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Popular Mechanics

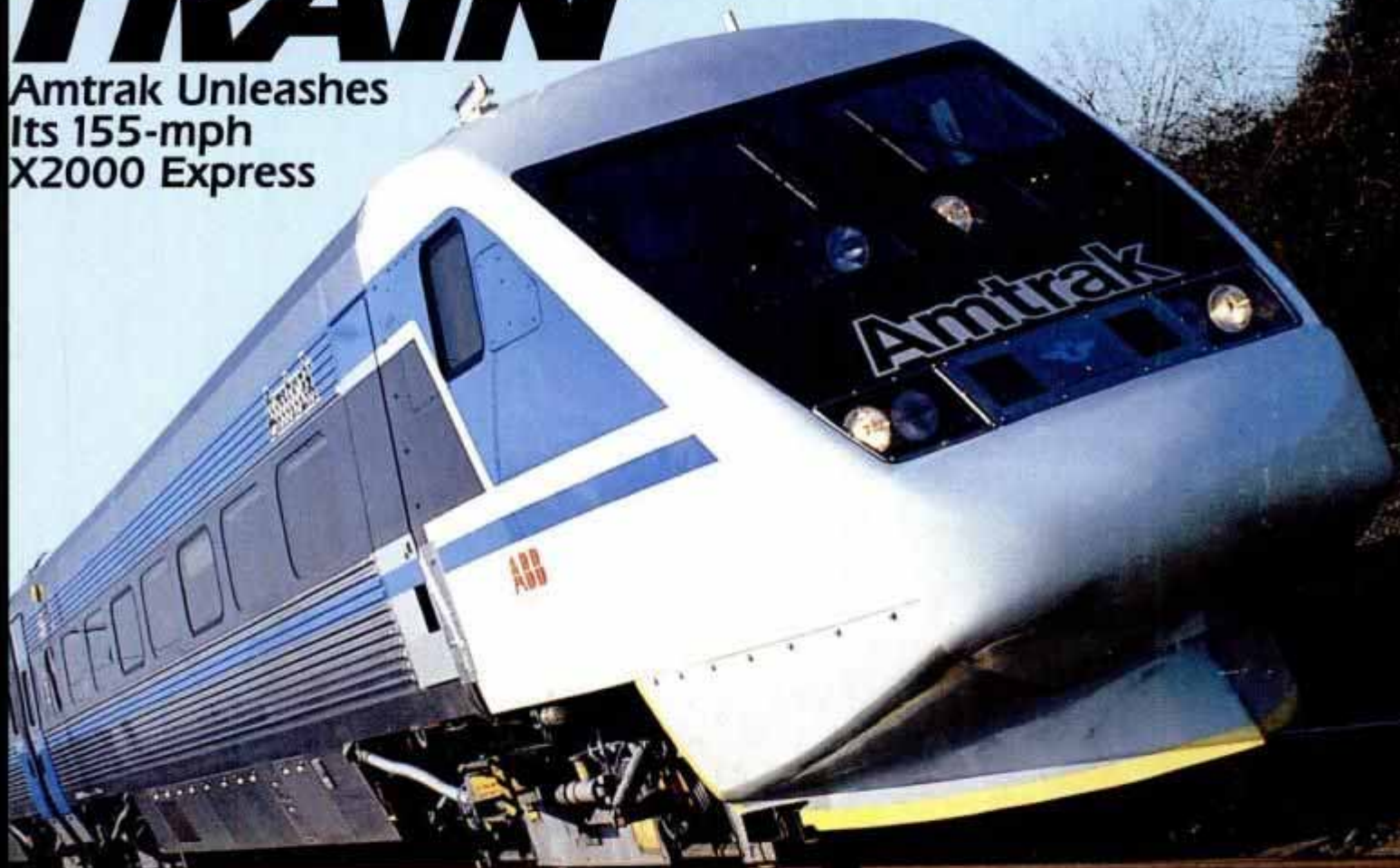


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March 1993

Dear Friends of **Popular Mechanics**:

People across the country are exercising more than ever to get in shape. We now have jogging Presidents, aerobic instructing actresses, iron pumping actors and baseball playing rock and roll stars. The peer pressure is becoming so great that I might even have to start working out!

Popular Mechanics readers are no different. In fact, you might be surprised to know that research shows our 9 million readers are more likely to participate in a number of exercise and sporting activities than most Americans.

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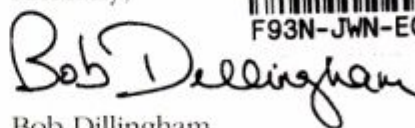
Source: Spring 1992 MRI

That's why I'm sure our readers will really enjoy the articles in this issue on "Home Gyms" and "Personal Watercraft." Catering to our readers interests and helping them get the best workout, these articles will describe the technology behind the equipment and the options available on the market.

Because of the diverse interests of our readers, in 1992 we created the **PM Must-Know Reader Panel**. Through an insert placed in the magazine, we recruited 3,000 **Popular Mechanics** readers, who were *Must-Know Men*, to be part of this national reader panel. These men are innovative, knowledgeable and informative consumers – men others go to for opinions, suggestions and recommendations on a wide range of products, services and technology.

If you would like to find out more about varied interests of our readers, I think the **PM Must-Know Reader Panel** is an exceptional opportunity for you to reach a very valuable source in the men's market. As part of a merchandising program we can set up research programs that will provide insightful information about your product or test new advertising creative through questionnaires, focus groups and phone surveys. Promotion programs can be created to distribute samples of your product to this key market. Give me a call if you want to learn more about this new program!

Sincerely,

Bob Dillingham
Publisher & Vice President

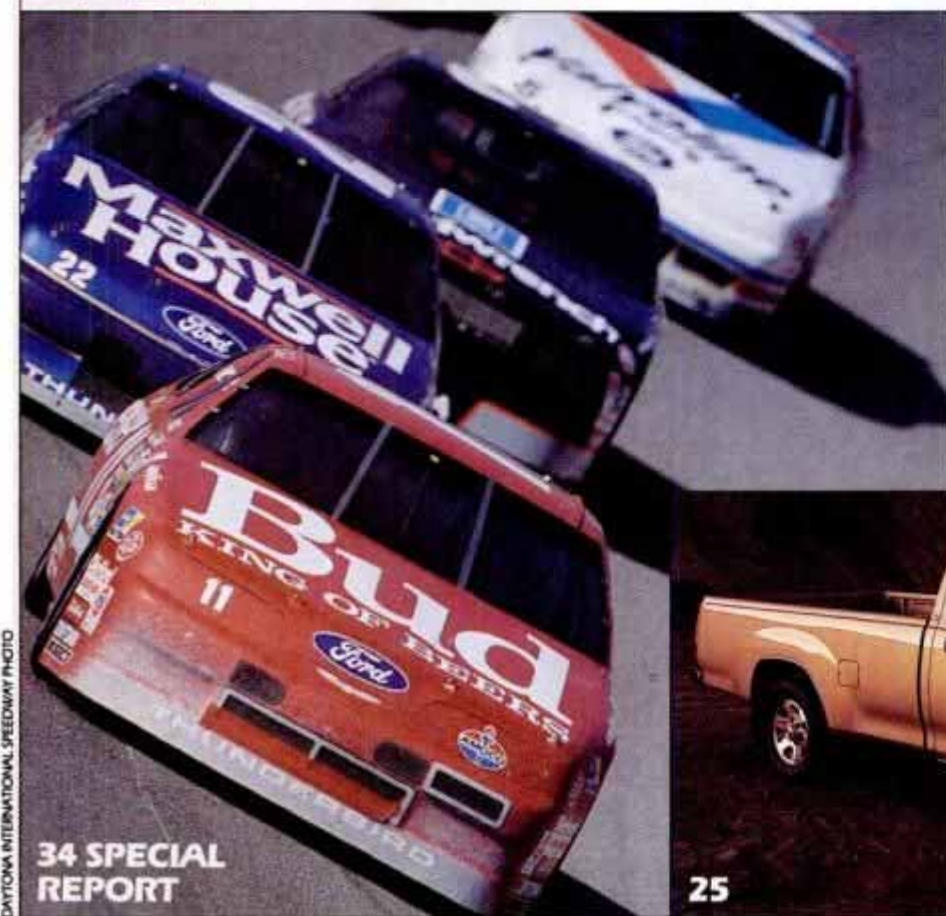
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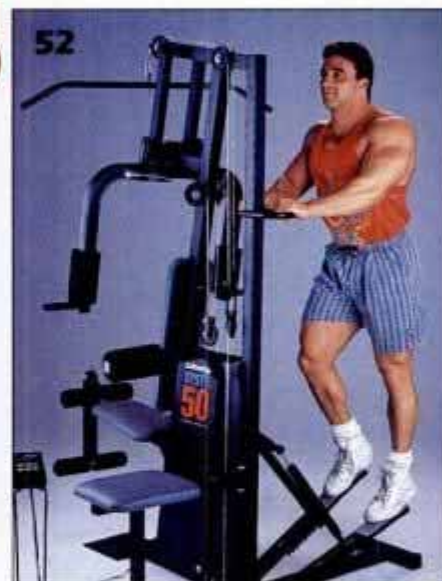
Popular[®] Mechanics

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VOLUME 170
NO. 3



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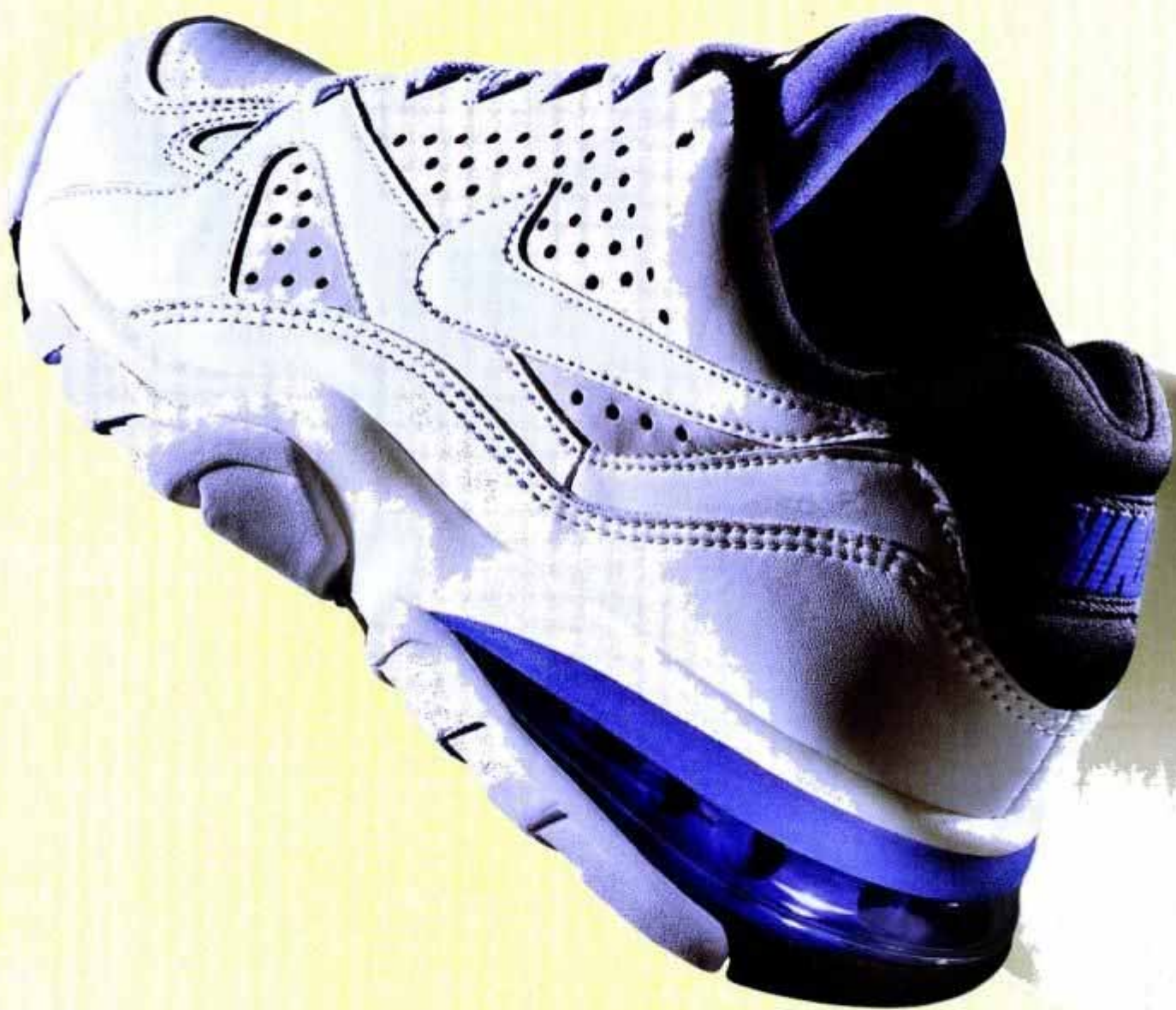
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train
train,
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and I can run,
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but I have big fun!*



NIKE



Материал: замшевый эластичный пластик

EDITOR'S NOTES

● By now, everyone knows that the Ford F-series full-size pickup truck is the best-selling vehicle in America and has been for years. The second best-selling vehicle is Chevy's full-size C/K-series pickup. The Chevy versus Ford battle of the big pickups has been an interesting one to watch over the years, with very entertaining TV commercials making claim and counterclaim to the glee of the amused viewing public. Hey, Ford and Chevy, don't look now but here comes Toyota. Toyota describes its new T100 pickup as "bigger" though not necessarily big. That's a politically correct way of saying that Toyota is low-keying its entry into the domestic auto industry's last bastion of market segment domination over the imports. That might be a real good idea in this period of "Buy American" fervor. Well, okay, how does the Toyota stack up against the Big Three's big trucks? You'll find out in this issue, starting on page 25, as our auto editors put all the big and "bigger" pickups through their paces. By the way, although Dodge's Ram has not been a real factor in that market segment, watch



Bob Trinchero, PM's Frank Vizard and Gina Trinchero sip Sutter Home's non-alcoholic Fré.

the battle turn white-hot next year when the all-new Dodge T300 joins the fray. . . . Some time ago when we wrote about non-alcoholic beer (see "Brewing For Zero," page 36, July '91), we proved that drinking and driving could be compatible. Now technology takes the concept one step further for those of us who enjoy a glass of wine with dinner. Gina and Bob Trinchero at the Sutter Home Winery in Sonoma, California, are employing new technology that allows them to remove virtually all of the alcohol from real wine. Don't confuse Sutter Home Fré with the white grape juice on your supermarket shelf. This is real wine, fermented, aged and processed like any other wine—but with the alcohol removed. The fascinating story begins on page 29.

. . . Right about the time you read this issue, the 1993 Winston Cup NASCAR racing season should be getting under way with the Daytona 500. What better time to take a look inside those 200-mph thunder machines you see blasting around Pocono, Darlington, Charlotte and Talladega? And don't miss the great cutaway poster of Winston Cup Champion Alan Kulwicki's Hooters Thunderbird. . . . Ready to shape up for spring? Want to buy a home fitness machine? Bewildered by the choices? Check out our comparison test, beginning on page 52, for immediate help. Till next time.

Joe Oldham

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LETTERS

Mercy Mission



I want Abe Dane's job. How do I apply? He flies in F-15s, goes to Sarajevo, joins the crews of the Navy's newest ships—it's unbelievable! This is a job? He gets paid for this?

ROY TANNER
PISCATAWAY, NJ

Abe Dane did an outstanding job of reporting the Operation Provide Promise story to your readers. Having been involved with Provide Promise since it began, I cannot tell you how much I personally appreciate the fact that he focused a lot of attention on the human beings involved in this operation.

DOUG MOORE, CHIEF,
MEDIA SUPPORT BRANCH
USAF, EUROPE

I was a member of the self-same 37th Troop Carrier Squadron nicknamed the Blue Tail Flies. At the time (1954-'55), we were stationed on the southern Japanese island of Kyushu at Ashia AFB. Missions were flown in and out of Korea, French Indochina and all over the Far East. The squadron was designated as combat cargo at that

time. The Fairchild C-119 Flying Boxcar was the aircraft we were operating. As a flight engineer, memories of some of those flights are still with me as they must be with my fellow aircrew members. I am glad to see that we still have people with skill and courage like the members of the Air Force's 37th Airlift Squadron keeping up the honorable tradition of service. Abe Dane is to be commended for having the fortitude to experience firsthand combat cargo.

ROBERTS. BUSH JR.
PETROLIA, CA

It's absolutely incredible to actually see the new generation of C-130 aircraft perform the maneuvers you described. I saw one do the kind of landing you described at an airshow a few years ago at Tinker AFB in Oklahoma. I thought for a minute that the darn thing was going to crash! Your piece was a good read. Not too heavy on the technical side and not the typical media whitewash that's found in the paper every day.

MOJO 158
PM BULLETIN BOARD

What is a PM editor doing in Sarajevo? He should spend more time editing my favorite magazine and less time on wartime mercy missions. I'd rather leave war to generals and statesmen. Even though, most likely, they do not know which end of a screwdriver is the handle.

W.M. HEVR
LAWTON, OK

Vette Mania

I find it amazing that there is *anyone* who is "one of the world's most noted authorities on Corvette history." Is there actually a significant number of people the world over who are deeply concerned with the history of the Corvette, and at the detail level of this apparently famous subscriber (i.e., the precise day of a given Corvette event)? More difficult to comprehend is the need for Corvette historians.

CHRIS MCGINN
PHILLIPS RANCH, CA

McGinn, have you been living on Mars? Or are you pulling my leg? You don't know the Corvette is revered as America's premier sports car? You don't know

that there is a Corvette cult in this country? You don't know that every year in Bloomington, Illinois, the last weekend in June, 50,000 people practically worship 10,000 Corvettes that are driven there from all over the country? Give me a break. —Ed.

Stroke It

For years PM has been a reliable source for all manner of things technical, but you are needlessly perpetuating a common error. If you consider that there are no 2-cycle engines and that all internal combustion engines are indeed 4-cycle, then it is continuing an old misnomer to identify them as 2-cycle. Even the turbojet and pure jet engines are 4-cycle. Perhaps you feel your readership is too limited to grasp those not-so-subtle subtleties. If so, why not accurately distinguish between them with the terms "combined cycle" and 4-cycle. Or better: "separate cycle." Your best bet is to eschew the word cycle altogether and stick with stroke.

V.S. NORTON
TECHNICAL CONSULTANT
SANTA MONICA, CA

Stroke it is.

—Ed.

Made In The Shade

As an avid reader of your magazine for many years, I have used your projects for inspiration and guidance. I recently completed the gazebo featured in your June '90 issue. I modified the plans to suit our needs. Not being a very good carpenter, I contracted out the roof and the steps. Thanks to my dad, Jack, Larry, Mark and Lou Ripley, I got it done.

LANNY RITZ
TALLMADGE, OH



Reader Larry Ritz built this gazebo from PM plans.

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

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THE NATIONAL AUTO QUIZ

1. Which passenger car production engine was the first to achieve 1 horsepower per cubic inch?

- A) 1949 Oldsmobile 303-cu.-in. Rocket V8. B) 1957 Chevrolet Corvette 283-cu.-in. fuel-injected V8. C) 1956 Chrysler 300B 354-cu.-in. Hemi V8. D) 1958 Pontiac 370-cu.-in. tripower V8.

2. The predominance of the color black for the Model T Ford was because:

- A) It was the only color available. B) It was Henry Ford's favorite color. C) Black paint dried faster than the other colors. D) More customers requested it.

3. Compared to regular-grade fuel, higher octane gas:

- A) Ignites more easily. B) Produces more power. C) Delivers more miles per gallon. D) Resists detonation (knocking).

4. Radiator antifreeze is usually based on:

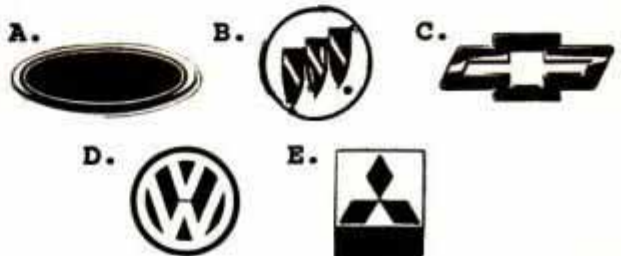
- A) Glycols. B) Alcohols. C) Silicones. D) Anaerobic compounds.

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Send your entries to:
National Auto Quiz
POPULAR MECHANICS
224 W. 57th St.
New York, NY 10019

5. Identify the following automotive logos.



6. The largest single cause of premature tire wear is:

- A) Improper inflation pressure. B) Poor alignment. C) Out of balance. D) Pot holes.

7. Which was the first car to have a transverse-mounted engine?

- A) Morris Minor. B) Renault Dauphine. C) Volkswagen Rabbit. D) Oldsmobile Toronado.

8. All cars in drag racing's quickest class—Top Fuel—have engines based on the:

- A) 426 Chrysler Hemi. B) 427 Chevrolet. C) Ford Boss 429. D) 500 Cadillac.

9. The current land speed record stands at:

- A) 772 mph. B) 598 mph. C) 633 mph. D) 621 mph.

ANSWERS
1. C 2. C 3. D 4. A 5. A, Ford, B. Buick,
C. Chevrolet, D. Volkswagen, E. Mit-
subishi 6. A 7. A 8. A 9. C

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And get better performance, performance, performance from your car's engine.

GUMOUT

Solutions to Engine Problems.™



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from the People at Pennzoil

TIME MACHINE

90 YEARS AGO: MARCH 1903

POPULAR MECHANICS

The "Cedric," the Largest Ship that Floats

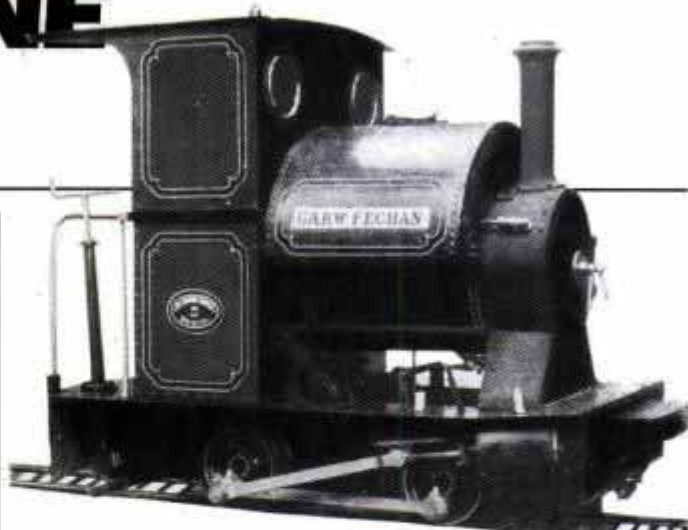


After her departure, the Cedric, of the White Star Line, will be the largest ship that ever sailed.

HER GREAT RECORDS
The Cedric is the largest ship that ever sailed. She is 700 feet long, 100 feet wide, and has a displacement of 38,200 tons. She carries 2,600 passengers and a crew of 335. She is the largest ship that ever sailed.

Ship Of The Line

Steaming into New York Harbor after its maiden voyage, the *Cedric* laid claim to the well-worn title of Biggest Boat Afloat. With a 38,200-ton displacement, the White Star liner carried 2600 passengers and a crew of 335—92 of whom manned the engine room. The vessel stretched 700 ft. in length, but wouldn't keep its crown for long. The *Cedric* was simply one in a long line of increasingly gigantic White Star ships, a line that culminated with the ill-fated *Titanic*.



Loco Motion

American railroad engineers were highly amused by England's narrow-gauge locomotives. The bizarre engines wobbled from side to side like

drunks as they plied industrial track. Cattle and chickens were said to keel over in sheer fright when they beheld these mechanical freaks.

60 YEARS AGO: MARCH 1933



Sub Mission

The captain of the *Falcon* detailed how, six years earlier, his crew had performed the first successful salvage of a sunken submarine. The *S-51* lay half-buried 135 ft. below the Atlantic surface, 15 miles off Block Island. Divers wielded fire hoses to blow a tunnel below the gashed hull, grueling work that touched off hair-raising cave-ins and took weeks to finish. Finally the crew could wrap chains around the waterlogged sub and lift the 1000-ton weight to the surface with pontoons.

Rock's Roots

Gibson introduced a system of amplification originally designed to bolster violins and cellos against broadsides from the brass section. The magnetic pickups lent "a sonorous, mellow tone, without distortion." Feedback remained a headache, however, although solid bodies would squelch that problem.

Jazzmen quickly hammered the electric guitar into the American musical lexicon.



30 YEARS AGO: MARCH 1963

Rambler and Ford Owners' Reports

POPULAR MECHANICS

Hurricane Killers Learn Where to Aim
How Spies Detectives Hunt
the Red Moon Probes



Complete Plans for
PN's Point-Riding Funabout
I Water Ski 106 MPH
The Newest on the Water

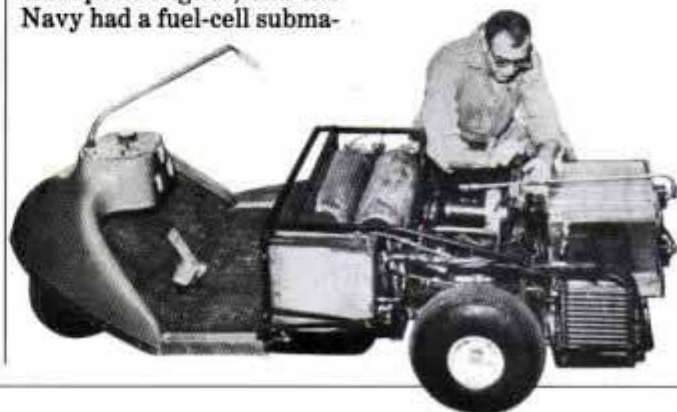
Hydro Dynamics

Interest in boating was reaching a high-water mark, so we packed in the coverage. A 3-point hydroplane was our spring project boat, but, meanwhile, wild watercraft gained momentum. The Germans bolted Wankel rotary engines into runabouts, while British aeronauticists were building a wingsail. And a Hartford, Connecticut, inventor molded a ramming catamaran out of polystyrene foam. But the new 152-mph dragsters drew the most attention.

Space Juice

Fuel cells were charging out of the laboratory. Pratt & Whitney provided fuel cells for Apollo flights, and the Navy had a fuel-cell subma-

rine in the works. By the '70s, we prophesied, the technology would be in widespread automotive use. **PM**



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ILLUSTRATION BY PAUL DIMARE

One-Step-To-Orbit Rocketry To Take First Step

WHITE SANDS, NM—This April, McDonnell Douglas engineers plan to fire off the DC-X, an experimental rocket sculpted like a giant saltshaker. Although the vehicle will initially spring only 600 ft. into the air, it'll herald technology that may revolutionize space travel.

Single-stage-to-orbit rockets bring technical complexity to bear in the cause of operational simplicity. No rocket has ever done the circus tricks that the DC-X will be asked to perform. Yet none has been as theoretically easy to service.

In its full-up demo to 30,000 ft., the DC-X's engines must fire at full thrust for liftoff, throttle back as

the rising vehicle lightens and shut off at the top of its arc. Then they'll reignite as retrorockets, bringing the DC-X down to a gentle landing on a 50-ft. landing pad.

Four new RL-10-A5 engines, adapted for sea-level operation from Centaur upper-stage boosters, will handle this workload. Pratt & Whitney has fitted each with a throttling mechanism.

Meanwhile, maintenance should consist merely of a gas purge to flush out moisture. Ground-based "pilots" will control the DC-X through a virtual-reality cockpit.

The DC-X's sponsor—the

Editor: Abe Dane
Assistant Editor: Greg Pope
Contributors: Katya Andresen,
Philip Chien, Scott Gourley

Strategic Defense Initiative Organization—may fund a follow-on DC-Y, able to hoist 40 tons into orbit.

Reusable DC-X single-stage test vehicle lifts off over the launch facilities at White Sands Missile Range.

Highlights This Month

- **Message In A Battle**—Covert laser leads rescuers to downed pilots.
- **Brains Go To Waste**—Smart trash cans talk back to garbage truck.
- **Stair Masters**—Tracked robots take dangerous steps.
- **Space Saver**—New mini-jetpack rescues errant astronauts.
- **Arm Curls**—Robotic tentacle flexes mechanical muscle.
- **Life Light**—Miniature belt-pack lasers aid combat medics.



Secret Message By Satellite

FORT BELVOIR, VA—An ongoing series of Shuttle experiments is testing a covert data-transmission system involving lasers and satellites. The first trial ran last December.

Battlefield Laser Acquisition Sensor Test (BLAST) is the name of the project, spearheaded by the Army.

BLAST works like this: As the Shuttle passes overhead, it wheels to point its windows toward

Earth. A ground crew flashes a message through the windows via a visible-light laser. The data encoded into the laser beam include the ground station's location, as determined by a Global Positioning System (GPS) receiver.

The Army likes the idea of a highly directional beacon (unlike a radio transmission that's easily tracked down by hostile forces), for use by a downed aviator or a scout behind enemy lines.

An operational follow-on to BLAST would integrate a GPS receiver, a palmtop computer and a laser that shoots an invisible infrared beam. The laser would send the message to a piggyback receiver on a future GPS satellite, which would relay it to a secure ground station.



Downed pilot sends SOS via satellite without tipping off enemy. BLAST's Shuttle hardware lies at left.



NASA PHOTO, ILLUSTRATION BY ED VALCIGURSKY

Hardware Overboard

HOUSTON, TX—This summer, Shuttle astronauts will heave an IMAX camera and a German ultraviolet telescope out the payload bay doors, so the crew can get on with the rest of the mission.

The jettisoned instruments will be bolted to a platform called the Shuttle Pallet Satellite, or ASTRO-SPAS. The telescope can point itself more precisely when floating on ASTRO-SPAS than it could mounted inside the Shuttle.

After six days the crew will retrieve the pallet.



ASTRO-SPAS platform will carry sensors outside the Shuttle this year and in 1994.

NASA PHOTO

Gut Check For Perseus

MANASSAS, VA—The unique high-altitude engine at the core of the unmanned *Perseus* aircraft (see *Tech Update*, page 14, March '92) is piling up ground-test time.

The Arion 1 powerplant is built around a 4-cylinder Rotax gasoline engine. Modifications allow the powerplant to handle liquid oxygen, recycle 80% of its exhaust gases and cast off heat into the wispy stratosphere.

Some components have



Extensively modified Rotax is the core of *Perseus's* Arion 1 powerplant.

gone into a vacuum chamber to simulate *Perseus's* realm above 82,000 ft. But the full engine won't flight-test until later this spring.

AURORA FLIGHT SCIENCES PHOTO

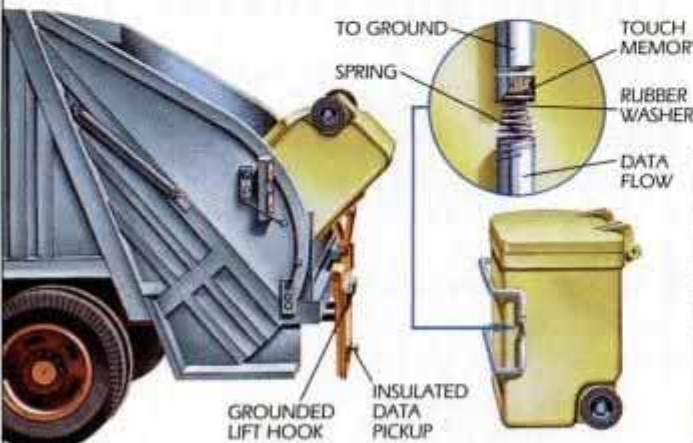
Smart Talkin' Trash

ATLANTA, GA—Engineers are putting impressive technology into garbage carts, as sanitation agencies seek to bill residents for every pound they throw away.

In Farmington, Minneso-

ta, miniature radio antennas in each cart broadcast account information to the truck as an automated lifting arm engages the vessel. A strain gage on the arm weighs the cart full, then empty, and transmits the weight figure to the truck's computer.

Meanwhile, Dallas Semiconductor has designed a system around touch-memory chips encased in stainless steel. The chips divulge the billing information through the cart's handle as the lifting arm hoists away, compressing a spring to close a circuit.



Touch memory (left) and radio tags (right) work with strain gages for pay-per-pound garbage service.

IPI ILLUSTRATION BY ADOLPHE BROTHMAN, CITY OF FARMINGTON PHOTO



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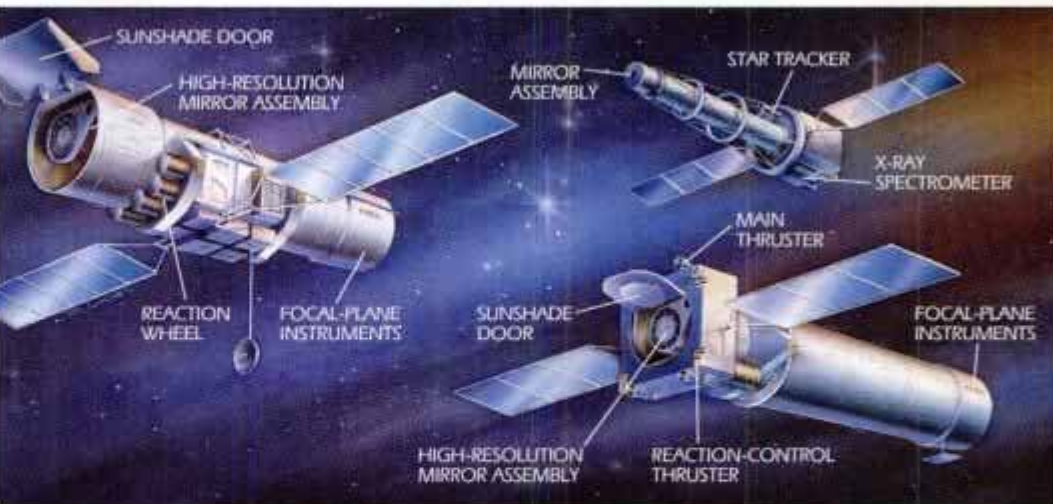
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AXAF Is Axed In Two

HUNTSVILLE, AL—NASA has chopped its orbiting X-ray telescope, slated for launch in 1999, into two separate spacecraft.

At \$2 billion and growing, the Advanced X-Ray Astrophysics Facility (AXAF) was threatening to break the bank. Trimming \$290 million off the price tag, NASA cut the number of costly X-ray-focusing mirrors from six to four. Each cylindrical mirror is gold-coated glass, with any irregularities polished down to a height of 5 atomic diameters.

But fewer mirrors add up to lower sensitivity. To compensate, the spacecraft will patrol a high elliptical orbit, permitting longer observa-



Single AXAF (left) has split into imaging AXAF-I (right, bottom) and spectroscopic AXAF-S (right, top).

tions unobstructed by Earth. The downside of this decision is that Shuttle astronauts won't have access to the telescope for maintenance.

In addition, astrophysicists have pulled out one key

instrument—the X-ray spectrometer—and designed a separate, cheaper spacecraft to carry it. The spectrometer doesn't require the same precision in its mirrors as the other instruments.

The Shuttle will release the larger, imaging spacecraft in 1998, while a Delta rocket will deploy the spectrometer satellite in 1999.

Transformer Robots Crawl Up Stairs



HILLSBOROUGH, NJ—Asking a robot to climb stairs is asking for trouble. If the robot runs on wheels, stairs loom as a disaster waiting to happen. Even mechanical legs, hard to choreograph under the best of circumstances, can stumble on steps.

Increasingly, robot builders are mastering stairs with shape-changing caterpillar tracks. These mechanisms stretch out flat to crawl up stairs, then shrink their foot-

prints to negotiate landings, corners and other tight spots.

A premiere proving ground for the machines is the Applied Robotics Test (ART) facility run by Public Service Electric & Gas, the New Jersey utility.

One newcomer to the ART lab is Andros Mark VI, made by Remotec Corp. of Oak Ridge, Tennessee. The Mark VI is the smaller brother of the tough Mark V-A, with which police mediate hostage negotiations and scout out

Andros rears up on doubly articulated tracks to change footprint and provide different camera angles.

holed-up suspects.

About the size of a colie, Andros rolls on a doubly articulated track that can fold to raise the machine's body and cameras. Like many of the robots tested at ART, Andros will find work inside nuclear powerplants.

Meanwhile, a squirrel-size crawler uses an even simpler mechanism to convert from a

flat crawler to a triangle. The Variable-Geometry Tracked Vehicle swings its lead rollers up to elevate its camera and shorten its footprint.

Designed by Inuktun Services of Nanaimo, British Columbia, the robot began life as a scaled-down prototype

for a larger machine, but proved to be equally useful in a smaller size.

Variable-Geometry Tracked Vehicle uses simple mechanism to convert from flat crawler to triangle.



PHOTOGRAPHS BY BELLAIRE



Errant Space Station astronauts rescue themselves with SAFER mini-jetpack.

veloping a self-rescue device that would strap to a spacewalker's backpack.

Called SAFER (Simplified Aid For EVA Rescue), the orbital life jacket looks like a smaller version of the Manned Maneuvering Unit (MMU) jetpack tested on Shuttle missions in 1984. Although it's not

designed to replace the MMU, the SAFER mini-jetpack would be able to offer most of the

larger jetpack's capabilities.

Weighing roughly 100 pounds, the unit provides propulsion through 24 pinky-size thrusters fueled with compressed nitrogen. A retractable controller would deploy to the astronaut's chest.

SAFER first stabilizes the loose astronaut. It automatically cancels any out-of-control tumbling, through computer-timed jet blasts from the thrusters. The remaining propellant whisks the astronaut back to an airlock.

In addition, an astronaut could don SAFER to inspect the Shuttle's engines, belly and other out-of-the-way spots.

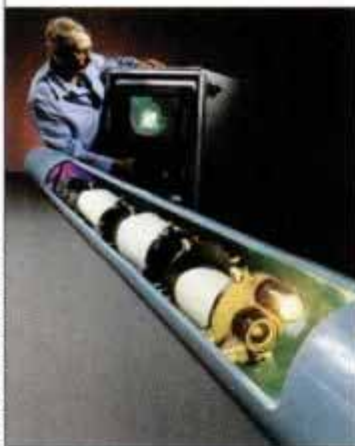
Johnson engineers plan to have a prototype ready for testing on a 1994 flight.

Jetpack For Stray Astronauts

HOUSTON, TX—An astronaut's worst nightmare is getting detached from the

tether during an extra-vehicular activity (EVA). NASA's Johnson Space Center is de-

Atomic Plumber's Helper



RICHLAND, WA—An articulating robotic crawler recently wormed its way through one of the world's nastiest sewer lines—the subterranean plumbing at the old Hanford nuclear-bomb research facilities.

Sealed off in 1979, the piping originally drained liquid waste from laboratories. As part of the ongoing cleanup effort, Westinghouse engi-

Four-sectioned drain train can snake through 6-in. plumbing in search of contamination.

neers built the little "drain train" to be the first to wriggle through 6-in. plumbing. Its mission: to look for cracks and sniff out any remaining radioactive contamination.

The vehicle carries a gamma-ray detector, lights and two miniature color video cameras, one of which can swivel 180°. A 1000-ft. cable brings up the rear.

Engineers from Long Island's stillborn Shoreham Nuclear Power Station may borrow the robot to scope out the plant's pipes buried under 4 ft. of concrete.

Helmet To Save Neck



SpineSaver helmet inflates airbag to cushion neck from crippling blows.

MERIDIAN, MS—A football helmet with a neck-swaddling airbag may prevent the kind of spinal injury that struck New York Jet Dennis Byrd last fall.

The SpineSaver helmet relies on a pressure sensor in its crown. Upon detecting a 500-pound force, the sensor triggers an airbag that drops to the shoulder pads. The airbag only deploys at a head-on blow, typical of dangerous "spearing" tackles.

Rush SportMedical will market the helmet by 1994.

Hot Coal-Gas Cleaner

SCHENECTADY, NY—General Electric has a promising new way to strip pollutants out of coal gas, a development that could make coal as thrifty and clean an electricity source as natural gas.

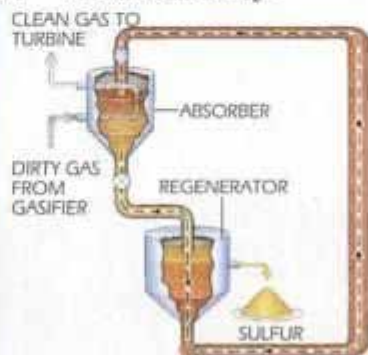
The process would fit into combined-cycle plants, which burn gas in a turbine generator and relay the exhaust heat to a second generator. The U.S. Department of Energy is building two combined-cycle coal-gasification plants.

Scrubbers that remove sulfurous com-

pounds from coal gas must run at cool temperatures. But the stream out of the gasifier can be as hot

as 1000° F. GE's technique operates at high temperatures, obviating the need to cool and reheat the gas.

GE says the process adds 1 or 2% to efficiency.



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Mechanical Python

PASADENA, CA—Engineers at Caltech have created a unique robotic creature that slithers like a serpent yet can seize objects like an octopus's tentacle.

The machine, nicknamed Snakey, consists of 10 articulating wheeled segments. Between each pair of wheel frames, three pistons expand and contract to inch the machine forward.

What makes Snakey run is a set of computer algorithms that describe the various wave movements of snake locomotion. These elegant mathematical formulas enable the robot to travel quickly and precisely, despite its complexity of moving parts. Such multijointed

mechanisms have rarely demonstrated both coordination and speed.

In addition, using similar programming, the robot can operate on its side to grasp and manipulate objects. Snakey curls around its target, then re-orientates the object by "walking" it.

Working with NASA's Jet Propulsion Laboratory, the engineers are building a miniature snake that will write at the end of a standard robotic arm on Space Station Freedom.

Future development efforts will focus on shrinking the machinery to tapeworm dimensions for use in gastrointestinal surgery.



Both tentacle and serpent, Snakey demonstrates its dexterity by wrapping around mock Soviet satellite.

Swimming To Mars

MOUNTAIN VIEW, CA—With its isolated location and extreme conditions, Antarctica comes as close to Mars as it gets on Earth.

That's why engineers from NASA's Ames Research Center traveled there last fall to test a virtual-reality robot-control technique.

A Super Phantom 2 robot mini-sub, built by Deep Ocean Engineering, was the mechanical guinea pig. A cable linked the remotely operated vehicle to hardware worn by a human controller. A solar-power system developed by NASA's Lewis Research Center supported the field camp.

The vehicle dove below the ice of frozen Lake Hoare in one of Antarctica's dry val-

leys. On the surface, the controller donned a 3D-video helmet and other apparatus that allowed him to steer the sub through body movements.

As a bonus, the robot probed the type of environment that might have fostered life on Mars several billion years ago. At the time that microbes emerged in Earth's oceans, Mars had plenty of water and a reasonable atmosphere.

Investigators hope to continue the Antarctic Space Analog Program by deploying a made-for-Mars habitat.



Super Phantom 2 robo-sub enters freezing lake during Antarctic field test of telepresence hardware.



Combat Medic's Laser

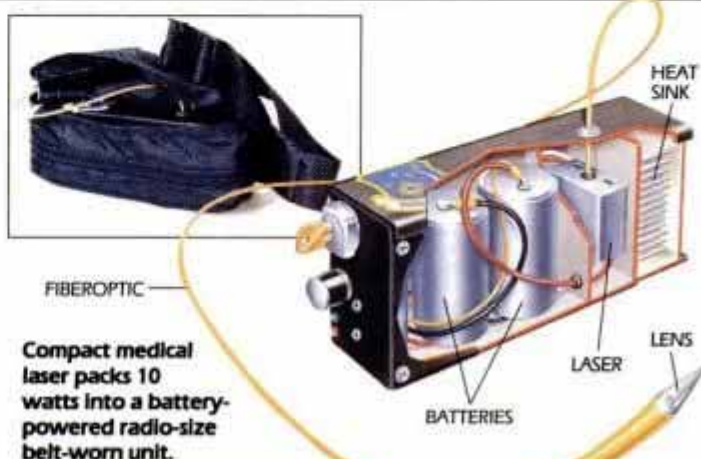
KIRTLAND AFB, NM—So compact are powerful lasers these days that the Air Force has designed one for battlefield medics.

The Laser Medical Belt Pack comes out of Phillips Laboratories. The 6-pound unit will deliver 10 watts of laser energy running off twin 2-volt batteries. By contrast, the desktop argon lasers used in many common medical procedures require wall-

socket power and only deliver 2 watts.

Combat rescue teams could wield the Air Force laser to cauterize wounds, stabilizing injuries on the battlefield before transport. An alternative fiberoptic tip would convert the device into a laser scalpel.

The Air Force plans to continue development with medical companies for civilian emergency applications. 



Compact medical laser packs 10 watts into a battery-powered radio-size belt-worn unit.

4x4

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What on earth makes the Toyota 4x4 so difficult to keep up with? Consider the earth itself. Long uphill climbs and deep washes demand this vehicle's 3.0-liter V6 engine, unique Hi-Trac independent front suspension and "shift-on-the-move" 4WDemand. But more than specifications, what keeps the 1993 Xtracab SR5 V6 out in front is its reputation. After all, when it comes to reliability and durability, Toyota's a tough act to follow. Call 1-800-GO-TOYOTA if you'd like a Truck brochure or the location of your nearest dealer.

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The “growth cycle” of the prostate: from birth through later life.



As a male develops from childhood through maturity, his prostate grows, stops growing, and can then start growing again in later life. To help you understand the vital role the prostate plays, here are some important facts.

The prostate at birth

Only males are born with a prostate gland. It's located at the base of the bladder, as shown in the diagram.

At birth, a baby boy's prostate is about the size of an almond, and it remains that size throughout childhood.



The prostate at puberty

During puberty, the prostate doubles in size. Then it stops growing. This is normal. The prostate is preparing for its main role in life — helping sexual reproduction.

The prostate supplies the milky fluid that helps transport the sperm through the penis during ejaculation. The prostatic fluid also aids conception by providing support and nourishment for the sperm and helping to make the vaginal canal less acidic.

The renewed growth of the prostate at middle age

In most men, after age 45, the prostate starts to enlarge and may continue to enlarge for the rest of a man's life. This growth may be benign prostate enlargement, a noncancerous condition. A major cause is the activity of a key hormone.

By itself, benign prostate enlargement isn't a problem. But, the prostate gland surrounds a section of the urethra, the tube that carries urine from the bladder through the penis. As the prostate continues to grow, it can squeeze the urethra (like pinching a straw) and interfere with the normal flow of urine, causing uncomfortable and embarrassing symptoms.

The prostate in later life

Not every man develops an enlarged prostate. And in those men who have the condition, it is not always progressive.

However, prostate enlargement is a common medical finding. In fact, more than half of men over 50 have an enlarged prostate.

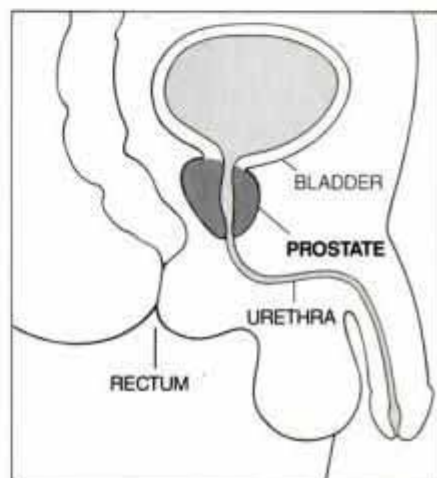
The urinary symptoms of an enlarged prostate

Among the symptoms commonly associated with an enlarged prostate are more frequent urination, especially during the night, or the sudden, almost uncontrollable urge to urinate. The added pressure on the urethra can also cause a weak, interrupted urine stream, a sense of the bladder not emptying com-

pletely, leakage, and difficulty in starting urination. It can even result in total blockage, a serious condition.

Why you should consult the doctor

Symptomatic benign prostate enlargement can be helped. Recent advances in treatment have been made, and today your doctor has several options. So now, more than ever, is an excellent time to consult your doctor. You and your doctor should discuss which treatment option would be best for you.



The prostate is located at the base of the bladder. It surrounds a part of the urethra, the tube that carries urine from the bladder through the penis. As the prostate enlarges, it can squeeze the urethra and cause urinary problems.

If you experience any symptoms, see your doctor and speak frankly about the problem. A simple rectal examination enables the doctor to feel, with a gloved finger, the size and condition of the prostate. This exam, and other tests the doctor may recommend, will also help to rule out the possibility of prostate cancer. Benign prostate enlargement is not cancer and does not turn into cancer.

Talk to your doctor, soon. It's important to you—and your family. And, for a free informative booklet, "What every man should know about his prostate," call 1-800-635-4452.



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TOYOTA T100 SR5

TOUGH TRUCKS

Five big pickups shoot it out for supertruck supremacy.

BY TONY SWAN, Automotive Editor

● For all the role expansion of the pickup truck in recent years—sports-car substitute, personal image machine, beach cruiser—there's a core activity that has remained constant: good old hard work.

But if the role of the real work truck hasn't changed much, its dimensions have. Until recently, if you wanted an all-around hauler your choice was limited to a full-size pickup from one of America's Big Three. Then the Dodge Dakota, a tad bigger than its compact pickup competitors, came along to blur the issue. And now we have Toyota's new T100, sized between the Dakota and the traditional standard trucks, to confuse the issue even more.

Which truck is right for you? That depends on how you're going to put it to work. Is the job small, medium or heavy duty? Will the truck be working full-time, part-time or only occasionally? Is carlike

comfort important? How about style? Fuel economy? Towing capacity?

Once you've answered these, you're still confronted with a variety of trucks. The trucks we assembled for this test were selected to reflect the spectrum of capabilities available. Due to big differences in size, muscle and payloads, these trucks aren't directly comparable. Instead, our test is aimed at illustrating the increasing competition for a growing segment of the U.S. marketplace.

Since all these trucks might have to work for a living, we added a load dimension to our test procedures. In addition to our regular instrumented tests, we conducted acceleration and braking tests with 1000 pounds of sand and rock on board.

Chevrolet C2500 Silverado

Our Chevy test truck was a ¾-ton model, powered by a 5.7-liter V8. It didn't have quite as much punch

TOUGH TRUCKS



CHEVROLET C2500 SILVERADO



with 1000 pounds in the bed, but it was far more comfortable to live with in terms of seating and ride. We can't say that we liked the Chevy's rainbow-hued electronic analog instrumentation, but the overall quality of materials and fit and finish are very good.

The Chevrolet C/K truck series—along with its counterparts from GMC Truck—offers a huge variety of engine, body style, driveline, payload and towing options. Chevy also boasts a choice of three diesels—including a 6.5-liter turbocharged V8.

Dodge Dakota Sport

Introduced in late 1986, the Dodge Dakota was billed as a midsize truck—a little bigger than the other compacts, including the Ford Ranger and Chevy S-10 Blazer. But when it comes to carrying the kind of all-around cargo that work trucks have to contend with, the Dakota isn't in the same class as the rest of this group. Although it can be ordered with an 8-ft. bed, there's not quite enough room between the wheel wells for that all-important slab of 4 × 8 plywood or

drywall to lie flat on the floor.

On the other hand, our test Dakota, powered by a 5.2-liter V8 engine, got the test crew's vote as the most fun to drive. With its middle engine option—a 3.9-liter V6 (180 hp, 225 ft.-lb. of torque)—it'll outperform the T100.

We liked the Dakota's seats, but the standard cab was a little cramped for real comfort. Ride quality, too, was jouncy in the standard truck with its short wheelbase, although it improves considerably in long-bed and Club Cab editions.

Dodge Ram 250

Here's the he-bear of the group. Dodge's full-size Ram truck affords a last look at the way pickups used to be—rough, tough, no-nonsense and unpleasant to drive for more than an hour or so. This model is due for replacement soon by the Dodge T-300.

Riding a ¾-ton chassis, our test truck came with an old-fashioned

SPECIFICATIONS AND DIMENSIONS

MANUFACTURER/ MODEL	BASE PRICE/ PRICE AS TESTED	ENGINE/ DISPLACEMENT (ci/cc)	ENGINE HP, NET/ TORQUE (ft.-lb.)	TRANS- MISSION TYPE	WHEELBASE/ LENGTH (in.)	TRACK FRONT/REAR (in.)	WIDTH/ HEIGHT (in.)	LEG-/HIP-/ SHOULDER-ROOM (in.)	CURB WEIGHT (lb.) WEIGHT/HP RATIO (lb./hp)	TOWING CAPACITY— AS TESTED (lb.)
Chevrolet C2500 Silverado	\$ 15,359/ \$ 21,410	OHV V8 350/5700	210 @ 4000 rpm/ 300 @ 2800 rpm	4-speed automatic	131.5/ 212.6	63.3/ 63.6	76.8/ 73.0	41.7/60.5/ 66.0	4021/ 19.1	8000
Dodge Dakota Sport	\$ 9943/ \$ 15,925	OHV V8 318/5200	230 @ 4800 rpm/ 280 @ 3200 rpm	4-speed automatic	112.0/ 189.0	58.5/ 58.5	68.4/ 64.5	41.8/56.1/ 58.7	3489/ 15.2	8900
Dodge Ram 250	\$ 15,010/ \$ 19,814	OHV V8 360/5900	230 @ 4000 rpm/ 325 @ 3200 rpm	4-speed automatic	131.0/ 219.8	63.4/ 65.6	79.5/ 72.9	39.4/65.0/ 64.0	4002/ 17.4	9200
Ford F-150 XLT	\$ 13,334/ \$ 18,944	OHV V8 302/5000	185 @ 3800 rpm/ 270 @ 2400 rpm	4-speed automatic	133.0/ 213.3	63.5/ 64.0	79.0/ 73.7	41.1/62.2/ 64.8	3960/ 21.4	7200
Toyota T100 SR5	\$ 15,718/ \$ 18,123	SOHC V6 183/3000	150 @ 4800 rpm/ 180 @ 3400 rpm	5-speed manual	121.8/ 209.1	61.6/ 63.7	75.2/ 66.7	42.4/59.4/ 62.4	3400/ 22.7	5000

Unladen performance numbers were taken with a full tank of fuel and a single occupant. Laden numbers were taken with approximately 1000 pounds of crushed stones arranged one bag deep on the cargo bed floor.

1. Times from a steady-state 40 to 70 mph.
2. Based on 12 basic maintenance functions.



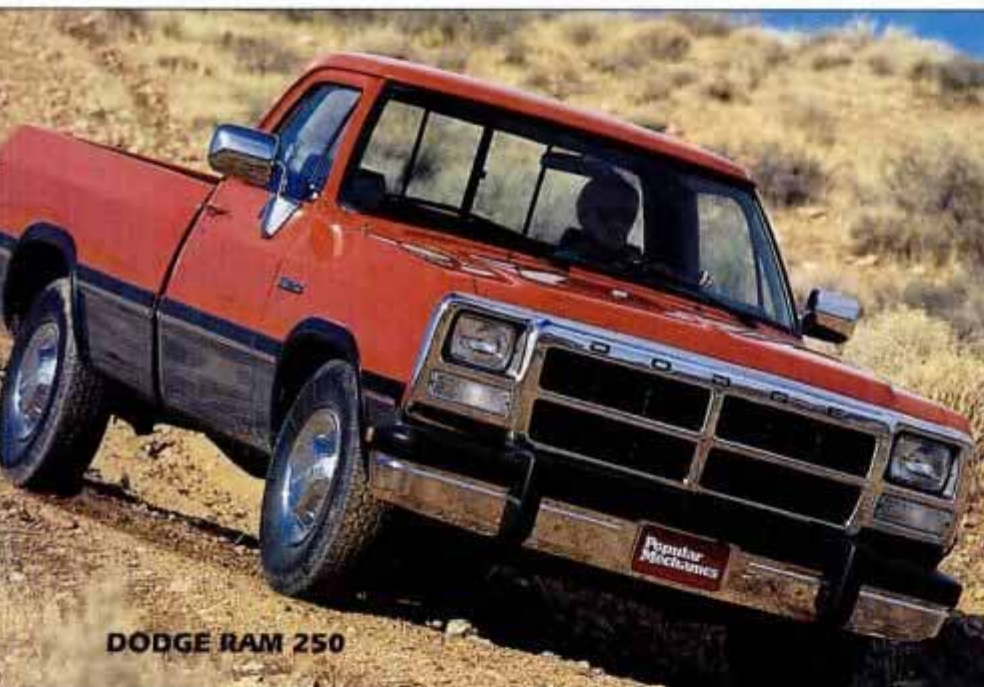
CHEVROLET C2500 SILVERADO



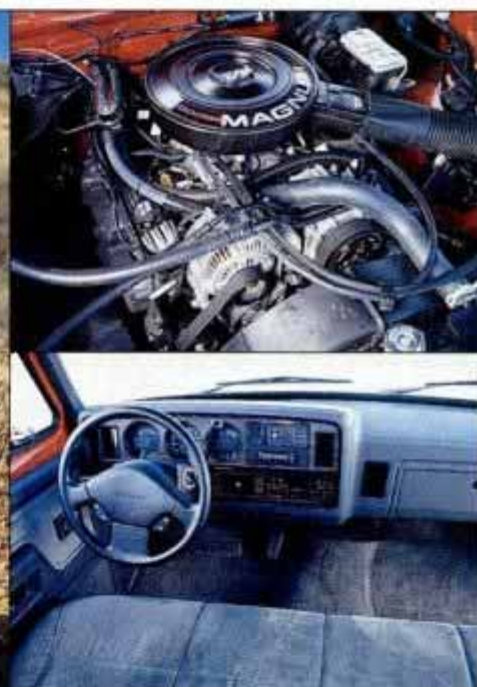
DODGE DAKOTA SPORT



DODGE DAKOTA SPORT



DODGE RAM 250



				TEST RESULTS					
MAXIMUM PAYLOAD/GVWR	CARGO BED DIMENSIONS (Floor Length/Width/Width Between Wheel Housings)	STEERING TYPE/TURNS LOCK-TO-LOCK	TURNING CIRCLE (ft.)	WHEELS/TIRES	FUEL ECONOMY (MPG EPA city/hwy.) PM test	ACCEL. 0-60 MPH (sec.) 1/4-MILE (sec. @ mph) (unladen/laden)	PASSING ¹ ACCEL. 40-70 MPH (sec.) (unladen/laden)	BRAKING 60-0 MPH (ft.) (unladen/laden)	PM ² SERVICEABILITY INDEX
2934/7200	97.8/64.7/ 49.1	Variable ratio power/NA	44.6	16 x 6.5-in. steel LT225/75R16D	14/19 16.5	11.1/17.07 - 78.8 11.2/17.83 - 75.8	10.0/ 10.7	161/ 185	10
1250/4300	77.0/59.6/ 45.0	Power rack & pinion/2.9	39.8	15 x 6-in. alloy/ P215/75R15	14/18 18.2	10.1/16.28 - 83.0 10.9/17.79 - 76.9	6.3/ 7.3	148/ 167	10
3141/7400	96.0/70.0/ 51.0	Recirc. ball/3.5	42.0	16 x 6-in. steel/ LT235/85R16E	12/16 15.0	11.3/17.82 - 74.6 12.0/19.40 - 70.0	7.7/ 8.6	168/ 189	9
1450/5450	98.3/70.0/ 50.8	Recirc. ball/3.5	47.0	15 x 6-in. steel/ P235/75R15	14/19 15.3	10.9/18.10 - 74.7 11.9/19.40 - 69.9	9.1/ 10.6	132/ 140	9
1600/5000	97.8/66.1/ 49.2	Power rack & pinion/3.84	37.8	15 x 6-in. alloy/ P235/75R15	16/21 23.0	11.7/18.04 - 72.4 13.0/19.64 - 68.0	10.2/ 12.3	136/ 151	9



DODGE RAM 250



FORD F-150 XLT



TOYOTA T100 SR5

PM PHOTOS BY RICH COX

TOUGH TRUCKS

bench seat and that steering-wheel-against-the-sternum driving position that's made generations of strong men ache at the end of a day's work.

However, though short on comfort, the Dodge was long on grunt. Revitalized two years ago, Dodge's 5.9-liter Magnum V8 makes 325 ft.-lb. of torque—more low-end muscle than you can get anywhere this side of one of the Ford or Chevy big-block V8s.

The big Ram hardly seemed to notice a ½-ton burden on its broad back, and emerged as the most cheerful load-hauler in our group. Like the full-size Ford and Chevy, it's available in a variety of body styles, bed lengths and load ratings, in 2- or 4wd and with engine options that include a 3.9-liter V6, a 5.2-liter V8 and a 5.9-liter inline diesel Six, besides the 5.9-liter V8.

Ford F-150 XLT

If any one truck sets the standard for American full-size pickups, this has to be it. Not only is this the best-selling truck in the country, it's also the best-selling vehicle overall.

Modestly redesigned just over a year ago, the F-150 has the most contemporary interior of the full-size trucks in this group, with carlike black-on-white analog instrumentation, bucket-style seats and excellent materials. Pavement ride quality was excellent, though on bumpy dirt roads the F-150, like all these trucks, was smoother with some weight in the back. We expect even better performance in this respect in the next generation of the F-series, when Ford will



FORD F-150 XLT



finally retire its venerated Twin I-Beam suspension system.

Our test truck's 5.0-liter V8 didn't measure up to the thrust provided by the bigger engines in the Dodge and Chevy, but like the other full-size trucks, Ford offers several engine options, ranging from its basic 4.9-liter inline Six to a stump-pulling 7.5-liter V8. Ford's only diesel offering is a big 7.3-liter V8. Also like the others, the Ford's range of body styles, drivetrains and load-bearing capabilities

allows buyers to truly spec their truck to their needs.

Toyota T100 SR5

Although it's within inches of full-size truck dimensions, with a cargo bed big enough to handle traditional pickup-size loads, Toyota's new big pickup stands out in this group for its differences, rather than its similarities.

Available at this stage of its development only in a standard cab/long bed body style, our T100 tester came to us in uplevel SR5 trim. It was the only member of the group with a manual transmission, due to test vehicle availability, which helped it keep pace with the other trucks. Even so, the T100's 3.0-liter sohc V6—the only engine offered at this point—had to work hard with a ½ ton of cargo in the bed, a load that ate up a big percentage of the suspension travel.

The T100 also stands out for its carlike comfort. It's roomier than the other trucks, with excellent bucket seats, quality materials and unusual amenities (for a pickup) like coin storage and a driver's footrest.

The light-duty truck classification embraces a broad range of capabilities, but it very accurately describes the T100. Compared to the traditional American full-size pickups, this isn't a full-time work truck, and it won't be until Toyota adds more muscle. We look for this to happen soon.

In the meantime, the T100 sets a welcome new standard for comfort and convenience that we look forward to seeing across the board. **PM**



TOYOTA T100 SR5



GRAPES WITHOUT WRATH

A new machine allows vintners to take the alcohol out of real wine.

BY FRANK VIZARD



● A smart-looking couple arrives at a friend's house for a visit. As they get comfortable on the sofa, the host appears with a tray of cheese and a bottle of wine for all to enjoy.

While this image of sophistication is one that the wine industry loves to perpetuate, the modern host may soon discover that his guests are avoiding alcoholic drinks of any kind. While it may be simply a matter of lifestyle, other reasons may well be at work. The woman may be pregnant or one may be the designated driver. Both may be trying to lose weight, shunning the extra calories that often accompany an alcoholic drink. There may be religious reasons.

What does the modern host do? Sutter Home, one of the largest wineries in California, is offering an alternative. The solution is non-alcoholic wine.

As a drink, non-alcoholic wine isn't new. Smaller wineries, most notably Ariel, have been selling non-alcoholic wine for some time with mixed reviews. In some instances, what these wines lack in kick is earnestly compensated for with pyrotechnical labeling. For example, one small winery, the Purple Pantry, recently released a beverage derived from White Zinfandel grapes called White Fang—a product Jack London might consider relatively toothless.

GRAPES WITHOUT WRATH

Sutter Home's non-alcoholic wine, Fré, may open a new chapter in the history of wine-making: The development of a non-alcoholic wine that tastes closer to wine than it does to grape juice.

Unlike other non-alcoholic wines, Sutter Home employs a new de-alcoholizing process that returns more of the taste elements—the essence—that gives wine its distinctive character. Sutter Home's entry into the market is significant not just because of the winery's size, but also for its track record of innovation. Bob Trinchero, the patriarch of Sutter Home, is largely responsible for popularizing the now ubiquitous White Zinfandel variety of wine. Early last year, Sutter Home came up with another innovation: A chillable red wine called Solé designed for white-wine drinkers seeking the lower cholesterol levels promised by red wine.

Following in her father's footsteps, daughter Gina has done much of the development work on Fré. Brother Roger is chief executive officer of the company. The Trincheros have owned Sutter Home since 1946. Sutter Home traces its lineage to 1890 when John Sutter and son Albert built their first winery in Napa Valley.

Fré is currently offered in two varieties. One is a White Zinfandel, boasting a pale salmon color. The other is a Chardonnay, characterized by a pale-gold straw color.

Except for the final de-alcoholizing step, both varieties are made in the same manner as their alcoholic namesakes. Grapes from the vineyard are crushed and clarified to remove impurities. The wine is then fermented in a cool, closed tank to prevent oxidation. As fermentation ends, the wine is moved, or raked, to clean barrels to separate it from spent yeasts and

grape solids. Further clarifying occurs over time, particularly if the wine is to be aged. When the wine is ready for bottling, a final light filtering is often done just before the wine reaches the bottling line.

The de-alcoholizing process is what separates Fré from other non-alcoholic wines. In the past, most wineries primarily relied on a de-alcoholization technique called reverse osmosis. The wine is pushed under high pressure through a membrane to remove the water and alcohol. What's left is a concentrate to which purified water is added to create a beverage.

Reverse osmosis has its drawbacks, however, say the Trincheros. "The pressure, unfortunately, appears to have a negative effect on the wine," says Gina, referring to the taste. Adding a lot of water was something they didn't want to do either.

The Trincheros soon became aware of a new Australian technology that seemed to address their concerns. The centerpiece of this new technology, marketed in the U.S. by Cone-Tech Inc. of Salinas, California, is a 13-ft.-high Spinning Cone Column.

From the outside, the Spinning Cone Column looks like a large steel tank. Inside the tank, however, is a maze of rotating and stationary cones. Each rotating cone is sandwiched between a pair of stationary cones. During the de-alcoholizing process the wine passes through all the cones twice.

The wine enters the Spinning Cone Column at the top of the cylinder and flows downward, pulled by gravity. At the same time, a stripping agent—in this case, nitrogen, which is a neutral gas—enters the bottom of the cylinder and moves upward.

Meanwhile, the cones attached to the column rotate, spinning the wine



into a fine, gossamer film. The wine moves up and out from the rotating cones by centrifugal force and then drains down over the stationary cones. All this turbulence lets more of the wine be exposed to the gas.

As the gas flows over the thin film of wine, it carries away the fragile essence or flavor ingredients of the wine. About 90% of the essence is removed even though the essence accounts for only 0.5% of the total volume. This procedure occurs at just above room temperature—a real plus since heat is a well-known enemy of wine. The essence is condensed out of the nitrogen gas conventionally.

The remaining 99.5% of the wine moves to the bottom of the cylinder. The wine, minus its essence, passes through the Spinning Cone Column a second time. At this point, the alcohol is removed using essentially the same separation technique used to remove the essence. Normally, about 50% of the total volume would be removed in order to get a wine with the required



Bob and Gina Trinchero of Sutter Home Winery check their non-alcoholic wine for color.



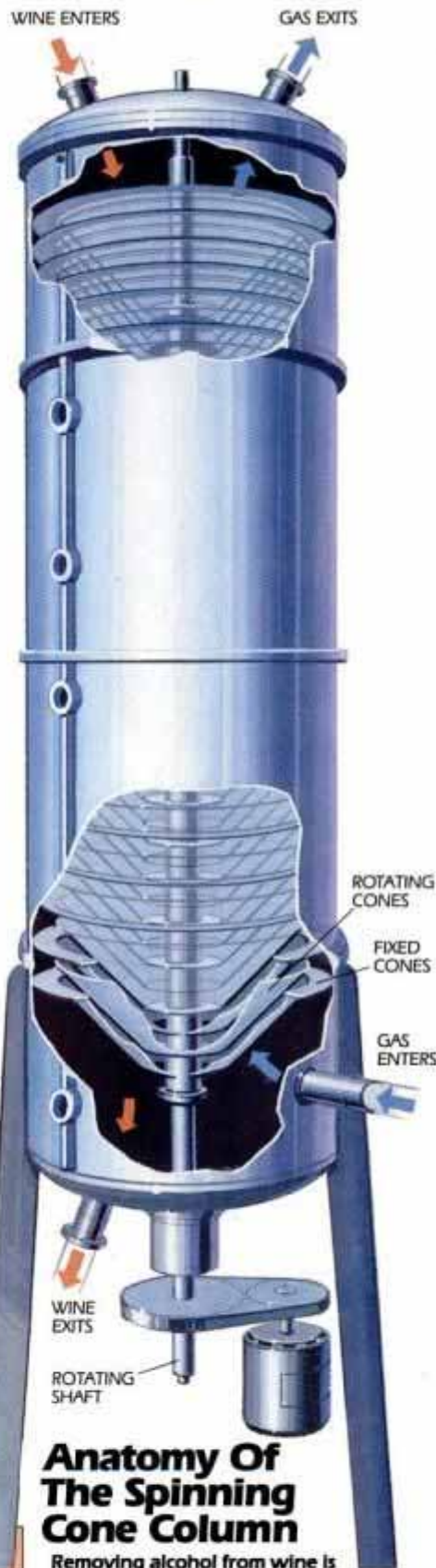
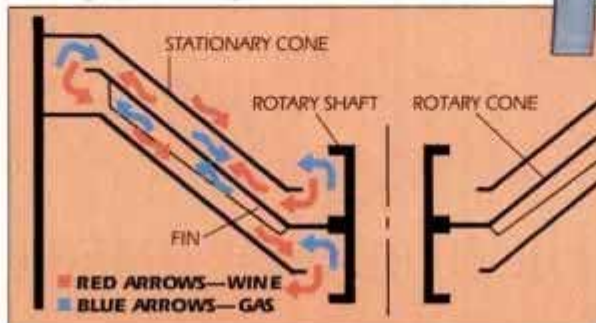
0.5% alcoholic content. The Spinning Cone Column removes only 20% of the total volume. Periodically, a small amount of non-alcoholic wine is re-injected into the Spinning Cone Column to maintain volume levels. The temptation was to use water but "the hope was that the use of wine as a re-injection liquid would add to the overall quality," says Bob Trincherio.

Once the alcohol is removed, the remaining non-alcoholic base and the essence are recombined. A third element, meté (what wineries call grape juice), is added as a sweetener. Meté is commonly used in wine-making and, as in normal wine production, meté of the same variety as the wine is used. How much meté is used depends upon the taste desired.

Ironically, non-alcoholic wine is an instance in which less is more, at least as far as price is concerned. Extra steps in the manufacturing process translates into added costs at retail.

Expect to pay at least 50 cents more per bottle at the store.

Is it worth the price? Based on our experience, Fré is something less than wine but more than grape juice. How well you like Fré probably will depend on how attached you are to wine in general. Connoisseurs may despise it, but casual sippers may find it to be a palatable alternative that goes well with cheese. Given the success of non-alcoholic beer (sales rose to 24-million cases in 1991), chances are that there will soon be a lot of people uncorking a bottle of Fré. **PM**



Anatomy Of The Spinning Cone Column

Removing alcohol from wine is a 2-stage process. In the first, wine descends to meet rising gas. Rotating and stationary cones mingle the two (left). The gas carries off the flavor elements to a holding area. A second pass removes the alcohol. The base liquid and the flavor elements are then recombined. Long tubes (top left) to and from the Spinning Cone Column help keep flow rates constant.

200 horsepower. Now in the convenient family pack.

CHEVROLET LUMINA EURO 3.4 SEDAN

Where's it written that moms and dads must only drive dull and frumpy cars? Not at Chevrolet. We've been putting high performance on the street for years. Now we're letting parents in on the action.



Why should kids have all the fun?

It's high time someone liberated the 4-door sedan. Gave it enough muscle to

work up a sweat. Like 200 horsepower, 4 cams, 24 valves — one of the highest-output V6s around.

Sound good?

Well, it gets even better.



How Corvette helped give Lumina a bigger trunk.

Lumina Euro's sport suspension borrows an idea from Corvette: a fiberglass transverse rear leaf spring — which not only delivers excellent road response and a smooth ride, it also makes for more trunk space. This in a car with more interior room than Camry, Accord or Taurus. Ingenious, huh?

How melted asphalt makes for a quieter car.

You'll find lots of thoughtful and surprising engineering in Lumina. For instance, we used baked-on asphalt noise-control patches and rigid steel beams under the interior to help isolate it, to keep the decibels down and the shakes out.

We gave it standard anti-lock brakes to help you steer and stop safely on slippery surfaces. In fact, we made over a dozen refinements this year alone. It wasn't easy creating a car this convenient and this fun. But then, what else would you expect from the Heartbeat of America?



THE HEARTBEAT OF AMERICA™



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LOW TECH, HIGH SPEED

It's brute force, not high tech, that makes the Winston Cup stockers fly.

BY BILL LOVELL • PM Photos by Don Hunter

● NASCAR's Winston Cup series projects a folksy, low-tech image that its legions of fans eat up like fried chicken. Forget the high-buck techno-wizardry of Formula One or IndyCars or IMSA GTP prototypes—the carbon-fiber brakes, active suspension systems, ground effects, carbon-fiber wheels, real-time telemetry, pneumatically operated valvetrains, electronically operated gear changes.

Yup. Winston Cup is just one big old festival of thundering yestertech, cold beer, fried chicken and grandstands overflowing with fans hollering for Bill, or Davey, or Dale, or D.W. Who cares what's under the sheetmetal. Ain't that right, Ferlin?

Well, yes

—and no. It certainly applies to most of the nuts and bolts and hardware. And it certainly applies on race day. But every other day of the week, that good ol' boy shade-tree mechanic image of Winston Cup stock car racing is seriously dated.

Chassis evolution

The Winston Cup chassis hasn't changed much over the past few years. Under the Ford, Chevy, Oldsmobile and Buick sheetmetal, you'll find a grid of massive steel tubing that's virtually identical from one car to the next, as specified by the NASCAR rule book. And the few changes that have come along are connected with driver safety.

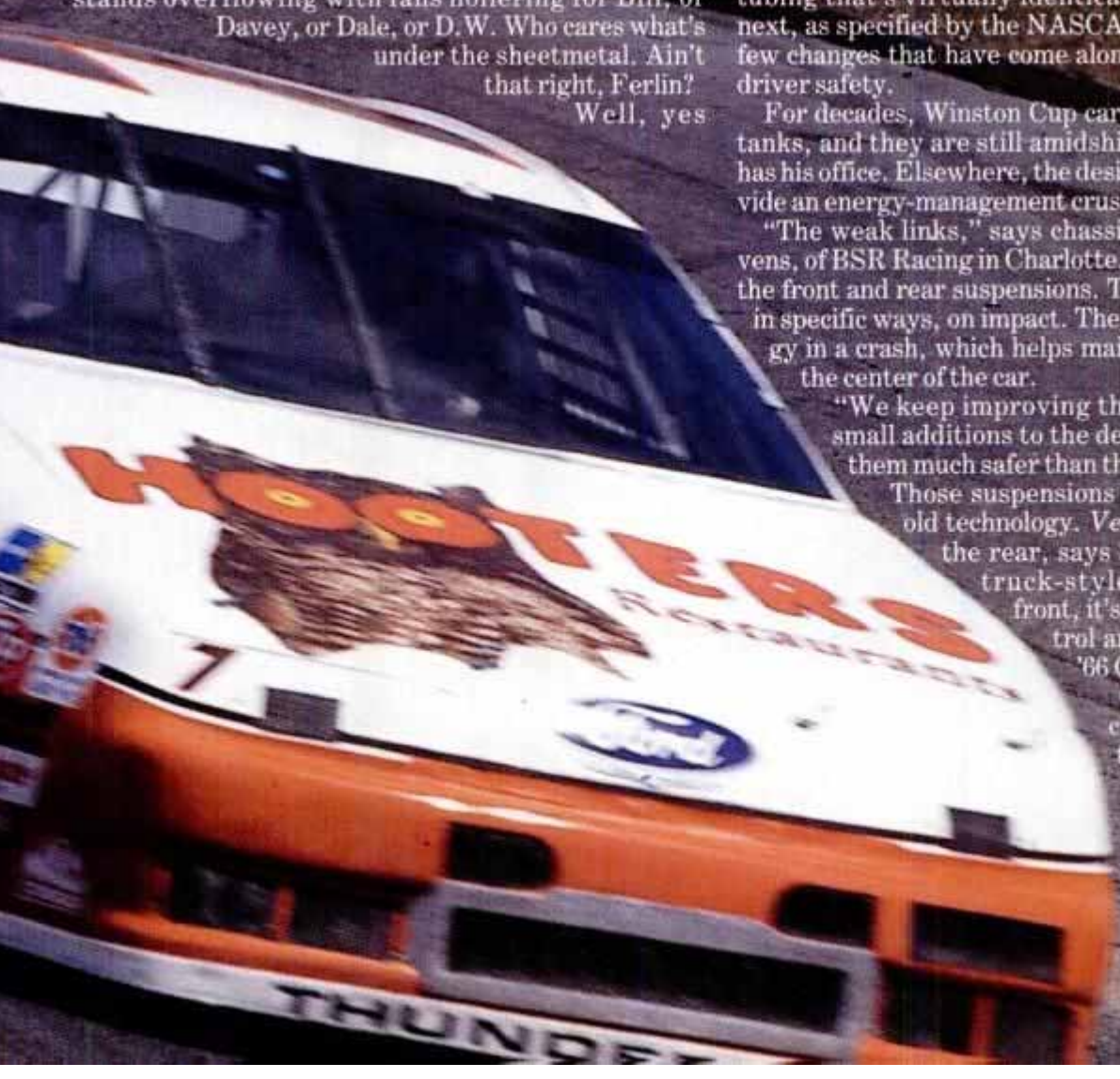
For decades, Winston Cup cars have been built like tanks, and they are still amidships, where the driver has his office. Elsewhere, the design has evolved to provide an energy-management crush zone.

"The weak links," says chassis-builder Butch Stevens, of BSR Racing in Charlotte, North Carolina, "are the front and rear suspensions. They're made to bend, in specific ways, on impact. They absorb a lot of energy in a crash, which helps maintain the integrity of the center of the car.

"We keep improving the chassis by making small additions to the designs. We're making them much safer than they used to be."

Those suspensions otherwise represent old technology. Very old technology. At the rear, says Stevens, "it's Chevy truck-style trailing arms. Up front, it's upper and lower control arms derived from the '66 Chevelle."

One thing that has changed, though, thanks to the advent of radial tires in Winston Cup racing, is an end to the old front-steer/rear-steer controversy. A front-steer car





5. KYLE PETTY

Pontiac Grand Prix

A 3-time pole winner in 1992, the third-generation driver from Randleman, North Carolina, was the series' second biggest lap leader of the season. Driving Sabco Racing's No. 42 Mello Yello Pontiac, he recorded a pair of victories during the season with nine top five and 17 finishes in the top-10 positions. Considered by many to be the strongest driver in the second half of the season, he earned \$1,107,063 for the year, plus took second place in "The Winston" all-star race.



6. MARK MARTIN

Ford Thunderbird

The Batesville, Arkansas, native finished the 1992 campaign with two victories, 10 top-5 and 17 top-10 finishes. Driving Jack Roush's No. 6 Valvoline Thunderbird, he enjoyed six front-row starts, including one pole, and was a leader in 17 of the 29 races. He concluded the season with earnings of \$1,000,571, his fourth straight year in excess of the \$1-million plateau, and was running at the finish of all but five events.



8. TERRY LABONTE

Chevrolet Lumina

The 1984 Winston Cup champion was winless in 1992 but had four top-5 race finishes, including a second, and 16 races where he ranked in the top 10 at the finish. The Corpus Christi, Texas, native drove Billy Hagan's No. 94 Sunoco Oldsmobiles and Chevrolets to the lead in four races. He concluded the year with earnings of \$600,381, to elevate his 14-year career total to more than \$7 million.



9. DARRELL WALTRIP

Chevrolet Lumina

The 3-time series champion from Franklin, Tennessee, won three times in 1992 as driver of his own No. 17 Western Auto Chevrolet. A leader in 14 of the 29 races, Waltrip was also a pole winner during the season and added a trio of victories to bring his career total to 84, third highest in the sport's history. He was also a pole winner and had 10 top-5 and 13 top-10 finishes for season winnings totaling \$876,492.





Popular Mechanics

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LOW TECH, HIGH SPEED

has its steering box and linkage located ahead of the front axle centerline, and rear-steer vice versa.

In the days of bias-ply tires, rear-steer was favored by race drivers who liked their cars a little loose, meaning that the rear end wanted to step out in the corners.

"With radials," says Stevens, "you need front-steer for stability. On ovals, where you're always turning left, you don't even want the car to think about turning right."

Radial tires have also all but eliminated the time-honored concept of ad-

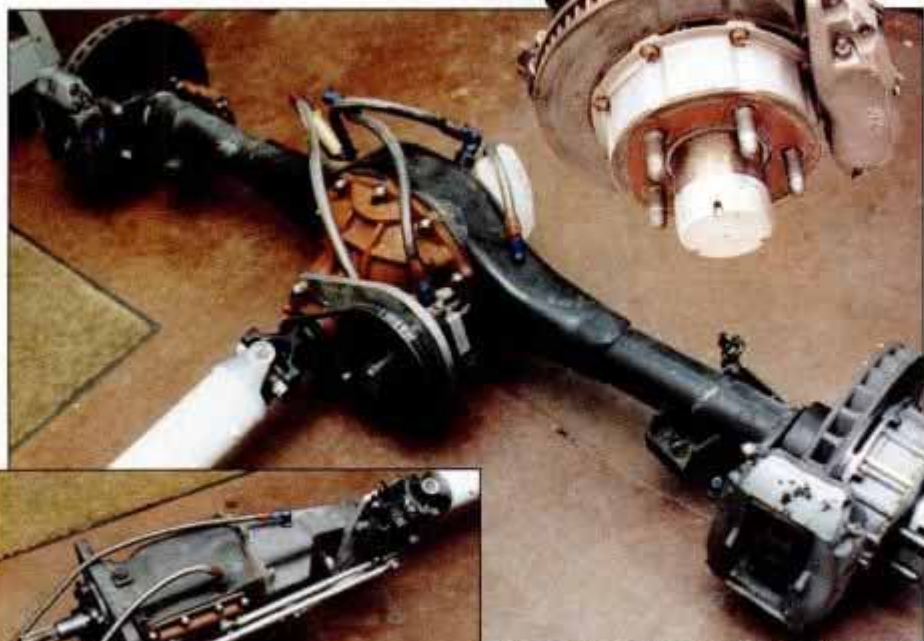


Nearly identical beneath the skin, all the cars have 3 x 4-in. frame rails and a safety cage of 1 1/4-in. tubing. Note fire extinguisher next to fuel tank.



justing handling by changing a car's "stagger" by fiddling with the pressure of the tires. Inflating or deflating a bias-ply tire produces much more change in circumference than in a radial-ply tire.

On the other hand, the equally cherished tradition of adding or subtracting a little "wedge"—weight-jacking at one or more of the car's corners to change its balance during the race—is still with us, and has been honed to a fine art.



No-nonsense suspension. Front is upper and lower control arms, rear is solid axle. Gearbox is 4-speed.



Tube steel

The basic Winston Cup chassis consists of 3 x 4-in. frame rails, while the roll cage is 1 1/4-in. seamless tubing with lots of cross-bracing. All the tubing is mild steel.

The outer skin, except for fiberglass-reinforced Kevlar nose and tail pieces, is all sheet steel—"rejected sheetmetal right off the assembly line," according to Stevens. NASCAR makes sure the body looks fairly stock by using templates cut out to resemble the dimensions of the production vehicle—the only real stock left in stock car racing. As an example, the dimensions of Alan Kulwicki's championship-winning 1992 Thunderbird closely approximate the production T-Bird, but the 110.0-in. wheelbase is 3.0 in. shorter and the minimum ride height is just 4.0 in.

All Winston Cup cars must weigh a minimum of 3500 pounds, with 1900 pounds to the left of the centerline (for oval track racing).

Most teams don't build their own chassis. Instead, they buy them off the shelf from guys like Stevens. And they buy a lot of them.

Bargain bullets

As noted, for major-league racing, a Winston Cup car is amazingly cheap. A BSR rolling chassis goes for \$40,000, including paint.

The engines haven't gone up all that much, either. Roush Racing, in Livonia, Michigan, will sell you a full-race

ANATOMY OF A WINSTON CUP CHAMPION

ALAN KULWICKI'S
FORD THUNDERBIRD





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TOP 10 FINISHERS



3. DAVEY ALLISON Ford Thunderbird

The second-generation race driver from Hueytown, Alabama, plucked two of the richest plums from the 1992 Winston Cup platter, winning the Daytona 500 opener and taking top honors in "The Winston" all-star race. He overcame injuries and personal tragedy to win five times and led a season high 2314.9 of 11,490.5 possible miles. Twice a pole winner, he also had 15 top-5 and 17 top-10 finishes in his \$1,955,628 season in Robert Yates's No. 28 Havoline Thunderbird.



4. HARRY GANT Oldsmobile Cutlass Supreme

Driving Leo Jackson's No. 33 Skoal Bandit Oldsmobile, Gant extended his feat as the oldest winning driver in Winston Cup racing by winning two races in 1992 at 52 years of age. He led 11 of the 29 races and finished in the top five in more than a third of the races and was among the top-10 finishers in just over half. A building contractor off the track, Gant is the oldest driver to win a 500-mile event in any form of racing. He earned \$1,122,776 in 1992 competition.



1993 NASCAR Winston Cup Schedule

DATE	TRACK	LOCATION
Feb. 14	Daytona International Speedway	Daytona Beach, FL

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7. RICKY RUDD Chevrolet Lumina

Driving Rick Hendrick's No. 5 Tide Chevrolet, Rudd was one of the dozen winners in 1992 Winston Cup competition and was also among the 14 pole winners of the season. The 1977 Rookie of the Year finished in the top five in one of every three starts and was among the top 10 in two of every three races. He led nine of the 29 events in 1992 and won \$793,903 after finishing second in the 1991 points chase.



10. STERLING MARTIN Ford Thunderbird

The 1983 Rookie of the Year didn't find his initial Winston Cup victory in 1992 but came close with three second-place finishes. He also enjoyed five times as top qualifier and was a leader in eight races. Driving Junior Johnson's No. 22 Maxwell House Coffee Ford Thunderbird, the second-generation Winston Cup racer had a half-dozen top-5 and 13 top-10 finishes, for seasonal winnings of \$649,048 in the 29 races.



FEB. 28	Norfolk International Raceway.....Norfolk, VA
March 7	Richmond International Raceway.....Richmond, VA
March 14	Atlanta Motor Speedway.....Hampton, GA
March 28	Darlington International Raceway.....Darlington, SC
April 4	Bristol International Raceway.....Bristol, TN
April 18	North Wilkesboro Speedway.....North Wilkesboro, NC
April 25	Martinsville Speedway.....Martinsville, VA
May 2	Talladega Superspeedway.....Talladega, AL
May 16	Sears Point International Raceway.....Sonoma, CA
May 22	Charlotte Motor Speedway.....Concord, NC
May 30	Charlotte Motor Speedway.....Concord, NC
June 6	Dover Downs International Speedway.....Dover, DE
June 13	Pocono International Raceway.....Long Pond, PA
June 20	Michigan International Speedway.....Brooklyn, MI
July 3	Daytona International Speedway.....Daytona Beach, FL
July 11	New Hampshire International Speedway.....Loudon, NH
July 18	Pocono International Raceway.....Long Pond, PA
July 25	Talladega Superspeedway.....Talladega, AL
Aug. 8	Watkins Glen International Raceway.....Watkins Glen, NY
Aug. 15	Michigan International Speedway.....Brooklyn, MI
Aug. 28	Bristol International Raceway.....Bristol, TN
Sept. 5	Darlington International Raceway.....Darlington, SC
Sept. 11	Richmond International Raceway.....Richmond, VA
Sept. 19	Dover Downs International Speedway.....Dover, DE
Sept. 26	Martinsville Speedway.....Martinsville, VA
Oct. 3	North Wilkesboro Speedway.....North Wilkesboro, NC
Oct. 10	Charlotte Motor Speedway.....Concord, NC
Oct. 24	North Carolina Motor Speedway.....Rockingham, NC
Oct. 31	Phoenix International Raceway.....Phoenix, AZ
Nov. 14	Atlanta Motor Speedway.....Hampton, GA

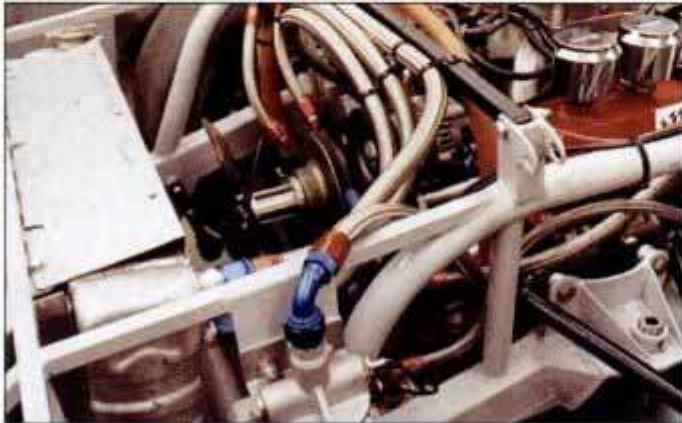
Popular
Mechanics

PHOTOS BY DON HUNTER; TEXT BY BOB LATFORD
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Outer body skin is sheetmetal. Front and rear sections are Kevlar and cover front- and rear-suspension components designed to deform in specific patterns on impact. Power comes from pushrod V8.



Winston Cup Ford V8 for \$30,000. And if pushrod V8s aren't high-tech, they do have decades of high-tech computer-aided development behind them, which means plenty of sources for proven racing pieces, and plenty of knowledgeable people to make them work—and work well.

Ford's 358-cu.-in. Winston Cup V8s are capable of 625 to 650 hp before the NASCAR carburetor restrictor plates, aimed at keeping superspeedway velocities below 200 mph, are

bolted on. The carburetors are single 4-bbl. Holleys, and the Roush motors use Ford ignition, Carillo connecting rods, Moldex crankshafts and Wiseco pistons.

The power finds its way through a GM-based 4-speed aluminum gearbox to a 9-in. Ford rear axle with full-floating differential. Virtually all Cup cars, regardless of brand, use this same setup.

With 3500 pounds of race car, the brakes are just like the rest of the set-

up—industrial strength. The 12-in. ventilated steel rotors are 1 3/8 in. thick, with twin-piston calipers front and rear. The front pistons are 2 in. dia., the rears 1 1/4 in., and the pad material is high-carbon metallic.

Midweek telemetrics

But for all the resistance to high-cost high-tech in the NASCAR inventory, advanced technology has been creeping in, through the magic of electronics.

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Complete cars look close to stock though dimensions are a few inches less than the showroom version. Cars must weigh at least 3500 pounds. This is Sterling Marlin's old Thunderbird.



PHOTO BY G. PHOTO

POSSIBLE DREAMS

Ninety years of Popular Mechanics come alive at Henry Ford Museum & Greenfield Village.

BY MARY SEELHORST

● Celebrating POPULAR MECHANICS' first anniversary in 1903, editor Henry Windsor saluted his unpretentious magazine: "Readers of the first issue of POPULAR MECHANICS searched in vain for the usual announcement of the great things the new paper was to accomplish. All they found were the two lines:

Tells you how to do things.

Written so you can understand it.

These mottoes have steadily been

Mary Seelhorst is curator of the "Possible Dreams" exhibit at Henry Ford Museum & Greenfield Village in Dearborn, Michigan.

adhered to and always will be."

Ninety years later, we are celebrating another one-year anniversary. It has been one year since "Possible Dreams: POPULAR MECHANICS and America's Enthusiasm for Technology" opened at Henry Ford Museum. One year since we began this series of articles reviewing the mechanical mania of the 20th century as seen in the exhibit. One year since PM celebrated its 90th birthday.

The exhibit wasn't quite finished when last year's March issue went to press, and we had to use artist's ren-

derings to illustrate the exhibit, along with some photos that were, well, not exactly in keeping with PM's reputation for up-to-the-minute reporting. Since that initial report, we've made many updates and improvements to an already exciting exhibit. For instance, we have completed a beautiful restoration of the Indy-winning Lotus of 1965 that was pictured in that article. Visitors to the exhibit can see this historic car looking like it did the day Jimmy Clark took the wheel on Memorial Day, 28 years ago.

Besides the Indy racer, the exhibit includes three other cars, a boat, a plane, a house, radios, appliances, furniture, motorcycles, a robot, a CD player, an X-ray shoe-fitter, motorized roller skates, a permanent-wave machine and dozens of other big, small and in-between things that bring 90 years of America's technological enthusiasm to life.

Bringing life to the past is one of the joys of restoring old machines, reading old issues of PM or working at a museum. Lucky indeed are those who get to do all three. But like POPULAR MECHANICS, Henry Ford Museum

(Please turn to page 83)

Its primary mission is to convert you.



Everything about the Ford Econoline is formulated to win you over.

Because the ultimate

**Ford Trucks.
The Best Never Rest.™**

van conversion begins with the ultimate in full-size vans. And

Econoline is the most advanced full-size van built today.

Econoline's unique features include Ford's exclusive "out front" design for more room up

front. The strength of body-on-frame construction.

Twin-I-Beam independent front suspension for smoothness and control.

Plus unsurpassed trailer towing capacity.

Rear anti-lock brakes are standard.

And Econoline is the only full-size

passenger van with a standard driver side air bag to supplement your safety belt.* So see your Ford dealer. And let him convert you to the Ford Econoline.



ECONOLINE



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

*All models except E-350. Air bag effectiveness depends on wearing your safety belts, so always buckle up. *Best-Built" claim based on an average of consumer-reported problems in a series of surveys of all '81-'92 models designed and built in North America. Sales by Division.

BULLET TRAIN FOR AMERICA

A new curve-hugging high-speed train puts America's rail riders on the fast track.

BY GREGORY T. POPE
PM Photos by Marty Katz

● West of Philadelphia, the old Harrisburg line shoots out straight to Downingtown, Pennsylvania, then begins to snake across the rolling Amish countryside. Streamlined GG1 locomotives patrolled this territory during the Pennsylvania Railroad's heyday, but now the tracks are far quieter. Light traffic and a winding course make this the perfect setting to test drive a new train—a train that Amtrak hopes will help it recapture the glory of passenger rail past.

Since its chaotic birth in 1971, Amtrak has shelled out

\$2.6 billion to refurbish its Northeast Corridor between Washington, D.C., New York and Boston. Today express Metroliners cover the 224 miles from New York to Washington in 2 hours and 35 minutes.

But Boston-bound passengers aren't so favored. First, trains must halt to swap locomotives in New Haven, Connecticut, where track electrification ends. Then the railroad wheels through a tortuous right of way laid a century ago. Because the F40PH diesel locomotives and Amfleet coaches can't careen around cor-



ners without risking derailment, the 230-mile New York-Boston leg still takes 4½ hours.

In fact, say some analysts, the entire Northeast is crying out for a supertrain to take the pressure off the airports and turnpikes. "Certainly along this tremendous corridor there's potential for much more ridership," argues Vukan Vuchic, professor of transportation engineering at the University of Pennsylvania. "Amtrak has done a good job, but it's still underutilized."

Enter the X2000. The \$13-million train, imported

from Sweden, was designed to convert existing tracks into bullet-train speedways. While the X2000 can do 155 mph on the straightaway, cornering is its forte. Thanks to an innovative suspension system and body-tilting mechanism, the X2000 can swing safely around curves 40% faster than a conventional train. Hugging the contours of the New England tracks, the train could trim 1½ hours off the New York-to-Boston timetable.

In Sweden, the X2000 has done just that to a once-grueling 4½-hour run between Stockholm and Gothen-

BULLET TRAIN



At Baltimore Harbor, diesel locomotive waits as Amtrak and ABB Traction personnel charge X2000's batteries and prep train for short haul to Northeast Corridor track.

burg. In November 1991, Amtrak, Swedish State Railways and manufacturer ABB Traction inked a deal to bring a spare X2000 to the Northeast Corridor. Last October, the train-set—a snake-nosed locomotive, four coaches and a food-service car—arrived in Baltimore, following some minor surgery to meet American rail specs.

The X2000 then began prowling its twisty 68-mile proving ground between Philadelphia and Lancaster, Pennsylvania. On a snowy December morning, POPULAR MECHANICS went along during a test run.

Suspended animation

One sensation stands out: The X2000 rides far smoother than the current Amtrak rolling stock. There's only a ghost of the vibration that can jar teeth on Metroliner runs. The cabin was quiet enough to permit whispered conversation.

But the train's unique capabilities came into play as we barreled into the first bend at Atglen, Pennsylvania. Any other train must brake to 75 mph to negotiate the curve, but the X2000 whipped around at a full 90 mph.

Standing up, a passenger notices the floor push gently against the left foot, as the view out the window pitches skyward. At a mere 0.15 g's—nothing to upset your balance—the force is nevertheless with you. That's because the tilting mechanism only cancels 70% of the centrifugal pull.

"I've been on this train when it's done 100% compensation," says Lutz Eisner, president of ABB Traction's U.S. subsidiary. "Believe me, you wouldn't want to be on board. You get physically seasick." The queasies

Tilting Mechanism



A hydraulic cylinder separates two structural bolsters, opening an angle between cabin and undercarriage.

arise, he explains, because neural signals from the eye—the tilting scenery—clash with those from the inner ear, which senses no change at all.

But you also wouldn't want to be on board with no tilt at all. During our re-

turn run, engineers deliberately disabled the mechanism on one car. As the train wheeled around a 75-mph bend at 101 mph, passengers almost tumbled into the aisle, while full cans of soda shot across tabletops. Back in the tilting cars, however, coffee barely sloshed in its cups.

Animated suspension

Beneath the floor lies the machinery that flattens out the ride. Each car rests on front and rear trucks that house two axles apiece. In a conventional train, when a truck rounds a bend, the axles rigidly follow the truck's heading, so the wheels run at a slight angle to the curved track.

That slim misalignment forces the engineer to slow down, to keep the wheels from jumping the track. But on the X2000, flexible rubber-and-steel chevrons link the axles to the truck. Because these components let the axles pivot freely, the wheels stay aligned with the track, allowing the engineer to whiz around corners.

Meanwhile, the tilting mechanism swings into action when the train tops 45 mph. Across the center of each truck lie two structural beams called bolsters. The lower one is fastened to the truck frame, the upper one connected to the passenger cabin through secondary air-suspension bags. Four pendulum rods and two computer-controlled hydraulic cylinders link the two bolsters.

When the train hits a curve, accelerometers mounted on the lead truck measure the lateral force and signal the computer to activate the tilt. Choreographed by the computer, the outside hydraulic cylinders on each car begin to expand, banking the cabins into the curve. Only the locomotive doesn't tilt, to ensure that its current-collecting pantograph arm doesn't lose touch with the catenary line.

Beyond its curve-taming suspension system, the X2000 can stop and go with anything else on rail. The locomotive carries four AC traction motors, developing a total of 4300 horsepower. Thanks to improvements in speed-control electronics, synchronous AC propulsion has

overtaken DC equipment as the choice for high-speed locomotion. The motors are lighter and, being brushless, require far less maintenance. They also supply impressive acceleration out of the curves.



Although brake and throttle lie in reverse of American layout, X2000's cab puts controls within easy reach of the engineer.



In all-first-class, European-style passenger cars, seat rows march from both ends to meet face to face in the middle.

Just as impressive is the braking system. High-speed trains typically have two braking methods, pneumatically triggered discs and so-called dynamic braking, which throws the motors into reverse, turning them into generators. Normally, the current that's generated flows into resistors and dissipates as heat.

But in the X2000, the dynamic braking is regenerative, sending the current back into the catenary for other trains to use. The X2000 also features a third brake, common on streetcars: an electromagnet on each truck that clamps to the rail for sudden halts. All this stopping power puts engineers at ease. "Best brakes on any train I've operated," remarks veteran transportation manager Donald Herman, who manned the cab during our test run.

Kick the tires yourself

If you're an East Coast train patron, you have a chance to check out all this technology. As of February 1, the X2000 has been making a daily Metroliner round trip between New York and Washington. On April 3, the train will commence operation between New Haven and Washington. Amtrak is seeking a waiver to take the train to 135 mph, 10 mph faster than the corridor's speed limit.

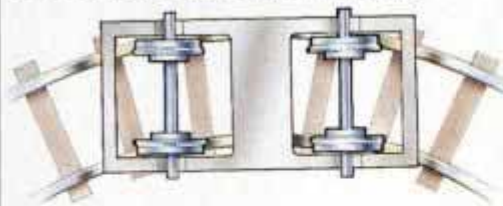
Starting in May, New Englanders can ride the X2000 between New Haven and Boston. Workers won't finish electrifying the track until 1997, so in the meantime Amtrak will haul the X2000 coaches with two RTL turbine-powered locomotives. Because the turbos lack the curve-handling and acceleration of the X2000 locomotive, the train won't show off its full poten-

tial. But passengers can still sample the luxurious interior, with fold-down tables, at-seat audio entertainment and airline-style cart service.

The train's performance, together with rider reaction, will help Amtrak shape specifications for the 26 high-speed trains it wants to replace the Metroliner fleet. ABB Traction, smelling a \$400-million contract, has already offered to build X2000-style trains at its Elmira Heights, New York, plant.

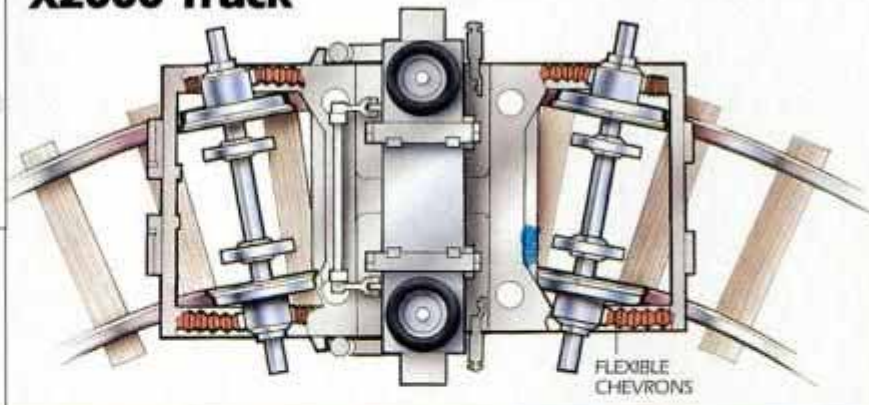
Meanwhile, riders in other parts of the country may not be left out. Transportation officials in Michigan, Illinois, Southern California and the Pacific Northwest have also expressed interest in the X2000. The swinging Swedish train may be just the ticket to revitalize America's 180,000 miles of rail. All aboard! **PM**

Conventional Truck



Flexible suspension system is pivotal to the X2000's unique cornering ability. Unlike trains with conventional trucks, X2000 features rubber-and-steel chevrons that allow axles to move independently of the rigid truck frame. Axle pivoting keeps wheels aligned with curved track, rather than locked to the truck's heading.

X2000 Truck



COMPARISON TEST



TRIMAX

Putting Trimax's innovative hydraulic-cylinder resistance system to a squat test is bodybuilder Rick Valente, host of ESPN's "Bodyshaping" show.

BASIC TRAINING

Quads, abs and pecs pop as TV's top muscle man joins PM to test five multistation home gyms.

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

● Ripped. Chiseled. Rock hard. On-lookers watch as the 2-man PM test team works out and these words just naturally come to mind. We're attacking five of the hottest home gyms on the market. We're pushing reps to the point of failure. We're building muscle mass and filling out tank tops and shorts like triathletes on race day.

Well, at least one of us is. My workout partner and co-tester for this story is Rick Valente, champion bodybuilder and host of ESPN's top-rated fitness show "Bodyshaping." While we're both working out, all the ripping and chiseling is being handled by Rick. My chief contribution is sweat.

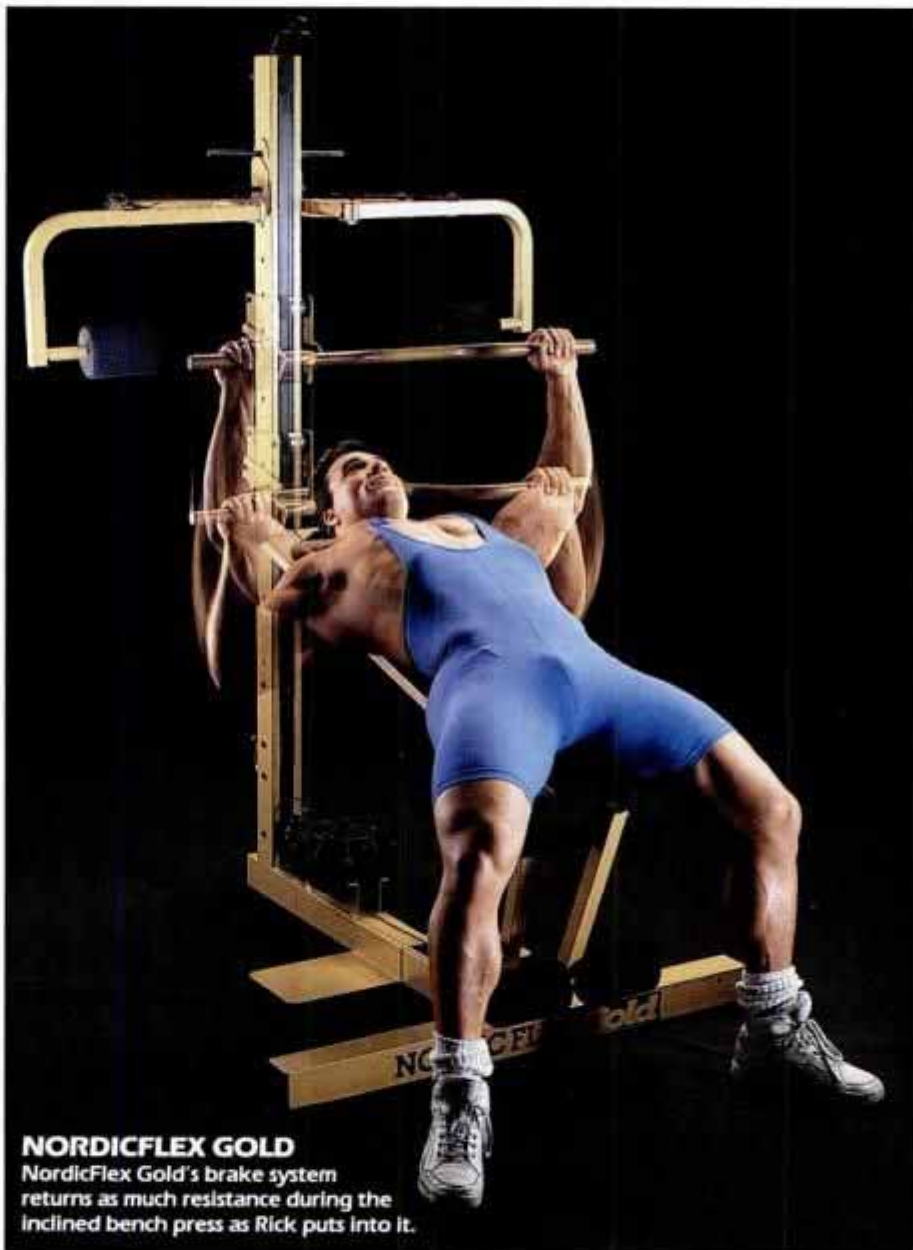
Unlike Rick, who's a lifelong fitness fanatic, I'm a weekend warrior. I go to the local health club and jog a couple of times a week, but I never seem to get truly in shape, at least not by muscle beach standards.

Between us, Rick and I represent opposite ends of the fitness spectrum, which makes us an ideal duo to evaluate home gyms—multistation weight-resistance equipment that's designed by people like Rick, but intended for people like me.

Our basic approach is to answer two primary questions. The first: What can you get if you take your annual health club dues and invest in a home gym? We selected five of the most popular models. Then we moved to the second question: How does each unit exercise the body's major muscle groups—shoulders, back, chest, arms, stomach, butt and legs? To attack each of these areas, Rick and I developed a circuit-training program, and then applied it to each machine over a period of three days.

Lifestyler 50 ERS

Built for Sears by the well-known Pro-Form Co., the Lifestyler 50 ERS



NORDICFLEX GOLD

NordicFlex Gold's brake system returns as much resistance during the inclined bench press as Rick puts into it.

is an entry-level machine that's easy to use. The ERS designation stands for Electronic Resistance System, which is the machine's most distinctive feature. To adjust levels, press a button and the pulley/cable system changes its fulcrum angle. Resistance ranges smoothly from 30 pounds to

250 pounds in 1-pound increments.

Like all test machines, the Lifestyler is a Swiss Army knife of features. Most are standard, but two are unique: 1. a stair stepper, which is powered by gas shocks, and 2. a multi-ab station for dedicated stomach work. Two others are notable by their

BASIC TRAINING

absence—a squat station for the legs and an overhead press station for the shoulders.

Once assembled, which is a time-consuming process, the Lifestyler is ready for circuit training without further modification—a trait it shares only with the Weider Power Stack.

Overall, the Lifestyler has average ergonomics, although several stations have restricted range of motion. One of its strengths, lightweight construction, is also a drawback. The thin frame shakes and rattles during workouts, especially when using the stair stepper. More seriously, the unit carries a strong advisement about positioning a counterweight when using the multi-ab machine.

Despite these drawbacks, the Lifestyler will find favor among weekend warriors, especially those just getting started. Priced at about \$500, it delivers appropriate value for its cost.

NordicFlex Gold

Already noted for its top-of-the-line aerobic machines, NordicTrack has recently expanded into strength training. Its new model is the NordicFlex Gold, a multistation anaerobic unit that features a cable-and-pulley system with a unique centrifugal brake. The beauty of the system is that the harder you work, the more resistance it delivers.

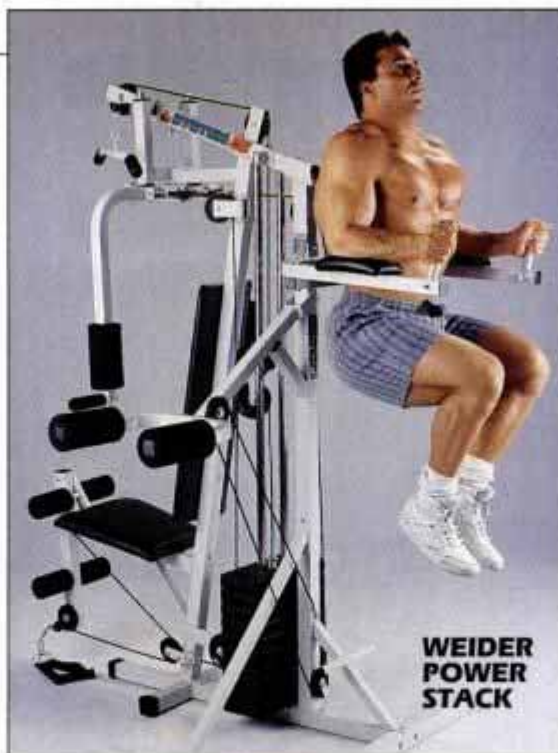
However, the NordicFlex isn't modification-free like the Lifestyler and Weider units. The pulley/cable system requires some adjustment, and a handful of components must go on and off during a typical workout. Adjustments are quick and easy, however, and the payoff is a complete range of stations to perform a full-body workout, unlike the two modification-free models.

Drawbacks are few on the NordicFlex. They include a narrow bench, a head-squeezing butterfly station, a knee-stressing leg station and a squat bar that needs shoulder pads.

With its sturdy construction, ergonomic design, versatile workout capability and midrange sticker price (just under \$1000), the NordicFlex Gold is a good choice for beginner and intermediate-level strength training.

Soloflex

Each of the test units is a mixed bag of strengths and weaknesses, but none more so than the stylish Soloflex. Simple to assemble, Soloflex is complex to use and requires well over an hour to go through a training circuit. Solidly composed of stout parts, the unit has loose connections and everything wobbles and shakes. Versatile enough to handle a full-body workout,



**WEIDER
POWER
STACK**

Unique to the affordable Power Stack is a dedicated station for doing knee raises and dips.

The unit uses a rubber-band weight-resistance system that restricts the full range of movement.

To be fair, Soloflex is the pioneer in home gyms with more than a decade of service. Consequently, a generation of weekend warriors owe their introduction to fitness to the black L-shaped unit. Clearly it's a durable ma-

chine, and many of the original models are still in use. And finally, it offers something only one other test unit (the Weider Power Stack) can match—positive and negative weight resistance.

However, because of its high retail price and surprisingly difficult system of operation, Soloflex is probably best suited for dedicated strength trainers who aren't discouraged easily.

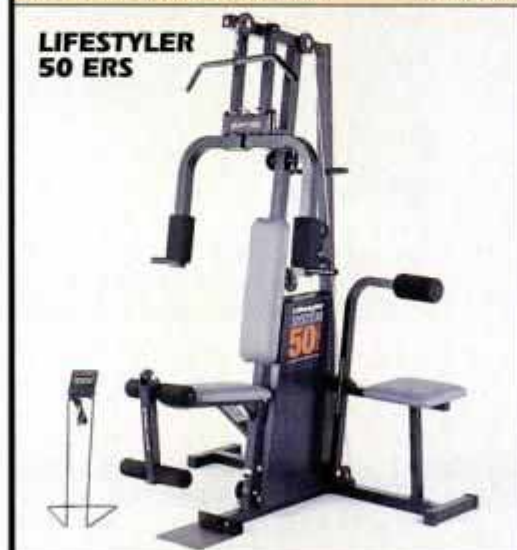
Trimax

Of all the test units, the Trimax is the one that most closely resembles the kind of state-of-the-art equipment generally found in local health clubs. In addition to rock-solid construction and well-conceived ergonomics, the Trimax is notable for an innovative weight-resistance system that uses smoothly articulating hydraulic shocks. Like the NordicFlex Gold, the more effort you put into the Trimax the more resistance it returns.

However, what's unique about the Trimax is its ability to deliver positive resistance during both the up and down parts of the exercise. The result is that two different muscle groups

SPECIFICATIONS AND DIMENSIONS

MANUFACTURER/MODEL/ ADDRESS	PRICE/ DISTRIBUTION	WEIGHT/HEIGHT/ WIDTH/LENGTH	RESISTANCE TYPE	SPECIAL FEATURES
Lifestyler 50 ERS Sears, 3333 Beverly Rd., Hoffman Est., IL 60179	\$499/Mail order, retail outlets	125 lb./62" 24"/77"	Pulley/cable with electronic control	Stair stepper, multi-ab station
NordicFlex Gold 104 Peavey Rd., Chaska, MN 55318	\$999/Mail order, retail outlets	155 lb./79" 49"/68"	Pulley/cable with centrifugal brake	Inclining bench, auto adjusting resistance
Soloflex 570 N.E. 53rd Ave., Hillsboro, OR 97124	\$1500/ Mail order only	235 lb./72" 48"/72"	Weight straps, rubber bands	Stylish frame looks good when not in use
Trimax 20 S. Main St., Janesville, WI 53545	\$1320/ Mail order only	240 lb./68" 48"/84"	Hydraulic cylinders or shocks	Inclining bench, auto adjusting resistance
Weider Power Stack 2677 El Presidio, Carson, CA 90810	\$399/Mail order, retail outlets	250 lb./78" 58"/56"	Pulley/cable with attached weights	Squat and dip/ knee-raise stations



**LIFESTYLER
50 ERS**



**NORDICFLEX
GOLD**

1. Limited-time offer reduces price by \$400. 2. Width of base, not extensions. 3. Units arrive partially assembled.



**LIFESTYLER
50 ERS**

The only aerobic station in the test is the Lifestyler's multispeed stair stepper.

are worked during each set, and overall training time is cut in half.

Other outstanding features on the Trimax include a built-in pulse meter, interval timer, reclining bench and superb overall ergonomics. The only drawback results from its double-positive weight-resistance system, which makes it difficult to isolate a

muscle group for serious body-builders. Those more interested in fitness training than in sculpting will find the Trimax a good long-term value.

Weider Power Stack

It ain't high tech, but there's something appealing about the simplicity of the affordable Power Stack. Like the Lifestyler, once the unit is assembled (an involved process), no further modification is required. You move from station to station quickly and easily.

Resistance is supplied by a pulley-and-weight system that has a maximum resistance of 200 pounds. The main benefit of the system is that it provides negative resistance during the return motion of each exercise. Two other features that set the Power Stack apart are its dedicated squat and dip/vertical

knee-raise stations. One feature notable by its absence is a shoulder-press station.

Ergonomics are about average on the Power Stack, although a few exercises have restricted movement. The unit rattles and shakes during use, but this is a result of its lightweight construction. Overall, the Power



SOLOFLEX

All components come on and off the SoloFlex's simple main frame between exercises.

Stack is the test's best value at around \$400 and a good entry-level unit.

Co-tester Rick Valente points out that there are three components to getting in shape: 1. weight-resistance training, 2. aerobics, and 3. diet. The machines in this test can only help with the first component. Okay, Rick. One down, two to go.

PM

TEST ANALYSIS

ASSEMBLY TIME/EASE (minutes)	WORKOUT TIME/EASE (minutes)	FULL-BODY WORKOUT CAPABILITY	OVERALL ERGONOMICS	CONSTRUCTION/DURABILITY	BEST FEATURES/DRAWBACKS	RATED LEVEL OF USE
90 min./ ⁷ Very involved	40 min./Simple and direct	No squats, no shoulder press	Average, some restricted movement	Very lightweight/Good in short run	Aerobic station/Requires counterweight	Entry to intermediate
40 min./About average difficulty	45 min./Some mechanics involved	Everything you need and more	Comfortable, smooth throughout	Solidly built/Long life expectancy	Auto-adjusting resistance/Squat bar needs pads	Beginners through experts
30 min./Main frame is simple	75 min./Major mechanics involved	Can do it all with effort	Below average, takes getting used to	Stout parts/Reliable over time	Versatility/Requires large blocks of time	Best for those already committed
40 min./Superb instruction kit	25 min./Quick, minimal mechanics	Everything you need and more	Smooth, comfortable, high-tech feel	Sturdy throughout/Built to last	Auto-adjusting resistance/No negative resistance	Beginners through experts
90 min./ ⁷ Very involved	35 min./Practical layout and design	Everything but a shoulder press	Average, some restricted movement	Lightweight frame/Average life expectancy	Full negative resistance/200 lb. max. weight	Entry to intermediate

SOLOFLEX



TRIMAX



**WEIDER
POWER
STACK**



STUNTS

JUMPIN' JIMMY

To prove the strength of its frame, GMC Truck goes bungee jumping.

BY CLIFF GROMER



• Conceived not as a new thrill ride (although you never know), but as an attention-getter for a GMC Truck sport/utility vehicle television commercial, the creative wizards on the Jimmy account at McCann/SAS thought the concept of a truck bungee jumping off a bridge would be a neat way to demonstrate the strength of the Jimmy's frame. Well, yes. After all, hanging a stock Jimmy sport/utility from its tow hitch has got to prove something—even if it means peace of mind, knowing your vehicle won't break in two hauling your bass boat to your favorite fishing spot.

How did they do that?

Of course, the first step in flinging a sport/ute into empty space and letting it dangle from its tail hook, is that you need some place to fling it from. A bridge is the logical choice, but the folks who own bridges usually don't line up for the chance of having vehicles driven off them, let alone placing untold and potentially dam-

aging peak stresses on the structure. Local government officials also aren't anxious about the prospect of their bridge being tied up for days with resulting traffic snarls. Fuming motorists don't take kindly to being informed that the delays are being caused by a film crew shooting a stunt for a television commercial.

So right off the bat, the folks at McCann/SAS had their problems. Looking for the strongest bridge they could find, the production company for the commercial settled

on the New River Gorge Bridge, located just outside of Beckley, West Virginia. With the longest steel arch span found in the

continental U.S., the New River Gorge Bridge is 3030 ft. long, stands 876 ft. high and measures 90 ft. from the roadway down to the top of the arch.

The 4-lane bridge is a main thoroughfare in the area, and the project would require closing down one lane of the bridge for about four days.

It took some quick and smooth talking on the part of the production company, plus some financial consideration, in order to get the wheels turning. The red tape involved was almost as monumental as the New River Gorge Bridge itself. The big problem was that nobody really knew

how much peak stress would be created by a high-diving, 3500-pound Jimmy, and how much stress the bridge could withstand. Obviously, no one would be pleased if the Jimmy, in this dramatic demonstration of towing strength, towed part of the New River Gorge Bridge down into the gorge below.

In order to demonstrate that the bridge would not be compromised by these frame fortitude frolics, the production team brought together GMC Truck engineers, West Virginia State Department officials, New Gorge River Bridge designers and architects and some high-strung individuals from Bungee Adventures—the bungee cord builders—to come up with a computer model that would answer the big questions. Everything was figured into the equation, including the Jimmy's center of gravity which would have an effect on how it would fall and also its coefficient of drag (Cd). Concern that adverse winds might blow the Jimmy back into the bridge before it cleared the arch called for designing an extra-long launching platform to push the vehicle farther away from the bridge.

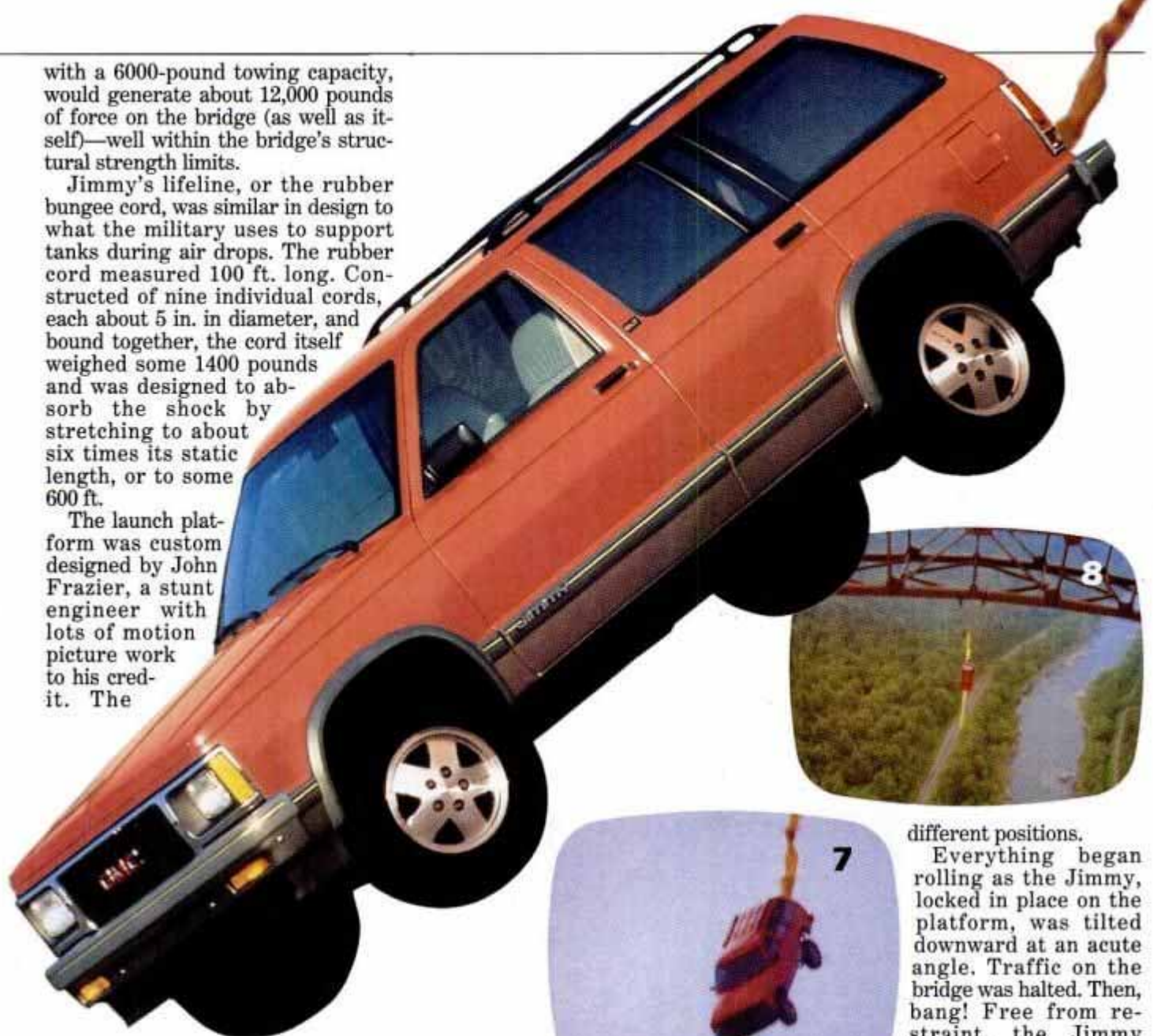
The computer model figured that the Jimmy,



with a 6000-pound towing capacity, would generate about 12,000 pounds of force on the bridge (as well as itself)—well within the bridge's structural strength limits.

Jimmy's lifeline, or the rubber bungee cord, was similar in design to what the military uses to support tanks during air drops. The rubber cord measured 100 ft. long. Constructed of nine individual cords, each about 5 in. in diameter, and bound together, the cord itself weighed some 1400 pounds and was designed to absorb the shock by stretching to about six times its static length, or to some 600 ft.

The launch platform was custom designed by John Frazier, a stunt engineer with lots of motion picture work to his credit. The



platform would be attached to the bridge, the Jimmy would be hoisted onto the platform by a crane and held fast in position by a hook and an exploding bolt. The bungee cord would be attached to a 1/2-in. hardened steel pin, which in turn would be attached to the factory receiver hitch. A hydraulic



would then take over. The computer seemed to think so, but you never really know when bungee jumping a Jimmy.

With the ink still wet on the permission papers, the production company took over one lane on the bridge and began getting into position. A totally stock Jimmy was brought in right off a dealership's lot in Rochester Hills, Michigan. Cameras were set up to record the event from seven

different positions.

Everything began rolling as the Jimmy, locked in place on the platform, was tilted downward at an acute angle. Traffic on the bridge was halted. Then, bang! Free from restraint, the Jimmy plunged down the platform and into nothingness.

Free-falling clear of the bridge, it yanked the bungee cord to its limit. The cord, Jimmy and bridge all held. Stretching to its ultimate length, the cord rebounded and bounced the Jimmy a couple of hundred feet up in the air, then earthward once again.

Now the problem was one of retrieving the Jimmy. A team was lowered from the bridge in a basket to attach a separate cable which was connected to a separate crane, and the Jimmy was reeled in like a fish.

With enough film footage on how the commercial was made along with great sequences from inside the vehicle as well as various angles to put together a short feature film, most of the good stuff ended up on the cutting room floor as it all had to be boiled down to 30- and 90-second spots. Even so, the ad boys will have to go to greater heights and lengths to outdo the jumpin' Jimmy act. **PM**

*“I spend a lot of time
comfortable. Even though my*



*Ask your Ford dealer about the 1993 model F-Series Preferred Care Program.
“Best-selling” claim based on sales by Division. Buckle up—together we can save lives.*

***in a truck, so it has to be
Ford pickup's built to stand up to***

***almost anything, it's a
pleasure to be in. My wife
likes
the
seats***

**Ford Trucks.
The Best Never Rest.™**

***and touches like the
coffee cup holder. She
also likes the fact we
can take the kids along.
Times have changed.
And the Ford full-size
pickup's changed right
along with them."***



THE BEST-SELLING AMERICAN TRUCKS
ARE BUILT FORD TOUGH.

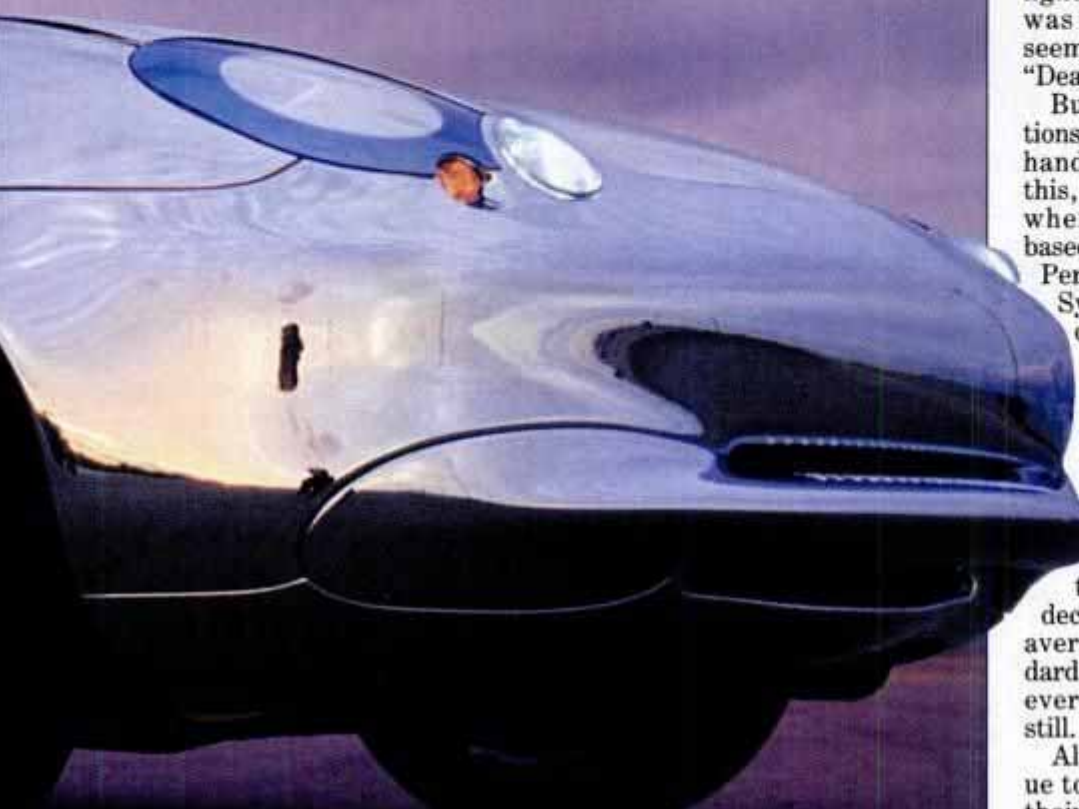




LIGHTS

We drive Synthesis 2010—Ford's 2-stroke answer for tomorrow's tough fuel-economy standards.





PEED

BY TONY SWAN, Automotive Editor; PM Photos by George Olson



Fabricated almost entirely of aluminum, Synthesis 2010 (top) weighs in at just 2050 pounds. Instrumentation (far left) looks mildly futuristic in daylight, with a CRT data screen concealed by new polymeric material. At night, the panel's lighting (center) lends a pastel glow to the interior. The neon rear-lighting array (left) is likely to find its way into production as early as 1994.

● When we first saw this new Ford concept car, it was hard to tell just what the concept was. With less than two weeks left before we were scheduled to drive the car at Firebird International Raceway, in Phoenix, Arizona, the car looked like one of those dismembered hulks you see sitting around in lower Manhattan. No doors, no interior, no wheels, no lights, wiring in disarray—if there was a concept to be discerned, it seemed to be an aftermath car from “Death Race 2000.”

But the guys at Milford Fabrications, a Michigan shop that regularly handles hurry-up projects such as this, had matters well in hand. And when we arrived at the Phoenix-based Bob Bondurant School of High Performance Driving, there was the Synthesis 2010, ready to roll and demonstrate its concept—meeting the divergent challenges of the next century.

Aluminum intensive

Safety considerations having to do with improved crashworthiness have conspired to add weight to most production automobiles over the past decade. At the same time, corporate average fuel economy (CAFE) standards have also become tougher, with every prospect of becoming tougher still.

Although all manufacturers continue to improve the fuel efficiency of their powertrains, the only real answer to the CAFE question is dramatic decreases in vehicle curb weights. As a result, Synthesis 2010 is fabricated almost entirely of aluminum—chassis, skin, door beams, even the ventilated rotors of its 4-wheel disc brakes. It also sports extruded-magnesium lower control arms at the rear of its strut suspension system and 18-in. cast-magnesium wheels.

Based loosely on a standard Taurus body shell, with an Orbital 2-stroke engine under the sloping hood, the Synthesis concept car weighs in at just 2050 pounds ready to go. A standard Taurus, by contrast, weighs a minimum of 3085 pounds. Ford's objective was to produce a family-size car capable of real-world fuel efficiency in the 50- to 60-mpg range.

Disco tech

As you'd expect of any concept car today, the Synthesis 2010 also has its fair share of gee-whiz gadgetry. This includes items that are becoming fairly standard fare, such as keyless entry (with no door handles), an on-board navigation system, a mini-CD

LIGHT SPEED



Orbital 1.2-liter 3-cylinder 80-hp 2-stroke engine sends power to the front wheels.

player, a hands-free voice-activated cellular telephone with voice recognition capability and a solar-powered ventilation system that purges hot air from the interior when the car is sitting in the sun.

The lighting system looks a little farther over the horizon. The headlamps are high-intensity discharge units, providing light by a gas discharge arc—a system that produces four times the illumination of conventional lamps with a 40% reduction in power draw, while taking up less space. The backup lights are operated by a remote light source system—a single bulb in the trunk that sends illumination to the twin lenses at the rear by fiberoptic cables. We particularly love the taillights, brake lights and turn signals, which emit their cheery glow by neon discharge.

Another interesting feature of the dash, head and taillamps is their Polymeric Reflective Material (PRM) cov-

ering. With the lights out, the PRM covers blend in with the aluminum bodywork, like a one-way mirror.

Orbital power

Use of the Orbital 2-stroke engine was very much in keeping with the futuristic character of the car. Although Ford is currently road-testing this engine in a fleet of European Fiestas, the company admits it will be some time before the 2-stroke is practical for production, owing to problems with emissions compliance over the long haul.

Bolted to a 5-speed manual transaxle, the Orbital engine in the Synthesis 2010 concept car is an oversquare 1.3-liter Triple with a bore of 84mm and a stroke of 72mm. Both the block and head are aluminum, with Nikasil-plated cylinder bores. The compression ratio is 10.5:1, and the cylinders are fed by direct injection—there are no intake valves.

Output is modest—80 hp at 5000 rpm, 91 ft.-lb. of torque at 3600 rpm—but adequate, thanks to the car's low curb weight.

Synthesis in motion

Although the Synthesis 2010 was designed to be a rolling testbed for the various systems and materials employed—something that can't be said of most concept cars—it had the fragile feel we've experienced in other hand-built cars. Accordingly, we were cautious when we put the car through its sedate paces on the Bondurant track—no hard cornering, no hard braking and not too many calls to Europe on the voice-activated phone.

Two major impressions emerged. First, there is more work to be done on the Orbital engine in the area of noise and vibration. The little 2-stroke Triple sounds and acts a lot like a diesel, particularly at idle.

Second, and more positive, reduced weight makes the most of even limited power, without compromising the feeling of size and security that goes with a midsize sedan.

A sub-impression, which emerged when the sun went down, is that we were very much taken with the car's pastel-dominated Miami Vice interior lighting. This, along with the shape and overall design, evolved under the direction of Mark Conforzi of the Ford Design Staff.

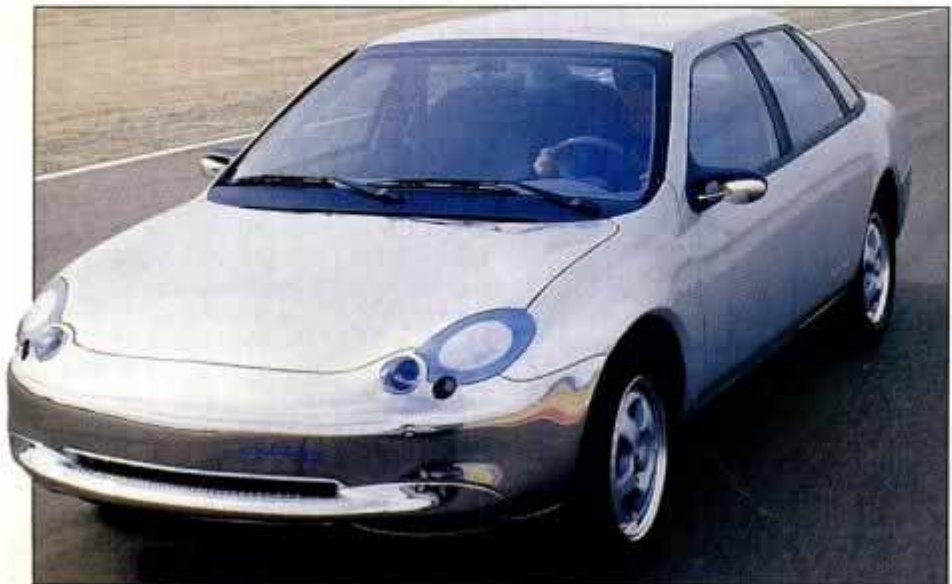
Future Fords

So what Synthesis 2010 elements, if any, are we likely to see on or in Ford cars in the near future? The 2-stroke engine is some way off. Ford doesn't expect to have it in production before the end of the century, and even then it's likely to be limited only to small displacements.

Similarly, we're probably not going to see mass-produced all-aluminum cars from Ford or anyone else anytime soon. Even though Ford learned a great deal about aluminum manufacturability through this project, steel continues to be much cheaper.

On the other hand, you can look for an expanding use of aluminum in future Ford cars. Already a leader in aluminum use, Ford likes its recyclability—Synthesis 2010 is 98% recyclable—and its inherent corrosion resistance. On the immediate horizon is the next generation of Ford's Taurus and Mercury Sable, which will have aluminum fenders and trim.

As for some of the other items on the car's exotic feature list, neon lighting isn't as far off as you might think. We expect to see it on some production cars when we preview Ford's 1994 offerings this summer. **PM**



Even with modest power, lightweight Synthesis 2010 provides adequate performance.



HOME IMPROVEMENT

CERAMIC TILE MAINTENANCE

A few simple steps today can keep your ceramic tile looking great tomorrow.

TEXT AND PHOTOS BY MERLE HENKENIUS

● Ceramic tile is an attractive and durable material that is especially popular above bathtubs and inside showers. It's so popular, that alternative surface materials are often offered in

styles that imitate the classic look of the real thing. However, tile isn't maintenance-free. When problems arise, you'll have two simple choices. You can fix them right away, for a few

dollars, or you can fix them later, for hundreds more. Once water penetrates the tile grout, wall damage can be extensive. Luckily, tile maintenance is easy and inexpensive—usually less than \$20—and requires only basic household tools.

Tile problems almost always begin with damaged grout joints, and for one of two reasons. In today's housing market, installers need to move through a job quickly. The problem is that tile work resists speed with two obstacles. The first is that tile mastic cures too slowly, the second is that tile grout cures too quickly.

The mastic used to glue tile to walls will set in a day, but takes days longer

to cure. If the spaces between the tiles are grouted too soon, the gases that must escape as the mastic cures create pinholes in the grout that allow water to penetrate behind the tile.

As for curing the grout, the best approach is a wet cure, where the normal drying rate is prolonged. When cured properly, the grout becomes hard and water resistant. If allowed to dry too quickly, the grout will have a soft, chalky surface that absorbs water. As water is absorbed, the grout swells, fractures and falls away. In either case, water reaches the drywall behind the tiles and destroys it.

Assessing the damage

How do you know when your ceramic tiles need help? To begin, look for discoloration in the grout. Dark spots in grout suggest that water is penetrating it, either because of pinhole openings or because the grout is loose.

As water penetrates these gaps, mold grows in them, holding more water and further weakening the grout in those areas. Where water mineral levels are high, the dark spots will be surrounded by lighter, yellow-orange discolorations. Of course, if small strips of grout have already fallen out, you'll have little time to waste. You should also closely examine the caulked seams in the corners and where tiles meet the tub. Where you find spots of dark discoloration or cracks, a repair is in order.

Preparing The Tile

The first step in bringing tiled walls up to standards is to remove any loose or degraded grout. Grout removal tools are available, but a simple carpet knife will do the job just fine. Force the blade into the problem area and dig out the grout a few inches on either side of the discoloration (Photo 1). If grout has already fallen, extend the openings to make sure no loose grout remains.

If the caulk joints around the tub and in the corners are discolored or cracked, the best approach is to remove it all with a sharp knife or razor-type scraper. Simply cut along each edge of the caulk seam. This will loosen the caulk so that you can pull it away in strips (Photo 2).

With the damaged caulk and grout

removed, clean the entire surface thoroughly so that the new grout, caulk and sealer can adhere properly. Any of the tub-and-tile cleaners on the market will work. If you prefer a home remedy, try a formulation consisting of ½ cup of household ammonia, ½ cup of white vinegar and ¼ cup of baking soda.

Scrub the tile with the cleaning mixture and rinse it lightly with water (Photo 3). If a few grout stains persist, scrub those areas vigorously with a toothbrush, using either your tile cleanser or diluted household bleach (Photo 4). Do not allow bleach to come into contact with any cleanser containing ammonia. When the entire surface is scrubbed clean, allow it to dry and wipe away any cleanser residue with a dry cloth (Photo 5).



1 Use a carpet knife or grout-removal tool to clear loose grout. Remove grout a few inches to either side of affected area.



2 Use a razor-type scraper or sharp knife to cut away damaged caulk from around the tub. Then, clean the joints thoroughly.



3 Use a tub-and-tile cleaner or homemade solution to remove soap scum, mildew or hard-water stains from tile.



4 Stubborn stains can be removed with a toothbrush. Use a tile cleanser or ordinary household bleach diluted with water.



5 Rinse the cleaning solution with clean water and allow the surface to dry. Then, buff away the residue with a soft cloth.

Replacing Damaged Grout

Grout comes in a variety of forms, from small premixed tubes that handle patching jobs, to dry powder grout for bigger projects. While the small premixed packages have the appeal of simplicity, they are not always the best choice. Often they're difficult to match perfectly with an existing

grout color, even when that color is white.

Dry grouts, on the other hand, are easy to mix in volume and can be used with an additive that retards drying. They can also be colored fairly precisely to match existing colors or to create new ones.

If you choose a dry mix, buy 1 to 3 pounds and make sure to get the dry-

ing-retarder additive as well. This is not the place to skimp on materials, and the additive will help assure a stronger grout. Begin by pouring about 2 cups of grout into a small bucket. Make sure the bucket is clean for best results. Follow by pouring a small amount of additive into the grout and mixing with a paint-stirring stick. You'll need to experiment, but

the end product should have the consistency of toothpaste (Photo 6).

Use a rubber float to spread the grout over the tiles (Photo 7). Sweep the float in several directions to make sure the grout is forced deep into the joints. Finally, use the float as a squeegee to skim as much of the excess from the tile as possible.

Follow by wiping the remaining grout from the tile with a damp cloth, regularly rinsing the cloth with water until the surface is relatively clean. Finally, wrap the cloth around a finger and smooth the joints individually (Photo 8). With this much done, let the grout set for 15 minutes, or until the residue on the tiles turns to a powdery white. Then buff the entire surface with a soft, dry cloth until it's completely clean.

With the use of the drying-retarder additive in the grout, the drying time will be substantially extended, so a wet cure is not absolutely necessary. Even so, the longer the drying time, the stronger the cure. If you choose to wet cure the grout, tape a sheet of plastic to the walls so it hangs over the tiles in a way that allows you to easily reach inside. Then, use a spray bottle filled with water to mist the tiles several times a day for a day or two to slow down the drying process and achieve a stronger grout (Photo 9).

Caulk And Sealant

You'll have two types of caulk to choose from—either silicone caulk or latex tub-and-tile caulk. While the latex variety is much easier to use, it has far less elasticity than silicone. And as caulk needs to absorb the natural flexing of the floor and walls, silicone is the better choice.

Silicone caulk can be a mess when you don't know what you're doing, but is really very manageable when you do. Here are the two basic guidelines:



10 Apply silicone caulk to the seam between tub and tile using even pressure and only enough caulk to fill the gap.



6 Mix powdered grout and a drying-retarder additive to the consistency of toothpaste. Use a clean container.



8 Wipe away the excess grout with a damp rag. Then use the rag and your finger to smooth each joint individually.



7 Use a rubber float to apply grout. Force grout into the joints between the tiles and then squeegee away the excess.



9 To slow drying by wet curing, drape plastic sheeting over tiles and coat the tiles with a mist of water several times a day.

Don't apply more than is absolutely needed to fill the joint, and don't apply more than you can smooth out before it gets tacky (usually no more than a 2- to 3-ft. bead).

Cut the smallest possible opening in the applicator tip and run the tube tip along the seam in an even, angled path while applying uniform pressure to the gun handle. Remember, apply no more caulk in the seam than is absolutely needed (Photo 10).

To smooth the caulk, draw a finger



11 Smooth the caulk so it blends with the surfaces. Periodically wet your finger with soapy water to keep caulk from dragging.

lightly along the bead so that the caulk is arched against the opposing angles of the walls at roughly 45°. A light touch is important here—don't press so hard that some of the caulk is forced to the sides of your finger. Keep a bowl of warm, soapy water (water with a little dishwashing liquid) nearby. If the caulk begins to get tacky, dip your finger into the bowl regularly to keep things flowing smoothly (Photo 11).

You'll need to apply a bead of caulk



12 Apply a thin bead of caulk between the tub spout and tiled wall. Then, wipe away excess with a facial tissue.



13 Sparingly apply a bead of silicone caulk around the faucet trim plate to keep water from traveling behind the wall.



14 Use a facial tissue to wipe all but a narrow bead of caulk from the trim-plate seam, so that caulk will be nearly invisible.



15 After the silicone caulk has cured, seal each grout joint with clear silicone sealer and follow by buffing with a soft, dry cloth.

all around the tub at the joint where the tub meets the wall. In addition, caulk the two vertical corner seams, and, if needed, the seam between the tub and floor. For an important bit of added protection, you'll also want to caulk the top half of the tub spout and the faucet trim plate.

The spout and trim will require a slightly different approach, as you'll want the bead to be all but invisible.

Apply a thin bead in the joint between the tile and fixture pieces (Photos 12 and 13). Then use a tissue to wipe away most of it (Photo 14). The goal is for the remaining caulk to form a bead less than $\frac{1}{16}$ in. wide that just seals the gap between the trim and tile. Keep wiping until all that is left on the surrounding tile is a slight film. Buff away this film after the silicone caulk has fully dried.

When the caulk has cured (36 to 72 hours depending on the brand), seal the grout with clear silicone sealer (Photo 15). This is an important step that takes only a few minutes. After all of the seams have been sealed, wipe the entire surface with a soft cloth. For long-term protection, you may wish to apply another coat of sealer the next time you clean your tiles, and periodically thereafter. **PM**

PRODUCT REVIEW

3M ADHESIVES

● 3M has supplied a wide range of adhesives to industry for years, but has offered only a small sampling to the consumer market. Now when you go shopping at your hardware store or home center, however, you'll find a new and varied line of 3M products.

The new offerings are aimed at a range of needs, including household and furniture repair and workshop and craft projects.

First is 3M's Super Strength Adhesive for clamp-free use on most household materials. Next, there's a Water-Resistant Adhesive that bonds fiberglass, fabrics and most woods, and 3M's Wood Glue provides a strong bond on wood and wood products.

A new Heavy-Duty Attachment Adhesive is a press-on adhesive for indoors and out, and a Craft & Workshop Spray Adhesive handles light-duty jobs. The line is rounded out with a Metal & Ceramic Adhesive, Super Glue Gel, Plastic & Model Cement and an Adhesive Remover & Surface Cleaner. Contact Consumer Relations, 3M DIY Division, 3M Center, 515-3N-02, St. Paul, MN 55144.

—Rosario Capotosto



Super Strength Adhesive is clamp free. This miter joint needs only a few minutes of hand pressure for a good bond.



Along with a full range of other household adhesives, 3M offers fast-acting Super Glue in a handy gel form.

EQUIPMENT TEST

**TROY-BILT
 CHIPPER/VAC**

TEXT AND PHOTOS BY
 STEVEN WILLSON,
 Home Improvement Editor

● If there ever was much fun in raking up leaves, it probably went out when open fires were banned and the wonderful autumn smell of burning leaves all but disappeared. Now the job is mostly dreaded and made worse by the huge bundles of broken branches that appear every spring and fall.

To help on both fronts, the folks at Troy-Bilt came up with this Chipper/Vac. It's available in a 5-hp self-propelled version—which we tested—that sells for \$1399 and a 4-hp push model that costs \$1099.

While the price tag may be a little daunting, be advised that this machine works very well and its overall fit and finish are exceptional. It offers three ways to collect leaves: a simple vacuum snout (standard equipment) that sucks up leaves as you drive the machine over the lawn, a rake-in tray (optional) that replaces the standard snout so you can rake large piles into the vacuum opening and a vacuum hose (optional) used to remove leaves from around flowerbeds, shrubs and other dense plantings. Our test machine performed all of these tasks very well—even on wet leaves. And the changeover between attachments was quick and easy.

The chipper function is just as easy to use, though the stated 3½-in.-dia. capacity ran contrary to our results. The most the machine would handle successfully—without pushing the branch—was 1½ in. The machine would chip away (somewhat) at 3-in. logs, but would always stall far from completing the job.

Unfortunately, the machine is unbelievably loud, measuring 96 dbA at 10 ft. The manufacturer concedes this point by supplying the buyer with earplugs, which may work for the user, but certainly won't for the neighbors. This one fault turned an otherwise great machine into one that is merely good.

For more information, contact Garden Way Inc., 102nd St. and Ninth Ave., Troy, NY 12180. **PM**



Rake-in tray attachment replaces standard vacuum snout for handling large piles of leaves. Just rake leaves onto tray.



Large-capacity chipper has protective gate to keep hands clear of chute. When not in use, gate folds down over chute.



Vacuum-hose attachment is 10 ft. long and designed primarily for cleaning between shrubs and other dense plantings.



Sturdy 3½-bushel collection bag has heavy-duty zipper along its bottom edge that makes emptying contents a breeze.



DAY 1. Project starts with 2-acre, pie-shaped, downward-sloping lot. White perk test pipes help determine septic location.



DAY 5. Lot is cleared and excavation begins. Rock ledge is reached 5 ft. down. Fill is brought in to soften slope angle.



DAY 13. Forms are erected for concrete foundation. Crushed stone provides drainage under slab to help keep basement dry.

HOME IMPROVEMENT

BUILDING BLOCKS

Construction highlights of a luxury manufactured home.

TEXT AND PHOTOS BY CLIFF GROMER

● The "instant house." No, we're not there yet, but modular manufactured housing is pointing the way. Trucked to the building site in box-like building blocks, the modular units are hoisted into position by crane, and the house takes its final form much more quickly than traditional stick-built construction. Because the modular units come manufactured with plumbing and electrical wiring already enclosed in the walls—which usually are

sheathed on both sides—a big plus with modularity is superior weather protection during construction.

Don't stereotype modular housing as cheesy, characterless, boxy econoshelters. These units run the gamut up to \$750,000 luxury homes with custom features, and blend right into the landscape up on "Snob Hill." Compared to conventional on-site frame construction, modularity can be less expensive due to controlled manufactur-

ing techniques and economies of scale. High quality also is possible for the same reasons.

Of course, there are no savings "coming out of the ground." Site preparation, septic, well and utilities are the same as with conventional construction, and foundation work must be even more exacting. There is no room for error here with a modular home. You can fudge a bit when constructing a stick-built home to adjust for an out-of-spec foundation.

To give you an idea of what you can expect when going modular, we followed the construction of this 4500-sq.-ft., 10-room, \$739,000 luxury home in Wilton, Connecticut. This house was custom designed by the contractor, R&R Lindentree Assoc., in Wilton, along with engineers from the builder, Avis Homes, in Avis,



DAY 14. Concrete pouring is completed. Accuracy to elevation and square is maintained to within $\frac{1}{16}$ in.



DAY 18. Foundation is stripped and garage is framed for accurate elevation. At this point, house is being built at the factory.



DAY 25. Garage framing is completed. Entire rear portion of house features stick-built construction for full walk-out basement.



DAY 30. Modular boxes begin arriving by truck. Average box weighs 32,000 pounds. This unit is the first-floor front entry.



DAY 30. First-floor rear section is hoisted into position. Steel cross banding and 2 x 4s stiffen boxes during transportation.



DAY 31. All seven boxes are in place. Roof consists of three hinged sections. Lower section, complete with soffit, flips down.



DAY 32. Roof shingles are installed. Dormers come preassembled and are hoisted by crane and installed in precut openings.



DAY 41. Exterior is just about complete except for siding. Front entry features porch and two bumped-out coat closets.



DAY 52. Prestained cedar siding and trim boards are applied. Balance of job includes heating system, flooring and interior work.

Pennsylvania. Once the plans were finalized, Avis used its CAD system to come up with the finished design.

The main structure of the house consists of seven modular boxes, each having an average weight of some 32,000 pounds. The front of the house was anchored to a conventional poured concrete foundation with primary footings seated on rock ledge. The foundation was accurate in height and square to $\frac{1}{16}$ in.

To take full advantage of the downward slope of the lot to the rear, the builder designed a full walk-out basement, so the rear of the house was stick-built on site. The garage, at the left side of the house, also was stick-built because the builder could not be sure of the exact elevation when grading operations were completed. The garage wall height was critical in or-

der to correctly mate with the boxes.

The entire project, from site preparation to completion, took less than three months, compared to an estimated five or six months for stick-built construction. Weather, subcontractor and pilferage problems are some of the main reasons for the longer build time. Then again, some on-site building contractors just work faster.

Once the boxes were hoisted and secured in position on the foundation, the house was sided with prestained cedar clapboard. The roof was made up of three hinged panels, with the top panel flipping up and the bottom panel (complete with soffits) flipping down. The roof was shingled on site, the chimneys and preassembled dormers installed in precut openings and the entrance facade constructed. It's possible, usually with smaller, ranch-

style homes (2-box size) to have the siding (usually vinyl) and the roofing installed at the factory.

While the cost of the actual modular boxes is less than the stick-built counterpart, you have to consider additional costs, such as transporting the modular units to the site and the crane needed to lift and position the boxes.

Things can start adding up if you're building in a fairly inaccessible location and you have to start putting in roads that are adequate for these large haulers. Bear in mind, the meter is running on the highway to the tune of about \$2 per mile per truck. So the farther your building site is located from the modular home factory, the more your home is going to cost.

Shown here are highlights of the key phases of construction and the timetable involved.

PM

TOOL TEST

**WAGNER
FINECOAT
SPRAY
SYSTEM**

TEXT AND PHOTOS BY
ROSARIO CAPOTOSTO,
Contributing Editor

● If you're looking for a quick and easy way to spray paint and other finishes without the waste associated with typical air-driven spray guns, you'll be interested in the Wagner FineCoat Spray System. It utilizes HVLV (high volume, low pressure) spray technology—a system that uses a large volume of air at low pressure to propel the finishes. We tried Wagner's new system and were impressed with its performance.

Typical high-pressure spraying systems produce a very fine finish, but are known for excessive overspray—as much as 75% of the paint or finish never lands on the work at all. Airless systems, on the other hand, deposit a high proportion of paint on the work, but finish quality suffers. HVLV spraying uses air pressure at about 4 psi to reduce overspray waste to as little as 20% while maintaining finish quality. Because typical compressors are designed for pressure rather than volume, Wagner's FineCoat HVLV system is powered by a turbine that moves the air at the appropriate volume and pressure.

The system comes with a flexible 15-ft. air hose that stores in the base of the turbine housing, and a 1-quart spray gun stores neatly in the housing top. The gun has a knob at the back of the handle for adjusting the amount of finish being sprayed, and the air cap at the nozzle can be adjusted for a round, horizontal or vertical spray pattern. A viscosity cup for checking finish consistency and an inflator nozzle for handling air mattresses and similar inflatables are also supplied.

To test the FineCoat system, we sprayed a board set in front of a paper backdrop on which a masking-tape X was applied. We then performed the identical operation with a standard spray gun. When the tape was peeled away, the HVLV sample showed far less overspray. We also tested the unit with stains, varnish and enamel



The Wagner FineCoat Spray System is a complete high-volume, low-pressure spraypainting package designed for use in your home and workshop.

on a variety of surfaces, and good results were obtained with all.

The Wagner FineCoat Spray System is designed to spray stains, shellacs, lacquers, urethanes, varnishes and latex paint that's not too heavy.

It's available at paint and hardware stores and home centers and through the Sears catalog for about \$180. For more information, contact Wagner Spray Tech Corp., 1770 Fernbrook Ln., Minneapolis, MN 55447. **PM**



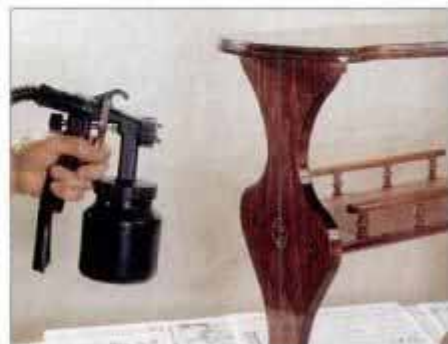
Included is a spray gun, turbine compressor, viscosity cup, inflator nozzle and air hose (shown in turbine base).



Finish flow rate is adjusted by turning a knob behind the handle. Spray pattern is adjusted by turning the air cap at front.



Backdrops behind test pieces show comparative overspray of HVLV system (left) and standard spray gun (right).



FineCoat system is capable of quality furniture finishes and can be used with a variety of finishing products.



SHOP PROJECT

RETURN OF A CLASSIC

A classic ash corner cabinet.

BY NEAL BARRETT

● For many of us, the quest for adequate storage space consumes quite a bit of our energy and time. It seems that our ability to accumulate objects just naturally exceeds our ability to find a proper place to keep them. One particularly nice solution to this problem is the corner cabinet. By combin-

ing areas for both display and enclosed storage, the corner cabinet offers a lot without sacrificing much valuable wall space. And because it's built to fit a corner, the cabinet uses its space efficiently. Another nice feature of this simple ash cabinet is that it complements many design schemes. If you prefer a cabinet that looks a little more contemporary, you can change the scrolled headpiece to something a little more austere.

The project is easy to build even if you don't have an elaborately equipped shop. Although we used full-size shop machines for much of the work, you could use power and hand tools. A circular saw, router, hand plane and an electric drill would do nicely. If you want to reduce the expense of the project, consider using poplar instead of ash. On the other hand, if expense isn't a problem, then you might consider using the more traditional walnut or cherry.

Color photo: J.R. Rost
Black-and-white photos: Neal Barrett
Technical art: Eugene Thompson
Photo stylist: Gabe Henick

Making Case Parts

Begin by ripping slightly overwidth pieces of 3/4-in.-thick ash plywood for the cabinet shelves. Due to the triangular shape of the shelves, you can get the best yield from your materials by nesting the shelf cutouts along the length of the plywood panel. Lay out the shelves, leaving about 1 in. between each.

Next, cut strips for edge banding the exposed shelf edges and glue them to the front edge of the shelves (Photo 1). When the glue has set, plane and sand the edge banding flush to the panel faces, then cut out the rough shape of each shelf.

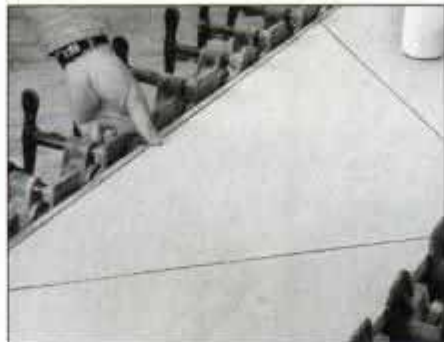
The shelves will be cut to finish size with a template and a flush trimming bit in a router. Make the template from a piece of 1/4-in. hardboard and screw it to the bottom of a shelf (Photo 2). Next, clamp the shelf firmly to the worktable and cut around the template with a flush trimming bit in the router (Photo 3).

Using the table saw, rip the panels for the case sides to rough width. Crosscut the pieces to finished length using a portable circular saw, guided by a straightedge clamped to the workpiece. Tilt the table saw blade to 45° and rip the long edges of the sides to finished dimension. Lay out the position of the shelves on each side, then bore pilot holes for attaching the sides to the shelves. Counterbore these holes on the outside surface of the sides.

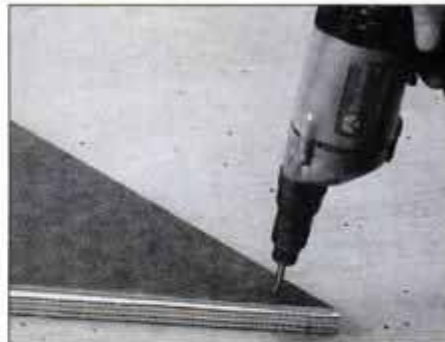
Cut out the parts for the cabinet face frame from 4/4 ash. Note that the face frame is assembled using joining plates, though other methods, such as dowels or mortise-and-tenon construction, will work as well. If you use mortise-and-tenon construction, you'll need to increase the length of the rails to accommodate the tenons.

Lay out the face frame parts on an assembly table and mark the position of the joining plates at each stile-rail joint. Note that the wider rails at the top and bottom of the frame can accommodate two plates per joint. Use the plate joiner to cut the slots in stiles and rails for the plates. Hold the workpiece and plate joiner firmly on the work surface while cutting the slots (Photos 4 and 5).

Apply glue to the joining plate slots and plates, and assemble the face frame. Use bar clamps to bring the joints tight, then compare opposite diagonal measurements to check that the face frame is square (Photo 6). If the frame is out of square, readjust the clamps to bring it into square.



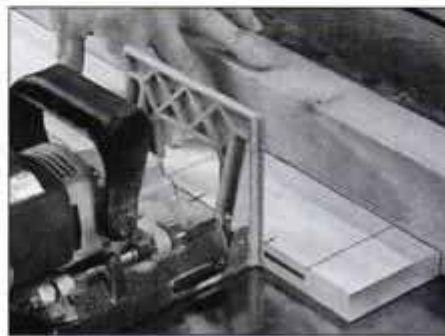
1 Lay out the shelves so they nest along the length of a piece of plywood. Then glue and clamp on the edge band.



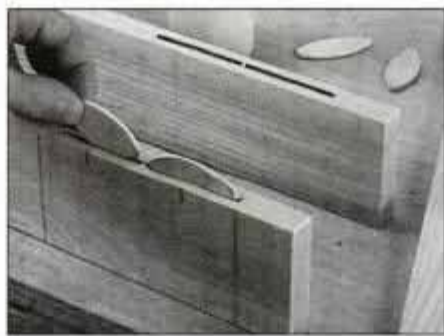
2 Cut out oversize shelf blanks. Make a hardboard template the shape of the shelf and screw it to the blank.



3 Clamp the shelf-blank template to the workbench. Use a flush trimming bit in the router to cut the blank to size.



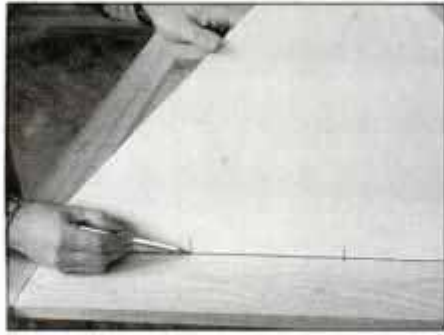
4 Lay out the position of the joining plates on face frame parts. The top and bottom rails have two plates per joint.



5 Spread glue in the plate joint slot. Insert the plates and spread a little glue on the plates, as well.



6 Clamp the face frame parts on a flat surface. Check diagonal measurements to be sure the face frame is square.



7 Mark the location of the joining plates on the face frame and on the top, middle and bottom shelves.



8 Cut joining plate slots on the back of the face frame using a straightedge to guide the plate joiner.

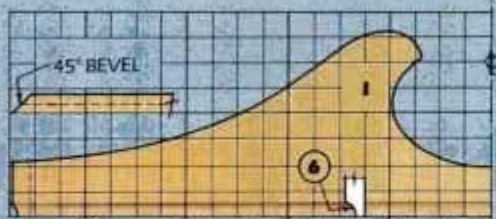
Set the table saw blade to 45° and then rip the long edges of the face frame. The case top, bottom and middle shelf are joined to the face frame with joining plates. Mark the position

of these joining plates on the shelves and the face frame (Photo 7). Cut the required slots with a straightedge clamped to the frame to position the plate joiner (Photo 8).

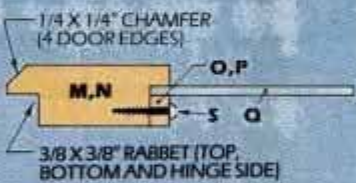
CORNER CABINET

16-1/4" DEEP X 37-3/4" WIDE X
86-3/4" HIGH

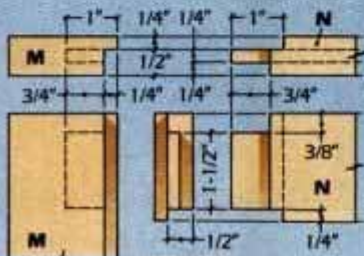
3/16"-DIA. COUNTERSUNK
PILOT HOLE (TYPICAL)



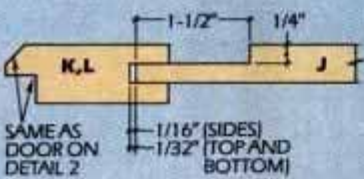
DETAIL 1—HEADPIECE I



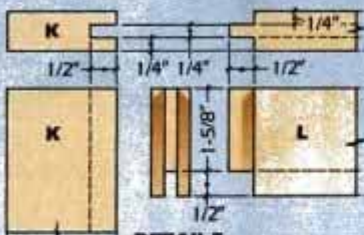
DETAIL 2—UPPER DOOR



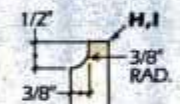
DETAIL 3
MORTISE AND TENON



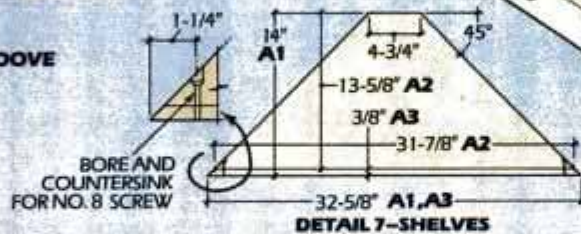
DETAIL 4—LOWER DOOR



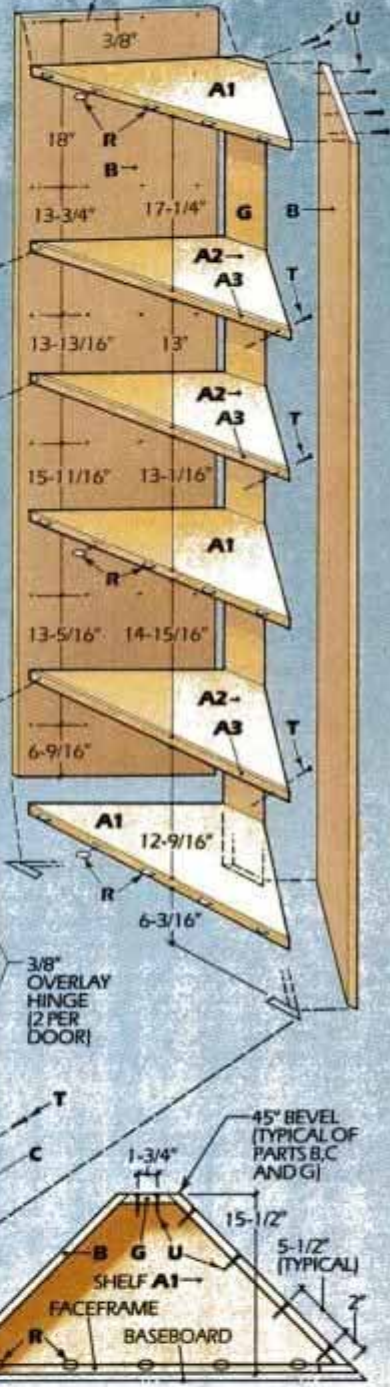
DETAIL 5
TENON AND GROOVE



DETAIL 6—COVE



DETAIL 7—SHELVES



CASE CROSS SECTION

MATERIALS LIST—CORNER CABINET

Key	No.	Size and description (use)
A1	3	3/4 x 14 x 32 3/4" ash plywood (shelf)
A2	3	3/4 x 13 3/4 x 81 1/2" ash plywood (shelf)
A3	3	3/8 x 3/4 x 32 3/4" ash (edge band)
B	2	3/4 x 20 1/2 x 81 1/2" ash plywood (side)
C	2	3/4 x 3 x 81 1/2" ash (stile)
D	1	3/4 x 5 x 30 1/2" ash (top rail)
E	1	3/4 x 3 1/2 x 30 1/2" ash (middle rail)
F	1	3/4 x 5 1/2 x 30 1/2" ash (bottom rail)
G	1	3/4 x 4 1/4 x 75 3/16" ash (back)

H	1	3/4 x 4 x 37 3/4" ash (baseboard)
I	1	3/4 x 7 1/4 x 37 3/4" ash (headpiece)
J	2	1/2 x 12 x 22 15/16" ash (door panel)
K	4	3/4 x 2 1/2 x 26 3/4" ash (lower door stiles)
L	4	3/4 x 2 1/2 x 12 3/4" ash (lower door rail)
M	4	3/4 x 2 1/2 x 41" ash (upper door stile)
N	4	3/4 x 2 1/2 x 13 1/2" ash (upper door rail)
O	4	1/4 x 3/8 x 37 3/4" ash (vertical stops)
P	4	1/4 x 3/8 x 11 1/2" ash (horizontal stops)
Q	2	1/2 x 11 1/2 x 37 3/4" glass (panel)

R	22	joining plates/biscuits
S	32	1/4" No. 4 rh screws
T	11	1 1/4" No. 8 fh screws
U	36	2" No. 8 fh screws

Misc: Tack cloth; McCloskey satin polyurethane; mineral spirits; sandpaper; steel wool; wood glue; four door pulls, Amerlock BP 3467-AE; eight hinges, Amerlock BP 7928-AE (3/4-in. overlay).

Case Assembly

Cut the case back from solid 4/4 ash or 3/4-in. ash plywood, and rip both edges at 45° on the table saw. Lay out the position of each shelf on the case back and use the drill press to bore and counterbore two pilot holes through the back for attaching each shelf.

Cut small triangular blocks from scrap stock and attach them with hot glue along the back edges of the top, bottom and middle shelves to act as clamping ears (Photo 9). These ears make assembly easy. They are attached with just a dot of hot glue and are removed with a chisel after the shelves are joined to the cabinet face. Presand all interior cabinet parts with 120- and 220-grit sandpaper, dust off and wipe with a tack cloth.

Apply glue to the joining plate slots and clamp the top, bottom and middle shelves to the face frame (Photo 10). Check that the shelves are square to the frame and let the glue set. While the glue sets, bore pilot holes through the edges of the remaining three shelves and attach them to the face frame with 1 1/4 in. No. 8 fh screws.

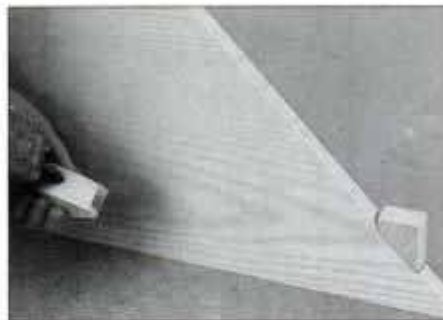
Position the case back and screw it to the backs of the shelves through the previously bored pilot holes (Photo 11). Before driving the screws, remember to check that the shelves are perpendicular to the cabinet face.

Remove the clamping ears from the shelf edges by prying gently under their edge with a sharp chisel. Cut the pieces for the baseboard trim and decorative headpiece to rough length and width. Then, crosscut to finish dimension using the miter gauge on the table saw with the blade tipped to 45°.

Reset the blade to 90°, and rip the baseboard to finished width. Trace the outline of the headpiece on the blank, and cut out the piece on the band saw (Photo 12). Stay on the waste side of the line as you cut. Then, use a drum sander in the drill press to remove the saw marks (Photo 13). If you don't have a drill press, carefully remove the saw marks using files and rasps. Finish by sanding the edge smooth. Use a cove bit in the router table to shape the molding on the bottom edge of the headpiece and the top edge of the baseboard (Photo 14).

Drill and countersink pilot holes through the back of the face frame for attaching the baseboard and headpiece. Attach both pieces using 1 1/4-in. No. 8 fh screws (Photo 15).

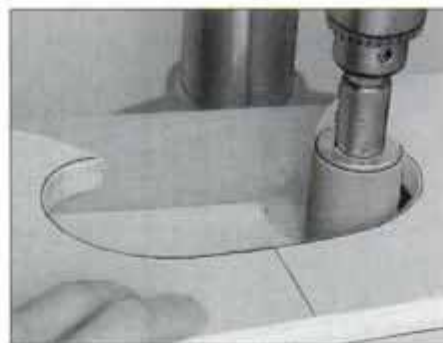
Place one of the case sides in its proper position and attach it with 2-in. No. 8 fh screws. Bore a pilot



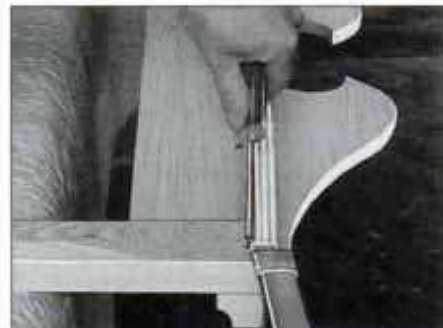
9 Use hot glue to attach small triangular clamping ears to the edges of the top, middle and bottom shelves.



11 Drive screws—through prebored and counterbored holes—from the case back into the back of each shelf.



13 Use a drum sander in the drill press to remove saw marks and refine the profile of the cabinet's headpiece.

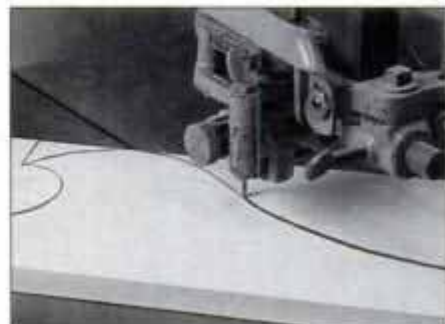


15 Hold the headpiece to the face frame with spring clamps. Bore pilot holes and screw the headpiece in place.

hole for each screw and drive four evenly spaced screws along the length of each shelf (Photo 16). This job is completed quickly with a power



10 Use joining plates and glue to attach the shelves to the face frame. Remove clamping ears later with a chisel.



12 Cut a 45° angle on the ends of the headpiece. Trace the profile on the workpiece and cut it to shape.



14 Use a cove molding bit in a router table to cut the cove on the headpiece and on the baseboard.



16 Bore pilot holes through the case sides, and attach the case sides by screwing them into the shelf edges.

screwdriver tip chucked in an electric drill. Attach the remaining side in the same way. When both sides are attached, stand the case up.

Door Construction

Rip and crosscut the door parts. Cut the mortises in the upper door stiles with a 1/4-in.-dia. straight bit in a plunge router. Clamp some scrap pieces of the same width as the stile next to the stile to serve as a base for the router (Photo 17). Use a sharp chisel to square the mortise ends. You can also bore out the bulk of the mortise on the drill press, then pare its sides and ends flat using a chisel.

Cut the rabbet on the upper door stiles and rails with dado blades in the table saw (Photo 18). Readjust the dado blade height and use the miter gauge in combination with the rip fence to cut the tenons on the upper door rails (Photos 19 and 20). It's safe to use the miter gauge and rip fence together in this operation, where normally it is not. In this case, cutting the tenon does not produce a scrap piece that can get wedged between the miter gauge and the fence.

Readjust the saw fence to cut the tenons on the lower door rails. Change the dado blades to cut the groove in the lower door stiles and rails.

Rip, crosscut and joint the stock for the lower door panels. Glue and clamp together two panels. After the glue has set, scrape and plane the panels smooth. Cut the panels to finished size. Then, using a straight bit in the router table, cut the wide rabbet around each panel.

Next, seal the panels with a coat of finish, thinned 50% with its proper solvent. Let the finish dry, and sand the panels lightly with 220-grit sandpaper before installing them.

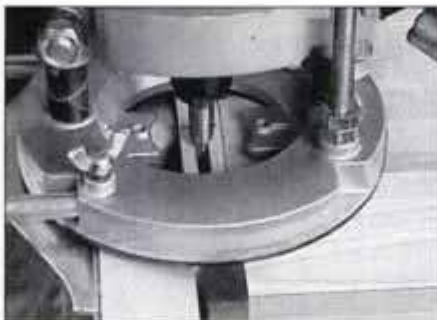
Apply glue to the mortises and tenons on the upper door and clamp the parts. Check the assembly for square and let the glue dry (Photo 21).

Glue and press together three pieces of each lower door, and slide the panel in place (Photo 22). Glue and press the stile in place, then clamp the door until the glue is dry. Cut the rabbet on three sides of each door on the router table.

Use a chamfer bit in the router table to cut the molded edge around the face of each door.

Mount the hinges to the back of each door. Next, clamp a board across the cabinet to support the doors during installation. Bore the pilot holes in the face frame and screw the door hinges in place (Photo 23).

Bore holes for the door pulls, but do not install them. Remove the doors from the cabinet. Fit the glass panels



17 To support the plunge router while cutting a mortise in an upper door stile, clamp scrap next to the stile.



18 Use dado blades in the table saw to cut the rabbet on the inner edges of the upper door stiles and rails.



19 Use the miter gauge and the rip fence to cut tenons on the upper door rails. Make the cheek cuts first.



20 Tip the rails on edge, butt them against the fence and cut the shoulder on each upper door rail tenon.



21 Glue and clamp the upper doors. Check the assembly for square by comparing diagonal measurements.



22 Slide the panel into the stile-rail assembly on a lower door. Then clamp the assembly with the remaining stile.



23 Clamp a straight board to the front of the cabinet to support the doors as you screw their hinges to the face frame.

in the upper doors and cut the stops to hold them. Bore pilot holes for screws, then install the stops to test their fit. Remove the stops and glass, then finish sand the case and doors.

Dust off thoroughly, then wipe the case with a tack cloth before finishing.

Apply a coat of satin polyurethane to the cabinet, thinned 20% with mineral spirits, and let it dry overnight. Then sand the cabinet lightly with 220-grit sandpaper. Dust off the workpiece again and apply the next coat unthinned. Let it dry overnight, sand it lightly with 220-grit paper, and apply the final coat. After it's dry, rub it out with 4/0 steel wool.

Install the glass in the upper doors, and reinstall the hinges and door pulls. Rehang the doors and the cabinet is done. For the neatest fit, remove and miter the baseboard along the walls where you will install the cabinet. Screw through the case sides into a stud to install the cabinet. **PM**

APPLIANCE CLINIC

BY STEVE TOTH,
 Contributing Editor

Ailing Dryer

My Whirlpool gas dryer, model No. LG5791XM, serial No. M50604591, has an ailment that I need help to fix. For five to 10 minutes after startup, the machine squeals and squeaks very loudly. Otherwise, it runs like new. I lubricated the drum drivebelt, the idler wheel and the drum support roller shafts, and I cleaned the rear groove in the drum, all without any improvement.

JOE JUSTIN
 WESTMINSTER, CA

You are on the right track. Set the temperature control to air fluff, then unplug the dryer from its power source.

Next, remove the drivebelt from the motor by pulling the idler pulley back toward the motor and slipping the belt off the motor drive pulley. Slowly release the tension on the idler-pulley assembly. Remove it from the dryer.

Plug the machine back into its power source and test run the dryer. If you get the squealing noise, it's probably coming from the motor bearings, which are factory lubricated and cannot be oiled. If there is no squeal with the belt off, then it's either the idler-pulley assembly, Whirlpool part No. 349241, or the two support rollers, Whirlpool part No. 691366. A pair of rollers costs \$15, and the idler-pulley assembly costs about \$7.

Because of the dryer's age, I suggest you replace all three parts. You should also give the appliance a good vacuuming inside, and check the condition of the belt. This is a good time to replace it if it shows signs of cracking or fraying.

Parts are available from any Whirlpool parts distributor in your area, or they can be ordered directly

from Whirlpool using the tollfree number, (800) 253-1301.

Washer Needs Belt

My 11-year-old Kenmore washing machine, model No. 110.82172110, serial No. C14121286, will be needing a drivebelt in the very near future. Is there an easy way to change it?

BILL VALONE
 FLORENCE, SC

Changing the drivebelt on your Kenmore washer is a fairly difficult re-

Out Of Control

I have a Hoover stainless-steel fry pan, Model 8661, that is in excellent shape except for the temperature control. I have tried for several years to replace the temperature control but with no luck. I have written to the company and the letter was returned stamped: "Out of Business." Can you help?

WILLIAM PRICE
 KINGSPORT, TN

The Hoover Co. is still in business, but stopped making your fry pan about 15 years ago and parts are no longer available. If your temperature control is still in good shape and the end of the control is not broken or burned, you can repair it. Send it to Bashor Appliance Service, 728 E. Main St., Trotwood, OH 45426; (513) 837-1873, with a check or money order for \$22, which includes shipping.

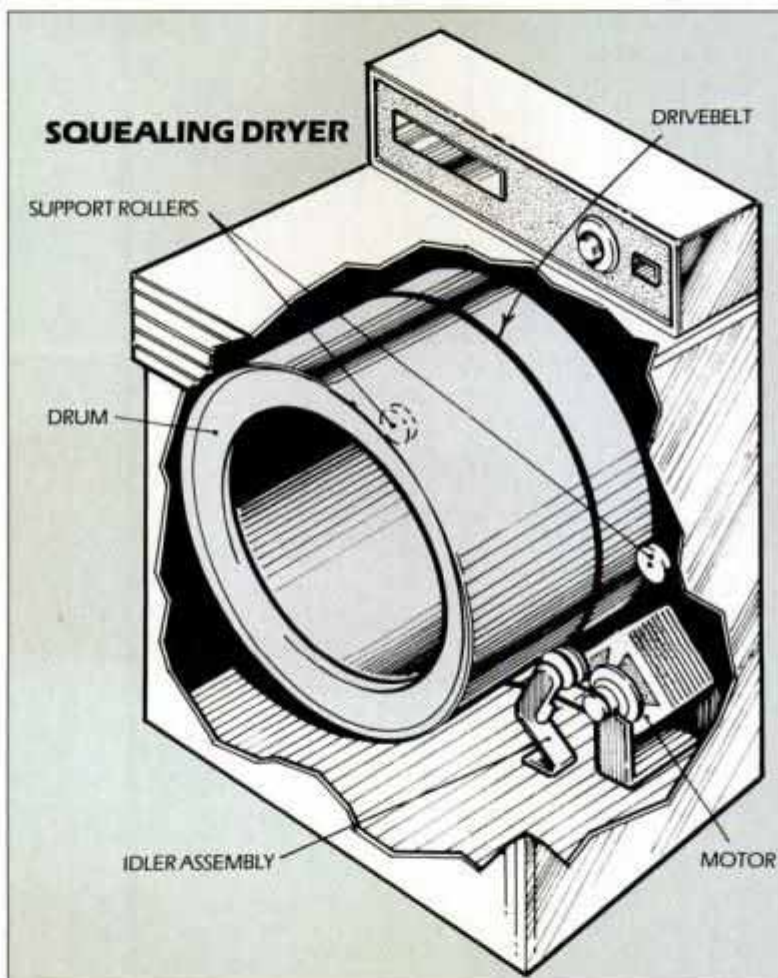
Old Range Needs New Thermostat

I have a Frigidaire Custom Imperial Flair Range, model No. RC1-645K. Parts cannot be found locally and we need thermostats for both the small and large ovens. Is there a source for these parts?

A.P. HENDERSON
 ORMOND BEACH, FL

*Replacement thermostats for your electric range are still available from the Frigidaire Co. These much needed parts can be ordered from any authorized Frigidaire parts distributor. For the name, address and phone number of a parts distributor located near you, call the Frigidaire action line, (800) 451-7007. The right-oven thermostat is part No. 09957108 and the left-oven thermostat is part No. 09957109. They cost about \$120 each, plus shipping. **PM***

DO YOU HAVE AN APPLIANCE PROBLEM?
 Just ask Steve about it. Send your question, along with the model and serial numbers, to Appliance Clinic, Popular Mechanics, 224 West 57th St., New York, NY 10019. While letters cannot be answered individually, problems of general interest will be discussed in the column.



A dryer's squeal may be due to worn-out support rollers, idler pulley or motor bearings. To see if it's the motor bearings, test run the dryer without the belt.

pair. To give you a better idea of what you are up against, stop by your local library and look at PM's article, "How To Replace A Washer Drive Belt," page 62, May '84.

Should you decide to go ahead with the repair, the replacement drivebelt, part No. 95495, will have instructions on the package.

Another source on how to install the belt is the Sears Do-It-Yourself Repair Manual for belt-drive washers, available from any Sears parts center under part No. 787206, Div. 26, source 110, for about \$10.

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NEW PRODUCTS

YARDWORK GEAR

BY ROY BERENDSOHN, Assistant Home Improvement Editor



Fills The Niche

John Deere has introduced two new products designed to help fill the niche between heavy commercial equipment and machines for a homeowner or someone who manages an estate. The Gator is a 6-wheel, 4-wheel-drive utility vehicle powered by an 18-hp liquid-cooled engine. It has a continuously variable transmission and an oil-bath lubricated transaxle. Its 11-cu.-ft. cargo box can carry 800 pounds of cargo. It costs about \$6600. The 14-hp Model 245 is Deere's least-expensive hydrostatic-drive lawn and garden tractor. It comes with a 38-in. or a 48-in. mower deck (\$4800 and \$5000). An optional mulching kit is available for the vehicle. The Gator and the Model 245 are sold at John Deere dealers. For more information, write John Deere, 1400 13th St., East Moline, IL 61244.

Harmonious

Honda's Harmony riding mowers are designed to give you maximum cutting capability at an affordable price. The two mowers in the line are powered by an 11-hp engine and have a 5-speed inline transmission. They have a top speed of about 5 mph. One has an electric start (\$1750), and the other has a recoil start (\$1550). Both have 30-in. cutting widths and adjustable cutting heights of 1 to 3.5 in. They also have plastic bodies and can be switched between bagging (5.7-bushel capacity), side discharge cutting and mulching. An accessory mulching kit is available for the mowers. Both models are sold at Honda Power Equipment Dealers. Write Honda, 4475 River Green Parkway, Duluth, GA 30136.



Electrifying

Simplicity takes a crack at making chipper/shredders nicer to use by introducing the electric 2C. Powered by a 1½-hp motor, the company says it will chip branches up to 1¼ in. in diameter and can reduce 10 bushels of yard debris down to one bushel. The machine weighs only 75 pounds, thanks in part to a plastic hopper and chipper cone. With the optional hose and leaf tray (about \$80), you can mulch leaves by directly vacuuming them up or raking them into the tray opening. The 2C costs about \$400 at Simplicity dealers. For more information, write Simplicity Manufacturing Inc., 500 N. Spring St., P.O. Box 997, Port Washington, WI 53074.

Fresh-Air Edger

The Weed Eater GE21 (\$180) is a gas edger with a difference: Its air intake isn't on the engine, it's on the underside of the T handle—a feature the manufacturer says extends engine life by reducing the amount of dirt that's pulled into the 21-cc, 2-cy-
 cle engine. The 15-pound machine edges to 1- and 2-in. depths, and converts between the two with a flip of a latch. Power is transmitted to the blade via a gear drive. The blade rotates clockwise, reducing bounce, according to Poulan, and leaving the edged trench cleaner. Write Poulan/Weed Eater, P.O. Box 91329, Shreveport, LA 71149.





Take Your Pick

The LawnCycler lawnmower converts quickly between mulching and side discharge cutting to help you adapt to changing cutting conditions. If the grass is tall and wet, flip up the spring-loaded mulching cover and snap on the side-discharge chute. No tools are required to make the conversion. The mower is available in both push and self-propelled models, with



deck diameters ranging from 20 to 22 in. Both side and rear bagging capabilities are also available. All the LawnCycler models are powered by a 5-horsepower 4-cycle engine. They range in price from about \$280 to \$550 at White Outdoor power product dealers. For more information, write White Outdoor Products Co., P.O. Box 361131, Cleveland, OH 44136.

Head On

By introducing the Mulchinator, Ryobi goes head to head with Black & Decker's CM500 in the U.S. cordless mower market. Unlike the B & D mower, the Mulchinator, as its name implies, is a mulching mower. It's powered by a 24-volt battery, and will cut for 60 to 100 minutes when fully charged, depending on mowing conditions (9000 to 35,000 sq. ft. of grass), Ryobi says. The plastic-body mower carries its recharging pack on board and recharges in 16 hours. It costs about \$400 at home centers and lawn and garden stores. For more information, write Ryobi America Corp., 5201 Pearman Dairy Rd., Suite 1, Anderson, SC 29625.



Long Reach

The MAC M1000 is an electric 3-hp pressure washer that comes with such handy features as a 35-ft.-long power cord and a built-in ground-fault circuit interrupter. The tool is powered by a 3-hp motor, and its pump is equipped with impressive-sounding features like ceramic pistons, sealed ball bearings and a stainless-steel valve. McCulloch says it uses 78% less water than a garden hose to accomplish an equivalent amount of cleaning. It costs about \$300 at outdoor power equipment dealers and home centers. Write McCulloch, P.O. Box 11990, Tucson, AZ 85734.



Ambidextrous

Husqvarna's new CRT 35 14-in. tiller has drive engagements on both the left and right handles, so you can walk next to it as you till. It's powered by a 3½-hp Briggs & Stratton engine, and its 12-in.-dia. counterrotating tines can till to 6 in. deep, even in packed soil, its manufacturer says. Its depth adjustment stake has seven positions. To guard against crop damage while using the machine as a cultivator, its tines are equipped with adjustable side plates. The machine costs about \$570 at Husqvarna dealers. For more information, write the company at 9006-J Perimeter Woods Dr., Charlotte, NC 28216.

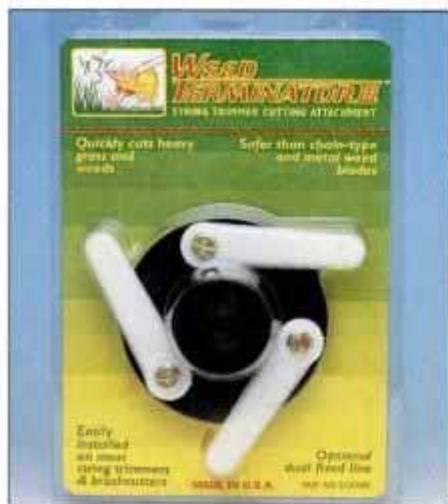
Blast Off

The MudBuster weighs only 12 pounds, but the gas-engine washer blasts off mud with 1000 psi of water pressure. Homelite claims that it delivers 20 times the power of a garden hose, yet uses 83% less water. It has an injector, so you can load it with cleaning chemicals when water alone won't clean sufficiently. To make the washer easy to use, Homelite equipped it with a 12-ft.-long hose, and its engine has a primer bulb which, the company says, allows you to pull-start the engine in just one to three pulls. It costs about \$270 at outdoor power equipment dealers and home centers. Write Homelite, P.O. Box 7047, Charlotte, NC 28241.



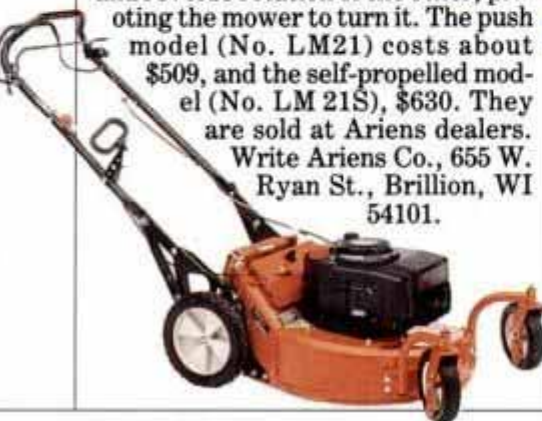
Goodbye Weeds

Homeowners who have to do heavy grass and weed trimming now have an additional choice in how they approach the job. Called the Weed Terminator III, this retrofit head replaces the string head on a gas-powered grass trimmer with a plastic disc and three pivoting plastic blades. It's designed to cut down not only heavy grass and weeds, but light brush too. It costs about \$16 at outdoor power equipment dealers, hardware stores and home centers. A professional model costs about \$18, and a combination string head/plastic blade model costs about \$17. Write The Source, 3400 Bradshaw Rd., Suite C-3, Sacramento, CA 95827.



Spin It Around

Commercial mowers have long had the mobility of front caster wheels. Now Ariens introduces two consumer versions—a push model and a self-propelled model—of this mower type, both with 21-in. decks. The rear bagger mowers store 2¼ bushels of clippings. They can also be converted to side-discharge mowers with a bolt-on chute. Both mowers are powered by a 5-hp Tecumseh engine, and the self-propelled model has a differential that causes forward rotation of one wheel and reverse rotation of the other, pivoting the mower to turn it. The push model (No. LM21) costs about \$509, and the self-propelled model (No. LM 21S), \$630. They are sold at Ariens dealers. Write Ariens Co., 655 W. Ryan St., Brillion, WI 54101.



The Long Haul

Ingersoll equipped its new diesel tractor for the long haul and then covered 44 of its components—from the power takeoff clutch to the cast-iron front axle—with a lifetime warranty. The

machine is powered by a 3-cylinder liquid-cooled diesel engine, and comes with power steering and a hydraulic transmission as standard equipment. A long list of hydraulic accessories also are available for this machine. These include a brush cutter, a snow thrower and a log splitter.

When equipped with a 3-blade, 48-in. hydraulic mower deck, the Ingersoll 3118D costs about \$8600 at Ingersoll dealers. For more information, write Ingersoll Equipment Co. Inc., 122 S. Fourth St., Winnebago, WI 54986.

Clean Sweep

Precision Hedge Corp. says its retrofit device for hedge trimmers can cut trimming time in half. The plastic channel bolts to the blade of your clipper and sweeps the clippings off the hedge as you cut. The consumer model costs about \$10, and the commercial model for gas hedge trimmers, about \$20. They're sold at home centers, outdoor power equipment dealers and (with a shipping charge) from Precision Hedge Corp., 1040 W. Jericho Turnpike, Smithtown, NY 11787.



Filing System

The Quick Sharp guide is designed to make filing a chain saw chain easier and more accurate than filing it free-hand. Use the guide with a round file or a chain saw file to sharpen the cutters. Use a flat file to bring the raker teeth to the correct height. The guide costs about \$6 postpaid. For more information, write Quick-Sharp Inc., 12 Reservoir Rd., Clinton, CT 06413.

Pocket Size

Troy-Bilt introduces its Mini-Tiller, a 23-pound machine powered by a 1.6-hp engine. Add or remove tines without tools to till a path from 6 to 9 in. wide. Its tine speed is controlled with a throttle lever on the handlebar. With optional attachments it aerates, edges and dethatches. It costs about \$320 at Troy-Bilt dealers. For more information, write Troy-Bilt, 102nd St. and Ninth Ave., Troy, NY 12180.



Multifaceted

When attached to a lightweight tiller or cultivator, The Hoffco Garden Seeder Attachment performs the following functions: It furrows the row, plants 30 varieties of seeds (through the rear hopper), fertilizes at rates of 1 pound per 100 ft. and up to 3 pounds per 100 ft. (through the front hopper), mounds over the row and marks the next row. Hoffco says it attaches to most lightweight tiller/cultivators (except Mantis). It costs about \$115 at lawn and garden equipment dealers. For more information, write Hoffco Inc., 358 N.W. F St., Richmond, IN 47374, or call (800) 999-8161. **PM**



HOMEOWNERS CLINIC

BY NORMAN BECKER, P.E., Contributing Editor

Air-Intake Benefit

What are the benefits of having a fresh-air intake on a gas-fired forced-air furnace? I'm especially interested in the health benefits of this feature. We live in a tight house in a very cold region of the country.

MARIANNE PARSONS
CHEBOYGAN, MI

If the house is very tight and there is minimal outside-air infiltration, a fresh-air intake is necessary to ensure that the gas furnace works at peak efficiency. Specifically, a fresh-air intake helps ensure complete combustion of the gas. It also reduces the chance that carbon monoxide from the furnace will reenter the house, a phenomenon in tight houses known as backdrafting.

A fresh-air intake is still a good idea in houses that are not very airtight. In this case, the fresh-air intake conserves energy by ensuring that combustion in the furnace does not rely on the air in the house, which has already been heated.

The cycle works this way: There is generally a negative pressure in a house. When heated air is used in the combustion process, it goes up the chimney as waste gas. This increases the negative pressure since the air in the house is being used to burn the gas. In a house that's not very tight, this causes more cold-air infiltration. This cold air must be heated,

which uses up more energy. An air intake uses unheated air to ensure combustion. Also, the negative pressure in the house does not increase because the air inside the house is not used for combustion.

For most homeowners, health problems resulting from indoor air contaminants are minimal. The typical American house built within the past 30 years has an average infiltration rate of 0.4 to 1 air change per hour. The air exchange rate for the living areas of the house should be 0.35 air change per hour.

However, some of the newer, tighter houses have an air exchange rate of 0.1 air change per hour. Without ventilation, this could result in stagnant indoor air, containing more than the usual amount of pollutants and bacteria. To prevent this, you must increase the amount of ventilation. Consult your local Yellow Pages for heating/cooling and ventilation contractors.

Metal Roof Condensation

I built a porch with a metal roof over it. We closed it in using storm windows, but have not installed heat. In the winter, condensation forms and runs off the inside of the roof. What is the best way to stop the condensation? Will installing plywood and shingles over the metal help? CLAIR DUTTON
JERSEY SHORE, PA

The way to stop the condensation from developing is to prevent the vapor in the porch air from contacting the cold metal roof. Putting plywood and shingles on top of the roof will not help.

Instead, you should put insulation underneath the roof and cover the insulation with a vapor barrier. With this installation, the vapor will not migrate beyond the vapor barrier. Also, because of the insulation, the vapor barrier will have a temperature that is above the dew point. Consequently, condensation will not develop. You can cover the insulation and vapor barrier with drywall or wood panels.

Toilet Tank Cover

I am looking for a replacement toilet tank cover for an American Standard Tank No. F409 in Regency Blue. Our local plumber claims that the cover is no longer available and wants to sell me a complete toilet. Since the color of the new toilet will not match that of the other bathroom fixtures, I am reluctant to buy it. Do you have any suggestions?

V. LUCA
SOUTH DAYTONA, FL

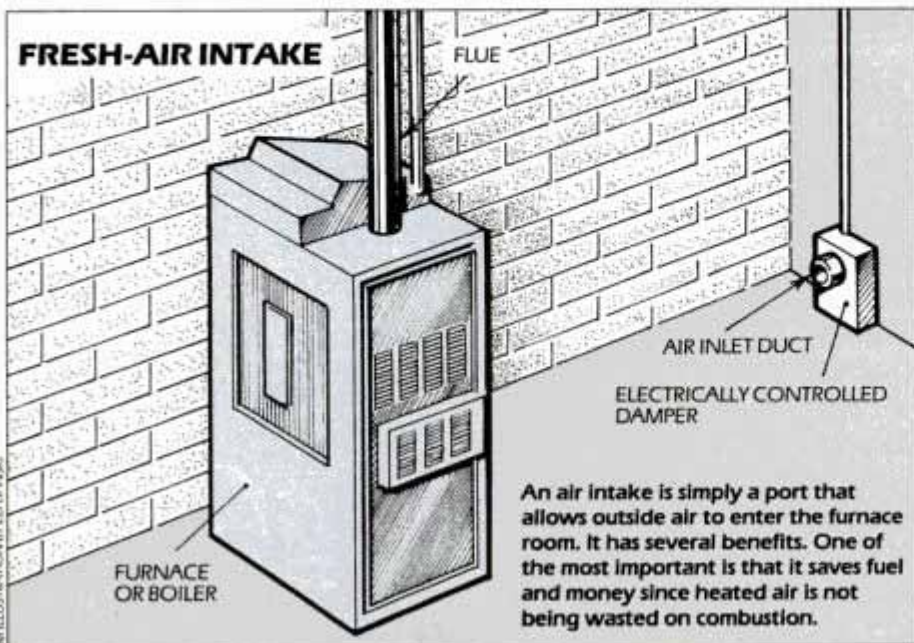
I called the American Standard Co. and inquired about the cover to your toilet tank. Although they no longer manufacture that particular model and color, they apparently still have some covers in stock. They suggest that you contact the American Standard wholesale distributor that covers your area to order the cover. If you don't know who the distributor is in your area, you can check with American Standard at (800) 223-0068. Ask for the Consumer Product Service Dept.

It's important to remember that just because an item is not available locally, and is no longer manufactured, this doesn't mean that the item is not available.

Always be sure to check with the manufacturer before you give up your search. Very often a few items still will be available. The cost of a telephone call may save you the cost of a total replacement. **PM**

DO YOU HAVE A HOME-MAINTENANCE OR REPAIR PROBLEM?

Just ask Norman about it. Send your question to Homeowners Clinic, Popular Mechanics, 224 West 57th St., New York, NY 10019. While letters cannot be answered individually, problems of general interest will be discussed in the column. For more home-repair and maintenance help, get PM's Home Care Guide, \$5.95 postpaid. Send your order(s) to Popular Mechanics, Box 1014, Radio City Station, New York, NY 10101.



looks ahead, inspiring people to learn from America's traditions of ingenuity, resourcefulness and innovation to help shape a better future.

Many letters exhibit visitors have written to PM's editor testify to the inspiration PM provided them in choosing to pursue a technical career. Some, like this one, promise future innovation:

Dear Mr. Oldham,

My father gets your magazine and I even read it sometimes. I'm very interested in the field of aerodynamics and I'm going to go to the Air Force Academy and become a military pilot. I want to get involved in the space program. I'm 13 years old. I loved the exhibit and I want to come back and bring my dad.

AMANDA CROWELL
ROCHESTER HILLS, MI

Perhaps someday Amanda will write back to report on her success, like Ralph Hall did back in 1953. Ralph sent photos taken in Milwaukee back in 1909 of himself and his pals building a glider from PM plans. As he put it, "Since then I have been a passenger in military planes in Europe during World Wars I and II, across the Pacific and all over Japan and Korea during the recent fracas. None of these flights provided the thrill or anticipation of that leap in the POP MECHANICS contraption." Ralph went on to become a lieutenant colonel in the Army, and one of his buddies became a vice president of Briggs & Stratton.

Through letters, feature articles and do-it-yourself instructions, PM has cataloged 90 years of dreams dreamed, experiments tested, ideas tried and lessons learned.

To dream of a better world and find a way to build it—this has been the collective American dream. Henry Haven Windsor, founder and first editor of PM, captured the essence of "Possible Dreams" back in 1924 when he said: "Everyone has inventive ability because every man, woman and child at some time or other has ideas which they put to use to save time, abolish drudgery, or add to their own happiness."

And the words Henry Windsor penned 90 years ago on PM's first birthday still apply today: "It is not our policy to herald the plans and improvements to be carried into execution during the ensuing year. We will only say there are some very pleasant surprises in store for the readers of POPULAR MECHANICS."

Happy Birthday, PM. Only nine more years until you hit 100. **PM**

NEED A POPULAR MECHANICS EDITORIAL INDEX?

SEE PAGE 87.

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 TOYOTA

CAR CARE

CAR CLINIC

BY MIKE ALLEN,
Associate Automotive Editor

Getting The Boot

My regular mechanic says it'll cost only about \$400 to repair a bad boot on my front axle. He wants to take almost the entire front suspension apart, and only about a hundred bucks of that is for labor.

I really don't have that much money for an unnecessary repair—especially when another front-end shop in town says they can put a quick boot on for only about \$60.

TOM FORSYTHE
LITTLE ROCK, AK

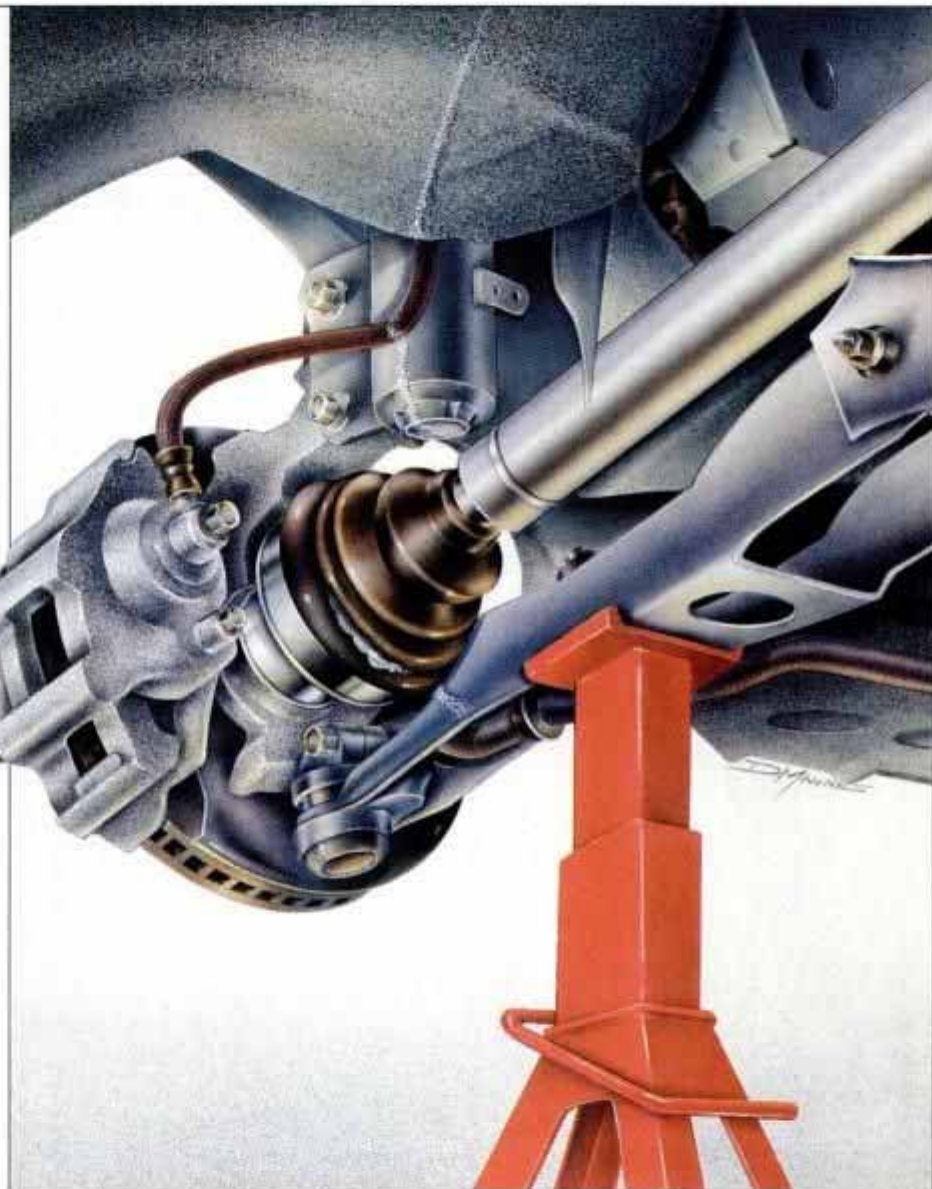
The estimate from each shop, which you sent me, is reasonable for the work that they want to perform. But I don't think the less-expensive repair is necessarily wise in your case.

Installing a quick boot involves simply cutting off the old, damaged boot and putting on a split boot that doesn't require the axle to be removed from the car. Fine and dandy, but . . .

Why is the old boot bad? If it's simply torn from road debris (or off-road debris for that matter), then you can probably just replace it.

But if you have a high-mileage vehicle, then the grease is probably dried out in all four CV-joints—not just the one with the failed boot. The boot may have expired simply from age and the ravages of road dirt and atmospheric pollution. In this case, you need to replace the other three boots as well, and clean out the old, dried-out grease. This involves removing the axles from the vehicle, properly cleaning them in running solvent and drying them with compressed air. Then your mechanic can inspect them for evidence of damage from running with too little lubrication, repack and reinstall them with new boots.

If the bad boot has been bad for a while, the CV-joint may be beyond redemption even if the grease is okay. First off, the tear in the boot has prob-



ably let the grease spray out all over the bottom of your car. Nature abhors a vacuum, road dirt and water will have infiltrated their way into the joint, and you've got a CV-joint that's beyond redemption. There's no way to properly inspect one of these joints without getting it off the car and cleaned up—which is why a split boot may not be a good idea in your case. You'll notice the more expensive estimate called for replacing the CV-joint inside the bad boot, but you may be able to rescue that one.

If you're really in a bad way cash-

flow-wise, it would be perfectly acceptable to defer work on the axle on the other side of the car for another month or so.

Let's Throw A Little Light On The Subject

I got a \$48 ticket in Oregon for having tinted windows. I asked the shop that put on the tint how to remove it. They wouldn't tell me—but they did say that they could remove it for \$18—per window.

FRANK TURNER
HAWTHORNE, NV

CAR CARE

Park the car in the sun, or gently warm the window with a hair dryer or a light bulb. Using a razor blade or fingernail, lift up the corner of the film and peel off the film. The film should peel off without tearing if you're careful and patient. A few drops of solvent, such as spray carb cleaner or lighter fluid, dribbled onto the glass along the parting line might help, too.

Be careful not to scratch the glass with the razor. Any remnants of the

adhesive can be cleaned up with solvent. Be careful not to damage any rubber seals or gaskets with the solvent. And if your car has been repainted, the solvent may damage the paint as well, so use it sparingly.

Prying Solution

I have read that a no-maintenance battery should be inspected for water level by prying open the tops and adding water if necessary. But the battery manufacturers say not to remove

the tops ever. Can you suggest what I should do?

FRED TRAGER
BARBERTON, OH

A maintenance-free battery uses a different alloy of lead (calcium instead of antimony, if you care) to reduce the number of water molecules electrolyzed into hydrogen and oxygen while the battery is being charged. Additionally, they have a larger internal volume to provide a larger reserve of water.

But eventually, they can outgas enough water to get low. If the caps can be pried up without breaking the battery case, and if you top up with nothing else but distilled water, it's entirely appropriate to do so.

But unless you have an overcharging alternator, an overly hot engine compartment or some kind of problem, you should never need to do so. So go ahead and check the level, add water as needed—but realize that this might be the result of some other problem.

All Tanked Up

My Ford F-150 pickup has dual tanks. Periodically when driving on the front tank, the engine will start to stall, just as if it's running out of gas. If I switch to the rear tank within 3 seconds, everything is all right. The gauge for the rear tank stays on FULL until the tank

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SERVICE TIPS

- 1987 and early '88 Dodge Colts may have brakes that squeal during light-to-medium braking as a result of faulty front brake pads. Replacing the pads and shims with new pads of a different compound should cure it.
- If the power door locks of your 1990 Accord try to lock themselves at random intervals, the wiring harness may be incorrectly routed inside the door. Remove the door panel, repair any chafed wiring and reposition the harness holder clip if necessary.
- Do the wipers of your 1986-'88 Jeep J-truck or Grand Wagoneer continue to run in slow speed when the switch is in the intermittent position? A new wiper motor, PN56002909, should correct the problem. It may be necessary to use the harness connector from the old motor on '86 models.
- 1987-'90 Buick Century, Skylark and Skyhawks that have a buzzing or rattle from the instrument panel in front of the driver brake application may have a faulty brake booster check valve.

CAR CARE

is three-quarters empty—then it reads correctly. It almost seems like it's getting some fuel from both tanks when the front tank is selected and the rear is one-quarter full or less.

ALLEN COUCH
MONTGOMERY, AL

If your truck has the factory-installed dual tanks that use a push-button changeover for both the fuel valve and the fuel gauge, there's probably an electrical problem in that circuit—probably a ground connection.

If you've got an aftermarket tank setup with a manual valve, or you've completely debugged the electrical system, then you may need to clean the tanks, lines and valve.

Try just cleaning the valve first, and add an inline filter—a large one—between the tank and valve to catch any junk in the tank. But if there's a lot of junk, you'll need to drop the tank and flush it. **PM**

DO YOU HAVE A CAR PROBLEM?

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

A Draining Situation

● In spite of the fact that most vehicle manufacturers don't recommend changing the ATF in your automatic transmission, it's still a good idea to do so every 30,000 miles or so. Doubly so if your car or truck is used in very hot climates or for towing, as elevated temperatures can really burn the additives out of the oil.

Problem is, almost half of the ATF is still inside the torque converter after you've drained the transmission pan completely. If you are on a regular schedule of changes, this shouldn't be a problem. Simply drain the pan—once a year or so should be fine—to replace half of the fluid.

Some torque converters actually have a drain plug of their own. You may need to remove a sheetmetal guard to access the back of the converter from under the car. If the drain plug doesn't happen to be on the bottom, turn over the motor a tooth at a time with a screwdriver on the starter motor teeth until it is. Be sure to refill with the type of ATF called for in the owner's manual.

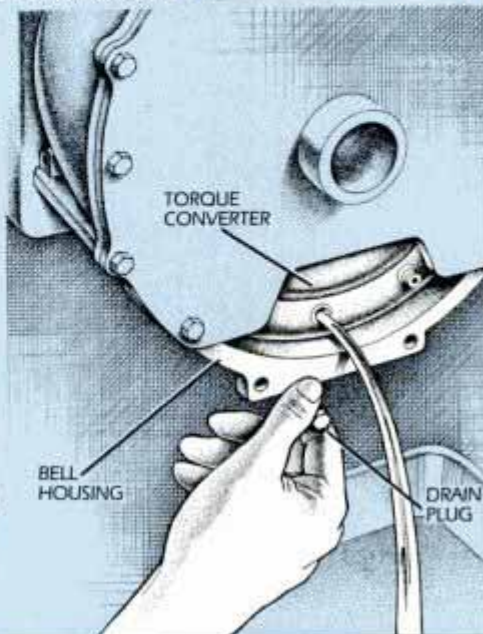


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MAINTENANCE BASICS

REPLACING A BATTERY

BY DON CHAIKIN,
Contributing Editor

● Over time, a battery loses its ability to hold the charge given to it by the alternator. As the chemicals in the battery age, the battery may not have even the energy to start the engine. Sensible maintenance suggests you replace the battery before you're stranded some cold, lonely night.

Test the battery's strength using a voltmeter. With ambient temperature of about 70° F, the meter should read at least 12 volts.

Or, if the starter motor groans or quickly loses verve as it struggles to crank the engine, the battery may be ready to be replaced. But before condemning your battery, inspect the rest of the charging system (see Maintenance Basics, "Charging Systems," page 76, Jan. '93).

You can buy an exact duplicate of your car's battery from the dealership or a quality replacement from an auto parts store or large discount chain.

Before you decide to take on the relatively simple task of replacing your vehicle's battery, remember that an automotive battery is filled with sulfuric acid. Spilled acid can burn your skin and through clothing. Wear workgloves, eye protection and old clothing when replacing a battery.

Buy a replacement battery that is rated as powerful enough to start your engine. The strength of auto batteries is rated in Cold Cranking Amps (CCA) and Hours Reserve.

Check that the positive and negative battery posts are at the same corners of the new battery as the old and that the new battery will sit securely in the battery tray.

Also check that your existing battery holddown bracket will work on the replacement battery. If you're not sure, or if the bracket is corroded, replace that as well as the battery.

● Begin by first undoing the ground-cable connection from the battery post. On all modern vehicles, this is the negative post.

● Loosen the nut and bolt holding the clamp connection to the post or remove the bolt if the battery has side terminals.



● Twist the cable clamp to loosen it on the post. If it is tight, use an inexpensive puller tool made for the job. Lay the cable aside.

With the ground disconnected, it is safe to undo the positive cable clamp.

● Remove the battery bracket. This may be held in place by wingnuts and require no tools, or it may be held by one or more hexnuts, requiring the correct-size socket or wrench. Lift out the old battery and carefully place it aside.

● Clean any corrosion from the battery tray and its compartment. A mixture of baking soda and water neutralizes acid corrosion. Flush with clean water.

● Place the battery in the tray, with the terminal posts at the proper cor-

ners. Reattach the holddown clamp or bracket and snug it in place.

● Clean the cable connections before attaching them to the new battery. An inexpensive wire brush, available at auto parts stores, does a fine job.

● Connect the positive cable to the battery's positive terminal. Be sure the cable clamp is squarely on the post, and snug the nut and bolt.

● Connect the ground cable to the battery's negative terminal post, and snug the nut and bolt.

For side-terminal batteries, clean both surfaces of the cable end and the threads of the cable bolts before attaching them. Again, connect the positive cable first.

● Coat the connections with petroleum jelly to retard corrosion. **PM**

SATURDAY MECHANIC

REPLACING YOUR CLUTCH

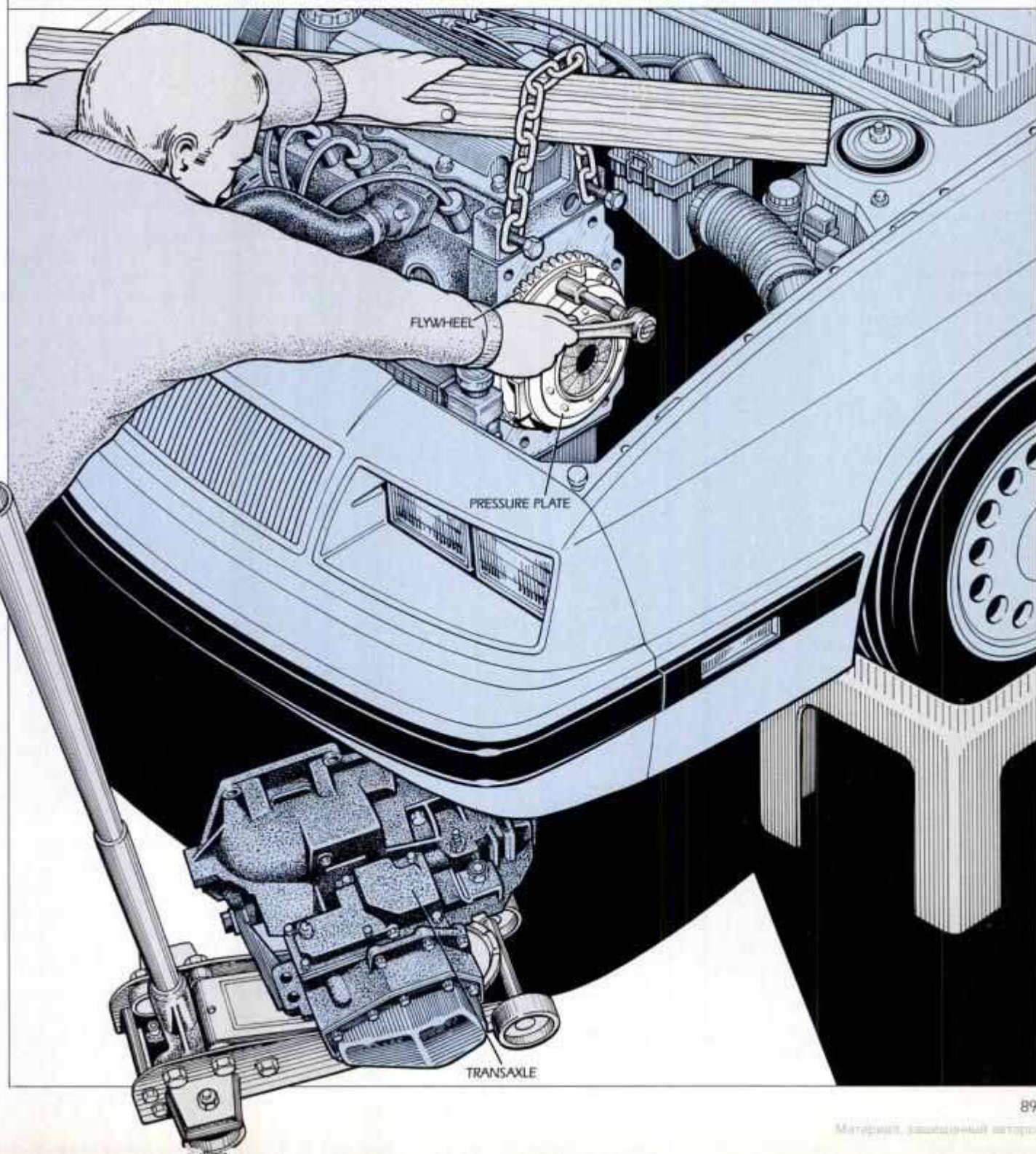
BY DON CHAIKIN, Contributing Editor

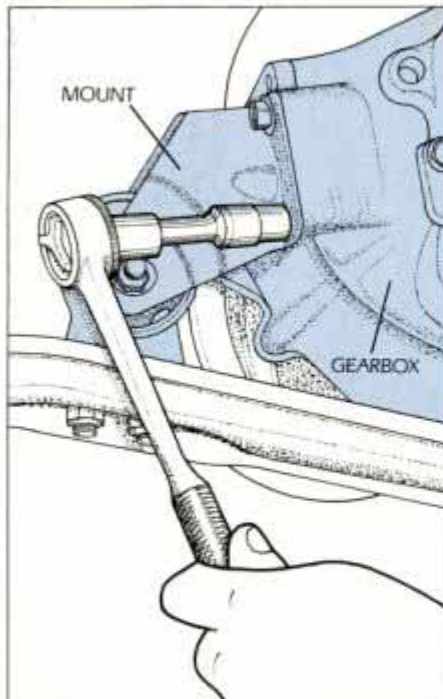
● This is the afternoon you've been dreaming about. The sky is crystal blue, the mountains beckon on the horizon and you finally have wooed the most desirable woman in the county into the passenger seat. But traffic on

the freeway is thick and moving at a frustrating five below the limit. Suddenly, you see your opportunity develop as a gap appears in the morass of Sunday drivers. You deftly knock the shift lever down a notch to THIRD

gear, release the clutch and tromp the gas pedal.

But all you get is a 350-horsepower scream of wasted power as you watch the tach needle jump to six grand while the speedometer needle slowly creeps up from 50 mph, accompanied by the acrid smell of fried clutch.





Support the engine of a front-engine car before undoing the transaxle mounts.

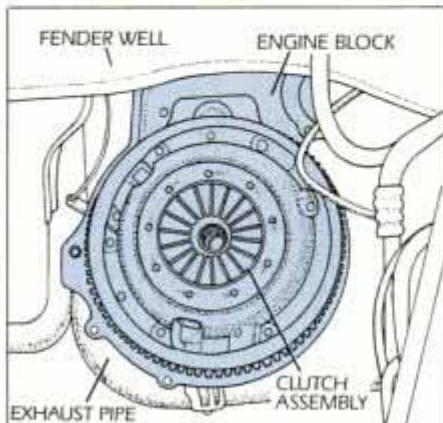
The weak link

No matter how sophisticated your car or truck—whether it is equipped with front-wheel drive, rear-wheel drive or all-wheel drive, be it a fuel-frugal econobox or a tire-smoking rocket sled—if it is equipped with a manual transmission, it also has a clutch.

And sooner or later the clutch will wear out and need to be replaced.

Actually, the term "clutch" used here refers to the entire assembly that channels engine power to the transmission. The clutch assembly consists of the engine's flywheel, a covered spring-loaded steel disc called the pressure plate, a friction disc referred to as the clutch disc and a release-bearing assembly commonly called the throwout bearing.

The pressure-plate assembly is



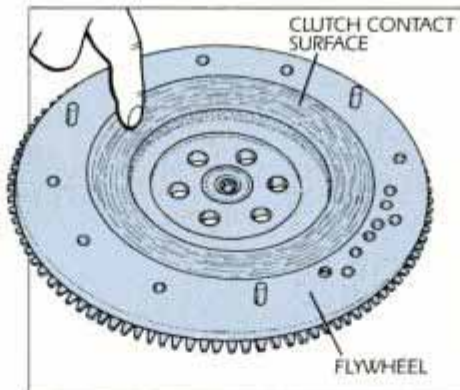
On a transverse-engine car, the flywheel and clutch are accessible from a wheel well.

bolted to the flywheel and sandwiches the friction disc between matching surfaces on the flywheel and pressure-plate disc. The center hub of the friction disc is splined to the transmission's input shaft. The friction disc can slide fore and aft on the shaft, but when it rotates, so does the shaft.

When the clutch is engaged, the heavy springs behind the steel pressure plate squeeze the friction disc solidly against the flywheel.

When the clutch is disengaged—when you step on the clutch pedal—the release bearing is forced against finger-like levers which release the spring force of the pressure plate. This allows the friction disc to slide away from the flywheel, disconnecting the transmission from the engine.

Each time you engage the clutch, the friction disc briefly slips—as it begins to contact the spinning flywheel, the friction disc must catch up to the flywheel in speed. This slipping action, as well as the normal function of maintaining friction between the pressure plate and flywheel, wears away the friction material. In addition, with time and use, the springs in



Check the flywheel's friction contact surface for scores, cracks and severe heat bluing.

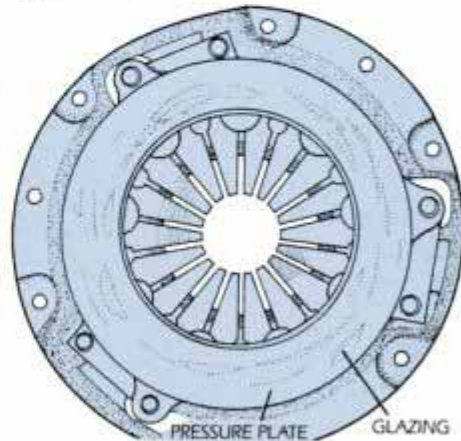
the pressure-plate assembly weaken, losing their grip on the friction disc.

Eventually, the clutch disc will begin to constantly slip between the flywheel and the steel pressure plate. That slippage is exaggerated by sudden and severe loads on the clutch—hard acceleration, pulling a heavy load or climbing a steep hill.

Normal use also weakens the springs in the hub of the friction disc. These springs absorb the rotational shocks when the friction disc engages the flywheel. Time also takes its toll on the release bearing which spins along with the clutch each time you step on the clutch pedal. And as the miles accumulate, the surfaces of the flywheel, pressure plate and clutch

disc can form ridges, cracks and scores. In addition, a leaking seal can saturate the clutch with oil.

Weak hub springs or an oil-saturated, glazed or otherwise damaged friction surface cause uneven clutch engagement, which results in chatter.



Glazing on the pressure plate can be from weak or broken pressure-plate springs.

Put in some slack

As the clutch wears, the linkage that operates it should be adjusted to ensure that the disc fully engages and disengages. Press down the pedal with your hand and use a ruler to measure how far the pedal travels before it starts moving the clutch. Either judge the difference in pedal resistance between the relatively light force of the return spring and the heavier resistance of the clutch itself or remove the return spring altogether to make the check. Typically, pedal free play can vary from 1/2 in. to 1 in.

Adjusting the free play in the linkage is usually done at the release-bearing fork on the clutch/flywheel housing. On vehicles with hydraulically activated clutch linkage, the adjustment may be made near the clutch pedal and the master cylinder or the release fork and the slave cylinder.

To restore the linkage's free play, you typically need to loosen a locknut or remove a retaining clip and then thread in or thread out the adjusting nut or rod. Tighten the locknut and remeasure the pedal's free play.

Getting to the heart of it

If adjusting the clutch linkage does not cure the problem, you're going to have to delve deeper. On almost all vehicles, this means removing the clutch assembly to inspect it. Once you've gone to the trouble of removing the clutch, you'll probably replace all of the parts.

Removing the clutch almost always means removing the transmission.

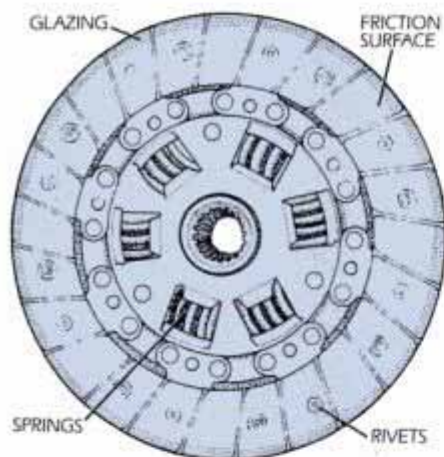
CAR CARE

And in front-wheel-drive cars, the task requires the removal of the transmission/differential unit—the transaxle—and this often involves removing both axle shafts.

And with most 4wd sport/utility vehicles and pickup trucks, removing the transmission involves the added complexity and weight of the 4-wheel drive's transfer case.

Depending on how many mounts your vehicle's engine sits on and where they are placed, you may have to support the engine before you begin removing the transmission. Most front-drive cars rely on mounts on the transaxle to help carry the engine.

You can support the engine with an engine hoist. Or you can tie the engine to a beam (a solid 4x4 does fine) lying across the engine compartment. Take care not to rest the beam on sheet-metal or any nonstructural steel. Also be sure not to let the beam foul against any accessories.



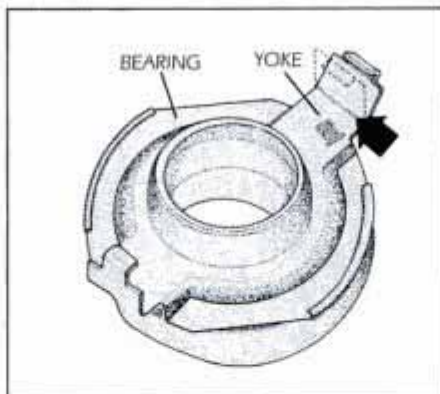
The friction material should be above the rivet heads. Weak hub springs cause chatter.

Once the weight of the engine is supported, you can begin.

Unless you have a pit in your garage floor or have a vehicle that sits tall off the ground, you will have to raise the vehicle to gain access beneath for you to work and to slide the transmission or transaxle out from under it. Jack up the vehicle and place it on safety stands. If the transmission can be removed without taking off any wheels, you can drive the vehicle onto work ramps.

Making the disconnection

Before removing the transmission from the engine, you must uncouple the transmission from the rest of the drivetrain. In the case of a rear-wheel-drive vehicle, this means removing the driveshaft from the rear of the transmission. With 4wd sport/



Cracked or broken yoke or a worn release-bearing hub causes chatter or slipping.

utility vehicles and trucks, you must disconnect the front driveshaft as well. With a front-wheel-drive vehicle, you must remove the axle shafts that attach the transaxle to the front wheels.

On many vehicles, once the drive-shaft or drive axles are removed from the transmission, there is nothing to prevent all of the transmission oil from pouring out of the housing. Some manufacturers recommend draining the oil from the transmission before removing it. Others recommend merely plugging the shaft or axle opening after removing the drive axles or driveshaft. However, if you have not replaced the gearbox oil within the recommended interval, drain the old oil and refill the transmission with fresh lubricant.

Before disconnecting the drive-shaft at the rear universal joint, mark the position of the driveshaft in the U-joint's yoke to maintain the drivetrain's balance when you reassemble. Once the driveshaft is disconnected at the rear, you can slide it forward into the transmission housing to gain enough space to clear the rear axle unit. Then slide the driveshaft out from the transmission. Take care not to damage the splines on the front end of the shaft, the transmission's rear oil seal or the front universal joint.

The procedures for removing the drive axles for front-wheel-drive vehicles vary from make to make. Depending on your car, you may have to remove the front wheels, the brake rotors, the lower strut mounts or other suspension links. You will also have to remove the nut or retaining clips at the ends of the shafts.

The axle retaining nut on some front-drive cars is self-locking and, once removed, must be discarded. Likewise, the retaining clips used on the ends of some drive axles must be replaced once removed as well.

However, once any retaining clips or nuts are removed, the drive axle should pull straight out of the transaxle. As with a rear-wheel-drive vehicle, take care not to damage the oil seals in the transaxle or the splines on the ends of the axle. In addition, with a front-wheel-drive vehicle, be sure not to damage the constant-velocity joints at each end of the drive axle. Take care not to pinch or tear the CV-joint boots.

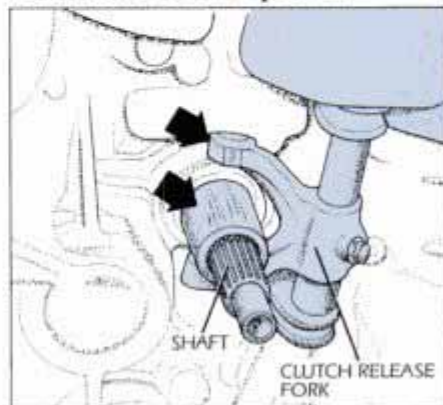
You must also disconnect the clutch and shift linkages as well as the speedometer cable from the transmission before you can remove the gearbox from the engine. If your vehicle has a hydraulically activated clutch linkage with the slave cylinder mounted on the transmission which requires you to disconnect the slave from the master, you will have to bleed the system the same way you bleed the brake system after you've reinstalled the transmission. Also, depending on your vehicle, you might have to remove the starter motor.

Once the transmission is free, you can unbolt it from its mounts and from the engine.

Before you slide the transmission off its locating dowels and away from the engine—which often requires some initial persuasion with a small pry bar—have the transmission properly supported by a floor jack with a large cradle or by a transmission jack. A front-wheel-drive transaxle or a transmission with a transfer case can weigh a few hundred pounds.

Once the transmission is removed from the engine, you can remove the clutch itself.

Partially loosen the bolts through the pressure plate that hold the clutch assembly to the flywheel. The springs in the pressure plate will push the plate out against the bolts. As you finish loosening and removing the bolts, the friction disc will slip down.



Damage to transmission shaft or bearing fork can snag the release bearing.

Be prepared to catch both the pressure plate and the friction disc when you remove the final bolt.

Fallout for inspection

With normal wear, the friction surfaces of the clutch disc should be worn, and if the clutch had been slipping badly, expect it to be glazed as well. The metal surface of the pressure plate may also show some heat bluing from slippage. Replacing them with new parts will solve the problem.

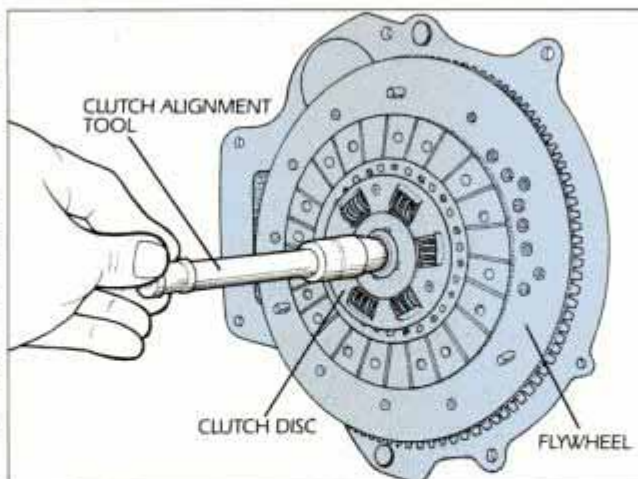
Inspect all the parts to determine if there is a problem other than from normal wear.

If even one of the disc-hub springs is broken or weak—possibly even loose—the clutch will chatter when engaged.

Oil soaked into the friction disc would cause chattering. It also indicates a leak at either the engine's rear main oil seal or the transmission's front oil seal.

Remove the flywheel from the engine to inspect the engine's oil seal for signs of leakage. If the seal is suspect, replace it. Also inspect the flywheel. If the flywheel is glazed, burned, cracked or scored, it must either be resurfaced or replaced. If your engine uses a pilot bearing in the center of the flywheel's hub, check that bearing. Replace it if it is at all suspect.

Remove the clutch-release bearing from its fork. Clean the transmission's input shaft and inspect it. If the surface around the shaft that the bearing rides on is deeply scored or



Clutch alignment tool centers the clutch friction disc on the flywheel so the transmission input shaft will install properly.

worn, the bearing will stick, causing partial or uneven clutch engagement. If the splines of the input shaft are damaged, the friction disc will stick. If there is any damage to the transmission shaft, it must be replaced. Also inspect the shaft's oil seal for leakage. Replace a leaking seal.

Operate the release-bearing fork—it should move freely and easily throughout its entire range. If it binds, it can prevent the clutch from fully engaging or disengaging.

Inspect the release bearing and its hub carefully. Spin the bearing—it should move freely, quietly and smoothly. Even if the release bearing seems good, replace it as a preventive measure. If the surface of the bearing's hub is scored or worn, the bearing will not slide smoothly on the transmission shaft—replace it.

Putting it all together

When installing the flywheel on the crankshaft, be certain that you follow the manufacturer's recommendations—some makers use flywheel mounting bolts that must be replaced if removed. Others use a special bolt locking plate.

With the flywheel in place and properly torqued down, you can install the new clutch disc and pressure plate. It is critical that the clutch friction disc be perfectly centered on the flywheel. To align the disc on the flywheel, use an old transmission input-shaft stub or an aligning tool.

This tool consists of various pilots which thread on a large dowel and a sliding cone-shaped sleeve which slips over the dowel.

Attach the pilot that fits snugly in the hole in the center of your engine's flywheel onto the dowel. Place the pilot firmly into the flywheel. Slip the

friction disc over the dowel.

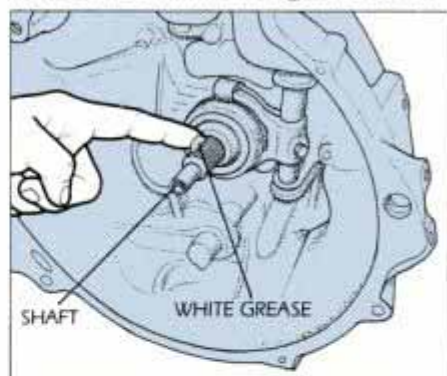
Note that the splined center hub of the friction disc is not the same on both sides. Take care to mount the friction disc with the side marked FLYWHEEL toward the engine.

Place the pressure plate over the friction disc and just start its bolts.

Slide the cone-shaped sleeve over the dowel handle so the cone goes into the splined hub of the friction disc. Firmly hold the sleeve against the friction disc to center it. Tighten the pressure plate's mounting bolts in a crisscross pattern, according to the manufacturer's specs.

Before installing the new release bearing, lightly coat the splines of the transmission's shaft with multipurpose grease. Also fill any grease cavity in the release bearing or its hub according to your vehicle-maker's specifications. Install the new release bearing—again taking care to install it so the rotating part of the bearing will bear against the pressure release fingers of the pressure plate.

Slide the transmission back under the vehicle and raise it so the input shaft is level with the center of the clutch assembly. Carefully align the transmission shaft with the clutch and slide the transmission against the en-

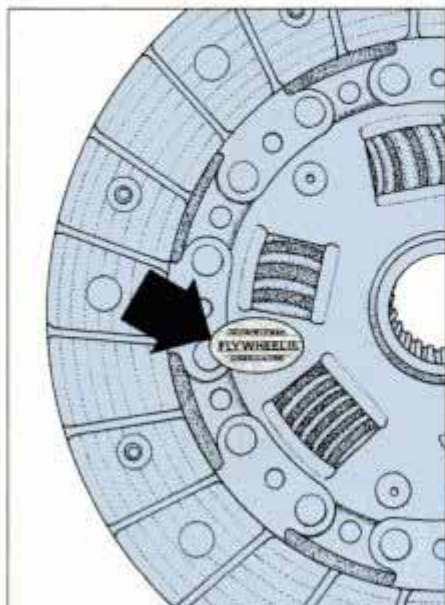


A dab of white grease on input shaft keeps bearing and clutch disc sliding freely.

gine. Slowly rotate the transmission's output shaft as you go. When the splines of the transmission's input shaft align with the splines of the clutch friction disc, the transmission should slide home.

Align the transmission housing, rotating it as necessary on its shaft, and replace the housing bolts.

Then reassemble everything you have removed, adjust the linkage for the new clutch, and you're ready to get the power back to the wheels. **PM**



Take care to install the new friction disc with the proper side against the flywheel.

HOW IT WORKS

MANUAL TRANSMISSION

BY DON CHAIKIN, Contributing Editor

● Since it is the nature of the internal combustion engine to produce its usable power over a relatively small speed range, your car or truck is equipped with a transmission.

The transmission contains different gearsets which offer varying ratios between the gears driven by the engine and the gears that drive the axles or driveshaft. By selecting the appropriate gear ratio, you can operate the engine at its most potent and efficient speed.

A manual transmission contains three or more distinct sets of gears. Some of the gears are permanently fixed to their shafts, others are not. All of the gears, except Reverse, are always meshing with a mate and are constantly spinning when the engine is running.

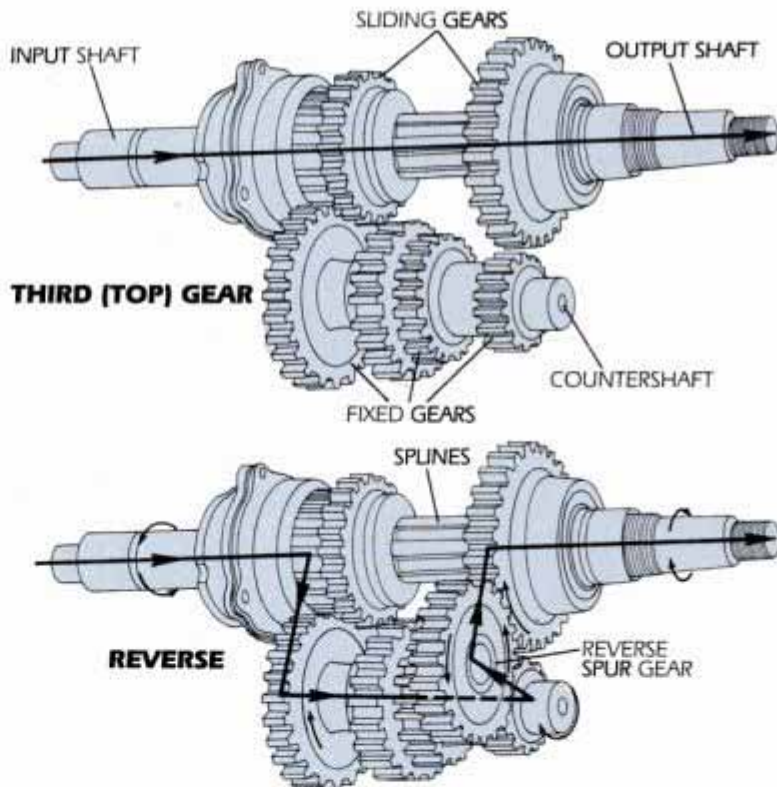
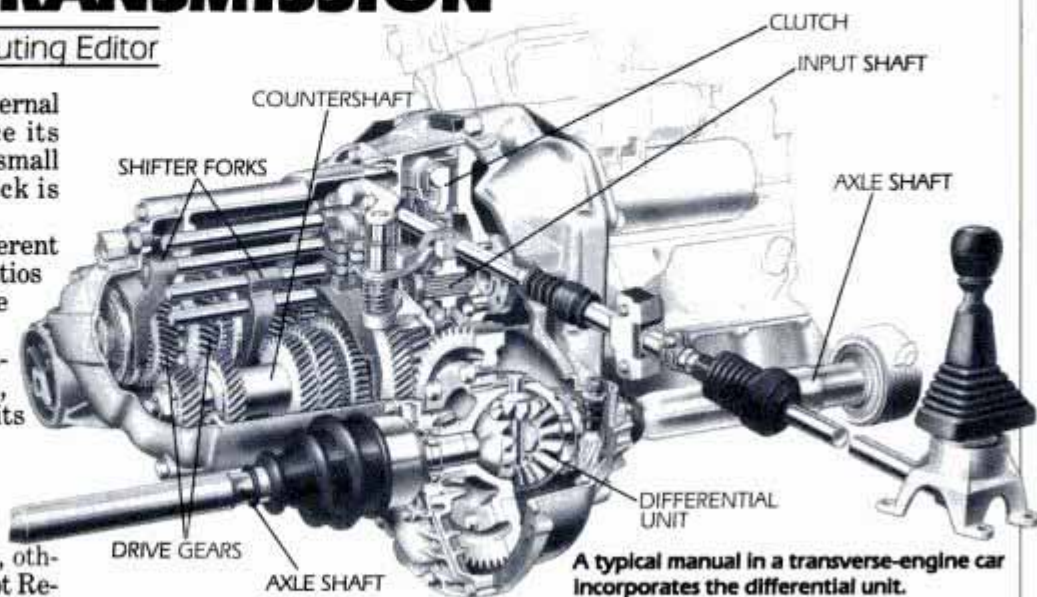
The engine's power is transmitted to the transmission by the clutch, which consists of a spring-loaded pressure plate and a clutch disc. The disc is faced on both sides with friction material and is squeezed by the pressure plate against the engine's flywheel. The clutch disc is splined to the transmission's input shaft. As the flywheel spins, so does the clutch disc, which in turn spins the transmission's input shaft.

The input shaft extends just far enough into the transmission case to allow space for a gear to be permanently attached to the shaft. This gear spins at the same speed as the engine—if the clutch is engaged.

This input gear meshes with a large gear on the countershaft. The countershaft, too, has different size gears permanently attached to it, which mate with corresponding drive gears on the transmission output shaft.

The gears on the transmission output shaft rotate on hubs on the shaft. Toothed collar rings between the output gears are splined to the output shaft and rotate with the shaft. These collars are connected to the shifter linkage. As you move the shift lever to select a gear, the linkage slides the collar against the appropriate output-shaft gear.

The sides of each output gear are cone shaped with a set of teeth—called drive dogs—around the circumference of the cone's base near the side of the gear. This cone slides into a



In top gear, the output-shaft gear slides to mesh directly with the input shaft. In Reverse, power flows from the countershaft to an idler gear then to the output.

similarly shaped cavity in the sliding gear, meshing the gear with the collar. This is called synchromesh. As you move the shift lever, the collar moves against the cone. As the cones begin to mate, the speed of the gear and the speed of the collar—which is the same as the speed of the output shaft—are synchronized. When the speeds are the same, a spring-loaded outer ring on the sliding collar slips over the dogs on the

gear, meshing the gear with the collar. This is called synchromesh.

When you shift into top speed, the shift linkage slides a collar between the input shaft and output shaft, connecting them directly.

Reverse gear is separated from its countershaft gear by a small idler gear, which accounts for the change in direction of the power flow. **FM**

CAR CARE

NEW PRODUCTS

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Nonflammable Tire Inflators

Many aerosol tire inflator/puncture sealers use a flammable propellant which makes inflating your flat potentially dangerous. However, Radiator Specialty Co. has introduced Gunk Nonflammable Puncture Seal, in 9-, 12- and 16-ounce cans—the two larger sizes feature a flexible hose for easy attachment to your flat. The maker claims that it contains no flammable solvents and no hydrocarbon gases. Prices range from \$1.39 to \$3.49. From Radiator Specialty Co., Charlotte, NC 28234-6080; (800) 438-4532.



Synthetic Motor Oil

Pennzoil has entered the synthetic engine-oil market with Performax, available in 5W-30, 10W-30 and 5W-50 viscosities, in 6-quart cartons. Performax features a unique-to-Pennzoil additive and offers improved low-temperature fluidity, resistance to high-temperature oxidation and viscosity loss due to shearing. Pennzoil claims the result is improved lubrication, reduced oil consumption and better exhaust emissions. Price is about \$4 per quart. From Pennzoil Co., Pennzoil Place, P.O. Box 2967, Houston, TX 77252-8200; (713) 546-6100.



Coolant Test Strips

You can test the strength of your engine's antifreeze coolant mixture using the same technology that your doctor uses to test your bodily fluids. Test strips, called CoolTrak, change color when immersed in room-temperature coolant for 15 seconds. Compare the color of the saturated strip with the supplied color chart to determine the strength of the coolant. In addition, CoolTrak tests the coolant's level of reserve alkalinity—which corresponds to its level of corrosion protection. CoolTrak works with both ethylene- and propylene glycol-based coolants. Available in 50-strip bottles for \$10.99. From Environmental Test Systems Inc., P.O. Box 4649, Elkhart, IN 46514; (800) 537-0106, Dept. 77.



Low-Price Multimeter

A 5-function, digital test meter has been introduced by Beckman Industrial. The Model DM2 (\$27.95) is about the size of a deck of playing cards (4.7 x 2.8 x 1 in.) and weighs 7 ounces. The unit measures low-level DC current—down to 0.01mA—as well as DC volts to 1000 volts, AC volts to 500 volts and resistance to 2 megohms while providing up to 200mA fused DC current measurements, all at 0.8% accuracy. It comes with test leads, a spare fuse and a manual. From Beckman Industrial Corp., Instrumentation Products Div., 3883 Ruffin Rd., San Diego, CA 92123-1898; (619) 495-3200.

Electronic Compass

The age of electronics has caught up with the dashboard compass, thanks to the Wayfinder (\$99.95), which uses military-based sensor technology. Pressing the unit's SET button, making a U-turn and pressing the button again calibrates the compass. An internal lithium battery keeps it calibrated for about a year, and its microprocessor-controlled magnetometer compensates for the stray magnetic fields that confuse standard compasses. A memory feature stores a direction of travel so you can retrace your steps. From Precision Navigation, 1350 Pear Ave., Suite A, Mountain View, CA 94043; (415) 962-8777. **PM**



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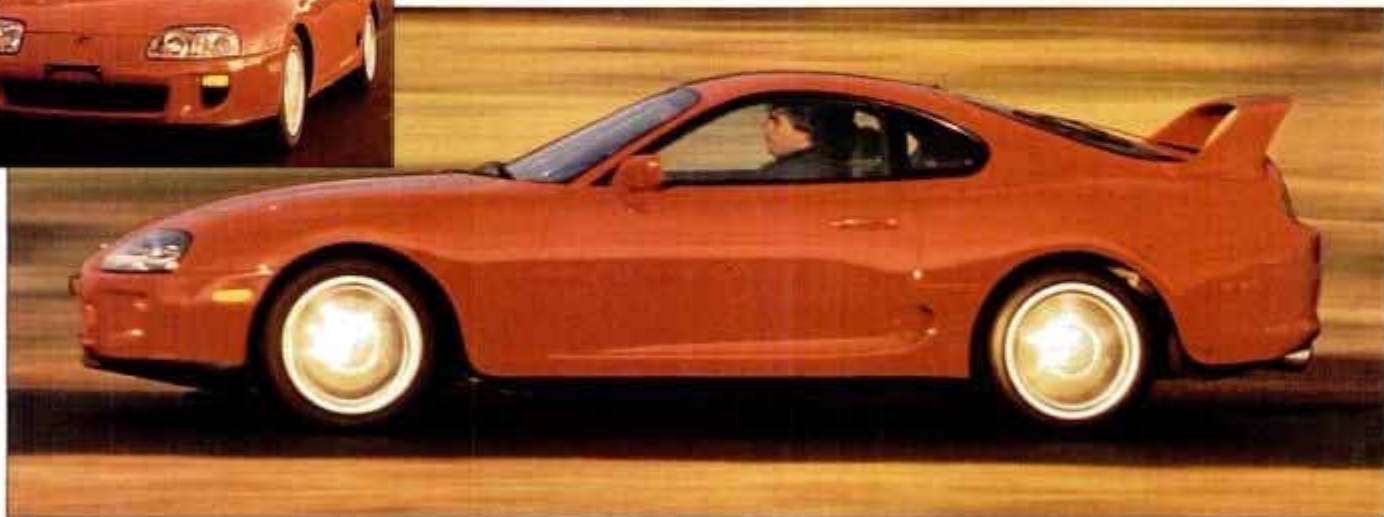
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NEW CARS



Toyota's Super Supra

● Although the market for high-end sports cars has contracted over the past three years, the competition in the segment has expanded dramatically—many more cars, with much more performance.

The latest combatant to enter this red-hot battleground is the car you're looking at here—the all-new Toyota Supra, due to hit dealer showrooms right about now. And to sum it up in a word, it is formidable.

As happens in the evolution of so many sporty luxury coupes, the Supra had become portly and soft over the course of three previous iterations. The new car, though far from light, has an altogether different character—it is firm, agile, precise and potent.

And even though it's far from having the kind of curb weight that helps make Mazda's new RX-7 such a bullet, it's considerably lighter than its predecessor—310 pounds in the case of the normally aspirated version. With a manual transmission, the basic Supra scales in at 3235 pounds, the turbo version at 3450.

Horsepower is the first chapter in any performance story, and the Supra's story begins impressively. The engine is basically the same 3.0-liter inline Six employed in the Lexus SC 300 coupe and GS 300 sedan, with a cast-iron block, direct ignition and an aluminum dohc 24-valve cylinder head. The normally aspirated edition makes 220 hp and 210 ft.-lb. of torque,



Supra's new cockpit-style interior enhances the car's sense of sports car intimacy.



Sequential twin turbochargers boost 3.0-liter dohc 24-valve V6 output to heady 320 hp.

but the intercooled sequential twin-turbo version is the real adrenaline pump. When both turbos are spooled up, there's 320 hp on the Supra's tap. That power, combined with an impressive peak torque of 315 ft.-lb. which comes on at 4000 rpm, gives you a very serious rush.

Mated to the turbo's new 6-speed manual transmission (a 5-speed is standard in the normally aspirated car, and a 4-speed automatic is option-

al), this provides an exceptionally stimulating level of scoot—0 to 60 mph in about 5 seconds. It's also interesting to note that both the non-turbo and the heavy breather manage to slide under the government's gas-guzzler status, with EPA city/highway fuel-economy ratings of 18/23 mpg (18/24 for the normally aspirated car with automatic transmission).

Gratifying as all the go-power is, though, the new Supra's handling strikes us as an even bigger achievement. Riding a 100.4-in. wheelbase, the new car is 4.2 in. shorter than its predecessor, with less front and rear overhang, a significantly wider track and a center of gravity that's an inch lower than before.

The chassis is noticeably stiffer than the old Supra, with higher spring rates and firmer shock damping (the old cockpit adjustable damping system is gone). The turbo version also includes a driver-select traction control system. Double wishbones at all four corners, a Torsen torque-sensing limited-slip differential (optional on the basic Supra, standard on the turbo) and antiroll bars at both ends round out the suspension particulars.

The tires are well suited to the intent of the chassis engineers—lots of grip. The normally aspirated car wears serious P225/50ZR16 tires front, P245/50ZR16s rear, mounted on wide (8.0-in. front, 9.0-in. rear) alloy wheels. There's even more rubber still to be found under the turbocar—

(Please turn to page 100)

P235/45ZR front, P255/40ZR rear—on 17-in. alloy wheels, 8.0 in. wide in front, 9.5 in. in the rear.

Combined with an exceptionally precise variable-assist rack-and-pinion power steering system, the net on all this hardware is real sports car performance—limited body roll, knife-edged directional changes, tenacious cornering and all that eager power waiting under the driver's right foot. Wow.

Wow also applies to the Supra's stopping power. Both versions have ventilated discs with spiral vanes fore and aft—11.7/12.1 in. for the basic Supra, 12.7/12.8 in. for the turbo—backed by a 4-channel antilock system with a lateral g sensor. Front calipers have dual pistons.

Inside, the new Supra has taken on the fighter-cockpit look and feel we associate with world-class sports cars. The bucket seats are snug and supportive without being confining. The straightforward analog gauges are well grouped and comprehensive, and major controls are where they should be. Front-seat legroom is plentiful, ditto for headroom, although the rear seat is a typical 2+2 and—believe it or not—even more cramped than in the previous Supra.

Toyota hasn't forgotten the luxury part of the equation. Power windows, door locks and side mirrors (heated),



A more contemporary aerodynamic exterior and redesigned interior distinguish GMC Truck's new Sonoma compact pickup. The optional Enhanced 4.3-liter V6 engine produces an ample 195 horsepower and 260 ft.-lb. of torque.



Four-door version of GMC's hot turbo Typhoon may be en route.

automatic climate control, illuminated locks, cruise control and a 6-speaker AM/FM/cassette sound system are all standard equipment. Major options include a removable aluminum sport-roof panel, leather upholstery and, of course, an even better sound

system that includes what's rapidly becoming a *de rigueur* feature—a compact-disc player.

Initial press response to the new Supra's styling was mixed. In particular, the Turbo's optional rear wing came in for some caustic comments, although it doesn't interfere with vision to the rear and does create measurable downforce. But most agreed that the exterior accurately reflects the sophisticated brute that lurks within—wickedly fast and capable of matching numbers with anything in its class, including price—about \$33,000 to \$39,000.

We'll reserve further judgment for a full road test, but based on first impressions we'd say world class clearly applies.

—Tony Swan

GMC Spices The Mix

Here's a first look at a couple of newcomers—one a production certainty, the other very likely—that'll add even more pizzazz to GMC Truck showrooms in the near future.

The first is the GMC Sonoma compact pickup, extensively redesigned for introduction as a 1994 model.

With its rounded contours and flush glass, the new Sonoma takes on a much more contemporary appearance. And there's also plenty of punch available, with the Enhanced version (optional) of GM's corporate 4.3-liter V6, which belts out 195 hp and 260 ft.-lb. of torque. All told, there are six engine/transmission combinations available for the Sonoma line, as well as basic rear-wheel drive or GM's user-friendly Insta-Trac shift-on-the-fly 4wd system.

Inside, the new Sonoma sports one of the more civilized interior treatments in all of pickup truckdom, with comfortable bucket seats upholstered



The Baby Benz Grows Up

● Redesigns come slowly at Mercedes-Benz, but when they come they're sweeping. This prototype, snapped in Germany, is a case in point. It's the next generation of the Mercedes 190-Class—the so-called Baby Benz.

But you won't be able to call it a baby anymore. Nor will you be able to call it a 190. The expected designation for

the new line, code named W202, is the Mercedes C-Class.

The new car is expected to be bigger than its predecessor, as well as more powerful and sportier. However, Mercedes is expected to hold pricing at the current 190-Class levels.

Due for the 1994 model year, the new line will probably be unveiled at the 1993 Geneva Auto Show.

in posh-looking fabric and a contemporary instrument panel with straightforward white-on-black analog gauges. The combination of near-flush glass, improved aero and better all-around sealing has also produced a significant reduction in road and wind noise.

So much for the absolute. The probable addition to the lineup is a 4-door version of GMC's hot Typhoon sport/utility vehicle.

Using the same body shell as the Chevy S-10 Blazer and Olds Bravada 4-doors, the proposed GMC version would employ the Typhoon's 4.3-liter intercooled turbocharged V6, which delivers a sizzling 285 hp and 0-to-60 mph performance in less than 6 seconds.

If the 4-door version reaches production, it will be strictly upscale, with leather interior and a premium sound system, in addition to full-time all-wheel drive and 4-wheel antilock braking. It will also feature a suspension setup tuned a bit softer than the 2-door Typhoon, in anticipation of family use.

The pre-production prototype shown here uses trim pieces borrowed from the Oldsmobile Bravada, and the 7 in. of additional wheelbase that are part and parcel with the 4-door versions of GM's compact sport/



New Subaru Impreza uses 16-valve dohc version of 1.8-liter opposed Four.

Subaru offerings—without abandoning traditional Subaru engineering virtues, like the carmaker's long-standing trademark—the availability of full-time all-wheel drive.

Built on the compact Legacy platform, the Impreza is a little bigger than the familiar Loyale series, which will continue in the Subaru lineup through '93 and into the '94 model year. With a 99.2-in. wheelbase—compared to the Loyale's 97.2 in.—ride quality is distinctly better than its smaller stablemate, while handling is competitive with subcompact pacesetters like the Honda Civic and Toyota Tercel.

Like the Loyale, the new Impreza is powered by a horizontally opposed sohc 1.8-liter aluminum Four. However, the Impreza engine sports four valves per cylinder and produces more power—110 horsepower compared to the Loyale's 90 hp. It can be



Mitsubishi will add a wagon to its posh Diamante lineup as a '93 midyear introduction.

utility vehicles provide much more rear-seat legroom than the 2-doors, as well as better ride quality.

Subaru Impreza

Although Subaru continues to struggle with its outsider image, the new Impreza subcompact series promises to bring this innovative car company much closer to the automotive mainstream.

Available as a formal sedan or the distinctive little wagon shown here, the new line is comfortable, roomy and devoid of the strange styling that has handicapped some of the previous

mates to either a 5-speed manual transmission (standard) or 4-speed automatic, and, as noted, full-time all-wheel drive is an option.

Passive safety features include a driver's airbag and the availability of antilock braking.

The Impreza is available in two trim levels—the standard L and the upscale LS—with prices ranging from about \$12,000 to \$16,000. We'll provide a detailed report of day-to-day life with this new car in upcoming issues, when a new Subaru Impreza Sport Wagon joins the PM long-term test fleet.



Diamante Wagon

Despite continuing growth in the minivan market, traditional station wagons are staging a modest comeback, and here's another proof: A wagon version of Mitsubishi's smooth Diamante sedan.

Conceived to compete in a growing midsize wagon group that embraces Mercury Sable and Toyota Camry at one end of the price spectrum to the Volvo 960, BMW 535i Touring and Mercedes-Benz 300TE at the other, the Diamante Wagon falls somewhere in the middle, both in price and interior volume.

At 190.2 in., the Diamante Wagon is 2.2 in. longer than its namesake sedan, riding the same 107.2-in. wheelbase. It's also 2.4 in. taller, which adds up to 37.4 cu. ft. of cargo space with the rear seat folded up, 72.1 with both portions of the split-folding seat lying flat.

With a curb weight of 3609 pounds, it's also about 200 pounds heavier than the sedan. Since it's offered only with the milder of the two Diamante motors—a 175-hp sohc 3.0-liter V6—and a 4-speed automatic, it's not likely to match the performance of the sporty European wagons.

On the other hand, it's roomy, it's filled with plenty of standard comfort/convenience features and, like the sedan, it's long on all-day comfort.

Look for Diamante Wagon pricing to start at about \$23,000.

Isuzu/Honda Sport/Ute

American Honda plans to get into the burgeoning sport/utility market in 1994 with a rebadged version of Isuzu's popular Rodeo.

The Honda version will be built at the Subaru/Isuzu joint-venture plant in Lafayette, Indiana, to the tune of some 20,000 units per year.

Isuzu, meanwhile, plans to suspend its red-ink carmaking operations to concentrate on its more profitable truck business. The Stylus and Impulse will still be available through most of this model year, though.

This also means that the next generation of Chevrolet's Geo Storm will be supplied by Suzuki.

AUTOMOBILES

DETROIT SPY REPORT

BY JIM DUNNE, Detroit Editor



S-10 Chevrolet

● Two versions of the new Chevy S-10 pickup will be offered next fall: a standard cab and an extended cab. Both will feature wider interiors and a choice of two engines—a 2.2-liter 4-cylinder or a 3.4-liter V6. Transmissions include an electronic-control 4-speed automatic. Note the camouflage panels on these prototypes that cover the rear wheel well, hood and front fenders. A light screen covers the grille.

Monte Carlo Revival

Chevy is testing this prototype of a new Monte Carlo in preparation for its release as a 1994½ model early next year. A paint scheme is designed to disguise the true lines of the car, but its new shape is easy to follow. Those "air scoops" in the bumper and the door handle in the B-pillar are simply painted disguises. But the low hood line, wide headlights and wrap-around rear deck will be seen on the production model.

Thunderbird '94

It's easy to make styling changes when you have a plastic front end like this Pontiac Thunderbird. Note that the major changes in this front end of the 1994 Thunderbird are limited to just the bumper and front fascia. However, the hood shape was also changed slightly to accommodate the new 4.6-liter V8 engine that Ford will install in this car. The wheels, too, are of a new design.

Electric Regenerator

All electric vehicles will use a regenerator system that converts braking power into a battery recharging system. As the car slows down, the road wheels power a generator to feed the



Monte Carlo nameplate is revived for '94½.

batteries. But the technique can go too far. You can get too much mechanical drag out of the generator. Ford limits its regenerator to a slight drag—like coasting down in high gear—so drive wheels do not lock up on slick or icy roads.

Explorer Suspension

Ford will move away from the famous Twin I-Beam suspension for light trucks beginning with the 1995 Explorer. While it won't say publicly, Ford has two major reasons for the change.

The Twin I-Beam suspension has problems holding front wheel alignment. The Twin I-Beam is known for this, and most mechanics are familiar with the drawback.

The second problem is with the height of the suspension. A differential on the Ford suspension raises the position of the engine almost 2 in. And that translates into higher hoods and less sleekness in the body profile. Prototypes of the 1995 Explorer—now under tests—have upper and lower control arms in the front suspensions. An air spring will also be available on upscale models. It's designed to raise the chassis while traveling over rough roadways.

Convertible Mark VIII

Lincoln is preparing a convertible model for the new Mark VIII. Look for this version to appear on sale in late summer. The softtop will be outfitted by ASC, the sunroof company, but sold as factory-built through Lincoln dealers. That means full factory warranty.

Cup Holders

If you design car interiors nowadays, you have to know about cup holders. This accessory is a must for new car designs. Even the luxury models like Cadillac's Brougham have them. The 1994 Dodge T300 pickup will have cup holders built into a special place as a result of unique research on the subject. Dodge designers checked the interiors of dozens of in-use pickup trucks to see where the owners kept their



'94 T-Bird gets new grille, hood to fit 4.6-liter modular V8.

cups. "Up high," is the answer. So the T300 will have two jumbo cup holders near the top of its instrument panel. Now, it's a rare car that lacks the cup holder.

More Firebird

Pontiac started to design the 1993 Firebird in the mid-1980s, and began testing with a front-drive chassis powered by a 24-valve V6.

"But, performance-wise, we preferred rear-wheel drive," says a Pontiac engineer. So a switch was made to V8 power and rear-drive. A change to upper-and-lower-control-arm front suspension and away from MacPherson struts gives a better ride. Pontiac-specified platinum-tipped spark plugs rated for 100,000 miles should make tuneups a task of the past.

Continental V8

A V8 engine and smoother body lines will be features of the 1995 Lincoln Continental. This prototype is running with the new engine. A plastic bra covers the design of the new grille and headlights. And body lines are partially concealed by black paint. Still, it is easy to see the car will be smoother in exterior appearance, with a larger look overall.

Ford Van

Ford will put the "Windstar" name on its new 1995 minivan. The Aerostar replacement will give Ford a new chance to compete with the Chrysler minivans, and offer a 3.8-liter V6 in a Taurus front-wheel drivetrain at its debut in the spring of 1994. Later, a 3.0-liter V6 will be available. A wheelbase of 120 in. is slightly longer than the 119.3 in. of the stretched Chrysler vehicles, but the overall length of 201 in. is more than 10 in. greater. Look for a 4-wheel-drive version of the Windstar to appear later as the trailer-towing option.

Roundoffs

Take a close look at the 1994 Chevy S-10 pickup and GMC Sonoma for a hint of the changes in store for GM's 1995 sport/utes. While front-end and grille styling will not be exact copies, rounded, smoother body surfaces with drop-hood look will be followed. Some models will offer bright metal in the grilles and wheel covers, but paint will cover all other surfaces. Even before the '95s are introduced, Olds will drop Bravada.



1995 Continental will get much-needed V8, smoother lines.

Ford Tempo

Ford's 1995 Tempo will follow the styling and design of its European cousin Sierra. The same sloping fender and hood lines, and the same type of front-wheel drive will be featured on both. But, while the American Tempo will not be available until early 1994, the Sierra will be on sale later this year. Combining the two Ford products in one basic design saves Ford development money and allows the company to use similar components from suppliers worldwide. **FM**

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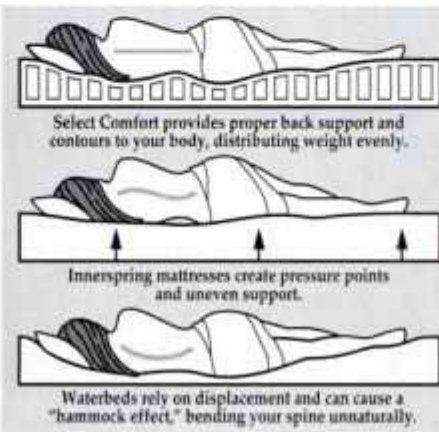
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BOATING

BLAST OFF

BY JIM YOUNGS



● I've experienced the future of personal watercraft and, in a word, it's fast. But before we get back to the future, it's important to understand the past, especially the roles played by Kawasaki and Yamaha in shaping the current boom in minijets. These two market leaders started out by developing and perfecting opposing minijet designs and philosophies. Now, as the future quickly approaches, they find themselves moving in the same wet-and-wild direction.

It was the best of all possible worlds for Kawasaki back in 1974 when it introduced the first Jet Ski. Kawasaki defined the personal watercraft market then and virtually had the business all to itself until 1986—the year Yamaha hit the water with its trend-setting WaveRunner.

Today, there are several large and legitimate challengers to Kawasaki's market dominance, but there's no doubt that the pioneering Jet Ski established a solid foundation for the evolution of the sport.

The original concept for the Jet Ski called for the operator to stand up and use a fair amount of physical strength, balance and finesse to become a proficient rider. The machine was a marvel of technology and still remains a potent force in the industry. In fact, to the dismay of Kawasaki's overpaid corporate lawyers, much of the gener-

al public misuses the brand name Jet Ski as the generic name for all personal watercraft.

Sitting pretty

When Yamaha eventually decided to enter the minijet market, it embarked on an opposite, more user-friendly approach than was possible with the stand-up Jet Ski. By enabling the operator to sit down while riding the WaveRunner, Yamaha produced a low-effort, easy-to-ride vehicle that practically anyone could master in short order. It opened up the sport to a much bigger market and became an instant success.

Kawasaki, Sea-Doo and other companies followed suit and developed

their own models of sit-down minijets, and this style of craft soon became the undisputed market leader.

However, Kawasaki didn't abandon its long-term investment in the stand-up market, which had grown to sizable proportions, partly due to a very successful professional and amateur international racing program administered by the International Jet Sports Boating Association (IJSBA). In the stand-up arena, Kawasaki continued to enjoy an exclusive market for several years after sit-down craft were introduced.

Then, three years ago, Yamaha decided it wanted a piece of the stand-up action and introduced the Super Jet,

(Please turn to page 107)



Adrenalin-pumping thrills from Yamaha: the WaveBlaster (top) and the Pro VXR (above).

which was aimed squarely at the Jet Ski market. To back up its commitment, Yamaha created a racing tour of its own to showcase the Super Jet—the Prime Hot Water Tour.

Adjusting to the challenge, early last year the IJSBA announced that it would expand its racing program to let Yamaha and other marques into the once-exclusive Jet Ski realm. Not only did this open the door for more Super Jet racing, but it also created new classes for sit-down minijets. The result is that excitement in the racing ranks is now running quite high. Both tours are showcasing all types of personal watercraft racing and both are being televised.

As the racing scene heats up, so does competition for what is undoubtedly the future of personal watercraft—performance machinery. This coming season will see the biggest advances in high-speed technology to date with lots of new offerings from veteran companies and newcomers alike.

Horsepower wars

Now, back to the future. As I said, it's fast, fast, fast. How fast? So fast that it grabs your attention in a big way and holds it. So fast that it pushes the outer edge of the envelope and causes you to beg for more.

One of the most significant of the new breed of hot-rod water vehicles is the WaveBlaster from Yamaha. This, folks, is something completely different. It so closely mimics the ride of a street motorcycle that it's uncanny.

Marketing surveys told Yamaha engineers that buyers were looking for a vehicle that more closely paralleled the motorcycle experience. To achieve that end, Yamaha set about creating a motorcycle for the water, and the WaveBlaster is the very successful result.

Aside from the huge 63-horse 701-cc engine, the big news about the WaveBlaster is its café-racer style seat, which is elevated about 4 in. higher than seats in conventional sit-down craft. The hull is narrower (34.6 in.) and shorter (95.7 in.), too, and it features a clever design that keeps the pump filled with water, even in tight turns.

The net result of these performance modifications is a unique handling phenomenon—each shift in the rider's weight enables the craft to lean sharply into turns like a motorcycle. Now, instead of slipping and sliding through turns, the Blaster pins them like it's riding on a rail. Thanks to the motorcycle-like handling and a big acceleration boost from the torque engine, the WaveBlaster is in a class by itself



The elevated seat on the WaveBlaster (right) contrasts with the conventional Pro VXR (left).

during high-speed, hard-turning slalom runs.

Despite its high-performance breeding, the WaveBlaster (\$5999) is a true sit-down, tandem minijet with a characteristically swift learning curve. It has an aft padded platform for easy reboarding after a fall and for a place to stand when the urge to hot-dog takes hold. Other outstanding features are a new bilge pump system, an improved visibility spout and a stainless-steel 3-blade impeller. It weighs 320 pounds.

The other new water-scorching model introduced by Yamaha this year is the Pro VXR, which is based on Yamaha's previous top-of-the-line machine and comes equipped with the same adrenalin-pumping 63-horse engine found in the WaveBlaster. Length is 109.1 in. Beam is 40.2 in. Weight is 408 pounds. The new Pro VXR (\$5999) is built to compete with the fastest conventional sit-down models and is one of the most exciting new hot-rods on the market.

The empire strikes back

Last year, Kawasaki continued its tradition of being an aggressive market presence by introducing two new vehicles, both powered by a huge 743-cc engine. One was a sit-down model, the Jet Ski 750SS, and the other a stand-up model, the Jet Ski 750SX. Both are machines to be reckoned with in terms of water-scorching performance and handling.

The tandem-riding, sit-down Jet Ski 750SS (\$5999) is eye-wateringly fast and satisfyingly responsive during radical maneuvering. It's 99.2 in. long, 40.2 in. wide, and weighs 375 pounds. As you would expect from a high-performance hull, it allows the pump to operate efficiently at all attitudes, even during tight turns.

The Jet Ski 750SX (\$5049) is a classic stand-up model that's about as forgiving and stable as a stand-up can be.

Particularly gratifying on the 750SX is its low-end punch. Top-end is impressive too, and is limited only by the rider's courage and confidence. The SX is nearly as unique in its own way as the Yamaha WaveBlaster. It's a civil brute that has surprisingly mild manners for cruising, but when someone makes the mistake of hurling a challenge at it, it growls and pounces like the beast it is.

As if 1992's twin 750s weren't enough, Kawasaki upped the ante this year with the introduction of a new 750SS Xi (\$6199). What makes this new sit-down model special is that the monster 743-cc engine has been beefed up by the addition of smoothly machined cylinders, a heavy crank, reinforced pistons and twin carburetors. The tweaking has given the 100-in.-long, 41-in.-wide Xi 75 horses to scald the water. It also includes a rider-adjustable trim system among other trick high-performance features. Weight is 386 pounds.

There's another new Kawasaki model for '93 that's based on the ubiquitous 743-cc engine, the Jet Ski Sport Tourer. Big touring vehicles by Yamaha and Sea-Doo have captured a large slice of the market recently, so Kawasaki decided it was time to play catch-up with the Sport Tourer. This model is a stretch, 3-person watercraft (122 in. long and 47 in. wide) with a difference. What sets it apart is the 70 horses that are developed by the powerful single-carb engine, which will give the cruising set a real kick in the pants.

At one time, it was an unwritten rule in the personal watercraft industry that engines would be tuned so that no stock vehicle would be able to crack the 40-mph barrier off the showroom floor. Why? Well, it seemed like the sensible thing to do at the time. Why break the 40-mph barrier now? Well, times have changed. And when you're having fun, why ask why? **PM**

A NEW VIDEO VISION

BY FRANK VIZARD, Electronics Editor



• As you may have noticed, the consumer electronics industry wants you to do more than just watch broadcasts or tapes on television. Already there have been a host of new technologies that use your TV as the viewing medium: CDTV from Commodore, CD-I from Philips and Photo CD from Kodak. What all these technologies have in common is that they all use compact discs as the audio/video medium.

The latest entry into the CD-ROM (read-only memory) field is the Video Information System (VIS) from Tandy, owner of the Radio Shack retail chain as well as others. Tandy sells the VIS player under its Memorex brand name.

As a system, VIS has two interesting attributes. One is a Save•It cartridge that allows the user to store game scores, preserve electronic bookmarks and store other selected information.

The second is that much of the software uses a Microsoft Windows-type operating system to present information. With the Compton's *Multimedia Encyclopedia*, for example, users can pull down a number of "windows" of data for display on the screen. You can also access sounds, pictures and some rather stilted videos for a variety of entries. The "multimedia" experience, though, is not automatic with each entry. In many instances, you're just reading text off a screen.

For the most part, though, the VIS machine behaves much like a stepped-up version of Commodore's CDTV system. Much of the software

available for VIS, in fact, consists of the same titles that appear in the CDTV catalog. And VIS didn't improve them much either.

As with CDTV, the quality of the software varies. Some of it goes from bad to worse. And spending good money to view three sketchy biographies of only three famous people seems like folly. Give me lots of sketches or one truly in depth.

To be fair, some of the software is good, particularly the titles aimed at children, and there are many of these. On some titles, a child can place the cursor over a word and then hear how it's pronounced. The child can also look up the meaning in a multimedia dictionary that may also provide sound and pictures.

Of course, maybe small children are the only ones who will put up with the long lag time between command and execution of functions. Frankly, the slow processing speed of the VIS machine is startling in an age when inexpensive 286 computers run faster than a speeding bullet. CDTV exhibited the same slowness



Tandy's VIS system (top) has learning titles that children will enjoy.

and fizzled in the marketplace.

The idea here seems to be to bring some computer power into the living room via the TV. For the moment, what you have is a pricey babysitter—list price for the Memorex MD 2500 is \$699. Until the software improves, the computer might prove to be a more cost-effective learning tool.

However, don't write off the product category entirely. Photo CD is probably a winner and CD-I looks like it has lots of potential, especially when it gains full-motion video capability in the near future. Other interesting CD-ROM systems are rumored to be under development as well. And, hey, they all play regular music CDs too. There's definitely a new vision of video coming. It's just a little blurry at the moment.

Long-Lasting Batteries

Move over alkaline batteries, the end may be at hand. Eveready is now offering an AA-size lithium battery in its Energizer line. Lithium batteries last up to three times longer than alkaline batteries. What does this mean in practical terms? Eveready says that in cameras, for example, lithium batteries will produce about 676 flashes out of a camera as opposed to an average of 197 with alkaline. List price for a pack of two AA lithium batteries is \$4.99.

Meanwhile, Duracell now has rechargeable nickel metal-hydride batteries, as opposed to nickel-cadmium, available for camcorders. The difference is that nickel metal-hydride batteries last about 40% longer.

Secondly, nickel metal-hydride

batteries don't have the memory problem associated with nickel-cadmium batteries. The latter tend to remember previous duty cycles and do not discharge completely.

Thirdly, cadmium is harmful to the environment, so its passing won't be missed.

Duracell is working to develop other nickel metal-hydride battery configurations and is seeking to develop standards with Toshiba and Varta, major players in the Japanese and European markets, respectively.

Survival Radio

If you're in the backwoods or out on a boat for an extended period of time, you've probably brought along a radio for company. The problem is that if you run out of batteries, all you're doing is carrying dead weight.

One radio that will always be worth its weight, though, is the AM/FM Solar Dynamo radio from Berk International, an importing firm. While this radio can run on two AA batteries, the great thing about it is that it has other power sources as well.

The top panel of the radio is a solar panel that charges up the battery by using either sunlight or incandescent light. If you're totally in the dark, just use the handcrank to power up—you get about 10 minutes of radio time for every minute you crank. You can also use a DC adapter.

The radio, which measures about 5.5 x 2.5 in. in size, isn't the biggest in the world. However, the tuner section seems to work better than the radio that I normally use even though it's at least 10 times the size of the Solar Dynamo.

There's also something reassuring about knowing you're not battery dependent in an emergency. In its own retro way, the Solar Dynamo is very charming.

List price is \$31.95. The Dynamo can be ordered by mail from Berk International, P.O. Box 5294, Garden Grove, CA 92645. **FM**



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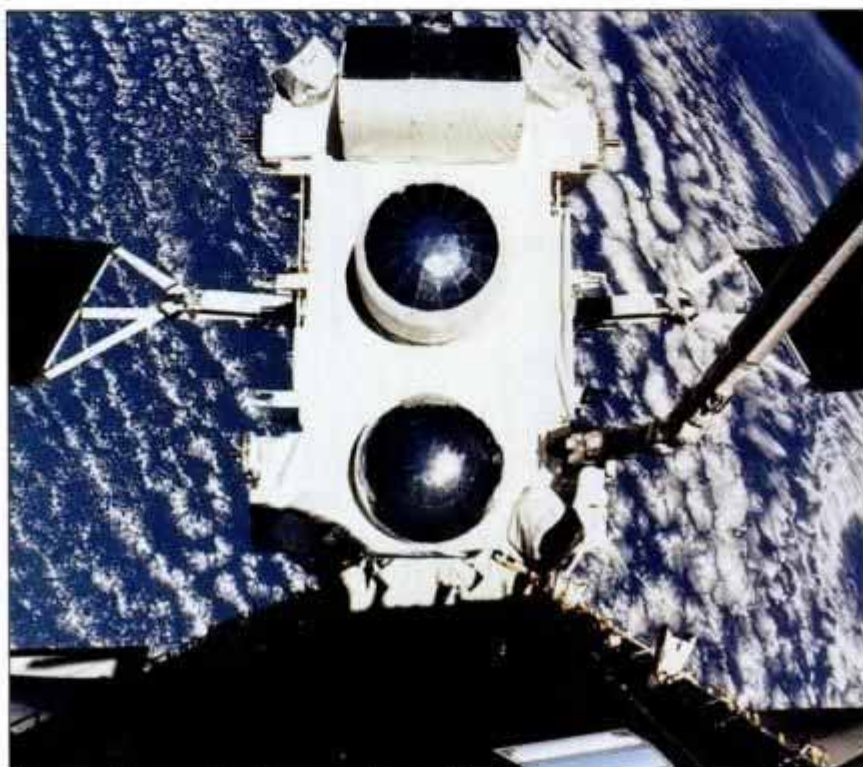
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GAMMA GAZING

BY ABE DANE, Science/Technology Editor

• More than a few astrophysicists probably find themselves secretly wishing that the Arthur Holly Compton Gamma Ray Observatory would just go away. It's not that the huge, \$600-million satellite hasn't done what it was supposed to. On the contrary, it performed so well during its first year and a half in orbit that we gave it a 1992 PM Design & Engineering Award. The thing that's got to be getting a little tedious is the way it keeps turning up totally unexpected phenomena that trash painstakingly developed and otherwise perfectly



satisfactory theories. It's creating a lot of problems for scientists, but also a lot of excitement.

The Gamma Ray Observatory (GRO) was conceived as the second in a series of four powerful astronomy spacecraft that NASA calls the Great Observatories. The program got off to a rocky start with the flawed Hubble Space Telescope, so apprehensions ran high in the spring of 1991 when the final preparations were made for GRO's launch.

But on April 5, the Shuttle *Atlantis* heaved the 35,000-pound satellite aloft without a hitch and almost exactly on schedule. In fact, it was one of the smoothest launches in Shuttle history. There were some tense moments, however, when the time came to deploy the satellite.

More massive than any science payload ever put into space, GRO had to be eased out of the Shuttle's cargo bay in a delicate series of steps expected to stretch over 8 hours. The trouble arose when, as the satellite dangled from the Shuttle's Remote Manipulator arm, its crucial high-gain antenna refused to unfold. Prepared for just such an eventuality, mission specialists Jay Apt and Jerry

L. Ross put on their spacesuits and stepped outside to solve the problem. It was the first NASA spacewalk in five years, but they quickly had the antenna unstuck. From there on, everything went just about as planned.

It's been pretty much that way ever since. With the exception of a couple of malfunctioning data recorders, the satellite has been extraordinarily well behaved for such a dense thick-
et of new and complex technology.



GRO's four instruments cover a broad band of energy levels from 20,000 electron volts to more than 30 billion.

This time, there were no misground mirrors and no jittery solar panels as there had been on Hubble. What's even more extraordinary, however, are the things that GRO has been seeing through its sky-piercing sensors.

Where the wild things are

The reason astronomers have been so eager to scan the sky's gamma-ray emissions is that it is in these screamingly high-frequencies that the most violent objects in the universe show themselves most brightly. Gamma-ray wavelengths are shorter than the breadth of an atom and more

than 10,000 times as energetic as light. They are given off by the nuclear maelstroms at the heart of such furious, galaxy-shaping phenomena as supernovas, quasars, pulsars, and possibly others as yet unknown.

But up 'til now, astronomers have been blind to the whole tumultuous gamma-ray drama, since gamma rays cannot penetrate Earth's atmosphere. Even from the vantage point of orbit, the rays are elusive. Their miniscule wavelengths zip right through most materials without leaving a trace, a fact which accounts for GRO's great bulk. To achieve the desired levels of sensitivity, detectors must contain great hunks of material dense enough to snag an appreciable

number of rays. The resulting interactions cause flashes of light, which are then picked up by photomultiplier tubes and reported back to Earth for analysis.

Each of GRO's four detectors is tuned to a different part of the gamma-ray spectrum. The Burst And Transient Source Experiment (BATSE) handles the low end of the range with a total of eight receivers placed at each of the spacecraft's corners to take in the whole sky at once. The Oriented Scintillation Spectrometer Experiment (OSSE) views the next band up. Its coverage is pretty much overlapped by the Imaging Compton Telescope (COMPTEL), the only one of the instruments that renders its data in the form of pictures. The Energetic Gamma Ray Experiment Telescope (EGRET) peers into the high end of the frequency range.

So far, it's been BATSE that has turned up the most baffling and potentially significant data. On an almost daily basis, its omnidirectional eyes have been recording sudden, and often very intense, flashes of gamma rays lasting anywhere from 1 second to more than a minute. No one knows where these bursts are coming from.

It's not the first time such bursts have been detected. They were actually discovered by accident in the '60s by U.S. Vela satellites looking for violations of the nuclear test ban treaty. The GRO findings deepen the mystery, however, because they undermine the earlier hypothesis that the bursts came from neutron stars. If this were true, GRO would have found the sources of the bursts to be distributed in a pattern fitting within the disc-like plane of our own galaxy. But GRO has found that they originate from all directions, with no discernible pattern at all.

Even more confounding, when GRO has homed in on the sources with COMPTEL and handed off coordinates for examination by other telescopes, they have found nothing unusual about those patches of sky. Theories abound on the nature and distance of the burst sources, but so far it's anybody's guess.

Among the other mysteries GRO has unearthed is a strange object called Geminga. Now thought to be an ancient neutron star, it is visible to EGRET, but not to lower-frequency detectors. Also, quasars, already known for their incredible brightness, appear far brighter in gamma rays. Scientists can't see how all this energy could escape the black holes thought to power the quasars. **PM**

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NASCAR TECH

(Continued from page 45)

You won't see it on race day, even though most of today's teams are using computers in the pits.

Where you see it is on a Tuesday or Wednesday, at a test session. And contrary to NASCAR's beloved image, it's very high-tech indeed.

Testing used to be a very cut-and-try laborious process. That was before James Graves, of Nova Computer Systems based in Nashville, Tennessee. Before Graves, crew chiefs made educated guesses.

Today they know.

Graves supplies teams with computer hardware, but his real forte is software. Properly applied, it can tell a racing team anything it needs to know. To date, 31 teams are using it.

The key is time-savings—a week or even a month of testing in a day.

"We can change seven or eight things on a car all at once," Graves says, "and know that they're all going in the same direction."

Teams use both real-time telemetry, fed to the pits by UHF radio, and on-board data systems that download to the team's computer when the car comes back to the pits. Despite the immediacy of the real-time approach, Graves says it isn't a replacement for the download method, be-

cause it's much more limited in the amount of data the link can convey.

"Our download system can monitor 128 items 200 times per second," he says, "and store 44 minutes worth of data. The system can simultaneously monitor such diverse items as fuel pressure, brake temperature, rear-spoiler angle, tire pressure and shock loads.

"The sensor monitoring is light years ahead of what the best driver can feel. All the driver can tell you is the symptoms. With our system, you know immediately if your upper A-arm is too short or your chassis is flexing in a corner."

Graves also has a strategy management system that teams can use in the pits on race day to track their performance versus the competition, and find out where they're gaining—or losing—ground on the track, information a driver can use when he's chasing the line through corners. Plus it can calculate fuel mileage, tire wear and all the things a crew chief needs to know to make the right decisions.

And despite NASCAR's low-tech approach to the sport, you can bet that crew chiefs on the top teams have graduated from guesswork. So while Winston Cup racing still may not qualify as rocket science, it's a long way from shade-tree mechanics. **PM**



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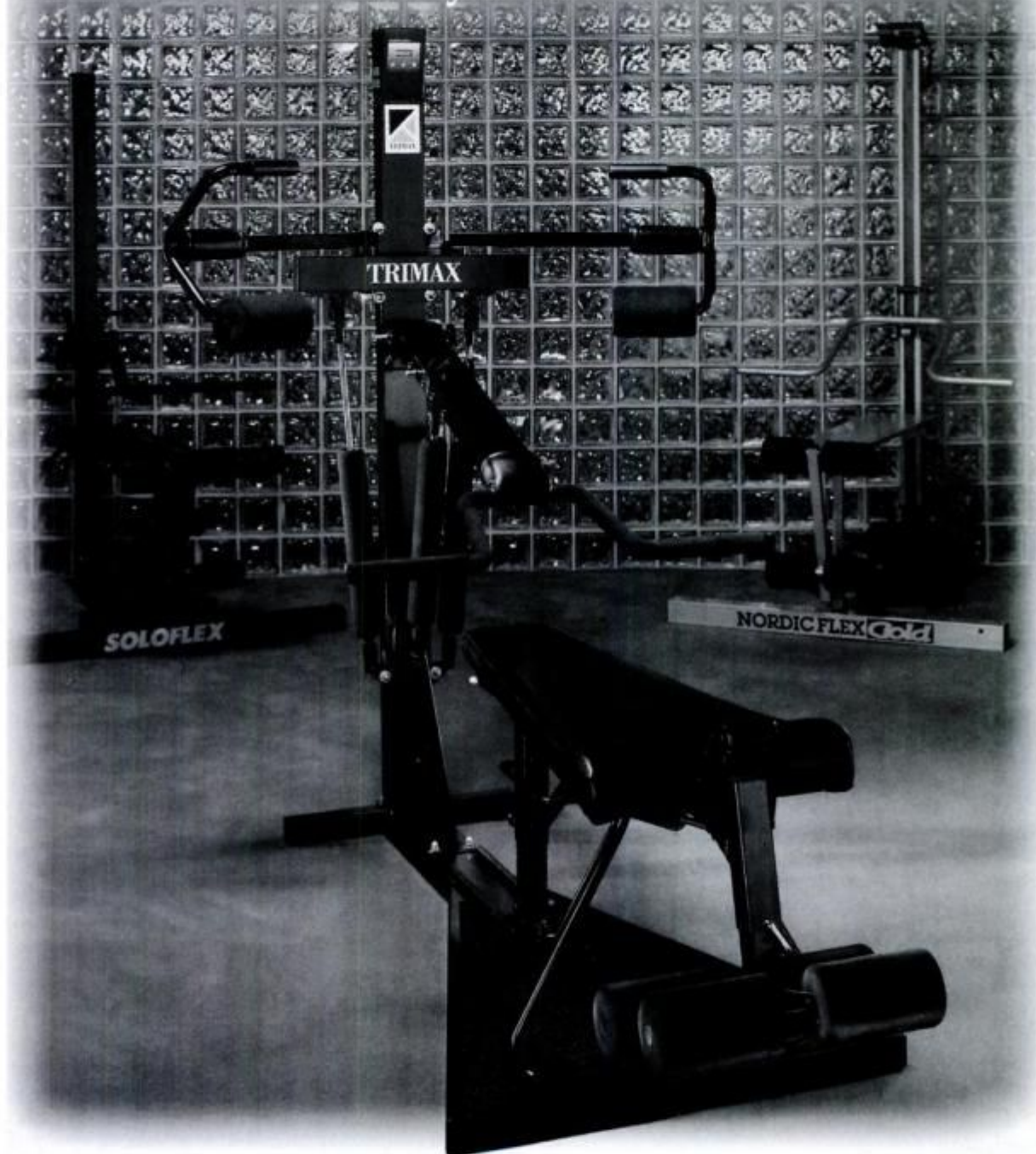
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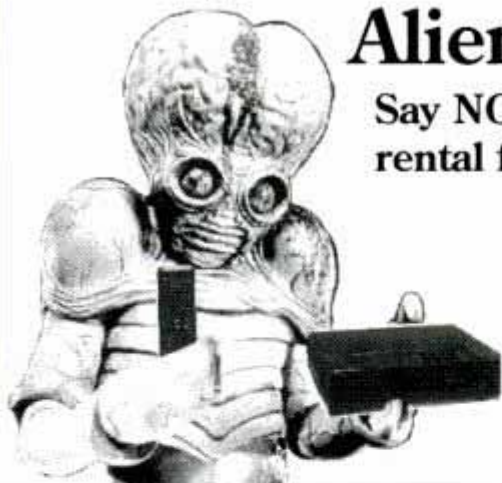
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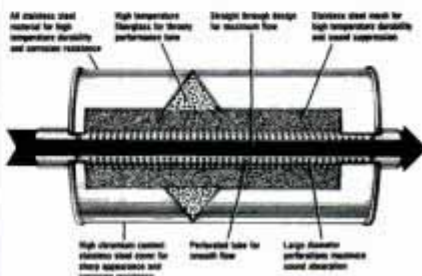
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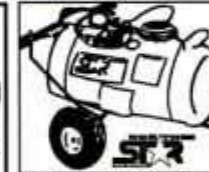
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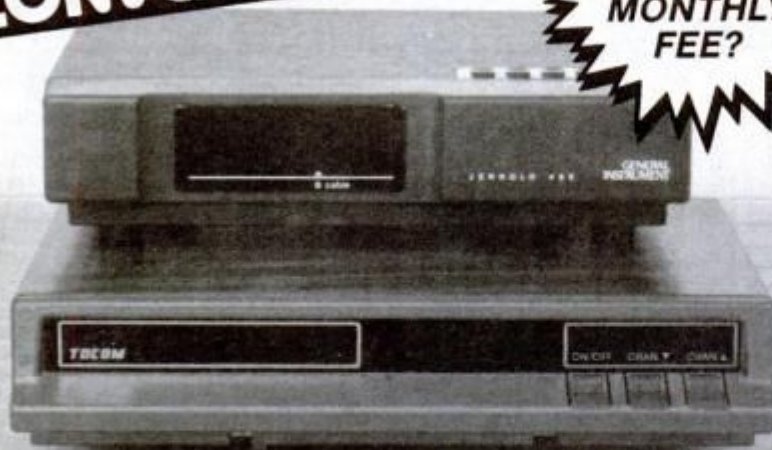
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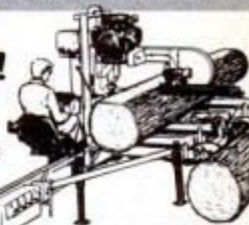
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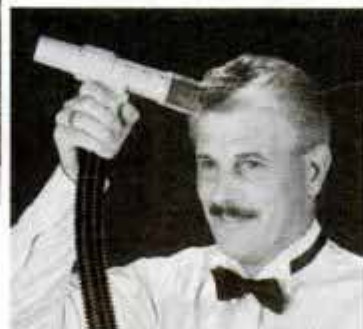
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LeSabre's seatbelts fit federally approved child safety seats.

features, the safety belt system, is also standard.

Put it all together and you have Buick's Total Safety Systems.[™] The culmination of Buick's dedication to your safety. The kind of safety that's

designed in from the start.

For more on LeSabre and Buick safety features, call 1-800-4A-BUICK.



Buick's PASS-Key[®] anti-theft system is vexing to would-be thieves.



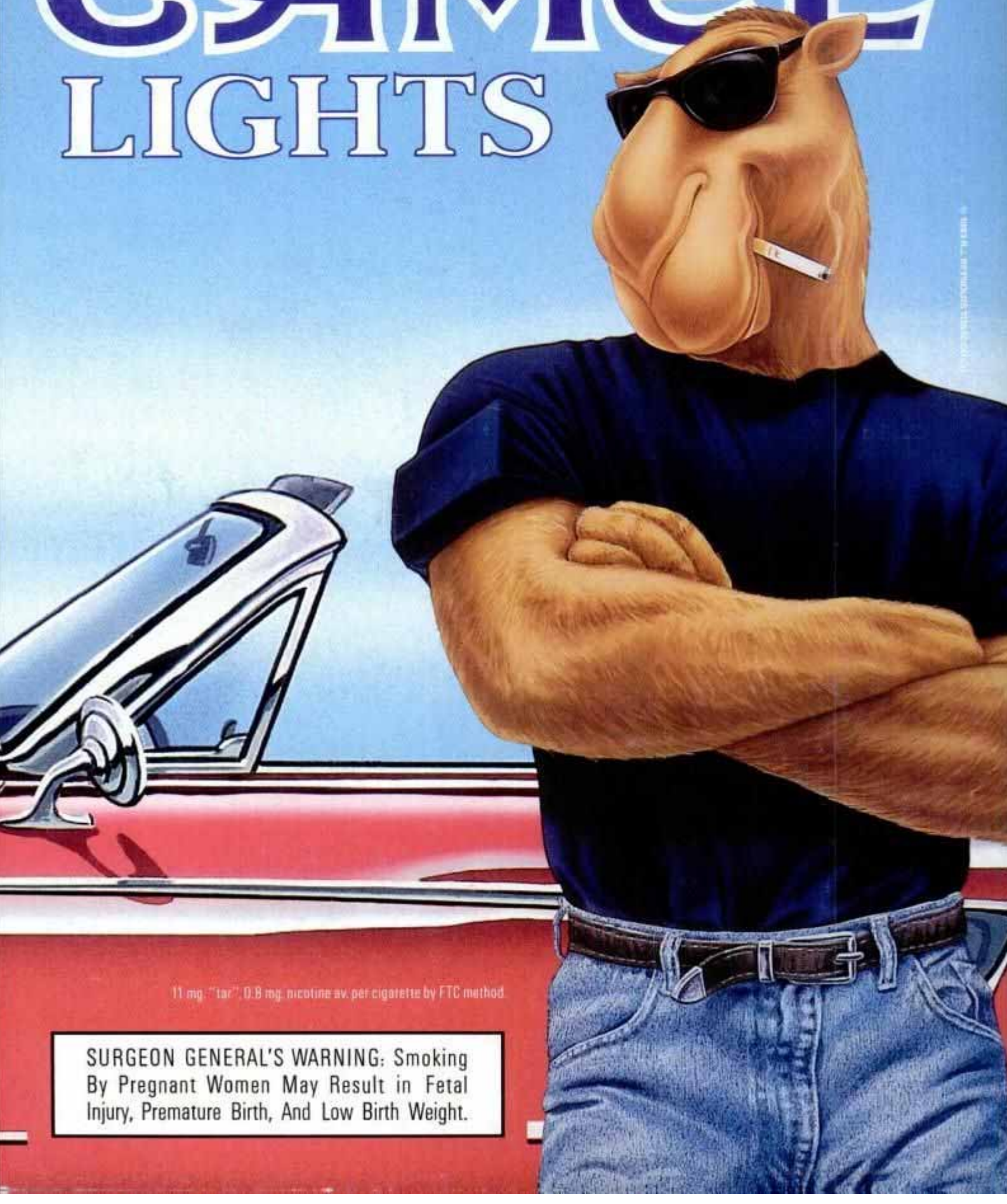
BUICK[®]

The New Symbol For Quality In America.

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CAMEL LIGHTS



11 mg. "tar", 0.8 mg. nicotine av. per cigarette by FTC method.

SURGEON GENERAL'S WARNING: Smoking By Pregnant Women May Result in Fetal Injury, Premature Birth, And Low Birth Weight.