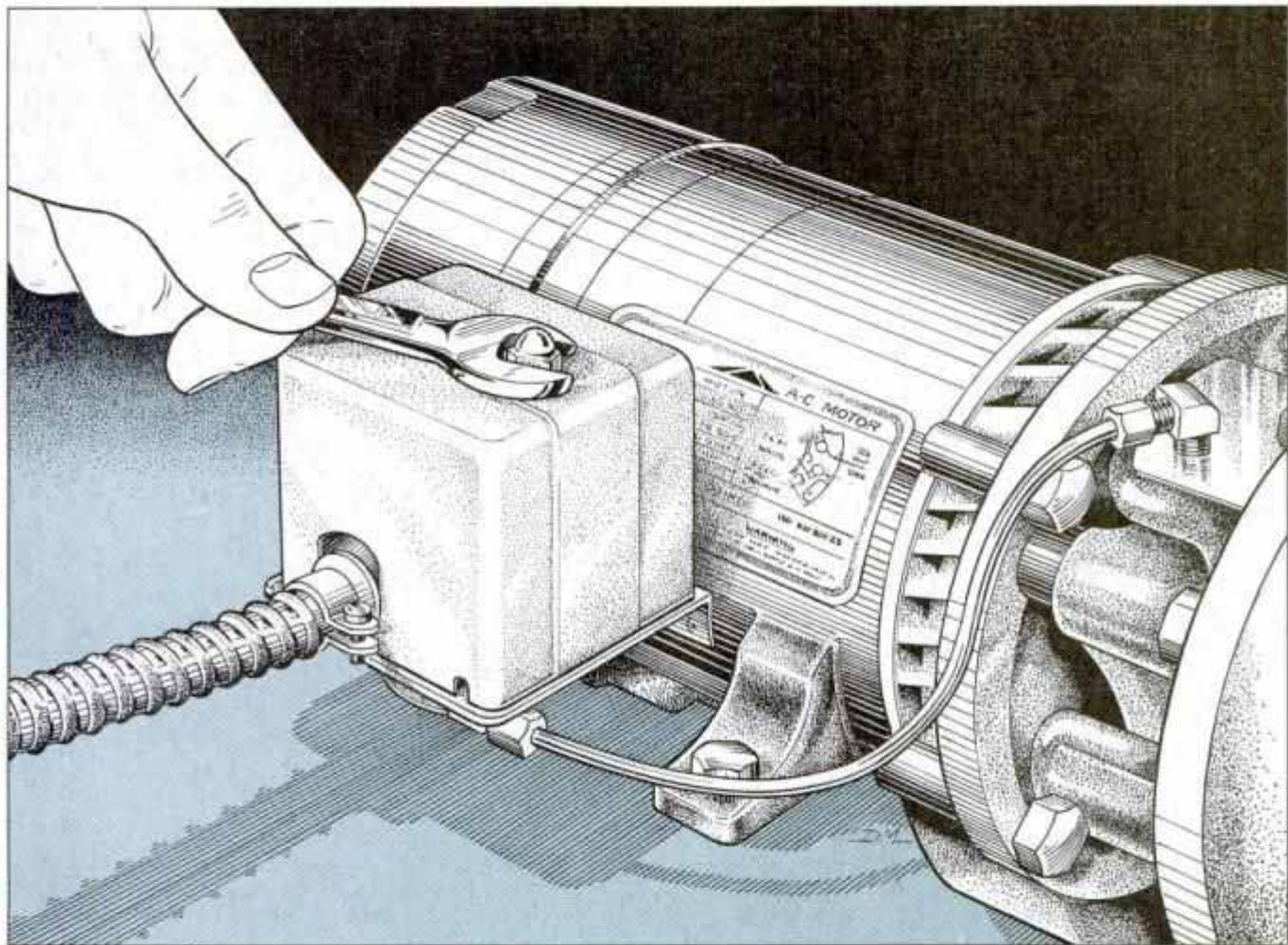
**THE TOUGH NEW
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THE PERFORMANCE DIVISION OF CHRYSLER MOTORS



BUCKLE UP FOR SAFETY.

How To Troubleshoot A WATER WELL

BY MERLE HENKENIUS; PM Illustrations by Don Mannes



THERE ARE roughly 13 million domestic water wells at work in the U.S. today. And while these systems are generally dependable, they can act up periodically. It's just in the nature of the beast. When a major component does fail, it's a good idea to hire a professional to make the repair. But most well system problems are minor and can cost little or nothing to fix. Learning to approach the problems symptomatically is the trick, and not a complicated trick, once you gain a general understanding of how water wells work.

To begin, there are four basic well types in use today, three are fairly modern and one is a holdover from

earlier times. They are most easily separated by their pumping mechanisms: piston pumps, single-drop and double-drop pipe jet pumps and submersible pumps. Piston pumps can be located either at the surface or inside the well casing, jet pumps are always at the surface and submersible pumps—as their name implies—are always positioned inside the well casing, suspended within the water table.

Piston pumps

Because few piston pumps have been installed since the 1950s, we'll focus on the other types. But a few words on these great old pumps is in order. A piston pump is nothing more than a

suction pump. Water is drawn into the pump cylinder by means of a moving piston that is fitted with leather seals which bear against the cylinder walls. In the old days, and today as well, many of these pumps were driven by windmills. The piston is connected to a rod that extends up through the well casing and is attached to the shaft driven by the wind against the windmill's characteristic paddles. A check valve within the piston holds the water in place while another stroke pulls more water into the cylinder and up the riser pipe. With each stroke more water is raised until it finally spills from the riser at the surface. In this application the piston

cylinder is submerged within the water well casing.

Piston pumps can also be located at the surface, either in the form of a classic hand-operated pitcher pump or in an electric version that features a cast-iron flywheel. These surface models function in the same basic way as the submersible piston pumps.

Jet pumps

As mentioned earlier, jet pumps come in two basic types: single-drop pipe and double-drop pipe. Both are located on the surface and operate by suction, so they are capable of lifting water only from shallower wells. They also need a continuous prime to work, which means the drop pipe or pipes plus the pump cavity have to be full of water in order to pull up more water. This prime is held by a foot valve as shown in the comparative drawings on page 85.

When the pump is turned on, the prime water is pushed through the pump by impellers and new water is pulled up behind the prime water.

The suction of a jet pump is further enhanced by an ejector. On single-drop systems, this ejector is located in the pump. Viewed simply, the ejector is nothing more than a restriction that boosts the velocity of the water passing through the pump. This creates a continuous vacuum that increases the lifting power of the pump.

On double-drop systems, the ejector is located at the bottom of the well and connects the two drop pipes. Water is drawn up through one pipe and once it gets to the pump, a portion is diverted into the second pipe. As the return water drops down this pipe, it passes through the ejector which creates even more pressure and greater lift in the suction pipe.

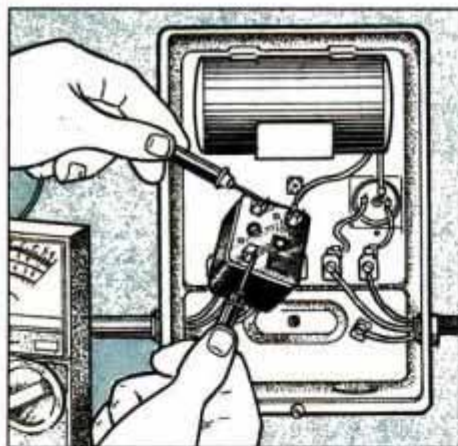
Because jet pumps are surface mounted, they must always fight the opposing forces of head pressure—the relative weight of a column of water—and atmospheric pressure. As such, their lifting power varies geographically. A single-drop pump may be able to lift water only from a 20-ft.-deep well in the mountains, but

could lift up to 30 ft. of water on the plains. A 2-drop system does substantially better, with many being able to lift water from 100 to 120 ft. deep. The design of the ejector is another variable with jet pumps; the smaller its restriction, the greater its lift.

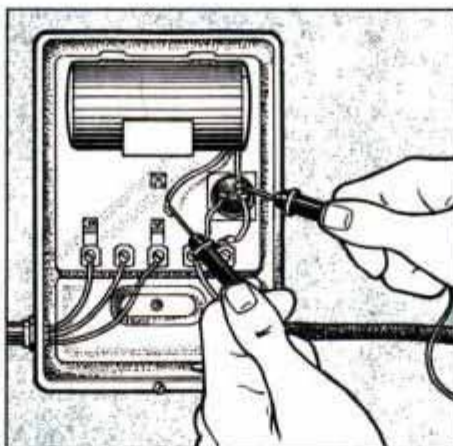
Submersible pumps

In these systems, the pump is suspended directly in the aquifer. The pump itself contains an impeller that is powered by a sealed electrical motor. When the pump turns on, it simply forces water up the drop pipe and into your home. A submersible pump is generally considered the most problem free. But it does have one major drawback: If a pump motor does burn out, you have to hire a professional with a truck-mounted derrick to retrieve and service the pump. This process is commonly called *pulling the well* and can be quite an expensive operation, especially if costly plantings and other landscaping are in the way.

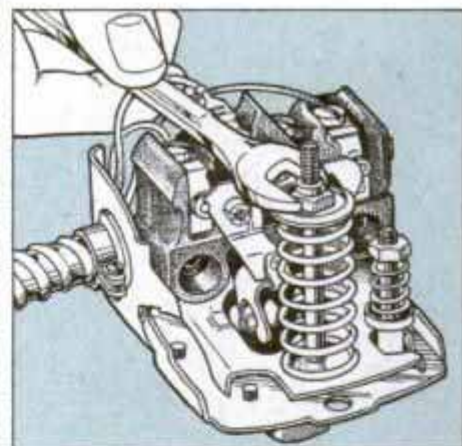
As you might expect, submersible pumps tend to be found in geographic



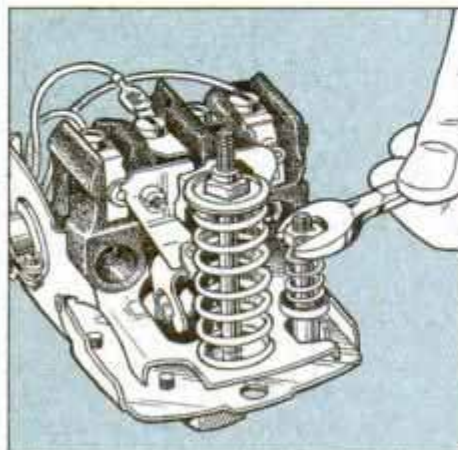
1 To test relay switch, set ohmmeter on Rx1 scale and touch probes to terminals. No movement of arrow means bad switch.



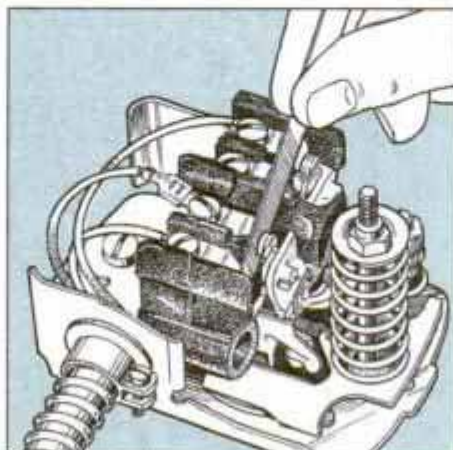
2 To test capacitor, leave ohmmeter on same setting and touch probes to terminals. No arrow movement means it's bad.



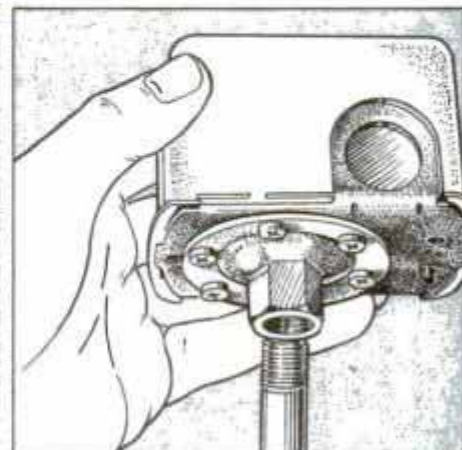
3 To repair drift in pressure switch, remove cover and tighten nut on top of high-pressure spring at least one full turn.



4 Adjust nut on low-pressure spring in same way. Then turn on, run pump through full cycle and note pressure readings.



5 Clean both sets of points with small file or matchbook cover. Remove any filings, then re-gap points to proper specification.

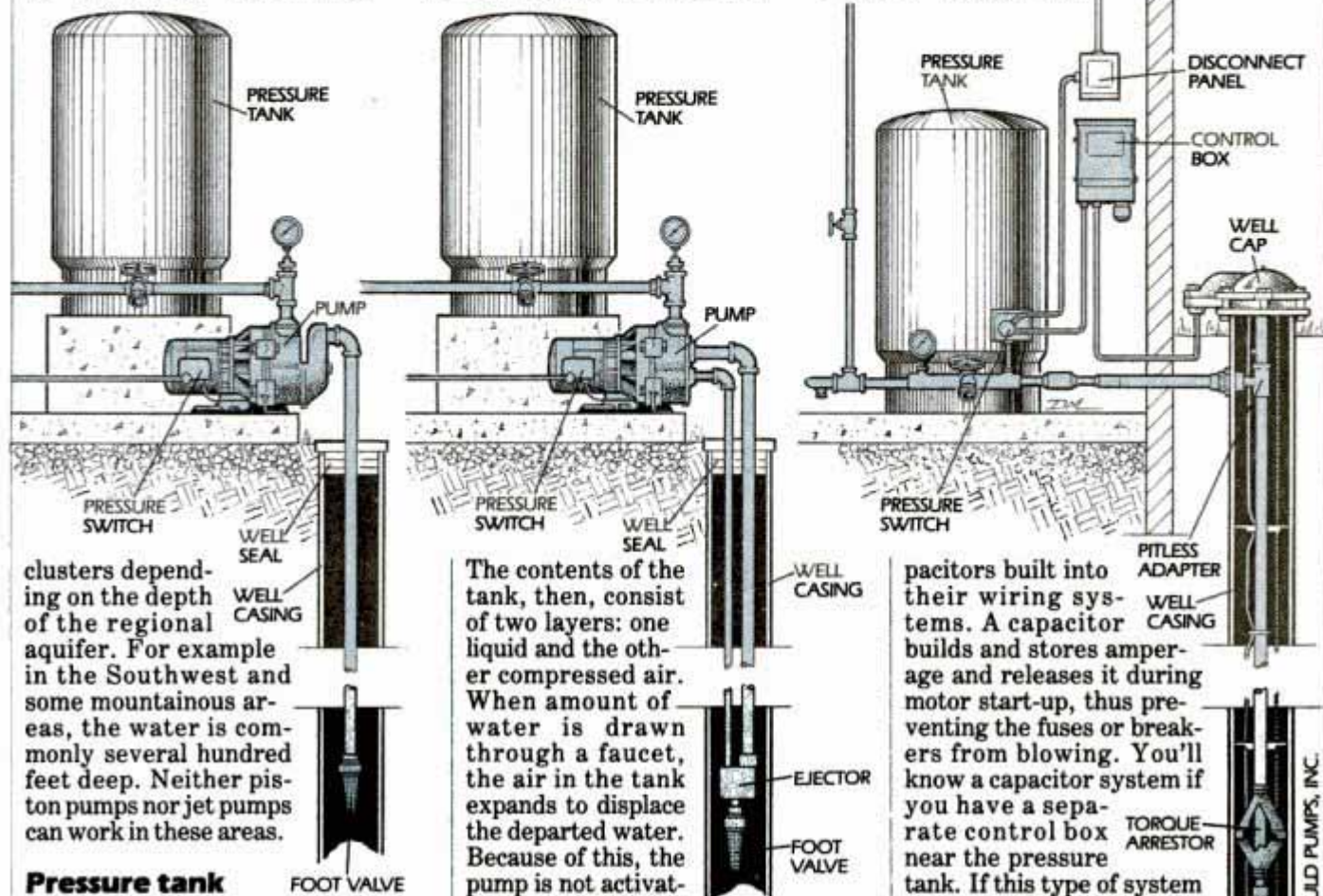


6 If you have to replace pressure switch, remove old switch and install new one of same rating. Attach wires accordingly.

SINGLE-DROP JET PUMP SYSTEM

DOUBLE-DROP JET PUMP SYSTEM

SUBMERSIBLE PUMP SYSTEM



clusters depending on the depth of the regional aquifer. For example in the Southwest and some mountainous areas, the water is commonly several hundred feet deep. Neither piston pumps nor jet pumps can work in these areas.

Pressure tank and switch

The pump may well deliver the water but it's the pressure tank and pressure switch that make the system work in your home. These two components are common to just about every well system and they account for most of the performance problems that well owners encounter. Before going into pressure-related service problems, let's first take a brief look at how this end of the system works.

A pressure tank is often just a galvanized steel tank with an air-injection valve at its top or bottom. Threaded into the side of the tank, near the bottom, is a brass tee that has several ports. The two ends of the tee connect the well piping and the house piping to the tank. A pressure switch, pressure gauge and drain valve are often threaded into this tee as well. Though in many cases, one or all of these are located elsewhere. Their individual position makes little difference in their performance.

When the system is newly installed, the air inside the tank is compressed against the top of the tank by the water pumped in from the well.

The contents of the tank, then, consist of two layers: one liquid and the other compressed air. When amount of water is drawn through a faucet, the air in the tank expands to displace the departed water. Because of this, the pump is not activated each time water is used but only after a substantial drop in tank pressure. This reduces wear and tear on the pump.

Tank pressure is indicated by the pressure gauge and monitored by the pressure switch. Pressure switches are calibrated to turn on the pump at one pressure and to turn it off at another. A 20/40 switch, for example, starts the pump when tank pressure drops to 20 psi and turns it off when the pressure reaches 40 psi.

Electrical problems

If you have water one day and don't have it the next, remember the obvious. As any well specialist will tell you, a good share of service calls amount to little more than blown fuses or tripped breakers. The reason for this is simple: Electric motors require up to eight times more amperage to start than to keep running. Because of this increase in demand, a momentary start-up overload will occasionally trip your breaker or blow your fuse.

The only pumps not plagued by start-up overloads are those with ca-

pacitors built into their wiring systems. A capacitor builds and stores amperage and releases it during motor start-up, thus preventing the fuses or breakers from blowing. You'll know a capacitor system if you have a separate control box near the pressure tank. If this type of system repeatedly trips breakers, then test across the relay switch with an ohmmeter (Fig. 1). Also test across the capacitor (Fig. 2). With the needle set to the Rx1 scale—for both tests—the needle should jump forward and then settle back when you touch the terminals. If the needle doesn't respond, assume a defective component and replace the relay switch, capacitor or both as required.

Pressure switch problems

The two most common pressure switch problems are drift and fouled contact points. In the first instance, the springs over the pressure-sensing diaphragms weaken with age, allowing the entire pressure range to drift upward. When this happens, the pump is likely to operate continuously or much longer than it normally does. This happens because the pump must build a higher level of pressure in the tank before satisfying the high-limit requirements of the switch. If this

TECHNICAL ASSISTANCE: GOULD PUMPS, INC.

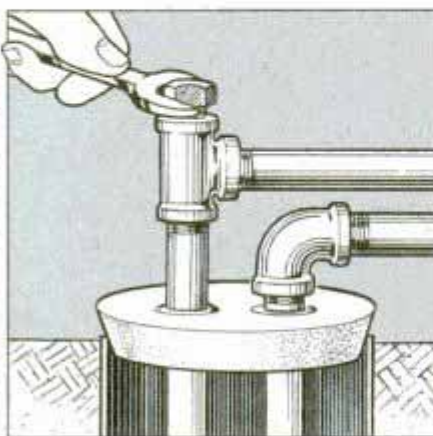


7 If tank is waterlogged, add air through snifter valve. Use compressed air, bicycle pump or drain tank completely and refill.

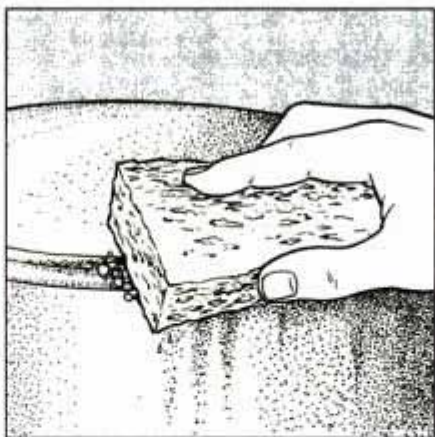
drift is beyond the pressure generating capacity of the pump, the pump will run until it overheats and trips a breaker.

To treat this problem, shut off the power to the pump and remove the pressure switch cover. You'll see two vertical springs with nuts holding them in place. If you lack manufacturer's instructions for the switch, assume that the longer spring controls the high limit. Using a small wrench, turn the nuts on top of both springs downward to compress the springs more (Fig. 3 and 4). Turn on the power, then draw some water from a faucet to allow the pump to operate through a complete cycle. Watch the pressure gauge and note the cut-in and cut-out pressures after your adjustment. The switch cover should have the recommended high and low pressure ratings for your switch printed on the manufacturer's label. Repeat the adjustment process until you obtain the proper ratings.

The second most common switch problem is simply one of maintenance.



9 If your jet pump system has priming nut above well cap, remove nut and fill pipe with water. Then reinstall plug.

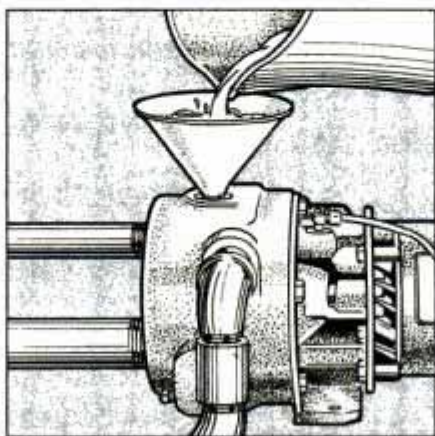


8 Check tank welds and snifter valve for air leaks by covering surface with soapy water and checking for air bubbles.

The switch contains contact points similar to those found in the distributors of older cars. When these points become fouled, resistance is created, which creates heat, which in turn trips the breaker.

To solve this problem, shut off the power, remove the switch cover and file the closed points behind both springs with a small point-gapping file or the striking surface on a matchbook (Fig. 5). Wipe away any filings and other dirt. Then turn on the power and check the pressure ratings through a complete pumping cycle. To get the proper ratings, you may have to adjust the gap somewhat.

If the switch fails to operate properly after the spring and points adjustments, it's time to replace it with one of the same pressure and voltage ratings (Fig. 6). To do this, simply shut off the power, drain the tank, undo the wires and unthread the old switch. Install the new one. Then turn on the power, check the pressure gauge through a complete cycle and adjust the springs if necessary.



10 Remove priming plug on top of pump and pour water into cavity until it overflows. Reinstall plug and tighten securely.

Waterlogged tanks

As mentioned earlier, your pump doesn't come on every time you draw a glass of water because part of the tank contains compressed air. Eventually, however, some of this air will be carried out with the water. Also, in some cases, a pinhole leak in the tank will allow the air to escape. When the air is reduced or gone, the tank is referred to as *waterlogged*. This causes the pump to turn on often and shut off early which shortens pump life.

If your tank has an air-injection or snifter valve, simply add more air to the tank using compressed air or even a bicycle pump (Fig. 7). As a rule of thumb, the pressure of the air you add should be 2 to 3 pounds less than the cut-in pressure of your switch.

If you don't have a snifter valve, simply drain the tank, which will allow more air to come in. Then refill the tank with water and you should be back in business. If a waterlogged tank is a frequent problem, however, suspect a tank leak, either at the snifter valve or on the surface particularly where the tank has been welded. To test for a leak, add more air, then sponge a rich mixture of liquid dishwashing soap and warm water onto the tank. If you see bubbles coming from the snifter valve, replace it. If you see bubbles on the tank, you'll want to replace the whole tank.

Repriming

As mentioned before, most of your well troubles will be associated with the electrical or pressure systems. This is particularly true if you have a submersible pump which is generally troublefree. Jet pumps, on the other hand, can lose their prime. When this happens, the pump will run continuously but deliver little or no water.

Luckily, repriming a jet pump is a quick fix. You'll find a prime nut on the pump and usually another one on the drop pipe—or one of the drop pipes—at the top of the well casing. Unthread these nuts and then simply pour pure water down the well until both openings overflow. Because the drop-pipe opening—if you have one—will be lower than that of the pump, fill the drop pipe first (Fig. 9), cap it off and move to the pump (Fig. 10). When the pump opening overflows, cap it off and restart the system. If the pump once again loses its prime soon after starting, assume that there's a clog in the foot valve. In this case, the drop pipe—or pipes—need to be pulled and the foot valve cleared or replaced.

How To Install A FREEZE-PROOF SILLCOCK

BY MERLE HENKENIUS; PM Illustrations by George Retseck

SILLCOCKS, also known as outdoor faucets or hose bibs, have come a long way in recent years. They have evolved into a freeze-proof design that eliminates the need to drain them in the fall.

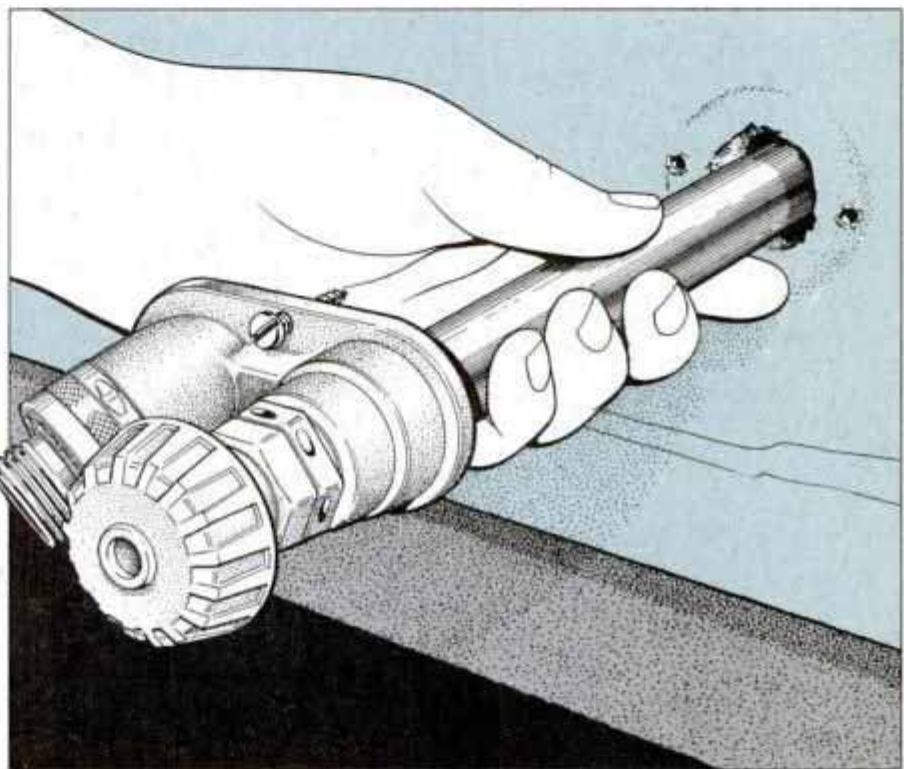
Virtually every homeowner in northern climes is familiar with the fall ritual of shutting off water to the house's sillcocks, then draining them. This prevents the water in the sillcock from freezing and breaking it. Freeze-proof sillcocks eliminate this ritual because they are self draining. You can even leave your garden hose attached to them year-round.

Freeze-proof sillcocks can replace standard sillcocks without major retrofitting. Because of this, they can be installed by someone with modest plumbing skills and a modest tool kit.

Sillcock evolution

In most homes built prior to the 1960s, sillcocks were little more than surface-mounted shutoff valves. Water flow to them was controlled by a shutoff valve installed well inside the house, to reduce the danger of it freezing.

Many a homeowner busy with other fall activities, however, forgot to drain the sillcock. To remedy the situ-

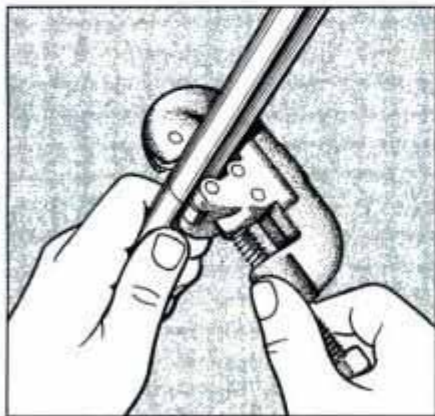


ation, the plumbing hardware industry introduced frost-proof sillcocks. These are equipped with extralong stems. The end of the stem reaches far enough inside the house so water

is shut off well away from where it could freeze.

Homeowners who thought they were safe with frost-proof sillcocks have left garden hoses attached to them only to have the sillcock burst during a cold snap. A vacuum may form from leaving the hose attached, preventing the sillcock from draining. This led to the development of the first freeze-proof sillcock. Freeze-proof sillcocks let air into the faucet through an opening called a vacuum breaker. This ensures the sillcock drains regardless of whether a hose is attached. Some also have a drain hole separate from the nozzle.

Freeze-proof sillcocks have stems from 6 to 30 in. long. The latter is for installations where the sillcock is placed on a wall cantilevered over the foundation. A typical 10-in. freeze-proof sillcock costs about \$24.



1 Begin installation by using a tubing cutter to cut supply line to the old sillcock.



2 Remove the old sillcock from outside, by unscrewing two flange screws from siding.



3 With water line cut, simply pull out old sillcock and length of pipe attached to it.

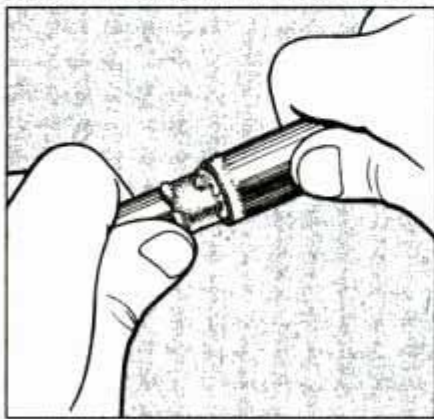
Installation

You may find the original sillcock was installed with iron or copper pipe. The former is slightly more difficult to remove and replace than the latter. Since copper is the more common of the two, it's the one we've shown. Also, once iron pipe is removed and the fittings are installed to connect copper pipe to it, the installation is the same for the two types of pipe.

In either case, shut off water at a point before the valve that controls the water flow to the sillcock. If you just shut the valve that feeds the sillcock, you won't be able to remove the valve. Open the sillcock, and drain that section of pipe.

With copper pipe, cut the supply line before the valve with a tubing cutter (Fig. 1). Remove the screws holding the sillcock to the house's siding. Pull out the sillcock.

To remove a sillcock installed with iron pipe, remove the screws holding the sillcock to the house's siding. Then, using two pipe wrenches, remove the interior valve and connecting pipe. Fasten one wrench to the pipe connecting the valve to the sill-



6 Push the sillcock into the end of the cut tubing. No coupling is necessary for joint.

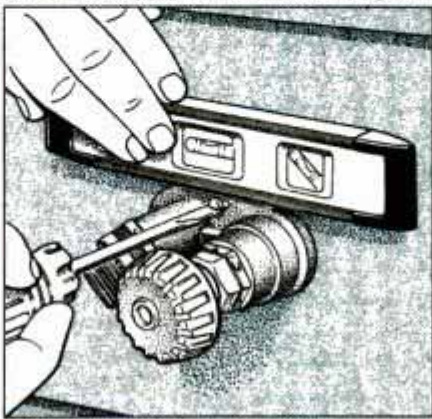


4 Prepare supply line for soldering by polishing away tarnish with steel wool.

cock. Fasten the second wrench to the valve, and slowly turn the pipe out of the valve. Keep one wrench on the valve and move the second wrench to the pipe on the other side of the valve. Carefully turn the valve off the end of the pipe.

With iron pipe, thread an iron coupling to the supply line and thread a copper adapter into that. Wrap the threads on both fittings with Teflon tape to ensure a leak-proof joint. In areas with high mineral content in the water, use a dielectric union to connect the iron supply line to a length of copper tubing that will receive the sillcock. Such a union will prevent electrolytic corrosion caused by joining dissimilar metals.

Now the procedure is the same for both copper and iron pipe. Push the sillcock in from the outside of the house, but don't screw it in place. Measure the distance from the adapter or the cut end of the copper tubing to the sillcock. Cut a connector piece of copper pipe to suit. If the sillcock is long enough, all that may be necessary is to fit the end of the sillcock over the supply line (this will depend



7 Level freeze-proof sillcock. Attach to siding by driving in flange screws.



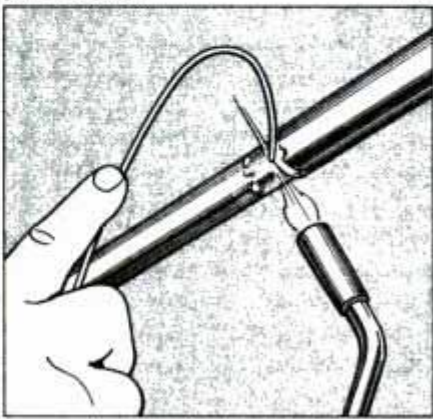
5 Apply noncorrosive flux to end of the cut tubing and end of the new sillcock.

on the sillcock and the hardware you use to connect to the feed line).

Clean all connecting surfaces with steel wool (Fig. 4) or emery cloth, and apply flux to the ends to be soldered (Fig. 5). Push the joints together. Before sweating the joints, check that the run of pipe leading to the sillcock slopes slightly downhill. If not, lift the run of pipe using pipe hanger strap. Nail the strap into a floor joist, wrap it around the pipe and fasten it with a small nut and bolt. You may have to nail a scrap block between the floor joists to position the pipe hanger tape.

Next, level the sillcock if the nozzle is mounted next to the handle (Fig. 7) and plumb it by eye if the nozzle is below the handle. Screw it to the siding. Back off the sillcock's handle so the washer on the stem's end won't get burned when you solder the joints.

Back inside, hold the solder above the joint, and heat the joint from below until the solder flows into the joint (Fig. 8). Quickly wipe the joint with a dry cloth to remove any solder globs and ensure a clean, bright joint. Turn on the water, check for leaks, and you're done. **PM**



8 Hold solder above joint and heat from below until solder melts and fills joint.

Homeowners' Clinic

BY NORMAN BECKER, P.E., Contributing Editor

Emergency Escape

I'm thinking of converting my third-floor attic area into a bedroom. Is there anything I should be particularly concerned about?

JOEL R. FRIED
SPRING VALLEY, NY

Your main concern should be to provide a safe exit in case of fire. Usually, there is only one stairway to the attic. If a fire develops in the floor below, the stairway may not be safe to use. If there is no exterior fire escape from the attic, then a rope or folding ladder should be provided.

Several manufacturers offer collapsible ladders designed for this. The JOMY Safety Ladder Co., Box 1758, Boulder, CO 80302 makes a UL-approved retractable aluminum ladder that folds into a compact tube shape. For information, call (800) 255-2591.

Also, the window opening must be large enough to permit easy escape. Some municipalities require a minimum open height or width of 18 in. and a total minimum open area of 4 sq. ft., and the bottom of the opening must be no more than 42 in. above the finished floor.

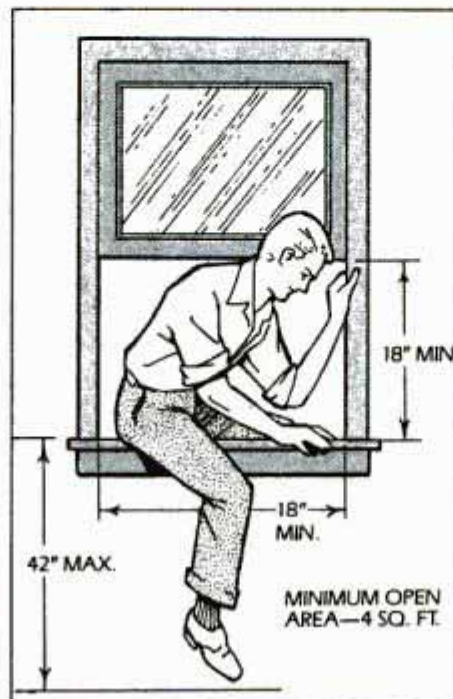
Check with your municipal building department for the specific regulations in your area.

Before beginning construction, you or your contractor must get a building permit. And you should adhere to all applicable building and electrical codes so you can obtain a Certificate of Occupancy (CO) for the new room.

Ultrasound Survey

We received letters from across the country responding to our request in the February '89 "Homeowners' Clinic" (page 81) for readers who use ultrasound insect repellents to write in and tell us of their experiences with them. Here's a sampling of the responses from our readers:

For the past seven years, we have kept an ultrasonic device operating full time in our kitchen. We have had no serious infiltration of bugs since then. Since our neighbors report problems with ants, and since we have none, we credit the device with



A window that serves as a fire escape, in a converted attic, is required to be big enough to allow for a safe exit.

discouraging them. As for now, we are believers!

ED MICKEY
INDIANTOWN, FL

I have two ultrasonic pest repellents, one in the kitchen and one in the bedroom. When we first bought this house, we had a lot of spiders and other insects. Since using the pest repellents, we have not had spiders, ants or even mice. It doesn't happen overnight; it takes a little time, so don't give up.

K. DEKORTE
HAWTHORNE, NJ

I have had an ultrasonic repeller for two years and think it's great. I live out in the country, and every year when the weather starts to get cold, the field mice start to move in. Since I have had the ultrasound unit, I have not had even one mouse move in. I also had a problem with tiny spiders that has stopped.

LINDA CAULDER
ROCKINGHAM, NC

I have used two ultrasonic pest repellents for rodents and insects with great success. Some units work and others

don't because the frequency must vary constantly or the pest can adapt to it. If it varies, the pest can't adapt and leaves for a quieter location.

I have also found that the device must be placed so the sound waves are not obstructed. Don't set it behind a box or appliance and expect it to work.

N. N. JONES
LEXINGTON, KY

The respondents said unanimously that ultrasonic devices are helpful in repelling, but not killing, insects and rodents.

Dr. George Rambo of the National Pest Control Association wrote to say that he has seen testimonials to ultrasonic repellents, but added that there are no scientific studies supporting ultrasonic pest control. Until there are scientific studies supporting the devices, he said, the NPCA will not advocate their use.

Water Alarm

We have a problem with an aging water heater. Its location is such that if it were to leak, it would flood the carpet in a first-story apartment. Is there an alarm that could warn the house's occupants in case of a leak?

PAUL BOLSTAD,
PISMO BEACH, CA

Automated Light Technologies, Southbridge, Massachusetts, makes a device called Floodhound Water Alarm that provides early warning of a leak from a water heater, plumbing, sump pump and so on.

The battery-operated device consists of a sensor and an alarm separated by a 6-ft. wire. Up to 50 ft. of wire can be spliced in to extend the distance between the sensor and alarm. With a fresh battery, the alarm will sound for about 12 hours.

The alarm costs about \$35 and is sold at home centers and hardware stores.

DO YOU HAVE A HOME-MAINTENANCE OR REPAIR PROBLEM?

Just ask Norman about it. Send your question to Homeowners' Clinic, Popular Mechanics, 224 West 57th St., New York, NY 10019. While letters cannot be answered individually, problems of general interest will be discussed in the column. For more home-repair and maintenance help, get PM's Home Care Guide, \$2.45 postpaid. Send your order(s) to Popular Mechanics, Box 1014, Radio City Station, New York, NY 10101.

Appliance Clinic

BY STEVE TOTH, Contributing Editor

No-Drain Dishwasher

I have a Sears dishwasher model No. 587.703203, serial No. 17978160885. After washing the dishes, about 4 or 5 quarts of water remain in the bottom of the machine. Could you offer some advice on what to do?

JOSEPH NADOLSKI
PHILADELPHIA, PA

The drain hose could be restricted, or the blades on the lower impeller might be broken. To check these, disconnect the power and remove the lower dish rack. Unscrew the nut on top of the lower spray arm and remove the arm. Soak up any standing water with a sponge.

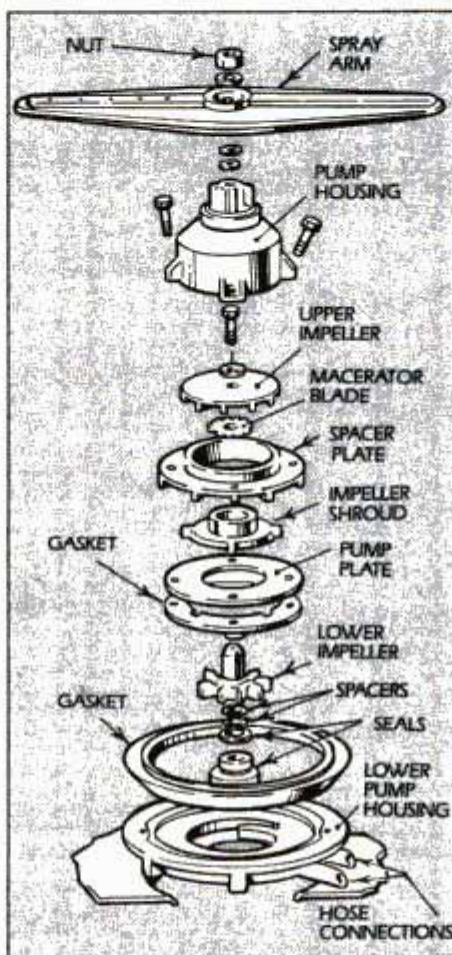
Close the door and remove the lower access panel at the machine's front. Place a shallow pan under the motor and pump assembly to catch water left in the pump housing, and remove the drain hose.

Check the drain hose for restrictions by pouring water down it. If you find a restriction that you can't free, replace the hose.

Next, check the lower pump impeller. Possibly, a piece of broken glass or similar material found its way down to the impeller and broke a few impeller blades. Remove the screws that hold the cone-shaped upper pump housing in place, and carefully lift the housing off the pump. Remove the upper impeller by unscrewing the $\frac{5}{16}$ -in. securing screw in the center. Remove the macerator blade and the plastic spacer that's held in place with two screws. Lift out the impeller shroud and steel pump plate.

Now you can inspect the lower impeller blades and the lower pump housing. If the impeller is damaged, you'll need to replace it along with the water seal directly underneath. These parts are available in a kit that includes both impellers, macerator blade, water seal, seal shim gauge, O-ring, washer and step-by-step instructions. The kit (part No. 808969) costs about \$13 and is available from any Sears parts or service center.

If the impeller is okay, inspect the plastic finger or vertical fence protruding from the lower pump housing. If this is damaged, the amount of water pumped out will be reduced.



A plugged drain hose or broken impeller blades could result in excessive water left in the bottom of the dishwasher.

The pump housing is Sears part No. 807711 and it costs about \$12.

Shaver Screen Search

Do you know where I can get a replacement screen for my Ronson model C-F-L electric shaver? T. LOUIE
LANHAM, MD

Yes, write to Ronson Service, 3533 Ocean View Blvd., Glendale, CA 91208. Send a check or money order for \$6.95 plus \$1 for postage along with a note stating that you need a replacement screen for your model C-F-L shaver. Ronson Service also stocks parts for many other Ronson small appliances.

Fridge Care

My G.E. refrigerator has the condenser and fan at the bottom under

the front grille. I'd like to lay the unit on its side so I can clean the condenser coils from underneath. Will laying the fridge on its side cause any problems? Are there any precautions that I should be taking?

BARRY ASHBY
LOMPOC, CA

Laying your G.E. fridge on its side won't harm it, but you should take some precautions.

First, unplug the unit. Remove shelves and drawers from inside of the refrigerator and freezer. Remove the bottom grille for access to the defrost water drain pan and condenser. Carefully remove the drain pan—it may have water in it—and clean the pan. Some newer models have nonremovable pans. In this case, sponge up the water and wipe out thoroughly.

Use a vacuum cleaner with a crevice attachment to remove as much dust as possible from the condenser coils. G.E. sells a condenser coil cleaning brush that's helpful in getting at the condenser's hard-to-reach areas. It's part No. WX14X51 and costs about \$6.

Tape the doors shut and place a blanket or drop cloth on the floor to protect both the refrigerator cabinet and the floor. You can lay the unit down on either side. However, if the condenser is clearly to one side, then lay this side on the floor. Do not run the refrigerator while it's on its side.

Underneath, you'll find fiberglass sound insulation. Do not pull it out or knock it loose—once loosened, the insulation could get into the fan and block the airflow through the condenser coils. When you're done cleaning the condenser, raise the refrigerator back up, insert the shelves and drawers, and plug it in.

Readers with other brands of refrigerators may have to leave the unit in the upright position for a few hours after cleaning before plugging in. Check with the manufacturer for the appropriate waiting period. **PM**

DO YOU HAVE AN APPLIANCE PROBLEM?
Just ask Steve about it. Send your question, along with the model and serial numbers, to Appliance Clinic, Popular Mechanics, 224 West 57th St., New York, NY 10019. While letters cannot be answered individually, problems of general interest will be discussed in the column.



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SmartLevel is a dramatic advance over the conventional bubble level. As you might expect, the idea came from a Silicon Valley

engineer, who first made his living as a trained carpenter. His work reflects the "state of the art" in the use of microelectronics and tool design.

Electronics: The Big Difference

SmartLevel's advanced digital electronics consist of a patented micro-calculator and gravity leveling sensor, housed in a tough polycarbonate module. That's the heart of the system. And what a difference over the old bubble!

Just four large buttons control the functions: on/off, leveling modes, sensitivity, and leveling reset. The LCD provides a clear digital readout of all functions. And the whole system runs on one standard 9-volt alkaline battery. It's that simple.

SmartLevel is a real "knockabout" tool. The sturdy 6-inch Sensor Module is weather-resistant, and truly rugged. Being tossed around or rained upon won't faze SmartLevel.

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The sleek aircraft aluminum and teak rail introduces the latest improvements in tool design. It is beautifully balanced and easy to handle, due to the unique triangular shape and broadened base. The teak complements the strong aluminum frame, and was chosen especially for its strength, durability, and

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Sensor module w/4' teak rail	SMT94		\$129.95	\$
Sensor module w/6' teak rail	SMT96		\$154.95	\$
Additional Components				
Sensor module only	SM		\$79.95	\$
2' teak rail only	TR2		\$25.00	\$
4' teak rail only	TR4		\$50.00	\$
6' teak rail only	TR6		\$75.00	\$

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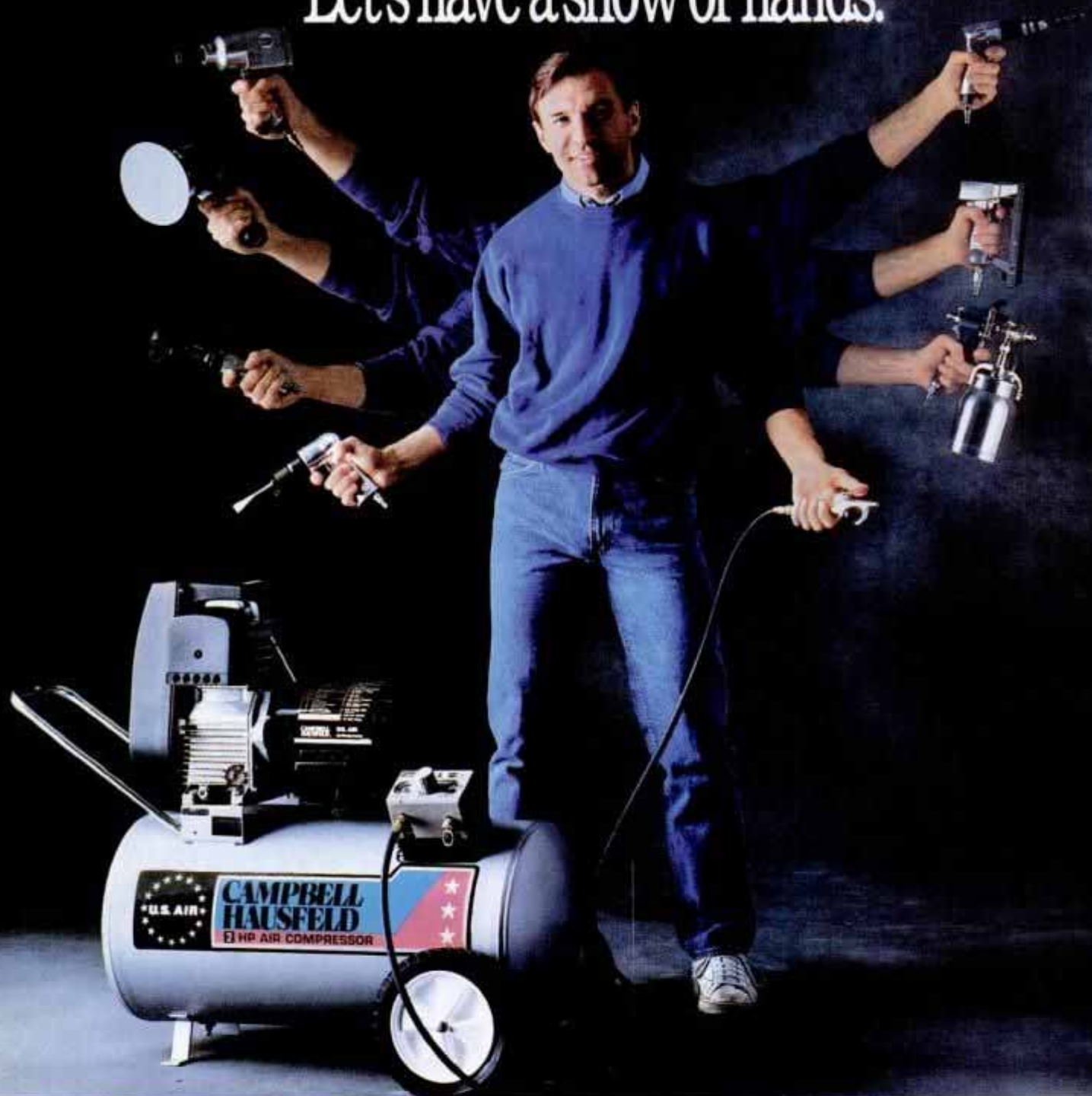


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NEW PRODUCT

RADON VENTING SYSTEM

THE concern over radon gas continues to grow as more communities across the country find higher concentrations of this gas in their homes. In some cases, passive mitigation seems to work just fine. By sealing all the openings in foundation walls and floors, many homeowners have been able to reduce the radon concentrations to acceptable levels.

But when this technique falls short, active mitigation is the only option.

The radon ventilation systems shown here were designed to provide active mitigation in a kit form that homeowners can install themselves. They utilize the sub-slab suction method of radon reduction, a method that's approved by the Environmental Protection Agency (EPA).

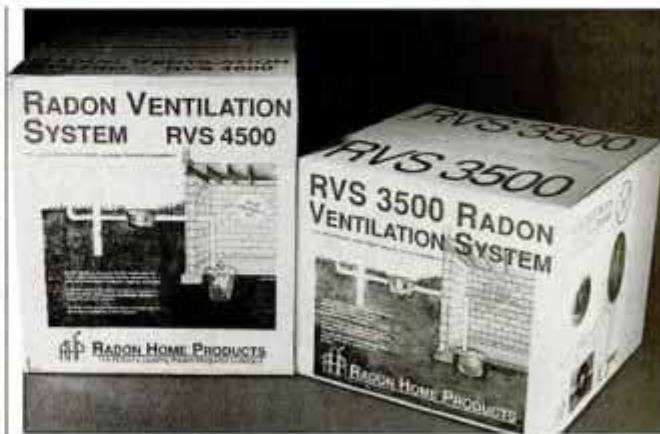
This method removes soil gases—including radon—from underneath the slab and pumps them outside where they dissipate harmlessly. Of course, you need a slab under your house for this system to work. It's not designed for basements or crawl spaces with earthen floors.

Both systems shown here have the following components in common: a radon collector *bucket* that you install below the slab; a weatherproof housing that holds a 6-in. centrifugal fan

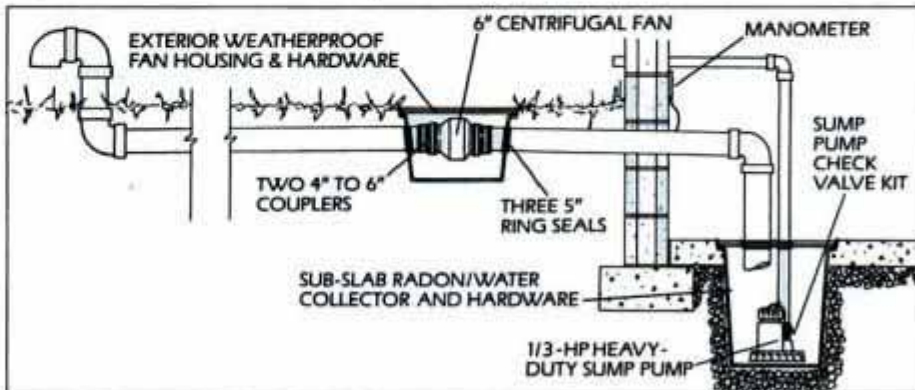
and is installed outside the house; and a manometer that tells you if the system is working. You can either buy the piping that connects these components from the manufacturer or from a local plumbing supply outfit. If your basement is dry, the RVS 3500 system has all the basic components you need. If your basement conditions are wet, either part of the time or all of the time, then you should opt for the RVS 4500. It has the same common components mentioned above, plus a sump pump and check valve to remove the water at the same time that it removes the radon.

The RVS 3500 sells for \$439.95; the RVS 4500 for \$579.95. The optional piping kits are \$58.95 and \$69.95, respectively. Write to Radon Home Products, Retail Distribution Center, P.O. Box 245, Canton, IL 61520.

—Steven Willson



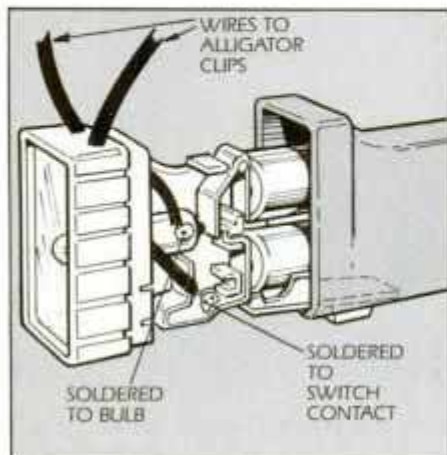
Ventilation kit comes in two different models. The 4500 (left) is designed for slab ventilation in wet conditions. It includes a sump pump. The 3500 (right) is designed for dry conditions.



The system works by pumping radon-laden air from underneath the foundation slab into the air outside where it dissipates harmlessly. Model 4500, with sump pump, is shown.

HINTS FROM READERS

FLASHLIGHT TESTER



For troubleshooting an electrical circuit, a continuity tester is all but indispensable. While you can buy them, I modified an ordinary flashlight to do the job.

I bored two holes in the flashlight case and inserted two wires. One wire was soldered to the ground of the light bulb and the other was soldered to the switch contact that touches the bulb ground when the switch is in the ON position. I then secured alligator clips to the free ends of the wires.

Touching the alligator clips together, or bridging a section of a good circuit, turns the light on. Make sure to disconnect the power before testing any circuit. Because this device sends current through the circuit you're testing, don't use it on integrated circuits such as those used on late-model cars.

—F.L. Seager

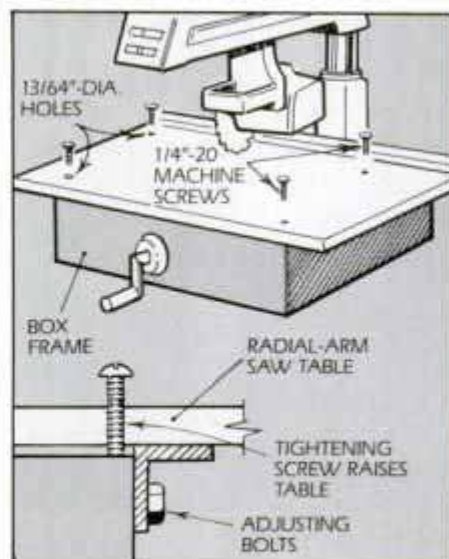
Lock Protector

Have you ever been frustrated by frozen door locks on your car? I beat the problem by covering my locks with an ordinary circular magnet so the moisture can't get in.

Most hardware stores sell the magnets with a hook mounted on the face. Although you can saw the hook off, leaving it on makes the magnet easier to remove.

—Theodore Anastas

Radial-Arm Saw Aid



For accurate work, radial-arm saw tables must be parallel to the arm of the saw. Adjusting the table is normally accomplished by loosening the table adjusting bolts and shifting the table into position.

To make table adjustments more accurate, I use four 1/4-in.-20 machine

So long



screws to raise or lower the table after the adjusting bolts have been loosened. I bored four $\frac{13}{64}$ -in.-dia. holes through the table over the corners of the box frame. The machine screws are then threaded into these under-size holes.

Turning the screws clockwise raises the table; turning them counterclockwise lowers it. The screws are then removed until readjustment is necessary again.

—W.M. Epling

Wallpaper Borders

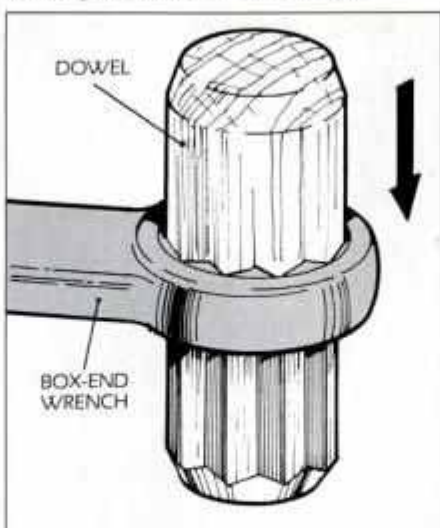
If you like the look of precut wallpaper borders but are deterred by their price, you can make your own.

Simply choose wallpaper with regularly appearing vertical stripes and cut the paper along its length following the stripes.

Depending on the pattern, it's often possible to cut full-roll-length borders by winding the roll tightly and cutting on a band saw with a fine-tooth blade. If the cut must end precisely on a pattern line, then do the job with scissors.

—Robert L. Taylor

Shop-Made Dowels



The next time you run out of fluted dowel pins for a woodworking project the solution may be lying in your tool box. Driving dowel stock through a box-end wrench with a hammer will make fluted dowels to any length. Use a $\frac{7}{32}$ -in. wrench for $\frac{1}{4}$ -in.-dia. dowels, $\frac{11}{32}$ -in. wrench for $\frac{3}{8}$ -in. dowels and $\frac{7}{16}$ -in. wrench for $\frac{1}{2}$ -in. dowels.

—Kenneth E. Kobezak

Charcoal Starter

If pine trees grow where you live, and you like to cook on an outdoor barbecue, here's a tip that may save you a few dollars on lighter fluid. Simply lay a pine cone in the barbecue and stack the charcoal in a pyramid around it. The dry cone ignites immediately and produces a good hot fire in less time than lighter fluid.

—James B. Robinson

Carving Foam




Looking for an easy and neat way to cut foam when making cushions? Try an electric carving knife. The twin reciprocating knife blades make smooth cuts even if the foam's several inches thick.

—Walter E. Burton

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HOME AND SHOP JOURNAL

NEW ACCESSORY PLATE JOINER

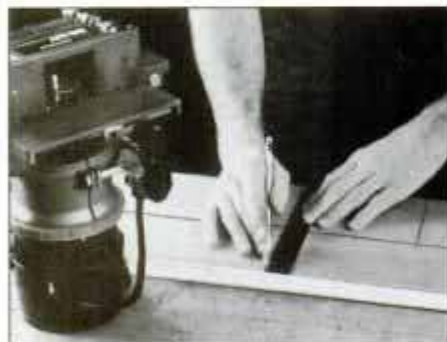


SEAR'S NEW Bis-Kit router accessory was designed to give woodworkers many of the capabilities of a dedicated plate joiner at a fraction of the cost. The kit, as shown above, consists of a base and carriage assembly, a 1/4-in.-shank, 3-winged carbide-tipped cutter and an assortment of standard compressed beech biscuits.

To install the kit, just remove the existing base plate on your router, replace it with the new base and carriage assembly, and tighten the cutter securely in place. This change-over takes just a couple of minutes.

The tool does have its limitations, though. You cannot cut joints in the middle of a board surface—to join a bookshelf to an end upright support, for example—but it does easily handle edge joining boards which is the primary plate-joining task. The kit sells for \$39.96 at Sears stores and through the Power & Hand Tool Catalog. For more information and details, write to: Sears, Dept. 703-PM, Sears Tower, Chicago, IL 60684.

—Steven Willson



1 To use the tool for edge joining, begin by establishing centerline for biscuit slots. Mark across surface of both mating boards.



2 Turn on router and push cutter into board edge. Then slide from side to side until index aligns with biscuit size marks.



3 Cut matching groove on mating board edge. Then apply glue to grooves and board edges. Insert biscuits and clamp.

LONG HAULERS

(Continued from page 64)

ginning to get a bit dated. The age shows in the lack of amenities—the headlight dimmer switch is still on the floor, for example, and there's no trip odometer.

The Club Wagon version of Ford's van is designed to carry seven—four seated in rotating captain's chairs, with three more positions available in a rear bench seat. The two front seats are also adjustable for fore-and-aft position and rake. The steering column on our Club Wagon is not adjustable, so you better like the driving position, or order the tilt-wheel.

In any case, we were more interested in this van's capabilities as a work truck than the interior embellishments, and in that column Ford gets high marks. The first thing we did was remove the passenger-side rear captain's chair by unbolting the pedestal, and also removing the rear bench by unlatching the quick-releases and lifting it out.

There are a couple of nice touches you don't notice about the Club Wagon until you begin loading mass quantities into its capacious maw. The side door locks in the open position, so you don't have to prop it, and the rear doors have easily removable pins on the retaining straps, allowing them to be opened *all* the way for really big loads, like 4x8 plywood.

Driveability matches the Club Wagon's look. It's a big, rugged van, tall, stiffly sprung for heavy loads and just a little bit underdamped. The steering is typical Ford truck—overboosted and a little numb on center.

But any complaints evaporate when you actually start towing. We towed about 400 miles into Ohio from New York, with a 2-axle flatbed trailer and the PM Racing Mustang, and frankly, there was little difference in the way the van handled. Keeping up with high-speed traffic was not only possible, it was easy, even in the mountains of central Pennsylvania. The 460 delivers 12-13 mpg empty, and an honest 10 mpg towing.

So far, we've had only one problem. The heater hoses that run to the rear-seat heater are routed right next to the EGR pipe, and aren't very well shielded or tied down. As a result, one of them melted, dropping all the coolant onto I-80. It took 3 hours to fix, mostly because the engine compartment is *really* hot, but also because it's nearly impossible to remove the engine cover.

Our next plan is to add a Class III hitch, and tow an even bigger trailer—our new 22-ft. Haulmark race-car hauler. We're sure it'll be up to the task.

—Mike Allen

We thought you'd like to see the nice round numbers you'll get with these Delta saws.

Here's a chance to cut yourself a \$100 rebate check from Delta when you buy either our 18" Electronic Variable Speed Scroll Saw or 14" Wood Cutting Band Saw.

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The 14" Band Saw, with its $6\frac{1}{4}$ " capacity and micrometer adjustable blade

guides, is perfect for contours, straight cuts and resawing.

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626 BRING WARMTH AND BEAUTY HOME

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628 POPULAR MECHANICS "PLANS AND IDEAS" CATALOG

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629 STRAIGHT SHOOTING

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Tips on Wood Finishing 30-page brochure includes details on beautifying and protecting new wood, plus restoration techniques for old wood. Many wood projects are outlined step-by-step, with over 50 photographs plus color charts from Minwax Co. Free

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Up in the air

No one had deliberately flown an airplane into a hurricane before the afternoon of July 27, 1943, when Army Air Corps Maj. Joseph P. Duckworth flew a single-engined AT-6 into a hurricane off Galveston, Texas. He made the trip twice that day, the first time taking navigator Lt. Ralph O'Hair, the second time taking weather officer Lt. William Jones-Burdick. There have been hurricane hunters ever since. However, surveillance aircraft are no longer available in the Western Pacific. The last typhoon surveillance mission was flown into Typhoon Cary on Aug. 15, 1987, ending 25 years of weather surveillance by WC-130 aircraft in the Far East. Since this final flight, meteorologists at the Joint Typhoon Warning Center in Guam have relied primarily on satellite data for typhoon forecasting. Using satellites is also much safer. The Air Force has lost 23 weather planes and 144 crewmen. The last plane, a WC-130H, was lost on Oct. 12, 1974, flying in Typhoon Bess in the South China Sea.

For weather reporting in the Atlantic, however, the National Hurricane Center still uses weather reconnaissance planes such as its own NOAA P-3s and the Air Force's WC-130s out of Keesler. (Not to be outdone, Russian planes flying out of Cuban bases flew into several hurricanes, including Gilbert, last summer.)

If one must fly through a hurricane, Keesler's covey of WC-130s are superbly suited to the task. According to Maj. Lee Moody, a Keesler meteorologist, the WC-130 is a stock, unmodified Hercules airframe that has been fitted with key instruments. Measuring temperature, wind and atmospheric pressure begins the task of profiling a storm for ground-based scientists. Instruments also monitor sea-surface temperature and sea state. A Doppler weather-search radar—augmented by a tail-mounted radar for measuring cloud height—gives an accurate picture of a storm center. Omega navigation equipment slaved to the plane's inertial navigation system accurately fixes the aircraft's position, which is crucial for precision storm plotting. A storm's vertical profile is determined with a dropsonde, a parachute-equipped canister that measures temperature, pressure, wind direction and humidity at 1000-ft. intervals from 10,000 ft. to the surface. A tiny transmitter sends data back to receiving units aboard the aircraft.

NOAA's specially configured P-3 Orion is similarly equipped, according to NOAA's senior aviator David Turner, but has several distinguishing features. A boom on the aircraft's nose is used to mount gust probes—which monitor low-level wind variabilities—and other instruments. The Orion's tail radar gives meteorologists a picture of cloud height and calculates turbulence based on the relative motion of cloud particles.

"I guess flying into a hurricane is dangerous," Turner says. "But so are a lot of things. All in all, we think we're pretty important because we fly right down there in the trenches."

Will men and women flying iron machines be replaced by orbiting satellites? Some meteorologists argue that satellites perform all the functions of an aircraft—without the potential for accidents. But Dr. Bob Sheets, director of the National Hurricane Center, sees a continued role for aircraft in the business of hurricane detection, tracking and especially assessing potential destructiveness:

"I think satellites have nowhere near replaced direct measurements made by aircraft. Satellites have been known to produce errors as great as 100 miles in terms of tracking and by somewhere between 20 and 50 knots

in intensity. That much difference has a major effect in the way the hurricane will push water onto a coastline—and in the way disaster relief parties will respond. A Category Two hurricane may cause evacuations of 100,000 people. A Category Three hurricane—just 20 knots stronger—will cause evacuations of 200,000 people. And we've got situations like that in Texas, Florida, even Atlantic City, New Jersey. The only means of taking these direct measurements is with aircraft."

With NOAA's P-3 Orion and the Air Force's WC-130 in the vanguard, the National Hurricane Center in Coral Gables, Florida, coordinates an array of sensors and instruments that detect and track killer storms. Anchored weather buoys and satellites in polar and geostationary orbits are increasingly capable of analyzing storm intensity. But it still takes men and women aboard rugged aircraft to pinpoint hurricanes and monitor strength.

Despite the mode of gathering, it requires skill and science to analyze the wisps of data that cascade into a full-blown hurricane. Whether from aerial reconnaissance platforms or satellites, hurricane hunting saves millions in property and human life. **PM**

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HELIPORT 2000

(Continued from page 57)

learned is directly transferable to nonmilitary helicopters like the proposed VLCT.

For instance, the Army's weight requirements are stringent and are leading to advances in composite construction that can be used in the commercial sector. The VLCT will be lighter and stronger than any comparably sized helicopter flying today.

Much work is also being done on stability augmentation. All helicopters are inherently unstable. When Sergei Sikorsky, then 14 years old, cut class on Sept. 15, 1939, to witness his father Igor's second flight in the world's first practical helicopter, the VS-300, he was underwhelmed.

"I expected dad to take off and tear around the patch," Sergei recalls. "But the machine got only a few feet off the ground. What I didn't know was that my father was learning to fly the most difficult-to-handle airship known to man. It was a miracle that he was able to keep it upright."

Flying helicopters requires a tremendous amount of skill and hand-eye coordination. This is why, instructors say, the new crop of student helicopter pilots are the best they've seen to date. The reason? They were brought up on electronic games. While most fixed-wing aircraft will continue to fly merrily along if you release the controls, do the same thing with some helicopters and they'll take off for parts not previously intended.

A recent visit to Sikorsky's LHX simulator in Stratford, Connecticut, confirmed the simplicity of future helicopter flight control systems. All inputs go through a single sidestick controller, replacing the collective, the cyclic and the throttle found aboard a normal helicopter. Computers take care of the rest. Control inputs are transmitted by a digital fly-by-light optical system, which is less susceptible to outside interference—like electromagnetic pulses on some future battlefield—than fly-by-wire systems. The VLCT would undoubtedly borrow from this revolutionary flight control system.

According to Bruce Hamilton, a psychologist at Sikorsky assigned to the LHX program, a clean-sheet approach is being taken to study and understand the man/machine interface. The objective is to make the operation of the aircraft as simple as possible for a single pilot, who will have to fly and fight at night while maneuvering as low as possible through terrain. Inroads are also being made in the development of thermal-imaging systems that will allow pilots to operate at night and in zero-ceiling, zero-

(Please turn to page 104.)

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HELIPORT 2000

(Continued from page 102)

visibility conditions. Hughes Aircraft is developing an advanced infrared detection set for the V-22 which will provide this capability. The set detects very small differences in heat to produce an image that resembles a black-and-white TV picture. Night vision systems will have an important role to play in the night, all-weather flight VLCT planners anticipate.

NOTAR tech

The McDonnell Douglas/Bell LHX team are taking a different approach to the issue of helicopter stability with their unique NOTAR anti-torque and yaw control system. Replacing the conventional tail rotor with an enclosed centerline fan and a unique slotted tail design, the maker's claims for NOTAR include simplicity, increased agility and reduced noise. The NOTAR system will also make for safer "hot re-arms" in the field, where a chopper's fuel and armaments are replenished with the turbines running and the tail rotor turning. NOTAR's first commercial introduction will be aboard McDonnell/Douglas's MDX civilian chopper.

The McDonnell Douglas/Bell version of the LHX will rely on a new hingeless/bearingless rotor system. The company has been demonstrating the agility afforded by the new glass-fiber/epoxy rotor by doing aerobatics in a Bell 22. The unhelicopter-like maneuvers include full loops and barrel rolls.

Whatever LHX system is ultimately selected, LHX control modes will foster the kind of agility and precision handling the VLCT will need at tight inner-city heliports.

Costs

According to David Lawrence, director of market planning for Sikorsky and one of the industry's most respected experts, a big challenge for the VLCT will be in reducing the cost of helicopter operation. It costs 5 cents per seat-mile to operate a 747. The cost for commuter airliners like the Shorts 330 ranges from 9 to 12 cents. The figure for helicopters is 50 cents per seat-mile, a significant challenge to the VTOL industry.

But the cost for failing to pursue VTOL technologies, for failing to relieve congested commercial airspace, will be further snarls in the increasingly vital system of moving people and goods. That's something to think about the next time you're seated in the back of a cab when your flight takes off without you. Think, too, about the potential for bringing helicopters and tiltrotors to our city centers—where the people are.

FALL FIRSTS (Continued from page 53)

myriad refinements to tune the geometry and specific components to meet the requirements of the 2-seat roadster chassis. Most significantly, 16x8 wheels with fat 225/55ZR-16 tires replace the 15-in. wheels used on the 560SL. And as you'd expect, an anti-lock braking system with massive stopping power is standard, as is a rear self-leveling system.

If these systems aren't enough to keep you from an unfortunate incident, it's hard to think of a safer place to be than a new SL. First of all, airbags are standard. Second, the SL is the first car to feature a fully automatic pop-up roll bar to protect occupants should the car spend any time with the shiny side down. Computerized sensors tell the roll bar that the car is in a precarious position and the roll bar pops up.

It works. During the press driving session at Estoril Race Course in Portugal, one of the drivers put a 500SL on its roof. Both driver and passenger were securely buckled inside the car and walked away unscathed.

The seatbelt system is the last link in this safety net. The seats, fabricated of high-strength steel and magnesium, are designed to withstand forces generated in a crash without losing structural integrity. In addition, the design allows the integral belts to remain at ideal angles for maximum protection.

We think the new SL just may be the safest car on Earth. And at a rumored price range of \$75,000 to \$90,000 (still pending at press time), the SL surely has to be the status symbol of 1990. —Joe Oldham

Infiniti Q45

Although Nissan went its own way with the styling of its new divisional flagship—the design is more reminiscent of Dearborn than Deutschland—the net is a car similar in size, capability and value to its Toyota Lexus counterpart.

At 0.30, the Q45 gives away a point of C_d to the LS 4000, but it offsets this disparity with substantially more muscle under the hood. The Q45's new 4.5-liter 32-valve dohc aluminum V8 makes 278 hp, and is capable of propelling its 3860-pound mass to 60 mph in 7.5 seconds. The engine is distinguished by high-tech touches, like sodium-filled exhaust valve stems and variable intake valve timing. Like the LS 400, top speed is rated at 150 mph, something we have yet to experience (our first session with the car was in British Columbia).

The Q45's suspension consists of multiple lateral links fore and aft, derived from the new 300ZX, with a

(Please turn to page 106)

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FALL FIRSTS (Continued from page 105)

front antiroll bar and coil springs. There's no air spring option, but Nissan is offering its Super HICAS (for High Capacity Actively Controlled Steering) 4-wheel steering system on the Touring version of the car.

Like the LS 400, the Q45 is quiet and leather-lined inside. However, the interior design scheme is a little less Mercedes, and a little more BMW, with an all-black instrument panel and white-on-black analog gauges. Power gets to the rear wheels through a 4-speed automatic that's linked into the engine management system for smoother operation, and a 3.58 limited-slip differential. Antilock braking is standard.

The Q45 will come to market in mid-November, with the usual laundry list of power options and amenities, priced at about \$38,000. While this inches it closer to some of its target competition, it's still an excellent buy in this category.

—Tony Swan

Infiniti M30

In contrast to its stablemate, which seems almost certain to achieve its objectives versus the competition, Infiniti's M30 coupe may have a little tougher sledding. Priced almost directly against Honda's successful Acura Legend Coupe, the M30 is basically a modestly restyled Nissan Leopard, a car that's been a solid player in the Japanese domestic market for several years. But, in contrast to cars like the Legend Coupe, the M30 feels dated.

The basic package is front engine/rear drive, using Nissan's solidly established 162-hp sohc port-injected 3.0-liter 12-valve V6—the same engine used in the previous generation of Z cars. Mated to a 4-speed automatic with lockup torque converter (the only transmission available), this old smoothie can push the 3465-pound coupe to 60 mph in a little less than 10 seconds, and is generally a little quicker than the Legend Coupe.

It's also a confidence-builder on a twisty byway, with no noteworthy bad habits in the handling department. Antilock braking is standard, and the cast-alloy wheels wear (215/60-15) VR-rated tires.

The M30's standard equipment inventory is consistent with the market niche the Infiniti marketing people are after, including a sunroof, a driver's air bag and more.

But even so, the car's interior and exterior designs don't seem to match the distinctive, contemporary look achieved with the Q45 sedan. Those descriptives will have to wait for the convertible version of the car, which is due in mid-1990.

—Tony Swan

FINDING VACUUM LEAKS

BY MORT SCHULTZ; PM Illustrations by Fred Wolff

THE VACUUM created in an intake manifold when the engine is running isn't really a vacuum—it's pressure that is less than whatever the atmospheric pressure happens to be outside the engine's induction system.

So, if outside atmospheric pressure is 14.7 pounds per square inch but 11.5 inside the manifold when the engine is running, the 11.5 is called vacuum. Consequently, when we talk about a vacuum leak, what we really mean is atmospheric air leaking into a

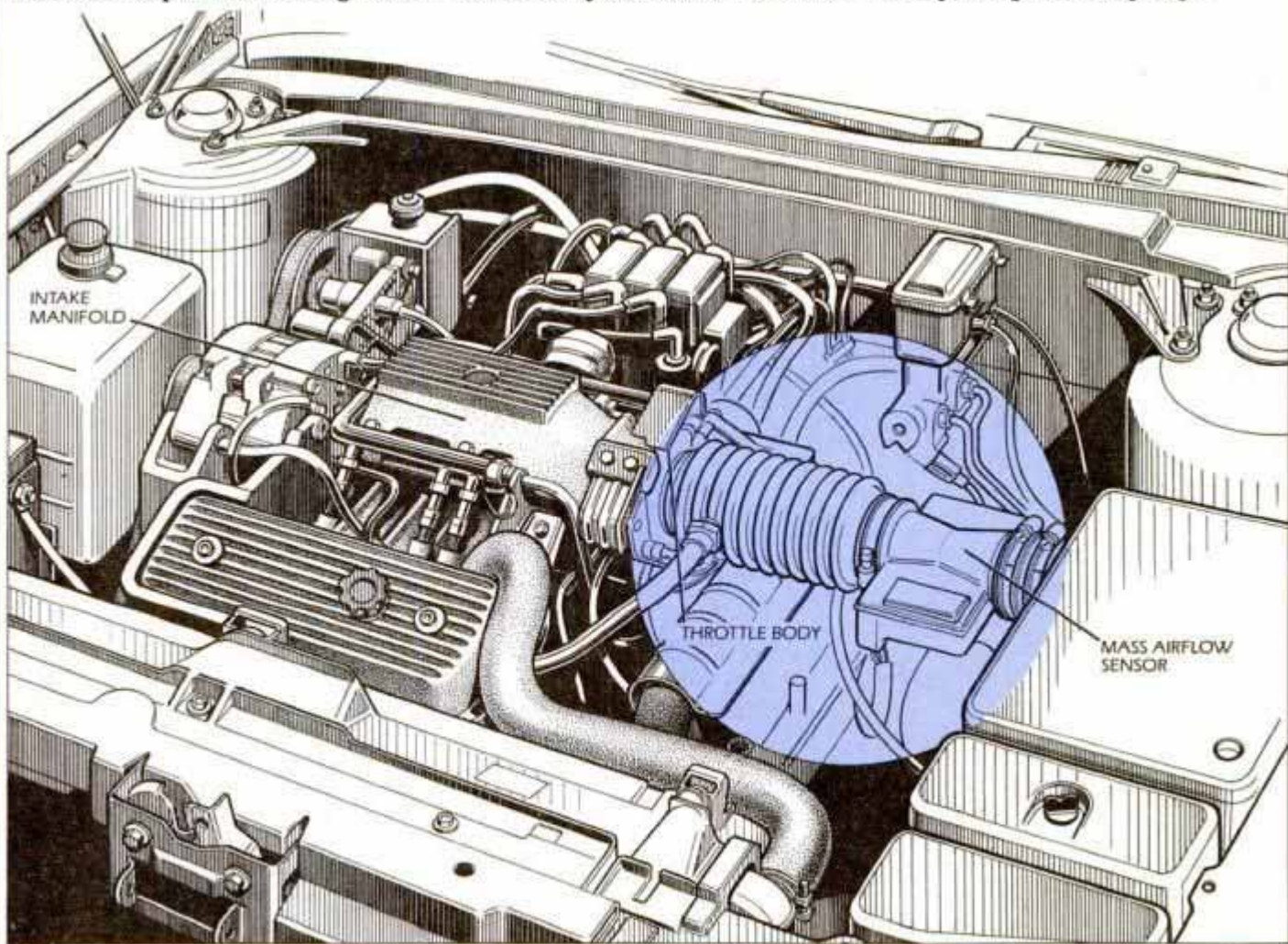
lower pressure area. Auto manufacturers put "check for vacuum loss" at the top of troubleshooting charts.

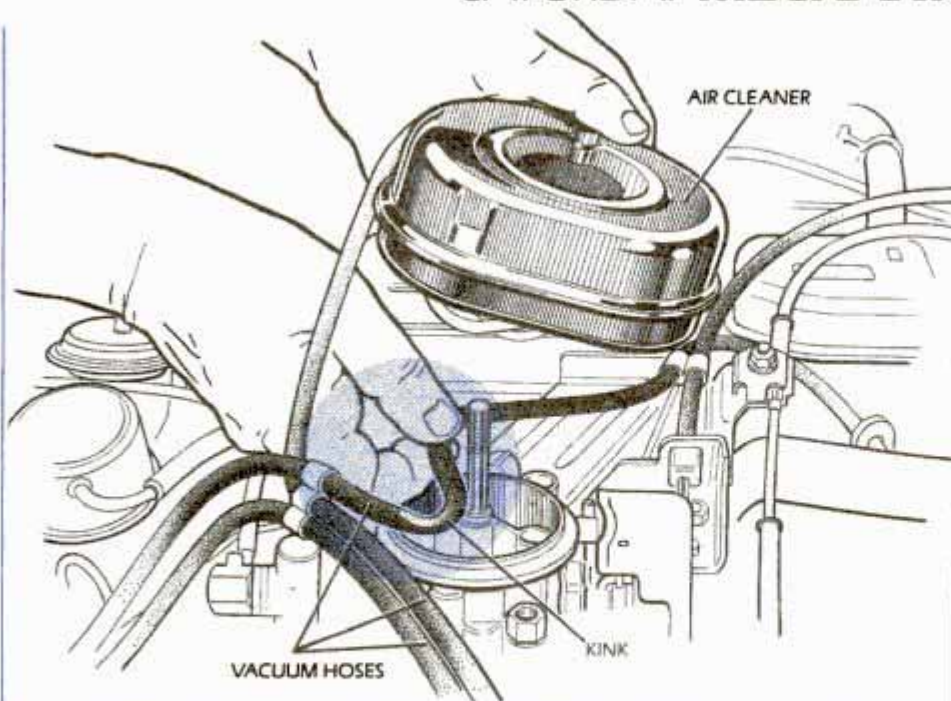
"I estimate that vacuum leaks and damaged vacuum components account for at least 60 percent of the engine driveability problems we're seeing," Dick Emrich says. He's a resident instructor at the General Motors Training Center in Moorestown, New Jersey. "That's why we emphasize the importance of vacuum to our students and teach them several methods they can use to track down

disruptions. Leaks are sometimes very elusive."

The check is threefold: (1) To be sure that air isn't leaking into the intake tract, (2) to see that components that need vacuum to function are really tapping into manifold vacuum, and (3) to be sure no component that is getting the vacuum supply it needs is damaged or malfunctioning.

Although technically not a vacuum leak, even a minor air leak between the mass airflow sensor and the throttle plates can make your engine run really rough.





1 A common source of vacuum-related driveability problems is pinched vacuum lines.

Problems galore

Depending upon which components are affected, the problems a disruption in vacuum cause are stalling, hard starting, hesitation (also known as sag and stumble when accelerating), too fast an idle, rough idling, surging, lack of power, missing, backfire, poor fuel economy, dieseling (engine run-on when the ignition is turned off), pinging (detonation, pre-ignition and spark knock), failure to pass a state emissions test, and a hydrogen sulfide (rotten egg) odor from the exhaust.

Wide-ranging scope

Components that need vacuum to operate are found all over the modern vehicle, meaning cars and light trucks built since 1970. The greatest number of these components, however, are found in 1975 to 1984 models.

Since about 1985, electronics has assumed the role of supplying power to some components that once used vacuum, but vacuum is still necessary for plenty of parts on 1985-88 cars and light trucks.

Depending on the engine, these are the exhaust gas recirculation valve, positive crankcase ventilation valve, fuel pressure regulator, distributor vacuum advance, air cleaner vacuum motor, deceleration valve, choke vacuum break, throttle modulator, manifold absolute pressure sensor, charcoal canister purge valve, air bypass valve, antibackfire valve, dashpot throttle stop, distributor modulator valve assembly, exhaust heat

control valve and a variety of vacuum switches, valves and regulators.

Nonengine parts also use vacuum created by the engine. These include the brake booster, automatic transmission, cruise control and climate control system.

Vacuum created inside the engine by the action of the pistons gets to parts through hoses connected to fittings (vacuum taps) on the carburetor (or EFI throttle body) and/or intake manifold. These hoses are the weakest links in the system, so it's with them that you begin to troubleshoot.

Sounds and sights

Don't get scared off by what seems to be a jumble of spaghetti in there. Although vacuum hoses seem to be everywhere, one that's leaking is not always that hard to pick out.

A leaking hose sometimes an-

nounces its existence with a hiss or whistle. To make it easier to pinpoint which hose among the many you see is creating a vacuum loss, use a 4-ft. length of $\frac{5}{16}$ -in. vacuum hose as a stethoscope. With the engine idling, hold one end of it to your ear and move the other end slowly over each vacuum hose, in turn. Be sure to scan around each component and vacuum tap to which the hose connects. The leak might be there.

If a vacuum hose is leaking where it connects to a tap on the engine or to a fitting of the component, see if it's just loose, and push it on the rest of the way. If not, the defective hose or component should be replaced.

Keep in mind that a hose doesn't have to be leaking for it to be the cause of vacuum loss that affects the operation of a vehicle. It could be blocked. This possibility is more likely when an engine performance problem develops immediately after you've done some work on the engine. You may have kinked or closed off a hose by accidentally shoving a part, such as the air cleaner, down on it (Fig. 1).

The chance of a hose getting clogged with debris is remote, but to make sure it hasn't happened, remove the hose and blow through it.

Squeezing it off

If a vacuum leak is severe enough to cause a misfire or rough idle, and it's not caused by a bad connection to the source of the vacuum (like the manifold or carb), you can sometimes localize it with a pair of pliers. Actually, anything that will squeeze the hose shut without permanently damaging it will do.

This method works best with non-computer-controlled vehicles, as the computer will try to compensate for the lost vacuum, and the idle may very well not be affected. But if the

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IGNITION (THROTTLE)—ADJUST WITH TRANSMISSION IN NEUTRAL.

- (1) DISCONNECT SPARK WIRE (BLACK CONNECTOR) NEAR THE DISTRIBUTOR. RESTART PREVIOUSLY WARNED UP ENGINE.
- (2) ADJUST THROTTLE TO 18" STICK, 800 RPM MAX.
- (3) TURN OFF ENGINE AND RESTORE ELECTRICAL CONNECTION.

FAST IDLE—ADJUST WITH TRANSMISSION IN NEUTRAL, DISCONNECT AND PLUG FOR VACUUM HOSE. PUT THE ADJUSTING SCREW ON KICKDOWN STOP OF THE FAST IDLE CAM. ADJUST FAST IDLE TO 1000 RPM WHEN THE ENGINE COOLING FAN IS OFF (1700 RPM FOR VEHICLE WITH LESS THAN 100 MILES). RECONNECT SPARK WIRE.

CHISEL IDLE—ADJUST WITH TRANSMISSION IN NEUTRAL. DISCONNECT AND PLUG VACUUM OPERATED THROTTLE MODULATOR. ACTIVATE ENGINE COOLING FAN BY PULLING A ZIPPER WIRE FROM THE FAN CONTROL TO GROUND.

ADJUST IDLE TO 800 BY TURNING ADJUSTING SCREW ON THROTTLE LEVER (700 RPM FOR VEHICLE WITH LESS THAN 100 MILES). ADJUST IDLE WITH TRANSMISSION IN SPLOTTED POSITION. RESTORE ELECTRICAL AND VACUUM CONNECTIONS.

IF IDLE ADJUSTMENT IS MADE, CHECK/ADJUST SOLE VEIL SETTING. SEE SHOP MANUAL.

IF IDLE ADJUSTMENT EXCEEDS 80 RPM, REEVALUATE TRAILER UNLOAD. SEE SHOP MANUAL.

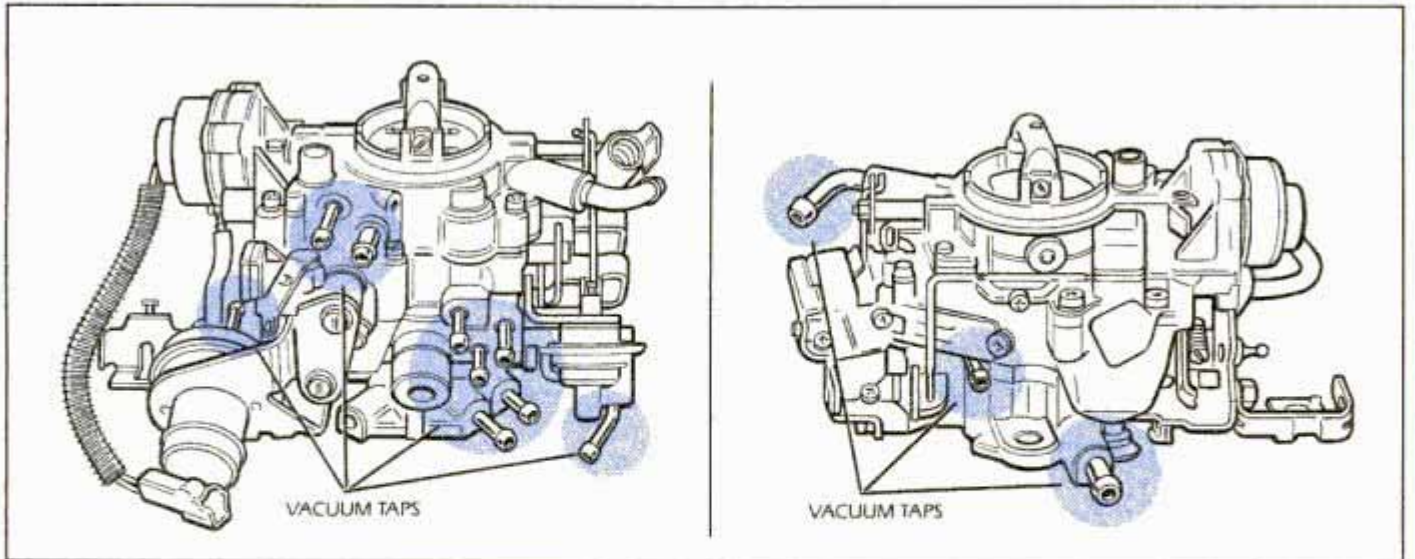
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VACUUM HOSE ROUTING

2 This engine compartment sticker will show you how that underhood spaghetti connects.



3 As if 12 vacuum taps weren't enough to have to deal with, some of these have several tees branching from them.

leak is severe enough, even the computer won't be able to compensate.

Use the pliers to squeeze the hoses close to the manifold or vacuum supply. If the idle quality picks up, the leak or malfunctioning component is outboard of the clamp. You can then move the clamp along the hose, away from the manifold, following any branches in the line. Or it's possible that the component, say a cruise control or choke pull-off, is defective and leaking. If so, then you'll be able to pinch the hose right next to the suspect component and still see a change in idle.

Chart chat

Use the vacuum hose routing chart mounted in the engine compartment (Fig. 2) to identify vacuum hoses and vacuum components. If it's missing or obliterated, you'll have to trace each hose back from its fitting on the engine to find branch hoses and vacuum components that intersect with it. This means first removing the air cleaner to locate the vacuum taps on the carburetor or throttle body and intake manifold (Fig. 3).

Other leak points

Not all vacuum leaks originate at the hoses. One common point is the carb or throttle body attach bolts. Intake manifolds can become loose where they meet the head. This type of leak can sometimes be found by spraying carb cleaner (*not* brake cleaner) on the suspect area. If the idle smooths out or picks up, the carb cleaner is being sucked in and burned. The vacuum leak has made the mixture too lean, so the extra fuel you spray in makes it richer momentarily, and

you've found the leak. Be careful, since carb cleaner is highly flammable (which, of course, is why it works).

Unfortunately, this method is less effective on computer-controlled systems, as the computer sees the lean mix and compensates automatically.

Fortunately, tightening the offending bolts near the leak often seals it up. If not, you may have to replace the gasket involved.

Using a vacuum gauge

There's no substitute for a vacuum gauge if you're troubleshooting a rough-running engine. If you're in the market for one, consider a handheld vacuum pump which incorporates a gauge. As a gauge, it can help you determine if engine vacuum is to specification and also if there is a nonvacuum-related defect. As a detection instrument, it can help you to find a leaking vacuum hose and damaged vacuum components (Fig. 4). Let's see how each is done.

Vacuum gauges are calibrated in terms of inches of mercury (in./Hg) instead of atmospheric pressure, to make them easier to read. They are set to give a reading of zero when the engine is off, instead of whatever the atmospheric pressure happens to be where the test is being made.

You need to know the exact vacuum specification for your engine. The range of 17-21 in./Hg, which is recommended by many general automotive repair manuals, is no longer applicable to most modern engines. Using it can lead to false test conclusions.

For example, the Buick 3.8-liter V6 engine with plenty of valve overlap has a normal vacuum of 15 in./Hg. Overlap means that during a combus-

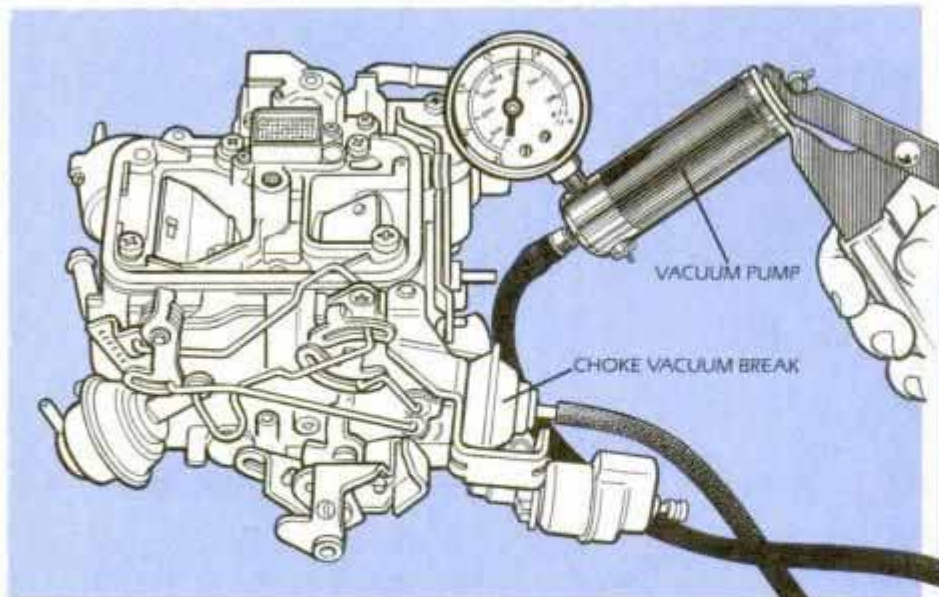
tion cycle the exhaust and intake valves in a cylinder are open simultaneously for a brief period. At high engine speeds this actually increases power, but at idle speeds it reduces vacuum somewhat. If you refer to that 17-21 in./Hg range on this engine, you may go in search of a vacuum leak that doesn't exist.

In checking vacuum with a vacuum gauge, keep in mind that specifications in service manuals are sea-level readings. That reading will drop by 1 in./Hg for every 1000 ft. you are above sea level. For example, a reading of 20 in./Hg in New York City (sea level) would be a reading of 15 in./Hg in Denver (5000 ft. above sea level) for the same engine. So, if you're in Denver and take the service manual reading as gospel, you could go wrong.

To see if the vacuum developed by the engine is up to spec, you have a few choices. You can disconnect a vacuum hose from a vacuum tap on the carburetor, TBI or intake manifold and connect the gauge to the fitting. Or you can disconnect the vacuum hose from the brake booster, remove the check valve and connect the gauge to the end of the hose—you will probably have to use an adapter to do this. Or you can disconnect a vacuum hose from an engine vacuum component and connect the gauge to the end of the hose—again, you'll probably have to use an adapter.

If there's any leak between the gauge and the source of vacuum, a true reading won't be obtained.

There's another important point here: Make sure the source of the vacuum into which you tap the gauge is manifold vacuum—not ported vacuum. Manifold vacuum is true engine



4 A handheld vacuum with gauge is essential for diagnosing problems.

vacuum. Ported vacuum is less than manifold (true) vacuum and will, therefore, lead to an erroneous test reading. A manifold vacuum tap is positioned below the carburetor or TBI throttle plate. A ported vacuum source lies above the throttle plate.

And there's still another precaution. If you decide to attach your gauge to a vacuum hose, see that the hose doesn't use a vacuum restrictor or vacuum delay upstream of where the gauge is connected (Fig. 5). This will affect the reading.

Start the engine and allow it to warm up. With the engine running at idle speed, the vacuum gauge should show a normal reading that holds steady. The gauge needle should neither waver nor drift.

Then, open and close the throttle rapidly. The gauge needle should drop below 5 in./Hg, bounce up to 2 or 3 in./Hg above normal and then settle at normal.

Suppose the needle holds steady at idling speed, but stays in the 4- to 7-in./Hg range. There's a loss of vacuum from the engine itself. Most often this loss is caused by loose carburetor or TBI mounting bolts, or a bad gasket between the carburetor or throttle body and intake manifold. Hopefully, that is. Otherwise, piston rings may be worn or there may be a loss of vacuum around the valves. Do a cylinder leakdown test to check out nonvacuum-related defects.

Suppose the vacuum gauge needle doesn't show a normal reading, but neither does it show a loss of vacuum. This is what you may be up against:

■ **A steady reading at idling speed of 8 to 14 in./Hg:** Ignition timing isn't set properly or there's a compression leak past the piston rings. A vacuum gauge needle that wavers slowly by 2 to 6 in./Hg from normal also suggests a compression leak.

■ **A sharp back-and-forth fluctuation at idling speed of about 5 in./Hg from normal:** Suspect a leaking head gasket or worn valve guides.

■ **A slow drifting at idling speed of about 5 in./Hg from normal:** The carburetor is not adjusted correctly.

■ **A steady reading at idling speed above normal:** There's a restriction in

the air-intake system. Look for a clogged air filter or sticky choke.

■ **A reading that drops to near zero when the throttle is opened and closed rapidly and rises but doesn't hit normal:** Look for a restriction in the exhaust system.

Along with cracked hoses and a bad carburetor (or TBI) gasket another cause of engine problems because of vacuum disruption is a split vacuum-component diaphragm. In other words, the component won't work although it's getting vacuum. To compound the problem, air is leaking into the intake, making the mixture lean.

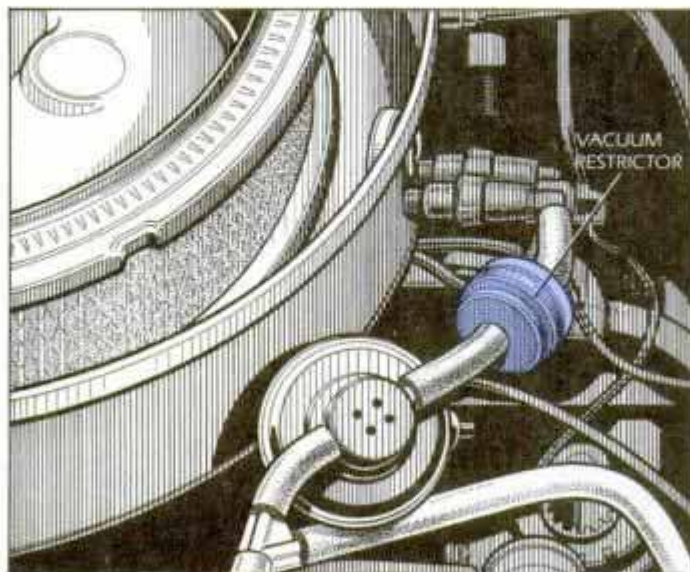
It takes patience to find out if there is a bad part. You may have to test all of them until you finally hit the one you're looking for. Disconnect the hose from the vacuum fitting of each component, attach the hand-vacuum pump to the fitting and apply vacuum. If the gauge needle doesn't rise or rises and falls, the part is defective.

About MPFI

Just because your engine has a multi-point fuel injection (MPFI) system, don't think you're off the hook. It too has engine vacuum taps that feed vacuum components. But as critical—and even more devious—is any leak at a point downstream of the mass airflow sensor. It will present you with an engine performance problem that will make you want to pull your hair out. If more air is sucked into an MPFI engine than the mass airflow sensor is supposed to let in, it will cause performance trouble in spades.

Okay, technically it can't be called a vacuum loss—the pressure in this area is usually not much less than atmospheric, and certainly isn't as low as inside the manifold. But it is downstream of the airflow sensor, so it's unaccounted for by computer.

Finding leaks here can be tougher, because there's usually no noise associated with them. You'll simply have to look for loose hose clamps, cracks hiding in the accordion pleats of the connecting piping, or cracks in plastic tubes. The carb cleaner trick sometimes works, but in order to keep from singeing off your eyebrows, be sure not to spray too near the distributor or the wiring.



5 Be sure your gauge taps into a vacuum line upstream of any vacuum restrictors. Otherwise, the gauge readings will be misleading.

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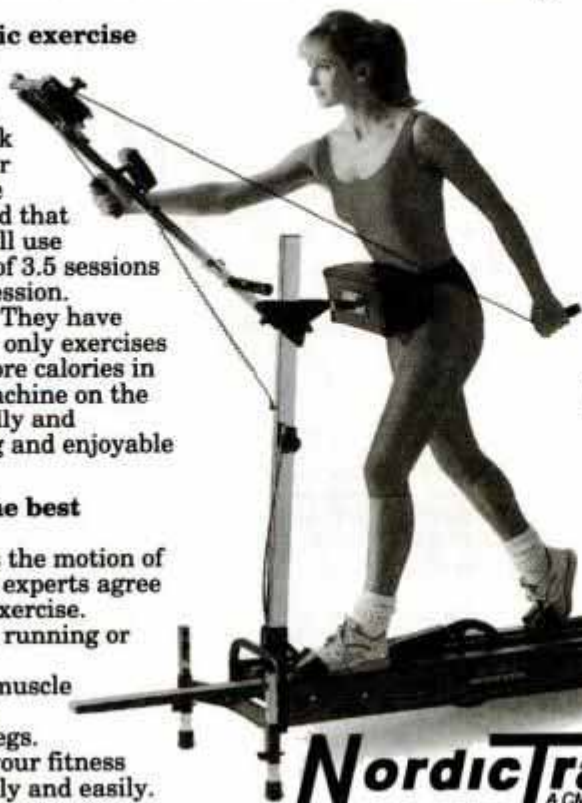
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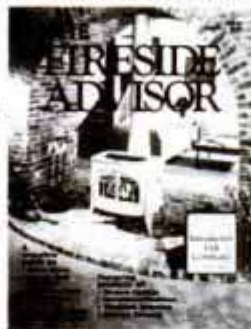
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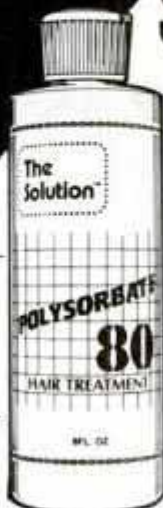


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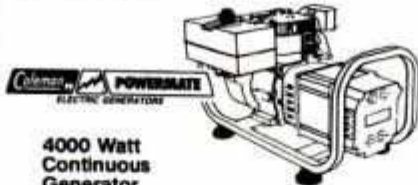
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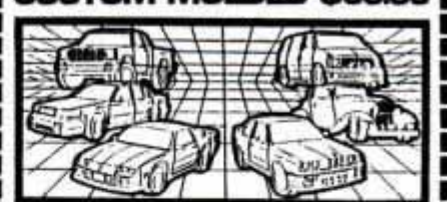
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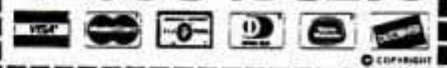
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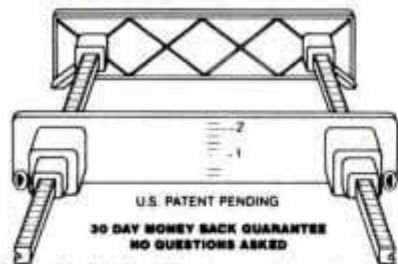
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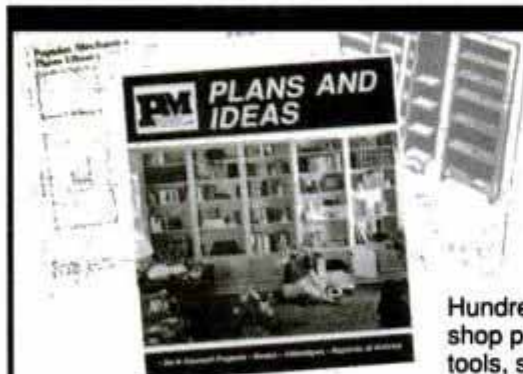
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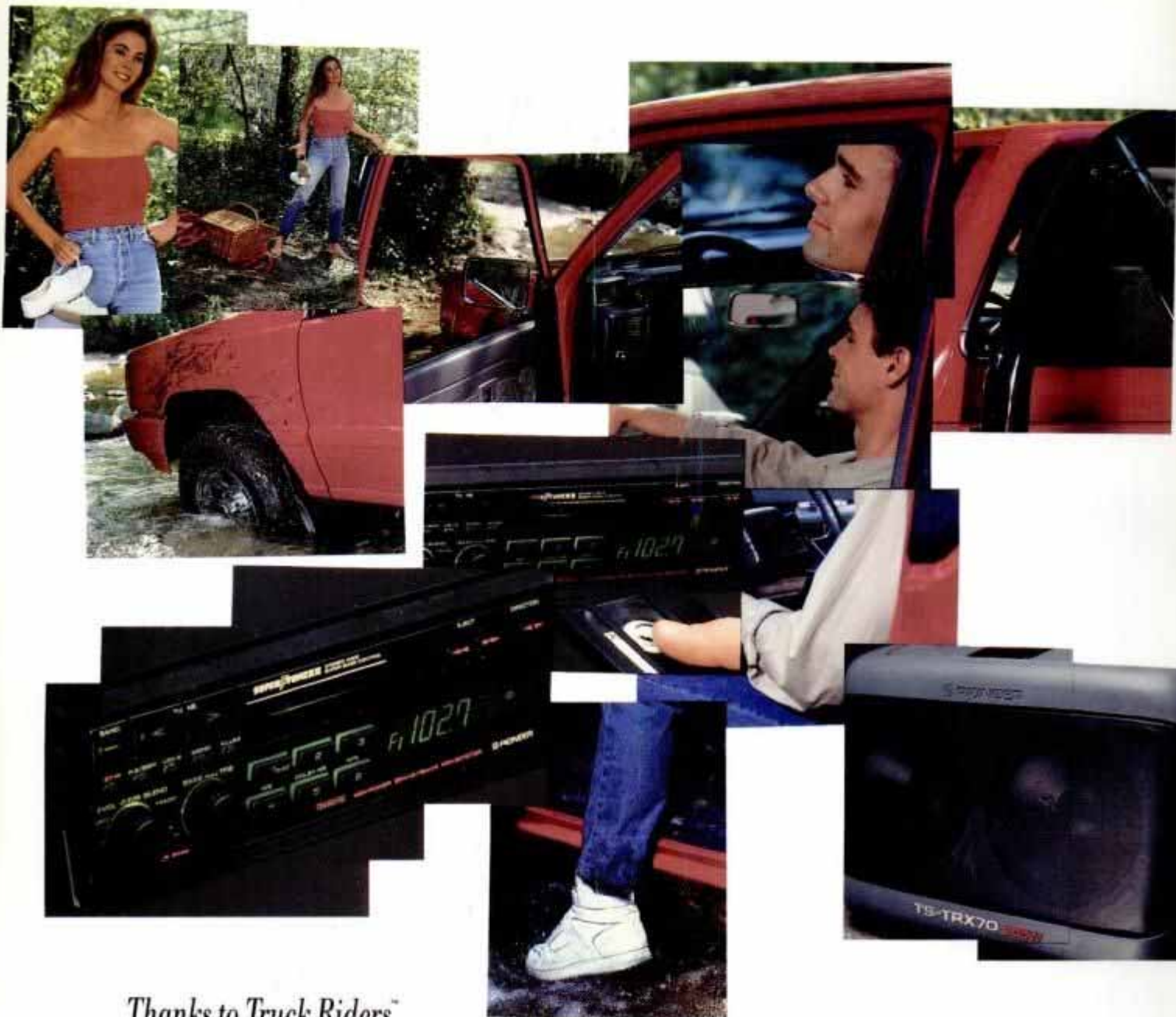
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