

JULY 1991 \$1.95

# Popular Mechanics

## NEW KILLER CHOPPER

Army's LH Attack Helicopter Packs State-Of-The-Art Electronics And Lethal Firepower



TOP-DOWN FUN TEST  
5 ECONO 4x4s

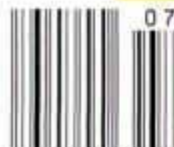
### SPECIAL REPORT

**DREAM HOMES**  
Complete Guide To  
Manufactured Housing

- Easy-To-Build Log Homes
- Post-And-Beam Designs
- Modular Contemporaries
- And Much More

**HEAVY LOAD TO TOW? NO PROBLEM!**  
Our 10-Way Tow Test  
Helps You Pick  
The Right Vehicle

08638



# To Be The Best-Selling Truck, Than Tough.

**BETTER  
VALUE  
RETENTION**

*A Ford F-150 is not only priced less than a comparable Chevy when you buy it,\*\* an independent survey predicts: over the next five years, the Ford will cost less to operate. And, will retain more of its value at trade-in time.\*\*\**

**LOWER  
OPERATING  
COST**



*Ford's exclusive "Touch Drive" system is now available on select F-150 pickups. It lets you switch from 2- to 4-wheel drive High and back, on the fly, at the push of a button. Automatic locking hubs are standard on all F-Series 4x4's and of course, manual hubs are optional at no extra cost.*

**P R N D 2 1**

*Ford's full-size pickups offer an advanced electronic automatic transmission designed for smoother shifting and 25% better highway mileage.\**



Buckle up—together we can save lives.

# You've Got To Be A Lot More

*Inside: F-Series pickups offer comfortable, well-appointed interiors in a wide choice of models. SuperCab shown.*



*Outside: Wide, deep pickup boxes provide big maximum payloads and cargo-handling flexibility that are tough to beat.*

If the truck you buy is going to last for years, it better be more than tough.

That's why Ford keeps making its trucks even more comfortable. The roomy interiors get better appointed, the choice of amenities, wider. And the list of engineering advances

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

grows longer. There are even new models like the sporty Nite Truck.

It's no wonder the competition has found that catching up is considerably more than tough.

*The F-150 Nite Truck: new for '91. Available only in black with special blacked out trim.*



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



"Best-Built" claim based on an average of consumer-reported problems in a series of surveys of all '81-'90 models designed and built in North America. "Best Selling" claim based on full-line sales by division.

\*EPA hwy. estimate 20 mpg. for 1991 E40D vs. 16 mpg. for 1990 C-6 transmission in F-150 4x2 with 4.9L engine.

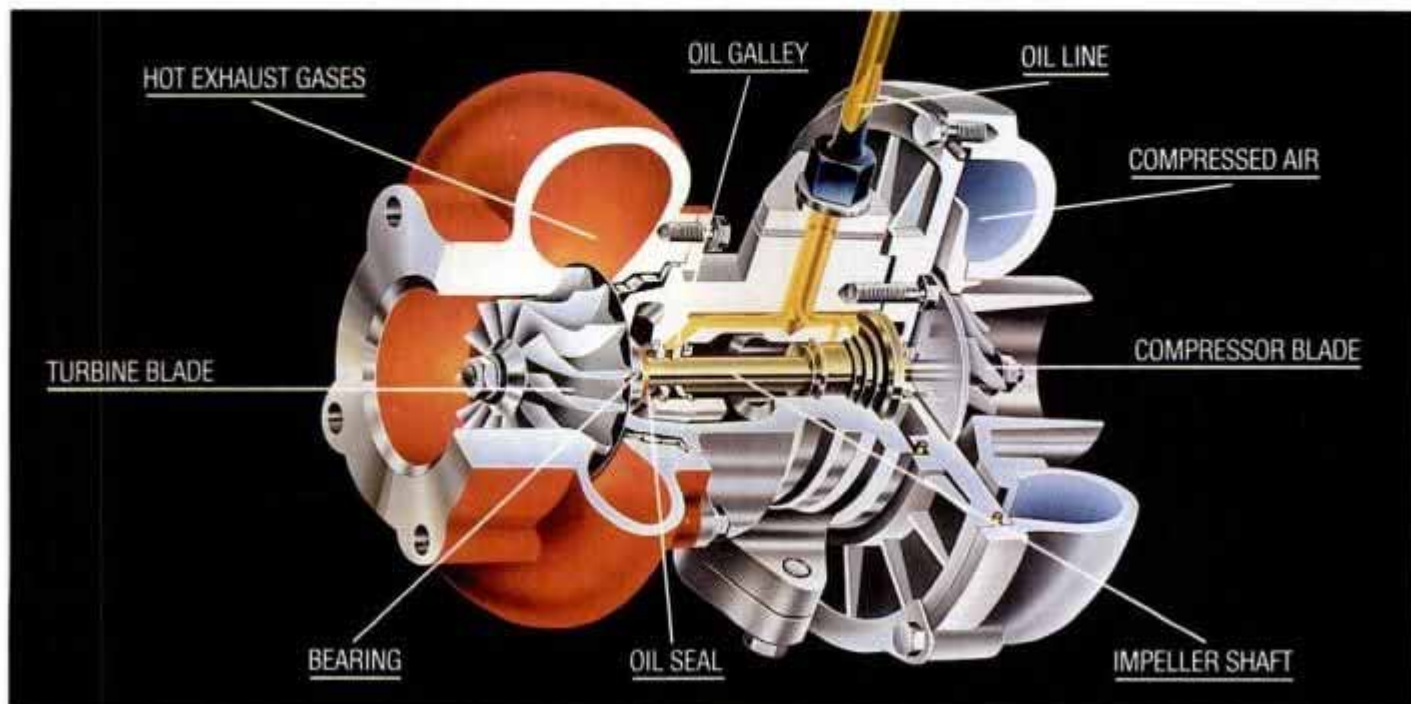
\*\*MSRP Ford F-150 XLT Lariat (auto trans.) vs. comp. equipped Chevy C1500.

\*\*\*The Complete Small Truck Cost Guide, 1991, IntelliChoice, Inc., San Jose, CA. F-150 vs. C1500 base models with selected options and most popular engines. Value retention based on projected 5-year value. Actual operating costs and resale prices may vary.



WXFT-DLR-7X3S

# The hardest chargers in racing.



**B**y compressing the air entering combustion chambers, turbochargers help propel race cars to higher speeds with smaller engines. Likewise they bring street cars high power when needed, and fuel economy when not. Problem is, forces that affect turbochargers — on the track and the street — are truly murderous.

### The 3 enemies of turbochargers.

1. Heat. The devil's own breath — hot exhaust gases emerging from cylinder heads at around 1,600°F — turns the turbine blade that propels the compressor blade along the impeller shaft. (Keep in mind that mild steel melts at 1,300°F.) In Indy cars, where intercoolers are prohibited by CART, there's not much to cool the turbocharger except air and oil.

2. Starting friction. Since turbochargers are made to run hot, it's only logical that they can be creaky when cold. This is especially true since impeller shafts always turn — even at idle. So the bearings along shafts

must have immediate and effective lubrication.

3. Deposits. In a turbocharger, deposits typically take the form of "coking" — the residue of frying oil. (Now, keep in mind here that motor oil enters the inferno of a turbo from the engine, where it's already likely to be hotter than boiling water.) Coking can devastate turbo bearings and oil seals, which in turn can spoil your day.

You may conclude from all this that any motor oil used to lubricate a turbocharged engine had better be high-quality stuff.

### Havoline Formula<sup>3</sup> to the rescue.

New Havoline Formula<sup>3</sup> Motor Oil from Texaco adds more life to your car in three ways: 1. Overall heat is reduced by oil functioning as a coolant. 2. Startup is helped by effectively lubricating bearings and other components. 3. Deposits are inhibited.

This makes Havoline Formula<sup>3</sup> ideal for most cars, including turbocharged race cars. The Formula<sup>3</sup> that

lubricates the Indy-car engines of Mario, Michael, and Jeff Andretti — and that performed so well in this year's 24 Hours of Daytona — is 100% identical to the Formula<sup>3</sup> you can buy off the shelves of Texaco stations or stores.

Because Texaco is competing for your business, we make it our business to learn from competing on the track. That's true of Formula<sup>3</sup> Motor Oil and also of System<sup>3</sup> gasolines, about which racing teaches us lessons in fuel management, combustion, and the control of octane appetite.

So the next time you look at a Texaco race car, consider looking to the Sign of the Star for your automotive needs. We're charging hard to win you as a customer.

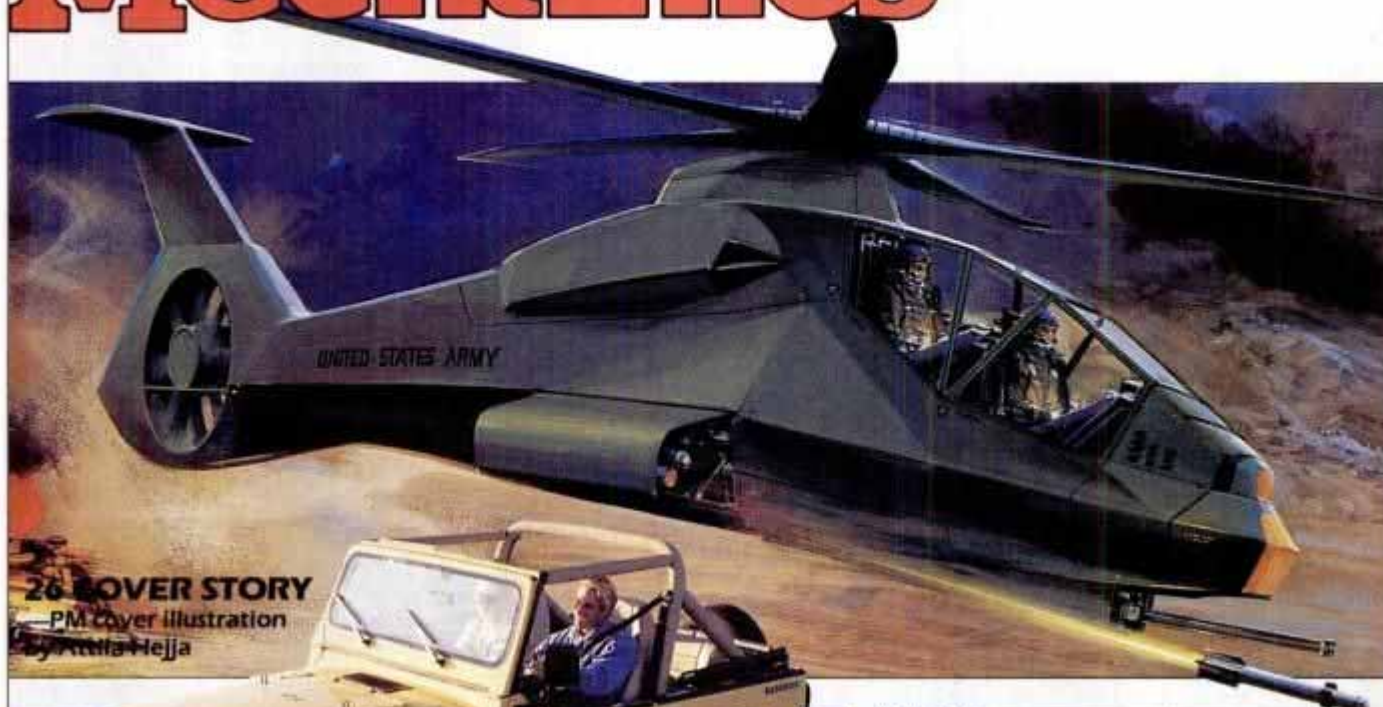


TEXACO SYSTEM<sup>3</sup> AND  
HAVOLINE FORMULA<sup>3</sup>

T E C H N O L O G Y I N M O T I O N

# Popular Mechanics®

JULY 1991  
VOLUME 168  
NO. 7



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—PM cover illustration  
by Anita Hejja



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# EDITOR'S NOTES

● It's one thing to sit in a press conference and listen to engineers rattle on about the technology incorporated into a new-model car. It's quite another thing to experience the new technology firsthand by pushing the car hundreds of miles from the south coast of France, through the French Alps and on to Geneva. That's exactly what I did recently when Mercedes-Benz invited me, and a group of journalists, to try out the new S-class sedans under combat conditions. Hell yes, I was impressed with the cars, as you can see from my report on page 96. But for \$125,000, I expected to be impressed. For \$125,000, you should get the best car in the entire world—and that's just what Mercedes-Benz may have built here. . . . When word got out that the team of Boeing Helicopters and Sikorsky Aircraft had won the Army's \$30-billion contract to build the new Light Helicopter, there was plenty of partying in the boardrooms of those two companies and lots of long faces at the losing team of Bell



Cannes, France, is a great seaside town—sort of like Asbury Park, New Jersey, with a French accent.

Helicopter Textron/McDonnell Douglas Helicopter. But for the winning team, the party might be over pretty quickly. The LH has to play many roles in combat situations and even be invisible to enemy radar, as Science/Technology Editor Abe Dane explains in this month's cover story starting on page 26. However, the most difficult role of all might be meeting cost budgets with no overruns. The Army expects to buy 1292 LHs for \$8.9 million each. And based on the A-12 program cancellation, Boeing/Sikorsky probably won't get a second chance if they go over budget. It will be interesting to watch what happens to the Army's newest toy. . . . Ever dream of building your own home? Many of us have. It's possible, and with today's state-of-the-art manufactured homes, it's more probable than ever. Check out our special report beginning on page 57. . . . And on page 30, you'll find our story on the biggest dinosaur fossils ever found—bones of a dinosaur even bigger than a Diplodocus, previously thought to be the largest creature that ever walked the Earth. It's Seismosaurus, so named because every step it took set off a small earthquake. Well, not really. But Seismosaurus is the biggest thing these days in paleontology. Seismosaurus was so big that when it sat around, it sat around. Okay, okay, I'm outta here. Till next time.

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Joe Oldham

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1983



1984



1985



1986



1987



1988



1989



1990



1991

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Father's Day?**

To send a gift of Crown Royal call 1-800-238-4373. Void where prohibited.

# LETTERS

## Hitting A Homer

Though your April article, "The Mechanics Of A Home Run," was interesting, the simple fact is the pitcher throws the ball and the batter hits it. And if I had to pick a great hitter as a role model, I would pick Ted Williams. He had a lifetime average of .344 with 521 homers. Charley Lau's lifetime average was .255 with 16 home runs.

JOHN WALTERS  
PORTER, IN

Nice touch having it done by Lou Piniella, but something was missing. You overlooked the ball factor in the home-run equation. And you also didn't mention what to do with the bat. One school produces the mighty line drives of a Mantle, Jackson, Garvey and Canseco, while the other produces the towering fly balls of Strawberry.

Strawberry, in using this method, is the only batter to ever have a foul ball clear Shea Stadium behind the batter's box.

RANDY S. MITCHELL  
PALM DESERT, CA

## Fords Forever

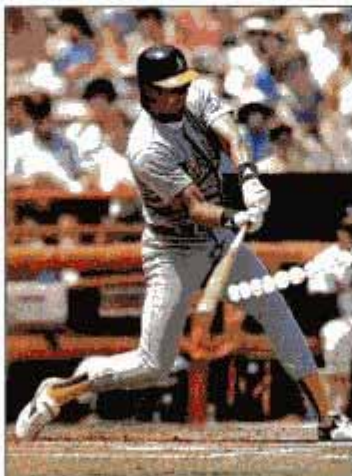
I am confused. You state that "Ford's F-150 not only outsells all other pickups on the road—it outsells absolutely everything on the road: cars, trucks, vans, you name it." Yet, you then refer to the Honda Accord in April's New Cars as "the best-selling car in America." Which is it, the F-150 or the Accord?

BUD WARREN  
GRASS LAKE, MI

*It's really not confusing. The Ford F-150 is the best-selling vehicle of all types in America, including cars. The Honda Accord is the best-selling car.*

*In order of sales, the lineup*

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



*is: 1. Ford full-size pickup (F-series), 2. Chevy full-size pickup (C/K series), 3. Honda Accord.* —Ed.

You said the 1992 Ford Crown Victoria is one of your favorite cars. It was mine also. I even had one on order until I discovered Ford is building them in Mexico. I canceled my order and bought a Cadillac instead. If Ford wants to build them in Mexico, then let Ford sell them to Mexicans. I am now going to purchase a Dodge D-150 instead of a Ford F-150 this weekend.

DONALD TAYLOR  
BRIDGETON, MO

*Who says the Crown Vic is built in Mexico? Actually, it's built in Canada. Some of the components are made in Mexico, but that's true of many cars, not just the Crown Victoria.* —Ed.

## When Worlds Collide

"Saturn Showdown" smacks of commercialism that could have been written by an advertising copywriter. The Saturn may be impressive to PM, but to me it's a carbon copy of what's already available in the GM stable. GM's problem is that it is either



in a rut or governed by blind bats. Why else would it come out with another model with the same turnoffs? If GM, or any other American carmaker, wants to regain a leadership position, it must realize the motoring public wants to spend more time on the road and less time in the repair shop.

JANUS  
ST. JAMES CITY, FL

It's refreshing to see an American car company build and produce a small car the equal of anything Japan can make. I've wanted to buy American for years, but the product just wasn't there. With the Saturn, it is, and I'll buy.

LEO VECCHIONE  
CLIFFWOOD BEACH, NJ

## Memory Lane

"A Gallery Of Great Cars" was interesting and well photographed. After a Cub Scout den meeting in Scotch Plains, New Jersey, during the 1955-56 school year, Drew Campbell's mom drove us home in her new 2-place T-Bird. We must have been packed in like sardines, but I still remember the car and ride 35 years later.

HAROLD M. COOMBS, JR.  
WINNSBORO, SC

## Tape Tip

I have a tip to add to your home improvement tip No. 54 in "65 Great Ways To Improve Your Home." You state that electrician's tape should not be used in conjunction with wirenuts. I have always added a turn of tape around the bottom of the nut and the wire as a safeguard. Because of this, I have received compliments from professional electricians. I have also found that it is handy and safer if tape is wrapped around the body of a switch or receptacle to cover the exposed terminals. It lessens the likelihood of shock if a mistake is made and the line is still hot.

DOUGLAS BECKSTEAD  
ANCHORAGE, AK

## What's New?

Tech Update recently reported about the invention of a new combined starter/alternator. It is not very new. My 1919/1920 Maxwell touring car has a Simms-Huff single unit starter/generator. And to the best of my knowledge, this unit had been in use several years prior to that time. It just goes to prove there is little new under the Sun.

GORDON A. NORBERG  
RIB LAKE, WI

Robert King's invention of a starter/alternator brings back one of my best childhood memories. A unique feature of our old 1925 Dodge Brothers touring car was a silent starter. It was silent because the starter shaft gear was permanently meshed with the camshaft timing chain. It makes me believe that King's starter/alternator is a result of product modification rather than invention.

C.F. ASHMORE  
TUCSON, AZ



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There's a place for chains. And a place for solid steel. At Genie, we believe the only chains in your garage should be on a bicycle. For strength, safety, security and reliability your garage door opener should be screw drive. Ten feet of solid steel that's so strong, so safe, so reliable we can offer the Pro-Tech® ten-year warranty.

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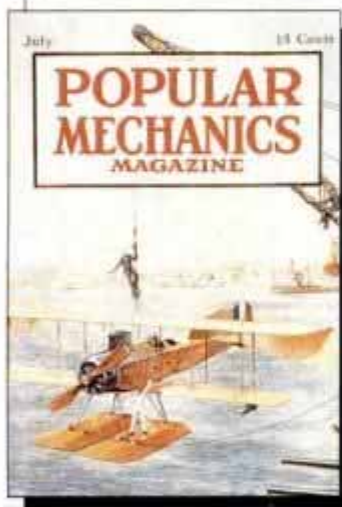
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# TIME MACHINE

75 YEARS AGO: JULY 1916



## Early Seabirds

Naval aviation took off quickly during World War I. Great Britain's Mediterranean fleet, stationed at Salonika, Greece, made good use of flying boats for reconnaissance, bombing runs, even antisubmarine warfare. Cranes lowered and raised the seaplanes off and on battleship decks. Elsewhere, converted merchant marine vessels provided flattops for wheeled aircraft. But the first dedicated aircraft carrier, HMS *Argus*, would enter the fray too late to see any action.



## Litter Gitter

Back in the U.S., cities were fighting a dirty war. Street sweepers couldn't keep up with burgeoning populations, so motorized vacuum

cleaners began inhaling refuse. Meanwhile, other cleaning trucks went door to door, offering to snake long vacuum hoses through building windows.

50 YEARS AGO: JULY 1941



## Spin The Bomber

As World War II unfolded, inventors became obsessed with devising odd schemes to loft heavily laden bombers. The captive-arm centrifugal launcher on our cover was typical. The plane would load on to the free end of the arm and start its engines. A propeller on the arm would lend additional impetus. Around and around she'd go until the plane gained sufficient speed to fly, at which point she was released. Somehow, however, this concept never got off the ground.

## Tanks A Lot

The U.S. Army had seen enough of the devastation wrought in Europe by Germany's panzer divisions. It was clearly time to beef up our own armor numbers. The M3 medium tank, forerunner



to the M4 Sherman, began rolling off assembly lines by the thousand, sporting a 75mm field gun, a 37mm turret-mounted anti-aircraft

gun and several small machine guns. Weighing only 28 tons, the M3 reflected U.S. preferences for light, highly mobile armor.

25 YEARS AGO: JULY 1966



## Down Cold

Testing the limits of human endurance, divers plunged beneath the ice of Antarctica to study Weddell seals, which frolic in the subfreezing water. But gurgling from divers' regulators blurred recordings of the seals' vocal sounds. So acousticians from Woods Hole Oceanographic Institute built a sub-ice observation chamber rigged with microphones. Not mike-shy, the seals responded by providing researchers with a cacophony of whistles, hoots and chirps.

## Fruit Machines

The Green Revolution was in full swing, and mechanized reapers invaded fields, targeting crops that were hard to harvest by any means other than hand labor. New to the farm a quarter-century ago were plum pickers that seize a tree by the trunk and shake it into dropping its yield, and cantaloupe harvesters that comb the fat fruit from the vine. And to loft human orange pickers, double-beam boom trucks began rolling through California's orchards. **PM**



# TECH UPDATE

News Of Tomorrow's Technology Today



BOEING ILLUSTRATION

## To Space And Back In A Single Bound

WASHINGTON, D.C.—With Shuttle flights sporadic and the National Aero-Space Plane (NASP) years away, Strategic Defense Initiative planners say they need a cheap, reusable manned launch vehicle. What's more, it must fly by 1995, at least for suborbital testing. So the SDI Office has asked four aerospace contractors to conceive single-stage-to-orbit (SSTO) vehicles based on existing technologies.

The idea is to truck payloads of 5 or 10 tons into orbit for between \$100 and \$1000 per pound (depending on how often the machine blasts off). Even the high figure is one-tenth of the cost of deployment by Shuttle. The SSTO

vehicle could capitalize on work done under the Advanced Launch Development Program (see page 16) and the NASP effort.

Predictably, concepts aired so far reflect each contractor's forté. Boeing has proposed a titanium-skinned winged spaceplane, operated like a commercial jetliner. Meanwhile, Shuttle manufacturer Rockwell has proposed a vertical-takeoff, horizontal-landing spacecraft. Rocketeers at both McDonnell Douglas and General Dynamics want to build vertical-takeoff vehicles that

Editor: Abe Dine  
Assistant Editor: Greg Pope  
Contributors: Oliver Futz, Mike Filon,  
Michael Lamm, Kathy Wolsard

return tail first, firing their engines to cushion landing.

SDI's decision may come as early as this summer.

**Boeing's horizontal-takeoff, horizontal-landing spaceplane is one idea for SDI's low-cost launch vehicle.**

### Highlights This Month

- **Flame Tamers**—The battle to quench Kuwait's oil inferno.
- **Gas Gauges**—Army's new gear to outfox chemical agents.
- **Heavy Liftoff**—NASA's coming megarockets take shape.
- **Jumbo's Big Brothers**—Plane builders eye future jets that will dwarf the 747.
- **Popular Micromechanics**—Japan's bid to commercialize tiny machines.
- **Good Vibrations**—Technology to take the chop out of choppers.

## Optical Neural-Net

IPSWICH, ENGLAND—Two technologies promise to revolutionize computing: optical processing, with speed and energy savings, and neural networks, with unique problem-solving abilities. So why not combine them?

Researchers at British Telecom (the U.K.'s phone company) have done just that, creating a simple optical neural-net. Beams of laser light replace the electronic interconnections that characterize a neural network.

Passing between arrays of diodes, light streams through a photorefractive

crystal containing a hologram. The hologram's pattern can be adjusted continuously to "teach" the neural-



Optical neural-net does 10 million calculations per second on a fraction of a watt.

net to solve a problem, such as face recognition. The system learns much faster than electronic equivalents.

FLARECRAFT CORP. PHOTO



## Flarecraft Are Here

WESTPORT, CT—The ground-effect craft that we detailed two years ago (see "License To Fly," page 57, July '89) has now debuted in the U.S. boat market.

Flarecraft 370, built by a subsidiary of Deutsche Aerospace, cruises at 72 miles per hour on a cushion of air compressed beneath its reverse dihedral wing. The ground effect enhances the vehicle's lift-to-drag ratio, squeezing a 280-mile range from 10 gallons of fuel. Minimum speed

Flarecraft skims above water surface during debut at Miami International Boat Show.

for ground effect is 42 mph.

Because drag climbs steeply with altitude, the Flarecraft can't fly more than a few feet in the air. This places it in the jurisdiction of the Coast Guard, rather than the FAA, so no pilot's license is required.

Flarecraft Corp. plans future models, including an 8-passenger commuter.

BRITISH TELECOM PHOTO

## Army Gears Up To Shut Down N.B.C. Threat

ABERDEEN, MD—How vulnerable were our troops to unconventional warfare during Operation Desert Storm? Although we'll never know exactly, the Army is making remote detection of nuclear, biological and chemical (N.B.C.) agents a priority.

At Aberdeen Proving Ground, recon researchers are testing the XM21, a portable detection and alarm system that can spot vapor clouds up to 3.8 miles away. The sensor, a Michelson in-



Fuchs N.B.C. recon vehicle (above), an amphibious 6-wheeler, is outfitted with detection gear. XM21 (below) identifies remote toxins from their infrared signature.



- MASS SPECTROMETER
- GPS POSITION/LOCATION SYSTEM
- GRENADE LAUNCHER
- CHEMICAL-AGENT DETECTOR
- ENGINE AIR INTAKE
- RADIATION DETECTOR
- MARKING SET
- AIR SAMPLE VACUUM HOSE
- SWIM PROPELLER
- SURFACE SAMPLING WHEEL

terferometer, scans infrared radiation, for the spectral signatures of toxic agents. By the mid-1990s, the XM21 should be installed in combat vehicles, vans and shelters.

Meanwhile, Army divisions in Saudi Arabia used about 60 Fuchs N.B.C. reconnaissance vehicles donated by the German government. Soldiers prefer the vehicles over the Army's old chemical recon machine, an M113 variant, because the Fuchs'

overpressure air system allows them to operate without MOPP-level 4 protective suits. They also needn't leave the vehicle, which is festooned with external samplers. The Fuchs carries its own mass spectrometer, enabling instant identification of suspicious agents.

General Dynamics and German manufacturer Thyssen Henschel will begin producing a U.S. version, the Fox, in 1994.

U.S. ARMY PHOTO



PM ILLUSTRATION BY ADOLPH E. BROTMAN; GENERAL DYNAMICS PHOTO



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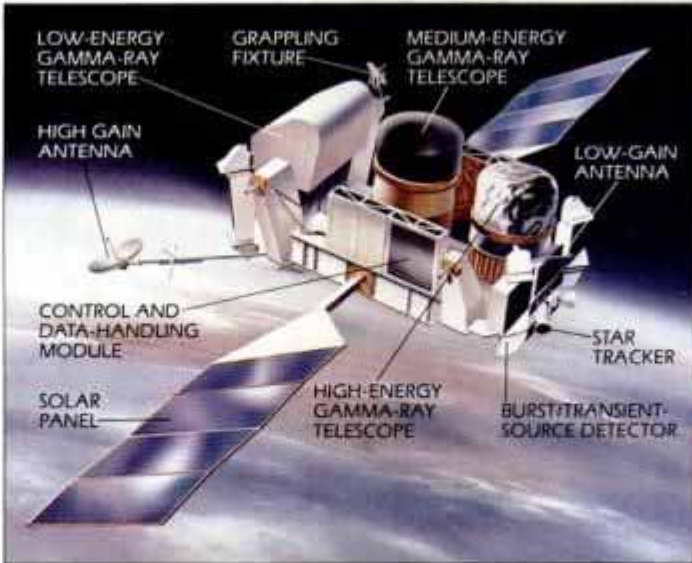
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## Probing Cosmic Powerhouses

GREENBELT, MD—Last April, Space Shuttle *Atlantis* deployed a monster telescope to peer at the true monsters of the universe: black holes, supernovae, neutron stars, quasars and other sources of gamma rays.

At 17 tons, the weight of a fully loaded tractor-trailer, the Gamma-Ray Observatory, or GRO (see "Eyes On The Universe," page 72, March '90), is the heaviest unmanned NASA spacecraft yet launched. It's also the first designed for in-orbit refueling, although NASA doesn't currently plan on extending GRO's mission beyond two years.

Three 6-ton instruments



TRW ILLUSTRATION AND PHOTO

Launched in April, GRO should begin sending back data from its three 6-ton instruments by mid May.

will detect gamma rays of different energies. Meanwhile, eight smaller detectors will monitor the sky for sudden

gamma-ray bursts and alert the other devices to these phenomena.

The observatory should

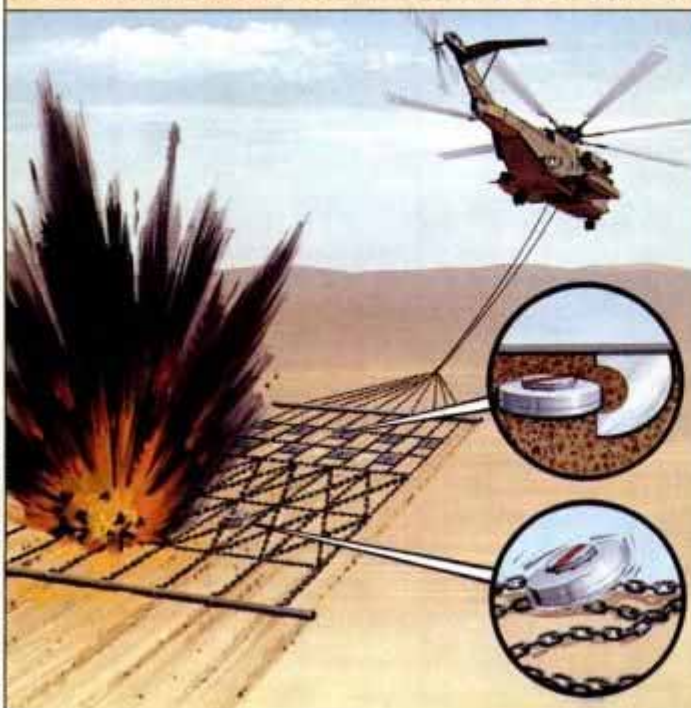
help visualize cosmic cataclysms like matter/antimatter collisions and stellar explosions.

## New Hellfighters Battle Mother Of All Infernos

BURGAN OIL FIELD, KUWAIT—Retreating Iraqi soldiers left a bitter farewell in the sands of Kuwait: thousands of buried land mines and hundreds of blazing oilwells. Cleanup will take all-out efforts by the Houston-based firefighters Red Adair, Inc., Wild Well Control and Boots & Coots. But scores of entrepreneurs, eager to try out new techniques, want a



Dozer-pushed Athey wagon clears wreckage and delivers explosives as hose cools debris.



piece of the action, too.

For example, to clear minefields, San Francisco inventor Bill Wattenburg has built a 30 x 40-ft. helicopter-towed chain blanket, toothed with harrow blades. The Army is testing it at Yuma Proving Ground. Meanwhile, the Kuwaitis have suggested using air cannons to sandblast swaths through minefields.

But to tame the oilwell fires, say the Houston firefighters, the old ways are the best ways. A boom crane, attached to a vehicle called an Athey wagon, first yanks hot metal debris from the well. The same boom then lowers

**Pulled by helicopter, Wattenburg chain blanket first churns up mines with harrow blades, then jostles them into exploding on chains.**

an explosive charge onto the wellhead. The detonation snuffs the fire by whisking oxygen from the well. Meanwhile, another boom pierces the well pipe with a stinger nozzle, through which mud flows to gum up the oil.

Boots & Coots has adapted this technique to let the crane cap the well with a tube into which liquid nitrogen coolant is pumped. And a Colorado engineering firm has suggested smothering flames by lowering 100-ton concrete domes over wellheads. A pipe protruding from the dome would then shunt the gushing oil into tankers.

Since it's estimated that the fires may burn for more than a year, there may be enough time to try many new methods.

PM ILLUSTRATIONS BY ED VALIGURSKY



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## New Heavy-Lifters Called For

WASHINGTON, D.C.—A new breed of unmanned heavy-lift space boosters is needed to cut the Shuttle's workload, concludes the Advisory Committee on the Future of the U.S. Space Program.

The big liquid-fueled rockets would combine existing Shuttle hardware with technology now emerging from the Advanced Launch Development Program (ALDP), jointly run by NASA and the Air Force.

A reusable engine/avionics module is one key component, at least as envisioned by ALDP contractor Boeing. After powering a launch, the unit would jettison and parachute into the sea, to be rescued and refurbished. At-sea recovery trials with a half-scale mockup are showing

Boeing tests recoverable propulsion module (left). Above, one concept of heavy-lift launches.

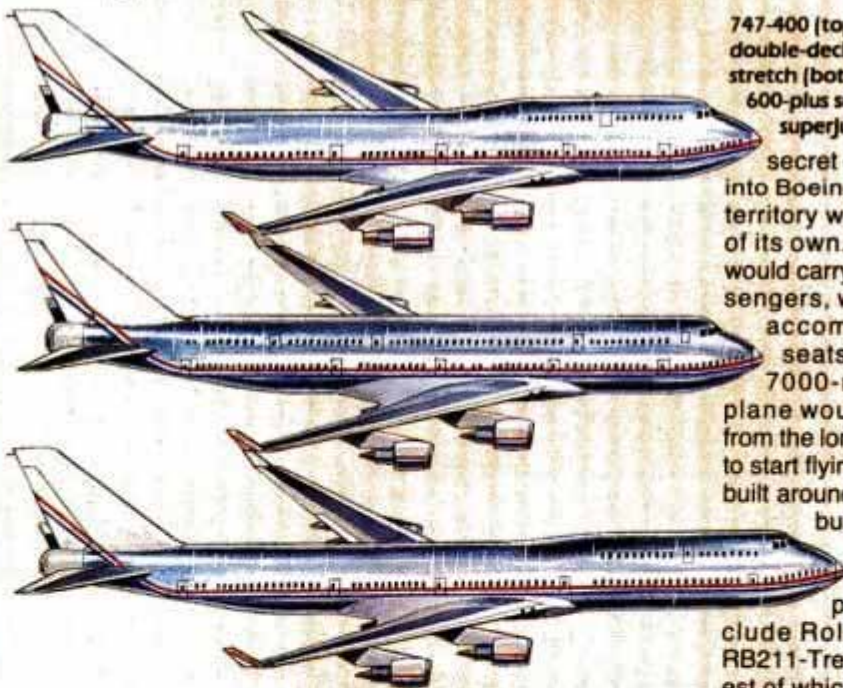
that splashdown wouldn't harm unprotected engines, Boeing says. But whether the rockets will go off in time to help hoist Space Station Freedom remains uncertain.

## Jetmakers Ready For A Growth Spurt

NEW YORK, NY—Air travel growth forecasts tell a troubling story: While more and more people want to fly, airport capacity won't grow to meet the demand, and stifling congestion looms. One way out of the bind is to fit more people in each plane. Superjumbos are beginning to make economic sense and may spark a new rivalry between jetmakers.

Widebody leader Boeing, which can barely crank out its new 747-400s fast enough, is already studying options to retain its jumbo-jet hegemony. Easiest would be to stretch the 747-400, adding extra double-deck fuselage before the wing and more single-deck to the rear. That would provide 70 or 80 more passenger seats.

Alternatively, Boeing designers have considered



747-400 (top) would go all double-decker (middle) or stretch (bottom) to evolve into 600-plus seater. Airbus superjumbo is below left.

secret of its desire to cut into Boeing's high-capacity territory with a superjumbo of its own. Such an animal would carry at least 600 passengers, with the option of accommodating 800 seats or reaching to a 7000-mile range. The plane would either evolve from the long-haul A340, due to start flying next year, or be built around two existing Airbus widebody fuselages put side by side. Powerplant possibilities include Rolls-Royce's new RB211-Trent jets, the strongest of which delivers 84,000 pounds of thrust.

Airbus says that if commercial carriers show enough interest, it would start building the big jet in 1997 for service entry in 2002. Boeing is less specific. But both manufacturers are counting on the Pacific Rim nations to generate the passenger pressure that will justify building big jets.

extending the double-deck clear back to the tail, adding between 125 and 170 seats. Not willing to tip its hand, Boeing also says it might simply develop an entirely new plane if it gauges positive market support.

Key ingredients in any of these variations could include a bigger wing, such as that now being built for the 747-400 freighter, and new engines, such as the new 86,000-pound-thrust GE-90 powerplant, slated for Boeing's twin-jet 777.

Meanwhile, European consortium Airbus has made no



AIRBUS ILLUSTRATION, PM ILLUSTRATIONS BY FRED WOLFF

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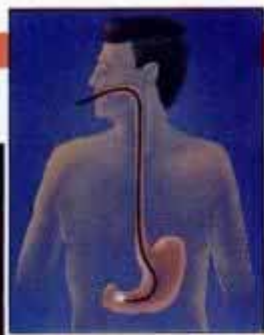
TOKYO, JAPAN—A surgical catheter brandishing an assortment of micromotor-driven instruments is one goal of the latest 10-year technology program by Japan's Ministry of International Trade and Industry.

The tip of the 1/5-in.-dia. device would have fiberoptic headlights and ports for microsurgical tools. Microactuators at each segment of the catheter would flex the tube to help it snake easily through the di-

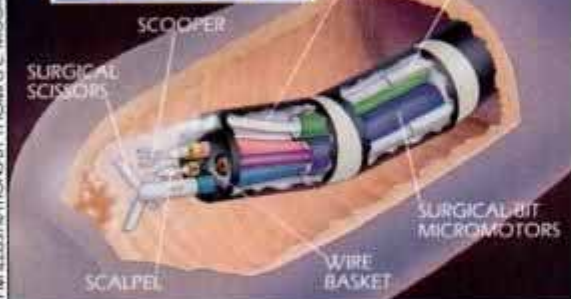
**Surgical catheter would adjust its shape with microactuators to ease passage through anatomical tubes.**

gestive tract. The surgeon would slip the machine down a patient's throat, then teleoperate via an external terminal. Tiny cameras would document the surgery illuminated by the headlights.

An electrostatic micromanipulator that's small enough to grab a blood cell or bacterium has already been fabricated at the University of California at Berkeley. Yet, while Japan lags the United States in micromachine research, Japanese industrial corporations are showing more interest in the results than U.S. companies.



PM ILLUSTRATIONS BY THOMAS C. MOORE

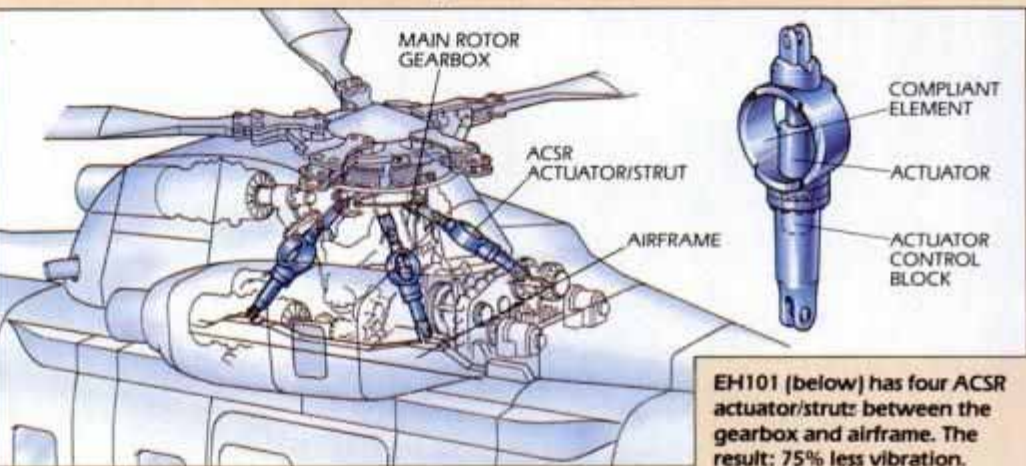


## New Tech Shakes Off Helicopter Vibrations

NEW YORK, NY—If helicopters didn't vibrate so much, they'd spend less time in the shop and ride far more comfortably. Yet up to now, they have been inescapably shaky, because as the aircraft moves forward, each rotor blade leaves turbulence in its wake to rattle the next blade. Since passive dampers don't solve the problem, engineers are turning to active electronic canceling techniques that squelch helicopter vibration at the flip of a switch.

One example is installed in the EH101, a big 3-engine transport helicopter under co-development by Great Britain's Westland Helicopters and Italy's Agusta. The system is called active control of structural response (ACSR).

Four ACSR struts run between the main rotor gearbox and the airframe. Driven by data from accelerometers



**EH101 (below) has four ACSR actuator/strut: between the gearbox and airframe. The result: 75% less vibration.**

and rotor-speed sensors, a piezoelectric actuator rapidly stretches and relaxes each strut to cancel out vibrations transmitted through the gearbox. Airframe vibrations related to the blade-passing frequency—a major component of helicopter shakes—drop by 75% on average, flight testers report.

Meanwhile, Massachu-

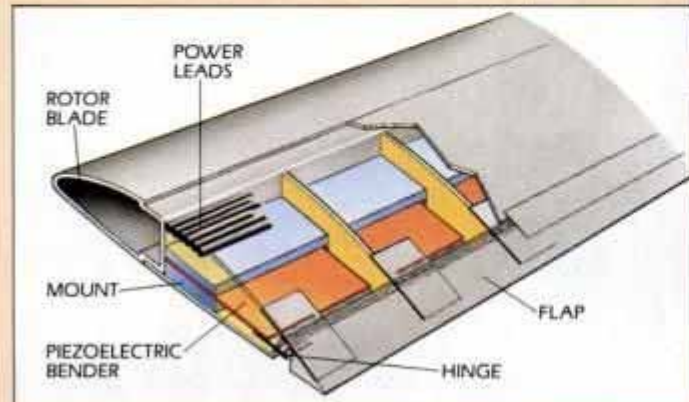


setts Institute of Technology aeronautics professor Steven Hall is experimenting with a system to address the problem at its source: the rotor blade itself. Working with a scale-model of a Boeing CH-47 Chinook, he has fitted flaps on the trailing edge of each rotor blade.

The flaps move up and down to compensate for changes in lift caused by tur-

bulence from other blades and airspeed changes as the blades rotate in forward flight. To control the flaps, piezoelectric sheets inside the blade expand and contract in response to signals from sensors.

How durable such devices prove over the long haul will determine their effectiveness in helping helicopters shake off their jittery image. **TU**



**Experimental system under development at MIT calms main rotor shakes with piezoelectrics connected to a trailing-edge flap.**

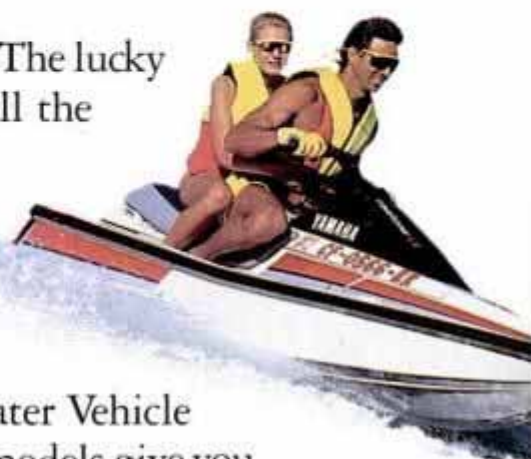
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# BEACH BANDITS



SUZUKI SIDEKICK JX

Surf's up! Sun's out! Tops down!  
We beach-test five 4wd ragtops.

BY RICK TITUS, West Coast Editor  
PM Photos by Mike Gaspar

• While there are loads of sport/utility vehicles to choose from these days, not many of them are designed just for fun. In fact, if your idea of sport/utility fun includes a folding top, there's just a bare half-dozen.

At a glance, this might seem to make the business of selection simpler than in other automotive areas. But when we rounded up five of these sports cars for the dirt, we learned that the choice isn't as simple as it appears. Each vehicle had its strengths, each had its weaknesses, and, with the obvious exception of a set of near-identical twins, each had its own personality.

## BEACH BANDITS



ISUZU AMIGO XS

Stir price disparities into this mix, and you wind up with a comparison that's difficult to call.

The evaluation began with our normal battery of instrumented tests—minus the skidpad, which we consider irrelevant with vehicles of this type—followed by a day of cruising California back roads and two days at the Pismo Beach recreational vehicle area. Since we don't regard these vehicles as real hardcore mountain goats—with the possible exception of the Jeep Wrangler—we didn't include any boulder-hopping.

Instead, we assessed this fleet in terms of how they're likely to be used—primarily as weekend toys, with the understanding that for at least a fair percentage of their potential owners they'd also serve as all-around transportation. Since their 4wd capabilities proved to be similar, we weighted our evaluation in favor of civilizing qualities—ride comfort, amenities and all-around driveability.

### Isuzu Amigo XS

Our first choice is the Isuzu Amigo. Clearly the most carlike in terms of

ride comfort and function, the Isuzu proved to be the most civilized in freeway commuting and city driving. This was due in part to its size. Weighing 3265 pounds, with the second largest interior volume in the fleet, the Amigo acts more like a car than a sport/utility vehicle.

Build quality was another of the Amigo's strong points. Fit and finish was up to automobile standards, and interior materials were high quality—all of which is reflected in the Isuzu's price tag.

The Amigo's soft-top was the easiest to use in this group, though that's not saying much here—they're *all* tricky to operate. But the tailgate is something else again. The rear window base has to be unsnapped along the rear gate and around both corners, then partially unzipped up both sides. Then you have to release the rear tire rack and swing it out of the way before you can open the gate.

In concept, this tailgate arrangement is much like the others, but in practice, it was the hardest to use.

The only other weakness that cropped up in the Amigo was the lack of steady-state pulling power on long hills. It was here that the Amigo's weight proved to be more than its 120 hp and 146 ft.-lb. of torque could handle without downshifting.

Part of the problem here was the



GEO TRACKER LSI





**JEEP WRANGLER S**

Amigo's optional (larger) 31x10.5 R15 LT MS Goodyear tires, which altered the final drive ratio. But, when we put the Amigo in the sand dunes, the big Goodyears quickly earned our respect with their excellent performance.

If the Amigo had just a bit more grunt, it would have been the walk-away winner in this comparison. But its combination of tepid highway cruising power and hefty price kept the voting close. Even so, this is the best all-around beach bandit going—a solid value in a very competitive class.

### **Geo Tracker/ Suzuki Sidekick**

Just behind the Amigo we wound up with a sort of subgroup composed of the Geo Tracker, Suzuki Sidekick and Daihatsu Rocky. This isn't really surprising since two of the vehicles share the same platform, and the third is nearly identical in design, construction and appearance.

In point order, it was the Geo Tracker, Suzuki Sidekick and Daihatsu Rocky. Oddly enough, despite being equipped with the same engine and tires, the Geo Tracker was a tenth of a second faster 0 to 60 mph, .3 mph faster in the quarter-mile, and pulled almost a half-mile more per gallon in the fuel-economy loop than its twin brother from Suzuki Sidekick.

The differences were most likely a function of how the engines were broken in, since both vehicles had nearly 4500 miles on them.

Besides their puppy-in-the-window looks (so cute you just have to take one home), the other Tracker/Sidekick strong points are interior finish and appointments. The brightly colored cloth seats, which provide surprising lateral support and comfort, and nicely detailed dashboards give the small interiors a sense of warmth, good planning and value.

Like the Amigo, power is not a

strong point, though the Tracker/Sidekick gearing is well chosen to make the most of it, particularly for off-road use. Both handled the tricky ups and downs of the Pismo dunes easily, and if there's anything to choose between them it's in their 4wd systems. The Tracker had automatic locking front hubs, the Sidekick's were manual.

Perhaps the least endearing quality of this twosome was ride quality. Short wheelbase and a suspension setup that's stiff enough for off-road driving add up to a choppy freeway



**DAIHATSU ROCKY SX**

## SPECIFICATIONS AND DIMENSIONS

MANUFACTURER/ MODEL	BASE PRICE/ PRICE AS TESTED	ENGINE/ DISPLACEMENT (ci/cc)	ENGINE HP, NET/ TORQUE (ft.-lb.)	ENGINE/ DRIVE LAYOUT	TRANS- MISSION TYPE	WHEEL- BASE/LENGTH (in.)	WIDTH/ HEIGHT (in.)	MIN. GROUND CLEARANCE (in.)	TRACK FRONT/REAR (in.)	CURB WEIGHT (lb.)
<b>Daihatsu Rocky SX</b>	\$10,321/ \$11,612	L4 SOHC 16V 97.0/1590	94 @ 5700 rpm/ 94 @ 3200 rpm	front/ rear, 4wd <sup>1</sup>	5-speed manual	85.6/ 148.2	68.5/ 67.7	8.1	57.9/57.9	2778
<b>Geo Tracker LSi</b>	\$11,995/ \$13,613	L4 SOHC 97.0/1590	80 @ 5400 rpm/ 94 @ 3000 rpm	front/ rear, 4wd <sup>1</sup>	5-speed manual	86.6/ 142.5	64.2/ 66.5	7.9	54.9/55.1	2238
<b>Isuzu Amigo XS</b>	\$13,599/ \$15,674	L4 SOHC 156.2/2559	120 @ 5000 rpm/ 146 @ 2600 rpm	front/ rear, 4wd <sup>1</sup>	5-speed manual	91.7/ 164.2	70.1/ 65.7	9.3	58.9/59.1	3265
<b>Jeep Wrangler S</b>	\$9910/ \$11,752	L4 OHV 150.4/2457	123 @ 5250 rpm/ 139 @ 3250 rpm	front rear, 4wd <sup>1</sup>	5-speed manual	93.4/ 153.0	66.0/ 72.0	9.7	58.0/58.0	2935
<b>Suzuki Sidekick JX</b>	\$10,299/ \$12,271	L4 SOHC 97.0/1590	80 @ 5400 rpm/ 94 @ 3000 rpm	front/ rear, 4wd <sup>1</sup>	5-speed manual	86.6/ 142.5	64.2/ 66.5	7.9	54.9/55.1	2370

1. Part-time 4wd system. 2. Times from a steady-state 40 to 70 mph. 3. Best speed achieved while weaving through eight cones placed in line, 100 ft. apart.

### Popular Mechanics Serviceability Index

● Sharp-eyed readers will notice an all-new entry in our data charts this month, both in this test and in our towing test (pages 40-41).

It's the POPULAR MECHANICS Serviceability Index, designed to provide a quick read on ease of routine maintenance tasks. Points are awarded for:

- Easy-to-read dipsticks, reservoirs.
- Dipsticks that can be used without burning your fingers.
- Air cleaners replaceable without removing other components.
- Oil filters accessible from above.
- Oil filter/drain plug design that channels oil directly to the drain pan.
- Fuseboxes easily found and reached.
- Fuseboxes clearly marked for function and rating, with spares and fuse-puller.
- Spark plugs clearly visible and readily removable.
- Spark plug replacement with warm engine.
- Self-tensioning drivebelts.
- Drivebelt ease of change.

We award a maximum of one point in each category, for a potential total of 12.

—Mike Allen



ISUZU  
AMIGO XS



DAIHATSU  
ROCKY SX

ride, particularly on sections of freeway crosshatched with expansion joints and pockmarked with potholes. We found enough freeway of this description to form a good basis for comparison. More than enough.

But the Tracker/Sidekick designers put their chips on off-road competence when they made their ride/handling choices, and we applaud this decision. They may look like toys, but these two 4wd minis can hold their own when the pavement ends.

### Daihatsu Rocky SX

A relative newcomer to this segment, the Rocky proved to be a very respectable contender, one that definitely merits a look-see for anyone who finds himself particularly attracted to the Tracker and Sidekick.

A little more macho in looks, the Rocky is a bit more stark inside, though quite comfortable. It's also im-

pressively well built, a quality we've noticed in other Daihatsu products.

Besides its construction, the Rocky's strongest suit is ride comfort, which was a pleasant surprise. Despite having the shortest wheelbase in the group, the Daihatsu's suspension absorbed shock and highway sine wave very well. We rated its all-around comfort second only to the substantially bigger Amigo.

The Rocky's engine is weak on the bottom end of the rpm range, but once it begins to breathe, the little 1.6-liter 4-cylinder pulls impressive midrange figures. In our 40-to-70-mph passing tests, it grabbed fastest time by a full 2 seconds, which translates nicely for highway use.

It is in fact the highway the Rocky likes best. Compliant ride, good steady-state performance and the lowest price-as-tested figure in the group add up to make the Rocky an effective blend of day-to-day pluggger and spare-time sportster.

### Jeep Wrangler S

Although it's not easy to tell at a glance, the Jeep has come a long way since it emerged from the storm clouds of World War II. That's because most of the changes—continuous chassis and drivetrain improvements—are out of sight. Jeep has deliberately preserved the tough Yankee character of this all-American invention—which is at best a mixed blessing.

On the down side, this includes a level of comfort and convenience that is crude, particularly in contrast to the Wrangler's imitators. Seating is marginal, top-up wind roar is deafening, and removing or erecting the top is an exercise that requires patience,



ISUZU AMIGO XS

## TEST RESULTS

STEERING TYPE/TURNS LOCK-TO-LOCK	TURNING CIRCLE (ft.)	BRAKE SYSTEM FRONT/REAR	FUEL ECONOMY (MPG EPA city/hwy.) PM test	ACCELERATION 0-60 MPH (sec.) 1/4-MILE (sec. @ mph)	PASSING <sup>1</sup> ACCELERATION 40-70 MPH (sec.)	BRAKING 60-0 MPH (ft.)	700-FT. <sup>2</sup> SLALOM MPH	EPA INTERIOR VOLUME (cu. ft.)	PM <sup>4</sup> SERVICEABILITY INDEX
Pwr. recirc. ball/ 3.0	37.0	F: 10.9-in. vented disc/ R: 10.0-in. drum	23/23 21.4	14.4 18.9 @ 67.0	12.8	155	50.1	86.3	8
Pwr. recirc. ball/ 3.8	32.2	F: 11.4-in. vented disc/ R: 8.6-in. drum	25/27 28.0	15.0 19.5 @ 64.7	16.9	148	53.1	87.0	9
Pwr. recirc. ball/ 3.6	33.5	F: 10.1-in. vented disc/ R: 10.4-in. disc	18/22 20.3	14.3 19.2 @ 67.5	15.9	154	51.8	91.6	9
Pwr. recirc. ball/ 3.6	32.9	F: 11.2-in. vented disc/ R: 9.0-in. drum	18/20 17.9	13.6 18.9 @ 68.7	16.4	159	53.1	92.8	11 1/2
Pwr. recirc. ball/ 3.8	35.4	F: 11.4-in. vented disc/ R: 8.6-in. drum	25/27 27.6	15.1 19.5 @ 64.7	16.8	148	53.0	87.0	9

Speeds provide index of transient response. 4. Based on 12 basic maintenance functions.



SUZUKI  
SIDEKICK JX



GEO  
TRACKER LSI



JEEP  
WRANGLER S

practice and a little bit of help.

We also think there's a little too much WWII left in the Wrangler's ride quality, compared to the rest of our test group. Though it has the longest wheelbase in this quintet, the Wrangler is simply too stiff for comfort on the street.

Our initial impressions of the Jeep's handling were also negative, until we became accustomed to its steering, which overreacts to initial input. Once committed to a turn, however, the feeling of stability comes back.

The fix from an engineering point of view would be to slow the steering ratio in the first few degrees of wheel movement; that is, variable ratio steering. The fix from a driver's point of view is to use smaller steering inputs for initial turn-in. Once we'd mastered this trick, we found the Jeep to be reasonably nimble, as shown in the slalom test.

On the plus side, the Jeep's interior is roomy and also the easiest to get at for cleaning—important when you've spent a couple of days charging around in sand and surf. And if it lacks sophistication versus the other beach bandits, it's also designed and built to take more punishment.

The Jeep's 2.5-liter Four provides plenty of torque, though its acceleration numbers are hampered by stump-pulling gear ratios. And if you want more muscle, you can order your Wrangler with Jeep's 180-hp 4.0-liter straight Six, still one of the best powerplants in the sport/utility market. Only the Jeep offers the option of more power.

On the one hand, the Wrangler is the least carlike of these vehicles. But on the other, it's the best qualified for really tough off-road use. So in a sense, the granddaddy of this class—a vehicle wrapped in legend, with its

own following—is in a class by itself. We can understand Jeep's reluctance to dilute that kind of panache.

## Postscripts

As is true of all vehicle categories, picking the beach bandit that's right for you entails some compromises. In our view, the Isuzu Amigo's combination of roominess, comfort and all-around usefulness makes it the best compromise as an everyday vehicle, as well as a weekend off-road ride.

With this general compromise in mind, the Sidekick, Tracker and Rocky are better left to younger drivers, who tend to prioritize jauntiness and fun ahead of comfort. As for the Jeep, if your concept of beach extends to desert dry lakes and surrounding mountains, this is one tough old soldier, likely to survive such use.

However, we do want to add one other note regarding compromises. All of these vehicles were designed with at least some off-road use in mind, producing consequent effects on handling. With their relatively high ground clearances and tallish aspect ratios (track versus height), these vehicles don't handle like street cars. They're really much more like light trucks.

But does that make them, as some publications have suggested, inherently dangerous? No. We reject this ill-informed notion entirely. For someone accustomed strictly to regular passenger cars, driving a sport/utility vehicle involves a period of adjustment. This is particularly true for younger drivers, whose excessive enthusiasm is more likely to put them into situations that are beyond their limited experience. But all that's really required is ordinary prudence. **PM**



## Dodge Dakota Convertible

● Although everyone loved the idea of the Dodge Dakota convertible when it came along a couple years back, not enough of us loved it for Dodge to continue it as a production option.

However, ASC, the firm that engi-

neered its convertibilization, still thinks it's a good idea, and will build ragtop versions of any regular cab Dakota model. It can be ordered through Dodge dealers for a suggested retail of \$3200 over the price of the truck.—Tony Swan



# THE ARMY'S NEWEST KILLER CHOPPER

Lightweight, agile and invisible to radar, the Army's LH will live and fight with frontline troops.

● Flying 500 miles into a moonless night, eight AH-64 Apaches follow the Tapline Road, then wind between the canyonlike walls of the desert wadis, stealing into Iraq. Lumbering along with the quick attack choppers are a Chinook for medivac and extra fuel, and a huge MH-53 Pave Low borrowed from the Special Operations Command for its precise navigation equipment. They have 20 minutes to knock out the Ground-Controlled Intercept Station ahead.

BY ABE DANE,  
Science/Technology Editor  
PM Illustration by John Berkey

Success will clear the path to Baghdad for the opening air strikes of Operation Desert Storm. Failure will leave a deadly network of radar-guided missiles and interceptor aircraft to wreak havoc on allied attack planes now preparing for that first plunge.

Infrared gun camera footage

shows what happened next. Popping up out of the ground clutter, the Apaches put their laser designators on target and launch Hellfire anti-tank missiles. Radar technicians running for cover are visible as warm spots on the screen as the missiles punch into the site's buildings one by one. A spray of 30mm cannon fire and Hydra rockets completes the devastation. Hovering 2 to 4 miles away, the Apaches assess the damage, making sure the Soviet-built Flat Face and Spoon Rest



radars are out of commission, then they withdraw into the night to begin the long flight home.

### Lessons of success

Ironically, this mission shows a glaring flaw in present-day Army aviation. The Apaches that carried out the raid are tank killers, heavily armored and relatively easy-to-detect aircraft designed to slug it out in a pitched battle, not to infiltrate deep behind enemy lines. The large support helicopters they required for the long-distance trek added to their vulnerability. Had conditions been a little worse, or the opposition a little more determined, the bold gambit might not have come off.

Unfortunately, nothing else in the Army inventory was up to the job. Antiquated Cobra gunships lack the sensors for night work, and the rest of the Army's Vietnam-era

fleet of light helicopters is fit for little more than scout duty.

### Enter the LH

Acquiring a machine to overcome this weakness is the Army's No. 1 priority. Over the past decade, it has sought to fill the gap through a series of technology initiatives culminating in a program it calls the LH, or Light Helicopter. This April, the program bore fruit in the form of a stealthy, all-composite aircraft with flying and fighting capabilities that may revolutionize Army tactics.

The new LH design was born of a 6-year competition between two contractor teams, spurred on by the promise of \$30 billion for the winner. Boeing and Sikorsky led a team proposing a sleek, lizardlike craft with missile racks that fold into the fuselage to enhance stealth. McDonnell Douglas teamed with Bell

to put forward a manta-ray-shaped vehicle, characterized by a sharp NOTAR (no tail rotor) tail and fixed, stub wings for weapons.

Both designs met, and in many respects exceeded, the Army's requirements. But the Boeing/Sikorsky team got the nod, largely because an extraordinarily well laid-out design made it easier to operate and maintain.

### Eyes of the Army

But the true measure of a combat aircraft comes in how well it carries out its mission. The LH, now known by the operational title RAH-66 Comanche, will earn its keep primarily as what the Army calls an armed reconnaissance helicopter. Maj. Gen. Rudolph Ostovich, commander of the Army Aviation Center at Fort Rucker, Alabama, and chairman of the board that evaluated the LH contenders, told PM how the

# KILLER CHOPPER



Comanche will play the role.

In the hours before battle, a commander's desire for information about the enemy becomes ravenous. The normal intelligence map, peppered with battalion and company symbols, is no longer enough. "When you're going to go bust somebody up, you want to know precisely where is that ZSU-23-4? Where is that SA-6 system?" Ostovich says. Then there is no substitute for helicopter reconnaissance.

Today, this risky work is carried out by unarmed OH-58 Kiowa Scouts flying close to the ground to avoid detection. Protection comes from the guns of an AH-1 Cobra flying overwatch a short distance back.

Much of the Comanche's reason for being is that it can fly such missions alone, without anyone riding shot-

gun. This capability arises from a design that is both inherently hard to detect and capable in combat.

## Built on a beam

The helicopter's strength comes from a composite box beam running up its center like a backbone. Shrouding the exterior is a tough composite hide formulated to absorb radar signals and shaped to deflect what it cannot absorb. Total radar cross-section is about 1% of that for previous light helicopters.

Because the Comanche's skin plays no structural role, anti-aircraft fire can pass right through it without weakening the airframe. The skin can also be divided up into as many access panels as needed to make life easy for maintenance crews. Under battle

conditions, for example, three soldiers at a forward area refueling point can refuel and rearm the helicopter in less than 13 minutes.

The heart of the Comanche's flying performance beats in twin LHTEC-T800 engines developed for the LH by Garrett and Allison. These 33-in.-long, 300-pound turbines crank out 1200 horsepower each, driving the aircraft to a top speed of 203 mph—8 mph better than the Army asked for.

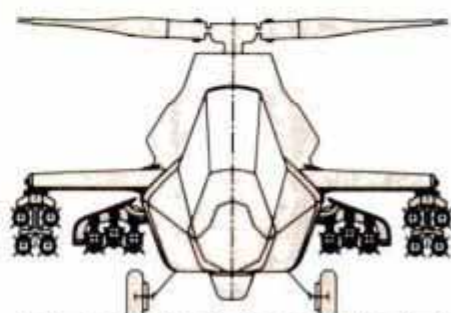
To avoid attracting heat-seeking missiles, the engines channel their exhaust through a system that mixes it with cool air sucked in through openings on top of the tail boom. Ejected through narrow slots along the boom's sides, the escaping gases are too cool for anti-aircraft missiles to lock onto. Stealth in the audible frequency range is achieved by enclosing the anti-torque fan in the vertical tail and by using a main rotor with five blades to reduce tip speed.



**Armed reconnaissance:** Four Hellfires, two Stingers hit targets of opportunity.



**Self deployment:** Drop tanks provide 1260-mile range, with two Stingers.



**Heavy attack:** Add-on wings make room for a full loadout of 14 Hellfires.



FAN-IN-FIN  
ANTI-TORQUE  
SYSTEM

### Looking for trouble

For reconnaissance, however, seeing is more important than not being seen. That's where the most advanced technology on the Comanche comes in. Two sets of sensors are housed in independently rotating turrets on the nose. Aimed by magnetic head position sensors and viewed through wide-angle helmet-mounted displays, these provide enhanced vision wherever the crewmen look.

Flying from the front seat, the pilot uses a second-generation forward-looking infrared sensor mounted in the top turret to guide the aircraft at night. The lower turret contains a more complex sensor suite used by the copilot/gunner.

Prior to a typical engagement, the helicopter would rise above the tree line for a few seconds, allowing the target acquisition sensors to automat-



Mockup (above) provides a preview of Boeing/Sikorsky's stealthy design.

ically scan their full field of view, then return to cover. While the pilot repositions for an attack, the copilot/gunner uses his aided target detection and classification system to analyze the sensor data. By matching infrared signatures with a preprogrammed library, the computerized system recognizes specific types of threats, providing the gunner with a prioritized list of targets. He then configures the helicopter's systems for the appropriate weaponry, and opens the retractable weapons bays.

When all is ready, the pilot maneuvers into the open. Twin sidearm controllers linked to a fly-by-wire control system aid him in dodging threats, while the gunner places the target in the crosshairs of his helmet-mounted display and pulls the trigger.

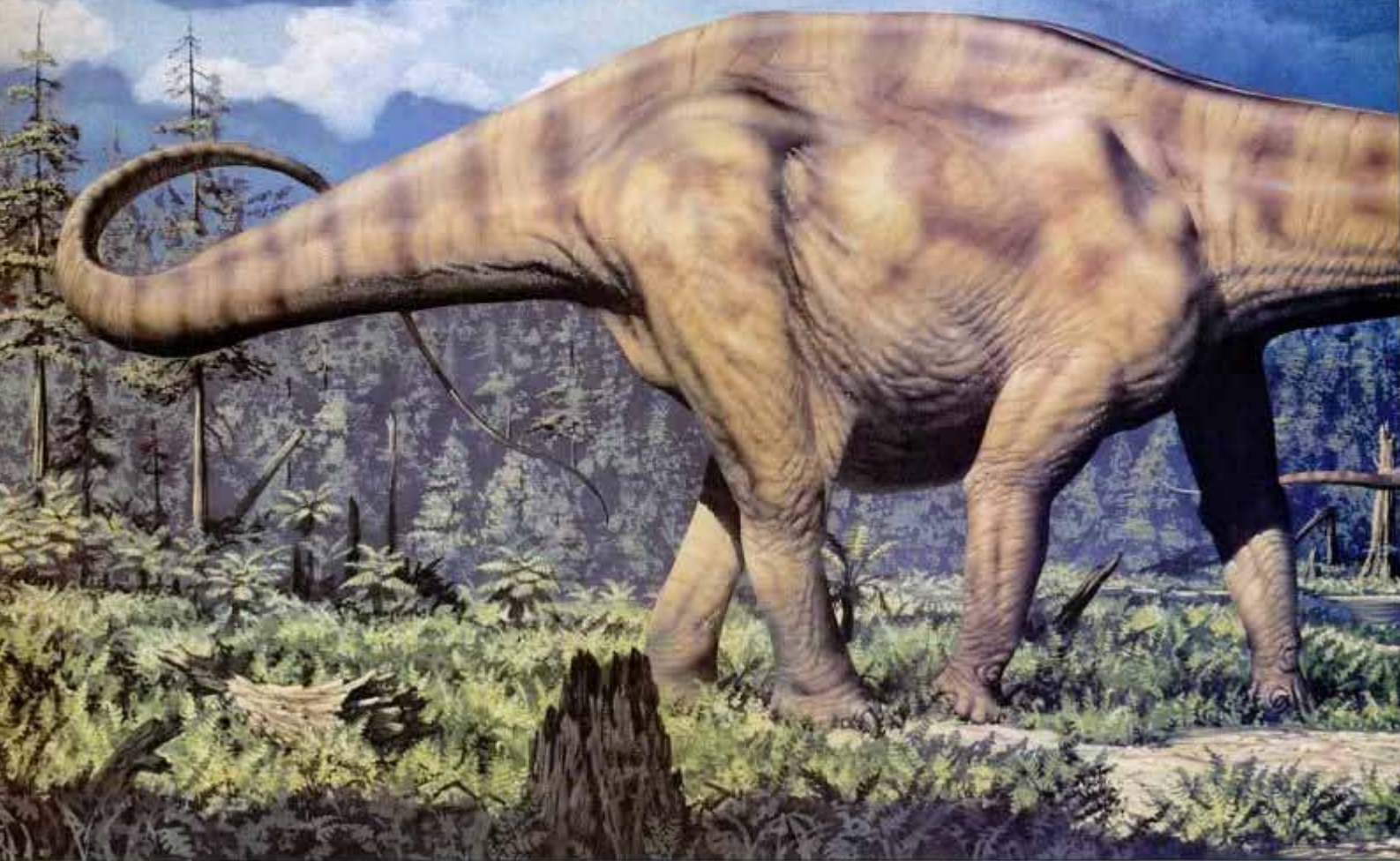
The variety of weapons the Comanche can carry gives an indication of its

**Twin multifunction displays augment helmet-mounted displays for night navigation and targeting.**

many missions. In its armed reconnaissance mode, four Hellfire anti-tank and four Stinger anti-aircraft missiles can be stowed in the retractable bays. As America's first helicopter designed for air-to-air combat, the Comanche may also go into battle with as many as 12 Stingers in the bays. For ground assaults, external weapons winglets may be clipped on in a 20-minute procedure that compromises stealth, but adds space for eight additional Hellfires. A lightweight, 2-barrel gatling gun slaved to the pilot's helmet spits out up to 1500 rounds of 20mm ammo a minute in close-in confrontations.

This gives just a glimpse of the abilities built into a design so complex that it filled a 45-ft. trailer with paper. Nine years after the first LH studies began, Ostovich seems pleased with the new weapon, which should begin entering the Army inventory in 1995. "It's a testimony to the research power resident in the American R&D centers," he says. "We've got the thinking power in the U.S., and that's the real leverage." **PM**





# THE HUNT FOR

Scientists are using the technology of tomorrow to uncover the past in their search for the largest animal that ever walked the Earth.

● In 1979, two hikers were approaching the lip of a mesa northwest of Albuquerque, New Mexico. Astonishment stopped them in their tracks. Protruding from the russet sandstone were the vertebrae of a giant. Wind and water had scoured the rock from the tailbones of a dinosaur that had once browsed through giant conifers 154 million years ago.

Six years passed before David Gillette, then curator of paleontology at the New Mexico Museum of Natural History, excavated the bones. "It took about a year of lab work," he recalls, "until I was confident that the dinosaur was not only new to New Mexico, it was new to science—and the largest dinosaur ever found."

Dubbing the monster *Seismosaurus* (earthquake lizard), Gillette

BY GREGORY T. POPE

gauged its length at around 120 ft.—23 ft. longer than its closest relative, the placid *Diplodocus*. But to find the rest of the skeleton and confirm that record length (now estimated to be closer to 140 ft.), he'd mobilize technology never before mustered in the cause of paleontology.

## Out of the Stone Age

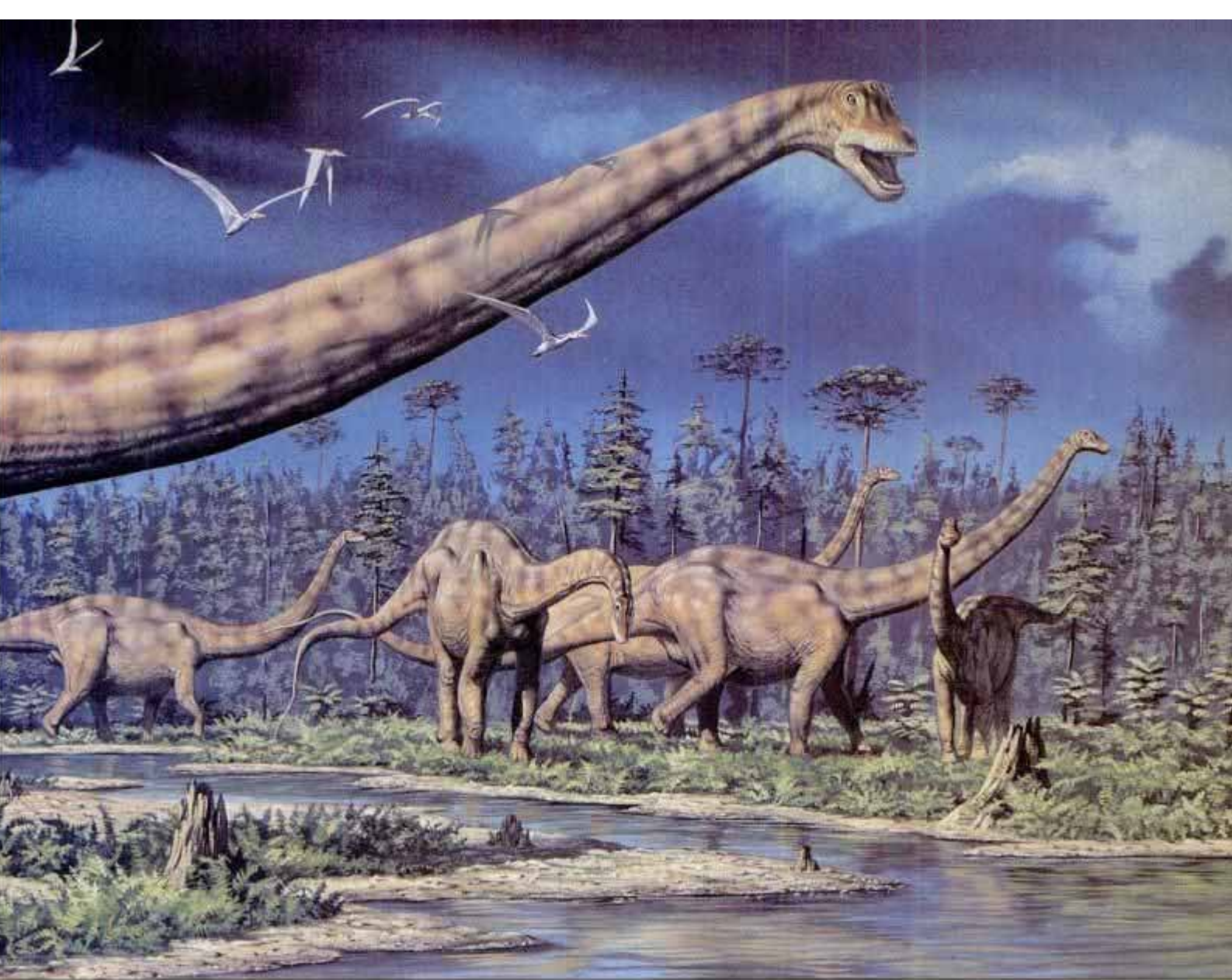
The equipment of the fossil hunter has been frozen in time since the 1870s, when the bitter rivals Edward Drinker Cope and O. C. Marsh raced each other to the dinosaur graveyards of Colorado and packed bones into Union Pacific boxcars for the long journey back East. The geological hammer, cold chisel, punch, bolster

and brush remain the tools of the trade.

But the search for *Seismosaurus* has quickly updated the paleontologist's toolbox. The gigantic skeleton has become a proving ground for leading-edge remote-sensing technologies like magnetometry, gamma-ray spectrometry, ground-penetrating radar and acoustic tomography. Tailored for bulky manmade artifacts like forgotten gas lines and buried toxic waste, these techniques are being refined to unprecedented acuity in the *Seismosaurus* hunt. And in the process, they are fast-forwarding paleontology into the 21st century.

Why the need for high-tech help? For one thing, most dinosaur skeletons are scattered across huge areas. Unable to peer into the ground and narrow the search, excavators could





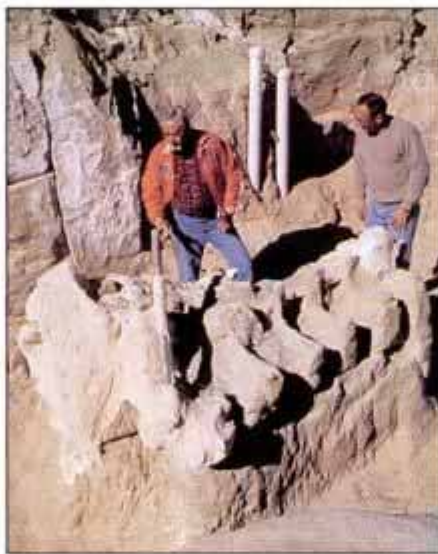
# SEISMOSAURUS

spend decades picking through an area twice the size of a football field. Worse, the bones of *Seismosaurus* are buried in federal territory under appraisal for protected wilderness status. Bureau of Land Management officials weren't about to let Gillette rip up the mesa on a fishing expedition.

But the site is also close to Los Alamos National Laboratories, birthplace of the atomic bomb and home to some of the nation's top technical minds. Late in 1985, Gillette outlined the problems to scientists there and piqued interest. "Dave complained that paleontology was still in the Dark Ages," recalls Roland Hagan, the geochemist who would organize the Los Alamos effort, "and that comment really caught my attention."

## Blood and iron

What followed were brainstorming sessions with several dozen Los Ala-



*Seismosaurus* vertebrae (above) suggest the gentle, herbivorous giant shown in our concept (top). High-tech sensing will help verify the hypothesis.

mos researchers who volunteered their time and services after working hours. Some were eager to try remote sensing, while others wanted to first unlock the fossils' secrets by pounding the bones with subatomic particles.

In the spring of 1987, a Los Alamos team began by coring an inch-wide column through rock and embedded bone. Those 18 in. of sample yielded crucial clues that opened up leads for the paleontological detective work.

First, Paul Hlava at neighboring Sandia National Labs zeroed in on a fossil-bone earmark. Training a beam of electrons on bone slices, he touched off X-rays whose signature indicated the presence of magnetite, an iron-rich mineral formed from the dinosaur's blood. The finding suggested that magnetometry might aid the hunt.

Harold Bowen, who worked at Los Alamos's linear accelerator, had built

# HUNT FOR SEISMOSAURUS



Seismic cannon (above) and ground-penetrating radar (right) are among the tools probing for *Seismosaurus*.

in his garage a proton-precession magnetometer, which detects subtle warps in the Earth's magnetic field caused by buried objects. In 1985, the same device led Bowen and treasure-hunting colleague Mel Fisher to \$500 million in gold and jewels on *Neustra Señora de Atocha*, a sunken Spanish galleon off the Florida coast.

That June, Bowen swept the top of the mesa three times with the home-built apparatus—and hit paydirt. He found some loose vertebral bones that had separated from the rest of the skeleton. The high-tech hunt was on.

## Going for the glow

Meanwhile, more bone slices from the core sample went into Los Alamos's workhorse OMEGA reactor, where neutron-activation analysis revealed that the bone was tinged with uranium. *Seismosaurus* is lodged in a layer of sandstone known as the Morrison Formation, famous for its bounty of dinosaur bones. It's also rich in uranium, which has an affinity for organic material such as bone. Nuclear detection technology, long a Los Alamos forté, came to the site that spring in the form of a handheld scintilliscopes operated by environmental-health physicist Don Van Etten.

"Well, beeps went off in several hot spots," he recalls, but the finds proved to be bone fragments on the surface. Anything a yard or more under the surface was invisible. As the search progressed, radiation detectors would prove of only limited use. On the plus side, gamma-ray spectrometry would help diggers declare surface areas bone-free so they could bring in mechanized excavators.

As this work progressed, teams from Sandia and Los Alamos laid out a surveying grid and systematically swept the mesa top with ground-penetrating radar (GPR). Developed in



the 1960s to intercept tunneling Viet Cong, GPR distinguishes two media of unequal conductivities, such as steel and earth. Bone and sandstone differ only subtly, but the GPR runs yielded consistent readings. Some large objects certainly lie under the mesa top, though whether they are dinosaur bones or geological anomalies remains to be seen.

While the Los Alamos team probed with the three remote-sensing technologies, excavators were at work with traditional handtools, using the tried-and-true method of following the bones in from the side of the cliff. To their delight, most of the vertebrae were still articulated, and diggers steadily unearthed the rest of the tail, pelvis, ribs and spine.

"There's no question that this is a world-class find," Hagan says. "Not only is the skeleton fairly complete, but it's been very well preserved in a benign environment." Chemical analysis has shown that fluorine from nearby groundwater had leached into the bones, arming them against rot the way fluoride compounds in tooth-

paste protect teeth.

As the dig progressed, the remote-sensing crews could compare their readings with actual bone locations. Initial results were mixed, with magnetometry showing the most promise, while GPR took in some false positives. Hagan, like all the researchers, is extremely conservative in discussing results: "We've come to this feeling: It's all an experiment, and the proof comes when the excavation is completely finished."

## Sound and vision

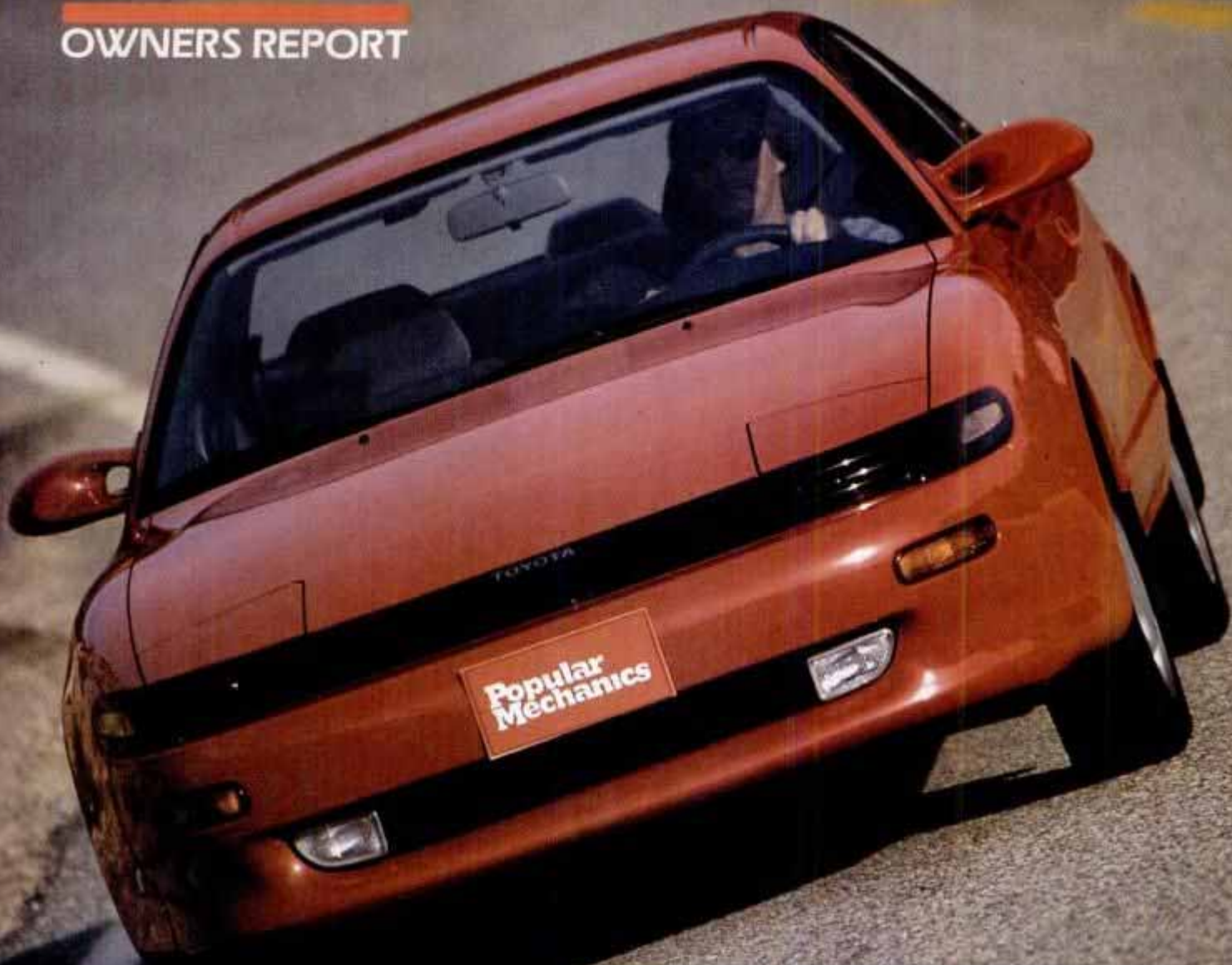
Round two began in April 1988 when Gillette rented a Bobcat earthmover and shaved 10 ft. from the top of the mesa. The remote-sensing teams updated their hardware and went to work again, 10 ft. closer to the bones.

And from Oak Ridge National Laboratory came Alan Witten, who had developed an acoustic tomography system to locate buried hazardous waste. The heart of his gear is a seismic cannon, a modified 8-gauge shotgun mounted on wheels. The gun fires a lead slug into the surface of the ground, touching off subterranean sound waves that are picked up by an array of hydrophones in a nearby borehole. Then the gun is shifted 2 ft. away and discharged again. After repeated firings, a computer assembles a cross-section image of the zone the way a medical processor creates a CAT scan from X-rays.

While the researchers have sharply debated the interpretation of Witten's results, acoustic tomography has certainly generated the strongest signals yet. The gray-scale images on Witten's laptop appeared to pinpoint two vertebrae unearthed in July 1989. The images also suggest an odd posture for *Seismosaurus*, which apparently died curled up, lying on its right flank, its neck arched back toward its tail. "Our images go right out along to the neck and show a definite rigor mortis position," Witten claims.

Today the excavation is continuing, supervised by Gillette, now Utah's state paleontologist, and local New Mexico scientists. Los Alamos teams are repeating remote-sensing surveys to ensure repeatability of data and to refine their techniques. "When we started, we were basically novices taking blind stabs," Hagan admits. "And looking into the ground is still horribly complex, but now we know a lot more about what we're doing."

Gillette feels the remote sensing may already have cut years from the excavation process. "The whole project has been both literally and figuratively ground-breaking," he says, "and all these technologies show high promise for other sites." **PM**



# TOYOTA CELICA

Toyota takes risks with styling—and wins.

BY MICHAEL LAMM, Contributing Editor  
PM Photos by Ron Hussey

• Toyota has been selling Celicas successfully for 20 years now. Very successfully. But throughout its long history, the Celica line has never faced a more competitive environment than it does today.

People who buy Celicas—younger women, mostly—usually shop such rivals as the Geo Storm, Isuzu Impulse, Nissan 240SX, Ford Probe, Mazda MX-6, Honda Prelude, Chevrolet Beretta, Pontiac Sunbird, Chevrolet Cavalier Z24, Dodge Charger and the Diamond Star trio: Plymouth Laser, Eagle Talon and Mitsubishi Eclipse.

Many of these nameplates didn't even exist three years ago.

Most of these sporty 2+2s share a similar price spread. And what a spread it is. In the Celica's case, you can pay as little as \$12,798 for the basic ST or as much as \$26,848 for a loaded All-Trac Turbo.

Besides the tough competition,

there's another big difference between the current Celica and the four previous incarnations. While Toyota usually plays it safe in the styling department, the current Celica is definitely high profile. With their Darth Vader brow ridges, their Coke bottle flanks and high sterns, these Celicas represent the most controversial styling job in the nameplate's history, producing double takes wherever they go.

And this is exactly what prompted

most of the Celica owners in our survey to sign on the dotted line: 72% cited styling as their main reason for buying. Styling also stood out as the Celica's single most-liked feature, with 81% of our respondents endorsing the new design, almost 42 percentage points over the next highest category, which was handling.

The fifth-generation Celicas are available in three body styles: coupe, liftback and convertible. Our survey was completed before the ragtop ver-



Owners liked Celica's interior, but 25% had problems with instrument lighting.



Although front seat rating was high, there were comfort and headroom complaints.



Toyota's 130-hp dohc 16-valve 2.2-liter Four powered 56.5% of Celicas in survey.

sion became available. Buyers can choose from four models: ST, GT, GT-S and the low-volume, high-performance 200-hp All-Trac Turbo (so low volume, in fact, that none showed up in our survey). All the Celicas come equipped with dohc 16-valve 4-cylinder engines, electronic fuel injection, front and rear antiroll bars, driver's-side airbags, variable-ratio rack-and-pinion power steering, plus the usual electronic amenities.

A technical description of the new

Celica sounds much like its predecessors, but there's actually little in the way of interchangeability of components. And the interior redesign is almost as sweeping as the exterior.

The entry-level Celica ST is available only as a coupe. It offers a 103-hp 1.6-liter Four, plus a choice of a 5-speed manual or a 4-speed automatic transmission. As in years past, Toyota biases the ST toward economy and a cushy ride, rather than slalom handling.

One step above the ST is the popular GT, which accounted for more than 55% of the Celicas in our survey. As the basis for the convertible, the GT is the only series available in all three body styles. It's a little stiffer than the ST, uses 6x14-in. wheels instead of 5x13, and has the 130-hp 2.2-liter engine, plus tilt steering, 50/50 fold-down rear seats, power mirrors and a full-size spare.

Representing only about 4% of Celica sales, the GT-S takes its owners to

## SUMMARY OF 1991 TOYOTA CELICA OWNERS REPORTS\*

<b>Total miles driven</b>	808,131	<b>Power sunroof</b>	53.1	<b>Average</b>	1.8	<b>Good</b>	52.6
<b>Purchase price:</b>		<b>Antilock braking</b>	28.2	<b>Poor</b>	0.0	<b>Average</b>	5.2
Average	\$15,303	<b>Power driver's seat</b>	7.4	<b>Comfort opinion, front seats:</b>		<b>Poor</b>	4.4
Range	\$11,900-\$20,650	<b>Specific likes:</b>		Excellent	48.2%	<b>Number of vehicles owned:</b>	
<b>Why did you choose the Celica?</b>		Styling	81.2%	Good	44.3	This vehicle only	40.4%
Styling	72.0%	Handling	39.5	Average	5.7	Two vehicles	27.2
Owned Celicas before	25.2	Power/performance	28.6	Poor	1.8	Three vehicles	21.1
Performance	22.0	Ride quality	23.5	<b>Comfort opinion, rear seats:</b>		Four or more	11.4
Reputation	17.3	Fuel economy	21.1	Excellent	11.9%	<b>Principal driver:</b>	
Price	15.9	<b>Specific dislikes:</b>		Good	37.2	Female	59.0%
<b>Model choice:</b>		No complaints	14.4%	Average	35.8	Male	37.8
Celica GT	55.4%	Insufficient headroom	13.1	Poor	15.1	Equal	3.2
Celica ST	41.1	Uncomfortable seating	13.1	<b>Mechanical trouble?</b>		<b>Age distribution of owners:</b>	
Celica GT-S	3.6	Poor rear vision	9.2	Yes	21.4%	Under 29	34.0%
<b>Engine choice:</b>		Cramped interior	6.5	No	78.6	30-49	51.8
2.2-liter Four	56.5%	Limited rear legroom	6.5	<b>What type of trouble?</b>		50-plus	14.1
1.6-liter Four	43.1	<b>Suggested changes:</b>		Miscellaneous electrical	31.3%	<b>Based on your experience</b>	
<b>Avg. mpg by engine, city/hwy:</b>		No changes	29.9%	Instrument lighting	25.0	<b>with your Celica, would</b>	
1.6-liter Four	26.5/32.4	More headroom	9.2	<b>Did you repair it yourself?</b>		<b>you buy a Toyota again?</b>	
2.2-liter Four	25.5/30.8	Improved seating comfort	7.1	Yes	2.0%	Yes	29.9%
<b>Transmission choice:</b>		Eliminate blind spots	4.9	No	98.0	No	9.0
5-speed manual	50.9%	More rear legroom	4.3	<b>Dealer repairs satisfactory?</b>		Maybe	60.7
4-speed automatic	49.1	Power side mirrors	4.3	Yes	78.9%	<b>If so, would it be a Celica?</b>	
<b>Major options:</b>		<b>Workmanship opinion:</b>		No	21.1	Yes	69.0%
Air conditioning	98.7%	Excellent	69.8%	<b>Dealer service opinion:</b>		No	3.5
Optional sound system	63.3	Good	28.4	Excellent	37.8%	Maybe	27.5

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

the edge of sports car country. It offers handling-oriented suspension tuning, 4-wheel-disc brakes and 6.5x15-in. alloy wheels with VR-rated tires. Antilock braking is optional. A front airdam, rear spoiler and ground-effects rocker panels give the GT-S a look that's consistent with its sporting intent.

Toyota quality, according to our Celica owners, remains as high as ever. More than a quarter of our respondents had owned Celicas before—undoubtedly a strong factor in their recent purchase decisions—and many told us that their previous cars had also been troublefree, well built and utterly reliable.

The new Celica's paint has been upgraded to protect against chipping, and "galvanealed" steel, a material employed in Lexus LS400 construction, is used in Celica manufacturing as well. Galvanealing entails applying heat and layered composite coatings to add stiffness to the sheetmetal. The process helps resist corrosion and muffles noise.

### 80% troublefree

Nearly 70% of our Celica owners rated the workmanship of their cars as excellent. And more than 80% reported no mechanical maladies of any kind. While this isn't the highest no-problems rating we've ever seen in our Owners Reports—the Lexus LS400 holds that distinction at 90%—it's very high indeed.

Of those who did have problems, the majority were related to a variety of minor electrical glitches, in particular a bad rheostat for the instrument lights.

Complaints relating to the car's design were few. The Celica's low ceiling bothered some of the taller drivers, particularly in sunroof-equipped cars (the sunroof reduces headroom by a little more than an inch). Not everyone found comfort in the bucket seats, and the hefty C-pillars produced some grumbling about limited driver sightlines.

There were also a few gripes about excessive window fogging, and, inevitably, a number of owners (4.3%) complained about the cramped rear-seat legroom.

### The yes factor

But as we noted, all the complaints reflected small minorities. When we got to the all-important bottom-line question—"Knowing what you know now, would you buy the same car again?"—69% of our respondents answered yes. And only 3.5% gave us an unequivocal no.

That's a response Toyota can take to the bank. **PM**



Of four models offered, the GT accounted for more than 55% of the Celicas in this survey, and more than 80% were coupes. Though controversial, the Celica's current styling rates high with owners, more than 80% listing looks as the car's best feature.

## EDITORS REPORT

### Beauty And The Beholder

● We don't like to spend a lot of time talking about styling. We think you're going to make up your own mind about sheetmetal.

Accordingly, we'll confine our remarks concerning the Celica's looks to how strongly it polarizes beholders. People seem to think it's either alluring or strange, with few falling between these extremes. Given the popularity of the line, we view this as a success for Toyota's design teams. In a segment that's awash with racy-looking wedge-shaped darts, the Celica strikes a defiantly distinctive note.

Our own enthusiasm for the Celica is centered below the surface, on an excellent range of powertrains and suspension setups to go with it.

Though we've spent a fair amount of time in Celicas of all kinds, we borrowed a new GT-S for a little refresher course. And we returned it with renewed respect for its all-around performance. While it's neither the quickest nor the best-handling car in this class, the GT-S combines enough of each to make it plenty of fun to drive.

The 130-hp 2.2-liter dohc 16-valve Four is gratifyingly responsive—very much like a racing engine. And the car's handling is positive, quick and unfailingly predictable. The ride/handling tradeoff in the GT-S leans toward aggressive cornering capabilities, making it a bit stiff on bumpy surfaces. But for drivers who want sports car feel with an extra set of seats, we think Toyota has hit a very viable balance.

Addressing a couple of the more salient owner complaints—driver sightlines and seating comfort—we agree and disagree.

There's no question that the styling interferes with vision in the rear quarters. The C-pillar and relatively small greenhouse produce some serious blind spots. Similarly, the lofty rear deck, topped by the GT-S spoiler, puts more guesswork in backing up than we would like.

On the other hand, we found the seats in our GT-S to be absolutely first rate. These are the best in the Celica family, but we regard the seats in lesser models to be perfectly acceptable.

We also found headroom in our sunroof GT-S was plentiful, at least for 6-ft. drivers, and complaints about rear legroom in 2+2 coupes just don't wash—they're all cramped.

At \$22,728, our GT-S was well out of the Celica mainstream. But if you trim away some of the extras—the 10-speaker AM/FM/cassette/CD sound system (\$1250), leather upholstery package (\$1530) and sunroof (\$675), the numbers get more competitive.

In any case, we think the GT-S, like all the other Celicas, represents a good value. It's well made, beautifully finished, fun to drive and built to endure. And if the styling tickles your fancy, you have the bonus of a car that doesn't look like all the others. Few Celica competitors provide this combination of distinctions.

—Tony Swan

TECHNOLOGY





# Brewing For ZERO

More brewers are taking the alcohol out of beer. Here's how it's done.

BY FRANK VIZARD

• The centuries-old art of beer making is becoming more of a science as brewers experiment with ways to make beer something it's never been before: non-alcoholic.

There seems to be little doubt that a market exists for a beverage that tastes like a beer but doesn't have any alcohol content. The problem is that the alcohol can't easily be removed without affecting the taste of the beer.

While the ultimate goal may be zero alcohol content, government regulations now define a non-alcoholic beer as one with 0.5% or less alcohol. As far as its ability to make drinkers tipsy, non-alcoholic beer, by this definition, is on par with fruit juice. Regular beer, by contrast, generally contains 4 to 5% alcohol.

Surprisingly, not every brewer of non-alcoholic beer pushes the alcohol content to the maximum despite the correlation to taste. For example, Kaliber, made by Guinness, contains only 0.02% alcohol. To put this in context, a 12-ounce glass of Kaliber has less alcohol content than a slice of white bread.

Basically, there are four ways to make beer devoid of alcohol, according to Dr. Joseph Owades, director of the

Center for Brewing Studies in San Francisco. The oldest and most widely used method is vacuum distillation. Beer is made in the normal fashion and then boiled so the alcohol evaporates. The problem with this method is that the esters disappear as well. Esters are organic compounds formed in the fermentation process that are largely responsible for a beer's distinctive taste. Brewers may reintroduce a touch of real beer for flavor. Other additives such as corn or cereal may also be used. Vacuum distillation is used by the majority of brewers currently offering non-alcoholic brands.

The diffusion or reverse osmosis method basically pushes beer against a semipermeable membrane. Only the smaller alcohol molecules pass through to the other side of the membrane. What's left is a brew minus its alcohol. While it sounds simple, this process is expensive due to the amount of equipment necessary. O'Doul's, made by Anheuser-Busch, is made in this manner.

A third method is only used thus far by Birell, a

## BREWING FOR ZERO

### How Near Beer?

● Can the alcohol be removed from beer without affecting the taste? The answer is yes, but some brewers are better at it than others. Generally speaking, a non-alcoholic beer tends to taste like its alcoholic counterpart. So if you don't like Pabst, for example, chances are you won't like Pabst N.A. Other brands, though, tend to stand on their own. PM's judging committee of staff and friends included (left to right): Mickey Arrove, Laura Quinn, Frank Vizard, Deborah Frank, Molly Gregor, Joe Oldham, Barbara Novak and Tony Swan.



PM PHOTO BY JEFFREY R. NACHBAR

BRAND	BREWER	HEAD/BEADINESS	COLOR	TEXTURE	BALANCE	AROMA	TASTE
<b>OUTSTANDING</b>							
1. Clausthaler	Binding	excellent	pale amber	smooth	full-bodied	beery	beery
2. Haake Beck	Beck	good	golden	smooth, light	full-bodied	hearty	malty
3. Sharp's	Miller	good	golden	smooth	full-bodied	beery	refreshingly light
<b>RECOMMENDED</b>							
4. Pabst N.A.	Pabst	lingering	light gold	smooth, slightly carbonated	hoppy	malty	light
5. Buckler	Heineken	fades quickly	dark gold	almost chewy	slightly malty	malty but weak	slightly bitter
<b>DRINKABLE</b>							
6. O'Doul's	Anheuser-Busch	toward foamy	sunshine	smooth, clean	toward malty	sweetish but not persistent	light, a touch nutty
7. Old Milwaukee N.A.	Stroh	half finger	pale yellow	smooth	hoppy	none, really	thin but hoppy
8. Texas Select	San Antonio	variable	apple juice	smooth, slightly carbonated	hoppy	fruity	light but beery
9. Birell	Hurlimann	all the way down	golden	carbonated	hoppy	malty	malty
10. Kaliber	Guinness	fair	amber	rough	malty	beery	bitter
11. NA	San Antonio	fades fast	amber	smooth	toward malty	malty	sweetish
12. Goetz Pale Near Beer	Pearl	good	golden	tangy	toward malty	early A.M. bar	sweet and nutty
13. Moussy	Cardinal	small	dark amber	smooth	malty	cloying	fruity
<b>POOR</b>							
14. Texas Light Dark	San Antonio	none	cola	syrupey	malty	sweet like soda	thin, sweet
15. Kingsbury	Heilemann	temporary	foggy yellow	prickly	hoppy	almost	sweetly bland
16. Hamm's N.A.	Pabst	good	sunny	bubbly	very malty	wet blanket	thinly sweet
17. Texas Light	San Antonio	big	weak apple juice	bumpy	sweetwater	wistfully sweet	watery

Swiss brewer. Birell employs a special yeast that ferments only 1% of the sugars found in the wort, the sugar-rich liquid barley malt that forms the basis for beer. Yeast cuts the sweetness of the wort, but ferments the sugar to create alcohol. A "stupid" yeast, like the one used by Birell, is often difficult to handle, which is why more brewers don't use it. Utica Club N.A., a regional brand of which PM was unable to obtain a sample, varies this methodology by making a wort that is less sweet than normal, thereby less reliant on yeast.

Judging from PM's taste test (see chart above), the most effective method of making non-alcoholic beer is to allow fermentation to start but then quickly arrest it. The yeast is then removed, and the brewing temperature lowered. As you might guess, this process is tricky, and timing is critical. If done incorrectly, this method will yield a brew that's far too sweet. Clausthaler, Haake Beck and Sharp's—PM's three favorites—all use this method. Sharp's, made by Miller Brewing Co., is the only domestic producer in the group. Clausthaler and Haake Beck hail from Germany.

Non-alcoholic beer is most often mentioned as an alternative for those

instances when an alcoholic beverage may be inappropriate, say at a business lunch. Near beer, as it is also called, is also touted as a way for revellers to avoid the hazards of drunken driving or as the beverage of choice for a designated driver.

#### Less calories

Non-alcoholic beer, however, can just as easily be portrayed as a thirst quencher or all-around health drink. Removing the alcohol from beer lowers the caloric content from about 150 to 55, making the drink suitable for dieters or athletes. A few non-alcoholic beers, like Goetz Pale Near Beer (brewed consecutively since Prohibition in the 1920s) and the other "Texas" brands, have between 65 and 70 calories, thanks to additives designed to give the beer a little more body.

The addition of "choicest grain" adds to the calorie count. Among the imports, Zero Plus, from the Norwegian brewer Ringes, is among the highest in calories at 70—despite only listing water, hops, yeast and malt as ingredients. Zero Plus debuted in the United States too late to be included in PM's taste test. By contrast, "lite" beer, from which the carbohydrates have been removed, is about 100 calo-

ries per 12-ounce serving.

Non-alcoholic beer costs more to brew, but taxes put the retail cost of a 6-pack on par with its alcoholic brethren. Every beer drinker, therefore, is seen as a potential customer—a thought that is attracting every big U.S. brewer into the market. Both the Anheuser-Busch launch of O'Doul's and the Miller launch of Sharp's are relatively recent. Coors is taking over the marketing of Moussy in the U.S., and Stroh's Old Milwaukee N.A. just debuted in May.

The entry of the big breweries into the market puts pressure on smaller brewers. Firestone & Fletcher, a small, highly rated California brewery that only made non-alcoholic beer, just recently stopped production. Some imports may also have to bow out of the market, as well, due to pricing pressure at retail.

In any event, there are plenty of brands from which to choose. Diehards may call it an exorcised brew—beer from which the spirits have been removed—but PM's taste test suggests that the best of the bunch has a place at the bar, whether it be as a thirst quencher, health or diet drink, or as the one to have when you're having one for the road. **PM**



## COMPARISON TEST

# GETTING HITCHED

We hitch up nine top tow vehicles and hit the road to see what pulls and what pales.

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

● Getting away from it all usually means bringing a great deal of it with you. Often, the best way to do this is with a tow hitch and trailer. The fun starts after you unload the dirt bikes, Jet Skis or speed boat and prepare to cut loose. But in transit, towing is serious business.

In many ways, these are the best and worst of times for tow vehicles. Sales of sport/utes and minivans, until recently a boom market, opened up the world of towing to a large number of people. But this is also the age of front-wheel drive, unitized-frame construction and downsized engines. Many previously top-rated vehicles now have reduced towing capacity.

Since POPULAR MECHANICS believes in "know before you tow," we decided it was time to put the new breed of haulers to a road test. We set a minimum tow rating of 1750 pounds, and identified nine categories that ranged from full-size van to minivan



GMC SIERRA SLE

# GETTING HITCHED

## SPECIFICATIONS AND DIMENSIONS

MANUFACTURER/ MODEL	BASE PRICE/ PRICE AS TESTED	ENGINE/ DISPLACEMENT (ci/cc)	ENGINE HP, NET/ TORQUE (ft.-lb.)	ENGINE/ DRIVE LAYOUT	TRANS- MISSION TYPE	WHEEL- BASE (in.)	LENGTH OVERALL (in.)	WIDTH OVERALL (in.)	TRACK FRONT/REAR (in.)	CURB WEIGHT (lb.)
<b>Buick Roadmaster Estate Wagon SE</b>	\$21,445/ \$24,837	V8 OHV 305/4998	170 @ 4200 rpm/ 255 @ 2400 rpm	front/ rear	4-speed automatic	115.9	217.7	79.9	62.1/64.1	4415
<b>Chevrolet Beauville Sportvan Extended</b>	\$21,150/ \$24,819	V8 OHV 350/5731	190 @ 4000 rpm/ 300 @ 2400 rpm	front/ rear	4-speed automatic	146	223.2	79.5	69.3/74	5552
<b>Dodge Dakota LE Club Cab</b>	\$11,241/ \$16,733	V8 OHV 318/5211	165 @ 4000 rpm/ 250 @ 2400 rpm	front/ rear	4-speed automatic	131	203.2	68.3	58.5/59.5	3460
<b>Dodge Grand Caravan LE</b>	\$19,306/ \$22,389	V6 OHV 201/3294	150 @ 4800 rpm/ 185 @ 3600 rpm	front/ front	4-speed automatic	119.3	192.8	72	59.9/62.1	3819
<b>Ford Aerostar XLT Eddie Bauer</b>	\$22,095/ \$23,104	V6 OHV 245/3958	155 @ 4200 rpm/ 200 @ 3800 rpm	front/ part-time 4wd	4-speed automatic	118.9	190.3	71.7	61.5/60	3478
<b>Ford Bronco Custom XLT Eddie Bauer</b>	\$24,866/ \$25,550	V8 OHV 351/5766	200 @ 4000 rpm/ 300 @ 2800 rpm	front/ part-time 4wd	4-speed automatic	104.7	180.5	79.1	65.1/64.4	4416
<b>GMC Sierra SLE</b>	\$16,282/ \$22,306	V8 OHV 454/7439	230 @ 3600 rpm/ 385 @ 1600 rpm	front/ part-time 4wd	4-speed automatic	131.5	212.6	76.8	64.1/63.9	5496
<b>Mazda MPV</b>	\$16,435/ \$23,096	V6 SOHC 180/2954	150 @ 5000 rpm/ 165 @ 4000 rpm	front/ rear	4-speed automatic	110.4	175.8	71.9	60.0/60.6	3492
<b>Toyota 4Runner SR5</b>	\$18,998/ \$25,681	V6 SOHC 181/2958	150 @ 4800 rpm/ 180 @ 3400 rpm	front/ part-time 4wd	5-speed manual	103.3	176	68.1	56.3/56.1	4005



FORD BRONCO CUSTOM  
XLT EDDIE BAUER

CHEVROLET BEAUVILLE  
SPORTVAN EXTENDED

TOYOTA 4RUNNER SR5

DODGE DAKOTA LE CLUB CAB

to sport/ute to pickup truck to station wagon. In each category, we picked a representative vehicle.

All tests were done twice: with and without load, an approach unique to PM among national magazines. For the heavy haulers, we pulled a trailer with a Chris-Craft 208 Cuddy, which has a combined weight of 4000 pounds. For the rest, we used a trailer with a Lowe 1730 aluminum fishing boat, which has a combined weight of 1750 pounds. All braking distance tests were done with the 1750-pound boat and trailer, which comes without surge brakes.

### Buick Roadmaster Estate Wagon SE

The return of the plush Buick Roadmaster in 1991 is good news for family towing. To the surprise of the test crew, its performance marks placed it among the leaders in heavy hauling.

While acceleration times seemed middle of the pack, consistency across the board revealed no weaknesses. On the contrary, several hundred miles of heavy towing showed that the 5-liter V8 small-block Chevy engine can handle every bit of the Roadmaster's 5000-pound tow rating.

How good is 4-wheel ABS? The

Roadmaster was the only test vehicle so equipped, and it clobbered the competition. Easy maintenance and mpg performance were other strong points. Welcome back Roadmaster.

*Vehicles in same class: Chevrolet Caprice Wagon, Oldsmobile Custom Cruiser.*

### Chevy Beauville Sportvan Extended

The Chevy Beauville Sportvan is primarily a people mover. Our test model, equipped with a 5.7-liter V8, was configured more like an airport shuttle—seating for 12 and upscale trim—

				TEST RESULTS					
AXLE RATIO	BRAKE SYSTEM FRONT/REAR	MAXIMUM TOW RATING (lb.)	TONGUE WEIGHT (lb.)	ACCELERATION 0-60 MPH (sec.) (SOLO/TOWING)	ACCELERATION 1/4-MILE (sec. @ mph) (SOLO/TOWING)	ACCELERATION 40-70 MPH (sec.) (SOLO/TOWING)	BRAKING 60-0 MPH (ft.) SOLO/TOWING	FUEL ECONOMY (MPG SOLO/TOWING)	PM SERVICEABILITY INDEX
3.23:1	F: 12.0-in. vented disc, ABS/ R: 11.0-in. drum, ABS	5000	600	10.95/ 23.2	17.94 @ 75.2/ 23.2 @ 57.1	11.4/ 37.3	136/ 153	26.2/ 11.2	10
3.73:1	F: 12.5-in. vented disc/ R: 13.0-in. drum, ABS	6500	1000	14.3/ 35.0	19.61 @ 61.7/ 25.1 @ 52.0	16.0/ NA	163/ 248	16.9/ 8.2	5½
3.90:1	F: 11.3-in. vented disc/ R: 10.0-in. drum, ABS	5900	700	9.95/ 33.4	17.38 @ 76.3/ 23.32 @ 55.81	9.7/ 35.8	165/ 214	12.5/ 10.4	10
2.52:1	F: 11.07-in. vented disc/ R: 8.95-in. drum	1750	600	12.5/ 21.6	18.86 @ 72.0/ 22.4 @ 60.7	12.9/ 26.7	142/ 202	17.7/ 13.4	10
3.73:1	F: 10.28-in. vented disc/ R: 10.0-in. drum, ABS	4500	450	10.7/ 33.6	17.87 @ 66.3/ 23.67 @ 56.48	10.6/ 44.8	160/ 269	18.5/ 14.4	6½
3.55:1	F: 11.72-in. vented disc/ R: 10.63-in. drum, ABS	7200	700	10.45/ 33.3	17.43 @ 74.8/ 22.86 @ 58.6	11.2/ 31.8	173/ 191	13.3/ 9.8	7
3.73:1	F: 12.5-in. vented disc/ R: 13.0-in. drum, ABS	7500	900	10.6/ 20.6	17.76 @ 76.1/ 21.89 @ 61.4	11.0/ 25.18	187/ 217	12.4/ 11.0	11½
3.91:1	F: 10.1-in. vented disc/ R: 10.2-in. drum, ABS	4500	450	12.35/ 22.25	18.74 @ 72.7/ 22.28 @ 60.25	10.9/ 21.2	176/ 230	17.8/ 9.5	10
4.10:1	F: 11.3-in. vented disc/ R: 11.6-in. drum, ABS	3500	350	12.2/ 20.15	18.4 @ 71.5/ 21.4 @ 61.2	12.2/ 21.9	157/ 228	17.8/ 13.1	8

FORD AEROSTAR  
XLT EDDIE BAUER



DODGE GRAND CARAVAN LE

BUICK ROADMASTER  
ESTATE WAGON SE



MAZDA MPV



GMC SIERRA SLE

than a typical tow vehicle. While there's no doubt the 350-cu.-in. engine can handle heavy hauling, the extended-length, full-size van's bulk slowed down performance. On the upside, the lengthy wheelbase gave it superb stability at highway speeds.

As equipped, our testers would be hard pressed to recommend the Sportvan for extensive towing at its 6500-pound rating. For serious towing, we suggest an upgrade to the 7.4-liter engine.

*Vehicles in same class: Dodge Ram Wagon, Ford Club Wagon, GMC Rally Van.*

### Dodge Dakota LE Club Cab

Not surprisingly, the V8-powered Dakota recorded solid performance marks across the board. However, after sweeping the fleet in nontowing tests, the 5.2-liter Chrysler engine strained a bit with the 4000-pound load. Still, it handled the 100-mile high-desert course with minimal downshifting, and its midsize length made the ride less rough and cramped than in most minipickups.

The Dakota has plenty of room under the hood for an uncluttered engine layout and was among the top scorers

in the PM Serviceability Index. The test crew also appreciated the 19 in. of additional cab length.

We wouldn't recommend a steady diet of trailering at the Dakota's maximum 5900-pound rating, but for loads somewhat less, it's an ideal hauler and one of our test fleet's best buys.

*Vehicles in same class: Chevrolet S-10 Pickup, Ford Ranger, GMC Sonoma, Jeep Comanche.*

### Dodge Grand Caravan

Front-wheel-drive vehicles aren't supposed to be ideal for towing, but the 3.3-liter V6-equipped Grand Car-

## GETTING HITCHED



avan LE racked up respectable numbers in performance tests and impressive consistency across the board.

The market-leading minivan experienced predictable strain and some wheelspin while pulling a load up a wet launch ramp. But hill climbing was good and maintaining highway speed a snap. Braking, with and without load, was outstanding. Overall gas economy was superb, and its PM serviceability rating was among the leaders. For occasional light towing, the family-friendly Grand Caravan can definitely hold its own.

*Vehicles in same class: Chevrolet Lumina APV, Oldsmobile Silhouette, Plymouth Voyager, Pontiac Trans Sport.*

### Ford Aerostar XLT Eddie Bauer

Although equipped with the smallest engine among the test's heavy haul-

ers, the 4wd Ford Aerostar put up respectable numbers when compared to its brawnier rivals. Hill climbing and highway speeds were no problem for the extended length minivan, and mpg figures were impressive.

Roomy interior space and comfort are Aerostar strong suits, especially when fitted with Eddie Bauer trim. Unfortunately, the engine layout makes routine maintenance fairly difficult. Also, the brakes showed a tendency to fade while under load.

Still, the Aerostar has a lot going for it, including rear-wheel ABS and a limited-slip rear axle, among many other desirable features, and we have no trouble recommending the Aerostar for occasional towing right up to its maximum rating of 4500 pounds.

*Vehicles in same class: Chevrolet Astro, GMC Safari, Mazda MPV, Toyota Previa, Volkswagen Vanagon.*

### Ford Bronco Custom XLT

After 25 years, the Ford Bronco still pulls its weight among full-size sport/utes. With the 4000-pound load, the Silver Anniversary Bronco's 351-cu.-in. V8 engine handled high mountain passes with ease and maintained highway speeds with minimal downshifting. Stability at speed was another Bronco strong point due to a well-behaved heavy-duty suspension.

Despite the Bronco's large front end, the 210-horse engine appears jammed in under the hood, and loses points for serviceability.

Overall, we rated the 4x4 Bronco, equipped with highly effective rear-wheel ABS, a close second in towing and a first in versatility among the heavy haulers.

*Vehicles in same class: Chevrolet Blazer, Dodge Ramcharger, GMC Jimmy.*

### GMC Sierra SLE

We expected a lot from the full-size Sierra pickup and got it. Equipped with a 454 big-block engine, the Sierra was our heavy-hauler champ in all performance categories. GMC's high-torque 230-horse V8 was especially impressive in low- and midrange acceleration, where it outpulled the competition by a wide margin.

After effortlessly conquering high

*(Please turn to page 95)*

## Chevrolet Suburban: The Texas Cadillac

● General Motors knows what all those GMC and Chevrolet Suburbans are being used for. Careful reading of the owner's manual reveals that for trailers under 2000 pounds, no towing package is needed. A ton of inherent capability is more than the *maximum* allowable tow rating for many vehicles with added-on heavy-duty parts.

That near-arrogant, Texas-size capability is what gives the Chevy Suburban its well-deserved place as the benchmark towmobile. Proof of that is found in the incredibly high proportion of Suburbans that can be found hooked up to high-ticket travel trailers at any RV campground in the land.

Ours came in fire-truck red, and lacked only the gold lettering on the doors and the Dalmatian to complete the picture. Yes, Suburbans are favorites with fire departments and para-

medics, too, for their ruggedness, capaciousness and longevity under abuse.

With this year's version of the injected 350 V8, our test Suburban (\$27,553) managed to post 12-second 0-to-60



mph times light, and second-rate 33-second times heavy. Subjectively it seemed more competent than that. Overall driveability was super, thanks to the electronically controlled automatic trans and well-calibrated cruise control.

Braking distances, at 183 and 267, were long, although control was excel-

lent. I was able to keep the fronts near the edge of lockup readily, and the rear-wheel-only ABS managed to keep the trailer behind us without undue drama. Blame the long distances on mud-

and snow-rated tires.

Suburbans are notoriously straightforward in their interior appointments, particularly the easy-to-read dashboard and no-frills instrumentation. Considering the fussiness often inflicted on us in the name of progress, the Suburban's modest interior is fine by me.

One last note: It's also available with the same big-block 454 as

our test-champ GMC pickup. And that's the combination of vehicle (Suburban) and drivetrain (7.4-liter V8) that's going to set the standard for towing for the foreseeable future. If you're considering buying the ultimate tow vehicle, the line forms here.

—Mike Allen

# JOURNAL



## OUTDOOR PROJECT

# BENCH MARK

An eye-catching and easy-to-build garden bench.

BY ROSARIO CAPOTOSTO, Contributing Editor

● This comfortable bench will add a handsome touch to any garden setting. And, if you don't have a garden, build it anyway, it's just as comfortable for lazy afternoons on your porch or deck.

We chose poplar, a moderately priced hardwood, for this project because it's easy to work with and takes paint well. Other woods will work as well, such as clear redwood and cedar, though these woods are more expen-

sive. Also, these woods require a special primer like Zinsser Bulls Eye 1-2-3 primer sealer to keep any stains from bleeding through. Painting the bench is a good idea because it helps the bench stand up to the elements. A clear finish like spar varnish will also work well. But no matter what finish you choose, be sure to use waterproof plastic resin glue if you're going to keep the bench outside. If you build it for interior use, you can use regular yellow glue.

**Color photo:** Rosario Capotosto  
**Black-and-white photos:** Rosario Capotosto  
**Technical art:** Eugene Thompson

## The Legs

Begin by making the legs. Glue together three pieces of lumber surfaced on two sides (S2S), one piece of  $\frac{3}{4}$ -in. stock (nominal) surrounded by two pieces of  $\frac{5}{8}$ -in. stock (nominal). This works out to be, in actual dimensions, a piece  $\frac{9}{16}$  in. thick sandwiched between two pieces  $1\frac{1}{16}$  in. thick.

The back legs are cut from a blank 8 in. wide  $\times$  34 in. long, and the front legs from a blank  $5\frac{1}{2}$  in. wide  $\times$  26 in. long. Rip and crosscut the leg blanks, then stack the pieces and bore pilot holes for 2-in. finish nails spaced  $\frac{1}{4}$  in. in from the side and ends (for alignment during gluing).

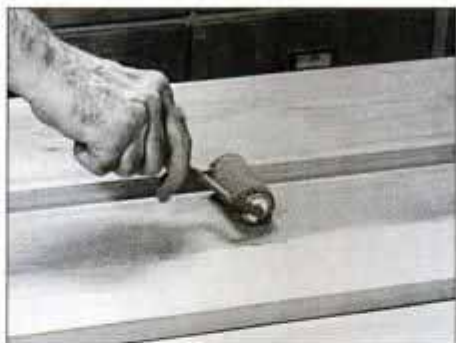
Spread plastic resin glue on the stock with a paintroller (Photo 1).

Make a template of the back legs on paper. Cut out the template, and, when the glue has dried, trace two legs on the blank, leaving about  $\frac{1}{2}$ -in. space between them (Photo 2). Separate the two legs by band sawing between them.

Next, make a ripping platform from plywood  $\frac{1}{4}$  in. thick  $\times$  8 in. wide  $\times$  35 in. long. Tack-nail the blank to the platform so the outside of the leg is parallel to the saw blade. Rip one face of the leg (Photo 3), reposition the leg, and rip the other face.

Make the inside cuts in two stopped passes. Raise the blade as high as possible, then set the rip fence for a  $2\frac{1}{2}$ -in.-wide cut. Stick a piece of masking tape to the saw table, and draw a line on the tape where the blade meets the table. Also, mark a line on the leg to indicate the back of the leg's knee. Rip the leg stopping just short of where the two reference lines meet. Flip the work end for end, and make the second pass (Photo 4). Complete the cut on the band saw.

Next, cut the angled end half laps on the leg tops. To do this safely and easily, make a jig from  $\frac{1}{2}$ -in. plywood, measuring 12 in. wide  $\times$  20 in. long. The plywood slides on two wood runners that ride in the table's miter gauge slots. Place the runners in the slots, then tack-nail the plywood to them. Screw a 2-in. wide and high  $\times$  12-in.-long block to the plywood at a  $43^\circ$  angle to the saw blade. Reverse



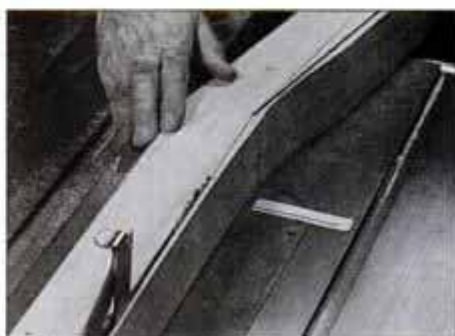
**1** Use a paintroller to quickly spread the plastic resin glue on boards that will be clamped together to form leg blanks.



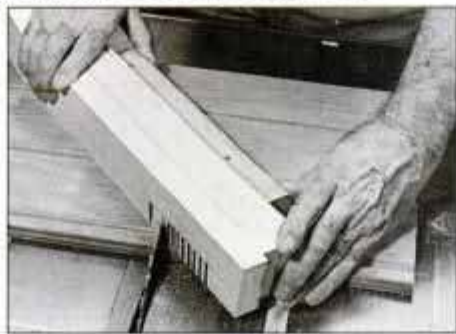
**2** Make the patterns for the rear legs, including mortise positions, from cardboard. Trace patterns onto stock.



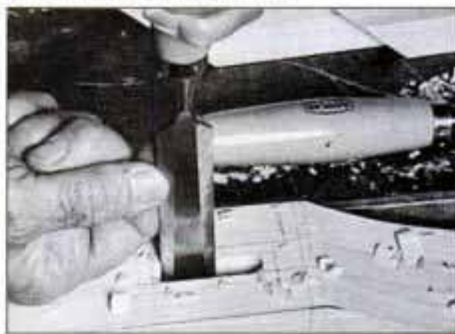
**3** Mount the blank on a ripping platform with its front edge aligned with the saw blade. Rip one edge, then the other.



**4** Mark the workpiece and saw table to prevent overcutting the rear leg face. Stop the cut before the marks line up.



**5** Hold legs on sliding platform and make repeated deep kerf cuts to form the angled half lap for the arched back rail.



**6** Remove the bulk of the mortise on the drill press by boring overlapping holes, then smooth the mortise with a sharp chisel.

the block when cutting the other leg.

Make a series of cuts 1 in. deep and  $\frac{1}{8}$  in. apart (Photo 5). The waste at the top of the leg is retained to keep the leg level. Clean out the waste between the saw kerfs with a chisel.

When the laps have been cut, cut off the waste at the legs' tops, leaving a bit extra to allow flush trimming later

when the top rail is attached. Band saw the tapers on the legs.

Next, cut the front legs to size, and mark the mortise locations for the rails, seat supports and stretchers on the front and rear legs. Cut the bulk of the mortises on the drill press by boring overlapping holes, then chisel the mortise sides flat (Photo 6).

## Rails And Supports

Rip and crosscut the lower back rail, front rail, seat supports, stretchers and armrests from  $\frac{3}{4}$ -in. stock. Cut the beveled ends on the rear of each armrest. Do not cut the profiles on the top edges of the seat supports until their tenons have been cut. Also, bore out and cut the mortises for the seat supports in the front and rear rails.

Cut the tenons on the table saw using a dado head and miter gauge. Clamp a small stopblock on the miter gauge fence. Rotate the stretcher after each pass. With a  $\frac{1}{2}$ -in.-wide dado blade, make one pass with the stretcher butted to the block and a second pass holding it away from the block. Chisel the corners of the tenons round to match the round ends of the

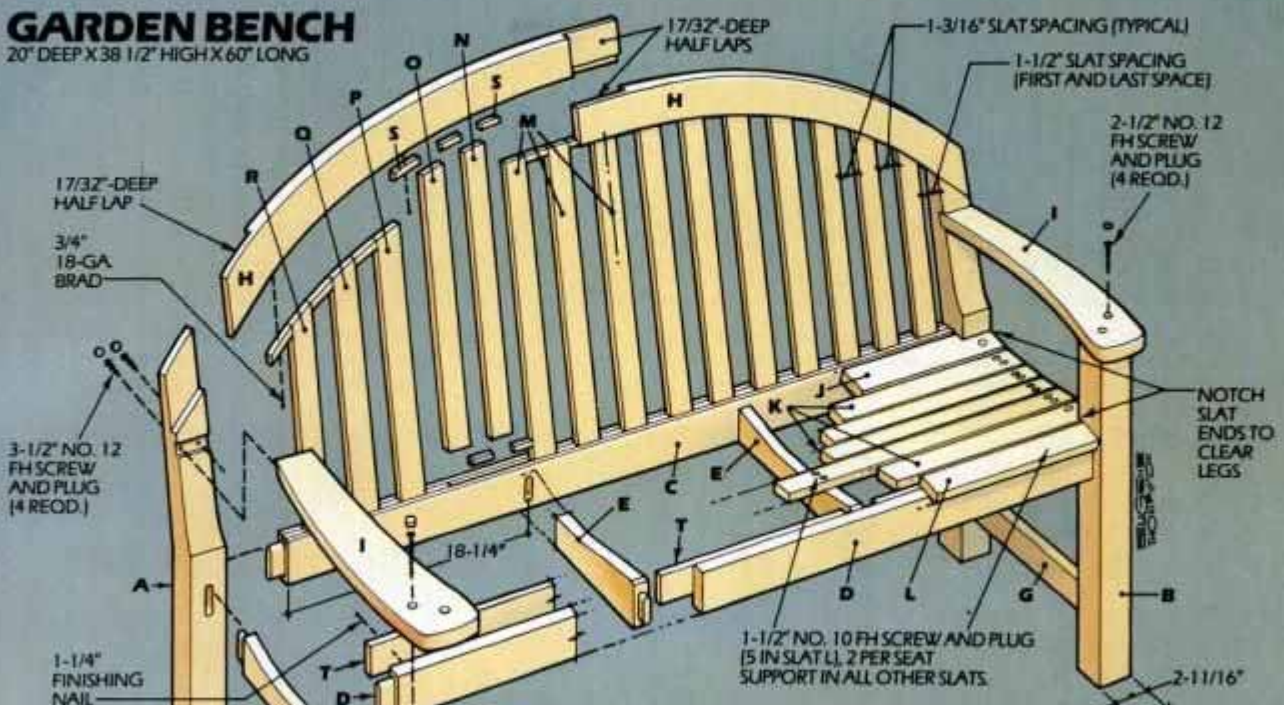
mortises (Photos 7 and 8).

Now, tilt the dado head to  $12^\circ$  and cut the  $\frac{1}{2}$ -in.-wide angled groove in the top edge of the lower rear rail.

Use the band saw to cut the six flats on the top edge of each seat support. If necessary, use a file or a narrow belt sander to true each flat (Photo 9). Next, rip an  $8^\circ$  bevel on the top edge of the front rail.

## GARDEN BENCH

20" DEEP X 38 1/2" HIGH X 60" LONG

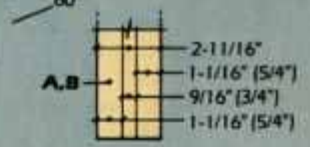


### MATERIALS LIST—GARDEN BENCH

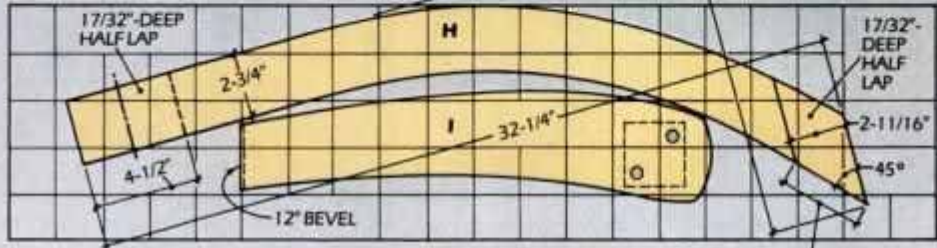
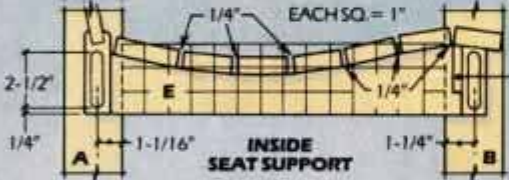
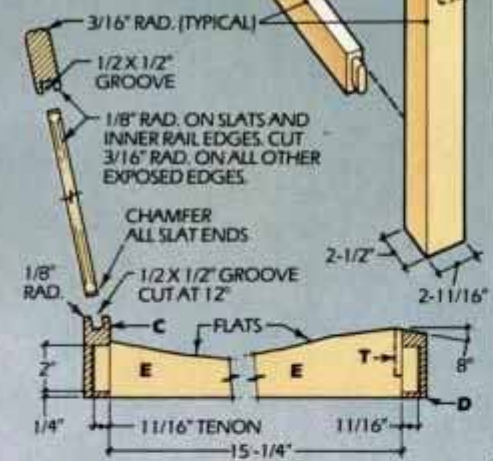
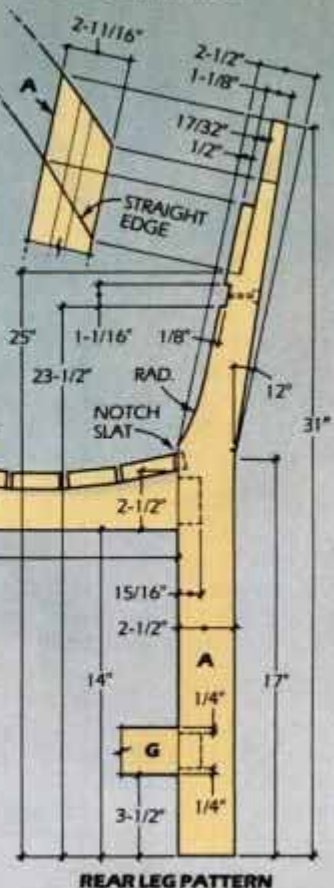
Key	No.	Size and description (use)
A	2	2 1/2 x 2 1/16 x 31 1/4" poplar (back leg)
B	2	2 1/2 x 2 1/16 x 23 1/2" poplar (front leg)
C	1	1 1/16 x 3 1/2 x 56 1/2" poplar (lower back rail)
D	1	1 1/16 x 3 x 56 1/2" poplar (front rail)
E	2	1 1/16 x 3 x 16 1/2" poplar (seat support)
F	2	1 1/16 x 3 x 15 1/4" poplar (seat support)
G	2	1 1/16 x 2 x 15 1/4" poplar (stretcher)
H	2	1 1/16 x 2 3/4 x 64 1/2" poplar (curved rail)
I	2	1 1/16 x 4 x 30" poplar (armrest)
J	1	1/4 x 2 3/4 x 60" poplar (rear seat slat)
K	5	1/4 x 2 3/4 x 60" poplar (seat slat)
L	1	1/4 x 2 3/4 x 54 1/2" poplar (front seat slat)
M	5	1/2 x 1 3/4 x 19 1/4" poplar (back slat)
N	2	1/2 x 1 3/4 x 19 1/4" poplar (back slat)
O	2	1/2 x 1 3/4 x 18 1/2" poplar (back slat)
P	2	1/2 x 1 3/4 x 18" poplar (back slat)
Q	2	1/2 x 1 3/4 x 16 1/2" poplar (back slat)
R	2	1/2 x 1 3/4 x 14 1/2" poplar (back slat)
S	32	1/2 x 1/2" (length cut to fit) poplar (filler block)
T	3	3/4 x 2 x 17" poplar (slat support cleat)

Misc: 49, 1 1/2" No. 10 fh wood screws; 4, 2 1/2" No. 12 fh wood screws; 4, 3 1/2" No. 12 fh wood screws; 1/2" dia. wood plugs; 1/8" 18-ga. brads; 1 1/4" finish nails; plastic resin glue, Zinsser Kover-Stain oil-based primer/sealer/stain killer, Benjamin Moore Impervex white latex high-gloss enamel.

**NOTE:** CUT ALL MORTISES 1/16" DEEPER THAN TENON LENGTH



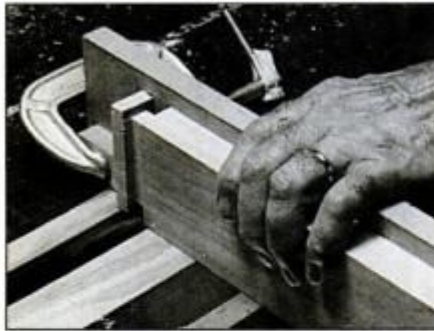
### LEG SLAB LAMINATION



TOP RAIL/ARMREST PATTERNS

STRAIGHT EDGE

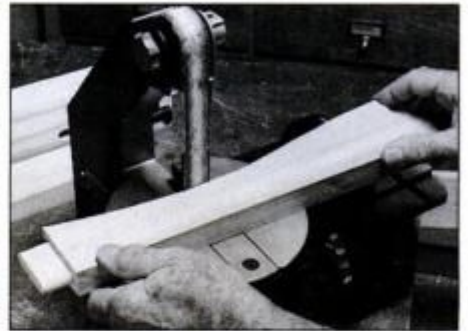
REAR LEG PATTERN



**7** Use miter gauge and stopblock to cut tenons on table saw. Butt rail to block on first pass, then cut remainder of tenon.



**8** Round off edges of tenons with a chisel to fit mortises. Other option is to square the ends of the mortise instead.



**9** Curved seat supports are really a series of six flats. Saw the supports, then use a strip sander or a file to true each flat.

## The Arched Rail

Draw a half section of the arched rail on paper. Cut out the template and trace the outline on two boards, each measuring a minimum 8½ in. wide × 38 in. long.

On both pieces, draw two straight lines approximately tangent to the rail's outside curve. Band saw these lines, then joint them flat. The jointed surface serves to rest against the miter gauge fence for cutting the half laps at the center and at the ends where the arched rail joins the rear leg assembly. The angle at which these flats are cut is not critical. Adjust the miter gauge as required for the shoulder cut.

Before cutting the half laps, band saw the inside curve on each half to make it easier to grip. Cut the ends flat where they butt against the shoulders on the leg half laps.

Cut the laps on the dado head (Photo 10). Make a test cut an inch away from the marked line on the shoulder and check that it's parallel to the shoulder. If not, adjust miter gauge.

Now, band saw the rail's outside curves and remove saw ripples with a spokeshave (Photo 11). Use a drum and disc sander to smooth the edges, then glue and clamp the two sections (Photo 12). Drive two ¼-in. brads into the joint to keep pieces from sliding.



**10** On each half of the arched rail, first cut the inside curve. Make a flat edge tangent to the curve, then cut the half lap.



**11** Cut the rail's outside curve on the band saw, then use a spokeshave to smooth away the saw marks and refine the curve.



**12** Glue and clamp the halves of the arched rail together with blocks on each side. Wax paper keeps glue off blocks.



**13** Cut the groove in the arched rail using a slotting cutter and router in a series of passes. Clamp stopblock to rail.

After the glue has dried, use the router and slotting cutter to cut the groove for the slats in the rail's bottom edge (Photo 13). Adjust the router base so a cut from each face of the

rail forms the outside edges of a ½-in.-wide groove. Readjust the router and remove the waste between the grooves. Clamp a stopblock at each end to control the cut.

## Assembly

Dry assemble the bench and butt the armrests against the rear legs. Mark their position (Photo 14). Disassemble the bench. Prop up the leg on the drill press with a wedge left from cutting the leg (Photo 15). Bore ⅜-in.-dia. holes in the leg and push dowel centers in the holes. Clamp a 12° beveled block to the leg and slide the armrest against it to mark pilot hole centers (Photo 16). Use a doweling jig to bore holes on the marks (Photo 17). Chisel notches in the legs.

Use the router with a ⅜-in.-rad.



**14** Dry assemble the bench with the arched rail clamped in place. Lay armrest on front leg and trace position on rear leg.



**15** Use the drill press to bore pilot holes for the screws that attach armrest to rear leg. Scrap wedge positions the leg.



rounding-over bit to ease the corners on the legs, stretchers, seat supports and front rail. Use a  $\frac{1}{8}$ -in.-rad. bit on the groove edges of the arched rail and the rail below it. Finish sand all completed parts.

Glue and clamp the rear legs to the lower rear rail. Temporarily clamp the arched rail in place to ensure the assembly is square. Glue and clamp the front legs to the front rail.

Fasten each spacer in the lower rail with glue and a  $\frac{3}{4}$ -in. 18-ga. brad. Use a slat cutoff to alternately space the blocks (Photo 18). Tip the assembly on its back. Use a framing square to carry the spacer locations to the curved rail (Photo 19).

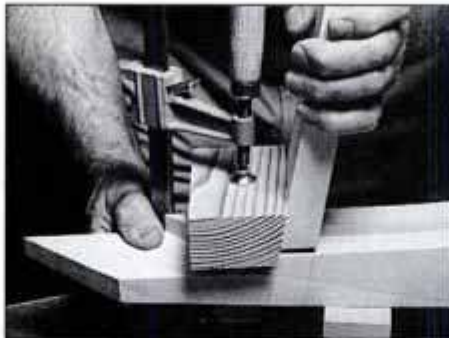
Rip the  $\frac{1}{2}$ -in.-thick back slats to width and crosscut them 1 in. oversize. Starting at the center slat and working to the ends, use two  $\frac{1}{4}$ -in.-thick gauging sticks to mark the length and curved end of each slat. Spread the sticks apart in each slat position and trace the rail's curve (Photo 20). Saw the curve on the gauging stick, and refit the stick to mark the slat's length. Transfer the length and curve from the gauging sticks to the slat, and cut it to shape.

Slide the slats and spacers in place, and trace the arched rail's curve on the spacers. Cut them to shape (Photo 21), and fasten them with glue and brads. Chamfer the slat ends and use a  $\frac{1}{8}$ -in.-rad. rounding-over bit on their exposed edges.

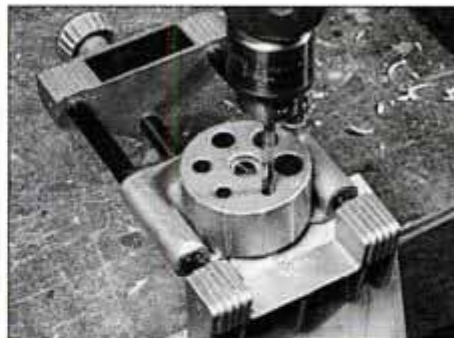
Insert the slats dry in the lower rail. Fit the arched rail on the slats and clamp two sticks across them to hold them parallel. Use masking tape front and back to secure the slats' tops to the arched rail. Raise the arched rail until the slats clear the mortises (Photo 22). Brush glue into the mortises. Lower the top rail and seat the slats. When the glue has dried, lift off the rail. Apply glue to the slat mortises, the half laps on the rail and the rear legs. Clamp the rail in place (Photo 23). When the glue is dry, pare the rail flush to each leg with a chisel. Sand the rail/leg corners and use the  $\frac{3}{16}$ -in.-rad. rounding-over bit on the rail's top corners.

Glue and clamp the rear leg assembly to the front assembly, spanned by the stretchers and seat supports.

Next, mark the screw locations on the slats and use a  $\frac{1}{2}$ -in.-dia. bit to bore  $\frac{3}{8}$ -in.-deep plug holes, as indicated in the drawing. Bore through pilot holes in the slats with a  $\frac{1}{8}$ -in.-dia. bit. Position the slats on the bench,  $\frac{1}{4}$ -in. spacer blocks between them. Bore  $\frac{1}{8}$ -in. pilot holes in the supports. Re-



**16** Lean armrest against angled block to mark pilot holes in end grain. Dowel centers are pushed into pilot holes in leg.



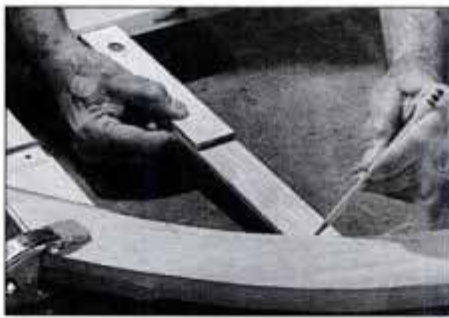
**17** Hold armrest vertically in a vise, and use a doweling jig to bore the pilot holes on marks left by the dowel centers.



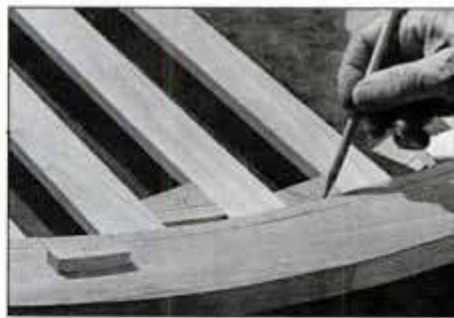
**18** Using a dummy slat for spacing, glue and nail spacer blocks in the bottom rail groove. Blocks negate need for mortising.



**19** Ensure perpendicular alignment of slats in bottom rail with a framing square. Mark slat positions on arched rail.



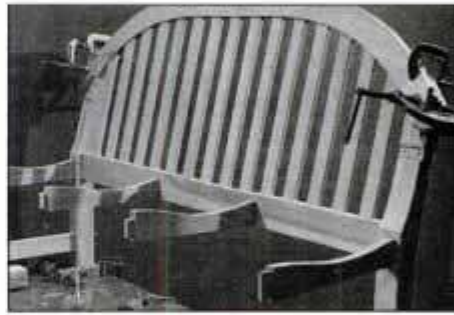
**20** Hold gauging sticks in bottom rail, mark curve at arched rail. Cut curve on sticks and use them to mark slat length.



**21** Cut spacer blocks for top rail overwide, mark rail's curve on blocks, then cut to fit. Number blocks in sequence.



**22** Raise arched rail with slats taped and clamped to it. Brush glue into slat mortises, and lower slats into position.



**23** When glue is dry on lower rail, glue and clamp arched rail to rear legs and slats. Next, glue and clamp remaining pieces.

move the slats and enlarge the  $\frac{1}{8}$ -in. holes to fit the screw shank. Round over the top slat corners, then screw them down. Glue and screw in the armrests. Glue the plugs into the screwholes, and when the glue is dry,

pare the plugs flush with a chisel.

We finished up by applying a coat of Zinsser Kover-Stain oil-based primer/sealer, followed by two coats of Benjamin Moore Impervex white latex high-gloss enamel. **PM**

# HOMEOWNERS CLINIC

BY NORMAN BECKER, P.E., Contributing Editor

## Stone Garden Wall

I'd like to build a free-standing stone garden wall in my rear yard. Can you give me some tips? **HERB COMELLA**  
FORT LEE, NJ

*There are two types of stone wall construction: a dry wall (built without mortar) and a wet wall (built with mortar).*

*With a dry wall, the stones can be quickly restacked if the wall is damaged. This wall needs no footing because it floats with frost heave. The base of the wall should be about 6 in. below grade. Use the largest stones for the base. This avoids the need to lift and place them.*

*The mortar in a wet wall keeps the stones in place and makes the wall act like a monolithic structure. Such a wall needs a footing extending below the frost line to protect it from heaving caused by freeze/thaw cycles.*

*Free-standing walls are usually no more than 4 ft. high and should be inclined from the vertical (battered) at a rate of 1/2 in. per foot of height.*

*For more information on building dry stone walls, see "Build A New England Stone Fence," on page 84, July '82.*

## Roofing Paper

Recently, I was approached by a homeowner who was concerned that

his roof did not appear to have roofing paper between the asphalt roof shingles and the roof deck. He was told by the contractor that the shingles were designed not to require roofing paper between the shingles and roof deck.

Despite assurances by the contractor, the homeowner remains skeptical that any such shingle exists. I would appreciate your comments.

**FRANK D'ONOFRIO JR., ESQ.**  
HARTSDALE, NY

*I checked with the Roofing Industry Educational Institute, and they said they knew of no shingle as you describe it. The type of shingle does not determine whether roofing paper is used, since the paper is supposed to provide additional protection against water penetration. Also, if a few shingles rip off in a windstorm, the paper is supposed to protect the roof deck. Most building codes require roofing paper.*

*Two building industry trade groups disagree on the subject. The National Association of Home Builders says it is not necessary to use the paper, and the Asphalt Roofing Manufacturers Association says it is necessary.*

*According to NAHB, when many of the shingle companies closed their organic shingle plants and started making inorganic-based (fiberglass)*

*shingles, they stopped making 15-pound felt (roofing paper) and started making fiberglass-based roofing paper. Contractors said the new paper wrinkled if it got rained on or if it was left in the sun too long.*

*The Asphalt Roofing Manufacturers Association says roofing paper is necessary because it has a bearing on fire resistance. Shingles are fire-rated as a component of a roof assembly that includes roofing paper and decking material. It also says the roofing paper helps shield the deck from wind-driven rain.*

*From the homeowner's point of view, I would recommend using roofing paper. It's worth it for the extra protection, and it may be required by the local building code.*

## Spalled Bricks

The exterior brick of our home is porous and is starting to crumble. We have had it tuck pointed and sprayed with a transparent water repellent. This has helped very little. Would painting the bricks with a vinyl or lucite paint stop the crumbling? Our home is 26 years old and otherwise in very good condition. Can you please help us?

**MRS. ROBERT WALLACE**  
OAK LAWN, IL

*Unfortunately, the only solution is to replace the deteriorated bricks. Water penetrates through cracks in the mortar joints. The water freezes and thaws, causing the bricks to spall.*

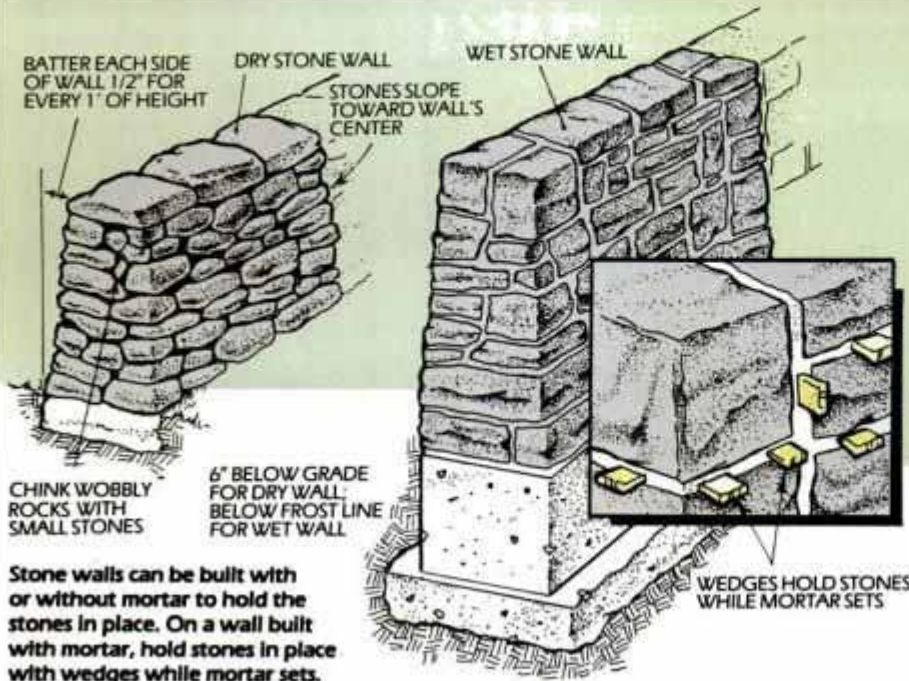
*Once the bricks spall, you cannot reverse the condition. You can only reduce further spalling by sealing cracked or open mortar joints.*

*Sealing the brick face with a clear, penetrating sealant is not recommended by the Brick Institute of America. It can cause more harm than good by trapping moisture that was present in the brick. This moisture freezes and causes the bricks to spall.*

*Painting the bricks is a stop-gap measure. The paint can act as an adhesive, keeping the crumbled pieces together. When the adhesive properties of the paint reach their life cycle, and the paint peels off, the crumbled pieces will peel off with it.*

## 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.*



Stone walls can be built with or without mortar to hold the stones in place. On a wall built with mortar, hold stones in place with wedges while mortar sets.

**TOOL REVIEW**

**PANASONIC  
CORDLESS  
DRILL**

TEXT AND PHOTOS BY  
THOMAS KLENCK, Associate  
Home Improvement Editor

● If you use a drill, chances are that you're already sold on the cordless variety. With adequate power for most jobs, they're simply too convenient to ignore. However, even the staunchest cordless advocate will admit that this high-tech hole borer is only dead weight in the toolbox when the battery needs recharging. And, when you're looking at about an hour until the next hole, it's time to find your standard drill.

Well, the folks who claim to be slightly ahead of their time are coming in right on cue with this entry. The Panasonic EY6205BC 12-volt, variable-speed/reversible cordless drill/driver recharges in a record-breaking 15 minutes.

We tested this tool and found the recharging claim to be accurate. Although the tool recharges quickly, its run-time performance is average in comparison to other 12-volt models. We drove 130 2-in. No. 10 screws into 2-in. lumber before the battery drained. A short 15 minutes later we bored 73 3/4-in.-dia. holes in the same stock. Although the charger is designed to automatically wait until the battery cools down before recharging, our continuous-use tests had little effect on battery temperature, and charging took place immediately.

Up until now, cordless drill manufacturers have offered an array of clips, pockets, slots and holes for holding the all-important chuck key. This Panasonic drill solves the problem the most sensible way yet—with a keyless chuck. Hand tightening the two chuck rings against each other locks the bit in place. If the chuck becomes overtightened in use, a small release rod (stored in the handle) can be used to pry the chuck open.

The reversing switch passes through the tool, above the trigger. Its large size makes it easy to reach and operate, and it has a central trigger-lock position. On top of the tool is the gear selector for choosing the high-torque low range (50 to 350 rpm)



The Panasonic EY6205BC 12-volt cordless drill has midhandle design and 15-minute recharge time. It comes with a keyless chuck and carrying case.



Directly above trigger is FORWARD/REVERSE switch. Keyless chuck has two rings that are tightened against one another.



Gray clutch ring behind chuck adjusts maximum torque to one of five settings. A sixth position locks the clutch for boring.



Top-mounted sliding switch shifts gears to change speed range from low (50 to 350 rpm) to high (150 to 1000 rpm).



Fast 15-minute charger features a 3-minute emergency charge feature that provides 20% of maximum battery power.

or the high range (150 to 1000 rpm).

For driving screws or light-duty nut and bolt tightening, the drill has five clutch positions, plus a lock-up position for drilling. Torque spacing is uniform, and Panasonic claims a maximum of 156 in.-lb. An especially nice touch is the electric brake—a real convenience when driving many screws.

The 15-minute charger also handles Panasonic's 12-volt 1/2-in. drill/driver, the 12-volt drywall screwdriver and a 9.6-volt drill/driver. The model EY6205BC that we tested comes with a carrying case and has a suggested list price of about \$353. Write to Panasonic Industrial Co., One Panasonic Way, Secaucus, NJ 07094. **FM**

# APPLIANCE CLINIC

BY STEVE TOTH,  
Contributing Editor

## Belt Slips

The drivebelt on my General Electric dryer, model No. DDE5900VAL, serial No. DF2-41124G, is starting to slip with a heavy load. The tension device is clean and working. The belt and drum are clean. How do I install a new belt over the drum?

CHARLES SCHULTZ  
KERRVILLE, TX

First, buy a drivebelt, GE part No. WE12X82 (about \$20). Unplug the dryer and remove the dryer's exhaust vent. Next, remove the  $\frac{5}{16}$ -in. screws holding the black access panel to the back, and remove the panel.

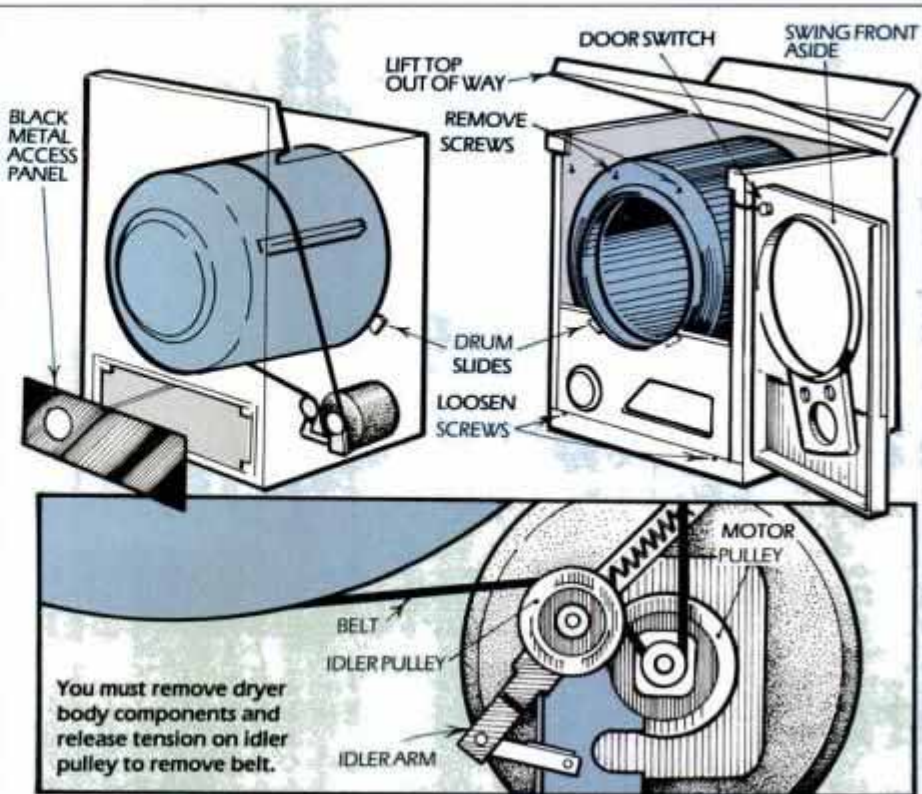
To loosen tension on the belt, grab the idler arm, and pull the arm down and away from the motor pulley. Ease the belt off the motor pulley, then slowly release the tension on the idler arm. Be careful when moving the idler arm. It's under high tension and could snap back.

Next, open the dryer door and remove the four Phillips-head screws under the front lip of the front panel. Raise the cabinet top and, with a towel over its front edge, lean it against the wall behind the dryer. Mark and remove the door switch wires.

Loosen the  $\frac{5}{16}$ -in. hexhead screws at the upper left- and righthand corners over the black kick plate. Remove the two screws at the top left and right corners inside the cabinet. Tip the front panel toward you, pick it straight up and off the bottom screws. There will be wires attached to this panel, so carefully swing it to your right and set it down.

Slide the old belt toward the drum's front and lift the drum at the front. Slip out the old belt at the bottom, and slide the new belt over the drum. Position the new belt with its grooved side facing the drum, where the old belt was located.

Vacuum out the lint inside the dryer, and check the two drum slides at the bottom of the cabinet's front, on which the drum sits. If the slide's nylon strip is worn or missing, it will put more drag on the drum, and that can cause the belt to slip. Remove one slide at a time by backing out the two screws that hold it to the cabinet's front, then lift the drum and slide out



the part. If you need new slides, order GE part No. WE25X60 and a special silicone oil to put on the new slides, GE part No. WE25X94.

Reassemble the dryer's front, put the new belt around the motor pulley, and pull the idler pulley to the left with your left hand. Slip the new belt over the top of the idler pulley. Slowly release the tension on the idler pulley to put tension on the belt. Turn the drum by hand to be sure the belt is aligned on the pulley. Reassemble the dryer, attach the vent, and reconnect the power to the dryer.

## Needs Lid Knob

We received a set of Revere Ware stainless-steel copper-clad cookware as a wedding gift in 1949. We are still using it. I want to locate a Bakelite knob for the lid of the roaster. The knob finally came apart, making the lid hard to handle.

Any help would be appreciated.

O. HARDIN  
HOUSTON, TX

Contact the Corning Revere Consumer Information Center, (703) 942-3500, 8 am to midnight EDT, seven days a week. A replacement knob costs about \$1.50, plus state tax and \$2.50 shipping. This part can be ordered over the telephone with a Visa, Master Card or American Express credit card.

## Washer Won't Pump

Can you help us find parts to get our Hoover compact washing machine, model No. T1001, serial No. 00148267, working again. It doesn't pump out water in the wash and spin cycles. We have replaced belts, but the pump seems frozen. Several appliance servicers told me that parts are not available.

ADA MURRAY  
CHEPACHET, RI

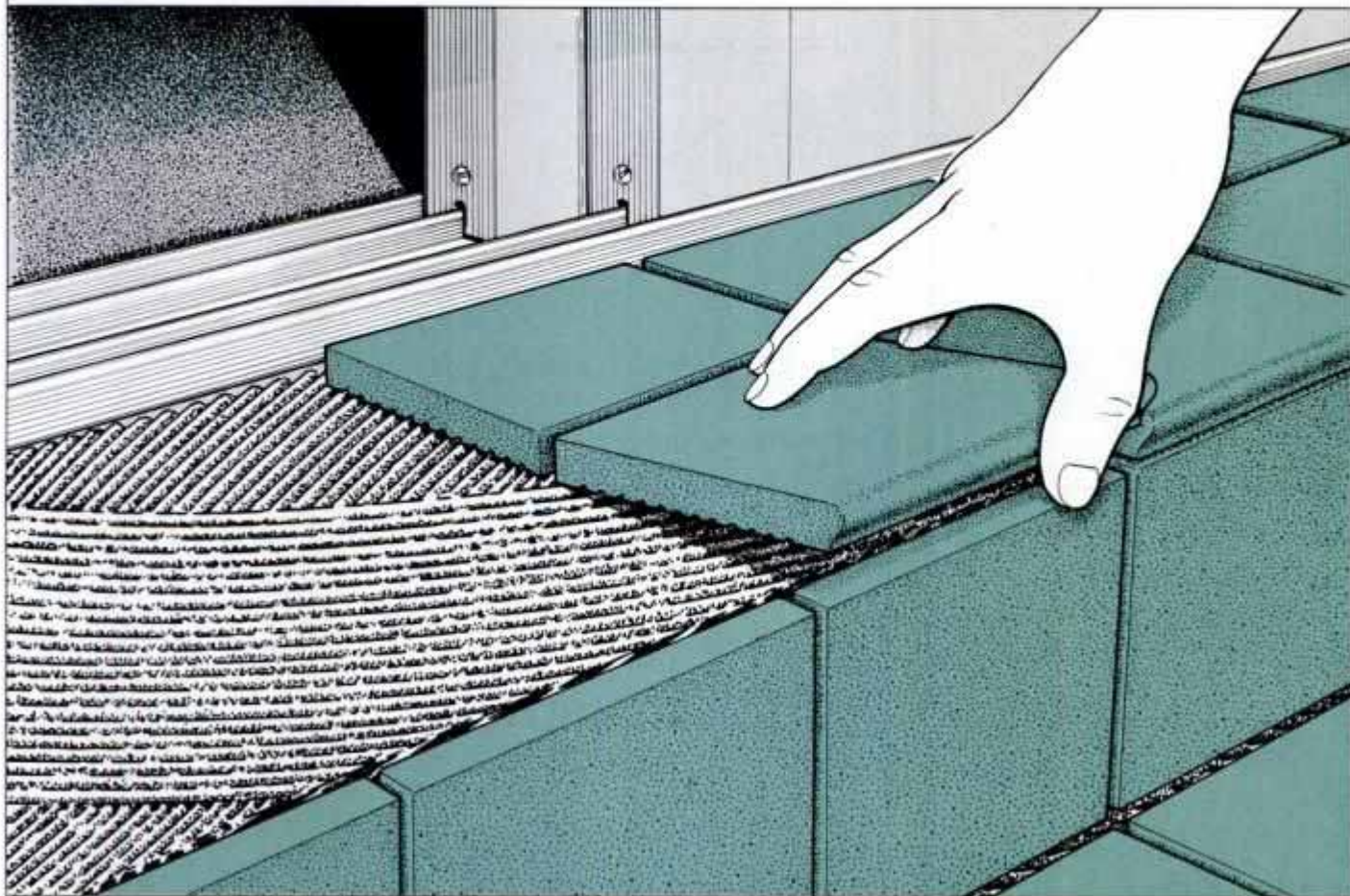
Before ordering a new pump, unplug the washer and check the pump pulley. Turn the pulley until you see a setscrew, then check that the setscrew is tight. The setscrew can loosen, preventing the pump from turning.

Hoover stopped making your model washer about 10 years ago, but many of the parts, such as the timer, main motor, water pump and water fill valve are still available.

A new water pump is part No. 162927 and costs about \$65. It can be ordered from Hoover by calling (216) 499-9200. You can pay for the part with a major credit card, check or money order, or you can ask for the name, address and phone number of a Hoover Service Center near you. **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.



## HOME IMPROVEMENT

# INSTALLING TILE ON A CONCRETE PATIO

BY NEAL BARRETT; PM Illustrations by George Retseck

● The 30 years after World War II saw an explosion of suburban growth, the largest in our country's history. Housing styles changed over the years, but one characteristic endured

—the backyard patio. Custom homes may have had a patio surfaced with brick or slate, but most other homes were provided with an unadorned concrete slab. Although concrete may

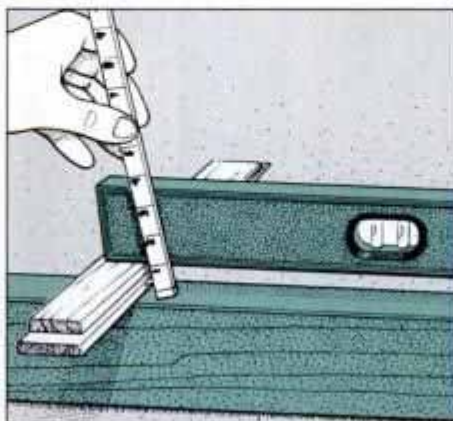
be quite serviceable, it lacks the aesthetic appeal of a nicely finished surface.

An attractive way to cover exterior concrete is with quarry tile. Because of its durability, quarry tile has long been considered the choice material for commercial restaurant kitchens. Recent improvements in grout and mortar have made it suitable for exterior slabs and steps. We chose 6 × 6 quarry tile by American Olean.

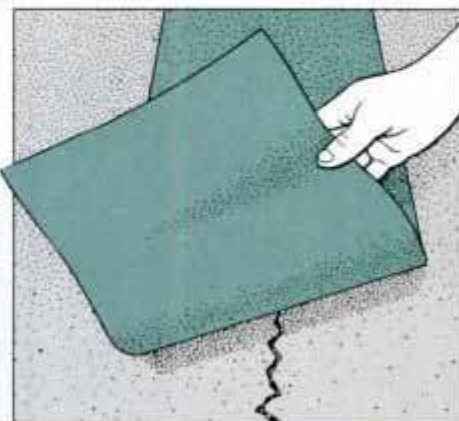
Of course, exterior tiles are subject to wear and stress that interior sur-



**1** Remove small spots of paint or grease with a belt sander. Sandblast the slab if the entire thing has been painted.



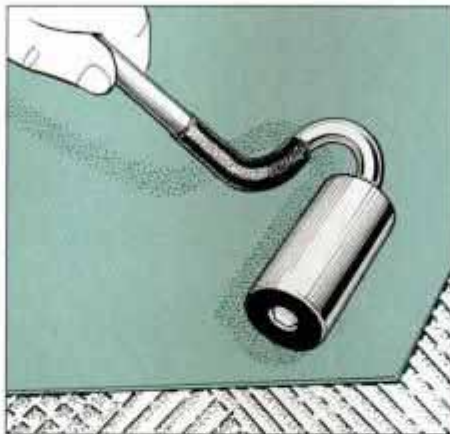
**2** Use a 2 × 4, a level and a ruler to check the slab's slope. Shim up level, then measure from 2 × 4 to bottom edge of level.



**3** Isolate cracks from the tile using Noble-Seal TS membrane. Cut the strips 12 in. wide, and center them over each crack.



**4** Where NobleSeal strips adjoin, cut a butt joint. Overlap the strips, and cut the joint with a razor knife and straightedge.



**5** Place NobleSeal membrane over dry-set mortar spread with a notched trowel. Roll over the membrane from center to edges.



**6** Determine the tile layout, then snap two perpendicular chalklines as a guide for laying the first course of tiles.

faces never see. As a result, certain installation procedures are mandatory if the job is to stand up to extremes of weather, especially in northern areas where the freeze/thaw cycle is encountered.

Chances are you will need several tile tools for this project. Because a homeowner is unlikely to own them, we decided to list them. You will need a tile cutter, a sponge float, two notched trowels, a chalkline, a J roller, a rubber mallet and nipper pliers.

### Preparing the slab

Any slab that has been exposed to years of weather, and countless barbecues, is not going to make an ideal surface for applying tile. The slab's surface has to be cleaned and repaired before applying tile. It's worth taking the time to prepare the concrete for tiles, because if you don't, they will likely come loose. On the other hand, a properly tiled slab will give you years of troublefree service.

The first step in tiling your patio is to inspect and clean the slab of grease

and paint. If either is present in small areas, you can use a handheld belt sander to remove them (Fig. 1). If the entire patio is greasy or painted, have it sandblasted or rent a sandblaster. (Check the Yellow Pages under sandblasting or paint removal.)

The slab should have been poured over a bed of gravel so water can drain from underneath, reducing the likelihood of heaving should the water beneath the slab freeze. Dig around the edge of the slab to determine whether or not a proper base exists—if it doesn't, don't tile the patio.

The slab should be sloped approximately  $\frac{1}{4}$  in. per ft. to drain water off its surface. To check this, lay a straight  $2 \times 4$  over the slab and place a level on it. Shim the low end of the level until it reads level. Measure the height from the  $2 \times 4$  to the bottom of the level (Fig. 2). The  $2 \times 4$  will help you avoid measuring from a low spot.

A minor discrepancy in the slab's pitch can be made up with the mortar bed under the tiles, but if the slab is level, again, it is best not to tile it.

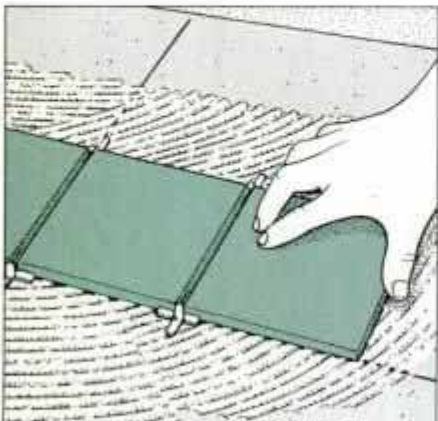
If the slab's pitch checks out, move

the  $2 \times 4$  across the slab to check for low spots that encourage standing water. Low spots or chips can be filled with the same dry-set mortar used for setting the tile (for depressions up to  $\frac{1}{4}$  in. deep) or a surfacing mix (for depressions more than  $\frac{1}{4}$  in. deep) available at lumberyards.

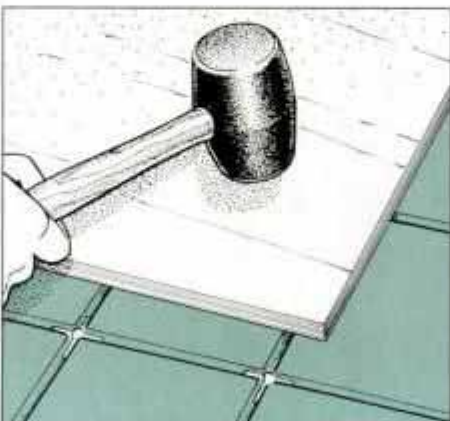
Cracks do not necessarily present a problem as long as the slab surface has remained in one plane. If one side of the crack is higher than the other by more than  $\frac{1}{16}$  in., then proceed no further, as this indicates movement that would crack or loosen the tiles.

For cracks that have remained in one plane, remove loose debris and fill the crack with dry-set mortar. For more protection, you can apply a crack-isolation membrane called NobleSeal TS (the Noble Co., 614 Monroe St., P.O. Box 350, Grand Haven, MI 49417; (616) 842-7844).

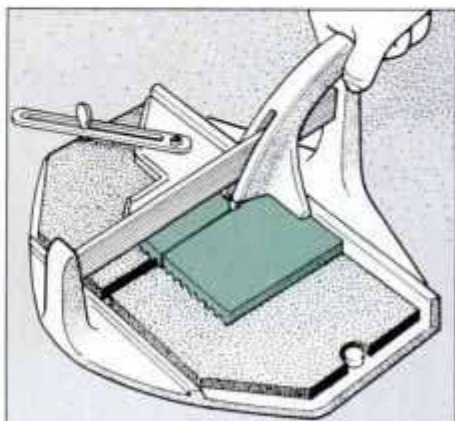
The membrane is a polyester-reinforced polyethylene sheet applied with dry-set mortar over cracks. Cut strips of the membrane 12 in. wide, and center them over the cracks (Fig. 3). Where two cracks converge, over-



**10** Begin installing the tiles along the chalklines. Use  $\frac{1}{4}$ -in. plastic tile spacers at each corner to ensure uniform grout lines.



**11** Within 15 minutes of installing tiles, cover them with a piece of plywood. Tap on plywood to set tiles firmly in place.



**12** To cut tiles near the center, score with a tile cutter, then apply pressure with cutter bar to snap the tile along the line.

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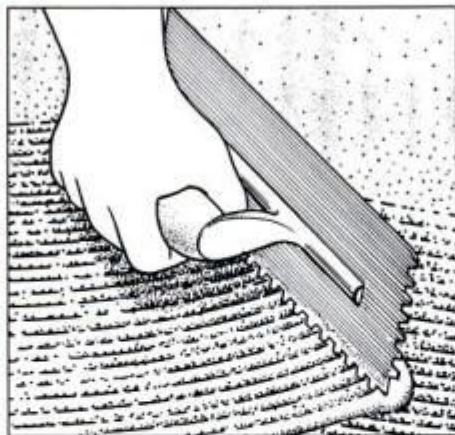
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# HORIZON





**7** Mix an acrylic additive into the dry-set mortar. This increases the mortar's bond strength and its flexibility.



**8** Spread mortar with trowel's flat side. Then apply more mortar with the trowel's notched side. Hold the trowel 90° to slab.



**9** To ensure a good bond, spread a thin coat of mortar on tile's ridged back before applying it. Use the trowel's flat face.

lap the sheets and cut through the joint with a sharp knife to form a butt joint (Fig. 4).

Apply dry-set mortar to the concrete surface with a  $\frac{1}{4} \times \frac{1}{4}$ -in. notched trowel, reposition the membrane and roll over it with a rubber hand roller to embed the membrane in the mortar (Fig. 5). The tile can be installed over the membrane while the mortar beneath it is still plastic or after the material has set for 48 hours.

The final precaution is to provide for proper expansion joints (also called control joints) in the concrete slab. These joints, commonly found running across sidewalks, allow a slab to crack, if need be, along the joint instead of elsewhere. The Tile Council of America recommends that, for exterior installations, the slab be provided with expansion joints at least every 16 ft. The slab should be separated from any foundation or retaining walls by an isolation joint, an asphalt impregnated strip that cushions a slab's movement against an object. If the slab is larger than 16 ft. in any direction, expansion joints should

have been provided when it was poured. If none exist, however, hire a mason to cut them into the slab with a masonry saw.

### Tile layout

Begin by dry laying a row of tiles, with proper spacing between them, the length and width of the slab. For  $6 \times 6$  tiles, a  $\frac{1}{4}$ -in.-wide space is typical, and to simplify the installation, plastic tile spacers are available from tile suppliers. Simply place a spacer at each tile corner. Adjust the rows so the cut tiles along the edges will be the same size. There are bullnose tiles available for use along any exposed edges. If using these bullnose tiles, simply make any required cuts from the square edge opposite the bullnose.

Keep in mind that expansion joints must continue through the tilework. In other words, don't bridge an expansion joint in the slab with a tile. Instead, the joints between tiles should fall over the expansion joints. When you are satisfied with the layout, make a pencil line on the slab three tile

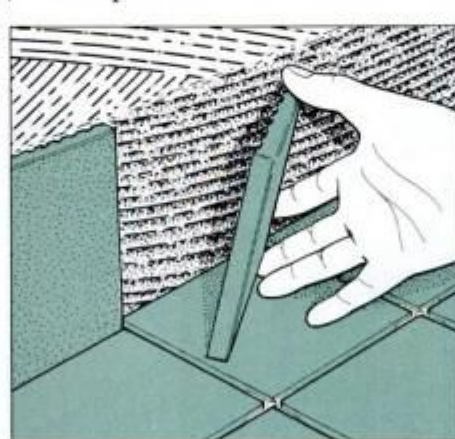
courses from the slab's edge and three courses from the foundation wall, if the slab abuts the house (Fig. 6). Snap chalklines (perpendicular to each other) through the pencil marks to indicate the position of the first tile courses.

The tiles are bonded to the slab with a dry-set mortar. In order to provide a more flexible bond, mix in an acrylic mortar additive (Fig. 7). We used American Olean Dry-Set Mortar with American Olean Acrylic Dry-Set Mortar Additive. Similar products are offered by other manufacturers. After mixing the mortar, let it sit or "slake" for 10 to 15 minutes, then re-mix before using it.

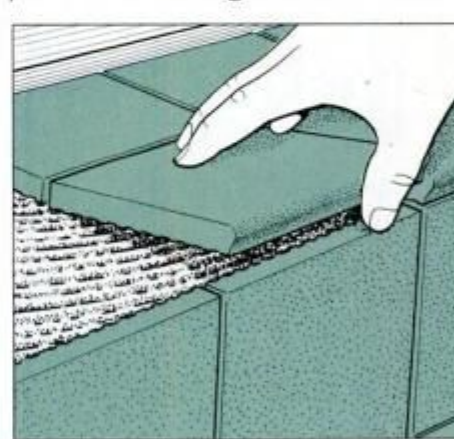
You can mix the mortar and additive with a stick or buy a paint/mortar mixer that chucks into a  $\frac{3}{8}$ -in. drill. Spread the mortar on the slab with the flat side of the trowel, then retrowel the mortar with a  $\frac{1}{4} \times \frac{3}{8}$ -in. notched trowel, held almost 90° to the slab surface (Fig. 8). Spread the mortar in an area that can be covered in 10 to 15 minutes. Spread a thin coat of mortar on the ridged back of each tile



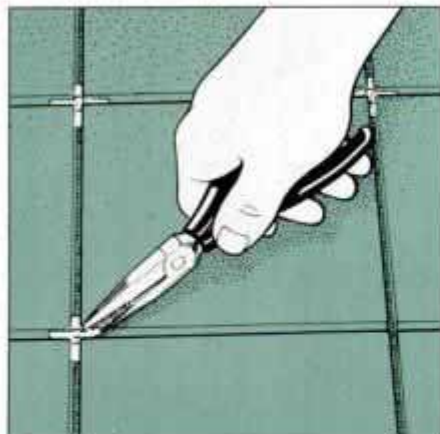
**13** For a cut near the tile's edge, score first with the tile cutter, then use tile nippers to nibble up to the line.



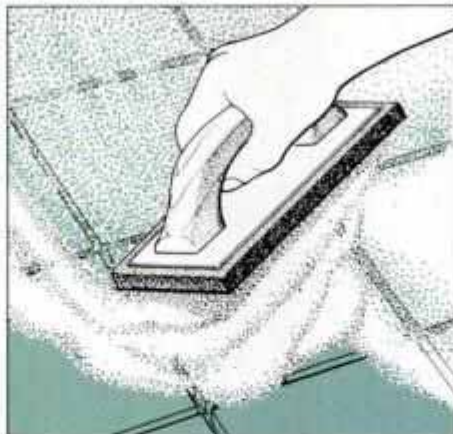
**14** Tile concrete stairs by beginning on the bottom riser. Spread mortar and attach tiles as before. Do the tread next.



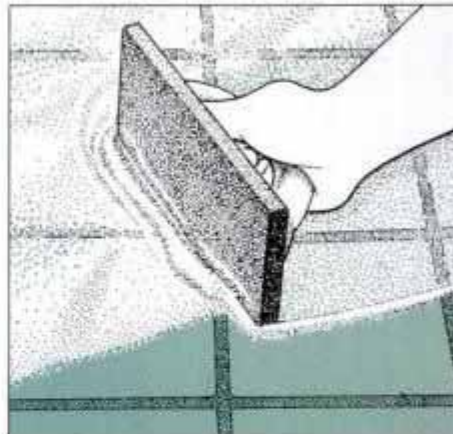
**15** Special treads are available that have carborundum grit embedded in them, for a safe, nonskid surface.



**16** Before grouting joints, pull out plastic spacers with needle-nose pliers. Work up the spacers evenly from four sides.



**17** Apply grout to the joints with a rubber float held at 45° to the tiles. Fill all the joints smooth and level.



**18** Scrape the excess grout from the tiles' face with the rubber float held at a 90° angle to the surface.

to ensure a good bond (Fig. 9).

Place each tile into the mortar, along the chalklines, using a slight twisting motion. Use spacers between the tiles to ensure uniform joints (Fig. 10).

"Beat-in" the first section of tiles by placing a small sheet of plywood over them and tapping on the plywood with a rubber mallet (Fig. 11). This ensures the tiles are well bonded to the surface.

There are two different kinds of tile cuts. If the cut is toward the center of the tile, place the tile in a tile cutter, score along the cutline and apply pressure with the cutter until the tile snaps (Fig. 12). If the cut is toward the tile's edge, score along the cutline, then use nippers (special cutting pliers) to remove small pieces and work up to the line (Fig. 13).

## Tiling steps

Use the same techniques to tile steps as you did to tile the slab. Spread mortar on the bottom riser and on the tiles, and apply them as before (Fig. 14). However, special tiles are avail-

able with carborundum grit embedded in them to provide a nonslip surface on the steps' treads. Tiles with a molded edge are also available for stair-tread use, although these tiles are 3/4 in. thick and command a considerably higher price (Fig. 15).

Cover the tiles with plastic sheeting to protect them from rain, and let them set for 48 hours. Before grouting, use a pair of needle-nose pliers to remove the plastic spacers from between the tiles (Fig. 16). The spacers should be easy to remove, working them up from four sides, if necessary. Don't jerk them from between the tiles. Do not walk directly on the tiles, but use 2-ft.-sq. pieces of plywood to distribute your weight over the tiles.

The joints between the tiles are filled with a sand-portland or dry-set grout mixed with an acrylic latex additive. We used American Olean's Sanded Floor Grout and Acrylic Grout Additive.

Apply grout to joints with a rubber float, holding the tool at a 45° angle to tile surface (Fig. 17). Work the grout into the joints, then hold the float at a

90° angle to scrape the excess grout from the surface (Fig. 18).

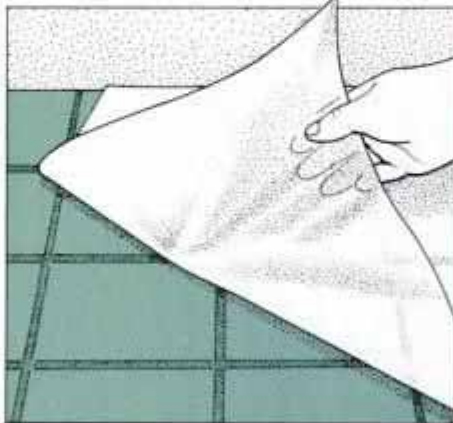
After the grout has set for about 15 minutes, use a damp sponge to wash the grout residue from tile surfaces (Fig. 19). Rinse the sponge frequently in clean water, and try not to soak the grout joints with additional water as you work. When working with acrylic-fortified grout, it is important to clean the tiles before the grout dries, because once dry, the grout is extremely difficult to remove.

Protect the newly laid tiles from the rain by covering the installation with plastic sheeting (Fig. 20). Keep off the patio for 72 hours. The acrylic additive in the mortar and grout remains soluble in water until it fully cures in four weeks. This will not prevent you from using the patio, but it should be covered when not being used until the latex additive has cured.

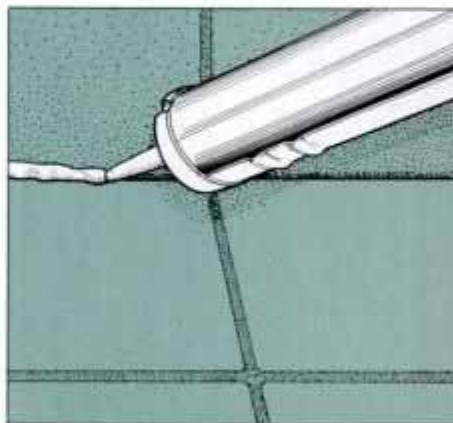
Seal the expansion joints with a urethane sealant. These sealants are available in tubes and are easily applied with a caulk gun (Fig. 21). Follow directions on the sealant tube for specific application instructions. **FM**



**19** Use a damp sponge to remove excess grout from tiles. Rinse sponge frequently in clean water. Wear rubber gloves.



**20** Cover tiles with plastic to protect them from rain. Acrylic additive in mortar and grout is water-soluble until both cure.



**21** Fill the expansion joints with a smooth and uniform bead of urethane sealant applied with a caulk gun.

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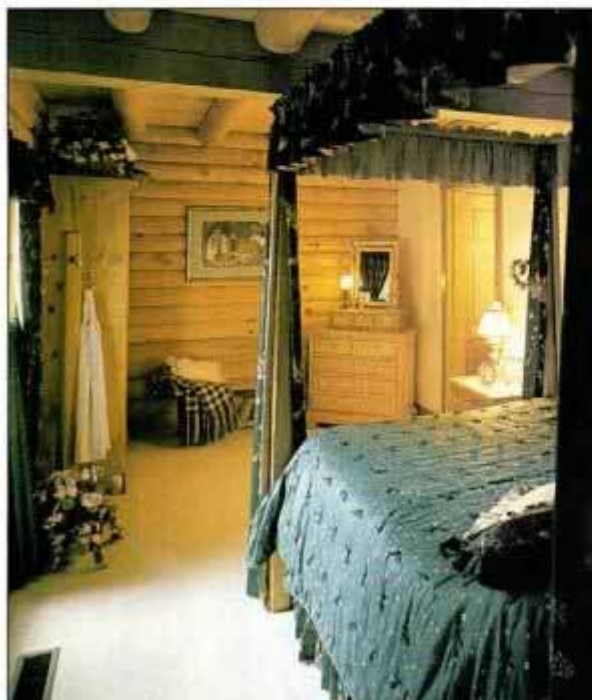
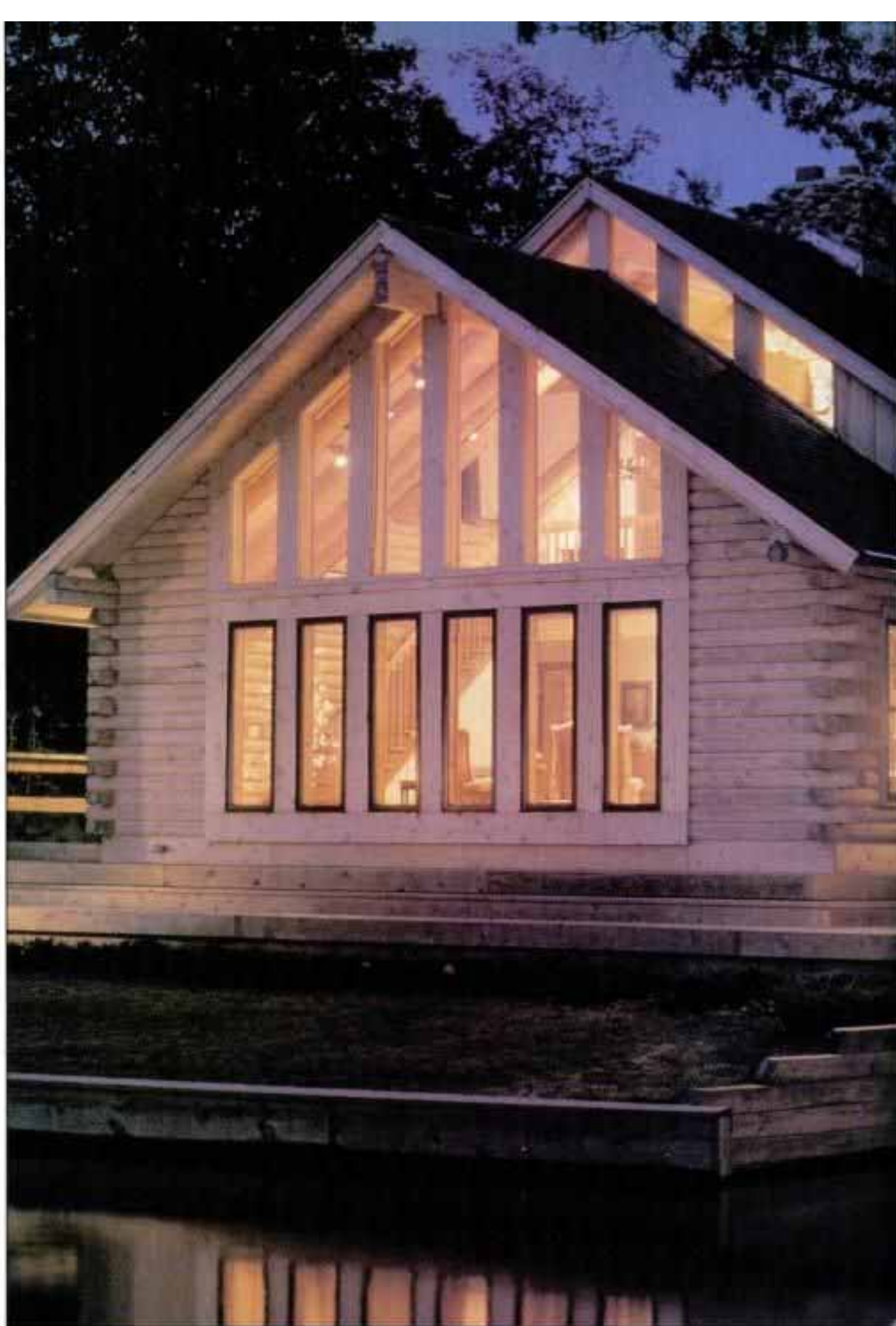
# HOME-BUILT

Today's manufactured housing offers a wealth of opportunity for people who want to build their own home.

BY DENNIS ESKOW

● Most Americans have grown up with the dream of owning their own home, an idea that is woven directly into the fabric of American life. And while this dream may still be viable for some, it certainly does come at an ever higher price. In fact, many of today's starter homes are completely out of reach for young families, even those with two wage earners. And the move-up market is almost as restrictive. Many people simply can't afford the high monthly payments that the current price tags require. In some quarters, you can even hear people discussing—with some seriousness—the idea of 100-year mortgages passed on from one generation to the next. Fortunately, there is a glimmer of hope in all this doom and gloom, and it's called factory-built housing.

Factory-built housing, often called manufactured housing, is a term used



Log homes have come a long way from the days of Daniel Boone. The stunning lakefront home shown above boasts glass-filled walls, high cathedral ceilings and the latest in other amenities. The structure can still, however, maintain the charm usually associated with log living, as shown in the warm and cozy bedroom at left.

to describe a home that was built—at least in part—at some kind of manufacturing facility, not on the building site. The fabricated components are then transported to the site where they are assembled into a house. There are several advantages to the manufactured approach. The first is time. By not being as exposed to the whims of Mother Nature, factory-builders can shorten the production schedule required to get a house from the drawing board to a lot. They can also monitor waste better, reduce theft and more accurately maintain inventories—all of which are very difficult to do when you are building out in the middle of an open field. The factory environment also permits the use of more sophisticated assembly equipment.



Wood is very machinable, and log manufacturers have taken advantage of this trait. The eye-catching white house (top, left and above) is actually a log home. The exterior surface of the logs looks like clapboard siding, and the interior surfaces have square corners.

Efficiencies like these can significantly reduce the cost of any house. The manufacturer then has the option of passing these savings along to the consumer or plowing the savings back into the product by delivering a higher-quality home. Any way you cut it, the end result is more value per dollar for the buyer.

Factory-built homes are available in a wide price range, with the low end starting around \$40,000 and the high end reaching in excess of \$750,000. But the list price of these houses can represent as little as one-third of their total cost. Additional funds go to land purchase, site preparation, mechanical systems and some interior finishing. For a thorough discussion on how to properly finance a factory-built home, see "Financing The Factory-

Built," which starts on page 62.

The selection of house type is nearly as broad as the price range, though the market is divided into some pretty clear categories: log homes, panelized homes (which includes the post-and-beam builders) and modular homes. These classifications are the ones established by the National Association of Home Builders' (NAHB) Building Systems Council. And, a discussion of each type will follow after we've taken a look at some factors that all three groups of houses have in common—namely—the design process, zoning restrictions and site preparation requirements.

## Design

It is an apparent contradiction within the factory-built housing industry

that the strength of the business—factory uniformity—is also its biggest weakness. How can someone design something that is relatively uniform and still have the unique qualities that most people look for in their own home? The best answer is that it takes some work. But today's manufacturers have learned lots of design tricks over the years, and now they have one of the most powerful design tools they've ever had: the personal computer.

Computer-Aided Design (CAD) has made it possible for manufacturers to offer buyers almost anything they want. Today, the buyer can sit at a computer with the builder or a contractor and see full-color renderings of all types of houses. These renderings can be turned, changed and en-

## FACTORY-BUILT HOUSING



Computer-Aided Design is a great timesaver in the design process. But it's equally invaluable as a sales tool. Manufacturers can quickly show customers site renderings (above), as well as detailed section views (right), plan views and elevations.



hanced with just a few keystrokes.

Lindal Cedar Homes of Seattle, Washington, for example, uses AutoCAD software. This can give prospective customers pounds of ideas in the form of a book chock-full of spectacular color photos, floor plans and a design planning grid. The grid has a master floor plan to help you get started, and employs the standard symbols for interior and exterior components. Lindal also uses AutoSketch, an AutoCAD subprogram, to help customers do rough drafts of their visions on computer. These very basic renderings are then refined by the AutoCAD program.

Of course, the time-honored method of roughly sketching your dream house and giving the sketch to a design team to upgrade is still widely used. Acorn Structures of Concord, Massachusetts, for example, has a design staff of 15 people, including three registered architects who work with buyers to create individualism in all their houses. Acorn does have a CAD system, but company President Art Milliken says the preferred design method is still on paper. CAD is used just to keep an accounting of the number of different-size panels that have to be cut at the factory.

Whether the design is done at a terminal or on a piece of paper doesn't matter as much as the issue of customized design. Many manufacturers thrive on changing standard models to better accommodate buyers' needs. Not only does this promote customer satisfaction, it also combats the frequent misconception that all manufactured housing looks alike.

This design flexibility, however, can make choosing something you like pretty daunting. To relieve this confusion, the American Institute of Architects (AIA) makes a very practical suggestion: Be sure to reserve final approval on any specific design feature until you've seen it in an actual house. Design problems sometimes don't show up until building time, and then they are corrected on site, sometimes in ways you won't like. Remember, what you see on the computer rendering may not be the same thing that ends up in your house.

When all the designing is done, the finished home can look remarkably stick-built. "When a modular, stick-built or panelized home is completed, you can't tell one from another if they were done well," says Steven Winter, the New York-based architect of hundreds of factory-built homes. "There was a time when modular houses were restricted to 1200-sq.-ft. bores, but that has changed." Over the years, he has led the revolution with 16-ft.-high cathedral ceilings, roof dormers, skylights and other eye-catching amenities. The size of modular models has also expanded, some to beyond 3000 sq. ft., with windows galore in all directions.

### Zoning

While you may not run into any trouble finding a design and a price that you like, you can run into some zoning roadblocks, especially if you are planning on building some or all of the house yourself. The first thing that you should remember is that local zoning boards are made up of a sampling

of citizens, including business people, school teachers and factory workers. Members are not usually required to have any practical knowledge about the building business in general or the housing market in particular. Because of this, their decisions can often be arbitrary and can only be reversed by a court.

To reduce your chances of running into trouble, be sure to visit your local zoning board before you purchase any home. Most manufacturers will provide you with plenty of color slides showing identical or similarly finished houses. Customized renderings and other product literature also should be available to present to your zoning board. If the board does have some objections to your chosen design, often the manufacturer will make the requested changes at little or no extra charge. Remember, getting a home approved in any area usually breaks new ground for the manufacturer's sales department, so they want to be as cooperative with you and the zoning board as they can be. If your area has enough potential for them, a manufacturer might even send an architect to meet with the zoning officials to help work out any differences.

Just one example of such cooperation involved Epoch Homes of Pembroke, New Hampshire, which had its triple-decker townhouses featured in an episode of the PBS program "This Old House." Epoch had to work out a deal with the neighborhood planning board to get approval for the houses shown on the air. Among other things, simple bay windows were

*(Please turn to page 64)*





TIMBEREG PHOTOS



Post-and-beam structures, like the house above, bear no resemblance to their humble forebears. Exposed beams in the kitchen (below) and soaring cathedral ceilings in the bedroom (left) are two of many interior design options made possible by this traditional technique.





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## FACTORY-BUILT HOUSING

transformed to walkout bays, replete with ornate parapets, to give the factory-built facade a traditional look. Such customizing only upped the cost of the building about 2%.

The biggest hurdle with a zoning board can be created simply by deciding you want to be your own builder or general contractor. Zoning boards are accustomed to dealing with professional builders who have known track records. First-time builders are looked on with a lot more skepticism. For this reason, you must be doubly careful about your homework.

Even before you buy the land for your house, find out exactly what permits are required and when they are supposed to be filed. Also, pay a visit to your local building inspector, and explain what type of house you want to build and ask for any advice that could help shepherd the project through the system. Finally, decide that you are going to have the patience of Job. If you can't do this, you



should consider hiring a builder to handle the project for you. In fact, even the most enthusiastic do-it-yourselfers should probably solicit construction bids from at least three builders before they tackle the job themselves. The extra cost of a good builder may well be worth it in the short and long term.

### Site Preparation

No matter what type of house is being built, there are only two points on

which you can get all factory-builders to agree: Properly preparing the building site is absolutely critical to a successful project, and foundation digging is a job for professionals only.

The first step in site preparation is to find out something about the land before you buy it. If public water is not available, you'll want to know how deep most of your neighbors had to drill for water. Of course, they may be luckier than you, but their input should give you a ballpark figure.

## Financing The Factory-Built

BY MARY WALTERS

● To hear the manufacturers tell it, financing a factory-built house isn't much different than getting a loan for any other type of home. After all, a mortgage is a mortgage is a mortgage no matter what kind of house you live in. Right? Not quite.

The truth is, coming up with the cash for a manufactured house—whether it's a log home, panelized house or modular structure—can be far more complicated than getting a mortgage on a house you'd buy through a real estate agent. In fact, financing a factory-built home requires much the same careful planning, attention to detail and concentrated effort you must put into building one.

Fortunately, if you're looking to build and finance a factory-built home now, you've got two trends working in your favor. First, in early spring, mortgage rates began edging downward toward 9%. Except for a blip in 1987, that's the lowest they've been in more than 10 years. While any number of wildcards could upset this trend—a spike in oil prices from another flare-up in the Persian Gulf comes to mind—most economists expect mortgage

rates to hover at the bottom end of a 9 to 10% range during the next year.

And, if you are like the majority of factory-built home buyers who hire a builder or general contractor to build at least some parts of your home, you may also be able to save on labor costs. The reason: In areas of the country where the housing industry has been in the doldrums, many builders are willing to cut their usual rates to get work. "The cost of hiring a builder is way down in some parts of the country," says Doug Reid of Acorn Structures, a panelized-home maker in Acton, Massachusetts. "You can easily save 10 to 15%."

Enough euphoria. Now back to the serious business of nailing down that loan.

Before you even begin talking to lenders, you should know that you will have to raise more cash than just the cost of the basic materials supplied in the manufacturer's kit. You've also got to finance what the factory doesn't provide—such necessities as plumbing, electricity, a heating and cooling system, improvements to the site (which usually include a water well and septic system), and often interior finishings like cabinets, flooring and major appliances. And, if you hire a contractor to help you build your home, you also have to pay for labor.

Exactly how much these different components add to the cost of the basic kit varies tremendously. For example, site preparation work, such as cutting and removing trees, grading the lot, excavating a foundation, drilling a well and installing a septic system, can easily run from \$10,000 to \$25,000, depending on the amount of work your site needs. If you use a general contractor who builds the entire house, including hiring subcontractors to do electrical, plumbing and other work, you can add another \$30,000 to \$50,000 in cost. Don't forget to add the cost of shipping the package to your site. That cost will vary depending on the manufacturer and the distance from the factory to your site, but you should figure on about \$2 per mile for each truck. Since many homes require two truckloads, transportation to your site from a factory 400 miles away could run about \$1600.

Of course, the actual costs you incur will depend on the size of the house you buy, the quality of materials used throughout and the amount of site work needed. "But a good rule of thumb is that a completely finished ready-to-move-into house will cost you two-and-a-half to three times the cost of the basic package," says Rich Horn, sales manager for



Panelized homes (far left) can feature stunning craftsmanship, like the ornate trimwork at left.

Don't forget, well drillers charge by the foot, and they can't guarantee at what depth they're going to find water. You'll keep paying until they do.

You'll also want to find out about the drainage characteristics of the soil on your property. This will help you locate your foundation in an area that will reduce the possibility of water entering it. It will also tell you the size and type of septic system that's needed if public sewers are not available.

A visit with your local U.S. Depart-

ment of Agriculture soil conservation agent should answer many of these questions, as well as others, like the presence of any hazardous-waste dump sites in the area, what the local weather conditions are, and how many sunny days a year are typical for the area.

In the past, land purchasers had to run perk tests and soil surveys to establish the best building site, well area and location for a septic system. All of these are still absolutely neces-

sary if your land is far from any subdivision or other zoned area.

But in the past decade, some of these tests have become unnecessary in areas that are already zoned for housing. Instead, the county planning department, water and soil conservation department, or office of environmental protection will have documents on file. You can request the environmental test results for the property you want to buy, as well as the neighboring properties.

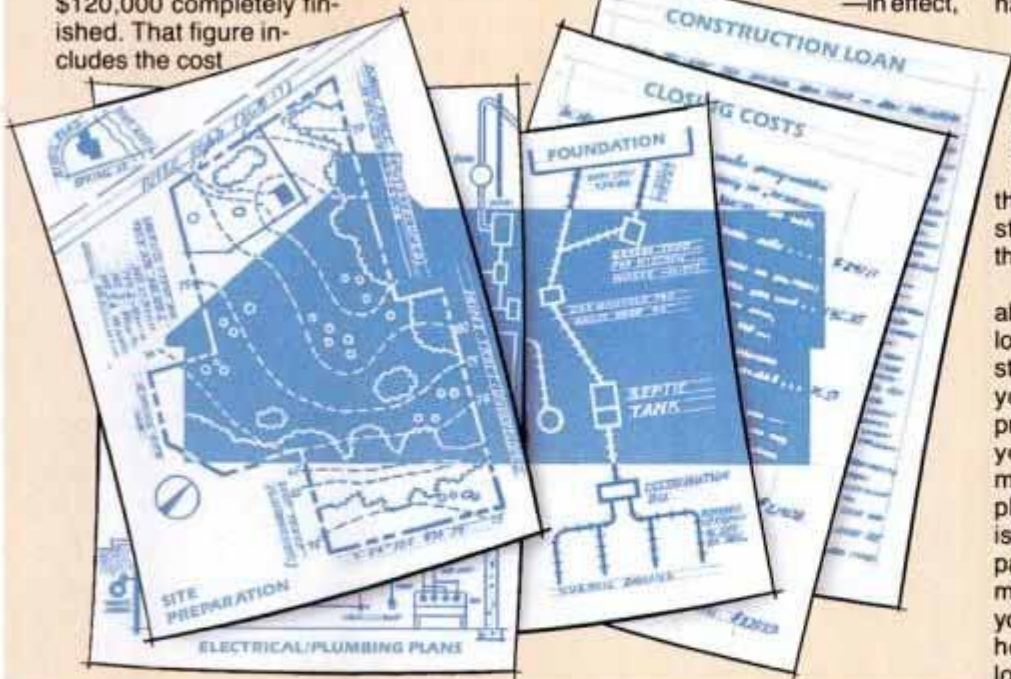
Other good sources of information are nearby neighbors and local newspapers. Neighbors will tell you if basement flooding or seepage is prevalent in the area. And local newspaper files in the town library may reveal any dangerous dumping in your area. Don't forget that all U.S. counties have flood-plain maps, usually available in the county planning office or the county engineer's office. Flood-plain maps classify areas in terms of "flood epochs." A 15-year flood plain

Northeastern Log Homes in Kenduskeagh, Maine. Thus, estimates Horn, a 1700-sq.-ft. log-home kit that sells for about \$40,000 would actually wind up costing anywhere from \$100,000 to \$120,000 completely finished. That figure includes the cost

of making your site ready for the home, but *not* the purchase price of your land. While it is possible to finance the land as well as the rest of the house, the whole process goes a lot more smoothly—and

lenders are much more likely to make a loan—if you already own the land on which you intend to build. In most cases, the land amounts to the homeowner's equity in the project—in effect,

them seem a bit unsure of whether they're interested in financing a manufactured house or, for that matter, exactly how to go about it. "Most mortgage companies and banks have no real system for financing a factory-built home," says David Straight, president of Eagle's Nest Homes, a panelized-home manufacturer in Canton, Georgia. As a result, you will find policies vary greatly from lender to lender and that there's nothing even approaching a standardized system for financing the construction of such a home. Generally speaking, you will probably need two loans—a construction loan and a home mortgage. The construction loan will provide the cash you need for the kit itself, site improvements and the other expenses you incur along the path from the manufacturer's package to a complete home. Once the house is finished, the construction loan will be paid off and replaced by a long-term mortgage—the same type of loan you would use to buy a conventional home. Usually, you will get these loans from separate lenders—the construction loan from a bank and the mortgage from a mortgage bank, an institution that specializes in home loans. You can also get a mortgage loan from a savings and loan associa-



of making your site ready for the home, but *not* the purchase price of your land. While it is possible to finance the land as well as the rest of the house, the whole process goes a lot more smoothly—and

the money you put in upfront, much like the down payment on a regular mortgage.

Once you're ready to start talking to lenders, don't be surprised if many of

## FACTORY-BUILT HOUSING

is a place where floods are expected every 15 years. A 5-year flood plain is not suitable for housing.

Site preparation, in the broadest sense of the term, should also include a lot of construction considerations. Street or road access—both for delivery of the house kit and for eventual access to the finished house—is important, as is the distance from the house to any pertinent utilities like gas and electric lines. Bringing these services to the house is a cost that is usually born by the homeowner and can really add up over long distances.

Many other considerations can also impact the house location. For this reason, it's a good idea to draw a rough plan of the property that accurately shows the proposed building site. Then show this plan to everyone concerned and get their views on the location. Often something that makes sense to the local soil conservation agent would drive a mason to distraction, or what makes sense in terms of



ACORN STRUCTURES PHOTOS

supplying the house with electricity will not take into account the value of a spectacular view.

Also, keep in mind that good site selection can make an enormous difference in the final cost of a building. One contractor told us that he built two subdivisions in the same community. The soil in the first one turned out to

be much sandier than the soil in the second one, which was made up of very dense clay. The soil in the second subdivision added almost \$15,000 to the cost of each house that was built there.

The second major point of agreement among all manufacturers is the need to have the building site exca-

tion or even another bank. In some cases, you may find a single lender who will, in effect, make both loans by giving you what is sometimes called a personal construction loan. Under this arrangement, the construction loan automatically converts to a mortgage when you've finished building.

Very few manufacturers offer financing. They're in business to sell houses, not lend money. But there are a few exceptions. Eagle's Nest, for example, owns part of a mortgage lending operation and provides mortgages on its homes. Usually, however, for financing advice, the manufacturer will direct you to the company's local dealer, sales rep or a builder who has constructed the homes. "A good builder or dealer should be able to suggest a few local banks and other lenders who have financed factory-built homes in the past," says Art Watkins, director of the Building Institute in Piermont, New York. "These recommendations can be a big help because at least then you're dealing with a lender who's familiar with this type of house."

Paradoxically enough, you begin your financing search at the end—that is, you look for the mortgage first. The reason behind this seemingly backward approach is simple. Bankers view construction

loans as risky ventures—after all, there's always the chance you won't finish the house or build it badly, eroding its market value—so they prefer to keep the term on these loans short. Once you get a commitment from a mortgage lender—that is, a promise to make a mortgage loan in the near future for a specific amount of money—the bank at least has a margin of safety knowing that funds will be there to pay off the construction loan.

In order to give you a mortgage, the mortgage lender must do what is known as a plan appraisal—essentially, his estimate of the market value of the house once it's built. To do that appraisal, the lender will need all the architectural drawings and plans for the house plus a detailed breakdown of the cost of all materials and labor needed to complete the house. You should also include the cost of your land and planned site improvements. If you are working with a builder or contractor, he should be able to provide the specs and cost estimates. "You want to give the lender as detailed a breakdown of costs as possible," says Northeastern Log Homes' Horn, "because he's going to estimate the market value of the house and make a loan based on that information."

You should also bring a copy of the deed to your building lot or land as well as copies of contracts with the house manufacturer and the builder or contrac-

tor. If you are using a contractor to help with the construction, it's a good idea to have him visit the bank with you since he may be able to answer any questions the banker may have about the price estimates or building plans.

Once the mortgage lender estimates the market value of the completed house and land, he can give you a mortgage commitment, usually for between 80 and 90% of the market value. Of course, as with any other mortgage, you will also have to show that you have enough income to make the monthly payments on that mortgage. Along with the mortgage commitment, the lender may also commit to a specific mortgage rate. Few lenders, however, will guarantee a given rate for more than 90 days. As a result, the actual rate you pay will be determined by the going market rates at the time you complete the house.

With a mortgage commitment in hand, you can begin trying different banks for a construction loan. The bank will want to see the same detailed price estimates that you showed to the mortgage lender. Again, if you have decided to hire a builder or general contractor, take him along on the trip to the bank.

Although lending policies differ from bank to bank, most construction loans last from six months to a year. During this time, you usually make interest payments only. The principal is repaid by the



Panelized houses can have contemporary interiors with high ceilings and clever window treatments.

vated by a professional. A corollary to this axiom would be to have the foundation work done professionally, too. It doesn't matter if you want a full basement with plenty of headroom or just the minimal crawlspace under your house. The foundation must be built to very tight tolerances, or the house kit won't fit properly. Remem-

ber that conventionally built homes can be easily changed to fit a sloppy foundation, but the factory-builts can't, especially if you are assembling the house yourself.

One final preconstruction site test that should be performed is for radon. Radon is a cancer-causing gas that can be present in the soil. When allowed

to vent into the open air, it's harmless. But when trapped inside a tightly insulated house, like the factory-built models we're discussing here, it can build up to dangerous levels. The presence of radon, in and of itself, should not force you to reject a building site. You'll just have to factor into the overall house price the cost of a subslab ventilation system. If you find radon, contact a local radon reduction company and get an estimate for the installation of a proper ventilation system. They're cheaper to install when the house is being built than after it's completed.

Now, onto a brief look at the three basic forms of factory-built housing.

## Log Homes

Log homes come in an astounding variety of sizes, styles and price ranges. Inexpensive rustic cabins attract many back-to-nature enthusiasts, especially as second homes, while highly architectural versions can stretch the

mortgage loan. Since many kinds of pre-fab houses can be built within three or four months, you will probably be able to pay off the construction loan well before it comes due. In fact, you'll want to repay it as early as possible since construction loans typically carry much higher rates than mortgage loans. Many banks, for example, charge three percentage points or more over the prime lending rate. With prime recently at 9%, that would put your construction loan at 12%. And some banks were recently charging 14% or more, well above the 9 to 10% rate on home mortgages.

The most important—and complicated—part of the financing is arranging a schedule that lets you tap the construction loan to pay the bills you incur as you build your home. Most banks allow you to do this in a series of four to six draws, each of which is tied to completing a specific stage of construction. Each bank may have its own particular timetable for draws, but a typical draw schedule might go something like this: the first draw when you've finished the foundation and other site work; the next when the home package has been shipped to the site; the following when you've put up a weather-tight shell; another after plumbing and electrical work has been in-

stalled; the next when all the interior work is finished; and, the final draw when the local building code official has given you a certificate of occupancy for the home. A bank appraiser will probably want to inspect the work at each stage before the bank will advance the funds.

It's crucial that you, the bank and, if you're using

that they've delivered a house and should be paid for it. The construction lender, on the other hand, views the home package not as a house, but as a pile of lumber that may eventually become a house. They may want to withhold payment until you've reached one of the stages of construction described above. Some give and take by all parties usually works out these impasses. You should be prepared, however, to come up with some of your own cash to get over any difficult periods without interrupting construction.

Finally, keep in mind that the better prepared you are when you seek out lenders, the more receptive they'll be. Have all your cost estimates, architectural plans and financial information showing your ability to handle the mortgage payments organized when you're ready to talk to the lenders. And when it comes to getting a mortgage, remember that it pays to shop around. Even though Eagle's Nest Homes offers mortgages, the company's dealers still encourage customers to check out local lenders. "If they can get a better rate," Straight says, "that may help us sell the home." **PM**



one, the builder work out a draw schedule that everyone can live with. Often, the home manufacturer or your contractor may want you to come up with money before the bank is ready to dole it out. For example, many manufacturers want anywhere from 10 to 50% of the cost before it's shipped and the balance when the package is delivered to your site. "Most manufacturers won't even unload the house until they get paid," Watkins says. Their reasoning is

## FACTORY-BUILT HOUSING



**Panelized construction:** Once the foundation is complete, the prefabricated walls are brought to the site and erected.



are today's joinery methods. Northeastern Log Homes, for example, machines their logs with a matching tongue-and-groove joint. They also supply caulking and foam gasket strips that are applied to both sides of the joint as the logs are laid up.

More than other factory-built housing, log-home companies tend to be local concerns. There are more than 540 log-home manufacturers—not to mention the countless sawmills that pre-cut log homes—across the nation. So there is rarely a need to travel great distances to find the model of your dreams.

Good log-home makers look for the highest available grades and species of wood. For instance, northern white cedar contains lots of air pockets that create better insulation. Western red cedar is considered insulating too, although less so. Southern yellow pine and fir are also considered to be among the better insulating woods.

### Panelized Homes

If the log manufacturers work with the smallest building unit size, namely one log, and the modular folks work with the biggest, one "box" (for the lack of a better word), then the panelized people occupy the middle ground, and what a fertile territory it is. Even though there are so many different panels available, they all do have one simple thing in common. Each was fabricated in a factory—typically 8 ft. high by somewhere between 4 and 40 ft. long—and then shipped to a building site. Once at the site, they can either be attached to a self-supporting building frame or joined together as load-bearing walls, depending on their design.

To further differentiate between panels, some are referred to as open, which means that the framing members come with only one layer of exterior sheathing on one side. Others are called closed because to some extent they are complete wall sections with sheathing on both sides, and insulation and electrical and plumbing components on the inside.

From these humble beginnings,  
*(Please turn to page 72)*

imaginations and budgets of wealthy primary home buyers. In some respects, the only thing that the log-home manufacturers have in common is the simple definition of a log home supplied by the NAHB's North American Log Homes Council: A log home is a structure having solid log walls that range from 6 to 15 in. in thickness. That's it.

Clearly the bulk of the market exists somewhere between the lowly cabin and the palatial compound, with a real slant toward customers who want to actually build the houses themselves. According to industry estimates, nearly 75% of all log-home buyers are do-it-yourselfers. The reason for this is simple to understand: The cost of a log home can be cut by as

much as 50% by building it yourself.

Log homes have long been popular in this country. But they fell out of favor rapidly after World War II with the onslaught of tract housing. When the energy crunch of the 1970s came along, however, the log business started to come back to life. Log homes were less expensive to build and could boast some impressive energy conservation features. In fact, some of today's log homes are so tight, you have to introduce outside air into a fireplace or wood stove, to avoid the danger of seriously depleting the oxygen supply inside the house.

Part of the reason that today's log homes are so tight is that the logs can be cut more precisely in the factory than on site. But equally important



**Modular homes are built almost entirely in the factory and then trucked in modules to the building site where they are erected.**



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some truly spectacular homes can result, a couple of which are shown on pages 64 and 66. The most eye-catching capability of panelized construction is the frequent use of open space. This is particularly true in post-and-beam homes.

Of course, post-and-beam construction is one of the oldest forms of building, something just about all of us have seen when we've looked in an old barn with an open hay loft. The framework for these structures consists of vertical posts and horizontal beams. Typically, the size of stock used for these components was so large that they could span large areas without needing additional support. When this type of building is applied to the residential market, unusual and distinctive spaces can be created.

The panelized manufacturers make use of this open, self-supporting post-and-beam structure to hang their panels in place. Because there are no load-bearing walls, the floor plans can be much more open, and cathedral ceilings are easy to accomplish.

Other panel manufacturers produce what they call self-supporting panels. Once these are joined together, they are strong enough to act as load-bearing walls. IBS, a multinational panelizer in Riverdale, New Jersey, builds its panels in 8 x 8-ft. squares using welded galvanized steel studs and exterior plywood sheathing. None of their panels weigh more than 130 pounds, so there is no



need for a crane to be at the building site. In some cases, these self-supporting panels can also span great open spaces and give the customer a real sense of buying something special.

As compared to log homes, the panelized structures aren't as friendly for do-it-yourselfers. While many manufacturers do offer various finish-it-yourself options to reduce the cost of the home, the major structure is almost always a contractor-installed system. Still, it's possible to knock

Though constructed of small modules, today's modular home doesn't have to look boxy. This contemporary has a purely custom look.



Modular construction is particularly suited to high-density residential construction, like the project above.

about 25% off the cost of a panelized home if you can do the electricity and plumbing work yourself, plus complete the painting, papering and other finishing chores.

### Modular Homes

As mentioned earlier, modular homes are built almost to completion inside a factory and then trucked to a prepared building site and lowered by crane to a set foundation. Usually before they're loaded on the truck, the

*(Please turn to page 74)*

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## FACTORY-BUILT HOUSING

modules contain electrical and plumbing systems and have finished interior and exterior walls. The pipes and wires from module to module are hooked to each other and to their service connections on the building site. Since they are so close to completion when delivered, modular homes offer slightly lower sticker prices than their stick-built counterparts. But substantial savings are more difficult to achieve because there's rarely any DIY work that the owner can take on.

Even though the basic building blocks for modular homes are a handful of standard boxes, some truly impressive and varied designs are possible, just one of which is shown on page 72. "We design with boxes, but we build along architectural lines," says Doug Bassett, of Epoch Homes. He has built a 3-story Colonial out of 10 "boxes," some with shorter than usual wall heights or lengths. A 2-box main hall with wings set back from the front can add architectural originality. And, varying roof slopes, outer building finishes and landscaping also give an original look to expensive modular housing. The modules may start out looking like boxes, but by the time they're in place, they can occupy any spot along the design spectrum from high-tech contemporaries to oldtime traditional homes.

Ryland Building Systems of Columbia, Maryland, for example, uses lovely wood and stone facades to give its finished homes a highly individualistic look. And Epoch Homes utilizes such details as "Captain's Walk" roof decks and other clever architectural devices to give its structures almost classical looks.

Finishing a modular home from the time it's delivered to the time the owner can move in is generally a 2-week affair. But the work is extremely specialized, and any serious mistakes can lead to problems that are nearly impossible to solve. For this reason, it's a good idea to steer clear of any major DIY participation. There are, however, several manufacturers who have owner-completion plans that allow the buyer to perform some of the work. These tasks include insulation and painting work and even some light mechanical work. Such packages can cut the move-in cost by 10 to 15%.

But the real motive for most modular buyers is speed of construction and

quality of the final product. The fit and finish that is possible in the controlled factory environment can rival the best that the custom-home market has to offer. At the high end of the housing market, these attributes are very attractive.

One last caveat about the modular option has to do with shipping costs.

Because the boxes are so complete when they leave the factory, they take up a lot of shipping room, which means a lot of trucking expense. This isn't much of an issue if the factory is around the corner, but if it's across the country, these charges can make or break a project. It costs roughly \$2 per mile per truck to deliver a house.



## How to paint windows.

If you've spent too many Saturdays suffering through the routine on the left, you'll appreciate the paint on the right:

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Water tends to simply bead up and evaporate, instead of "pooling" and then seeping into the wood.

## FACTORY-BUILT HOUSING

Cross-country delivery of a house that requires three trucks could cost \$18,000. So, when shopping in the modular market, be sure to establish what the delivery costs are going to be before you agree to anything. In fact, the same advice pertains to the log- and panelized-home manufacturers as well.

### The \$60,000 Home

In many ways, the nagging issue for all factory-builders is affordability. If they can create models for first-time buyers that cost significantly less than conventionally built homes, they would have a tremendous competitive advantage. How low can they go and still retain some semblance of design

and value? If you can get the land cheaply enough and are willing to live in a bare-bones home, \$60,000 for everything is certainly possible. To get there though, you have to start with land that's less than \$10,000, a septic system for less than \$2500 and a water well for less than \$2000. Each of these goals is certainly reachable in rural areas and possible within traveling distance to most major cities.

Rene and Sandra Plante, for instance, purchased 24 acres of pastureland from a relative in Sheffield, Vermont. They wound up building a 4-season vacation home on the property for just under \$60,000—land included. Of course, they did quite a bit of work themselves. A local contractor built the bulk of their Northeastern Log Home, which had one bedroom, a sleeping loft, a combined living room, kitchen and dining area, and a bathroom. But the Plantes dug their own water well, hung their own doors, installed the window and door casings and baseboard trim, and laid their own plywood subfloor which they eventually covered with carpet.

Originally, the Plantes were going to have a stick-built house put up on the property, one made with lots of glass on the front side of the building. But the prospective builder thought the area was too windy for a house with such large glass areas. So they decided to look elsewhere and discovered the log-home option.

"The price was astoundingly low," Plante said. "But the real surprise came in the winter when the wind really started howling. The log home is so tight, we can keep the thermostat in the mid-60s and not notice any cold spots." They did their share of the work on weekends with help from friends, and the building was in livable condition within a month of the day the contractor completed the foundation.

The absolute bargain price for a conventional-looking home that has plenty of room for an average family is a build-it-yourself model from Miles Homes of Minneapolis, Minnesota. Miles prides itself on being able to get you into a 4-bedroom, 2½-bath house for less than \$90,000. This includes realistic costs for land, site preparation and other add-ons. You have to build the house entirely yourself from a kit with numbered framing members and

*(Please turn to page 76)*



## How to paint windows less often.

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## FACTORY-BUILT HOUSING

a step-by-step builder's cookbook. This approach is bound to take more than a month, but it's a great way to get the most house for your money.

### The Million-Dollar Home

Most people would think that the whole point of the factory-built process is to keep down the cost of quality housing. Therefore, by definition, it should be difficult to find a \$1 million factory-built home. And it is, if you are only talking about the price of the basic house kit. The highest prices of upscale manufacturers such as Epoch, Lindal, Northern Homes and Timberpeg never get beyond \$750,000. But it doesn't take long before the add-ons run the price tag into seven figures.

Northern's Michael Carusone says the most expensive model he ever built cost about \$3.5 million complete. "The land alone was over \$1 million," he said. It was prime real estate in Greenwich, Connecticut, and fulfilled the adage that if you want to build a luxury home, you have to put it on a luxury lot. This site had plenty of room, excellent drainage, a good surrounding community, and it was situated in a high, open spot that was easily accessible by road but still very private.

The completed house itself cost about \$750,000, the most-expensive paneled house Northern could produce. It included more than 4000 sq. ft. of interior space with four bedrooms, three-and-a-half baths, a hardwood balcony overlooking a great room, a wet bar, a 2-car garage and a library with a vaulted ceiling. The landscaping ran \$200,000, the slate roof added another \$15,000, and the owner wanted solid cherry doors throughout, each costing about \$1000. At what must have seemed like quite a bargain, a greenhouse wing and indoor swimming pool were included for another \$30,000.

### Warranties

It doesn't make much difference if you paid \$60,000 or \$1 million for your house if it starts to fall apart before the ink is dry on the mortgage. Clearly, it makes good sense to look for some warranties on the work you are paying for. Unfortunately, most warranties issued by housing manufacturers are vague and generalized.

# UNLEASH THE CLASSIC

## 427

They speak of a lifetime guarantee on the workmanship of all components. But these often aren't in writing, except for a 1- or 2-paragraph note in the building manual or sales brochure. Builders all agree, however, that anyone who has been in business long enough to have multiple checkable references will be likely to honor an implied warranty. Conventional builders have always relied on good word of mouth to sell houses, and factory-builders are no different.

But times are changing, and implied warranties aren't enough anymore to satisfy many consumers. So some builders have begun offering detailed written warranties. These are insured by third parties and are usually good for 10 years, which is longer than the average American homeowner keeps any one house.

Many manufacturers now offer a standard HOW (Homeowners Warranty) policy, which is actually a 10-year warranty from the factory to the local builder. If there is a problem, the homeowner must hold the local builder responsible. HOWs do not usually add any cost to a home, and they do provide some peace of mind to those who don't trust the system.

But the best way to ensure a satisfactory job is to hold back a portion of the final payment—either to the manufacturer or to the builder, if you use one—until you are satisfied with the product. If this isn't possible, be sure to schedule a walkthrough with your builder's or manufacturer's representative, about one month after moving into your home. Point out any defects in workmanship and materials that you think are substandard and ask that they be fixed. Follow up with a letter outlining the same to all concerned parties. This will serve as useful documentation if you need to resolve any problems in court. **PM**

### SOURCE LIST

For a complete directory of factory-built housing manufacturers, write to: Building Systems Councils of NAHB, 15th and M streets N.W., Washington, D.C. 20005. Ask for its complete list of Building Systems Council members, which includes the names, addresses and telephone numbers, and a brief description of the housing each builds.

And, for information on the building code requirements for factory-built housing, write to: Council of American Building Officials, 5360 S. Workman Mill Rd., Whittier, CA 90601.



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# CAR CARE

## MAINTENANCE BASICS

### DEGREASING YOUR ENGINE

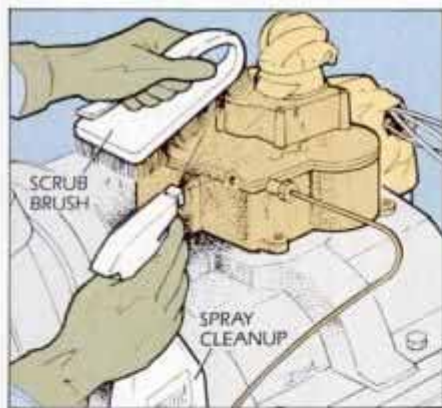
BY DON CHAIKIN

● Accumulated underhood dirt and grease can cut into your engine's performance. But even a moderate coating of grit and grime will cut into your enthusiasm for basic engine maintenance. The bonus is it's easier—problems are quick to spot and correct.

Degreasing even the most neglected engine is easy—and inexpensive. Follow these steps:

Begin by carefully shopping for a quality engine degreaser.

- Buy one that's environmentally safe and biodegradable.
- Cleaners that are slightly caustic



Stubborn dirt will need scrubbing with a brush. Be careful near carb and distributor.

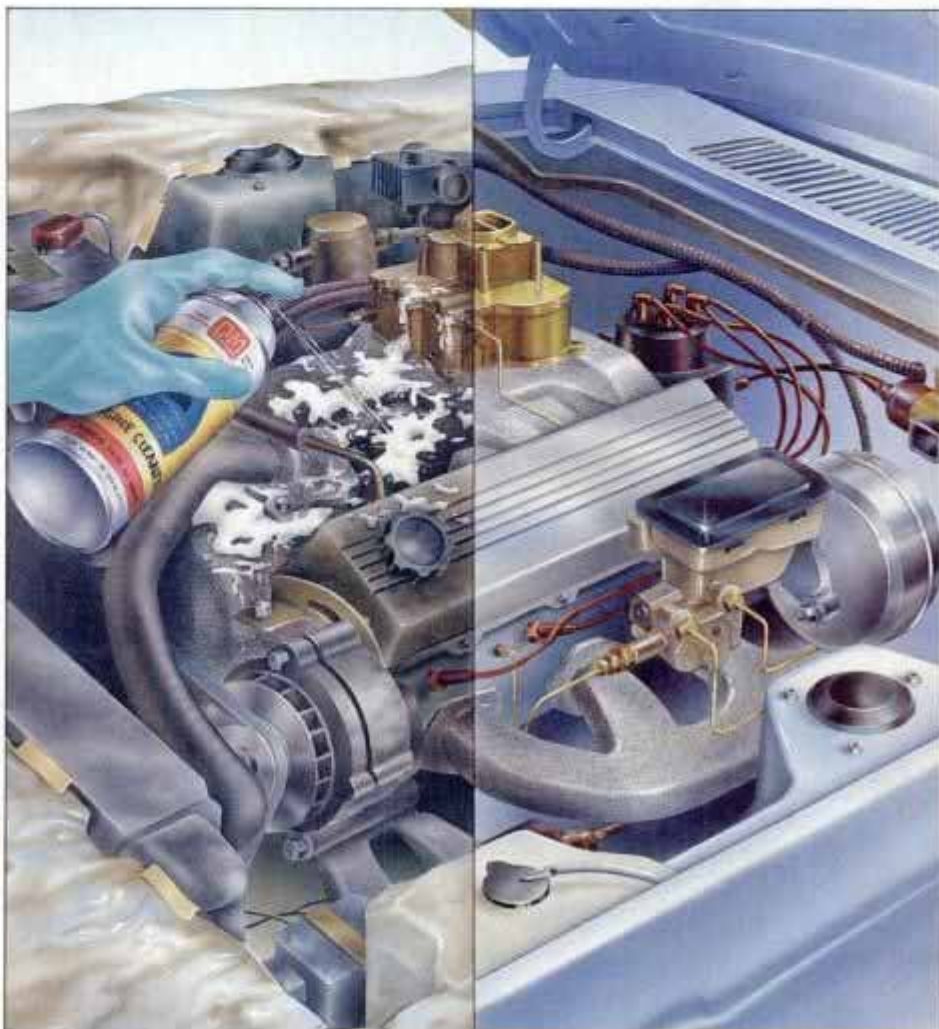
will lightly etch aluminum components, making them look new.

Next, protect body panels and electrical components from engine cleaner and water.

- Cover fenders, grille and windshield with plastic trash bags.
- Seal the air intake, carb opening or throttle housing with plastic.
- Wrap the distributor cap, exposed connections on the ignition coil and starter motor.

Assess how grime-covered the engine is. Even the most potent cleaners have trouble cutting through a quarter-inch of caked-on grease.

- Use a gasket scraper or putty knife to scrape accumulations of crud.



A clean engine makes for easier maintenance, and runs cooler to boot.

- Dig caked-on dirt and mud from crevices, using an old screwdriver.

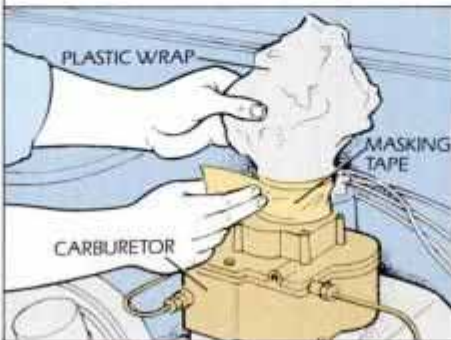
Now apply the degreaser to the engine, firewall, fender liners and the rest of the engine compartment. Follow the directions on the cleaner: Some recommend being used on a cold engine, some a warm engine.

Engine cleaners are still potent chemicals. Wear safety goggles and a

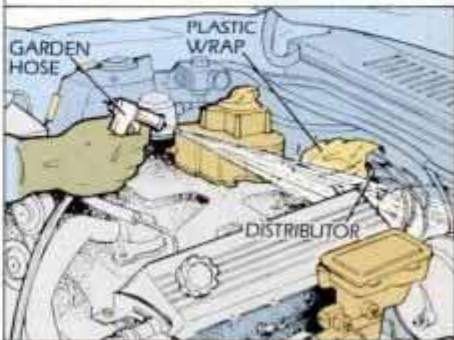
pair of rubber or vinyl work gloves.

Use a strong stream of water to wash off the cleaner. Attack specific, stubborn spots individually.

Use a wire brush and water to clean corrosion from battery terminals and tray. If there's a lot of white chalky buildup, wipe the battery and connections with a baking-soda-and-water paste, then hose it clean. **PM**



Cover carb inlet and distributor with plastic or foil to keep dirt and water out.



Rinse off the engine degreaser with plenty of water from the garden hose.

## HOW IT WORKS SHOCK ABSORBERS

BY DON CHAIKIN

● To understand how shock absorbers work, it helps to understand what they do—and what they don't. For example, they do *not* absorb shocks. The springs absorb shocks. The shock absorbers merely control the springs.

### Bumps and grinds

When one of your car's wheels hits a bump or pothole, the wheel is forced up toward the car. As the wheel moves up, it compresses the spring that attaches it to the car. After you drive over the bump, the spring extends, pushing the wheel back onto the road. However, with no control, the spring would extend *beyond* its original length and then compress again, a little less than it did when the wheel first hit the bump.

This process of extension and compression would go on until all the energy the spring had received from that bump was dissipated. By then the car would be wallowing and bouncing out of control, particularly if the wheels were hitting new bumps.

The shock absorber's function is to control, or damp, all of that bouncing. In fact, in Europe shock absorbers are more accurately called spring dampers.

### Oil damping

When the wheel is forced up after a bump, that wheel's shock absorber compresses along with the spring.

A shock absorber is basically an oil-filled cylinder with a piston rod protruding from one end of the cylinder. Both the cylinder and piston rod are attached to the car—one end to the underbody, the other to the sus-

pension component near the wheel. When the wheel hits a bump, the same force that compresses the spring drives the shock absorber's piston rod down in the oil-filled cylinder. After the bump, as the spring rebounds, the piston is forced up in the cylinder. This moving through oil is what quickly stops the wheel's up-and-down motion.

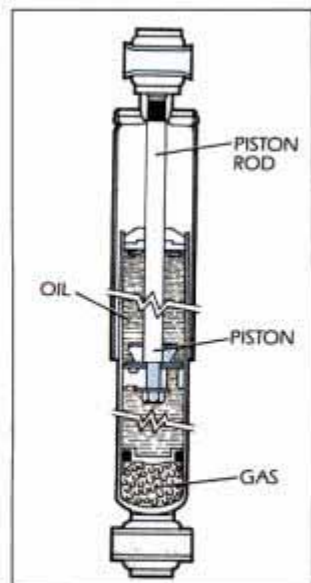
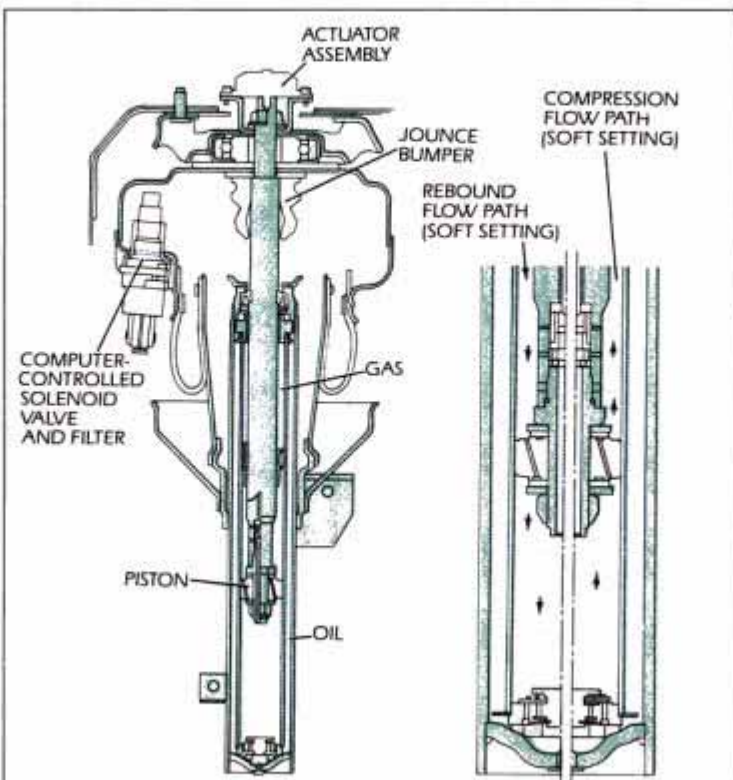
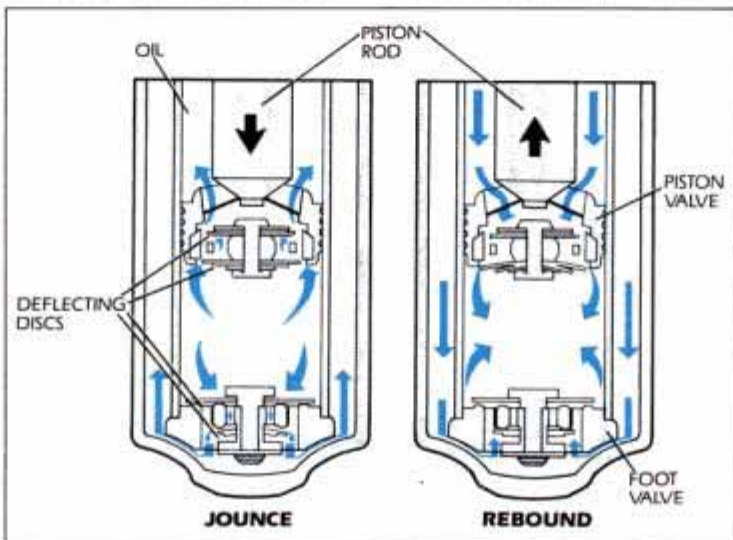
When the piston moves down in the oil, the oil ahead of the piston has to go somewhere, since fluids cannot be compressed. Some of the oil is forced through a one-way valve to the other side of the piston, to keep both sides of the shock absorber's inner tube completely filled with oil. The rest of it is forced through a valve at the bottom

of the cylinder into a reservoir, which is actually another tube surrounding the inner tube.

As the piston travels back up, oil moves through another one-way valve through the piston, and oil is drawn back into the bottom of the cylinder through a valve from the reservoir.

The firmness of the shock absorber is directly affected by how quickly the oil can pass through the valves. The slower the flow, the stiffer the damping action. Some sophisticated shocks have valves that are automatically adjusted by an on-board computer as you drive, changing how quickly the oil flows.

The oil reservoir has air at its top that expands and compresses as the oil flows in and out. Under heavy action, the air can mix with the oil, producing a negative effect on performance. The cure for this condition can be found in shock absorbers that substitute an inert gas for air. The gas won't mix with the oil as readily. Generally more expensive, and associated with high-performance applications, shock absorbers of this type are referred to variously as gas-filled, gas-charged or, simply, gas shocks. **PM**



All shocks use oil metered through valves to damp excess suspension movement. Gas shocks use high-pressure nitrogen to control frothing. Some sophisticated shocks use computer-controlled valves.

## SATURDAY MECHANIC

# HOW TO WAX YOUR CAR

BY DON CHAIKIN

● You've finished cleaning up your car. You've dug all the crud from the suspension and hosed off the underbody. You've cleaned all the globs of road tar from behind the wheel openings. You've removed all the dead bugs and dried, caked-on bird droppings. And you've even dried the car with lintfree rags. Now you're ready to finish the job and put down a layer of wax. But something's wrong here—instead of that rich metallic paint shining through, the car is looking duller and duller as you work. What's wrong?

Or maybe after you've just washed your car, it still looks dirty. That screaming-red finish barely murmurs

—it's hazy and chalky. And no matter how much wax you use, it *still* looks as dull as it did when you started. What's going on here?

What's going on is that you're learning there's more to waxing your car than just buying the most expensive finish-care product you can find. Besides having to select from pastes, liquids, aerosols and even mousses, you've got to know which of the ever-expanding list of products is safe and appropriate. Do you need a wax, polish or cleaner? And what are the differences among them?

You may have inadvertently discovered that using the wrong type of product can result in a less-than-

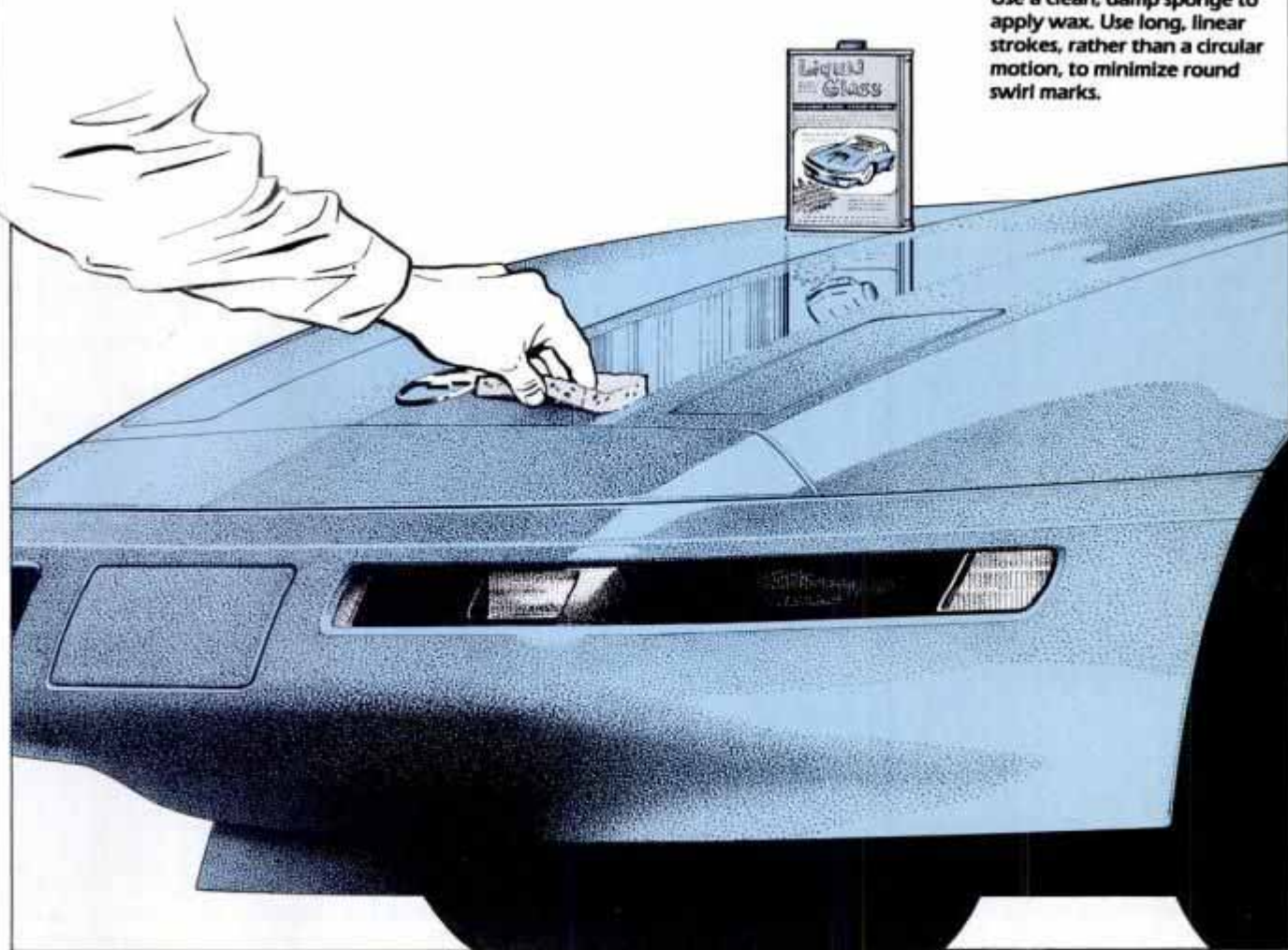
showroom shine. And you may have also just discovered that using a product that's totally wrong can actually do more harm than good—perhaps to the point of actually damaging the paint surface.

Before you even start washing your car to prepare it for waxing, you need to understand what makes your car dirty and dull-looking. And you should understand what you need to make it shine—regardless of the type of finish the car has.

### Weather or not

When your car rolls off the assembly line, the paint is glistening. But as soon as the car leaves the factory, the

Use a clean, damp sponge to apply wax. Use long, linear strokes, rather than a circular motion, to minimize round swirl marks.



PM ILLUSTRATION BY FRED WOLFF

# CAR CARE



Start with a car wash preparation and plenty of clean water.

glisten begins to fade. Once outside, your car's finish is attacked by the Sun's rays, acid rain, industrial fallout, salt and dust in the wind, and plain old dirt.

The most harmful element on this list is the Sun's ultraviolet rays. The UV causes the top layer of the finish to oxidize. With lacquer and enamel finishes, oxidation takes the form of "dead" paint, recognizable as a chalky, white film. The UV also oxidizes the top layer of clearcoat/basecoat paints, which are becoming very common on new cars.

The days when cars were all covered with lacquer paint are long gone. The popular clearcoat/basecoat paints have a layer of pigmented paint, usually an acrylic—often with tiny metallic particles in the mix—which gives the car its color. Over this is a layer of clear paint, which gives the car's fin-

ish a deep and lustrous look.

But since the clearcoat is out there against nature, it suffers the ravages. With time and exposure, the clearcoat stops looking so clear as a result of being etched by dirt and dust particles, and yellowing from exposure to the Sun's UV rays.

## Shine on through

Since a high-gloss, shiny look is one that reflects the most light, just like a mirror, the first steps in shining your car are smoothing and repairing the surface. Therefore, regardless of the type of finish on your car—clearcoat/basecoat, enamel or lacquer—you have to remove the oxidation from the finish to get it to shine. You also have to repair the damage done by dust, grit and airborne corrosives. How you remove the oxidation and repair the damage, however, depends on what

type of finish your car has.

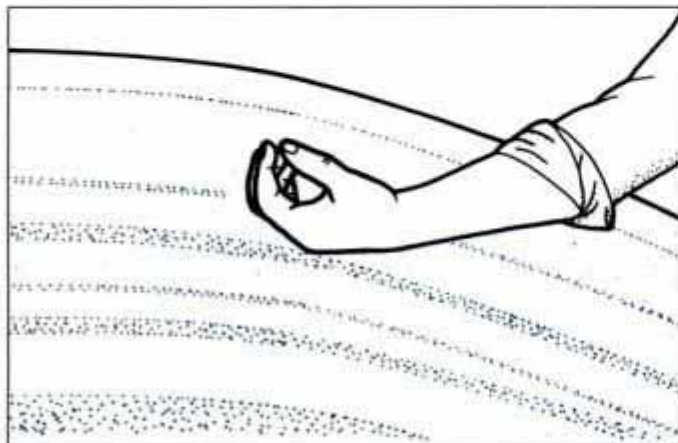
Oxidation is removed from single-coat paints by rubbing the oxidized layer, using a very fine abrasive. The abrasive can be part of the formulation of the waxing product or a separate product. However, if you try rubbing off the oxidation from a clearcoat/basecoat with a product that's not meant specifically for clearcoats, you'll end up rubbing completely through the clear layer, exposing the less-than-shiny basecoat.

Accordingly, before you set out to buy the best finish-care product you can, you need to know what type of paint you're dealing with. If you don't know, check with your car dealer. You'll find the factory paint code listed somewhere on your car—possibly on a door jamb decal or on a plate under the hood. The code tells both the specific color of the paint and also the type of finish.

## Waxy definitions

Once you've determined what type of finish your car has and which type of abrasive or nonabrasive product to use, you're still faced with the dilemma of selecting from a host of liquids, pastes and mousses that are marketed as waxes, polishes and cleaners. As you read the labels of the products, you'll even find some products that call themselves waxless waxes.

For the sake of clarity, think of waxes as products that do nothing but add shine and luster to the car's finish by leaving a layer of glossy material—possibly a genuine wax or a synthetic—over the finish. Polishes are products that contain very fine abrasives to smooth and brighten the surface. Cleaners remove surface damage either through abrasive action—possibly with coarser abrasives than those found in polishes—or



Check for oxidation by dragging the back of your hand across the suspect finish. The roof and hood are most prone to such damage.



Seriously oxidized finishes can be rescued with careful use of abrasives. The abrasives can be in the waxing product or separate.

# CAR CARE

chemically. The convenient one-step products combine waxes and cleaners or polishes to do the cleaning and shining all at once.

When you're looking through the bewildering array of waxes and one-step products, check the list of active ingredients. Some of the wax products actually do contain some wax, the most preferable being carnauba, derived from carnauba palm trees. Just about all quality products have silicone in them. However, all silicones are not equal. Most of the products have silicone fluids or oils which make the product easy to apply.

But better products also contain silicone resins or amino-active silicones. These give the polish a longer working life and add to the durability of the finish. And the more durable the protection you leave on the car's paint, the better for the paint underneath. You must understand that the layer of wax protecting the paint amounts to only a few *billionths* of an inch. The tougher the layer is and the longer it lasts, the better.

And while you're checking the labels, look for a product that has some sort of ultraviolet-ray blocker. Since most of the damage to your car's finish is from the Sun, one of the most important developments in finish-care products is the UV blocker. Basically, these are the same kinds of sunscreen compounds found in modern suntan lotions. The UV blockers allow the light of the Sun to pass through to your car's paint, so you can see the shine, but they filter out at least some of the UV, reducing oxidation. You'll find UV blockers in more and more waxes.

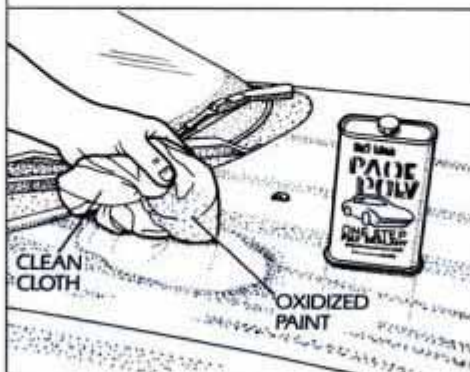
If you wash and wax your car regularly—at least three or four times a year—and you don't live or drive where there's an inordinate amount of airborne corrosives, one of the quality one-step products will do the job for you. If your car is subjected regularly to intense sunlight, acid rain, blowing sand and dust, or salt air, you may have to resort to performing individual cleaning, polishing and shining steps to get your car to glisten the way you want it to.

## Step one: the wash

Okay, now that you know what type of finish your car has and what type of wax you need for it, you're ready to shine your car. And to ensure that it glistens more brightly

than ever before, start by washing it. If you wax a car that's anything less than perfectly clean, you'll scratch the finish as you shine.

Begin by parking your car in a shady spot, but not under a tree where it will be prone to sap and bird droppings. Try to start early in the



If color shows on the rag, you're removing at least some of the paint.

day, when the car won't be hot from the sun and to ensure that you'll be able to finish the job long before dark—important so the wax can cure before dew starts to settle.

Hose the car down thoroughly, starting on the roof. Use plenty of water at high pressure. The idea is to float the dirt and grit off with the water rather than rub it into the finish with your wash rag. Periodically hose the car as you work, just to keep it wet and dustfree.

Next, start sudsing the car, using warm water and a special car wash cleaner—not household detergent. The car wash preparations have water-softening ingredients to prevent mineral deposits, and the mild cleansing agents won't strip too much of the wax that's already on the car. Start sudsing and washing the lower sections of the body first, rinsing each

section as you go, to avoid streaks.

Work in small areas, washing and rinsing, working your way back up to the roof. Wring your sponge and change the water in your wash bucket frequently to avoid rubbing dirt into the finish as you wash. Don't rub stubborn stains—you could rub through the finish, particularly a clearcoat. Any stains that won't come off with water and cleaner need to be removed chemically, using a special bug and tar remover. After you've cleaned a stain with bug and tar remover, wash the area with soap and water.

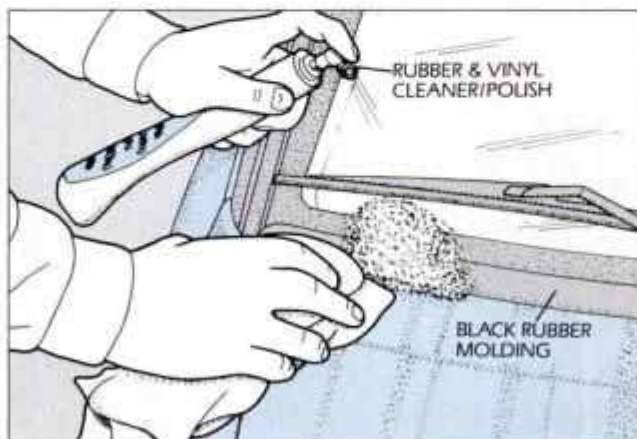
Once the car is washed, dry it thoroughly. You can use a chamois cloth—a tanned hide of sheep, lamb or deer, or synthetic imitations—to dry the car. Or you can use an old terry-cloth towel. The older the towel the better, since old towels are softer than new ones and they leave less lint. Dry the car starting at the roof, and work your way down. Wring the drying cloth frequently to prevent droplets from spotting the finish.

## Prewax prep

Before you wax the car, inspect it for any minor nicks or scratches in the paint. These should be tended to before you continue. Any rust spots should be sanded down to bare metal. Apply a primer to inhibit further rust. After the primer is dry, use touchup paint to hide the damage. Nicks in clearcoat cars require the additional step of having a layer of clear paint over the pigmented touchup.

Before you start polishing, determine how badly the finish is oxidized. If your car has enamel or lacquer paint and you can see that it looks hazy or chalky, you know you have to remove the oxidized layer. If you can't see the oxidation, or if your car has a clearcoat, run the back of your hand over the roof and hood, the surfaces most prone to UV damage. If the clean surface feels rough and drags against your skin, you should attend to the oxidation before you wax.

Oxidation on a single-coat paint can be removed with a polish or abrasive cleaner. The severity of the oxidation determines how coarse an abrasive you need. If the oxidation is barely perceptible, a one-step wax and polish will do the job. If it's more severe, take the time to perform the extra step of polishing before you wax. Apply the polish and remove it by hand, working on



Black rubber and plastic parts can be shined with a cleaner/polish product that's intended for vinyl.

## CAR CARE

small sections at a time. Your applicator cloth or sponge will turn the color of the car as you work since you are removing a fine layer of pigmented paint.

Do not use a product labeled as a rubbing compound. Rubbing compounds are fairly coarse abrasives and are used to remove deep scratches and to prepare for repainting. Rubbing compounds remove a heavy layer of your car's finish, not just the oxidized layer. And don't use a power buffer with a polish or cleaner because this too could remove more than the oxidation.

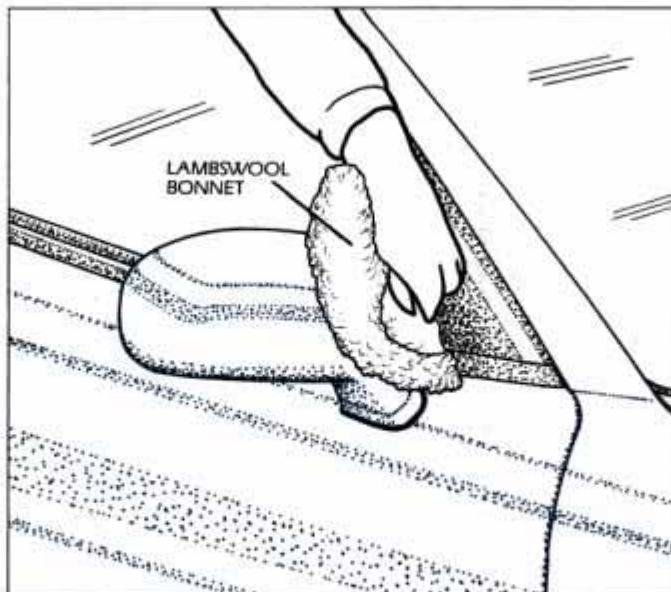
Cars with clearcoats can be cleansed of their oxidized layer with special nonabrasive chemical cleaners. These are labeled as safe for clearcoat finishes.

### Glossing up

Finally, with the oxidation and dirt removed, you can shine your car. Start on the roof and work your way down, taking small sections at a time. Don't wax an area larger than one-fourth of the roof before allowing it to dry to a haze and wiping it off. Frequently turn and rinse the applicator as you go. Again, don't be alarmed if the applicator comes up the color of your car when you're using a one-step polish/wax—these are designed to remove the layer of dead paint as they shine.

If you want your car to shine like a show car, try these tips, from John Heywang, maker of Liquid Glass finish products, Teaneck, New Jersey. Put the wax on and remove it in a linear rather than circular motion. By wiping in circles, you'll leave swirl marks, perceptible after the wax has cured. Always use a clean, damp applicator, since damp applicators have less friction than dry ones. This means they're easier to use and leave more wax on the surface. It's a good idea to buy a bag of small household sponges to use as applicators. They're small, easy to use and you can keep changing sponges as you work. Remember to keep them damp with clean, lukewarm water.

If you're using a totally nonabrasive wax and don't



Use a fresh lambswool bonnet or glove to complete buffing areas that are not accessible to the electric buffer.

mind subtle swirl marks, you can add to the luster by buffing the wax with a power buffer, orbital polisher or even a polishing attachment on your power drill. It's essential that the bonnets be perfectly clean, so have at least three or four of them ready, and change them as you work. Again, a little dampness adds to the shine as you work by reducing friction between the bonnet and wax. Use the bonnet as a glove to buff areas inaccessible to the power buffer.

There are several products on the market now that actually have pigment to match your car's paint blended in with the wax. These have two advantages. The annoying little ridges of white waxy buildup in the gaps around the hood and doors can take a long time to chase and rub off. The colored products don't eliminate

them—but they are certainly a lot less obtrusive. You will still probably have to go back and clean up after yourself, but not nearly as carefully.

But there's another fringe benefit. If there's a scratch or two in the paint, down through the clear, and even a little into the primer, pigment-matched waxes will actually mask the scratch. Depending on the exactness of the match on color, even major scratches are much less obtrusive. Just remember that bare metal or rust must be covered with primer.

In all cases, take care to keep wax off flat black and plastic surfaces. Wipe off any spillover immediately. These surfaces should be polished separately with products specifically formulated for them. Otherwise, you'll wind up with a white or pinkish haze instead of a shine.

### Make it last

No matter which type of product you've used, and no matter what type of finish it's on, sooner or later you will have to re wax the car. There are a few waxes advertised as lasting for about a year.

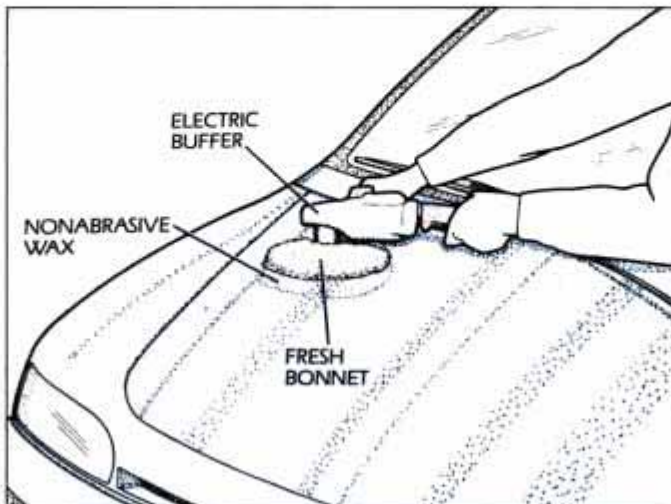
To know for sure if there's still wax on the car, sprinkle water on it: When water won't bead up on the car's surface, there's no wax left.

To help keep the finish from dulling, make the car wash a once-a-month maintenance habit. And make waxing a 3-to-4-times-a-year project. You can also take some preventive steps to keep the finish shining like new.

First and foremost, garage your car to keep it from the Sun's rays and airborne corrosives. If you can't garage it, make sure you park it under a car port or keep a car cover on it.

The other big destroyers of shine are grit and dirt, so hose off your car frequently to float away dirt.

And resist the temptation to wipe down a car that's been in the rain. Unless the car was deluged, there are all types of matter and grit in the water standing on the car. Wiping down the car with a towel will scratch the finish as you wipe off all that dirty water.



Try applying wax with an electric buffer. But stick to completing a small area before moving on to another section.

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## CAR CLINIC

BY MIKE ALLEN,  
Assistant Automotive Editor

### Stuck On You

I just bought a really nice used car—but the former owner had pasted more than two dozen bumper stickers all over the front and rear end. I did manage to scrape some of them off the chrome bumper without scratching it too badly. But I'm reluctant to try that on the painted surfaces. My wife suggested steel wool, but that sounds like it will be just as bad as the razor blades.

How can I remove these stickers without damaging the paint?

LEROY MADSEN  
RENO, NV

*A vinyl sticker will usually pull right off if it hasn't been on very long. But with the Nevada sun baking them on, it isn't very long before the vinyl and adhesive get hardened.*

*First, try using a hair dryer to heat the surface, and carefully pull up the corner of the vinyl sticker. Patience may see the sticker lifting up, but go slowly.*

*No help? Does the sticker just tear off before it lifts? Go down to the auto parts store and get some 3M Woodgrain & Stripe Remover. This aerosol has a solvent that will soften the vinyl and its adhesive without damaging the paint. (If the car has ever been repainted, the aftermarket finish may not be as permanent as the original—try some remover on an unobtrusive area first. Otherwise, simply follow the directions on the can.) This stuff is intended for wholesale removal of stripes and woodgrain trim by bodyshops that need to repaint the area underneath the trim—but those are made of basically the same material as the bumper stickers.*

*3M also manufactures a companion product for removing the leftover adhesive, but kerosene, diesel fuel or commercial bug and tar remover products seem to work as well.*

### Fandango

I have a 1981 Citation, and after several mechanics and \$300, nobody can get the electric cooling fan to work properly. They've replaced three relays, two thermostats and fiddled with the wiring endlessly.

In exasperation, the last mechanic wired the fan directly to the key and said the fan motor should last at least



a year this way. I'm willing to spend \$150 a year to replace the fan motor—if it will really last that long. Will it?

Please don't tell me to get another mechanic—I've run out of them.

T. SLAPIKAS  
CHESAPEAKE, VA

*You don't need another mechanic—you need a better mechanic. But the last mechanic had a fairly good grip on the problem when he wired the fan directly—at least he wasn't willing to run your labor bill up any higher. Good for him.*

*Most cars that have air conditioning run their electric fans constantly whenever the a/c is on—so the fan motor is rated for 100% duty cycle, and should last a long time. So don't worry about it.*

*However, you are running the fan a lot when you don't need to—before the engine is warmed up and most of the time when the car is moving forward*

*through the air at any speed. The air blowing through the radiator provides plenty of cooling on its own.*

*If you can't get anyone to fix this properly, think about adding a switch on the dash to turn off the fan when it's not needed—but you'll have to watch the coolant temperature gauge carefully. Your engine will warm up faster and last longer if it's not overcooled.*

### Aftermath

The intake manifold on my 1988 GMC Jimmy 4x4 started to leak coolant into the oil. The dealer replaced the gaskets, flushed the block and changed the oil. The repair seems to have stopped the leak, but I understand from other people that several major problems could result from this.

What should I expect, and what can I do?

SHEILA HELGESON  
BRECKENRIDGE, MN



## CAR CARE

It all depends on how long the coolant was circulating with the oil.

One consequence would be corroded bearings wearing out prematurely. The babbitt metal bearing shell has little resistance to water-induced corrosion, even if the water is mixed with oil.

The second thing would be premature camshaft and lifter wear, again started by corrosion. The iron camshaft will be pitted by corrosion and begin to wear rapidly as the pits destroy the surface finish of the lobes where they contact the lifters.

Regular oil analysis, done with frequent oil changes (every 1000 miles for the next 4000 miles), will be able to spot this bearing and camshaft wear without disassembling the engine. Also, be sure you monitor the oil and coolant very carefully, as the gasket problem may or may not be cured.

### A Polarizing Question

Some of us shadetree mechanics and farmers were discussing auto and tractor batteries the other day. This question came up: When were most cars and trucks changed from positive ground to negative, and more importantly, why?

MARTIN MENGES  
HUDGINS, VA

Most car and truck applications changed over to negative ground electrical systems in the '50s, although a few diehards (notably the British) stuck with the old way into the '60s.

There's a sound reason. Electrons flow from negative to positive. That sounds wrong, but Benjamin Franklin was wrong when he adopted the conventions for positive and negative back in the 18th century. We've been stuck with it ever since.

What does this have to do with cars? Simple. The spark plug has two electrodes—a ground electrode and a center post electrode. The ground electrode is generally hotter than the center because it's stuck farther out into the combustion chamber. And the electrons are more willing to jump across the gap from the hotter surface than the colder one. In a situation where the ignition system is marginally capable, a negative ground system is more likely to fire reliably. This is probably one of the reasons that Brit cars have a bad rep for not starting on rainy days.

Of course modern, transistorized ignition systems have enough power to ignite a wet firecracker, so negative

(Please turn to page 88)

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## WANT TO TALK TO A POPULAR MECHANICS EDITOR?

Turn to the Hotlines listing on page 76.

# CAR CARE

## Rubber Buggy Bumpers

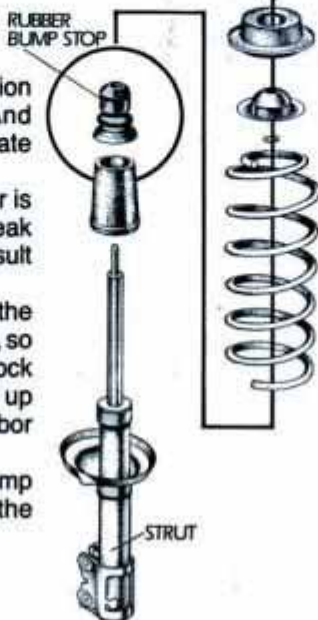
● Your car has reached the point where just backing down the driveway causes the front struts to bottom out with a large metallic thump. But the ride quality seems fine—no uncontrolled motion. And it's too soon for your shocks to be gone completely.

Poke your head into the wheel well and be sure the bump rubbers are in place. These are there to prevent metal-to-metal contact when the suspension is compressed nearly to the limit of its travel. And sometimes they'll give up the ghost and disintegrate prematurely.

When this happens, that metallic thump you hear is the strut bottoming out—I've seen shock towers break their spot-welds clean off the inner fenders as a result of the stress this causes.

Unfortunately, the labor to remove and replace the strut represents most of the price of changing these, so you ought to think really hard about replacing the shock insert in the strut when it's all apart—unless you're up to dealing with the spring compressors to do the labor yourself.

New shocks are supposed to come with fresh bump rubbers—be sure yours are replaced whenever the shocks are.



PM ILLUSTRATION BY ADOLPHE BROTMAN

grounding is now simply an industry convention.

## How Fast Is It?

My son bought a Pro Racing Speedometer (by Autometer) at a speed shop for his '78 Grand Prix, which has a Turbohydramatic TH350 automatic transmission.

He's called more than a dozen places looking for the appropriate speedo cable to use with this combination. The Pontiac dealer told him to try the Chevy dealer—but they couldn't help either. We're stumped.

MONDO 45

(MESSAGE ON THE PM COMPUTER BULLETIN BOARD)

*This is an easy one. A good speedometer shop should be able to make a custom speedometer cable for you very inexpensively. Bring them the speedo and the old cable. They'll be able to crimp the appropriate fittings onto a new length of inner cable. If you want to mount the new speedo someplace where the old cable won't reach, they can make a new outer sheath any length you need.*

## Chips Ahoy

A few issues back, you answered a letter from a reader where you stated that modern computer-controlled cars needed a constant supply of electrical current "to retain the computer's memory" (page 74, Jan. '91). Is this right? If the battery is removed for replacement or charging, does the computer need to be reprogrammed? Wouldn't the computer's memory be permanent, in ROM, and your statement be incorrect?

WILLIAM ALLEN COEY  
SAN BRUNO, CA

*We're both right, William.*

*The modern automobile's computer has a program, stored in read only memory (ROM). This memory is on a small replaceable chip socketed onto the computer's circuit board, and it's preprogrammed at the factory. This program has enough intelligence to start the engine and run it in "open-loop" mode. In this mode, preprogrammed values (that's computer-speak for guesstimate) are used for the amount of fuel delivered and the amount of spark advance. These are safe values—ones that won't run the engine too lean or poke a hole in a piston with spark knock. They are also values that are way out of the ballpark on emissions and mileage.*

*Once the engine warms up a little, the computer starts to teach itself to*

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## CAR CARE

use better values for fuel and spark. Using the O<sub>2</sub> sensor for reference, it leans out the mixture and runs the timing up, and then stores these newer, more accurate values in its random access memory (RAM).

This RAM is the memory I was referring to, and it needs a constant source of current to be available for the next time you start your car.

This learning cycle takes a few minutes and requires that the car be driven a few miles, after being properly warmed up. So if it becomes necessary to remove or disconnect the battery, don't be surprised if your car acts a little odd for 10 minutes or so the next morning.

Incidentally, if you've got a CHECK ENGINE light that's on, and you think the problem has been remedied, you can disconnect the battery or briefly remove the fuel-injection fuse to clear the RAM of the trouble code that triggered the light. If the problem was transient, the light will go off. If the problem remains, it will immediately come on again. Removing the fuse is preferred because it won't reset the radio stations or the clock.

PM

### SERVICE TIPS

- Ford TSB 90-18-3 covers a wide range of FoMoCo vehicles between 1983 and 1990. If you've got buzzing or humming from the fuel pump after the key is turned off, or a battery that's often too discharged to start the vehicle, you may need a new fuel pump relay. P/N F19Z-9345-A
- 1990 Honda Accords have an incorrect valve lash adjustment specified on the emissions tag under the hood, according to TSB 89-045. The lash settings shown on the tag are correct, but the lash should be measured between the rocker arm and the valve, not between the cam and the rocker. The TSB simply calls for a blank sticker to cover up the incorrect information.
- Some 1989 Allantés may have improperly machined rocker arm support bars. If the mounting holes for the rocker arm pivot are too close to the edge of the forged steel support, the rocker arm pivot can hang over the edge of the support bar and crack. TSB T-90-15
- 1990 Chrysler products with 3.0L engines may have a valve train ticking noise caused by a rocker arm casting burr in the area of the rocker arm bore shaft. The burr can be removed with a stone or No. 500 sandpaper. TSB 09-02-90 P-1785
- If there's a ticking noise coming from the firewall area of your 1989 or 1990 Suzuki GT, TSB TS 4-09 03150 says it may be caused by the fuel rail. If the noise goes away briefly when the fuel pump relay is removed, you've identified the culprit. Replace the fuel rail with a revised rail that should eliminate the noise.

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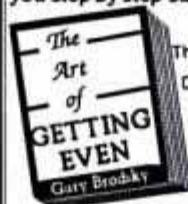
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## CAR CARE

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### Mr. Good Winch

Whether you're axle-deep in mud or hauling your bass boat out of the water, there's nothing like a mechanical advantage to make the task easier. A relatively inexpensive and portable advantage is the WonderWinch from Ramsey. This electric unit weighs 20 pounds and is 9½ in. long and 6½ in. high, making it easy to stow. The WonderWinch has a 1.3-hp motor capable of pulling 2500 pounds. It costs \$275. From Ramsey Winch Co., P.O. Box 581510, Tulsa, OK 74158; (918) 438-2760.



### Rack It Up

Sports cars are more fun for two than for one—until you try loading two people's worth of luggage. This convenient solution from Atlantic Design combines a secure yet temporary luggage rack with a soft-sided, heavy-gauge nylon carrying bag. The system consists of a base pad, made from car-cover material, a waterproof, vi-

nyl-lined nylon bag with double zippers, mounting straps and hooks. The hooks are vinyl clad, to keep them from scratching your car's finish. Available in a standard size (13 × 13 × 30 in.) for \$159.95 or extra large (16 × 16 × 36 in.) for \$179.95. Write Atlantic Design, Inc., 977 Seminole Trail, Suite 308, Charlottesville, VA 22906; (800) 966-4016.

### No Mess, No Fuss

Despite the simplicity of the task of changing your engine oil and filter, it's still a loathsome task because of the mess. An innovative and neat way to change both oil and filter is via this development called FilterLock. With this system, the oil filter is mounted



anywhere you want to put it conveniently under the hood. Braided, high-pressure hoses connect the filter to the engine. Plus, the oil drain plug is replaced by a cable-operated valve which is locked closed by the oil filter. The valve cannot open when the filter is in place. FilterLock carries a price of \$49.95 and is distributed by Purolator. It's from Depco Industries, 4444 W. Ohio St., Chicago, IL 60624; (312) 722-3200.

### Computerized Checkout

Gone forever are the days of setting breaker point gaps with a matchbook cover. In fact, gone forever are breaker points. Keeping your modern car running right requires the latest information and diagnostic equipment. The Auto Logic CPA-90P is a modern, microprocessor-based version of your old dwell/tachometer. In addition to giving you simultaneous engine speed and dwell-equivalent digital readouts, the CPA-90P can do cylinder-balance and pulse-frequency checks. The CPA-90P is menu-driven—you simply follow the instructions it gives you. Cost for the CPA-90P is \$239.95. A model with fewer features, the 90P, costs \$139.95. From Auto Logic, Inc., 648 Royal Palm Beach Blvd., West Palm Beach, FL 33411; (407) 684-1179. **PM**





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## OLD HOUSE RESTORATION

# PLASTER WORK

BY BOB VILA, Contributing Editor

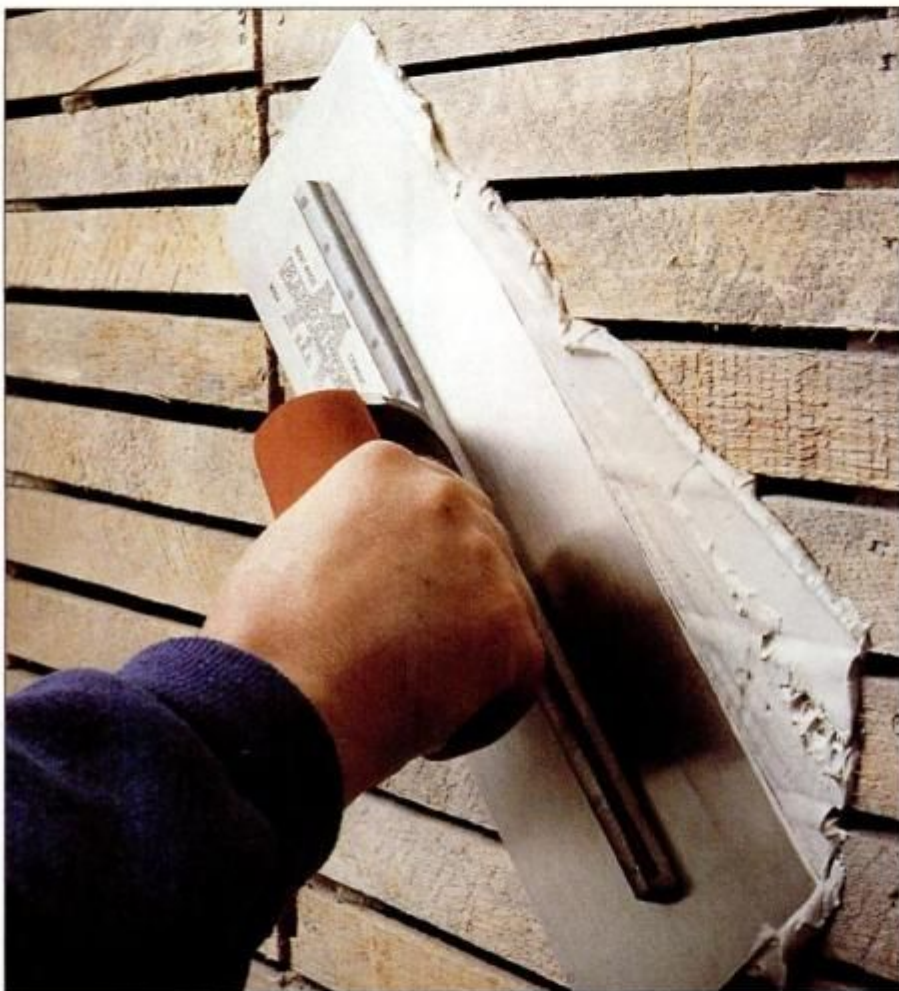


PHOTO BY THOMAS KLENCK

● The unmistakable period feel of an old house is often directly related to the beauty and character of its plaster walls. While I don't recommend that the average old-house owner try to replaster an entire wall or room, minor repair patches can be executed by the sophisticated do-it-yourselfer with success.

### Lath is the key

Lath provides a base or reinforcement for plaster. Most old-house owners are probably familiar with wood lath—horizontal boards nailed to the wood framing. When wet plaster is applied, it's squeezed through these openings and hardened. This in turn forms keys, which are, in essence, a mechanical bond that reinforces or

holds the plaster in place.

In very early American houses, wood lath was often hand split. It wasn't until about the 1870s that machine-made wood lath began to be used as a base for plaster. Metal lath has also been used from the late 1800s in America. Aside from its common use in corners and for curved surfaces, it is largely used in commercial buildings.

Today, there are different varieties of metal lath available. The original form, an expanded metal sheet that, when pulled apart, forms diamond-shaped spaces for plaster to key is still common, and it's the one I recommend for restoration work. Often referred to as diamond mesh, choose a good 3.4 pound-per-sq.-yard lath that can be easily cut with a pair of nippers. The other two forms, woven and welded wire, require a paper backing

Though plaster work is difficult to master, common repairs are well within the capabilities of the average homeowner.

because of their large openings.

The third type of lath, called gypsum board lath, plasterboard or button board, was used in the early 1900s. Essentially a compressed gypsum board with a rag paper facing, it was sometimes perforated to provide holes for the plaster to form its important mechanical bond, or key—hence the term button board. By the end of the 1930s, this was about the only lath used in residential work. So if you're restoring a home in this age group or younger, there's a very good chance your plaster walls are reinforced with gypsum board lath. Today, gypsum crystals in the plasterboard's paper facing provide a chemical bond for the wet plaster rather than the mechanical keys formed through the old board's perforations.

### Different coats

Plaster is commonly applied in two or three coats. The first coat, called the scratch coat, is applied directly to the lath and provides the wall's base. Generally about  $\frac{3}{8}$  in. thick, its roughened or, as the name for it implies, scratched top provides a surface for the second or brown coat to adhere to. This is also about  $\frac{3}{8}$  in. thick. Essentially a leveling coat, the brown coat provides a base for the  $\frac{1}{8}$ -in.-thick final or finish coat that's responsible for the smooth whiteness we associate with plaster walls. In a 2-coat system, like that commonly used with gypsum board lath, there would only be a single basecoat, followed by the thin, smooth finish layer.

Up until the early 1900s, plaster for these two coats consisted of a mixture of lime putty (which is quick lime and water), water, sand and animal hair. The finish coat had no hair and only a small bit of sand or aggregate, but contained more lime than the basecoat. Early lime plasters dried very slowly as they combined with carbon dioxide in the air. This meant a long wait for paint or paper—sometimes as much as a year or more.

Gypsum plaster eventually replaced lime plaster, and with good reason. Since gypsum cures when its

*"Home Again With Bob Vila" is the title of our contributing editor's new TV show.*

water dries out, it begins to set almost immediately and is completely dry in a few weeks. If you're repairing old plaster today, in most instances a gypsum plaster mix will work well. To create a chemical bond between the old and new plaster, use a liquid bonding agent. Wetting the edges of the old plaster prevents it from sucking out the moisture in the new patching plaster, which will cause your repair work to pop and crack.

The finish or white coat is a mixture of lime and gypsum. In the proper proportion, this finish coat should have the consistency of mayonnaise. In days past, plasterers mixed this important final coat on the job. Today, you can find mill-mixed finish coats for restoration work.

### Patching practices today

When patching plaster walls today, old wood lath is often covered with expanded metal lath or diamond mesh, which is stapled or wired to the wood. This provides a secure base for the new plaster to key. If you're restoring plaster with gypsum lath that's damaged or broken, it must be replaced for your repair work to last. Cut back the lath to where it's good and solid, preferably to the nearest supporting stud. Then push a long, slim piece of new gypsum lath through the hole, pulling it close to the old lath and securing it there. A slight buildup of the basecoat will bring your plaster work even with what was originally there.

Dealing with cracks in plaster walls, large and small, is another problem that often faces old-house owners. Small hairline cracks, if they aren't a sign of a serious structural problem, can add character to a room. Depending on where the cracks are and how you feel about them, they are sometimes best left alone. But when the circumstances dictate patching, drywall joint compound often does the trick. Dampen the old plaster around the crack before patching.

For larger cracks, say those over  $\frac{3}{16}$  in. wide, use a gypsum patching compound, which is essentially a mix of pure gypsum or plaster of Paris and aggregate. Again, make sure the wall is wet on all sides of the crack to prevent it from pulling moisture from the wet patch too quickly. It's best to use a liquid bonding agent here, too. When dry, use fine sandpaper to smooth the patch. You may need to add a thin coat of drywall joint compound to obtain that important smooth finish.

If you've got major plaster damage and need to replaster entire walls or rooms, hire a pro. Just look up plaster contractors in your Yellow Pages for estimates.

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# DETROIT SPY REPORT

BY JIM DUNNE, Detroit Editor



## Jeep ZJ Set For 1993

● After a long gestation period, it looks like Jeep's Wagoneer replacement will be production-ready for the 1993 model year.

Bigger than the current Cherokee, with a wheelbase of 105.9 in. and overall length of 176.7 in., the new Wagoneer, known until now by its ZJ code name, will fall between the 2-door and 4-door versions of the Ford Explorer size-wise.

Intended to compete one market notch above the Cherokee, the Wagoneer will offer a choice of either the current straight-Six or a 318-cu.-in. V8. Buyers will also have a choice of either 4-speed automatic or 5-speed manual transmission.

## Marking Up

Yes, Lincoln will add another Roman numeral to its Mark series next year when the new Mark VIII will be ready for the market.

Exterior styling will be sleek, low and rounded—consistent with Ford's aero-design trends. In the front, tiny headlight strips and a sloping grille



The 1993 Mark VIII will feature lower hoodline, rounded contours.

will dominate the styling. At the rear, a vestigial spare-tire bump presses up on the deck lid.

Although the personal luxury Lincoln will continue as a rear-drive design, it will offer all-independent suspension for the first time.

## Saturn Scorecard

Although Saturn has had difficulty getting up to speed on production, initial market response seems to indicate GM is hitting a bull's-eye. Early Saturn buyers are saying that their second choice—after Saturn—was an import.

Since General Motors created the Saturn Corporation as a way of reclaiming sales territory lost to Japanese imports, it looks like the strategy is paying off.

## Fiery Firebird

The hottest Firebird this side of a racetrack will find its way into select dealerships this summer.

Dubbed the Firehawk, after the International Motor Sports Association (IMSA) racing series, the limited-production Firebird offers 350 hp and 390 ft.-lb. of torque from its modified

5.7-liter small-block V8. That's enough to hustle the Firehawk to 60 mph in 4.6 seconds and through the quarter-mile in the

low 13-second bracket. Top speed is 160 mph.

The Firehawk complies with emissions regulations and is expected to turn in 25 mpg highway fuel economy.

SLP (for Street Legal Performance) Engineering, of Toms River, New Jersey, will handle the Firehawk's go-fast modifications. The package can be ordered through Pontiac dealers for \$39,995. Production is expected to be limited to 250 cars.

## Cool Cummins

That popular Cummins diesel engine offered in the Dodge pickup truck line now is available with intercooler and 4-speed automatic transmission. The 5.9-liter turbocharged Six develops 400 ft.-lb. of torque, making it ideal as a trailer-tower.

Dodge claims the 4-speed will add 2 to 4 mpg to overall fuel economy.

Ford and GM also offer high-torque diesel engines in their light-truck lines, a segment of the market that appears to be growing.



The 300-hp dohc 32-valve aluminum-alloy 4.6-liter V8 will debut in 1993 Mark VIII.

## Mark VIII V8

The first variation on Ford's 4.6-liter modular V8 engine will make its debut in the 1993 Lincoln Mark VIII.

In high-performance trim, the 4.6-liter V8 engine will feature dual-overhead cams and four valves per cylinder, as well as aluminum-alloy block and heads.

Although there's no official word, insiders are talking 300 hp, which should give the Mark VIII performance that will match the best of the personal luxury cars—imported and domestic.

PM



## GETTING HITCHED

(Continued from page 42)

desert hills for hundreds of miles, the test crew found another reason to be impressed. Under the hood is an uncluttered layout that makes routine service a snap. Out of a top score of 12 on the PM Serviceability Index, the Sierra walloped the competition with a near-perfect 11½.

Nothing beats cubic inches in a 4x4 pickup for heavy towing, which places the Sierra at the head of its class.

*Vehicles in same class: Chevrolet C2500, Dodge Ram 250, Ford F-250, Jeep Comanche.*

### Mazda MPV

Like the 4Runner, our Mazda MPV was equipped with a weight-carrying hitch and rated to tow up to 3500 pounds. Consequently, it handled the 1750-pound boat and trailer with little effort. Mazda's 18-valve, 3.0-liter V6 proved to be especially torquey at the top of the power band, where it easily beat the competition in passing acceleration while under load.

Gas economy for the rear-wheel-drive MPV was a bit disappointing, and it showed a slight sensitivity to tongue weight. But a terrific ride and agile handling made the family-size minivan a popular favorite among the test crew. It finished near the top in the PM Serviceability Index, too.

Equipped with a weight-distributing hitch and a mandatory load-leveling system, the spirited, family-size MPV is rated to tow 4500 pounds.

*Vehicles in same class: Chevrolet Astro, Ford Aerostar, GMC Safari, Toyota Previa, VW Vanagon.*

### Toyota 4Runner SR5

The light-hauling crown goes to the Toyota 4Runner compact sport/ute. While towing the 1750-pound boat and trailer, the 4Runner posted top acceleration figures across the board. Braking distance and PM serviceability ranking were midrange, but overall gas economy was impressive.

Although the 4Runner displayed a slight sensitivity to tongue weight, it was stable at highway speeds and showed plenty of power up hills. Low-to-the-floor seating may not be to everyone's liking, but few will complain about terrific handling and a crisp ride provided by a topnotch suspension.



Equipped with a 150-horse, 3.0-liter V6, the versatile 4Runner towed our light load with ease and would serve equally well right up to its 3500-pound maximum rating.

*Vehicles in same class: Chevrolet S-10 Blazer, Ford Explorer, GMC S/T Jimmy, Isuzu Rodeo, Isuzu Trooper, Jeep Cherokee, Mitsubishi Montero, Nissan Pathfinder, Oldsmobile Bravada, Range Rover.*

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# NEW CARS



## Mercedes-Benz Tour De Force

• Before anyone from the press had even driven it, it was being called the best car in the world. And now that we've driven the new S-Class sedans from Mercedes-Benz, we're still using phrases like "best in the world." These are benchmark cars—a technological tour de force that will set the standards by which other automobiles are judged for years to come.

As one Mercedes-Benz executive said, "the new S-Class sedan is what is currently possible" in a production automobile. What is possible comes at a price, of course. As much as \$125,000 for the flagship 600SEL. That's a little heavy for most of us, but the technical specifications are interesting nonetheless.

Any discussion of these cars must start with the engines, in particular the new 408-hp 6.0-liter (365-cu.-in.) V12, a 60° dohc 48-valve design that's as smooth as it is powerful.

Also in this engine family are the 326-hp 5.0-liter V8, introduced with the 500SL, and a new 286-hp 4.2-liter V8. Other U.S. options are a 3.2-liter Six and a 3.5-liter turbodiesel.

The car brims with other techno-

logical touches. The accelerator is electronically activated—no linkage. The catalytic converter is the largest in the world. The climate control system is free of chlorofluorocarbons, and purifies incoming air through a charcoal-activated filter. Side windows are double glazed, for sound and climate insulation. ABS is standard, as are airbags for the driver and front passenger. There's even a door-closing servo-system.

Technology also adds up at the curb. The 600SEL weighs in at a round 5837 pounds. But with 408 hp, it feels light and nimble.

Just how good is all this technology on the road? One experience summed it up for us. We drove the cars from



New S-Class dashboard includes airbags for both driver and passenger.



Potent new 408-hp 6.0-liter dohc 48-valve aluminum V12 is also silky smooth.

Cannes, in the south of France, north through the French Alps and across the border to Geneva. On one stretch of twisty Alpine road we were pushing pretty well—around 190 kilometers per hour (about 118 mph).

We felt as one with the big Merc—safe, secure and invincible. Then we whistled around a blind bend and ran into a monsoon downpour. After letting off the gas an instant to regain our composure (the car didn't even twitch), we flicked on the wipers and never even had to slacken the pace.

Few cars in the world could have produced the same sense of security—at any price. —Joe Oldham



## Lexus SC400

Six years ago, the luxury sports coupe segment belonged largely to two German car manufacturers. Today, it's *the* hotbed of design and development activity, with contenders from the U.S., Germany, Japan, England and even Sweden. New cars, new names and some of the flashiest gee-whiz engineering in the industry highlight this battleground, and the only clear winner is the consumer.

Now, Lexus is staking a claim on this hotly contested turf with its new SC400—a sports coupe that is almost certain to provoke more than its share of imitators.

Conceived at Toyota's Calty Design Center in Newport Beach, California, the SC400 is strikingly handsome, and much more distinctive than its sedan counterpart. And it's as aerodynamically clean as its looks suggest it is, with a Cd of 0.32 (0.31

Smaller, lower and lighter than its sedan counterpart, sleek Lexus SC400 coupe is expected to do the 0-to-60 dash in less than 7 seconds. Front-end styling provides a more distinctive look than the sedan. Clean, integrated dash lends sense of command and intimacy to SC's cockpit.

with the optional rear spoiler).

It's also smaller in every dimension and 185 pounds lighter.

### Improved 0 to 60

Unlike the sleek bodywork, the running gear is familiar, with the 250-hp dohc 32-valve 4.0-liter Lexus V8 sending its smooth power to the rear wheels through an electronically controlled 4-speed automatic transmission. However, the transmission's gearing has been altered for the coupe, and this, along with reduced curb weight, helps saw some time off the sedan's 0-to-60 performance, from just over 8 seconds for the 4-door to under 7 for the SC. Top speed is limited to 150 mph.

Though it still doesn't feel quite as athletic as some of the German super-

cars, the SC400's double wishbone suspension is capable, competent and forgiving. It's also significantly smoother in ride quality than a good many cars in this class. And it's as quiet inside as the LS400 sedan, which puts the SC near the top of the heap.

Like the sedan, 3-channel antilock braking is standard, and both Goodyear and Bridgestone have developed new 225/55 V-rated tires for the new 16-in. alloy wheels. The wheels were designed to help dissipate brake heat buildup.

### Easy-access doors

An interesting comfort/convenience touch is the easy-access door hinge, which swings the leading edge of the door out and forward to make getting in and out easier.

The all-leather interior is beautifully finished, with excellent bolstered seats for four passengers, though rear-seat legroom is limited. Bird's-eye maple is used for interior trim, and tastefully so. And the Lexus electroluminescent analog instrumentation, clearly visible night or day, lends a distinctive touch to the coupe's cockpit, just as it does in the sedan.

Options like a hands-free cellular phone (soon to be the only cellular phone legal for cars in many states), the trunk-mounted 12-disc CD changer, Nakamichi sound system and traction control seem right at home in this posh environment.

Lexus SC400 pricing will probably start at just under \$40,000, a tidy sum, but well below some of the comparable entries from Mercedes-Benz, BMW and Jaguar. Combine that with outstanding looks and the LS400's phenomenal owner satisfaction, and it's hard to bet against the SC's chances, even in the toughest game in town.

—Rick Titus

(More New Cars on page 98)

## Mazda's Mini V6

● Mazda's MX-3 will be available with the smallest capacity V6 engine in series production. The 1.8-liter motor fits into a space just adequate for the 1.6-liter inline Four that's standard in the 1992 model sports coupe.

Mounted transversely for front-wheel drive, the V6 is the only 6-cylinder engine available in the pocket-rocket vehicle class. Mazda chose the 6-cylinder configuration for its superior smoothness, as well as improved throttle response over an equivalent-performance Four. The 24-valve, 4-cam engine produces 130 horsepower at 6500 rpm, and 115 ft.-lb. of torque at 4500. The 5-speed manual transmission version gets 28 mpg EPA highway, while the 4-speed auto delivers 27.



With an aluminum block and heads, the MX-3 uses cast-in iron cylinder liners. Hydraulic lash adjusters are used for quietness and low maintenance. Borrowed from the RX-7 is a "linear" airflow meter that provides extremely accurate airflow

measurement. The sequential port fuel injection uses side-feed fuel injectors, which are quieter and provide an improved throttle response.

The engineers at Mazda are said to have spent a consid-

erable amount of development time on tuning the automobile's exhaust note for the correct combination that achieves a sports-carlike sound, as the MX-3 is intended to appeal to consumers who like a sporty kind of car.

—Mike Allen

PM PHOTO BY BOB PALLSON



Styling of new Bonneville line provides stronger distinction between lower trim levels and sporty SSEi (below). Redesigned instrument panel is more integrated.

### Beautified Bonneville

Pontiac's successful big-car line will have a distinctly new look this fall when the new Bonnevilles hit dealer showrooms. Besides improved aerodynamics and more trunk space, the redesign will also provide more visual separation between the lower trim levels and the sporty SSEi, which will be available with a 195-hp version of GM's new supercharged 3800 V6.

As the photos indicate, the SSEi has shed its old boy-racer look in favor of an integrated grille/bumper/air-dam and a much more subtle rear deck spoiler. The net result is a much more

sophisticated look, one that seems to be more in step with the sport/luxury sedan segment.

Other SSEi goodies include traction control, a head-up display, standard antilock brakes, and airbags for both the driver and front-seat passenger.

Although overall length has been



stretched 2.5 in., the new Bonnevilles will ride the same 110.8-in. wheelbase as the current edition.

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New LeSabre has more contemporary appearance and improved aerodynamics.

### 1992 Buick LeSabre

If any one car has helped Buick gain ground in the marketplace, it would have to be the popular LeSabre. With four doors, room for six adults and the kind of stately good looks and performance that define the Buick experience, the LeSabre has been Buick's best-selling model. And its latest incarnation, for 1992, offers more of the same, only better still.

Available in two models, the Custom and Limited, the '92 LeSabre is 3 in. longer, with smooth, distinctive lines, a driver's-side airbag, optional

antilock braking and the latest version of GM's 3800 V6 engine.

Coefficient of drag (Cd) is down from .35 to .32. The hood is low and wide, and there's lots of glass, with narrow A- and B-pillars.

Improved aero means improved interior quiet, and the curving rear deck covers a bigger trunk—16.9 cu. ft.—which is where most of the increased length went.

Standard instrumentation—a rectangular speedometer and warning lights—is improved, though we prefer the optional round analog gauges.

There's more power for '92—170 hp and, perhaps more important, 220 ft.-lb. of torque, helpful in getting 3500 pounds of Buick moving with some urgency.

—Don Chaikin

### Supercharged 3800

If power is one of the essentials of a luxury car, the supercharged 3800 V6 should appear in more than a few 1992 Buick Park Avenue Ultras.

Fed by a Roots-type positive displacement blower, the supercharged 3800 V6 makes 205 hp at 4400 rpm and 260 ft.-lb. of torque at 2600. Buick says this is enough to get the 3600-pound car to 60 mph in less than 9 seconds.

The price premium is expected to be about \$1000.

PM



Supercharged 3800 V6 gives Buick Park Avenue Ultra 205 hp, 260 ft.-lb. of torque.

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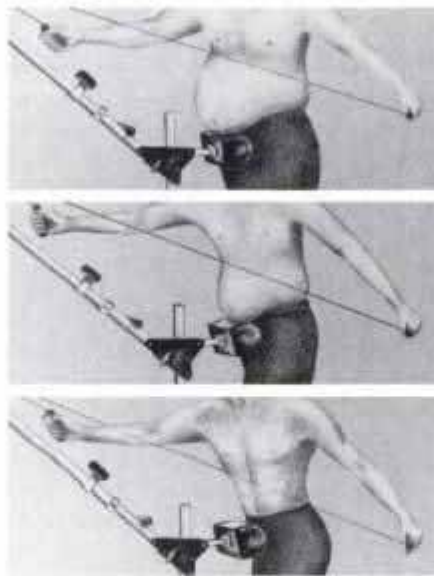
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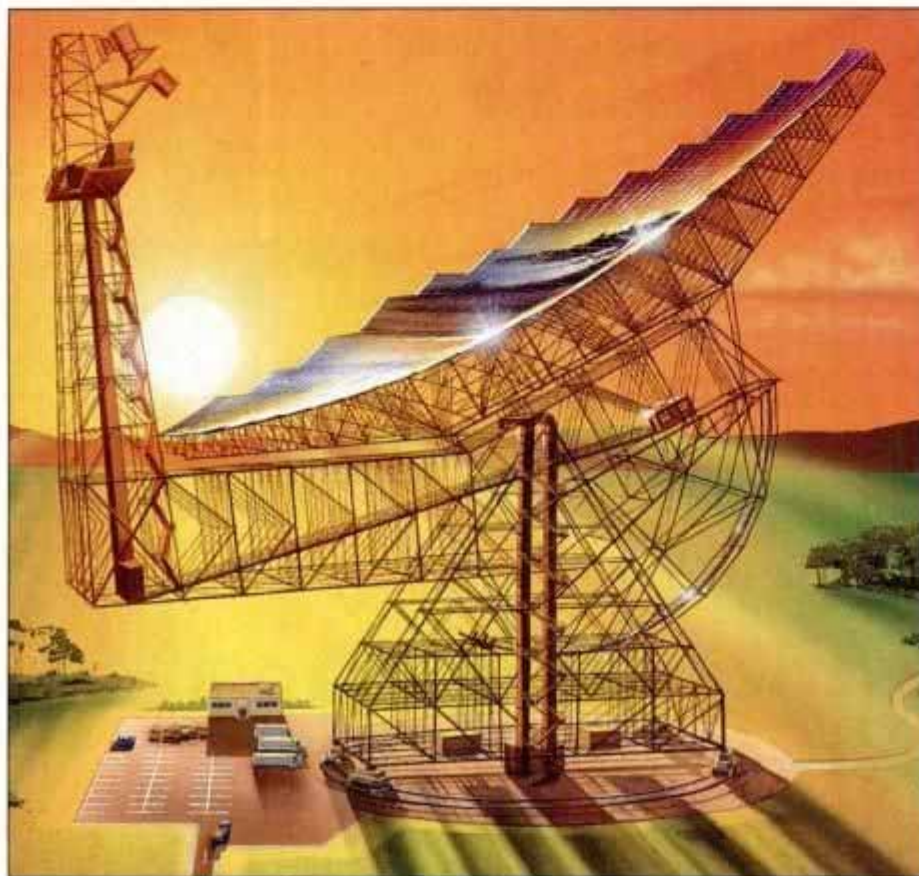
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## SCIENCE

# GREEN BANK COMEBACK

BY ABE DANE, Science/Technology Editor



FM ILLUSTRATION BY PAUL DIMMARE

● On a windless night in 1988, a ½-in.-thick steel gusset plate gave way, and a soaring cathedral of science collapsed into a pile of twisted metal. It was a tremendous loss. The 300-ft.-dia. Radio Telescope at Green Bank, West Virginia, had been the largest steerable radio telescope in the United States, and one of only two such instruments in the world. Although nearly 30 years old, its vast dish remained productive, gathering and focusing faint celestial signals, telling the stories of distant worlds.

But this is not a tale of capabilities lost. This summer, ground is to be broken on a new Green Bank telescope—one bigger than its predecessor, and a quantum leap more sensitive and precise. The contrasts between old and new illustrate 30 years of progress on several fronts.

Few human artifacts can match the combination of towering size and microscopic precision called for in the new telescope. The 475-ft.-high framework will incorporate 12 million

pounds of steel, yet its pointing mechanism is exact enough to hit the red spot on Jupiter's surface. The 330-ft.-dia. reflective face of the dish comprises 2006 reinforced aluminum panels spread over an area of 2¼ acres, but at no point will they deviate from a perfect parabola by more than the thickness of a sheet of paper.

According to Jay Lockman, a scientist in the basic research division of the National Radio Astronomy Observatory, which is in charge of the instrument, one of its most important features is the positioning of its focal point. Unlike most large radio telescopes, which place their receivers, or feeds, on a tripod over the center of the dish, the new Green Bank telescope is configured as an offset parabola. That means the feeds are at the end of a single arm rising out of the side of the dish (see illustration above). "You don't have anything blocking the rays," says John Gurney, vice president for engineering at Radiation Systems, Inc., which is build-

ing the telescope. As a result, radio energy falls on the entire dish.

The offset design is, however, considerably more challenging to execute. Compensating for this are computerized tools that give today's engineers a big edge over their counterparts of 30 years ago. One method in particular, known as finite element modeling, has found extensive use enabling designers to predict the stresses on each component of the telescope. The same technique was used to analyze the design of the old telescope after it collapsed, and was instrumental in pinpointing the cause. "The bottom line is that a telescope like the old one would not be allowed to be built today," says Lockman.

Even after the telescope is built, computers will continue to control its shape. Each corner of each of the panels making up its face is supported by a screw-type actuator that moves in response to computer commands. The computer uses data from a laser ranging system mounted on the feed arm to keep each panel in exactly the right position, compensating for thermal expansion and wind.

Scheduled for completion in September of 1994, the resulting telescope will be one for which "there are no rival instruments in the world," according to Lockman. And while he won't go so far as to say he's glad the old one fell down, what's rising in its place must do more than a little to soften the blow. **FM**



Spontaneous collapse of the 30-year-old observatory gave rise to a new design.

WIDE WORLD PHOTO

## ELECTRONICS

# MUSIC MAKER

BY FRANK VIZARD, Electronics Editor



● Yamaha hopes to do for music making what Sony's Walkman did for music listening. The QY10, says Yamaha, can make composers of us all.

The QY10 is certainly portable, being about the size of a VHS video cassette. And like a personal stereo, you listen to it through headphones.

At this point, any similarity to a personal stereo ends. Stored on a microchip inside the QY10 are 30 "sampled" instruments. Sampled means that each instrument's sound has been digitally recorded and can now be played back at the touch of a button. The musical palette includes piano, electrical guitar and a fairly realistic brass section.

There are also 26 drum sounds, ranging from the basic snare or rim shot to the more exotic timbal and agogo bells beats. Rhythms can be set in any of 76 preset styles. Rhythmic choices include basic rock-and-roll to the more cutting-edge sound of New York '90s funk. All these rhythms can be called up by keying in the appropriate number for each rhythm. The numbers and useful information are contained in an easy-to-use operations manual. There are also 24 additional memory slots so you can record your own rhythm patterns.

Music composition really begins when you start to combine rhythm patterns, chords and melody to create an original song. You can choose between 20 available chord types, and if

you should make a change for one instrument, backup instruments adjust to the new chord change. The QY10 allows you to mix tracks, as well.

The QY10 liberates the music fan from bulky equipment. And while the uses for professionals are obvious, the QY10 is of real interest to amateurs and beginners. Camcorder enthusiasts, for example, can create their own soundtracks. The QY10 has both MIDI inputs and outputs, as well as a "line out" for connection to an external audio system.

For those who don't know a chord of music from a cord of wood, the QY10 is an excellent teacher. By simply pushing a few buttons, you can hear what different chords and arrangements sound like and how they can be used to create a song. List price for the QY10 is \$399.

### Headphones With Bass

The hardest part of the musical spectrum for headphones to reproduce is low bass notes. The problem is one of dimensions. Bass is reproduced by large woofers that are too big to wrap around your ears.

Sennheiser gets around this problem in its top HD 560 model by adapting a well-known technique used for home speakers. Each earphone features a tiny tuned bass port that enhances bass response. While this approach can yield boomy bass if done

incorrectly, Sennheiser performs this miniature act of engineering beautifully. Not only is the bass tight and accurate, but there's also a sense of detail and spaciousness not found with many other headphones.

The HD 560 is a luxury liner in terms of both sound and comfort. Velvet-covered earphones comfort your ears while the weight is unobtrusive. At a list price of \$269, the Sennheiser HD 560 is more expensive than most, but it's definitely a first-class ticket that lives up to its billing.

### From The Bookshelf

While space doesn't permit lengthy reviews, a few books have caught our eye in recent months. These include:

● *How To Keep Your VCR Alive*, by Steve Thomas. Subtitled *VCR Repair For The Total Klutz*, the book sells for \$24.95 and is published by Worthington Publishing Co. in Tampa, Florida.

● *Using Your Camera*, by George Schaub. PM's own photo columnist provides a basic guide to 35mm photography. List price is \$18.95, and it's published by Amphoto in New York, New York.

● *Designing, Building, And Testing Your Own Speaker System*, by David B. Weens. The title tells it all. The style isn't what you'd call breezy, but it does show you how to construct a variety of enclosures. Tab Books in Blue Ridge Summit, Pennsylvania, is the publisher. List price is \$16.95. **PM**



Sennheiser's HD 560 headphones use tuned ports for better bass.

## BOATING

# SALMON AND SUZUKI

BY JOHN WOOLDRIDGE, Contributing Editor



PHOTO BY NEIL RABINOWITZ

● Fast moving tides boil the waters between the San Juan and Orcas islands, located off the coast of Oregon. Large, irregularly patterned waves often batter small boats in this gorgeous part of the country, but the Wellcraft 236 walk-around fishing boat I'm in punches easily through the swells, thanks to the Suzuki 225 EFI outboard that growls powerfully on the transom.

Rounding the islands, we head southwest for Middle Bank, about 6 miles offshore. The gray light of dawn barely glimmers in the sky. We won't be back this way for many hours. Winter chinook salmon, locally known as blackmouth, are feeding at Middle Bank, and we are hellbent to make it there before their breakfast.

The new breed of small offshore fishing boats has opened fresh vistas to fishermen no longer content to troll the coastlines. Deep-V center consoles and walk-around cuddys are the weapons of choice, but when the bite is on miles from shore, you're only as good as your motor.

### Strong, quiet type

Suzuki, an outboard manufacturer since 1965 and one of the first Japanese marine imports marketed in the United States (1977), has been quietly building a reputation among fishing

guides, charter captains and commercial operators as a dependable source of power. To some boaters, this may be surprising. It's not surprising that Suzuki engines are dependable, but that its reputation is merely growing without fanfare.

Suzuki, after all, was the builder that introduced oil injection to the consumer marine market, which took the guesswork and mess out of pre-mixing fuel and oil. Suzuki was also the first to put the oil reservoir under the engine cowl and eliminate the need for a separate, space-eating storage compartment. Electronic fuel injection, which debuted in the growling 225, is another technology brought to the outboard market by not-so-quiet Suzuki.

All three high-tech features are standard in the 225-hp V6, which is mounted away from our transom on a fixed bracket. Next to it is a 15-hp Suzuki kicker motor, which hangs on an adjustable bracket. Both engines are used individually for trolling, depending on the circumstances, and they perform flawlessly in this rough environment.

Our early morning, cold-weather start is a good test for the EFI and Microlink computer management systems, which handle the strain effortlessly. To maximize the burn of every

fuel charge, each cylinder head is equipped with dual spark plugs. To reduce piston-ring friction and heat buildup, cylinder walls are plated with a boron-composite coating, another area where Suzuki is on the leading edge. Ceramic-fiber reinforced pistons are used to help prolong a life of high temperatures and high compression.

### Taste of the Northwest

Downriggers are essential to deep-water salmon fishing in the Pacific Northwest, and we have four. The two aft are rigged to stream directly behind and below the boat. The two forward are turned outward at 90° to widen the path of our bait.

I have a fish on before all the baits are set out. Electric downriggers make it easy to raise baits and to reel in lines for a clear field in which to fight the fish. By the time we lower the baits again, a frisky 10-pound chinook is icing down in our fishbox.

The sun came out at that moment, and stayed out for the two days we ocean-tested the Suzuki outboards. Due south of us, the snowcapped Olympic Mountains rose to inspiring heights. More inspiring, however, was the sight of the huge flashing silver salmon that filled our nets. We caught our limit by noon, and headed home. **PM**



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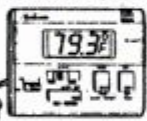
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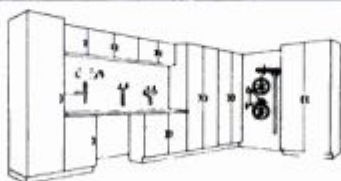


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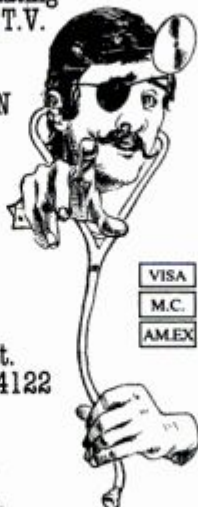
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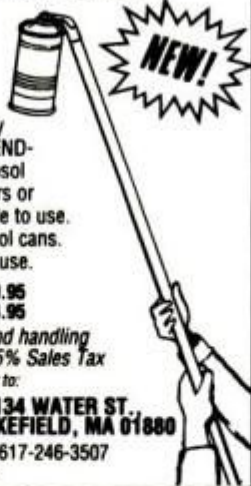
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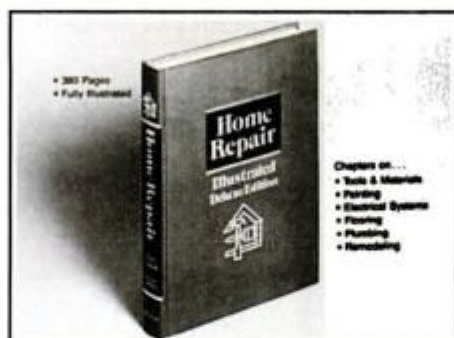
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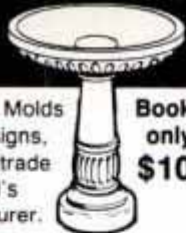
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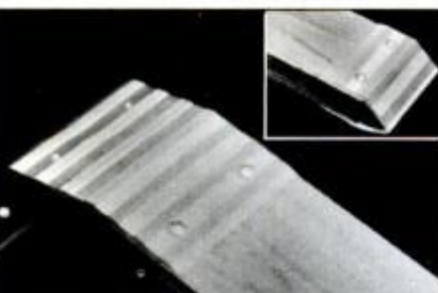
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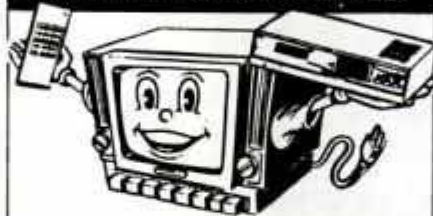
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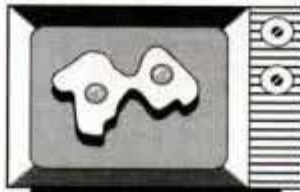
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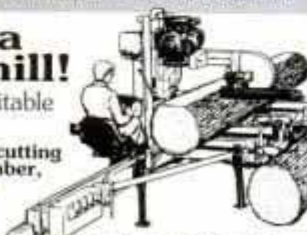
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PREVIEW

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SEND  
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YOUR IDEA OF  
THE ULTIMATE  
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IT BACK.

Design the ultimate in liquor cabinets and send in a description and plans. If we decide yours is the best, we'll build it for you. And send it back. Free.

#### OFFICIAL RULES

1. No Purchase Necessary. To enter, create your vision of the ultimate liquor cabinet, then transfer your ideas onto a set of blueprints or plans. Your design entry must include a sketch with a detailed visual description of your cabinet, its size, and your choice of the materials, colors and finishes to be utilized. After identifying each page of your design entry by printing your name, address, zip code and phone number, mail your entry to: "The Canadian Club/Popular Mechanics Ultimate Liquor Cabinet Contest," P.O. Box 514, Sayreville, NJ 08871. The contest begins on May 15, 1991 and ends September 30, 1991. All entries must be received no later than October 11, 1991.
2. The sponsors are not responsible for incomplete, late, lost, postage due, misdirected mail or correspondence. Limit one design entry per person, group or organization.
3. Submitted entries will be evaluated by the editors of Popular Mechanics Magazine. Entries will be judged on the basis of: A) Originality 50%, B) Aesthetics 15%, C) Uniqueness 15%, D) Function 10%, E) Soundness of Design 10%. In the event of a tie, the winner will be judged on the accuracy and clarity of the submitted plans. By entering this contest, entrants accept and agree to these rules and to the decisions of the judges, which are final and binding.
4. The design must be original and must be owned by the entrant. The design must not have been previously built or have won any award. All entries become the property of the sponsors and will not be returned. The winning entrant will be required to execute all necessary documents to transfer any right, title or interest in the design they have created for their entry without additional compensation.
5. One Grand Prize: The Ultimate Liquor Cabinet built to the winner's design and material specifications. The prize includes the acquisition of all materials, labor and shipping and handling costs to the address specified by the winner (approximate value (not to exceed) \$5,000.00). The actual prize value of the winners' Liquor Cabinet is determined by the winners' materials and specifications, therefore, the prizes' dollar value may be less than \$5,000.00. In such a circumstance the cash difference will not be awarded.
6. The winner will be notified by registered mail on or about February 7, 1992 and will be required to sign an Affidavit of Eligibility and Release and consent to the commercial use of their name, likeness and winning design without additional compensation. The Affidavit of Eligibility and Release must be returned within 20 days of senders' postmark, or eligibility will be forfeited and an alternate winner will be selected.
7. This contest is open to residents of the U.S.A. who have attained twenty one years of age as of May 15, 1991, except employees and their immediate families of Hiram Walker & Sons, Inc. and Popular Mechanics Magazine, and the Hearst Corporation, their subsidiaries, affiliates, licensed distributors, retailers, advertising, and promotion agencies, including Marden-Kane, Inc. Void where prohibited or restricted by law. All federal, state and local laws, statutes or regulations apply.
8. The prize can not be substituted or transferred by the winner. Taxes are the sole responsibility of the winner.
9. For the name of the prize winner, send a stamped, self-addressed envelope to: "WINNERS LIST, THE ULTIMATE LIQUOR CABINET CONTEST," P.O. Box 705, Sayreville, NJ 08871. The winner's name will be available on or about March 20, 1992.
10. Popular Mechanics editors will not enter into any conversation or correspondence with any entrant regarding this contest or its rules.



# THE ULTIMATE LIQUOR CABINET

SCALE  $\frac{1"}{8} = 1'-0"$  DATE 2/18/91 DRAWN BY *Pat Chyllin*

DETAIL B-B'



THE ULTIMATE  
FINISHING TOUCH.

MIRROR SMOKE-GLASS  
SEE SPECIFICATION LIST

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AS SHOWN

SEE DETAIL  
A-A'

FLOOR  
SURFACE



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