

# Popular Mechanics

**BLUE WATER BATTLEERS**



We Pick The Best Offshore Fishing Boats

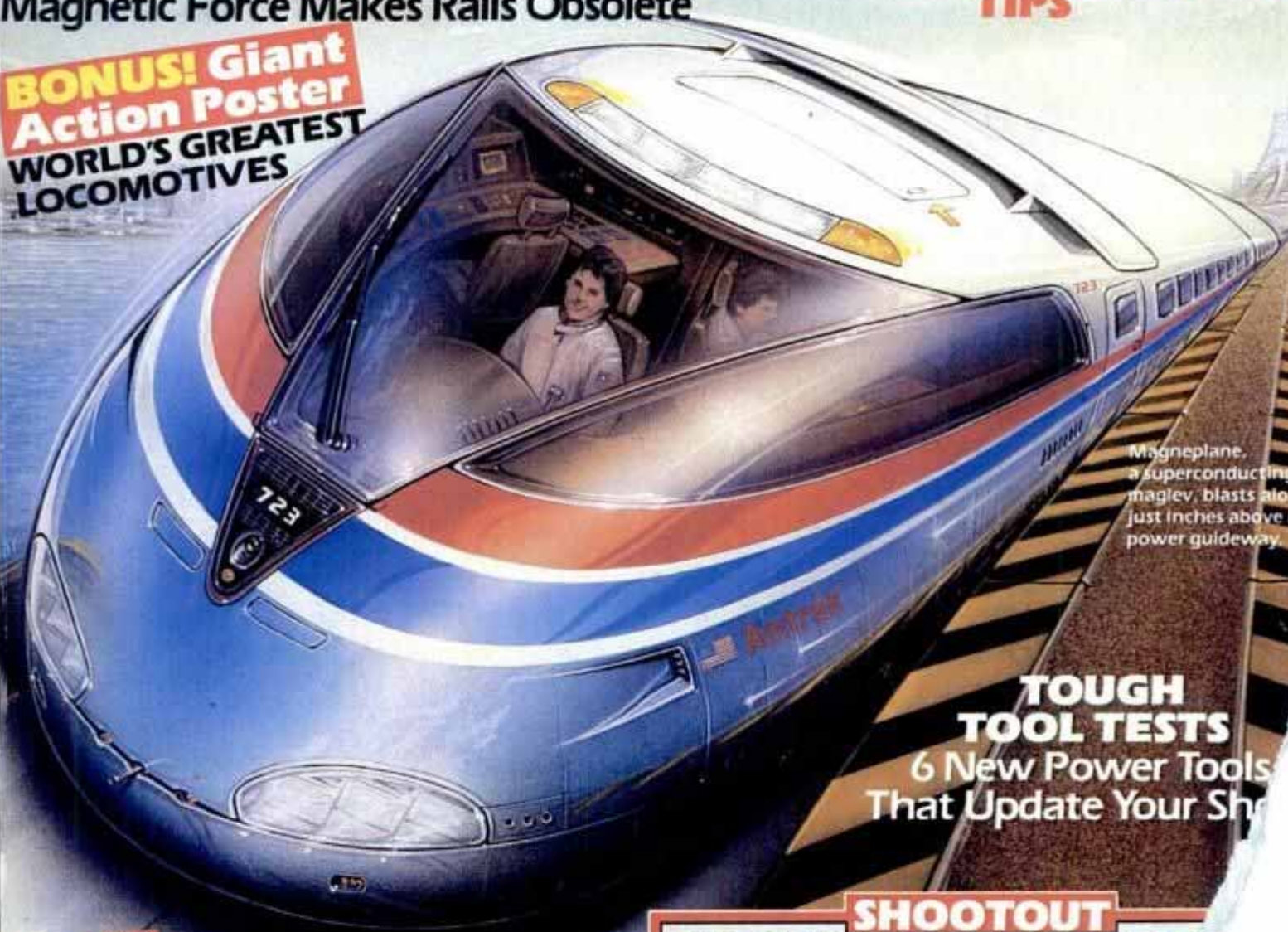
**300 MPH EXPRESS!**

## FUTURETRAIN

Magnetic Force Makes Rails Obsolete

**BOB VILA'S OLD HOUSE RESTORATION TIPS**

**BONUS! Giant Action Poster**  
WORLD'S GREATEST LOCOMOTIVES



Magneplane, a superconducting maglev, blasts along just inches above its power guideway.

**TOUGH TOOL TESTS**  
6 New Power Tools That Update Your Shop

**POW!**  
**ANATOMY OF A KNOCKOUT PUNCH**  
How The Brain Reacts To Boxing's Most Devastating Blow

### SHOOTOUT

#### AMERICA'S PERSONAL-DRIVING MACHINE

- Buick Regal ● Chrysler LeBaron
- Ford Thunderbird ● Pontiac Grand Prix
- Oldsmobile Cutlass Supreme



**FAST FURNITURE**  
2 Unique Tables You Build In A Weekend





### America's best-selling mini-van\*

Your first look tells you Aerostar is a superbly versatile mini-van, with a style all its own. Its design is sleek, modern, aerodynamic. The wind works for it, not against it. With luxurious touches throughout and its special options, Ford Aerostar is America's best-selling mini-van.

### New Eddie Bauer style.

This year there's a sporty *Eddie Bauer*® model with dual front Captain's Chairs, special two-tone paint, unique interior appointments, and more. It's Aerostar with the good looks of the great outdoors!

### Designed to move you.

But Aerostar's success isn't based only on distinctive looks. Its standard 3.0L V-6 has multi-port Electronic Fuel Injection for easier starting and smooth running. It delivers a spirited 145 horsepower. That's greater than any Chrysler mini-van. And it's powerful enough to tow an impressive 4900 lbs.\*\*

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Aerostar's advanced styling gives you loads of useable space. It comfortably seats up to 7 people.† Or remove both rear seats, and create 139 cu. ft. of cargo space. You can even convert Aerostar into a sleeper with the

# Nobody does it better... the 1988 Ford Aerostar.



up—together we can save lives.





folding seat-bed option.<sup>†</sup> All this in a mini-van that's a breeze to handle and park, practically anywhere, even inside your garage.

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\*Based on manufacturer's reported model year retail deliveries through July 31, 1987. \*\*When properly equipped. Towing rating is reduced by passenger and cargo weight in towing vehicle. †With optional rear bench seat. Seat-bed optional on XL only.

Have you driven a Ford...lately?

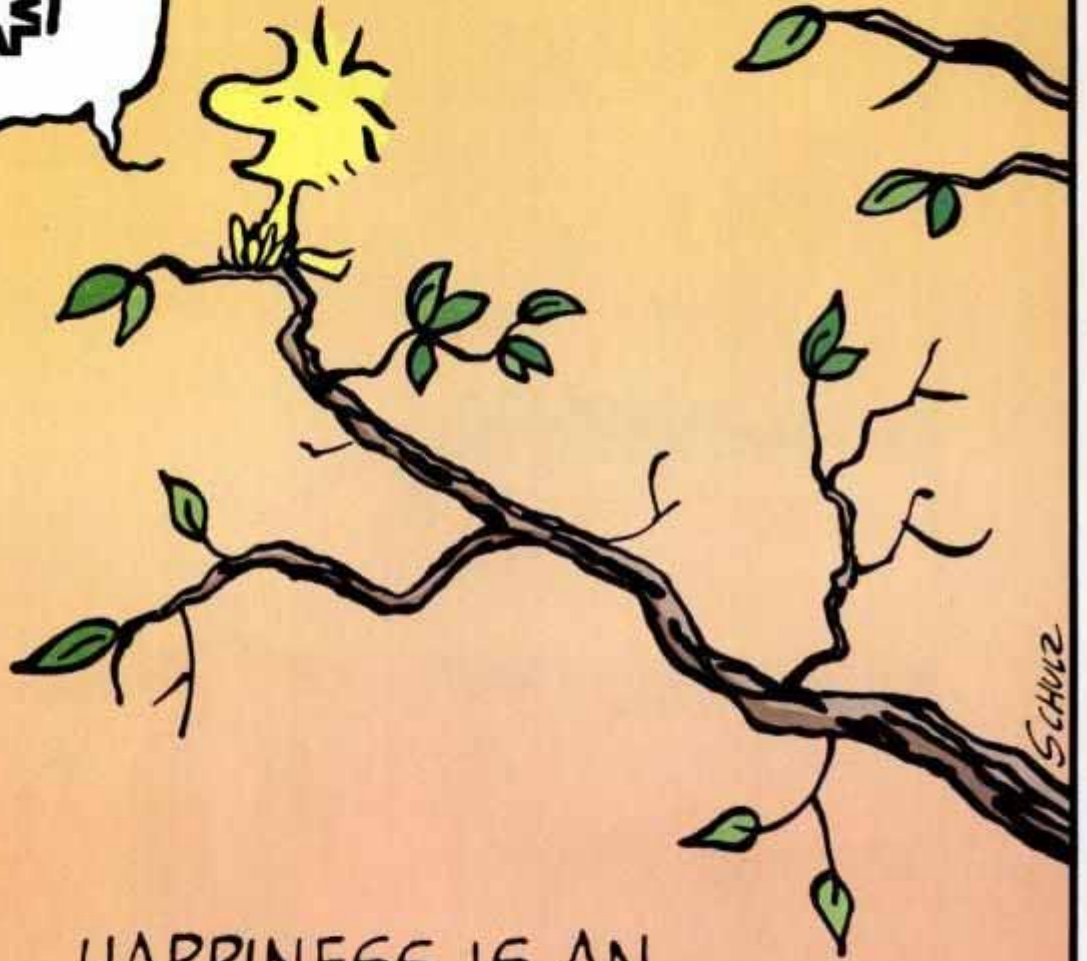
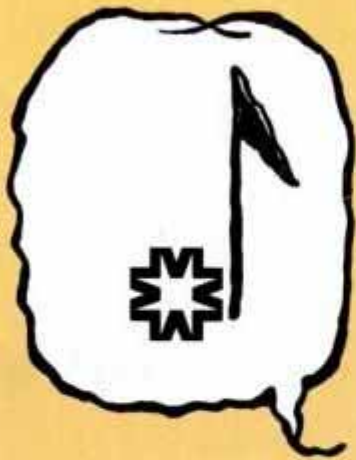


This One



YDXT-HE8-7F32





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# LETTERS

## Ozone Update

**I** ENJOYED Tim Cole's April article on Antarctica ("South To The Pole," page 72). He made it quite clear that although Antarctica is many thousands of miles away, the scientific phenomena that occur there have an impact on our lives at home. If our polar scientists are correct, then Antarctica may give us an early warning sign that continued environmental indifference will be our ultimate undoing. Is there any hope we can reverse the damage that has already been done to our atmosphere? Is it possible we can somehow arrest the global warming that may one day drastically change Earth's climate?

KEVIN BAKER  
FAIRFIELD, CT

*The damage to Earth's protective ozone layer is significant and long-lasting. Scientists estimate that it would take several decades for the atmosphere to restore ozone to mid-1960 levels, even if total production of chlorofluorocarbons—the chemicals that appear to be depleting the ozone—ceased right now. The Montreal Protocol On Substances That Deplete The Ozone Layer was signed in December, involving 31 nations in the fight to save our atmosphere. Recently, E.I. du Pont de Nemours & Co., the world's largest maker of chlorofluorocarbons (or CFCs), decided to cease producing the chemical as evidence against CFCs continues to mount. These efforts by government and industry are encouraging, but we have a long way to go before our life-sustaining atmosphere is brought back to health.*

### Get Your Motor Runnin'

As spring approached this year, I knew I'd have to find a shop to get my mower going. Then I received my first subscription issue of PM, March '88. What a pleasant surprise to find your story "How To Overhaul A Small Engine" (page 119)! I never dreamed of tackling the job myself without first taking a course. I took the engine apart and found a sheared flywheel key. Your suggestion that a simple stand be built to hold the engine on the workbench was

especially appreciated. The repair and overhaul was a teaching lesson for me and my 8-year-old boy. He was able to see how an internal combustion engine works.

DAVID WHITE  
BARTLESVILLE, OK

## All Steamed Up

I read with interest the third story in your Car Of The Future series "Power For Tomorrow" (page 53, March '88). What was missing was any reference to steam power. It's a proven concept.

Steam engines are powerful, have few moving parts, and cause little air pollution. One of the great American cars and the finest steam car was Abner Doble's. The Doble's of the early '20s, 4-cylinder supercars with incredible torque, got up their head of steam in a minute and a half from the time you lit the burner with the electric ignition switch. Most people don't realize that it is actually steam that powers the U.S. Navy's supercarriers. The nuclear reactors only heat the water.

A.N. DE LOCHE  
BEARDSTOWN, IL



Cole at pole to report on science experiments in the works.

## Shy Tires

Did anyone else notice the tires on the S-10 Blazer in "The Case For Customizing" story (page 86, March '88) in your Sport Utility report? They're on backward. Look under the truck: You can see the raised white lettering reading BFGoodrich facing inward.

ALAN J. EBBINGA  
SLAYTON, MN

*You're the sharp-eyed reader of the month! There's nothing wrong with the installation. The owner of this ute just prefers the blackwall look.*

## PM On The Road

Congratulations on your run with the crazy Canadians ("Pan American Express," page 77, Feb. '88)! It brought back memories of my own travels through South America during my trek from Antarctica to the Arctic. I took the scenic route so it took me 17 months and 45,000 miles (it's a long story!). Thanks for the adventure.

CHRIS J. WELLS  
TORONTO, CANADA





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and Bud Light  
join with  
**USA TODAY**

to give baseball fans something  
new. Now you can also



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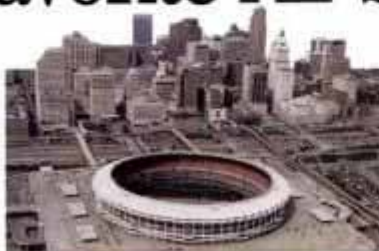


free, wherever you see  
this Budweiser and  
Bud Light display.



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favorite All-Stars

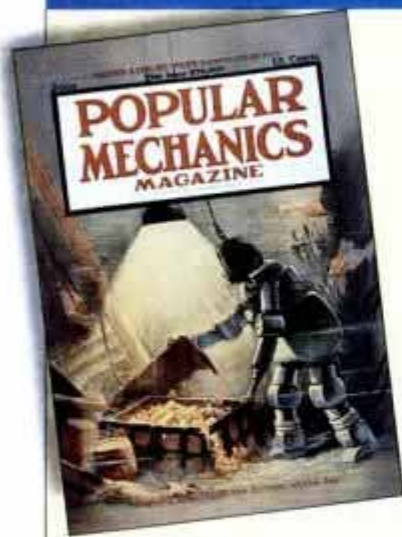
and be a part of a  
baseball tradition.





# TIME MACHINE

75 YEARS AGO: June 1913



Diving for gold.

## Getting In Deep

A year after the Titanic disaster, the rage among inventors was apparatus for deep-water diving and for treasure-hunting. The gear detailed in PM's cover story included an aluminum diving suit with watertight articulated joints and arms ending in hook-type manipulators. On the drawing board was a 2-man spherical vessel that would come to life two decades later as the bathysphere. The 1913 version was to be equipped with a drill and electromagnets to grip the iron hull of a sunken ship.



Steaming through the air on the flying boat *Napoleon*.

## Winged Steamboat

This early transatlantic design was to run on twin coke-fired steam turbines. Its

100-ft. wingspan would have been a record-breaker. But the 5000-pound behemoth never got off the ground.

50 YEARS AGO: June 1938



Flying a giant.

## Big Bird

By 1938, long-distance flying was becoming a routine transportation option, thanks to the emergence of airliners like the DC-4—the jumbo of its day. Breakthroughs then included four 12-cylinder radial engines totaling over 6000 hp, a retractable tricycle landing gear with nose wheel, a top speed of 237 mph at 8000 ft., and a service ceiling of 23,000 ft. The DC-4 had flush rivets, a first for a large plane, and made 1-stop transcontinental flights, carrying 42 passengers and 3½ tons of mail.

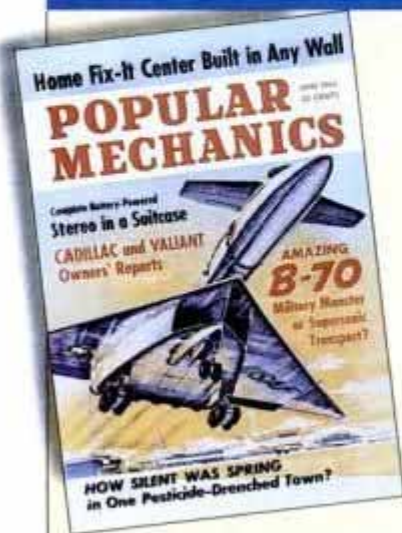


Hammering the horsehide.

## Rabbit Ball

Fifty years ago this question was sparking major-league arguments: Was the American League's baseball livelier than the National League's ball? To settle the debate, the leagues teamed up with the National Bureau of Standards to develop an artificial slugger: a baseball cannon. Fed balls from both leagues, the cannon delivered some tape-measure blasts. The balls proved equally spunky, but Hank Greenberg's 58 American League homers that year didn't help to quell a perennial controversy.

25 YEARS AGO: June 1963



Breaking speed barriers.

## Supersonic Bomb

In June 1963, PM looked at the B-70, the Mach 3 strategic bomber that never came to be. The Air Force, Defense Department and Congress battled for a decade over the plane, designed as a B-52 replacement in an era of ICBMs. The outcome—with a \$2 billion price tag—was a trio of weaponless prototypes that proved little more than airworthiness. But the B-70 effort helped pioneer supersonic technologies, such as the stainless-steel honeycomb airframe designed to take the punish-

ment of 600° temperatures. The plane's sleek fuselage and delta-wing configuration would later be echoed in the Concorde SST.

## Atoms For Apples

Twenty-five years ago the FDA considered bombarding groceries with radiation to kill microbes that cause spoilage. An idea ahead of its time, food irradiation is still a hot issue.

## Water Bug

A summertime shop project, this 1½-ft. motorized model boat flitted along the surface

on three flipper-shaped planing feet mounted on long struts. You ran the critter off a spinning rod, watching it climb out of the water to water-ski across a pond. **PM**



Skimming the surface like a water strider on hybrid hydrofoils.



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**Chevy beats Ford.  
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**THE**  
*Heartbeat*

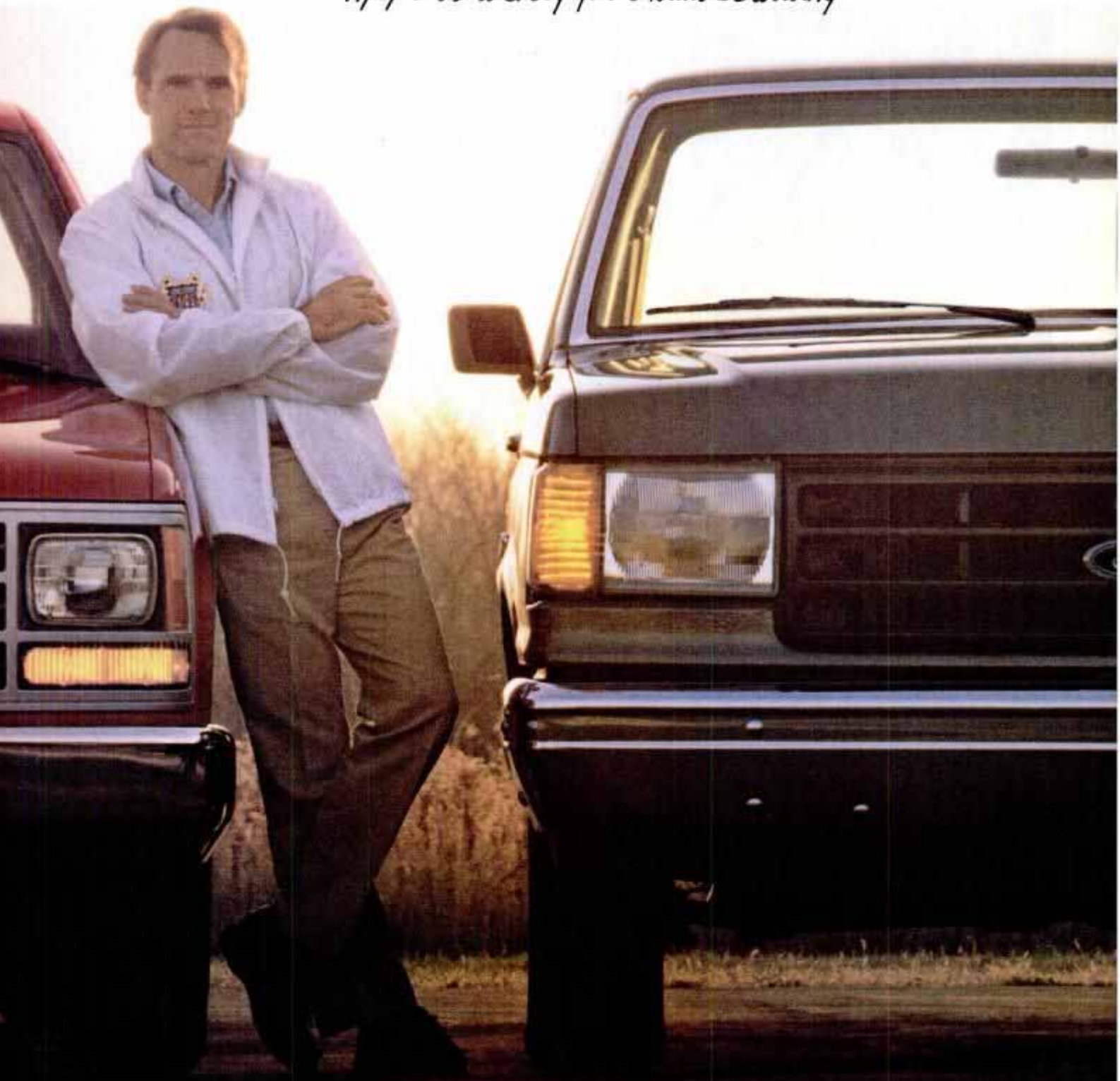
**OF AMERICA**  **TODAY'S CHEVY TRUCK**



In official tests by the United States Auto Club, Chevy beat Ford. Standard half-ton to standard half-ton, both with half-ton payloads, both with the best automatic transmissions\* available, the full-size Chevy pickup beat Ford.

In 0 to 60 acceleration. In 40 to 55 MPH passing. In level and uphill trailer-towing acceleration. In wet-surface handling through a pylon course. The results are as clear as black and white: In performance where you want it most, Chevy with Vortec V6 beats Ford. And USAC tests prove it.

*Maybe it's a Chevy you should be driving*



Let's get it  
together...  
buckle up.

QUALITY COMMITMENT PLAN

See your Chevy dealer for terms and  
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Solid proof of the quality built into every new  
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\*Tests conducted with Chevy C1500 equipped with standard engine and available 4-speed automatic, and Ford F-150 equipped with standard engine and available 3-speed automatic.



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The 1957 Corvette

The Champion OE93

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In short, Champion oil and air filters are engineered for the highest standards in the industry. As well as some other high standards. Yours.



The 1981 Aston Martin

The Champion AF131



The 1988 Range Rover

The Champion OE01



CHAMPION. TUNE-UP PRODUCTS YOU CAN RELY ON.

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## Robo-Cop Speed Trap

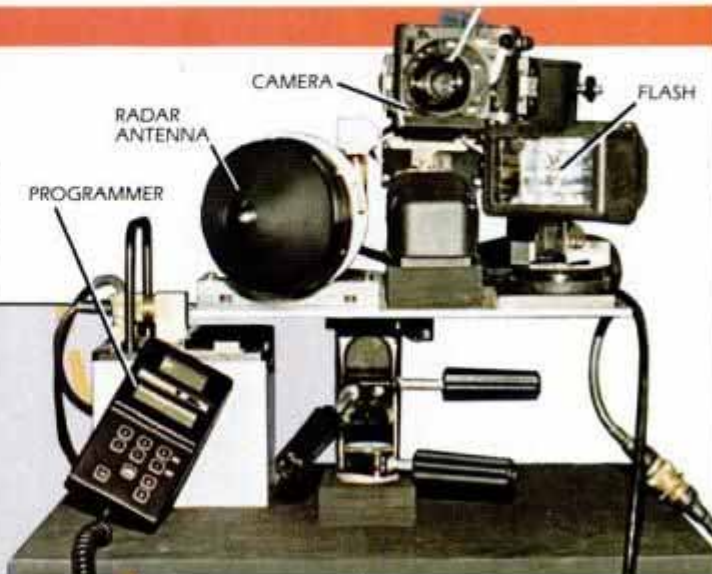
FRIENDSWORTH, TX— Speed demons may soon have to contend with a new breed of highway cop. Traffic Monitoring Technologies is

offering a Swiss-developed automatic traffic monitor that detects, photographs and tickets speeders from the back of an unmarked car.



PM ILLUSTRATION BY ED VALIGURSKY

Innocent-looking wagon on median shoulder directs Doppler radar antenna at 22° angle into oncoming traffic. The parabolic reflector-type antenna can be set for range up to 132 ft.



TMT PHOTO

The brain of the system is a microprocessor that coordinates a camera, strobe flash unit and Doppler radar an-



tenna. Through a handheld programming unit, an officer plugs in the trigger speed. When a passing vehicle exceeds this speed, the radar antenna sends a signal to trip the camera's shutter and fire the flash. Violators traced through the plate number get tickets in the mail.

**Photo-radar apparatus (top) generates snapshot of unsuspecting violator (above), complete with speed, date and time.**

Editor: Tim Cole  
Assistant Editor: Gregory T. Pope  
Contributor: Mike Fillan



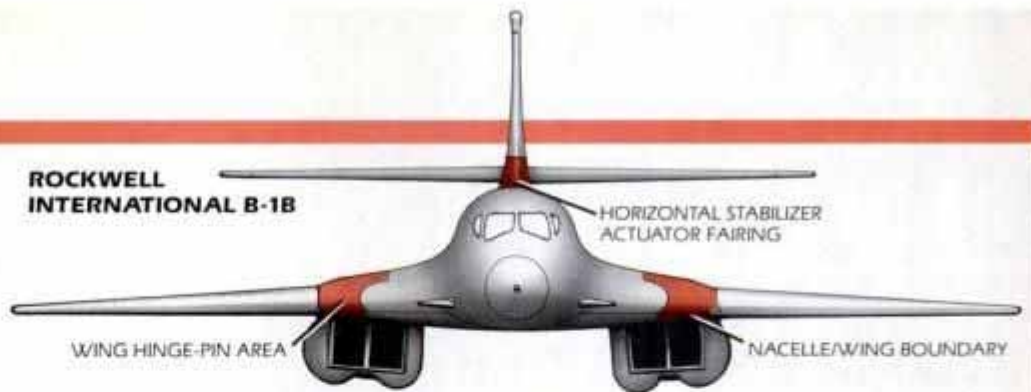
## B-1B's Bird Blockers

PALMDALE, CA—Last year's training-run crash that killed three crewmen highlighted the low-flying bomber's susceptibility to bird strikes.

Rockwell International and Air Force workers are now retrofitting the remaining 99 B-1B's with deflectors to shield vulnerable fuel, electrical and hydraulic lines.

The protection consists of Kevlar blankets or shrouds that fit under the aircraft's skin in vital areas. The material—best known for bulletproof vest applications

ROCKWELL INTERNATIONAL B-1B



Front view of B-1B shows areas to be outfitted with Kevlar protection.

—is lightweight but able to absorb Mach 0.9 impacts.

Areas slated for Kevlar installation are the upper edge of the 2-engine nacelle, the wing-nacelle boundary, the leading edge of the wing around the pivot section, and a fairing at the tail base that houses the horizontal stabilizer's actuator.



At left, wing hinge-pin laid open to show fuel lines and electrical conduits. At right, Kevlar blanket covering vulnerable components.

## Space Goals for 1990s

WASHINGTON, DC—A newly focused and revitalized U.S. space policy calls for commercial enterprise to handle civilian launch requirements. To lighten the backlogged Shuttle manifest, NASA will use privately operated expendable boosters whenever possible.

NASA will also perfect the

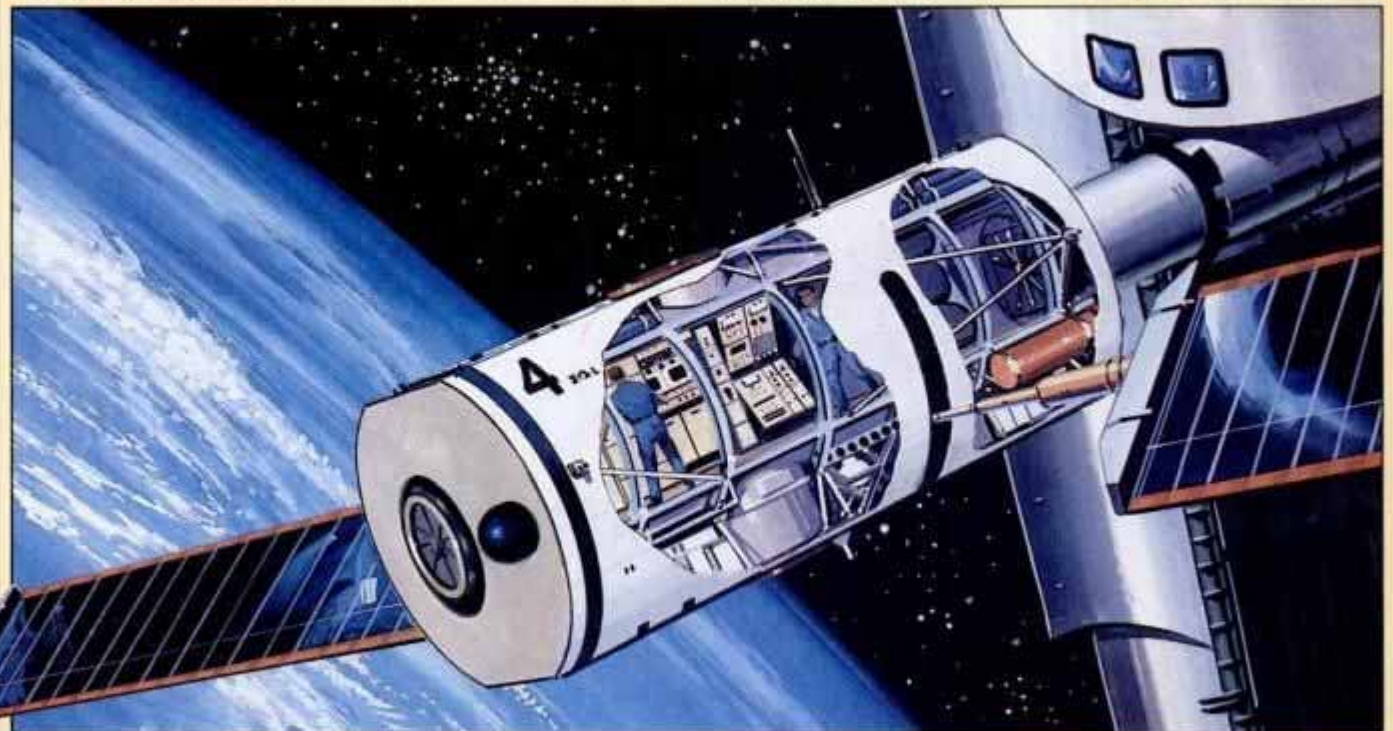
technology needed to get manned solar-system exploration underway in the 21st century. For the 1990s, priorities will be the know-how behind a manned Moon base and several unmanned Mars missions. Critical research areas include closed-loop life support, aerobraking, orbital transfer/maneuvering and

cryogenic storage and handling. Along with these goals, announced last February,



Robot to tend NASA's microgravity crystal growth on ISF.

President Reagan pledged federal support for a private space research lab—the Industrial Space Facility (ISF)—to be deployed from the Shuttle in 1992. NASA plans to lease space on the 35 × 14½-ft. canister, in part to pretest Space Station equipment. The facility will give space-based manufacturing a headstart while the Space Station is being built.



Astronaut programming ISF's automated systems prior to detachment from Shuttle. Facility will run unmanned between Shuttle launches.

PM ILLUSTRATION BY GEORGE RETSECK  
ROCKWELL PHOTOS  
GEORGIA TECH-PHOTO

PM ILLUSTRATION BY ED VAUGURSKY



## Wall-Crawling Robot

PARIS, FRANCE—This hand-sized robot—called the Crab—can climb walls and negotiate curves. Its feet are pairs of electromagnets that are turned on and off to grip and release metal surfaces. Designed by French defense contractor CRAM, the Crab can be fitted with a miniature camera or endoscope for surveillance tasks. Alternatively, it can go on detection-and-retrieval assignments into the narrow inner reaches of turbine engines or nuclear-plant generators.



Crab can walk with up to 6.6 lbs. in its mechanical gripper.

PM ILLUSTRATION BY ED VALIGURSKY

## Future Tanks Are Canned

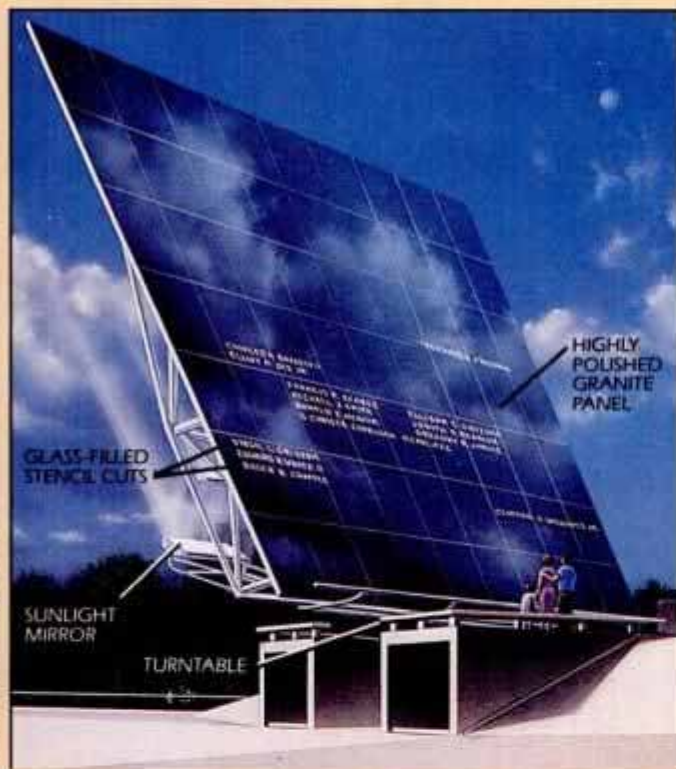
WASHINGTON, DC—Trimming the '88 defense budget has affected the Armored Gun System ("Tanks For Tomorrow," page 68,

May '88). Since the Army canceled the program, the lightweight tanks must test overseas markets. **Stingray seeking a buyer.**



CADILLAC-GAGE PHOTO

## Tribute to Fallen Astronauts



Space Mirror memorial at Kennedy Space Center's Spaceport USA.

CAPE CANAVERAL, FL—Scheduled for completion in 1990, the memorial will honor the 14 American astronauts who have died in space disasters. Driven by a computerized satellite-tracking mechanism, the 40 x 50-ft. monument will slowly revolve as the Sun crosses the sky. Slabs of black granite, polished to a mirrorlike finish and mounted on a steel armature, will always reflect empty sky, without glare. Sunlight will bounce off rear-mounted mirrors and shine through the astronauts' names that are cut into the granite like stencils. Glass inserts will fill the stencil cuts, diffusing the sunlight. At night, spotlights will emblazon the names among the stars.

PM ILLUSTRATION BY JERRY LOFARO

## Brain Surgeon's Robot Helper

PITTSBURGH, PA—Researchers at Carnegie-Mellon University are looking into systems that combine the convenience of robotic instrument control with the sophistication of real-time human perception.

One application under in-

vestigation is a robotic system that constantly repositions a brain surgeon's microscope. The key is a low-frequency magnetic sensor strapped to the surgeon's head. The sensor transmits tiny changes in head position to the robotic arm holding the microscope, which duplicates those changes. Since a surgeon using a microscope always stares straight ahead, he must shift his head to change his field of view.

In addition, through a voice-command processor, the surgeon can tell the robot to pivot the microscope around a point of interest, allowing different perspectives of the operating site. The combination could speed operations by letting the surgeon work continuously without reorienting the microscope.



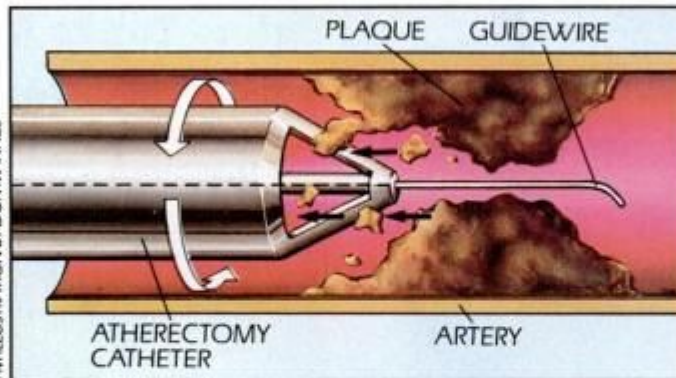
Magnetic sensor and microphone permit hands-off microscope use.

CARNEGIE-MELLON PHOTO



## Roto-Rooter Artery Cleaner

DURHAM, NC—New technology for rooting out clogged arteries comes out of Duke University Medical Center. Called an atherectomy catheter, the device is a slender tube that ends at a metal cone notched with triangular razor-sharp openings. The cone, powered by a handheld gun, spins at 700 to 800 rpm, boring out plaque, fatty deposits from cholesterol-rich diet. The plaque is sucked through the openings. Duke doctors are currently testing the technique on leg arteries, hoping to move up to heart arteries if the tests go smoothly. The atherectomy catheter can clean out long stretches of



Atherectomy catheter threads through artery, drilling out plaque.

plaque deposits in arteries usually marked for coronary bypass surgery. And unlike balloon angioplasty, which simply enlarges passages through clogged blood vessels, the atherectomy catheter's plaque-removing action should prevent recurring blocks.

## Twin-Wheel Mars Rover

TUCSON, AZ—University of Arizona engineers are steadily improving performance of a simple, inexpensive autonomous rover called the Mars Ball. The vehicle moves by inflating and de-

flating its eight sectors in programmed sequences. Joining the two huge tires is a single 16-ft. axis that could carry sampling equipment. Thanks to the independently inflatable tire sectors, the Mars Ball can move over obstacles 1½ ft. high without help from Earth. The rover can also handle 15° slopes. Initial tests indicate that it can travel on Mars at 3 ft. per minute under solar power.



Mars Ball wheels stand 12 ft. high when fully inflated.

## Light-Show Technologies Blaze At Disney World

LAKE BUENA VISTA, FL—For sheer special-effects fire-power it's hard to beat Epcot Center's new nighttime extravaganza "IllumiNations." The spectacle centers around Epcot's array of international showcase buildings and features thousands of lights and fireworks.

The show is coordinated by



Sorcerer Mickey kicks off the magic of IllumiNations.

an analog tape recorder that sends an identical time code, a steady stream of clicks, to a host of dedicated processors called remote interface cabinets (RICs). The RICs trigger lights, projections and pyrotechnics. Before each performance begins, a central mainframe computer sends each RIC individual instructions detailing which time click should trigger which ef-



Megaprojections turn the Bavarian castle—Germany's showcase—into a giant toyshop.

fect. Reloading this cue data every night ensures that the information won't deteriorate in a RIC's magnetic memory.

Perhaps the most striking effects are the transformations that occur when huge projections are cast on the showcase buildings themselves. Projectors loaded with 2-ft.-sq. transparencies

throw images whose brilliance is fired by mercury-vapor photolamps with power ratings in the kilowatt range. Such projectors have been used for opera backdrops but not for permanent outdoor shows like IllumiNations.

Lasers and searchlights cut through the night sky during the show. Three lasers

also create color animated images as they scan across the ends of optical fibers. The images appear at the fibers' other ends on a huge globe. Seeking maximum brilliance, Disney picked lasers over conventional lights to draw the images. The searchlights were once used on American armored vehicles.





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Car and Driver	BMW Roundel	Car and Driver	BMW Roundel	Car and Driver	BMW Roundel	BMW Roundel	BMW Roundel	Car and Driver	BMW Roundel	Popular Mechanics
▶ 1 <sup>st</sup> Escort Bearfinder Fuzzbuster Double Nickel Hawk Eye Snooper Radar Sentry Super Eliminator Whistler Fox Super Buster X-Kaliber	▶ 1 <sup>st</sup> Escort Whistler Fox Radar Intercept Fuzzbuster Fox Sidewinder Fuzzbuster Bearfinder Snooper	▶ 1 <sup>st</sup> Escort Fox Whistler Radar Intercept	▶ 1 <sup>st</sup> Escort Gul Whistler Fuzzbuster Fox Radar Intercept Snooper	▶ 1 <sup>st</sup> Escort Gul Bel K40 Radar Intercept Whistler Radio Shack Fuzzbuster Fox Phantom	▶ 1 <sup>st</sup> Escort Whistler Fox Radio Shack	▶ 1 <sup>st</sup> Escort Whistler Bel Fuzzbuster Cobra Fox K40 Gul Radar Intercept Radio Shack	▶ 1 <sup>st</sup> Passport ▶ 2 <sup>nd</sup> Escort Whistler K40 Fuzzbuster Uniden Cobra Bel Snooper Whistler Bel Fox Fox Bel	▶ 1 <sup>st</sup> Passport (Escort not tested) Cobra Uniden Radio Shack Bel Whistler Sparkomatic Fox Gul	▶ 1 <sup>st</sup> Passport ▶ 2 <sup>nd</sup> Escort Bel Whistler Mazon Radio Shack Uniden Fox Cobra Bel Snooper Fuzzbuster Sparkomatic Sunkyang	▶ 1 <sup>st</sup> Escort ▶ 2 <sup>nd</sup> Passport Bel Snooper Uniden Whistler Cobra Gul Radio Shack Sparkomatic Mazon

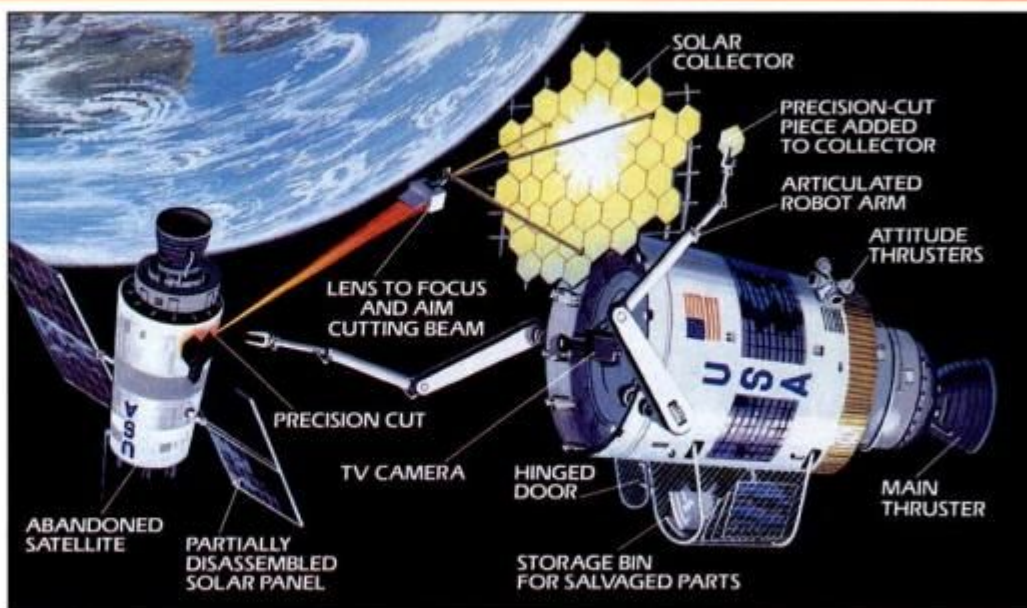
© 1988 Cincinnati Microwave, Inc.



## Space Junk Processor

TUCSON, AZ—Thirty years of space travel have left dead satellites, rocket boosters and other space flotsam that threaten high-speed spacecraft and occasionally tumble back into the atmosphere.

One solution: Kumar Ramohalli's autonomous space junk eater. The University of Arizona engineer proposes sending into orbit a fleet of these craft, which would use infrared radar to hunt down space junk. Each vehicle would brandish a 10½-ft.-dia. concave mirror made from hexagonal reflectors. The mirror would focus sunlight into a beam hot enough to cut through spacecraft skin. Robotic arms would add reflective pieces of space junk to the periphery of the



Solar blowtorch carves up one of over 6000 pieces of space junk currently in orbit.

mirror, while components worth salvaging would be tucked into a storage bin. Anything left over would be melted down and tacked to

the rear of the mirror.

After processing enough items, the craft would either await pickup by Shuttle or fall toward Earth where it

would burn up before hitting the surface. The idea may become even more compelling as space becomes more crowded in the 1990s.

## New Approach To Solar Fridge

NANTES, FRANCE—A French solar refrigerator uses virtually no moving parts. Instead of driving a condenser, the solar energy heats charcoal, which adsorbs and evaporates methanol from a reservoir. The chilling effect of the evaporation drives down the refrigerator's temperature. The system's simplicity makes it ideal for cooling medicine or food in remote locations.

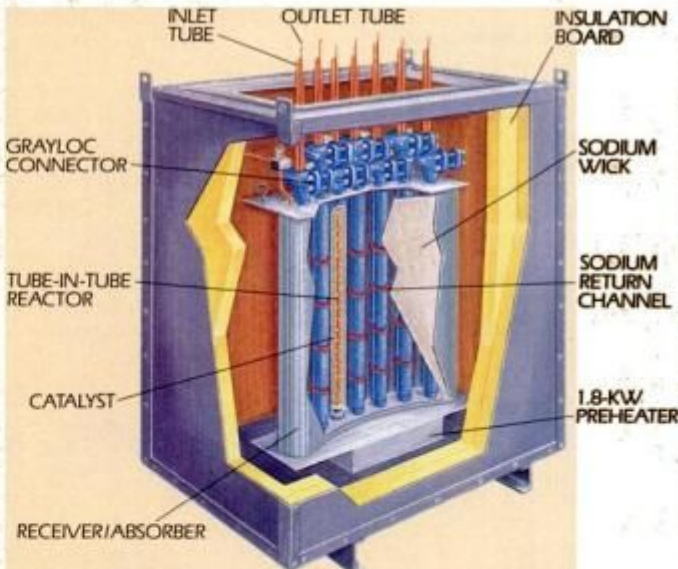


When it's 109° F outside, solar-powered fridge's inside is 47°.

## Heat Transport Without Insulation

REHOVOT, ISRAEL—This arid nation has long been interested in transferring the heat of its southern deserts to its industrial centers. Researchers here at the Weizmann Institute of Science have teamed up with Sandia National Laboratory engineers from the U.S. to develop a way to transport thermal energy without insulation.

The system under investigation uses heat collected by a solar furnace to drive a chemical reaction. Inside an insulated box, a curved receiver/absorber contains seven tubes into which methane and carbon dioxide are piped. As solar energy heats up the box, sodium evaporates from screen-mesh wicks along the receiver's inside face. The sodium condenses on the tubes, heating them evenly. The sodium, now a liquid, runs through guidance channels to the base of the receiver, where the screen wicks pick it up and redistribute it along the inside face.



Inside the Sandia-Weizmann solar reactor, sodium acts as an intermediary heat transfer fluid. Box will sit under parabolic solar mirror.

Inside the tubes, the gases flow through a catalyst bed, absorbing the heat of condensation and reacting to form carbon monoxide and hydrogen. These products exit through a second tube within the reactor tube. The reactor tubes join with exterior transport tubes through

Grayloc connectors, which use the pressure of the gases in the tubes to generate a weld-quality seal.

The gases then flow at room temperature to their destination where they are converted back to carbon dioxide and methane, releasing heat.





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for you."

*Garry Sowerby*  
— Garry Sowerby

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Its toughness and reliability are evidenced by Garry Sowerby's record-setting journey. Its aerodynamic good looks speak for themselves. Its 4' X 8' bed and standard GVWR of 5,200 pounds (including passengers, cargo and vehicle) show its capacity to take care of business.

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See why on next page.





# OUTDOORS

BY JOE SKORUPA

## New Boats Scorch Biscayne Bay



Speed and style converge in OMC's concept boat, which looks and runs like a Ferrari of the water.

**R**ON BAKER, test driver for OMC, turns the key and the bored-out, small-block V8 comes to life.

"This boat's been clocked at 81 mph with a 1-person load," Baker says, as I zip up my heavy-duty flotation vest and buckle the seat's built-in shoulder harness.

We push away from the Miami International Boat Show display dock and all eyes turn in our direction. Even at idle speed the sleek concept boat, built by OMC and Four Winns, makes a scorching, high-performance statement—lush-red gel coat with bold black accents, low-profile aerodynamics, smoky wraparound windscreen, molded air intake, racing bucket seats and fastback engine cover.

We leave the channel and enter Biscayne Bay. The sunny Miami day is warm and calm, and the protected water is nearly flat.

Baker moves the throttle forward and the hull leaps out of the water. Despite through-transom exhaust and 478 horses of raw power, the engine's roar is relatively quiet, due to high-performance mufflers and exhaust vents that emerge beneath the swim platform.

We make a flat-out, top-end run straight for the causeway bridge. The over-size, Eurostyle instruments



Under functional intake is 351-cu.-in. block bored to 403 cu. in.

register 6100 rpm and 74 mph. On the return run, the needle hits 75.

The reinforced, deep-V hull of the concept boat, popped from the mold of a 201 Liberator, displays a sure-footed planing attitude at full throttle, and shows no signs of misbehaving while carving

high-speed turns.

What's OMC and Four Winns doing with a wave-burner like this? I'd heard rumors, but I wanted to get it directly from the main man himself.

"Did you really chip off a piece of your wife's Ferrari," I ask OMC boss Charlie Strang, (whose name emblazons the boat's brilliant gel coat) "and turn it over to R & D with instructions to match color and speed?"

"Not exactly," laughs OMC's chairman of the board and chief executive officer. "I got the idea last summer at the Four Winns dealer meeting. We were talking and someone said I should be driving the new 201 Liberator. Someone else thought it would be a good idea if the boat matched my new car, my wife's red Ferrari.



New HP series SCAT Hovercraft runs faster, carries heavier loads.

"I said, 'Okay, I've got a can of red paint taken from the last spray gun used to paint my car, let's see if you can match it. And while we're at it, let's make it run like a Ferrari, too.'"

To make it even more interesting, there were several other stipulations, according to Strang. The boat not only had to be fast and stylish, but practical too. It had to run on pumped gas, have adequate seating, manageable handling and an acceptable noise level.

The 20-ft. 9-in. Liberator hull is compact and light, and so, as a further challenge, it was decided the engine had to be a small-block V8. Although some high-performance modifications could be made, it had to be matched to a near-stock OMC Cobra stern-drive with standard power steering, transmission, trim system and propeller. Consequently, the engine couldn't be too radical. The objective was to test basic OMC equipment with high-performance output.

At this point, OMC asked Ford if the company would like to get involved in the concept-boat project and FoMoCo responded by coming up with what is essentially a race engine detuned. The stroke of the 351-cu.-in. engine is increased to 3.875 in. and the bore increased to 4.07 in., which brings the total displacement to 403 cu. in.

Engine weight was further reduced by using aluminum for the head and intake manifold. The bored-out engine is light and powerful. Photo stress analysis, Ultrasound, X-ray inspection and computers were used in the modification process to assure structural integrity.

The engineers at Four Winns rose to the challenge by reducing hull weight by nearly one-third. They did this by utilizing tri-axial woven-roving matting,



which tests as strong as conventional matting, but is much lighter.

The final element to make this a true luxury sports sedan of the water was styling—*panache*.

Ferrari red is what Charlie Strang wanted and Ferrari red is what he got. A deep, brilliant, acrylic red is used inside and out. Accents of silver and black are used to avoid overkill.

Appointments are impressive and innovative, such as fastback engine cover with functional air intake, soft-touch microprocessor-controlled switches, isolated windscreen (mounted with space left for air flow-through to diminish drag and cockpit buffeting), oversized instruments (with red needle and markings) and AM/FM stereo cassette player with touch-sensitive controls and dual stations (one in cuddy, one near driver).

Other interesting features include four ergonomic racing bucket seats, black stainless-steel hardware, plush red velour sleeping pad with mirror in cuddy, integrated swim platform and an overall fit and finish worthy of an imported luxury 4-door sports sedan.

What's the future of this concept boat? Right now it's a one-of-a-kind model with no plans for production—unless the market demands this kind of boat. Don't be surprised to see something like it in 1989, if the response at the Miami show was any indication.

The boat show featured other interesting waterscorchers. The new 43-ft. Scarab Don Johnson Signature Edition was on hand for anyone who considers himself "the coolest guy on the block," according to the Miami Vice star. The Signature Edition is a sensuous, sleek, high-performance machine with twin, V12, 630-hp Lamborghini engines and MerCruiser Speedmaster stern drives. It may be cool, but it's also hot.

Another new scorcher at the show flew over the water rather than through it. The SCAT HP is a new hovercraft with enough power to run 45 mph or carry 500 pounds. It's powered by a 35-hp Cuyuna 2-cycle, 2-cylinder engine. A larger version, the SCAT HP 12, runs about as fast plus it carries up to 750 pounds. It's powered by a 500-cc, 2-cylinder, 45-hp Rotax engine. Both are made by SCAT Hovercraft, of Miami.

Even more impressive, was the debut of the Air Rider Hunter, by Buderus Aviation, of Jensen Beach, Florida. This 3-person hovercraft had an enclosed passenger compartment and the molded, aerodynamic contours of a space vehicle. Its power is supplied by a 70-hp, 4-stroke, 2-cylinder, horizontally opposed engine capable of 62 mph.

There were a number of other interesting new boats and personal watercraft represented at the show, some of which deserve the no-holds-barred PM comparison-test treatment. Several are

already in the works. Look for these feature stories in coming issues.

## True Montere Value

Fisher Mountain Bikes, of San Rafael, California, was thrilled that I got my hands on one of their top models, the Montare XT, and wrote a piece on it in my February '87 "Outdoors" column (page 44). I was thrilled, too, because I rode it for several months and came to feel it was one of the best mountain bikes I've ever ridden.

However, the price I quoted, which had been supplied to me, was in error. This upsets Fisher and, even more importantly, it upsets me.

Readers should know that the bike I tested, the Montare XT, actually costs \$1175. A similar model, the Montare SC, which carries Shimano Deore equipment as opposed to the Deore XT on my test bike, costs \$975. Both bikes have indexed shifting, Biopace chainrings, Shimano U-brakes, Fisher Rhino stems and the trademark Fisher frame.

Mountain bike season is in full swing now and I'll be reporting on a new model in a forthcoming column.

## Computer Casting

Few of us thought we'd ever need to recharge a battery pack for our baitcasting reels, but that's precisely the situation with the new Ryobi E1 baitcaster. The E1 requires a rechargeable battery, located in the bottom of the reel, as a power source to run its computer.

That's right, the E1 also features computer circuitry—Ryobi's Computer Control Systems (CCS) technology, which eliminates backlash without retarding casting distances. Its automatic magnetic braking is computer activated only when the spool is about to overrun. The rest of the time it revolves freely for maximum-distance casting.

Aside from the computer, other features include shielded stainless-steel ball bearings, right/left retrieve convertibility, a synthetic housing made of graphite and potassium-titanium-oxide (called Ceratec), and curiously, a manual mode, which must be for those fishermen who stubbornly insist on being self-reliant. Price is \$85 to \$99. **PM**



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# ELECTRONICS

BY STEPHEN A. BOOTH

## Energy To Go

**S**UMMER'S almost here, and that's the season when most people expend more energy outdoors than any other time of year. Not necessarily muscular energy, though. The more sedentary athletes among us might participate vicariously, following the action by radio or with a film camera. This means we'll use batteries instead of vitamins to generate our energy.

According to industry estimates, Americans buy about 3 billion batteries a year. And St. Louis-based Eveready claims that 40 percent of these are used in portable audio equipment alone.

Indeed, the consumer electronics business has spawned a host of products that enables us to entertain ourselves away from an electrical socket. Tape recorders, radios, boomboxes, CD players, TVs and video camcorders have all gone portable. Meanwhile, the types of batteries available to power them have proliferated. Most recently, Eveready introduced its Conductor line of alkaline cells, optimized for use with portable audio products—especially those equipped for tape recording. Other companies surely will follow. Perhaps the time has come to review the types of batteries available, in order to choose the right one for the job. In the interest of space, we'll stick to the types most often used in portable electronics and photo gear.

Batteries are classified two ways, as primary or secondary. Secondary batteries can be recharged. Primary cells cannot. There are several types of primary batteries, including carbon-zinc, zinc-chloride, alkaline and lithium. The most widely available of the rechargeable secondary cells is the NiCd (pronounced ny-cad).

Besides chemical type,



Eveready's Conductor alkalines are optimized for audio use.

batteries come in a variety of sizes. The cylindrical AAA, AA, C and D cells differ in dimensions but all are rated at 1.5 volts (if NiCd, they're rated at 1.2 volts but labeled "for 1.5-volt applications"). The other commonly used battery sizes include the boxy, rectangular 9-volt cell (7.5 volts if NiCd) and the flat, rectangular J cell (6 volts) used in remote con-

trols and some cameras.

You don't get much choice in choosing battery size, because the equipment designer has already chosen for you. A boombox, for example, might be configured to use a certain number of large D cells, whereas the size-conscious designer of a shirt-pocket radio might specify a single AAA cell. The two cells share a 1.5-volt rating.

The difference in size relates to capacity.

Under identical power demands, the larger D cell will supply power longer than AAA of the same type because it contains more chemical materials from which to generate power. This makes them more convenient for power-hungry devices such as portable TVs. If you had to run a 5-in. TV on the same number of AAA cells, you'd be replacing them pretty frequently in the course of a day at the beach. For this reason, an option offered with portables that use small cells is the auxiliary power-pack. It plugs into the external power jack and lets you bypass the integral cells with larger-capacity outboard batteries.

Where you do get an element of choice is in selecting the type of battery for powering a product—unless the manufacturer specifies or prohibits a specific type (sometimes the case with cameras). To pick the right battery, it helps to know how the hardware works.

Products that use batteries continue to function until the battery's voltage drops

*(Please turn to page 31)*

## Keep Time To The Beat Of A Different Drummer

**I**T ISN'T Dick Tracy's 2-way wrist radio, but you might find the headphone-portable Radio Watch even more useful for catching news, traffic or late scores when you're on the run.

Besides keeping you punctual with time and date, this LCD wristwatch from Michael Frank Imports can keep you current with its built-in AM radio. Unlike some novelty radios which offer only a single, fixed frequency, this one pulls in the entire AM band from 540 to 1600 KHz. Moreover, you won't have to struggle to keep an earplug in place as you walk. The Radio Watch uses a 2-channel, lightweight

headphone to transmit AM mono to both ears. The headphone regulates volume in place of a control.

In our ears-on workout, we found the fixed level adequate for listeners with normal hearing, and steady for the entire life of the battery (the button cell expires abruptly when its power falls below the cutoff point of the Radio Watch). The radio section drains power only when the headphone is attached. A separate battery powers the watch.

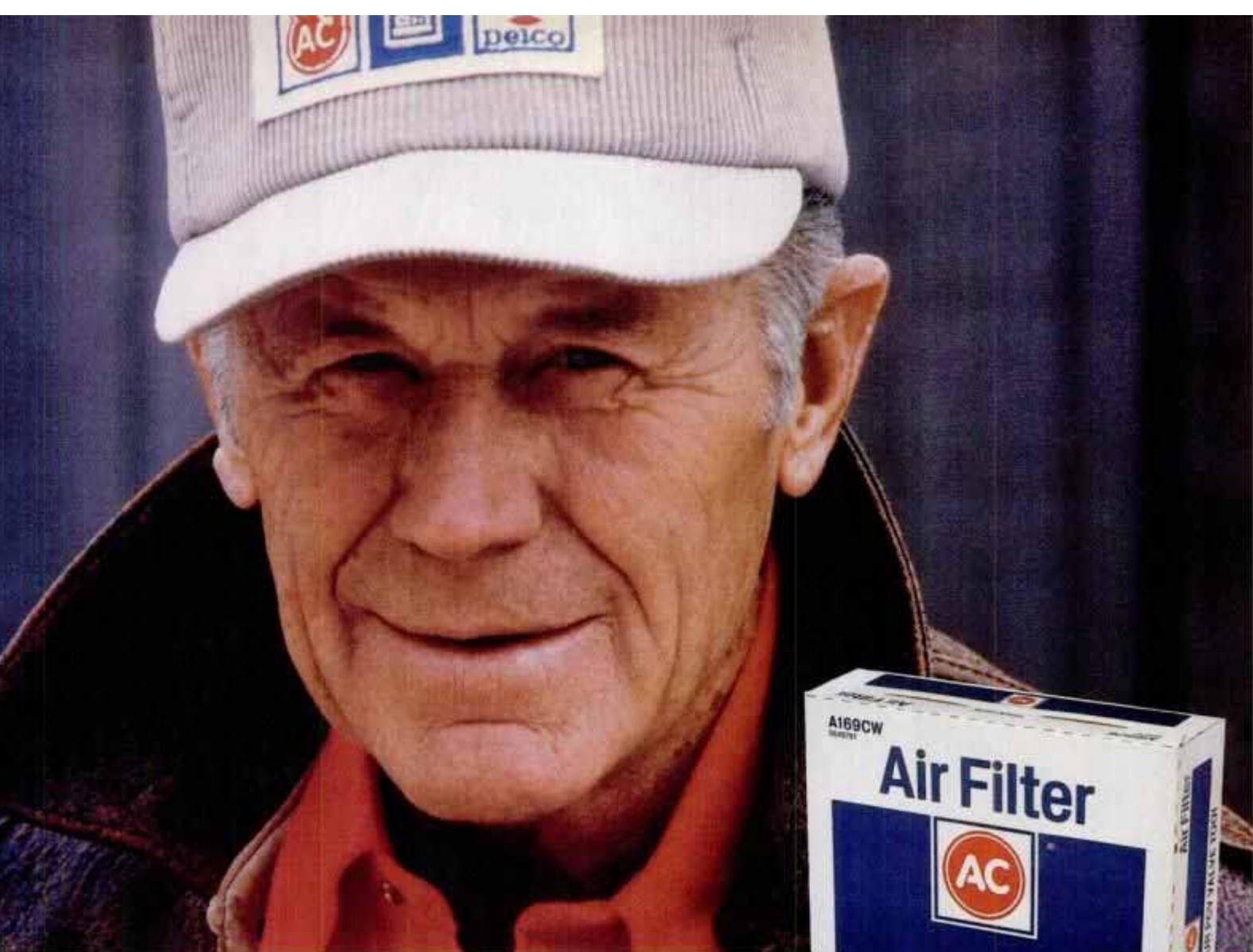
Radio Watch costs \$14.85 and can be mail-

ordered from Michael Frank Imports, 4703 Guadalajara, San Antonio, TX 78223.



Radio Watch headphones are 2-channel mono.





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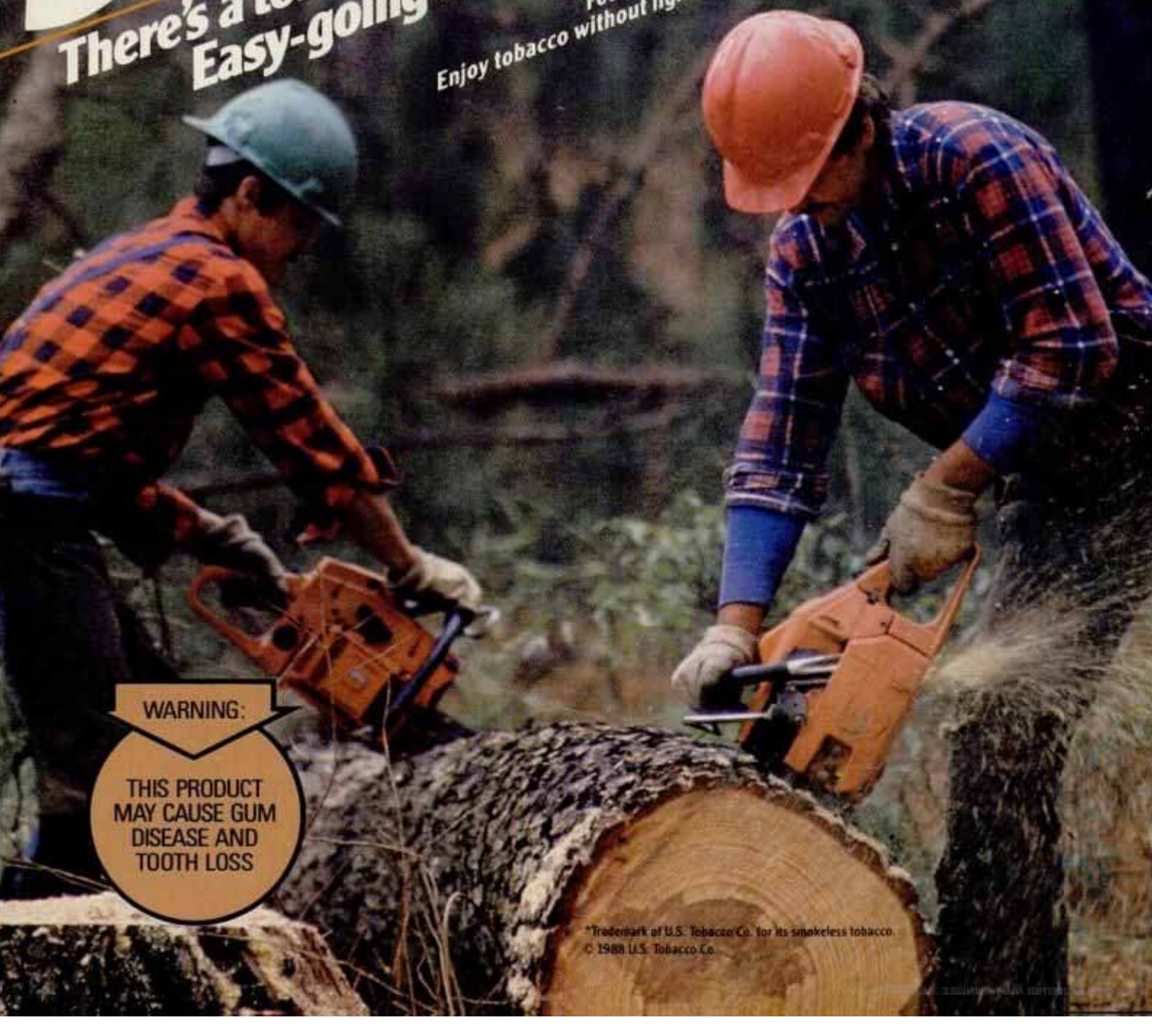
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## ELECTRONICS

(Continued from page 28)

below a certain level, called the cutoff point. Have you ever noticed how a battery that is seemingly dead in one product goes on to have a second life in another? That's because the first device might have a cutoff point of 1.0 volt while the second will operate until the battery's output dips to 0.8 volt.

Despite identical voltage ratings, battery types differ in the degree of slope of their voltage-discharge curves. For some batteries, the discharge slope descends more steeply than for others. This means they arrive at the hardware's cutoff point more quickly.

Carbon-zinc cells, the so-called general purpose battery and the least expensive, has the steepest slope of all. Zinc-chloride batteries, sometimes called heavy-duty, super- or extra-power cells, have a less severe slope and therefore take longer to reach the cutoff point. Alkaline batteries coast along a very slight downhill grade, which accounts for their advertised longevity. Lithium cells have almost no curve or slope to their discharge pattern. They put out virtually constant voltage (whatever their rating) until they exhaust their potential. The same goes for NiCd cells, which can be recharged.

There's more to what determines a battery's usefulness besides the voltage-discharge curve of its chemistry. Other factors include temperature, the current demands of the hardware, and whether the product will be used continuously or intermittently.

Carbon-zinc cells don't perform well at temperature extremes, and have a shorter shelf life than other types. But they're well-suited to devices that either require low current drain, or that are used infrequently. These include flashlights, remote controls, toys, radios and smoke detectors.

Zinc-chloride cells can operate at lower temperatures than carbon-zinc. Their chemical structure gives them 50 percent more capacity than carbon-zinc, so they deliver current longer. This recommends them for duty in products that either require moderate-to-heavy current drain, or that get regular use. The devices in this gray area might include the ones previously mentioned, as well as calculators, tape recorders and electronic games.

Alkaline batteries have a roughly 2-year shelf life at room temperature, so they're a good choice for devices that receive infrequent use but which must be ready for instant and reliable operation, such as flashlights. Alkalines also operate at more extreme temperatures than the first two types (from -20° to +130° F). Their energy capacity—several times greater than carbon-zinc and zinc-

chloride—and their long voltage-discharge slope make them ideal for devices needing high current drain and long-term voltage stability.

A good example of this type of product is the headphone-stereo tape recorder. For hi-fi results, the recorder section needs a steady voltage to magnetize the tape and to transport it at the proper speed. Accordingly, the cutoff point comes sooner than it would in a flashlight. In fact, Eveready touts its Conductor alkaline for portable audio products because its voltage-discharge slope remains flatter for a longer time than Eveready's Energizer alkalines—thereby evading the cutoff point until the Conductor runs out of music.

Other applications where alkalines make sense include cameras with flash units (an alkaline will recharge the flash quickly), portable TVs, electronic games—anything that requires high current drain, or a high pulse charge (as in photo flashes), or that gets continuous or regular use.

At this writing, NiCd and lithium cells usually equal or exceed all other types in the areas of operating-temperature latitude, shelf life, power capacity and ability to handle high current drain and pulse-charge demand.

Lithium is currently cited as having a shelf life as long as 10 years, and NiCd cells can be recharged hundreds of

times. Whereas lithiums will operate at extremely cold temperatures, NiCd cells aren't reliable below +32° F. At this writing, though, lithiums are relatively expensive, and a commercially feasible rechargeable lithium remains the goal of every battery manufacturer.

Because of its unique chemistry, the NiCd cell may be recharged. The influx of electricity reverses the chemical action that caused electricity to flow from the battery in the first place. For the record, a NiCd placed in the recharger designed for it can't be overcharged (ditto for products that have a built-in rechargeable cell). As for undercharging—the allegation popularly known as NiCd memory—battery manufacturers say it's a misnomer.

NiCd memory is alleged to occur when a partially discharged, then partially recharged, cell refuses to operate any longer than the depth of the last recharge. Battery manufacturers say that for this to happen, the battery would have to be discharged to exactly the same voltage level then recharged from that point at least 100 times. Barring such a coincidence, most cases of battery failure attributed to NiCd memory probably are the result of one internal cell going dead. This, manufacturers say, would cause a voltage drop steep enough to reach the hardware's cutoff point sooner than normally. **PM**

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# OLD HOUSE RESTORATION

BY BOB VILA

## Restoration Bathroom Fixtures

**T**HE GOOD old days weren't always so good—at least when it comes to bathroom fixtures. No one, no matter how much of a purist, would forfeit the luxuries of modern plumbing in the name of restoration.

But remodeling a bath to something close to its original state—at least as far as the main fixtures go—may be easier than you realize. Many companies specialize in supplying reproduction period fixtures that look remarkably like the real thing. And finding the real thing, if that's all you'll accept in your period home, may be quite a bit more difficult, but it is still possible. If the original sinks and tubs are still in place, but are stained and chipped, a new coat of porcelain may be all that's needed to rehab your bath.

### The bath is born

The bathroom, as we know it today, was born in the late 1800s. If your house predates the existence of indoor plumbing, chances are the bathroom was probably added sometime around the turn-of-the-century. Many times a spare bedroom, end of a room or closet was converted to a bath, or a room was added specifically for this purpose.

In most cases, an antique bathroom mimics this time in history. So returning this room to its original look isn't too complicated. Most of the fixtures you'll choose are patterned after those that were

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



Antique fixtures are distinctive and often hard to find. A good alternative is a new fixture like Kohler's Birthday Bath that is reminiscent of antique tubs.

popular then. If you're thinking pedestal sinks and clawfoot tubs, you're right.

Pedestal sinks were seen from the 1880s on. Up until around the '20s, these sinks had a plain, rounded style. True, there were some fancy, sculptured ornate sinks around then. But these pieces, for the most part, were specially made for the very rich. From the late '20s and on through the '40s, pedestal sinks maintained a squared off, art deco look. They were hexagonal, with straight lines and corners.

Wall-hung sinks with exposed piping were generally found in smaller bathrooms. Drop-in sinks became popular in the '60s, when vanities were used to cover the unattractive piping and to provide badly needed storage.

Although sinks were made from both cast iron and vitreous china, few of the latter survived predemolition removal. But as far as I know, most of today's reproduction sinks are made from this material.

Clawfoot tubs were around even earlier than in-

door plumbing. In the 1850s and '60s, it wasn't uncommon to see these tubs made out of copper with an oak rim. Tub made out of tin were considered the economy version of the copper ones. The turn-of-the-century saw these stylish tubs made out of cast iron with a porcelain coating. The old clawfoot tubs were being replaced in the early '20s with the built-in tubs similar to the ones used today. This signified progress. No longer did folks have to worry about splashing water around the tub (or cleaning underneath it). An enclosed tub was much more practical for showering, too.

Like everything else, toilets or commodes also changed over the years. The high overhead tanks with pull chains, popular at the turn-of-the-century, were usually made from either vitreous china or the more decorative copper-lined oak. There was a practical reason for these high tanks: They were gravity fed, which aided flushing in this age of unpressurized water.

Most old fixtures were

marked with a manufacture date. So if you've still got the originals intact, check the bowl and tub bottoms for these markings. They're fun to find!

### Finding antique fixtures today

Thanks to the fine selection of reproduction tubs, toilets and sinks that are available today, you shouldn't have a problem finding a fixture suitable for your old bathroom. Many of the suppliers included in the source list at the end of this column

sell direct from mail-order catalogs. Believe it or not, almost everything can be shipped across country—even a cast iron tub! Fixtures that exceed the popular parcel mail services' weight limits are simply crated and trucked. Depending on factors like distance and weight, expect to pay about \$200 to have a tub shipped to you. If you must have the real thing, start your search close to home at local salvage companies or demolition sites. You may find an old fixture reasonably priced that's in pretty good shape. It's best when you're searching for salvaged plumbing goods to bring along a friend who's knowledgeable when it comes to valves and other hardware. Make sure the fixture will fit properly in the space you've got for it, and be sure you can replace any missing or damaged hardware.

Some of the companies who sell repros also deal in salvaged goods. Of course, it may get a bit complicated conducting business like this over a distance. But some of

*(Please turn to page 35)*



# THE HONDA LAWN MOWER. PROOF THAT INNOVATION BREEDS IMITATION.

Ten years ago, all lawn mowers were basically the same. Then came the Honda Lawn Mower. It wasn't like the others. It was innovative. Advanced. Reliable. And it set new standards for what a lawn mower should be.

Before long, other manufacturers began to follow Honda's lead. To this day, Honda continues to innovate. And other man-

ufacturers continue to imitate. Honda has learned to live

with imitations. But that doesn't mean you have to. For the name of the Honda Power Equipment dealer nearest you, look in the Yellow Pages, or call the toll-free number listed below.

*Honda was first to introduce a system which allows the user to stop the mower's blade without disengaging the transmission.*

*Honda was first to introduce the ergonomically designed curved handle.*

*Honda was first to introduce the easy on/easy off grass bag attachment.*

*Honda was first to introduce a dependable blade brake clutch.*

*Honda was first to introduce non-binding sealed aircraft cables.*

*Honda was first to introduce the Over-head Valve engine and shaft drive.*



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## OLD HOUSE RESTORATION

(Continued from page 32)

these folks would be happy to discuss what type of fixture you're looking for over the phone, then send photos or copies of old plumbing catalog pages to help you choose what's right for your home.

### Rehabbing what you've got

If your bath has its original old fixtures, but they're discolored, chipped and scratched, it's probably cheaper to have them resurfaced than to replace them. Some companies offer resurfacing kits for the do-it-yourselfer, but as far as I'm concerned, it's a job best left to the pros. And even then, you've got to take care choosing a company to do this work.

In most cases, this process involves repainting the surface with either a liquid synthetic porcelain, acrylic, epoxy or urethane. But like any paint job, resurfacing is only as good as its preparation. The surface should be cleaned thoroughly, then etched to create microscopic pores. All faults, chips and fractures are usually filled and a primer or an adhesion coat applied. This is generally followed by several applications of the final coat.

The best thing to do when you're shopping for someone to do this work is to go with a company that offers a 5-year guarantee. A ballpark figure for having a bathtub resurfaced is about \$250 to \$300 (of course, this may vary depending on geographic location and other factors). Once a fixture is resurfaced, only use nonabrasive, foam cleaners to prevent cracking and peeling.

There's another important part of bathroom fixture rehab I've barely mentioned: fittings, which is a topic I'll tackle next month. Until then, if you've been thinking of rehabbing a bath or two, take a walk through your local sal-



A wide variety of antique and reproduction pedestal sinks are available these days.

vage yard. Browse through a few supplier catalogs. Then turn to these pages next month to learn how to put your period bath together. **PM**



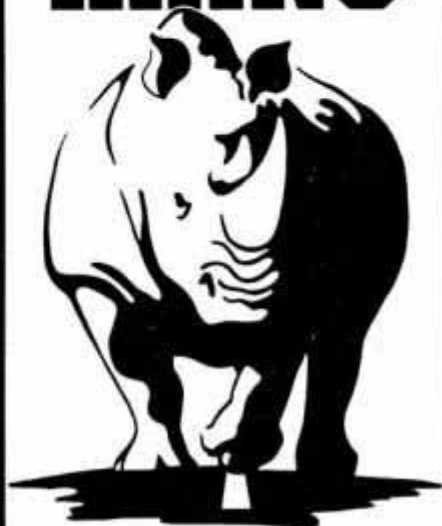
Some antique fixtures combine materials like the china toilet with wood seat and tank.

### Source List

Some suppliers of period and traditionally designed bathroom fixtures:

- A Ball Plumbing Supply, 1703 W. Burnside St., Portland, OR 97209, (503) 228-0026
- Antique Baths and Kitchens, 2220 Carlton Way, Santa Barbara, CA 93109, (805) 962-8598
- Barclay Products Limited, 424 N. Oakley Blvd., Chicago, IL 60612, (312) 243-1444
- Bathroom Machineries, D.E.A., Domestic Environmental Alternatives, 495 Main St., P.O. Box 1020, Murphys, CA 95247, (209) 728-2031
- Besco Plumbing, 729 Atlantic Ave., Boston, MA 02111, (617) 423-4535
- The Brass Finial, 2408 Riverton Rd., Cinnaminson, NJ 08077, (609) 786-9337
- Cumberland General Store, Route 3, Crossville, TN 38555, (800) 334-4640 [in TN: (615) 484-8481]
- Decorum Hardware Specialties, 235 Commercial St., Rt. 1A, Portland, ME 04101, (207) 775-3346
- Heads Up, A Division of Sonoma Woodworks, Inc., 133 Copeland St., Petaluma, CA 94952, (800) 358-9080 [in CA: (707) 762-5548]
- Kohler Co., Kohler, WI 53044, (414) 457-4441
- Mac The Antique Plumber Inc., 885 57th St., Sacramento, CA 95819, (916) 454-4507
- Remodelers & Renovators: Supplies For Vintage Houses, 1920 N. Liberty, Boise, ID 83704, (208) 323-1089
- The Renovator's Supply, Inc., Millers Falls, MA 01349, (413) 659-2211
- Restoration Works, Inc., P.O. Box 486, Buffalo, NY 14205, (716) 856-8000
- Roy Electric Co., Inc., 1054 Coney Island Ave., Brooklyn, NY 11230, (718) 434-7002
- The Sink Factory, 2140 San Pablo Ave., Berkeley, CA 94702, (415) 548-3967
- Sunrise Specialty, 2204 San Pablo Ave., Berkeley, CA 94702, (415) 845-4751
- Tennessee Tub, Inc., 6682 Charlotte Pike, Nashville, TN 37209, (615) 352-1939
- Victorian Warehouse, 190 Grace St., Auburn, CA 95603, (916) 823-0374
- Walker Mercantile Co., P.O. Box 210129, Bellevue, TN 37221, (800) 645-3213 [in TN: (615) 646-5084]

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\*For complete details contact your Armstrong dealer.



**ARMSTRONG** 



# HOME VIDEO

BY FRANK VIZARD

## 3-D—Ready For Primetime

**A**LFRED HITCHCOCK'S "Dial M For Murder" and Andy Warhol's "Frankenstein" are just two of the many films that have been shot in 3-D over the past three decades. The idea, of course, is to add a perception of depth to movies in order to increase their sense of realism. But even if you've never seen a 3-D film, you're probably familiar with the technique's popular image—a theater full of people wearing cardboard glasses.

Soon, you'll be seeing a home full of people wearing cardboard glasses. Yes, 3-D is coming to television. Specifically, it will be used in the season finale of ABC's popular "Moonlighting" series: Coca-Cola is sponsoring the effort and plans to distribute 40 million glasses to viewers nationwide.

While the effect remains the same, the 3-D technology that will be used for "Moonlighting" is new. The problem with 3-D in the past, at least as far as broadcasters are concerned, has been that if you did not wear your special glasses, what you'd see is an unfocused double image more annoying than typical ghosts. The new technique solves this problem: You can watch the 3-D sequence without glasses and experience no disruption in your viewing. In fact, the picture might look sharper. Of course, you will not experience the 3-D effect without wearing the glasses.

Older 3-D technology relies on presenting two different images on the screen at the same time. Red and blue filters built into the cardboard glasses allow each eye to see only one or the other of the two images on the screen. The data seen by each eye is combined and processed in the brain as a 3-dimensional image. A variant, used in videogames, relies on liquid-crystal filters in



See Cybill's curves and Bruce's whirls in 3-D on "Moonlighting."

the glasses to present the left-eye and the right-eye image as each is flashed in sequence on the screen. Each eye is actually looking at the same scene filmed from a slightly different perspective, and the brain translates this information into a stereoscopic image.

Like older methods, the 3-D technique employed for "Moonlighting" uses filters to fool the brain into seeing something that isn't there. But the new technique, developed by Nuoptics Associates of West Lake Village, California, does not put two images on the screen. Instead, this 3-D effect is created by complex choreography between the actors and the camera, as well as the use of a proprietary film-to-video transfer process. One immediate benefit is the lack of eye strain often associated with viewing 3-D images. This eye strain is caused by information spilling over from one image and affecting your perception of the second image.

The Nuoptics approach builds upon what is called the Pulfrich effect. When a pendulum swinging back and forth in a straight line perpendicular to the viewer is viewed with a filter over one eye, the pendulum appears

to trace out an oval. The effect is subtle, but it demonstrates a linkage between our perception of motion and depth that Nuoptics, under the direction of president and founder Terry Beard, exploits and expands upon.

What happens is that the filter effectively delays the processing of the visual image by one eye. In this instance, the delaying filter is the violet filter over the right eye. The filter over the left eye is light green, and its task is to maximize the time delay effect of the violet filter while also minimizing the brightness difference between the right and left eye. When you look through the glasses you don't notice the coloration of the lenses—things appear perfectly clear.

The filters are only part of the story. During the shooting of the TV episode, the actors must choreograph their movements in relation to the camera, which is moving slowly but continuously. This complex choreography between actors and camera enhances the time delay effect caused by the filters in the glasses. The action is also filmed at high speed, up to 120 frames per second. Filming is routinely done at a

speed of 24 fps.

Beard won't divulge the exact techniques used by Nuoptics but he does reveal that the film-to-video transfer process is critical. Most TV shows are shot on film and then transferred to videotape for broadcasting. Nuoptics does the same but uses a nonstandard, proprietary process. The portion of the "Moonlighting" episode affected by the Nuoptics processing should appear sharper than the normal TV image.

Only selected portions of the "Moonlighting" season finale will be shot in 3-D, not the entire episode. The stars of the show, Cybill Shepherd and Bruce Willis (a.k.a. Maddie Hayes and David Addison), will likely break down the fourth wall by telling you directly when to put on your 3-D glasses. The Nuoptics 3-D process will also be used during a 60-second Coke commercial to be aired during the show.

Chances are this won't be the last you'll see of 3-D on TV. Beard hints that Coke has additional plans to use the Nuoptics process. He says he is pursuing other projects as well, and that he hopes Nuoptics will be involved in the upcoming Summer Olympics.

So save those special glasses for future events. Keep in mind too that you can tape the "Moonlighting" episode for repeated viewings of the 3-D effect.

### If You Can't Beat 'Em

The big video format war is finally drawing to a close. Sony, the only remaining proponent of the Beta video format, intends to begin selling machines of the rival VHS format as well.

Sony insists that it will not abandon Beta users but the



company's announcement concedes dominance of the VCR market in the U.S. to VHS. Sony's announcement is also likely to make video moviemakers even more unwilling to release titles in the Beta format.

Sony says it will introduce VHS machines in Europe first. U.S. sales should follow later this year.

The Beta/VHS format battle had been shaping up to look like one of those medieval wars that lasted half a century or more.

Sony introduced the Beta VCR in 1975 but its technological banner wavered when Matsushita bowed its incompatible, but less expensive VHS format a year later. For the next 13 years, Sony manned the battlements in defiance of VHS, but allied manufacturers deserted the cause.

Of the 170-million VCRs sold worldwide, only about 12 percent, or 20 million, use the Beta format. Sony's announcement will likely precipitate an even greater decline in Beta sales in the United States. Beta, however, is a strong format in countries such as Mexico and Indonesia so it's probable that Sony will still produce new Beta equipment for those markets.

Exactly how Sony's announcement will influence its plans for future video products remains to be seen. Sony's Extended Definition Beta (a.k.a. ED-Beta), meant to rival Super-VHS, might see its introduction suspended, or repositioned solely as a format for prosumers—either well-heeled video fanatics or video professionals. Or perhaps Sony will be content to address those customers with SVHS machines of its own.

Certainly, Sony's decision will allow the company to devote more resources to the development of the diminutive 8mm format, a product that has a small market share so far.

## Roll Your Own

Although more camcorders are coming equipped with many features that will improve the quality of your final production, relatively inexpensive accessories can also be used toward the same end.

Minolta, for example, is marketing Cokin Filter Video Kits developed by French photographer Jean Coquin. Two versions of the kit are available.

The \$65 kit includes an A-type filter holder, a Star-8 filter, a graduated Tobacco TZ filter, a graduated fluorescent blue B2 filter and a linear polarizing filter, as well as lens adapter rings of either 46mm, 49mm or 52mm diameter to fit all models.

The \$35 kit includes the A-filter holder, a screw-in skylight/1A filter, a linear polarizing filter, a gray neutral density 4X filter as well as the versatile adapter rings.

## Making Movies

There's more to recording good videos than just having the right hardware. Some tips on home moviemaking come by way of the Electronics Industries Assn., and the advice can be boiled down to a handy 10-point checklist.

■ Know your camcorder. Read the manual thoroughly and shoot a few practice tapes before starting.

■ Do a preshoot test. Check that everything works.

■ Plan your shots. Like Hitchcock, map the scene before you record. Advanced students can use a story board.

■ Check the lighting. Remember that backlighting might cause unwanted silhouettes. Directly recording a light source might leave a white spot or streak on the tape. You might have to rethink your shooting angles.

■ Keep it steady. Don't move while everyone else is. Pan slowly, and use the zoom to get close to the action.

■ Label and date your tapes. Otherwise, you'll never find anything again.

■ Take care of your investment. Put the lens cover on as soon as you wrap your last shot. Don't leave a tape in the camcorder any longer than you have to.

■ Service equipment regularly. An inspection once a year is sufficient.

■ Plan for extended trips. Bring extra batteries, extra tape and a battery charger. Do not let your camcorder pass through an airport X-ray machine. Unlike photo film, the X-rays themselves are not so much the problem as is the magnetic field generated by the X-ray machine. Delicate electronic chips and recording heads might be damaged.

■ Always use top-quality tape. Inferior, Brand X videotape can shorten the life of your camcorder by leaving a metallic residue on the recording heads. EIA's pamphlet can be obtained by sending a 37-cent, stamped, self-addressed envelope to the Electronic Industries Assn., Camcorders, P.O. Box 19100, Washington, DC 20006.

## Talent Hunt

If you're a home videomaker looking for a larger audience than your immediate family, send copies of your best video productions to Video Alternatives, Suite 405, 1620 Country Club Plaza Dr., St. Charles, MO 63303 or call (800) 626-2721 for more information.

"We're looking for all types of videos—cute pet tricks, how-to's, just about anything," says company president Tom Wahl. "Just send good high-quality shots and we'll take it from there."

Wahl says that a variety of video footage on the same theme—stupid pet tricks, for instance—might be compiled into a single production. Contributors are paid royalties based on the length of the material used and sales of the finished product.

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# CAR CLINIC

BY MORT SCHULTZ

## GM Camshafts

**I** OWN A 1981 Chevrolet Malibu classic that has a 229-cu.-in. V6 engine. Two years ago, at 38,000 miles, the camshaft had to be replaced. GM paid half the cost. A few months ago I began hearing clacking sounds and decided to do an overhaul since the engine had gone 98,000 miles. I found two lobes of the camshaft rounded off and two worn lifters. I would like to know why this condition occurs. I've heard that GM engines are notorious for bad camshafts.

FRED KAGAN  
SPRING VALLEY, NY

*There are two main reasons for premature cam-*

*shaft failure: misaligned lifter bores and improper hardening of the camshaft during production.*

*From what you say in the part of your letter we've omitted here, it's apparent that your worn camshaft falls into the misaligned category. Let's hold our discussion of that for a moment and talk about inadequate hardening, which is what you're talking about relating to GM's supposed reputation for bad camshafts.*

*That reputation came about because of the soft cam issue, as it was called, which affected 1975-82 305-cu.-in. V8 engines—not your V6. It resulted*

*in an agreement between GM and the Federal Trade Commission. In that agreement, GM extended the warranty on 305-cu.-in. engine camshafts to five years or 50,000 miles, whichever occurred first. Depending upon how a camshaft failed, and at what mileage, GM offered the customer a certain amount of compensation.*

*If the customer wasn't satisfied with the offer, he or she had the option of asking for arbitration. But even if the customer failed to win the case, he could still collect on GM's original offer.*

*As I said, I doubt if your situation falls into the "soft cam" category. Although improperly hardened camshafts aren't confined to 1975-82 305-cu.-in. engines, they haven't shown up in great numbers on other model engines. Besides, you mention two worn lifters. This is the key. If the cam lobes don't line up perfectly with the lifter bores, the lobes and lifters will wear. It's unlikely that two camshafts, the original and the replacement, would have the same two lifter lobes fail. This leads me to suspect the lifter bores in the block.*

*Camshafts also must be indexed correctly fore-and-aft in the block, another potential problem area that can lead to premature cam failure. This can be fixed by machining or shimming the timing gear thrust face on the cam. No modification of the block should be necessary.*

*Other readers who find similar problems, whether from a soft cam, or incorrectly placed or misaligned bores, should not simply replace the cam and lifters. All the filings from the worn cam lobes are lurking inside your engine, have*

*probably already damaged your oil pump and will return to haunt you again.*

*Disassembly of the entire engine is the only way of ensuring a proper repair. While the block is at the machine shop, the offending lifter bores can be bored out, sleeved and rebored correctly, eliminating the problem permanently.*

*The number one cause of camshaft failure is poor lubrication, so be sure to change oil frequently—3000 miles or 90 days isn't unreasonable. Be sure to follow the manufacturer's recommendations for this vehicle: SF-rated SAE No. 30 or 10W30 oil, depending on the ambient temperature.*

### GM's Power Steering Offer

I own two 1984 Buick Centurys, and both have the same problem of unresponsive power steering for about half a minute after I start the engines in the morning. After this, the power steering in both cars takes hold, and they act like they should. Do you have any ideas what should be done?

JOSEPH P. HENRY  
SAN LEANDRO, CA

*No ideas—just a solution. Many owners of the 4.6 million 1982-85 GM front-wheel-drive cars on the road today (see the list below) are in the same boat. As you describe it, the symptoms displayed by faulty units are no power assist for periods ranging from several seconds to as long as 2 minutes upon starting a cold engine. The failure is more likely to occur when the ambient temperature is low.*

*GM has offered to make a repair free of charge. The*

*(Please turn to page 40)*

### Hammering The Point Home

You've got a rattle coming from somewhere. But just where is it originating? Could be from inside one of the doors, from a loose fender liner, from inside the roof or from a loose bumper. All in all, one of the most difficult things for any mechanic, amateur or professional, is to pinpoint the source of a body noise. This tip can help.

Bounce a rubber mallet—*gently*—over every inch of the body where you suspect the rattle is originating. If you hear the rattle, you've pinpointed something that's loose inside of the panel.

Open it up, fix it and the annoying noise should be a thing of the past.





# 7,321 miles...



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\*Unsolicited testimonial from Bob Vande Weerd, Rock Valley, IA.



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## CAR CLINIC

(Continued from page 38)

repair involves installing new seals to prevent loss of pressure when the steering gear is cold. If that repair doesn't work, a new gear assembly will be installed.

GM states that the offer to make the repair gratis applies to cars that are

no more than five years old or have been driven less than 50,000 miles.

The cars involved are 1982-84 Buick Skyhawk-Skylark-Century, Cadillac Cimarron, Chevrolet Cavalier-Citation-Celebrity, Oldsmobile Firenza-Omega-Cutlass Ciera and Pontiac Sunbird-Phoenix-6000. Also 1985 Buick Electra, Cadillac DeVille and Oldsmobile 98.

## Manual Mania

In your January '88 "Car Clinic" you gave information about where readers can get shop manuals for older Oldsmobiles. The man who asked the question had a 1960 model. I wonder if you can help those of us who are restoring older Fords. In my case, the car is a 1967 LTD Sport Coupe equipped with a 390-cu.-in. engine.

TOM SIFFORD  
HOUSTON, TX

The company that handles production and distribution of shop manuals for Ford, Chevy and Pontiac—Helm, Inc.—has decided there's enough demand to print more. The company is proceeding to do just that by reproducing the complete shop manuals in loose-leaf (3-hole punch) format from stored originals which are on microfilm. Reproductions of FoMoCo, Cadillac, Chevy and Pontiac shop manuals are now available for models manufactured from 1960 onward. Mail your requests to Helm, Inc., 14310 Hamilton Ave., Highland Park, MI 48203, or call (313) 865-5000.

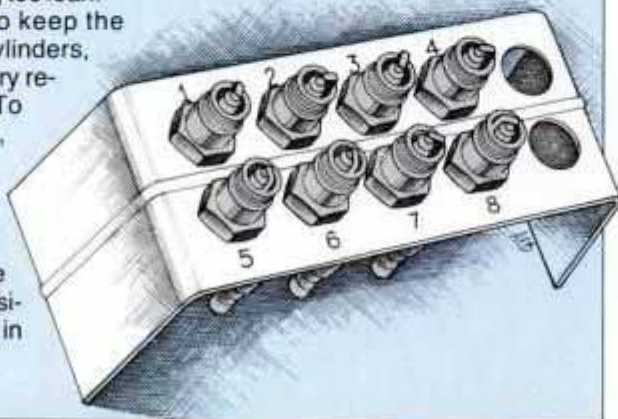
## Pure Logic

I have a 1987 Plymouth Caravelle with a 2.5-liter engine and EFI. My

## By The Numbers

As always, sparkplugs are an excellent tool for diagnosing the innermost secrets of your engine. After even a few miles, each has a story to tell. A plug may be telling you that its cylinder is overheating, or is burning oil, or is running too lean.

However, if you fail to keep the plugs matched to their cylinders, you won't know which story relates to which cylinder. To keep the record straight, buy or make a spark-plug rack. Each hole is labeled with a number, but you'll probably find it much simpler to arrange the plugs in the same physical relationship they had in the engine.



# PLYMOUTH THE PRIDE'S INSIDE.

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\*J.D. Power and Assoc., 1987 Compact Truck CSI/customer satisfaction with product quality and dealer service on 1986 models. \*\*Based on traditional sticker price of options if purchased separately. †Protects engine and powertrain for 7 years or 70,000 miles and outer body rust-through for 7 years or 100,000 miles. See limited warranty at dealer. Restrictions apply. ††Sticker price excludes title, taxes, destination charges and luggage rack. BUCKLE UP FOR SAFETY.



brother has a 1987 Dodge 600 with 2.2-liter engine and EFI. Although we have different models, we have the same problem. The owner's manuals for both vehicles recommend shifting into Neutral when the air conditioner is operating in hot weather in stop-and-go traffic. When we do this, the idle is rough, more so in my brother's 600 than in my Caravelle. His engine almost stalls. Is there help?

JOSEPH SWANSEY  
PITTSBURGH, PA

*Your brother might be in luck, but you may have to wait awhile for a solution. There is a new electronic module that resolves this problem of fluctuating idle speed in the 2.2-liter engine when the air conditioner is on.*

*This is not the case for your 2.5-liter engine—not yet, anyway. Chrysler is working on a redesigned module for your car. The module I'm referring to is the logic module—the one that does all the brain work. Both your vehicle and your brother's have another module called a power module, which carries out the commands of the logic modules and controls the vehicles' fuel-injection systems.*

*Anyway, to find out if a new logic module will be any good to your brother, you should:*

■ *Warm up the engine, turn on the air conditioner, switch on the headlights, and shift into Drive.*

■ *Switch headlights between high and low beams and check idle.*

■ *If the idle is unstable when (1) you turn on the air conditioner or (2) when headlights are flipped between high and low beams, put more load on the alternator.*

*This is done by turning the blower motor on high, turning on the rear window defroster, and switching on the sound system.*

*If doing this causes the idle to stabilize, install the new logic module (part No. 5227880). Ignition timing also has to be retarded from what's specified (12° BTDC) to 8° BTDC.*

*If your brother doesn't get the response that indicates a need for the new logic module, he should ask his dealer to test the EFI system according to Chrysler's driveability test procedure. The part that's failing will probably be uncovered. I'll bet it's the throttle-position sensor or automatic-idle speed-control motor. **PM***

#### DO YOU HAVE A CAR PROBLEM?

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

#### SERVICE TIPS

■ Before you replace brake pads or wheel bearings as a cure for low-speed grinding noises during braking in your '86-'87 Ford Ranger or Bronco II, have a dealer check technical service bulletin (TSB) 87-23-11. Some brake components—rotors and calipers among them—may have to be replaced.

■ A tappet (ticking) noise from one or both cylinder heads of an '88 Chrysler Motors vehicle equipped with 3.9- or 5.2-liter engine may not go away unless you have new push rods (part No. 4483721) installed. That's what Chrysler advises in TSB 09-08-87.

■ Chevy tells "Car Clinic" that it, too, has a valve train noise situation with some of the 4-cylinder engines in '88 Cavaliers, Corsicas and Berettas, because two valve spring seats may have been inadvertently installed during production. They state in TSB 88-134-6E that where two seats are found, the rocker arm for that valve should be replaced and one seat installed.

■ For abnormal rear tire wear on '84-'86 Nissan Sentras and '83-'86 Pulsars, have a dealer check TSB's WT85-006 and WT87-001.

You may have to replace the rear control arms. If so, procedures outlined in TSB TS88-016 regarding installation of control arm bushings should be followed. If the shop manual information about the bushings is followed, the new control arms could be damaged.

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**7/70**

Division of Chrysler Motors



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Linda Pobst



\*In competition, Firehawk performance radials are modified by shaving their treads to racing depth. See your Firestone retailer for written speed rating and tire safety information.



# INSIDE DETROIT

BY JIM DUNNE

## Now This Is A Car



The 1991 Caprice: Full-size cars are back.

**W**ITH apologies to other claimants, I refer to the 1991 Chevrolet Caprice as a car in the truest sense of the word. No small econobox, this full-size Chevy will be even larger on the outside than today's Caprice. The shape of the outside mirrors even had to be changed in order to comply with highway width restrictions for motorcars.

Look for all the good old features that made American cars the kings of the road, things like a V8 engine, rear-wheel drive, frame and body construction.

In addition, the future Caprice will have a sleek aerodynamic shape, fuel-injected engine, antilock brakes and an adjustable suspension.

Despite the change in buying habits that favors smaller, front-wheel-drive cars, Caprice remains a strong seller in Chevy's lineup. The car shown above, an early prototype, was taped to keep the glued-on trim in place while it was being shipped to a consumer styling clinic.

### Plastic Engine

The material actually is a phenolic composite reinforced with fiberglass. It may be used in the engine block, head, valve covers and oil pan. Inside, though, there is a lot of metal—iron, aluminum and steel—for cylinder liners, pistons, valve seats, cams, cranks and bearings. That's the Polimotor design offered to the auto companies by Rogers Corp., of Man-

chester, Connecticut.

What Detroit will end up with, if the Polimotor design is adopted, is a 4-cylinder 2.3-liter inline engine that weighs 175 pounds, in contrast with the 350 pounds of a cast-iron engine of similar size. That means the parts in the front of the car can be made lighter, so weight savings—and ultimately fuel economy—increase. Other benefits include less machining, quieter operation and a smaller investment in a new engine manufacturing line.

Detroit is resistant to the new material for a number of reasons. Right now engine designers are comfortable with iron, and to a lesser degree with aluminum. Also, new engine manufacturing lines are not built every year, and to install a completely new system to accommodate phenolic would take four to six years.

Finally, there is the problem of scrap. What do you do with a million or so old engine blocks made of phenolic?

### Eagle Summit

Jeep Eagle will have an Eagle Summit in its lineup next year when Diamond Star Motors begins production at its new plant in Normal, Illinois. The subcompact is Eagle's version of the Mitsubishi Mirage. It is a 4-place sedan that uses front-wheel drive and a 4-cylinder engine of



Saturn prototype for planned launch date in late 1990 to mid-1991.

less than 2.0 liters. Summit will be produced alongside the sporty 2+2 coupe that Diamond Star will build for Mitsubishi, Eagle and Plymouth dealers in this country.

### GM's Saturn

"It's dead nuts on." That's the comment of a Saturn official about the prototype. Our

photo shows it undergoing durability testing at one of General Motors' proving grounds last winter.

This is the first photo of the car that shows its true shape and styling.

Most obvious of the styling themes is the use of curved shapes in fenders, C-pillar and lower bumper.

Note the short overhang at the rear, where the wheels have been extended rearward to produce a longer wheelbase for a smoother ride.

The prototype shown here may be a sporty version of the base Saturn model.

Extensions to the front bumper, rocker panels and rear bumper appear to be ground effects panels which

are usually associated with sporty models.

The car also appears to have extra-large wheel openings. That is an indicator that larger tires than the size on this prototype may be an option on upscale models.

The front-wheel-drive Saturn will use a completely new 1.9-liter 4-cylinder, all-aluminum engine.

Sized somewhere between a subcompact and compact, the Saturn lineup will consist of two 2-door sedans and one 4-door.

Introduction is slated for some time between late 1990 to mid-1991.

Saturn models will be sold in the United States by Saturn Corp. through a new network of Saturn dealers. Saturn Corp. is a subsidiary of General Motors.

*(Please turn to page 44)*



Chrysler's new Eagle Summit, also known as Mitsubishi Mirage.





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## INSIDE DETROIT

(Continued from page 43)

### Lost Allure

Chrysler almost put a 2-door version of the Premier into production when it took over American Motors last summer. But the sleek Giugiaro-designed coupe was killed by Chrysler management after financial experts at the company figured the investment in tooling up would not bring in the profits that should come from a specialty car.

Word is that American Motors had all but tooled up to build the Allure alongside the Premier at Bramalea, Ontario. When Chrysler management, including Lee Iacocca, saw the Allure for the first time, shortly after purchasing American Motors, the reaction was highly favorable. The Allure was, along with the Jeep Cherokee, one of the outstanding products in the AMC lineup. But the cost of building the car with its expensive Renault-supplied powertrain left too little profit in the venture. So the Allure was dropped.

Today, all that remains of the Allure is a couple of worn-looking prototypes that are ready for the scrapyard. What did the car look like? I'll have photos in this column next month. Then you will see a striking similarity between the Allure and the new Cutlass Supreme.

### Pop-Top Corvette

Be on the lookout for a removable hard-top roof for the Corvette convertible next year. GM is testing a fiberglass shell roof for the sports car, and expects to have it ready for installation when the 1989 models make their appearance. The roof fits on the car when the convertible top is swung down into its storage compartment.

### Different Seats

That is the plan of two researchers from Nissan who point out that seating needs for drivers are different from those of passengers.

"By nature, the driver's seat should be made for work, while the passenger's seat is for comfort," the researchers point out.

Up to now, the driver's seat has gotten all the attention. But the driver must work at operating the car. The passenger's main occupation is viewing the scenery and relaxing.

For the passenger, the researchers designed a seat that tilts in two unusual ways. The top of the seat back tilts forward a few degrees to support the passenger's upper shoulders and head. At the same time, the seat cushion tilts up at the front and slides forward slightly. These changes in position let the passenger recline slightly, yet still view the roadway ahead. The passenger's body is held in place at all times.

PM

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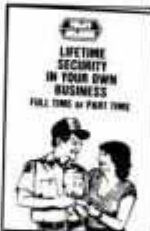
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# CYCLES

BY NORMAN MAYERSOHN

## Going Mainstream



With the Hawk GT, Honda will reach a wider spectrum of tradition-minded riders.

**H**AVING met the needs in recent years of motorcycling's most committed enthusiasts with brilliant, narrow-focus machinery, Japan's Big Four are reaching out for broader appeal in 1988. Showrooms are highlighting all-new models which are more versatile, and in many cases, more sensible choices.

For proof, take a look at Honda's Hawk GT. It's got the classic, simple lines that traditionalists yearn for, and the torquey punch of a V-twin, so it's deliciously attractive without resorting to the application of exhibitionist graphics.

Still, the Hawk GT's leading edge credentials should satisfy all but the most hard-bitten technomaven. The liquid-cooled 647-cc engine uses an offset crankpin design to minimize vibration.

A close inspection of the Hawk GT rear end reveals Honda's new Pro-Arm aluminum swingarm, adapted from Honda's mighty endurance racers. Because it uses a single arm on the left side, rear wheel service is quick—the disc brake and chain need not be removed.

An aluminum twin-spar rectangular section frame contributes to the sensible dry weight of 350 pounds. At \$3598, the Hawk GT covers a

wide range of riding styles at an easy-to-swallow price.

The all-out Superbikes (Yamaha FZR1000, Honda Hurricane 1000, Suzuki GSX-R1100) maintain status quo in 1988, with only Kawasaki's 1000-cc ZX-10 Ninja substantially revised. The hottest competition among the replica racers has shifted to the 600-cc class, particu-

zularly now that Suzuki has unveiled its challenger. Suzuki's GSX600F Katana is a wide-appeal outgrowth of the single purpose GSX-R series, domesticated for long distance amicability.

Because it is manufactured in the Land of the Rising



Suzuki's Katana 600 is a newcomer to the middleweight fray.

larly now that Suzuki has unveiled its challenger. Suzuki's GSX600F Katana is a wide-appeal outgrowth of the single purpose GSX-R series, domesticated for long distance amicability.

The transformation from track-ready sprinter to highway ally took a complete rethink of the motorcycle package. Most apparent is the bodywork—instead of the all-business angularity of the GSX-R, the Katana gets softly molded panels. And stepping back from the Su-

zuki strong suit of low-mass machinery, the Katana 600 takes on a massive steel perimeter frame that makes it at least 20 pounds heavier than its competitors but allows more humane ergonomics.

Yen, the Suzuki Katana 600 has been spared of some niceties in order to keep the price attractive. But for \$3999 the 600-cc class just got one more title contender. Transcontinental touring rigs took a great leap forward with the introduction of Honda's standard-setting Gold Wing 13 years ago. Rivals for the class leadership position have chipped away at the Gold Wing's stature, evoking this definitive response: the GL1500, a 6-cylinder luxury touring motor-

cycle, complete with a Reverse gear, powered by the starter motor. Available only in fully loaded form, the new Gold Wing will make your wallet \$9998 dollars slimmer. Fully loaded means just that, too. With electronic cruise control, 24-watt-per-channel stereo and on-board air compressor, it weighs in at 800+ pounds.

Harley-Davidson's '88 model lineup continues the evolutionary approach to progress, with the Tour Glide Classic and Sport Glide getting detail improvements to better their long distance prowess. And the biggest Sportster is now 1200 cc.

BMW's surprise for '88 is the reintroduction of the R100 twins, absent from this country since 1984. Most appealing is the dual-purpose R100GS, easily the status symbol of on/off road machinery. BMW's antilock brake system will be available later this year on K100RS models, adding \$1000 over the cost of non-ABS models.

The trend toward full-scale styling treatments for smaller displacement machines results in a number of eye-catching models which are reduced in both weight and price, without losing in the fun factor. Yamaha has a 400-cc version of the FZR series (with a 14,000-rpm red-line!) and Honda will sell you an electric blue and magenta 250-cc Interceptor VTR.

But the big news in downsizing is in the cruiser bike genre. Yamaha's shot at the boulevard crowd is the Route 66, a 250-cc V-Twin with all the classic styling cues. From the teardrop tank to the pullback handlebars, the Route 66 is full-on American Traditional. Kawasaki's new mini-brute, the Eliminator 250, carries a tough guy profile in a compact package. The parallel Twin engine is lifted from the pocket rocket Ninja 250 with a few modifications to improve low-end power. **PM**





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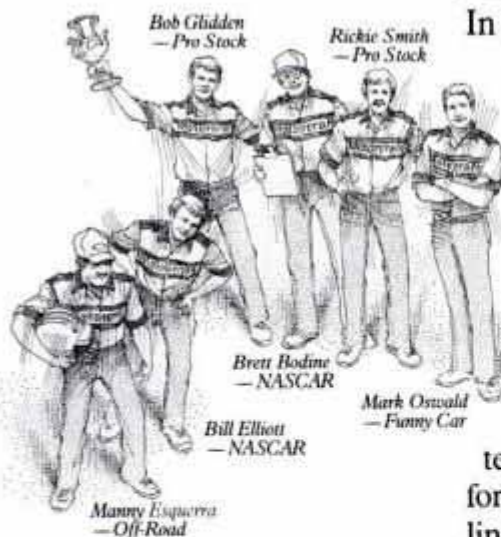
In 1987, the Motorcraft Team won four World Championships: NHRA Pro Stock, IHRA Pro Stock and Funny Car, and SCORE/HDRA Off-Road.

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# AVIATION

BY FRED MACKERODT

## What's Up With Burt Rutan?



Burt Rutan's solution for the STOL transport of tomorrow: Not exactly a biplane.

**W**HEN you ask airplane designer Burt Rutan to solve a problem, you just know his solution is going to be something out of the ordinary. Rutan doesn't think like you, me or anybody else for that matter. Just look at his designs for the globe-circling Voyager and the Beech Starship and you know his ideas come from another world.

All of his aircraft have wings, of course, but what kind of wings and how they are placed make the Rutan difference.

His latest design for an Advanced Technological Tactical Transport (AT<sup>3</sup>) is typical Rutan.

The problem: Design and build a transport aircraft for the Defense Advanced Research Projects Agency that's bigger and faster than a helicopter, but smaller than a C-130 transport. Throw in a range of almost 3000 miles, a cruise speed of 326 knots and a payload of 14 troops and 5000 pounds of cargo. And—oh, yes!—make this aircraft capable of getting into and out of unimproved jungle clearings in 1000 ft. or less.

Beginning with a clean sheet of paper (Rutan's mind is always in the clean-sheet mode), Burt came up with the plane you see here, the Beech AT<sup>3</sup>.

This aircraft is actually a 62-percent proof-of-concept flying model which first took

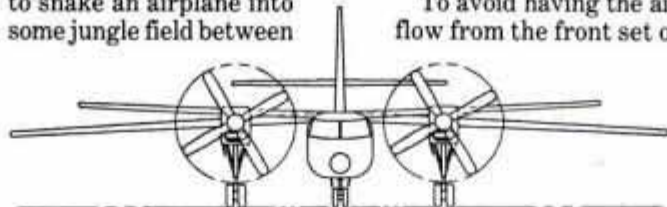
to the air last January.

The most obvious Rutan innovation on the AT<sup>3</sup> is the two sets of wings. Wings with a high aspect ratio (in other words, long, thin wings) reduce drag and do great things for cruise performance. However, the longer wings get, the more cumbersome they become—not exactly the situation you want when you're trying to snake an airplane into some jungle field between

ratio wings. Because they are so long and thin, they don't have the stiffness necessary to resist torsional loads. Simply put, they twist relatively easily. The tandem setup converts the loads that would normally try to twist the wings into bending loads—and this bending force is absorbed with no problem.

Rutan's solutions usually answer multiple questions.

To avoid having the air flow from the front set of



The anhedral/dihedral combination of the Beech AT<sup>3</sup>.

a palm tree and a giant ant-hill. Rutan's twin wings provide the best combination of long, thin structures with enough wing area to provide plenty of lift.

This tandem-wing setup also leaves plenty of room behind the engines for the long nacelles which are used to carry the huge fuel load necessary to provide the AT<sup>3</sup>'s range. This fuel would normally be carried in the wings. Also, having the heaviest portions of the fuselage and fuel tanks cradled between the two sets of wings should do a lot for its weight-and-balance flexibility.

But the most important reason for the tandem setup is a property of high aspect

wings interfere with the rear set, the front set are dihedral (slanted up from the center), while the rear set are anhedral (pointed down).

As if the tandem wings weren't enough, Rutan's flap setup for the AT<sup>3</sup> is even more way out. Wing flaps are used to increase lift. They allow an aircraft to get off the ground at a slower speed than it would otherwise have to reach without having the flaps extended. But extended flaps also create drag, which translates into slower acceleration and longer take-off runs.

To solve the problems of getting the airplane to take-off speed as quickly as possible, and yet keep that speed

down as low as possible, Rutan developed what he calls jump flaps: When the AT<sup>3</sup> hits 50 knots in the takeoff roll, the pilot activates a special lever which deploys the flaps almost instantly.

In a flight demonstration before a group of writers and military types this February, Beech Aircraft's test pilot honked the AT<sup>3</sup> off the ground in 500 ft., then got it back down, and stopped in slightly less than 500 ft.

Oh yes, there's another thing about Burt Rutan's ideas. They're not just different—they work!

### Super Video

I once read a book on lion taming. It began: "First, get the lion's attention . . ."

Video has great potential for training pilots, helping pilots to stay current, and even attracting new pilots into aviation. But most of the aviation videos I've seen to date have been neither interesting nor effective. They're either tapes of old FAA films, or low-budget productions done with a minimum of imagination and at a minimum of expense. A while ago, I invested more than \$200 in a set of six test preparation tapes for the FAA commercial pilot exam from a company called Aviation Training Center. I never got past viewing the first tape. I dozed off halfway through it. I was bored stiff watching two guys sitting in front of the camera, asking each other questions.

I recently reviewed another videotape, however, which I think shows video's great potential to the fullest. I sat glued to my chair watching the 97 minutes of the first tape in ABC's Wide World of Flying series. In a television-magazine format, this initial tape included a pilot report of the Piper Malibu and the Lancair kit aircraft with

*(Please turn to page 52)*



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## AVIATION

(Continued from page 50)



Flying guru Barry Schiff on camera in ABC's great aviation video.

some great plane-to-plane shots, in-the-air comparisons of three loran systems, an excellent piece on takeoff technique by professional pilot and writer Barry Schiff, and a nostalgic, from-the-cockpit look at the B-17.

The main features are interspersed with Flight Quiz segments and special reports on safety, pilot technique and general aviation trends.

A year's subscription for four quarterly editions costs \$99.95 and the number to call for information is (800) 999-8783. I can't recommend anything more highly, especially to the fine folks at the FAA concerned with pilot training and proficiency. This is the way it should be done, fellas.

## Flying Vacations

One of the great parts of this job is that I get to go to air shows. But this also presents a problem. This country has the world's greatest lineup of aircraft extravaganzas, and I can't possibly get to see all of them. So I sat down the other day to select just four events I'm going to attend this summer.

Any one of these four events would make a great vacation experience for anyone with the flying bug:

■ **Dayton Air and Trade Show:** My first stop this summer is going to be the Dayton International Airport in Vandalia, Ohio. The trade portion takes place July 21 through 24, and the air show is on Saturday and Sunday, the 23rd and 24th. If you're figuring on making the journey to Dayton, the kicker is that this mid-Ohio town is also the site of the U.S. Air Force Museum at nearby Wright-Patterson Air Force Base. The gate price at the air show is \$8 for adults and \$4 for children. The number to call is (513) 898-5901. You can reach the Air Force Museum at (513) 255-3284, and the price here couldn't be any better. It's free!

■ **Oshkosh 1988:** The annual bash of the Experimental Aircraft Assn. in Oshkosh, Wisconsin, is going to take place from July 29 to August 5 this year. The great-granddaddy of fly-ins, Osh-

kosh represents the biggest general aviation happening in the world. The show portion is spectacular, and the EAA volunteers who run it provide a week packed with things to do and see. Information on Oshkosh is available from the EAA at (414) 426-4800. Leave a full day to see the great EAA museum.

■ **Sussex Air Show:** This is a little show when compared with the two extravaganzas above, but it's still one of the summer's great events. Taking place on the weekend of August 26, 27 and 28 in Sussex, New Jersey, the show has a down-home atmosphere, but offers a world-class selection of airplanes and aerobatic performances. Sussex also offers one complete day—August 25—devoted to flying models. The number to call is (201) 875-9919.

■ **Confederate Air Force Airshow '88:** If vintage warbirds are your bag, then this yearly event in Harlingen, Texas, can't be missed. The dates for 1988 are October 6 to 9 and I am definitely going to enlist. There are planes available for viewing, both in the air and on the ground. Some of the rarer examples are a B-29 Superfortress, A6M2 Zero, SBD Dauntless, SB2C Helldiver, P82 Twin Mustang, and B-23 and B-26 bombers. Gate prices are \$8 and \$10, and the number to call for more information is (512) 425-1057. **PM**

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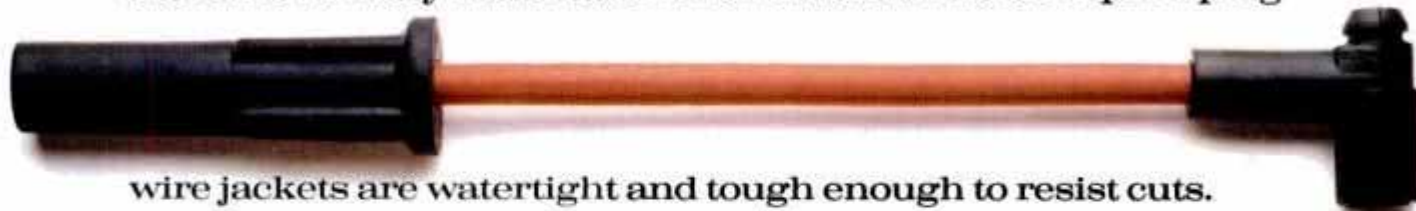
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# FREEWHEELING

BY TONY SWAN

## Final Rites For Fiero

**W**HILE we know too well that sentimentality seldom colors decisions in autodom, the news of impending doom for Pontiac's jaunty little Fiero still caused shock and dismay at our house.

Although Pontiac spent some \$30 million on suspension upgrades last year, the bottom has fallen out of sales. Model year 1988 will be Fiero's last.

Naturally, this provoked outcry and criticism from a number of sectors, particularly the United Auto Workers. Shutting down the Fiero assembly plant—in Pontiac, Michigan—will idle some 1100 workers, roughly half the number employed when the factory ran close to capacity (110,000) in 1984.

UAW critics contend that the inadequacies of the original Fiero—with its make-do suspension and tepid powertrain—plus corporate indifference to the fate of the car, assured its demise. Engine bay fires that led to an '84 recall didn't help much, either.

Pontiac, for its part, cited a shrinking market segment and skyrocketing insurance costs.

The car created a sensation when it ran up first-year

sales of 101,720. In 1985, the total slipped slightly to 90,691, fell to 71,283 in 1986, and then plunged to 47,156 last year.

The 1987 total is about 3000 under the minimum production volume required to keep the Fiero plant running, and '88 sales are running a dismal 40 percent behind '87.

So who's to blame? There's no question that the original Fiero had a number of weak spots, though the current edition is at least up to the level of its prime competition—the Honda CRX, Mazda RX-7 and Toyota MR2.

And there's also no question that the 2-seater segment has suffered. Mazda's RX-7, one of the solid performers in this field, went from sales of 55,696 in '84 to 38,345 in '87.

The MR2 had its best year in '85 with 32,309 sales, then sank to 15,847 last year.

Only the CRX, with its

more utility-oriented interpretation of the 2-seat concept, seems to be bullet-proof. Sales in '84 totaled 48,445, 57,152 in '85, 64,106 in '86 and 48,355 last year as the factory readied for a model changeover.

Current sales for both MR2 and RX-7 are well behind year-ago, while the new CRX seems to be strong as ever.

Pontiac General Manager Mike Losh isn't about to say that Honda has it right and everyone else is wrong, but he does admit the CRX is "clearly different and clearly a competitor."

"But I think what we're also seeing is a change in consumer preferences—a preference for more utility."

"We clearly caught the market at the right time in '84. But it seems apparent that the market wasn't nearly as deep as first-year sales seemed to indicate."

Losh rejects the UAW criticisms.

"I take exception to the implication that the car didn't get any engineering attention until last year. There were lots of ongoing improvements."

"As for marketing, the Fiero actually got a disproportionate share of our resources."

"No question, it's a decision nobody at Pontiac feels very good about. Still, we do feel Fiero did a lot for Pontiac, and at a critical time."

As for how we feel here at PM, we can only say that in contrast to the many anonymous models that come and go, here's one we'll truly miss.

## The Airless Spare

Just when we'd all decided the pneumatic tire was here to stay, along comes Uniroyal Goodrich to say maybe we don't really need inflatability after all. Not in spare tires anyway.

Ever since American cars began shrinking back in the '70s, designers have been trying to dream up ways to retrieve the suddenly precious trunk space once devoted to full-size spare tires. The skinny little inflatable temporary spare, with its range limit of about 3000 miles, has been the most effective response to that challenge so far. This noninflatable newcomer is the la-

*(Please turn to page 56)*



Fiero '88: Performance is competent, looks are world class, but days are numbered.



Airless spare's polyurethane construction technique combines outstanding deformability and resilience with extremely low weight.



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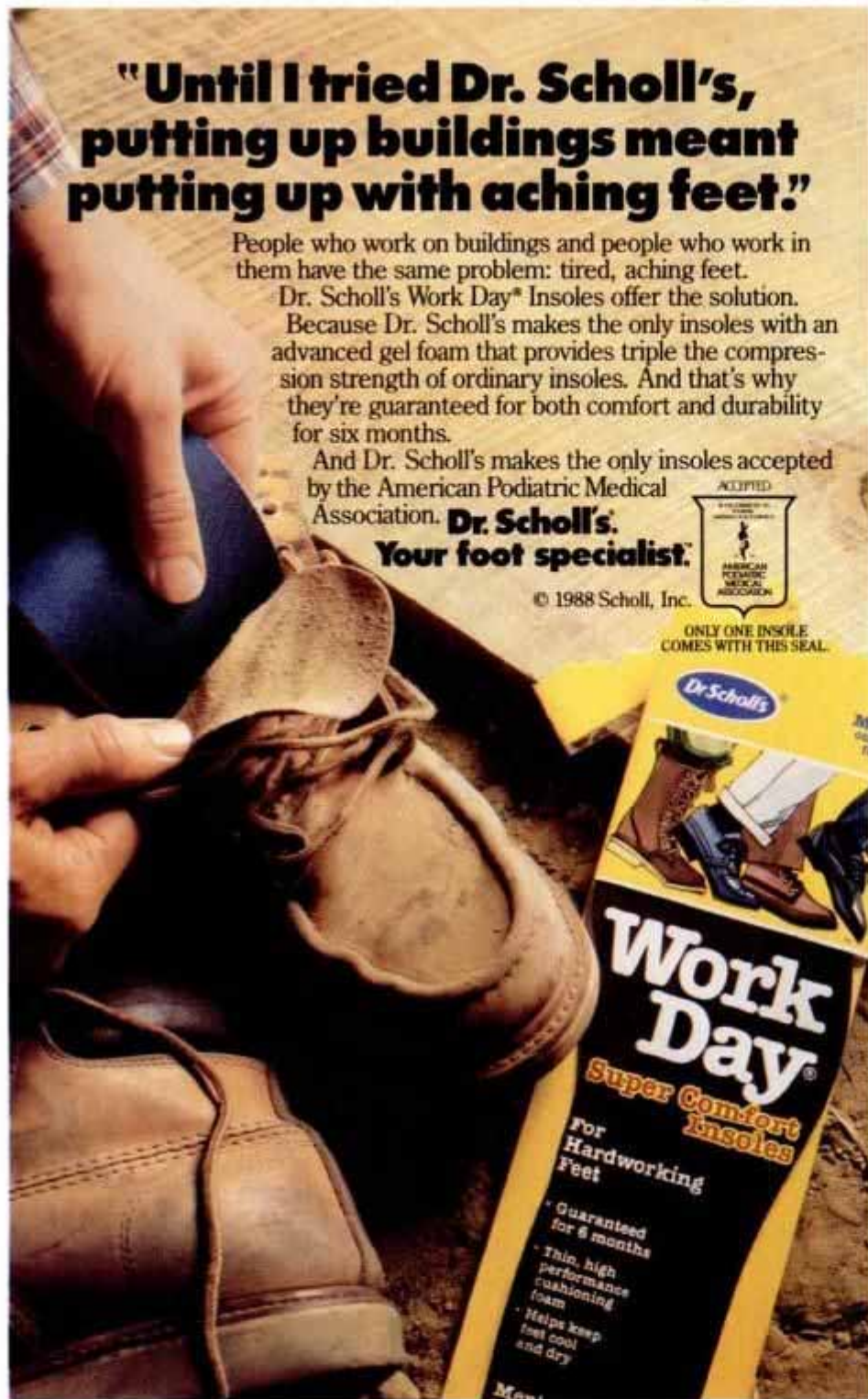
And Dr. Scholl's makes the only insoles accepted by the American Podiatric Medical Association.

**Dr. Scholl's.**  
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ONLY ONE INSOLE COMES WITH THIS SEAL.



## Adventures In Moving

Do-it-yourself moving is one of those activities that normally inspires about as much glee as the prospect of a root canal or your own exclusive appointment with an IRS auditor. But even though this activity will always be low on allure, it's good to know that someone out there has been thinking of ways to make it a little easier.

The latest step forward comes from U-Haul, which has been America's foremost name in d-i-y relocation since World War II. The Phoenix-based company has just announced a new 27-ft. van that employs a number of noteworthy tech touches to get loading height down to just 24 in., which is about half the height of the normal all-purpose rent-a-truck.

The van rides on pneumatic springs, developed by Goodyear, that can be deflated via a dashboard switch for loading, lowering the cargo bed the final 6 in. to the 2-ft. height. The springs reinflate when the ignition is switched on, and also automatically compensate for ride height when the van has been crammed to the ceiling with goods, household or otherwise.

Goodyear also supplies the tires, which are low-profile radials, another unusual feature on a truck of this size, something that applies to the 4-wheel disc brakes as well.

The truck itself is supplied by Navistar, which developed a special dropped chassis for the U-Haul application. Power comes from a 170-hp 7.5-liter diesel mated to a 5-speed manual transmission. An automatic transmission may be available in the future. In the meantime, though, the 5-speed is remarkably easy to drive.

Cargo capacity is 1500 cu. ft., making this the largest d-i-y moving van in the business, about 33 percent bigger than anything U-Haul has previously made available.

For further information on the new U-Haul "Super Movers," contact U-Haul, 2727 N. Central Ave., Phoenix, AZ 85004, (602) 263-6504. **PM**

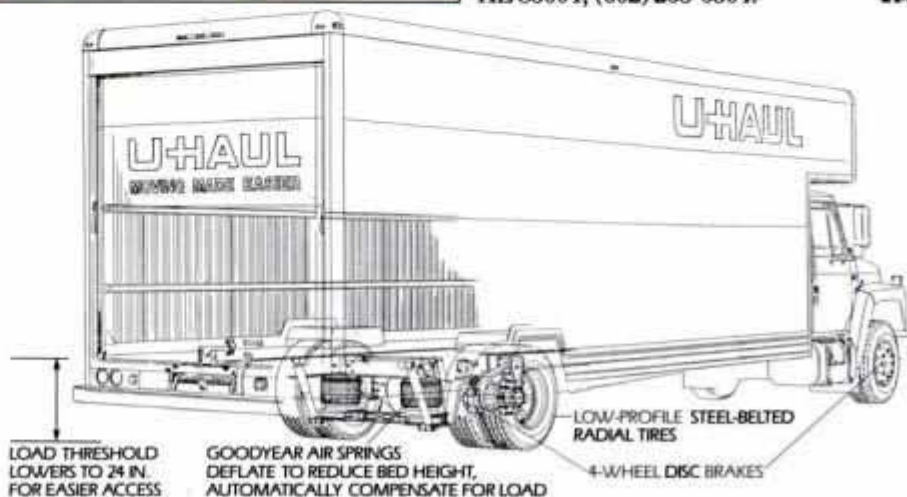
## FREEWHEELING

(Continued from page 54)

test—as well as the most intriguing.

The Uniroyal Goodrich tire uses internal polyurethane cushioning instead of air, making it puncture-proof and highly compact. Its treaded surface is good for 3000 miles, and weight is low.

About the only drawback at this stage of the airless spare's development timetable—installation as original equipment is still some years away—is cost, which runs about 35 percent higher than the inflatables currently used by most manufacturers.





# HINTS FROM READERS

## Unpainting Wood



Searching secondhand furniture dealers and antique shops for that diamond-in-the-rough can be a real time-consuming job. The hard work, however, begins when you go to remove the layers of paint or varnish with a chemical stripper. Next time you start an unpainting project, try this tip. After applying a uniform coat of paint remover, press a sheet of newspaper over the chemical. This seems to reduce evaporation and help the chemical penetrate the wood. You can test whether this process will make a difference on your job by first trying it on an area alongside an application of stripper without the newspaper. —Walter Burton

## Screwdriver I.D.

It seems that whenever I go to my toolbox for a Phillips screwdriver, all I can find are the slot-head variety. To help locate the tool I need, I painted the handles of each type screwdriver a unique color for quick identification. Any bright colors will do. And, I'm always sure which tools are mine when I work with friends. —Scott Baker

## Repairing Threads

When taking my table saw apart to replace the spindle bearings, I forced the height adjustment screw and damaged part of the thread. This prevented normal raising and lowering of the blade. Realizing it was next to impossible to find replacement parts for my old saw, I applied valve grinding compound to the threads and worked the screw back and forth over the damaged area. Now, the height adjustment works great. The same idea can be used to clean rusted threads. —Owen Lower

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For a free copy of Tips on Wood Finishing write to Minwax Co. Inc., Dept. PM-068, P.O. Box 426, Little Falls, NJ 07424.



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## To The Edge Of The Universe

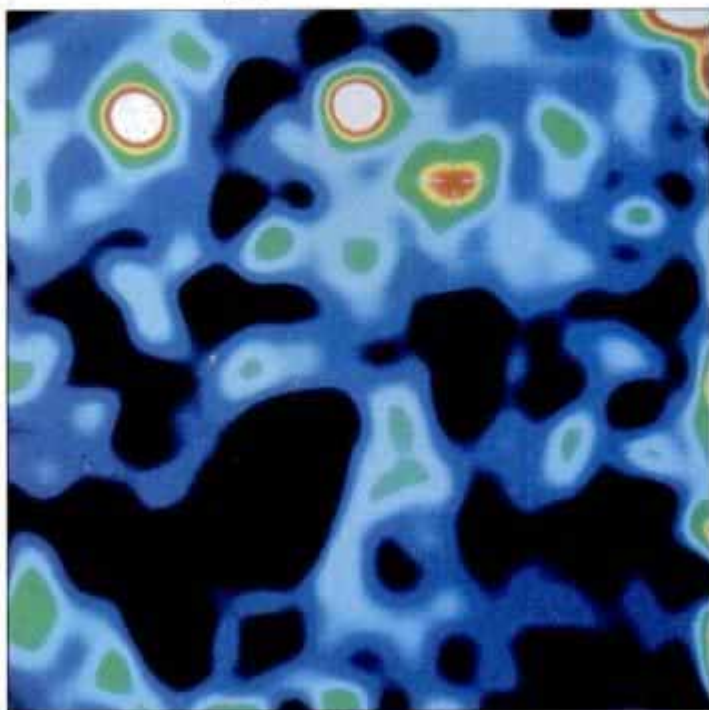
**T**HE DARK shape covered by the crosshairs in the computer-generated image opposite is thought to be an emerging star system 17-billion light years from Earth. If Richard Elston, Marcia Lebofsky Rieke and George Rieke of the University of Arizona are correct, this astrophysical entity may also be the most distant object ever recorded, a primordial galaxy on the very edge of our Universe in the process of forming stars in a brilliant quasar. The Arizona discovery has caused a lot of excitement among astronomers. It's not every day that we're able to peer out to the beginning of time, observing star clusters that are coalescing at the very instant of the Big Bang.

"Basically, to explain these objects, you need a very luminous galaxy, one rapidly making the bulk of its stars," Richard Elston recently told the American Astronomical Society. "But these are also very red, which implies they are at more than redshift 6."

Redshift is an expression that astronomers use to describe the light coming from an object as it shifts toward the red end of the spectrum. A function of the Doppler effect, redshift is a measure of how fast an object is moving away from Earth. Scientists think most galaxies appear at redshift 2—particularly brilliant, newly formed quasars may have a redshift of 4.5.

Exploring the sky at right angles to the plane of the Milky Way, the team scoured the night for objects more than 10,000 times dimmer in the infrared than the background sky itself. The technique yielded numerous objects for each degree of sky covered before they found objects with redshift 6.

Even more amazing is the newly developed technology that allowed the University



Observing the heavens in this day and age means analyzing computer-generated images on a video screen.

of Arizona team to draw a bead on the distant quasar.

Elston fitted the 61-in. telescope at the University of Arizona's Steward Observatory with an infrared camera developed by Marcia Rieke. The 2-micron wavelength camera has a 64x64 grid of heat-sensing detectors positioned on a 1/8-in.-sq. mercury-cadmium-telluride chip. With precisely 4096 detectors in the array, the team could accomplish 4096 times the sensing that old-style, single-element infrared arrays once allowed.

George Rieke says, "If I had started this research

with the detectors available when I started doing infrared astronomy 16 years ago, it literally would have taken the age of the universe to complete it."

### Back To Reality

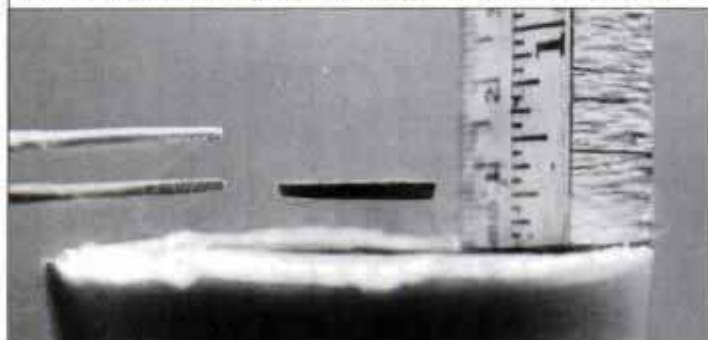
In this issue, on page 78, you'll find a special hallmark of *POPULAR MECHANICS*, an element of this magazine that quite elegantly characterizes who we've been, who we are and who we will be as the magazine approaches its century mark in 2002.

As we've done throughout our history, we're transporting you over the horizon for a

visual peek at the future. We are proposing a time in the middle of the next century when superconducting magnetic levitation has transformed our nation's rail system into a dream machine of speed and comfort. Probability or pipe dream? Regardless of how you feel, it is conceivable that low-temperature superconductivity's cushion of magnetism may one day make high-speed train travel commonplace, a tantalizing promise as transition temperatures of superconducting compounds continue to rise. Scientists at IBM recently mixed thallium, barium, calcium, copper and oxygen to create a superconductor that loses all electrical resistance at 234° below 0° F, the highest temperature recorded to date. Copper oxides that include yttrium and lanthanum have produced superconductors at -321° and -396° F, respectively. The new compound has caused a great deal of excitement in the increasingly feverish quest for high-temperature superconductors. Will the prize ultimately lead to supertrains and magic carpet rides? Not for a long, long time according to Franklin G. Reick, president of Fluoramics Inc., a superconductor development firm in Saddle River, New Jersey.

"The real applications in the reasonable future will be small," according to Reick. "Coils for microwaves. Gyroscopes without mechanical bearings. Infrared detectors for tracking and astronomical measurement. Detectors for external weak magnetic fields. Fast switching devices for certain superfast computers. The successful companies in this field will be the ones that won't necessarily think big."

Reick is right, of course, but it's still okay to dream a little—as we've been doing for nearly a century. **PM**



Meissner effect demonstrated: Magnet floats above superconductor.





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conventional motor oil. Mobil 1 costs more. But more people use it every day—because it doesn't pay to play with fire.

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# The revolutionary Goodyear An entirely new direction in

For years, the challenge in light truck tires has remained the same:

To make a tire that works as well off the road as it does on the road. And vice-versa.



*A Goodyear Wrangler MT "contact patch." Where the Wrangler MT demonstrates its difference and superiority.*

Existing technology did not meet the challenge.

What was needed was a breakthrough in design.

What was needed was the new Goodyear Wrangler MT, the first unidirectional radial light truck tire.

The Wrangler MT radial features a unique "one way" tread pattern.

Because of this unidirectional tread pattern, the Wrangler MT delivers

Maximum Traction in the most severe off-road conditions. Including mud. Sand. And rock.

On the road, the same unidirectional tread pattern gives superior wet and dry traction. Excellent handling. And exceptional treadwear.

The Wrangler MT may be a new idea in radial light truck tires. But it is a proven idea.

During its development, the Wrangler MT was tested. Severely. By ten-time HDRA/SCORE Champion Walker Evans. In actual off-road racing.

As you can see, the Goodyear Wrangler MT is different from other light truck radial tires.

And this difference ultimately shows itself in the most critical area of all: the "contact patches" of the tires. Where your truck or sport vehicle meets and responds to the road. Or the rocks. Or the dirt. Or the mud.

The unidirectional Wrangler MT radial is the newest member of the Wrangler family of light truck tires. And no one else has a radial like it.



**GOODYEAR**

BECAUSE THERE REALLY IS A DIFFERENCE.



# Wrangler MT radial. tread design. And performance.





# TOOL TEST

## Tilting-Head Band Saw



Band saw features a tilting head for bevel cutting. Release bevel lock and turn hand crank to desired angle. LCD reads out bevel angle.

**S**EARS recently introduced a unique, 12-in., electronic band saw for the home workshop that has several worthwhile features. First, unlike most band saws that have

tilting worktables, the Sears tool has a fixed table and a saw head that tilts (up to 45°) for bevel cuts. I found that cutting precise bevels on a flat, stable surface is much easier than working on a slanted table. The tilting-head design also allows the saw to have an extra-large, 23 × 27-in. worktable.

Powered by a 2-speed, 1½-hp motor, the saw operates at 3000 fpm (woodcutting) and 1500 fpm (metalcutting). An electronic LCD indicator provides digital readouts of blade speed, blade tension and bevel angle. The distance from the blade to the throat is 12 in. and it will cut a board up to 6 in. thick.

Other features that I really like include a built-in

worklight and storage cabinet base. The saw even comes with an abrasive belt and platen for conversion to a narrow belt sander.

The saw (model No. 24741) costs \$440 at larger Sears stores and through the Sears 1988 catalog. Contact Sears, Sears Tower, Dept. 703-PM, Chicago, IL 60684.

—Rosario Capotosto



The 12-in. saw comes with a large stationary worktable and a storage cabinet with a shelf behind a molded plastic door.



An electronic LCD readout provides an easy, accurate way to set blade speed (shown), tension and bevel angle up to 45°.



To change blades, remove upper wheel guard and front section of the worktable. The saw accepts 80-in. blades up to ½ in. wide.



With the blade guide raised, the saw can handle 6-in.-thick stock. This is very useful for resawing thick boards into thinner ones.

## Perfectly Square Setup Tool

This electronic device, called Square-It, allows you to test and then adjust various stationary

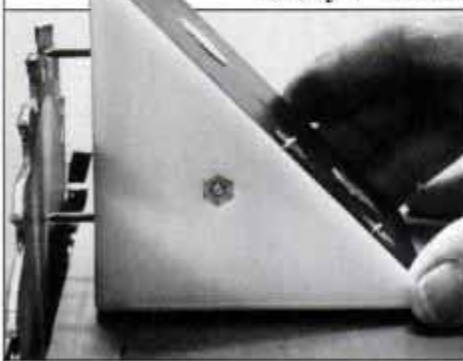
power tools to ensure precise square (90°) and 45° settings. I tried Square-It to adjust several shop tools including a table saw, jointer, radial-arm saw, disc and belt sander, scroll saw, drill press and band saw.

It's very easy to use and, best of all, it requires just a couple of minutes to adjust each tool. Simply touch the square's metal probes to the tool's blade, bit, fence or other metal work surface. If it's

square, a light bulb inside the square will illuminate. When the bulb doesn't light up, adjust the tool slightly until the sides of the square are illuminated. There is a separate set of probes used for checking

45° surfaces. Square-It costs \$54 postpaid from Zac Products, 34 Renwick St., New York, NY 10013. For more details call toll-free (800) 441-0101.

—Rosario Capotosto



To square up a table saw blade, simply touch the blade with the square's two metal probes.



Adjust the blade, if necessary, until the translucent sides of the square light up. Square comes with two AA-size batteries.



Two additional probes are utilized for checking 45° surfaces. Be sure that tool is disconnected from outlet before testing.



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**Profile in Quality #9:** *To many people the quality of a car is the dependability of the car. Not just when it's new, but thousands of miles down the road. Ford's quality is well documented. In nationwide surveys, for 7 years running, owners of Lincoln, Mercury and Ford cars and light trucks have reported fewer problems, on average, than owners of any other vehicles designed and built in North America.\* This dependability is backed by Ford Motor Company's 6 year/60,000 mile powertrain warranty.\*\**



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Ford Motor Company  
has designed and built  
the highest quality  
American cars and trucks  
for 7 years running.**



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\*Based on an average of owner-reported problems in a series of surveys of '81-'87 models designed and built in North America.  
\*\*Restrictions and deductible apply. Ask your dealer for a copy of this limited warranty. **Buckle up—Together we can save lives.**



# AMERICAN FLYERS

Detroit's personal coupes square off  
in a home-grown hoedown.

By RICH TAYLOR, Contributing Editor  
PM Photos by John Lamm

**T**HE BUICK REGAL, Oldsmobile Cutlass Supreme and Pontiac Grand Prix are the most important new General Motors cars in years. They're exciting, dynamic and, most important, different—different from their competitors and different from one another.

All three are built on the same front-wheel-drive GM-10 chassis. But GM, stung by rising criticism of look-alike car lines, took special care to give each



PONTIAC GRAND PRIX SE





OLDSMOBILE CUTLASS SUPREME



FORD THUNDERBIRD SPORT

car distinctive styling, inside and out. The result is a set of handsome triplets, related but not identical.

The GM-10s will ultimately be full car lines, with 4-door sedans and wagons scheduled to appear for 1990, along with a Chevy Monte Carlo built on the same platform. But for now, the three GM sporty coupes will compete side-by-side in the middle-class personal/luxury market against Chrysler's pretty LeBaron and Ford's sleek rear-drive Thunderbird.

To see how the new contenders stack up against the establishment—and each other—we brought them all to the elaborate facilities at Pomona's L.A. County Fairgrounds for a full day of instrumented testing. Then we spent two days driving around the

twisting canyon roads of the San Gabriel Mountains, punctuated by a quick cruise down the freeway to Palm Springs and back.

Thanks to a torrential rain storm that washed away our photo sessions, we even got to spend another three days with the cars a month later. In all, we put thousands of miles on our test cars, in everything from sun-baked desert to high-altitude snow.

### Pontiac Grand Prix SE

When the dust, mud and snow had settled, we found ourselves just about deadlocked on the question of a winner, between two of the GM-10s—the Olds Cutlass Supreme and the rakish Pontiac Grand Prix.

Like most new cars, the base Grand

Prix has a wedge-shaped silhouette with low, pointed nose and high tail. The steeply raked windshield and rear window, flush-mounted glass and trim combine to give the base Grand Prix a coefficient of drag of just .287—the best aerodynamics of any production car ever tested in General Motors' wind tunnel.

From the front, a stylized version of Pontiac's traditional twin nostrils gives the Grand Prix a quickly recognizable face. The rear is dominated by equally distinctive spider-web taillights, contoured to the fender shape. Our SE version also carried aerodynamic rocker panels and road-hugging air dams front and rear. The overall effect is that of an exciting, modern sports machine with a lot of dynamic surface development and visual flair.

If anything, the Grand Prix's interior is even more flamboyant. Our test car was dominated by optional bucket seats—front *and* rear—that just might be the best seats available in any production car. The full-power front buckets go far beyond even expensive aftermarket seats with features like three individual lumbar support adjustments, upper side-bolster adjustment and individually adjustable thigh supports.

Swoopy door handles, an ovoid instrument nacelle and dramatically contrasting gray tones and textures create the high-tech, no-nonsense



Good old V8 torque gives Thunderbird Sport muscle for dragstrip launches and smooth freeway cruising. Ford will not make its V8 available in early models of next Bird, due in 1989.





CHRYSLER LeBARON  
TURBO COUPE

BUICK REGAL  
LIMITED

PONTIAC GRAND PRIX SE

ambience of an expensive biz jet. The controls are arranged as pushbuttons around the edges of the instrument pod, with seat controls split between the center console and the seat sides. The 4-spoke, leather-covered steering wheel has unique swellings at 10 and 2, like an aircraft control wheel.

The unusual instrument panel, mixing familiar mechanical-needle gauges—tachometer, oil pressure, coolant temperature and voltage—with digital speedometer, odometer and bar-type fuel gauge isn't the strongest feature of the Grand Prix dashboard, but gets the job done.

The GM-10 chassis is a straightforward mix of current General Motors technology. The engine is the 2.8-liter V6 used in everything from Cavaliers to S-10 pickups for almost a decade. In the GM-10s, it's supplied in 130-hp tune, bolted to either a 4-speed overdrive automatic, which was the case with all our test cars, or 5-speed Getrag gearbox. There is a MacPherson strut at each wheel, with coil springs in front and a transverse fiberglass leaf spring in the rear, a la Corvette.

Four-wheel disc brakes are standard, though without ABS, and the

sporty SE version we tested comes with both front and rear antiroll bars. The hottest tires available are P215/65R-15 Goodyear Eagle GT+4s. In everyday driving, the Grand Prix is terrific. It'll cruise all day at 80 mph, corners like an IMSA racer, and has a forgiving freeway ride. Four passengers can comfortably travel almost indefinitely, and even the Delco audio system is above reproach.

At the Pomona track, the three GM-10s had nearly identical performance. None was able to break 10 seconds 0-to-60, and quarter-mile acceleration was a full second and 10 mph slower than the Thunderbird or LeBaron. Transient handling was better than the Thunderbird, but not as quick as the nippy little Chrysler.

With a ready-to-race weight of nearly 3300 pounds, the Grand Prix and its siblings are carrying 25 pounds per horsepower—too much for sparkling acceleration. GM's new 165-hp, SFI 3800 V6 would be just about right, as would the higher-powered edition of the Olds Quad 4, which is due for '89. Even on all-season tires, however, the three GM-10s circled the skidpad with excellent performance—flat, stable handling and a

top average of .85 G.

All in all, the Grand Prix is a home run, first time out. You can always find something to criticize on any car, but overall, the Grand Prix SE is just about perfect for its youthful audience. Its bold styling and comfortable interior will impress pedestrians and passengers alike, while its responsive handling and lovely freeway manners will put a smile on the driver's face.

### Oldsmobile Cutlass Supreme

Compared to the flashy, youth-oriented Grand Prix, the Cutlass Supreme is simpler and more elegant. The rounded, aquiline nose is more refined than the Pontiac's, with only a discrete under-bumper air intake. At the rear, the Cutlass has traditional Oldsmobile vertical taillights.

Instead of Pontiac's 5-spoke wheels, the Cutlass Supreme has BBS-style alloy spider-web wheels. These are displayed in open wheelwells, minus the Grand Prix's flares, and the tire size on our International Series was identical to the Grand Prix SE. The Cutlass Supreme SL and International Series also have Mercedes-style lower body cladding.

The most noticeable distinguishing feature of the Cutlass Supreme is an unusual C-pillar treatment, reminiscent of the original Mazda RX-7. In this, the side window glass is brought all the way back to meet the rear win-



dow glass, with no external C-pillar at all. A black edge disguises an interior structural member. Not only is it sleek, it's very different from the other GM-10s.

Inside, Oldsmobile offers terrific optional bucket seats nearly identical to those in the Grand Prix, minus the adjustable thigh bolsters. The Cutlass dash is clean and straightforward, with a square-cut instrument cluster and controls on European-style stalks. The 2-spoke steering wheel is fat-rimmed, though much plainer than the Grand Prix's. Door panels and upholstery are Euro-style functional compared to the Pontiac's radical chic.

The instrumentation in the Cutlass Supreme may very well represent the solution to the ongoing digital versus analog battle. Spread across the dash is a perfect replica of six traditional white-on-black analog gauges, painstakingly executed with vacuum fluorescent technology—a technological tour-de-force that seems to be an effective combination of tradition and tomorrow.

Oldsmobile's engineers calibrate the GM-10 suspension differently than Pontiac's. The Grand Prix is a trifle sportier, requiring a bit of hands-on experience before its advantage in transient response can be fully exploited. The Olds, in contrast, is

more linear in its handling response, and inspires instant confidence. The end result is very nearly the same, however, though the Grand Prix might be a tenth or two quicker on a road-racing circuit.

Everyday driving is the same, too. The Grand Prix seems certain to score with its younger target market, thanks in large measure to its bolder All-American styling and interior, but that's a matter of taste. Many buyers will obviously opt for the more subtle, European flavor of the Cutlass Supreme—and to be honest, we could be equally happy living with either one. It will be interesting to see, a year or two from now, which group of buyers turns out to be larger.

## Buick Regal Limited

The three GM-10s are a perfect reflection of General Motors' new marketing strategy. The idea is to give each division a new, more definitive identity. Thus, Chevrolet is now the youth division, Pontiac builds excitement, Oldsmobile is international and Cadillac is luxury. This leaves Buick to be the traditional division.

As interpreted in the Regal, tradition mandates a vertical Buick waterfall grille, a certain amount of chrome trim, full-width taillights and optional wire-spoke wheelcovers. The roofline is an echo of the turret top used on the

Reatta and Riviera—much more formal than the fastback Grand Prix and Cutlass Supreme. The overall impression is more of a sophisticated 2-door sedan than a sports coupe.

The Regal's interior is solidly in the Buick tradition, with wood-grain on the door panels, dashboard and steering wheel hub. The seats are cushy velour-covered buckets with limited lateral support, the instruments are vacuum fluorescent digitals and the car is available only with an automatic transmission, operated by a column shifter.

On the other hand, the Regal is available with a Gran Sport package that includes firmer suspension tuning, 15-in. alloy wheels and a leather-wrapped steering wheel. An exterior appearance package adds a tasteful front air dam, rocker panel moldings, fog lamps and black-out trim. Even with these sporty options, however, the Regal seems a trifle dowdy compared to the Grand Prix.

Our test Regal came with optional 195/70R-15 GT+4s, included as part of the Gran Sport package. But even this is a suspension tuned more for compliance than hard cornering. The Regal has a smoother freeway ride than either the Grand Prix or the Cutlass, but doesn't quite measure up to its cousins in handling and braking. At the drag strip, the Regal's smaller

Profiles of our American Flyer fleet illustrate impact of aerodynamics on contemporary styling. Buick Regal rates a praiseworthy  $C_d$  of 0.31, Chrysler LeBaron Turbo Coupe a surprisingly high 0.37 and Thunderbird, the group's spiritual progenitor, a so-so 0.34. Grand Prix came in at 0.31 in SE trim, while Cutlass Supreme was group champ at 0.30.



Buick Regal combines traditional luxury cues like wood-grain panelling and velour upholstery with digital instrumentation. Controls for sound system and heating/ventilation are easy to use.



LeBaron Turbo Coupe seems underinstrumented compared to its American Flyer rivals. Special all-white GTC edition is available with analog instrument package.

## SPECIFICATIONS AND DIMENSIONS

MANUFACTURER/ MODEL	PRICE: LIST/ AS TESTED	ENGINE/ DISPLACEMENT (ci/cc)	ENGINE HP, NET/ TORQUE (lb.-ft.)	ENGINE DRIVE LAYOUT	TRANS- MISSION TYPE	WHEEL- BASE (in./mm)	LENGTH OVERALL (in./mm)	WIDTH OVERALL (in./mm)	TRACK FRONT/REAR (in./mm)
<b>Buick Regal Limited</b>	\$15,600/ \$16,572	V6, OHV 173/2835	130 @ 4800 rpm/ 160 @ 3600 rpm	front/ front	4-speed auto	107.5/ 2730	192.2/ 4881	71.8/ 1795	F:59.3/1506 R:58.0/1473
<b>Chrysler LeBaron Turbo Coupe</b>	\$11,295/ \$18,006	L4, SOHC, turbocharged 135/2212	146 @ 5200 rpm/ 170 @ 3600 rpm	front/ front	3-speed auto	100.3/ 2546	184.9/ 4697	68.5/ 1739	F:57.6/1464 R:57.6/1464
<b>Ford Thunderbird Sport</b>	\$15,927/ \$18,795	V8, OHV 302/4950	150 @ 3200 rpm/ 270 @ 2000 rpm	front/ rear	4-speed auto	104.2/ 2605	202.1/ 5052	71.1/ 1778	F:58.1/1476 R:58.5/1486
<b>Oldsmobile Cutlass Supreme</b>	\$15,644/ \$17,883	V6, OHV 173/2835	130 @ 4800 rpm/ 170 @ 3600 rpm	front/ front	4-speed auto	107.5/ 2730	192.1/ 4879	71.0/ 1777	F:59.5/1511 R:58.0/1473
<b>Pontiac Grand Prix SE</b>	\$15,249/ \$17,528	V6, OHV 173/2835	130 @ 4800 rpm/ 170 @ 3600 rpm	front/ front	4-speed auto	107.5/ 2730	193.9/ 4925	71.0/ 1777	F:59.5/1511 R:58.0/1473

1. Best speed achieved while weaving through seven cones placed in-line, 100 ft. apart; speeds provide index of transient response.

2. G-force generated during steady-state travel around a 200-ft.-dia. circle. Chart number represents an average of three circuits clockwise and three counterclockwise.





User-friendly Olds wasn't quite as quick in transitions as Pontiac Grand Prix, but inspired instant confidence for most drivers.

Regal's softer suspension and smaller tire footprint limited cornering capability, but car's freeway ride was best of the three GM-10s.

diameter (by 6mm) tires lowered its effective final drive ratio, giving it a small edge on the Cutlass and Grand Prix.

It's really quite remarkable how General Motors' designers have been able to give these three GM-10s such different personalities. We'd predict that the relatively sedate Regal will appeal to an older customer than the bold Grand Prix, with the elegant Cutlass Supreme falling somewhere between. This is in perfect accord with GM's Master Plan to give each division greater individual identity and its own market niche.

### Ford Thunderbird Sport

Next year, the popular T-bird will be replaced with a new V6-powered coupe that will update the current Bird's svelte lines. The new-generation T-Birds that came along in 1983 were the first of Jack Telnack's aero designs and their success has led directly to Ford's enviable position as a design leader and the most profitable U.S. car company.

Although Ford has one of the industry's more potent V8 engines in its arsenal—the 225-hp HO 5.0-liter that

propels both the Mustang GT and Lincoln Mark VII LSC—the company has chosen to reinforce the T-Bird's high-tech image by powering the flagship Turbo Coupe with a 190-hp 2.3-liter intercooled turbo Four.

Consequently, if you want a V8 Thunderbird, your only choice is the relatively tepid Sport model, limited to 150 hp, 4-speed automatic transmission, a disc/drum braking system without the option of ABS, and relatively tame tires—215/70HR-14 Eagle GTs in contrast to the Turbo Coupe's 225/60VR-16s.

*(Please turn to page 109)*



T-Bird's classic white-on-black analog gauges stood out. Seating wasn't a match for Grand Prix and Cutlass, but delivered good comfort, adjustability.



Pontiac Grand Prix SE: Digital speedometer, though readily readable, seemed inconsistent with ultra-sporty appointments. Color-coded control switches around instrument cowling drew praise.



Cutlass Supreme combines look of analog instruments with vacuum fluorescent technology, for attractive solution to analog versus digital.

### TEST RESULTS

CURB WEIGHT (lbs.)	STEERING TYPE/TURNS LOCK-TO-LOCK	BRAKE SYSTEM FRONT/REAR	FUEL ECONOMY (EPA city/PM test)	ACCELERATION 0-60 MPH (sec.) 1/4-MILE (sec. @ mph)	BRAKING 60-0 MPH (ft.)	700-FT. <sup>1</sup> SLALOM (mph)	SKIDPAD <sup>2</sup> 200-FT. CIRCLE (G)	CARGO <sup>3</sup> VOLUME (cu. ft.)	INTERIOR <sup>4</sup> SPACE INDEX
2953	power rack-and-pinion/2.8	F:10.5-in. vented disc/ R:10.0-in. disc	20/ 21.29	10.05 17.36 @ 79.51	160	60.95	.82	15.7	156.0
2875	power rack-and-pinion/2.5	F:10.0-in. vented disc/ R:7.87-in. drum	20/ 20.66	8.75 16.94 @ 83.22	173	63.29	.79	14.6	156.49
3215	power rack-and-pinion/2.3	F:10.1-in. vented disc/ R:9.0-in. drum	18/ <b>22.60</b>	9.05 16.76 @ 86.90	185	59.98	.76	14.6	146.97
3175	power rack-and-pinion/2.8	F:10.5-in. vented disc/ R:10.0-in. disc	19/ 21.68	10.65 17.72 @ 76.75	152	61.66	.85	16.0	156.47
3113	power rack-and-pinion/2.8	F:10.5-in. vented disc/ R:10.0-in. disc	20/ 20.31	10.60 17.71 @ 76.89	158	61.72	.84	15.0	152.76

3. Indicates maximum cargo volume as determined by EPA calculations with rear seatbacks (when applicable) in normal position.

4. Front-seat width × headroom × legroom + rear-seat width × headroom × legroom + 1000.

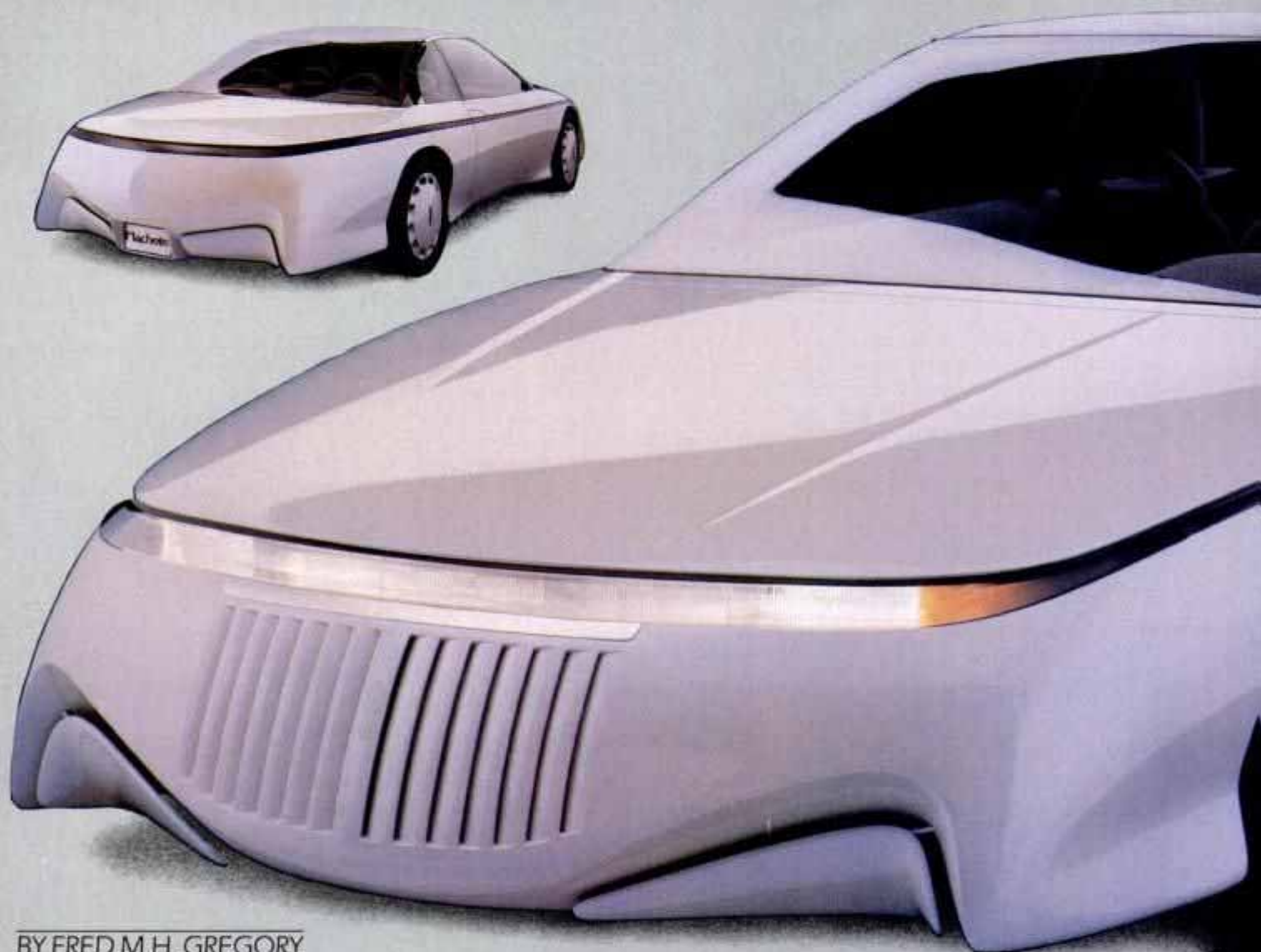




## CAR OF THE FUTURE

PART 6 OF A SERIES

# THE SHAPES OF



BY FRED M.H. GREGORY

**T**HE '50s WERE a wild time for cars in general, and a period of unrestrained exuberance for American designers in particular. Unfettered by the constraints that restrict automotive designers today, stylists ran amok through a landscape of fins, chrome and sculpted metal. Dream cars were popping out of Detroit studios like flowers in spring. Anything was possible. It was the Age of Style.

What's that got to do with the cars we'll be seeing in the future? Well, today it's the same thing all over again, except the stylists have long since taken to calling themselves designers and we're being assaulted by a new onslaught of dream cars (or, if you prefer, concept cars, show cars, cars of the future—they're all the same) from carmakers around the world. Call it the New Age of Style.

And if we compare the two periods, we can get more

than just a hint of what real cars might look like in the not-too-distant future.

Then, as now, there was a lot of hype, and for excellent reasons. Dream cars are a good deal more than just designers' whims. They're carefully calculated commercial projects intended to generate publicity, lure people into auto shows, and raise the general level of interest among potential buyers.

Still, the occasional dream car does reach production virtually unchanged—the Corvette is a classic example. And many design themes, like multiple headlights and wraparound windshields, first appeared on exotic show-stoppers like the General Motors Le Sabre, part of the Motorama entourage in 1950, and Ford's otherworldly 1956 Mystere.

The current bumper crop of dream cars, with a bizarre exception here and there, can also yield hints



# CARS TO COME



Though clearly not of our time, Lincoln's Machete concept car (above and opposite) is less radical in its overall design than many dream machines and thus closer to production likelihood. The Machete's  $C_d$  is a respectable 0.25. Pontiac's swoopy Banshee (below) is just under 4 ft. high and sports a 230-hp 4.0-liter monoblock twin-cam V8. Look for elements of this design in future Firebirds.

about what we'll be seeing well into the next century. And the biggest hint, which comes as no news to anyone, is that everything is going to be "aerodynamic." This can be seen as solidly in keeping with the first law of automotive design: Form follows profit.

There are no other laws.

After the resounding success of Ford's aero cars, an automaker deviates from this theme only at its peril.

That means tomorrow's cars will have softer, more rounded contours, smoother surfaces and, in some cases, seem a little chubbier in appearance. It does *not* mean that they'll all look alike. Jack J. Telnack, Ford's vice president for design, and the man credited with creating the aero look, says, "All birds are aerodynamic, but they have different missions. You can tell the difference between a canary and a vulture. All fish are hydrodynamic, but you can tell the difference between a goldfish and a shark. And it's the same thing with automobiles. They all have different missions. They can all have aero principles, but all look different."

And that, after aero style, will be the second dominant design theme of the future: emphasis of difference. The failure of GM's alphabet approach to design (where the A, J, X or whatever body was shared by almost all the divisions and it became all but impossible for the American car-buying public to tell an Oldsmobile, Pontiac, Buick, Chevrolet or Cadillac from one another at a distance of more than 10 yards) has hammered this lesson into corporate minds.

Nor can one discount the increasing dreariness of the International Style. This is best illustrated by the rise and decline of Giorgetto Giugiaro's design for the original Volkswagen Rabbit. It was all flat planes, boxy corners and crisp lines. The style was appealing, efficient and correct in an energy-conscious time, when there was a reaction against anything superfluous and excessive. Soon, however, every car in that segment adopted the look, and after a

few years, with literally millions of subtle







## CAR OF THE FUTURE

variations populating the streets, it became thoroughly boring.

To keep that sort of thing from happening, Bruno Sacco, the design director for Mercedes-Benz says, "In the future it will be far more important to emphasize and outline the design philosophies of marques."

For companies like Mercedes, BMW and Jaguar, which have worked long and hard to develop their own unique look, that may be easier than for others, particularly the major multiline Japanese firms and GM. It's something GM has been aware of for some time, and its recent spate of dream cars are aimed directly at reestablishing the identities of its divisions. The Corvette Indy is as different from



Chevy's Venture shows how aerodynamics can be compatible with 4-door family cars.

this way: "The name of the game will not be volume anymore. It won't be how efficiently the cookie cutter can be utilized, but how to produce different batches of cookies."

And the ingredients of these cookies and how they're baked will also have a great deal to do with how they look. Tomorrow's designs will be influenced by new kinds of components, materials and manufacturing techniques. We're seeing some of this already. Just look at what designers are doing with the fronts of cars now that they aren't limited by round or square headlights. And there's much more to come. Tom Gale, Chrysler's design chief, says, "When you look at the speed of material development, I think that's one very fertile area for really changing the way an automobile appears."



Offbeat Plymouth Slingshot suggests a dune buggy with wind-tunnel development.

the Pontiac Banshee as the Buick Sceptre is from the Cadillac Voyage. GM's vice president of design, Chuck Jordan, says, "Probably the best example of the direction we're moving would be the Corvette Indy. We think the shape of the car has got to be the design." That is, the identity will be defined by a car's total look and not just by the time-honored practice of adding surface fillips and gewgaws.

Presumably, that means the difference between a Pontiac and a Chevy will be more than just a grille and taillights. Judging from the Japanese dream cars, they have yet to confront the marque identity problem as successfully.

There's still a generic quality to most of them, but some, particularly the playful vehicles like the multicolored Suzuki Jo-Car (a deliberate and apt takeoff on the word joker) and utility models like the Nissan Jura, point to a third major trend of the future—the emergence of completely new cars.

There will be a great many more models rolling into the marketplace, narrowly focused on specific uses, from practical to recreational. Just look at the Plymouth Slingshot, a 2-seat concept car that combines elements of dune buggy, commuter car and sports car. Nothing like it exists today, but there may be a market for such a car in a few years, particularly if it's affordable.

Patrick le Quement, director of Volkswagen's advanced design studio, sees the coming fragmentation

To cite specifics, Gale notes, "We're going to see considerable use of glass as it begins to share surface area that might today be dominated by sheetmetal. We'll see more and more of that, and that's really a revolution in materials technology."

Lighter and stronger materials will also facilitate the design of modular cars. Gerald P. Hirshberg, vice president of design for Nissan Design International in California, the group that designed Nissan's new modular Pulsar, says, "The automobile used to be either right or wrong when you purchased it. Now it's becoming something that can be changed once it's purchased. That kind of relationship is going to be extraordinarily meaningful as we move into the 21st century."







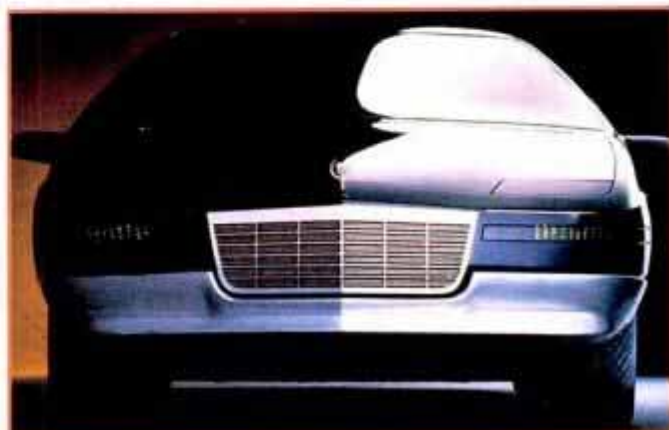
4wd Cadillac Voyage (above and right) is a rolling development lab.

Ah, the 21st century. It's less than 12 years away—not long, especially by the way the auto industry measures time, with new models on the drawing boards—and in the design computers—some five to six years in advance of actual production startup. Which means that today's designers have a pretty good idea of what cars of the new millennium will look like. A far better notion than, say, fashion designers have about women's hemlines in the first year of the next century.

But even though they know specifics on what's coming down the 21st century pike, the car designers aren't talking. While they love to carry on at great length about their general philosophies and speculate about the future in broad terms, getting them to discuss specifics is like trying to get a KGB agent to chat about Soviet espionage techniques.

Still, the exact shape of a fender, or the look of a grille aren't really all that important anymore.

John Schinella, one of Detroit's brightest design talents and director of the new General Motors Advanced Concept Center in California, maintains there's something more important than mere looks: "In the future there's going to be more emphasis on what the real need



of the vehicle is—not just styling. What's that vehicle going to do? Who's the customer, and what's he going to do with it? First you establish those premises and then you design around them. The way the line is drawn isn't going to be as important as clarifying the concept. The fender shape, whatever, that's going to be a given. Those will be right, but now the package has got to be right. What is it that's going to make the customer lay down cold cash and choose one car over another in the showroom?"

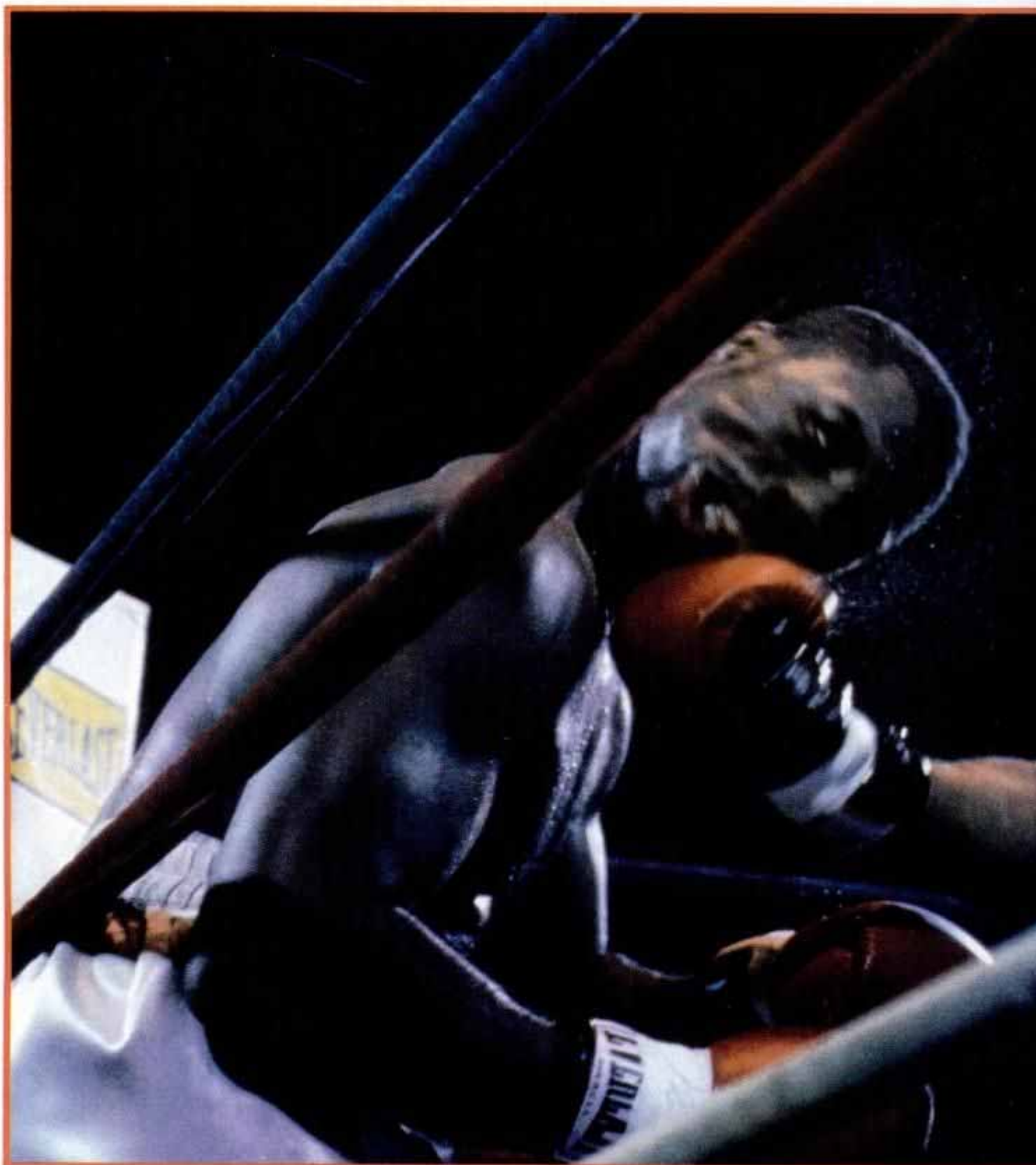
What indeed. Cataloging the possibilities very nearly requires a calculator. But that's precisely what makes speculating about the future of the automobile so much fun. Anything is possible. **FM**



Dodge Intrepid sports a glass canopy and midships 2.2-liter 16-valve turbo.



# The Mechanics Of A **KNOCKOUT**





# PUNCH

The forces and the physiology that can hammer a mighty boxer down for the count.

BY WILLIAM J. HOCHSWENDER

**E**VER SINCE THE Romans conquered the Greeks and changed boxing from an honored military discipline into a blood spectacle for the elite, the knockout has been the goal of the sport. It is one of the few occasions in any athletic contest where symbolic conquest and real conquest merge. It is a kind of death, a small sleep, that rarely becomes real. It can be sudden and categorical—10 seconds in dreamland for the loser, absolute victory for the winner.

It can also be disturbing.

One thinks of Mike Tyson's first round onslaught against Marvis Frazier (shown left), in which a rapid-fire sequence of upper cuts had Frazier's senseless head jerking and bobbing eerily atop his powerful frame. Or the recent Tyson-Larry Holmes finale, where the once-dominant former champion was smashed into a dazed state before succumbing to a punch that snapped his head back violently and sent him flopping to the canvas like a lifeless doll.

Both of these climaxes illustrate important biomechanical and medical points about the nature of the knockout itself—how a fighter loses consciousness, why some boxers are bigger punchers than others, what constitutes a glass jaw, and so on. However, even when it comes to the brute force of the boxing ring, a knockout punch is so subtle and complex that it not only eludes our senses but baffles the understanding of scientists. The so-called sweet science still holds its mysteries.

Certainly boxing, like most other sports, can be appreciated on many levels. The first-time observer at ringside will see and appreciate a much different prizefight than a veteran fan, or even an ex-boxer or trainer. Boxing insiders convincingly offer bits of wisdom that challenge the most educated conclusions of physicians.

Ray Arcel, 88, who has trained 20 world champions, from Barney Ross and Tony Zale to Roberto Duran and Larry Holmes, believes the knockout will always defy analysis. "I've seen guys go down from a light tap and not move," he says. "Of course, generally, there has to be some power behind the blow, but it's not how hard you get hit, but where and when you get hit. I don't think anybody can ever explain it."

He cites the example of Jim Braddock whom he trained to defend his heavyweight title

**Mike Tyson, a well-known practitioner of the knockout punch, plying his trade on the head of fellow heavyweight Marvis Frazier.**





# KNOCKOUT PUNCH

against Joe Louis. "Braddock went out in the first round and hit Louis on the chin and put him on his back. No one could believe it, because he wasn't a puncher. But he could take it. He had been hit harder by guys with more power, and he'd survived. But, then, when Louis hit him, he went down."

Arceel also recalls a strange episode in the career of Ezzard Charles. Charles was a great boxer as a heavyweight champion, and *no one* could knock him out—not even Rocky Marciano, who fought him to a bloody decision. But in the last round of one of Charles' four fights with Jersey Joe Walcott, he got hit with a punch, Arceel remembers, "that could've knocked a wall down. Charles lasted out the round, but the punch, a left hook, left an impression."

The next time the two fighters met, the unstoppable Charles was stopped in the seventh round, flattened by a single left hook that came out of nowhere, and which, Arceel believes, was a carbon copy of the punch he had earlier survived. "He just knew somewhere in his mind that it *should* have knocked him out."

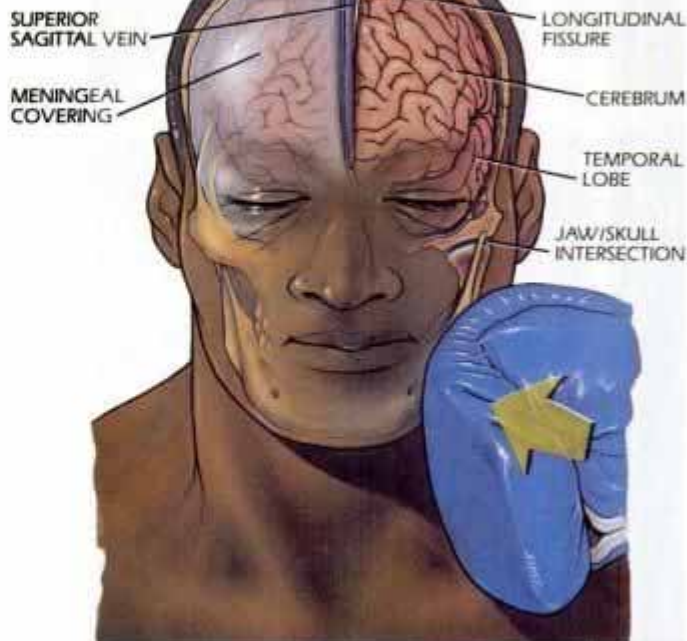
## Medically speaking

Technically, a knockout punch is simply a form of cerebral concussion. It results in either unconsciousness or a groggy state that makes it impossible for the boxer to rise from the canvas or continue. According to Dr. King Liu, a sports-medicine researcher at the University of Iowa Medical School, "A concussion can be defined as a dramatic loss of consciousness caused by a disruption of neurons in the reticular formation in the brain stem."

This means that when a blow is delivered to the head, it causes a variation—what Liu calls a high-pressure gradient—between the brain and the spinal cord, a twisting and tearing of the regulatory cells (neurons) that results in a shutdown. In other words, the jawbone sends a message to the brain: Go to sleep.

Barry D. Jordan, M.D., medical director of the New York State Athletic Commission, divides the knockout

## PRE-IMPACT



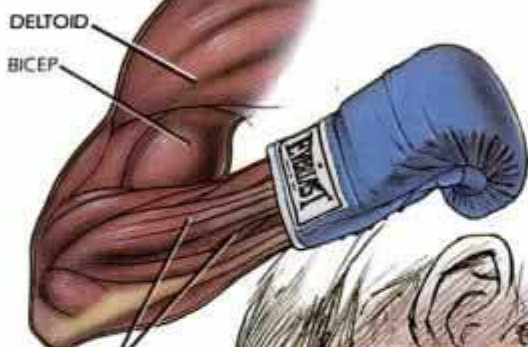
The brain, meninges and attendant blood vessels reside within the protective shell of the skull.

into four categories of severity. In Type 1, the boxer is dazed and unable to defend himself—out on his feet. This commonly results in a technical knockout. Type 2 is when the boxer is knocked to the canvas and cannot rise before the count of 10, yet remains conscious. In type 3, the fighter is knocked unconscious but recovers quickly. Type 4 involves a longer period of unconsciousness.

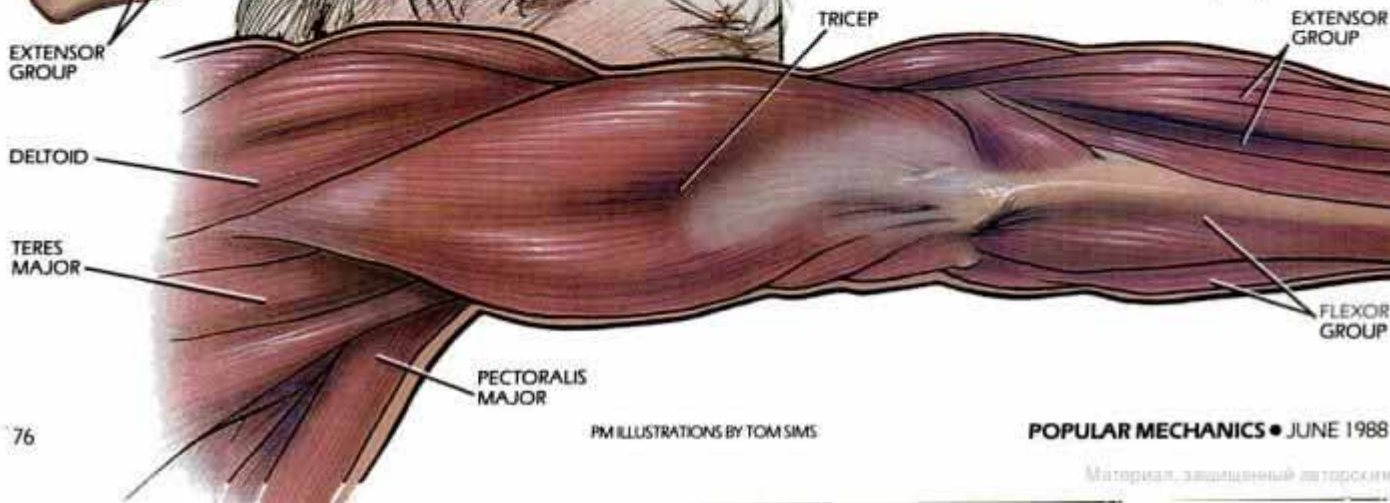
Jordan, who has published original research on the neurological aspects of boxing, is a student of the knockout. "Basically, what causes the KO is rotational acceleration, a spinning of the brain," he says. "Picture the brain as, say, a mushroom or a cauliflower. During a knockout, the stalk doesn't move, but the spin at the top causes you to lose consciousness. That's why headgear won't prevent KOs. It doesn't preclude the acceleration."

Professional boxers can deliver blows with such force to the movable head that the brain smacks against the skull, tearing nerve fibers, the meningeal sac that supports the brain and blood vessels. The direction and power of the blow determines the severity of this tearing.

## PRE-PUNCH



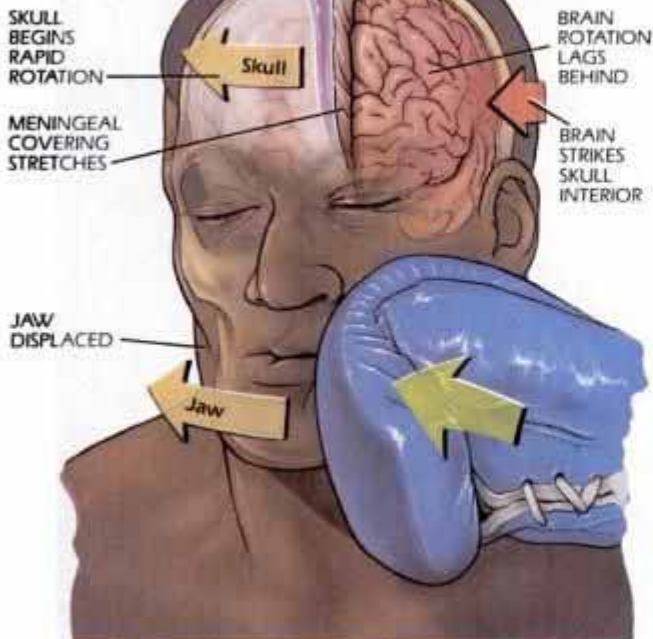
## PUNCH



A knockout punch can begin at the feet, ripple through the torso, and culminate with a complex interaction of several muscle groups in the arm.

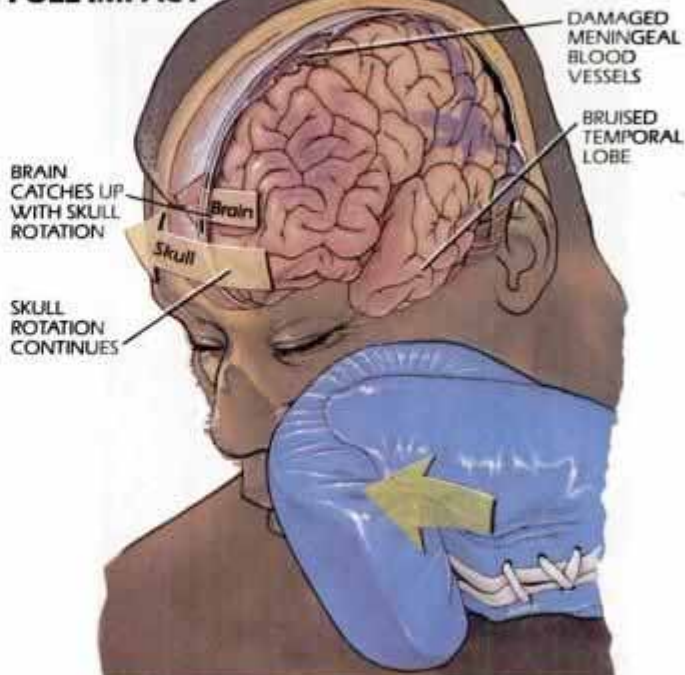


## MID-IMPACT



A blow to the head begins a rapid rotation of the skull, bruising the brain and meningeal covering.

## FULL IMPACT



Rotation of the brain relative to the brain stem and the collision of brain with skull results in a knockout.

## A question of physics

There are two basic kinds of acceleration: rotational (or angular) and linear (or translational). The former tends to be caused by roundhouse punches or hooks, the latter by straight shots. According to Dr. Jordan, linear acceleration, caused by a punch that sends the head straight back, is not as likely to cause a KO. But, as he points out, "Obvi-

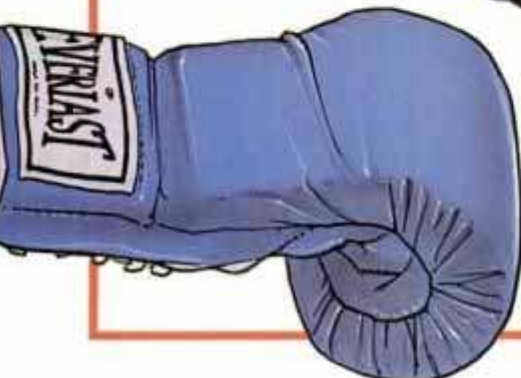
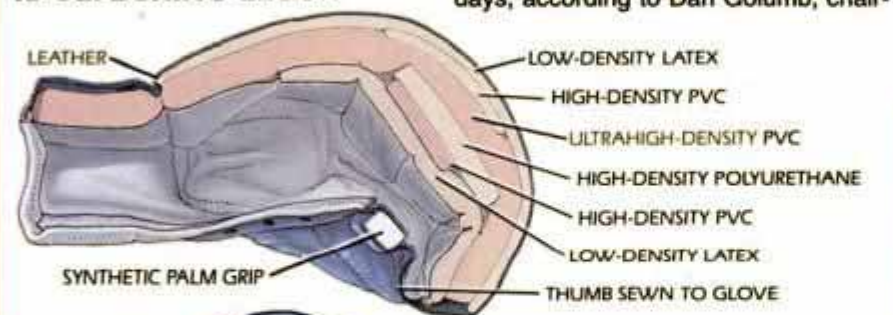
ously, the right amount of force can cause a KO: It depends on where it is applied."

Referring to the Tyson-Holmes bout, Jordan observes that the first knockdown, a right to Holmes' temple—an example of linear or translational movement—did cause acceleration. It left the former champ rubber-legged and uncoordinated—a Type 1 state. [\(Please turn to page 112\)](#)

## PROTECTION FOR THE PUGILIST

**T**ED "KID" LEWIS climbed into the ring in 1914 wearing rudimentary protective headgear—along with a tooth guard—and changed boxing for-

### 12-OZ. BOXING GLOVE



ever. In this early instance, however, the equipment was designed to prevent cosmetic injuries, not ward off knockouts. Indeed, protecting the puncher was considered more important in those early days, according to Dan Golumb, chair-

Triple-density foam encased in leather limits head injury, particularly the cauliflower ear. Still, no amount of polyurethane, PVC or latex can diminish rapid skull rotation—and the KOs that often result.—T.C.

### OLYMPIC HEADGEAR



man of Everlast. He points out that the first gloves were nothing more than skintight leather mits meant to help a boxer avoid hand injuries. So much for the victim. These days, equipment is designed with the punchee in mind. Multidensity synthetic foams absorb the loading that would otherwise be transmitted to an opponent's vitals. Sewing up the thumb dramatically reduces eye damage.



**COVER STORY**

# SUPERTRAIN

New superconductors rekindle interest in levitated locomotives.

BY GREGORY T. POPE

CONDUCTIVE ALUMINUM GUIDEWAY SHEET

3-PHASE PROPULSION WINDING

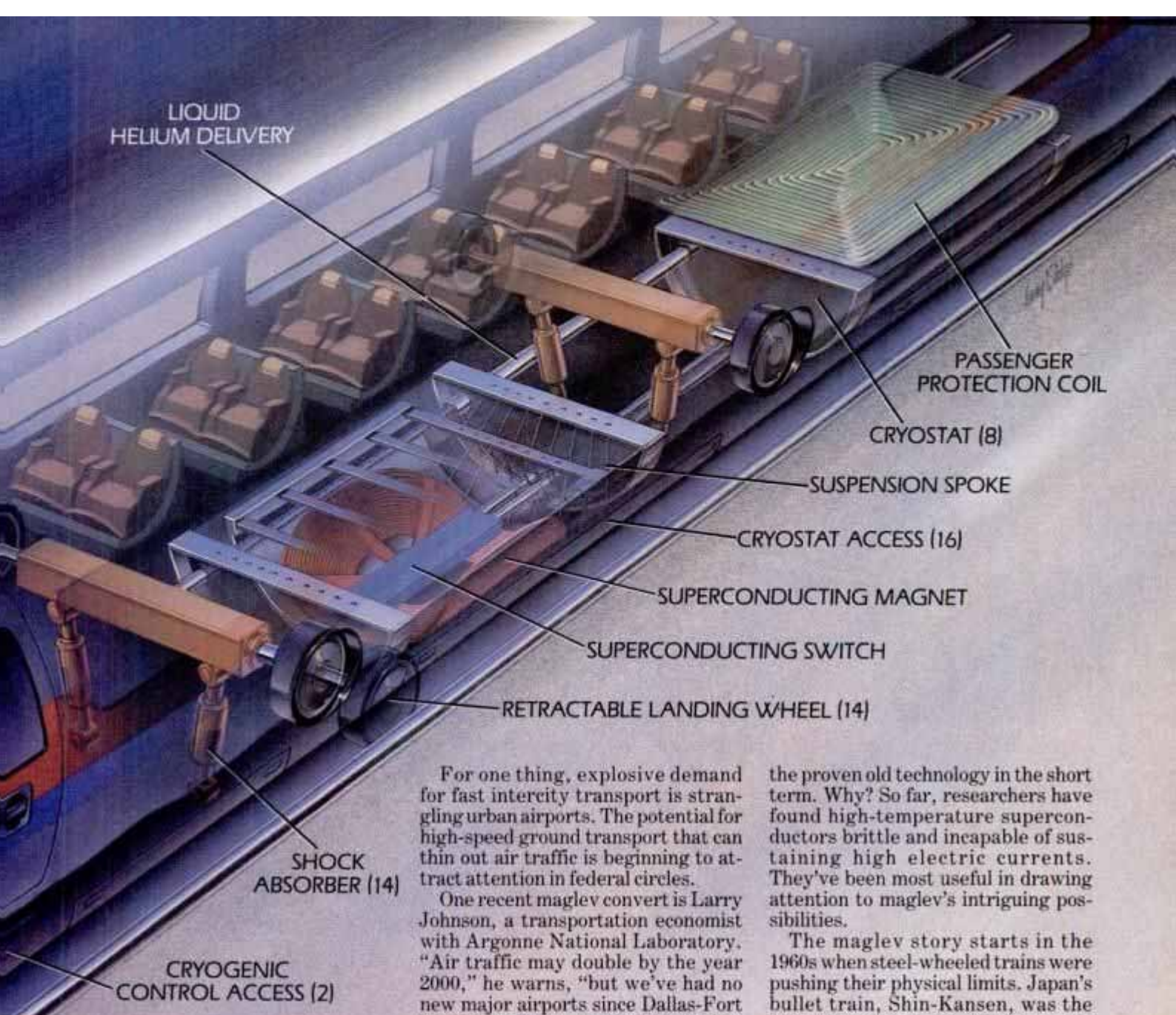
ESCAPE HATCH

ANTENNA

RIM TRACK FOR LANDING WHEELS

A U.S. maglev concept, Magneplane floats on magnetic cushion. Superconducting magnets, housed in semicylindrical cryostats along vehicle's belly, provide lift by inducing opposing eddy currents in guideway's conductive sheet. Retractable landing wheels deploy at speeds under 40 mph. Propulsion winding in guideway track carries electromagnetic wave that pulls train's magnets.





**L**AS VEGAS, June 1, 2050—With 96 Los Angeles-bound passengers, the aerodynamic 1-car train begins its descent from the elevated station. Hard plastic wheels roll along the rims of the track, or guideway, and hum as the train gains speed. Thirty mph . . . 40 . . . then the wheels retract into the body of the vehicle as it reaches a straight "acceleration track." Suspended a foot off the guideway, the train gains momentum until it slices through the air at 300 mph, hissing like a huge rigid snake.

We're riding aboard a maglev, or magnetically levitated train. A long time coming, this futuristic shuttle has already arrived in certain areas of the world. The technology behind its floating magic has been feasible for over a decade. But only recently have developments taken place that could lead to the United States' first commercial maglev.

For one thing, explosive demand for fast intercity transport is strangling urban airports. The potential for high-speed ground transport that can thin out air traffic is beginning to attract attention in federal circles.

One recent maglev convert is Larry Johnson, a transportation economist with Argonne National Laboratory. "Air traffic may double by the year 2000," he warns, "but we've had no new major airports since Dallas-Fort Worth. Maglevs can link downtown areas 200 to 400 miles apart much faster than airport connections."

Last year's breakthrough in high-temperature superconductivity furnished another incentive for an American maglev. Suddenly researchers are scrambling to find work for the new superconductors, ceramics that carry electricity without resistance when chilled with liquid nitrogen. One potential large-scale application: Powerful yet compact electromagnets. The near-term maglevs of the 1990s may fly on conventional electromagnets. But the maglevs of the 21st century will float on so-called electrodynamic suspension systems that depend on big magnets made of superconducting materials cooled with liquid helium.

The new-technology nitrogen-cooled superconductors would use far simpler refrigeration systems. But both American and Japanese maglev engineers say they're sticking with

the proven old technology in the short term. Why? So far, researchers have found high-temperature superconductors brittle and incapable of sustaining high electric currents. They've been most useful in drawing attention to maglev's intriguing possibilities.

The maglev story starts in the 1960s when steel-wheeled trains were pushing their physical limits. Japan's bullet train, Shin-Kansen, was the first to top 125 mph, but its tracks need nightly realignment. Today's wheeled speed-recordholder, France's 163-mph TGV, runs on tracks that can't deviate by more than 0.16 in. without risking derailment.

Backed by their governments, American, Canadian, British, German, Romanian and Japanese researchers began studies. The motivations were clear: Besides solving transportation worries, maglevs would be environmentally benign, use  $\frac{1}{10}$ th the energy of electric trains, and need less maintenance, thanks to friction-free locomotion. But in 1975, while overseas maglev projects took off, the U.S. initiative was abruptly grounded by a funding cutoff.

### Push or pull

Today, maglev concepts exist in various stages of maturity. They call for either attraction (electromagnetic) or repulsion (electrodynamic) suspension to get off the ground.



## SUPERTRAIN

Around the world by maglev (clockwise from top): Japan's electromagnetic 100-mph HSST, slated for Las Vegas; England's electromagnetic 25-mph Birmingham people mover, proposed for Atlantic City, N.J.; Japan's electrodynamic 250-mph MLU, still in prototype stage; West Germany's electromagnetic Transrapid, one generation from commercial service and current maglev speed king at 252 mph.



HSST PHOTO



TRANSRAPID PHOTO



AMERICAN MAGLEV PHOTO



JAPAN RAILWAYS PHOTO

With attraction suspension, the car carries conventional electromagnets powered by on-board batteries. The magnets—cobalt-samarium coils wrapping iron cores—line the inner lip of a flange on the car that's slung beneath the rails. Once powered up, the magnets in the flange are attracted upward toward the rails, and the vehicle defies gravity. With the repulsion system, magnetic force generated by cryogenic coils in the belly of the train push against an opposing magnetic force in the guideway.

Right now, attraction systems are closer to revenue operation than repulsion levitation. In Birmingham, England a low-speed electromagnetic people mover—the world's only operating maglev—has shuttled passengers from rail station to airport since 1985. An American company is working to implement the Birmingham system in Atlantic City, at New York's LaGuardia Airport, and even in the subway tunnels of Manhattan. Meanwhile, by 1990 Japan's intermediate-speed HSST—which carried Emperor Hirohito among 600,000

Expo '85 visitors—will be whisking gamblers from downtown Las Vegas to the casino strip.

But neither system is designed to top 125 mph. High-speed electromagnetic levitation is the exclusive domain of Transrapid. A product of a government-supported West German industrial consortium, Transrapid is the only high-speed maglev that is one generation away from commercial reality. In December 1987, a 196-seat prototype set a maglev speed record of 252 mph. How does Transrapid reach its breakneck velocity? Like all maglevs, its propulsion system is based on a linear motor. Consider an ordinary rotary-type magnetic motor. Current-fed coils on the external stator produce a coordinated magnetic force that turns the internal rotor. Now imagine cutting the motor and laying it out flat. Instead of rotating, the magnetic force races along a line.

In Transrapid, wayside power substations feed current to the guideway. A computer tracks the position of the train and energizes only the section of the guideway over which the train is

moving. The current surges through 3-phase windings along the bottom of the twin rails, generating a traveling magnetic force.

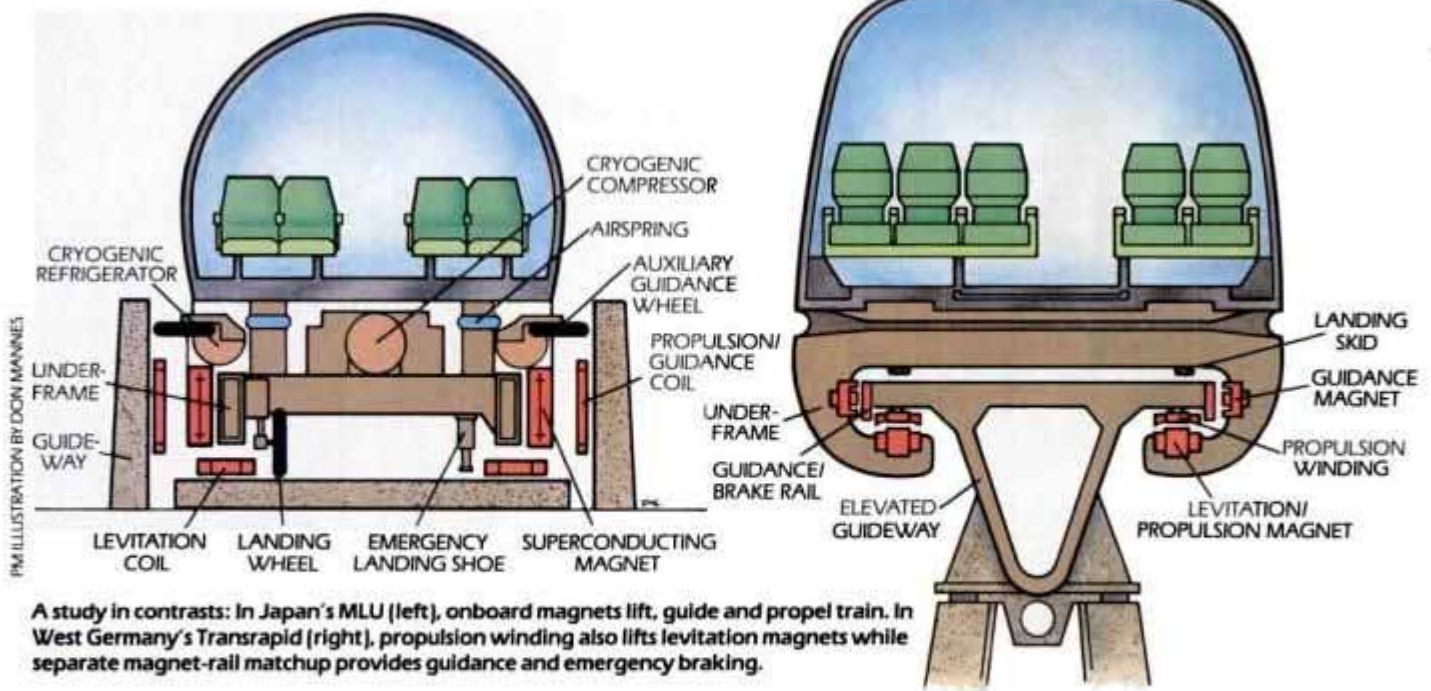
The train rides like a surfboard on this magnetic wave, which grips and propels the vehicle's levitation electromagnets. Speed is controlled by adjusting the voltage and frequency of the guideway current. This current also induces currents in supplementary coils on the vehicle—those coils charge the on-board batteries. Meanwhile, a second set of magnets keeps the train aligned with the rails.

But there's one major drawback in an electromagnetic suspension system like Transrapid—inherent instability. The attraction force becomes stronger if the vehicle's magnets approach the rail. Keeping a constant clearance gap—about  $\frac{3}{8}$  in.—is essential. For Transrapid, that has meant very precise track construction and a complex suspension control system. Sensors constantly monitor the gaps and send information to a microprocessor that adjusts the current flowing to the electromagnets. If



## ELECTRODYNAMIC (REPULSION) SYSTEM

## ELECTROMAGNETIC (ATTRACTION) SYSTEM



A study in contrasts: In Japan's MLU (left), onboard magnets lift, guide and propel train. In West Germany's Transrapid (right), propulsion winding also lifts levitation magnets while separate magnet-rail matchup provides guidance and emergency braking.

track flaws or vibrations bring the magnets too close to the rail, power is lowered and the attraction force weakens.

Attraction levitation—though a more mature technology—may be overtaken by repulsion levitation because of the stability problem. At the moment, two repulsion-mode systems look most promising for high-speed applications. One is a full-scale experimental Japanese maglev: the MLU. The other is Magneplane, the radical American design mothballed in 1975 after the cash flow dried up.

Electrodynamic, or repulsion, suspension works like this: A current runs around a moving coil that passes over a stationary coil. The current triggers magnetic flux which penetrates more and more of the passive coil as the moving coil passes over it. As long as the magnetic flux through the passive coil is either increasing or decreasing, it induces an opposite current in the passive coil which repels the moving coil. That repulsion generates lift. Only when the moving coil is directly over the passive coil is there no change in flux. The repulsion weakens, causing drag.

Put a series of coils on a moving maglev vehicle and stationary coils in a guideway, and you have an electrodynamic suspension system. The faster you go, the less time the moving coils spend directly over the passive coils. That means that electrodynamic drag, unlike aerodynamic drag, decreases with increasing speed. Like a plane at takeoff, an electrodynamic maglev rolls on wheels until it's moving fast enough for lift to overcome drag—usually at 40 to 50 mph.

But the real benefit to electrodynamic suspension is its natural stability. The repulsion force increases sharply if the vehicle coil approaches the guideway coil. Moreover, equipped with powerful superconducting magnets, the trains can float a foot off the guideway. That's more than enough room to tolerate guideway flaws.

Since the early 1970s the Japanese Railways Group (JRG) has been testing repulsion-levitation vehicles, the latest of which hit 250 mph. The system has basic electrodynamic suspension: passive coils sunk into a concrete guideway, with superconducting magnets on board the vehicle. Mount-

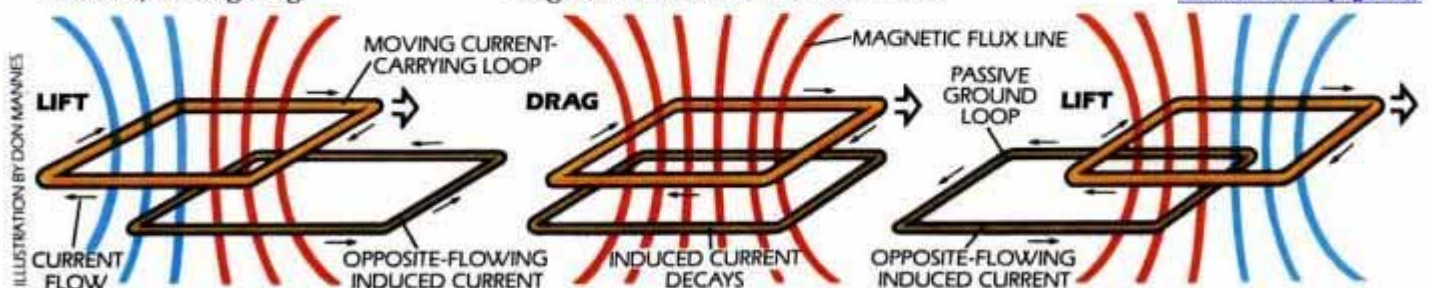
ed along the vertical sides of the guideway—face-to-face with the superconducting magnets—are coils linked by cable. Charged in rapid succession, they whisk the vehicle up to speed. Magnetic fields generated by these side coils also keep the vehicle lined up above the levitation coils.

The Japanese maglev has farther to go to reach commercial reality than Transrapid. On-board refrigeration is still a major hurdle. Though they use much less power than Transrapid's electromagnets, the superconducting magnets must be chilled reliably to  $-452^{\circ}\text{F}$ . That requires complex, maintenance-intensive liquid-helium cryogenics. JRG engineers have made progress in shrinking the cryogenic apparatus, and they are currently experimenting with an integrated magnet-cryostat cassette.

Maneuverability is another question mark. The Japanese have tested their train only on a straightline run, whereas the Transrapid test track includes loops that the train handles easily.

Even farther down the line is Magneplane, the United States' best hope

*(Please turn to page 114)*



Repulsion levitation simplified: Current-carrying loop (as in a magnetic coil) moves over stationary passive ground loop. Lift occurs when magnetic flux penetration (in red) increases or decreases. Drag occurs when moving loop is directly overhead and diminishes at higher speeds.



**PM  
COMPARISON  
TEST**

# OFFSHORE POWER PLAY

Salt spray flies as we make a blue-water assault on five wave-busting fish battlers.

BY JOE SKORUPA  
Boating/Outdoors Editor  
PM Photos by Skip Gandy

**B**LUEWATER fishing is serious business. To a crew out in the rollers of the Gulf Stream or an offshore canyon, a boat is much more than a recreational toy. It's a fishing machine.

Boats like these are held to an exacting standard, a rigorous combination of seaworthiness and fish-fighting support known as fishability. And that's exactly what we looked for in a fleet of top walkaround cabin models recently assembled in Miami.

The five offshore test boats were outfitted with twin, counter-rotating, 150-hp Yamaha outboards, and put through a battery of tests. The boats were the Aquasport 250 Express Fisherman, Grady-White Sailfish 255, Hydra-Sports 2500 WA, Pursuit 2550 Cuddy Cabin Outboard and Seawolf 26 Walk Around Cuddy.

We selected our winner after a se-

ries of speed tests, measurements and observations, but our ultimate criterion was fishability, a unified blending of sport-tech form and function.

The boats in our test fleet carried dream-machine price tags—\$40,000 to \$50,000. But the value was there in terms of impressive performance and quality of design and workmanship—much of it reflecting the signs of hand craftsmanship rather than the assembly line.

## Grady-White Sailfish 255

It's easy to see why Grady-Whites are limited-production boats. The Sailfish 255 finished ahead of the fleet in five of the eight ranked categories and second in top-end speed. This combination of careful design and outstanding performance made it the boat our test team would most like to take offshore for trophy billfish.



Hull re-entry after a prop-out water leap is about to be tested by the highflying Seawolf 26 WA Cuddy. Racing for open sea (left, from the top) are the Seawolf 26, Hydra-Sports 2500 WA, Aquasport 250 Express, Grady-White Sailfish 255 and Pursuit 2550 WA Cuddy.





SEAWOLF 26

SEAWOLF  
2600 CC



# OFFSHORE POWER PLAY



**PURSUIT 2550 CUDDY CABIN**

Most impressive were the test winner's remarkable seaworthiness and masterly fit and finish. The Sailfish 255 knifed through rollers like a Mercedes of the water. It ran with an exceptionally soft re-entry through the chop and its reverse chines threw salt spray well away from the cockpit.

Superb attention to detail showed in the built-in tackle box, washdown pump, molded-in anchor locker, fold-down, motor-well bulkhead and well-appointed hot/cold galley.

The boat's wide 9-ft. 6-in. beam, gave it room to post winning numbers in stowage, cockpit, cabin and sleeping pad space. But it also added weight, which accounts for the 4375-pound boat's last-place times on handling and hole-shot runs.

High windscreens with opening side vents, splash cover on gauges, and enclosed radio box were nice helm touches, although throttle was a bit too high and forward for comfortable access to wide-open position.

Price was another category where the Sailfish 255 led the fleet, about \$49,000 (with twin Yamaha 150s, roughly \$16,000), but our winner allows no compromise on quality and the result is the consummate fish battler.

## Pursuit 2550 Cuddy

Fleet-leading top-end speed and second-place finishes in acceleration runs and performance course times made the Pursuit 2550 Cuddy a driver's favorite. It was a solid wavebuster in a choppy sea and a dry one, too, due to

its well-placed reverse hull chines.

From its distinctive pearl-gray hull to its hinged motor-well bulkhead, which keeps out water and engine noise, the Pursuit showed a thoughtful craftsman's flair. Through-gunnel aft cleats with hawse plates, rubber-sealed hatch locks, big self-bailing scuppers, plexiglass gauge cover and molded-in gas fill were among many outstanding design details.

Visibility forward was good, except for an annoying windshield wiper motor. View of two dash-mounted monitors—showing rpm, oil level and trim level—was also fine. But looking down to check side-mounted gauges—gas, oil pressure and voltmeter—took some getting used to.

The cabin was somewhat dark, due to the selection of small, opening cross hatches, but ventilation was good because of large entryway and skylight hatches. Sleeping pad was second largest in the fleet.

The superbly crafted Pursuit was second to none in perhaps the most important area—it placed within the top three in all test categories, the most consistent boat in the fleet.

## Hydra-Sports 2500 WA

Outstanding offshore performance is the name of the game for the Hydra-Sports 2500 WA, which ran as

### TEST PARAMETERS

Each boat was propped and tuned by Yamaha. All were equipped with twin, counter-rotating Yamaha 150-hp outboards. Top-end, acceleration and performance course figures are the result of averaging four test runs for each boat with two adults aboard and matched fuel loads. The performance course began from a dead stop and included full-throttle 90° and 180° turns. Test site was Biscayne Bay, Miami.



#### OVERALL RANKING/MAKE/MODEL

1. GRADY-WHITE SAILFISH 255

2. PURSUIT 2550 CUDDY CABIN

#### LOA/Beam/Weight/Fuel Capacity

25'4"/114"/4375 lb./198 gal.

24'9"/102"/3400 lb./149 gal.

#### Cockpit Area (sq. ft.)/Ranking

54.94/1, open, obstruction-free space

53.6/3, roomy, with optional padded seating areas

#### Stowage (cu. ft.)/Ranking

44.76/1, immense insulated boxes to store fish

28.34/3, adequate for fish, less so for gear

#### Cabin (cu. ft.)/Ranking

183.5/1, copious with all the comforts of home

168.2/3, somewhat dark, but good ventilation

#### Top End (mph)/Ranking

45.38/2, surprisingly swift for its weight

45.88/1, eats up water between fishing spots

#### Acceleration 0-35 mph (sec.)/Ranking

6.92/5, heavy hull held it back

6.35/2, jumps up on plane

#### Performance Course (sec.)/Ranking

35.88/5, sluggish but smooth as a Mercedes in a chop

33.59/2, smooth, rattle-free and dry at speed

#### Sleeping Pad (sq. ft.)/Ranking

46.16/1, only boat that sleeps 3 comfortably

41.85/2, spacious for 2

#### Fit-and-Finish/Ranking

Uncompromising from plush cabin to stout hardware/1

Superb attention to detail/2 (tied)

#### Price as tested (including twin Yamahas)

\$49,000

\$43,000

#### Address

Grady-White Boats, P.O. Box 1527, Greenville, NC 27835, (919) 752-2111

S2 Yachts, 725 E. 40th St., Holland, MI 49423, (616) 392-7163

Three-hundred horses of counter-rotating Yamaha power gave the boats a highly maneuverable, torque-free ride.



Step-up seat deck offers superb forward visibility. Controls and dash gauges are easily accessible.



Side-mounted panel takes getting used to, but visibility forward and seat comfort are superb.





smoothly as a sports sedan through the rollers and tied with Pursuit for a No. 2 ranking in overall fit and finish.

Despite middle numbers in acceleration and top-end speeds, the 2500 WA blew away the competition on the performance course. Out in the chop, it knifed dryly through the waves with a soft hull re-entry.

Stowage space, which had lots of room for tackle boxes and coolers, was notably generous, second largest in the fleet. Sleeping pad was adequate. But total cabin space and cockpit area, although well laid out, weren't among the leaders.

Molded fiberglass, teak and outfitting work were cut, finished and supported to perfection. We especially liked the big self-bailing scuppers, stout hardware, well lit and ventilated cabin, wing vents in windscreen, heavy-duty nonskid deck surface, and molded-in anchor locker.

Command station was among the best in the fleet and exceptionally user-friendly, with a high, tight gauge pattern on the dash, excellent forward visibility, comfortable throttle position and large open area for additional electronic instruments.

With the second-lowest price tag in the fleet, the Hydra-Sports 2500 WA is among the highest in offshore, wavebusting value.



GRADY-WHITE SAILFISH 255

### Seawolf 26

The beauty of a walkaround cabin is that it provides shelter from the elements, *plus* a 360° fishing radius, two areas where the Seawolf 26 places special emphasis.

Second-place finishes in cockpit area and cabin volume, which includes the tallest standing headroom in the fleet, gave the Seawolf room to fight fish and space for creature comfort. Stowage, however, was the smallest of the fleet, as was the sleeping pad. And the cabin, despite its roominess, was dark and exposed a fair amount of naked fiberglass.

Sports-car speed and handling may not be vital in a fishing boat and they aren't strong points for the Seawolf. Top-end, hole-shot

and performance course results were off the pace. Hull re-entry in the chop was also a bit hard, with noticeable rattling and cabin flex.

Minor problems at the helm were a slightly obstructed forward view due to the tall cabin, low throttle and sightline obstruction of gauges. The driver has a step-pad to increase forward visibility while standing. Companion seat needs one as well. Both need footrests in seated position.

On the upside, the Seawolf was a fundamentally solid fishing machine. The brand-new boat's design glitches are correctable and will likely be worked out as this model in Watkins Yacht's new powerboat line finds its niche in the market.

*(Please turn to page 136)*



#### 3. HYDRA-SPORTS 2500 WA

25'96"/3200 lb./164 gal.

49.35/4, adequate space, open layout

42.93/2, large fish boxes and rounded livewell

143.22/5, small but comfortable

44.5/3, fast enough to cover a wide range

6.66/4, within a fraction of the leaders

33.15/1, superb handling makes up for raw speed

39.31/3, sufficient for overnighters

Shows a craftsman's touch/2 (tied)

\$41,000

Hydra-Sports, 100 Oceanside Dr., Nashville, TN 37204, (615) 385-3652

#### 4. SEAWOLF 26

25'10"/102"/4150 lb./195 gal.

54.69/2, plentiful fighting room

25.9/5, large oval livewell, surprisingly small fish box

177.78/2, extraordinary standing headroom

43.38/5, off the pace but won't be noticeable in rollers

6.46/3, not far off despite second heaviest hull

35.07/4, tended to misbehave in hard turns

38.19/5, functional but smallest of fleet

Needs to eliminate rattling and cabin flex/3

\$44,500

Watkins Yachts, 12645 49th St. N., Clearwater, FL 34622, (813) 573-3684

#### 5. AQUASPORT 250 EXPRESS FISHERMAN

26'4"/96"/2900 lb./125 gal.

40.1/5, smallest by far

26.15/4, limited space in fish boxes

146.85/4, although small, bright and well ventilated

43.88/4, fast enough for fishing and recreational use

5.89/1, it leaped out of water at touch of throttle

34.43/3, hole-shot speed made up for misbehavior

39.03/4, adequate for 2, no more

Sporty good looks, but unsophisticated detailing/4

\$38,000

Aquasport, 7925 W. 2nd Ct., Hialeah, FL 33014, (305) 822-1921

Outstanding gauge pattern and control positioning. Plexiglass splash cover is a nice touch.



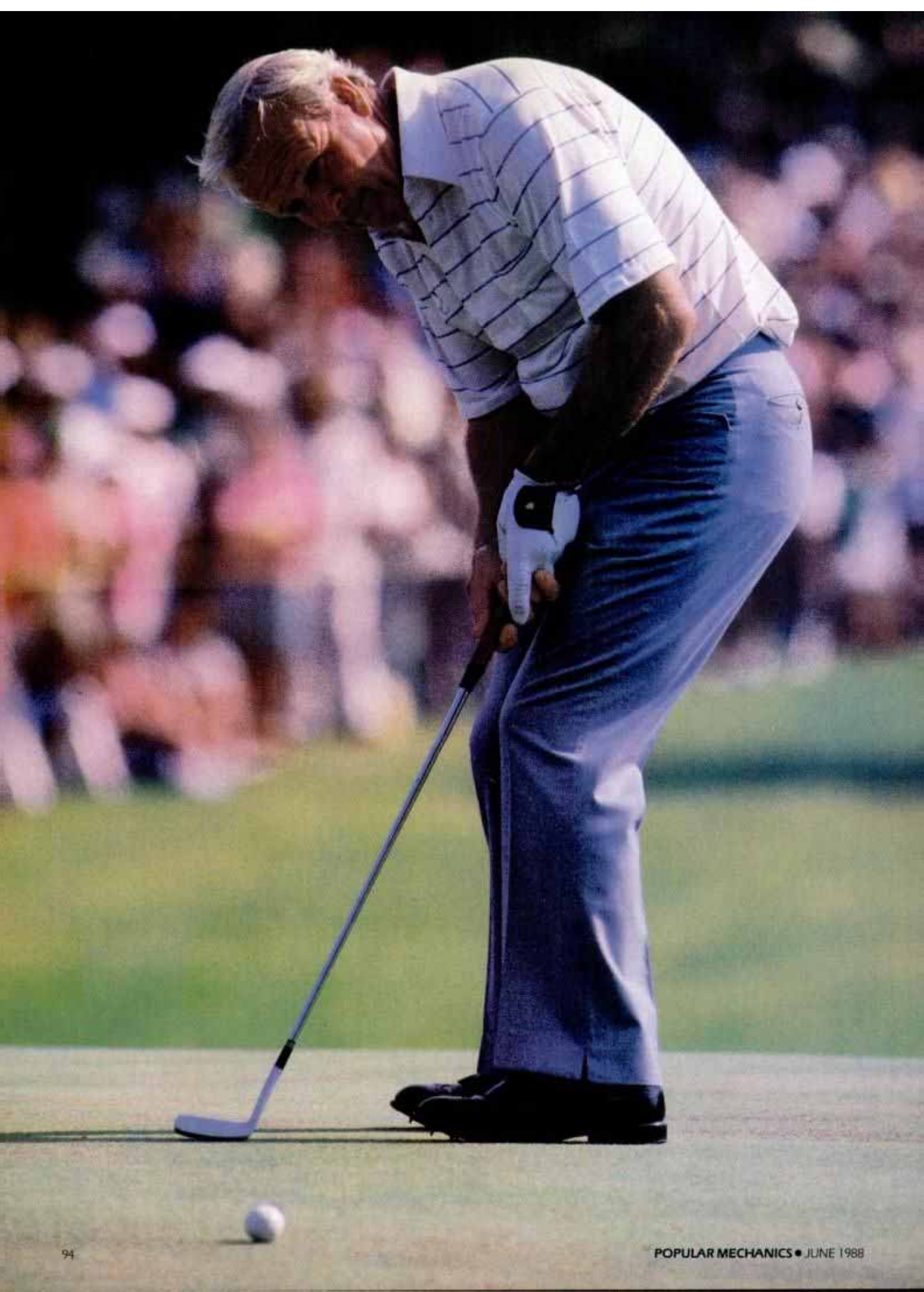
Throttle low and tight against gunwale. Plenty of room for additional electronic instruments.



Throttle bangs into wheel. But superb gauge sightlines and accessibility to other controls.









New golf clubs tee off with the latest in aerospace technology.

BY BRIAN McCALLEN

**T**O FULLY appreciate the wealth of new golf club configurations on the market, it is important to understand the essential nature of a golfer. Golfers are embarked on a lifetime quest for improvement. In the typical golfer's mind, most of this improvement is linked to increased distance and better accuracy. Therefore, golf club products that promote the two are sought out by serious players seeking the competitive edge, especially if their wallets can handle the price.

In the end, of course, high-tech equipment can carry a golfer only so far. In the words of one prominent golf instructor, "If golfers spent half as much time grooving their swings as they do shopping around for the latest game-improvement equipment, they'd be much better off. You can't buy better golf shots."



# DIFFERENT STROKES

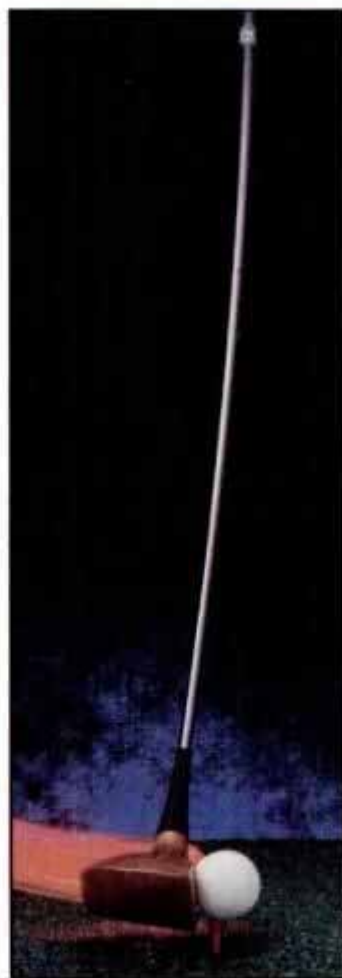
No, but you can try. Here's a roundup of the latest in golf shafts and clubheads.

## The shaft

In the same way that the wings of a plane are far more crucial to flight than the fuselage, the shaft is the most important part of the golf club because it transfers energy generated by the body to the clubhead. After a disappointing debut in the early 1970s, graphite has re-emerged as the top component in golf club shafts.

Graphite, a soft black lustrous carbon that is created when polyacrylonitrile fiber is heated in an inert atmosphere at temperatures approaching 5000° F, is usually combined with epoxy resin to form a composite. The graphite portion of this matrix is manufactured into a threadlike form, with each strand containing more than 10,000 individual filaments. There are 860 miles of graphite fibers in a single golf club shaft. The more times these filaments, which are one-tenth the diameter of a human hair, are subjected to the pyrolysis process in which hydrocarbon-type materials are burned, the higher the tensile strength. The higher the grade, the more costly and stiffer the composite thread becomes. Several manufacturers also use boron (boron tetrachloride gas mixed with hydrogen and heated to 2000° C) in their graphite composites. Boron is twice as strong and twice as stiff as steel, yet is only one-third the weight.

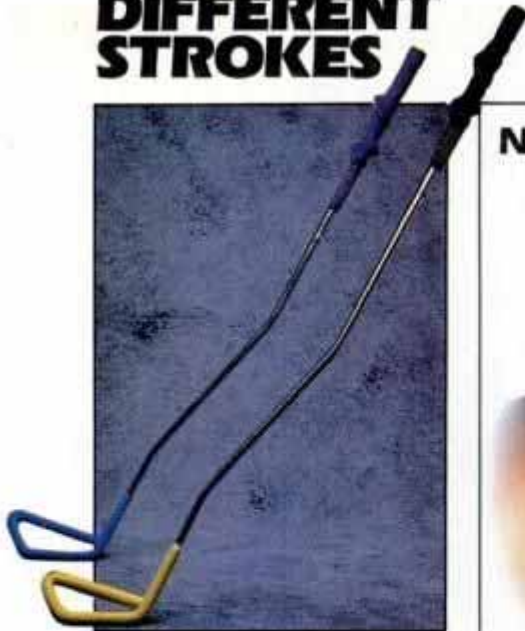
Early graphite shafts suffered from two major problems: First, the tensile strength of the raw material utilized was so low that the torsional properties of the shaft could not be controlled. The shaft was simply too whippy. Second, these lighter-than-steel shafts encouraged manufacturers to use heavy clubheads in order to maintain traditional swing weights. This combination only increased the instability of an already unstable golf shaft.



The changing shape of golf: Improving the eye-hand relationship is the focus of ProGroup's Axiom II Irons (top), which have visual clues painted at an angle on the clubface grooves. While graphite shafts continue to make inroads, Ti-Shaft's titanium driver (left) optimizes weight and flex. Makers of the Power Pod (above) claim an 80-percent increase in club face area.

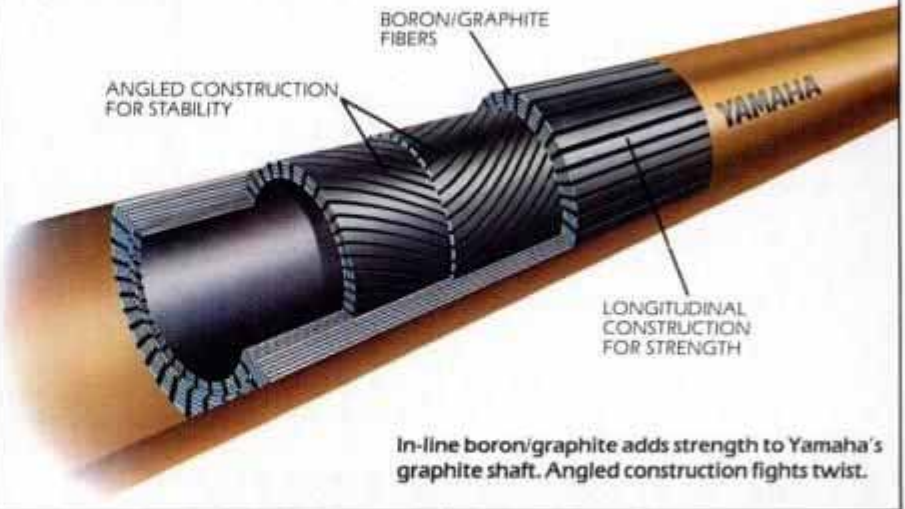


## DIFFERENT STROKES



The Matzie Swing Trainer helps golfers master proper swing path.

## NEW-TECH GOLF CLUB SHAFT



In-line boron/graphite adds strength to Yamaha's graphite shaft. Angled construction fights twist.

According to Frank Thomas, technical director at the United States Golf Assn., today's manufacturers are learning how to use graphite to change the torsional characteristics of a shaft by varying the orientation of the fibers (as seen in the illustration above right).

According to manufacturers, golfers can expect two major advantages from playing a set of graphite-shafted woods or irons. The first is a better swing plane and squarer contact resulting in greater distance and straighter shots. Second, graphite fibers, unlike steel, act as an insulator rather than a conductor of vibration.

In addition, the average nominal weight of a graphite shaft is 85 to 90 grams. A typical steel shaft weighs in at 120 grams. Extra weight can be transferred in graphite-shafted clubs to the clubhead, resulting in greater mass behind the ball and increased distance.

The second most highly valued shaft material on the market is titanium. According to Ti-Shaft spokesman Dale Humphrey, the new shaft was designed by an engineer who used a computer to select the best material available for a golf shaft regardless of price. With weight, strength, low torque and other considerations factored in, the answer came back "titanium."

The new Ti-Shaft is an improvement over an earlier titanium-alloy tube introduced in 1976. In the new shaft, the structure of the alloy is aligned in a radial direction during the forming process, producing better dimensional and shape characteristics. And like graphite, titanium-shafted clubs are being sold today for far less than their introductory price. Some complain that titanium-shafted clubs have the feel of a fungo bat, but they are popular with several tour pros and may carve a niche in the market.

### The clubhead

Clubheads have come a long way from the days when Scottish professionals carved beech, apple and pear wood into long-nosed clubs faced with leather to soften the shock of impact. Today, graphite, steel and even ceramics are being used in the manufacture of game-improvement woods.

Although the steel-head drivers and fairway woods that have taken the market by storm propose to be new, they are not. The first metal wood appeared in 1906 and flopped. Aluminum-head woods were in brief vogue during the 1940s, but kiln-dried, oil-hardened persimmon wood heads were the clubs of choice because of their supe-

## Distance: Is It Skin Deep?

THE ADVERTISEMENT for Bost Enterprises' Condor, a so-called nonconforming golf ball, promises the kind of consistent 400-yard performance that may one day render golf courses obsolete. "The physics are there," according to a Bost spokesman, who cites 3 grams of added weight and a size reduction of five one-hundredths of an inch for the Condor's lofty performance.

Professional golfers and golf tour administrators don't see it that way. Clearly ruffled by this effort to soup up the golf ball, Frank Thomas of the United States Golf Assn. says, "Distance should be earned with skill, not bought in a box."—T.C.



Makers claim that smaller size and added weight may give the 1-piece nonconforming ball (right) added performance.

rior feel and click at impact. They remain the choice of many better players to this day.

Though most major golf club manufacturers now carry metal woods, the top producer is Taylor Made, which first attracted attention with its line of Pittsburgh Persimmon clubs. These hollow stainless-steel clubs are perimeter-weighted away from the center of gravity to reduce torque and twisting on off-center hits.

While perceived primarily as a shaft material, graphite is also being used in clubheads, both woods and irons. In general, there are two types of graphite heads: 1) Powder graphite or short fiber graphite pellets mixed with epoxy, preheated to a melted state, and then injected under pressure into a closed mold; 2) Long

(Please turn to page 107)





# Workshop Warriors

## A Cut Above

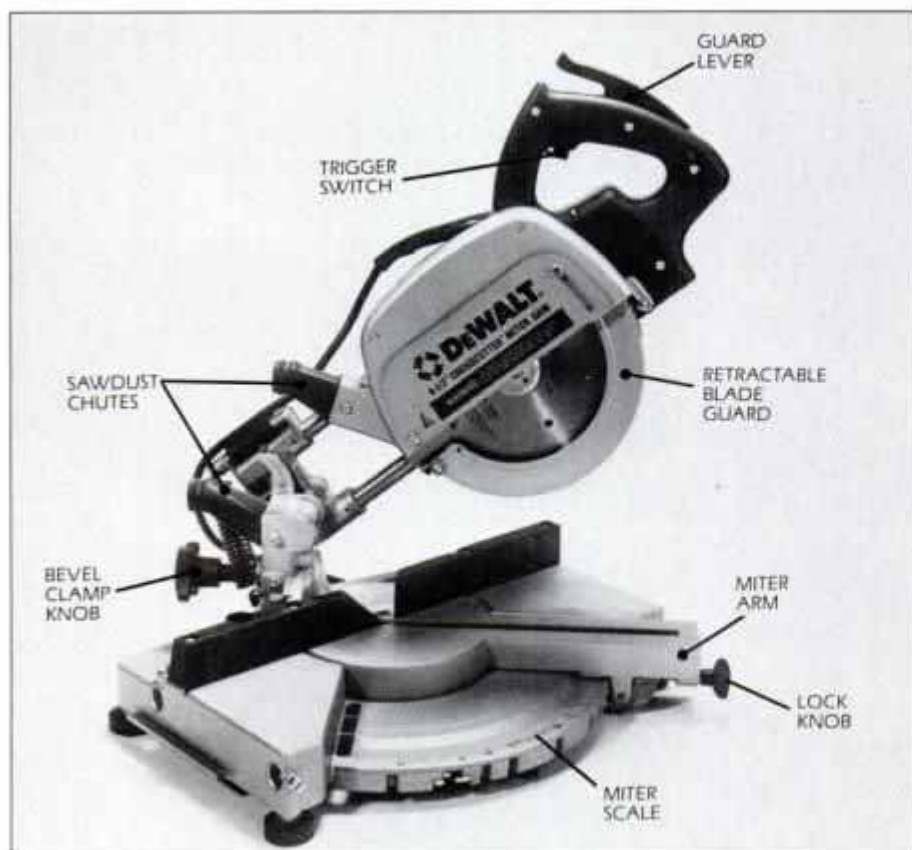
**O**F ALL THE POWER miter saws introduced over the past few years, the new DeWalt Crosscutter is the most impressive. First, it's a compound miter saw so that you can crosscut, miter, bevel and cut tricky compound angles. Quality construction is visible throughout including an all-ball-bearing, 11½-amp, 6500-rpm motor, a heavy-duty, die-cast aluminum base and rotating, slotted worktable. Most impressive, however, are its cutting

capacities which are outstanding for a comparatively small saw. In fact, the Crosscutter weighs just 32 pounds.

Although the saw uses a rather small 8½-in.-dia. blade, it can crosscut through a 2x10 at 90°. At 45°, it can miter-cut a 2x6. The superior cutting capacities are due to the Crosscutter's unique telescoping head. The saw head extends on two parallel steel rods to reach out over wide workpieces. Lower the spinning blade into the work and then *push* back toward the fence to complete the cut. To cut narrow workpieces, simply lower the blade as with a standard miter saw.



## TOOL TESTS



Shown here with its major parts identified is the new DeWalt Crosscutter. It's a versatile, compact, 8½-in. power miter saw that can crosscut through a 2x10 and miter-cut a 2x6.



Slotted miter arm pivots left and right for miters up to 45°. Nine positive stops ensure accuracy for the most frequently cut miters.



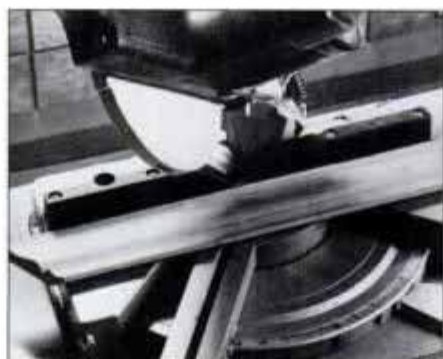
Adjust the bevel angle of the saw by adjusting the bevel lock knob. Note that the saw head is mounted on two parallel steel rods.



To crosscut a wide board, first pull the handle to extend saw head. Then, start the saw, lower it and push back toward the fence.

Since the saw cuts on the push stroke, it's equipped with a negative rake-angle blade. The blade's 24 carbide-tipped teeth tilt backward 15°.

The saw head pivots left and right for cutting miters up to 45°. There are positive stops at zero, 15°, 22.5°, 31.62° and 45°. For bevel cuts, the



Cutting tricky compound angles on crown molding is easy with the Crosscutter. Set positive stops at 31.62° miter and 33.85° bevel.

head tilts 45° left and right. In addition, the bevel scale has a mark at 33.85°. This odd angle is used to cut crown molding to the proper angle. Set the bevel indicator at 33.85° and the miter scale to 31.62°, and the saw will cut the exact compound angle necessary for 90° corners.



Accessory holddown clamp, attached to the left fence, is necessary when cutting workpieces too short to hold safely by hand.

The saw's cutting capacities are: crosscut—2¼ × 9⅞ in., miter—2¼ ×

## Portable Power—No Strings Attached

AS A LONG-TIME fan of Dremel's superversatile Moto-Tool, I was anxious to try the newest member of the Moto-Tool family, the Free-wheeler—a cordless rotary power tool. After testing the tool thorough-

ly, I certainly was impressed.

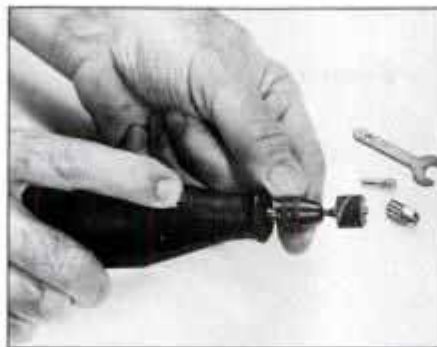
This tool weighs about 1 pound and is powered by five nickel-cadmium batteries that are sealed in the tool's tough plastic housing. A plug-in charger brings the batteries to full

It accepts all the standard Moto-Tool bits and accessories to cut, sand, rout, engrave, carve, polish, grind, drill and saw a wide variety of different materials. And since it's cordless,





Cordless Freewheeler comes with a plug-in charger. The 2-speed tool—15,000 and 20,000 rpm—recharges in about 3 hours.



Keyless chuck makes changing bits quick and easy. Push shaft-lock button forward with index finger and then loosen chuck by hand.



The versatile, cordless Freewheeler excels at numerous home and shop jobs. Here, it's used to remove rust from a car door panel.



Compact size permits sharpening lawnmower blades without removing blade. Be sure to disconnect sparkplug wire first.



Freewheeler is also available in a convenient kit that consists of a plastic charging stand/storage tray and 30 versatile accessories.

the Freewheeler is especially useful for working where dragging an extension cord isn't convenient or possible, such as on a roof, boat or in an attic or camper. It's also handy for arts and

crafts projects where a trailing cord would get in the way.

The Freewheeler and charger cost about \$71. The Freewheeler is also available in a convenient kit (\$94)

which includes the tool, charger, plastic charging stand/bit storage tray and 30 accessories. For details, contact Dremel, Marketing Dept.—PM, 4915 21st St., Racine, WI 53406.



Freud 4-in.-dia. blade removed and three sizes of football-shaped wood biscuits are made of compressed beech.

## Biscuit Recipe

**B**ISCUIT joiners, also called plate joiners, provide a fast, accurate and very easy way to assemble many basic wood joints. A few years ago, biscuit joiners started to make the transition from professional shops to the home workshop. However, the high cost of a typical biscuit joiner has excluded many woodworkers. I recently tested the new Freud joiner and found it simple to use and affordable. Its list price is \$285, but it's commonly sold for less than \$200.

The tool consists of a compact, 5-amp motor that powers a 4-in.-dia., 6-tooth, carbide-tipped blade at 10,000 rpm. A spring-loaded, sliding base and adjustable fence align the blade with the workpiece edge. To form 45° miter joints, reverse the fence.

To use, simply push the tool into mating edges to make semicircular grooves. The grooves accept a football-shaped spline, called a biscuit, made of compressed beech. When

*(Please turn to page 118)*







# Matched Set

**I**F YOU'RE having trouble getting a weekend alone in your shop, then we've got the solution. Just leave POPULAR MECHANICS open to this page on the kitchen table. Once the rest of the family gets an eyeful of our two solid cherry tables, they're liable to lock you in the shop until the tables are done.

Both are interesting departures from the norm. The 3-legged table is ideal for the hall, foyer or against a living room wall. If you're looking for more surface area, the unique 5-legged table will provide an exciting accent to any room. Both tables feature similar construction techniques and joinery. So, once you've built one, the second will go that much easier. And, they can be made with ordinary portable power tools.

The tabletops and rails are all made from nominal 1-in. stock. This typically measures  $\frac{13}{16}$  in. thick. However, be sure to check the actual thickness

of your material and adjust our specifications if necessary.

The legs are shaped from  $1\frac{1}{2}$ -in.-sq. cherry. Buy 2-in. lumber for these and, if possible, have your dealer plane the stock to  $1\frac{1}{2}$  in. thick. If this isn't possible, then square the stock to size with your circular saw.

## The 5-legged table

Prepare the 1-in. stock for the tabletop and rails by using a hand plane to trim one edge of each board straight and true. Clamp a straightedge guide parallel to the trued edge of each workpiece to serve as a guide for your circular saw. Rip the tabletop stock to roughly 5 in. wide and rip the rails exactly to width. Smooth all edges.

The top is made by edge-gluing seven boards. Draw a full-size outline of the top on paper and lay out the positions of the boards to determine their lengths. Crosscut each board slightly longer than necessary.

Next, position the pieces edge-to-edge on your worktable. Because this top is large and it's usual to expect wood to shrink slightly after it adjusts

to the dry air in your home, the top is held to the rails by only six screws near the central glue joint (see drawing). This allows the remaining surface area to move freely. Place the boards so that the wood's annual rings—seen on the board ends—point upward. In this way, any drying out will cause the boards to press tightly against the rails.

Lay out the outline with chalk and letter the boards for identification when assembling. Mark the dowel positions on each joint and use a doweling jig to bore the holes. Glue the top together in two stages (photo 5).

After the glue has dried, place the top good side down on your worktable and mark the cutting outline. Use your circular saw guided by a straightedge to cut to the outline (photo 7). Then, smooth both top surfaces with a hand plane or belt sander and clean up the saw marks.

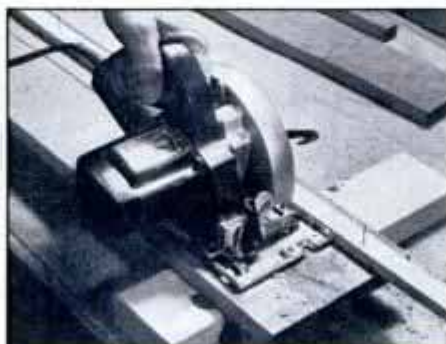
## Making the legs

Construct the leg tapering jig as shown in the drawing. Crosscut the  $1\frac{1}{2}$ -in.-sq. leg blanks 6 in. longer than

Color photo: J.R. Rost  
Black-and-white photos: Rosario Capotosto  
Technical art: Eugene Thompson



**1** Plane one edge of each tabletop board straight and square before ripping. Use the longest plane you have for best results.



**2** Use a straightedge tacked in board's waste area—parallel to finished edge—to guide circular saw when ripping to width.



**3** After crosscutting boards oversize, lay them edge-to-edge and mark for identification. Chalk marks are easy to remove.



## WEEKEND WORKSHOP

their finished dimension. Place a leg blank in the jig, tape back the blade guard on your circular saw so it won't interfere with the cut and adjust the blade depth. Don't forget that the guard has been fixed in this position when you finish each cut. Do not move the saw until the blade stops rotating.

Make the first taper cut stopping short of the leg end as shown in the drawing. This leaves the waste in place for support when the next cut is made. Then, rotate the blank and repeat the cut. After cutting two tapers on each leg, use a right-angle guide to cut the legs to length (photo 11). Smooth the sawn surfaces.

Construct the jig for routing angled mortises in the legs from stock. Keep the beveled cutoffs later as clamping cauls and for

port shim for this jig. The jig shown is dimensioned for use with a  $\frac{1}{16}$ -in. offset template guide and a  $\frac{1}{2}$ -in.-dia. straight bit.

Route angled mortises on one face of each leg. Then, remove the plywood template and stop and secure them at the other end of the jig for routing the remaining mortises.

### Table assembly

First, cut a template to hold each leg in position at the corners (photo 13). Tack the template at one corner, hold a leg in place and trace the outline of the leg end on the underside of the

Next, glue two legs to one rail. Use the cutoffs from the mortising jig as clamping pads and place wax paper under the assembly to prevent excess glue from securing the legs and rail to the top. Then glue up a leg assembly for an opposing side (photo 14).

After the glue has set on the first two units, glue the third connecting rail in place and clamp. Let the glue set and then glue and clamp the fifth leg and fourth rail in position. Finally, add the last rail in the same manner. Mark the centers for the screw pilot holes in the top and bore. Then, screw the top in place.

finished the table with a coat of min Moore Cherry Penetrating followed by two coats of Satin Varnish. The underside of the as given a coat of sanding sealer.



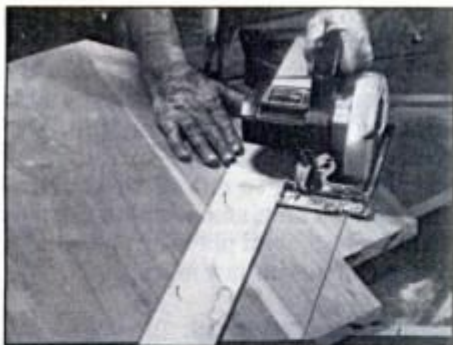
**4** Keep the same side of doweling jig on working face of each board to ensure good alignment. Tape on bit acts as depth gauge.



**5** Assemble top in two stages. Lightly clamp flat, sturdy cauls across joints with wax paper between cauls and tabletop.



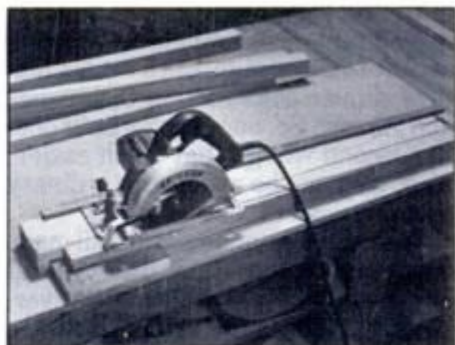
**6** Make a cardboard template of the 108° corner angle to aid in laying out the table outline on the underside of the tabletop.



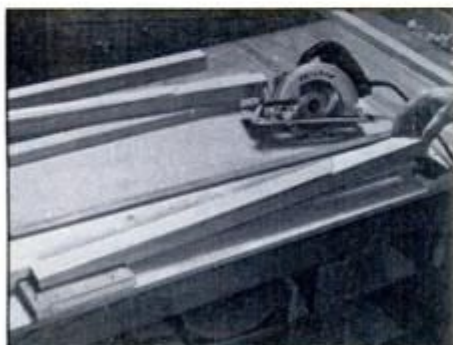
**7** Tack a straight cutting guide to top so it's parallel to—and correctly spaced from—the outline. Use a sharp blade.



**8** Smooth the tabletop surfaces with a belt sander or hand plane for a good connection to rails and a smooth, flat top surface.



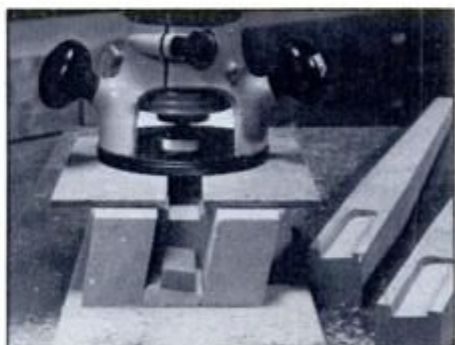
**9** Cut leg tapers with a circular saw. Stock is held in jig and saw is guided by a straight strip. Stop cut about 6 in. from the end.



**10** Rotate the leg blank to cut the second taper. Note that blade guard is taped in retracted position. Work with extra care.



**11** A T-shaped right-angle guide aids in cutting legs squarely to length. Clamp two legs together and cut in one pass.

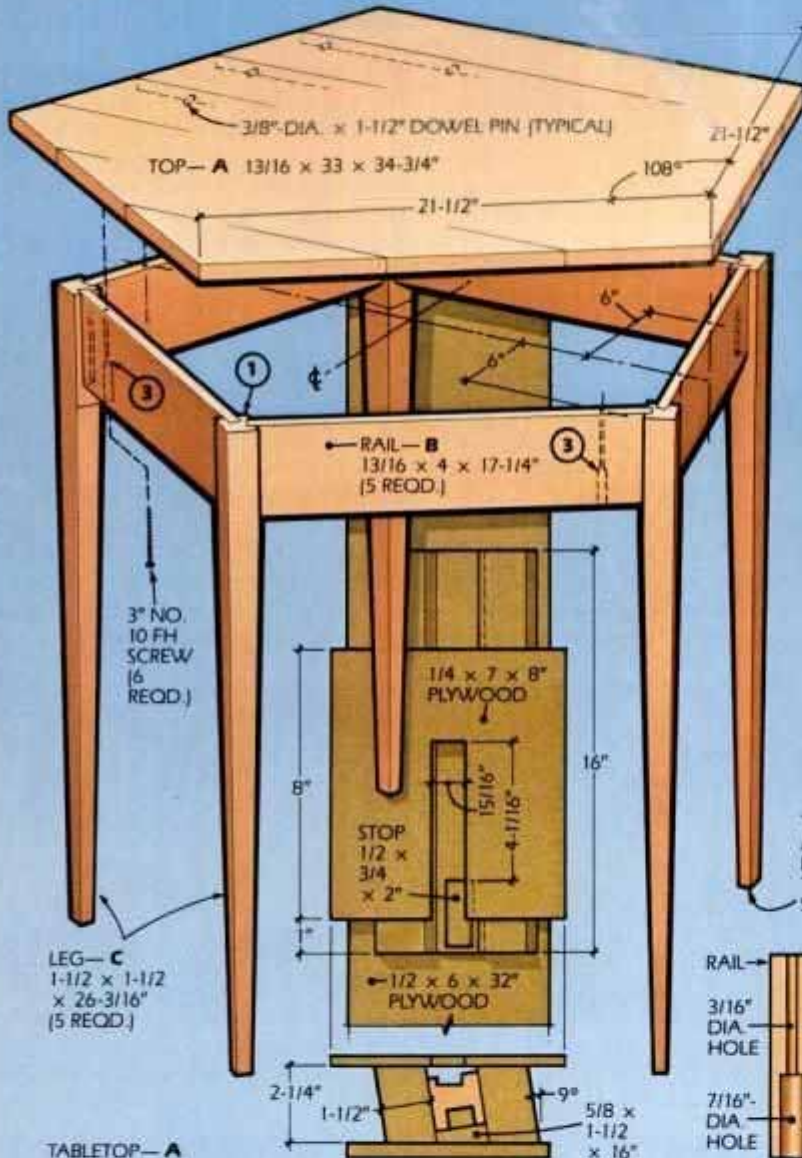
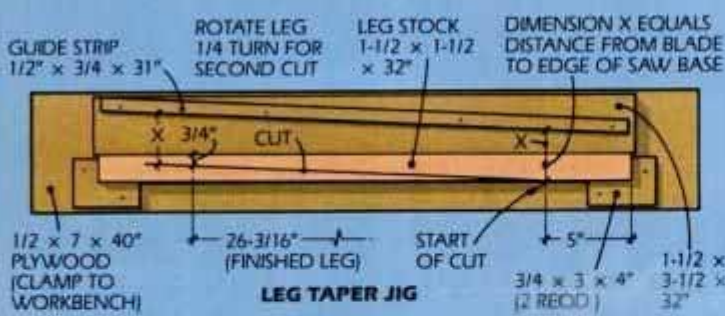


**12** Angled mortise is cut on this jig. Plywood template guides width and length of cut. Use  $\frac{1}{2}$ -in. bit and template guide.



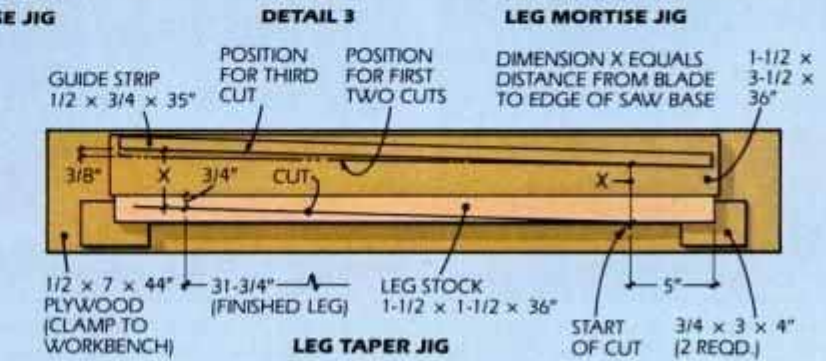
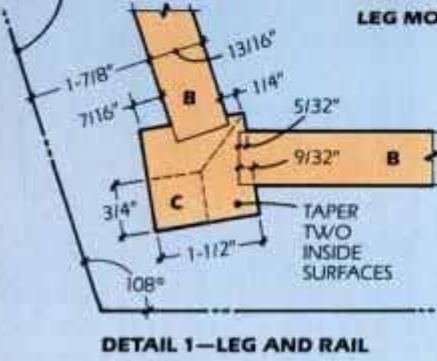
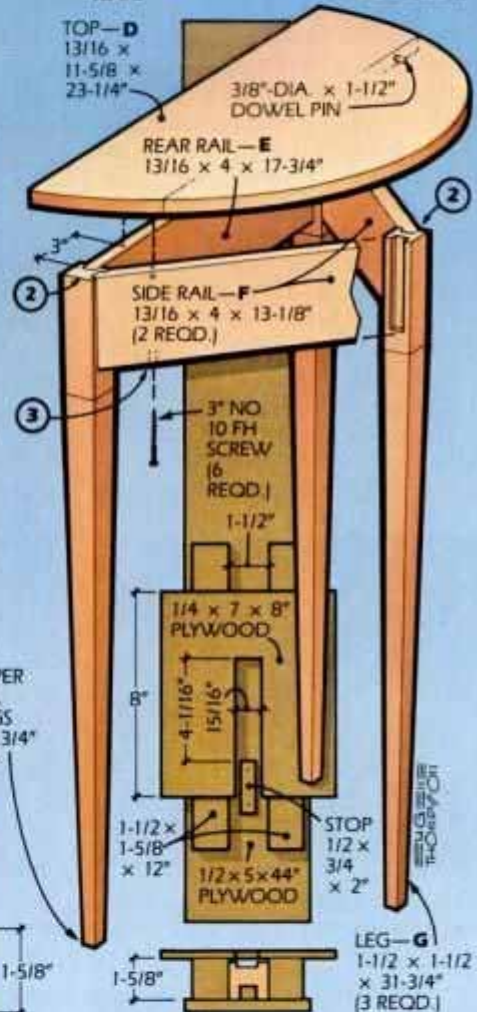
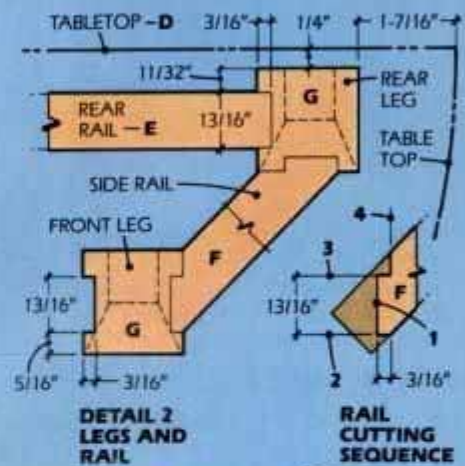
## 5-LEGGED TABLE

27" HIGH x 33" WIDE x 34-3/4" DEEP



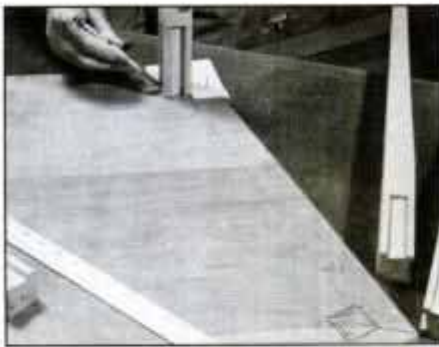
## 3-LEGGED TABLE

11-5/8" DEEP x 23-1/4" WIDE x 32-9/16" HIGH





## WEEKEND WORKSHOP



**13** Corner template helps position the legs. Draw outline of each leg end and measure correct rail lengths between legs.



**14** Glue two opposing leg assemblies first, using marked side of top as a guide. Use wax paper to keep excess glue off the top.



**15** After adding the connecting rail, glue and clamp the fourth rail and last leg to the assembly. Finally, add the remaining rail.

### The 3-legged table

This piece bears a resemblance to the first table in leg detailing and construction. It differs, however, in the leg to rail joint and the fact that the legs are tapered on three sides.

Begin by gluing up the top as shown in the drawing. After the glue is dry, belt sand or plane the top smooth and flat and use a sabre saw to cut the arc. Most ordinary circle cutting guides are not large enough to handle this radius. You can make your own guide from a length of mild steel. Hammer it over at one end to produce an L-shape and bore a pivot hole in the folded end in line with the cutting edge of the blade (photo 3). Use a sharp blade with adequate set for this cut. You can also cut the arc by following a line scribed with trammel points or a large

compass. Smooth the curved edge with a cabinet scraper and sandpaper.

Construct the leg tapering jig for the 3-legged table as shown in the drawing. First, cut one side taper, then rotate the blank 180° and cut the second taper on each leg.

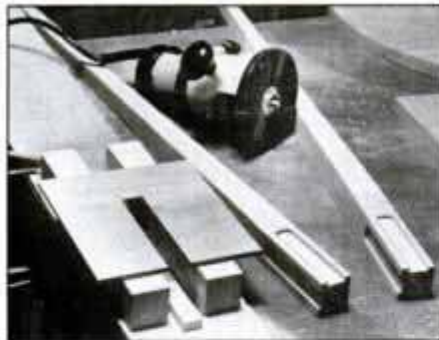
Next, readjust the guide strip for the outward facing taper and cut each leg. Crosscut the legs to length with a circular saw and right-angle cutting guide.

Set up the leg mortising jig and equip your router with a 1/2-in.-dia. straight bit and 1/16-in. offset template guide. Then, cut the 3/16 × 13/16-in. mortises in the legs.

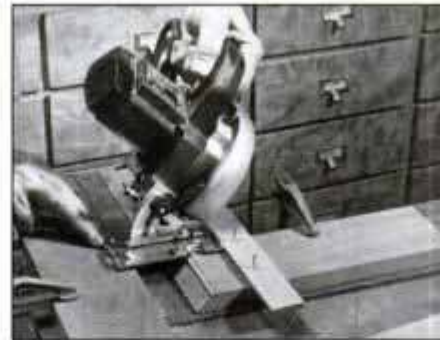
Set your circular saw to 45° and adjust the depth for crosscutting both ends of the two angled rails. Make a T-square guide and clamp or nail it to the

rails to ensure square cuts. After the first cut, readjust the T-square guide and make the second cut as shown in the drawing. The third and fourth cuts are slots that combine to form the notch in the rail end. Make sure the blade depth is set appropriately for these cuts.

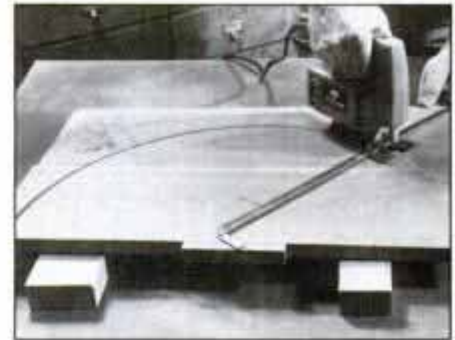
Prepare for assembly by boring the screw holes in the rails for attaching the top. Glue the rear rail to two legs and temporarily clamp the assembly in position on the tabletop with wax paper in between. After the glue has set, join the two front rails to the rear legs and remaining front leg using angled cauls to provide uniform clamping pressure. Finally, mark and bore the screw pilot holes in the top and secure it to the leg assembly. Install with 3-in. No. 10 fh screws. **PM**



**1** The mortising jig for the 3-legged table produces square cuts. Use a 1/16-in. offset template guide and 1/2-in.-dia. bit.



**2** After cutting bevel and slot, set blade depth for cutting the notch and guide saw with a strip tacked squarely to rail.



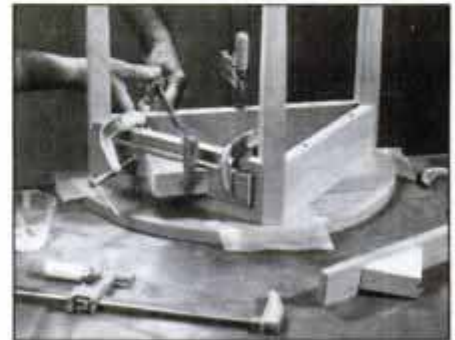
**3** Top is prepared by gluing two boards edge-to-edge. Use a sabre saw with circle cutting guide to cut the tabletop shape.



**4** Clean up the rough-sawn edge with a cabinet scraper. Finish by sanding with a palm sander or with sandpaper and block.



**5** Assemble the rear rail and two legs with glue and clamp until dry. Use a layout drawn on underside of top as a guide.



**6** Angled clamping jigs secured to the front rails with small clamps aid when drawing the rail to leg joints together.



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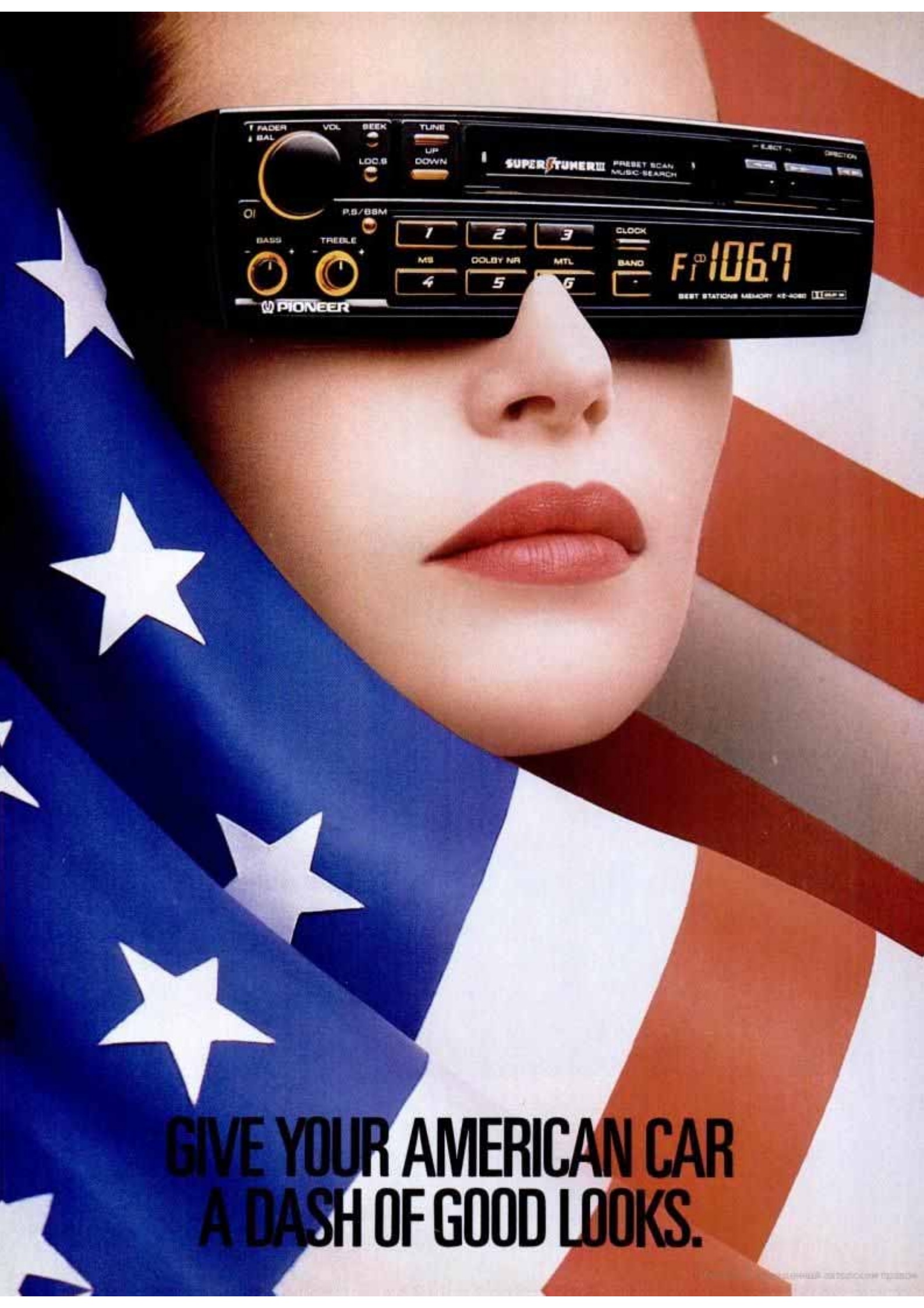
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## DIFFERENT STROKES

(Continued from page 96)

continuous graphite fibers woven into a tight mesh cloth, handwrapped around a urethane foam center or placed in an open cavity of a heated mold and compressed under high pressure.

Compression-molded heads are considered superior to the injection-molded variety. Manufacturers claim that long graphite fibers are stronger than the short-grained variety. But

petite by normal standards, the manufacturer claims the Power Pod's hitting area is 80 percent larger than standard clubs.

Irons, like woods, have undergone a revolution of sorts, with exotic materials and new head shapes replacing iron forgings and classic streamlined looks. The commotion first began in 1969 when a former engineer by the name of Karsten Solheim introduced his perimeter-weighted, investment-cast, cavity-back Ping irons. Even Thomas, whose job it is to sort



PHOTOS BY TOM GERZYSKI

Karsten engineers use laser theodolite and meteorological instruments to test Ping irons.

the big difference between the two is in the weighting.

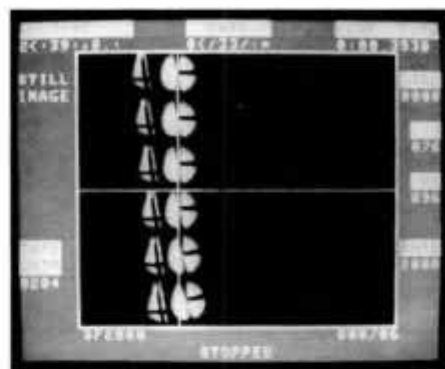
Compression molding allows clubmakers to redistribute the weight to the sides of the head and experiment with the center of gravity and perimeter weighting of the clubhead.

While steel woods must be smaller in size to accommodate the weightiness of metal construction, graphite offers the same shape and controlled feel of wood with superior repulsion at impact. Also, graphite does not fatigue with age.

But graphite isn't the only space-age material that has found its way into the business of golf club manufacturing. Fila, better known for its tennis wear, is producing a perimeter-weighted ceramic-composite wood head that is lightweight and built to withstand shock and vibration.

While clubhead material continues a steady evolution, clubhead shape had not changed much until the advent of the Power Pod, a cyclopean piece of cone-shaped hardware that proposes to eliminate the slice, the plague of most duffers.

The Power Pod is engineered to prevent the toe of the club from opening at impact, thereby warranting against a slice. Though the clubhead is



Stop-action photos illustrate the optimum impact area and spin effect on the ball.

through new equipment proposals and find out if they conform to the Rules of Golf, said that peripheral-weighted irons increase the moment of inertia and decrease the effect of angular twisting.

Not all new golf club configurations are derived from exotic new materials. A case in point is ProGroup's Axiom irons.

What at first appears to be yet another clone of the heel-toe weighted, investment-cast, battleship gray club is just that—but with a unique arrangement of grooves. Most irons have scoring lines that face down the

(Please turn to page 108)



## DIFFERENT STROKES

(Continued from page 107)

target line. The Axiom irons have a series of white-painted grooves that lean inward, along what would be an inside-out swing path.

ProGroup claims that these visual cues on the face of the club encourage a player to take the club on the proper inside path on the backswing.

Arnold Palmer, who certainly knows the difference between target line and swing path, believes in the altered geometry of the Axiom irons and plays them on the Senior Tour.

### Putters

The me-too phenomenon in golf club design was never stronger than after Jack Nicklaus' stunning Masters victory two years ago. The putter he used enroute to his green jacket was the Response ZT700 by MacGregor, a putter he himself helped to design (Nicklaus owns MacGregor). A heel-toe weighted putter with an offset hosel, or neck, extra-long blade and high center of gravity, this oversized putter is designed to minimize twisting during the putting stroke. The Response ZT700 has spawned a host of look-alikes, including Cleveland Classic's Big Foot BP2, Pal Joey, Torque

Master, Ray Cook's K10, Otey Crisman's Otey III, Sigma's Hammerhead and Slotline's Big Mo. Many are as long as a banana, would make a plumber blush, and visually reduce the golf ball to the size of a marble.

Having serious problems on the greens? It might be time to experiment with the Slim Jim from Matzie, which is available in four different lengths. Designed and popularized by Senior Tour star Charlie Owens, this 1½-pound putter is characterized by a split grip and unusually long shaft that encourages an upright stance and pendulum stroke.

### Clubface grooves

One of the most controversial developments in club design has been the issue of clubface grooves, with the perceived spin benefits of the new U-shaped grooves measured against the traditional V-shaped grooves.

Before 1984, the rules stipulated that: 1) all grooves be V-shaped, with the angle at the bottom at least 90°; 2) the width of a groove could not be greater than .035 in.; 3) the space between the grooves be at least three times the width of an adjacent groove.

In 1984, an appendix to the Rules of Golf showed three acceptable groove shapes—of which the V was one. But

since the advent of investment casting of irons, shallow U-shaped grooves have become the norm.

In dry conditions, there is very little difference between the spin imparted by V-shaped or U-shaped grooves. However, some players claim the new groove configurations are lessening the incidence or severity of what pro golfers call flyers, or extra-long shots that result when grass (especially wet grass) gets between the ball and the clubface, reducing spin rate. It seems that box grooves provide more resistance to the ball sliding up a lubricated clubface, thus diminishing the flyer effect.

This degree of control matters a great deal to players who compete professionally, but for the average player (a 17-handicap male and a 31-handicap female), the matter of clubface marking may be tantamount to owning a Ferrari but reserving it for trips to the corner store. In the words of the USGA's Frank Thomas, "There are only about 200 people in the world who can properly take advantage of U-shaped grooves."

It appears that fundamentals are still the key to golf in this highly technical world. As Thomas says, "We're still far behind in the art of matching golf equipment to people." **PM**



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## AMERICAN FLYERS

(Continued from page 69)

No matter. We still think the V8 suits the Thunderbird better than the Four. The V8 Sport's acceleration isn't really too far from the Turbo Coupe's—and with 225 hp would be even better, without the high rpm activity of the busy turbo. Even with only 150 hp, our test Thunderbird was significantly quicker than the three new GM-10s at the dragstrip, and its laid-back, low-rpm V8 performance made this our favorite freeway flyer.

The Thunderbird's styling is now so familiar there's not much to discuss. You either like it or you don't. We think the smooth, rounded style is still very pretty and contemporary, with really excellent detailing and surface development. Ford is to be applauded for not loading down the T-Bird with add-on aerodynamic bits, but letting the lovely body shape show instead. In the future, we'll look back and consider this a true landmark classic car, the beginning of a great period at Ford.

The Thunderbird's interior is very straightforward and functional, with six analog gauges, a leather-covered steering wheel that might have been borrowed from the SVO Mustang, and seats that look and sit just like a pair of expensive Recaros. These twin buckets aren't quite as good as the optional seats in the Grand Prix and Cutlass Supreme, but they are *very* comfortable.

In fact, we really couldn't find anything to complain about inside the Thunderbird, except that the console-mounted power window switches push down for up, and vice versa. It took some getting used to.

At the track, the T-Bird's V8 loafed through our testing, miles and seconds ahead of the GM-10s. The GM cars beat the T-Bird in braking, surely because their 4-wheel discs are more efficient. From other tests, we know the Turbo Bird or Mark VII with ABS 4-wheel discs can out-stop the GM-10s. In the slalom and skidpad, the Thunderbird's soft suspension settings helped to slide it into last place—not far behind, but definitely not as quick around a corner as the fatigued, front-drive competition.

Like its cousin the Mark VII LSC, the Thunderbird Sport is great fun to drive. The combination of effortless power, neutral handling, superb ride quality and excellent cockpit ergonomics—not to mention the best fuel economy in this group, despite the largest engine and highest curb weight—make it a wonderfully comfortable car, particularly for long-distance driving. The V8 should be both durable and easy to repair, and routine maintenance should be easier than on the transverse V6 GM-10s with their relatively crowded engine compartments.

We like the Thunderbird Sport, though we'd like it more if Ford had given it the same equipment as the Turbo Coupe, plus the HO V8. A die-hard enthusiast could build such a car, and since all the necessary parts are bolt-ons readily available either from Ford or from the aftermarket, it wouldn't be too difficult or expensive. The result would certainly be the ultimate Thunderbird—and perhaps, the ultimate American Flyer.

## Chrysler LeBaron Turbo Coupe

This must be the prettiest car Chrysler has ever built. From its trim nose, with hidden headlights flanking a fine-lined formal grille, to its simple derriere with full-width taillights, the clean-limbed LeBaron has a timeless, classy appearance from every angle. There's nothing gimmicky about it, and not one styling afterthought—just good taste. Chrysler ought to be able to sell this car without change well into the '90s, when it will *still* look good.

The LeBaron chassis, like most of Chrysler's cars, is derived from the original K-car. There are MacPherson struts in the front with a beam axle in the

(Please turn to page 110)

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## AMERICAN FLYERS

(Continued from page 109)

rear. The brakes are vented discs in the front with drums in back, and the engine options are Chrysler's 2.5-liter Four or the 146-hp 2.2-liter Turbo I. Starting with 1989 LeBarons, you'll be able to order a new 2.5-liter turbo with balance shafts, plus 4-wheel disc brakes.

Not that the LeBaron is deficient in power. The lightweight speedster zipped off a 0-to-60 run in only 8.75 seconds and the quarter-mile in 16.54 at 83.22 mph. This makes it a full 2 seconds quicker, 0-to-60, than the Grand Prix or Cutlass, and 1.25 seconds quicker through the quarter-mile. That's a significant difference, enough to make the LeBaron feel frisky and sprightly in everyday driving compared to the relaxed GM-10s.

Every K-car derivative we've ever sampled has performed competently in our handling tests, and the LeBaron is no exception. It won our slalom competition with an impressive 63.29-mph clocking—significantly better than any of the other sporty coupes. It's easy and quick to toss around, and fun to drive fast. A .79 G clocking on the skidpad would have been even better if our test LeBaron

had come with optional 205/60R-15 Eagle GTs rather than the standard 205/70R-15 Eagle GT+4s.

After the suggestion conveyed by the seductive exterior, sliding behind the wheel of the LeBaron can be something of a disappointment. The bucket seats, even with leather upholstery, are no better than okay, and suffer in comparison to the Olds and the Grand Prix.

Certain items of the interior hardware seem to have been borrowed from other Chrysler cars, and the plastic burl walnut interior trim just doesn't seem to convey a quality message. And the vacuum fluorescent digital instrumentation isn't likely to win the hearts of enthusiasts.

Chrysler has just introduced a new all-white GTC model, available as a coupe or convertible, that comes only with analog gauges. We think that's definitely progress. Add the larger turbo engine and all-disc brakes of the '89 models, and you'll have a reasonable competitor for the new GM-10s—as well as for the new T-Bird.

The LeBaron is pretty, it's attractively priced, it's potent, it's fun to drive, even with its over-assisted power steering. The chassis has been in production so long, it ought to be completely sorted out and totally reli-

able, although even with the refinements installed for the LeBaron Coupe it has begun to become dated. But where the LeBaron falls short is inside. The Grand Prix and Cutlass have definitely raised the ante in this class with their wonderful seats and ergonomics, and the Thunderbird is nearly their equal.

## Conclusion

As we suggested, our test crew split right down the middle on the who's who in this group (though there seemed to be general agreement that neither the Regal, the Thunderbird nor the LeBaron were as tempting as our top twosome).

Some were seduced by the flash, flare and aggressive handling capabilities of the Grand Prix SE. The rest liked the clean styling, instrumentation and overall user friendliness of the Olds.

But there *was* consensus on two points. First, that the GM-10s are exceptionally well-executed new car entries—the best the General has given us in quite some time.

Even so (consensus point No. 2), more power would make all of them more interesting. And if more power appeals to you, you might want to check the 1989 editions. **FM**

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## KNOCKOUT PUNCH

(Continued from page 77)

A groggy fighter who has lost control of his neck muscles, as Holmes had, becomes even more vulnerable to sudden rotational acceleration. Thus, the final punch—maybe not as powerful as the first—a sweeping left uppercut to the point of the chin, rapidly swiveled Holmes' head, resulting in a Type 3 knockout. It's important to note that the severity of the punch in the Tyson-Holmes example is not the issue. The punch that flattened Holmes was hardly the kind of haymaker one associates with a knockout. The video replay indicated a lightning-quick poke to the chin, followed by Holmes' head snapping, and a somewhat graceless collapse to the mat—reminiscent of a falling tree.

Here, it is worth mentioning that even a straight punch causes some degree of rotational acceleration. As Dr. Jordan has written, "In reality, the distinction between a punch that causes a purely rotational or linear acceleration is mostly theoretical, because the force produced by a blow is usually some variable combination of linear and rotational acceleration."

The linear component and the rotational component—individually or in

concert—are the root cause of the knockout. And when these two dynamic boxing elements merge and mix, the mystery of the knockout only deepens.

There is one last type of acceleration, or rather deceleration, to be considered. This is not caused by punches but by impact of the fighter's head on the canvas. This collision between the brain and skull on rapid deceleration only aggravates the effects of rotation of the brain within the skull, and can lead to bruises on the brain's lobes.

Knockouts have also been known to result from injuries to the carotid, the chief artery passing up the neck to the brain—usually from a very powerful blow to the neck, which compresses the carotid sinus, deprives the brain of oxygen-carrying blood, and causes shock and injury to the cerebrum.

And then there are body punches. As Ray Arcel observes, "I've seen boxers who could absorb a terrific amount of punishment get tapped in the solar plexus and go face down."

### Skill and science

So what makes a Louis or a Tyson so devastating a puncher? Moreover, what makes a physically unimposing boxer a knockout artist? And what makes one fighter better able to with-

stand a big blow than the next guy? Is there such a thing as a glass jaw?

As is well-known to anyone who's had his fair share of fights, there are guys built like Arnold Schwarzenegger who couldn't KO a dandelion, and there are scrawny dudes who can flatten a truck with one shot. The mystery of punching power is elusive.

As Jackie Graham, former deputy commissioner of the New York State Athletic Commission points out, George Foreman and Gerry Cooney are both known as arm punchers, fighters who don't maximize the force of the blow by using their bodies for leverage. Yet both somehow succeeded in knocking out most of their opponents—and quickly. Foreman and Cooney belie the notion that punching power must be truly forceful to achieve a knockout. While a Joe Frazier or a Mike Tyson can accomplish knockouts by planting their feet and rotating their entire bodies behind the force of a blow, arm punchers seem to knock out their opponents with a feathery quickness.

Graham remembers Lew Jenkins, a great lightweight champion of the 1930s: "He had hands the size of a little girl's and pipestem arms, and he was drunk half of the time. Yet he could punch like a mule. It has to do

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### Ask Newton

Nevertheless, certain classic principles apply. As Dr. Jordan has written in the *Archives Of Neurology*: “The concussive properties of a boxer’s punch relate to the manner in which the punch is delivered and how the mechanical forces are transferred and absorbed through the intracranial cavity . . . the force transmitted by a punch is directly proportional to the mass of the glove and the velocity of the swing, and is inversely proportional to the total mass opposing the punch.”

In essence, Newton’s Second and Third Laws. At the most basic level, the force of the punch is computed by size or mass of the gloved fist times its speed (Force = Mass × Acceleration). But since we are discussing two bodies in motion, we must also consider that the force of the glove on the head is equal and opposite to the force of the head on the glove. This resistance of the head and neck to the effects of rotation must be considered when calculating the ability of a boxer to take a punch.

Newton’s Third Law comes into play most intriguingly in the technique known as rolling with the punch. Many clever boxers, notably Muhammad Ali in recent times, diminish the impact of a blow by abruptly pulling back their head at the instant of collision—rolling with it, so to speak. In this manner, skull and brain accelerate more in unison, thus diffusing the damage of the blow.

It is easy to see, therefore, that a sudden, unexpected punch that catches a fighter unprepared, his jaw hung like a lantern, can result in a tremendous acceleration of the head. The soft brain, which does not move as fast as the skull itself, is deformed, with resultant stress to, and even tearing of, nerves and blood vessels in the brain’s protective meninges. A knockout punch.

An additional biomechanical factor is the duration of contact. According to Dr. Liu, “Relatively low-magnitude blows with a long contact period can do the same job as a more forceful punch. A good analogy is found in karate. In trying to break a stack of bricks with a blow of your hand, you might discover that in the split second the force applied reaches a certain level and the pain in your hand is intense, you would withdraw. But a ka-

rate master maintains contact until the bricks are broken. A good boxer, in the same sense, follows through.”

As to why some fighters can absorb more punishment than others, says Dr. Liu, “Individual variations in the way brains are constructed enable some people to sustain a higher brain pressure gradient—or rotational acceleration—than others. It’s simply part of the variation in all of nature.”

Do some boxers suffer from the so-called “glass jaw?” Ray Arcel contends that the term is nothing more than “a newspaper expression.”

“We never used it,” Arcel explains.

“Certain areas, certain nerve centers, in some individuals, may be more susceptible to a punch. In my own experience, certain guys were made of sterner stuff than others. Let’s face it. The human body was never made to be punched.”

True. But since the advent of this primordial sport, the human body has absorbed and delivered countless blows. Perfecting the knockout punch has and always will be the ultimate goal in a competition mixing skill and toughness with what professional boxers know as an inner, undefinable fire.

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PM58

## SUPERTRAIN

(Continued from page 89)

for a homegrown maglev. Though no full-scale Magneplane has ever existed, the concept boasts theoretical advantages over both Transrapid and the Japanese maglev.

Magneplane is the brainchild of Henry Kolm, co-founder of M.I.T.'s Francis Bitter National Magnet Laboratory. The original Magneplane was patented in 1970 while Kolm was still at M.I.T. By 1974, sponsored by the National Science Foundation and an industrial consortium, Kolm's group had built a 1/25-scale model and a 400-ft. guideway. That's as far as the project went, however, since the Federal funding was withdrawn in 1975.

Kolm now heads Electromagnetic Launch Research, Inc., which is developing strategic-defense launch catapults and hypervelocity coilguns. He is also an avid private pilot, a hobby that has influenced the design of Magneplane.

"Other maglevs are in reality wheel-less trains," he explains, "but Magneplane is essentially a wingless airplane."

Kolm originally modeled Magneplane after the fuselage of a DC-9 with a rounded snout and cylindrical cross-section. Mounted along inside the semicircular belly of the train are a series of flat superconducting magnets in the shape of an inverted saddle.

Instead of guideway coils, however, Magneplane floats over a trough-shaped sheet of aluminum. The train's superconducting magnets induce so-called eddy currents in the aluminum. Eddy currents act as if they were guideway coils, generating a repulsion force that lifts the vehicle.

Through the center of the guideway meanders a 3-phase winding. Current running through the winding provides propulsion, as in the Transrap-

id, by generating a magnetic wave that locks with the on-board levitation magnets.

One potential drawback to Magneplane's propulsion is a low-frequency heave, or galloping motion. But the oscillations can be damped, according to Kolm, by coupling the output of an on-board accelerometer with the computer system controlling the propulsion current. When the train moves down, for example, the guideway current is boosted slightly to push the magnets—and hence the vehicle—away.

The semicircular guideway will allow Magneplane to move around curves by banking like an airplane. The alternative is building a fixed banking angle into the guideway at a curved stretch. That, however, would require the train to negotiate the curve at an exact preordained speed to avoid crunching passengers with G force.

Kolm envisions Magneplane being operated more like an airline than a railroad. Computer-controlled propulsion can sustain numerous vehicles running with as little as 30 seconds separating them.

Moreover, passenger pickup and discharge could take place on off-guideway, elevated platforms. Such a system would allow an army of 1-car Magneplanes to run a network of overlapping nonstop routes—a more efficient system than a single train making many stops.

Is America ready to levitate? Magneplane's future depends on the government's willingness to commit dollars. The Japanese and German governments have already pumped millions of yens and deutsche marks into maglev projects. Closing the maglev gap may become a Federal priority. If so, look for U.S.-built supertrains to bring our rail system into the 21st century. **PM**

## The FAST Act: Will It Fly Through Congress?

**M**AGLEV technology has at least one supporter on Capitol Hill—Sen. Daniel Patrick Moynihan (D-NY), who last October introduced the Federal Advanced Superconducting Transportation (FAST) Act. Here's what he recently told PM about a U.S. maglev initiative:

"We haven't experienced a quantum leap in passenger transportation technology since 1903 when the Wright brothers flew at Kitty Hawk.

"That's why I introduced the first legislation that provides a blueprint for a federal effort to assist in the development and implementation of a U.S. magnetic-levitation system.

"My bill once again calls upon NASA to

lead the country in the development of this technology. It would provide \$100 million in R&D funds so that we can catch up with the Japanese and Germans and have a commercial technology in 2 years.

"Senate Bill 1794 also establishes a new office within the Department of Transportation to draft standards for the national development of maglev and to work with state and local entities to provide the necessary ingredients for actual construction of such systems in the 1990s.

"It's now time we get back in the transportation race. It's a challenge that is in many ways as important as the space race that captivated the nation in the 1960s."





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\*Scientific test results included in NordicTrack brochure.

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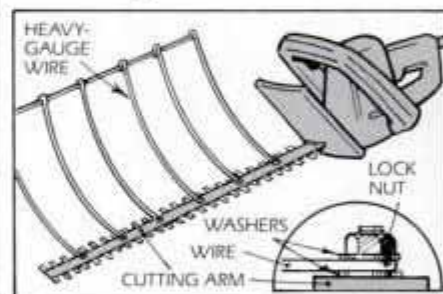
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# HINTS FROM READERS

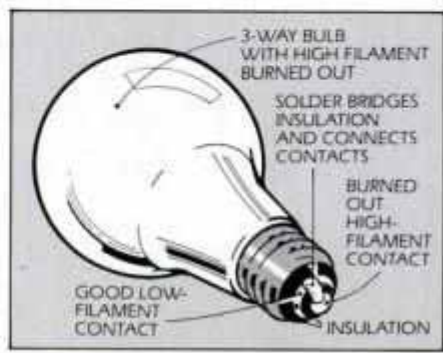
## Cuttings Catcher



Although I use a power trimmer, I've found it difficult in the past to remove all the cuttings from the top of my wide hedge. Having grown up on a farm, I recalled the old reaper that had a bed to catch the hay and decided to try the idea on my trimmer. I attached heavy-gauge wires to the cutting arm bolts and bent them to contain the cuttings. The tension of the bolts on the cutting arm controls the cutting blade tension so I used lock washers under the nuts to keep the wires tight and the blade tension correct.—*Lowell Powers*

## Reusing 3-Way Bulbs

Your 3-way lamp has just burned out on the two higher settings. It still works on the lowest setting. Throw it out? You can salvage this bulb for use in a normal light receptacle with this handy tip. Inspect the end of the bulb that screws into the receptacle. The dot of metal in the center connects to the burned-out high filament in the bulb. After a ring of insulating material, there's a metal ring that connects to the low filament. Apply a bead of solder to connect this ring with the center dot and bridge the insulation. Now install the bulb in a normal receptacle for continued use at the lowest setting.—*Phil Baker*







This drill solved our water shortage problem.

**B**ut, seeing is believing. Thank you, DeepRock.

**MY FRIENDS THOUGHT** I had lost my mind. The idea that the children and I could drill a water well by ourselves sounded like an impossible dream. However, we had to have more water for our large garden and lawn.

#### AN EASY WAY

Then I saw an advertisement that claims that you can drill your own well with a Hydra-Drill and save a lot of money. I had never even watched a well being drilled, much less drilled one myself, so I assumed it would be difficult. But they offered a free brochure, so I sent for it.

When the information came, I was delighted to find it contained a wealth of material. In addition to pictures and descriptions of the equipment, there is a very informative booklet about drilling your own water well.

I was impressed with the information package, but I wondered what we would do if we ran into a problem while we were drilling. Then I thought—well, they have a free consulting service with a toll-free telephone. Any company that is willing to go out on a limb like that, knowing they'll get calls from all over must have a lot of confidence in their product. So I took a deep breath, crossed my fingers, and ordered a Hydra-Drill.

#### TWO SURPRISES

Much to my amazement, the Hydra-Drill arrived from the factory in Alabama in just 7 days. That was my first surprise.

My second surprise was the simplicity and ease of operating the Hydra-Drill. The kids wanted to operate it, but there really wasn't much for them to do. There isn't any big mess and it's more like play than work. Best of all, we were drilling exactly where I wanted the well.

#### SPARKLING, CLEAR WATER

The biggest thrill came when we hit water. It was such an exhilarating experience, I can hardly describe it. We

# "They Didn't Think The Children And I Could Drill A Water Well."

— Mary Hickman

had drilled down into the earth and found sparkling, clear, delicious water! It was such fun, the kids are eager to drill some more wells.

It must be contagious; my friends are getting caught up in it, too. When we started, they thought it was a pie-in-the-sky idea. Now they've got the well-drilling bug and I could sell my Hydra-Drill in a minute.

#### IF YOU ASK ME

To anyone considering drilling a Hydra-Drill well, my advice is this: Sure it's a challenge, but don't be afraid. It's an exciting and satisfying experience. If you ask me if I think it's worth doing, I'll say, "Yes, I do. I really do!"

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## TOOL TESTS

### WORKSHOP WARRIORS

(Continued from page 99)



Mark center of spline joints on mating boards. Then, hold tool against board edge and push forward to cut a spline groove.



Glue biscuits into spline grooves and glue and clamp boards together. Compressed-beech biscuits swell as they absorb the glue.



Reverse the fence to cut spline grooves in mitered surfaces. Note that two sizes of biscuits are used to assemble this type of wood joint.



To cut spline grooves well away from the board's edge, remove the fence and clamp in place wood blocks that will guide the tool.

glued in place, the splines expand to fit tightly in the grooves. The depth of cut can be adjusted for three size biscuits: No. 0 ( $\frac{3}{8} \times 1\frac{1}{4}$  in.), No. 10 ( $\frac{3}{8} \times 2\frac{1}{2}$  in.), and No. 20 ( $1 \times 2\frac{3}{4}$  in.). A box of 1000 biscuits cost about \$35.

I found that the real beauty of this tool is in the time saved making wood

joints. Unlike dowel pin joints and other common joints which require timely layout and exact positioning, mating biscuit-spline joints can be misaligned slightly, up to about  $\frac{1}{8}$  in., and still produce a perfect joint.

Contact Freud, 218 Feld Ave., High Point, NC 27264.

## Benchtop Belt Sander



Compact benchtop belt sander accepts a narrow, 1-in.-wide  $\times$  30-in. abrasive belt for precise sanding and tool sharpening chores.

**D**ELTA recently introduced a versatile, narrow-belt sander that's designed to handle various sanding and grinding chores on wood, metal and plastics. Its compact, benchtop size and affordable price make it ideal for woodworking, handicrafts, metalworking and general shop work.

A  $\frac{1}{4}$ -hp motor drives a 1-in.-wide  $\times$  30-in. abrasive belt at 3150 fpm. The narrow belt is great for sanding in tight, hard-to-reach spots. If you're used to working on a large stationary sander, as I am, you'll discover that a lighter touch is needed here to avoid stalling the motor. I found the sander especially useful for deburring metal workpieces and sharpening tools. The relatively slow-running belt minimizes the danger of drawing the tool's temper by overheating the steel—a common problem when sharpening on a bench grinder.

(Please turn to page 131)



# Power Plus Mark II™

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formance and economy of your Ford 6.9 at a very affordable price!

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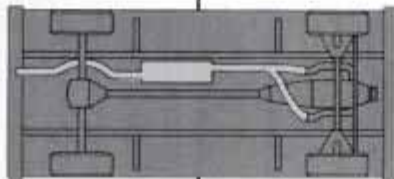
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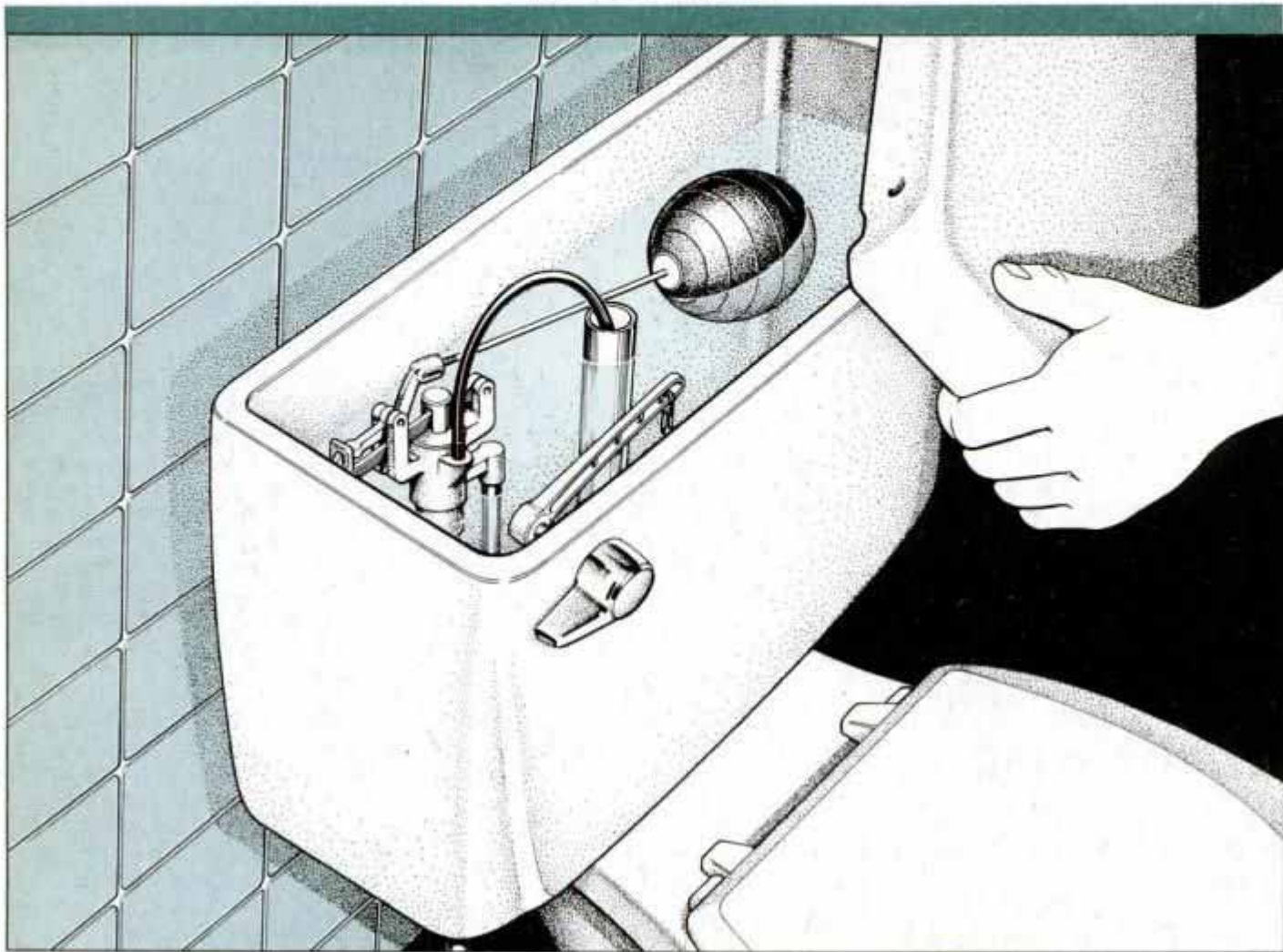


\*See 7/70 powertrain & 7/100 outer body rust-through limited warranty at dealer. Restrictions apply.

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## Complete Guide To TOILET REPAIR

BY MERLE HENKENIUS  
Illustrations by George Retseck

**M**OST residential toilets are simple, straightforward pieces of equipment and, because of this, are *very* durable and dependable. Still, like every mechanical system, they will eventually break down and need repair. Fortunately, most of the repairs are not only inexpensive but also easy to accomplish. In fact, just about any toilet can be completely rebuilt—for under \$20—in just a few hours.

To begin with, there are two kinds of toilets in residential use today. By far the most common is the 2-piece tank-and-bowl type. These toilets flush primarily by the weight of the water held in their tanks. This weight, also known as head pressure,



1 A 2-piece toilet is a simple mechanical device that operates on water pressure and gravity. When the toilet is flushed, water drops by gravity from the tank into the bowl and forces the bowl water into the waste line of your home's plumbing system. Replacement water flows into the storage tank from the pressurized supply line so it's ready for the cycle to begin again.





**2** A dirty bowl usually means poor water flow from rim openings. To check clogged openings, hold mirror under rim.

allows the unit to operate with very few mechanical parts.

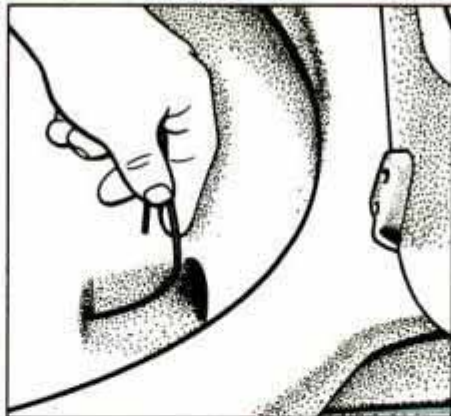
The other type differs in that it is made in one piece. These toilets are offered by a variety of companies, but are generally known as silent-flush models. Aside from appearance, the main difference is that silent-flush toilets rely less on gravity and more on control valves. Silent-flush toilets are complicated enough to require an article all their own, so only 2-piece toilets will be discussed here.

## How a 2-piece toilet works

When you press down on your toilet's flush lever, it pulls up a chain, or wire, connected to a rubber stopper which is shaped like a ball or a flapper. This lifts the stopper off of its flush valve seat which connects the tank and the bowl. Basically, this pulls the plug on the stored water and sends it into the bowl. The stopper is hollow and has a trapped bubble of air inside. This air bubble holds up the stopper until the receding water level carries it back down onto its seat.

When the water level drops, a hollow float ball attached to a brass rod drops with it. The other end of the rod controls a stopper inside a water inlet valve, called a ballcock. The rod acts as a lever. When the ball goes down it pulls this stopper up, allowing water from your supply system to rush through the valve and into the tank. As the tank begins to fill, the weight of the water presses on the seated flush valve stopper and forces a seal preventing the water from leaving the tank. As the rising water level carries the float ball up, the inlet valve stopper is forced back into the ballcock and the water is shut off.

The bowl on the other hand, has no mechanical parts. In terms of design, it is little more than a vitreous china

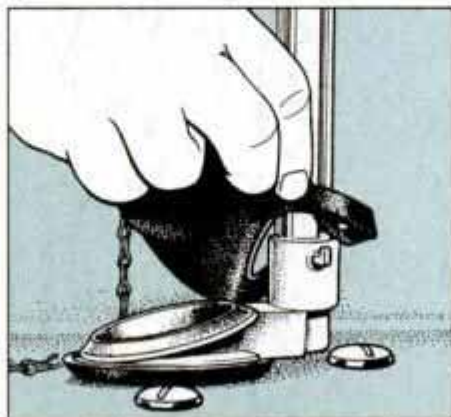


**3** If the bowl flushes sluggishly, check for a bacteria-clogged siphon hole. Bend a coat hanger and use it to clear the hole.

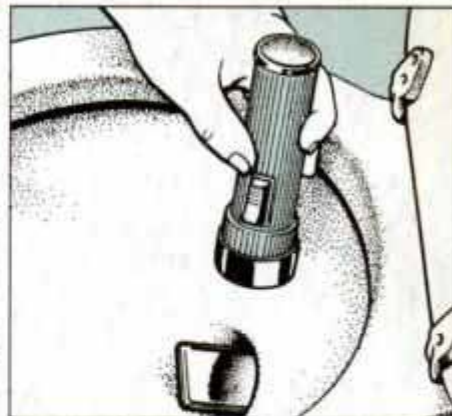
water trap, not unlike the p-trap under your kitchen sink. The water you see standing in the bowl is the water held by the trap. This water serves two important functions. It keeps the bowl clean and seals off the sewer gas that is always present in your drainage pipes. Without this trapped water, every toilet would need a mechanical seal, similar to those found in airplane toilets.

When the flush valve is opened, the water rushes into the hollow rim of the bowl by force of gravity. The rim has a dozen or so small, slanted openings and one larger opening. The smaller openings are visible under the rim and send water coursing down the sides of the bowl in a diagonal pattern. The larger opening, about 1/2 in. dia., dumps a forceful jet of water into a channel inside the bowl. Though this channel is concealed, its opening is directly across from the drain opening in the toilet.

A toilet then is flushed by water sent from two directions. Water from the rim openings cleans the bowl and starts the trapped water in its spiral up through the trap. The water from



**8** Once the collar is cut off, simply hook the flapper eyelets over the side pegs and connect the lift chain to the flush lever.



**4** To check for a partial blockage at the top of the trap, shine a flashlight onto a mirror placed in the bottom of the bowl.

the larger opening sends a jet of water into the drain and forces the trap.

As soon as water spills over the trap, a siphoning action pulls the rest of the water in the bowl with it. When not enough water is left to fill the narrow passage at the top of the trap, the siphon is broken and all the water pulled to the top of the trap slips back into the bowl. Aside from the small amount of water added through the overflow tube, the water left standing in the bowl after a flush is the water that didn't make it over the trap.

That's how a toilet is meant to work, but let one component fail and you'll be left with an often confusing array of symptoms. The good news is that these symptoms are your quickest route to effective repairs.

**■ Symptom No. 1: Your toilet flushes normally but is sluggish and often needs more than one flush to clear the bowl. The sides of the bowl are also stained and need frequent cleaning.**

Toilets that flush sluggishly do so for one of three reasons. If the toilet has never flushed properly, you can count on a flawed trap or an inadequate vent in the waste line. As these



**9** To remove a defective tank ball, hold the lift wire with pliers and unthread the ball. Old, brittle rubber will often tear.



# THE BETTER HOME



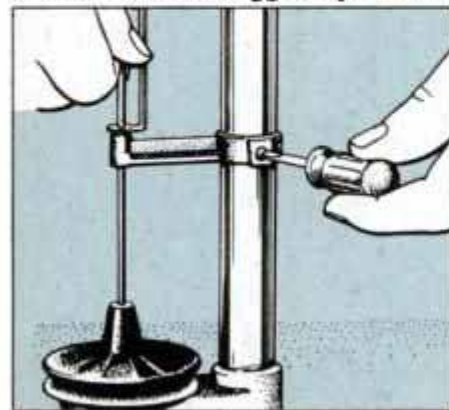
**5** To clear congested rim holes, pour a  $50/50$  mixture of warm water and vinegar into the flush valve. Then ream holes with wire.

conditions are rare, save investigating them for last. More probably the trouble is a bacteria-clogged siphon hole or partial clog at top of trap.

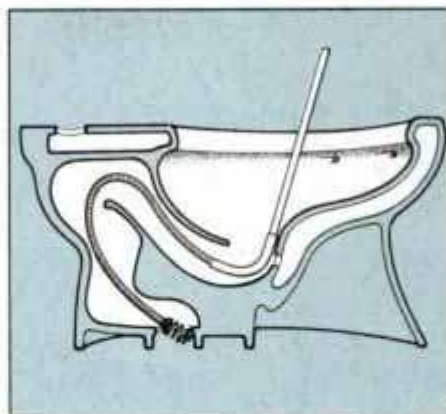
Bubbles are a sure sign of a partially blocked trap. Flush the toilet and watch for air bubbles between  $1/8$  and  $1/4$  in. dia. They will rise out of the trap opening halfway through the flush. As the water goes down, the bubbles will come up. Items that can cause a partial blockage are toothpaste caps, cotton swabs and hair pins. A partial blockage usually means that some such obstruction rests against the side of the top of the trap.

To locate the blockage, dip the water out of the bowl with a paper cup. Then hold a pocket mirror at an angle facing into the drain opening. Shine a flashlight into the mirror so that the beam is bounced toward the top of the trap. This will allow you to see the obstruction. When you learn its shape and location, fashion a hook from a piece of wire and snag the blockage. Then, flush the toilet several times to clear the passageway.

If you see no obvious bubbles, assume a bacteria-clogged siphon hole



**10** If the tank ball drifts to one side as it falls, loosen screw in lift-wire guide, then rotate guide until wire falls properly.



**6** Use closet auger to clear large obstructions. Auger's cable is long enough to reach the soil pipe below the bowl.

and mineral-clogged rim openings. You will usually be able to see a build-up in the siphon hole. To clear the opening, ream it with a piece of wire. The clog should fall forward into the bowl as you work.

If your toilet seems to need cleaning more and more frequently, flush the toilet and watch the action of the water as it spills from the rim openings. It should course down the sides of the bowl diagonally. If the water slides straight down the sides of the bowl, the rim openings are partially clogged with calcified minerals and bacteria.

To correct this problem, shut the water off and empty the tank. Then, while holding the flush valve stopper up, pour a  $50/50$  mixture of warm water and white vinegar into the flush valve opening. Much of it will drain into the bowl, but some will be trapped at the clogged openings. Let it stand for half an hour. Then ream each opening with a wire. If the openings are really clogged, start with a rigid wire—a coat hanger is ideal—and work up in size to a small screwdriver. To keep the problem from recurring, install a



**11** Before installing new ball or flapper, sand valve seat flush with fine sandpaper. To avoid damage, use light touch.



**7** If replacing flapper on a flush valve that has no side pegs, slip collar over the tube. If pegs are present then cut off collar.

chlorine tank treatment and use lime-dissolving bowl cleaner.

As for improper venting or a flawed bowl trap, check the venting first. Each toilet in your home must have its own 2-in. vent or be within 6 ft. of a full-size vertical stack. This evaluation may require a plumber. If you are sure your bathroom is properly vented, assume a flawed toilet.

**■ Symptom No. 2: Your toilet clogs and overflows, or passes only water.**

A toilet that does not flush at all is likely to have a larger blockage at the top of its trap. Such a blockage may be caused by too much paper, but is more likely the result of a foreign object and paper combination. Occasionally, you will be able to retrieve a full blockage with the mirror-and-wire method or a plunger, but a closet auger is often a better alternative.

To use a closet auger, pull the cable back through the handle so that only the pilot spring shows at the bend. Then insert the bend into the drain opening of the toilet and push the cable through the housing until it stops against the top of the trap. When you feel the resistance of the trap bend, crank the cable in a clockwise direction. If you feel a snag, continue to crank in the same direction while retrieving the cable.

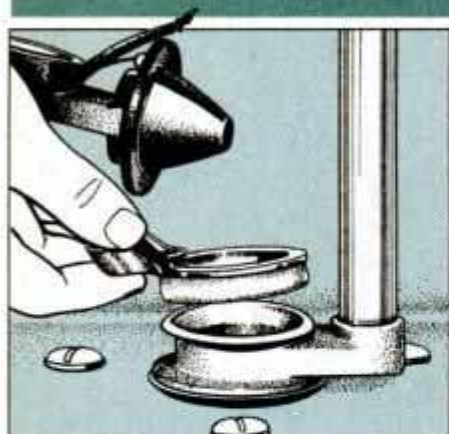
If you can't feel a snag, continue cranking through the drain until you run out of cable. Then retrieve the cable and repeat the process several times more. Finally, flush the toilet repeatedly and watch for bubbles that indicate a partial blockage.

**■ Symptom No. 3: Your toilet continues to run until you wiggle the flush handle.**

This is a common problem that is almost always a quick fix. It is either caused by a lift chain that is too long or by a lift-wire guide that is poorly



# THE BETTER HOME



**12** If seat is damaged beyond repair, it must be replaced or retrofitted with new seat as shown. Epoxy bonds it to old seat.

aligned. Which one depends upon the design of the flush valve. Start by shutting off the water and flushing the toilet. If your flush valve has a rubber flapper, look for too much play in its lift chain. To make the adjustment, unhook the chain at tank lever and reconnect it in a lower link. Try for an adjustment that leaves no more than  $\frac{1}{2}$  in. of slack in the chain.

If your toilet has a flush valve with a lift wire and a tank ball, (some are ball-shaped and some are wedge-shaped), start by removing the tank lid and watching the action of the lift wire and tank ball through several flushes. This should give you a good idea as to where the ball is landing and in how the guide should be moved.

Use one hand to steady the flush valve's overflow tube and another to loosen the setscrew in the guide. With the setscrew loosened, move the guide only slightly in the desired direction. Then tighten the screw and turn the water back on.

■ **Symptom No. 4: The water comes on in your toilet tank automatically every half hour or so, runs for a minute, then shuts off.**

This phantom operation stumps a lot of homeowners, and is especially annoying in the middle of the night. In most cases, all that is required here is a new flapper ball or tank ball. If your toilet has a flapper, buy a universal replacement. A universal flapper has an eyelet on each side—where it hinges—and a center collar made to fit over an overflow tube.

You will need one or the other, but not both. If your flush valve has side pegs for the eyelets, cut the collar from the flapper.

In any case, empty the tank and slip the old flapper from its eyelets, or cut through its collar with a utility knife or scissors. Before installing the new



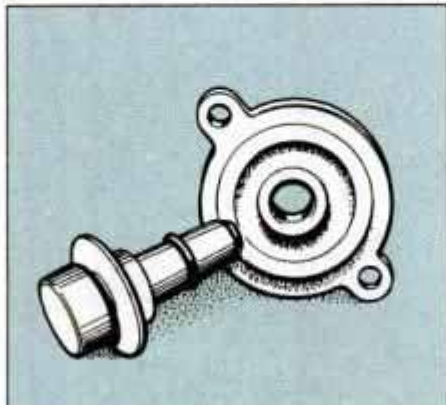
**13** If you find a broken overflow tube, pull old tube out, pry threads from the flush valve, and thread a new tube in place.

flapper, run a finger around the flush valve seat. Through years of use, dissolved mineral salts in the water can calcify on the flush valve and keep the flapper from seating properly. If the seat feels rough or gritty, sand it lightly with grit cloth or sandpaper.

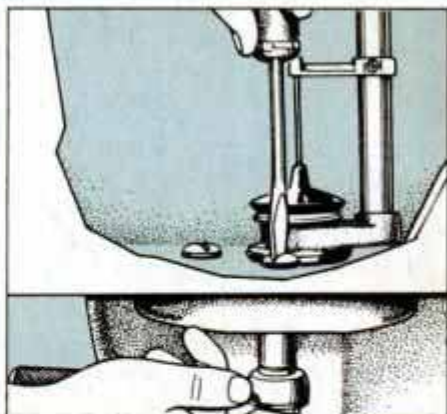
If your toilet has a tank ball instead of a flapper, repair will differ slightly. Start by shutting off the water and draining the tank. Then hold the lower lift wire steady with a pair of pliers and unthread the ball from the wire. Rubber tank balls deteriorate with age, so don't be surprised if the ball strips away from its threaded brass insert. If this happens, simply hold the insert with one plier and thread the lift wire from it with another. With the old ball removed, sand the flush valve seat, and thread the new tank ball onto the lower lift wire.

■ **Symptom No. 5: Your toilet continues to come on at regular intervals, even though the tank ball or flush valve has been replaced and the flush valve seat has been sanded.**

This symptom means that your flush valve seat has a factory defect or is simply worn out. The best solution,



**18** Ballcock seals differ by manufacturer. This one features a plastic plunger with an O-ring and a separate seat seal.



**14** To separate a tank from a bowl, first unscrew the tank bolts. Hold one end with a screwdriver—use a socket on the other.

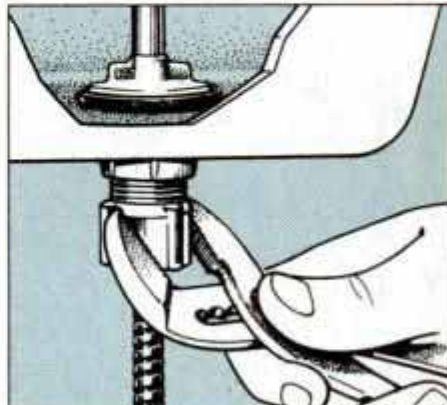
of course, is to replace the valve, but replacement will require that you separate the tank from the bowl. If your stool has a wall-mounted tank with a fragile chrome flush valve connecting the bowl, or if breaking your toilet in half sounds like more than you want to tackle right now, try an epoxy seat replacement kit.

Start by shutting the water off and flushing the toilet. Follow by sponging the remaining water from the tank and drying the flush valve seat. With the seat dry, sand it lightly until it feels smooth. Remove the epoxy from the kit and press it onto the bottom of the replacement seat. Then press the replacement seat firmly onto the flush valve and connect the lift chain to the flush lever.

## Replacing a flush valve

A better and more reliable solution is simply to replace the flush valve. You'll find both plastic and brass versions at your local hardware store. Brass will last longer and will be less likely to cause problems later.

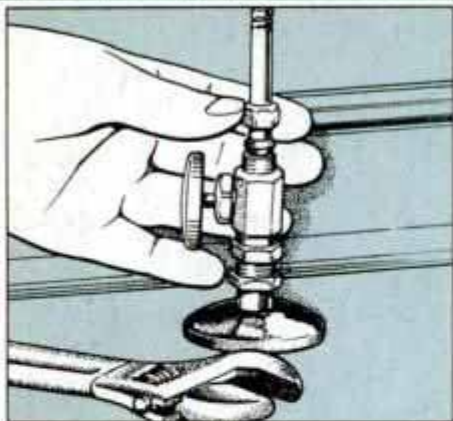
Replacing a flush valve is not that difficult, but expect it to take an hour



**19** To remove ballcock, start by unthreading nut under tank that holds water-supply tube to ballcock shank.



# THE BETTER HOME



**15** Next, remove the water supply line. This can be done at ballcock connection under the tank or at the shutoff valve.

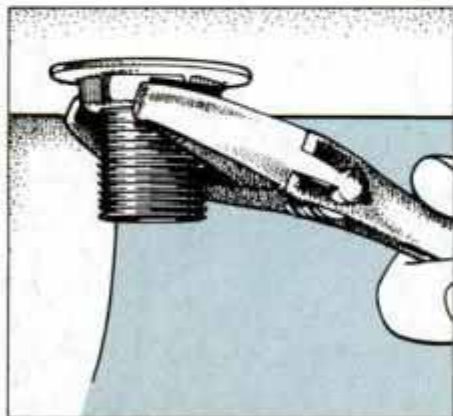
or so. Begin by shutting the water off and flushing the toilet. Then sponge all remaining water from the tank and disconnect the water supply tube from the ballcock. With the tank empty, remove the tank bolt nuts, lift the tank from the bowl, and set it upside down on the floor.

To remove the flush valve, pry the washer from the valve spud and undo the large spud nut. You'll then be able to pull the valve out from the inside.

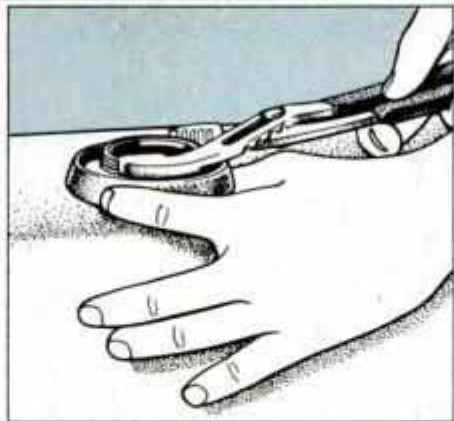
Before installing the new valve, sand the area around the tank opening. Then coat the tank washer with pipe-joint compound or petroleum jelly and insert the valve spud through the tank. Turn the spud nut onto the spud hand tight, plus about three complete turns. Finally, slide the new spud washer onto the spud and set the tank back in place.

If your toilet is more than a few years old, buy new tank bolts and washers. Corroded bolts and brittle washers are usually more trouble than they are worth.

In any case, slide a rubber washer onto each tank bolt. Drop the tank bolts through the tank holes and



**20** Next, loosen and remove the hexhead jam nut that actually holds the ballcock to the tank. Hold the ballcock from inside.



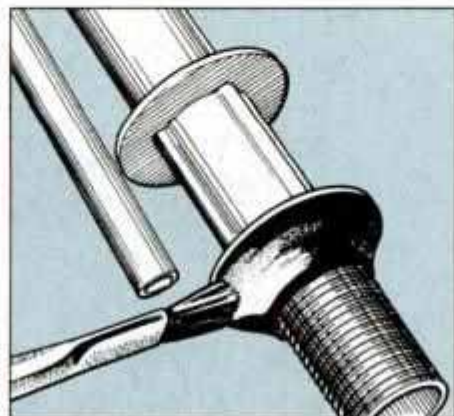
**16** If you must replace a flush valve, separate the tank and bowl, then turn the tank over. Remove the washer and nut.

through the corresponding holes in the bowl. Then start a rubber washer, a metal washer and nut onto each bolt from below and tighten the nuts.

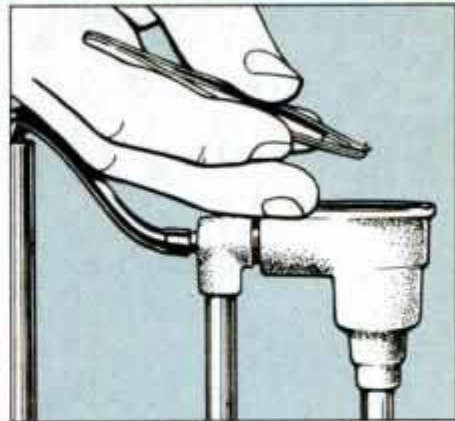
When tightening tank bolts, remember that vitreous china can break under too much pressure. Don't tighten any one bolt all the way down. Rather, move from bolt to bolt, tightening each only a few rounds before moving to the next. Keep in mind that with most brands, the tank does not actually touch the bowl, but is suspended by the spud washer. In any case, stop tightening the tank bolts as soon as you feel firm resistance. Then reconnect the toilet supply tube, connect the flapper chain to the tank lever, and turn on the water.

**■ Symptom No. 6: Your toilet does not shut off completely, but trickles a small stream of water into the bowl. You will also hear a slight but prolonged hissing sound.**

These symptoms invariably signal trouble at the ballcock. In most cases, the ballcock needs a new seal or needs to be replaced entirely. In a few cases, the problem may only be sediment in the diaphragm. In any case, shut the



**21** Before installing ballcock, clean opening. Coat ballcock washer with pipe-joint compound or petroleum jelly.



**17** Sediment causes ballcock to perform poorly. To check, take off diaphragm cover and remove particles with tweezers.

water off and remove the diaphragm screws from the top of the ballcock. Then lift the float, float arm and diaphragm cover off the ballcock.

If the trouble is sediment, you'll be able to see it in the diaphragm. Use tweezers to pick it out. If you don't find sediment, assume a faulty seat or diaphragm seal. As for repair, you'll have two choices. You can either replace the seal or replace the entire ballcock assembly. The factors influencing your decision will be the condition of the diaphragm seat and the material of the ballcock.

Because imperfections in plastic ballcocks are difficult to see or feel, you will often be better off replacing a troublesome plastic model. If your ballcock is made of brass, and if the seat shows no signs of wear, a diaphragm seal kit will save you time.

Ballcock diaphragm designs are proprietary, so your best bet is a kit made by your toilet's manufacturer.

## Replacing a ballcock

Replacing a ballcock is not hard. You'll have to drain the tank, but you won't need to disturb the tank-to-bowl connection. Loosen the compression nut that holds the supply tube to the shank of the ballcock. Next, loosen the jamb nut that holds the ballcock in place. With the nut removed, the entire assembly should lift right out.

Before installing your new ballcock, apply pipe-joint compound to the rubber washer. Insert the shank through the tank opening, tighten the jamb nut and reconnect the supply tube. You'll probably have to adjust the float level on the ballcock. Bend the rod for large adjustments. For minor corrections, use the adjustment screw at the top of the diaphragm. Shoot for a water level about an inch below the top of the overflow tube.





**22** If sediment is a problem, a Fluidmaster ballcock replacement makes sense. It comes apart easily for cleaning.

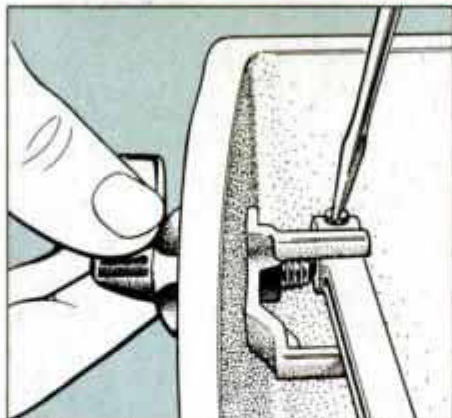
■ **Symptom No. 7: Tank handle falls out or is loose.**

The only trick to replacing a flush lever is in remembering that it has left-hand threads. Armed with this information, the rest is a matter of loosening the retaining nut and pulling the lever out by the handle. The replacement handle will go in the same way, only in reverse order. If your toilet's flush lever is made in two pieces, loosen the setscrew in the lever before undoing the nut.

■ **Symptom No. 8: Water appears around the base of the toilet. The toilet may also rock side-to-side slightly when used.**

Water around a toilet is a sure sign that the seal between the bowl and toilet flange has been broken.

Bowl gaskets come in three forms: rubber, beeswax and a newer rubber covered by wax. Each has its advantages and disadvantages. Wax gaskets are by far the most popular, primarily because one size fits nearly every installation and because they are inexpensive, costing about \$1. Rubber gaskets, on the other hand, seldom leak once installed, are reus-

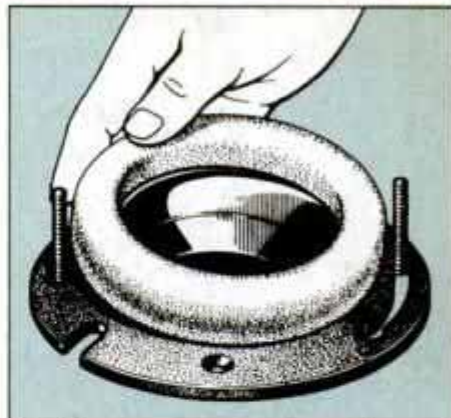


**23** To replace 2-piece flush lever, loosen screw and remove handle. One-piece levers have nuts with left-hand threads.

able and are less problematic when the right thickness of gasket is used. The disadvantage is that the right thickness must be determined in advance, which is not always easy. Rubber gaskets are also more expensive, \$3 to \$6. New, wax-covered rubber gaskets (\$3 to \$4) are a compromise between the two. They provide the strong seal associated with rubber units and also afford the minor gap-filling capabilities of the wax gaskets.

In determining which gasket to use, consider the use the toilet will get and the kind of floor supporting it. If the toilet will be used by a very heavy or handicapped person, or if the floor level has been raised by subflooring or quarry tile, rubber gaskets are a better choice. Wax gaskets will hold up well in other situations.

To reset a toilet, drain the tank and dip all water out of the bowl. Then undo the supply tube connection, either at the ballcock or at the shutoff valve. Once this is done, pry the caps from the closet bolts at the base of the bowl and undo the nuts from the bolts. Then straddle the bowl, grasp it on each side near the seat hinges and pull



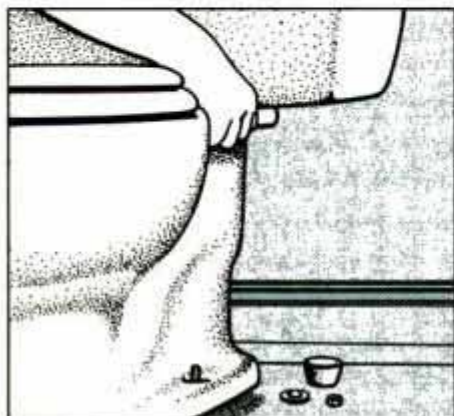
**24** Wax ring gasket forms seal between bowl and waste line. Gaskets also come in rubber and wax-covered rubber.

up. Set the toilet down on a few sheets of newspaper and gently lay it over on its side. This will expose the horn, or drain opening of the toilet.

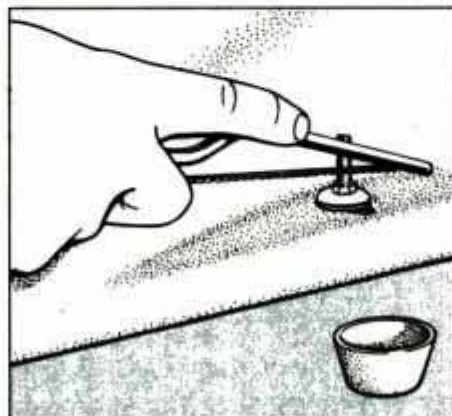
Use a putty knife to scrape all remaining wax from around the horn of the bowl and from the bowl flange on the floor. Next, slide the old closet bolts from the flange and replace with new bolts. Press a new gasket onto the flange so it's centered between the bolts. Then pick the bowl up and walk it over to the flange. Align it so that you can see the closet bolts through holes in the base. Then settle bowl down onto the gasket.

Before tightening the closet bolt nuts, make sure the back of the tank sits square with the wall. Then tighten the bolts, each a little at a time. Draw the nuts down only until you feel firm resistance. Then sit or stand on the toilet to compress the gasket further. This should allow you to draw the bolts down another two rounds.

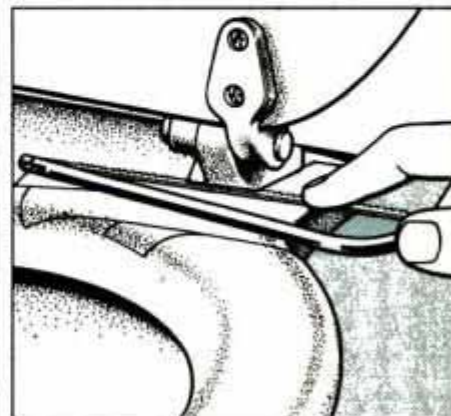
Finally turn the water back on. After a few days of normal use, tighten the closet bolts again until they feel snug. Then snap the caps over the bolts to complete the job. **PM**



**25** When moving a toilet with the tank attached, you'll get the best balance point if you hold the bowl near the seat hinges.



**26** To secure toilet, tighten hold-down nuts until bowl doesn't rock. Then cut off bolt tops and snap caps in place.



**27** To replace broken seat, hinge bolts must be removed. If rusted, cover bowl rim with tape and cut bolts with hacksaw.



# Homeowners' Clinic

BY NORMAN BECKER, P.E.

## Venting Island Sink

I'm planning some improvements to my kitchen that include locating the sink in a central island cabinet. I'm unsure of how to vent the drain. Do you have any ideas? FRED REINER  
OWINGS MILLS, MD

*I agree that proper venting of the sink drain is important. Otherwise it's possible for the water seal, normally maintained in the drain trap, to be siphoned out by water flowing rapidly down the drain. If this happens, sewer gases will escape into the room.*

*There are many ways to adequately vent an island sink. However, before installing any system, check with the building department in your area to see if your design complies with the local building codes.*

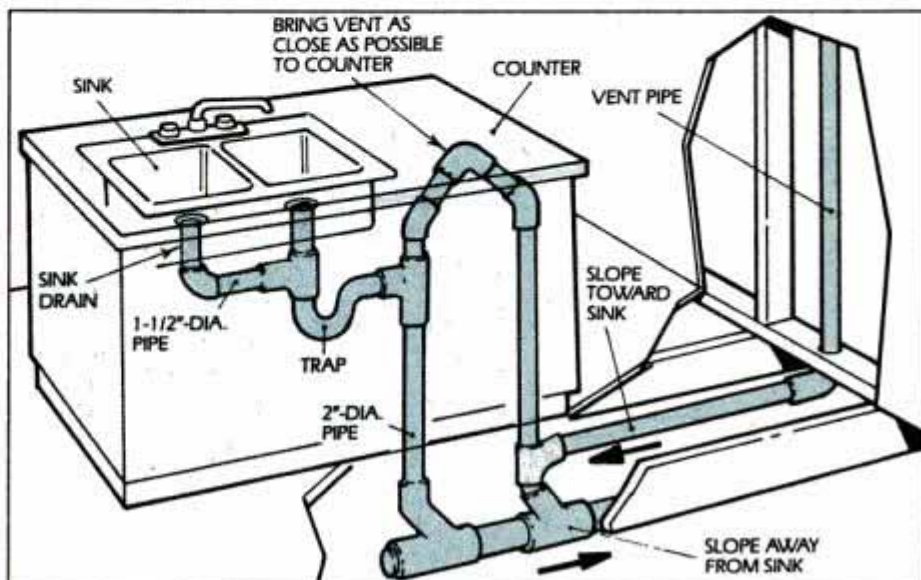
The Residential Plumbing Inspector's Manual, published by the American Society of Sanitary Engineering, offers an arrangement that may be suitable for your needs (see drawing). Install the vent piping under the counter as high as possible. Then, return it downward and connect it to the horizontal sink drain immediately downstream from the vertical drain section. The returned vent is connected to the horizontal drain and to the vent pipe immediately below the floor with Y-branch fittings. The vent pipe should be carried up through the nearest partition or be connected to other vents.

Drainage fittings should be used on all parts of the vent below the floor and a minimum slope of 1/4 in. per ft. back to the drain should be maintained. The return bend under the counter can be a 1-piece fitting, or assembled with 45° and 90° fittings. The island sink drain, upstream of the returned vent, should serve no other fixtures.

## Exhausting Problems

The fans in my bathrooms discharge into my attic which is insulated and vented at each end with louvered gable vents. Will this system cause the insulation to become damp? Should I do anything about it?

EVERETT M. AIKMAN  
SO. CHATHAM, MA



Drawing shows pipe configuration for venting a sink mounted in a central island cabinet. Proper venting maintains water seal in trap which keeps sewer gases from escaping.

*Discharging moisture-laden air into your attic can cause condensation problems, especially if the attic isn't adequately ventilated. In my experience, most vented attics remain inadequately ventilated because insect screens and louvers reduce the effective vent openings.*

*If there's a vapor barrier on the attic floor, then the unobstructed vent opening should be 1/300 of the floor area. Double the required vent size if there is no vapor barrier.*

*The most effective way to solve your problem is to discharge the moisture-laden air outside the house. A flexible duct connected to the fan and run under the insulation to an exterior wall where a hole can be cut will do the job. Install a weatherproof vent hood over the exterior wall opening. Attaching the flexible duct to an existing attic vent opening is not recommended because the duct will partially block the opening.*

*Another way to terminate the duct is to run it directly up through a hole in the roof.*

*In this case, the duct should be as short as possible to prevent condensation inside the duct during the winter months. A suitable vent hood must be installed and the joints between the hood and roof must be sealed to prevent leakage.*

## Service Tip

The season has arrived when do-it-yourselfers begin repairing and constructing concrete paths, patios and other structures. Before undertaking masonry projects, there are several precautions to be observed. Few people realize that wet concrete is very caustic. It can severely burn the skin and seriously damage the eyes.

The Portland Cement Assn. recommends the following when working with fresh concrete:

- Wear a long-sleeved shirt and waterproof gloves for protection.
- Wear long pants and boots. Pants should be tucked into boots high enough or tight enough to keep out wet concrete.
- Wear waterproof knee pads when finishing concrete from a kneeling position.
- If your skin is irritated, wash the affected area with fresh water. Lanolin cream generally relieves the discomfort.

*Do you have a home-maintenance or repair problem? Send it to Homeowners' Clinic, Popular Mechanics, 224 West 57th St., New York, NY 10019. Letters cannot be answered individually, but problems of wide interest will be discussed in the column. For more home-repair and maintenance help, get PM's Home Care Guide, \$2.45 postpaid. Send your order(s) to Popular Mechanics, Box 1014, Radio City Station, New York, NY 10101.*



# Appliance Clinic

BY STEVE TOTH

## Needs A Good Belt

Our Whirlpool electric dryer model No. LVE6700 is getting noisy. I've been told that a pulley is loose and that I need a new belt. How can I do the job myself?

F. BRITTNER  
PITTSBURGH, PA

To get at the drive belt and check the support rollers and idler pulley, you'll need to remove the front panel. First, unplug the dryer. Then lift the lint screen cover and remove the two screws found underneath. Insert a narrow putty knife between the top and front of the cabinet about 2 in. in from one corner. Push in on the putty knife to free the locking clip and lift up on that corner. Move to the other side, repeat the procedure and raise the top. Place an old towel over the top panel edge to protect it when it's laid against the wall behind the dryer.

Next, remove the two upper screws found on the inside of the front panel. Pull the front panel out about 1 in. and lift up sharply to release it from the spring clips at the bottom. Try to free one side at a time. Then, move it around to the right side of the dryer and let it rest on the cabinet side. It's normal for the drum to sag a few inches when you remove this panel.

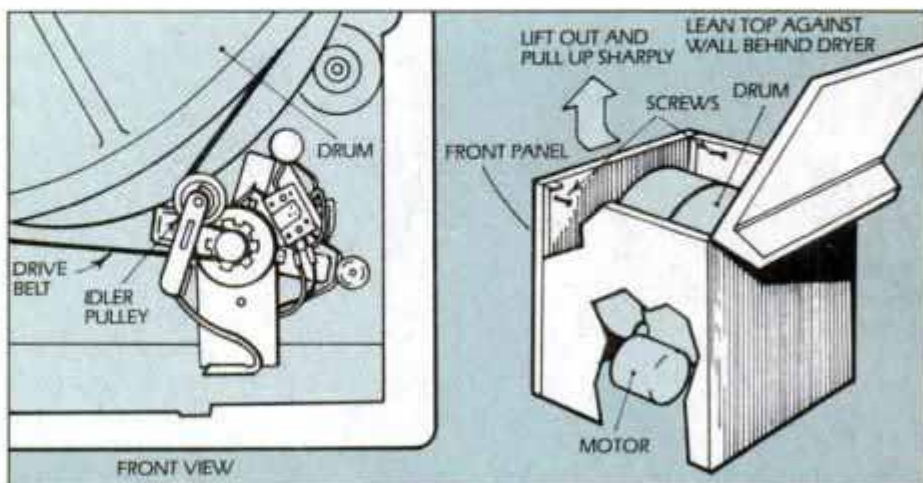
Look under the right side of the drum to find the idler pulley. Release the tension on the belt by lifting the idler pulley up and to the right. Then remove the belt from the motor shaft. Lift the drum off of the support rollers and out of the front of the dryer. Vacuum the inside of the dryer.

The drive belt (part No. 341241) and idler pulley (part No. 691366) cost about \$6 each and are available from any authorized Whirlpool parts distributor. Both parts come with installation instructions. Whirlpool also offers a repair manual (part No. 677818) for gas and electric dryers. The manual costs \$7.50.

## Ice Maker Shoots Cubes

The ice maker in our J.C. Penny refrigerator model No. 86702704210, serial No. CH510489 doesn't just drop the cubes into the bin—it shoots them all over the freezer. Can you help?

DELORES ALISSIO  
GROVE CITY, PA



Remove front panel to access the drive belt and pulleys. Lift idler pulley up and to the right to loosen the drive belt. Remove the drum and examine components for wear.

Start by checking the ice cube size. If they're smaller than normal, they'll tend to fly farther when ejected. Check the water level in the ice maker mold. It should be within 1/4 in. from the top for properly sized ice cubes. If the level is low, check the water valve on the supply line that leads to the water fill valve on the refrigerator. Disassemble the water valve and check for sediment buildup. Also, check the metal strainer on the inside of the water fill valve.

If you still have a problem with the water level, then you'll have to adjust the water fill height screw that's located under the front cover of the ice maker. Turn the screw to the plus side to raise the water level.

Note that one full turn alters the water level by 20 cc.

The next thing to check is the temperature of the freezer compartment. If it's not between 0° and 8°, then adjust the temperature control.

If your ice cubes are still flipping, then check the rake that scrapes them off the ejector pads. Plastic rakes are prone to flipping cubes and should be replaced with the metal (spring-loaded) type. Ask for G.E. part No. WR29X137. The new rake costs about \$8.

Also, some ice makers have a dark gray stainless-steel ejector pad that can cause the ice cubes to stick. It can be replaced with a new aluminum pad, rod and seal kit.

It's G.E. part No. WR29X144 and

costs about \$26. Make sure you unplug your refrigerator before installing these parts to avoid damage to the ice maker's electrical components or wiring. Both kits are available complete with instructions from any G.E. parts distributor.

## Needs A Switch

I'm having trouble finding a part for my outmoded top-loading G.E. dishwasher model No. AC100A16, serial No. 50-205898. The part I need is the timer that controls the washing cycle and turns the unit off.

BYRON A. BAUR  
ERIE, PA

G.E. stopped making the timer for your vintage dishwasher several years ago. My suggestion is to have your timer rebuilt. T & E Timer Inc., 53 E. 10 Mile Rd., Madison Heights, MI 48071, told me that there is a good chance that they have the parts in stock. Send them your timer along with a note that includes your name, address, phone number and instructions to repair and return the unit to you.

They'll inform you of all of the repair costs and shipping charges. If they can't repair it, they'll return it at no charge. **PM**

If you have a problem with any appliance, send your question, with the model and serial numbers to Appliance Clinic, Popular Mechanics, 224 West 57th St., New York, NY 10019. Sorry, but letters cannot be answered individually. Problems of wide interest will be discussed in this column.



# .22 CAL. PELLET FIRING TARGET PISTOLS

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Don't be fooled by the appearance of these glasses! These are not ordinary sunglasses. They may look like high fashion sunglasses (in fact, they are designed after some of the most expensive brand names on the market today — e.g. Porsche™, Carrera™, etc.) — but are actually the latest breakthrough in sunglass technology. Ambervision's™ scientific design filters out blue and ultraviolet portions of the light spectrum that have been proven to be harmful to your eyes. By filtering out these dangerous rays, not only are your eyes protected from damage, but your vision is enhanced to a new level of perceptual eyesight!

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Vision enhancement eyeglasses have been nationally advertised by others in leading media at many times this price. In fact, you would think that high-tech vision enhancement Super-Glasses like these would sell for well over \$100.00. But during this nationwide publicity campaign, you don't pay \$100.00 — or even half that much. You pay an incredible give away price of just \$10! But this offer is for a limited time and only available through THIS nationwide publicity campaign for a limited time.

### A New World Through New Eyes

Just imagine what it would be like to look through glasses that make the world seem sharper, more vibrant, more alive and more cheerful. Slip on a pair of these sleek designer sunglass "look alikes" and you'll notice a marked improvement in your vision. The world will

seem so crisp, so clear, that you'll feel as if someone had just given you a new set of eyes. This vision enhancement experience is so incredibly phenomenal that you literally "won't believe your eyes!" Thousands of professional golfers, hunters, and skiers have already discovered and reaped the benefits of these indispensable Super-Glasses — now you too can experience the excitement of ENHANCED EYESIGHT!

### What About Sunglasses

The unbelievable truth is that ORDINARY sunglasses may be dangerous to your eyes. Everybody knows that your eyes automatically adjust to light. When you wear plain darkened lenses, your pupils open wider to adjust for darkness — but this becomes harmful because your eyes are now letting MORE dangerous UV rays in.

Ambervision™ lenses are gradiated to help shield against overhead light. These glasses are made with one of the finest lens materials available for sunglasses — cast in CR-39™ with UV400 protection, even an optometrist would be impressed! The lightweight frames are designed for ultra comfortable wear and tear and the molded nose rest is designed to rest comfortably on your nose. The hinge design of these frames allows them to be the perfect "one size fits all" eyeglasses. Your "Super-Glasses" even come complete with a luxurious black suede-like protective pouch. No wonder these are the most popular and fastest selling sunglasses ever sold by this giant new home shopping club!

These Ambervision™ Super-Glasses will not be sold to any wholesalers, dealers, or retailers at this price. They are only

## READ THIS

Please do not be misled by imitations. Ambervision's™ are the only glasses of this type that have been proven SUPERIOR to the famous BluBlockers™ (that sell for many times our price) by an independent lab. Nobody else can make this claim. You shouldn't trust your valuable eyesight to anything less than the best!

available through this special publicity campaign for a limited time. There is a limit of two (2) pairs per address at this price, but requests that are mailed early enough (before June 30) may request up to five. Each pair of Super Glasses is covered by a full one year money back guarantee.

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## TOOL TESTS

### WORKSHOP WARRIORS

(Continued from page 118)



To change belts, first remove the side panel. Push in the belt-tracking knob to release the tension and then replace the abrasive belt.



With the platen removed, the belt fits into tight spots. This also allows the belt to flex and conform to irregular-shaped pieces.



Use the top wheel of sander to shape inside curves. Apply light pressure to avoid clogging the belt and stalling the 1/4-hp motor.



Narrow belt is excellent for sharpening all types of tools, knives and scissors. Always wear eye protection when using sander.

Replace the sanding belt with a buffing belt and you can tackle polishing and cleaning jobs. There's even a place for installing a flexible shaft which can be used to drive a sanding drum or disc, wire wheel and various bits and burrs. Other features include

a belt-tracking adjustment knob, removable platen and a 5 x 5-in. tilting, cast-aluminum worktable.

The sander costs about \$70. For details, contact Delta, 246 Alpha Dr., Pittsburgh, PA 15238. Or, call toll-free (800) 438-2486.

## Foolproof Drill Bit Sharpener

**H**ERE'S a drill bit sharpener unlike any other sharpener that I've tried. It is extremely easy to use,

very effective and affordable. The sharpener, which is simply a small

(Please turn to page 132)



Sharpener, with collets and grinding wheels, is powered by any pistol-grip electric drill.

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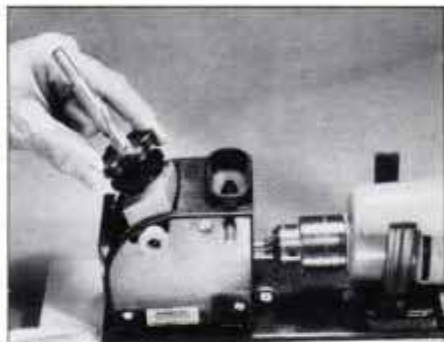
## TOOL TESTS

### WORKSHOP WARRIORS

(Continued from page 131)



With the bit clamped into the holder, place it in the first position, as shown. This sets the depth of the bit and prevents overgrinding.



Set the second position to the correct lip cutting angle and turn on the drill. Insert the bit, as shown, and rotate it a couple of times.

grinding jig, is powered by any pistol-grip electric drill.

The unit comes with two interchangeable grinding wheels—aluminum-oxide and silicone-carbide—for sharpening high-speed steel twist drill bits and carbide-tipped masonry bits. It accepts bits ranging from 1/8 in. to 1/2 in. dia. and can be used to resharpen broken bits, too.

First, put the clamp-on collet on the dull bit and insert it in the opening at the top of the unit. This will set the bit to the proper depth and prevent overgrinding. Next, select the appropriate lip cutting angle (from 80° to 130°), switch on the drill and rotate the bit a couple revolutions. This automatically grinds the preselected lip cutting angle and lip relief. After some practice, it should take about 1 minute to



These closeup views show a twist drill bit before it was sharpened (left) and after (right). Broken bits can be resharpened, too.

sharpen a bit. The Martek sharpening kit includes a carrying case, two grinding wheels, collets, bit holders and a dressing stone for keeping the wheels in peak condition. It costs \$75.45 postpaid from Garrett Wade, 161 Avenue of the Americas, New York, NY 10013.

## Multirange Socket



This one adjustable socket will replace the 20 sockets shown in the background. It fits onto a standard 3/8-in. drive ratchet handle.



A quick turn of the knurled collar opens and closes the socket's three steel jaws. It has a maximum capacity of 5/8 in. or 16 mm.

**N**OW HERE'S a terrific tool: the Channellock 906 adjustable socket. This one socket can replace 20 individual sockets including 11 standard sizes (7/16 in. to 3/4 in.) and nine metric sizes (8 mm to 16 mm). The Channellock socket's three jaws are easily adjusted, with one hand, by turning its knurled collar.

The socket is made of high-grade forged steel and is tough enough, ac-

cording to Channellock, to withstand 1200 in.-lbs. of torque. The 906 adjustable socket fits a 3/8-in.-drive ratchet wrench and costs about \$20. The socket, complete with ratchet wrench and clip-on leather holster, costs about \$40. Look for the socket at hardware stores and home centers. For more information, contact Channellock, 1306 S. Main St., Meadville, PA 16335.

PM



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I knew TUFOIL® was a superior product. After all, I've been working on the problems of dispersing Teflon® or Fluon®-like colloids in oil since the early 1970's and getting patents all over the world. But here was confirmation from on high! My reaction was, "Wow! TUFOIL's slipperier than Teflon!"

Their test data showed a steel on steel 4-ball surface friction of .029 with remarkably low wear. I rushed to my library, grabbed a lubricant handbook to see if my memory was correct. Sure enough! Teflon was listed at .04.

**TUFOIL is not just a little slipperier than Teflon. It's a lot slipperier than Teflon.** There was the handbook data right in front of me!

People ask, "Why don't the oil companies use or recommend TUFOIL?" It's simple. The big oil companies' profit comes from gasoline, not lubricants. The auto companies' comes from car sales. Just think. Some of our test cars are pushing 200,000 miles. If Detroit recommended TUFOIL, they might cut their sales in half... not likely! Some of our customers' cars are well over 200,000 miles, with their engines purring like kittens.

Historically, the most important inventions have been made by independent inventors working alone. They do not and have not come from large well financed research labs or institutions. The best creative inventors have always chafed under the restraints of bureaucracy.

So it's up to you to decide for yourself, just as tens of thousands of our customers already have!

Customers send us letters raving about **improved starting, smoother operation, spectacular acceleration, gas savings and much longer trouble-free engine life.**

TUFOIL has been written up in prestigious scientific journals, newspapers such as the Wall Street Journal, Boston Globe, New York Times and Christian Science Monitor and tested in Universi-

ties and laboratories all over the world. The results are overwhelming! As far as we can see, TUFOIL has the **lowest friction and wear of any known lubricant.** TUFOIL is making history!

For the last few years, we've been running full page award-winning ads in **NASA Tech Briefs.** In them, we call TUFOIL, "The Transistor of Lubrication." Our competitors are way back in the vacuum tube era with products primitive by comparison. No other lubricant even comes close.

We're occasionally asked about lubricants that claim to be one-time engine treatments. The answer is simple! **There is no record in the scientific literature that we've seen so far, that a one-time treatment by any lubricant will last the life of an engine.** So don't believe it!

**TUFOIL means big savings for you, your car or your machines!** So rush your order now and get these marvelous benefits.

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- Makes engines run better, last longer

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... R. W., Yarmouth Port, Ma.

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

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U.S. Patent No. 4,284,518

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## HINTS FROM READERS

### Shop Wax



Next time you're cutting with a hand-saw, try applying a little paraffin wax and save on elbow grease. Lubricating the handsaw's blade by rubbing some paraffin on it will reduce friction without interfering with the blade's cutting action. Squares, miter gauges and other pieces of equipment will all slide easier with this treatment.

—Walter E. Burton



### Installing Cove

When installing cove molding, it's often difficult to keep it square due to its beveled back. This jig simplifies the job. Carefully trace and cut the profile of the cove in the corner of a jig board. Hold the molding in place (as shown), then nail.—Norman E. Johnson

### Garden Protection

To discourage animals from trespassing into newly seeded gardens, cover the seedbeds with sections of chicken wire that are shaped to arch over the ground. The chicken wire permits watering and can be reused each spring for annual protection from pests.

—Louis Hochman

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Our kit materials may be better than those used in the original Swift. The keel section and frames are pre-cut plywood, ready for quick assembly. And the hull is planked twice; first with thick, flexible limewood for strength, and then overlaid with planks of African walnut for lasting beauty.

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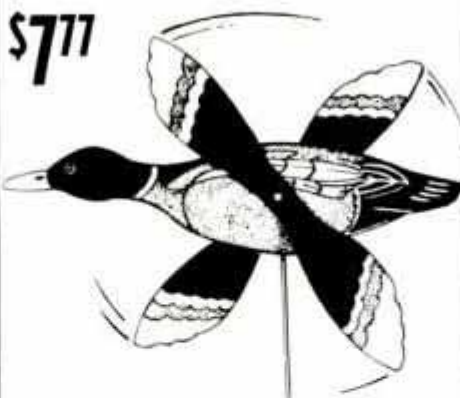
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## OFFSHORE POWER PLAY

(Continued from page 93)

### Aquasport 250 Express

Versatility is the standard the 250 Express Fisherman measures itself against. Its wide-open cockpit, although the smallest in the test, gives sufficient fish-fighting room while its low price and sporty blue-gray hull make it ideal for family recreation.

The Express Fisherman was a greyhound in the hole shot, but it finished off the pace in top-end speed and performance course times. In the rollers, it gave a hard, rattling ride.

Stowage was surprisingly tight, as was cabin space and the sleeping pad. But fit and finish and overall workmanship were the areas most noticeably affected by cost-containment. The fold-down splash wall didn't lie flat or lock in down position, aft stowage boxes had no rubber hatch liners, and drains in the cabin were simply punched-out holes.

The helm station, which has rubber-sealed controls, offered superb visibility forward and a good view of the gauges. The uncomfortable throttle, however, bumped into the driver's leg in full Reverse and into the steering wheel in full Forward.

But fishermen and their families will appreciate the Aquasport's bright, well-ventilated cabin, as well as its easy-to-take price.

### Power Choice

We selected counter-rotating Yamaha 150-hp outboards for power. We were anxious to test Yamaha's unique control system and determine if the ride was indeed torque-free.

Prior to counter rotation—a dual outboard system where one propeller spins to the right and one to the left—double right-hand torque caused arm-tiring fatigue and made a level ride nearly impossible. Counter-rotating props, we found, not only solved these problems, but increased overall maneuverability.

The Dual Binnacle Control, a Yamaha innovation, enables the driver to trim and tilt both outboards at the same time with a single switch, plus it offers separate switches for individual fine tuning. Other distinctive features, such as matched starter keys plus dual and individual motor warning alarms, make it one of the most advanced controls on the market.

Our test boats proved to be impressive, 25-footers, easy to maintain and sturdy enough for the open sea. Each had its strengths and weaknesses, but, needless to say, we'd be more than happy to go out to the Gulf Stream for marlin or tuna in any one of them, the sooner the better. **PM**

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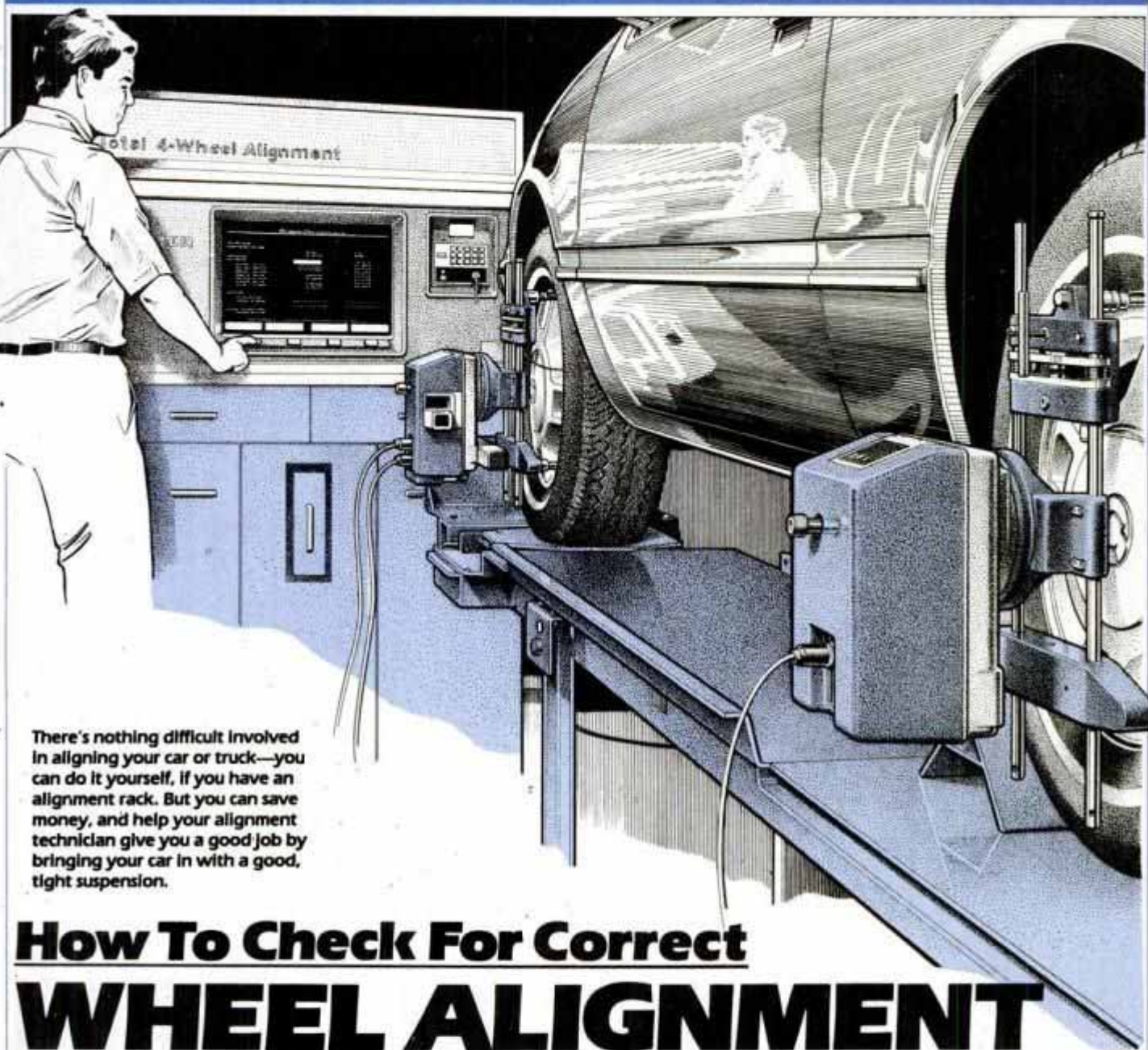
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# SATURDAY MECHANIC



There's nothing difficult involved in aligning your car or truck—you can do it yourself, if you have an alignment rack. But you can save money, and help your alignment technician give you a good job by bringing your car in with a good, tight suspension.

## How To Check For Correct WHEEL ALIGNMENT

BY MORT SCHULTZ

**W**HILE the basics of wheel alignment are within the scope of most Saturday mechanics, for lack of a \$25,000 alignment rack and a place to set it up, most of us have to assign the job to a professional mechanic. But that doesn't have to mean turning one's back and hoping for the best. Alignment should be a joint venture between owner and technician.

Take care of the preliminaries. Be sure alignment is needed and make certain the job is done properly.

Many shops are using methods that are obsolete. If a technician speaks only in terms of *front-wheel* alignment, for instance, be wary. Front-wheel alignment is just about a dead issue, so unless it's a slip of the tongue, someone talking about front-wheel alignment is behind the times. Most cars today require alignment of all four wheels.

### Why alignment?

Alignment—adjusting the suspension so the wheels roll straight and

true—is a must if you want even tire wear, precise steering and the most optimum fuel economy possible.

The second greatest cause of abnormal and/or rapid tire wear is misaligned wheels. (First, as it always has been, is underinflation.) Whatever the reason, abnormal tire wear can be spotted before it gets too bad by inspecting tires frequently (Fig. 1).

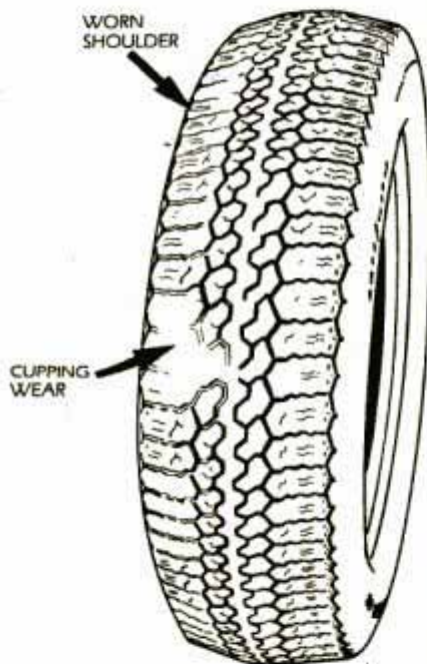
The most common symptom of misalignment is a drift or pull to one side. Other telltales are looseness in the steering wheel, a steering wheel that



is off-center when front wheels are straight, a sensation that the car is wandering over the road, and high-effort steering. It's not unusual to feel misalignment at the steering wheel before tire wear becomes apparent, so that's the time to take care of it.

Vibration could also be symptomatic of misalignment, but misalignment is a secondary condition that crops up if vibration continues. Vibration is usually caused by unbalanced or out-of-round wheel/tire assemblies. Other reasons are excessive tire runout, drive shaft imbalance and brake rotor/drum unevenness.

An unbalanced wheel/tire assembly—that is, an unequal weight distribution about the circumference of the assembly—and wheel misalignment are not the same thing, but they are interrelated. The constant bouncing of unbalanced wheel/tire assemblies



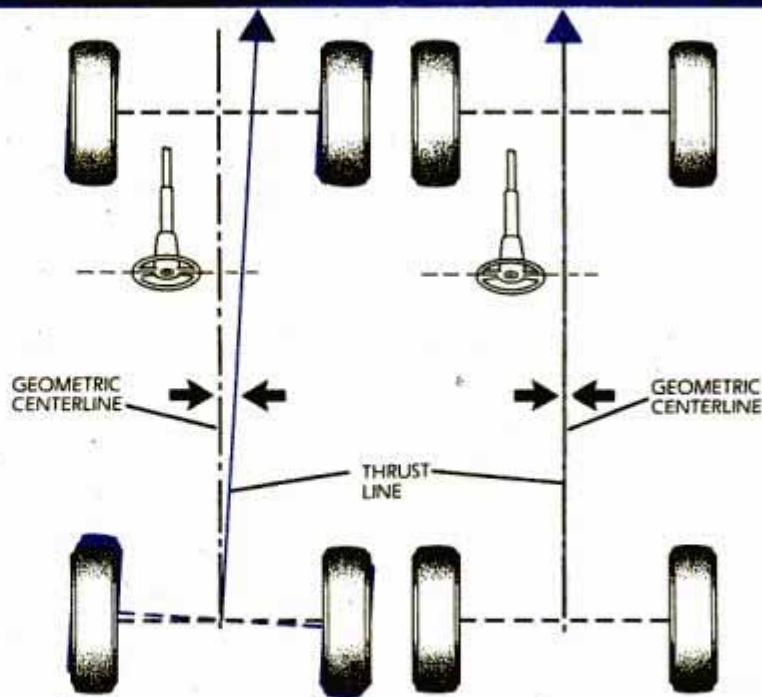
**1** Cupping and rapid shoulder wear are probably from improperly adjusted toe-in.

will result in wear to suspension components which, in turn, leads to misaligned wheels.

### Roll a four

It's easy enough to determine if your car is a candidate for 4-wheel alignment. If it's a front-wheel drive with independent or beam-axle suspension at the rear, or if it's a rear-wheel-drive car equipped with independent rear suspension, you should have either a total 4-wheel alignment or thrust-line alignment done (Fig. 2).

A thrust-line alignment measures



**2** A complete 4-wheel alignment is necessary to correct thrust that's off centerline.

the toe-angle of the rear wheels. The rear-wheel toe-angle measurement is used as a reference to adjust the alignment of the front wheels. The intent is to bring the front wheels into line with the rear wheels to assure more precise steering and the longest possible tire wear. If the toe-angle of the rear wheels doesn't meet the established specification, the rear suspension is damaged.

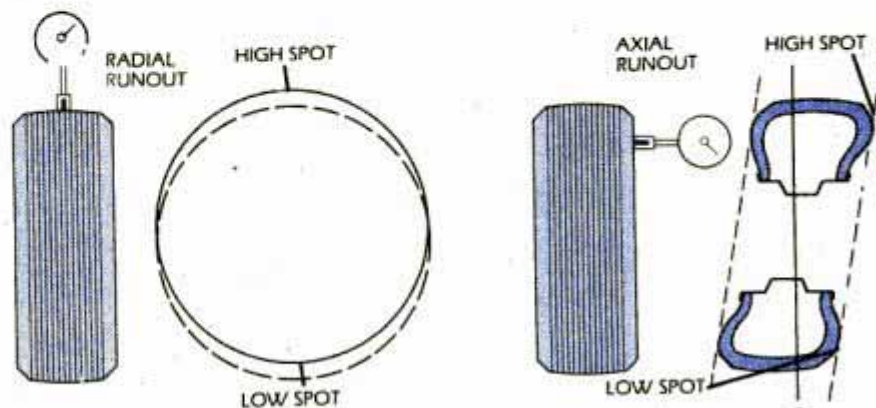
On cars with rear wheels whose camber-angle as well as toe-angle can be set, each wheel—front and rear—is adjusted individually to a precise position. This is called total 4-wheel alignment. As long as suspension and steering components are not damaged, it automatically brings the thrust line of the rear wheels into line with the front wheels.

Owner's manuals aren't always clear whether total 4-wheel align-

ment can be done for the particular car or if you must settle for thrust-line alignment, which is less precise. If you don't know, ask your alignment shop or a dealer.

Some models in the 4-wheel alignment category are Chrysler Corp. front-wheel-drive cars, FoMoCo front-wheel-drive cars except Fiesta, most full-size GM front-wheel-drive cars since '79 (also Corvette and Fiero), BMWs since '84, all Hondas except wagons, front-wheel-drive and '86-'87 rear-wheel-drive Mazdas, some Mitsubishi front- and rear-wheel-drive cars, Nissan Maxima and 300ZX, all Porsches, some Subarus, all Toyota front-wheel-drive cars as well as some rear-drive models, and rear-drive VWs.

Thrust-line alignment costs about \$10 more than aligning the front wheels only, which owners of older



**3** Radial or lateral runout is more likely to cause tire-shake than improper alignment.



rear-drive cars with solid rear-axle suspension systems still have done. Even they, however, can benefit from an occasional thrust-line alignment, because in time the rear wheels of cars with solid rear axles can go out of alignment.

Total 4-wheel alignment costs about \$10 more than thrust-line alignment, but this is only for putting the car on a 4-wheel alignment machine and measuring angles. If alignment has to be reset, the charge is about \$10 more per wheel—plus parts. It's not unusual, then, for a 4-wheel alignment to cost almost \$100.

### What you can do yourself

By doing some of the preliminary work on your own, you can assure yourself that the feel you're getting is really being caused by misalignment and not a condition that can be solved with a little air, for example.

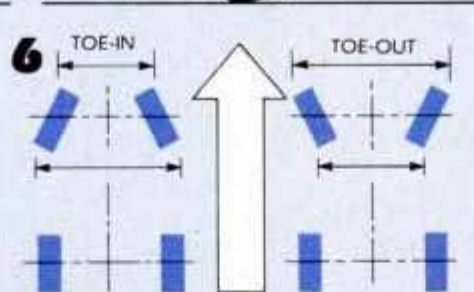
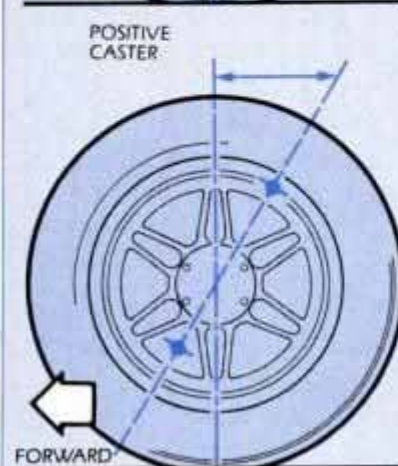
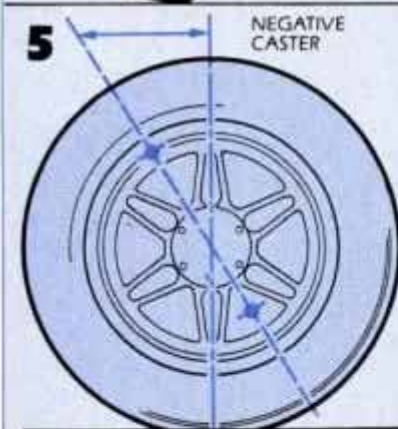
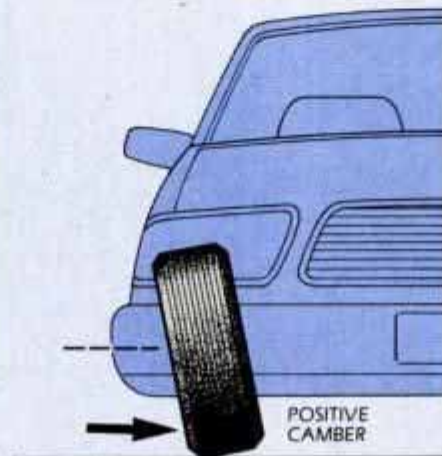
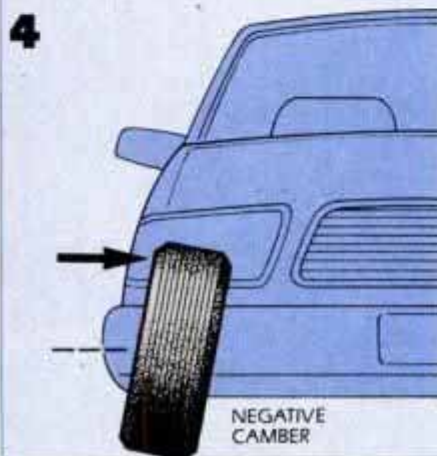
An imbalance in tire inflation, which can cause drifting or pulling to one side, is easily detected. Just inflate both tires on the same end of the car to the same pressure.

A variance of a couple of pounds, even within the recommended spec range, can affect handling.

What about tire sizes and tread pat-

terns? Are they the same, especially on the same end of the car? You can't expect good handling if tires are mismatched. Even replacing a partly worn tire with a new one—say for instance the spare—can make your car pull because of the difference in the diameter between the new and old tire. And don't get your car aligned when the tires are mismatched, because you'll be out of alignment again as soon as you replace them. The alignment rack assumes that all four tires are identical, and properly inflated.

Two kinds of sensations you'll feel coming through the steering wheel



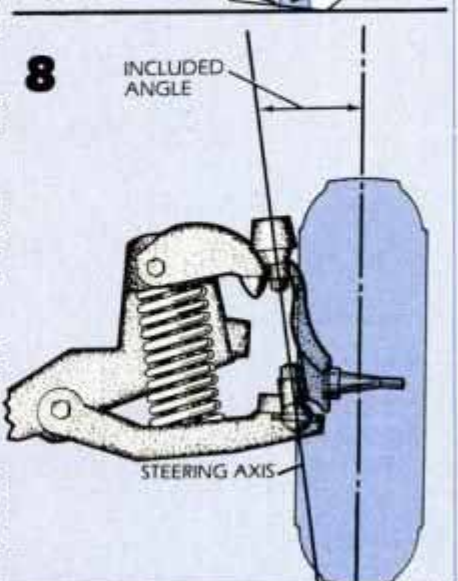
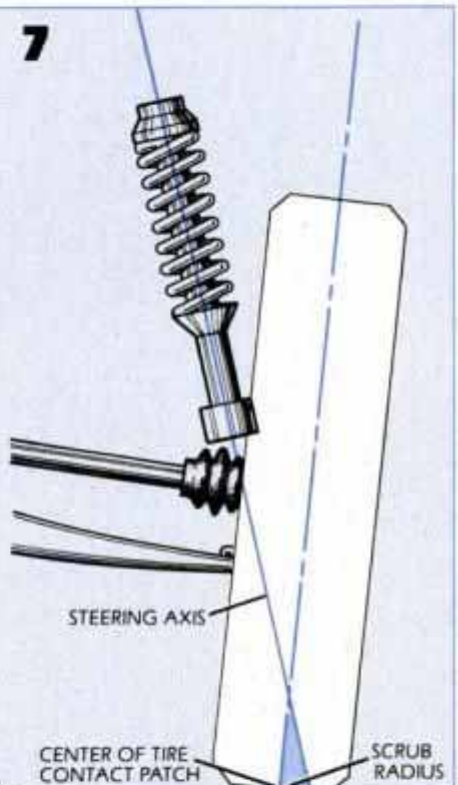
**4** Camber is usually adjusted to just slightly negative (in at the top) so tire will stand more upright when vehicle rolls during cornering.

**5** Correct caster provides self-centering while cornering, straight-line stability. Some vehicles specify positive caster, some negative.

**6** Moderate toe-in, where distance between front of wheels is narrower than distance between rear, is necessary to provide straight-line stability. Toe-in needs to be checked on rear end of vehicle as well.

**7** Steering axis inclination and wheel offset determine scrub radius. Scrub radius is important for stability, especially under braking, and must be the same on both sides of the vehicle.

**8** Included angle is measured between the steering axis and the tire centerline, and is useful mainly to identify damaged or bent suspension components like spindles or struts. It's not something that normally is adjustable.





with modern cars are lateral drift and torque-steer pull. Lateral drift occurs when driving at a constant speed and indicates wheel misalignment. Torque-steer pull affects some front-wheel-drive cars only during quick acceleration.

Torque steer can be aggravated by misalignment. The car actually steers to the left or right unless you fight the steering wheel to keep it going straight.

To pin down lateral drift and torque-steer pull, drive the car on a straight and level surface. To test for lateral drift, maintain a constant speed, take your hands off the steering wheel briefly, and note the direction and severity of the drift. To test for torque steer, accelerate quickly to a speed of 40 to 50 mph from a speed of 10 to 15 mph and note the direction and severity of the pull.

Now, switch the front tires from side to side and do the test again. If the drift or pull is the same, you've probably got a vehicle-related problem—often misalignment, but maybe a steering or brake system malfunction. If the drift or pull has changed direction or its severity is reduced, it is being caused by the tires. In fact, just switching tires from side to side may get rid of the drift or reduce the pull to an acceptable level.

If not, return the tires to their original positions and then switch the right front and right rear. Does this get rid of or reduce the severity of the drift or pull? If the answer is no, put tires back where they were, switch the left front with the left rear and test again. If the condition doesn't clear up, you can have the tires

checked for runout. A tire with runout wants to roll in an arc, which can cause a car to drift or pull (Fig. 3).

Incidentally, car manufacturers specify in maintenance instructions how often tire rotation should be done to avoid the feel tire wear can present and also to get maximum mileage from tires. Where the tire rotation interval is not spelled out, rotate at 6000 to 8000 miles (assuming you're starting with a new set) and then every 18,000 to 24,000 miles. If your owner's manual doesn't state how to rotate tires, cross-rotation is recommended for all-season tires, front-to-rear for directional-tread tires.

## Alignment? Not yet

Whether you do it yourself or have a professional do it, all components in the front and rear of your car should be inspected before alignment. If a worn or bent part stays put, doing the alignment is a waste of money. The condition you hope to clear up will continue to ruin tires. All of the following must be in good shape to achieve accurate alignment:

- Coil and/or leaf springs or torsion bars.
- Tie-rod ends and sleeves, idler and pitman arms, rack-mounting bushings, sway bar, steering linkages and steering gear.
- Wheel bearings, wheel spindles and ball joints.
- Upper and lower front- and rear-control arm bushings, strut rod or brake reaction-rod bushings, and stabilizer link and frame bushings.
- Struts and shock absorbers, strut mountings and bearings, and shock mounting bolts and bushings.

It's possible to inspect all of the above in your driveway, but you'll need to safely set the car on jackstands. This unloads the suspension, allowing you to properly check for loose bushings and the like. It takes 45 minutes to an hour to really inspect everything properly.

Before driving the car onto the alignment rack, discuss with the technician the way it should be loaded. For example, if you're a salesperson who keeps heavy carrying cases in the trunk, you'll want them in the trunk as alignment is being done. Removing them, having wheels aligned and then returning them to the trunk will throw alignment off when you hit the road. If you're a 250-pounder, maybe you too should be in the car as alignment is being done. Most alignment shops keep sandbags around for just this purpose. Don't forget about that snowplow that's mounted to the front of your pickup all winter—it will certainly affect the way your alignment should be done.

## Figuring the angles

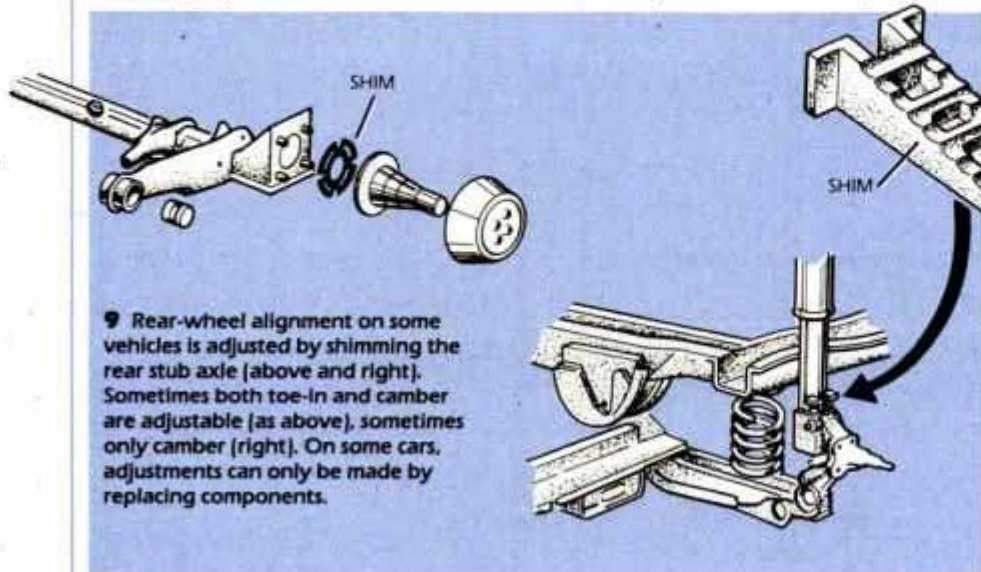
Illustrations of angles that should be measured and, if necessary, reset are illustrated in Figures 4 through 8. Adjustments should be made to the car manufacturer's *preferred* settings, not simply to "within specifications."

If this will be your first-ever 4-wheel alignment, and the car has adjustable rear wheels, you may be interested in knowing that the camber angles of the rear wheels of some cars are set with shims or wedges (Fig. 9). Toe-angle settings are altered by using shims, turning tie-rod adjusters or adjusting a cam.

Once alignment is done, the two most commonly unanswered questions are: "When next?" and "Can a pothole knock alignment out of whack?" According to Hunter Engineering Co., the major manufacturer of total 4-wheel alignment racks, a car's alignment should be checked every 10,000 miles or once a year. And, yes, a pothole can knock alignment out of kilter, but usually only if the jolt damages a suspension or steering component.

Generally, day-in day-out wear and tear is the primary cause of misalignment—not a bout with a pothole. But after such an encounter, be especially critical of the way your car feels. If there's doubt about it, have alignment checked.


PM



9 Rear-wheel alignment on some vehicles is adjusted by shimming the rear stub axle (above and right). Sometimes both toe-in and camber are adjustable (as above), sometimes only camber (right). On some cars, adjustments can only be made by replacing components.



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"Poly" is short for polytetrafluoroethylene (TFE), the slipperiest substance known to man. (1981 Guinness Book of World Records). Petrolon Corporation, makers of Slick 50, invented a way to permanently bind this slippery chemical to your engine with one treatment. Just one quart of Slick 50 can reduce engine friction, increase gas mileage and horsepower and reduce engine operating temperature, causing your oil and engine to last longer...plus it reduces metal wear, defraying costly overhauls.

## Years of Testing and Use Have Proved it True!

Slick 50 has been thoroughly tested in independent laboratories and out on the road:

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

One of the country's most respected research institutes reported applying a powerful ultrasonic cleaning process to a Slick 50 treated engine and were surprised at its permanence. "We actually expected the Petrolon Slick 50 TFE Resin coating to also be removed, but later found it was still there."

TUV, a German testing laboratory with credentials every bit as prestigious as our Underwriters Laboratories, tested Slick 50 in 1986. They found substantial increases in both gas mileage and horsepower. Their tests showed that these gains were due to a reduction in friction.

The Federal Aviation Administration has fully accepted a similar product for aircraft—Slick 50 Aircraft Piston Engine Treatment (F.A.R. #33.49). This FAA endurance test-simulated 1400 hours of engine use.

The power technology laboratory at a leading southwestern university stated, "Slick 50 does increase horsepower and decrease fuel consumption in tests done at the university."

The Space Shuttle Columbia uses the chemical "poly" in its gears and bearings because it is the only chemical lubricant which can withstand the heat and corrosive elements of space.

Perhaps most dramatic of all is a torture test overseen by the Automotive Services Council for Pennsylvania and shown on WTVF television. Three cars with 75,000 to 129,000 miles on them were treated with Slick 50. Six months later the oil was drained from each vehicle, and the cars driven without the oil plugs for about a half hour. The water temperature never rose and the engines sustained no apparent damage.



## It's Easy to Treat Your Engine

A few minutes before oil and filter change, add the engine flush you get free with each order to clean out the engine. Let the engine idle for 5 minutes. Then drain the oil, change the filter and add the proper amount of oil, less one quart. Add one quart of Slick 50, drive for 30 minutes, and leave it in the crankcase for at least 3,000 miles. As the engine operates, the oil carries the "Poly" between the parts where it is burnished into the pores of the metal.

## Only One Treatment Necessary

It's permanent, so you do it only once, not each time you change oil. One quart of Slick 50 will treat all standard 4, 6 and 8-cylinder gasoline and diesel engines.

## Works with Most Oils

Slick 50 will work with all petroleum-based oils and all synthetics compatible with petroleum-based oils with the exception of graphite oils. However, once an engine is treated, you can go back to a graphite type if desired.

## 4 Ways Slick 50 Saves You Money

Your actual percentages may vary depending on your driving, vehicle condition, weather and geographic location, but no matter what your conditions, Slick 50 can:

1. Increase mileage
2. Increase horsepower (small economy cars and large RV's really need this)
3. Reduce operating temperatures, thus increasing the lubrication and life of the oil and engine.
4. Minimize or eliminate costly overhauls by reducing engine wear

Up to 90% of the engine wear on a car can be caused by lubrication starvation cars experience when first started before the oil begins to circulate. Slick 50 can eliminate this problem for less than the cost of two tanks of gas.

## Slick 50 Will Not Affect Your Warranty

Slick 50 is suspended in an excellent grade of petroleum oil which meets or exceeds every manufacturer's engine warranty requirements. In addition, this oil carries an American Petroleum Institute service classification SF-CC-CD.

## There's No Risk with Our Money Back Guarantee

Use Slick 50 for 3000 miles. If you don't notice an improvement in engine performance, return your invoice with a short note telling why, for a prompt full refund—no questions asked.

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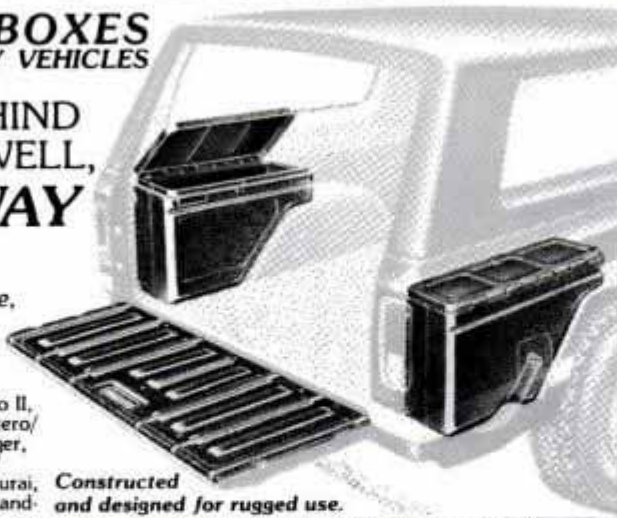
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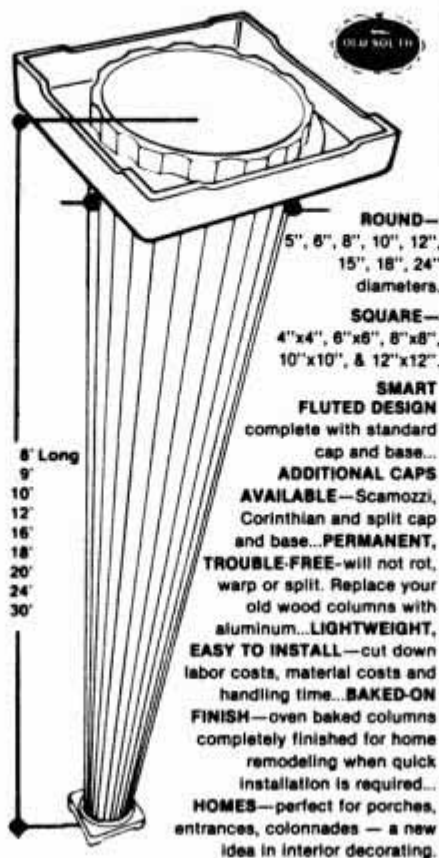
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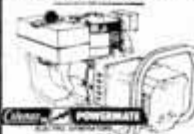
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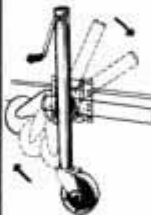
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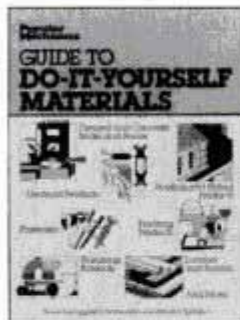
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(Continued on next page)



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(Continued from preceding page)

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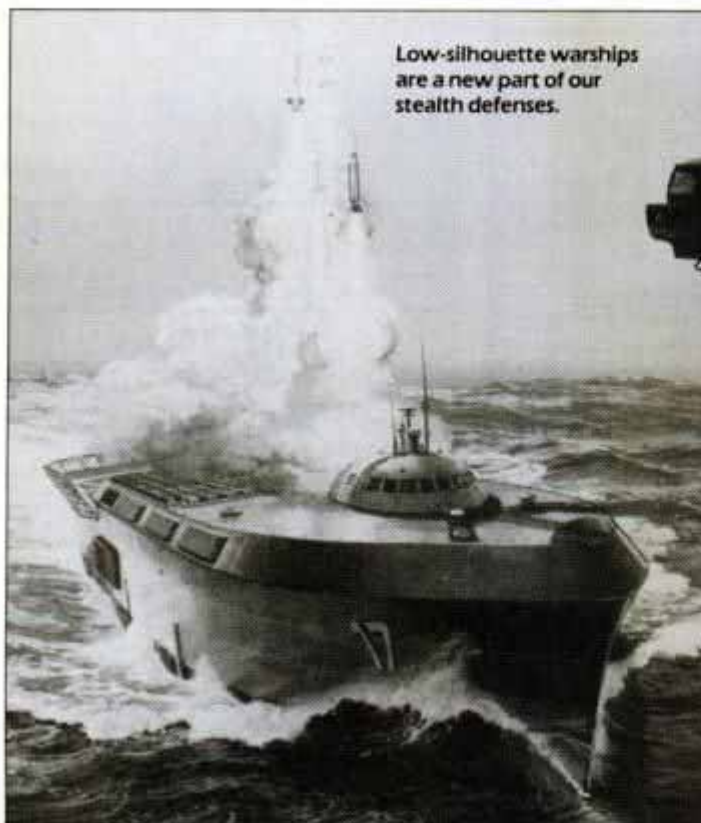
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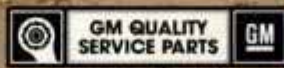


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