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VOLUME 170
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EDITOR'S NOTES

● Hey, here we go again! Racing, that is. If you're a regular reader, you know this is a pretty common activity for us. POPULAR MECHANICS has been involved in racing ever since there was such a thing as racing. We even covered the first Indy 500 in 1911. Our photographer? Henry Ford. In the past few years, we've been involved in showroom stock road racing, Baja off-road competition and, last year, in the SCCA Trans Am Series. Now, we're really going big league for 1993 as we team up with Dick Simon Racing, headquartered in Indianapolis, to compete in the PPG IndyCar Series, including the famed Indianapolis 500. We'll have our name on three cars throughout the series—those driven by Scott Brayton, Raul Boesel and Jimmy Vasser. The whole story is in our special IndyCar coverage this issue, beginning on page 46,



Meet the PM/Dick Simon Racing drivers (l. to r.): Scott Brayton, Raul Boesel and Jimmy Vasser (and me). As we went to press, Boesel and Vasser finished 2-3 at Phoenix. More next month.

and includes a great cutaway poster of Scott's car. Meanwhile, watch the IndyCar series at a track near you or on ABC and ESPN and in our Motorsports pages all season long. So come along for the ride and help us cheer our guys home. . . . Our cover story this month is ostensibly about a new aircraft design—a passenger airliner that can take off and land like a helicopter, straight up and down. But really, it's an article about congestion in our cities and at our airports. An airport with runways takes up huge amounts of land—a scarce and valuable commodity, especially in or near large cities where most people want airports to be located for convenience. A vertical takeoff/landing site takes up only a fraction of the land required for a conventional airport, allowing land and space to be used for other people-friendly uses. Sounds like a great idea to me. Now if they can only get it off the ground. . . . If you're one of our readers who likes to play Mr. Fix-It around the house, our Home Improvement editors have put together a terrific little minisection for you this month that guides you through some of the more common appliance repairs you're likely to encounter. Check out "Basic Appliance Maintenance" in the Home & Shop Journal beginning on page 63. . . . No question that the new-generation Camry is a grand-slam home run for Toyota. It's a great-looking, great-performing car, as we said last year when we long-term tested one. And Toyota's selling the hell out of it. So what's the problem? Find out in our exclusive Owners Report on page 33. Till next time.


Joe Oldham

Popular Mechanics

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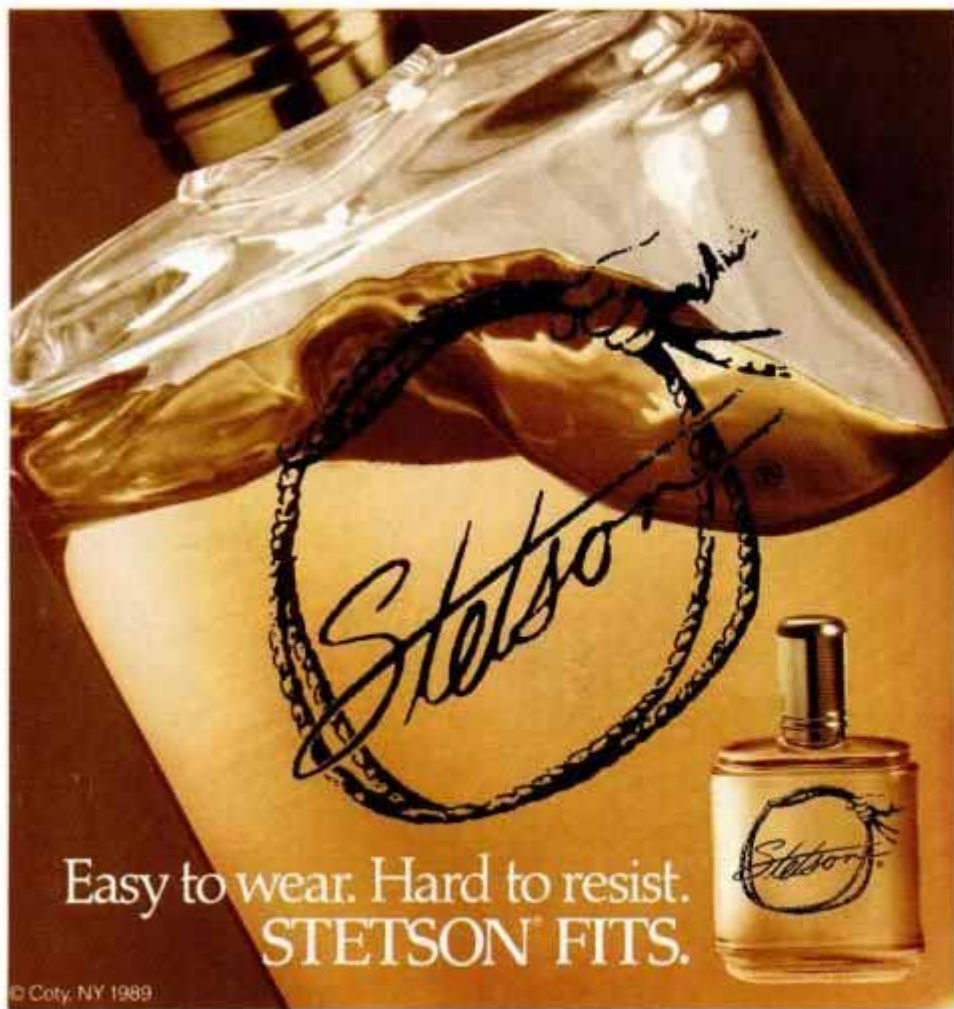
L.C. Shaffer's 1924 Two-Owner Classic (An Unbelievable True Story)

In 1951, L.C. was given a Coleman® stove that its original owner had used since 1924. L.C. thought it might still have some life in it. So for the next 40-odd years, he fired it up on every hunting trip and at every fishing hole. And used it every day at every construction site he worked. Including a big job in Nevada when he cooked three meals a day on it for nine months.

L.C. is now 81, and his Coleman stove is 69. L.C. says they're both a long way from retirement.

Coleman 

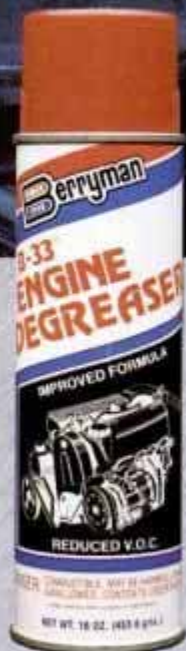
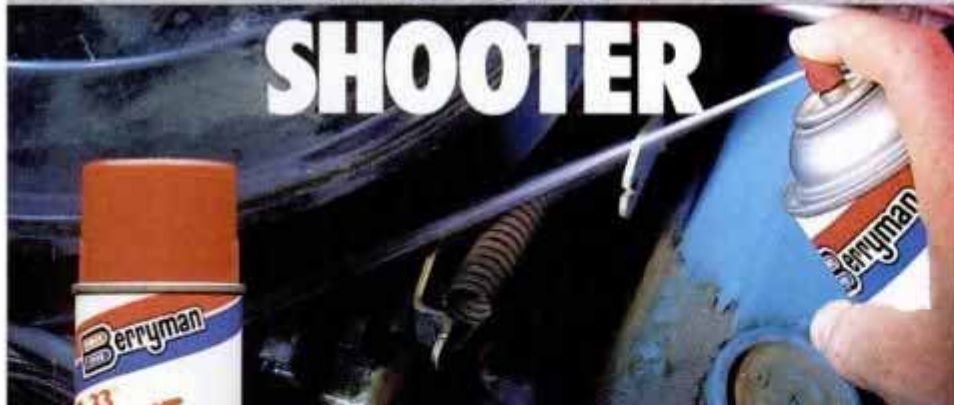
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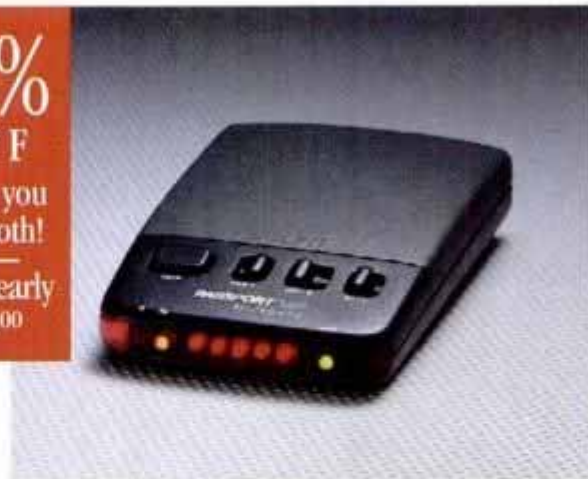
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All Aboard!



Your story on America's version of the bullet train was very coherent and easy to understand, much more so than any formal railroad magazine that has written about the project. I have always loved trains, and can recall being the only African-American youngster throughout grade school to express a career interest in becoming a locomotive operator with Amtrak.

DARNELL W.M. TERRY
ANN ARBOR, MI

The tilting bullet train strikes me as rubber gloves for a leaky pen. If we really want to revitalize American rail travel, we should be building new straight-level railways without road crossings.

JIM CABOT
LEHIGH ACRES, FL

Is the X2000 really America's first bullet train? In terms of absolute speed, the Amtrak Metroliners were designed to be capable of 160 mph, and one was pushed to 165 mph during a test in March of 1969. At about the same time, Turbotrains built in the U.S. for Canadian National Railways and the U.S. Depart-

Letters are subject to editing for length, style and format.

ment of Transportation reached 171 mph in tests. Neither, however, were allowed to operate at these speeds because of antiquated signaling and roadbeds. These projects were initiated more than 25 years ago. There's no telling where we would be now had some of the \$2 trillion that went into defense over the past two decades been redirected to other technologies, including high-speed rail. At the very least, we wouldn't have to purchase our high-speed trains elsewhere.

MARK D. WILLIAMS
SACRAMENTO, CA

I'm happy to see the old technologies of movable axles, tilting car bodies and regenerative braking are being put to use.

DALLAS SCHMITT
BELLEVILLE, IL

It has been a little over a year since I was struck by a 55-mph Norfolk-Southern train in a station in North Carolina while standing in the "loading area," shooting some video. The air currents pulled me off balance and did permanent damage to me and my equipment. The railroads kill and in-

jure thousands of innocent people every single year. Until the federal and state governments get their act together and require adequate safeguards for the population, these bullet trains are out of the question!

MICHAEL EDWARDS
WILMINGTON, NC

According to your explanation, cars tilt and axles pivot, except for the locomotive. Nothing is said about the engine's axles. If high-speed cornering is possible because of the cars' innovative tilting and pivoting capability, what permits the locomotive to high-speed corner? Why doesn't the slight misalignment of the wheels-to-curved-track force the engineer to slow down to keep the wheels from jumping the track?

S.K. MIDDLETON
PHOENIX, AZ

Science/Technology Editor Abe Dane replies: *Although the locomotive doesn't tilt, its axles have the same flexible suspension as those of the cars. It's this suspension that keeps the wheels on track. The tilt simply makes the ride comfortable.*

In reference to the train's regenerative dynamic braking system, how will the regenerated power be synchronized with the catenary's AC power to transfer it back into the catenary?

ALAN M. FINKELMAN
ENDICOTT, NY

Dane replies: *Modern AC-propulsion locomotives are stuffed with solid-state power-conditioning electronics. When the motors act as alternators, the power generated flows first through this circuitry, which converts the current from AC to DC. It then converts the DC to AC, synchronized with that in the catenary.*

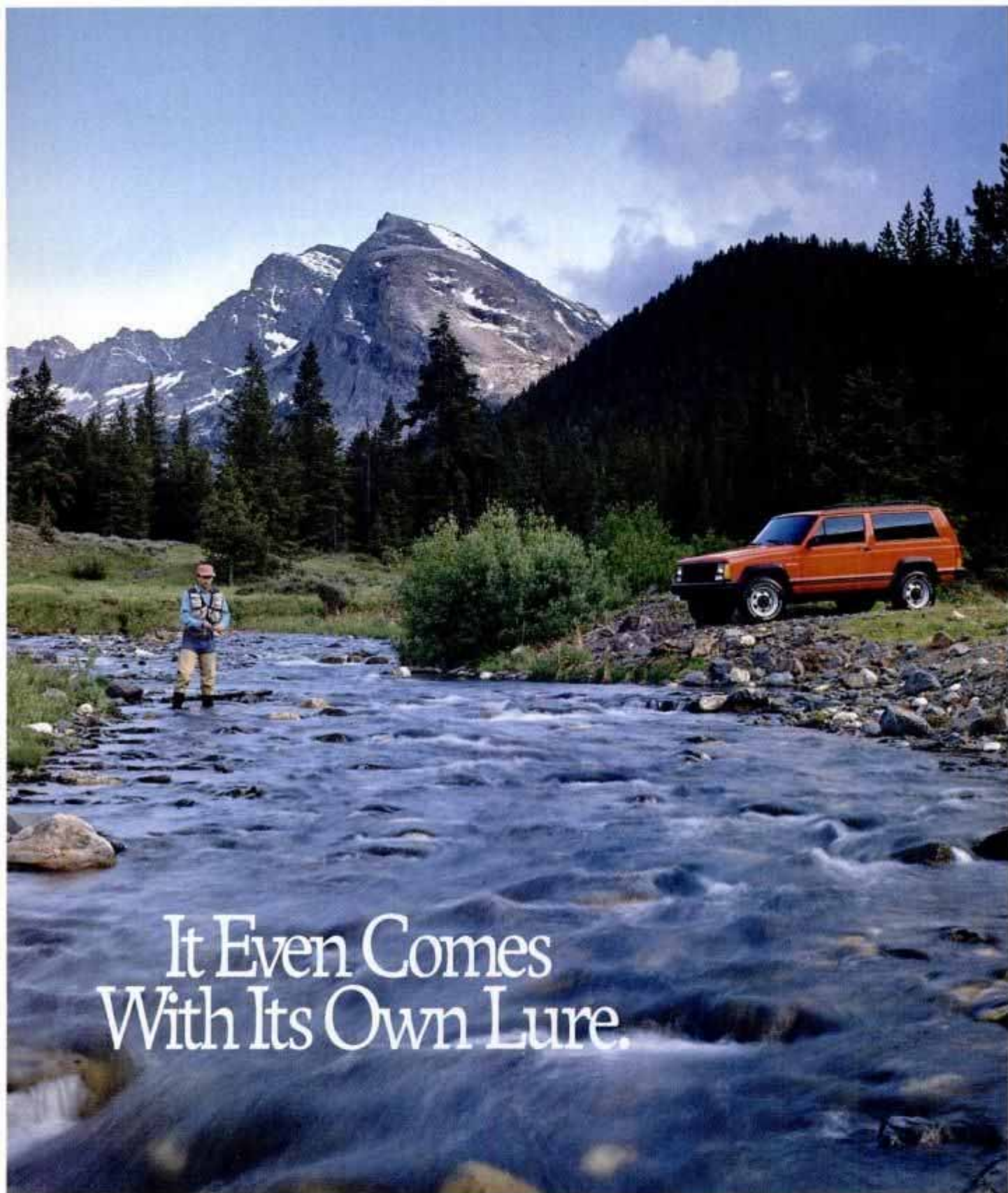
Red Oak Racer

When I was a little girl, my dad always had POPULAR MECHANICS magazines and POPULAR MECHANICS Do-It-Yourself Encyclopedias around the house. I'd often dream of making all the fun projects outlined in your materials. I finally fulfilled my dreams by building the red oak racer featured in your Home & Shop Journal section. Your staff did an excellent job writing easy-to-follow plans and providing photos and technical drawings that were most helpful. I used some oak stair-step planks a neighbor gave me. They were accidentally left outside and weathered too badly to be used as stairs. I was able to plane the planks down to the specified widths and sizes needed to make a racer for my little friend Dallin. I look forward to making more of the projects I used to only dream about.

JILL SPENCE
ANAHEIM, CA



Reader Jill Spence built this wagon for her friend Dallin.



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Why is Hunter the style leader?

Below is just a sampling. With over 278 styles to choose from, you may soon find yourself wanting a Hunter fan for every room in your home.



Why do Hunter fans move more air?



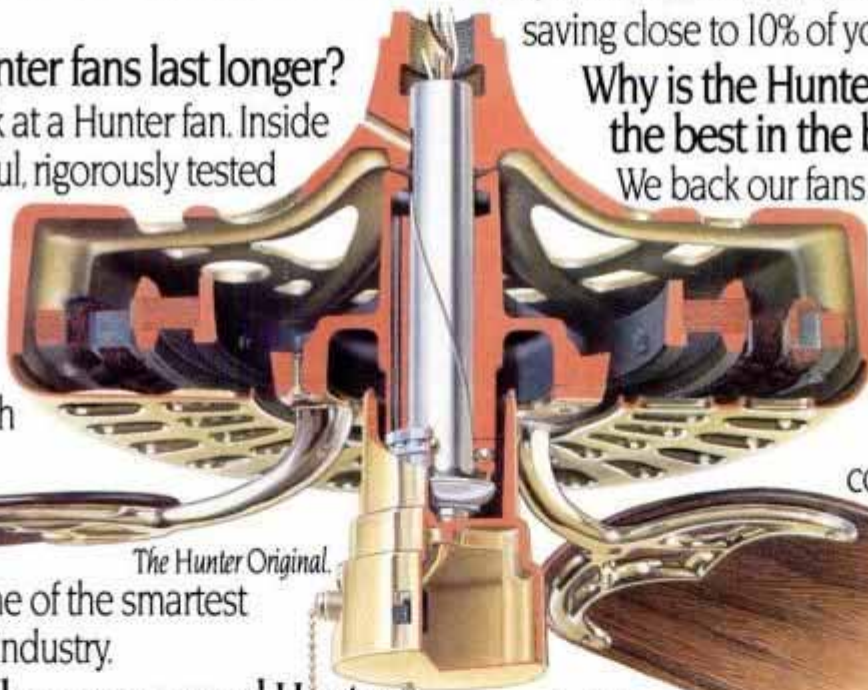
Hunter.

Others.

The greater the angle of the blade, the greater the air movement. And because we don't compromise on the motor or materials, we're able to set our blades at a more severe pitch for greater air movement. And greater comfort.

Why do Hunter fans last longer?

Take a good look at a Hunter fan. Inside you'll find a powerful, rigorously tested motor with high quality shielded bearings that keep out dust and dirt. And outside, a finish second to none.



The Hunter Original.

Plus, of course, some of the smartest engineering in the industry.

Was there actually a man named Hunter?

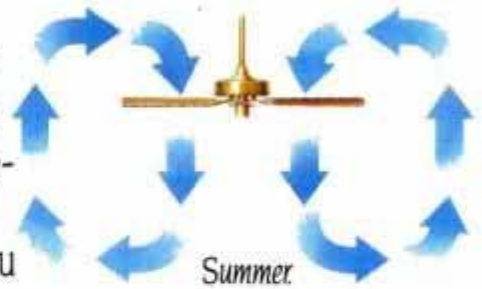


Yes. Two of them, in fact. Over 100 years ago, John Hunter and his son, James, by making use of a new fangled technology called electricity,

unveiled the world's first electrically powered ceiling fan. And from that point forward, made sure that the name Hunter stood for quality and craftsmanship.

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TIME MACHINE

90 YEARS AGO: JUNE 1903

POPULAR MECHANICS

Telephone Without Wires a Success



When two ships passed in the night, a telephone call passed between them. The setting was the Hudson River, where Fulton's steamboats first ran. On each vessel, wires snaked from a receiver/transmitter in the pilothouse to a copper plate held under water. Although "the messages were not as distinct as they can be made," they were clear enough to encourage further experiments in ship-to-ship communications.

Ship Talk

When two ships passed in the night, a telephone call passed between them. The setting was the Hudson River, where Fulton's steamboats first ran. On each vessel, wires snaked from a receiver/transmitter in the pilothouse to a copper plate held under water. Although "the messages were not as distinct as they can be made," they were clear enough to encourage further experiments in ship-to-ship communications.

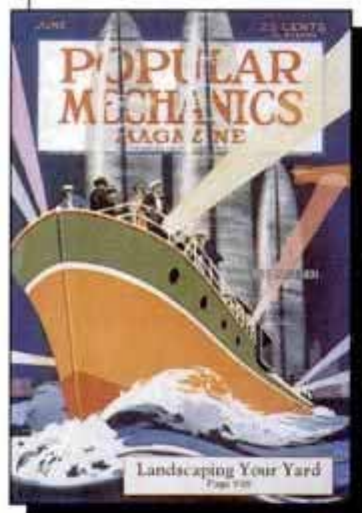


Don't Walk

Visitors to expositions in Chicago and Paris rode the continuous train—a cross between a moving sidewalk

and a streetcar. New York officials considered running an endless streetcar between its East River bridges.

60 YEARS AGO: JUNE 1933



Rotor Craft

At the coming 1933 World's Fair, we were told, the wind would whip across Lake Michigan to drive three rotating wings on a 70-ft. cabin cruiser. Mounted like masts, the 25-ft.-high aluminum rotors would provide four times the propulsion power of conventional sails and act as stabilizers in choppy water. After the Sun set, colored lights splashed across the spinning rotors, offering a scintillating effect, visible for miles.

Beauty And The Bridge

Between 700-ft. steel towers, twin arcs of cable would hang like swallows' flights across 4200 ft. of bay. The world's tallest, longest suspension bridge was now under construction at San Francisco's Golden Gate. Never



before had a bridge spanned the mouth of a major ocean harbor. Construction crews battled capricious currents to sink one pier's foundation into a huge watertight cofferdam. Meanwhile, engineers ordered 100,000 tons of steel, including enough cable wire to girdle the equator three times—plus 5000 miles.

30 YEARS AGO: JUNE 1963

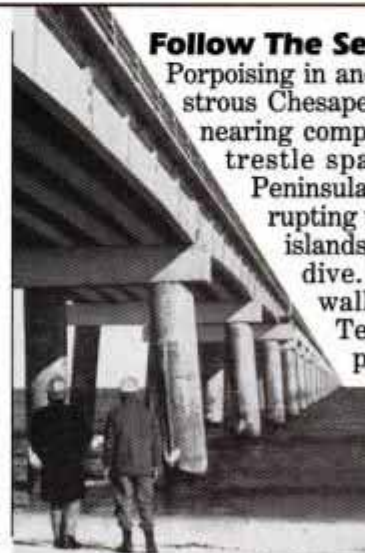


Cold War Casualty

Six jet engines and nowhere to fly—such was the fate of the XB-70 Valkyrie. Despite the bomber's awesome performance—Mach 3 at 70,000 ft.—only three "research prototypes" were built. Soviet progress in anti-aircraft missiles made high-altitude nuclear bombing obsolete. The project blazed a trail for the U.S. supersonic passenger transport program that also went nowhere. On the plus side, the XB-70 demonstrated honeycomb construction.

Follow The Seagull

Porpoising in and out of the waves, the monstrous Chesapeake Bay Bridge-Tunnel was nearing completion. The 2-lane, 17½-mile trestle span connects the Delmarva Peninsula with Virginia Beach. Interrupting the crossing are two artificial islands, under which prefab tunnels dive. Tugs towed these double-wall conduits 1700 miles from Texas. Crews sunk them into place by pouring concrete between their inner and outer steel walls. Ships pass through milewide channels carved into the islands to reach the Hampton Roads naval yards.



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removing light rust from intricate surfaces – like ornamental wrought iron furniture and railing – with the Metal Finishing Pad.

Remove paint and adhesive from glass and wood easily with the Scraper Blade. Wax and polish tight spots and angles with the Wax/Buffering Pad; ideal for car detailing.



Remove paint and varnish from hard-to-reach surfaces easily with the Stripping Pad.

Or smooth bare wood and prepare newly painted surfaces between finish coats with the Finishing Pad.

The Ryobi Detail Sander. It's fast, versatile and easy to use. For even more details, stop by your Ryobi dealer today or call 1-800-525-2579.

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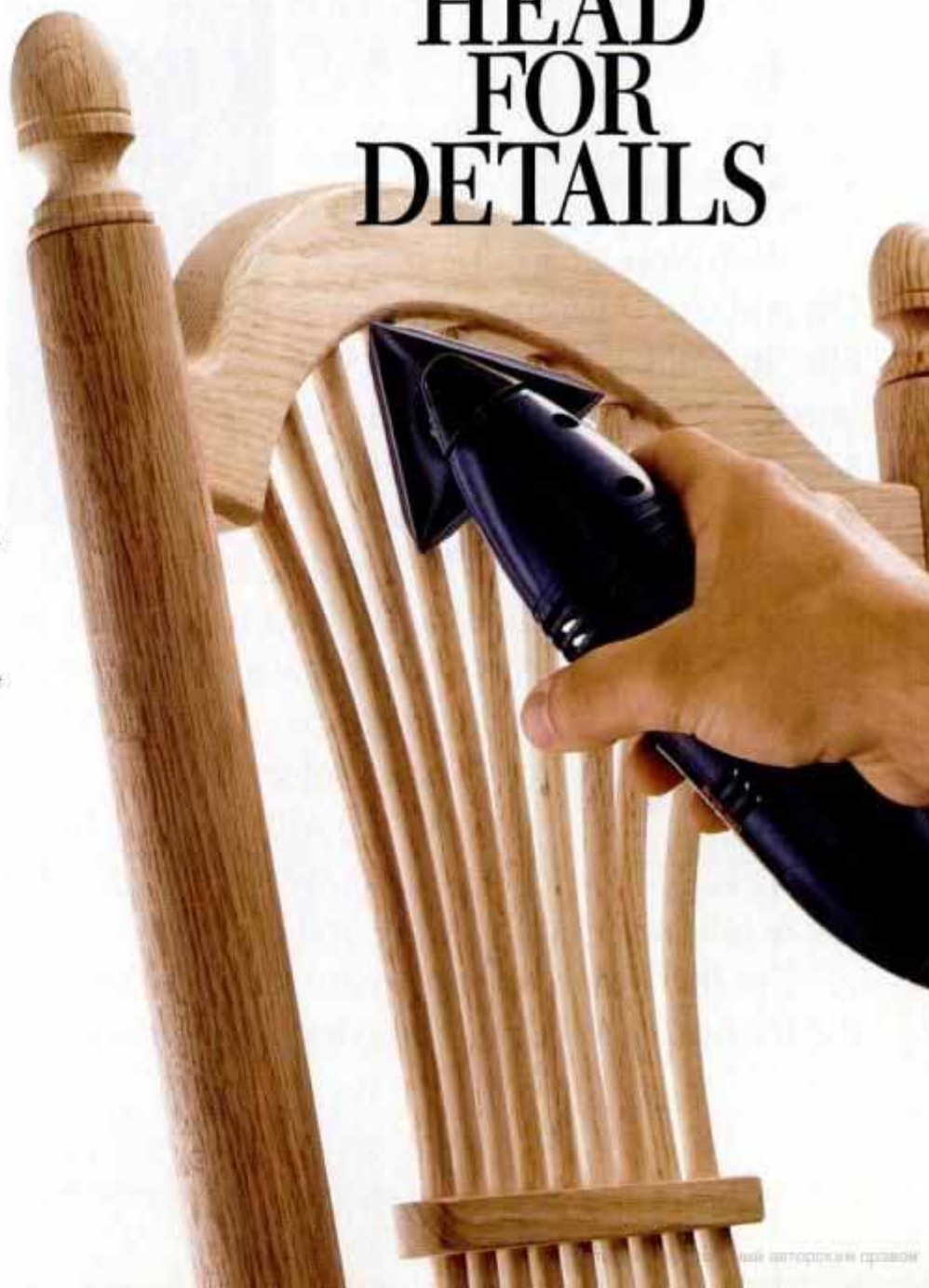
RYOBI[®]

Making Innovative Concepts A Reality[™]

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A HEAD FOR DETAILS



BY CUTTING YOUR BEARD BELOW THE SKIN, NORELCO RAISES THE STANDARDS OF SHAVING.

It sounds incredible.

But that's because it is.

Norelco® can actually shave below skin level in complete comfort.

How is this possible?

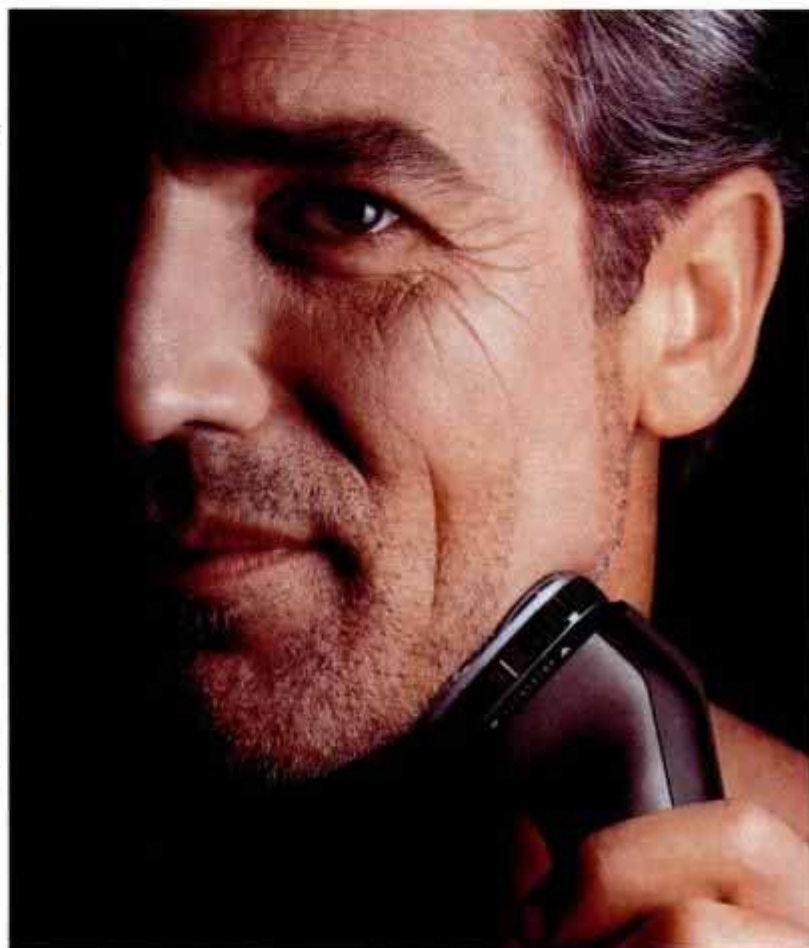


Razor combs quickly direct hair to the "Lift and Cut" system.

Lifter notches into hair and lifts it up.

Blade cuts lifted hair which drops back below skin level.

With Norelco's patented "Lift and Cut"™ system, a precision lifter in front of the blade notches into the hair and lifts it up. After a blade cuts it, the hair shaft can actually drop *below* skin level.



Floating heads move up and down to hug the contours of your face.

The result is an incredibly close shave. And since the blades don't touch your face, you're also rewarded with a comfortable shave.

This comfort is made more exceptional with floating heads. They glide over your face, effortlessly following every curve and contour.

Put the Norelco razor to the test. And experience the highest standards of shaving for yourself.



Norelco®

We make close comfortable.

TECH UPDATE

News Of Tomorrow's Technology Today



A Roof To Remember: The Alamodome

SAN ANTONIO, TX—When the Spurs open at home next year, they'll tip off under a top that owes more to river crossings than roofing.

Despite its name, the newly completed Alamodome is crowned with a huge flat roof, low enough in profile to duck below San Antonio's historic skyline. W.E. Simpson Co. engineered the innovative scheme, which evolved from the new cable-stayed bridges such as Florida's Sunshine Skyway.

Four 314-ft. masts hold up the roof's 3000-ton weight through sets of steel cables. Each mast is then buttressed by two sets of tie-back cables that plunge earthward, transferring the load into

the ground. Relieved of the roof load, the sides of the building need only support the stadium seats.

Bigger than a football field, the roof's central rectangle has a steel skeleton, with four bowstring trusses around its perimeter. The curved underside of each truss is a steel cable thrown into tension by the roof's weight. Tensioned cables can carry far more load for their weight than can structural steel members.

Slide bearings allow the flat roof to expand or contract with the weather.

Planners in other growing

cities may well remember the Alamodome for its \$105 million price tag, cheap for a 65,000-seat stadium.

Alamodome holds up its 3000-ton roof with a unique technique borrowed from cable-stayed bridges.

Highlights This Month

- **In And Out And About**—Single device combines solenoid and motor action.
- **Welcome To The Real World**—Idealized superjet in sensible clothing.
- **Beams, Bits And Bytes**—Optical computer flashes through programs.
- **Bottom Dweller**—New swimming machine will spend months on seafloor.
- **Robo-Mop**—Mechanical janitor to clean out post-office restrooms.
- **We Deliver**—Army's muscle-armed trucks feed frontline forces.

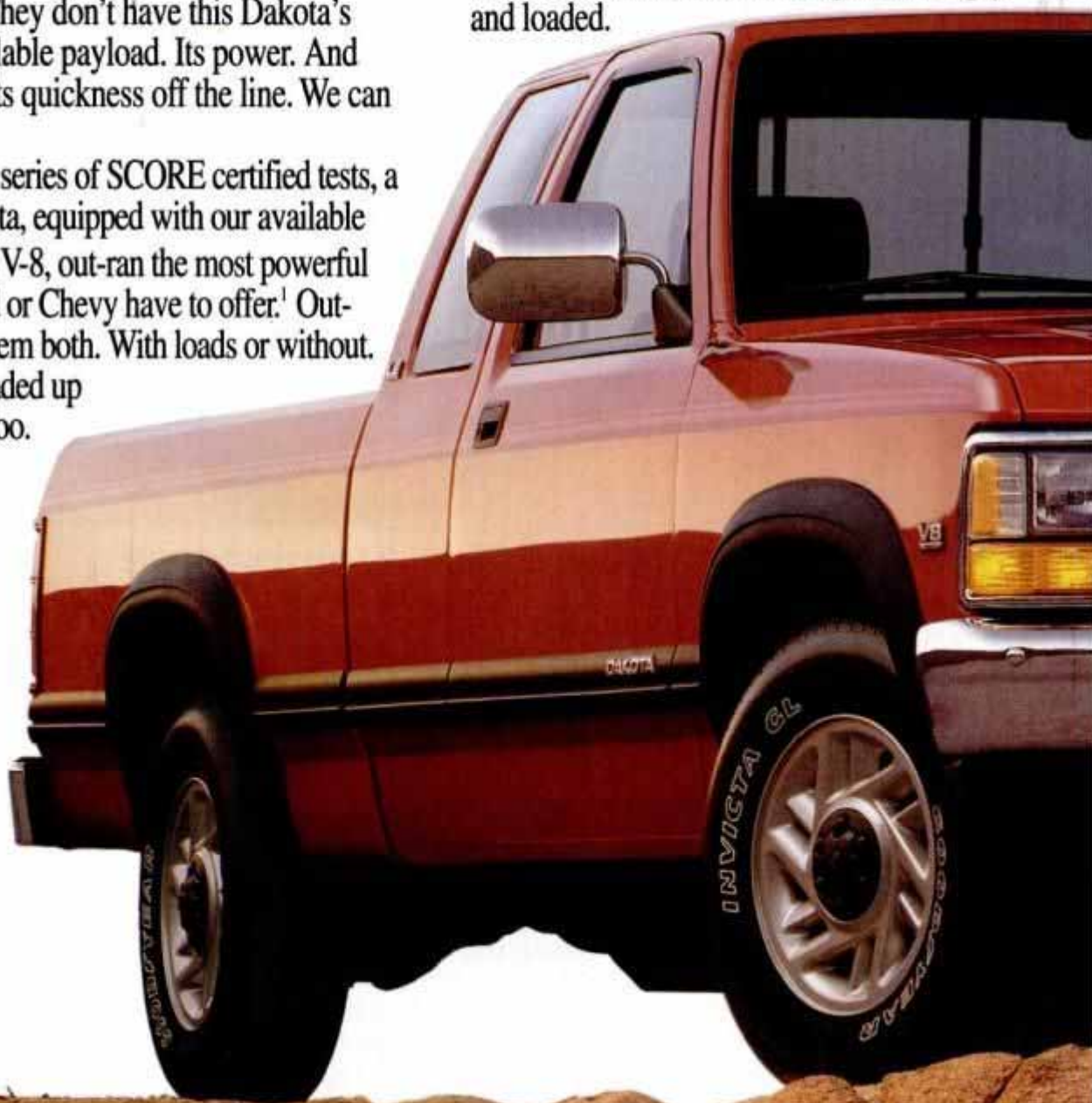
Editor: Abe Dane
Writer: Greg Pope
Reporters: Mike Fillon, Scott Gourley,
Herb Shuldiner

“Out-powers and Chevy and Ford compact or

Comparing a Dodge Dakota V-8 to other pickups is easy. There's simply no comparison. Compacts like Ranger and S-10 can't measure up. They don't have this Dakota's room. Its available payload. Its power. And certainly not its quickness off the line. We can prove it, too.

In a whole series of SCORE certified tests, a mid-size Dakota, equipped with our available 5.2L Magnum V-8, out-ran the most powerful compacts Ford or Chevy have to offer.¹ Out-accelerating them both. With loads or without. Even when loaded up with a trailer, too.

With that 230 hp power plant pulling for it, Dakota over-powers *full-size* Ford and Chevy half-tons, as well. Out-running them, empty and loaded.

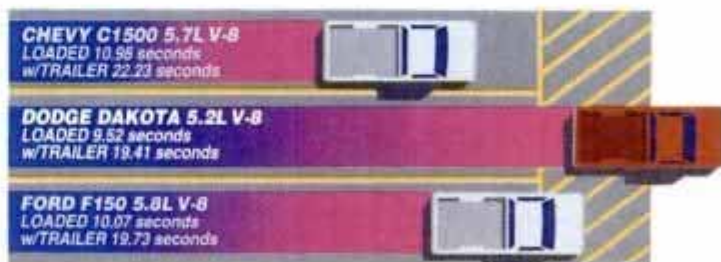


out-accelerates hands down, half-ton."

-Certified by SCORE International, January 1992

And delivering more horsepower and more available towing than a standard F150 or C1500 pickup.

The warranty's no contest either. Dakota is backed by a choice unmatched by any truck manufacturer, anywhere.



Dodge Dakota 4x2 Club Cab out-paces full-size regular cab pickups 0-60, with 1,150 lbs payload and with 6,040 lbs combined payload and trailer weight.¹

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All in all, it's one very powerful story. Just one more example of how our Magnum engines make Dodge the most powerful line of trucks you can buy.³ Call 1-800-4-A-DODGE for a free product brochure.



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5.2L Magnum V-8

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¹All trucks equipped with auto. trans. & max. avail. axle ratios. Versus Ford & Chevy compact extended cabs 0-60, Dakota 4x2 Club Cab out-ran them w/960 lbs payload & w/5,850 lbs combined payload and trailer weight. Graph not proportional to test data. ²See limited warranties, restrictions & details at dealer.

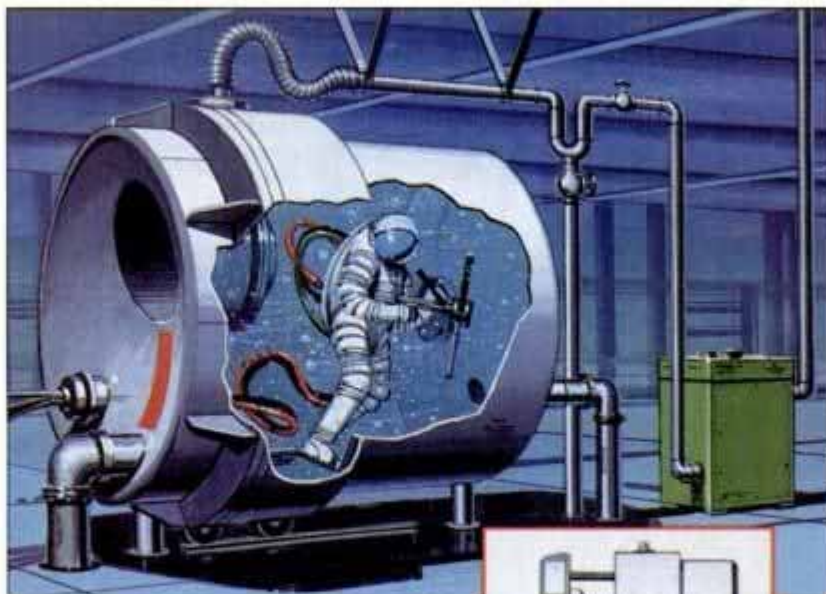
Excludes normal maintenance, adjustments & wear items. ³Overall total scores of combined model segment comparisons. All claims & comparisons based on '92 models/data.



Buoyancy Without The Bends

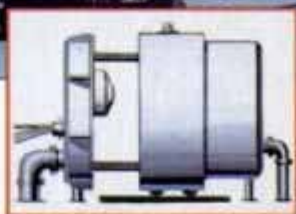
MOFFETT FIELD, CA—When astronauts emerge from training sessions in neutral-buoyancy tanks, they must spend hours in a decompression chamber, with a medical team nearby in case someone gets the bends. Now engineers at NASA's Ames Research Center have devised a way to skip the compression in the first place.

To mimic a spacewalk while submerged, the internal pressure of a spacesuit must be substantially greater than the external water pressure. The internal air pressure inflates the suit so that it becomes stiff and



Low-pressure neutral-buoyancy tank, with rollback ring door (right) would obviate decompression.

difficult to move around in, just as it would be in the vacuum of space. It also subjects the astronaut to so much pressure that he'll



have to decompress.

But why pressurize the air in the spacesuit, reason

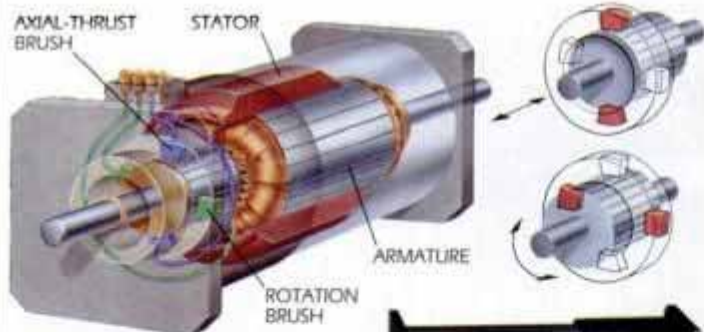
the Ames researchers—why not just depressurize the water?

Instead of diving into an open-air pool, the astronaut would practice in a hermetically sealed chamber, held at an artificially low pressure by a vacuum pump. Air pumped to the spacesuit would come in at just below atmospheric pressure.

To allow access to the tank, a collar-like door would slide back like a ring on a finger, opening a gap through which the trainee would enter. Alternatively, the user could climb into the space-suit through a portal.

Although Ames has tested the system on a small chamber, NASA currently has no funding to apply the technique to an operational tank.

One Motor, Two Motions



DC motor features two brush sets, along with modified bearings and commutator, to permit both thrust and rotation.

COLUMBUS, OH—A single actuator from Battelle Labs can turn like a motor or jab like a solenoid—or work both motions at once.

Although the device resembles a textbook direct-current motor, two sets of brushes allow its dual action.

One pair of brushes controls rotation. Fed current, they generate the classic perpendicular alignment of stator and armature magnetic fields, which chase each other around the axis.

The other pair controls axial movement, by setting

up two magnetic fields parallel to each other. If the armature is offset a little, the fields repulse each other and the axis moves in and out in response to a current.

While the current, fist-size machine puts out 0.10 hp, Battelle inventor Jim Dvorsky says the technique could work in bigger or smaller motors. Lawnmower starters, sonar scanners and car door locks and windows are likely applications. The first commercial products are due out by year's end.

Wet-Vac Crudbuster

COLUMBIA, MD—Skulking at the bottom of an oil-storage tank, a unique submersible robot can vacuum out sediment and pinpoint structural flaws—while the oil remains in the tank.

Developed by ARD Corp. and Public Service Electric & Gas of New Jersey, the vehicle is called OTIS, for Oil Tank Inspection and Surveillance.

The tracked robot derives from ARD's SuperScavenger telerobots, which work in nuclear-power and chemical-processing plants. Built to bathe in fuel oil, OTIS peers through the amber fluid with an infrared



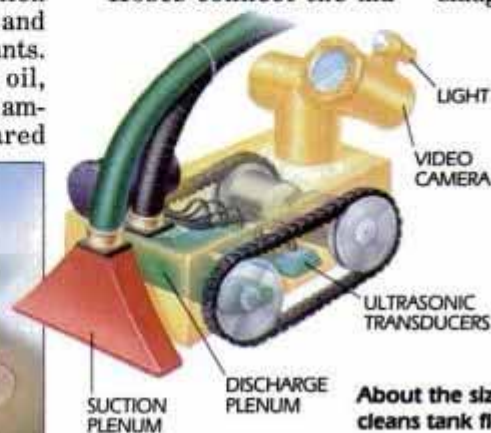
video camera and navigates with ultrasound.

Hoses connect the ma-

chine with an external filtering apparatus, to clean sludge-laden oil.

Meanwhile, a bank of ultrasonic transducers ping away at the bottom of the tank. OTIS recognizes ultrasonic returns that suggest cracks, pits or thinning metal.

Field trials are underway at a New Jersey generating plant.



About the size of a child's sled, OTIS cleans tank floors and checks for cracks.

PH ILLUSTRATION BY GEORGE RETZICK, BATTELLE PHOTO

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Waverider's Reality Check

HAMPTON, VA—A theorist's ideal for a hypersonic aircraft shape, the waverider is undergoing wind-tunnel tests to determine how it would function as a real-world plane.

In its purest form, a waverider (see Tech Update, page 16, Dec. '90) would surf on its own shockwave. The aircraft would enjoy a tremendous lift-to-drag ratio because it's sculpted to confine the shock pressure to the plane's underside.

At NASA's Langley Research Center, engineers are fleshing out the pristine waverider form with real-plane accoutrements, such as control surfaces and engine inlets.

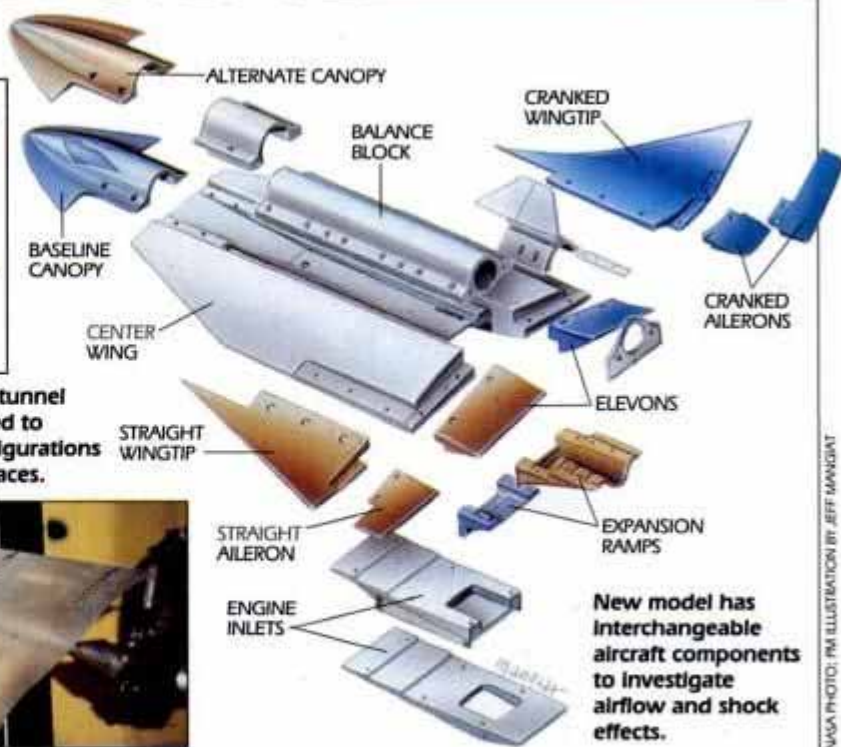
The Langley researchers used a University of Maryland computer program to



Original waverider wind-tunnel shape (below) has evolved to model two different configurations with realistic control surfaces.



design a waverider shape optimized for Mach-4 travel. Machinists then built a wind-tunnel model with various interchangeable wing-



New model has interchangeable aircraft components to investigate airflow and shock effects.

tips, control surfaces, canopies and engine parts. Of especial interest is the addition of cranked wingtips to improve lateral stability.

Meanwhile, NASA-Ames is studying how to integrate scramjet engines without disrupting the waveriding performance.

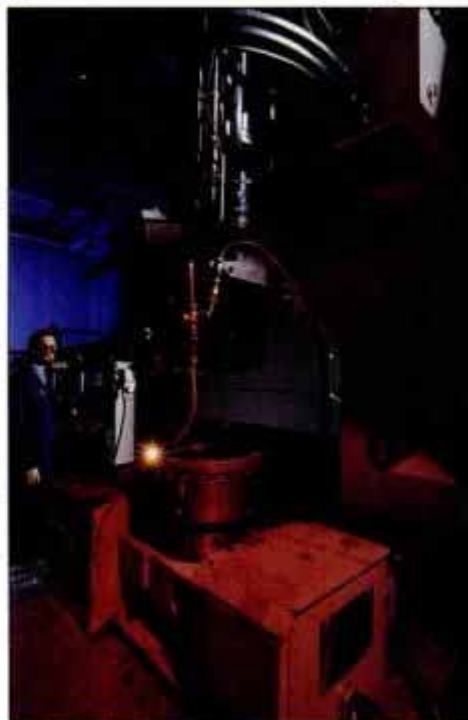
Light-Sword Steel Treatment

PEORIA, IL—Laser heat treatment, which can spot-harden steel parts without distorting them, has automakers scrambling for a competitive edge. For example, Caterpillar has joined forces with Argonne National Laboratories to exploit this new, but closely guarded, technology.

Two areas are under investigation. Researchers are tailoring advanced coatings, which help steel soak up the heat of the laser. In addition, engineers are harnessing solid-state lasers, which emit infrared light at wavelengths steel can absorb without coatings. Solid-state lasers can now put out wattages high enough for industrial applications.

Huge truck differential gets a shot of infrared laser heat treatment.

Meanwhile, at Battelle Labs in Columbus, Ohio, lasers are vaporizing a thin coating sandwiched between a metal part and a transparent cover. Expanding, the vapor exerts pressure against the metal, strengthening it by compression, rather like shot-peening.



Light-Speed Computation

BOULDER, CO—The world's first general-purpose optical computer uses light beams, not electricity, to flash through calculations.

Built at the University of Colorado, the Bit-Serial Optical Computer is the only machine to both crunch numbers and store its instructions with pulses of light.

Whipping around fiberoptic loops, 12-ft.-long laser pulses represent individual

Sprawling over desk, prototype fiberoptic computer features 66 optical switches.

bits of information. Other laser beams activate optical switches to route the bits through simple processing pathways.

About the size of a desk, the computer has the processing power of an early PC. The engineers are working on a palm-size version, to run 400 times faster. Such a machine could direct traffic on a fiberoptic "information superhighway."

UNIVERSITY OF COLORADO PHOTO

NASA PHOTO; IRI ILLUSTRATION BY JEFF MANKIN

CATERPILLAR PHOTO

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Free-Style Sea Trekker

WOODS HOLE, MA—To go where no machine has gone before, an enterprising robot named ABE will soon explore the ocean floor for up to a year at a stretch.

ABE (short for Autonomous Benthic Explorer) is the latest gadget from the Deep Submergence Laboratory at Woods Hole Oceanographic Institute. The vehicle is the first intelligent undersea machine ever turned loose for a prolonged tour of duty.

Unlike *Jason*, Woods Hole's bigger unmanned vehicle, ABE works without a tether from a mothership. And unlike the Navy's free-swimming AUSS (see Science, page 104), ABE receives no supervisory control.

On deployment, ABE will sink to the sea floor between 12,000 and 18,000 ft. down. The machine will spend much of its underwater time shut down, to conserve battery life.

But once a day the vehicle will wake up, swim about a pre-planned course, snap photos, make videos and take various water measurements before powering down again. Gyros, a fluxgate compass and short-range sonar will help ABE stay on course.



Struts connect twin buoyancy tanks, each containing three glass spheres, with ABE's 8-ft.-long instrument housing, for a stable triangular configuration.

Although its first few missions will run for six weeks, ABE will work its way up to year-long sea surveys. Initially, ABE will probe the

bizarre seascape around midocean hydrothermal vents. Other locales planned for ABE investigation include ocean dump sites.



Seismic isolation bearings display extraordinary shear strength.



Quake Shock Absorbers

ARGONNE, IL—When The Big One finally hits, buildings with seismic isolation devices are likely to come through unscathed. So suggest the results of a 3-year shakedown in Japan.

The devices are fat spool-like bearings, made of alternating steel and rubber layers. A Japanese building equipped with the bearings survived 50 earthquakes without damage.

Developed at Argonne National Laboratories, the bearings replace the solid ground connection in a building's foundation.

When the earth rocks, all the energy is trapped in the bearings, which remain stable under severe shear. Once the vibrations pass, the devices bounce back to their original shape.

Other devices under examination include coils soaked in viscous fluid, sliding Teflon bearings and rubber-lead energy absorbers.

World's Smartest Johnnymop

DANBURY, CT—Robots may be poised to take over one of the nation's most unloved jobs—cleaning out the bathrooms at post offices.

An automated custodian's assistant called Scrubmate will follow a human janitor into the bathroom on its own power. Once inside, it's plugged into a socket, and its hose attached to a water supply.

Guided by a digital map of the bathroom, Scrubmate rolls in and out of stalls. Strain gages allow its arm to

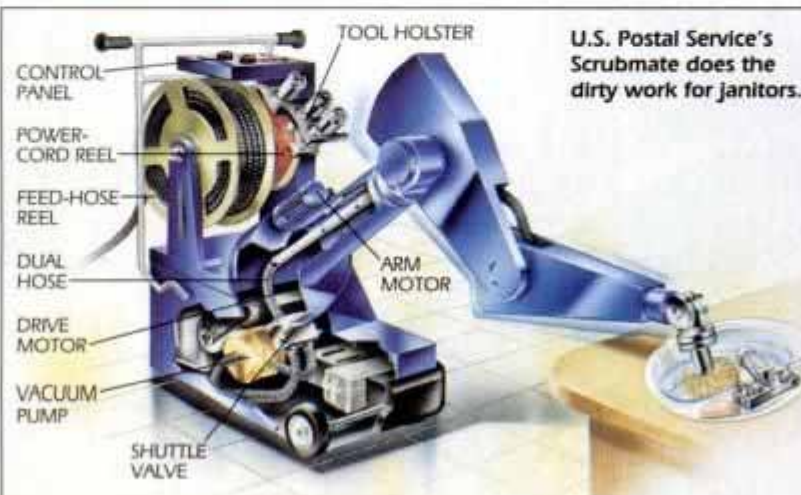
sense the shape of a fixture and apply the appropriate degree of elbow grease.

A concentric hose that snakes through its arm delivers hot soapy water and vacuums back the dirty waste. Scrubmate's arm can

tomahawk back over its shoulder and switch tools as it moves from toilets to sinks to floors.

Should the unexpected occur—such as an occupied stall or a clogged toilet—the robot will inform the janitor through a recorded message.

Designed by Transitions Research Corp. (robot guru Joseph Engleberger's company), Scrubmate isn't designed to replace janitors but to free them up for less distasteful work. Four units will enter service this fall at East Coast post offices.



U.S. Postal Service's Scrubmate does the dirty work for janitors.

The Ultimate Replica of the Most Famous Automobile Ever

Ford

The 1913 Ford Model T



Shown smaller than actual size of 8 1/2" long. Scale 1:16.



The definitive precision-engineered 1:16 scale replica of the Fabulous Ford Model T...with actual working parts and genuine leather seats.

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THE 1913 FORD MODEL T. Crafted by hand from more than 100 separate parts and equipped with the full complement of operating features. The doors and hood close. The steering and road wheels actually turn.

This custom-made model comes equipped with a fabric top and soft seats upholstered in genuine leather.

And every detail is authentic, down to the actual tread pattern on the tires, the hand and foot brakes and the intricately detailed engine. The radiator frame, wheel hubs, lights and lamps are among the many features plated in brass. The vintage style dashboard and firewall are specially crafted in wood veneer.

The 1913 Model T. A bargain then. A bargain now at just \$135.

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Franklin Mint Precision Models® Simply Miles Ahead.

Army's Speedy Delivery Truck



OSHKOSH, WI—Resupplying combat forces should be easier with a truck-and-trailer combo under production by Oshkosh Truck Corp.

A 10-wheel-drive 500-hp truck, derived from the 10-ton HEMTT vehicle, is the centerpiece of the new Palletized Load System, or

PLS. From within the cab, the driver will push buttons to operate the hydraulics.

Unloading a flatrack, which can hold eight standard pallets of equipment, takes less than a minute. And because the flatrack drops down to the ground, there's no need for a forklift

or a swarm of personnel.

Although Great Britain and France already have PLS, the U.S. version offers much broader off-road capabilities. The truck itself has three steering axles and a central tire-inflation system.

The PLS initially will pro-

vide artillery-ammo resupply. Other uses under study by the Army include transporting medical shelters, ribbon bridges and command centers—even serving as a rocket-launch platform.

Navy's Thrifty Turbines

WASHINGTON, DC—By 1996, the annual fuel bill for the Navy's turbine-propelled warships could approach \$500 million. Reason enough, the Navy reckons, to have Rolls-Royce and Westinghouse develop a new engine that will consume 30% less fuel.

The WR21 will have parts plucked from various RB211-type engines, widely used on airliners. But the marine turbine incorporates two fuel-saving technologies never before applied to an aero powerplant. These will prove especially thrifty at low speeds.

First, an inter-cooler slips in between the medium-pressure and high-pressure compressors. The unit draws in water from a separate heat exchanger to cool air as it's being compressed. Because that eases the workload on the compressor, the engine can crank out more power.

Second, an exhaust-heat recuperator boosts the air's temperature before it enters the engine's combustor. The technique cuts the amount of fuel the engine must con-

sume in raising the air temperature to run the turbine most efficiently. The recuperator also cools off the turbine exhaust, which then offers a less inviting target to heat-seeking missiles.

Although the first engines are due in 1999, the Navy may accel-

erate development for some earlier at-sea trials.

The WR21 may also herald integrated power systems, by which turbines generate both electricity and propulsion for a ship.



Robot applies glass fibers and plastic binder with consistent, craftsmanlike precision.

Facelift For Fiberglass

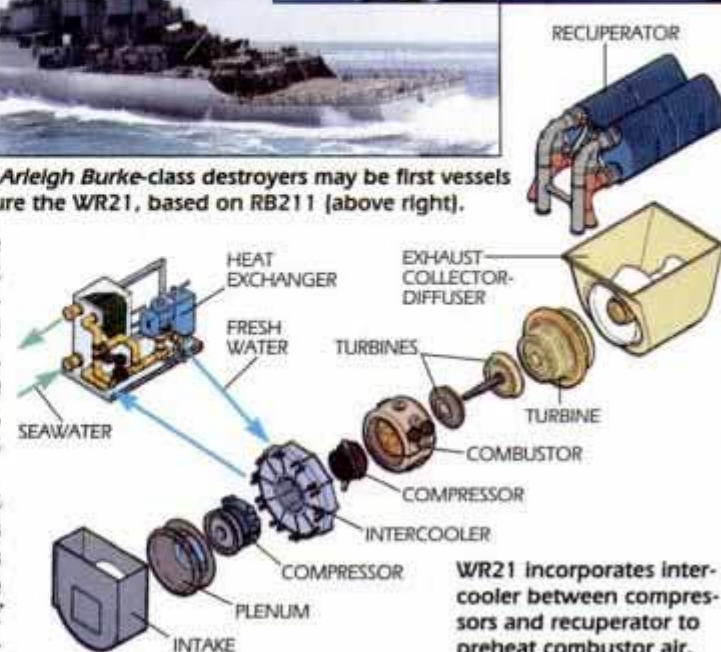
BATTICE, BELGIUM—Single-piece composite car bodies may one day roll off assembly lines, thanks to a new twist on fiberglass spray-forming.

Owens-Corning's European R&D wing developed the process, known as P-4.

In conventional fiberglass forming, the fibers and a plastic binder are sprayed over a mold by hand. In contrast, the P-4 process features a robotic arm that can orient the fibers to control rigidity. It can also apply more fibers to curves and edges, which require greater strength.



Future Arleigh Burke-class destroyers may be first vessels to feature the WR21, based on RB211 (above right).



WR21 incorporates inter-cooler between compressors and recuperator to preheat combustor air.

When we started making tires for highway driving, this was a highway.

Highways have come a long way since then. And so have Kelly-Springfield tires.



Before 1894, when we made America's first successful rubber carriage tire, most people were happy if their tires made it to the nearest muddy road.

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After all, this is America. And being first only gets you so far. What's more important is the fact that today we make more aftermarket tires than anyone else in America.

But we all had to start somewhere. And someone had to be first.

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THE NATIONAL AUTO QUIZ

1. Which auto manufacturer was noted for its push-button automatic transmission gear selector in the mid 1950s?



A) General Motors. B) Chrysler. C) Ford. D) Jaguar.

2. When checking your battery's state of charge with a digital voltmeter connected across the battery terminals, a reading of 12.0 volts indicates your battery is:

A) Fully charged. B) 75% charged. C) 50% charged. D) 25% charged.

3. The name "Heavy Chevy" most accurately refers to:

A) A 1971-72 Malibu factory option package. B) A 3/4-ton Chevrolet dualie pickup. C) A big block powered '30s Chevy hot rod. D) A Chevrolet Suburban.

4. Electronic ignition is triggered by a:

A) Module triggering an ignition coil. B) Pickup coil triggering a module. C) Pickup coil triggering an ignition coil. D) Both A & B.

5. Who is generally credited with creating the 1964 Mustang?

A) Henry Ford II. B) Edsel Ford. C) Lee Iacocca. D) Roger Smith.

6. A turbocharger wastegate controls the:

A) Air inlet to the turbo. B) Air outlet from the turbo. C) Exhaust flow to the turbo. D) Exhaust flow from the turbo.

7. Most bolt torque specifications are for bolts having:

A) Clean threads only. B) Clean and lubricated threads. C) Dirty threads. D) Dirty threads, but add 25% for clean threads.

8. How long after you change your oil does it start to turn black?

A) Immediately. B) 100 miles. C) 500 miles. D) 1000 miles.

9. In 1990, a ZR-1 Corvette established a new 24-hour speed endurance record of 175.88 MPH. When was the previous record set, and by what car?

A) 1968/Ford Mustang. B) 1976/Mercedes-Benz C111/2. C) 1970/Dodge Daytona. D) 1940/Mormon Meteor III.

10. Which of the following is true about running an engine on methanol fuel?

A) Methanol is corrosive to fuel systems. B) Engines produce more power with 85/15 methanol/gasoline blend than with straight gas. C) Methanol can be produced from oil, natural gas and coal. D) All of the preceding.

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ANSWERS
1. B 2. D (A fully charged battery should read 12.6 volts) 3. A 4. B
5. C 6. C 7. B 8. A 9. D 10. D

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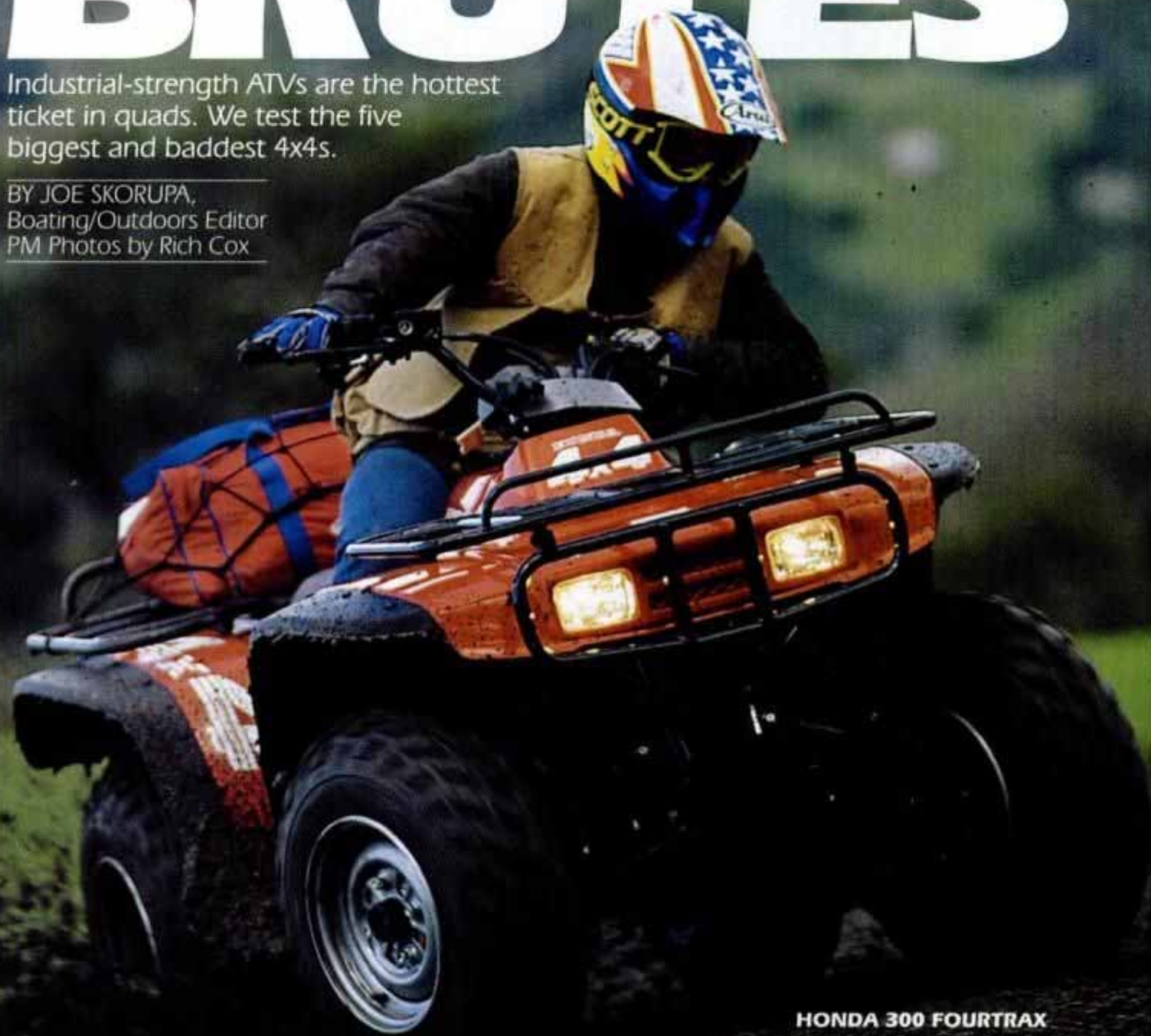
HAVE YOU DRIVEN
A FORD LATELY?

Why We Race

BACKCOUNTRY BRUTES

Industrial-strength ATVs are the hottest ticket in quads. We test the five biggest and baddest 4x4s.

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



HONDA 300 FOURTRAX

● Once outclassed by faster, nimbler sport machines, a new generation of monster ATVs has taken over as the king of quads. With big wheels, huge displacements and plenty of attitude, these trailbusters are the current E-ticket in the world of flying dirt.

Not only do these brawny 4x4s eat up grunt work like a team of oxen, but they come equipped with a cargo-rack's worth of sophisticated technology and de-

liver full-throttle excitement when the work is done. Forget about the old images of ATVs as crude cousins of dirt bikes or of controversial 3-wheelers. Current backcountry brutes aren't your father's ATV.

What's changed about these quads, basically, is that they're built to work like mules but ride like horses. They feature adjustable independent suspensions with MacPherson struts, double wishbones and at least

BACKCOUNTRY BRUTES



POLARIS 4x4 350

No shifting with Polaris's automatic transmission (left). No foot pegs either since it has unique footwells.

5 in. of travel. They have liquid-cooled engines, overhead cams and up to 400cc of displacement for massive torque production.

In addition to sophisticated components, these ATVs have enough built-in or optional features to make a Swiss Army knife envious. Towing hitches, front and rear carrying racks, stowage boxes, cargo extenders, holding nets, gun racks and helmet holders are just a few of the features that turn these haulers into true multipurpose machines.

To find out just how versatile and rugged these ATVs are, we brought a test fleet to the Warren Ranch in San Simeon, California. Although the rainiest winter in a decade turned the trails into gumbo and hampered testing, the PM team wrung out the fleet by spending three days doing what these ATVs were designed for—heavy towing, steep hill climbing, severe rock crawling and backcountry cruising.

Honda 300 Fourtrax

Honda hit a bull's-eye in 1988 when it introduced its top-of-the-line 300 Fourtrax, and the model quickly became a best seller. However, the creation of a bigger, badder class of ATVs has finally caught up to the leader.

Despite delivering a smooth, comfortable, near-sporty ride, the test team found that the Fourtrax is out-muscled compared with the rest of the fleet. With its single-range transmission and slightly underpowered 282cc engine, the Fourtrax requires

frequent shifting when cruising up hills. It requires even more shifting when towing. Clearly this model's next iteration calls for a dual-range transmission or a larger engine, or both. Tightening up the wide turning radius would also help.

Strong suits are full-time 4wd, a super-low First gear and a compactness that serves the Fourtrax well for cornering and rock crawling. The suspension is exceptionally well tuned for its light weight, size and power. Its cruising feel is second to none.

Although not a true draught horse,

the Fourtrax is an attractive alternative because of its ease of operation, sportiness and fleet-leading price.

Kawasaki Bayou 400

The first of the new monster ATVs, the Kawasaki Bayou raised the ante for modern workhorses when it was introduced in mid-1992. Not only is it equipped with a fleet-leading 391cc engine, but its tow rating (1100 pounds) and tongue-weight rating (88 pounds) are also fleet leaders.

Although the Bayou is muscular, don't call it unsophisticated. The 4-valve sohc engine is liquid cooled. The front axle features limited-slip differential. And the suspension features double wishbones with adjustable shocks in the front and semi-independent dual shocks in the rear.

On the trail, the Bayou has head-snapping power, a performance-tight suspension and a narrow turning radius. Essentially, what you have is the heart of a sport machine in a utility vehicle's body. Smooth, fluid cruising isn't necessarily this taut performer's strong suit, but hill climbing, rock crawling and towing are. All in all, the big Kawie sets a tough standard to beat in the emerging class of monster ATVs.

Polaris 4x4 350

Compared with the West Coast builders, Polaris has always gone its own way. While the others were focused on 3-wheelers and sport machines, Minnesota-based Polaris quietly built 4-wheel utility ATVs from day one. Then, when the Californians decided to move into utility, they found Polaris already there and

SPECIFICATIONS AND DIMENSIONS

MANUFACTURER/MODEL/ ADDRESS	PRICE AS TESTED	WHEELBASE/ LENGTH/WIDTH/ SEAT HEIGHT	FUEL CAPACITY/ WEIGHT/TOW RATING/CLEARANCE	ENGINE/ DISPLACEMENT	TRANSMISSION
Honda 300 Fourtrax 1919 Torrance Blvd., Torrance, CA 90501	\$4299	48.6"/75.2" 43.7"/31.1"	3.3 gal./520 lb./ 850 lb./6.3"	4-stroke, air cooled, sohc/282cc	5-speed w/reverse, full-time 4wd
Kawasaki Bayou 400 9950 Jaronimo Rd., Irvine, CA 92718	\$5099	47.2"/79.5" 44.5"/31.3"	3.17 gal./595 lb./ 1100 lb./7.2"	4-stroke, liquid cooled, sohc/391cc	5-speed w/reverse, full-time 4wd
Polaris 4x4 350 1225 Hwy. 169 N., Minneapolis, MN 55441	\$4749	49.75"/77.0" 44.5"/34.0"	4.0 gal./560 lb./ 850 lb./6.0"	2-stroke, liquid cooled, oil-injected/352cc	Automatic w/reverse, dual-range, shift-on-fly
Suzuki King Quad 3251 E. Imperial Hwy., Brea, CA 92621	\$4899	45.9"/81.1" 47.2"/30.5"	3.2 gal./604 lb./ 904 lb./8.3"	4-stroke, pointless ignition, sohc/280cc	5-speed w/reverse, triple-range, 4wd
Yamaha Kodiak 400 6555 Kestrel Ave., Cypress, CA 90630	\$5299	47.6"/76.8" 45.3"/32.7"	3.0 gal./604 lb./ 904 lb./7.1"	4-stroke, oil cooler, sohc/387cc	5-speed w/reverse, dual-range, full-time 4wd



HONDA 300 FOURTRAX



KAWASAKI BAYOU 400



KAWASAKI BAYOU 400
The Kawle's big engine (left) is liquid cooled and has a cold-start carburetor primer pump. Note the steel external oil lines to prevent leaks.



SUZUKI KING QUAD
Full instrumentation and multiple shift levers for the sophisticated triple-range transmission (left) give the King Quad a great deal of control over its ride.



doing very well, thank you.

With the fleet's only 2-stroke engine and automatic variable transmission, power delivery is immediate. In hill climbing, towing, rock climbing and overall performance, the Polaris was second to none. Its torque-sensing transmission delivered smooth, robust power on demand in all conditions and loads.

Not everyone will like Polaris's exposed chain drive, footwells (instead of foot pegs) or tall, bulky profile, but there's plenty to like about the dual MacPherson struts in the front, dual-

range transmission and liquid-cooled, oil-injected engine. The biggest nit to pick was with its downhill performance, especially while towing. The transmission tends to freewheel and pick up speed. Also, the main brake system relies on a single hydraulic disc brake on the driveshaft, which doesn't deliver the stopping power of dual-lever front and rear brakes.

In many ways the 4x4 350 carves its own niche, but as other players move in this direction, they'll learn that Polaris is hard to beat on turf it's occupied for quite some time.

Suzuki King Quad

Suzuki invented 4-wheel ATVs a decade ago and has maintained a front-runner position in quads ever since. However, like the Honda 300 Fourtrax, the Suzuki King Quad represents a compromise between sportiness and utility. It's equipped with numerous high-tech features and an overall outstanding ride, but the ante has been upped and the King Quad's small 280cc engine makes it hard to compete with the big boys in terms of raw torque.

Yet, despite being underpowered,

TEST RESULTS

SUSPENSION FRONT/REAR	BRAKES FRONT/REAR	TURNING RADIUS/HANDLING	HILL CLIMBING	ROCK CRAWLING	TOWING	OVERALL PERFORMANCE
Double wishbone/ Single shock	Hydraulic drums/ Mechanical drum	13' 3" Taut but smooth	Frequent shifting on steep grades	Light, low, compact; one of the best	Super-low First gear a plus, frequent shifting	Superb sporty feel, but underpowered
Double wishbone w/shocks/ Torque tube link	Hydraulic drums/ Mechanical drum	10' 9" Performance light	Power to spare, sets the pace	Limited-slip front differential a plus	Pulls loads like a team of oxen	A hard worker with aggressive traits
MacPherson struts/ Single shock	Single hydraulic disc on driveshaft/Mechanical drum	10' 4" Surprisingly nimble	Robust power, tops in operational ease	Low clearance, tall profile make rocks tricky	Downhill freewheeling is tricky, uphill no problem	Strong as an ox, easy to operate
Ind. double A-arm w/shocks/ Ind. swing axle w/shock	Hydraulic drums/ Mechanical drum	12' 1" Sporty aspirations	Frequent shifting, 3 gear ranges help	Tops for clearance, locking front differential	No problems once in correct gear range	Lots of shifting, but a gear for every situation
Double A-arm w/shocks/ Swing axle w/shock	Hydraulic drums/ Mechanical drum	11' 3" Big, bad bear	Plenty of power for any long grade	High clearance a bonus on big machine	Handles a big load with some downshifting	A top contender in all categories



POLARIS 4x4 350



SUZUKI KING QUAD



YAMAHA KODIAK 400

BACKCOUNTRY BRUTES



Before heading off into the coastal mountains on the Warren Ranch, the test fleet gears up for the outback. From left to right: Yamaha Kodiak 400, Honda 300 Fourtrax, Polaris 4x4 350, Kawasaki Bayou 400 and Suzuki King Quad.

the King Quad scored well in hill climbing (although a fair amount of shifting is required), towing and overall performance. Also, it was unsurpassed for creeping and crawling over rocks.

How so? Well, to make up for the small engine, Suzuki gives the King Quad a sophisticated transmission. Not only does it have three ranges (high, low and super-low) and 15 gears, but it also has 2wd and 4wd. Not everyone will appreciate all the shifting, but there's no doubt it makes the King Quad highly versatile.

As mentioned, the King Quad is a

top rock crawler. Its transmission helps, but what really does the trick is a big 8.3 in. of ground clearance and front locking differential. Perhaps its most unique feature is independent front and rear suspensions. On off-camber trails, the rear wheels tilt slightly to follow terrain. It may look disconcerting to followers, but the ride is smooth and stable.

Although much about the King



A torque-control front differential (above) gives the Kodiak sure-footed control when the trail turns to mud.



**YAMAHA
KODIAK 400**

Quad betrays a sport breeding, the sophisticated transmission makes it a worthy workhorse.

Yamaha Kodiak 400

Surpassing the Big Bear as the top carnivore in the Yamaha food chain, the new Kodiak has an Alaska-size 2-valve sohc 387cc engine that's equipped with an oil radiator and a thermostatically controlled fan. This setup pumps out enough torque to place the Kodiak among the leaders in hill climbing, towing and overall performance. It also enabled the Kodiak to place at the head of the class in rock climbing and maneuverability.

Like the Polaris 4x4 350, the Kodiak operates and feels like a true utility vehicle with no sporty pretensions. To help make the point, Yamaha builds optional rack extenders for carrying mucho cargo and a side-mount gun rack for protecting a firearm during hunting expeditions into the outback. Other special features include a helmet holder, backup kick starter, auxiliary pump for the carburetor and a torque-control front differential.

While the Kodiak is a true utility ATV, that doesn't mean it's all work and no play. As a matter of fact, that's the beauty of all the beasts in this class. When the work is done, they enable you to cruise down the trail and head off into the sunset. **PM**

Clothing for photography supplied by: Cabela's, 812 13th Ave., Sidney, NE 69160. Columbia Sportswear, 6600 N. Baltimore, Portland, OR 97203.

OWNERS REPORT

TOYOTA CAMRY

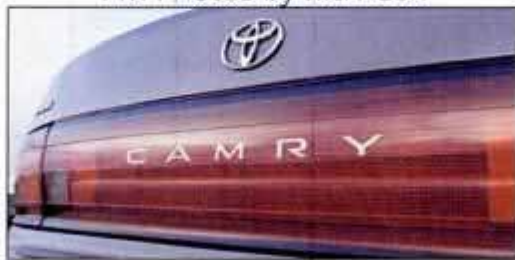
Living with Toyota's latest megahit.



● The 1992 model year was a big one for the Camry—literally. Toyota's mainstream sedan grew in every dimension in its latest makeover, and in the process became a frontline player in the tough mid-size sedan market. As such, it squares up against some of the best-selling cars in the country—Ford Taurus, Honda Accord, Chevy Lumina—and, to date, has measured up very well.

Like the Accord, the Camry is an import nameplate that's assembled in the United States—Kentucky, in this case—with sufficient local content to meet the require-

BY MICHAEL LAMM,
Contributing Editor
PM Photos by Rich Cox



ment for a domestic automobile. Almost all of our Camry owners wanted the 24-valve V6. Most of the owners in our survey chose the Camry's basic 130-hp 2.2-liter dohc 16-valve 4-cylinder engine. Fewer than a third ordered the optional 185-hp 3.0-liter dohc 24-valve V6. Almost all of our Camry owners wanted the 4-speed automatic transmission—only 5.4% opted for the 5-speed manual.

ment for a domestic automobile.

Sharing a number of structural and mechanical elements with the Lexus ES 300, the Camry comes in 4-door sedan and station wagon body styles. The wagon was added after this survey was completed.

Most of the owners in our survey chose the Camry's basic 130-hp 2.2-liter dohc 16-valve 4-cylinder engine. Fewer than a third ordered the optional 185-hp 3.0-liter dohc

TOYOTA CAMRY



Controls, instruments pleased most owners.



Front-seat comfort drew high praise.



Some 4-cylinder owners wished for a V6.

A few—a very few—owners of 4-cylinder Camrys told us they wish they'd sprung for the V6. The Four feels weak on the bottom end, said 4.4% of our respondents. The V6 adds approximately \$1650 to the net cost of the Camry DX, LE and XLE

series. It's standard only in the sporty SE, which comes with the 5-speed transaxle, a lower axle ratio, slightly stiffer suspension, V-rated P205/65VR15 tires, 4-wheel disc brakes (standard on all V6 Camrys) and slightly quicker 15.9:1 steering.

Camry offers few free-standing options. Standard equipment choices move up through the four series. About the only items you can order specifically are the V6 engine, anti-lock brakes (\$1130 to \$1245), leather seats for the XLE, a moonroof, alloy

SUMMARY OF TOYOTA CAMRY OWNERS REPORTS*

Total miles driven	1,988,357	Excellent	76.0%	Ride quality	24.7	Yes	19.0
Average miles driven	6118	Good	22.5	Quiet operation	22.4	What type of trouble?	
Purchase price:		Average	1.5	Specific dislikes:		Suspension system	12.6%
Average	\$17,995	Poor	0.0	No complaints	17.2%	Odd vibrations	7.9
Range	\$13,900-\$24,600	Braking:		Mpg lower than expected	10.1	Windshield wipers	7.9
Why did you choose the Camry?		Excellent	68.2%	Noises and rattles	8.9	Air conditioner	6.3
Styling	41.2%	Good	28.8	Price	6.9	Dealer repairs satisfactory?	
Previous ownership	37.7	Average	2.7	Ride quality	6.0	Yes	66.0%
Reputation	25.0	Poor	0.3	Compromised comfort	5.2	No	34.0
Performance	16.2	Overall performance:		Engine power (4-cylinder)	4.4	Dealer service opinion:	
Price/value	10.7	Excellent	71.0%	Suggested changes:		Excellent	53.0%
Quality	9.1	Good	27.2	No changes	10.0%	Good	40.0
Handling	8.4	Average	1.5	Make ABS standard	6.9	Average	4.8
Model choices:		Poor	0.3	More power (4-cylinder)	6.5	Poor	2.2
LE	68.3%	Control layout:		Change seat angle	6.0	Number of vehicles owned:	
XLE	17.5	Excellent	68.9%	Dual airbags	6.0	This vehicle only	30.3%
Basic Camry (Deluxe)	13.9	Good	27.2	Better mpg	6.0	Two vehicles	46.2
SE	0.3	Average	1.5	Workmanship opinion:		Three vehicles	15.6
Options/Accessories:		Poor	0.3	Excellent	76.2%	Four or more	7.8
Moonroof	31.4%	Instrumentation:		Good	21.0	Principal driver:	
Antilock brakes	29.4	Excellent	66.8%	Average	2.5	Female	53.7%
Avg. mpg, city/hwy., EPA:		Good	29.6	Poor	0.3	Male	40.8
2.2-liter 4/5-speed	22/29	Average	3.4	Comfort opinion, front seats:		Equal	5.5
2.2-liter 4/automatic	21/27	Poor	0.3	Excellent	71.9%	Age distribution of owners:	
3.0-liter V6/automatic	18/25	Driver sightlines:		Good	24.2	Under 29	7.6%
Engine choices:		Excellent	62.1%	Average	6.4	30-49	42.4
2.2-liter Four	71.3%	Good	32.1	Poor	0.0	50-plus	50.0
3.0-liter V6	28.7	Average	4.9	Comfort opinion, rear seats:		Based on your experience, would you buy a Camry if you had it to do over again?	
Transmission choice:		Poor	0.9	Excellent	52.4%	Yes	70.0%
4-speed automatic	94.6%	Specific likes:		Good	41.2	Maybe	23.3
5-speed manual	5.4	Styling	54.5%	Average	6.4	No	6.7
Engine power:		Handling	39.8	Poor	0.0	Mechanical trouble?	
		Comfort	27.8	No	81.0%		
		Performance	25.8				

* Percentages might not equal 100% due to rounding up or insufficient data.

wheels (both standard on XLE) and premium sound systems. A driver's airbag is standard on all models, as are 60/40 split folding rear seats, front recliners, a tilt steering wheel and an AM/FM ETR audio system.

Those are the basics, but what's it like to own a new Camry? Does it measure up to Toyota's high standards for trouble-free automobiles?

Judging by our survey, not quite. About one in five of our respondents experienced problems of some type. Most were minor irritations—orange-peel in the paint, wind leaks around windows, bad remote decklid release adjustment, vibrations, poorly installed upholstery, wheel misalignment on delivery and a gas-cap holder that snapped off for some owners the first time they tried to use it.

While we did register a few more serious complaints—suspension strut leaks and air-conditioner malfunctions—they were so rare as to be of almost no statistical significance.

Dealer flak

Judging by our survey group, dealer prep seems to be as much of a culprit here as build quality. And more than a third of our owners with mechanical problems said their dealers didn't fix their cars properly on the first visit.

Toyota dealers took some heat for arrogant sales policies, too.

"They think it's still a seller's market," grumbled one respondent.

The new Camry's styling got a lot of praise, and 41.2% of our respondents listed styling as one of the big reasons they were attracted to the car. Most owners felt the Camry's ride was quiet, but some considered it perhaps a bit too firm. In part, complaints about ride quality could be attributed to the seats, which some owners thought were a bit too thin in the cushioning department.

On the other hand, 76% gave the Camry's handling top marks.

Camry loyalists

At the bottom line, the large majority of our Camry owners were pleased with their cars, saying they'd make the same choice if they had it to do over again. Indeed, many of our respondents have owned a series of Camrys over the years.

But our survey also revealed a significant minority that expressed some doubt about its choice. While it's clear that Camry is a winner, this isn't the ringing endorsement we've seen for some other Toyota products. Perhaps the inherent problems associated with big volume in the midsize segment are catching up with Toyota—or at least with some of its dealers. **PM**



Though conservative, Camry's rounded, contemporary good looks scored high with owners. Previous ownership and Toyota's reputation were also prime persuaders.

EDITORS REPORT

Portrait Of A Winner

● As a result of its most recent redesign, the Camry has gone from merely very good to outstanding. Toyota now has one of the best entries in the midsize field, a car that's put its share of pressure on the Honda Accord and the Ford Taurus.

Smooth styling and improved roominess are certainly key elements in the Camry's increased appeal as a family sedan. But the quality that sets it apart in our view is how little fuss it generates in going about its business. This is the basic currency of the all-around family sedan, and the Camry pays a high return on investment.

Most of the pleasant hours we've spent in new Camrys were V6-powered. This is a superb engine—smooth, quiet and powerful—that helps to make the Camry one of the best traveling companions in its class.

The 4-cylinder version isn't quite so compelling. Although it stirs the car along well enough at freeway speeds, acceleration is so-so and the engine sounds busy when the driver demands peak power. We recommend the V6, which is one of the best in the business.

Measured against its competition, we think the Camry's handling is very good. It's devoid of vices and totally predictable. Toyota has done a particularly good job with the Camry's power steering, which provides much better on-center feel than many competing makes. And the ride quality is of the all-day variety.

An important element of all-day comfort, of course, is all-day seating. The Camry's seats are kind to the gluteal portions of the anatomy. In a car with a fuel range of 400-plus miles, this is important.

Our only quibble with the Camry's interior appointments is the general mousiness of the fabrics—with the exception of the XLE's optional leather, of course. However, Toyota is already addressing this issue, and we'll see better-looking interiors in upcoming Camrys.

We don't know what to think about the survey owners who reported unhappiness with their dealers. In the course of our just-completed long-term evaluation of a '92 Camry LE V6, we didn't have any occasion to test the one-time-fix index of the dealer service department, simply because nothing ever needed fixing. Nothing. All our Camry ever required was routine service, and we're inclined to regard this car as bulletproof.

We also regard the Camry's fuel economy as competitive for this class. Our '92 LE V6 long-termer, equipped with a 4-speed automatic, delivered 22.6 mpg during its year of PM service. The 4-cylinder LE automatic pictured here turned in 25.4 mpg during a week of driving in and around Los Angeles.

On balance, we're inclined to give the Toyota Camry even higher marks than its owners do. To say it another way, what's wrong with this picture? Nothing.

—Tony Swan

You deserve the car you want,
not the car you have to
settle for.



*Except battery, tires and normal maintenance. See limited warranty at dealer. †Whichever comes first. See your dealer for terms of this limited warranty. **See your dealer for details. ***MSRP including dealer prep and \$800 Down Payment Assistance. Tax, license, destination charge and optional equipment additional. The Chevrolet Emblem and Lumina are registered trademarks of GM Corp.

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Like V6, air conditioning, automatic, power door locks, plus the security of standard anti-lock brakes (ABS).

You deserve all that and more. And you get it in the Chevy Lumina Euro Sedan.

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COVER STORY

JUMP-JET

Japan seeks to join the vertical takeoff club with a novel lift-fan design.

BY DAVID W. FREEMAN; PM Illustration by John Berkey

• You are an aircraft designer. Your assignment is to devise the next-generation passenger transport. Specifications call for a capacity of 100 passengers, a top speed of Mach 0.8, a range of 1600 miles and an operational ceiling in excess of 32,000 ft. Your aircraft must be reliable. Very comfortable. And quiet enough to meet increasingly stringent noise regulations. Finally, your aircraft must be sufficiently economical to compete head-to-head with the commercial airliners now in service.

Oh, yes—one last thing. Your aircraft must be capable of taking off and landing vertically from an unprepared site no more than 200



AIRLINER



sq. meters in size—a tiny fraction of a conventional airport runway.

If you're stumped, you're not the only one. For decades, designers in this country and abroad have been engaged in an on-again, off-again effort to develop just such a machine—a commercially viable aircraft that combines the short-hop virtuosity of a helicopter with the speed, economy and comfort of a fixed-wing jet aircraft. In other words, the Holy Grail of commercial aviation.

Yet, despite numerous promising designs, as well as a handful of prototypes and production models (most notably the Bell/Boeing V-22 Osprey now being tested for the U.S. Armed Forces), most existing and proposed VTOL aircraft have been prop-driven machines—tilt-rotors, tilt-wings and other aircraft designed for short hauls, small payloads and low speeds. Fine aircraft, in many cases, but lacking the specs to compete with other modes of intercity transportation.

If, on the other hand, you've got a few good ideas, there may be a job waiting for you in Tokyo. There, aviation designers from the National Aerospace Laboratory (NAL) are working to create just such an aircraft. Pictured here is what the team has come up with so far.

This proposed VTOL aircraft represents more than

an ambitious early step into novel aircraft technology. Says Masanori Endoh, head of NAL's VTOL development program, the aircraft will spark a worldwide revolution in commercial aviation.

"We must build this big VTOL aircraft as soon as possible," says Endoh, "because it will open the horizon for a new air-transport network suitable for the 21st century. Once we build it, we will no longer need conventional airports."

Endoh's aircraft isn't on the tarmac just quite yet, of course. Several hurdles remain uncrossed: ever-tightening government R&D budgets and certain design challenges, including development of a powerful and reliable lift fan. Moreover, even in the rosiest scenario presented by Endoh, the first flight of the finished VTOL prototype won't come for another decade, at least. But there is reason for optimism. According to Endoh, preliminary studies of the proposed aircraft's propulsion system, as well as computer analysis and wind-tunnel testing of its airframe, suggest that the NAL aircraft will meet all the criteria outlined above.

It doesn't take an aeronautical genius to appreciate the appeal of a VTOL transport. Just ask any hapless traveler who has fought heavy traffic on the road to and from distant airports, or awaited takeoff on a packed runway.

Urban planners have traditionally tried to reduce

JUMP-JET AIRLINER

such delays by adding new infrastructure—more runways, bigger terminals and higher-capacity highways around existing airports. But new construction of this type seldom provides more than temporary relief. In addition, the clearing of wooded areas and pouring of new concrete become less and less attractive as competition grows for land in crowded metropolitan areas. Already this approach is altogether impractical in a country like Japan, where small size, mountainous terrain and high population density render new infrastructure especially undesirable. Hence, it's no surprise to aviation experts that VTOL transports will likely first appear in the Orient.

The Japanese designers hope to shorten air-travel delays by concentrating on new hardware rather than new infrastructure—that is, not by boosting access to centralized airports, but by building a new class of aircraft capable of flying out of tiny decentralized airports located only a short walk from downtown districts. In the United States, the Federal Aviation Administration has already commissioned vertiport feasibility studies for 15 different cities.

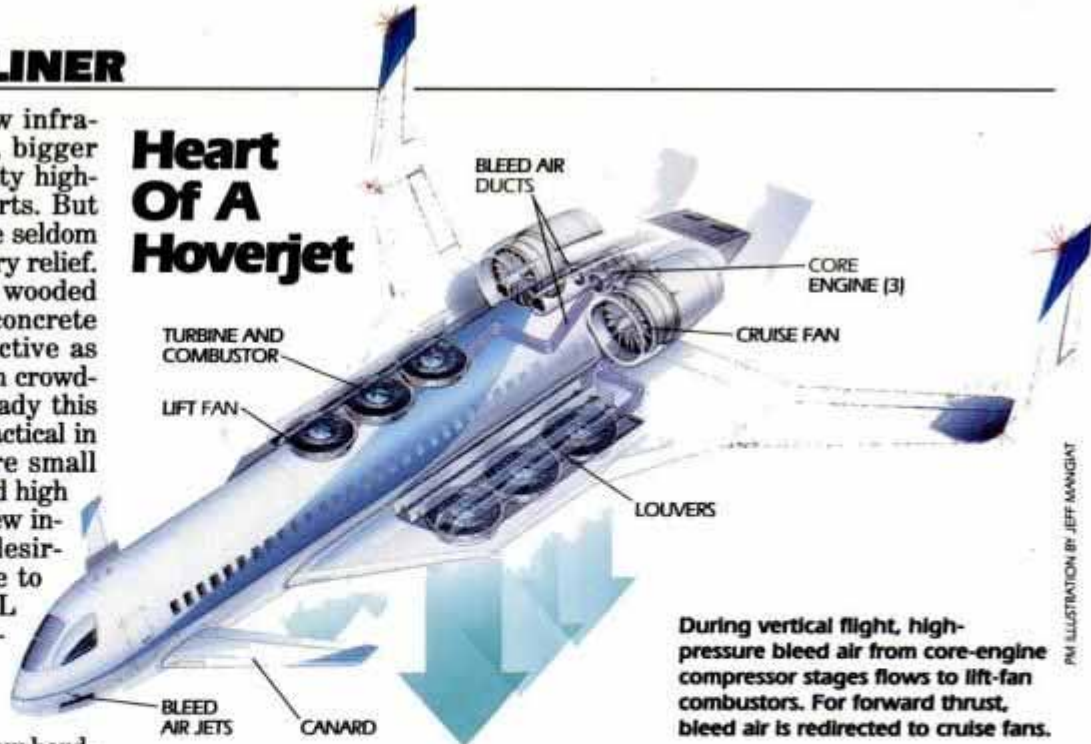
The cost of flying on the proposed VTOL aircraft remains uncertain. Endoh predicts a ticket price 20% higher than that for flying on a conventional airliner. Other aviation experts aren't quite as sanguine. Says one, the cost will be so high initially that the aircraft's only users will be wealthy tourists and companies shipping high-value cargo. However, he says, prices should soon drop to competitive levels.

As presently envisioned, the NAL VTOL transport would employ a narrow, tailless airframe, with twin canards sprouting from the fuselage just aft of the cockpit and narrow, dramatically swept wings set far aft. In place of a conventional tail, the design calls for winglets shaped alike but proportionally much larger than those found on some existing airliners. The aircraft, equipped throughout with advanced fly-by-wire technology, would be approximately 100 ft. long, with a wingspan of 79 ft.

This unusual configuration helps ensure stability—especially during low-speed and vertical operation when the absence of horizontal air-speed renders control surfaces ineffective.

"We tried many shapes," recalls Endoh. "However, to reduce the danger of uncontrolled roll, pitch and yaw, we had to make sure the center

Heart Of A Hoverjet



During vertical flight, high-pressure bleed air from core-engine compressor stages flows to lift-fan combustors. For forward thrust, bleed air is redirected to cruise fans.

PM ILLUSTRATION BY JEFF MANNING

of gravity was on the lift engines. That left us with just one possible design."

For reduced weight and increased rigidity, the NAL team plans to fashion virtually all elements of the structure—including fan blades and engine components—from ultralight carbon-fiber composites.

The aircraft would be powered by a unique system employing lift and cruise fans powered by a trio of aft-mounted turbine powerplants. For forward thrust, high-pressure bleed air tapped from the compressors of these three "core" engines would be routed to twin, 7-ft. cruise fans. At the center of each fan, is a combustor where fuel would mix with the bleed air and ignite. The expanding gases would spin a turbine linked to the fan by a reduction gear, producing 24,000 pounds of thrust per side.

During vertical takeoff and landing, bleed air would be ducted to six 8-ft. rotors encased within the wings and shielded on both upper and lower wing surfaces by controllable louvers. Collectively, these 200-blade rotors—each molded from a single piece of carbon fiber and each fitted with its own combustor, turbine and reduction gear—would generate in excess of 130,000 pounds of thrust.

Perhaps surprisingly, the lift fans should not be especially noisy. "Because the fan speed is very low, and because the sound produced by the one-piece fan mechanism will be extremely high-pitched," predicts Endoh, "our aircraft will be quieter than a conventional helicopter. However, just to make sure, we will use sound-absorbing liners inside the louvers. It will cause no environmental problem."

As the craft rises, the louvers work

in tandem with several small low-pressure bleed air jets positioned at several points along the fuselage to maximize low-speed maneuverability and stability. To facilitate the transition from vertical to horizontal flight, the pilot gradually redirects bleed air from the rotors to the cruise fans, simultaneously closing the louvers to seal off the rotors. Closing the louvers boosts the wings' effective surface area, thereby increasing aerodynamic lift. (In fact, the pilot can easily seal off the louvers and get the aircraft airborne using a conventional rolling takeoff.)

Once the craft reaches altitude, one of its core engines is shut down. The louvers remain closed and the lift fans disengaged until the aircraft slows for a vertical landing.

If one of the three core engines fails in flight, the two remaining engines should produce enough power to keep the aircraft aloft. And if one of the lift fans conks out? In that case, says Endoh, the fan located directly adjacent to or diagonally across from the failed fan would instantaneously shut down to preserve a balanced pattern of thrust. The aircraft could fly, he says, with only four operational lift fans.

And what if a third fan stops? "In that case," says a NASA Ames scientist, "you hope for a controlled crash."

Quips like that notwithstanding, aviation experts familiar with the basics of the NAL approach are duly impressed by the proposed aircraft's safety and versatility, not to mention its apparent feasibility. As long as Endoh can persuade his government that the project deserves additional funding, expect to hear more from the designers at NAL.

STATE POKER



● Walk into a Las Vegas or Atlantic City gambling casino and you'll be greeted by the sight of a horde of people playing slot machines. Odds are it's the first gambling activity you'll try. Pop a quarter or dollar into the slot and play a game of chance. Is Lady Luck with you tonight?

You may be asking yourself the same question the next time you visit a bar, nightclub or bowling alley. In the near future, you're just as likely to see a slot machine in your neighborhood as you are in a casino. However, the "house," as gamblers call it, isn't the

New multigame video slot machines linked to computers promise a rich bonanza.

BY FRANK VIZARD, *Electronics Editor*

local proprietor. You're betting with the state government.

Why are state governments interested in a business that was once the purview of shady operators and tinged with moral ambiguity? The simple answer, of course, is money. Many states, thanks to the recession, are facing revenue problems of gigantic proportions. Over the past few years, state government budgets have been pared to the tune of billions of dollars. But costs continue to rise, led by Medicaid and the construction of new prisons—both of which are growing at a rate of



The cornerstone of video lottery is a touch-sensitive screen that allows a player to make choices quickly. Since the number of machines installed at each location is limited, one machine offers a multitude of games. Bally's V7000 machine (above right) offers 10 games.

more than 15% per year.

The federal government, faced with its own huge deficit, has scaled back its financial support of state governments. Combine this with public resistance to new taxes and you have a situation in which states are caught between a financial rock and a hard place.

For the states, operating slot machines is simply an extension of existing state lotteries or "lotos" that began in New Hampshire in 1964. Beyond even lotto, legalized gambling is on the rise in many states, whether it be on Mississippi riverboats or on Indian reservations, as in Connecticut.

But with slot machines spread out all over a state, legalized gambling could well become ubiquitous in the 1990s. Five states—Oregon, Montana, Louisiana, South Dakota and Rhode Island—already have slot machines operating. Legislation is pending in many states. And while the political process is often slow, the prospect of additional revenue promises to make video lottery a growth industry.

Video bandits

These slot machines are not the old-fashioned mechanical one-arm bandits of yesteryear. Today's slot machines look much like videogames. In fact, the states don't refer to them as slot machines, preferring the designation "video lottery terminal."

In many respects, the spread of video lottery is driven by technology that guarantees entertainment and security. The new video lottery machines are packed with microprocessors that allow one machine to offer a multitude of games. One machine, for

example, can play a variety of poker, blackjack and keno games. Games can also be configured around sports themes or operate like plain, old bingo. Bally Gaming's new V7000 video lottery machine, for example, offers as many as 10 games.

Poker alone, of course, has hundreds of variations and a video lottery machine may offer everything from "Jacks or Better" to "Deuces Wild." Outcomes are determined independently by a random number generator within each machine.

This versatility dovetails nicely with the more general restrictions on video lottery. So far, state governments are allowing only a few video lottery machines per location. South Dakota, for instance, places a limit of 10 machines per location with a license to serve liquor. Oregon allows only five machines per location. With only a few machines allowed per site, machines have to appeal to as wide an audience as possible.

Some sites, however, may have many machines. In Louisiana, for example, an unlimited amount of video lottery machines can be installed at parimutuel racing facilities and at off-track betting parlors. Up to 50 machines can be placed at a single truckstop. In other locations, only three machines can be installed.

Much of a game's appeal derives from how quickly a player can interact with the machine. And certainly, the quicker a player can play the game, the more games he will play. Here again, video lottery is technology driven.

The cornerstone of the video lottery machine is the touch-sensitive screen that gives the player instant gratification. While there are a vari-

ety of touch-screen technologies available, most machines use a capacitive overlay technology developed by MicroTouch Systems Inc., based in Wilmington, Massachusetts.

The MicroTouch screen has a thin-film conductive coating through which a low-voltage AC electric charge is distributed. When your finger touches the screen, it draws away some of the energy. Controllers measure the amount of current drawn from the sides of the screen, plotting an X and Y axis, to determine the point of contact. The machine records the touch within 15 milliseconds after contact.

While seemingly simple in principle, capacitive overlay technology reacts better than others to light touches and has the fastest reaction time—critical features for players who want to play quickly and often.

Capacitive overlay screens can also handle rough treatment, being almost impervious to water, dirt and grease. If a player spills a drink onto the machine, the machine will keep playing. Considering the environment in which these machines must operate, toughness is a prerequisite.

Paper winnings

For the most part, video lottery machines at retail locations are played the same way as at a casino. The difference is mainly in how a player collects his winnings.

Instead of money clinking into a tray, a printer installed in the machine issues a ticket for the amount owed to the player. The ticket is then given to the local operator—bar, bowling alley or whatever—for cash.

Since video lottery games are primarily entertainment devices, the

winning payout percentage is high—between 85% and 94%—and is comparable to a casino operation. Payout cycles vary. Some machines are programmed to pay out small wins very quickly, while others make a big payout but less frequently.

Of the remaining net revenue, the state typically gets between 35% and 55%, depending on whether the state owns the machines or just licenses private operators. Oregon and Rhode Island own their machines, for example.

No tampering

What's to prevent someone from cashing in a winning ticket more than once? In a word: technology. In fact, it is the control measure that is making video lottery gambling viable.

Picture a bank of video lottery machines against the wall in your local saloon or restaurant. Each machine is connected by fiberoptic cable to a validation machine controlled by the cashier. When a player presents a ticket to the cashier, it is compared against the game and betting information recorded by the video lottery machine and against a record of previously cashed tickets. Cash is paid only when the data on the ticket matches with the electronically stored information in the validation machine.

Each video lottery machine is also connected to a central computer run by the state. This computer network, which includes regional centers and a central site, allows the state to continuously monitor the performance of a machine. In an on-line fiberoptic system, the monitoring can be virtually continuous. If the system uses older copper-wire phone lines, each machine can be dialed up and checked daily.

Generally, there is some type of electronic link between the central computer network and an individual video lottery machine. This "cluster controller" acts like an electronic crew chief, monitoring the group of video lottery machines at a given location. One cluster controller, as designed in a system by International Game Technology of Reno, Nevada, can control up to 255 single-game video lottery machines or a variable amount of multiple-game machines.

This flexibility is necessary in case a state dictates that only a single game—poker or keno, for example—can be played on a video lottery machine. In Louisiana, for instance, video lottery machines offer only video poker.

The computer network safeguards each machine from tampering. Just as important perhaps from the state's viewpoint, the computer system allows the state government to know immediately how much revenue it has collected from each machine. Funds owed the state are transferred electronically from the retail location to the state's coffers. Collecting a day's worth of game-playing information takes less than 1 minute per machine.

Video lottery play could also become an entirely cashless procedure. "Smart" debit cards could be bought from a local retailer, for instance, that would add or subtract credits as they accumulate. Each card could have a \$10 ceiling, for example, to prevent abuses.

An on-line computer system also allows the state to develop a progressive gaming option in which all the video lottery machines are linked to a central jackpot. A progressive game, for example, could award a multimillion dollar jackpot to a single winner. While progressive games are common in Las Vegas and Atlantic City casinos, no state has implemented a progressive game thus far.

Computer monitoring systems for video lotteries are constructed by companies with experience in gaming. These companies include Bally Gaming International, International Game Technology, WMS Industries and Video Lottery Technologies. Similar systems have been built in Canada, Australia and Europe.

The bottom line

The revenue generated by video lottery machines is clearly a shot in the arm for the treasuries of state governments. In South Dakota, net income from video lottery alone is expected to be \$45 million in 1993. Prior to video lottery, net income from lotteries was only \$7.3 million. Machines in South Dakota are restricted to the 2100 locations licensed to serve liquor.

Just how popular video lottery machines can be is seen in the financial numbers for Montana. In 1990, Montana estimated the amount of video wagering at \$251.8 million, which represents 87% of a total that includes live keno, lotto, bingo and horse racing activities.

A populous state like New York, by contrast, has about 25,000 locations licensed to serve liquor. Outfitted with video lottery machines, the revenue generated at these locations promises to be upward of \$535 million per year.

With this type of money at stake, you can bet that video lottery machines will be in your area soon. **PM**



Inside A Video Slot Machine

A video lottery machine works the same as a casino slot machine. For cashless wagering, a printer is installed next to the hopper.

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THE BEST-BUILT, BEST-SELLING AMERICAN TRUCKS
ARE BUILT FORD TOUGH.



INDY '93

An inside look at the machines that will make 1993 the best season in Indycar history.

BY RICH TAYLOR, Contributing Editor



● As we count down to the 77th Indy 500, it's plain that 1993 is going to be the most exciting Indycar season in years—perhaps the most exciting ever. Four-time Indy 500 champs A.J. Foyt and Rick Mears have retired, it's true, and Michael Andretti has left to race Formula One in Europe. But youthful hotshoe Robby Gordon has replaced A.J. in the Copenhagen Lola, talented Canadian Paul Tracy has replaced Rick in the Marlboro Penske and reigning Formula One World

Champion Nigel Mansell has replaced Michael in the Kmart Lola.

Add in 3-time PPG Indycar Champion Bobby Rahal, 1992 Indy 500 winner Al Unser Jr., Emerson Fittipaldi—the only driver other than Mario Andretti to have won a Formula One World Championship, IndyCar Championship and the Indy 500—plus young hotshoes like Scott Brayton and Raul Boesel and it's clear that we're in for a whale of a show. What other race series

TECH



has ever had a supporting cast on the level of former Indy winners Arie Luyendyk, Danny Sullivan and Mario Andretti? Not to mention hard-charging Canadian Scott Goodyear, who came within a car length of winning Indy last May.

The 1993 Indycar rules are so strict that every driver is racing with essentially the same equipment, and—theoretically—has an equal chance of winning. There are only three chassis—Lola, Penske and MGD—and a choice of five engines: three generations of the Chevrolet Indy V8, the Ford-Cosworth XB V8 or the Buick V6. And every car rolls on identical Goodyear tires. Of course, within this narrow framework each team has the freedom to make its own refinements. So while all the cars are the same, they're all different, too.

Chassis Rules

Three different groups are involved in Indycar rule-making: Championship Auto Racing Teams (CART), the United States Auto Club (USAC) and the Indianapolis Motor Speedway. New unified rules went into effect at the first race of the 1993 season in Australia and are expected to continue at least through the last race in 1995. They keep the cars and engines much as they were in 1992, while making them safer and less expensive.

The new rules specify a car between 190 and 195 in. long and 78.5 in. wide to the outside of the wheels (bodywork can be only 63 in. wide and 32 in. high). The car must have a minimum wheelbase of 96 in. and weigh at least 1550 pounds, not including fuel or driver. Front wheel rims can be no wider than 10 in., rear



Formula One champion Nigel Mansell.

INDYTECH '93



The POPULAR MECHANICS/Dick Simon Racing Lola driven by Scott Brayton is standard, state-of-the-art Indycar weaponry. Built to the '93 rules, the Lola chassis has a carefully contoured aero bottom tub (top right), plumbing work tucked under the side pods (center right) and massive outboard front disc brakes (bottom right).

wheel rims are limited to 14 in. There are dozens of other detailed specifications governing dimensions, materials and even crash performance.

Crashing into one of Indy's concrete walls at 200 mph or more is a prospect that haunts all drivers. The 5-in. nose extension required for '93 is designed to address this hazard. This new nose is required to be wider, taller and stronger than before, leaving more room around the driver's legs and feet. Also, exposed chassis tubing in the cockpit floor is outlawed. The new design was conceived to give drivers a chance to pull their legs back behind the dashboard bulkhead when disaster impends.

In addition, there are a number of very specific rules aimed at keeping speeds from escalating, particularly at Indy. For example, the rear wing cannot measure more than 12 in.

front to back, the underbody "ground-effects" contours are more strictly controlled to limit cornering speeds, the rear engine cover can't be any smaller than those used in '92 and flush-faced aerodynamic wheels



Flush-faced aerodynamic wheels are now banned in favor of open-faced alloys.

are no longer allowed. According to Penske Team Manager Chuck Sprague, just uncovering the wheel centers takes about 2 mph off of top speeds at Indy.

Other rules are aimed at keeping costs in line. Honda, Nissan and Toyota have all expressed interest in entering Indycar racing in 1994. The rulemakers are obviously afraid that these companies, particularly Honda, might import expensive Formula One technology and raise the costs for everyone. Even as it is, it costs about a half-million dollars to put a car on the track, and well over \$10 million to run a whole season.

Consequently, a whole group of "anti-Honda" rules have been enacted. Indycars are now prohibited from using Formula One-style electronic fly-by-wire throttles, computer-controlled differentials, traction control,

antilock brakes, carbon-fiber clutches, automatic transmissions, computer-controlled suspensions and on-board 2-way telemetry. To be fair, most of these devices also will be banned in Formula One in 1994.

Lola T93/00

Based in Britain, Lola produces the only Indycar "customer" model—some 3-dozen new cars each year—so three-quarters of the field at any given race will be Lolas. Last year Lola produced two versions—one with a low engine cover, allowed by the compact design of the Ford-Cosworth V8, and another with larger bodywork to hold the Chevrolet and Buick engines. The 1993 version is based on the '92 Lola-Cosworth, though Lola has built four cars with larger decklids for John Menard's Buick-powered team.

The most readily apparent change is the Lola's longer nose and a longer, wider monocoque fabricated—like all current Indycars—from carbon-fiber composite. The needle point of the nose now projects well beyond the wings. The easiest way to spot a Lola at speed around The Brickyard is probably by the curving wing that sweeps up in front of each rear tire.

Thanks to their wide availability, you'll see Lolas near the front of the pack all year, and you can bet they'll win their share of races. All the PM/Dick Simon Racing Team cars (see "PM Racing Team '93") are Lolas, and we hope one or more of them will find their way into the winner's circle this year.

Penske Chevy '93

Emerson Fittipaldi, Paul Tracy and Stefan Johansson will be the only drivers running the latest Penske chassis. Created by ex-Lola designer Nigel Bennett and built in Poole, England, the new Penske looks very similar to the new Lola. The easiest way to spot a Penske? Aside from Team Penske's red-and-white Marlboro paint scheme, the Penske nose has a high center section with dihedral canard wings like a World War II F4U Corsair fighter. This gives better airflow to the underbody ground-effects area.

According to Penske Team Manager Chuck Sprague, the '93 car "is a significant redesign. The chassis is heavier, the nose is longer, the rear engine cover is lower and smoother. The rear suspension has been changed—the lower wishbone is now above the surface of the underwing, the upper wishbone is in the air-stream above the bodywork. This is

the way Lola has been doing it for a couple of years.

"We've also altered the way the radiators are mounted," says Sprague. "They now stand vertically with the outer edge forward. That's also the way Lola has been doing it."

Rahal-Hogan MGD

Bobby Rahal's team has acquired the entire Truesports operation, including the chassis that Scott Pruett debuted last year. Bobby will race an updated version of the old Truesports car until after Indy, then switch to the new MGD. According to chief designer Don Halliday, the new car will use a dihedral front wing and probably large end plates like the current car.

As Halliday says, "From the stands, the fans will think it looks like the 1992 car, but underneath, the '93 chassis is substantially different. It's

stronger and safer than the Lola or Penske, I think. The composite chassis of those two cars are laid up inside a female mold. Our car is laid up over a male mold. This allows us to pull the bodywork down tight around the chassis for better aerodynamics."

In 1992, Bobby Rahal made history by being the first owner/driver in modern times to win the PPG Indycar Championship. This year, he has a chance of being the first owner/driver/constructor to win. That would be a coup of major proportions.

For all their subtle differences, though, the Lola, the Penske and the MGD are nearly identical. They are certainly more similar than Indycars have been in past years.

Indy Power

Indycar rules are even more strict when it comes to engines. Eight cylinders are the maximum. You are

Indy Power



● When the green flag drops on May 30, most drivers will punch the throttle open on one of these four engines (only Eddie Cheever has a Chevy V8/B), unleashing thousands of horsepower, 850 at a time. And while hopes will be high inside all 33 cockpits, in reality, only a fraction of the cars in the race will have a realistic chance of reaching the winner's circle—those running either the Ford XB or the Chevy/C.

The Ford XB powered Nigel Mansell to a win in the first race of this season. But he had to battle Emerson Fittipaldi's Chevy/C-powered car all the way.

With both the Ford and Chevy/C producing just about equal amounts of power, it comes down to stamina and fuel economy as the defining factors in winning races this year. In Surfer's Paradise in Australia, the Chevy/C was a very thirsty powerplant, which might mean extra pit stops for teams running the C.

And what of the Buick V6 and Chevy/A? The Buicks produce prodigious horsepower but break a lot. The old reliable Chevy/A isn't in the horsepower league of the XB and C, but might be the only thing running at the end of the race.

—Joe Oldham

INDYTECH '93



TM PHOTO BY ART FLORES

The '93 Penske Chevy, carrying the Marlboro colors, moves closer than previous designs to the Lola chassis, incorporating many similar characteristics.

still allowed to race a normally aspirated stock-block V8 of up to 390 cu. in. (6393cc), but the last big stock-block at Indy was Kevin Cogan's Eagle-Pontiac in 1984. It used what was essentially a NASCAR Winston Cup V8 and was well off the pace.

Turbocharged stock-block engines with pushrod valvetrains, like Buick's V6, are allowed a maximum displacement of 209.3 cu. in. (3430cc) and a maximum intake-manifold pressure of 50 in. of mercury (24.4 psi). Turbocharged engines with overhead camshafts are limited to only 161.7 cu. in. (2650cc) and a maximum intake-manifold pressure of 45 in. of mercury (22.0 psi). This would include all the Chevys and Fords.

In either case, you're only allowed a single turbocharger and a maximum of four valves per cylinder, mechanically operated (no pneumatic valves). Cylinder bores must be round—none of Honda's trick oval pistons wanted here. Other prohibitions: no exotic metals, ceramics or plastics in the engine, no variable camshaft tim-

ing, no variable-length intakes and no variable-geometry turbos.

By far the most controversial engine rule is another anti-Honda measure, meant to keep newcomers from building a car and running away with the series the way the McLaren-Hondas did in Formula One. Any new engine design in Indycar racing—that means anything except the existing Chevrolet, Ford and Buick powerplants—must be made available to at least three cars on two different teams the first year and six cars on three teams the second year.

This means that Honda, Nissan, Toyota or anybody else who wants to go Indycar racing for a full season would have to build and maintain at least 50 engines the first year and 100 engines the second year, without any certainty that the design is a winner. It's interesting to note that Chevrolet didn't have to operate under these rules during the development of the Chevy Indy V8. The Indycar establishment has effectively closed the game to newcomers.

Buick V6

Pancho Carter put a Buick V6 on the Indy 500 pole in 1985, Jim Crawford's Buick-powered car led the race in 1988 and Roberto Guerrero's Buick V6 won the pole position again last year. But while the Buicks obviously make enough horsepower, they've always been short on stamina. After spending millions, Buick withdrew its factory support after the 1992 season. Nevertheless, John Menard has purchased four new Lola chassis for Gary Bettenhausen and Kevin Cogan, and will continue to develop the only stock-block in Indycar racing.

Based—loosely—on Buick's 3300 V6, it has two valves per cylinder, with rollers on the valve lifters, pushrods and rockers. It has a dry sump and aluminum block. In Indy tune, it produces around 850 hp, competitive with the Chevrolet and Ford V8s. It's also much less expensive.

Thanks in part to its Delco-designed engine control computer and larger displacement, the Buick V6 has a very flat torque curve compared to the Chevrolet V8s. The engine itself is also very lightweight and compact, though the exhaust system and intake plenum are quite bulky. Without factory help, however, Menard's team is fighting an uphill battle.

Chevrolet V8/C

While the Chevy V8/A completely dominated Indycar racing from 1986 to 1992, and while you'll see some drivers like Jimmy Vassar, Dominic

(Please turn to page 114)

Pacing The Pack



● Before the starting flag even drops for the 77th running of the Indianapolis 500 on May 30, Chevrolet will have chalked up two Indy records. One will be for the greatest number of times a specific make has been named the Official Pace Car. Chevrolet will have paced The Brickyard nine times since its first outing in 1948. Other Chevy models receiving the honor include the 1955 Bel Air, 1967 Camaro, 1969 Camaro, 1978 Corvette, 1982 Camaro Z28, 1986 Corvette, 1990 Beretta and the current 1993 Camaro Z28. The

four Camaros in the historical car lineup qualify the marque for the second of the two records—the greatest number of times a specific model has paced the race.

While special consumer Pace Car editions have been offered by various carmakers over the years, these models, for the most part, have been graphics packages that, under the sheetmetal, have borne little resemblance to the hardware found in the actual Pace Cars.

Such isn't the case, however, with the 1993 Camaro Z28 Pace Car, which will

be able to pace the Indy 500 in box stock form. Only the required USAC safety package, consisting of strobe lights, roll bar, safety harness and on-board fire extinguisher, will distinguish the hardware of the three actual Z28 Pace Cars from their showroom brethren.

Pace Car power comes from a second-generation 5.7-liter LT1 V8, with 275 horsepower and 325 ft.-lb. of torque.

The engine is mated to a 4-speed overdrive automatic transmission. Rear-axle ratio is 3.23 to 1, while Goodyear Eagle GS-C P245/50ZR16 steel-belted radials provide tenacious traction.

Of course, the Official Pace Car sports a special paint scheme—black over white, with a rainbow ribbon spiral highlighting the diagonal separation of the two colors along the sides and back of the car. And a special gold emblem flush-mounted on the hood is the finishing touch.

While, in actuality, every '93 Z28 is a Pace Car under the skin, Chevy is building 625 special editions with a complete Pace Car graphics package.

—Cliff Gromer



22 PM RACING TEAM '93

Fasten your seatbelts as we join Dick Simon Racing for our wildest ride yet.

● How fast is fast? It's relative, of course. Many of us have traveled at speeds well in excess of 500 mph at one time or another (in an airplane) and thought nothing of it. But in an Indycar, with concrete walls and Armco barriers looming up at 200 mph or more, it's a different story. The distinctions between winning and losing, between triumph and disaster, even between life and death are measured in the tiniest fragments of seconds.

It's a realm that demands extraordinary driving skills. The ability to anticipate and react to situa-

BY TONY SWAN, Automotive Editor

tions before they can evolve into crashes. The ability to ride the razor's edge that separates maximum cornering speed from loss of control. The ability to extract peak performance, lap after lap, from an 800-hp thoroughbred engine without running up the extra 100 rpm that produces expensive junk. The ability to orchestrate all this activity while some 30 other drivers are trying to do exactly the same.

Although there are thousands of racing drivers worldwide, few possess these abilities—combined with

PM RACING TEAM '93



SCOTT BRAYTON LOLA T93/06 FORD-COSWORTH XB

Scott Brayton has seen action in 12 previous Indycar campaigns. The son of former Indycar driver Lee Brayton, Scott began racing go-karts in '74 and won the Skip Barber Driving School championship in '79. Sponsored by Amway, the 34-year-old Michigan native was sixth at Indy in '89. Rolling into '92, he's scored 38 top-10 finishes in 130 Indycar starts.

the desire to win—in sufficient magnitude to compete in the PPG Indycar Series. This is arguably the most intensely competitive form of racing on the planet. Though the cars lack the money-is-no-object technology of Formula One, they're technically sophisticated in their own right. And, more important from the spectator's point of view, they place far more emphasis on driving skill.

As we said, only a few can aspire to this high-speed arena. And we've found a few who are willing to take us along for the ride.

Team PM

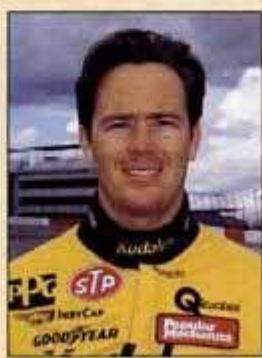
To give you—and us—a better idea of what it's like out there, we're joining forces for '93 with the Dick Simon Racing team as a co-sponsor. With three of the team's four cars wearing PM logos, you'll have a chance to pick your ride from race to race—or stick with one car through the season.

Either way, we'll be on-board throughout the year, with monthly updates as our cars campaign in what promises to be the best Indycar season in history. And even though early season attention has focused on

the Newman/Haas team, featuring 1992 Formula One champion Nigel Mansell, we expect our team to be in the hunt for three reasons: good drivers, good equipment and a man who knows how to orchestrate a competitive effort better than most.

Dick Simon has been involved in Indycar racing since 1969, starting out as a driver and graduating to team ownership—which he shares with his wife Dianne—in 1983. He retired from driving in 1988, and since then has concentrated on the myriad

(Please turn to page 62)



JIMMY VASSER LOLA T92/00 CHEVROLET INDY V8/A

At 27, Californian Jimmy Vasser is young by Indycar standards. But he's been racing for 20 years, beginning with quarter-midgets at age 6. He won an SCCA Pro Formula Ford crown in '84, then went on to impressive seasons in Formula Atlantic and Formula 2000 cars. Vasser made 11 Indycar starts in '92, his rookie season. He's co-sponsored by Kodalux and STP.

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PM RACING TEAM '93



RAUL BOESEL LOLA T93/06 FORD-COSWORTH XB

Co-sponsored by Duracell and Mobil 1, Raul Boesel brings a rich mix of experience to his eighth Indycar season. The 35-year-old Brazilian has driven in F1, the World Sports Car Championship and IMSA's GTP series. He was the fastest Indy rookie in '85 and was voted Most Improved Driver in '86. Through 1992 he had 88 Indycar starts and 35 top-10 finishes.

duties that go with running an Indycar team—promoting, orchestrating test sessions, playing father confessor to his drivers and, most important of all, soliciting sponsors and keeping them happy. It goes well beyond being a full-time job.

Critical ingredients

So with 23 years of experience, what does Dick Simon see as the critical ingredients for success?

"There are two," he says. "You obviously have to have enough money in order to have the right equipment.

"But beyond that, having the right people is the key element, from the drivers and crew chiefs right through the whole organization. And as much as any team out there, I think we have the right people."

Beyond his organizational abilities, Simon thinks one of the most important qualities he brings to his role is his driving experience.

"I know what they're experiencing when they're going around out there," he says. "A lot of times I can tell what's going on with the car just by looking at their eyes when they come back to the pits."

Complementary talents

Driving experience is also helpful when it comes to assessing the strengths of the drivers, and Simon sees his '93 confederation as a group with complementary skills.

"Raul Boesel and Scotty Brayton work particularly well together," he says, "which helps a lot in nailing the right setup.

"Raul is especially good on road courses. He did a good job with us in

'86, but I think he's even better now because he's matured a lot. He has the ability to drive the car close to the edge without abusing it.

"Scotty is a very talented all-around driver. A lot of people think he's only good on ovals, but he has the talent to put the car well up on any grid. He ran up front a number of times last year, and we're expecting him to have lots of podium (top-three) finishes this season. He's due.

"Jimmy Vasser is a younger driver, and he's still trying to find the balance between driving right on the edge and knowing when to back off. That's going to be the key to his year. But he's a charger. In Australia he put a year-old chassis with a Chevy V8/A engine into the top 10 on the grid, and he was the third-fastest Chevy in the whole field."

Although she's not part of the PM team, sports-car veteran Lyn St. James rounds out Simon's list of regulars for '93. Following up on her success as '92 Indy 500 Rookie of the Year, St. James will be driving a JC Penney-sponsored Lola T93/06, powered by a Ford-Cosworth XB V8.

Auspicious debut

Australia marked the debut of the '93 Indycar season, and it was an auspicious outing for the PM team. All three PM cars qualified in the top 10—with Boesel leading the contingent in eighth place, followed by Vasser and Brayton. Although racing incidents damped this promising lineup, Boesel managed to come back from a near-tangle to finish eighth and Simon came home pumped up on his team's prospects for the rest of the season.

"I thought we started well," he says. "We're really looking forward to the rest of this season."

Indycars and F1

With Mansell making his Indycar debut this season, there is, inevitably, endless debate concerning the relative merits of the two series. And even though the cars look very similar, Simon sees big differences.

"In Formula One, the technology has gotten to the point that the driver doesn't really have to do anything but stand on the gas. Nigel's comments bear this out.

"Indycars are a lot different. It's really good old raw racing. It requires all the driver's talents and the coordination of a dancer. You have to do everything—braking, cornering, downshifting and so on—just right.

"And it's also a much better show. The teams are much more closely matched than in Formula One, so the racing is much closer. There were at least 15 cars in Australia that were capable of winning. You can't say that about Formula One."

Beyond stronger overall competition, Simon sees improved safety as one of the biggest changes in the past five years.

"It's been upgraded tremendously," he says, "and we all think this is an important priority.

"The new rule for '93, with the extended nose, is a good example of this. Jimmy Vasser's car was modified to meet the new regs, and when he crashed in Australia, it crushed the nose and he walked away."

What else is there to say? Just one thing: Drivers, start your engines. **PM**

HOME&SHOP JOURNAL



HOME IMPROVEMENT

BASIC APPLIANCE MAINTENANCE

TEXT AND PHOTOS BY MERLE HENKENIUS

● Routine maintenance of household appliances will pay for itself in improved efficiency, longer life and improved appearance. The same sort of diligence most of us give our automobile maintenance schedules should be extended to the appliances in our kitchens and laundry areas. While it's true that a refrigerator costs far less than a new car, taken in total,

appliances are no small investment. Just keeping them clean, inside and out, can make a world of difference.

Servicing refrigerators

Like air conditioners, refrigerators move a lot of air across their condenser coils. With this air comes dust, pet hair and lint that cling to the coils, reducing their ability to dis-

sipate heat. When this happens, the compressor runs longer and cools less. This makes for an inefficient appliance and higher electric bills.

Cleaning these coils twice a year makes a big difference and will take only minutes to complete. As for gaining access, the condenser coils are behind the grille below the door.

The location of the evaporator plate (or evaporator coil) will vary. On older models, the evaporator coil is next to the compressor motor at the back of the appliance behind an access panel. Newer models usually have an exposed coil in the form of a large metal grid on the refrigerator's back.

As the condenser coil does most of the work, it will deserve the greater



1 The grille is held to the refrigerator with clips. Snap out the grille to access the condenser coil.

share of your attention. Begin by lifting the grille from its place below the front door (Photo 1). The coil probably will be loaded with clusters of greasy fuzz. Use a vacuum cleaner to pull the dust from the coil (Photo 2). If the coil feels very greasy, use a spray bottle and some degreasing cleaner to rinse the fin tubes.

Next, pull out the refrigerator so you can work on the compressor compartment. Remove the access panel and vacuum the compressor and evaporator coil (Photo 3). Finally, replace the grille and access panel and move back the refrigerator.

Servicing kitchen ranges

Of the two types of kitchen ranges, gas-fired models require more maintenance than electric models. The reason is that gas is flamed from the burners, which can become clogged. Electric ranges come with direct electrical connections, which remain more or less intact.

Probably the most familiar sources of trouble are rangetop pilot flames. Many of us who grew up with gas ranges can recall a box of kitchen matches permanently installed atop the refrigerator. Our parents just gave up the fight, shut down the pilots for good and lit the top burners with a match.

Today, pilot flames are a little more reliable, but still can leave us mumbling to ourselves, "If they can put a man on the moon..." Well, you get the idea.

There are two problems. First, the pilot orifice may become clogged with carbon grit. Second, the flame shield under the cooktop can accumulate carbon and soot, reducing the flame space between the orifice and the shield.

In either case, tip up the cooktop,



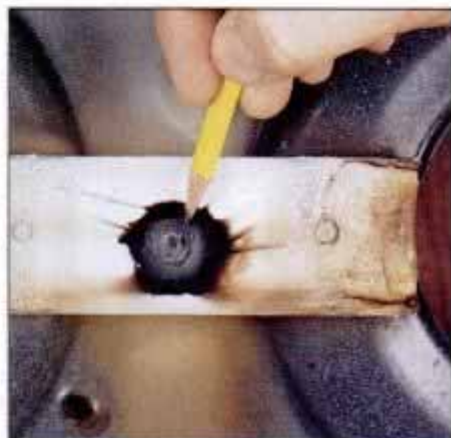
2 Use a vacuum cleaner to pull the matted dust from the coil. If necessary, clean the tubes with degreaser.



3 Also vacuum the evaporator coil and compressor. Often these are located at the back of the refrigerator.



4 To inspect the burners and pilot light on a gas-fired range, lift its top and prop it up with a rod.



5 Here, carbon has built up on the pilot flame shield to nearly 1/4 in. deep. This restricts airflow to the flame.



6 Clean soot and carbon from the pilot orifice using a safety pin. Work gently to avoid damaging the orifice.



7 Gas burners are not held in place with fasteners. Lift them out to inspect and clean them.

and check for carbon buildup (Photos 4 and 5). If you find buildup on the shield, remove the cooktop completely and scrape off the carbon with a knife. Then, for good measure, use a safety pin or thin wire to clean the pilot flame orifice (Photo 6). Do this to both sides of the top before lighting the pilots. If the pilot flames seem too tall or too short, follow the

pilot feed lines back to the mixing valve at the control panel and adjust the flames using the slotted adjustment screw.

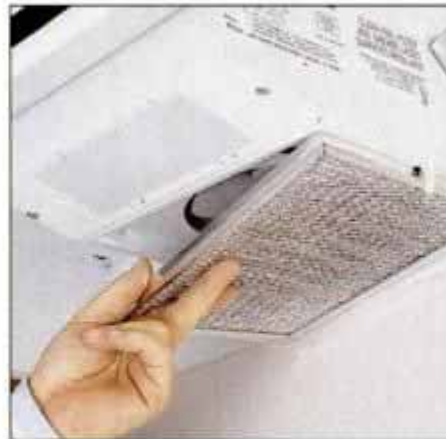
While you've got the cooktop tilted up or removed, check the flame at each burner. If several openings in a burner appear to be clogged, clear them with the same pin or wire (Photos 7 and 8). Then clean the area un-



8 Gently clean soot from the burner openings using a safety pin. Work around the burner's circumference.



9 After removing the heating elements, lift out and clean the reflecting pan and the surface below the pan.



10 Once a month, clean the underside of the range hood and remove the filter so it can be washed out.



11 Rinse dust and grease out of the hood filter using hot water. Let the filter dry before reinstalling it.



12 Use a hand mirror to check for a slimy accumulation along the bottom door gasket on a dishwasher.



13 Lift off the water-level float and clean the tube the float rides on. Dirt can cause the float to malfunction.



14 Check the holes in the spray arm to be sure none are clogged. Here, a small piece of shredded plastic blocks a hole.

der the burners and replace the top. A similar approach can be used to correct a temperamental pilot near the oven burner.

As for electric ranges, the only maintenance you need to do amounts to keeping the various surfaces clean. This is often easier than it looks. But usually heating elements can be lifted out for easy access, as can the re-

fecting pans beneath the element (Photo 9). If your range has a trim ring that is separate from the reflecting pan, make sure to reinstall the pan and ring in the correct order or the element will be crooked. Many models feature removable cooktops for easy cleaning of spills.

Another appliance associated with kitchen ranges is the vented range

hood. The culprit here is often a clogged filter. Simply remove the filter once a month and run hot water through it to rinse out the dust and grease that collect (Photos 10 and 11).

Servicing dishwashers

Usually all you need to do to keep a dishwasher in good working order is to keep its door gasket and spray arms clean. And you should periodically clean any debris from under the heating element.

While the door gasket may appear clean where it is plainly visible, there's a good chance its bottom section is covered with slimy dirt, which can cause the door to leak. Hold a hand mirror to the bottom of the door to reveal any accumulation of dirt (Photo 12).

Use a strong, nonabrasive household cleaner to remove the dirt from the gasket and door panel. You can also lift the water-level float from the base of the cabinet to check for dirt. If the float gets too dirty, it can stick in place, throwing the water level out of whack (Photo 13).

While you're at it, check the openings in the spray arms for small shreds of plastic (Photo 14). Remove these shreds with a pair of tweezers.

Also check the drain area regularly for bread-sack fasteners, small measuring spoons or other kitchen items. Not only can these items be baked onto the heating element, they may break up and chip the food-grinding impellers located in the drain.

Finally, make sure some water remains in the base of the dishwasher. If you seldom use your dishwasher, add water periodically. If left to dry out, the pump seals may leak when the dishwasher is used.



15 Washers and dryers work best, and last longer, when level. Check the machine side to side and front to back.



16 Clean the drums and doors on washers and dryers to remove dyes that leach from new clothing.



17 To release a soiled and sticky fabric-softener reservoir, lift up on the friction ring (in blue).



18 The reservoir should lift free of the agitator shaft. Clean the reservoir in the sink using warm water.



19 Install a rubber friction fitting to firmly fasten the washer discharge hose inside the plumbing standpipe.

the case of the self-leveling legs, lift the low side of the appliance until that leg extends to the proper height.

To keep the finish on these appliances looking good, wash them regularly with a mild detergent (Photo 16). Clothing dyes can stain the insides of washers and dryers, so clean their drums frequently, especially after washing new clothes.

Some components, such as the fabric-softener reservoir on a washing machine, can be removed for better cleaning. The reservoir is often held in place by a friction ring. Just lift this and the reservoir will detach from the agitator (Photos 17 and 18).

And, finally, you should fasten the washer discharge hose to the plumbing standpipe. A washer discharge pump is capable of moving 50 to 60 gallons of water per minute. That much pressure has a tendency to lift the discharge hose right out of its plumbing pipe. There are several devices made for this problem, including a friction-fit gasket (Photo 19).

Lacking a factory-made solution, use wire or duct tape to secure the hose. A loose discharge hose can do hundreds of dollars of water damage.

Because dryers produce so much lint, you'll need to pay particular attention to the lint trap and the dryer vent tube. Remove and clean the lint trap with each load (Photo 20). Failing to clean the lint trap regularly can cause the dryer to overheat and could start a fire. A clogged lint trap makes the dryer operate inefficiently.

Also, check the vent tube twice a year, especially if your dryer vents upward, as do most dryers located in basements. Pull out the dryer to get behind it. Then pull the vent from the dryer connection. This will allow you to shake any lint and debris accumulation from the tube (Photo 21). **PM**



20 Clean the lint from your dryer's lint trap after every load to prevent overheating and the danger of a lint fire.



21 Remove the dryer's vent tube twice a year and shake or vacuum out the accumulated lint and debris inside it.

Servicing washers and dryers

The best things you can do for your clothes washer and dryer are to keep them level and clean. If they are out of level, their moving parts will wear unevenly and excessively. Service technicians can tell you that most of the laundry appliances they encounter are completely out of level. In some cases, "self-leveling" legs

compound the problem because they don't always level the appliance. Instead, they're used simply to close the gap between the appliance and the floor.

To properly align an appliance, place a small level on the top frame of the unit to determine where the problem is (Photo 15). Then, thread the legs up or down accordingly or, in

TOOL TECHNIQUES

THICKNESS PLANER

There's more to this woodshop workhorse than meets the eye.

TEXT AND PHOTOS BY
ROSARIO CAPOTOSTO,
Contributing Editor



● When you buy lumber, you take it for granted that you'll cut the pieces to length and rip them to width to suit your project. You don't expect the lumberyard to handle these chores—they are why you had a shop set up in the first place. However, in most cases, you simply have to accept lumber in the few thicknesses offered and make your work conform to what's available.

Sooner or later, though, you'll want the same flexibility for handling custom thicknessing as you have with crosscutting and ripping. And, when that time comes, you'll want a thickness planer.

Not so long ago, thickness planers were rarely found in typical home workshops. The machines were large

and expensive, designed essentially for commercial operations. Over the past several years, the picture has changed. Compact, affordable planers are now available to suit the needs of small shops, and are increasingly popular with home woodworkers.

In addition to expanding the scope of your work, a planer allows you to work with rough-sawn lumber. You can access a wider range of woods, and take advantage of lower prices on species you'd normally buy as surfaced stock.

Thickness planers are designed to perform one simple operation—smooth a face of a board so it's parallel to the opposite face. Planing is accomplished by a rapidly rotating

double- or triple-knife cutterhead that skims the surface of the work as it's held down against the planer table. Power-driven infeed and outfeed rollers grip and move the stock past the cutterhead. The depth of cut is controlled by one of two methods, depending on the design of the machine. With some planers, the table height is adjustable to bring the work closer or farther from the cutterhead. In other designs, the table is stationary and the cutterhead assembly is lowered into the work.

Planer size is designated by the length of the knives—which determines the maximum width of stock that can be handled—and the maxi-

imum distance the table can be moved away from the knives. Small planers range in width capacity between 6 and 12 in., with maximum thicknessing ranging from 4 to 6 in. Minimum thicknessing capacities range from $\frac{1}{4}$ to $\frac{3}{32}$ in. (Photo 1).

These small planers typically operate at a fixed feed rate. This means that the number of cuts per inch is



1 Compact thickness planers are ideal for small shops and tight budgets. This model handles stock sizes up to 6 x 12 in.

not adjustable. One version, the Shopsmith Professional Planer, features variable speed capacity through separate motors for the cutterhead and feed rollers (Photo 2). This allows you to increase the cuts per inch, producing a better surface on difficult woods.

Other planers accept molding knives in place of standard straight



2 Shopsmith thickness planer features separate motors that drive the cutterhead and feed rollers so feed rate is variable.

knives. The Craftsman planer/molder features an open-side design which doubles stock-width capacity and cuts moldings on edges, regardless of stock width (Photo 3).

In addition to dedicated thickness planers, some manufacturers offer their versions in combination with a down-scale jointer for conveniently truing stock before it's thicknessed.



3 Sears planer also accepts molding knives. Open-side design permits molding the edges of a wide board.

Basic Operation

The planer is a simple machine that requires no special skills to operate, but you do need to follow certain procedures for the best results. Typical planers have only one control—the elevation crank or wheel that sets the stock thickness. A scale and pointer indicate the current thickness setting (Photo 4).

Some small planers can remove as much as $\frac{1}{8}$ in. in one pass. In general, a heavier cut will not produce as fine a surface as a lighter cut. When thicknessing work that requires much stock to be removed, make the final few passes with a light cut.

Planer tables are relatively short, so it's best to use a pair of roller stands to support long or heavy lumber on the infeed and outfeed sides (Photo 5). You can buy adjustable stands, or simply buy the rollers and make your own (see "Outfeed Stand," page 92, Nov. '91).



4 Planer thickness setting is adjusted with a wheel that controls table height. Pointer indicates thickness on a scale.

To operate a thickness planer, first set the planer table to slightly less than the maximum stock thickness. Then, turn on the power, stand to one side and feed the board under the infeed roller. Once the roller takes



5 Long or heavy stock requires the extra support of adjustable roller stands at infeed and outfeed sides of planer.

hold, move to the outfeed side to get the board as it exits. Whenever feasible, plane both sides of a board the same amount to equalize stresses in the stock that are relieved as material is removed.

Stock Problems

Thickness planers are not designed to true or flatten irregular work—a job reserved for the jointer or a hand plane. Instead, they are designed to plane one face of a board so that it's parallel to the opposite face. Therefore, you'll find that warped boards will exit the planer at the thickness you desire, but not any flatter than

when they entered the machine.

While the best procedure is to flatten one surface of the stock before thicknessing, there are a few techniques that enable you to do the job with your planer. These tips are especially helpful for truing stock that's too wide for your jointer. Whether your stock is badly warped or not, cut the lumber to rough size

before planing. This reduces the effect of any warp, which allows you to realize the maximum thickness from each piece.

Because the feed rollers exert great pressure, stock that's cupped will be bent flat just as it's being planed. While this effect diminishes with heavier stock, you can eliminate the problem in thinner work by plac-



6 To flatten cupped work on a thickness planer, secure a shim on the concave side. Shim height lines up with stock edges.



7 The shim supports the center of cupped stock and eliminates any bending caused by feed-roller pressure.



8 Heavy cupped lumber is often strong enough to resist feed-roller pressure. Always plane convex side first.



9 To check for twist, lay a straight stick at each end of the work. If the sticks aren't parallel, the board is twisted.



10 Adjustable jig holds twisted stock so it can be planed flat. Drywall screws placed in sidewalls hold work securely.



11 Make successive passes to flatten twisted surface. Initial passes may have to be hand fed due to irregular worksurface.

ing a shim between the bed and the concave side of the workpiece. Simply adjust the shim thickness so the edges of the work just contact the bed. Use hot-melt glue to hold the shim in place (Photos 6, 7 and 8). Once one side is planed, remove the shim and plane the other side.

Before planing unjointed lumber, check for twist by laying a straight stick across each end (Photo 9). If the sticks aren't parallel, the board's twisted. You can flatten twisted stock with a specialized jig to hold the

work. Our version is made of a double 3/4-in. plywood bed and two sidewalls made from 5/4 stock. Make one sidewall adjustable to handle different stock widths by attaching it to the base with carriage bolts that fit through slotted holes.

To flatten twisted lumber with this jig, first adjust the sidewall to the stock width, and then position the stock so the highest corners are level. Secure the stock with drywall screws driven through the sidewalls (Photo 10).

Make successive shallow passes until the surface is flattened (Photo 11). Because of twist, the feed rollers may not remain in continuous contact with the work, and there may be periods when the assembly must be pushed and pulled through the planer by hand. Be sure to keep your hands a safe distance away from the machine and use roller stands to support the jig. After one side is planed, remove the work from the jig and plane the opposite side in the normal manner.

Planer Problems

Once you've mastered a few basic techniques for flattening and truing stock, it's time to look at improving the quality of the planed surfaces your machine is producing. While this tool is a great time and labor saver, there are a few common problems that you can learn to control.

Snipe—If you've noticed a slight depression in the finished surface at the start, end or both ends of a cut, you're experiencing a problem com-

mon to most planers called snipe (Photo 12). It's caused by a deflection of the board as it enters or leaves the area under the cutterhead.

Although you may be able to make certain adjustments in feed-roller pressure to help reduce the effect, it's often difficult to eliminate entirely. One solution is to feed a piece of scrap lumber through the planer first, followed by the workpiece butted against the end of the scrap. If you're planing several pieces, simply

feed them one after the other, continually butting the ends (Photo 13). Use a piece of scrap after the last piece to eliminate snipe at the end.

The other solution is simply to cut your stock long enough so you can saw off the ends after the wood is planed.

Tearout—If the grain is angled up toward the cutterhead, the knives will lift the wood fibers and tear out small chunks (Photo 14). The fix is to make sure the predominant grain di-

rection is angled down toward the direction of feed. Wood with wild or reversing grain is best handled by making very shallow passes and by feeding the work diagonally for a smoother, shearing cut (Photo 15).

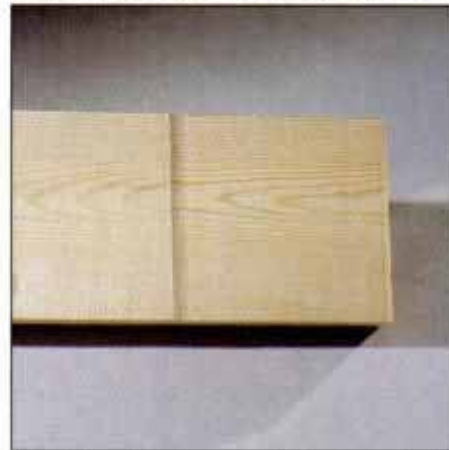
Washboarding—This refers to uniform, parallel ripples that run from edge to edge across the board and are caused by individual knife cuts (Photo 16). Washboarding may be caused by trying to remove too much wood in one pass, but also can result from an uneven knife setting. If one knife is set too high, it will do most of the work and the individual cuts will be spaced farther apart.

Pockmarks—Dents or impressions on the planed surface are caused by the imprint of wood chips stuck to the feed rollers (Photo 17). Residue from resinous woods that collects on the rollers causes the chips to adhere. You can solve the problem by keeping the rollers clean with an alcohol-dampened cloth.

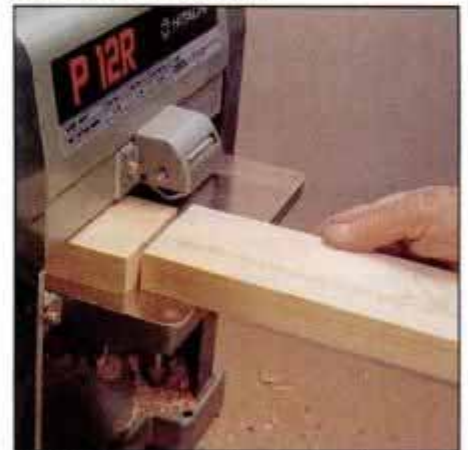
Ridges—If you begin to notice raised ridges that run the length of your work, your planer knives are

nicked (Photo 18). Such damage to the knives can be caused by gritty particles embedded in the wood or by nails hidden below the surface. It also can be caused by glue lines in laminated stock. Although it's difficult to avoid embedded particles, take special care to search for and remove nails in wood that you've salvaged for planing. To reduce the

dulling effect of glue lines, remove all excess glue before running the work through the machine (Photo 19). The best solution for nicked knives is a resharpening. However, you can often reset the knives so they're slightly offset and the nicks are no longer in line. This way, the good section of one knife follows the nick on another knife.



12 Snipe is a deeper cut at one or both ends of a board. It occurs as the board deflects under feed-roller pressure.



13 Eliminate snipe by planing boards in continuous succession. Use scrap stock for the first and last pieces.



14 Tearout comes from planing against the grain. Make sure that the grain slopes down toward the direction of feed.



15 For wild or reversing grain, feed the work through diagonally for a smoother cut. Make shallow passes.



16 Washboarding, or ripples across the board, is caused by coarse knife cuts. Check that knives are at the same height.



17 Chips of wood that adhere to the feed rollers cause pockmarks in a planed surface. Clean rollers with alcohol.



18 Ridges that run along the length of the work are caused by nicks in knives. Resharpen knives to eliminate problem.



19 In addition to nails and other particles, glue lines can wear nicks in knives. Remove excess glue before planing.

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Special Tricks

Of course, the bulk of your planing will involve bringing single boards to the uniform, parallel thicknesses necessary for most woodworking projects. However, you can extend the usefulness of your machine with a few simple techniques.

Planing thin stock—While most planers are limited to a minimum thickness capacity of about 1/4 in., you can produce thinner stock with either one of two methods: The work can be secured to a backer board, or you can use a shopmade auxiliary platform to raise the stock high enough to contact the cutters. Both methods simulate thicker stock.

To use a backer board, choose a board that's flat and has parallel faces. Then glue the stock to be planed to the backer board at the lead, infeed end only. Carpenter's glue is the best choice for gluing the end because it's strong and the glue layer is thin. You can also use hot-melt glue or a strong double-face tape to hold the work to the backer board (Photo 20). The advantage of these alternatives is that you're able to pry off and make use of the whole workpiece, although a thicker adhesive line causes the end to be planed slightly thinner. With carpenter's glue, you have to saw the workpiece off of the backer board.

An auxiliary platform is simply a flat board placed on the bed with a cleat at the infeed end to keep it from moving through the planer (Photo 21). The backer board is best for very thin work because the glued lead end resists the lifting action of the cutterhead. In either case, planing thin stock demands very shallow cuts—particularly when working with difficult-grain woods.

Keep in mind that there are limita-

tions to how thin you can plane stock, and some woods can be taken thinner than others without breaking. Always proceed cautiously with shallow cuts, and stand to one side of the machine.

Planing bevels—Another special technique allows you to plane bevels across the width of the work. Simply secure a shim to one side of the work so it's tilted at the required angle (Photo 22). It's best to use a few dabs of hot glue to hold the shim in place. Take very light cuts—especially at the beginning of the operation. Until a substantial portion of the bevel is formed, the pressure of the rollers on a heavy cut will tend to flip up the work parallel to the bed.

Planing tapers—To plane lengthwise tapers such as you might use for table legs, mount the work on a simple jig that holds it at an angle. To make an adjustable jig, cut two pieces of plywood slightly longer and wider than your work and attach them at one end with a hinge. Then, use a pine block to raise the opposite end of the jig to the desired angle

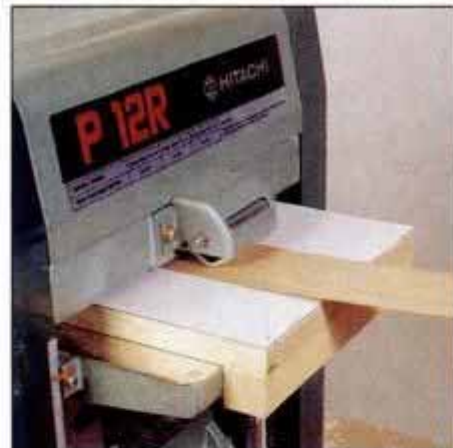
and tack it in place. Cut several smaller blocks to support the angled platform at 4- to 6-in. spacings (Photo 23). Secure the workpiece to the jig by tacking cleats to the inclined board, butting them against the work at each end. When feeding the jig through the planer, make shallow passes. It's also a good idea to use stock that's longer than required so you can cut off ends with snipe.

Gang planing—Thickness planers can also be used to bring stock to a uniform width and to plane the edges parallel. However, narrow stock—less than about 1 in. thick—or stock that's much wider than it is thick will tend to lean over under the pressure of the feed rollers, resulting in an out-of-square edge.

You can, though, successfully plane stock on edge if you gang plane several pieces together (Photo 24). This evens out feed-roller pressure across the planing area and reduces the tendency for the work to lean. Avoid taking heavy cuts as this can force the pieces to lean over, resulting in an out-of-square cross section. **PM**



20 Plane thin stock by gluing it to a flat, parallel backer board. Apply the glue at the infeed end of the work only.



21 Auxiliary platform effectively raises the table height for thin stock. Cleat on the infeed side holds platform in place.



22 To plane shallow bevels, secure a shim along the edge. Take shallow passes so feed rollers don't flip up stock.



23 Plane long tapers with a jig that holds stock at the correct angle. This jig is hinged at one end for a range of tapers.



24 Trim several pieces to width by ganging them together and feeding them through the planer at the same time.

APPLIANCE CLINIC

BY STEVE TOTH,
Contributing Editor

Fridge Is Separating

Our General Electric no-frost side-by-side refrigerator/freezer, model No. TFF-22K, is experiencing panel-to-frame separation. That is, the side panels (inside when viewed from the front) are popping loose from the frame that separates the refrigerator and freezer compartments. The frame also seems a bit warm around where the door seals fit. Is this unit a goner?

JIM WASHINGTON
BREMERTON, WA

I suspect that the retaining clips—which are built into the plastic breaker strip that separates the outside of the case from the metal liner—have broken.

The only reliable way to correct your problem is to order the complete breaker strip, take out the old one and snap in the new part. This is not an easy job. Sometimes you have to break out the old part a piece at a time. The replacement breaker trim does not come with installation instructions, and you will notice that the new part is a little bigger than the old one.

You will need to cut the breaker trim to fit using a razor knife, then seal each corner with white silicone. For a repair such as this, it might be wise to call the GE answer

line at (800) 626-2000 and discuss the repair with a GE technician.

Also, before ordering the part, recheck your model number. It seems there is a letter missing.

The frame you refer to that separates the fresh food and freezer compartments is called a mullion. Behind the mullion is a low-wattage heater which keeps the exterior from sweating. This area is supposed to be warm.

Under Pressure

We have a Wearever Bounty Pressure Cooker, model No. 3614. We need the replacement part, Safety Plug No. 3617-4. Could you help us locate a source for this part?

J. BONE
PRAIRIE GROVE, AR

Contact F.M. Co., 14623 E. Palm Ave., Hacienda Heights, CA 91745; (818) 336-3877. This company bought up the remaining inventory from Wearever Cookware. The company still has the handles and sealing ring for your model pressure cooker, but it does not have a safety plug. It is working on getting the safety plugs made, however. If you send them a large, stamped self-addressed envelope and a note stating that you need a safety plug for your model pressure cooker, they will send you an order form as soon as they have the part in stock.

So Long To An Old Friend

I have a Toastmaster 2-slice toaster, model No. 1B15, serial No. A3395723. It needs one heating plate (the heat-

ing wire is broken), and I don't know where to get it.

REYNOLD BEITLER
OSSINEKE, MI

The folks at Toastmaster say they no longer stock parts for your model toaster. The production run of your toaster started in 1950 and ran well into the next decade. Sorry, it looks like you'll have to replace it.

Transformer Question

Most rechargeable items plug into a charger/transformer that, in turn, is plugged into a wall outlet. If the transformer is plugged in, but the appliance is not connected to the charger cord, does the transformer still use electricity? Is there a fire hazard with these transformers?

DAVID A. DEVERE
PITTSBURGH, PA

I contacted the people at Underwriters Laboratories, and they tell me that the transformer uses electricity, but at a lesser rate than it would draw if the appliance was plugged into the transformer while being recharged.

Providing that the transformer is used properly and has a UL listing attached to it, then there is no fire hazard associated with the device.

Needs Shaver Parts

I have a Ronson Model RFD-2 shaver. Lately, I have been unable to purchase replacement screens and cutters, and the shavers have disappeared from the stores. Has Ronson folded?

JAMES VARIN
GUALALA, CA

Ronson got out of the shaver business many years ago. Windmere Corp. entered into an agreement with Ronson in 1984 to license the Ronson name on shavers it distributed.

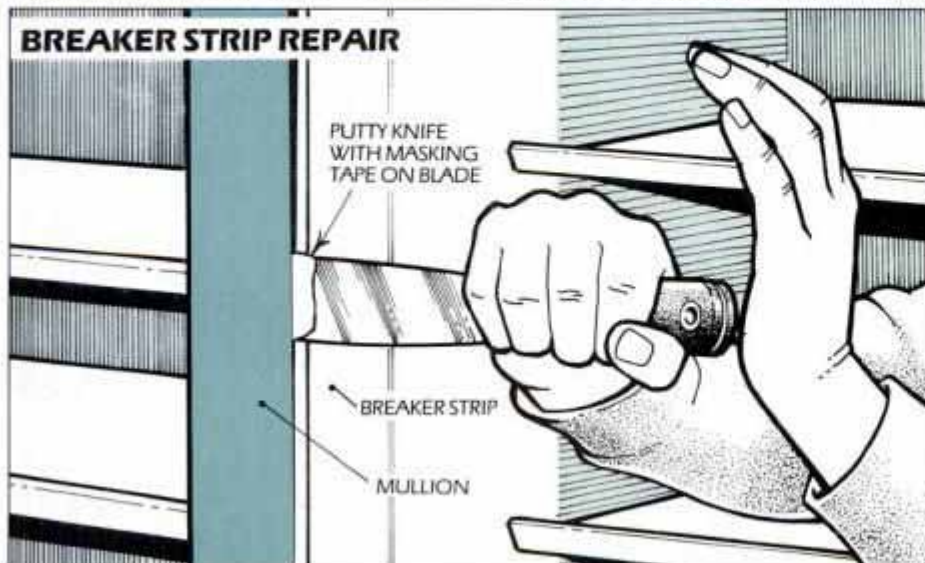
About two years ago, Windmere gave up the Ronson name and now sells shavers under its name.

Ronson parts can be ordered from Windmere by calling the company's parts department at (800) 327-7100 or writing to: Windmere Shaver Parts, 5980 Miami Lakes Dr., Miami Lakes, FL 33014, Attn.: Ron Strap.

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.



Removing the breaker strip from a refrigerator can be difficult. Often it's best to pry the strip away from the appliance's liner using a putty knife.

NEW PRODUCTS

THE WELL-EQUIPPED HOME

BY ROY BERENDSOHN, Assistant Home Improvement Editor



Stand Tall

This 13-in.-high plastic step stool is combined with a toolbox without sacrificing its usefulness as a stool—its manufacturer says it will support up to 300 pounds. The toolbox is equipped with a removable tray inside, and the top of the stool has an inset cushioned grip handle. The Roughneck Step Stool Tool Box from Rubbermaid costs about \$25 at hardware stores and home centers. For more information, write Rubbermaid, 1147 Akron Rd., Wooster, OH 44691.



Combination Innovation

If you're remodeling a bathroom or kitchen, you can save yourself a little additional rewiring by installing this combined single-pole switch and GFCI-protected outlet. The switch is 8.3 amps, and the outlet is 15 amps. It costs about \$24 at hardware stores and electrical supply houses. For more information, write Leviton Manufacturing Co., 59-25 Little Neck Parkway, Little Neck, NY 11362, Attn.: Customer Service.



Seamless Fit

If you're remodeling a bathroom, you might consider replacing the tiled wall with a one-piece, seamless ABS plastic tub wall. The model shown has ledges molded into it to hold common bath products. Another option has more elaborate shelves. The tub wall comes folded in a carton and is attached to the drywall with any adhesive that is compatible with extruded polystyrene (Styrofoam).



The enclosures cost from \$200 to \$300 at home centers. Write Lyons Industries Inc., P.O. Box 88, Dowagiac, MI 49047.

Not Black Or White

Shingles don't have to be black, white or gray. A new range of colors,

including green and blue, is available from Owens-Corning in its Shadow series. The brightly colored Fiberglas shingles have a Class A fire rating and a 40-year prorated product and labor warranty. And the shingles are designed to have a strong, dark shadow line to accent their bright colors. A square of the shingles costs about \$75. The shingles are sold at roofing suppliers and home centers. For more information, write Owens-Corning Fiberglas Corp., Fiberglas Tower, Toledo, OH 43659.





Stick Together

Epox-it is an epoxy repair kit that makes it easier for homeowners to bond ceramic, concrete, plastic, fiberglass, metal and wood, says its manufacturer. The kit consists of equal amounts of resin and hardener paste, mixing sticks and a tray. The epoxy sets in minutes and is suitable for outdoor applications. The hardened epoxy can be sanded, painted or even stained, says its manufacturer. The kit costs about \$4 at hardware stores and home centers. For more information, write ITW-Devcon, Consumer Division, 226 Gerry Dr., Wood Dale, IL 60191.



Light Speed

The Revolution is a new angle on flashlights. You can clip it on to your pocket or belt. And its head pivots to put the light where you want it. The head swivels through nearly 360° and the light beam adjusts from a spot to a floodlight. Its handle is textured to provide a good grip and the flashlight comes with a one-year warranty. The flashlight measures about 1 in. in diameter and is 6½ in. long. It costs about \$22 with two AA batteries and about \$20 without batteries. It's sold at hardware stores and home centers. For information, write Streamlight Inc., 1030 W. Germantown Pike, Norristown, PA 19403.

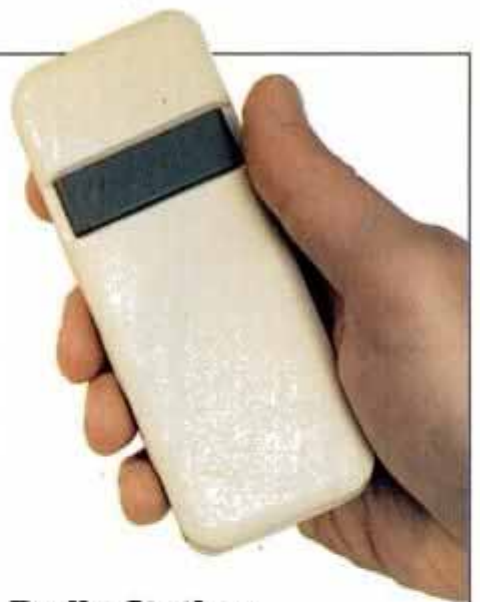
Power Station

Generac says the overhead valve engine that powers its 3500 XL generator offers three to five times the operating life of conventional portable generator engines. It's also quieter, thanks to an oversize muffler, a sound-deadening air intake and an idle control that reduces rpm when the generator is not under load, the company says. The 3500-watt generator has five outlets for 120- and 240-volt power at 15 and 30 amps, and it has a built-in circuit breaker. It costs about \$800 at Generac dealers and home centers. For more information, write Generac, P.O. Box 8, Waukesha, WI 53187.



It's No Joke

This cart may have a funny name, but it's designed to carry a 250-pound load. It's made from aluminum tube and sheet, with plastic hinges and foam-filled tires that can't be deflated. The 10-pound cart folds down to about 2½ in. thick × 20 in. wide ×



Radio Station

You can make your home's lighting easier to use without rewiring by using this wireless switch kit and accessory remote control. These devices use radio waves to turn lights on and off from as far away as 50 ft. Screw the receiver into a bulb socket and attach the light switch to a wall with double-faced adhesive tape or the screws that are provided. The handheld remote control can be used in conjunction with the switch or with other wireless switch products in the line. The switch and socket cost about \$28 and the remote control, about \$15 (9-volt battery not included). Both devices are sold at hardware stores and home centers. For more information, write Heath Zenith, 455 Riverview Dr., P.O. Box 1288, Benton Harbor, MI 49023-1288.



27 in. tall in seconds without tools. The cart comes with its own elastic cord for securing bulky cargo. Called the RuXXac-cart, it costs about \$90 (plus shipping) from the Good Friends Catalog, 1025 W. 8th St., Kansas City, MO 64101-1200; (800) 892-8022.



A Little Variety

This plug-in timer turns lights and appliances on and off at slightly different times every day to make it appear that the house is occupied. The 15-amp device can be programmed for two settings per day, and it can keep a light or appliance on for as long as 23 hours or as short as 45 minutes. The UL-listed timer costs about \$10 at hardware stores and home centers. For more information, write Intermatic Inc., Intermatic Plaza, Spring Grove, IL 60081.

Out, Out Damned Spot

While this isn't your typical home improvement product, we think it's so handy that we had to let you know about it. This 47-page book measures only 3 in. x 5 in., but it's packed with the most stain-removal information we've ever seen. That's no surprise—author Herb Barndt is an associate professor at the Philadelphia College of Textiles and an expert on stain removal. The book opens with seven stain-removal formulas. None of

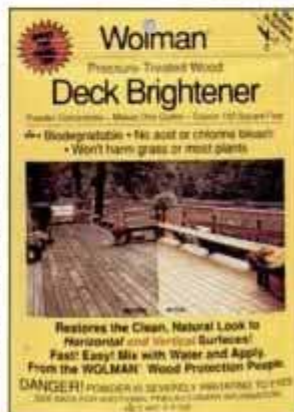
them require exotic potions—everything you need, from white vinegar to detergent is available at your grocery. What follows is an alphabetical



listing of common substances starting with aftershave and ending with yogurt. Each material comes with a list of which stain-removal formula to use. It's that easy. It costs about \$3 at book stores or (with shipping) from Doubleday, 666 Fifth Ave., New York, NY 10103; (800) 223-6834, ext. 9479. (NY residents call (212) 492-9479.)

Better And Brighter

Wolman has improved the formulation of its long-running Deck Brightener, a powder concentrate that, when mixed with water, produces a cleaning solution for aged and dirty wood decks—even those that have been stained or painted. Wolman says the improved formula cleans more thoroughly and, because it produces a thicker foam as well, it clings better to vertical surfaces, thus cleaning them more thoroughly. It's sold in 2¼-pound canisters and 6.4-ounce packets (about \$6 and \$17) at home centers and paint stores. Write Kop-Coat Inc., Wolman Protection Products Division, Koppers Building K-1850, Pittsburgh, PA 15219.



Take The Heat

The Seahorse converts an electric water heater to gas fire without having to install a flue. It consists of a heat exchanger that mounts to the outside wall and connects to your electric water heater with two pipes. One pipe takes cold water out of the heater and sends it to the Seahorse. The other pipe routes the heated water from the Seahorse to the water heater. The device costs about \$800 (plus installation). It's sold by heating and cooling distributors. Write Gas-Fired Products Inc., P.O. Box 36485, Charlotte, NC 28236.



Showers Likely

This shower filter takes a new approach to dealing with chlorine in tap water. It has filter media of granulated copper and zinc, which convert chlorine into zinc chloride, a material widely used in sunscreen lotion and that is listed by the federal government as a food product. It has a built-in ON/OFF button and a low-flow showerhead to conserve water. According to the manufacturer, this filter lasts for about one year, and it costs about \$50 at hardware and plumbing supply stores. For more information, write Sprite Industries, 2512 E. Fender Ave., Fullerton, CA 92631. **PM**

Bat Box

The makers of this polyethylene mailbox claim that it will withstand vandalizing blows up to the force of those from a baseball bat. And, because it's plastic, it is maintenance free. Also, the mailbox has an optional rear door, so you can open it while standing behind the box and not on the road edge. The box is sold in yellow, black, tan, brown, green, white and gray. The single-door model costs about \$40 and the double door, about \$45 (plus shipping) from Country Wise, 5125 Duffy Rd., Lancaster, OH 43130.



CONSUMER GUIDE

HIGH-TECH WINDOWS

BY FRAN DONEGAN

PM Illustrations by Don Mannes

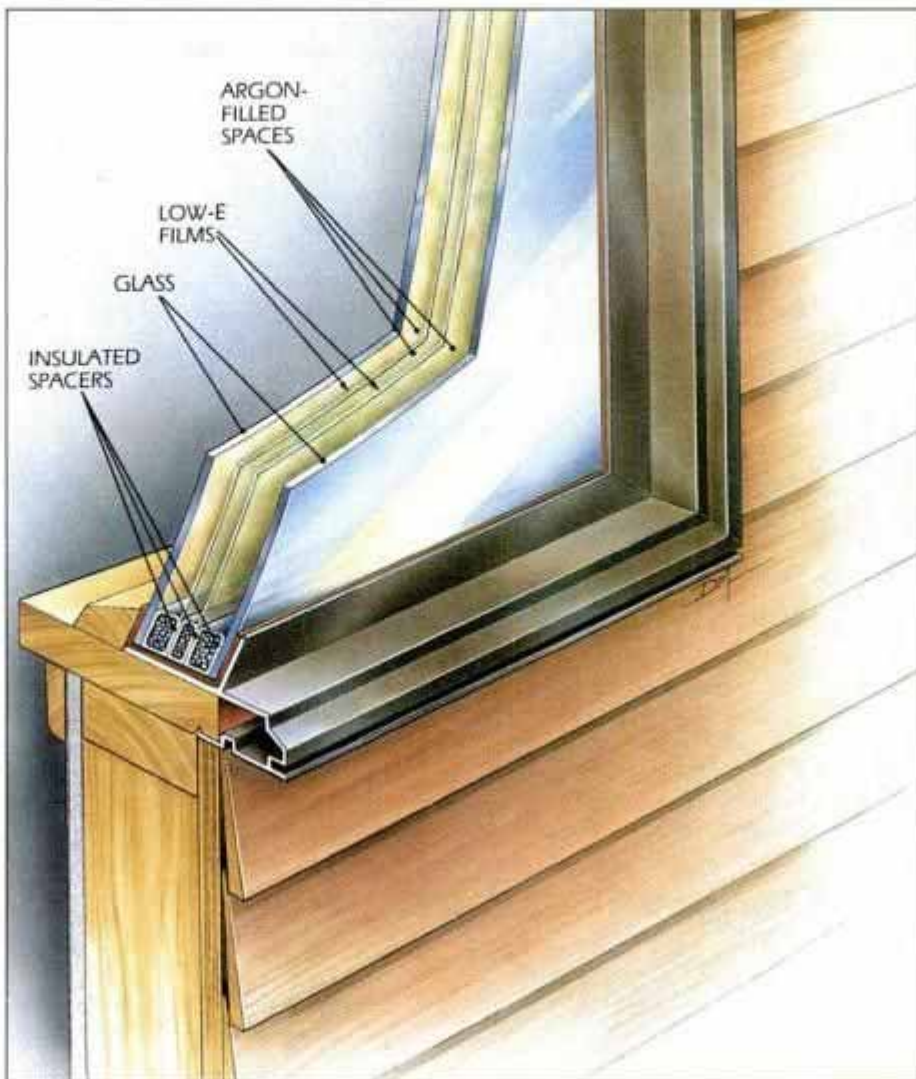
● If you're in the market for new windows, you've probably noticed that the subject isn't as simple as a wood frame and a few panes of glass—and it hasn't been for some time. Today's marketplace boasts a wide variety of products and some pretty impressive price tags to boot. And, over the past several years, advances in technology have shown that windows can play a much more important role in conserving energy than we ever thought before.

As recently as 1980, people who replaced their old windows with double-glazed units were at the forefront in the fight to save energy. Those who opted for triple-glazed windows—the limit of technology at the time—were considered energy fanatics. But even those fanatics were just toying with the weakest link in the energy chain of their homes. Those triple-glazed units had insulation values of about R-3, while the walls that held them had R-values that ranged from 11 to 19. In many well-insulated houses, therefore, the windows were simply holes in the wall where vast amounts of energy escaped. In fact, the average home lost about 25% of the energy it consumed through heat loss at the windows.

Today, things are different. Most windows are still energy drains, but there are units available that are much more energy efficient than the glazing systems of the past. Some windows boast insulation values as high as R-8. While this still isn't R-19, research has shown that it's possible for some of the new high-tech windows to outperform an R-19 wall from an energy standpoint.

A little history

R-8 glazing is at the end of current technological advances and accounts for a very small part of the window market. In fact, Southwall Technologies is the only company that still makes it. Hurd Millwork uses the glass in its Insul-8 windows. Though plain double-glazed windows do make up the bulk of the market, fortunately, most window manufacturers are now selling windows with some ver-



Modern windows use low-E film and gases such as argon to augment the energy efficiency of multiple glazing. Insulated spacers improve overall window performance.

sion of high-performance glazing.

Manufacturers are able to offer these better-insulated glazings because of the development of low-E (low-emissivity) coatings. Basically, a low-E coating does a good job of reflecting radiant heat—the kind of heat given off by bodies, furniture and some heating systems in the form of radiant energy. When applied to a window, the coating reflects the radiant heat back into the home, raising the R-value of the window. Some low-E coatings are also used to reflect outside heat radiated by the street and buildings.

Some coatings are bonded to the glass, others are incorporated into the glass, and still others are applied to a film that's suspended between two panes of glass. There are pros and cons for each type of coating. For example, coatings that are bonded to the surface of the glass, called soft coat, offer the best insulating properties. However, coatings that are a part of the glass, called hard

coat, are more durable.

As we'll discuss, the type of coating probably doesn't mean all that much to the homeowner who is buying new windows. What does mean a lot is that the low-E coatings are invisible and that the windows containing them have insulation values of about R-3. That means that a double-pane window with a low-E coating has the same insulating properties as a triple-glazed window, but the low-E window is about 50% lighter.

To increase the thermal effectiveness of low-E windows, manufacturers can fill the airspace between the panes with an inert gas, usually argon (but others are used). These gases are more effective than air at decreasing heat loss through conduction and, therefore, act as insulators much like traditional insulation. When combined with reflective low-E coatings, gas-filled double-glazed windows can have an insulation value of around R-4.

Some manufacturers have com-

bined available technology with newer ideas to produce relatively high-R window glazing systems. Weather Shield, for example, uses three panes of glass, applies a low-E coating to two of them and fills the airspaces with argon. The result is an R-value of 6.67. Hurd's windows contain two low-E films suspended between two panes of glass. All four spaces are filled with krypton, resulting in a value of R-8.

Of course, all this technology comes with a price. Although costs will vary from manufacturer to manufacturer, low-E coatings add 15% to 20% to the cost of standard double-glazed windows. Some manufacturers will add argon at no extra cost, but others charge for the service. The higher-R windows cost about 25% to 30% more than the basic low-E versions.

The heftier price tags may be worth the investment. The Department of Energy estimates that on a new home, windows using low-E technology—on average—will save enough energy to pay for themselves in about four years. For the higher-R

products, the payback is eight years.

The scenario for replacement windows may be different. If the windows need to be replaced because they are damaged or due to remodeling plans, the payback period will be about the same as for new construction. But if your existing double-glazed windows are in good condition, the payback will be longer since a window easily can last 15 to 20 years.

State of the art

What do the advances mean? Well, a few years ago Lawrence Berkeley Laboratory of the University of California, under a contract with the Department of Energy, built some window prototypes that pushed the available technology to the limit. One of the reasons for the testing was that many building codes and standards-writing groups tried to achieve energy efficiency by limiting the window area in new buildings. They reasoned that since windows are energy drains, the less window area the less wasted energy.

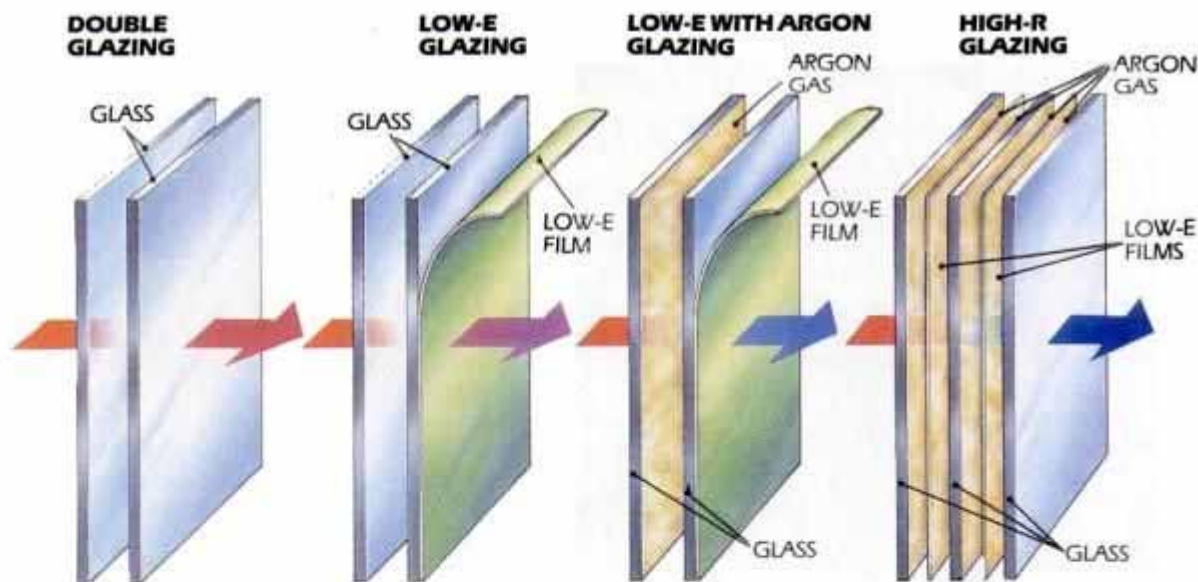
Lawrence Berkeley Laboratory

took a different approach. "Our goal was to make windows as efficient as the wall that holds them," says Steven Selkowitz, program leader of the building technologies program. The group modified commercially available windows so they had R-values in the 6 to 10 range. The test results showed that the prototypes did better in tests than an R-19 wall when it came to controlling bottom-line energy costs.

"Over a 4- or 5-day period, our field tests showed that the window loses more heat than the wall at night," says Selkowitz, "but even on cloudy days, the window gains enough energy to outperform the wall, which is always losing energy. And, perhaps even more importantly, the windows can be facing north—they don't need to be facing south as we thought in the past."

The prototypes that LBL used are not for sale, although the technology is available to manufacturers. Besides showing what's possible in window efficiency, the LBL tests pointed out two weak spots in window technology: the spaces between the

RELATIVE HEAT LOSS OF WINDOW TYPES



CENTER-OF-GLASS R VALUE	R2	R2.44 TO R2.94	R3.57	R6.67 TO R8
SHADING COEFFICIENT	.91	.86 TO .75	.75 TO .66	.60 TO .52
RELATIVE COST	1	1.2	1.2 TO 1.3	1.6 TO 1.7

Chart indicates typical glazing designs employed in energy-efficient windows. Costs are given as multiples of standard double-glazed windows. High-R glazing can be as effective as insulated walls because it admits solar energy during the day.

panes of glass and the window frames themselves.

Most window manufacturers use aluminum spacers to separate the panes in a double-glazed window. Aluminum is a terrible insulator and actually lowers the efficiency of the whole unit. Manufacturers are experimenting with rubber and fiberglass spacers to cut heat loss in this area.

Many window frames have lower R-values than the high-R glazings they hold. This reduces the overall effectiveness of the window. For example, in the LBL tests, glazing systems that measure R-3.7 in the center of the glass produced overall readings—when the frame and spacers were taken into account—of R-2.85 for wood frames with aluminum spacers and R-2 for aluminum frames with aluminum spacers.

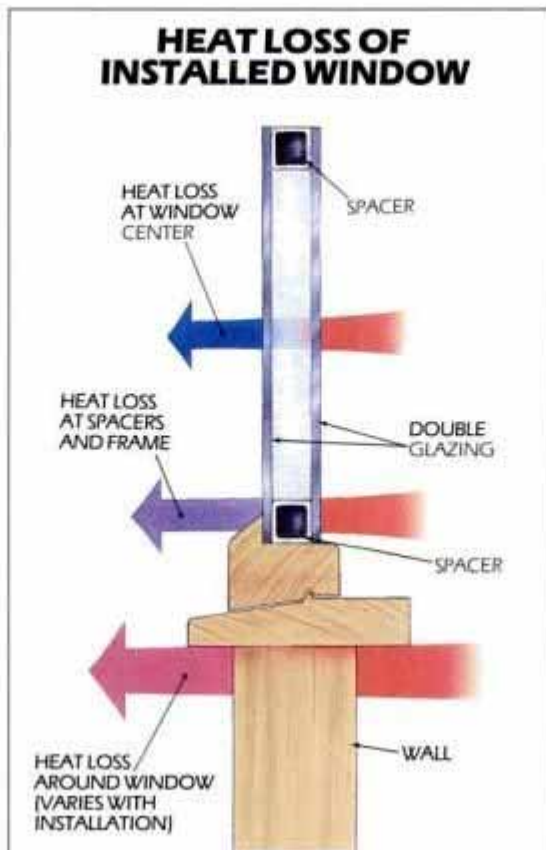
How to buy windows

The LBL high-efficiency window tests are important to window buyers because they show that the R-value of the glazing system is only a part of the whole efficiency story. The window frames play an important role in the buying decision, as does the location of the house and where in the house the new windows will be installed.

For example, cutting heat loss is important in Minneapolis, but not so important in Orlando. By the same token, a window on the north side of a house in a cold climate should be designed to save energy through heat loss by conduction and radiation. Those on the south side should save energy by allowing as much solar energy as possible to pass through. Here are some points to consider when shopping for new windows:

Energy ratings—Most manufacturers provide both the center-of-glass and the entire window energy ratings. Obviously, the entire window R-value is a better indicator of performance. Don't be confused if you see a U-value alongside of the familiar R-rating. They are actually different sides of the same coin. R-values measure resistance to heat transfer—the higher the better. U-values measure heat transfer—the lower the better. To keep everything straight, convert U-values to R-values by dividing the U-value into 1.

Shading coefficient—This rating tells how much solar energy a window captures. A single pane of glass has a shading coefficient of 1. A



In many new windows, heat lost at the spacers and window frame is greater than that lost through the glazing. Overall effectiveness also relies on proper installation of the window.

blocked window would be rated at 0. In the LBL tests, the windows had shading coefficients above 0.5.

So, if reducing cooling costs is important in your area, pick a window that has a low shading coefficient. Tinted windows are good choices, but low-E window technology designed for warm climates can also produce low shading coefficients while providing clear glass.

Handling light—Besides letting heat energy pass through, windows also allow light into our homes. Not all windows do this equally. Clear double-glazed windows allow about 77% of the visible light to pass through. Low-E glass allows about 70%, and a high-R window, around 62%. Part of the light is in the form of the ultraviolet radiation that's responsible for the fading of carpets and furniture. You'll find windows that allow through everything from around 50% of the UV radiation to windows that let through less than 1%.

Air infiltration—This is important in all climates. Windows should be well constructed and allow a minimum of air infiltration. The design of some types of windows makes them tighter than others. Casement and awning windows are tighter than

double-hung windows, for example. A rating of 0.02 or 0.03 is very tight. A rating of 0.5 is loose. These ratings apply to the window itself, not the actual installation. Keep in mind that stopping leaks around a window once it's in the wall is the responsibility of the installer. A poor installation can negate the benefits you might expect to realize from an efficient window.

Buying windows can get confusing. The trick is to decide what each window should do and then buy the system that best meets those goals. Fortunately, additional help may be on the way. A group of window manufacturers, utility companies, builder and architect organizations and consumer groups have formed the National Fenestration Rating Council (NFRC). The goal of this group is to "... develop uniform and credible energy ratings for windows," says Wiley DuPont of the NFRC. "We want to put all windows on a level playing field."

To achieve this goal, the NFRC wants to develop uniform standards for measuring U-values, solar heat gain, air infiltration, optical properties and condensation resistance. It is hoped that this work will lead to overall energy ratings for windows, similar to the standardized efficiency ratings for cars.

Currently, the NFRC has developed uniform standards for measuring U-values, and the state of California has asked the NFRC to administer a labeling and certification program for its new energy code. The new code allows combinations of building components to meet the standards, so tradeoffs among components such as windows, insulation levels, furnace efficiency and the like are allowed. The important part of the code is that all windows sold in the state must carry the NFRC U-value label. Wiley believes that since all windows shipped to California will carry the label, the large manufacturers will affix the label to all of their windows. Washington, Oregon, Idaho and Alaska have already expressed interest in using the new procedure.

The effect the rating system has on buying windows is yet to be known. For the meantime, though, shoppers should consider what they want their windows to do and then shop around for the best price and performance.

PM

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HOME
IMPROVEMENT

INSTALLING
FIBER-
REINFORCED
WALLBOARD

A drywall alternative for more plaster-like walls.

BY GENE & KATIE HAMILTON
PM Illustrations by George Retseck

● For more than 10 years, a wallboard material made of fiber-reinforced gypsum plaster has been used in European construction and remodeling. The material, which is made of gypsum and recycled paper, has made its way across the Atlantic and a similar product is now being distributed in the United States.

The new wallboard is called FiberBond and it's manufactured by Louisiana Pacific. Walls finished with the material have a look and feel that is closer to traditional plaster than drywall. The wallboard is a denser, nonlaminated material without paper facing or backing.

FiberBond is available in 4 × 8-, 4 × 10- and 4 × 12-ft. sheets, from 3/8 to 1/2 in. thick. Because of its denseness, a 4 × 8 sheet of 1/2-in. board weighs about 25% more than a comparable sheet of drywall. The manufacturer claims that the product is stronger and more fire-resistant than drywall and that its high density helps to deaden sound. It also claims that FiberBond is more moisture-resistant. Unlike ordinary drywall, the new paneling is beveled on all four edges and tape isn't required on flat seams—only on inside corners.

Trying it out

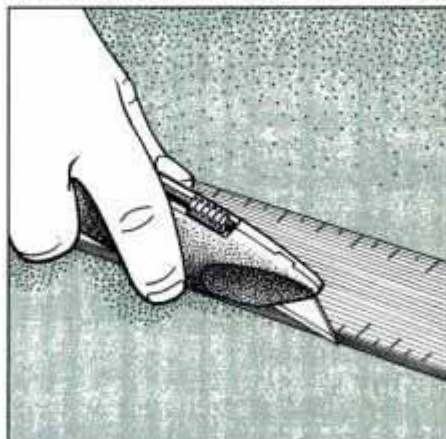
Working with a drywall contractor, we installed 60 sheets of 1/2-in.-thick, 4 × 8 fiber-reinforced paneling in our 100-year-old house. We were impressed with its strength and density, and found the material to be a lot tougher than drywall. Because the panels are heavy, they're harder to move around and position. The material is also harder to cut.

On the plus side, the new paneling's strength and density make it a much more forgiving material to in-

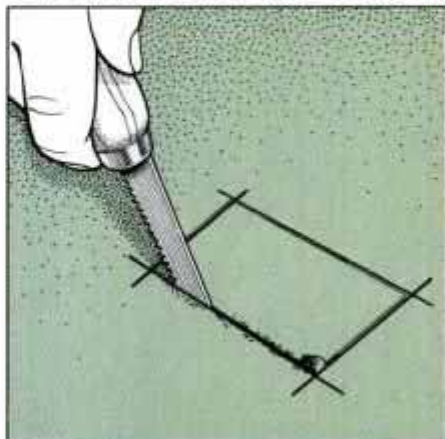


stall on old walls. Hanging the board with glue and nails is easier than hanging drywall because it's almost impossible to crush the surface with an overzealous hammer blow. Drywall screws are harder to start, but

you can't drive the head right through the board as with drywall. Once in place, the screw draws the board up tight against the wall framing. We also tried installing the board with an air-powered stapler,



1 Make straight cuts on FiberBond by first scoring along the cutline with a utility knife. Then bend to snap the piece in two.



2 Cut electrical box openings and notches with a sabre saw or drywall saw. Bore a hole at one corner to start the cut.



3 After cutting a fiber-reinforced panel to size, use a Surform tool or coarse rasp to chamfer the square edge.

which turned out to be the fastest method for hanging the material.

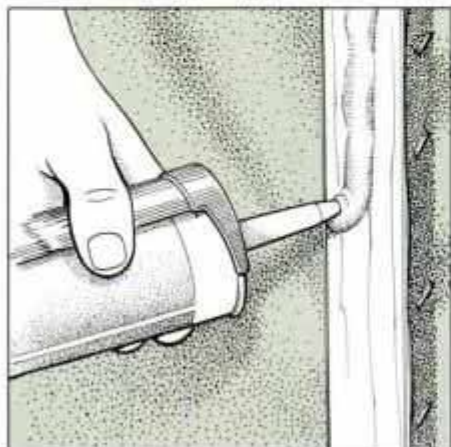
Fiber-reinforced paneling isn't as flexible as drywall, and since it has tapered edges on all four sides, the corners are vulnerable to breaking off and chipping. In fact, it's not difficult to accidentally break in half a sheet of the wallboard if you're not careful in handling.

In principle, installing fiber-reinforced paneling is the same as installing standard drywall. However, its unique characteristics demand a few changes in technique.

Cutting

The material is much harder to cut than drywall, but the same basic tools are used to get the job done. To cut straight edges, use a utility knife and a straightedge to score the panel (Fig. 1). Then snap the board in two by bending it back on the side opposite the score.

Notching or cutting inside corners can be handled by several means, including using a sabre saw or a drywall saw. Use a drywall saw to cut



4 Adhesive and nails are one option for hanging. Apply ordinary drywall adhesive to studs in a generous bead.

holes for outlets and switches (Fig. 2). However, because the material is so tough, it's best to begin these cutouts with a hole bored at one of the inside corners.

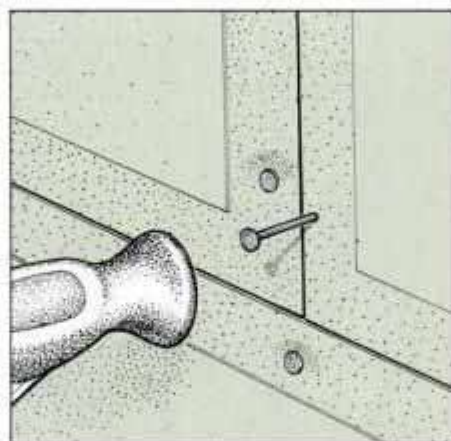
Keep in mind that, unlike drywall, you can't hack away small areas with a utility knife to get a stubborn piece to fit. The best method is to measure carefully and accurately before you cut. Because this is a solid material,



5 After hanging the upper panel in a horizontal installation, use a drywall jack to lift the lower panel into position.

you can, however, use a rasp or Surform tool to fine-tune a cut.

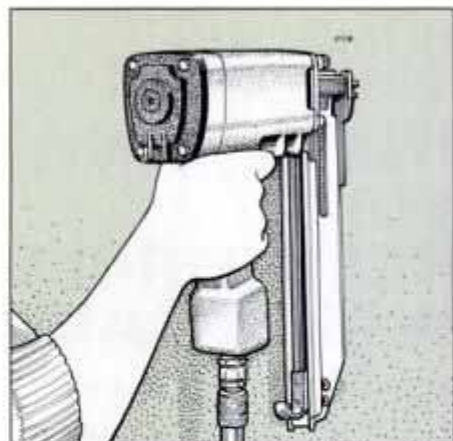
The tapered edges make installing full sheets easy, but as soon as a full sheet is cut, there's a nontapered edge to contend with. To help ensure a smooth seam at this square edge, it's best to chamfer the edge before hanging. Use a Surform tool or coarse rasp to cut a 1/2-in.-wide, 45° bevel along the edge (Fig. 3).



6 Drive nails, setting the heads slightly below the surface. Fiber-reinforced panels accept nails close to the edge.

Hanging

Fiber-reinforced wallboard is hung like ordinary drywall, except a 1/8-in.-wide gap must be left between the edges of adjacent sheets. Nails are easily driven through the material.

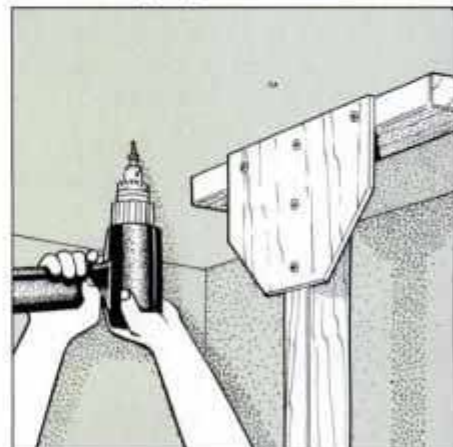


7 For the fastest installation, use a heavy-duty air-powered stapler to hang fiber-reinforced wallboard.

And you use wallboard adhesive the same way you do with drywall, applying it with a caulking gun (Fig. 4).

For most applications, a wallboard installation with horizontal seams creates the best results. First hang an upper panel against the ceiling, then install the lower sheet. Make the lower sheet about 1/2 in. to 1 in. narrower than the actual distance from the edge of the upper sheet to the floor so that the panel goes into place easily. To lift up the lower sheet to the upper sheet, use a drywall jack. Simply push the front of the jack under the panel and step on it to raise and hold the board in place for fastening (Fig. 5). Once the board is in position, drive drywall nails, setting the heads slightly below the surface (Fig. 6).

Drywall screws are a little more difficult to get started but, otherwise, they work the same as they would with standard drywall. To get the screws seated below the board's surface, set the depth adjustment of your drywall gun deeper than you would for ordinary drywall. You'll also have



8 Use T-braces to support wallboard during overhead installation. Drywall screws draw panel tight to ceiling.

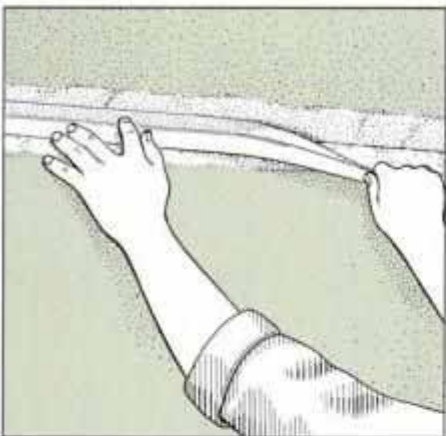
to push harder to keep the driver bit firmly seated in the screwhead. Fastening with screws is an especially good choice when installing fiber-reinforced panels over old plaster.

In addition to standard drywall screws, nails and adhesives, staples can be used because they don't pull through. A heavy-duty air-powered stapler is required to shoot the staples through the board and into the wall studs (Fig. 7).

When installing ordinary drywall overhead, a set of T-braces is all but essential, and the extra weight of fiber-reinforced paneling makes



9 Begin finishing the flat joints with a coat of FiberBond Dri Mix—no tape is required. Remove excess with a drywall knife.



10 At the inside corners, apply base compound and add drywall tape. Then smooth compound with drywall knife.

having T-braces an absolute must. Make the length of the braces the same or slightly longer than the distance from the floor to the ceiling. Then, have a helper wedge the T-brace between the panel and the floor as the panel is lifted to the ceiling. Once the brace is secure, install the fasteners (Fig. 8).

Finishing

Finishing fiber-reinforced wallboard is probably the most unique part of

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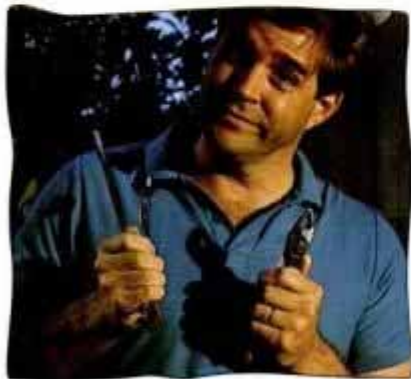
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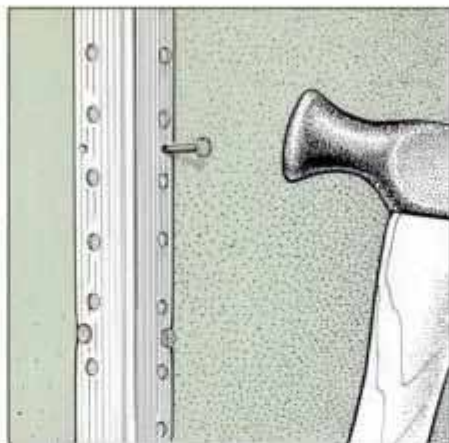


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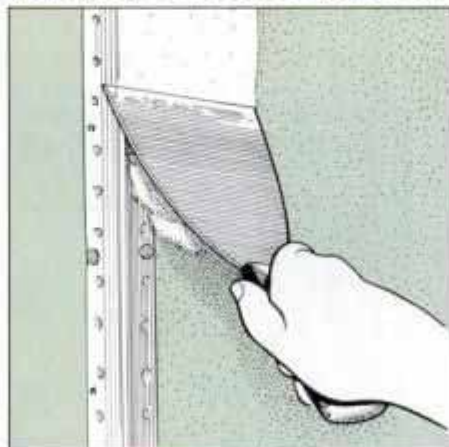
11 Attach metal corner bead to outside corners in preparation for compound. Use nails, screws or staples for the job.

the whole process. In contrast to traditional drywall, the flat joints do not have to be reinforced with paper or fiber-mesh drywall tape.

Begin finishing the flat joints by applying a basecoat of FiberBond Dri Mix joint compound that fills the hollow area created by the tapered edges. Avoid covering the area outside the tapers, and trim the application flush with a drywall knife.

Allow the Dri Mix base compound to dry thoroughly because it shrinks slightly, like most other compounds. After it's dry, apply a second, topcoat of standard, ready-mixed drywall joint compound and spread it to a feathered edge several inches beyond the edges of the basecoat application (Fig. 9). When the topcoat is dry, it's ready to be sanded.

The inside corners are finished like they would be with standard drywall. First, apply the Dri Mix compound to the joint, and then lay the tape in the compound (Fig. 10). Smooth and press the tape in place with a 4-in. knife. Once the joint is dry, apply a topcoat of joint com-



12 After corner bead is installed, apply ordinary joint compound, let dry and then apply a second coat.

pound and spread it several inches wider than the joint.

Outside corners are also treated in the same manner as standard drywall finishing. Nail, screw or staple metal corner bead to the outside corners (Fig. 11), and then cover the bead with a 6-in. band of joint compound (Fig. 12). You don't need the Dri Mix basecoat for outside corners. One coat of joint compound will almost do the job, but a second coat makes it perfect.

Cover nails, screws or staples with a first spot coat of Dri Mix compound. Then, after any necessary



13 Use Dri Mix base compound for the first coat over the fasteners. Then, apply a second coat of joint compound.



14 Smooth the compound with fine sandpaper and use a sanding stick to easily handle hard-to-reach areas.

sanding, follow with joint compound, applied at right angles to the first coat (Fig. 13).

When it comes to sanding the joints, you'll really appreciate the benefits of this solid wallboard. Because there's no paper top layer, there's no chance of scuffing the surface next to the compound. In fact, this wallboard is finish sanded at the factory—any additional sanding has no effect, except to further smooth the surface (Fig. 14).

PM

HOMEOWNERS CLINIC

BY NORMAN BECKER, P.E., Contributing Editor

Rotting Railroad Ties

I built a retaining wall of used railroad ties. In a few areas, the rot is creating holes. Is there any way I can remedy this, besides rebuilding the entire wall?

VICTOR DAI
MONTAGUE, NJ

There really isn't much you can do about repairing the rotting sections in your retaining wall. There are epoxy fillers that are used to rehabilitate rotting trim in houses, but they're not intended for retaining walls. If you only have a few sections that are rotted, and if the structural bracing for the wall (tie backs) has not deteriorated, then rebuilding the entire wall should not be necessary. You can remove and replace the extensively rotted ties.

Rotten used railroad ties are not unusual. This is because the species of wood that are used for railroad ties are difficult to impregnate with creosote. Consequently, there is quite a lot of untreated wood and moisture in the interior of the ties. When the ties dry, they check and split, exposing the interior to decay.

Furthermore, creosote consists of many components, some of which are water soluble. Over time, the creosote retained in the tie is depleted as these components leach out. Eventually decay occurs.

Hot-Water Temp

Most hot-water tanks have a dial for water temperatures at their bottoms. They read HOT, WARM and NORMAL. What are the temperatures at the three settings? I've heard of a code in most places that says the minimum temperature should be 120° F and the maximum 140° F.

WILLIAM NEILD
WOODBRIDGE, VA

Not all water-heater manufacturers use the same names for the thermostat settings. Nevertheless, the settings are basically HOT, MEDIUM and WARM. On some water heaters there is also a vacation setting. According to the manufacturers, the respective temperatures are 160° F, 140° F, 120° F and 60° F. These temperatures are not precise, as there can be a difference of 10° F or more between the dial setting and the water temperature.

The thermostat for a tank-type water heater is at the lower portion of the tank. Since hot water rises, the temperature of the water at the top of the tank (where the hot-water outlet pipe is located) will be higher than the water surrounding the thermostat. Also consider that hot water loses heat as it flows through the distribution pipes.

For the most part, a thermostat setting that produces a water tem-

perature of 140° F will be adequate for household appliances such as clothes washers and dishwashers. However, when dishes are to be washed by hand or when bathing, a water temperature of 120° F is probably too hot for most people and needs to be tempered with a bit of cold water. (If you have small children in your house, consider keeping the maximum temperature at 120° F.)

A thermostat setting higher than 140° F wastes energy and shortens the water heater's life. A water temperature in excess of 160° F is a potential hazard because a person can be scalded while showering if the shower's mixing valve is faulty.

Faded Awnings

I have fiberglass awnings on my house. They are more than 10 years old and in good condition but fading. They are coral and white. What can I do to brighten their appearance?

ANNE KOERPER
PARMA, OH

If the panels are in good condition, hose off the accumulated dust and dirt. If the dirt is caked on, you may have to use a pressure washer. You should hose down the fiberglass panels periodically to prevent dirt from accumulating.

If you decide to wash the awnings, don't use a detergent, such as those that contain ammonia or chlorine. This may cause the awnings to become yellow. Instead, use a nonabrasive soap.

When the panels have weathered extensively and fibers appear on their surface, one manufacturer recommends that you rinse the awnings with a garden hose and then lightly scrub their surfaces with No. 0 steel wool. Soak the steel-wool pad in water periodically to free the glass fibers that build up. Rinse off the awnings and let them dry.

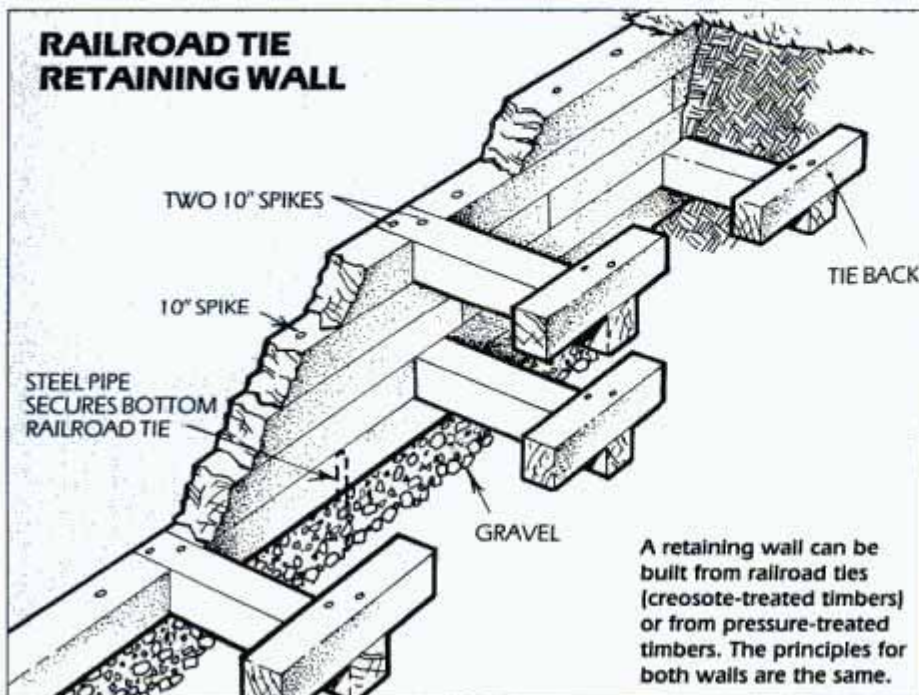
Next, you can coat the awnings with NuGlass High Gloss Acrylic Refinisher. According to Filon, the product's manufacturer, NuGlass is a weather-resistant coating that restores surface gloss, improves light transmission and brightens colors. For more information, call Filon at (800) 443-4566.

PM

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.

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CAR CARE

CAR CLINIC

BY MIKE ALLEN,
Associate Automotive Editor

Wake Up, You Hoser

I was driving down the freeway last week when a radiator hose failed, precipitating an expensive tow and an inconvenient delay. The mechanic who replaced the hose insisted on replacing both upper and lower radiator hoses, and although I was skeptical, I was glad he did after I saw the hoses. Although they looked and felt fine from the outside, the inner rubber had completely disintegrated. How can this happen on a 2-year-old car? Was the antifreeze I installed last winter defective?

GLENN KEYS
TULSA, OK

Radiator hoses have traditionally failed from the outside in.

Oddly enough, I just had a talk with a couple of "techsperts" from Gates Rubber, a leading manufacturer of hoses and belts for OEMs and the aftermarket. The problem you saw is becoming more common, and it's not related to your antifreeze, either.

They think the problem is related to the higher underhood temperatures on modern cars. Coolant fluid, being half water, is electrically conductive. As it's pumped through the engine, it can actually induce electrical currents into the rubber hoses. Paradoxically, the rubber hose is conductive as well because of the high carbon black content in the rubber. The electrical current flowing through the rubber seems to cause a change in the chemical composition of the rubber—and the hose fails from the inside.

Gates is reformulating the rubber it uses in its aftermarket hoses to cure this problem. I dare say other hose manufacturers will as well.

I've always recommended replacing hoses on a 4-year schedule, regardless of how good the hose appears when inspecting—looks like that may not be good enough. I'm



going to start inspecting the inside of upper radiator hoses for cracking whenever the system is drained enough to remove the upper hose without spilling any coolant—at least every two years.

Common Problem

My wife's 1985 Pontiac 6000 STE has a digital dash. There's an intermittent in the speedometer, causing it

to read low or zero at random intervals. At the same time, the transmission torque-converter clutch will disengage. If we're using the cruise control, it will cut out at the same time.

The dealer can't find anything wrong, and the only real thing he has done is to disconnect the torque-converter clutch from the computer so it never engages at all.

We've also noticed a buzz in the

CAR CARE

stereo that is directly related to the speed of the car. What's the common factor between these problems?

DALE RINGLER
EAGLE RIVER, AK

Tell the dealer to reconnect the torque-converter clutch. While he's down there, have him replace the sender for the speedometer. This electronic sender tells the engine computer how fast the car is traveling down the road—and the computer needs this to know when to engage the TCC. When this info is missing, it disengages it. Surprise—the cruise control uses the same sender. I'll bet there's something loose electrically that's causing the buzz in the radio, too.

I'd bet my lunch money that there's a trouble code set in the computer's diagnostics telling anybody who bothered to look that the vehicle speed sensor is fried. **PM**

DO YOU HAVE A CAR PROBLEM?

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

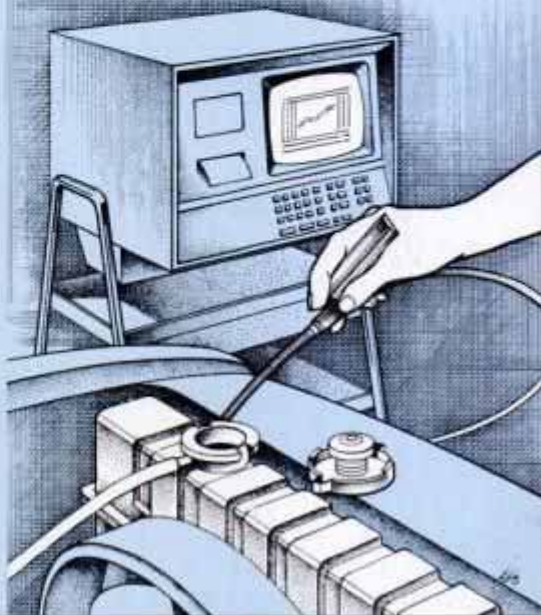
Something's Rotten In Denmark

● Well, not rotten, actually. My elderly pickup truck had finally developed an overheating problem. Radiator seemed fine—the whole cooling system checked out perfect, in fact.

Hmmmm. A head gasket? But there was no water in the oil, no oil in the water and none of the plugs showed signs of coolant.

So, I drove over to a shop that has an exhaust gas analyzer. With the engine cooled off enough to remove the radiator cap and run at idle, we sniffed the radiator neck with the exhaust probe.

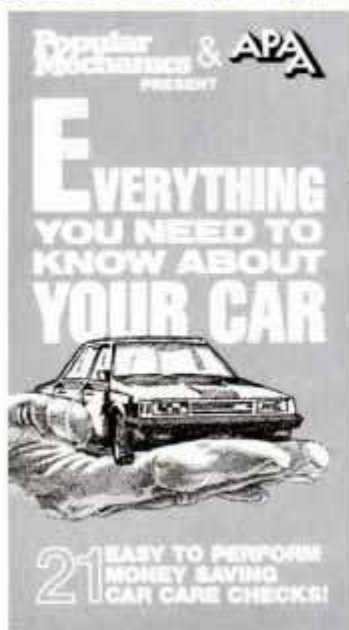
Sure enough, plenty of carbon monoxide—which could only come from exhaust gas leaking into the water jacket. This means a major project—pulling the heads to mill them and replace the head gasket—but then it's a good excuse to install those unleaded-gas exhaust valves while the heads are off.



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MAINTENANCE BASICS

NEW A/C REFRIGERANT

BY PAUL WEISSLER

● It happened last November, so you probably didn't even notice. But if you now try to buy a small can of air-conditioning R-12, you'll be told that it was taken off the market for environmental reasons, that not much is being produced and that only professionals can buy it. You've surely also heard that the automobile industry worldwide is rushing to install redesigned air-conditioning systems with a new product—environmentally more-acceptable R-134a. These moves affect service of both existing and new cars.

Let's save the planet

R-12, commonly called Freon, which is DuPont's trade name for it, is a chlorinated fluorocarbon, or CFC. The chlorine atoms in CFCs that get into the air (such as leakage from auto a/c systems) make their way up to the stratosphere, about 20 miles above Earth, where they interact with and work to erode the ozone layer, which protects us from the Sun's harmful ultraviolet rays.

By international agreement, Refrigerant-12 production was cut sharply. It stops in 1995. The R-12 that is currently being made is primarily committed to uses other than servicing cars. Some is for new cars, because all the cars and assembly lines just can't change so fast.

Small cans (once 14 ounces, now 12 ounces) of R-12 legally are supposed to be sold only to professionals who are both trained and certified in recycling R-12 and have the equipment to do so because it is now illegal to vent R-12 to the atmosphere. The recycling equipment pulls the R-12 from a car's a/c system, purifies it and puts it back in the car, along with any additional R-12 that's needed after a leak has been repaired.

Not so peaceful coexistence

You'll see cans of R-134a on the shelves for sale next to the cans of R-12, but R-12 and R-134a cannot be mixed or interchanged. Air-conditioning systems that use R-134a have been designed not to accept R-12. The diameter and threads of the con-



New automotive a/c systems use Refrigerant-134a, which is not compatible with old R-12 systems. Not only does the refrigerant canister itself have a different connector (inset), but the system requires different gauge manifolds with large, quick-disconnect fittings and even different hoses—none of which fits the old-fashioned a/c systems.

nectors are different in an R-134a system from those in an R-12 system. Even the connectors and hoses are different so you cannot mistakenly try to add R-12 to an R-134a system and vice versa. In fact, using the wrong refrigerant can seriously damage an a/c system.

A loophole in the law permits you to buy large cans (20 pounds or more) of R-12. The large cans actually available are 30 pounds, and with the current R-12 tax of \$3.35 a pound and the price of R-12 soaring, you

could spend hundreds of dollars. In addition, R-12 must be stored carefully to minimize leakage, and even then, you might find there's been a substantial loss years later when you try to use it. Your best bet is to get a leak fixed and enjoy the cool air on a consistent basis.

Fixed right

In any case, it now makes good dollars-sense, as well as good ecological sense, to fix a leaking system. Most leaks are at O-ring fittings—a low-

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cost repair—and many others also are in the under-\$100 category, not including replacement R-12. If you're planning to hold onto your car or truck, you can justify spending more.

Even if the refrigeration part of the system needs repair, it may not require a lot of R-12. The loss of even less than a half-pound of refrigerant is enough to cause a major reduction in a/c performance.

When the well runs dry

All this means that you can expect to run into difficulties when you service

your vehicle's a/c system. As production of R-12 ends, recycling has been stepped up—even to the point of scavenging R-12 from cars in wrecking yards. But the simple reality is that there is not enough R-12 around to service all the cars that need it. You already may be facing the possibility of not being able to find any R-12 at any price.

What are you to do if you can't get R-12? You could convert the system to another refrigerant, but there is no other refrigerant you can just "drop in" to an R-12 system and have

it work satisfactorily and safely. Any alternative refrigerant requires some system modifications and/or special procedures to work.

Conversion to R-134a is the choice of the auto industry, and GM is including brochures in its new cars saying it will convert cars whose systems fail under warranty if R-12 is "no longer available or affordable."

Retrofit procedures and parts required have been developed by carmakers and the SAE. However, the specifics of the conversions will vary widely between cars—even among different years and models of the same make.

But beware: There's a lot of "home-brew" refrigerant out there that is being sold as a "drop-in" substitute for R-12. No carmaker approves any one of them. These universal refrigerants have performance, safety (some are flammable) and toxicity problems. Even a "safe" blend, such as one DuPont is testing, has a high leak rate and it "disassociates" (comes apart at the seams, so what's left is chemically different from what was put in) when it leaks. Remember, you cannot simply top off your a/c system with a blend.

No professional repair shop—other than the installer—will touch a system with a blend. And any shop that would install a home-brew blend is one you should avoid in the first place. Don't let anyone talk you into a blend, period.

Several blends contain R-22, a household/commercial refrigerant, which is being sold by itself in auto parts stores. Your old R-12-can tap will fit the R-22 can, so you could put pure R-22 into an R-12 system—a terrible mistake. A/C performance will suffer, the system will leak and the compressor will fail pretty quickly.

Also consider that a competent and properly equipped professional can't—and won't knowingly—touch a system filled with some strange brew, because he can't pull the blend into an R-12 or R-134a recycling machine without contaminating his equipment.

If your system was not properly identified, or you didn't tell the shop what alternate refrigerant you had used, and it later learns that your system damaged its equipment, you could be legally liable. Planned conversions to R-134a, for example, include R-134a adapters that cover existing service fittings, so a shop shouldn't make a mistake. **PM**

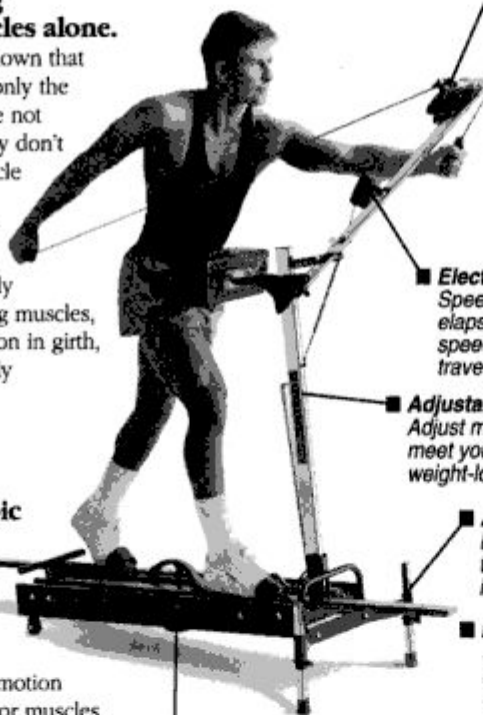
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POPULAR MECHANICS • JUNE 1993

SATURDAY MECHANIC

REPLACING YOUR TIMING BELT

BY JOHN DECKER

● You're humming down the turnpike at 55 mph. The engine has never run better, purring like the proverbial sewing machine. But then it suddenly quits—almost as if someone had turned off the ignition. As you dodge traffic while trying to coast to the shoulder, you repeatedly crank over the engine, but it doesn't even try to catch.

Now what?

Your car has just broken a camshaft timing belt.

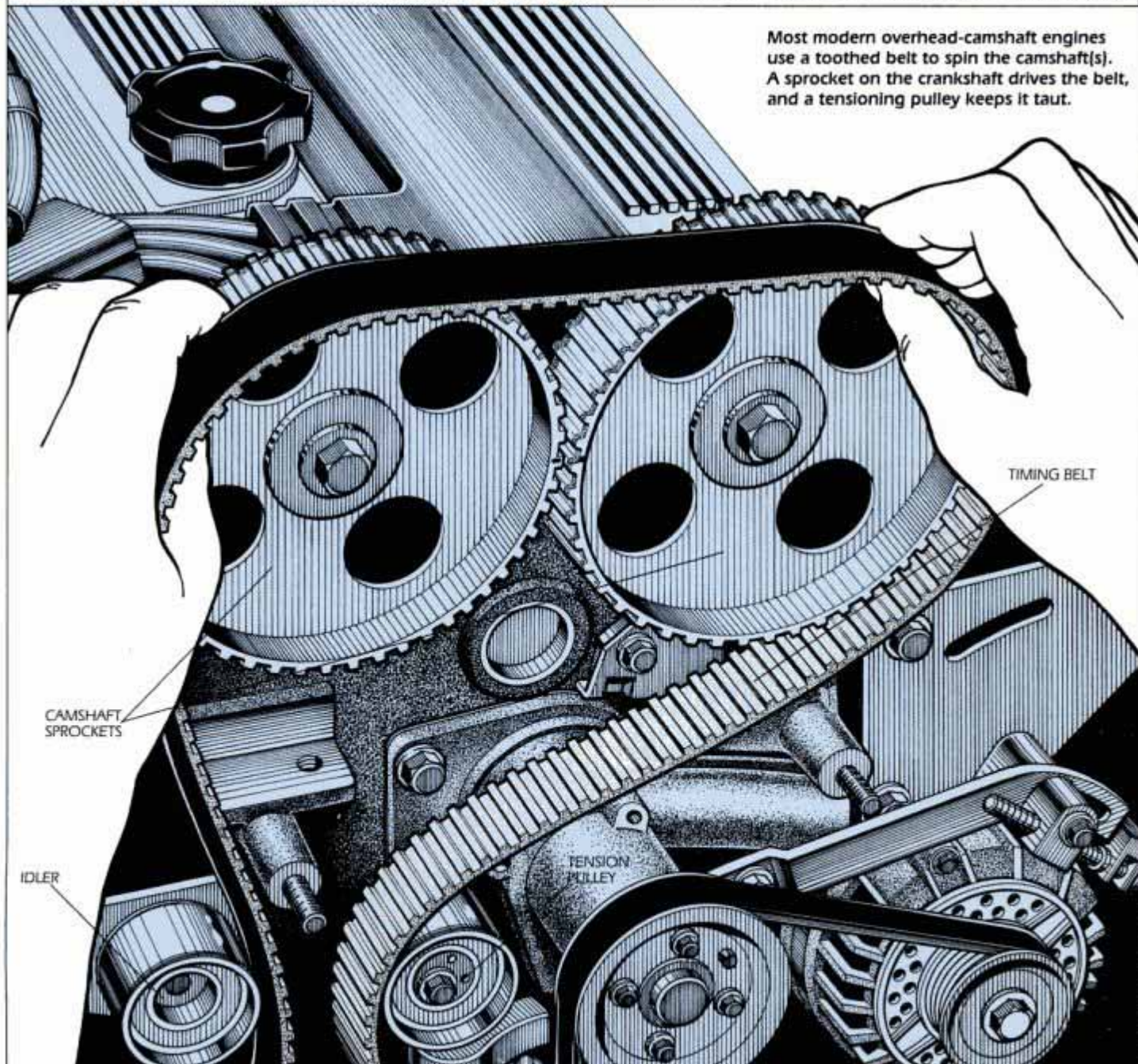
Belts versus chains

Timing belts were first introduced in the mid-'60s. Since then, they have gained broad acceptance. Today, more than 500 models of cars and light trucks are equipped with belts.

Before the introduction of timing belts, overhead-cam engines used

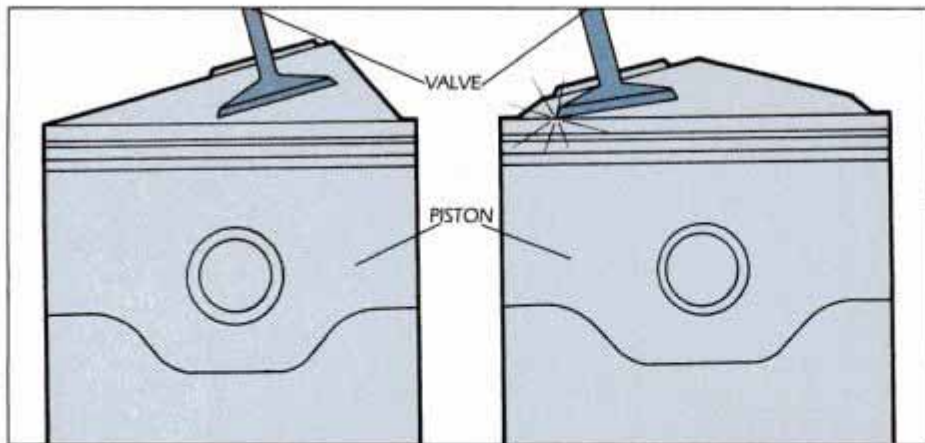
timing chains. But belts have many advantages over chains—not the least of which is lower design, engineering and production costs.

Timing belts also take up less room, and they run much quieter than a chain. They also weigh less and require no lubrication. Overall, belts are also much less complicated than chain designs, and they also often serve to drive other components,



Most modern overhead-camshaft engines use a toothed belt to spin the camshaft(s). A sprocket on the crankshaft drives the belt, and a tensioning pulley keeps it taut.

PM ILLUSTRATION BY RUSSELL VON SAUBER



In noninterference engines (left), the fully open valve cannot foul against the top of the piston. In the interference type (right), the valve can hit the piston.

such as the water pump, distributor, oil pump and fuel pump.

It's all in the timing

The timing belt keeps the upper and lower halves of an engine connected and running in perfect sync: The crankshaft spins the timing belt, which, in turn, spins the camshaft to open and close the valves. The result is the elegantly timed sequence of the 4-stroke-cycle engine—intake, compression, power, exhaust. When the timing belt breaks, the 4-stroke cycle becomes a no-stroke cycle and the engine quits.

Running interference

In the world of broken timing belts, there are only two important kinds of engine designs: Interference and noninterference. Noninterference, or free-running, engines are designed with a little extra clearance between the tops of the pistons and the fully open valves inside combustion chambers. This little-noticed design feature only becomes significant when the timing belt breaks. The extra room prevents an open valve from contacting a piston.

In an interference engine, there isn't any extra clearance: When the timing belt breaks, the pistons strike the open valves—usually with catastrophic results.

How much damage occurs depends on how fast the engine is running

when the belt lets go. Damage can range from a couple of bent valves at low rpm, to broken valves, damaged pistons, scarred cylinder walls and a cracked cylinder head at a higher rpm.

When the timing belt breaks in a noninterference engine, installing a new belt is all that's needed to restore a healthy 4-stroke cycle.

Why would any car company design an interference engine? There's good reason: Adding the necessary clearance in the combustion chambers to make an engine a noninterference design sacrifices compression. Lower compression means less efficiency and lower horsepower.

In all, about 40% of the engines with timing belts are higher compression, interference designs. As the demand for engine efficiency increases in the coming years, expect the percentage of interference engine designs to increase.

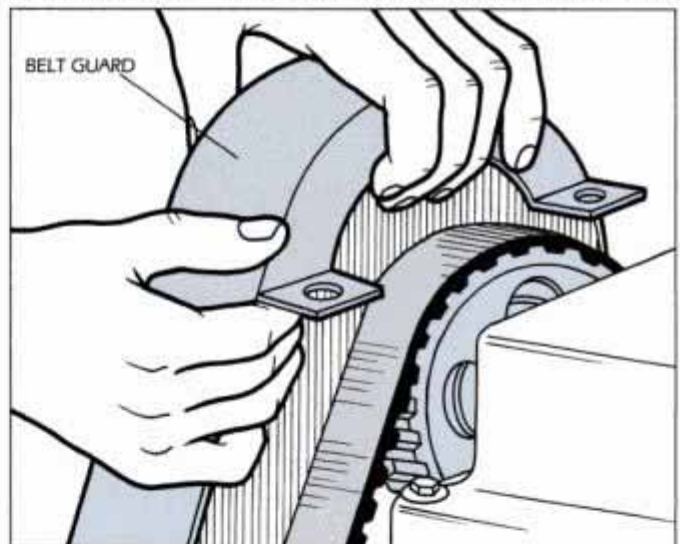
Belt fitness

Of course, the key to avoiding a belt problem lies in keeping it in good

shape and replacing it at the manufacturer's recommended interval. How long a belt ultimately will last depends on many factors. Chief among these is how well the engine is designed. The less torque loading, or vibration, placed on the belt, the longer it will last. Oil, dirt and heat also significantly reduce belt life.

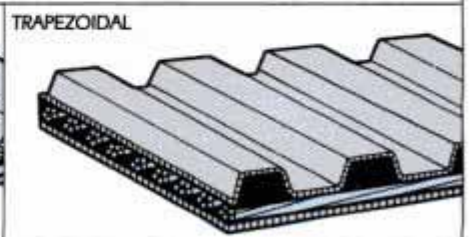
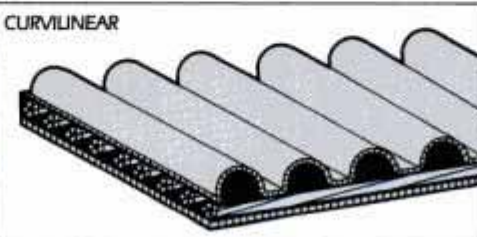
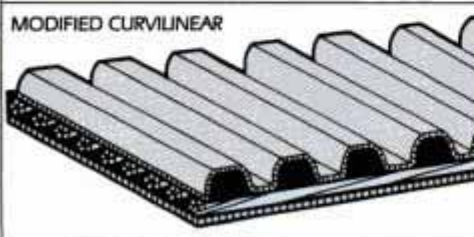
In the early days of timing belts, many carmakers didn't bother specifying when a timing belt should be changed. But over the years, they've learned that the timing belt should be changed at specified intervals. For example, on early Ford Escorts with the 1.6-liter engine, Ford issued a recall that specified a belt change at 24,000 miles.

Fortunately, carmakers have been able to significantly reduce torque loading. And better shielding from heat, dirt and oil has made for longer lasting belts. The belts themselves also have been improved. Most timing belts are constructed of neo-



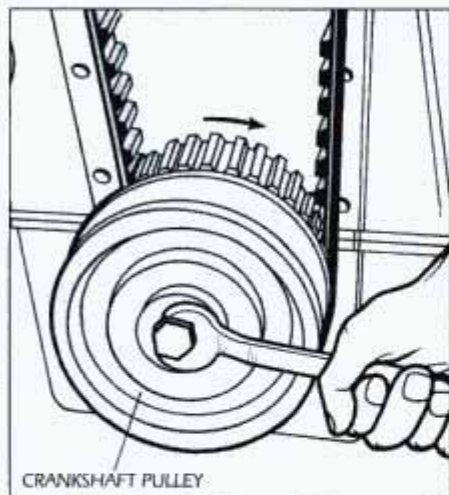
First, remove a plastic or stamped metal belt cover for access. You might also have to remove some accessories or drivebelts.

prene. But many newer cars are now equipped with belts constructed of a new material known generically as HNBR (Hydrogenated Nitrile Butadiene Rubber). (Gates Rubber Co. calls it HSN for Highly Saturated Nitrile.) No matter what it's called, this material stands up to heat and



Carmakers use three distinct belt-tooth profiles. Replacement belts must have the same tooth profile as the original.

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Turn the engine by hand to align the timing marks before removing the old belt.

oil contamination much better than neoprene.

With all of the improvements to engines and their timing belts, many manufacturers now typically call for timing-belt replacement at 60,000 miles. A few carmakers are even talking about increasing the interval to 90,000 miles on new models in the coming years.

Don't bother trying to inspect a timing belt. Beltmakers used to have all kinds of visual inspections to determine if a belt was going bad or whether a used belt was worth reinstalling or not. But given the relatively low price of a belt—roughly \$30 to \$60—and the potential for en-

gine destruction should the belt fail, it simply makes sense to change the belt at the recommended interval, or even near the recommended interval if you are doing other engine work that would make changing the belt easier. If your car doesn't have a recommended interval, Gates Rubber Co. recommends changing the belt at 60,000 miles, or sooner.

It's also penny wise and pound foolish to reinstall a used timing belt for any reason. And if you ever find a timing belt that is oil soaked, you should replace it as soon as possible.

Removing belts

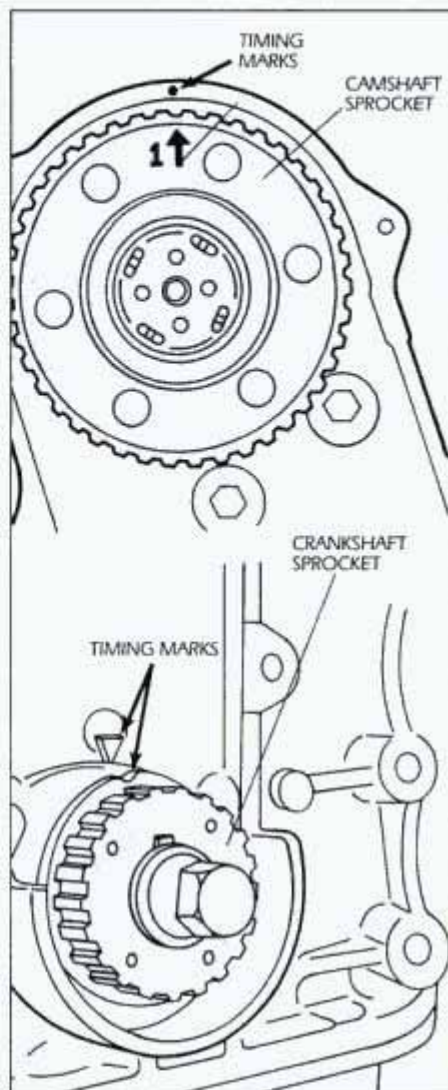
By and large, changing a timing belt is fairly straightforward. But the procedures vary widely depending on engine design, make and model. What follows is a general procedure. To change the belt on your car or light truck, consult a service manual for specific instructions.

Begin by disconnecting the cable from the ground terminal of the battery. Next, remove the distributor cap, then rotate the engine by hand until the timing mark on the crankshaft pulley is aligned with the 0° mark on the timing scale. At the same time, the distributor rotor should be aligned with the index mark on the distributor housing, which indicates that the rotor is in the firing position for No. 1 cylinder.

After you've rotated the engine to the No. 1 firing position, remove any items that interfere with removing the timing-belt cover. These may include accessory drivebelts, radiator hoses, the radiator, the crankshaft pulley or even an engine mount on some poorly designed front-wheel-drive models with a transverse-mounted engine.

The timing cover usually is made of sheetmetal or plastic. Remove the bolts that hold it to the engine and lift it off.

Once the cover is off you can see the timing belt. Double check that the engine is in the proper firing position by

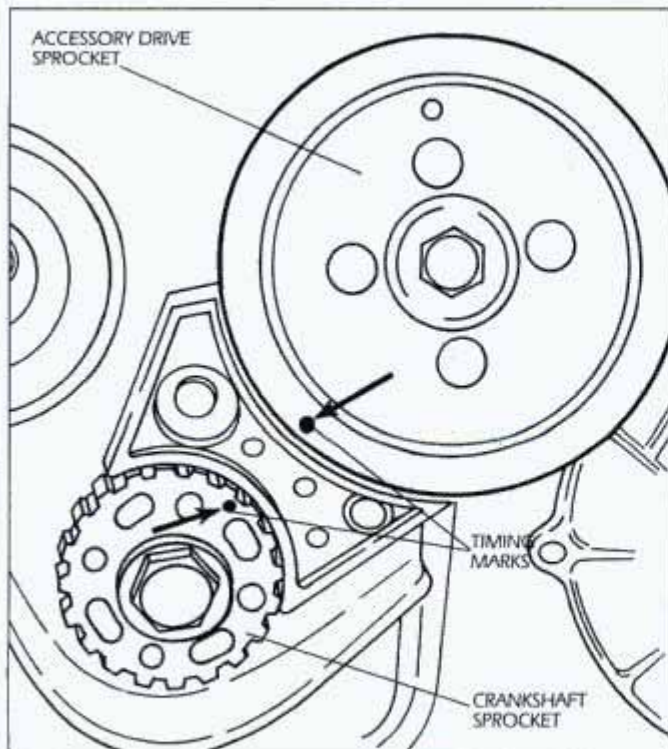


Align marks on the sprockets with marks on the block and cylinder head.

looking for marks on the camshaft sprocket and the crankshaft pulley. Many engines have a small dot or indexing line on the pulleys that align with corresponding marks on the block or head. The same is true of the accessory shaft. On some engines, the indexing mark on the camshaft sprocket aligns with the parting line of the first camshaft bearing tower.

Check the belt and immediate areas for signs of oil or other fluid leakage. Possible areas of leakage include the crankshaft main seal, the accessory-shaft seal and the cam seal. All three seals are located behind their respective timing-belt pulleys. Oil leaks also can come from the front of the cam cover and the oil pan. It is imperative that oil leaks be repaired before the belt is replaced.

To remove the timing belt, loosen its tensioner. On some cars, this may require a special tool. For instance, on early Ford Escorts, a special offset wrench is needed to reach a ten-



Depending on your engine, you might have to align the crankshaft sprocket with a mark on an accessory drive sprocket.

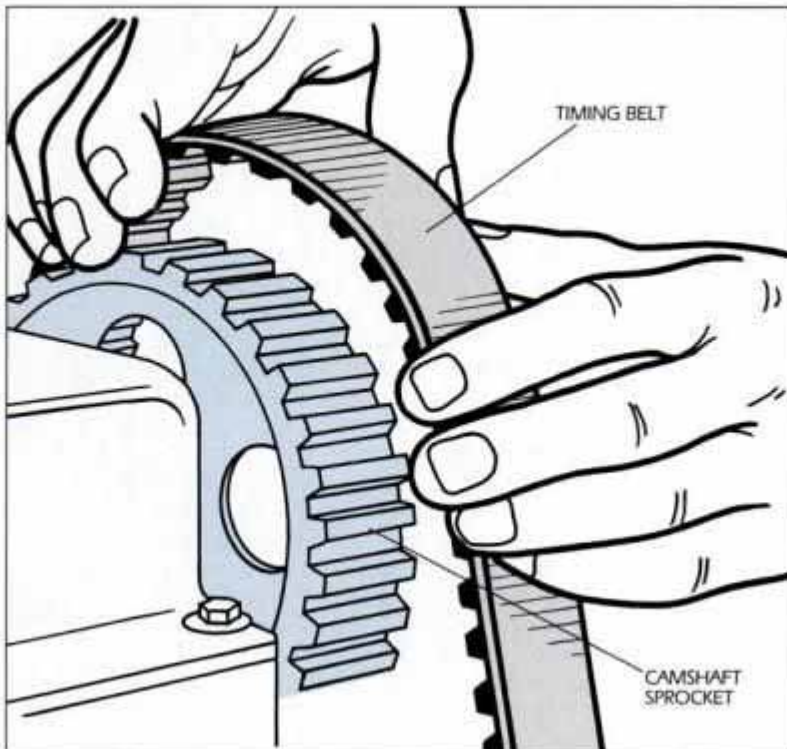
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sioner bolt that is directly behind an engine mount.

Many engines have a spring-loaded tensioner. If that's the case, loosen the bolts holding the tensioner, then pry the tensioner away from the belt and retighten the bolts so the tensioner remains off the belt.

With the belt tension relieved, the timing belt should slide off of the camshaft and crankshaft pulleys fairly easily. However, heat and miles may have the belt sticking in its grooves—pry it off with an old screwdriver or small pry bar if necessary.

Once the timing belt has been removed, do not rotate the crankshaft or camshaft. This is especially critical with interference engines because turning either shaft independently of the other can cause the pis-



With the belt tensioner fully loosened, the replacement belt should slip into place by hand. Be careful not to rotate the sprockets as you install the belt.

tions to contact the valves, resulting in engine damage.

timing belts, unlike regular belts, are sold in a box.

Getting belted

Since their introduction, timing belts have been designed with three different profiles: trapezoidal, curvilinear and modified curvilinear. All three look strikingly similar. The teeth must also be spaced properly and the belt must be the proper width. If any one of these factors isn't perfect, the timing belt is likely to self-destruct in a very short amount of time. That's why the part number must match exactly.

Timing belts are extremely tough when they're installed on the car. But they're rather fragile if they are twisted or bent into any configuration other than the one they were designed for. That's why

PHOTO ILLUSTRATION BY RON CARBON



Lots of plugs can This one started a

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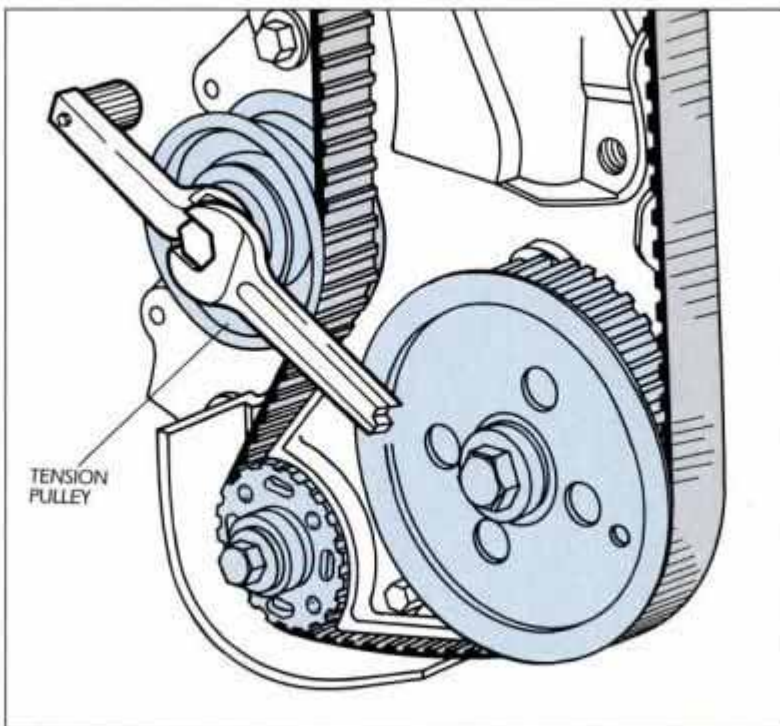
Installing belts

Never try to force or pry a belt over the sprockets when installing it. If the belt doesn't go on easily, you either have the wrong belt or the idler pulley is not loose enough.

After you slide the timing belt into position, make sure that the belt is properly installed around each of the sprockets and that the teeth on the belt mesh properly with the teeth on the sprockets.

On engines with spring-loaded tensioners, loosen the tensioner fasteners so the idler pulley contacts the belt. Be careful not to let the pulley snap against the belt—this might cause damage.

Whatever you do, don't try to guess the proper belt tension. Proper belt tensioning is a critical measurement and belt life



With the new belt in place, check the timing marks and readjust the tension pulley. Proper belt tension is critical.

will suffer if it isn't done correctly.

Once proper belt tension is restored, verify that all the indexing

marks on the accessory shaft, crankshaft and camshaft pulleys are still aligned. Then, using a wrench on the crankshaft pulley, rotate the engine—in its normal direction of operation—at least two complete revolutions. If you run into any hard resistance, it's possible that the timing is off—so recheck the position of all the timing marks and try again. If they aren't off, loosen the belt tensioner and reinstall the belt so the marks align and repeat the retensioning procedure before turning the engine over by hand again.

After the belt is properly tensioned and the marks align, reinstall the timing cover,

pulleys and the other items you removed, start the engine and you're done.

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HOW IT WORKS

POWER STEERING

BY DON CHAIKIN,
Contributing Editor

● Your car's steering wheel is actually a lever. It provides the mechanical advantage you need to overcome the weight on the front wheels so you can make those front wheels change direction. However, to provide good steering feel, control and low effort without a steering wheel that's the diameter of a HulaHoop, many cars are equipped with power steering. With power steering, the mechanical lever—the steering wheel—is helped by hydraulic pressure.

A belt-driven hydraulic pump provides highly pressurized fluid to the steering gearbox. A relief valve keeps system pressure within safe limits by bleeding fluid from the pressurized side of the pump back to the return, or suction, side. The hydraulic fluid is carried to the steering unit in steel tubes or reinforced hose. A return tube or hose carries the depressurized fluid back to the pump or reservoir from the steering unit.

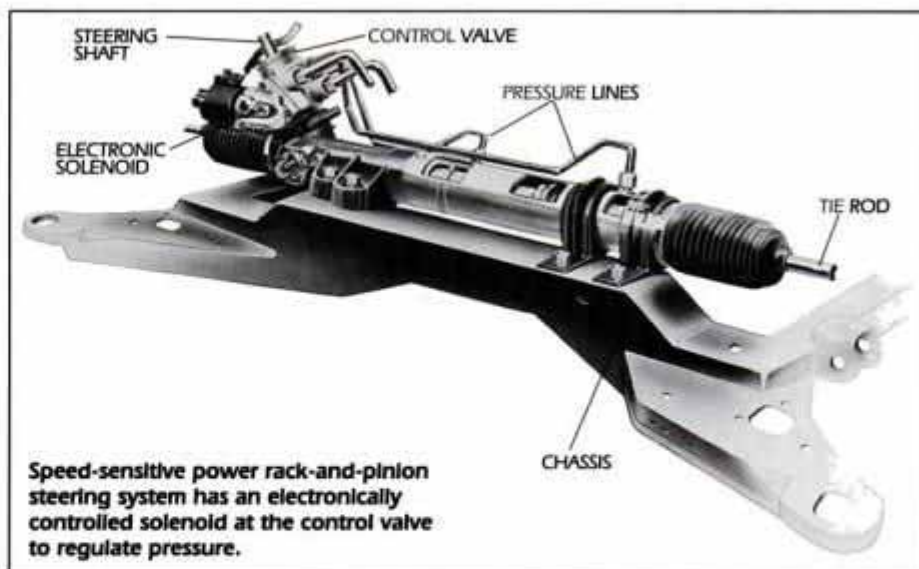
One shaft, dual purposes

At the end of the steering shaft inside the gearbox there is a control valve. This valve directs the flow of the pressurized fluid within the steering unit as per your directions—how you turn the steering wheel.

When the steering wheel is in the straight-ahead position, the control valve directs equal amounts of pressurized fluid to both sides of the steering gear, keeping the pressure on both sides of the gear equal. As you turn the steering wheel, the shaft moves the control valve at the same time that it moves the steering gear. As the control valve moves, it allows the pressurized fluid to flow to the side of the steering gear appropriate for the direction you are turning.

In a rack-and-pinion steering system, the steering rack has seals which partition the rack housing and, in effect, make the rack a piston. As the control valve in the steering gearbox directs the pressurized fluid, it moves to the appropriate chamber in the rack. There, the fluid pushes against the rack seal, helping move the rack.

A crossover tube keeps the fluid

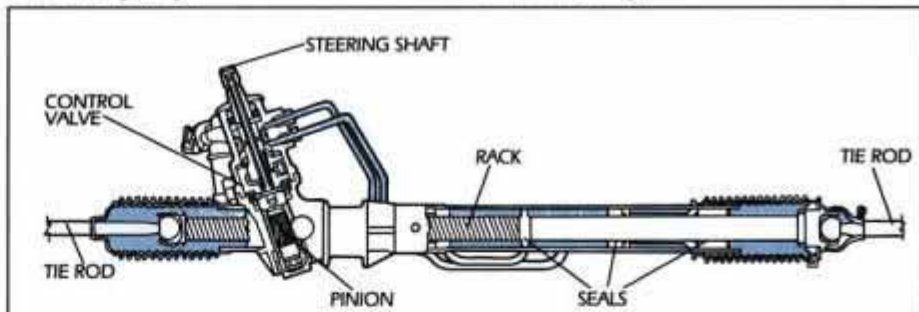


inside the rack housing flowing from one chamber to the other as the rack seals push against it. This prevents the rack from hydra-locking.

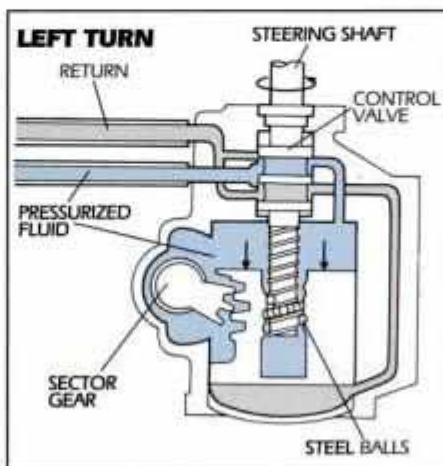
The effect is similar with a parallelogram system. As the worm gear at the end of the steering shaft turns inside the sliding gear, the control valve directs pressurized fluid to one side of the sliding gear or the other. As the sliding gear moves the sector gear to turn the Pitman arm, it also pushes nonpressurized fluid back toward the pump.

How fast, how light

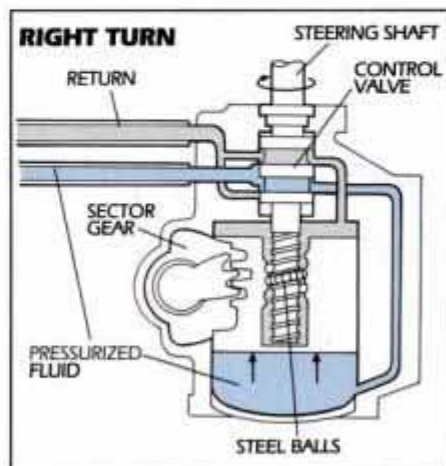
Thanks to electronic controls, the amount of hydraulic assist provided at the steering gear can be varied. Sensors keep the engine's electronic control unit apprised of engine and road speed. Based on that information, the ECU can quickly open and close the pressure-relief valve in the power-steering pump to regulate the pressure output of the pump, giving more assist for parking and more feel and feedback for high-speed maneuvering.



Seals around the rack separate the rack housing into pressurized chambers. A crossover tube allows fluid to flow from one side of the seals to the other.



The valve directs pressurized fluid against the sliding gear, helping move the gear.



Here, the control valve reverses the direction of the flow of pressurized fluid.

PHOTO ILLUSTRATIONS BY ION CARBON

PM HOTLINES

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NEW CARS

**Barchetta Allegro**

● Of course you don't need a car like this—but we'll give odds that some of you, like us, will want one. It's the Maserati Barchetta Stradale, a streetgoing version of a race car that's been the star of a single-make series in Italy.

The specifications are enough to bring out the Walter Mitty in any of us: Midengine, backbone chassis, double-wishbone suspension, less than 2000 pounds ready to roll—powered by a 2.0-liter dohc 24-valve intercooled twin-turbo V6 rated at 306 hp, mated to a close-ratio 6-speed gearbox. There are ventilated disc brakes at all four corners, with P245/40ZR18 tires front, P285/35ZR18 rear.

Maserati claims 0-to-60 times of less than 5 seconds, and a top-speed capability in excess of 185 mph.

While this may look like another of those mouthwatering creations that

never quite make it to the United States, the Stradale already meets European crash and emissions standards. That means the only major obstacle to U.S. availability is compliance with federal passive-restraint regulations. Though meeting all the various U.S. standards would undoubtedly add weight and erode horsepower, Maserati is looking into it.

Mazda B-Series

Here's another product of the Ford/Mazda alliance—Mazda's new B-Series pickups: B2300, B3000 and B4000.

But if you were shopping at a Ford store, you'd call them Rangers. Although Mazda has made a number of its own interior and exterior design tweaks, its new B-Series line is Ranger-based, and assembly will take place at Ford's truck plant in Edison, New Jersey.

As with the Ranger lineup, the B-Series will be available in regular-cab and extended-cab versions, with short- and long-bed variations. Engine offerings are the same as the Ranger—a 98-hp 2.3-liter Four, a 145-hp 3.0-liter V6 and a torquey 160-hp 4.0-liter V6.

Also like Ranger, the Mazdas are

available with either 5-speed manual (standard) or automatic transmissions, with either 2- or 4-wheel drive.

Beyond some size, payload and towing advantages versus competing compacts from Nissan and Toyota, the domestically produced B-Series avoids the 25% duty on imported pickups, which should put them on a more competitive price footing than the previous Mazda pickup line.

1994 Mitsubishi Galant

Mitsubishi's passenger-car lineup has historically been a bit off-center from its competition, but the new Galant sedan changes that strategy. Considerably bigger than its predecessor, the latest Galant is designed to go head to head with the major players in the midsize market—Ford Taurus, Honda Accord and Toyota Camry. Like Accord and Camry, the Galant will be assembled in the U.S., at Mitsubishi's Diamond Star facility in Normal, Illinois.

The Galant's only drawback in this battle plan is the absence of a V6 engine option, something offered by both Taurus and Camry and expected in the next-generation Accord, due for 1994. Aside from that, the



Sporty Trooper RS 2-door is 17 in. shorter, 150 lb. lighter than 4-door. Mazda's new Ranger-based B-Series pickups will be built by Ford.



New Mitsubishi Galant offers roomy interior, two 4-cylinder engine options.

Galant stacks up very well indeed. Although slightly narrower than the Camry, it offers similar leg and headroom, fore and aft. Aerodynamic efficiency is much improved—0.29 Cd versus 0.35 Cd for the previous Galant—and the styling is much more mainstream.

Besides being roomy, the Galant is also quiet, partly because of attention to aerodynamics, partly because of attention to isolating the passenger cabin from the chassis.

Safety equipment is consistent with coming passive-restraint regulations—dual front airbags and 3-point seatbelts, fore and aft with height-adjustable upper anchors. Antilock braking is available on all but the basic Galant S.

For all its good looks and comfort improvements, though, what we like best about the new Galant emerges on the road. Thanks to a much stiffer unibody and an all-new 4-wheel multilink suspension system, the Galant's handling is on a par with anything in its class and better than most. Straight-line stability is excellent, transient response crisp and predictability in any situation is 100%. The top-of-the-line GS model—the only Galant with a rear antiroll bar, plus a heavier bar up front—is the nimblest of the bunch, but all members of the family are devoid of vices.

Two versions of the same 2.4-liter 4-cylinder engine are offered—a 141-hp sohc edition, standard in the first three trim levels, and a 160-hp dohc variant for the GS. Power for either engine compares favorably with

competing Fours. Mitsubishi plans to add a V6 option later this year.

A 5-speed manual is the standard transmission for base and GS models, with a new "fuzzy logic" 4-speed automatic offered as standard equipment on the ES and LS editions.

Another new tech feature—GS models only—is a variable-assist electronic rack-and-pinion power-steering unit. However, in our view the standard power steering delivers better all-around feel.

The final element in the Galant's challenge to the midsize market is attractive pricing. Look for it to run about \$500 north of the Nissan Altima—about \$13,500 to \$19,500. If you've been thinking midsize, it would be a mistake to leave this one off your list. —Tony Swan

Isuzu Trooper RS

Isuzu is expanding its Trooper lineup for mid-'93 with the addition of a sporty 2-door—the Trooper RS.



Station-wagon version of Volvo 850 series is due for this fall.

Mechanically identical to the 4-door, employing the 190-hp twin-cam version of the line's 3.2-liter V6, the RS is 17 in. shorter and some 150 pounds lighter. It also rides a shorter wheelbase, making it a little handier in tight quarters.

Inside, the RS offers the same front-seat legroom as the 4-door, but rear-seat legroom shrinks by almost 7 in.

Equipped with lots of comfort/convenience features, the RS carries a basic (5-speed) price tag of \$23,350.

Birthday Buick

David Dunbar Buick isn't with us anymore, but his car is about to celebrate its 90th birthday. Buick is commemorating the occasion with a loaded LeSabre Custom, which will wear a 90th anniversary badge on its front fenders.

Besides basic LeSabre standards, like a driver's airbag, ABS, a/c and an AM/FM sound system, the 90th Anniversary LeSabre will include a cassette-tape player, cruise control, a power driver's seat, power antenna and the buyer's choice of alloy wheels or wire wheel covers.

Price for the Anniversary LeSabre is \$18,999, compared to \$19,935 for a standard Custom model.



Anniversary LeSabre celebrates Buick's 90th year.

Volvo 850 Wagon

Station wagons have played a key part in Volvo's success in the U.S., so the addition of a wagon to the sporty new 850 lineup is no surprise. But like the rest of the 850 series, it does mark another departure—the first front-drive Volvo wagon.

Thanks to its ultratall taillights, extending from the bumper to the roof, it will also avoid confusion with any other wagon on the road.

Consistent with Volvo's traditional emphasis on safety, the 850 Wagon includes dual airbags, self-adjusting 3-point seatbelts front and rear, an integrated child booster cushion, 4-wheel disc brakes with ABS and Volvo's advanced side-impact protection system as standard equipment.

The 850 Wagon is due in U.S. showrooms this fall. **PM**

RV LITE

BY JOE SKORUPA, Boating/Outdoors Editor



● A road hog. Who me? No way! I'd rather be caught behind the wheel of a rusty old Yugo than a bulked-out rolling silo. Call me crazy, but I just can't see tooling around in something with the grace and handling of a boxcar on steroids. Sure, I admire people possessed with the wandering spirit, but must they wander in an aluminum-sided Conestoga wagon? The point of wandering is to get away from home, not to equip it with an engine and drive it around with you.

Besides, I'd never be able to handle the guilt. Knowing that a mile of cars stretches behind me whenever I'm on a 2-lane highway would weigh heavily on my mind. I'd be uncomfortable with the fact that I was the reason all those drivers were going blind with frustration. Believe me, I know how maddening it is to be forced to maintain the legal 55-mph speed limit.

On the other hand, there's an interesting alternative to driving a tanker-size RV. It's called a pop-up or fold-down camper, depending on who's doing the calling. Last fall I had the occasion to use one, and I found that it had most of the features of the bigger land yachts, but none of the oh-so-lovely wood-embossed

aluminum siding. The model I spent time with was actually fairly compact and somewhat aerodynamic. And, importantly, when matched to a tow vehicle with sufficient power, the whole package was as peppy as the normal traffic flow on either 2-lane highways or interstates.

All in all, my fold-down camper experience was guilt-free RVing, or RV lite, if you will.

The camper I used last fall was the Jayco Cardinal (\$8788), a top model in the upscale Designer Series. Although the unit is larger than most cars, the Cardinal will store easily in any standard driveway when folded down. It's 18 ft. 10 in. long and 7 ft. 1 in. wide. Height is a low 4 ft. 8 in. Its compact shape enables the Jayco to ride inside the slipstream of the tow vehicle for minimal drag.

As mentioned earlier, there's no "chic" aluminum siding on the Cardinal, which is a hallmark of good taste

that runs through all models in the Designer Series. The Cardinal's exterior is made of smooth, durable fiberglass. Front and rear trailer/camper components are finished off with removable ABS plastic caps.

Fully opened, the Cardinal stretches out to an impressive 24 ft. 2 in. long with an expansive interior height of 6 ft. 5 in.

Two things surprised me when I set up the camper. The first was how easy it was. Setup time was about 15 minutes and easily accomplished singlehandedly, if necessary. The second was how logically the interior elements were structured. Instead of being a Rube Goldberg gizmo with inefficient low-tech mechanisms, the Cardinal is a marvel of design sensibility.

After unhooking the corner latches, I simply cranked a lever and effortlessly raised the roof. Hidden from sight, the Cardinal is equipped with an enclosed lifting system that

uses a winch, galvanized-steel cables, a series of pulleys and four steel push-rods (one in each corner). Slight nudging may be required if part of the tent canvas fails to unfold properly, but this is never the fault of the lifting system itself. In fact, Jayco is so confident about the long-



With a setup time of less than 15 minutes, the Jayco Cardinal produces happy campers.

term durability of the lifting system that it offers original owners a lifetime warranty.

Once the roof is raised, it becomes easy to pull out the front and rear bunks. The long overhangs are supported by exterior brackets that slide into secure slots on the camper frame. At this point, the camper and the heavy-duty canvas walls are extended to their full length, and it's time to enter the unit.

As noted, the interior features of the Cardinal fit together and perform multiple duties. The double-hinged screen door, for example, drops down from the ceiling and locks securely into the doorjamb. An overhead cabinet slides from its folded-down position in the middle of the room to a new position when the trailer opens up. A wardrobe cabinet lifts off the floor and fills a dedicated place along the back wall. Two dinette tables emerge from the bed areas and set up in seconds. One of the dinettes, by the way, drops down to the sofa level and helps form an instant double bed—the third double-bed, incidentally, in this roomy camper.

A final feature of note—the unique gas range. Knowing its customers well, Jayco designers made the gas range a removable unit that can be lifted out of its interior position and set up on an exterior wall. The outside position is equipped with a hidden gas connection, and is located close to the main doorway for easy access to food and utensils.

While the Cardinal's interior wasn't finished with oak and brass appointments, it looked like it was. The overall effect of the woody cabinets, combined with the big gas range, the double porcelain sinks, the vanity, copious countertops, the ice-box and numerous built-in drawers make this lightweight RV truly feel like a home away from home.

But no matter how many amenities you bring with you, a camper isn't a home, and to me that's its primary appeal. To emphasize the point, the Cardinal has wraparound windows that flood the interior with air and light. Ah, wilderness. Naturally, the windows are screened. Camping in the wild is one thing. Kamikaze bugs are another.

Being an old trailer hound, I was very curious about the Cardinal's road manners. In years past, these units were notoriously jumpy and inclined to wander behind the tow vehicle. I'm glad to report that state-of-the-art technology has solved these problems.

Although the size and weight of

the Cardinal (2200 pounds) is appropriate for mounting on either a single-axle or a tandem-axle trailer, Jayco opted to use the stronger, sturdier, better-handling tandem. Using, the same philosophy, it selected a torsion-bar suspension system, which enables each wheel to react to bumps independently. Frankly, I've found that torsion-bar suspension provides the smoothest trailer ride on the road.

The result of these fundamental decisions was that after hitching the Cardinal to my tow vehicle, I didn't have to give it a second thought. Its road manners were impeccable—no swaying, no bouncing, no problem with tongue weight or balance. Somebody at Jayco should be commended for doing her homework.

My tow vehicle of choice was a new Pontiac Trans Sport SE. Actually, it wasn't my choice. The Cardinal and the Trans Sport came linked together as a test package. If it had been up to me, it's doubtful I'd have chosen a unitized-body, front-wheel-drive minivan as a tow vehicle. I've towed with these oversize passenger cars before and found that performance is usually underwhelming.

But the new Trans Sport SE came

equipped with a big 165-horse 3.8-liter engine—a new option that ups torque production to a respectable 220 ft.-lb. at 3200 rpm. Because of the surge in power, this Trans Sport is rated to tow up to 3000 pounds, which is good news for minivan aficionados.

As mentioned earlier, the Trans Sport was a peppy performer while towing the Jayco Cardinal. This includes both climbing steep hills and zipping along at superhighway speeds. Average fuel economy when solo was 24.5 mpg and under tow, 21.7 mpg.

After a couple of short shake-down trips, my wife and I headed off to the scenic Delaware River Valley for a long weekend of Jayco Cardinal camping. Typical of far too many of my recent vacations, it poured buckets of rain every day, which proved to be the ultimate test. My wife and I spent so many consecutive hours in our Jayco Cardinal camper that we were beginning to get cabin fever, but the Cardinal showed no such signs of weather-related distress. The Cardinal handled the soggy weekend with colors flying. I wish I could say the same for my wife and me. Is it possible to get a Cardinal rain check? **FM**

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ROBOTS OF THE DEEP

BY ABE DANE, Science/Technology Editor



● For more than a decade, some of the Navy's keenest designers and engineers have been trying to get out of mowing the lawn. And lately, it's begun to look like they've succeeded.

The undertaking is not as slothful as it sounds. In this case, "mowing the lawn" is deep-sea search and salvage jargon for the tremendously costly procedure required whenever something worth recovering—a stricken airplane, a wayward missile, a hydrogen bomb—gets lost on the ocean floor.

To find it again, a ship drags a weighted, sonar-equipped device called a tow fish back and forth over the bottom. The tether linking the ship with the tow fish is often several miles long, making it extremely difficult to maneuver. Speeds are generally less than 1

knot, and the ship has to swing miles wide on turns to keep the tow fish from crashing into the bottom.

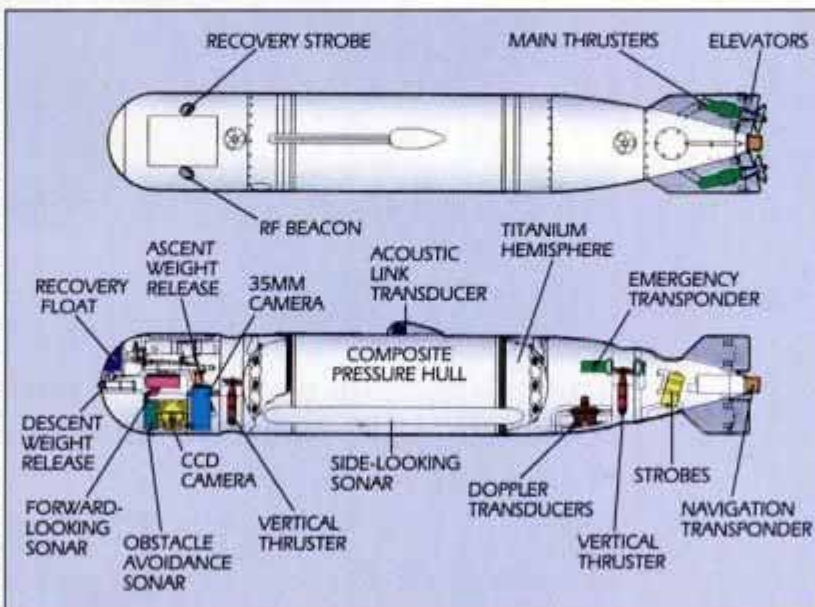
Even more limiting, whenever the sonar finds anything interesting, the ship can't just stop for a closer look. The tow fish has to be carefully

reeled in and a separate remotely operated camera system lowered. In short, even with the most advanced technology, finding things in the deep ocean has remained a major hassle.

The obvious solution would be to snip that cumbersome umbilical

between the ship and the tow fish. But to do that, you'd either have to find a way for the submersible to communicate with shipboard operators through miles of water, or make the sub smart enough to work on its own. Until recently, neither was feasible.

Since the early 1970s, however, a team at the Naval Ocean Systems Center in San Diego (now called the Naval Command Control and Ocean Surveillance Center RDT&E Division, or NRaD) has been working on cer-



AUSS design withstands deep-ocean pressures to put sensors on the bottom.

tain key technologies. Their goal: to create an entirely new breed of under-sea craft—a truly robotic sub that could be unleashed like a hound to sniff around miles beneath the sea, then home in and investigate whatever it found.

In 1979, the group felt that the technology was ready to begin work on such a craft in earnest. Until recently, the Navy kept quiet about the program, but over the past year or so, details have begun surfacing.

The first prototype of the Advanced Unmanned Search System (AUSS) was completed in 1984. It never went deeper than about 2500 ft. But in a series of 89 dives, engineers used it to test and integrate the basic components of a far more capable craft to come.

The most problematic of these components was the acoustic link that kept the sub in contact with the mother ship via bursts of coded sound waves. NRaD's prototype system broke new ground in speed and accuracy. And that set the stage for a full-scale effort to build a practical operational system able to dive to 20,000 ft.

Practically everything on AUSS required original thinking by the designers. "There is nothing that can be minimized in this," says Mike

Cooke, who headed the program. "Every little bit fits into the overall picture—from the emergency systems on board to the sensors to the computers. Everything is highly interrelated."

To withstand the pressure exerted by miles of seawater, new carbon-fiber-composite winding techniques were employed in constructing the center section of the sub's hull (see [Tech Update, page 22](#), Apr. '90). Five times stronger per pound than steel, this composite cylinder encases the sub's parallel-processing computers and the silver zinc batteries which power the craft for up to 20 hours between charges. Side-looking sonar (SLS) capable of scanning a 2-mile-wide swath of seafloor for objects as small as a watermelon is built into two external pods. And in a free-flooding forward fairing made of buoyant Spectra composite there are watertight housings containing a forward-looking sonar (FLS) to help home in on objects of interest, and electronic CCD and 35mm-film cameras to snap pictures of them. Images from the CCD camera or sonars can be beamed up by an acoustic link fast enough to get them to the surface in as little as 15 seconds.

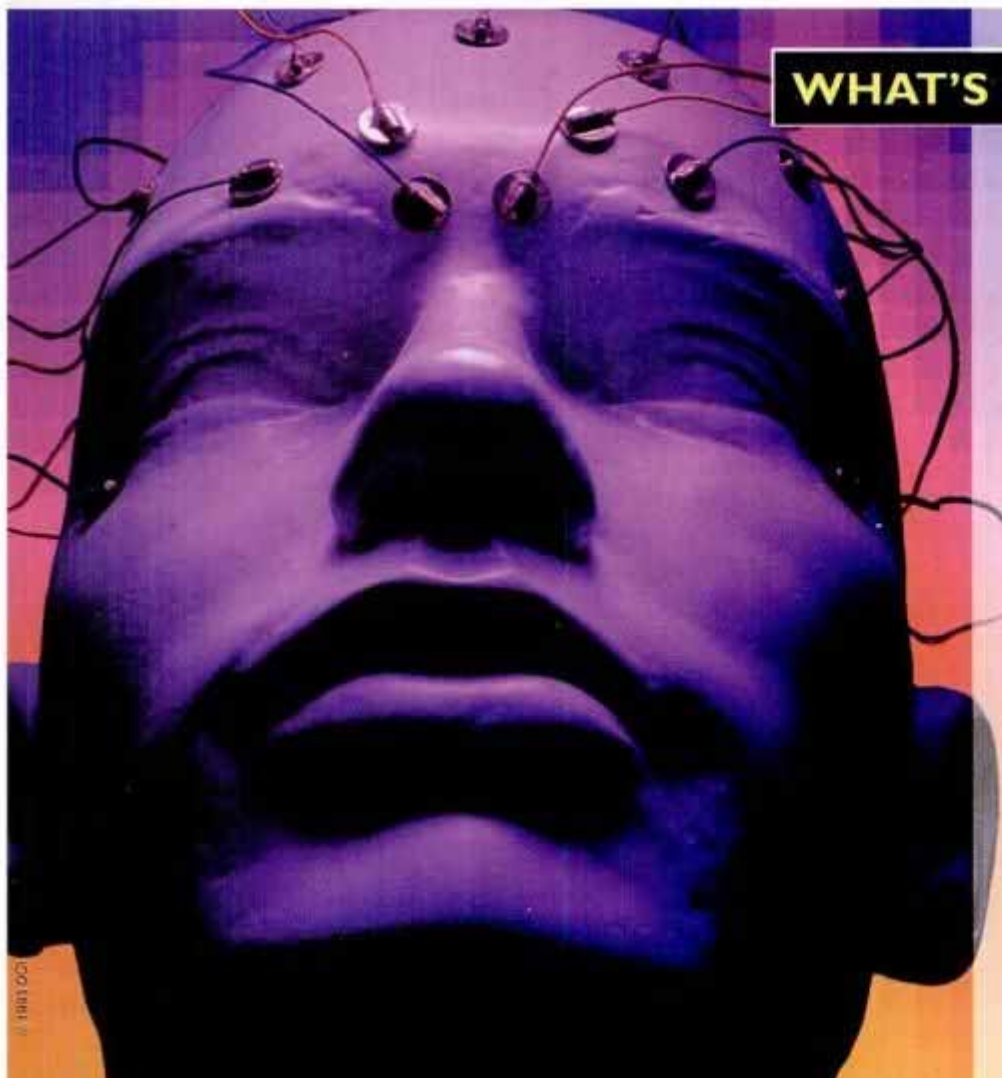
On a typical mission, the 17-ft., 2800-pound craft slides down a ramp

into the sea, then sinks with the help of a weighted line. The line is released, and AUSS cruises 100 ft. off the ocean floor at about 5 knots, following a search pattern under the guidance of its own computers and sensors. SLS images are continuously shot back to the surface.

When operators spot an interesting contact, they command AUSS to stop, and then to travel to the target's vicinity. About 75 ft. off, an FLS scan is ordered to get more detail, and with another command, the sub travels directly above the target, snaps a CCD picture and transmits it back. Then the search pattern is resumed.

Thus, within a period of 10 to 20 minutes, with only a few simple commands, AUSS can go from automatically "mowing the lawn," to inspecting an object up close, then get back to wide-area searching. At the end of a search, it drops ascent weights and bobs to the surface.

Although the Navy has no immediate plans for AUSS, its capabilities show the way toward a whole new approach to deep-sea exploration. Already, work is underway on a variety of other tetherless, unmanned subs, including ABE (see [Tech Update, page 22](#)) with potential applications in scientific and commercial research. **FM**



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DIAL A PICTURE

BY FRANK VIZARD, Electronics Editor



A new technology from AT&T called Picasso allows you to send a video still image and voice communications simultaneously over existing phone lines. The picture is in color and has surprising detail.

Picasso also has some outputs more commonly seen on a computer. There's a serial port, an annotation port and a parallel port. This means you can connect accessories like a mouse to use as a pointing device. You can also connect a video printer for a hard copy of a picture.

Picasso, while being a telephone, would make many computers blush since there is the equivalent of four 486 computers inside the device. Under the hood is an array of digital signal processors. These processors perform high-speed addition, multiplication, digital filtering, data decoding and formatting chores. One of these processors is capable of performing 40-million instructions per second with up to five basic operations

within each instruction. The ability of these processors to do digital computations on analog information makes them ideally suited for products like Picasso.

Just how good are the pictures generated by Picasso? The picture of the parrot (above) should give you

(Please turn to page 110)

● Ever since Alexander Graham Bell made the first telephone call in 1876, everyone has been waiting for the next step: conversation with pictures.

For some time now, we've been on the verge of this experience. Last year, AT&T debuted a videophone. Although the phone provides an image, the picture quality is relatively poor and the motion is very jerky.

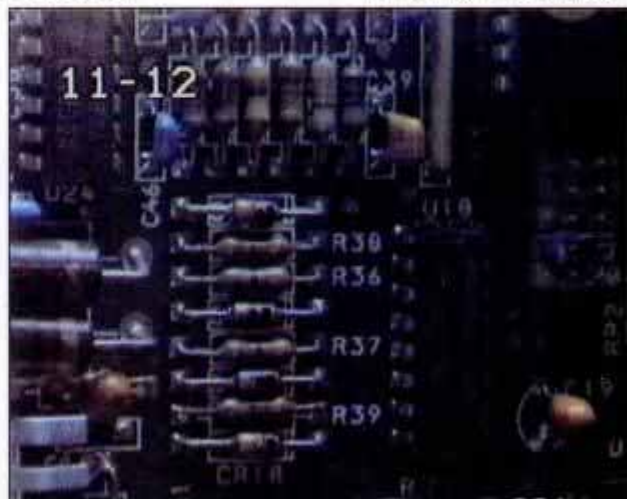
But perhaps motion video isn't something we really need. If you think about it, most images we want to see don't move much or at all. If someone were trying to show you an object on a videophone, your first request might likely be, "Hold still."

Perhaps with this thought in mind, AT&T is introducing a new telephone that lets you send high-quality-color still pictures over existing phone lines. What's more, this new technology allows you to send your voice and an image at the same time. People at each end of the phone can discuss the image that they're seeing.

Given the new telephone's ability to transmit quality color images, it is appropriately called Picasso. Unlike

a videophone, however, Picasso doesn't have a built-in camera and display screen. To capture an image you need a camcorder or still video camera, for example. And, by not including a display screen, users of Picasso have a lot of flexibility as far as viewing the transmitted image is concerned. Picasso can be connected to a small LCD screen for desktop viewing or to a large-screen TV, so images can be seen at meetings.

While Picasso doesn't look much different than the average office telephone, its capabilities become evident once you look at the phone's rear panel. Like a VCR, there are video inputs and outputs. In fact, there are two sets of video plugs—one for standard video connections and another S-Video set for higher-resolution sources like Super VHS.



Picasso allows you to zoom in on a portion of the picture for closer and more detailed examinations.

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Researchers from Japan, Germany and Carnegie Mellon University in Pittsburgh, Pennsylvania, already have had limited success in 3-way translations using small vocabularies. The difficulty is in combining three technologies: speech recognition, machine-language translation and speech synthesis.

While the technology required for extensive vocabularies is daunting, researchers hope that simple tasks, like making hotel reservations across national borders, will be made easier.

The biggest project of them all is yet to come, and all the major phone companies—AT&T, MCI and Sprint—as well as the regional operators are unified in their approach to it. President Clinton wants to spur development of a nationwide "electronic data highway." While it remains to be seen just how this network will be built, the phone companies want to be a part of it.

Perhaps toward this end, telephone companies also are increasing their investment and buying cable TV systems. Southwestern Bell recently bought Hauser Communications' cable TV system in Washington state, for example. In the event of an electronic data highway, whoever controls the wire link to a household stands to make a lot of money.

Captioned TV

You probably associate captions on television with bad imported movies, but starting this summer, all TVs 13 in. and larger will include captioning. Previously, a separate decoder was necessary to view the text.

Captioned programs were originally conceived for the hearing impaired. In the TV listing, captioned programs bear a "CC" symbol. On encoded programs, subtitles are instantly matched with on-screen dialogue or narration.

But even if your hearing is good, captioning has its advantages. There are actually four types of captioning. CC-1 displays the narration tied to a primary audio channel. CC-2 can be used to display the text in another language. Text 1 can be used to broadcast stock prices, weather, sports results or other information. Text 2 is an alternate for Text 1.

Closed captioning lets you follow a program even when the volume is turned down, a feature that's handy when someone is sleeping. Closed captioning turns your TV into a karaoke machine since you can see the words to songs on MTV. Closed captioning will also help children learn how to spell. And sports fans can follow the commentary even if their buddies drown out the audio. **FM**

ELECTRONICS

(Continued from page 106)

some idea as to the quality of the color reproduction. And the picture of the circuit board is representative of the kind of detail that is possible. With Picasso technology, you can zoom in on any portion of a picture to examine it in greater detail. Pictures can also be stored in memory.

Part of the appeal of Picasso is its relatively low cost. Each phone is \$3000—a much lower cost than previous efforts to marry still pictures and voice communications. Of course, you need two to tango, so to speak, as a Picasso phone will only communicate still pictures to another Picasso.

While Picasso is more expensive than your average garden-variety telephone, many businesses can expect to see immediate savings in time and travel costs. For instance, for anyone working with a photographer, repeated trips to the studio are no longer needed.

Picasso also may help some businesses expand. For example, real-estate brokers can call up accurate and detailed views of houses from almost anywhere to show prospective customers. Picasso is likely to paint a broad picture across many kinds of businesses.

Picasso is actually just one of the numerous new technology projects in which the phone companies are now involved. NYNEX, to name one, is offering voice-dialing. Simply say the name of the person you want to call into the receiver and the connection is made.

What's interesting about this development is that the NYNEX voice-dialing option is the first to be supported by a computer network. The caller's voice travels to a speech recognizer at the central switching office. The name you asked for is compared against preprogrammed speech patterns stored in memory. Once a software program makes the match, the call is completed.

NYNEX says the system can handle about 50 names per phone. The system also is sophisticated enough so that more than one person can use the same phone. At a cost of \$4 to \$6 per month, voice-dialing should be a boon to the visually impaired.

Automatic Translator

Further away from fruition is a research project that would basically turn the telephone into a universal translator. The idea is to make an English speaker instantly understandable to a Japanese speaker, for example, and vice versa.

AUTOMOBILES

DETROIT SPY REPORT

BY JIM DUNNE, Detroit Editor

1995 Lumina

● Major restyling is in store for the midsize Chevy sedan next year. Scheduled for introduction as a 1995 model in early 1994, the Lumina will shed its boxy shape and take on a profile similar to the Taurus. Inside, airbags will protect both driver and passenger, while under the hood, Chevy will stick to an updated 3.8-liter V6 engine and 4-speed electronic-shift transmission. Note the simple styling at the rear wheel/rear door seam. The absence of a "dogleg" insert between the wheel and door improves the quality of fit and finish for the basic sheetmetal and for any plastic cladding that may be applied later.



Chevrolet Monte Carlo

Chevy will drop the Lumina name and revive Monte Carlo as the model name for this 1995 midsize coupe. Twin to the Lumina beneath the sheetmetal, the Monte Carlo will be the first of the GM midsize coupes to be restyled in this cycle. Later—probably in 1995—Grand Prix, Regal and Cutlass Supreme will display much more advanced styling in their versions of the GM W-car lines. This prototype, pictured below, is equipped with dual airbags for front-seat passenger and driver. Its instrument panel may be dual as well—it has a Pontiac Grand Prix steering wheel, while a Monte Carlo logo is embossed on the glovebox door surface.

Delayed Grand Prix

Grand Prix is a sister car to the Chevrolet Lumina. But the Pontiac model will not be restyled until a year after the Lumina makes its debut in early 1994. Pontiac decided to leapfrog past a restyling job that it had planned for introduction at the same time as the Lumina debut. The leapfrog redo delayed the Grand Prix another full year. Insiders at Pontiac say the Grand Prix will have a more exciting design than the Lumina/Monte Carlo. Others say that the Grand Prix will be similar in exterior appearance to Chrysler's LH line—including a cab-forward profile and wheels set out to the corners of the car's body.

Brake-Light Response

Look for more brake lights with body-color lenses in future cars. Tests that compare red lenses with body-color lenses show that the switch to red with body-color lenses gets quicker responses. A blue car with a blue brake-light lens will get a quicker response from a following driver than any car with a red brake-light lens. (Both lights shine red when brakes are applied.) The reaction-time advantage of body-color lamps is slight, only about 33 milliseconds. But what the tests show is that designers can paint cars—and their brake-light lenses—all one color. This won't affect safety. In fact,

(Please turn to page 112)



Chevrolet's dormant Monte Carlo nameplate will be reborn when the coupe version of the next-generation Lumina arrives next year.

the quicker response time to the red lights flashing inside a body-color lens may mean a slightly sooner warning for following drivers.

Dodge Sport Coupe

Goodbye Daytona. Here is the replacement, as yet unnamed. The new car, with completely new styling and

tion. (Note in the rear-end photo of the disguised prototype Windstar, the split doors are simply painted on. The real door is a standard hatch type with a single backlite.)

Chrysler V8

If you want to play with the big boys, Chrysler knows the rules. It must

front suspension system, similar to that planned for the Explorer and Ranger. Ford will discard its venerable Twin I-Beam front suspension and use upper and lower control arms. Styling will be dramatically changed, too. Ford's '96 pickup prototypes show the same jutting grille and set-back fenders that you see on Dodge's 1994 Ram pickup. Finally, Ford will probably introduce a new V10 gasoline engine—of 7.8-liter displacement—for the F-series trucks. It will be based on the current 5.8-liter V8-engine design.

Smart Mirrors

Look for big advances in rearview mirrors in the next five years. One mirror supplier—Donnelly Corp.—has a system that selectively dims rearview mirrors. Instead of the



Daytona replacement will come from Mitsubishi Diamond Star plant in Illinois.

a revised engine lineup, will be introduced to the public officially next year as a 1995 model. Engines include two 2.0-liter Fours, a 2.4-liter Four and a 2.5-liter V6—the latter is built by Mitsubishi. Sport coupes for Dodge (like this one), and a Chrysler version that replaces the LeBaron, will be built at Mitsubishi's Diamond Star plant in Normal, Illinois. Both new models will move upscale in market class to compete with the Thunderbirds and new Monte Carlos.

Ford Windstar

Windstar, based on the Taurus drivetrain, will carry Ford's attack on Chrysler's domination of the minivan market starting next year. The Ford will feature front-wheel drive, a longer, wider body than the Chryslers and an engine lineup that ranges up to a 3.8-liter V6. Four-speed automatic and dual airbags will be standard. Windstar will eventually replace Aerostar in Ford's small-van lineup, but the two will be sold side by side during ramp-up of Windstar produc-



offer a V8 engine in its top luxury cars like New Yorker and LHS—and not just any V8. It needs a 4.0-plus liter all-aluminum twin cam that will stand up to the Northstars, Lexus, Infiniti and Ford's modular 4.6-liter. Look for Chrysler to offer a modern V8 in its top sedans starting in the latter half of the 1990s.

Ford's 1996 F-Series Pickup

Ford is not standing still in its pickup leadership role. A new full-size pickup—loaded with surprises—is planned for 1996. Start with a new

whole mirror dimming when struck by bright lights, only that part of the mirror reflecting the lights is dimmed. The rest of the surface reflects without dimming. And, as the bright lights move to different parts of the mirror, only those parts dim. The smart mirror is expensive, maybe 10 times the cost of standard mirrors. But, price aside, they could start appearing on luxury cars within five years.

Dodge's Big Ram

Dodge will launch a full line of pickup models next fall when the completely



New front-wheel-drive Ford Windstar will use the Taurus drivetrain, eventually replacing the current rear-wheel-drive Aerostar minivan.



Tandem-axle Dodge Ram pickup will be available next fall.

redesigned Ram truck is introduced. Among the body styles is this tandem-axle, the biggest Ram model. In addition to its dual rear-wheel chassis, this prototype was equipped with a Cummins 6-cylinder turbocharged diesel engine. Other engines slated for the Ram line include a new V10 gasoline engine of 8.0-liter displacement, and V8s of 5.2 and 5.9 liters.

Ford Middle/Compact

Somewhere between Taurus and Tempo. That's where this new Ford sedan fits into the Ford lineup for 1994. As yet unnamed, but a near copy of Ford's European Mondeo, the new car was first intended to replace the Tempo. But its size is closer to that of the Taurus. So Ford changed plans and chose to add the



European Mondeo small car will be the basis for an all-new Ford.

new model in its lineup between the Taurus and Tempo. While Mondeo is built in 4-door, 5-door and station-wagon versions, Americans will only get a 4-door.

Escort Stretch

Why build a completely new car when you already have one that will do the job? That's the question Ford planners answered when they decided to replace the future Tempo with a stretched version of the Escort. The new Tempo is a long way away—1996, according to Ford's calendar.

ence, questions are asked about when Mazda will add a 4-door model to its Navajo line. Navajo is the Explorer clone that Ford builds. Mazda never answers directly, but the latest hints are that Ford will build a Navajo 4-door when its revised 1995 Explorer is introduced. Then Mazda will introduce a Navajo 4-door with the new Ford front suspension. Ford plans to drop the Twin I-Beam front axle and switch to the conventional upper and lower control arms.

One styling note: Headlights are laid back sharply on the fascia, leaving a vertical dimension of just a couple of inches and an ultrasleek appearance.

Navajo 4-Door

Be patient. At every Mazda press conference, questions are asked about when Mazda will add a 4-door model to its Navajo line. Navajo is the Ex-



Chrysler's new Neon subcompact reflects LH design philosophy.

plorer models, but the long wheelbase-to-short overall length ratio of the LH models can be seen in Neon's profile. The new design will give the Explorer—and the Navajo—surfer front-end alignment and a lower hood profile.

Steel Vs. Plastic

The fight continues over who gets the nod for body-panel materials on future cars. Steel is strong, easily recyclable and relatively cheap. Plastic can be molded into intricate shapes, will take a bump without damage and is light in weight. Now the steel companies are talking about the safety of steel. Because it is strong, you can build crush resistance into steel body panels. That means protection. Plas-

tic panels need a backup system for crush resistance. That could mean extra cost—and weight. Insiders look for steel to be around a long time, citing its low cost. But plastic panels have a place too. They are almost ideal for low-production, frequently changing body styles.

Plymouth/Dodge Neon

Chrysler will sell this all-new subcompact 4-door model through both Plymouth and Dodge dealers under a single name, Neon. Chassis details include a 4-cylinder engine driving the front wheels and independent suspension on all four wheels. Styling is unique, even among other Chry-

ler models, but the long wheelbase-to-short overall length ratio of the LH models can be seen in Neon's profile.

Ford Taurus, 1995

Prototypes of the 1995 Ford Taurus are showing up at test sites. Some prototypes are not complete cars, as revealed by this photo. The complete rear bumper assembly has not been installed. Styling features of note include "lock box" sections in the doors that put the handle mechanism outside the door surface, and a severe slope to the windshield that puts the base of the glass almost directly over the front axle line.

The lock box design could lead to thinner doors and more room for passengers inside. The windshield design is similar to the cab-forward profile of Chrysler's LH models. It also adds to the feeling of more room inside the car. **PM**



Ford Taurus for 1995 mirrors cab-forward industry theme.

Dobson, Christian Danner, Robbie Buhl and Brian Till still using the Chevy V8/A, most of the competitive teams have moved on to the untried Chevy V8/C.

What about the Chevy V8/B? In 1992, Ilmor refined the Chevrolet Indy V8, making it both lighter and smaller. The B engine was available only to the Penske team, and while they didn't have a bad year—Penske Bs won four races and the Marlboro Challenge—the championship went elsewhere. This year, only Eddie Cheever will have a Chevy/B engine in his Penske, since team owner

Norm Turley bought Penske's year-old cars.

The big news for 1993 is the introduction of the Chevy V8/C, which will be used by all the top Chevy drivers including Bobby Rahal, Al Unser Jr., Emerson Fittipaldi, Paul Tracy, Danny Sullivan, Teo Fabi, Roberto Guerrero and Robby Gordon. Expect that two-thirds to three-quarters of any Indycar field this year will be powered by the Chevy/C.

Compared with the A and B engines, the Chevy/C is lighter, smaller and more powerful. The basic engine fits inside a 22-in. cube, weighs less

than 330 pounds and produces around 850 hp at 13,000 rpm. It's an unusual 80° V8, fitted with Rochester fuel-injection and Delco's fourth-generation engine management system called Gen IV. This system is built around a 32-bit microprocessor and is both quicker and smarter than the previous Gen III.

The key to the V8/C design isn't something you can see. It looks very much like the Chevy/B. On the inside, however, the crankshaft has been lowered nearly 1.5 in. in the block, so the whole engine can be more compact and can be mounted lower in the chassis. It also has a flat 180° crankshaft and wet cylinder liners. A new intake-manifold plenum gives a broader power curve.

Like the Chevy/B, there's an individual Delco ignition coil for each cylinder. The Chevy/C can use an ignition pickup off the front of the crankshaft or a magnetic pickup off the back. The engine's compression ratio is 11.0:1, and it uses 22.0 psi of boost.

Like all the Chevy Indy V8s, the new C is assembled in this country from parts produced by Ilmor in England. Penske, headquartered in Reading, Pennsylvania, prepares engines for Penske Racing and Tony Bettenhausen's cars, which insiders call the Penske B team. All other teams are serviced by VDS, in Midland, Texas.

Ford-Cosworth XB V8

In 1992, Newman-Haas switched from Chevrolet to the untried Ford-Cosworth XB V8 and got results—along with some teething problems. Even so, if Bobby Rahal had finished fifth instead of third in the last race of the season at Laguna Seca, Michael Andretti would have won the 1992 PPG IndyCar Championship for Ford. The XB obviously works. This year, not only Newman-Haas drivers Mario Andretti and Nigel Mansell, but Scott Brayton, Raul Boesel, Lyn St. James, Arie Luyendyk and Scott Goodyear will be Ford-powered.

Produced in Northampton, England, the XB is the latest development of the old Cosworth DFX. The XB is smaller and lighter than even the latest Chevy/C. It also has slightly more power, more torque and thriftier fuel consumption than the Chevy/A or B. In most respects, though, it is very similar to the Chevy. How it will fare compared with the new C we'll only learn as the 1993 Indycar season unfolds—which is why we have races. Which is what this season promises to deliver—a vintage season, the sort that Indycar connoisseurs will treasure for years to come.

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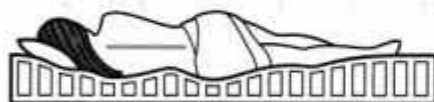
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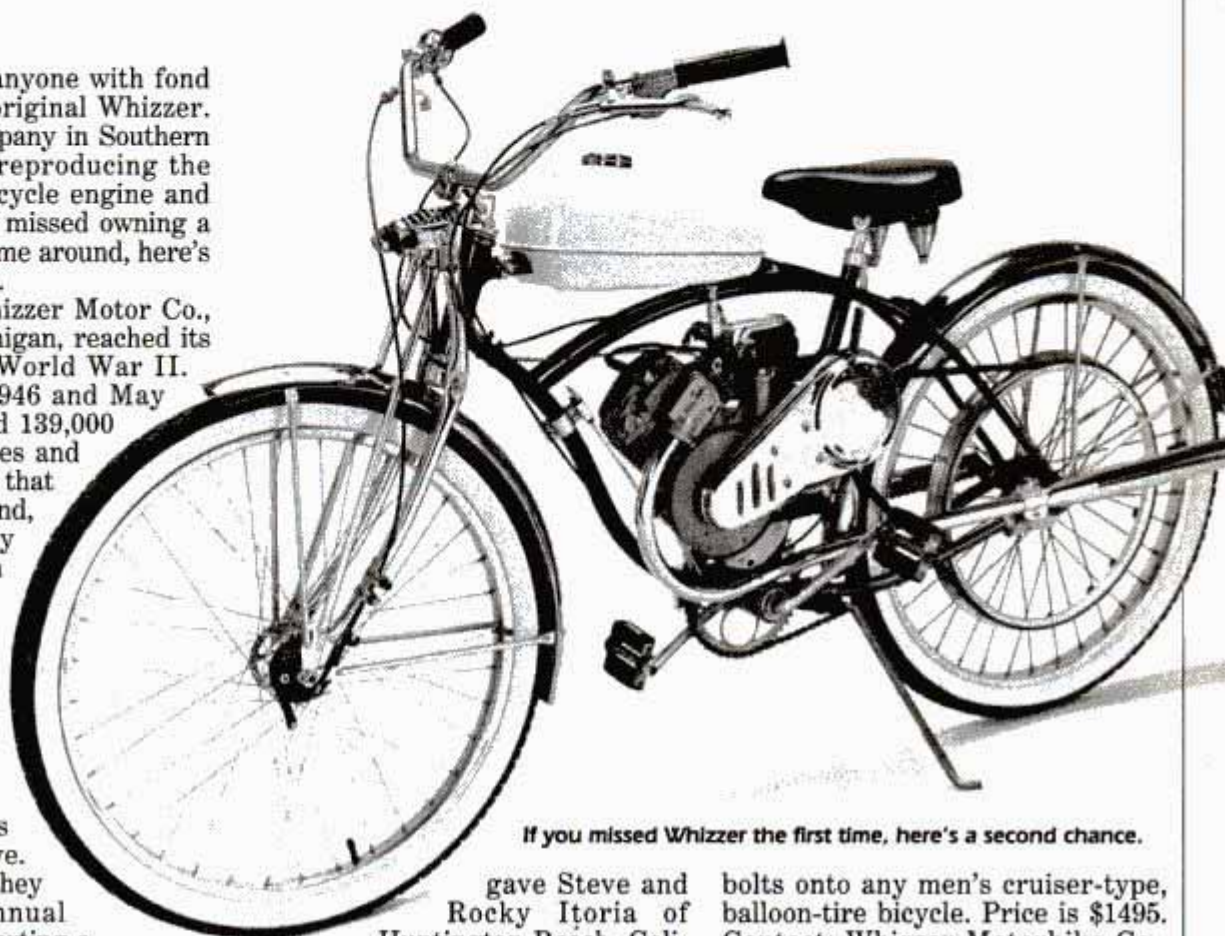
BY MICHAEL LAMM, Contributing Editor

● Good news for anyone with fond memories of the original Whizzer. There's a new company in Southern California that's reproducing the classic Whizzer bicycle engine and adapter kit. If you missed owning a Whizzer the first time around, here's your second chance.

The original Whizzer Motor Co., from Pontiac, Michigan, reached its zenith just after World War II. Between March 1946 and May 1948, Whizzer sold 139,000 Model H motorbikes and motor kits. Kits at that time cost \$89.95, and, according to factory literature, any teen could bolt one to his balloon-tire bicycle in an afternoon.

The old Whizzer factory shut its doors in 1964, but a growing legion of enthusiasts kept the flame alive. By the mid-1980s, they were staging annual Whiz-ins and supporting a healthy market for used, restored and unused old-stock Whizzer kits and bikes. Virgin motor kits currently bring upward of \$2000.

All this enthusiasm and nostalgia



If you missed Whizzer the first time, here's a second chance.

gave Steve and Rocky Itoria of Huntington Beach, California, the idea of producing brand-new Whizzer motor kits in the old style, but with improved technology. Their latter-day Whizzer engine is again a 4-stroke 1-lunger, and it displaces the same 8.45 cu. in.

Outwardly, it looks amazingly like the original. The cylinder barrel and crankcase, though, are now cast in one piece instead of separately. Construction is of high-silicon aluminum, and the updated powerplant uses an electronic ignition and a Mikuni 18mm carburetor.

Output is now approximately 4 hp, versus the earlier 3 hp, and fuel mileage is said to be 100 to 125 mpg. You start the engine by pedaling and then shutting the compression release. Some riders prefer to start it with the rear tire lifted off the ground.

The Whizzer kit includes the engine, 3-point spring-mounting system, fuel tank, clutch assembly, drive and drive pulleys, drivebelt and belt guard and control cables, plus grips and levers for throttle and compression release.

As before, the new Whizzer engine

bolts onto any men's cruiser-type, balloon-tire bicycle. Price is \$1495. Contact: Whizzer Motorbike Co., 15671 Commerce Ln., Huntington Beach, CA 92649; (714) 893-7674.

Taking note of the Whizzer revival is a second California company, National Sales Co., which recently introduced a bolt-on bike-motor kit called the MX-5 Superbike (\$425). This lightweight motor (14.8 pounds) is a 2-cycle 1-lunger that delivers 1.93 hp at 6500 rpm. It has an electronic ignition, a motorcycle twist-grip throttle, an automatic centrifugal clutch and a fuel capacity of 1.25 liters.

The MX-5 Superbike not only will fit most cruiser-type bikes, but also most standard-frame street and mountain bikes. To engage the motor while pedaling, the rider flips a handlebar-mounted lever to lower the engine onto the rear tire. The motor starts automatically without the need of a manual clutch. When not in use, the rider flips a lever and completely disengages the motor for normal bike riding. Estimated fuel consumption is more than 200 mpg.

Contact: National Sales Co., P.O. Box 7205-E780, Santa Cruz, CA 95061; (408) 479-4362. **PM**



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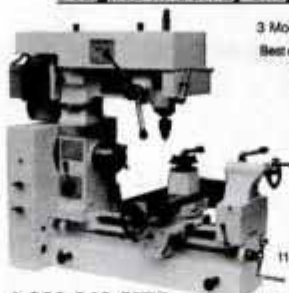
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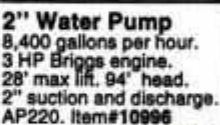
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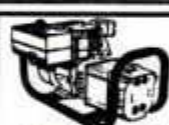


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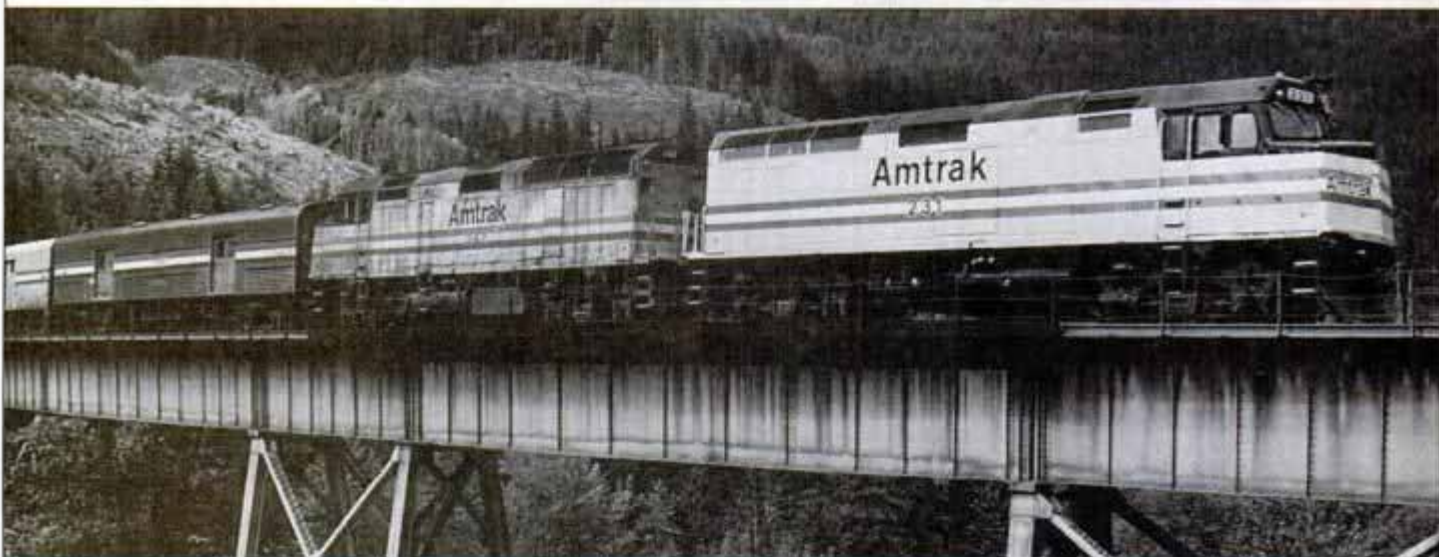
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