

NOVEMBER 1992 \$1.95



Popular Mechanics

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Winterize Your Boat, Motor And Trailer The Right Way

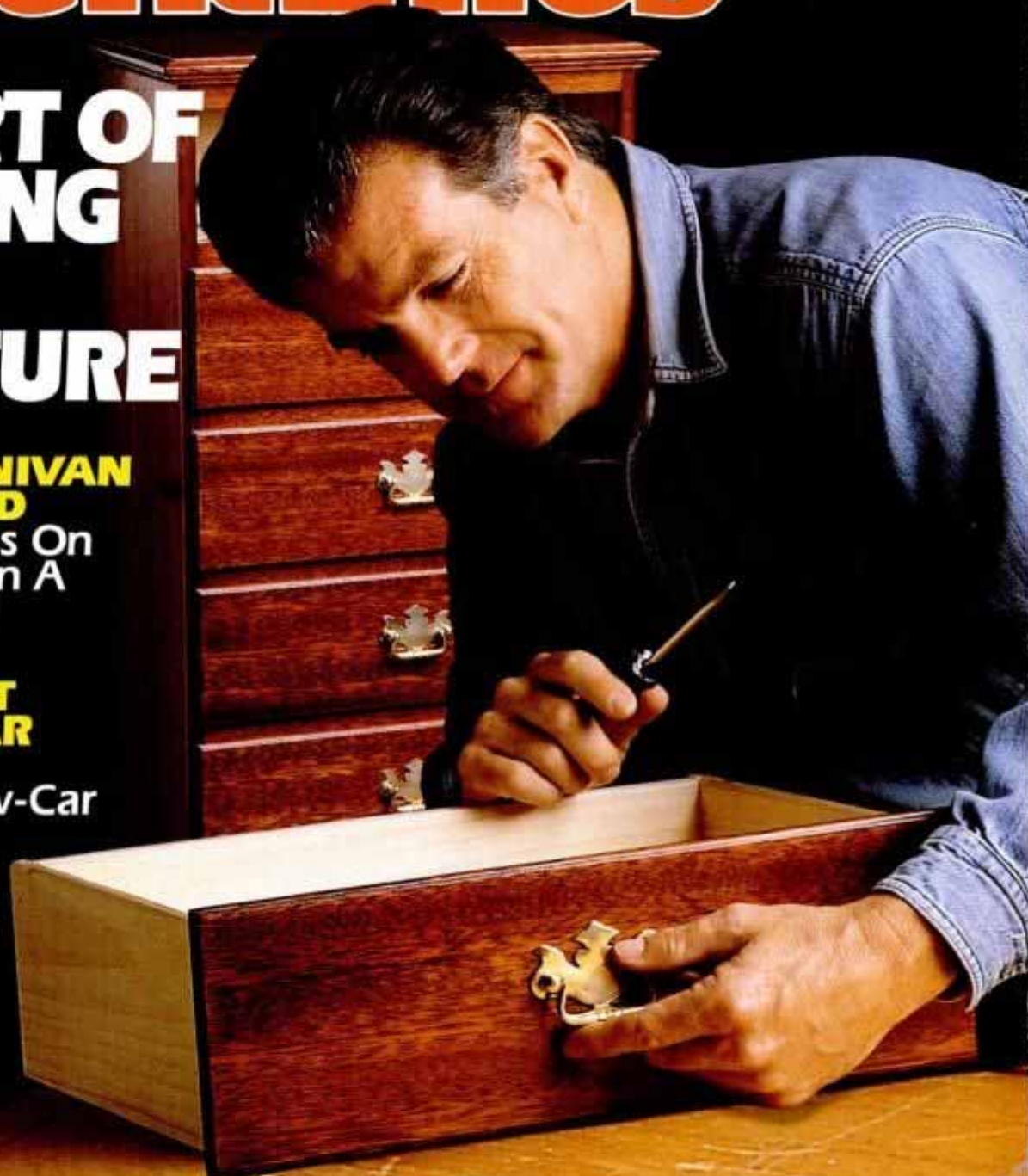
THE ART OF CRAFTING FINE FURNITURE

CHRYSLER MINIVAN VS. THE WORLD

The Champ Takes On All Challengers In A 10-Way Shootout

HOW TO PAINT YOUR OWN CAR

Step-By-Step To A Beautiful Show-Car Finish



SPECIAL

WOODWORKING ISSUE

6 Great Furniture Pieces For Any Skill Level—Beginner To Master Craftsman



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*Based on 1991 New Vehicle Buyer Survey.

Escort

Taurus

HAVE YOU DRIVEN A FORD LATELY?





November 1992

Dear Friends of **Popular Mechanics**:

As the home becomes the center of activity and family involvement, more homeowners are performing improvements to make their homes more comfortable. In fact, today it's the trend for men and women to personally partake in home improvements. That's why it comes as no surprise to me that comedian Tim Allen's show, "Home Improvement," is one of the hottest programs on television today. It also doesn't surprise me that Tim Allen has a subscription to **Popular Mechanics**.

Participating in home improvements and remodeling projects is a **PM** reader's pride and joy. More than two-thirds of **Popular Mechanics'** readers (6,444,000) are homeowners who get satisfaction from doing things themselves. Written for our readers' interests, nearly one third of **Popular Mechanics'** monthly editorial is devoted to home improvement-related articles. **PM** provides information to help guide our 4,405,000 readers who personally perform home improvements.

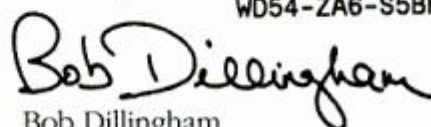
Popular Mechanics' home-related editorial spans home improvements, remodeling, building, tools and hardware, and gardening. So far in 1992, from January through July, 167.3 editorial pages related to home improvement category. And featured in this issue is our annual *Woodworking Guide* which contains plans and step-by-step how-to information for building several pieces of furniture for various rooms of the house.

It's **PM's** editorial mission to provide information geared to today's active men. And due to our readers expressing the need – by means of letters, phone calls, and computer mail – for more home improvement articles, we will be enhancing our home-improvement editorial. Beginning with the December issue, the Home & Shop Journal will become even more home centered than it presently is. It will lead off each month with a home improvement-related article, and all home improvement articles will be in full color, including how-to and step-by-step segments.

As these changes make for a more useful and attractive editorial section, advertisers too will benefit. **Popular Mechanics'** readers rely on the information they find in our home-related editorial and advertisements a bit more heavily than when watching Allen's *Tool Time*.

Source: 1992 Hall's Magazine Reports
1992 Spring MRI

Sincerely,

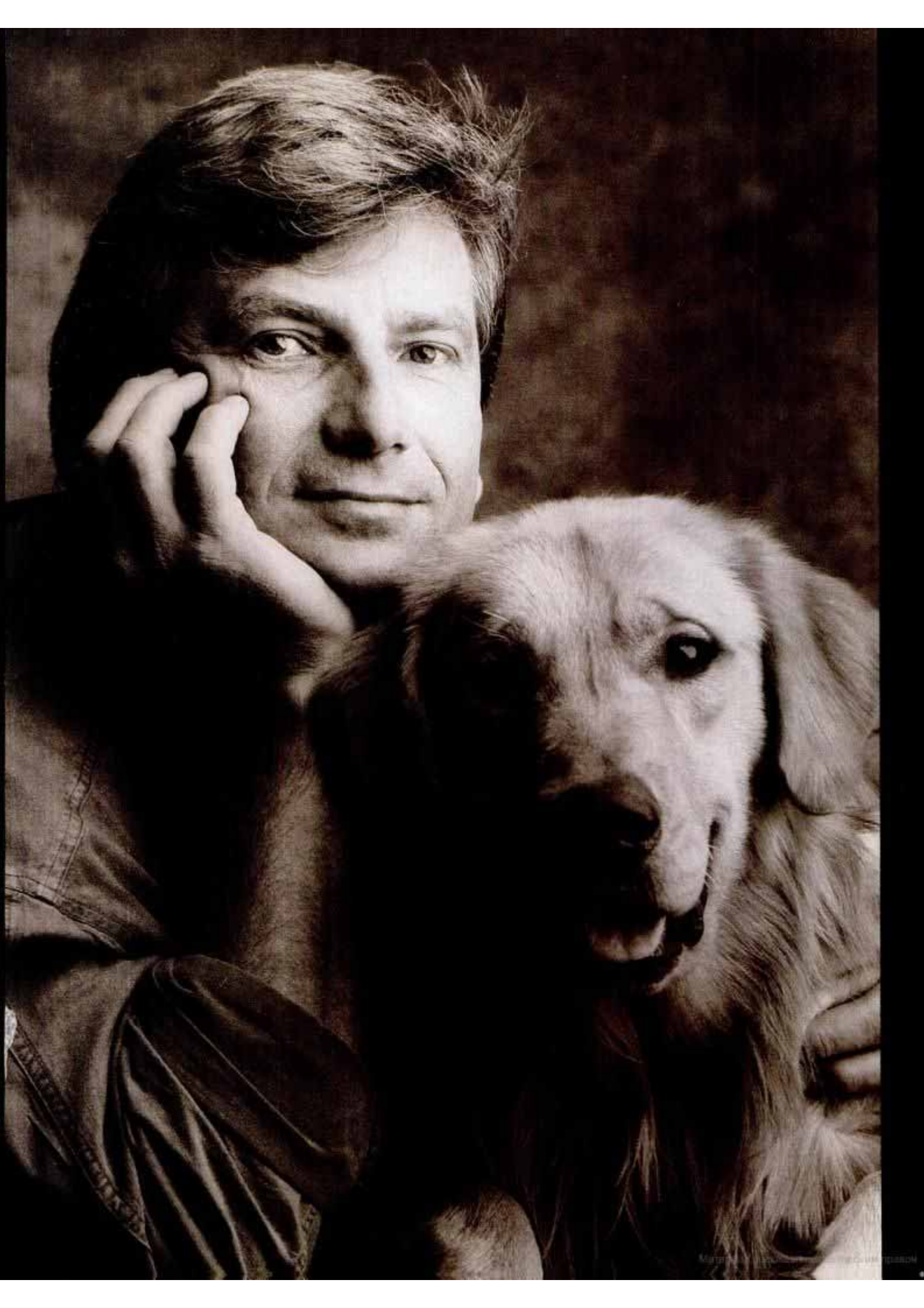
A handwritten signature in black ink that reads "Bob Dillingham". The signature is written in a cursive, flowing style.

Bob Dillingham
Vice President & Publisher

This One



WD54-ZA6-S5BK



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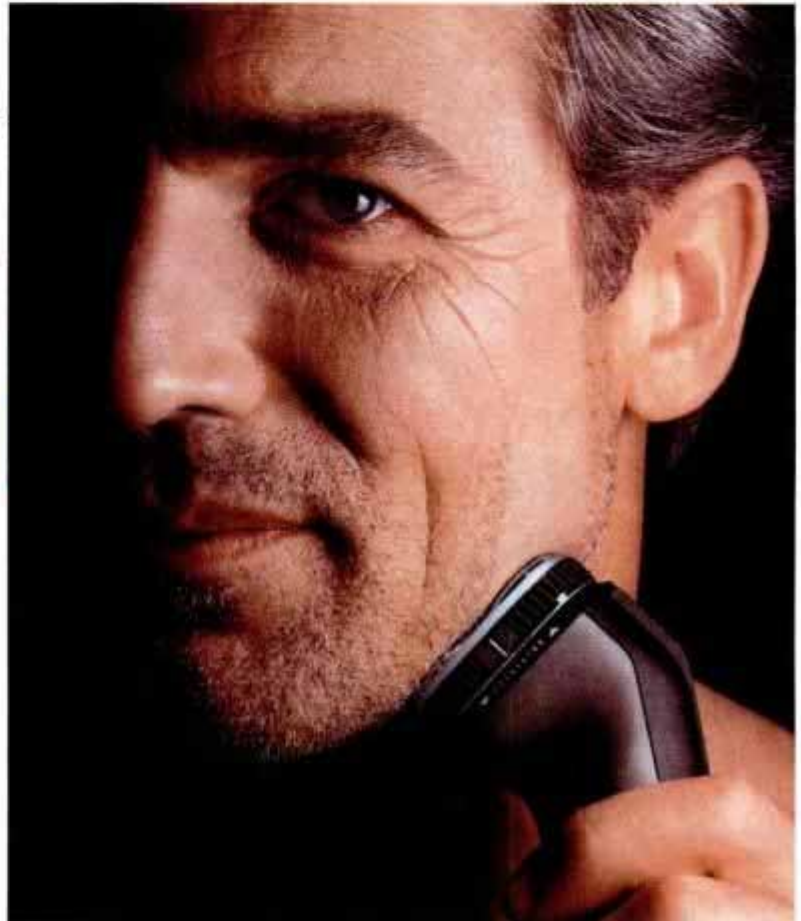


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PM ILLUSTRATION BY KEITH FERRELL



PM PHOTO BY RICH COOK



PM PHOTO BY RICARDO CAPOTORTO

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your jeans that should loosen up.

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EDITOR'S NOTES

● There wasn't much for Americans to cheer about in the bleak days of early 1942. Then something happened. Lt. Col. James E. Doolittle organized and trained a squadron of B-25 bombers that took off from an aircraft carrier and took a whack at the Japanese empire, heretofore thought invincible. The raid caused little actual damage in Tokyo. But the symbolic gesture—the realization that the war could come right into the backyard of the Japanese—was powerful stuff, both here in America and in Japan. Doolittle's raid is today, arguably, the most famous air raid in history. What's more, the raid certainly resulted in the most famous half-minute in history, thanks to the Hollywood version, "30 Seconds Over Tokyo," starring Spencer Tracy. Today, 50 years after the fact, we can still marvel at Doolittle's daring and courageous strike at the Japanese. Contributor William Garvey's words and some great historic photos from the United States Air Force Museum help you relive the event. But to really set the tone, we commissioned artist and PM contributor Keith Ferris to illustrate what it must have been like during those 30 seconds that have lasted a lifetime. Ferris chose to depict one of the two planes that turned left after passing over Tokyo, then skimmed low past Yokohama and outran Japanese fighters over Tokyo Bay. Not many know about the numerous modifications made to the B-25s to make them suitable for the mission. Artist John



Graphics Director Bryan Canniff and artist Keith Ferris.

Batchelor's cutaway provides an inside look at what it took to make it happen. Relive history beginning on page 33. . . This year's annual **Woodworking Issue** features projects, projects, projects. Furniture making is a very trendy activity these days, but we know you were into it long before it became fashionable. Whatever your woodworking skill level, there's something in this issue that you can have fun making and be proud of when it's on display in your home. . . For a lot of us in Northern climes, it's almost that time again. But it's not too late to winterize your boat, motor and trailer before the snow flies. We don't mean just wrapping some tarps around it and pushing it behind the garage either. There's a right way and a wrong way to do it. Naturally, we tell you the right way, starting on page 38. . . One of the healthiest segments in the automotive marketplace is the minivan segment. Chrysler's chunk of that market is a hefty over-50%. Chrysler invented the minivan, and since its introduction, the Dodge Caravan/Plymouth Voyager has been the benchmark by which all other minivans are measured. Now, the second-generation Chrysler minivan is being challenged once again by both imports and domestics that want to be your minivan choice. Is the Chrysler up to the challenge? Find out on page 52 as our auto editors run them all through their paces. Till next time.


Joe Oldham

Popular Mechanics

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As you can see, our engineers have clearly designed the 1993 Caprice with your safety in mind. Whether it's Caprice's

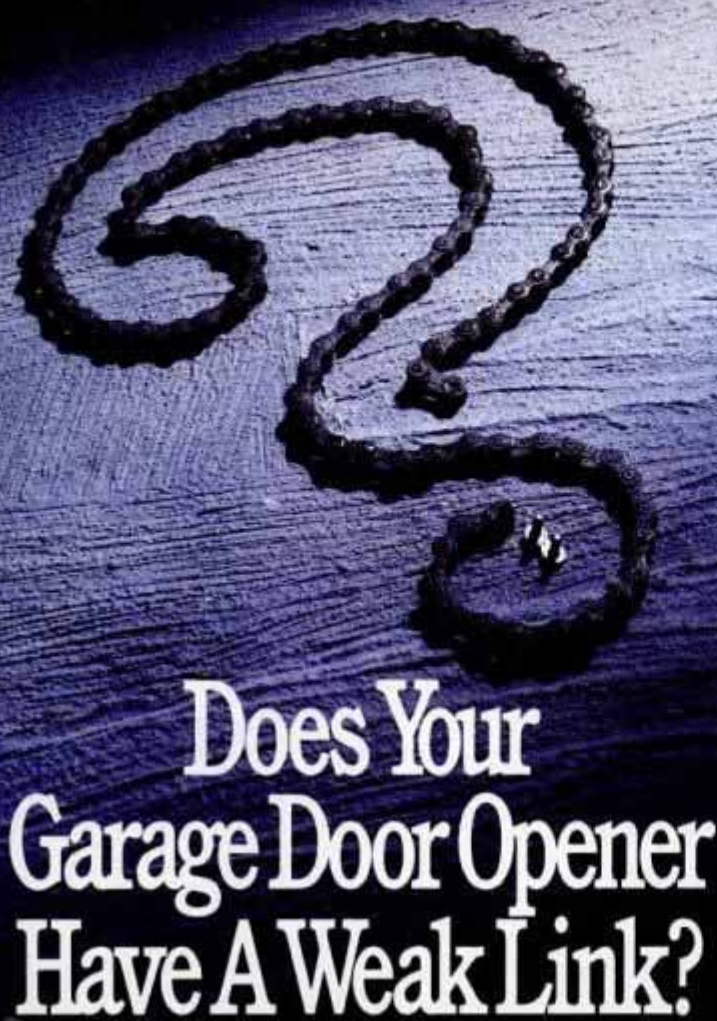


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LETTERS

America's Secret Forces



I'm looking at your September '92 cover showing frustrated fearsome-looking characters, all dressed up, rearing to go and, wouldn't you know it, no war to fight. But give us time. We will find something, somewhere and we will be there as usual meddling all over again. Convert swords into plowshares? What's that?

IGOR DE LISSOVOY
LAKELAND, FL

I enjoyed Abe Dane's article on "America's Secret Commandos." My few contacts with the "snake eaters" (mostly Navy SEALs) back in the early '70s made me glad that they were on my side. I'm convinced that these individuals are in fact something special and remain our best hope for survival in an unstable world.

DAVE LEWIS
NORMAN, OK

The Soviet AK-74 rifle was described in your article as the U.S. designation for the AK-47 rifle. This is incorrect: The 1950s vintage AK-47 fires a 7.62mm bullet. The 1970s AK-74 fires a much smaller, 5.45mm round. The two rifles share

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

the same basic design, but are distinctly different weapons systems.

WADE PETRILAK
WARMINSTER, PA

Your article on Commandos was exceptionally well-researched. However, a few key weapons seem to have been overlooked. The U.S. military also uses a McMillan .50-caliber sniper weapon. The SEALs frequently use SIG P.226 9mm handguns. And the Marines use a 7.62mm sniper weapon designated M40A1, which is equivalent to the M24.

RICK CHISHOLM
ONTARIO, CANADA

Super Bowl

My dad liked the bowls you made in the Home & Shop Journal's shop techniques article, so he followed your instructions and made a couple. Then he constructed a set of lamps using the same technique. Here's the finished result. By the way, he also built the table it's sitting on.

LISA PETERSON
LOCKPORT, IL

Millionth Corvette

Your October Editor's Notes column says, "When the first one rolled off the old St. Louis plant line in January 1953 . . ." This is incorrect. The correct chronology of the Corvette is as follows:

Jan. 18, 1953: The first Corvette prototype is shown to the public at the GM Motorama at the Waldorf-Astoria Hotel in New York City.

June 30, 1953: The first production Corvette is completed on a small pilot line in Flint, Michigan.

December 1954: The last of 300 1953 Corvettes are

completed in Flint within a few days of Christmas. Using new production tooling, 1954 production begins. Fifteen 1954 Corvettes are built in a new facility in St. Louis. The exact dates of these two events are unknown.

NOLAND ADAMS
EL DORADO, CA

Mr. Adams, who happens to be one of the world's most noted authorities on Corvette history, is absolutely correct. I've written a few Corvette histories myself and I do know better. Please pardon my momentary brain fade. —Ed.



PM's bowl-making project as built by a creative reader.

Political Science

As a young man, I relied on your magazine to give me scientifically correct information. Even while attending college to obtain a degree in aeronautical engineering I read PM to keep up with trends in other engineering and scientific fields. Now as a retired engineer with 30-plus years in

the field, I am still reading PM. But lately, I find that you seem to be more interested in being politically correct rather than scientifically correct. Case in point: Most of your staff writes as though ozone depletion and the "hole" over the Antarctic are scientifically proven to be caused primarily by manmade CFCs. The "hole" is actually not a hole but a depletion of as little as 8%. Not only that, this depletion was discovered in the '30s, long before man started producing CFCs in quantity. It cannot be proven to be anything other than a natural phenomenon. The chemistry of chlorine affecting the ozone layer is undeniable, but nature puts out millions of tons a year from volcanoes and the ocean. Man's output is only 750,000 tons per year, maximum. I hope PM takes its science more seriously than political correctness so that a new generation of people reading and learning from the magazine will have a knowledgeable understanding of what is happening around them.

EDWARD BINDER
ATHOL, NY

It's not that we are interested in being politically correct. It's more that we have a long history of viewing the world in the context of the current prevailing attitude of our society as a whole. That's where the "Popular" in our name comes from. There is a lot of science yet to be proven by clinical evidence. No one yet has seen a black hole, but the prevailing attitude in the astronomical community is that they exist. No one has clinically proven that cigarette

(Please turn to page 16)

Combat Signaler

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smoke causes lung cancer but we accept the fact nonetheless. No one has proven that global warming exists either. But our society already acts as if it is fact. We view the hole in the ozone layer in the same way. —Ed.

A Lesson In Civics

What a glowing review of the 1992 Honda Civic in your September Owners Report. How could it be so wrong? This mass of changes to what was acknowledged as the perfect small car can only suggest that Honda has been infiltrated by GM saboteurs. The car is larger, and that's fine. But why did they remove the dash tray? Is this what you mean by the "cutting edge in small-object storage?" And look at those goofy exterior door handles. That's an improvement? You did mention the lost vision to the rear over the bustle trunk. But you forgot to mention the sedan's rear quarter posts that are over twice as wide as before. It's a good thing that rear visibility has nothing to do with safety. Improvements in drivetrain, ride and handling are nice. But, frankly, the 1991 Civic is much better looking. It has balance, proportion, the perfect interior and is engineered beautifully for comfort and convenience. We expect such poor design from American manufacturers and we get it. We don't expect it from Honda.

RANDY SCHLACK
McHENRY, IL

I appreciate being quoted verbatim in the Civic Owners Report. I now have nearly 12,000 miles on this car and what I said in the survey still goes. It's truly an amazing automobile.

FRED WERNE
MEMPHIS, TN

Double Whammy

The article on 2-cycle engine development makes for interesting reading but it also begs the question why. There is no argument with the concept that it could produce a lighter car, but what seems to be needed on dealer lots is not a lighter car, but a better car. Our leaders in the automotive industry are unable to make a distinction between fuel efficiency and fuel economy. Since automotive engineers have not yet developed optimum efficiency in the current 4-stroke engine, it's illogical for them to turn to the 2-cycle engine, where problems are even more formidable.

JANUS
ST. JAMES CITY, FL

Possible Dreams

In reference to Mary Seelhorst's article on the aviation section of the ex-

hibit at Henry Ford Museum, the Curtiss OX-5 engine was more than a "tinkerer's delight." It was a very reliable aviation engine for its day. Glenn Curtiss, a true mechanical genius, developed it from his work with motorcycles. This engine was a large, water-cooled 8-cylinder on a 90° V. From 502 cu. in., it produced 90 horsepower at only 1450 rpm. The OX-5 soldiered into the mid-1930s with an air-cooled conversion by a Milwaukee engineer/entrepreneur Kurt Tank. This reduced the weight, and increased horsepower. The creative genius of Glenn Curtiss is often overshadowed by Orville and Wilbur Wright. The latter did not develop an aircraft engine in the pre- and post-WWI period that rivaled the OX-5.

THE REV. DR. ORVILLE LANHAM
AVIATION HISTORIAN
BELLEVUE COLLEGE

I've enjoyed Mary Seelhorst's articles on the museum exhibit, particularly the one on aviation that mentions Earle Ovington, who I knew personally when I was a teenager. The Ovingtons boarded their two children with my mother for the summer and came to see them and us. Earle was flying the Curtiss Seagulls for Glenn Curtiss in Atlantic City at the time. We've been to the Glenn Curtiss Museum in Lockport, New York, but there was not a thing there about Ovington. We plan to see the "Possible Dreams" exhibit in Dearborn as we were there several years ago.

FRED L. MOSS
GOFFSTOWN, NH

The "Possible Dreams" exhibit at Henry Ford Museum is fantastic. It rekindled many memories. It also made me feel my age, 51, revealing as we live we are becoming history. Your magazine has helped many of us realize our dreams. I just wish the exhibit were larger. PATRICIA CARROLL

DETROIT, MI

As a 16-year-old teen avidly interested in technology, this exhibit opened a new area of interest to me—the history of technology. Although history and technology both appeal to me, only rarely have I seen them together. I hope the "Possible Dreams" exhibit will be extended as history progresses.

JOCELYN D. PACE
MOORELAND, IN

The "Possible Dreams: POPULAR MECHANICS And America's Enthusiasm For Technology" exhibit will remain on display at Henry Ford Museum in Dearborn, Michigan, through December 1993. **PM**

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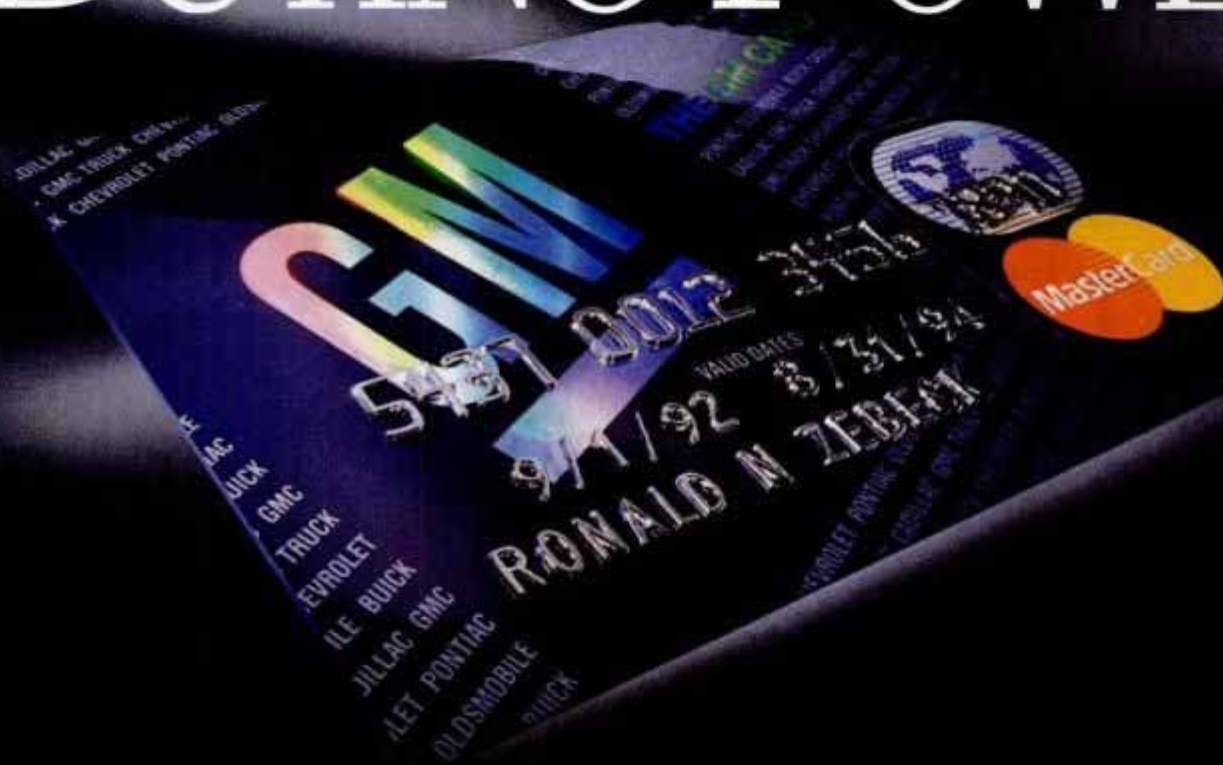
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TIME MACHINE

90 YEARS AGO: NOVEMBER 1902

POPULAR MECHANICS

Largest Sewer in the World



Recent Unusually Unlucky... Street Works Done in Chicago

Chicago Flush

At the turn of the century, the Windy City was reengineering its natural arteries and adding a few artificial ones. Nearly complete was the world's largest sewer, through which 900,000 gallons of Lake Michigan water would rush every minute. After sluicing out the city south of 21st Street, the 20-ft.-wide conduit emptied into the new Ship and Sanitary Canal, flushing away the city's "unhealthful accumulations" toward the Gulf of Mexico.



Stupid Car Tricks

The ferocious automobile—the terror of the streets—had finally been tamed. Its capricious accelerations were in the past. Now showmen dreamed up ridiculous

maneuvers to demonstrate the submission of the once-proud mechanical beast. One Midwestern manufacturer even drove his vehicle up a pair of wooden planks and ran it around his roof.

60 YEARS AGO: NOVEMBER 1932

POPULAR MECHANICS MAGAZINE

SEE PAGE 363



Special Effects

Aerial photography was coming into its own, and flying shutterbugs pushed the envelope, striving to outsnap each other. In the still-camera world, photogrammetry was becoming the mapmaker's tool of choice. But it was the motion-picture industry that spurred the cameraman to daredevilry. One Illinois cinematographer strapped himself to a biplane and cranked away as the pilot threaded through Chicago's skyscrapers and divebombed after plunging parachuters.

V-2's Granddaddy

Germany's rocket enthusiasts, both amateur and academic, were quickly becoming world-class technologists. The Germans focused on liquid propulsion, but unlike Goddard's spidery contraptions, their rockets were robust projectiles. Experimenters were already swathing the hot combustion chamber with cold liquid oxygen. The "warhead" was an altimeter on a parachute, but the Nazis soon took over and diverted the research to far less innocent ends.



30 YEARS AGO: NOVEMBER 1962

Add-On Entertainment Center: Complete Plans

POPULAR MECHANICS

Could How Can We Store Scientific Knowledge?

10 Head-Start Projects For Christmas



Shooting Gallery

Blasting away in the basement was no problem for the PM reader of the early '60s. Wax bullets were cheap and easy to mold. You could even fire them off a heavy plate-glass mirror to practice your quick-draw moves. If you preferred the real thing, we offered plans for a steel Venetian-blind bullet trap. Then, of course, there were BB guns and pneumatic rifles to pepper old phone books. Key ingredient for the indoor range: acoustic tiling, to save the family from shell shock.

Space Invaders

Frozen to near absolute zero in a high vacuum, germ



spores could survive the rigors of space. The thought sent chills through NASA headquarters—suppose a future spacecraft returning from Mars inadvertently brought home a deadly microorganism? After all, in the 1960s Mars and even Venus were considered likely niches for extraterrestrial life. Chemists at the Army's Fort Detrick offered some help, developing sterilization techniques based on biological-warfare defense.

PM



Or get our new clean air filter.

If airborne dust, pollen, and other particles in your home are forcing you to take extreme measures, take a good look at the new Filtrete™ Clean Air Filter from 3M.

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TECH UPDATE

News Of Tomorrow's Technology Today



Supersonic Sport Plane Takes Maiden Flight

MOJAVE, CA—On July 8, near Edwards Air Force Base, the BD-10 (see "Homebuilt Machbuster," page 68, Dec. '89) finally knifed into the sky for the first time. Ironically, the world's cheapest supersonic aircraft flew as the world's costliest—the Space Shuttle—had to postpone an Edwards AFB touchdown.

Keeping to an appropriately cautious test schedule for such a pioneering craft, veteran pilot Ed Gillespie didn't push Jim Bede's Serial No. 1 beyond 240 mph. Nor did he retract the landing gear (although the wheels were raised on a follow-up flight). But the jet did give engineers a wealth of data on its performance characteristics.

And much of that information was good news, according to Bede and the rest of the development team. The General Electric CJ-610-6 engine performed well: Accelerations and decelerations went smoothly, and the powerplant stayed cool. Flaps functioned fine.

Flight film showed a slight airflow disturbance on the outer wing. The turbulence touched off a mild buffeting—rather like a stall warning—at speeds below 160 mph. When the wing's leading-edge flaps were drooped 15°, the buffeting occurred only under 136 mph.

Bede believes he's traced the problem to the notch in the wing's leading-edge flap. For the next sequence of test flights, engineers have taped the notch out of existence.

After racking up about 2 hours of test flying, the BD-10 was packed up and then shipped to Oshkosh, Wisconsin, for display at the annual EAA Fly-In. There, PM could contrast the finished article with our impressions from last year's Fly-In.

And the aircraft appears remarkably well finished for a homebuilt prototype. The Air-Force-gray primer coat now hides beneath gleaming

red, white and blue paint. The panel, surprisingly conventional, holds a full complement of instruments and radios. The only piece of special test instrumentation in evidence is an ultrasensitive airspeed indicator.

In the BD-10's first two outings, Gillespie didn't take the jet above 10,000 ft., so it wasn't necessary to pressurize the cockpit. The aircraft has returned to Bede's St. Louis shop for canopy seals

BD-10 buzzes California's Mojave Desert at 200 mph during its second subsonic flight test on July 21.

and other upgrades needed for higher flight. Then it's back out to Mojave, where Gillespie will block out the subsonic envelope for another 90 days or so. Those tests should be underway by the time this issue is published. After that, the sound barrier beckons. We'll keep you posted.

Highlights This Month

- **Mars Invaders**—Earth's flying saucers to target the Red Planet.
- **Crater Creator**—Stealthy bomber missile rips up runways.
- **Flywheels On Wheels**—Mechanical batteries for electric cars.
- **Battle Of The Whirly-Drones**—Contest airs out flying robots.
- **Chopper Boppers**—Skeet-shooting minefield blows up helicopters.
- **Space For Rent**—Commercial rocket program takes shape.

Editor: Abe Dane
Assistant Editor: Greg Pope
Contributors: Philip Chien, Mike Fillon,
Cliff Gromer, Luke Hill



Earth's invasion of Mars begins with the deployment of 16 landers across the Red Planet.

is now under development at NASA's Jet Propulsion Laboratory.

MESUR calls for 16 spacecraft to fly to the Red Planet in groups of four, starting in 1999. A Delta II rocket would launch each quartet. The landers would then plunge straight to the Martian surface, shielded by an aerobrake shell. On the way down they'd toss propulsion hardware and open parachutes.

The MESUR landers, each only a yard across, would bring weather stations, seismometers, soil-analysis equipment and other sensors. Some of these could be borne over the surface on microrovers.

NASA hopes to fire off a single test lander in 1996.

Sixteen Mars Landers

PASADENA, CA—Like "The War Of The Worlds" in reverse, plans are afoot to launch an invasion of Mars

with an armada of miniature landers. The project, called the Mars Environmental Survey Network (MESUR),

Robots' Mothership

WARREN, MI—To control its growing swarm of experimental unmanned vehicles, the Army has converted an old Roland-missile carrier into a robot command center.

The vehicle holds a driver, a commander and two robot operators. Each operator can supervise two vehicles at once via microwave and VHF links. TV monitors show video from the robot's cameras. Built by FMC Corp., the command center

is run by the Tank-Automotive Research, Development and Engineering Center.



Robotic command center undergoes field trials with robot Humvees.

Sweetness Spotter

WEST LAFAYETTE, IN—Engineers at Purdue University have invented a device that measures the ripeness of produce without squeezing it.

The machine operates like a hospital's magnetic-resonance imager. But instead of building a 3D anatomical picture, the machine simply prints out the amount of sugar in an apple or an ear of corn. The device will cost less than \$20,000—far less than an imager.

Supermarkets could use



Ripeness sensor uses magnetic resonance to measure amount of sugar in produce.

the machine to decide which produce to store and which to sell. Farmers could use it to decide when to harvest.

Hunter Snares Drone Job

FORT HUACHUCA, AZ—The Pentagon's new short-range unmanned air vehicle (see Tech Update, page 22, Aug. '91) is Hunter, the product of TRW and Israel Aircraft Industries.

Army and Marine personnel are already practicing with scaled-down mini-Hunters (the full-scale airframe has a 29-ft. wingspan). According to current plans, 48 Hunter systems will ultimately be fielded. Each system consists of eight aircraft, a mission-planning station, a control

station, two data-receiving terminals and four remote terminals—plus trucks and generators. The remotes allow Hunter's surveillance and targeting data to be

pipled directly to intelligence or artillery commanders. Planned upgrades include synthetic aperture radar that will allow Hunter to track moving targets.



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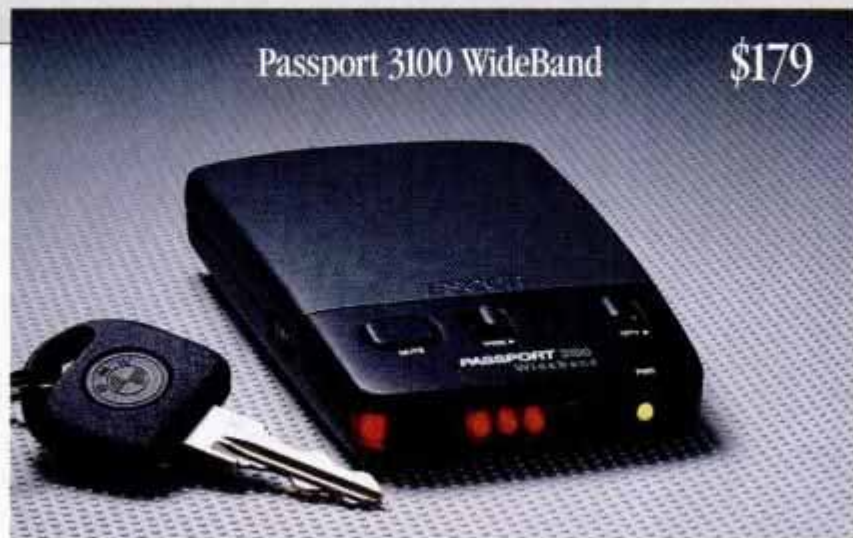


*Includes occupants, equipment and cargo.
Buckle Up! Do it for those who live you. © 1992 Toyota Motor Sales, U.S.A., Inc.

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7 Ways To Delight

1



Passport 3100 WideBand

\$179

For Total Radar Coverage

Passport 3100 WideBand is the perfect choice for drivers who own a two-band detector and are ready to step up to the latest, most complete radar technology available. Passport 3100 WideBand detects every type of traffic radar currently used today, including X, K, Ka, Photo radar and Stalker.

All wide band detectors are not created equal. Some actually "miss" part of the broadcast signal at selected frequencies – like a radio that can't pick

up every station. But Passport 3100 WideBand doesn't miss a thing. If radar is there, you'll know it instantly.

Passport 3100 WideBand: radar detection at its best.

FEATURES: *Digital Signal Processing • Long range detection • Anti-falsing circuitry • Signal strength meter • Mute button • Band selector switch • Visual and audible alert system • City/highway switch*

2



\$199

Passport 3200 WideBand

offers additional features and accessories. Call today for more information.

4



\$99

Passport 2200 is a full-featured X and K band radar detector. Combining incredible value with superior detection performance, Passport 2200 will delight the driver in your life.

FEATURES: *Digital Signal Processing • Long range detection • Visual and audible alerts • Dim switch • Signal strength meter • K-band indicator • Mute switch • City/highway switch*

5



\$79

Passport 2100 offers great X and K band performance at a very affordable price. Easy to understand and use, Passport 2100 is a perfect choice for the first-time user or for the person who's ready to step up to Escort quality.

FEATURES: *Long range detection • Visual and audible alerts • Signal strength meter • Mute switch • City/highway switch*

6



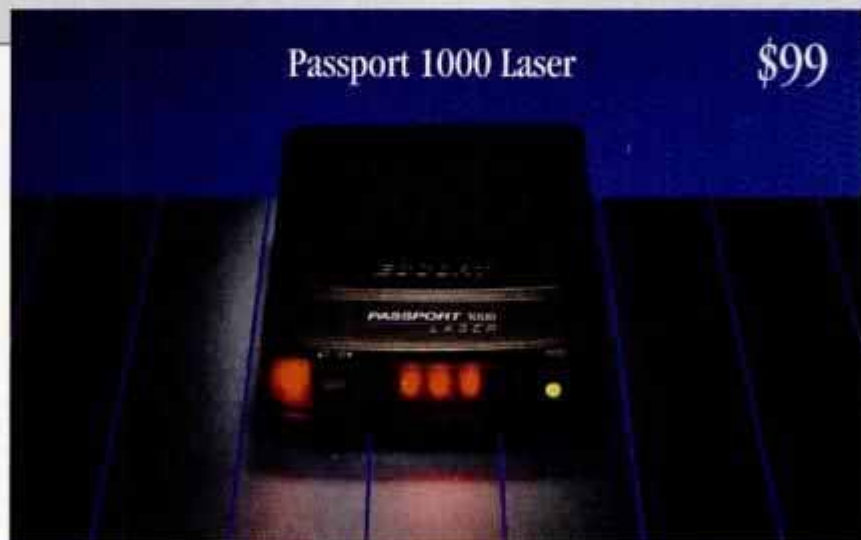
\$49

Passport 2000 is a good, basic X and K band radar detector. It doesn't come with a lot of fancy features, but it does have the quality for which Escort is known. And its price makes Passport 2000 the perfect stocking stuffer.

FEATURES: *Alert light • Audible alert tone • City/highway switch*

Your Favorite Driver

3



Passport 1000 Laser

\$99

The Worlds First – and Best – Laser Detector

Passport 1000 Laser provides complete protection from the new laser technology. If your favorite driver already owns a radar detector, this is the perfect gift.

A radar detector doesn't pick up laser. If your favorite driver doesn't have a laser detector, he's not fully protected. Passport 1000 Laser works with a radar detector to provide complete radar and laser protection.

While laser manufacturers have spent a lot of time claiming that laser is

undetected, Passport's complex circuitry finds it easily. In fact, Passport 1000 Laser can detect a laser signal up to 2 miles from the source.

Passport 1000 Laser: innovative technology – available first from Escort.

FEATURES: Long range laser detection • Digital PRT detection • Pulse Width Discrimination • Signal strength meter • Dark mode • Adjustable volume • Compatible with most radar detectors

WHAT IS LASER?

Laser guns calculate speed by transmitting short pulses of light energy and measuring the time it takes for the reflection to return. Once transmitted, the laser signal is dispersed due to atmospheric particles such as dust, water vapor, and car exhaust. Passport 1000 Laser's complex circuitry easily detects this dispersed signal.

7

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Stealth Missile To Bomb Runways



VELIZY, FRANCE—France and Germany have developed an air-launched stand-off weapon designed to strew cratering submunitions over runways and spare pilots needlessly hazardous duty.

The air-launched missile, called Apache, is tailored for

release from French Mirage 2000 and Rafale fighters and German Tornado strike aircraft. Tornados flown by British pilots in Operation Desert Storm took significant losses during low-level raids on Iraqi air bases.

A little shorter than a Tomahawk cruise missile,

Apache will swoop from its carrier aircraft about 90 miles away from its target. After getting a last-minute position update from the carrier, Apache will sneak in at low altitude, propelled by a turbojet. France's first military spy satellite, *Helios*, due for launch in 1994, will probably

Apache stand-off weapons will keep Tornados clear of heavily defended air bases.

provide target coordinates.

Apaches, which like Exocet anti-ship missiles will be offered for export, can also carry other specialized ground-attack submunitions.

Rocket Drops Skirt

WEST PALM BEACH, FL—For real efficiency, rocket engines need big nozzles against which expanding gases can thrust. But on a rocket's upper stage, a big nozzle can guzzle precious space.

Now the latest Centaur upper stage, carried on Titan and Atlas boosters, has a nozzle that extends like a zoom lens to provide extra thrust surface.

The RL10A-4, made by Pratt & Whitney, is the first liquid-fueled rocket with an extendible nozzle. Several sol-

id-rocket engines already have such nozzles, but solid fuel combusts at relatively low temperatures. Hotter-burning liquid-fueled engines have their nozzles swathed with fuel piping to carry away heat. To make such a complex nozzle extendible would be impractical.

Instead, Pratt & Whitney added a skirt lined with the metal niobium, which can withstand the 1404° F exhaust temperatures.

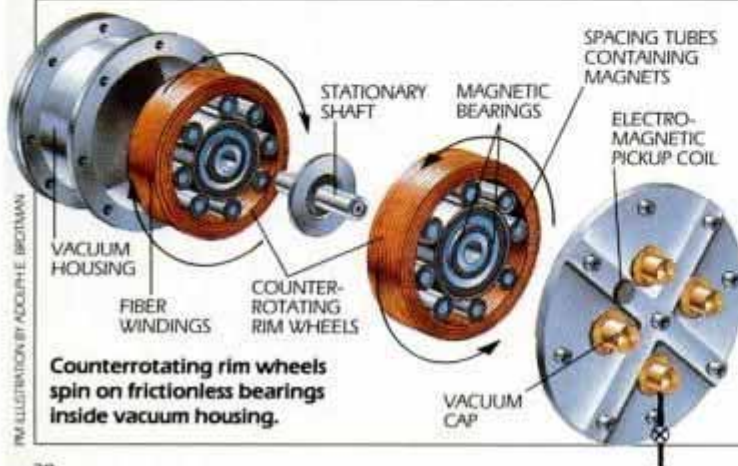
The RL10A-4 debuted last June, orbiting an Intelsat communications satellite.



New Centaur rocket engine has extending nozzle cone coated with heat-resistant niobium. The cone is controlled by a system of three actuators.



PRATT & WHITNEY PHOTOS



Counterrotating rim wheels spin on frictionless bearings inside vacuum housing.

Latest Spin On Flywheels

BELLEVUE, WA—Flywheel technology has at last matured to the point where the spinning devices may challenge chemical batteries as powerplants for electric cars.

American Flywheel Systems has patented a device featuring two counterrotating rim wheels, which spin at 200,000 rpm in a vacuum. A magnetic bearing virtually

eliminates friction. And tube assemblies that connect each rim wheel to the bearing hub allow the wheel to expand radially during rotation. The wheels themselves are made of carbon-fiber windings.

The developers say flywheels travel farther on a single charge than chemical batteries and can unleash more power for quicker acceleration.



AH-64A APACHE HELICOPTER

**IT HAS ELEVEN BRAINS.
BUT IT CAN'T
THINK LIKE A LEADER.**

The Apache helicopter's 11 computer brains perform thousands of calculations per second. Even seeing in the dark is no problem for this high-tech wonder.

But in today's high-tech Army there's one thing machines can't replace—leaders. Talented men and women who love the challenge of high-tech and have the confidence to lead and motivate others. Army ROTC is a college elective that will help you develop leadership skills, right now. Because it's hands-on leadership training.

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while they're still climbing in their vulnerable boost phase.

The weapon would have to weigh roughly a ton and deliver several megawatts per shot. Livermore's compact solid-state laser has a much better chance of meeting the weight requirement than SDI's well-researched chem-

Airborne antimissile weapon would build on Livermore's kw-caliber diode-pumped laser.



Flyweight Laser Weapons

LIVERMORE, CA—A kilowatt laser the size of a grapefruit could lead to a weapon for zapping Scud-type missiles at the speed of light. Lawrence Livermore National Laboratories, which has demonstrated this compact technology, has proposed scaling the laser up to

several thousand kilowatts and mounting it on a plane.

Developed under a program called Defender, the laser consists of a slab of neodymium glass pumped into firing by efficient solid-state laser diodes. In an airborne application, jet fuel could be channeled to circulate

around the laser diodes. The fuel would cool off the devices after the main laser blasts away for as long as 20 seconds.

The Strategic Defense Initiative Office, which has never given up on the notion of laser weapons, has shown interest. From a range of 60 to 90 miles, a laser could knock out tactical ballistic missiles

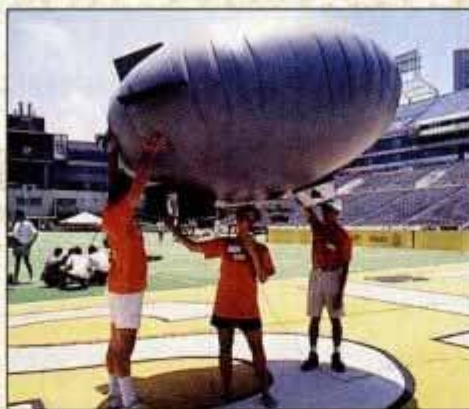
ical laser technology.

Intriguingly, Russian physicists have recently offered American scientists advances in laser-beam quality control that could bring the idea to fruition much faster.

Robot Rotorcraft? Wait Till Next Year

ATLANTA, GA—Flying robots gathered here last June for a showdown, hoping to achieve what flying robots have never achieved before. But despite some creative engineering, for the second straight year they didn't achieve it.

The competition, sponsored by the Association of Unmanned Vehicle Systems, is meant to spur development of vertical-takeoff machines that can think for themselves. The task is therefore difficult. The vehicle must lift off, find



a bin containing six metal discs, fly each disc over a 3-ft. barrier and deposit it in a second bin—all of this with no human intervention.

Eight colleges entered vehicles, including miniature helicopters, blimps, tailsitters and flying saucers.

Teams were al-

Georgia Tech's helicopter carried visual targets for remote cameras.

San Diego State brought one of three microblimps to the competition.

lowed to ring the venue with sensors, such as cameras or detectors that picked up ultrasonic pulses from the vehicle. The sensors kept track of the vehicle's position. Using this data, a remote computer could then send commands by radio to the vehicle's motors to steer the machine around the arena.

Each vehicle also came with its own ingenious methods of locating and seizing the discs. The University of Texas tailsitter, for example, deployed a magnet on a tether. Southern Tech's helicopter unreel a subvehicle with an arm to feel around for discs on the ground. Unfortunately, the subvehicle fell outside the bin.

In fact, none of the vehicles

came close to completing the task. But contest officials noted improvements over last year's entries. While machines tripped and crashed last year, this year many of the vehicles at least were able to demonstrate stable flight. Organizers and participants believe that full execution of the task is probably a year away.



Second Georgia Tech team's flying gyroscope got high marks for stability.



Minefield Looks Up

PICATINNY ARSENAL, NJ—The Army's wide-area mine, or WAM, technology (see *Tech Update*, page 24, June '91) has spawned a similar weapon to scare enemy rotorcraft out of an area.

Like WAM, the anti-helicopter mine uses acoustic sensors to identify the whir of an unfriendly helicopter. The device then lofts a spinning skeet submunition equipped with infrared sensors. Once it spots the aircraft, the submunition fires a shotgun pattern of shaped-charged slugs in the target's direction.

Like a WAM array, an anti-helicopter minefield could be activated and shut down by remote, allowing safe



Wide-area mines could pick up and pick off enemy helicopters as well as tanks.

passage to friendly choppers. The mines would force enemy helicopters to fly high,

where they'd be sitting ducks for surface-to-air missiles.

Ferranti Defense & Space

and WAM-maker Textron Defense Systems are developing the mines.

PM Powers Solar Racer

BOSTON, MA—Cars flying the PM colors are not con-

finied to the screaming world of Trans-Am racing (see *Mo-*

torsports, page 122). We've also thrown our weight behind a quieter competitor: the Wild Solarcat II. Stu-

dents at Villanova University built the sun-powered speedster.

The 585-pound package won the 1992 American Tour de Sol, a back-road run from Albany to Boston. Average speed was 30 mph, but the gung-ho Villanova team believes 70 mph is possible.

Made of Kevlar, Nomex and aluminum, Wild Solarcat II is sheathed with 8000 solar cells.



Rockets For Profit



BALTIMORE, MD—Plans to launch a commercial space-flight service for microgravity experiments are moving right along.

NASA is seeding the marketplace with its Commercial Experiment Transporter, or COMET, rocket (see *Tech Update*, page 20, Jan. '91).

COMET is scheduled for the first of three flights this winter. NASA's Centers for the Commercial Development of Space, funded jointly by industry and government, supplies the payloads.

But Westinghouse is already organizing a for-profit follow-on service called Westar, probably using COMET hardware.

COMET will consist of a Conestoga 1620, a cluster of Castor strap-on solid rockets, tipped with a newly designed Star 48V upper stage. The Thiokol-built 48V has a vectored nozzle that eliminates the need to spin-stabilize the spacecraft.

Some experiments will run in a reentry module devel-

oped by Space Industries Inc. After a 30-day orbit, that module will touch down at Hill Air Force Base in Utah. A separate free-flying

module will remain in space for several more months.

Westinghouse hopes to get the commercial operation off the ground in late 1993. **TU**



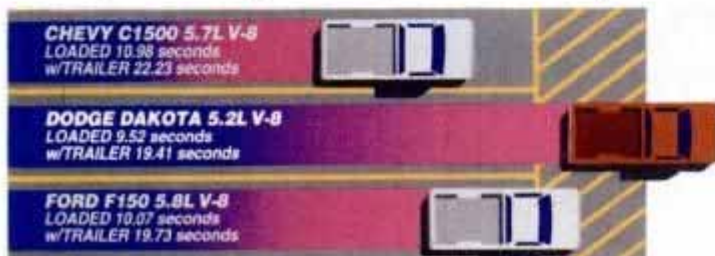
Star 48V upper stage, test-fired in June, will boost COMET and Westar payloads.



"Out-powers Ford and Chevy hands down."

- Certified by SCORE International, January 1992

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¹Dakota 4x2 Club Cab out-ran Ford & Chevy compact extended cabs 0-60, empty, w/560 lbs payload & w/5,850 lbs combined payload & trailer weight. All trucks equipped with auto. trans. & max. avail. axle ratios. Graph not proportional to test data. ²Overall total combined model scores. All claims and comparisons based on '92 models/data.

36

30 SECONDS OVER TOKYO



50th anniversary of the most famous air raid in history.

BY WILLIAM GARVEY

● It's hard to imagine now, but not all that long ago the United States was left bleeding and humiliated by an attacker who, confident he'd paralyzed his victim, went on to grab everything within reach. It was January 1942, and what had been the engines of the country's pride and power in the Pacific, its Asiatic fleet, was a collection of sunken hulls and twisted superstructures leaking fuel oil and sailors' blood into Pearl Harbor's once-azure water.

In the month that had passed since the Day of Infamy put the U.S. Navy out of action, the Japanese forces rampaged across the Pacific. Every day the news got worse. We needed a victory bad.

Almost from the moment he learned of the unprovoked surprise attack on the Hawaiian Islands, President Franklin D. Roosevelt demanded that his military leaders strike back. Specifically, he wanted American airplanes to bomb the Japanese

home islands—to put it right in their face. And he wanted those bombs to fall soon.

The problem was that there was no apparent way to comply. There were no bombers based anywhere near striking distance of Japan, and moving one of the

Navy's precious carriers close enough to conduct such a mission with naval aircraft would make it vulnerable to overwhelming retaliation.

But then an unlikely 4-striper came up with an audacious idea. Capt. Francis Low, a submariner, suggested a strike with long-range Army bombers launched from a Navy flat-top operating well away from the Japanese coast. The idea caught fire in Washington—theoretically it would work. And the best man to put the theory into flight was the balding, middle-aged lieutenant colonel right down the hall.

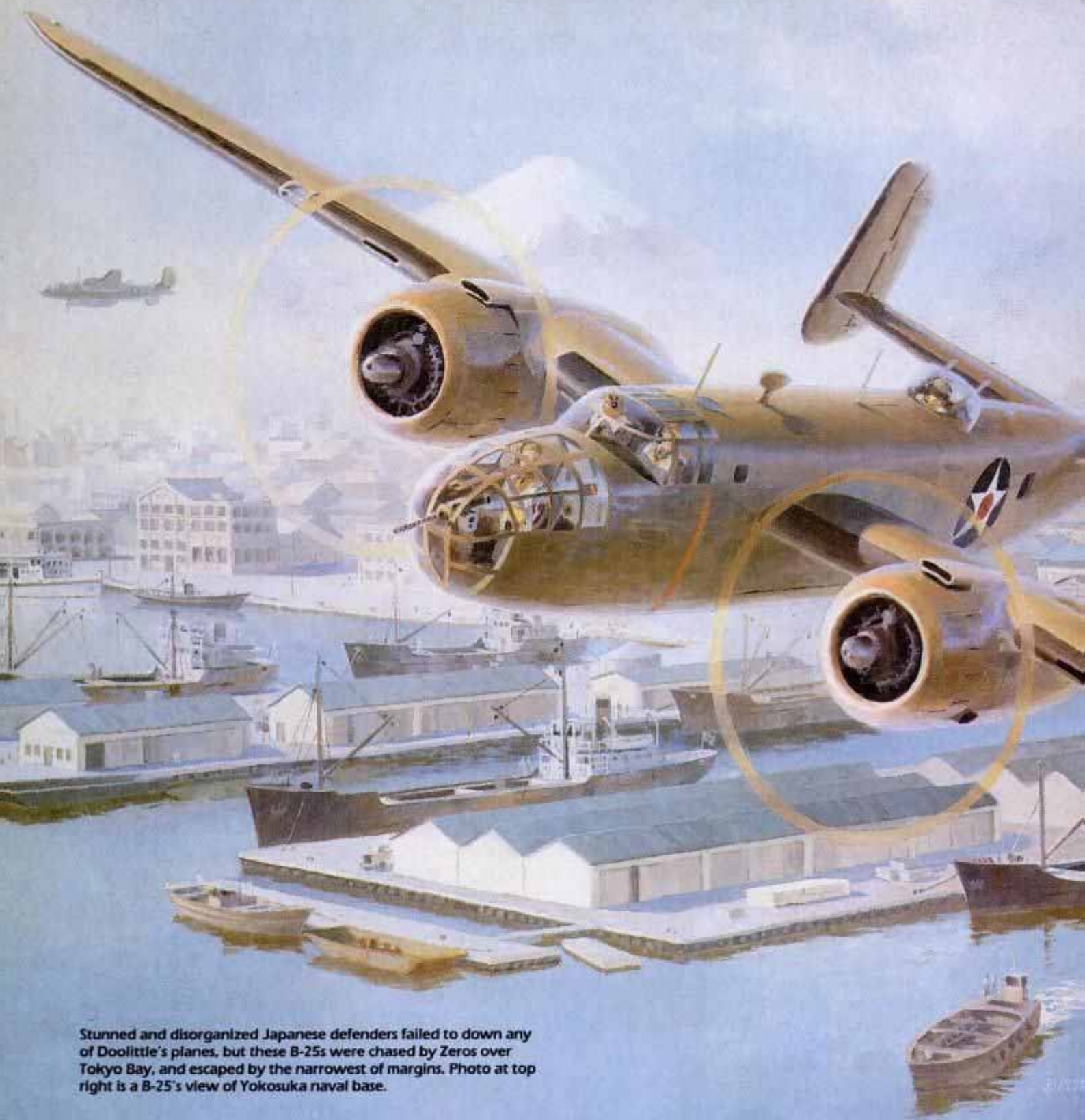
Years before the outbreak of war, James H. Doolittle had already se-



The *Hornet's* B-25s launched 400 miles from Tokyo, led by then-Lt. Col. James Doolittle.

TOP PHOTO FROM USAF COLLECTION, NATIONAL AIR & SPACE MUSEUM;
BOTTOM PHOTO FROM USAF MUSEUM

30 SECONDS OVER TOKYO

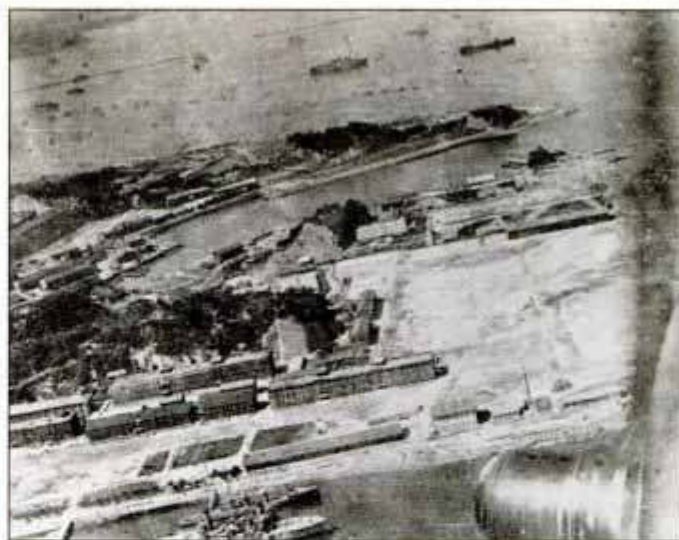


Stunned and disorganized Japanese defenders failed to down any of Doolittle's planes, but these B-25s were chased by Zeros over Tokyo Bay, and escaped by the narrowest of margins. Photo at top right is a B-25's view of Yokosuka naval base.

cured his place in the Hall of Aviation Immortals. A "daredevil" pilot who actually calculated all risks very carefully—he held a Ph.D. in aeronautical science from MIT—Doolittle had set transcontinental speed records, won a brace of races, performed the first outside loop and conducted the first "blind" flight on instruments. As the war clouds gathered, he returned to active duty and was stationed in Washington, D.C., when the carrier-borne bomber idea was broached. Doolittle

was told to help find the right bomber.

The rough criteria for the aircraft: It had to be able to operate from an exceedingly confined space and take off in less than 500 ft. while hauling a ton of bombs and enough fuel to fly 2000 miles. Only one airplane in the inventory fit the bill: the new North American B-25 Mitchell medium bomber. And it would require modifications. Doolittle requested and got the nod to honcho what was officially the "Special Project," and things



LIPBETTMANN PHOTO

special training. Richard Cole, one of the copilots selected, remembers the speculation that went on every night about the upcoming mission. They all knew it would involve flying off a carrier. After all, a Navy instructor had been assigned to them for that task. But why and where?

It was during this phase of training for short-field takeoffs that Cole's pilot became ill and had to drop out. To prevent theirs from becoming one of the project's reserve aircraft, the crew appealed to the operations officer. He replied, "The old man's coming in this afternoon. He'll fly with you and if everything goes right, you've got yourself a pilot."

Cole says he and his three other crewmen were ecstatic for the chance to stay in the mission, "but we had no idea who the old man was." On March 3, they and the rest of the men gathered at Eglin found out.

"My name's Doolittle," the one-time collegiate fighter told the assembly. "I've been put in charge of the project that you men have volunteered for. It's a tough one, and it will be the most dangerous thing any of you have ever done." He told them of the importance and urgency of training that lay ahead, but withheld the name of their destination. Secrecy, he explained, was of critical importance.

As the pilots refined their short-field takeoff technique, modifications proceeded on the aircraft. Doolittle ordered the bottom gun turret removed (the mission would be so low-level the only enemy planes below them would be sitting on the ground) and replaced with a 60-gallon fuel tank. De-icing boots were installed, as well as anti-ice for the props. Liaison radios were removed and phony twin .50s (they were broomsticks painted black, actually) were installed in the tail to make enemy fighters think twice about attacking from the rear.

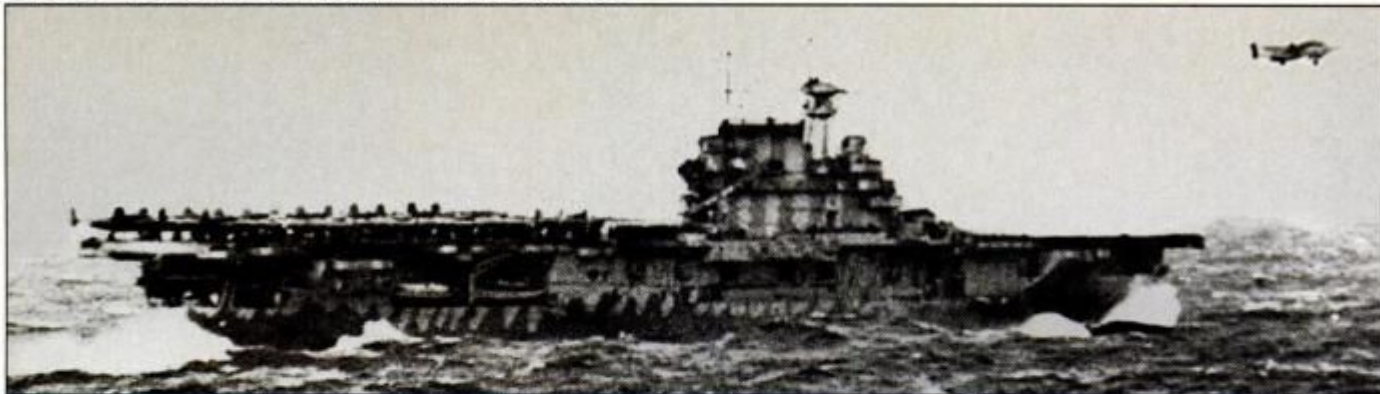
The B-25s were normally equipped with the super-secret, high-altitude Norden bombsight, which lost its effectiveness below 4000 ft. Since bomb release on this mission was planned for 1500 ft., the Norden sight was replaced with a rudimentary sighting device composed of two pieces of aluminum that Eglin technicians fashioned specifically for the mission. Whereas the Norden cost more than \$10,000, the value of the Eglin sight was estimated at 20 cents. Each.

Although Doolittle was in charge, he had not yet been assigned to lead the actual strike, something he was

started happening very quickly.

Two dozen B-25s were fitted with specially designed rubber tanks inserted in the bomb bay and above. Also, some aircraft were fitted with automatic cameras. Meanwhile, crews assigned to the 17th Bombardment Group—among the most experienced B-25 airmen in the service—were told that volunteers were needed for an important, dangerous mission. They all wanted in. Those chosen were sent to Eglin Field in Florida for

30 SECONDS OVER TOKYO



burning to do. So with crew training well underway, he flew to Washington and put the request directly to Gen. Henry "Hap" Arnold, chief of staff for the Army Air Forces.

Then 45, Doolittle was thought to be too old for combat and, besides, he was too valuable an aide. Arnold had no intention of granting the request. But Doolittle persisted until the general reluctantly agreed—with the stipulation that Doolittle must also get the okay from Gen. Millard Harmon, Arnold's chief of staff.

Doolittle smelled a rat. Exiting Arnold's office he raced down the hall to Harmon's desk and told the surprised general that Arnold said he could lead the raid if Harmon agreed. "Sure, Jim," he responded. "Whatever is all right with Hap is all right with me." Doolittle left. Just outside the office he heard Harmon's intercom come to life and then heard Harmon say, "But Hap, I just gave him my permission." The quick-footed colonel then high-tailed it back to Florida and waited for Arnold to yank his chain. But he never did.

On April 2, the carrier *Hornet* steamed out of San Francisco Bay with 16 Mitchell bombers tied down on its deck. Still, only a handful of men knew their true purpose and destination. That afternoon as the *Hornet* sped west into the open Pacific, the ship's loudspeaker suddenly blared the stupendous news: "This force is bound for Tokyo."

Richard Cole remembers the moment, "Cheers went up everywhere. Everyone was happy." America was punching back.

The plan of action called for the *Hornet* and the seven cruisers and destroyers accompanying it to rendezvous with Adm. William F. Halsey's 8-ship group in mid-Pacific, forming Task Force 16. The armada would then steam to within 400 miles of Tokyo, launch Doolittle's raiders and run full-speed back home. After dropping 32,000 pounds of ordnance on Tokyo, Yokohama, Nagoya, Osaka and Kobe, the bombers were to continue west to airfields located in sections of mainland China still unoccupied by the Japanese. They were to land, refuel and



Sixteen B-25s crammed the flight deck of the *Hornet* (above) until takeoff (top).

fly farther inland to Chungking and await further orders. The bombing was to occur at night, and landings were to take place at dawn. Total flight distance was approximately 2000 miles.

It didn't quite work out that way. On the morning of April 18, Navy lookouts spotted a Japanese fishing boat which they soon realized was really a radio-equipped sentry. Even though they were still more than 200 miles short of their intended launch point, Halsey knew the whole task force was in jeopardy of attack. He flashed a signal to the *Hornet*: "Launch planes. To Col. Doolittle and gallant command, good luck and God bless you."

Suddenly the *Hornet's* Klaxons sounded and loudspeakers shouted, "Army pilots, man your planes!" Eighty pilots, bombardiers, navigators and gunners scrambled topside. Richard Cole and his crew were on deck in a flash. "I wanted to make sure I was there before him [Doolittle]," he says. Tiedowns were ripped down and chocks pulled as the *Hornet* turned directly into a howling wind. The weather was foul with rain squalls, low clouds and 30-ft. seas.

After confirming that his bombs were armed, Doolittle climbed aboard. His was the lead plane, of course. He brought his two Wright R-2600s to life, checked the instruments and eyed the flagman on the deck ahead. At 31,000 pounds, his plane was 2000 pounds over its maximum. He had only 460 ft. of runway, and he had never flown off a carrier before. None of his men had either.

Checklist complete, Doolittle gave a thumbs-up to the flagman, who signaled back to advance throttles. Then, just as the foredeck began moving up from a swell, the signal officer knelt and pointed his checkered flag at the bow. Go! Doolittle released the brakes. Its big props screaming, the B-25 began to lumber forward.

Every eye on the ship moved with it. As the aircraft passed the *Hornet's* island, Doolittle hauled back on the yoke and the nose wheel came up. Moments later the mains broke free. He was airborne with 100 ft. to spare.



Doolittle aircrew is escorted by friendly Chinese near the site where its B-25 crash-landed.



DEEP FREEZE BOATING

When cold winter winds blow, you need to prepare your boat for hibernation. Here's how.

BY JOHN WOOLDRIDGE, Contributing Editor
PM Illustrations by Sergio Roffo

● Outside, the cold, gray skies are punctuated by drifting flurries that gradually settle to the ground and form a thickening blanket of snow. Inside, you reach for another log to toss on the hearth, and then put your Top-siders up by the fire. Just beyond the exterior wall of the fireplace, your boat is slowly being engulfed in winter's freezing embrace, but you're secure in the knowledge that a weekend's worth of maintenance is keeping it safeguarded against harm.

Winterizing maintenance is a fact of



Flushing out raw water is easy using a built-in garden hose port. Special attachments are needed for older engines.

life for boaters, and it's not confined to those living in the northern half of the country. Hibernation, or any long lay-off, can be just as destructive to a boat in the Deep South as to one in the deep freeze. Inactivity is the culprit, and if you don't prepare for it, you run the risk of incurring costly repair bills, devaluing your investment and shortening the operating life of your rig. Here's how to make sure that when you put your boat to bed it doesn't wake up with a cracked block, shorted wiring or heavy corrosion.



To finish up with the hull, wash it down thoroughly with a biodegradable cleaner. Then, use a good marine polish. Liquids are easy to use and can be buffed by hand or by using an orbital polisher.

Moving topside, clean metal or fiberglass surfaces with an all-purpose cleaner. Clean and polish marine upholstery on seats and padded panels with vinyl cleaner and restorer. Mildew sprays do a great job on most surfaces, particularly when followed by a light rinse of fresh water. However, since most are based on a 5% bleach solution, they may cause discoloration of some painted and laminated surfaces. When in doubt, read the label. This advice goes for all cleaners. Finally, vacuum sand and dirt out of the carpet, lockers and odd corners where grime accumulates.

If your boat has a removable MSD (marine sanitation device), clean and dry it before storage. Built-in MSDs, sinks and showers must be completely drained. Then, finish up by pumping in a water-system antifreeze.

Next comes the engine

Before you decommission your engine, carefully read your owner's manual. Be sure you understand all manufacturer warnings and liabilities. If you still have questions, call your dealer.

When the boat is on the trailer, the first thing to do is to lower the engine or outdrive to the normal operating (vertical) position, and then open the engine cover. Examine the engine or powerhead for worn or loose wires, electrical connections, hoses, clamps and other accessible components. Repair these as needed. Be sure to check the condition of the hoses for brittleness, softness or cracking. Replace as necessary.

On older-model engines, removing and replacing water-pump impellers was an annual ritual, and even though current high-tech impellers are very tough, it's still wise to inspect them. If your impeller needs changing, be sure to install a new gasket before re-assembling the water pump.

Check the condition and tension of all drivebelts on inboard and stern-drive engines. Lubricate all throttle and gearshift controls, cables and linkages. Clean corrosion from all bat-

tery cables and terminals, and then coat them with a light application of petroleum-based jelly.

Disassemble, examine and clean fuel-line screens and replace fuel filters. Change the oil filter if necessary. Be sure to add oil stabilizer to your reservoir and fuel stabilizer to your gas tank. This will help prevent internal corrosion and gumming, which can develop when gas and oil



After draining the old gear-case lube and examining it for signs of wear, slowly refill until lube appears at the upper port.

slowly break down in storage. After topping off the gas tank, add a fuel water absorber to remove moisture that may form through condensation. There are some new additives on the market that not only stabilize fuel, but also coat internal engine parts with corrosion inhibitors. Add these to your tank before topping it off. At this time, it's also a good idea to top off

power trim and steering fluids.

Before cranking the engine one final time, attach a water hose to a factory-recommended flushing device fitted to your drive. Then turn on the water and start the engine. Run it in idle without engaging the gears, and don't rev the engine. Let the engine run just long enough to completely flush raw water from the



Wedge a block of wood between prop and anti-ventilation plate before loosening prop nut and inspecting hub and splines.

cooling system, without risking overheating.

Fogging oil can be sprayed through the carburetor intake just prior to shutdown. It will prevent the internal engine parts from rusting. Observe engine gauges to ensure that all are

Start with the hull

Closely inspect the exterior hull for dings, barnacles and blisters. To do it right, use a hose to spray off all slime immediately after hauling out.

In a worst-case scenario, you may find some weed or barnacle growth. Both should be scraped away gently but firmly while still wet. If you've been in salt water, the barnacles may leave circular footprints that need to be sanded or scraped off before a coat of anti-fouling paint is applied.

Next, look for blisters or bulges caused by water migrating through the gelcoat. Blisters must be punctured, drained, dried and patched with an epoxy-based fiberglass filler. This is a good time to touch up dock rash and bruises with carefully color-matched fiberglass patches. Aluminum boats get dings and dents, too, and gentle pounding with a rubber mallet will probably do the trick. Tears and gashes will require professional patching or welding.

DEEP FREEZE BOATING

working. Then shut down the fuel line and let the engine burn off all the gasoline remaining in the carb. Then switch off the ignition and shut down the engine for the season.

To further protect the engine or powerhead, cover it with anti-corrosion spray. Remove the air-cleaner/flame arrestor and spray cleaner/protectant into the carburetor. Replace the filter, if applicable, and securely reattach the air cleaner. Then remove old spark plugs and spray rust inhibitor into the cylinders before installing new plugs that are already gapped to the correct specifications.

Next, put a block of wood between the prop and the ventilation plate to prevent rotation as you loosen the prop locknut. Remove the prop and check for dings, damaged rubber hubs or worn shaft splines. Before replacing the prop, grease the shaft. Be sure that the locknut is on tight and the cotter pin is in place.

Remove the oil fill and vent plugs from the lower unit and carefully inspect the drained lubricant. Metal filings, a milky color or a burnt appearance indicates that there are problems requiring immediate dealer service. If all looks fine, inject gearcase lubricant into the lower fill and



With the wheel and hub removed, clean and inspect the brake lining for wear.

replace the plugs. Then, inspect the zinc anodes for corrosion. Replace them if significantly reduced in size.

Lubricate the driveshaft, engine coupler spline, U-joints, hinge pins, swivel pin, gimbal bearing, steering-cable ram and tilt-lock mechanism on sterndrives and outboards using the greases that are specifically formulated for each area by the manufacturer.

After disconnecting the battery cables, remove the battery, clean it and store it in a cool, dry location. Follow manufacturer instructions for checking electrolyte and charge levels periodically throughout the winter. After the battery is removed, spray the electrical-system connections behind the instrument panel with a moisture repellent.



Gouges, cracks or blisters must be carefully patched with epoxy-based fiberglass filler.

Don't forget the trailer

Obviously, the best time to check your trailer is when the boat is in the water. Check safety chains and attachment points for wear or corrosion. Inspect rollers for signs of wear and bunks for missing padding. Repair as necessary. Look for corrosion on the frame, and remove any with a wire brush or a sanding disc on an electric drill or grinder. While you're at it, remove all traces of road dirt or rust from the axle and springs. Rinse thoroughly with water and allow it to dry. Prime with a rust-inhibiting coating before repainting.

Next inspect the trailer coupler, the tongue jack and any roller assemblies. Use a hand-operated grease gun to relube as necessary. Then, block the wheels, jack up one side of the trailer, pull off the tires and remove the grease caps. Inspect the wheel bearings closely for wear, then relube. Repeat the procedure on the other side. If you don't already have them, this is a good time to install wheel-bearing protectors.

Check your tires for wear and replace them if the tread is too smooth. Don't forget to also check your spare. If your trailer has surge or hydraulic brakes, inspect the brake pads for wear and make sure the settings are

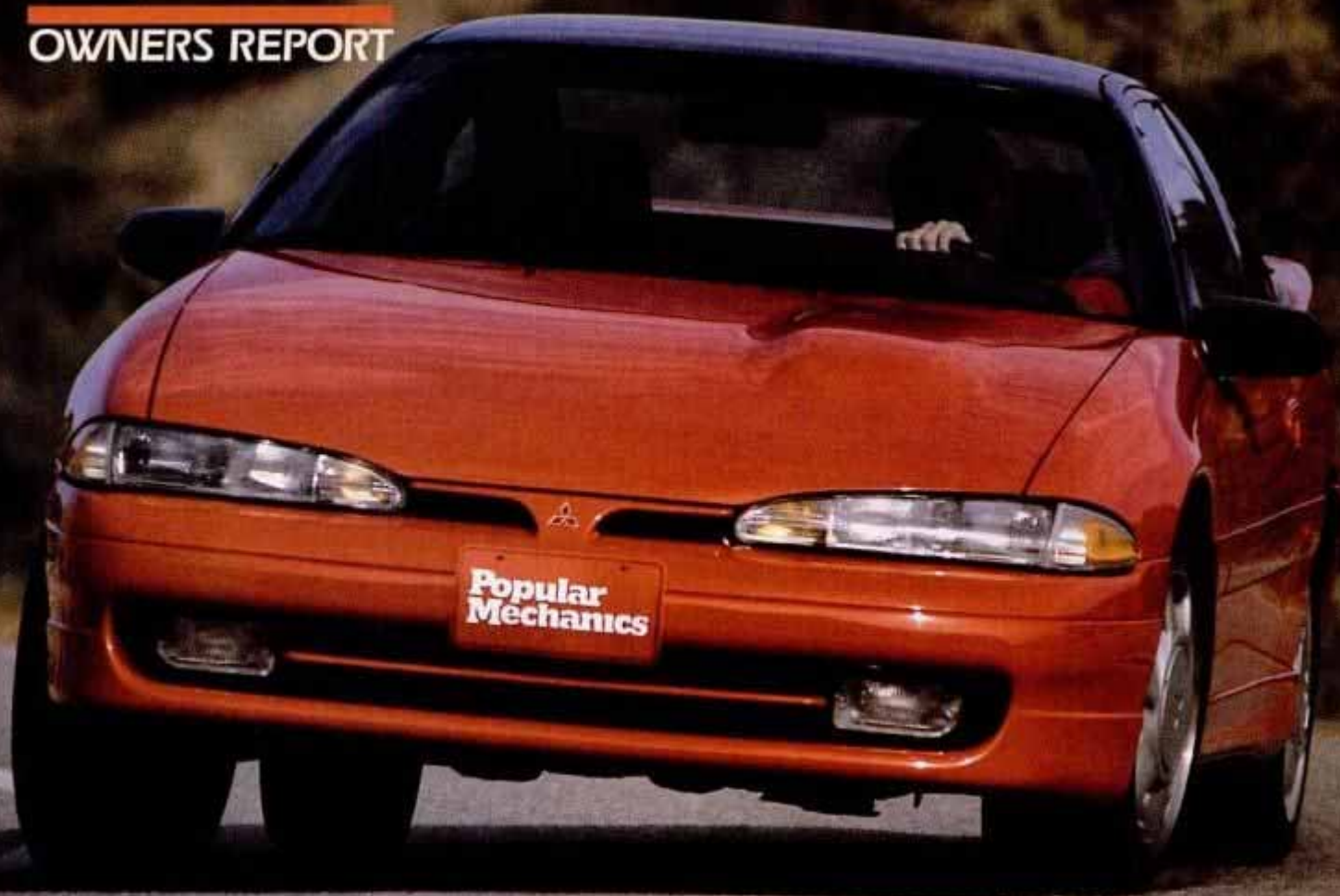
properly adjusted. (See your owner's manual for specifications and procedures.) Then connect the electrical harness to your tow vehicle and check all of the trailer lights, changing bulbs when required.

Put chocks beneath the wheels to prevent movement. Also, put blocks beneath the trailer tongue and the back end for the same reason. Consider using a canvas cover that has a center pole to promote water runoff. Old canvas loses its waterproofing, so be sure to spray it with a water guard each year.

Don't forget to visit your boat occasionally to check on its hibernation. If you've put it to bed properly, it shouldn't require more than a few loving pats on the transom. **FM**



A squeeze from the lube gun does the trick on the bearings.



MITSUBISHI ECLIPSE, EAGLE TALON, PLYMOUTH LASER

The Diamond-Star coupes win hearts with sexy styling and bang for the buck.

BY MICHAEL LAMM, Contributing Editor; PM Photos by Ron Hussey

● In 1985, Chrysler and Mitsubishi teamed up to build a new factory in Normal, Illinois—Diamond-Star Motors Corp.—and it wasn't long before this marriage produced a set of precocious triplets: the Mitsubishi Eclipse, Eagle Talon and Plymouth Laser.

Response was instantaneous and uniformly positive. The Diamond-Star sport coupes quickly emerged as best buys in their class.

Chrysler gets credit for the styling—a significant credit, judging by the responses of our surveyed owners—while Mitsubishi handled the engineering and interior design. The cars are based on the Mitsubishi Galant sedan platform, with the wheelbase shortened from 102.4 in. to 97.2. The standard suspension system and 4-wheel disc brakes are also from the

Galant, as is most of the optional all-wheel-drive system.

All powertrain components are from Mitsubishi's facilities in Kyoto, Japan, but there are enough parts from U.S. sources to give the cars a local content rating of about 60%.

The coupes offer two engine displacements in four power ratings. Standard coupes in the Laser and Eclipse lines use Mitsubishi's 92-hp 1.8-liter sohc Four, smoothed by twin balance shafts. Next comes a 2.0-liter dohc 16-valve Four, rated at 135 hp—a rating that leaps to 190 hp with the addition of a turbocharger and intercooler. And with awd, the output spools up to 195 hp.

Transmission choices are the more or less universal 5-speed manual (standard) or 4-speed automatic. All-

wheel-drive versions use a center differential with viscous drive and have a more sophisticated toe-compensating independent rear suspension in place of the simpler beam axle found underneath front-drive models.

Chrysler Chairman Lee Iacocca once remarked that many Americans buy Japanese—versus U.S.—brand cars almost as a reflex. He used the Diamond-Star triplets as an illustration, pointing out that these are essentially identical cars, built in the same plant. Two are sold by Chrysler dealers and one by Mitsubishi. But even though Mitsubishi has far fewer dealers than Chrysler, it's the Japanese nameplate that sells in greater volume.

The striking sales disparity, according to Iacocca, lies in a perception



that the Japanese brand name promises better quality.

Several of the owners in our survey group vindicated Iacocca's position. A Kentucky counselor, for example, wrote on his questionnaire: "I think what really sold me on the Eclipse was finding out it's made by Mitsubishi. Japanese cars and their attentiveness to mechanical perfection is respected by this car buyer."



Cockpit-style instrument and control layout is functional as well as attractive.



In awd tune, the Mitsubishi 2.0-liter dohc 16-valve turbo Four generates 195 hp.

SUMMARY OF DIAMOND-STAR COUPE OWNERS REPORTS*

Total miles driven:	1,683,928	Average	1.4	Hard to shift (manual)	6.2	Excellent	36.0%
Average miles driven:	7869	Poor	0.5	Suggested changes:		Good	60.0
Purchase price:		Braking:		Better rearward vision	15.5%	Average	4.0
Average	\$14,512	Excellent	62.4%	Better low-rpm acceleration	10.1	Poor	0.0
Range	\$9800-\$21,500	Good	31.2	Front seat height adjustment	9.5	Dealer service opinion for the Mitsubishi Eclipse:	
Why did you choose a Diamond-Star coupe?		Average	6.0	Chip-resistant finish	8.8	Excellent	34.9%
Styling	77.0%	Poor	0.5	More interior space	8.1	Good	41.3
Price/value	40.7	Overall performance:		Improved shifting (manual)	7.4	Average	17.6
Performance	23.0	Excellent	63.0%	Workmanship opinion:		Poor	3.9
Reputation	19.8	Good	35.2	Excellent	58.3%	Dealer service opinion for the Eagle Talon:	
Handling	14.8	Average	1.9	Good	39.8	Excellent	31.4%
Model choice, Eagle Talon:		Poor	0.0	Average	1.9	Good	47.1
Talon (base coupe)	16.4%	Control layout:		Poor	0.0	Average	17.6
Talon TSi all-wheel drive	13.2	Excellent	72.8%	Comfort opinion, front seats:		Poor	3.9
Talon TSi Turbo	2.7	Good	24.9	Excellent	60.7%	Overall service opinion:	
Model choice, Mitsubishi Eclipse:		Average	1.8	Good	33.3	Excellent	32.2%
Eclipse GS 16V	18.7%	Poor	0.5	Average	38.2	Good	50.9
Eclipse (base coupe)	9.1	Instrumentation:		Poor	0.5	Average	13.1
Eclipse GSX all-wheel drive	5.0	Excellent	72.8%	Comfort opinion, rear seats:		Poor	3.7
Eclipse GS Turbo	2.7	Good	24.9	Excellent	5.1%	Number of vehicles owned:	
Model choice, Plymouth Laser:		Average	2.3	Good	18.1	This vehicle only	37.0%
Laser RS	18.3%	Poor	0.0	Average	38.2	Two vehicles	28.7
Laser (base coupe)	9.6	Driver sightlines:		Poor	38.7	Three vehicles	15.7
Laser RS Turbo	4.1	Excellent	34.1%	Mechanical trouble?		Four or more	18.6
Avg. mpg, city/hwy.:		Good	36.4	No	69.4%	Principal driver:	
1.8-liter Four	27.9/32.8	Average	22.1	Yes	30.6	Male	50.5%
2.0-liter Four	24.3/29.5	Poor	7.4	What type of trouble?		Female	48.6
2.0-liter turbo Four	21.7/26.3	Specific likes:		Cruise control	28.8%	Equal	0.9
2.0-liter turbo Four, awd	21.1/25.4	Styling	76.8%	Shift mechanism	15.2	Age distribution of owners:	
Transmission choices:		Handling	51.2	Brakes	7.6	Under 29	50.5%
5-speed manual	67.0%	Engine power	31.9	Power windows	7.6	30-49 years	41.2
4-speed automatic	33.0	Overall performance	27.1	Electrical system	6.1	50-plus	8.3
Engine power:		Comfort/roominess	22.2	Air conditioning	6.1	Based on your experience, would you buy a Diamond-Star coupe if you had it to do over again?	
Excellent	56.0%	Low operating costs	18.8	Repair it yourself?		Yes	69.4%
Good	39.9	Specific dislikes:		No	93.9%	Maybe	22.7
Average	3.7	Poor rearward vision	16.6%	Yes	6.1	No	7.9
Poor	0.5	Rear seat too small	13.5	Dealer repairs satisfactory?			
Handling:		Front seat adjustability	10.9	Yes	67.3%		
Excellent	76.1%	Insufficient power	10.4	No	32.7		
Good	22.0	No complaints	9.3	Dealer service opinion for the Plymouth Laser:			
		Paint chips easily	6.2				

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

As our questionnaires piled up, it became clear that many Eclipse owners believed their cars had been built in Japan, or by Japanese workers. And as a result, it came as no great surprise that the Eclipse received a better workmanship rating than the Chrysler-badged cars. Only 19.2% of the Eclipse owners surveyed reported needing repairs, versus nearly twice that number for the Laser and Talon—37.1% and 35.2%, respectively.

'Poor man's Stealth'

Regardless of brand name, though, all three cars checked out similarly in terms of comfort, handling and economy. The main reason people chose one of these triplets was styling. Most respondents also noted that these coupes make driving a lot of fun. "A poor man's Stealth," noted a New Jersey craft supervisor.

Consistent with driving fun, 67% chose the 5-speed manual gearbox (which drew its share of complaints). Just under 10% ordered turbocharged engines, while over 18% opted for an all-wheel-drive package (which includes the turbomotor).

Over 45% paid the \$628-\$925 premium for ABS. Airbags aren't available, and grumbings were heard about the motorized front shoulder belts.

Front seat comfort satisfied 94% of our owners, even drawing praise from tall drivers, but the abbreviated rear buckets—typical of 2+2 coupes—were rated fair to poor by almost 77%. No one, though, chose these cars expecting to take the rear seats seriously.

The largest number of mechanical complaints—28.8%—centered on the cruise control. In early models, a vacuum leak caused false signals to the actuator. Replacing a vacuum hose fixed the cruise problem.

Another big gripe had to do with restricted vision out the back window and rear quarters. The problem stems from a combination of low seats, wide roof pillars, bulky headrests and the high tail on models with rear-deck spoilers. However, instrument and control layout received good marks.

Star loyalty

The Diamond-Star cars face a broad range of competitors—imported and domestic. Despite all these temptations, though, our Diamond-Star owners agreed they'd gotten the best deal—as well as the best-looking deal—for their money. And even though many of these owners will probably move up to something with four doors next time around, nearly 70% said they'd happily buy an Eclipse, Laser or Talon if they had it to do over again. **PM**



Diamond-Star styling was the No. 1 element in capturing hearts of prospective buyers. However, broad roof pillars, high rear-deck spoiler and low seating position restricted rear vision for some owners. Paradoxically, Mitsubishi models outsell those from Chrysler.

EDITORS REPORT

Star Quality

● At their introduction three years ago, the Diamond-Star trio—Mitsubishi Eclipse, Eagle Talon and Plymouth Laser—immediately hustled to the head of their intensely competitive class. With their aggressive good looks, technical sophistication, excellent performance and attractive pricing, the new cars quickly came to be regarded as best buys on the long and tempting sport coupe menu.

But this is a menu that changes dramatically from one year to the next. As we roll into 1993, there are several new entries to tempt shoppers—Ford's new Probe GT, Mazda's MX-6, Honda's 190-hp VTEC Prelude, to name just a few. To find out how the Diamond-Star trio stacks up today, we strapped on a Mitsubishi Eclipse GSX for a few days of L.A. cruising and California back-road blasting.

The GSX—Mitsubishi's equivalent of the Eagle Talon TSi and the Plymouth Laser RS Turbo AWD—is the top of the line, equipped with an impressive list of go-fast goodies: all-wheel drive, ABS, limited-slip rear differential and a turbocharged, intercooled 2.0-liter dohc 16-valve Four, producing 195 hp at 6000 rpm. Even with 3093 pounds of awd Eclipse to haul around, this is enough punch to get you from 0 to 60 mph in less than 7 seconds. We suspect the few owners who found their cars short of grunt opted for one of the normally aspirated powerplants.

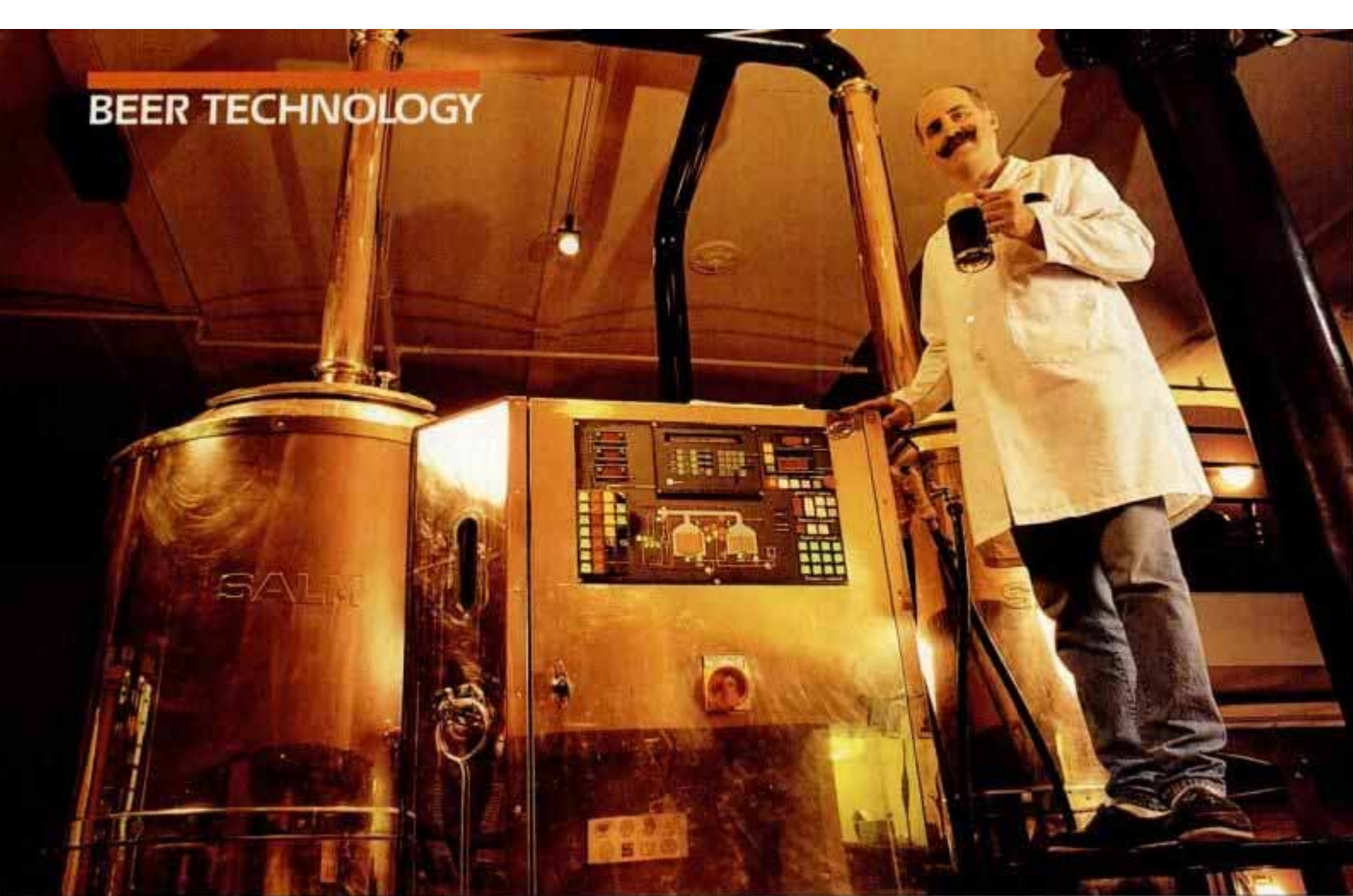
There are some areas where the Di-

amond-Star cars fall short of their competitors. Our GSX test car was a little noisy under hard acceleration, the shift linkage isn't as precise as some, the tiny sound system controls are extremely difficult to use when the car is moving and we agree with owner complaints concerning restricted rear vision. Also, torque steer is an irritating problem in front-drive turbo models. Although few of the owners in our survey group opted for the front-drive turbo, we're still surprised that we didn't hear more torque-steer complaints.

On the other hand, there's a lot of performance wrapped up in this sexy little package. Although there's a fair amount of body roll, handling is good, particularly in awd models, and braking performance rates with the best.

Our GSX test car was equipped with 6-way adjustable bucket seats that included adjustable torso bolsters, but even on basic models the seating reinforces the sporty look and feel of these cars. This can also be said for the control and instrument layout arrayed around the driver. It's a cockpit-style design that still looks fresh after three years on the market.

At \$20,577, our loaded Eclipse GSX can't be called cheap. But measured against comparable competitors, this car still represents an exceptional value. And for drivers who don't need the whole high-tech laundry list, the lesser members of the Diamond-Star lineup rate as bargains. —Tony Swan



THE LOCAL BEER RETURNS

In a micro-brewery, high-tech is served by the glass.

BY STEPHEN A. BOOTH, Contributing Editor

● Order a beer at Zip City and you'll get a remarkable brew not found anywhere else. And while no one will dispute Zip City's special claim, hundreds of other establishments across the country are also voicing their uniqueness with home-grown beer.

Like a growing number of restaurant/bars in both large and small cities, New York's Zip City is more accurately described as a micro-brewery. Zip City brews beer on the premises, in full view of its clientele. Brewmaster Jeffrey Sillman and others like him are pushing back the clock to a simpler era, when the beer enjoyed by most Americans was produced locally. And while brewing beer may not sound overly complicated, high technology is what makes a place like Zip City work.

"There's nothing wrong with a Bud or any of the packaged beers," says Zip City's Sillman. "It quenches your

thirst, it's refreshing, and that's the job it's supposed to do. Our kind of beer, though, has a different purpose. It's something you enjoy with food, something you sip while you converse with friends or just ruminates over."

While Zip City is at the forefront of modern micro-brewing, the recipe for success is deliberately simple. Besides a heaping dose of the brewmaster's knowhow, all that goes into the beer is water, barley, yeast and hops—the only ingredients permitted by the Bavarian Reinheitsgebot, or Purity Law, of 1516. The carbonation that occurs on its own, in the barrel, is what winds up in the glass. There's no controlled injection of carbon dioxide, as is necessary for packaged beers.

This is pretty much the formula observed by America's 252 other micro-breweries—the designation accorded to facilities that produce fewer than 15,000 barrels a year (at 31 gallons per

barrel). While individual micro-brewery output is small, collectively their impact is growing larger. Last year, micro-beers outsold import brands in Seattle, Washington, according to the National Microbrewers Association. Portland, Oregon, should achieve the same distinction this year.

Belly-up to Zip City's bar and your eyes are drawn to two huge, shiny copper vats. You might see something similar at other brew-pubs, but these tubs are linked by a high-tech computer panel with rows of buttons, electronic readouts and green and red indicator lights.

What you're seeing is the Rolls-Royce of brewing, the Salm BrewMatic of Vienna, Austria—\$400,000 worth of hardware born of American patents and one of only 29 worldwide (Canada, Israel and Russia each have one—the rest are quenching thirsts in Europe). Unlike many other micro-

breweries, the tanks are displayed openly, raised on a sort of poop deck where the lab-coated brewmaster uses his nose and computer to control the vessels under his command.

Other brew-pubs, with so-called active boilers at customer level, must shield the vats behind safety glass. But Zip City's gas-fired boiler is in the basement, a configuration unique to the Salm system. The boiling continues in pressurized valves that constantly circulate the liquid mash through some 450 pounds of grist—malted barley—in the bar-level mash ton (German for vessel) and lauter (grain-catching) ton.

"The flow is always through the boiler, but with the pressurized boiling in the valves, we get 98% energy efficiency," says Sillman, explaining that other systems, which boil only in a tank, inevitably dissipate energy.

After an hour or more of boiling, during which hops are added three times for their preservative, flavoring and aromatic values, what emerges from the copper vessels is a translucent liquid called the wort (pronounced "wurt"), an unfermented malt-hops-and-water mixture. From here, things go downhill.

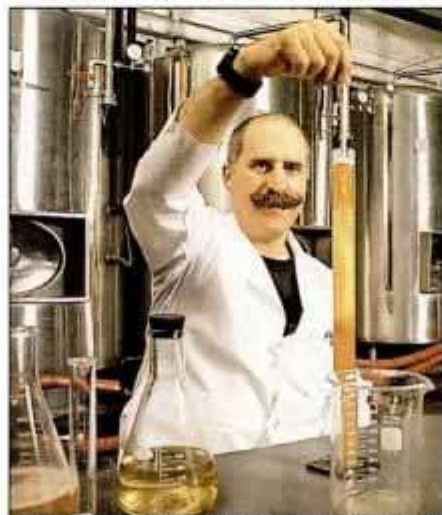
In the cool basement stand another 18 tanks, an explosion-proof room for storing some 5 tons of barley and a \$9000 mill for cracking it. The mill gives you more control over the grist, and you can check the quality of the kernels, says Sillman. Zip City warehouses several different grains, with evocative names like Munich, Vienna and CaraPils.

The 18 stainless-steel tanks include four for serving, nine for storage (called lagering), three fermenters and two whirlpools. The whirlpools

are used to siphon off solids left from the mash. From here, the clear wort goes to the fermenting tanks, where the special brewer's yeasts are added—or "pitched." The yeasts can be re-used about a dozen times.

Fermenting takes about a week, because Zip City makes only lager beers. Most micro-breweries make ales—a simpler, quicker and less costly process. Ale yeasts are fermented at higher temperatures (55° to 75° F) for only about three days, and then aged for two weeks.

By contrast, lagers use yeasts that



Quality control is the secret of success for Zip City brewmaster Jeffrey Sillman.

ferment long and cool, beginning at about 55° F and coming down to about 38° at the end of a week. After fermentation, Sillman transfers the brew to the lagering—or aging—tanks. This stage lasts from three to eight or more weeks, depending upon beer type. During this time, the temperature remains at 38° F.

One day before the beer is trans-

ferred to the serving tanks, the temperature is brought down to 35° F to settle the yeasts. The finished product rests at 39° in the serving tanks and emerges at about 42° in the glass—the "perfect" drinking temperature, according to Sillman.

The temperature at all of these stages is regulated by changes Sillman programs into the Salm Brew-Matic's computer. The actual cooling is performed by an energy-saving exothermic system: The cooling element is contained in plastic balls that alter their state to either generate or store cold.

Although what Sillman calls the "world's smallest computer-controlled cellar" costs twice as much as typical micro-brewing facilities, he says the savings in man-hours and energy will pay off in the long run.

"More tanks! More tanks! We've been running at capacity since we opened," laments Sillman. Expansion plans call for another fermenter and lagering tank, plus two more serving tanks. These serving tanks are a story in themselves.

In many bars, Sillman explains, kegged beer is pushed up to the taps by compressed air. But air is the enemy of beer, causing oxidation and spoilage. "Better places push the beer with carbon dioxide, and this is okay if the goods move fast. But the gas is rapidly absorbed into cold beer, especially given the large surface area in the tank, and you lose taste."

Zip City's Salm tanks beat nature by containing the beer in Mylar bladders that are not permeable to gases. Compressed air squeezes the bladders pushing the beer through chilled pipes to the taps. The taps are unusual in that they have extra-long nozzles that reach to the bottom of the serving glass for pouring in the Bavarian head-first manner. The bartender first blows a thick head of foam into the glass, then slowly fills it from the bottom so that the head rises and floats above the beer—protecting it from damaging air.

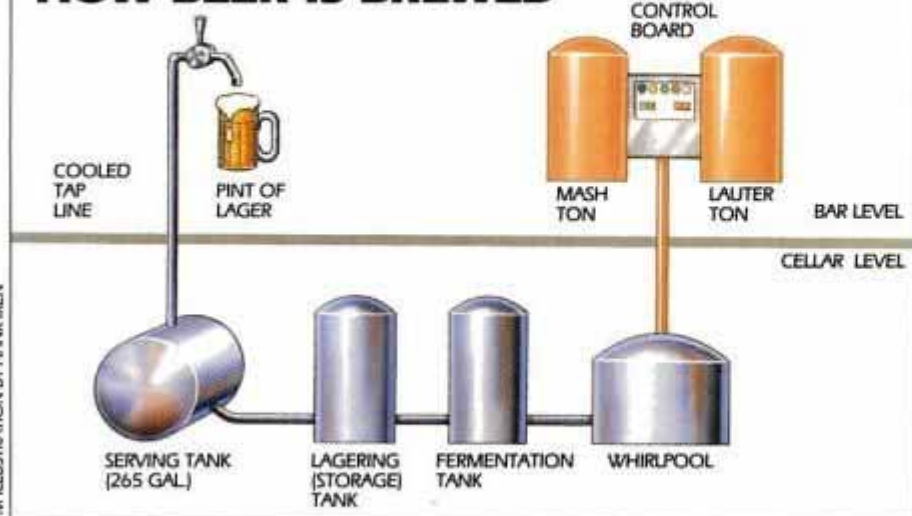
Zip City's beer is translucent, not clear and transparent, because Sillman doesn't filter it. The beer tastes rich and smells intensely fresh because he doesn't pasteurize it. This isn't necessary because the beer travels only 35 ft. from tank to tap, and sells out before any spoilage can occur. As for filtering away sediments or yeast particles, that, to Jeff Sillman, is a matter of taste—and health.

"We feel that natural beer has more flavor, character and is healthier for you," says Sillman. "That's why the Germans call it liquid bread."

Anybody hungry?

FM

HOW BEER IS BREWED



At Zip City, the master control board is located at bar level between the copper mash ton and lauter ton, where grains, hops and water mix. Oxygen-free serving tanks and cool pipes keep the brew fresh and cold on the way to the long-nozzled tap.

LONG-TERM TEST CARS

● Since our last update (July '92), the PM long-term test fleet has gone from virtually all-new to almost mature. This time around we're saying good-bye—reluctantly—to an exceptional Oldsmobile and examining the results of a test diet consisting primarily of full-time, flat-out driving.

Chevrolet Corvette Convertible

We've now driven our '92 Corvette through winter, spring, summer and autumn. And as we prepare to return it to Chevrolet, one fact becomes crystal clear. The combination of the new-for-'92 Goodyear GS-C tires and the Acceleration Slip Regulation (ASR) system makes the Corvette, for the first time in its 40-year existence, a true car for all seasons.

No longer do you have to park the Vette all winter, to be brought out only on those days when the roads are dry and clean. Now you can blast through just about any road condition you'll run into—short of very deep snow or mud—and get through. No more white knuckles every time you see a snowflake while driving a Corvette. No more wishing you had the clapped-out family clunker when the weather turns foul.

No, none of that anymore. Today's Corvette is a safe, stable ride that you can drive with confidence through good weather and bad, over wet, slick, even snow-covered roadways and hardly slow the pace. No, the '92 Corvette isn't a Blazer, but it no longer gives you heart attacks either. Any of you who have driven a Corvette on a snow-covered road knows what we're talking about.

This is not to say that the Corvette is a perfect car, the wonder machine of the age. Far from it. We've mentioned the difficulty in

Farewell to one of GM's best, and our torture-test results.

ingress and egress, the squeaks and rattles and the several electrical squawks we've encountered. Frankly, we expected better from a \$43,000 car. And we had none of these problems in the last Corvette we tested, an '87 convertible.

On the other hand, with the hardtop removed, softtop down and the Vette thoroughly in summer mode, all the minor irritations quickly faded. We spent most of the summer this way—top down, wind in hair and sun on forehead. And you know what? All is forgiven. We don't care about the CD player that quit, then healed itself. We don't care about the door latch that came loose or the cruise control that never really worked right. When the top is down and you are enjoying 300 horsepower and world-class handling, there is no finer sports car anywhere on Earth.

As the Corvette departs our test fleet, we'll reiterate one sore point again until someone at Chevrolet listens. We still think it's a disgrace that the lowliest Chevrolet truck has better instrumentation than the Corvette. —Joe Oldham

Toyota Camry LE

With 5654 miles of California streets and freeways behind it, our Camry just keeps getting better.

Though the world is increasingly filled with excellent V6 engines, the Camry's 3.0-liter 24-valve dohc stands out. Smooth, quiet and powerful, the Camry's V6 and 4-speed automatic deliver seamless all-around operation that reminds us of the best traits of American V8 sedans from the '50s and '60s. And the V6 hasn't used a drop of oil other than a change at 3077 miles.

We're also impressed with the car's



CHEVROLET CORVETTE CONVERTIBLE



range. During some long-haul LA-to-San Francisco freeway blitzes, we recorded a couple stretches with almost 450 miles between pit stops. On both of these excursions, our fuel economy climbed to over 26 mpg, 2 mpg higher than the EPA highway projection for this car/powertrain combination. Considering the average speeds on these trips, this is an especially impressive performance.

Our overall fuel economy stands at 21.7 miles per gallon.

Sitting in a car for 400-plus miles of nonstop motoring provides the driver with an exceptional comfort index. Here, too, the Camry is virtually impossible to fault. There's plenty of room for the driver to adjust his position frequently to ward off fatigue. The seats never start feeling like a picket fence and the occupants can converse at living-room volume levels, regardless of the car's velocity.

Like the Olds Eighty Eight, this one will be tough to part with when the test is completed.

—Tony Swan

Pontiac Bonneville SSEi

Beware! This car is addictive. You slip into a tan leather bucket seat, crank up the super-

charged, fuel-injected 3.8-liter V6 engine, put it into gear and you just want to go, and go, and go. This is a car for driving.

Packing 205 hp, the engine is more than eager when you put the pedal down. You never feel like you need more power—not in *this* Bonnie.

And the SSEi's suspension calibration is well suited to the powerplant—which means you won't like a steady diet of inner-city potholes in this car. What you will like is twisty 2-laners and expressway on-ramps.

So yes, we love driving our test Bonneville. But we also have to report that the car has had its share of bad days since our last writeup.

At about 3400 miles, the engine's cam sensor decided to pack it in. The computer put the engine into the limp-home mode and we were able to get the car back to the PM garage. While the car was at Cunningham Pontiac, in Queens, New York, for repairs, we also asked the dealer to fix three pieces of interior trim that had come loose while bouncing around on those inner-city potholes. Cunning-

ham's service department successfully repaired the engine and two of the three trim pieces—all under warranty. We have not had any engine problems since, but the trim pieces have come loose again.

By the way, several other magazines have tested Bonnevilles this year and apparently ours was the only test car to have these problems. And at 7500 miles, we've had no other difficulties.

—Joe Oldham

Ford Crown Victoria Touring Sedan

One look at the \$27,000 price tag on this top-of-the-line Ford may set you back. But the 1992 Crown Victoria Touring Sedan is loaded with a lineup of safety and convenience equipment that's surprising to find in a type of car that some may regard as a leftover from another era.

Yes, it has antilock brakes. Yes, traction control is included. And yes, there are two front-seat airbags. In addition, Ford threw in a quick-defrost windshield, leather seats, enough electrical assists to outfit a midsize video arcade, alloy wheels and an air-spring rear suspension.

Is this a full-size car? Yes.

Is this about as fully equipped with the



PONTIAC
BONNEVILLE SSEi



**FORD CROWN VICTORIA
TOURING SEDAN**

most up-to-date accessories as you will find on a high-production model? Yes. Can you take this car to any road surface and expect controlled handling and dependable high performance? Yes.

After almost 15,000 miles of road conditions varying from hot dry pavement to wet ice and snow, the sohc 4.6-liter V8-powered chassis re-

in front of the driver.

A minor criticism here is the use of a band of fake wood trim on the face of the panel. Its black coloring with indistinct gray grain is unlike anything you'll see in nature. Why this sort of trim is still regarded as a luxury touch is a mystery to us.

For all its convenience and comfort, Ford dropped the ball on one

dan hums along without a hitch. All systems are go and have been throughout its 9-month life on the road.

Stop this car only for oil and filter changes. No more needs to be done.

But today, dependable quality is just the bare minimum that new car buyers look for.

—Jim Dunne



NISSAN NX 2000

mained responsive and quietly unperturbed.

About the only operating flaw that we've logged during all these miles with the Crown Vic is with the 4-speed automatic overdrive transmission which sometimes—especially at startup on a cold morning—was slow to deliver full power in low gear.

For a car that weighs almost 2 tons, with a 210-horsepower engine, the Crown Vic fuel economy is one of its most rewarding features. We measured more than 20 miles per gallon in mixed highway/city driving when new. Then it gradually improved to more than 24 mpg.

The appearance of the Crown Vic passenger cabin is just as much a departure from earlier models as its exterior. Gauges are large, round and analog—and they are located directly

point: The car has no cup holders. Even Cadillac's Fleetwood Broughams have special cup holders for Pete's sake.

As for inherent quality, this Crown Vic ranks with some world-class cars. Its sole assembly defect was a minor "itch" in the IP that we heard only when traveling on rough roadways.

Five years ago, anyone buying this Crown Victoria would have been asking for trouble. An American sedan, loaded with a laundry list of extras like antilock brakes, traction control and automatic locking was certain to self-destruct somewhere. At least that was the outlook before U.S. automakers got smart about quality.

With today's Ford, the picture is completely different. After all these miles of mixed city/highway driving, the 1992 Crown Victoria Touring Se-

Nissan NX 2000

As we expected, road racing is showing us things about our Nissan NX 2000 that no amount of street use could ever reveal. The braking system is an example. Road tests have already told us that the NX 2000 stops well. But no road test ever subjects a braking system to the repeated heavy demands of racing. We're pleased to report that the NX 2000 not only delivers good stops the first few laps, it continues to do so from flag to flag, with excellent control and without a trace of fade. In fact, the NX 2000's brakes give it a distinct edge versus the principal competition in its racing class—cars like the Honda CRX Si, Toyota MR2 and Mitsubishi Mirage Turbo.

Handling is another strong suit. Though the NX 2000, like most front-drive coupes, has inherent understeer, its standard viscous limited-slip differential provides good grip coming off corners and, more important, prevents wheelspin.

On-track experiences have also increased our respect for this car's engine. The 140-hp dohc 16-valve 2.0-liter Four behaves very much like a pure racing engine—free-revving, with lots of midrange punch. It's clearly the hottest powerplant in the subcompact coupe class.

As we mentioned in our first report, we're augmenting our torture-test with an evaluation of Valvoline's new synthetic oil, and this has proved to be a timely test. In hot weather



CADILLAC SEVILLE

with high track temperatures—in California, they're the only conditions our car has seen—the NX 2000's bottom-breathing cooling system tends to build up heat. When the computer sees heat, it retards ignition timing and richens the fuel/air mix, which is fine for engine preservation, but not so good for racing performance.

One of the many benefits claimed for Valvoline's synthetic, which was developed with racing stresses in mind, is superior heat dissipation. And we can say that we've seen a small but measurable reduction in operating temps since we've been using it. This is a trait that pays off not only in racing, but in heavy-duty work like towing, too.

Valvoline also has stacks of dyno runs demonstrating horsepower gains with the synthetic. This is tougher for us to assess, partly because we haven't had our NX on a dyno, but mostly because so many other guys are using it too.

—Tony Swan

Cadillac Seville

This is the second report on our '92 Seville long-termer, and we can report that this car gets more admiring glances than some of the exotic sports cars we've driven in the past few years. Everyone who sees it thinks it's a beautiful car. And it is—possibly one of the most beautiful to come out of General Motors design studios in years.

The Seville is also beautiful on the road. We've taken several long trips with the car and, thanks to the speed-sensitive suspension, responsive steering and its growling 4.9-liter fuel-injected aluminum V8, this car just gobbles up interstates. And even though it lacks the aggressive handling of the STS edition, it's no slouch on the byways, either.

If we have one gripe with the handling, it's that the suspension engi-

neers went too far in the softness of the ride at very low speeds. Once the car reaches about 20 mph, the computer begins to stiffen things up nicely, and from there on up it's just pure driving pleasure.

So far—7105 miles—nothing has broken, fallen off or failed to work properly.

—Joe Oldham

Oldsmobile Eighty Eight Royale LSS

This is a tough one. It's time for us to give back the Olds Eighty Eight Royale that we've lived with for the past year.

Frankly, we don't want to.

After spending 10 months and almost 20,000 miles with our LSS, we have to say that this is one of the best cars General Motors has ever built. If you've been looking for flaws, as we have, you've probably noticed that our periodic reports on this car have been, well, dull. There just hasn't been anything to report in the

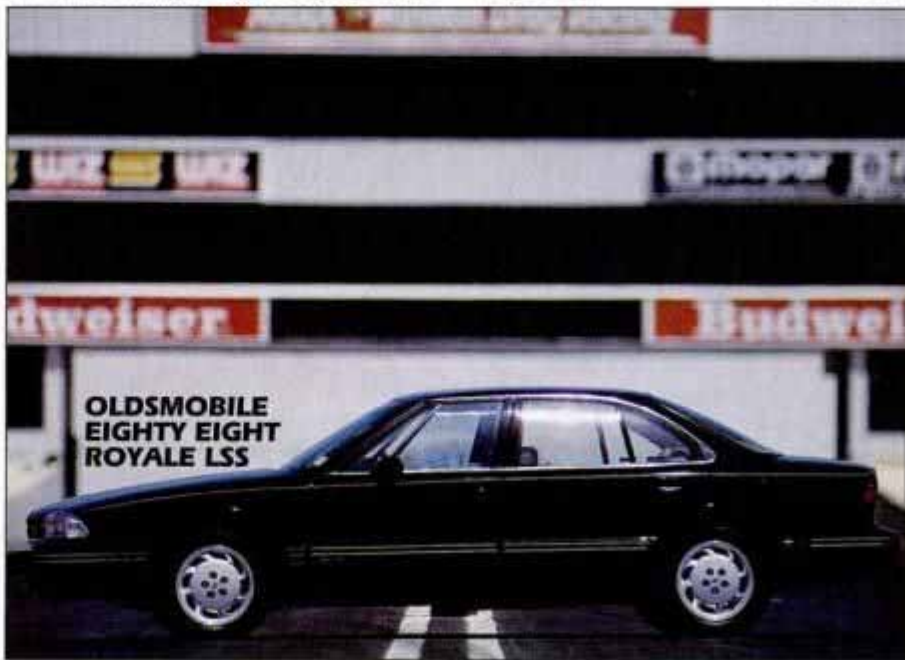
way of problems.

No, no car is perfect. Not even this one. But what we can fault falls into the category of personal preference. A couple of editors thought the seats were mounted too low, even in the full up position. A couple of us felt that the dash was poorly designed and not very well integrated with the rest of the interior. A few complained about the 18.2 mpg overall fuel economy, despite the fact that we all drove the car very hard.

Still, the Olds was one of the favorites of the fleet while it was with us. And no one ever complained about the roadability, fine handling, great ride, sumptuous leather interior and overall comfort of this car.

If you're thinking about buying an Olds Eighty Eight Royale—and we think you should—by all means order the FE2 suspension. It transforms the car from a very nice family cruiser into a responsive sport sedan that will make you start looking for the long way home.

—Joe Oldham





POSSIBLE DREAMS

From trench warfare in Europe to missile launchers in the desert, America's war machines have kept the U.S. military on the cutting edge.

BY MARY SEELHORST

● **Irresistible Force.** A perfect description of the deadly technologies of war that have nonetheless fascinated millions of Americans over the past 90 years. *POPULAR MECHANICS* used this double entendre as the title of an article, and Henry Ford Museum chose it as a section title for the exhibit "Possible Dreams: *POPULAR MECHANICS* and America's Enthusiasm for Technology." War and the threat of war have long driven techno-

logical development, but never more rapidly or with such destructive consequences as in this century. From turn-of-the-century submarines to up-to-the-minute B-2 Stealth bombers, the irresistible force that repels enemies also attracts enthusiasts.

No exhibit on technological enthusiasm would be complete without a look at military hardware—especially not an exhibit based on *POPULAR MECHANICS*. A PM reader once observed, "With magazines like yours, the Russians don't need spies—they can read it all in PM." But despite its importance to the magazine and the

nation, the space allotted in the "Possible Dreams" exhibit did not allow for tanks, dreadnoughts or aircraft carriers. What to do?

Most Americans never see the stuff of war firsthand. Interest in the machines of war often develops from what we read in magazines, see on television and play with as children. So visitors to the exhibit will see military toys displayed against a backdrop of PM's military covers and graphics—in many ways far more telling of our enthusiasm than the actual hardware. After all, as a 1926 *POPULAR MECHANICS* headline declared, "Toys Make The Man."

Toys never lag far behind state-of-the-art hardware. "Regardless of whether battles are fought from the bomb-proof trenches in France, across a parlor floor or in a bathtub, the exigencies of war are met with the latest implements," read PM's holiday toy review in 1915. Just after WWII ended, PM commented, "So far children haven't demanded toy atomic bombs. But most of the other weapons of World War II are available as playthings." And even before the Stealth bomber had been revealed to the public, a PM cover suggested its shadowy form and toymakers had

(Please turn to page 123)



***“I spend a lot of time
in a truck, so it has to be***

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

comfortable. And even though my Ford pickup's built to stand up to almost anything, it's a pleasure to be in. My wife likes the seats and touches like the coffee cup holder. She also likes the fact we can take the kids along. Times have changed. And the Ford full-size pickup's changed right along with them.”



THE BEST-SELLING AMERICAN TRUCKS
ARE BUILT FORD TOUGH.



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

COMPARISON TEST

VANITY



BY TONY SWAN, Automotive Editor; PM Photos by Rich Cox

● Although Chrysler invented the minivan as we know it—and still controls about half the market—the field has expanded dramatically since the days when your minivan choices were limited to the Dodge Caravan and Plymouth Voyager.

Today it's a veritable supermarket, with 17 nameplates contending for pieces of a total market that may approach 1.5 million in 1993.

The benefit of all this variety is that, more than ever before, there's a minivan in the mix that addresses your specific needs. We've tailored our test to this point—finding the minivan that's best for you. Each

has its virtues, each has shortfalls.

With this goal in mind, we felt comfortable with the mixed bag of vans in this roundup. Some have all-wheel drive, some don't. There's a stretch edition, and one even has a 5-speed manual transmission. The mix helps in illustrating the range of variations on the original theme.

Chevrolet Astro LT

LT stands for Luxury Touring, and this Astro is loaded—front and rear air conditioning, AM/FM/cassette sound system, power locks, power windows, power mirrors, 7-passenger seating, alloy wheels, heavy-

duty towing package and awd—just to hit the highlights.

It's a very pleasant package, but adds \$8000-plus to the bottom line.

Also available as the GMC Safari, the stretched Astro is big. Seating seven in comfort is a snap—though we wonder why the center seat backs don't recline to improve rear-seat access.

The Astro has a Dutch door arrangement at the rear—a lift-up rear window, with vertically split demi-doors beneath—that's very nifty. And we were impressed with the vehicle's security, which we tested by locking the keys inside.

FAIR

With the minivan bazaar bigger and better than ever before, does Chrysler still rule?



The PM minivan street fair (top row, l. to r.): Ford Aerostar Eddie Bauer, Dodge Caravan SE, Chevrolet Astro LT, Pontiac Trans Sport SE, Mazda MPV, Toyota Previa LE All-Trac; (bottom row, l. to r.): Mercury Villager LS, Mitsubishi Expo LRV Sport, Mitsubishi Expo SP, Nissan Quest GXE.

The Astro simply can't be opened by slim-jims and other lock-picks.

We also tested the Astro's towing capabilities by hauling an auto transporter and a race car to San Francisco and back. The Astro's 4.3-liter V6 performed very well in this role—better than we expected.

But after all, the Astro is basically a truck in minivan clothing. While the ride quality is civilized, its behavior is trucklike. If heavy hauling is one of your parameters, the Astro/Safari twins should be at the top of your list. If carlike driving is a priority, there are better choices.

Dodge Caravan SE

Along with its Chryco siblings—Chrysler Town & Country and Plymouth Voyager—the Caravan has long been the minivan gold standard.

Redesigned just over a year ago, our Caravan (a '92 model) had 7-passenger seating, a 150-hp 3.0-liter sohc V6 (supplied by Mitsubishi) and a 4-speed automatic transmission. Chrysler's minivan leadership meant that the redesign could focus on evolutionary refinements rather

than a revolutionary makeover. This approach shows to good advantage inside and out, with an interior that's better looking and more functional, the first use of a driver's airbag in a minivan and a contemporary exterior.

As always, the Caravan's long suit is all-around driveability that's quiet, mannerly and as easy to manage as any midsize sedan. We like the smooth Mitsu V6, though Chrysler's own 3.3-liter V6 offers

VANITY FAIR



MERCURY VILLAGER LS



CHEVROLET ASTRO LT



NISSAN QUEST GXE



MAZDA MPV

more low-end grunt. And we found the Dodge Caravan's driver sightlines to be exemplary.

But the Caravan falls a bit short in seating flexibility. Some of the other minivans offer seats that can be folded up—or removed—more easily to maximize cargo volume.

But that factor, of course, is important in proportion to your needs. And in any case, if a carlike minivan is what you want, you *have* to check out the Caravan—or one of its clones—

because this is the standard by which the others are judged.

Ford Aerostar Eddie Bauer

Like the Astro/Safari twins, there's a lot of pickup truck lurking beneath the Aerostar. This is another big, strong workhorse that thrives on big family-size loads and hard work. It's also the only other minivan in this fleet capable of serious towing.

Ford offers both 3.0- and 4.0-liter

V6 engines for the Aerostar. We opted for the excellent 4.0-liter, with its man-size torque, which sends power to the wheels through a 4-speed automatic transmission. We were surprised to learn that when you order this combination, all-wheel drive is built into the deal.

As the other maxi-mini of the group, the Aerostar offers plenty of room for seven passengers and some of the best seats in the test. Like the Astro, our Aerostar was awash with

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.)	TRACK FRONT/REAR (in.)	WIDTH/ HEIGHT (in.)	HEAD-, LEGROOM F/C/R (in.)	CURB WEIGHT (lb.) HP/WEIGHT RATIO (lb./hp)
Chevrolet Astro LT	\$ 18,145/ \$ 26,067	V6 OHV 262/4293	200 @ 4400 rpm/ 260 @ 3600 rpm	front/ awd	4-speed automatic	111.0/ 186.8	65.1/ 65.1	77.5/ 76.2	H: 39.2/37.9/38.3 L: 41.6/36.5/38.5	3987/ 19.94
Dodge Caravan SE	\$ 20,583/ \$ 22,268	V6 SOHC 181.4/2973	142 @ 5000 rpm/ 171 @ 2400 rpm	front/ front	3-speed automatic	112.3/ 178.1	59.9/ 62.1	72.0/ 66.0	H: 39.1/38.5/37.6 L: 41.5/37.6/35.0	3275/ 23.06
Ford Aerostar Eddie Bauer	\$ 23,414/ \$ 25,605	V6 OHV 245/4015	155 @ 4000 rpm/ 225 @ 2400 rpm	front/ awd	4-speed automatic	118.9/ 174.9	61.5/ 61.5	71.7/ 73.6	H: 39.5/38.1/38.4 L: 41.4/37.9/37.0	3584/ 23.10
Mazda MPV	\$ 20,685/ \$ 26,818	V6 SOHC 180.3/2954	155 @ 5000 rpm/ 169 @ 4000 rpm	front/ awd	4-speed automatic	110.4/ 175.8	60.0/ 60.8	72.3/ 70.8	H: 40.0/39.0/37.7 L: 40.6/34.8/36.1	4010/ 25.87
Mercury Villager LS	\$ 21,798/ \$ 26,015	V6 SOHC 182/2960	151 @ 4800 rpm/ 174 @ 4400 rpm	front/ front	4-speed automatic	112.2/ 189.9	63.4/ 63.4	73.7/ 67.6	H: 39.4/39.7/37.3 L: 39.9/34.8/36.7	4015/ 26.42
Mitsubishi Expo LRV Sport	\$ 11,989/ \$ 15,852	I4 DOHC 16V 112/1834	113 @ 6000 rpm/ 116 @ 4500 rpm	front/ front	5-speed manual	99.2/ 168.6	57.5/ 57.5	66.7/ 64.4	H: 40.0/38.6/NA L: 40.8/36.1/NA	2723/ 24.09
Mitsubishi Expo SP	\$ 15,209/ \$ 18,528	I4 SOHC 144/2351	116 @ 5000 rpm/ 136 @ 3500 rpm	front/ front	4-speed automatic	107.1/ 177.4	57.5/ 57.5	66.7/ 62.6	H: 39.3/39.3/36.9 L: 40.5/37.7/28.7	3009/ 25.93
Nissan Quest GXE	\$ 21,750/ \$ 22,050	V6 SOHC 182/2960	151 @ 4800 rpm/ 174 @ 4400 rpm	front/ front	4-speed automatic	112.2/ 189.9	63.4/ 63.4	73.7/ 67.6	H: 39.4/39.7/37.3 L: 39.9/34.8/36.7	3990/ 26.42
Pontiac Trans Sport SE	\$ 16,225/ \$ 21,423	V6 OHV 231/3785	170 @ 4800 rpm/ 225 @ 3200 rpm	front/ front	4-speed automatic	109.8/ 194.5	58.7/ 60.9	74.6/ 65.7	H: 39.2/38.7/37.5 L: 40.1/36.9/34.0	3598/ 21.16
Toyota Previa LE All-Trac	\$ 25,518/ \$ 26,413	I4 DOHC 16V 148.8/2438	138 @ 5000 rpm/ 154 @ 4000 rpm	front/ awd	4-speed automatic	112.8/ 187.0	61.6/ 61.2	70.8/ 68.7	H: 39.4/38.9/37.8 L: 40.1/36.6/36.3	3780/ 27.39



CHEVROLET ASTRO LT



DODGE CARAVAN SE



FORD AEROSTAR EDDIE BAUER



MAZDA MPV



MERCURY VILLAGER LS

1. Times from a steady-state 40 to 70 mph. 2. Best speed achieved while weaving through 8 cones placed in line, 100 ft. apart. Speeds provide index of transient response. 3. Based on 12 basic maintenance functions.



FORD AEROSTAR EDDIE BAUER



DODGE CARAVAN SE



MITSUBISHI EXPO SP



MITSUBISHI EXPO LRV SPORT

extras. The Eddie Bauer trim package lends a spiffy touch, as it does in other truck-based Ford products.

Ride quality tends toward the stiff side, though our test crew gave Aerostar a handling edge over the Astro.

Weak points are the comparative lack of seating/cargo adaptability and routine serviceability, which is about the worst in the group.

Nevertheless, if your minivan job demands trucklike capabilities, the Aerostar merits a thorough tryout.

Mazda MPV

Mazda's minivan resembles its Ford and Chevy counterparts in that it employs a rear-drive pickup truck chassis. But it's distinct from the maximinis in size and agility, something that's reflected in its slalom performance (helped a bit by its optional awd system). The MPV is one of the few minivans that's actually fun to drive on a twisty road.

Compact size has its drawbacks. If real 7-passenger seating is on your

agenda, you'll find the MPV cramped, and the convertibility of seating to cargo space is not very handy. We also have mixed feelings about the MPV's hinged second door on the passenger's side, which can be awkward in a crowded parking lot.

On the other hand, the MPV looks good, operates quietly and serves well as an all-around passenger vehicle. Its 3.0-liter sohc V6 engine provides better-than-average punch and has enough low-end grunt to handle

TEST RESULTS

STEERING TYPE/TURNS LOCK-TO-LOCK	TURNING CIRCLE (ft.)	WHEELS/TIRES	BRAKE SYSTEM FRONT/REAR	FUEL ECONOMY (MPG EPA city/hwy.) PM test	ACCELERATION 0-60 MPH (sec.) 1/4-MILE (sec. @ mph)	PASSING ¹ ACCELERATION 40-70 MPH (sec.)	BRAKING 60-0 MPH (ft.)	700-FT. ² SLALOM MPH	PM ³ SERVICEABILITY INDEX
Power rack & pinion/2.7	40.5	15 x 6-in. steel P215/75R15	Disc/drum, 4-wheel ABS 11.6-in. vented/9.5-in.	15/20 20	12.95 20.55/66.9	11.7	154	54.2	6
Power rack & pinion/2.96	40.5	15 x 6-in. alloy P205/70R15	Disc/drum 10.2-in./9-in.	19/23 24.3	15.8 20.34/68.7	10.2	136	57.5	8
Power rack & pinion/2.75	42.4	14 x 5.5-in. steel P215/70R14	Disc/drum, rear-wheel ABS 10.2-in./10-in.	15/19 19.5	12.95 19.13/69.0	10.6	195	54.2	1
Power rack & pinion/3.6	39.6	15 x 6-in. alloy P215/65R15	Disc/drum, rear-wheel ABS 10.1-in. vented/10.2-in.	15/19 23	15.6 20.41/66.0	9.7	157	58.2	6
Power rack & pinion/3.0	39.4	15 x 5.5-in. alloy P205/75R15	Disc/drum, 4-wheel ABS 10.5-in. vented/10-in.	17/23 28.1	16.7 21.02/67.2	10.6	162	57.5	9
Power rack & pinion/3.15	33.4	14 x 5.5-in. alloy P205/70R14	Disc/disc, 4-wheel ABS 10.1-in. vented/8-in.	23/29 34.6	12.85 18.96/72.6	8.8	136	60.4	10
Power rack & pinion/3.15	36.0	14 x 5.5-in. alloy P205/70R14	Disc/disc, 4-wheel ABS 10.1-in. vented/9-in.	21/27 25.7	15.45 20.4/69.6	10.7	156	58.2	8
Power rack & pinion/3.0	39.4	15 x 6.5-in. alloy P205/75R15	Disc/drum, 4-wheel ABS 10.9-in. vented/9.8-in.	17/23 28.2	17.1 21.27/66.8	10.6	165	57.5	9
Power rack & pinion/3.05	38.0	15 x 6-in. alloy P205/70R15	Disc/drum, 4-wheel ABS 10.9-in. vented/8.9-in.	17/24 23.6	12.95 19.06/72.78	8.3	167	55.5	6
Power rack & pinion/3.5	37.4	15 x 6-in. steel P215/65R15	Disc/disc 9.7-in. vented/10.9-in. vented	17/20 24.3	19.05 21.82/62.86	12.7	147	56.8	5



MITSUBISHI EXPO LRV SPORT



MITSUBISHI EXPO SP



NISSAN QUEST GXE



PONTIAC TRANS SPORT SE



TOYOTA PREVIA LE ALL-TRAC



PONTIAC TRANS SPORT SE



TOYOTA PREVIA LE ALL-TRAC

bigger-than-average towing chores. And if fun-to-drive is a priority, it just about tops the list.

Mercury Villager LS/ Nissan Quest GXE

While it's clear that Chrysler's minivans have spawned many competitors, we think these two are the first to make a direct challenge to the champs—a very successful challenge.

Virtually identical save for trim details, the Villager and Quest are similar to the Caravan and its clones in most exterior dimensions. They are longer than the standard Caravan, however, by almost a foot—nearly as

long as the stretched Grand Caravan.

The Caravan offers better front- and middle-seat legroom, while Villager and Quest have more rear legroom and more cargo space behind it.

Jointly designed by Ford and Nissan and assembled at Ford's Avon Lake, Ohio, factory, the Quest and Villager also provide a driving experience that's as carlike as it gets. The 150-hp sohc V6 is smooth, quiet and potent enough to satisfy most buyers in this class. And steering feel is just about the best in the bunch.

We were also impressed with the new vans' routine serviceability, which was near the top of the group.

With almost 10 years of development behind it, the Caravan offers a range of powertrain options that won't show up in Nissan or Mercury showrooms for a while—three different engines, three transmissions and awd. It also has a driver's airbag and an optional integrated child seat, things the Quest and Villager lack.

But the newcomers still score well on the safety scale, with side intrusion door beams, reinforced center pillars, front and rear crush zones and 5-mph bumpers—well enough to meet 1993 federal safety standards for passenger cars (as distinct from trucks).

And when it comes to rearranging seating to improve cargo space, the Quest and Villager have the advantage. The center seat backs fold flat, creating tables with built-in cup holders. The rear seats fold up to expand the rear cargo area, and with the center seats removed, the rear seats can slide all the way to the front seat backs on built-in rails.

If the center seats could be removed without a wrench, this would be the most flexible setup of all. But even so, it gives Quest and Villager an edge over the Caravan—enough of an edge for these two to emerge as a joint tester's choice among the carlike minivans.



Volkswagen Eurovan

● Chrysler can reasonably claim to have created the modern minivan, but the true origin of the species can be traced to Germany some 43 years ago. That's when the first Volkswagen Microbus rolled onto the scene, and VW has been updating the concept ever since.

Until now. The new VW Eurovan abandons the old rear-engine, rear-drive Microbus/Vanagon tradition for a front-engine, front-drive layout and a more aerodynamic body shell.

The Eurovan came along too late for our test, but we can pass along some of its vital statistics.

Not only is the engine-drive configuration new, so is the engine. A 109-hp 2.5-liter Five replaces the old boxer Four, and is available with either a 5-speed manual or 4-speed automatic. Although rated output seems tame compared to most minivans, Volks-

wagen places the Eurovan's maximum towing capability at 4400 pounds.

VW's four decades of experience shows to advantage in the Eurovan's interior volume, 201 cu. ft.—tops among minivans and amazing in a package that's hardly any longer than a Honda Accord sedan. The new van also features low step-up and lift-over heights, for easier access and loading.

Specifications

Price range	\$16,640-\$21,850
Layout	Front-engine, front-drive
Engine	109-hp 2.5-liter sohc L-5
Transmissions	5M, 4A
Wheelbase	115 in.
Track, f/r	62/60.6
Length	186.6 in.
Width	72.4 in.
Height	75.6 in.
Curb weight	3800 lb. (est.)
Brakes	Disc/drum (ABS optional)

Mitsubishi Expo SP/ Expo LRV Sport

Here, as elsewhere in the automotive spectrum, Mitsubishi goes its own way. In fact, the Expo and Expo LRV are so different that Mitsubishi refuses to call them minivans. The official designation is sport wagons.

Well, dimensions notwithstanding, they look like minivans to us. More important, they have minivan traits—more cargo capacity than sedans or station wagons of comparable wheelbase, flexible seating and, for the Expo at least, places for seven.

Although the Expo is compact, it's almost as long as the Caravan, with comparable legroom in the first two rows of seats. Third-row legroom, however, is skimpy.

There's also considerable adjust-
(Please turn to page 129)

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Electric Energy Efficiency— A House Open to Ideas

Electric energy efficiency is the key to a

future that preserves our environment while providing the creature comforts we take for granted in our homes. Basically, there are three steps to making your home a model of efficiency. Step 1: Make sure you have a properly insulated thermal shell. Step 2: Install efficient electric lighting and appliances. Step 3: Control your home environment with convenient automation devices. Illustrated below are some of the new technologies demonstrated in the building and electric utility industries' SMART Houses and other advanced technology projects. In the pages that follow, you can read about the dramatic changes electricity will bring about as it takes you into the future.

Better insulating materials create a thermal shell so efficient that you can heat and cool the house with a smaller-capacity heat pump.

Individually controlled temperature zones, with remote sensors, can be programmed to deliver heating and cooling according to the time of day when the zones are used.

Temperatures for individual zones are controlled and programmed from a touch-screen computer.



Scroll-compressor heat pumps outperform earlier models by 25 percent, use less electricity, and operate with practically no noise.

Electrically operated duct baffles, responding to programmed commands, divert warm and cold air to specific zones in the house.

Insulated ducts reduce air leakage by as much as 30 percent—so more warm or cool air gets to the room.

Motion sensors, programmed on your personal computer, control outdoor security lighting.

More Heat for Less Cost



50 years ago . . .

Forced air rapidly heated every room in the home from a central furnace that converted fossil fuel into heat—a marked improvement over slow-moving (and noisy!) steam heat.

Tomorrow . . .

Compact heat pumps will be 400 percent more efficient than fossil-fuel furnaces. Inside the house, more-efficient controls will deliver the desired temperature to each room, further increasing the comfort level. These high-efficiency heat pumps will also be able to divert some of the heat they generate to produce domestic hot water—not only in the summer, when that heat is a natural by-product of the air-conditioning cycle, but in winter too!



If bill-paying time at your house is like it is for most of us, one of the biggest items on your housing budget, after the rent or mortgage payments, is the cost of energy. And the biggest chunk of that goes to pay for heating and cooling—46 percent, according to the U.S. Department of Energy.

Now imagine a heating system that's three times more efficient than the most efficient fossil-fuel furnaces. Depending on where in the country you live, this increased efficiency can reduce the dollar value of that 46 percent significantly. No, this isn't something astronauts are testing on the space shuttle, it's a modern heat pump—a system you can buy today.

A heat pump works just like a refrigerator, using a compressor and refrigerant coils to move the heat from one place to another. In the winter, one type of heat pump takes heat from outside air—there's plenty of heat in that air even when the temperature is in the 30s—and pumps it into the house as warm air. In summer, the process reverses to provide air-conditioning. The heat pump removes heat from inside the house just as a refrigerator removes heat from the food compartment.

A second type of heat pump does the same thing, but instead of using the outside air as its source of heat, it uses the ground, which has a constant temperature of about 50 degrees.

Since heat pumps don't convert fuel into heat, their efficiency is measured differently from that of fossil-fuel furnaces. In the heating mode, this efficiency is expressed as a Heating Season Performance Factor, or HSPF number—the higher the number, the more efficient the heat pump.

In January 1992, the Department of Energy set a minimum standard for heat-pump efficiency at an HSPF of 6.8. Most of today's heat pumps are much more efficient and have HSPF numbers approaching 10.

In contrast, a conventional furnace converts fossil fuel into heat. A high-efficiency furnace can convert about 92 percent of fuel into useful heat. Not bad. It comes up short, however, when stacked against a heat pump with an HSPF of 10. The heat pump is three times more efficient. And as efficiency goes up, the cost of operation goes down.

Quiet Now

Noise. It may not be the most pressing environmental topic, but according to Derrick Marris, director of advanced technology for Carrier Corporation, controlling noise pollution is a key issue for the '90s. A new generation of scroll-compressor heat pumps, with just two moving parts, will be 15 percent quieter than the last generation of reciprocating-compressor units they will replace. These new heat pumps also have variable-speed motors that allow them to operate at less than full capacity most of the time, so heating and cooling will be both quieter and more efficient—making you a good neighbor for those around you.



THE INSIDE STORY.

WILLIS CARRIER WAS THE FIRST INSIDE GUY.

Following a hunch he had about the relationship between humidity and coolness, Willis Carrier had a groundbreaking idea. In 1902, he put his idea to practical use. He invented air conditioning. Suddenly, being inside was comfortable year-round.



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What began with Willis Carrier's brainstorm and hard work has been

carried on by Carrier people all across the country. Residential air conditioning and heating has become a comfortable way of life, and Carrier dealers have become the "Inside Guys" people count on. Innovations such as energy saving heating and

cooling equipment, humidifiers, air cleaners and electronic comfort controls have reinforced Carrier's name as #1 in comfort from coast to coast.

THE BRAND INSIDE AMERICA.

Carrier is the brand that homeowners know best. Since 1902, American consumers have relied on Carrier products for efficiency and

comfort. And that confidence is why more Americans choose Carrier heating and cooling products.



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New Electric Lights Brighten the Future

Over 100 years ago . . .

With the invention of the incandescent light bulb, Thomas A. Edison made lighting in the home safe and affordable and ushered in the Electric Age.



Tomorrow . . .

Compact fluorescents and E-Lamps, with lives of between 10,000 and 14,000 hours, last so long you'll think they're part of your home. E-Lamps are a one-time purchase. These high-efficiency lights give you the same conveniences you take for granted with any light bulb: They work on three-way fixtures, and you can dim them to change the mood in a room.



Most of us can remember our mothers telling us to turn off the lights when we leave a room. It's still good advice because the cost of lighting makes up about 6 percent of your monthly utility bill. But by the end of the century, new technology will revolutionize how we light our homes.

These new lights are distant cousins of the old four-foot fluorescent tube. Although these new lights can also be called fluorescent, the similarity ends there. One type, the compact fluorescent, a half-inch-diameter tube bent to form a compact U-shaped unit just a few inches long, is so efficient that an 18-watt compact provides the same warm-light output as a 75-watt incandescent bulb—and it lasts 12 times longer.

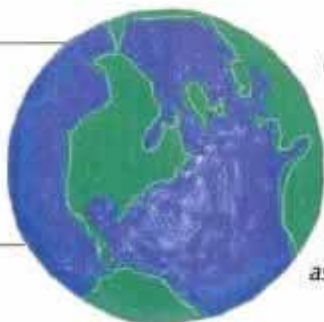
In terms of your wallet, if you're paying 8 cents per kilowatt-hour for power, the new compact fluorescent will cut your electric bill by \$46.60 over its 10,000-hour life. And forget about flickering bulbs when you turn them on: Like the incandescents, they turn on and off instantly.

Another light-bulb technology was announced last June. These new E-Lamps combine electrical and chemical technologies. As with the compacts, the light in the E-Lamp comes from a gas inside the bulb that glows. Similarly, you can use lower-wattage bulbs—a 25-watt E-Lamp replaces a 100-watt incandescent.

The difference is in the technology—E-Lamps use radio waves to activate the gas, rather than the electrical current that the compacts use. Projections are that E-Lamps will last for 14 years and give the same energy savings as the compacts. And because of their small size and traditional A-line shape, they will fit all light fixtures.

Green Light for the Environment

Money isn't all these new lights save; they're also good for the environment. The same 18-watt bulb that saves you \$46.60 requires so little electricity to operate that, over its 10,000 hours of use, it will cut carbon-dioxide emissions into the atmosphere by 10%. And because one compact has the same lifespan as 12 incandescents, waste disposal is reduced by millions of bulbs a year.





CELEBRITIES PORTRAYED BY LOOK ALIKES

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**See the official warranty for details of terms and conditions. For the Millennium retailer nearest you, call 1-800-CAN-POWER. © 1992 Millennium Power System.*

THE POWER TO LAST A LIFETIME.

Comfort Zones

Heat pumps are the most efficient way to heat or cool a house, but making the air either hot or cold is just one part of an efficient system that costs you less to operate. Getting the warm or cool air to those rooms where it's needed, and when, is just as important.

Dividing your house into heating and cooling zones is the most efficient way to maximize the efficiency you're already getting from your heat pump. In a zoned house, temperature sensors replace a single thermostat. These sensors are located in the various parts of your house and report back to a central control unit. Like thermostats, they can be programmed to hold a temperature for so many hours and then change to a lower or higher temperature. But unlike a thermostat, which can affect the whole house with one setting, zone sensors affect only specific rooms or groups of rooms.

They work by controlling baffles in the ductwork. When the sensor in one zone calls for heating or cooling, it triggers the baffles, which open to allow the air into that zone. When no heating or cooling is called for, the baffles close and divert the

air to where it is needed. "A properly designed zoning system can cut the cost of heating and cooling by up to 30 percent," says Joe Summa, manager of residential control systems at Carrier, "and at the same time offers increased comfort by eliminating pockets of air that are too hot or too cold."

Typically, in a house with four zones, one zone contains the kitchen and family room, another the living room, dining room, and home office or den. The third zone is usually for the bedrooms, and the fourth is for rooms that are seldom used or for the basement. A house with two zones would have the bedrooms in one zone and the rest of the rooms in the other.

To take full advantage of zoning, program the temperature settings for each zone according to how and when the rooms in the zone are used. For example, program bedroom temperatures to warm up right before bedtime, cool off while you sleep, and warm up again before you rise. Set the daytime temperature for the bedroom zone to minimize the demand on the heat pump (cooler in winter, warmer in summer).

Zoning also allows you to downsize the heat pump you buy because you heat your house more efficiently. The set-back and air-mixing capabilities of a zoned system mean that you can install a smaller unit. Since heat is delivered more efficiently, you can use a heat pump that has a smaller energy capacity. This saves money at the initial purchase, and the smaller unit uses less electricity, so the savings continue every month.

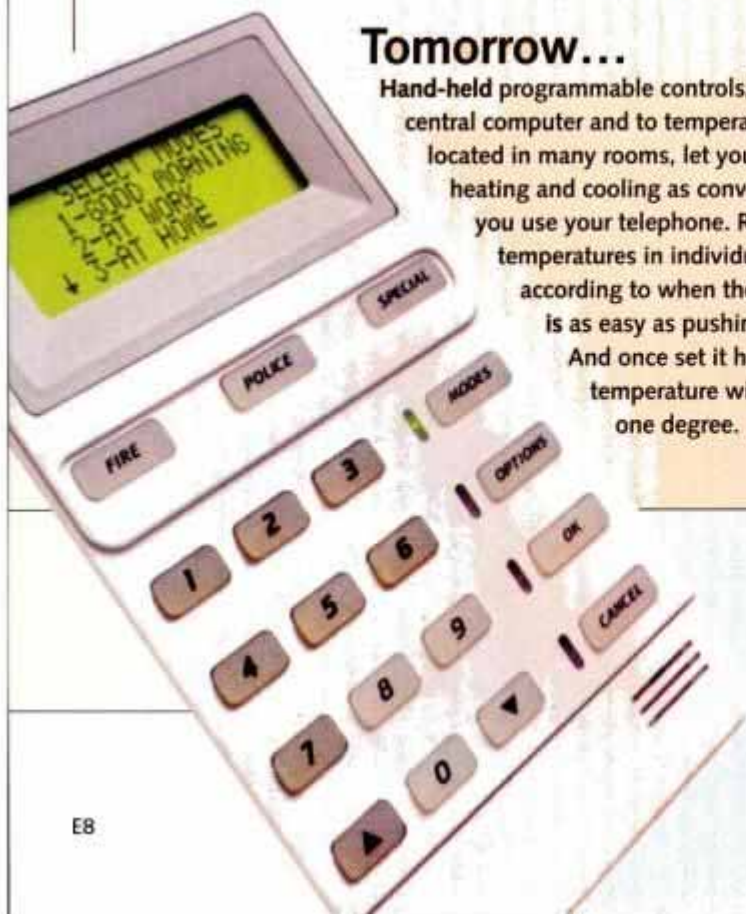
Yesterday...

The thermostat was invented to control heating. A simple mercury switch manually opened and closed an electrical circuit leading to the furnace. Once set, the thermostat responded to the temperature in the room where it was mounted and, within a range of six degrees or so, kept the whole house at a uniform temperature.



Tomorrow...

Hand-held programmable controls, linked to a central computer and to temperature sensors located in many rooms, let you control heating and cooling as conveniently as you use your telephone. Regulating temperatures in individual rooms according to when they are in use is as easy as pushing a button. And once set it holds that temperature within half of one degree.





Cooking moist, tender, healthy fish is wonderful. Scrubbing the fishy splatters out of the seams and crevices on your range isn't. That's why Tappan created the Scrub-Saver smoothtop range. Its upswept design features a large seamless glass cooktop that simply can't catch and hide splatters. Plus, unlike other ranges, the cooktop is made from a special ceramic



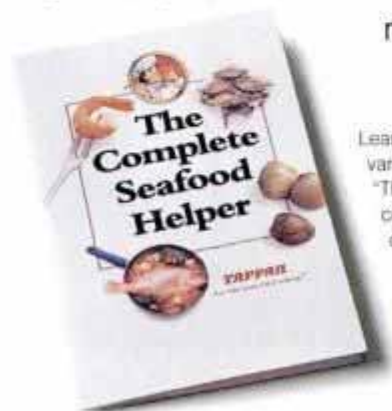
The 10-minute rule... for perfectly done fish, cook for 10 minutes per inch of thickness.

The Tappan Scrub-Saver™ Electric Range. Finally, A Range That Doesn't Catch Fish.



To tell if fish is fresh or has been frozen, lightly press the fillet with your finger. If it springs back, it's fresh.

that's virtually impossible to stain or crack. And whether you're sautéing, poaching, baking, or broiling, our even-heat elements and automatic self-cleaning oven won't leave fish overcooked at one end and raw at the other. Tappan Scrub-Saver electric ranges. Designed for people who love to cook. By people who feel the same.



Learn how to buy, store, season, and cook a wide variety of ocean and fresh-water seafood with "The Tappan Cook's Helper" series. For your free copy and the name of your nearest Tappan dealer, call 1-800-537-5530.

TAPPAN
For The Love Of Cooking®

Power Sharing

The wires that bring electricity into your home connect you to more than just the power plant at the edge of town. At the other end of those wires, your electric utility company is working on ways to decrease what you pay for the electricity you use. They are doing this by increasing the efficiency of the appliances that use electricity and by helping you use those appliances wisely.

The electric utility companies call this strategy Demand Side Management, or DSM, and the idea behind it is simple. When you use electricity more efficiently, it costs less to have the same level of comfort and convenience, which is good for you. Better efficiency also means less fuel combustion, which is good for the environment.

There are many facets to DSM. On the research side, money invested by electric

utility companies has led directly to the highest-efficiency heat pump currently available, the HydroTech 2000 from Carrier. More recently, another investment has resulted in the development of a light bulb that may last 20 years and use 75 percent less electricity than the standard incandescent bulb we're all used to. Research funded by electric utility companies has also led to cleaner methods for burning the American coal that fuels most power-generating plants. Emissions of sulfur dioxide have been cut by 95 percent, while the energy yield from the coal has increased by as much as 150 percent.

Day to day, some electric utility companies offer reductions on residential electric rates to customers who install energy-efficient heating-and-cooling systems, thermal windows, or additional insulation. Others will actually lend you some of the money needed to make these improvements or give you a cash rebate when the job is done.

Across the country, electric utility companies work with home builders to develop and implement energy-efficient construction programs. The resulting houses, labeled by such names as Energy Crafted Homes or Good Cents Homes, qualify for what's called the Energy Efficient Mortgage. In this type of mortgage, the anticipated savings on utility bills resulting from higher construction standards are plowed back into the financial calculations that determine how much mortgage money a prospective buyer can borrow. Lenders who participate in Energy Efficient Mortgage programs usually allow buyers of these homes to stretch their debt-to-income ratio by two percent. In some cases this allows the buyer to qualify for a more expensive home. In others it can make the difference between affording or not affording a home.

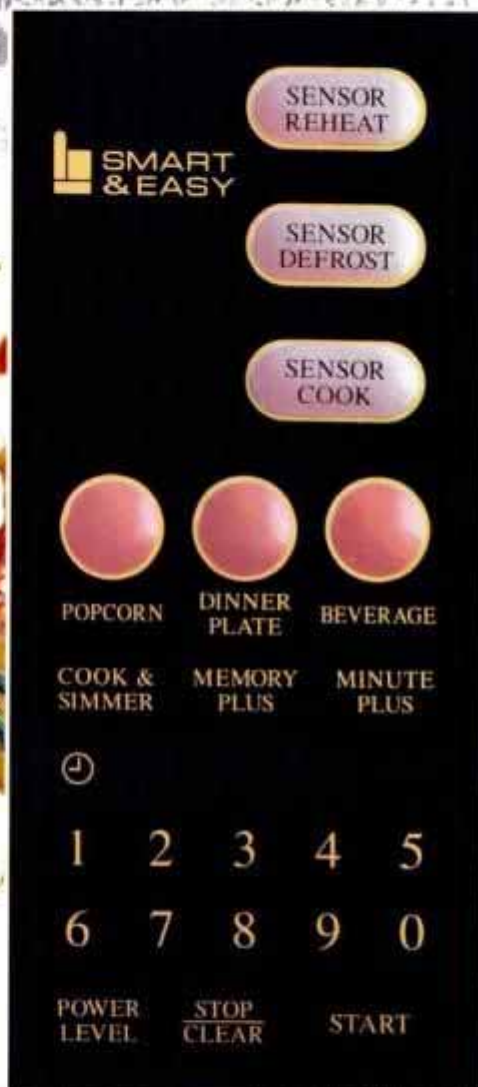
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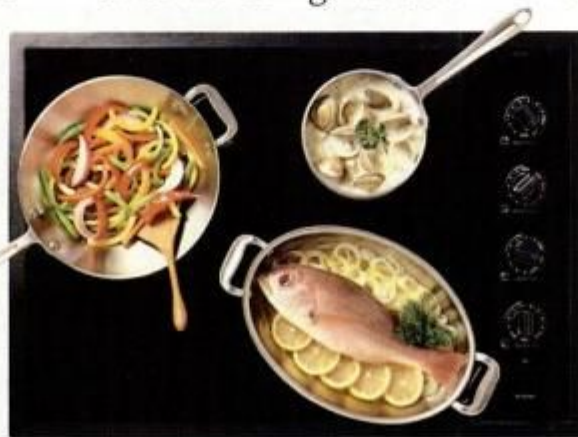
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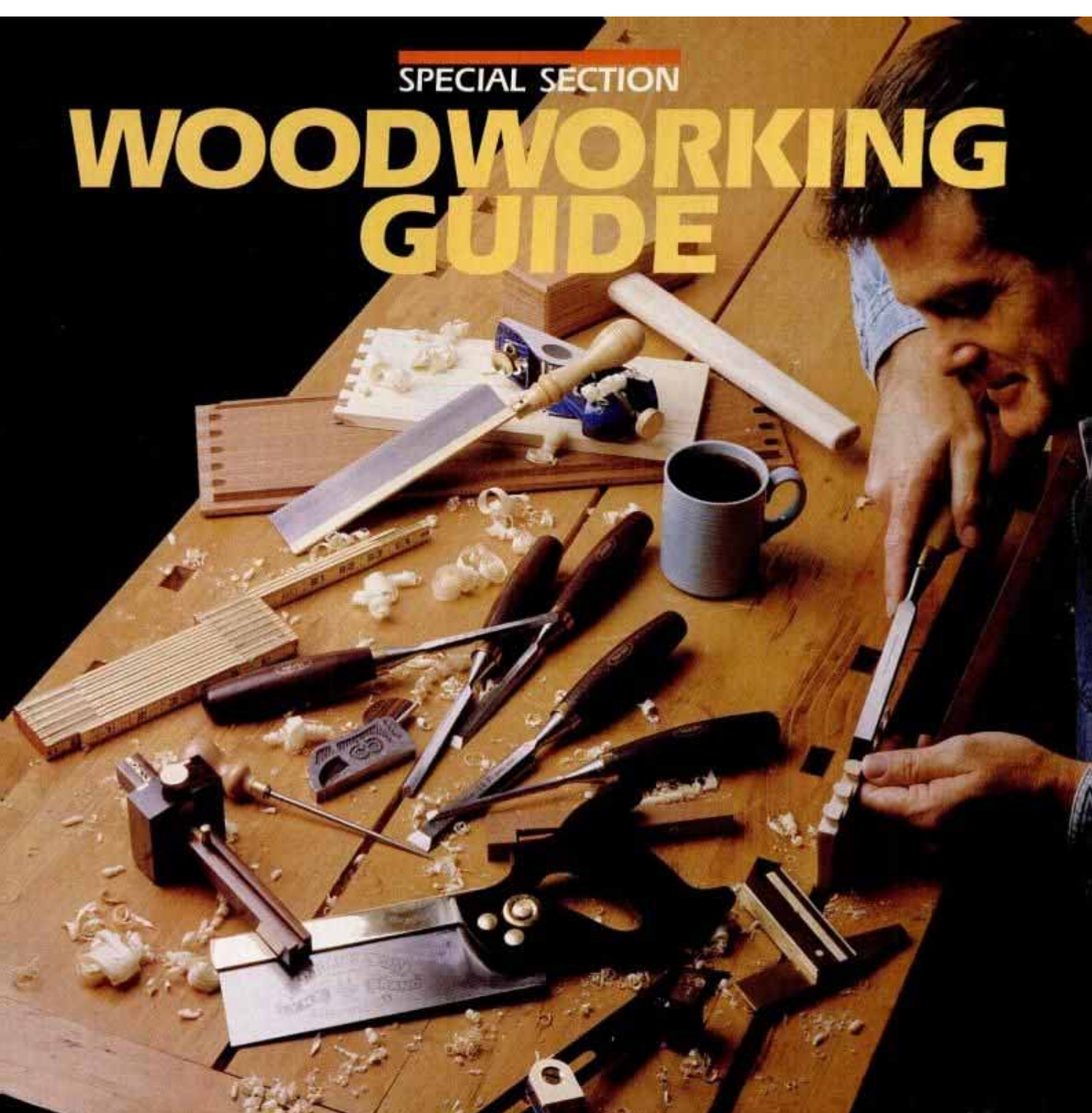
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SPECIAL SECTION

WOODWORKING GUIDE



6 Great Furniture Projects

- An easy mahogany clock for beginning woodworkers
- A solid oak coat rack made with portable tools
- A simple pine cupboard rooted in the Shaker tradition
- A traditional folding card table you can make in a weekend
- A narrow chest of drawers that is both distinctive and versatile
- And, a stunning cherry clothes press modified to hold a TV and VCR

Plus: 5 easy jigs for securely holding portable power tools

PM PHOTO BY DIET FRANK



Keeping Time

A simple mantel clock you can build in a few hours.

By Rosario Capotosto, Contributing Editor

● As the lead-off project in this year's Woodworking Guide, this simple mantel clock sets the stage perfectly. It's easy and inexpensive to build, plus it gives the beginning woodworker a way to test the waters without putting too much at risk. This piece is not, however, without its challenges. The rounded top looks easy to shape, but actually requires a pretty steady hand when cutting and sanding. And our clever approach to thinning stock—by using a router instead of a hand plane or power planer—can open up a whole new world of uses for this most versatile tool.

We chose mahogany, available at a local hardwood dealer, for our project. But you can opt for any species of wood, and because so little is required, you can come by your raw materials just about anywhere.

Stock preparation

Begin by laying out the circular cutting lines on the face piece using a compass (Photo 1). Then bore a hole on the waste side of the clock movement hole line to allow blade entry for the internal cut. Using a sabre saw, cut on the inside of this line to drop out the waste (Photo 2). Once the cut is complete, chuck a sanding drum in your drill and sand the wall of the opening until the clock movement fits snugly into the hole (Photo 3).

Next rip the stock to finished width, allowing a bit extra for final smoothing with a hand plane. Use a straight piece of wood to act as a guide while sawing (Photo 4). Then make a freehand cut to shape the top curve. With the front board completed, make an identical back piece, but this time

without the hole cutout. Then put these pieces aside while you work on the center piece.

Planing with a router

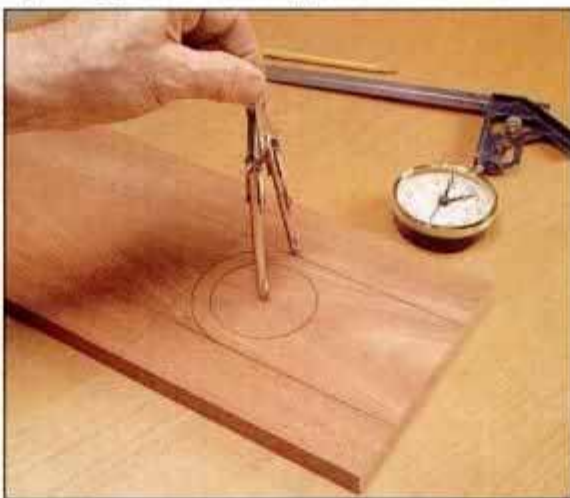
Because this piece is made from a front and back piece that are both $\frac{3}{4}$ in. thick and a middle piece that is $\frac{1}{2}$ in. thick, some thickness planing is required. Normally, one would use a

band saw, planer, hand plane or even a portable power planer to reduce the thickness of the middle board from $\frac{3}{4}$ in. to $\frac{1}{2}$ in. But for this project we decided to show you how to accomplish this with a router.

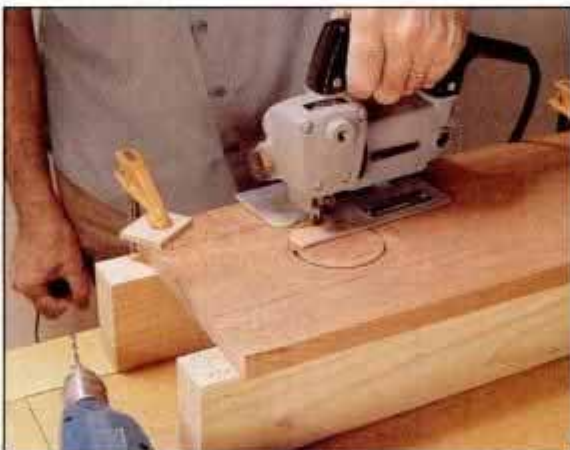
All you have to do is fabricate the oversize subbase shown in the drawing. Simply cut the plywood stock to size and bore a 1-in.-dia. bit clearance hole through the center. Then remove your router's baseplate and attach this panel in its place. Its long base will bridge the area being routed, thus keeping the machine—and cutter—on one consistent plane.

To reduce the thickness of the board, make repeated passes across the grain to remove the bulk of the waste (Photo 5). You should stop these cuts about $\frac{1}{16}$ in. above the finished thickness. Then readjust the router so it will cut to the finished dimension. These final shallow passes should give the board a smooth, glass-like surface.

Once the routing is finished, cut the stock to match the exact size and shape of the other two boards. Then glue and clamp together all three. You'll need three or four C-clamps and a couple of scrap boards to protect the surface of the relatively soft mahogany stock. First, apply a thin coat of glue to the mating surfaces (Photo 6), and then drive a couple of 1-in. brads through the back of the center board and into the back of the front board. Attach the back board in the same way. Then cover the assembly with scrap wood and clamp se-



1 First mark the straight cutlines for the sides on your stock. Then, using a compass, mark the circular cutlines.



2 Bore a blade-entry hole in the waste area, then cut along the line to form cutout for the clock movement.

Lead photo: J.R. Rost
How-to photos: Rosario Capotosto
Technical art: Eugene Thompson
Photo stylist: Gabe Herrick

curely. The brads will keep the pieces from sliding out of place during the clamping process.

Once the glue has dried, scrape off any excess squeeze-out and then plane the straight edges smooth.

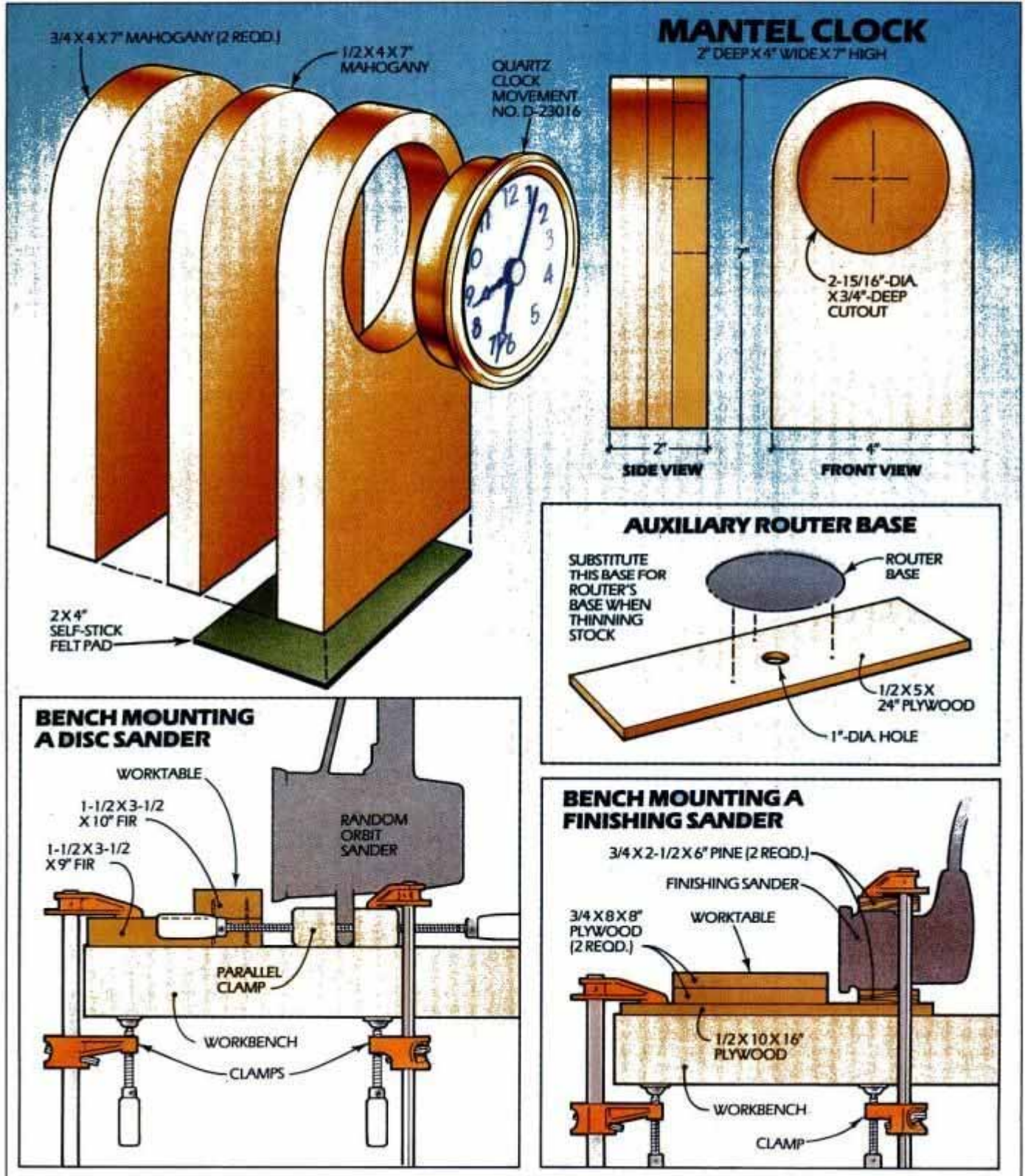
Finish sanding

To sand the broad, semicircular top of the clock assembly, we rigged up a

jig—shown in the drawing—to hold a portable disc sander. All that's required are a few clamps and a couple of pieces of scrap 2×4 . Just tighten the sander until it is firmly in place, turn it on and hold the workpiece on the 2×4 table (Photo 7). We used a Bosch sander for this operation, but just about any finishing sander can be used in a similar way.

Just make sure that when the tool is clamped in place it is absolutely stable and won't move when you push a workpiece up against it.

We started with 120-grit, followed by 180- and 220-grit, sandpaper. If you don't have this type of sander, you can do basically the same thing with a finishing sander clamped firmly to your workbench.



WOODWORKING GUIDE

To complete the project, apply two coats of polyurethane. We used McCloskey's Satin Finish and sanded lightly between coats.

Once the piece is dry, apply a self-sticking felt pad to the bottom to avoid scratching furniture tops—these pads are commonly available at hardware and crafts stores. Then, slide the clock movement into place. The movement we used requires an AA battery and is available from Armor Products, Box 445, East Northport, NY 11731. Ask for model No. D-23016. It costs \$18.75, postpaid. **PM**



3 Use a sanding drum to smooth the wall of the cutout. Test fit the movement.



4 Cut the stock to width using a wood straightedge to guide the saw.



5 Attach an oversize base to a router and rout the middle board to thickness.



6 Apply glue evenly to mating surfaces, then install clamps until glue is dry.



7 Use a bench-mounted sander to shape the top curve of the workpiece.

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The Pro Approach



Hangin' Tough

A traditional clothes tree that can grace anyone's hallway.

By Rosario Capotosto, Contributing Editor

● This attractive and easy-to-build clothes tree is based on a design that was common in homes and offices during the first half of this century. Like those pieces of the past, this one is made of solid white oak—stained a dark color to bring out its dramatic grain—and is outfitted with black iron hooks that can accommodate the heaviest of coats.

It's difficult to know why this versatile piece fell out of vogue. Perhaps it went the way of spacious hallways or was driven from sight by the ubiquitous entry closet that became a staple of the post-war housing boom. Whatever the reason, apparently a lot of us want them back. Today these clothes trees—in both traditional and exotic forms—are some of the more popular items at antique shops and flea markets. And, if you can spare just a little space in your hall or foyer and are willing to devote a few hours to the building process, you can easily make your own. Here's how.

Getting started

As with the preceding mantel clock story and the following card table project, this piece can be made easily with hand or portable power tools, especially if you make use of some of the jigs we show throughout the guide. The basic, straight cutting chores are handled with a portable circular saw mounted in a shop-built table. (See page 77 for building plans.) And for controlled sanding operations, you might want to build one of the simple jigs for portable power sanders shown on page 60.

Post construction

Begin construction by ripping the post stock to size. We used our

shop-built table for this job after we clamped a straightedge guide to its surface and the extension table to its outfeed side (Photo 1). Once these boards are ripped to width, cut them to rough length (Photo 2). Apply glue to the mating surfaces, clamp the boards together and set them aside until they dry.

Next, scrape off any hard glue beads. Then plane one of the laminated sides of this post assembly until it's flat, smooth and square to its adjacent sides. Place this planed side against the table saw's straightedge guide and rip the opposite side to finished width. Remove any saw marks or imperfections with a hand plane, always working in the same direction as the

grain. If your saw can't cut through the full thickness of the assembly, just rip one side as deep as you can. Then flip over the board, end for end, and cut it again. Cut the post to finished length, making sure to square up both ends, then turn to the base.

Base construction

The large dados that comprise the middle half lap joint featured on the crossed base members are not cut out of solid wood. Instead they are formed by gluing up several layers of blocks—selectively spaced—to create the overall thickness required.

Start by cutting the 5/4 stock to size. Then plane the edges smooth if necessary, being careful to maintain consistent widths on all the pieces. Accurate spacing of the piggybacked blocks that form the dado is essential for a well-fitted joint. To get it right, dry assemble the base, good faces down, using spring clamps to hold the components together (Photo 3). Next, bore pilot holes for the finishing nails in each block (Photo 4) and code each piece before disassembly to avoid mismatching the parts during the gluing process. Apply glue to each surface, drive in the nails to keep the parts in proper alignment and clamp securely. Wipe off any glue that squeezes into the dado.

While the glue is drying, cut the stock for the pads (Photo 5). These are made by hand sawing and planing, or by cutting with a bandsaw, if you have one. Then, nail and glue them in place on the base arms (Photo 6) and clamp securely. The stock also can be



1 Rip post stock to width on a table saw or a table-mounted circular saw with extension table.



2 This shop-built table works well for crosscuts using a fixed-angle miter gauge and an extension table.

Lead photo: J.R. Rost
How-to photos: Rosario Capotosto
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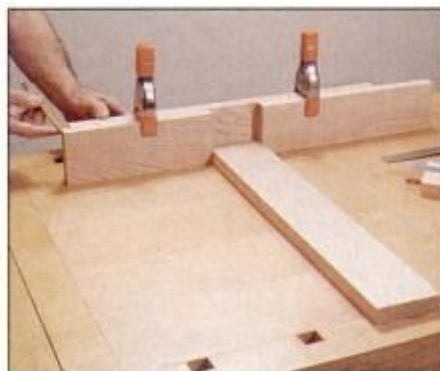
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thinned by using a router fitted with an oversize base, as shown in the drawing on page 60.

Next, using a crosscut saw, cut the broad, angled faces on the top surface of each base arm (Photo 7). Then plane the surface smooth and square. Use a router with a 1/4-in.-rad. rounding-over bit to ease the corners. The larger radii shown in the plans are formed by hand sanding or using a bench-mounted finishing sander, as shown on page 60. Finish sand the base parts, then assemble them with glue and screws. Check for square and then put aside while the post supports are made.



3 Temporarily clamp mating base members together to establish a tight fit. Then mark the short blocks to length and cut.



5 Once the base pads are resawed and planed smooth, cut them to length. Then glue and nail them to the base members.



9 Smooth the post support edges with a spokeshave. Use the type with a curved base and always cut with the grain.

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Post supports

Cut the post support blanks from 5/4 stock, then lay out and cut the curved outlines using a sabre saw (Photo 8). Smooth the curved edges with a spokeshave (Photo 9), using the curved-base type to work the concave portions and the flat-base type for the convex sections. Finish up the supports by rounding over the edges with a router (Photo 10).

Because the supports are attached to the post with dowel pins, a doweling jig is essential for achieving perfectly aligned perpendicular holes. Draw matching centerlines on the post and supports, then bore $\frac{5}{16}$ -in.-

dia. holes to a depth of $1\frac{1}{16}$ in. for each member (Photo 11).

Next, bore the holes for the lag-screw that joins the post to the assembled base using a drill guide to keep the holes square. Then, bore the lag-screw pilot hole in the end of the post (Photo 12). A drill guide is indispensable in making this hole.

Final assembly is accomplished in two stages. First, join the supports to the post with glue, dowels and clamps (Photo 13). Then, once this glue has cured, dry assemble the base and post and bore the pilot holes for the screws that join the two. Remove the base from the post, then bore and counter-



4 Dry assemble base components with masking tape and bore pilot holes for alignment nails that hold pieces square.



5 Use a sharp rip saw—or band saw—to resaw stock to a $\frac{3}{8}$ -in. thickness. Make the cut on the waste side of the line.



7 Use a crosscut saw to cut inclines on the top surface of the base members. Remove any cut marks by hand planing.



8 Carefully lay out the profile of the post supports, and then make the curved cuts with a sabre saw and sharp blade.



10 Ease sharp edges using router with rounding-over bit. Hold small pieces to a clamped scrap piece with masking tape.



11 Bore dowel holes in post and post supports using a doweling jig. Attach tape to drill bit to act as depth gauge.

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20-1/2" WIDE X 20-1/2" DEEP X 72" HIGH

5/16" DIA. X 1-1/4" DOWEL PIN (8 REQD.)

CLOTHES HOOK (4 REQD.)

1" RAD

2-1/4" SQUARE

EACH SQ = 1"

5/16" DIA. X 1 1/16" DEEP DOWEL HOLES (TYPICAL)

1/4" RAD. ON OUTSIDE EDGES

3/8"-DIA. HOLE

1-1/8" X 3/8"-DEEP COUNTERBORE

3-1/2"

3/8" RAD.

1/2"

1-1/4"

3-1/4"

1/2"

4"

4"

1"

2"

BOTTOM AND ELEVATION VIEWS

MATERIALS LIST—CLOTHES TREE

Key	No.	Size and description (use)
A	1	2 1/4 x 2 1/4 x 69 1/2" oak (post)
B	2	1 1/16 x 3 1/4 x 20 1/2" oak (long base member)
C	4	1 1/16 x 3 1/4 x 8 1/2" oak (short base member)
D	4	3/4 x 3 1/4 x 4 1/4" oak (base pad)
E	4	1 1/16 x 4 1/2 x 18" oak (post support)

Misc.: One 3/8 x 5" lag screw and washer; four 1 3/4" No. 10 fh screws; four No. 10 fh screws; 16 3/4" brads; 16 4d finishing nails; eight 5/16"-dia. x 1 1/4" dowel pins; carpenter's glue; 120- and 220-grit sandpaper; Minwax Jacobean Stain and Semi-Gloss Polyurethane.

3" NO. 10 FH SCREW (4 REQD.)

1-3/4" NO. 10 FH SCREW (4 REQD.)

3/8 X 5" LAG SCREW AND WASHER

4d FINISHING NAILS

3/4" BRADS

EASE THIS EDGE

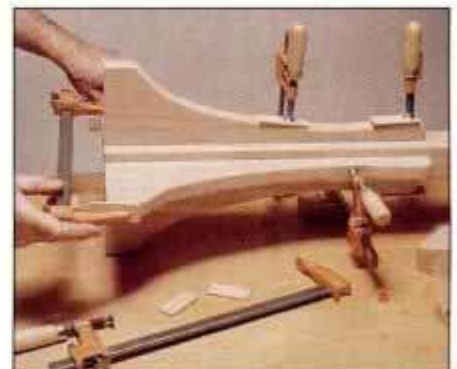
sink the screwholes in the base. Once these holes are complete, join the two assemblies with glue, screws and the center lag screw.

Next, bore the holes for the hook screws, then sand the entire project using 120-grit, followed by 220-grit, sandpaper. Remove all the dust, then stain and finish the piece. We used Minwax Jacobean Stain, followed by two coats of Minwax Semi-Gloss Polyurethane.

The cast-iron hooks (Hallway Hook No. SHF 15) are available from Van Dyke's, P.O. Box 278, Woonsocket, SD 57385. A set of four costs \$12, postpaid.



12 Bore a lag screw clearance hole in the base assembly. Then bore a pilot hole in the post using a drill guide.



13 Glue and clamp the post supports to the post and when the assembly is dry, join it to the base with its lag screw.

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Cleaning Up

A versatile pine cupboard for towels, linens and other storage needs.

By Rosario Capotosto, Contributing Editor

● There are few things more versatile than a simple pine cupboard, especially one like this that was inspired by old Shaker designs. The original versions of this venerable piece were used for storing vegetable and fruit preserves. But its traditional bearings have long since been obscured and now cabinets like this are used for just about anything, from pots and pans to toys to linens.

Constructed of solid pine, this cabinet features three roomy shelves and a frame-and-panel door that swings on self-closing hinges. We used No. 2 pine because it's still pretty affordable. But lumber of this grade can be twisted and usually features large knots, some of which are loose. To avoid, or at least minimize, these imperfections be sure to plan your work to cut around the bad areas. Another solution is simply to buy No. 1, or Select, pine. This grade is more expensive, but it's also much straighter and has fewer knots.

Sides and top

Once you've selected the best arrangement of boards, cut them to size, joint the mating edges and arrange them flat on your workbench. Hold them together with masking tape while you mark the circular cutout at the bottom with a compass (Photo 1). Next, mark the locations for your joining plates, or biscuits, which should be about 8 in. apart (Photo 2). Be sure to avoid placing a plate where the circular cutout falls.

Apply glue to the slots (Photo 3), the plates and the edges of the boards. Then insert the plates, slide the boards together and clamp securely. Use cross cauls (Photo 4) to keep the panel from bowing. When the glue has set,

scrape off any squeeze-out and use a belt sander, if necessary, to smooth the surface. Assemble the top panel in the same way.

Cut the top and side panels to width and length. If you're using a table saw, place the miter gauge in the reverse position—against the leading edge of the panel—to start the cut (Photo 5). These panels are so wide that if the miter gauge is behind the back edge, it can't reach its table groove. When the trailing edge clears the front of the table, shut off the power and, without moving the panel, put the miter gauge in its regular po-

sition and then complete the cut.

Use a band saw, a sabre saw with a pivot guide or careful freehand cutting to make the curved cutout (Photo 6). Next, using a 3/4-in. straight bit and a router with an edge guide, cut the lengthwise grooves for the face frame in the sides and the top. Use the same bit to cut the rabbet along the back edge of each panel to receive the case back (Photo 7). Also, cut the crossgrain dados on the sides with the same bit. But this time, use wood strips tack-nailed to the surface to act as a routing guide (Photo 8).

Face frame

The face frame is assembled with mortise-and-tenon joints. Begin by cutting the rails and stiles to size, then lay out the mortises in the stiles and the tenons on the rails. Using a drill press—or a portable drill and drill guide—and a 1/4-in. bit, bore a series of overlapping holes in the stiles to form the mortises. Use a chisel to square the corners and trim the walls of each mortise smooth. Then, cut the rail tenons with a dado head in your table saw and assemble the frame with glue and clamps. Make sure the assembly is square.

While the glue is drying on the face frame, use a router to round over the edges on the top and side panels. Then cut the shelves to size and sand them and the other panels smooth. Once the face frame is sanded, remove all the dust from the parts and assemble the case in this order: First, lay one side panel on the bench and apply glue to its groove and da-



This simple pine cabinet has three deep shelves for holding all kinds of wide or tall items.

Lead photos: J.R. Rost
How-to photos: Rosario Capotosto
Technical art: Eugene Thompson
Photo stylist: Gabe Herrick

does. Then, spread glue on the end grain of all the shelves and place them in the dados on the side panel (Photo 9). Apply glue to the edge of the face frame and squeeze it into place. Then, apply glue to the joints on the second side and push it into place.

Once everything is together, carefully lay the assembly on its back, install the clamps and check for square. When the glue has set, remove the clamps, glue the top in place and reinstall the clamps.

Door construction

Cut the stock for the rails and stiles to size and mark the parts for the mor-

tises and tenons that will join them. Cut these joints the same way you cut them on the face frame, using the drill press for the mortises and the table saw for the tenons (Photo 10).

Fabricate each door panel by lap joining three pieces of pine lattice. The lattice is $\frac{1}{4}$ in. thick and $3\frac{1}{2}$ in. wide, and the lap joints are formed by rabbets cut in the edges of the lattice boards. Cut these using a dado head in your table saw, making sure to clamp an auxiliary fence and a featherboard to your saw's fence (Photo 11).

Once the cutting is done, glue the lattice pieces together using masking tape as clamps (Photo 12). Use a piece

of wax paper under this assembly to keep it from sticking to your workbench. When the glue is dry, sand all the panels smooth and set them aside.

Next, dry assemble the doorframe with clamps to check for fit and square. Then rout the inside edges of the doorframe to give them shape (Photo 13).

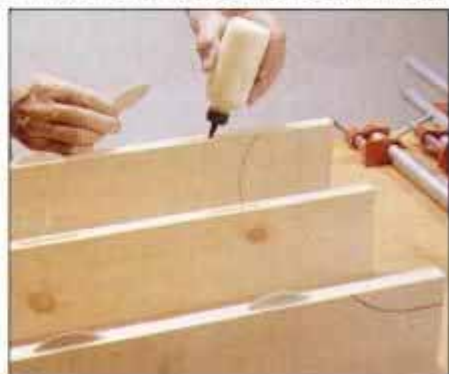
Disassemble the pieces, apply glue to the mortises and tenons and push the parts together. Slide the door panels into their grooves—but don't use any glue to hold them (Photo 14). They should float so they can move with changes in temperature and humidity. Clamp the whole assembly



1 Align the stock for the sides, and lay out the circular cutout for the feet and the location of the joining plates.



2 Using a plate joiner, cut the plate slots in the board edges. Work on a flat surface or the slots will not align.



3 Squeeze glue into slots first, then insert plates. Once the plates are installed, apply glue to the board edges.



4 Join the boards with bar or pipe clamps first. Then clamp wood cauls across the surface to keep the panel flat.



5 Glue and clamp together boards for the top panel. Once the glue has dried, cut the panel to size on the table saw.



6 Use a sabre saw with a pivot guide, or work freehand, to cut the legs to shape. Cut from the back side of the panel.



7 Cut a stopped rabbet for the back panel in the case sides, using a router with an edge guide and a straight cutting bit.

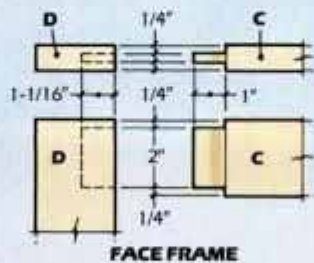
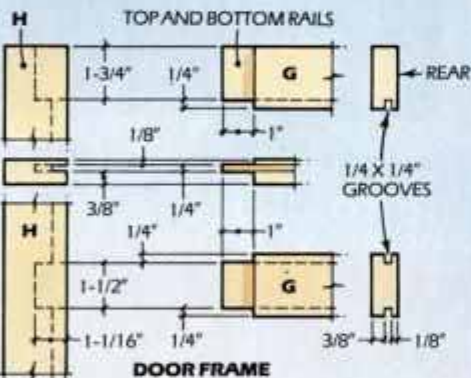
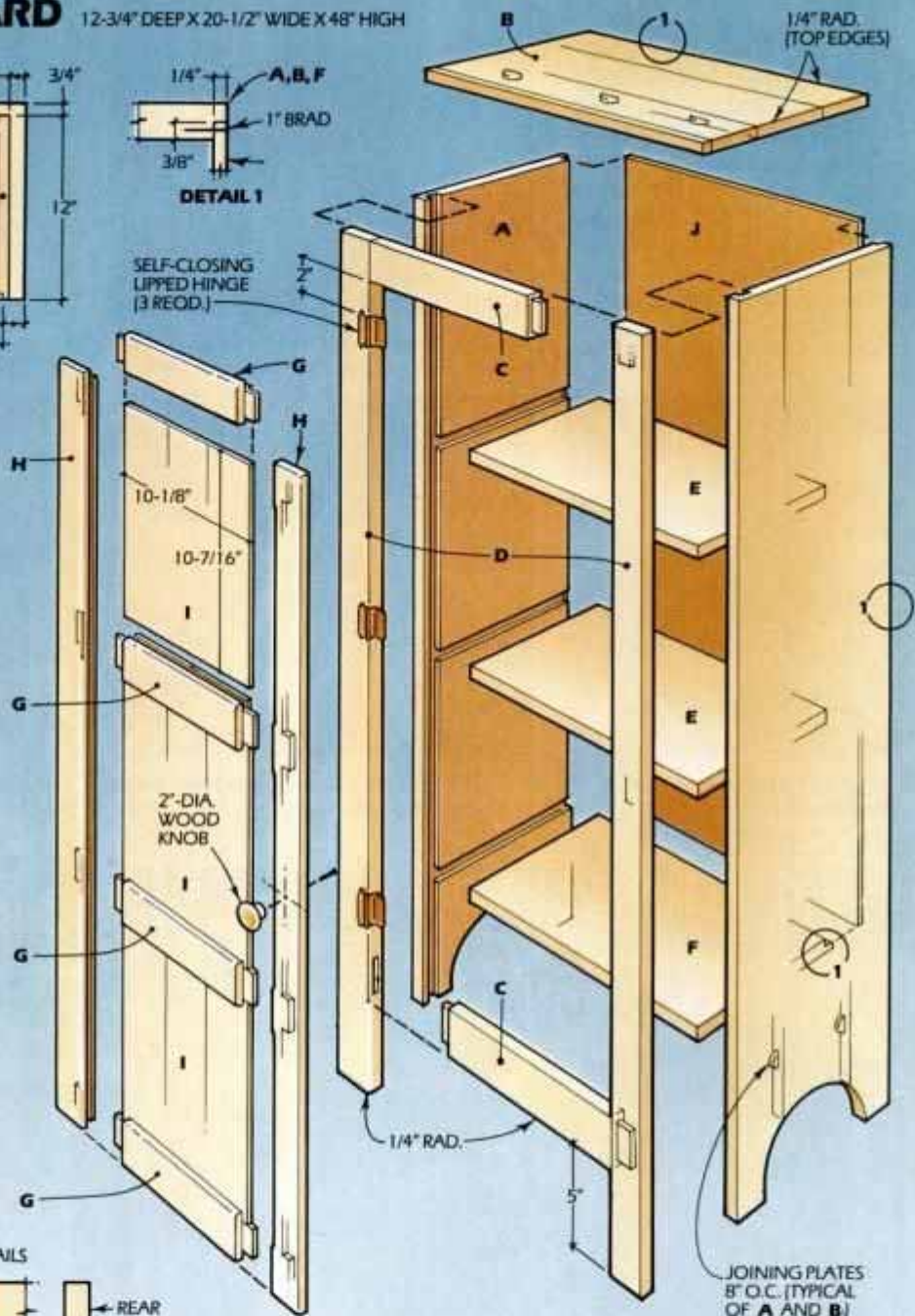
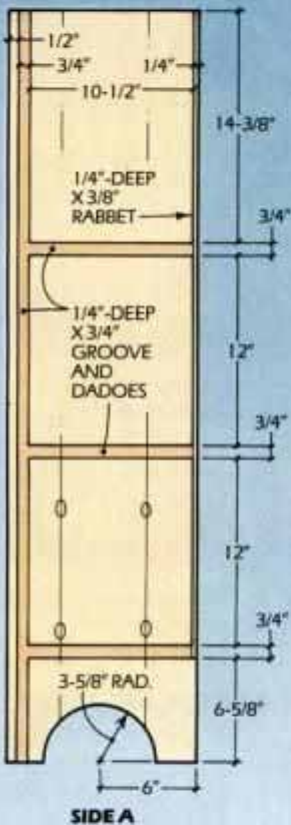
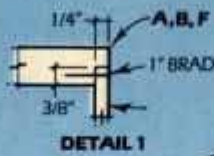
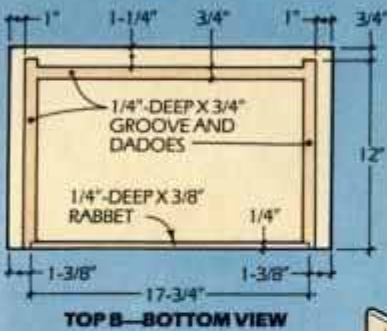


8 Cut shelf dados using an L-shaped guide. Place the short leg into the long dado and tack the other leg to the side.



9 Assemble piece on its side. First glue the face frame and shelves to one side, then add second side and clamp.

PINE CUPBOARD 12-3/4" DEEP X 20-1/2" WIDE X 48" HIGH



MATERIALS LIST—PINE CUPBOARD

Key	No.	Size and description (use)
A	2	3/4 x 12 x 47 1/2" pine (side)
B	1	3/4 x 12 1/4 x 20 1/2" pine (top)
C	2	3/4 x 2 1/2 x 14 1/2" pine (rail)
D	2	3/4 x 2 1/2 x 47 1/2" pine (stile)
E	2	3/4 x 10 1/2 x 17 1/2" pine (shelf)
F	1	3/4 x 10 1/2 x 17 1/2" pine (bottom)
G	4	3/4 x 2 x 11 1/2" pine (door rail)
H	2	3/4 x 2 x 38" pine (door stile)
I	3	3/4 x 10 1/2 x 10 1/2" pine (panel)
J	1	3/4 x 17 1/4 x 40 1/2" plywood (back)

Misc: 1" brads; carpenter's glue; 120- and 220-grit sandpaper; Amerock No. BP 342S-BB self-closing lipped hinge (3 reqd.); Amerock No. BP 814 WD 2"-dia. wood knob; Minwax Wood Conditioner, Golden Oak Stain and Satin Polyurethane.

WOODWORKING GUIDE

and set it aside until it's dry. Then remove the clamps and rout the rabbet around the back edge of the door using a straight bit and an edge guide.

Finish sand the door and case with 120-grit, followed by 220-grit, sandpaper. Bore the hinge holes and temporarily mount the door to check for proper fit. Also, attach the back panel at this point. Then remove the door and finish the piece. We used Minwax Wood Conditioner to promote even staining, then applied Minwax Golden Oak Stain followed by two coats of Minwax Satin Polyurethane. **FM**



10 Use a dado head in a table saw to cut the tenons on the ends of the door rails.



11 Cut lattice stock to size for door panels. Then cut rabbets on mating edges.



12 Join panels with glue and tape. Wax paper keeps assembly from sticking.



13 Dry assemble doorframe. Then make bead cuts on inside edges.



14 Join door parts by gluing rails to stiles. Do not glue door panels in place.

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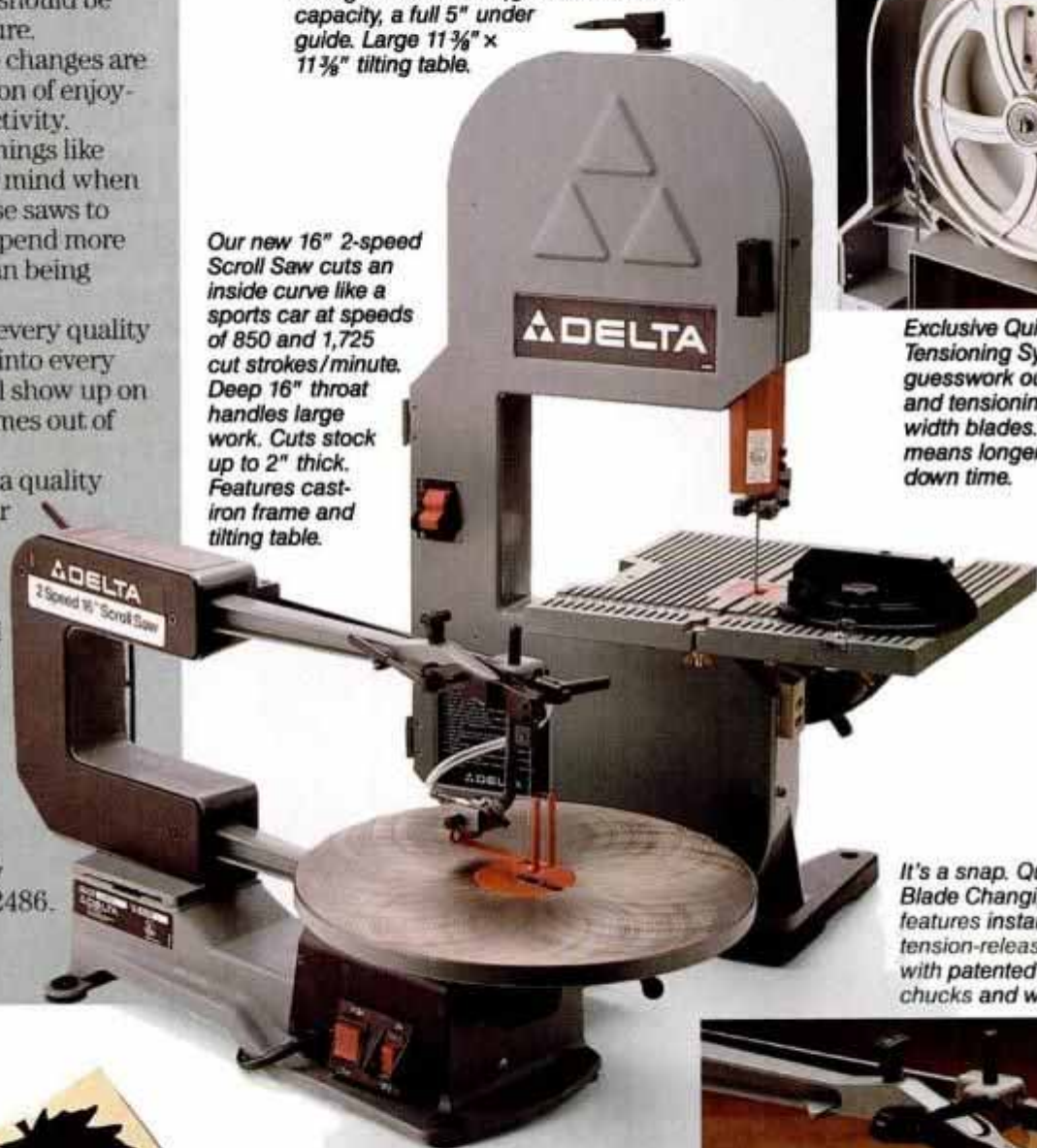
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Playing Fair

A compact folding table for card games and extra dinner guests.

By Rosario Capotosto, Contributing Editor

● The common folding table—or card table as many of us grew up calling it—is the height of simplicity and versatility in furniture design. Its sturdy and spacious top can comfortably accommodate four adults with full table service, and when the need for it passes, it can easily fold up and fit in almost any closet.

Metal versions of this clever piece are still available, but wood models have fallen out of favor, probably because the distinctive hardware needed to make the legs fold was not readily available. But recently The Woodworker's Store started selling the real thing, and we thought it would be fun to give it a try. The hardware turned out to be very sturdy and easy to install.

Many of these old tables also featured a wood top covered with a thin piece of leather that wore into a wonderfully smooth surface as the years went by. Though you can certainly use leather for the top of this piece, we decided to opt for a pliable vinyl sheet—available in a variety of colors and surface textures at most retail fabric shops—to see how it would fare. The material was very workable and much less expensive than leather. So we feel it's a sensible alternative to the classic top.

Top frame

Because a project like this requires cutting stock into relatively narrow strips, the work is best done on a table saw. But if you have only a portable circular saw, you can still tackle this job with ease if you install your saw in the simple shop-built table shown in Photo 1. Our version is dimensioned for a relatively small, 5½-in. saw. But if your saw is bigger,

simply alter the dimensions to suit your particular needs.

The accessories include a straight wood strip—which must be clamped in place—to serve as a rip fence and a one-position miter gauge with a fixed fence that aids in making right-angle crosscuts. Finally, for safety purposes, we've included a see-through saw-blade guard.

Begin construction by ripping the stock to width for the top frame pieces (Photo 2) and crosscutting them to length. If the saw leaves rough edges, use a hand plane to remove them. Next, mark the ends of each board for the half lap joints as shown in Photo 3. It's best to stack the actual pieces in their final overlapped position to en-

sure accuracy in marking. Note that the joint lines alternate on the board ends as you move around the frame.

Cut the rabbets for these half lap joints using a router with a straight bit and the jig shown in Photo 4. (Building instructions appear in the artwork on page 77.) To use the jig, clamp the work in place and make the passes required to shave away the waste. The depth of cut should equal half the thickness of the stock.

To assemble the frame, you'll need four C-clamps and eight scrap wood pads. Apply glue to the mating surfaces of each joint and drive a pair of ⅝-in. brads into the back of each to keep the members from shifting around during clamping (Photo 5). Install the clamps and protective pads and then set the whole assembly aside until dry. Once the glue has cured, remove any squeeze-out by using a sharp chisel or cabinet scraper.

Next, using a router, cut the rabbet on the inside edge of the frame that will receive the top panel (Photo 6). The plan calls for a ⅝-in.-deep rabbet, which represents the combined thickness of the plywood and the vinyl fabric. Since product sizes can vary so much, it's best to check the thickness of the materials that you have and adjust your router depth accordingly.

To complete the top frame, use a sabre saw or a coping saw to cut the radii on the four corners. Sand away any saw ripples, then use a router to round over all of the outside edges. Finish sand the entire assembly with 120-grit, followed by 220-grit, sandpaper.



This sturdy card table is made of white oak and has heavy-duty folding hardware to make storage a breeze.

Lead photos: J.R. Rost
How-to photos: Rosario Capotosto
Technical art: Eugene Thompson
Photo stylist: Gabe Herick

Apron

Cut the four apron pieces to length and width, then rout a rabbet on one end of each piece as shown in the plans. Apply glue and drive two 1-in. brads in each corner joint. Lay the frame edge down on the workbench, check the assembly for square with a triangle or square, then use masking tape to keep the assembly from moving until the glue sets (Photo 7). Once the glue is dry, round over the bottom corners, sand the faces smooth, then put the assembly aside. Remember to handle the apron with care. It won't be structurally sound until it's attached to the bottom of the top frame.



1 A shopmade table for your circular saw will yield easier, more accurate cuts. See drawing for building directions.

Legs

Cut the 1¼-in.-sq. legs from a blank made by gluing together two ¾-in. × 6-in. boards. Spread the glue on the surface of both boards (Photo 8), and use at least six C-clamps to distribute the pressure evenly.

When the glue has set, hand plane one edge of the slab so it's straight, flat and smooth. Then set the fence on the circular saw table to rip the four legs. If the blade projection is too shallow on your table to make a through cut, just flip over the stock and make a second pass (Photo 9).

Mark the hole locations for the leg brace rivets as indicated on the tem-



2 Using shop-built table, rip top frame members to width. Clamp blade guard in place and use pushstick for safety.

plate that comes with the hardware. Cut to shape and sand smooth the round top of each leg. Then bore the rivet clearance holes. These holes must be perfectly perpendicular to the surface of the leg, so some form of drill guide should be used for this job (Photo 10). Finish sand the legs with 120-grit, followed by 220-grit, sandpaper before attaching the hardware. Also be sure to round over the outside corner edges of the legs.

Because the upper screwholes for this brace are located close to the top edge, where drill access would be impossible after assembly, mark and bore the pilot holes now (Photo 11).

Next, clamp the apron in place and bore screw pilot holes through the apron and into the underside of the top frame. Remove the apron and enlarge the holes to match the screw shank size. Then counterbore for the screwheads and reattach to the top.

Top panel

If your circular saw is still mounted to the table, remove it to cut the top plywood panel to size. Use a clamped straightedge strip to guide the saw, and once the panel is cut, round the corners to match the inside corners of the top frame. When the panel fits exactly, turn over the assembly and



3 Align the top frame members as shown, then mark cutting lines for corner half lap joints directly on the boards.



4 Use our easy-to-build router jig for cutting the half lap joints. Just slide in the stock, clamp in place and rout.



5 Assemble frame parts facedown. Apply glue, then drive two alignment brads through both pieces and clamp.



6 Use a router and a rabbet bit to make the recess cut in the top frame for the top panel. Make cut in several passes.



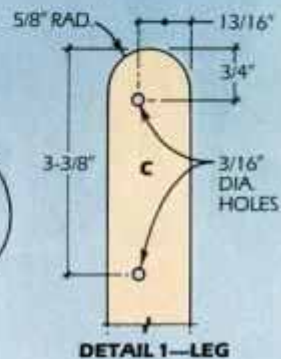
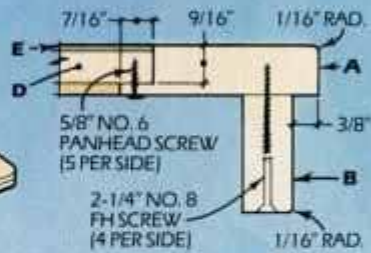
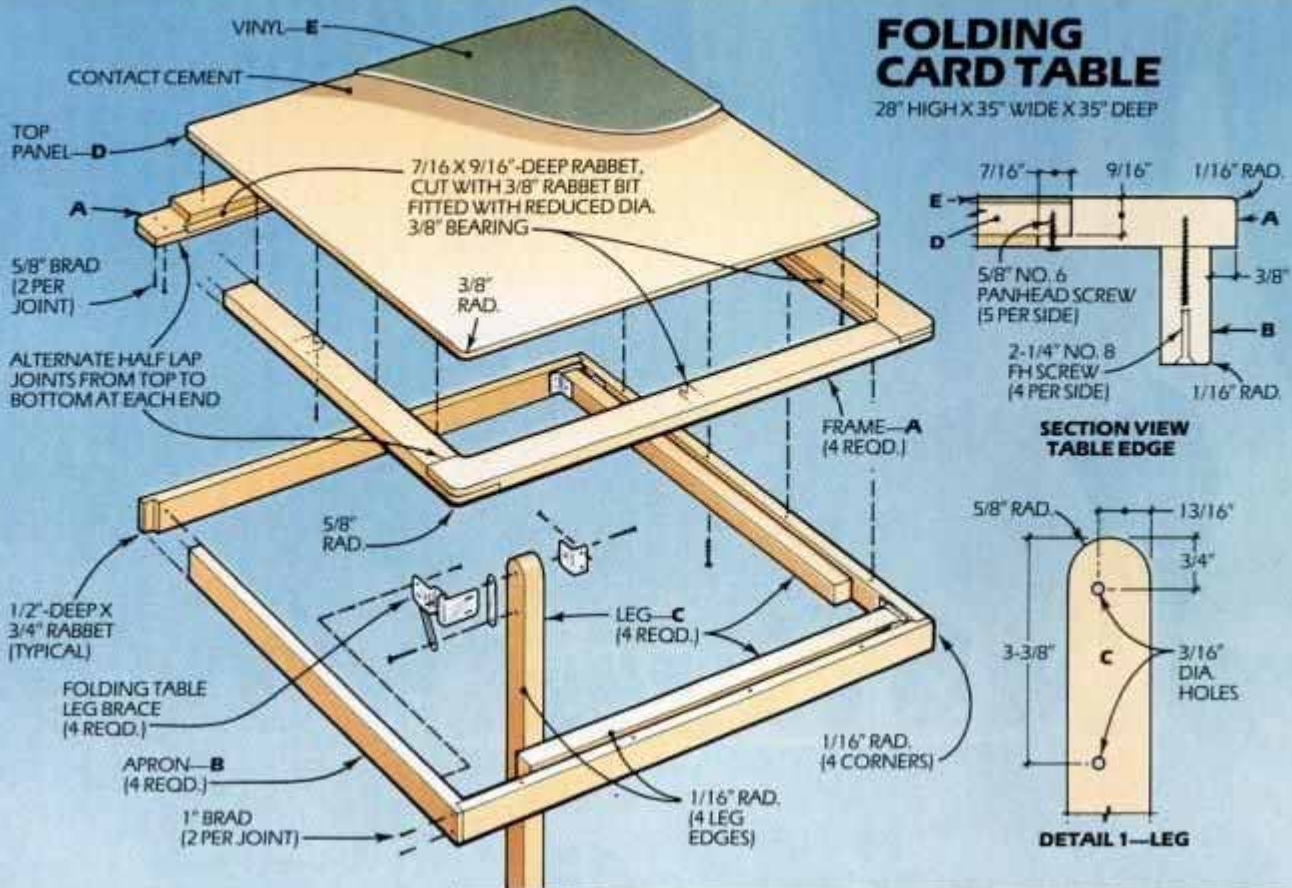
7 Fabricate the apron pieces, then join them with glue and brads. Hold the joint in square alignment using masking tape.



8 Obtain the stock for the legs by gluing up two ¾ boards. Spread the glue evenly and clamp boards securely.

FOLDING CARD TABLE

28" HIGH X 35" WIDE X 35" DEEP



MATERIALS LIST—CARD TABLE

Key	No.	Size and description (use)
A	4	3/4 x 3 x 36" oak (top frame)
B	4	3/4 x 1 1/2 x 34 1/2" oak (apron)
C	4	1 1/4 x 1 1/2 x 27 1/2" oak (leg)
D	1	1/2 x 29 1/2 x 29 1/2" plywood (top)
E	1	36 x 36" vinyl sheet

Misc: 5/8" brads; 1" brads; 5/8" No. 6 panhead screws; 2 1/4" No. 8 fh screws; 120- and 220-grit sandpaper; carpenter's glue; contact cement.

ROUTER JIG FOR CUTTING FRAME JOINTS

DIMENSIONS MUST MATCH ROUTER BASE-TO-CUTTER MEASUREMENT

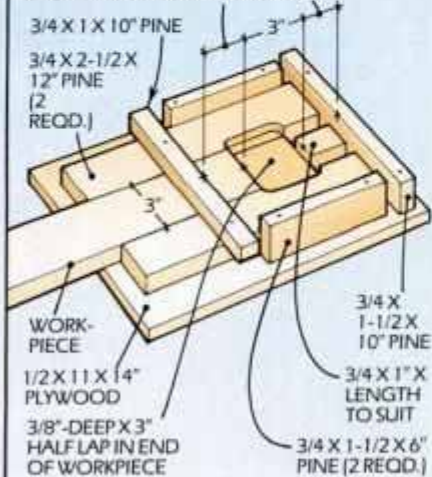
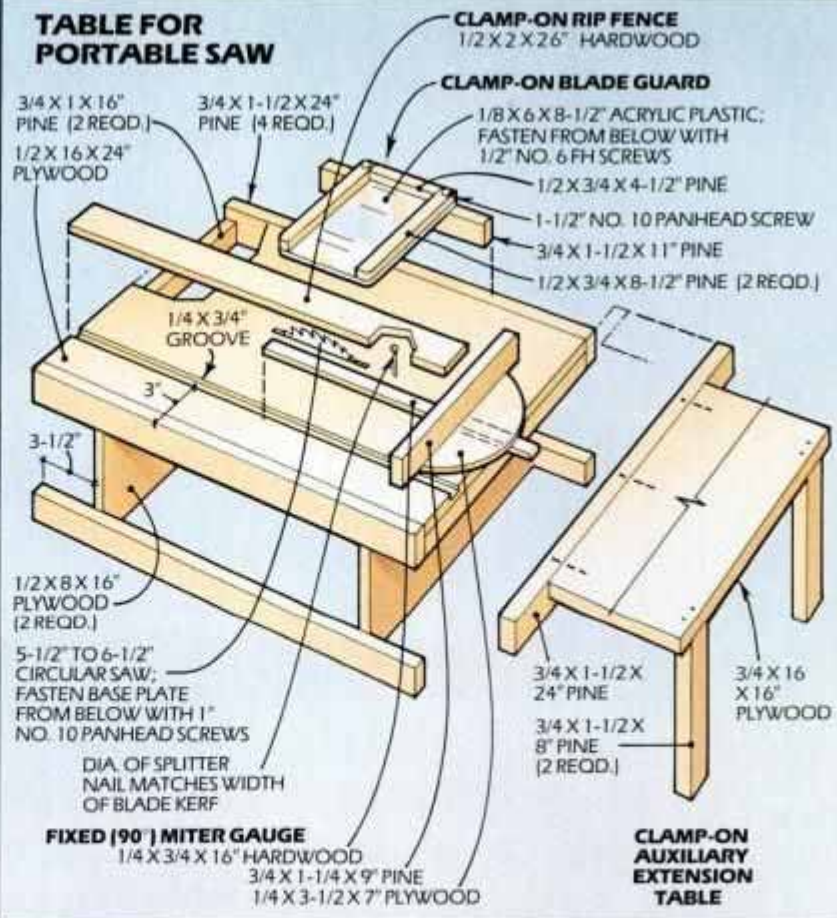
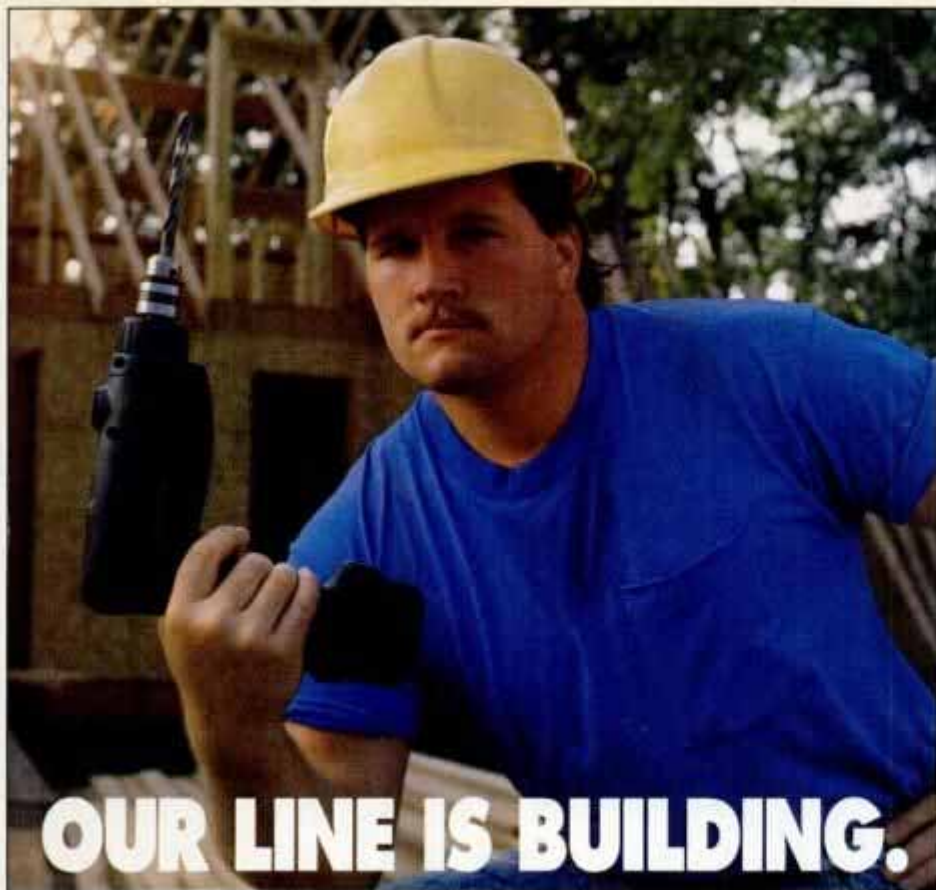


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bore pilot holes for the screws that join the two.

Next, cut the vinyl fabric about 2 in. larger than the top panel in both directions. Tape down the corners to keep it in place, then apply a coat of contact cement to the back of the vinyl (Photo 12). Also apply a coat of cement to the top side of the panel. Allow the cement to dry according to the manufacturer's instructions.

The cement-coated surfaces will bond immediately and permanently when contact is made, so you must take precautions against misalignment. We used what is called the slip-sheet method. To use this, just cut



9 If you use our table to rip the legs, its shallow blade projection requires cutting in two passes, one on each side.



12 Cut the sheet vinyl to rough size. Then using a short bristle brush, apply contact cement to its bottom side.



15 Use a roller to smooth the vinyl in place. Then turn over the panel and trim off the excess with a sharp utility knife.

two pieces of kraft paper slightly bigger than half the size of the panel. Then lay the paper on the panel (Photo 13), slightly overlapping the pieces in the middle. Position the vinyl so it overhangs the panel on all sides, too. Then slide out one paper sheet and allow the cement surfaces to make contact. While holding up the other end of the vinyl, slide out the remaining sheet (Photo 14) and carefully lower the rest of the vinyl into place. Allow it to make contact slowly as the other hand sweeps across the surface to press it into place. Exert final pressure with a roller, then turn over the panel and use a sharp knife to trim off

the excess (Photo 15).

While the top panel is still separate from the top frame, apply the finish of your choice (Photo 16). We used three coats of Minwax Colonial Walnut Wood-Sheen Stain and Finish, allowing 2 hours of drying time between coats. Seal the back of the panel with two coats of shellac. When everything is dry, attach the legs and top (Photo 17), and you're done.

The folding leg hardware is available from The Woodworker's Store, 21801 Industrial Blvd., Rogers, MN 55374. A pair is part No. 63198. The two pairs needed for this project cost \$25.40, postpaid. **PM**



10 Lay out brace rivet holes in the legs. Then bore them using a drill with a guide to keep holes perpendicular.



11 Temporarily place all the folding hardware on the legs and aprons. Then mark all the bracket screwholes.



13 Cut the top plywood panel to size and shape. Then sand it smooth and cover it with two pieces of kraft paper.



14 Carefully align the vinyl over the kraft paper, then lower it into place. Slip out the paper sheets one at a time.



16 Check the top panel for fit. Then remove, finish sand the frame and apply the finish before installing the top.



17 Attach the legs to the frame assembly and slide the top panel into place. Attach the panel with screws from below.

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Standing Tall

A 7-drawer mahogany chest that can fit just about anywhere.

By Rosario Capotosto, Contributing Editor

● Most dressers are basically horizontal furniture pieces, and with good reason. This shape allows for plenty of drawer space and yields a broad flat surface on top that is always handy in a bedroom. Of course, a substantial dresser can occupy quite a bit of floor space, which is a real problem in a smaller bedroom.

The obvious way to cope with such tight quarters is to create a piece that is predominately vertical. It should occupy a smaller footprint and achieve its large storage volume by extending up much higher. Its only shortcoming would be a lack of a large, open top.

The piece shown here is just such a problem solver, and it is by no means a new idea. Such pieces have been around for centuries and have borne many different names—from the traditional high-boy chest description, to the enticing appellation of lingerie chest (one drawer for each day of the week), to the more prosaic description of tall chest. No matter what the name, the virtues of this piece remain unchanged: It has a lot of storage space and can fit just about anywhere.

Our version is made of solid mahogany, with a little poplar thrown in for the drawer and divider-frame parts. We chose mahogany to impart a traditional feel to the piece. But you can use any wood species you'd like—the construction details remain the same.

Case sides and top

Begin by joining narrower boards to make up the top and sides. Cut the boards about 1 in. longer than the finished size to allow for trimming after gluing. Also, add a bit extra in width for

the same reason. Keep in mind that if you don't have a jointer, you can effectively joint your edges on a table saw. Just tack-nail a metal straightedge guide to one side of a board, letting it extend just over the edge. Then make your rip cut, keeping the metal guide against the fence for the entire cut (Photo 1). This will create one straight edge. To straighten the other, simply turn over the board and rip the rough edge.

Once all your stock is prepared,



1 To straighten stock on table saw, tack-nail metal rule to one edge, then rip. Remove rule and rip other edge.



2 Because pencil marks are hard to see on darker woods, apply tape to edge then lay out frame dados.

glue and clamp the boards together, let them dry and then use a cabinet scraper or belt sander to smooth the surfaces. Finish up the edge-joining process by cutting the panels to finished size.

Next, mark the side panels for the dados and rabbets. If you want your pencil marks to be more visible, make them on a strip of masking tape—applied along the edge—rather than on the surface of the dark mahogany (Photo 2). Then set up a dado blade in your radial saw and cut all the dados (Photo 3). When these are done, readjust the blade to make the rabbet cuts on the top edges of the sides and the end edges of the top. Next, using a router with a rabbet or straight bit, cut the stopped rabbets on the sides and top for the case back. Use a sharp chisel to square the corners.

To join the narrow strips to the front of the sides and top, begin by marking the location of the joining plates. Then use the jointer to cut slots for No. 0 plates (Photo 4). Spread glue in the slots, on the plates and on the edge, then push the boards together. Install clamps and set the assembly aside to dry (Photo 5).

Support frames

Rip poplar stock to width for the drawer support frames and crosscut the frame members to length. Mark the short pieces for mortises and the long ones for tenons. Then mount a dado blade in a radial-arm or table saw and cut the tenons (Photo 6). Be sure to clamp a stopblock in place on the fence so that all of the repeti-

Lead photo: J.R. Rost
How-to photos: Rosario Capotosto
Technical art: Eugene Thompson
Photo stylist: Gabe Herrick

tive cuts will be exactly the same.

Begin cutting the mortises by boring a series of overlapping holes in the stock (Photo 7). Once the holes are bored, use a chisel to pare the walls of the mortises smooth (Photo 8). Before joining the frame members, several specialized holes must be bored. First are the slotted holes near the back of each side frame member. These holes are for the screws that help hold the frames to the sides.

Next, bore three clearance holes in each front frame member for three alignment nails. These nails are used to position the mahogany facing strips that will cover the front of the frames

later. Finally, bore the holes for the drawer stopblocks. Then apply glue to the mortise and tenon joints, push the parts together and clamp securely (Photo 9). Check for square and put the assemblies aside to dry.

Case assembly

Begin by laying one side panel face-down on your bench. Then slide a frame into each dado and check for fit. On the edge of each front frame, mark the corner formed by the frame and the dado (Photo 10). Remove the frames and install them in the other side panel and mark the dado joints again. The distance between these

two marks on each frame represents the length on the facing strip. Next, cut these mahogany strips to length, then glue, clamp and nail them to the frames (Photo 11).

Once all the facing strips are in place, dry assemble the case to check for proper fit (Photo 12). Then bore pilot holes for the three flathead screws in the top rabbets on each side. Measure for the back plywood panel, cut it to size and set it aside.

Because the final case assembly can take awhile, we recommend using slow-setting hide glue for this phase of the work. Begin by gluing and screwing the top to one side panel. Apply glue to the entire rabbet joint, because the grain runs the same way in the top and side and therefore wood movement will not be a problem. On the frame assemblies, however, glue is applied only to the front third of the dado and frame. The back of the frame is held to the side with screws.

When all the frames have been installed, apply glue to all the joints on the second side panel. Then, with a helper, carefully position this panel over the frame assemblies and push the joints together, working from one end of the case to the other. Install clamps and check for square.

While the glue dries on the case, fabricate the top and bottom moldings using a table-mounted router. Form the top molding—on a 1-in.-wide strip—with two passes over two different bits: first, a $1\frac{5}{16}$ -in. cove-and-bead bit (Bosch No. 85604M), then an ogee fillet bit (Sears No. 21257). On the first pass, hold the board broad face down. When you switch to the ogee bit, run the work on its edge.

Form the base moldings with the same bits but on separate strips of stock. First, run a 2-in.-wide strip—on edge—over the ogee bit. Then switch bits and run a $1\frac{1}{2}$ -in.-wide strip—broad face down—over the cove-and-bead bit (Photo 13). Glue



3 Adjust radial-arm saw for proper dado depth then test cut a scrap block. When satisfied, cut dados in both case sides.



4 Clean out mortises in frame members using sharp chisel. Mortise walls should be exactly perpendicular to stock edge.



5 Apply glue to frame mortises and tenons, then clamp securely. Check for square and readjust clamps if necessary.



6 Cut to size narrow stock that closes front of the dados. Use plate joiner to cut matching slots in side and strip.



7 Place No. 0 plates in side slots and push strip onto plates. Check for fit, and when satisfied, glue and clamp.

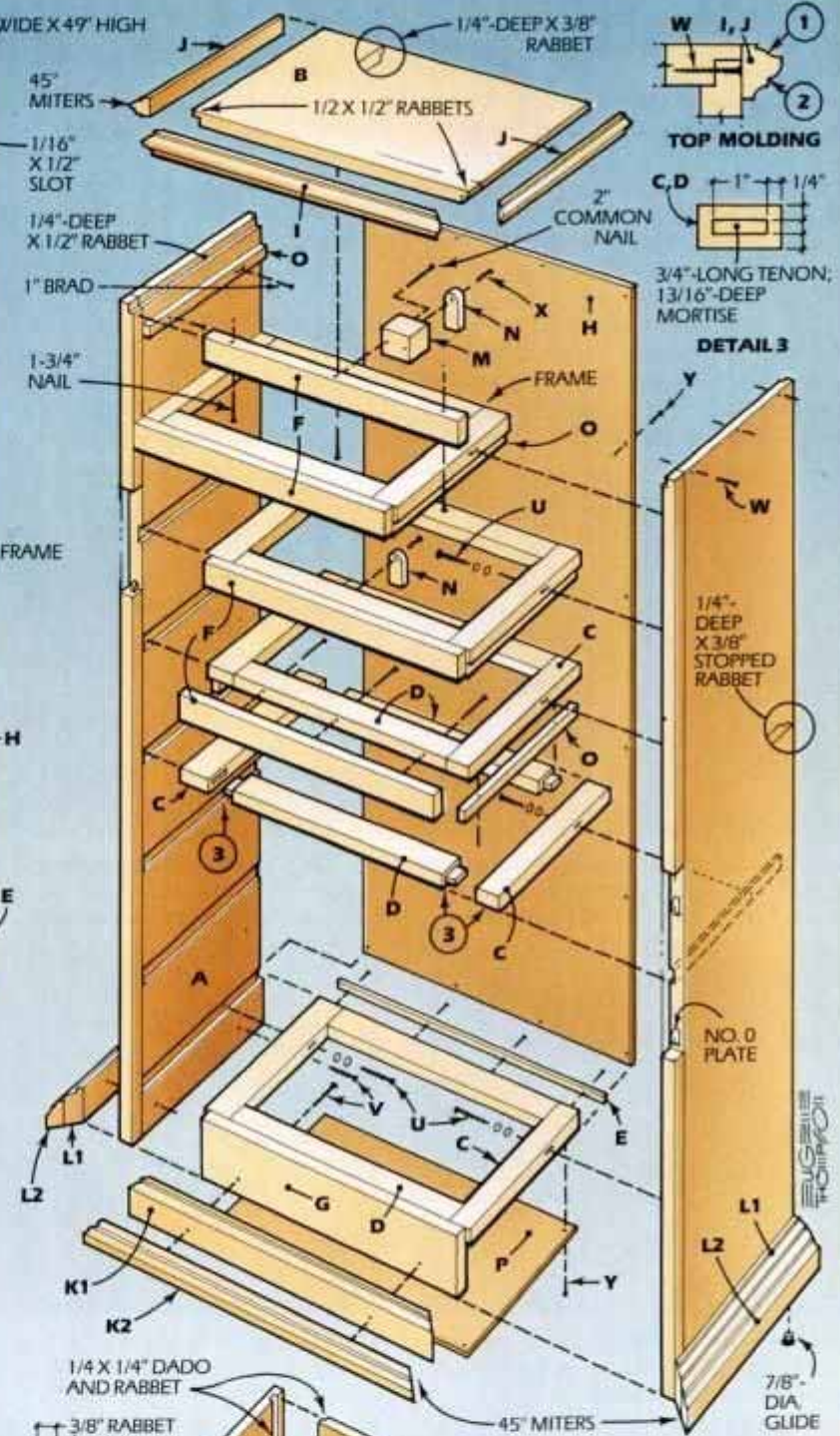
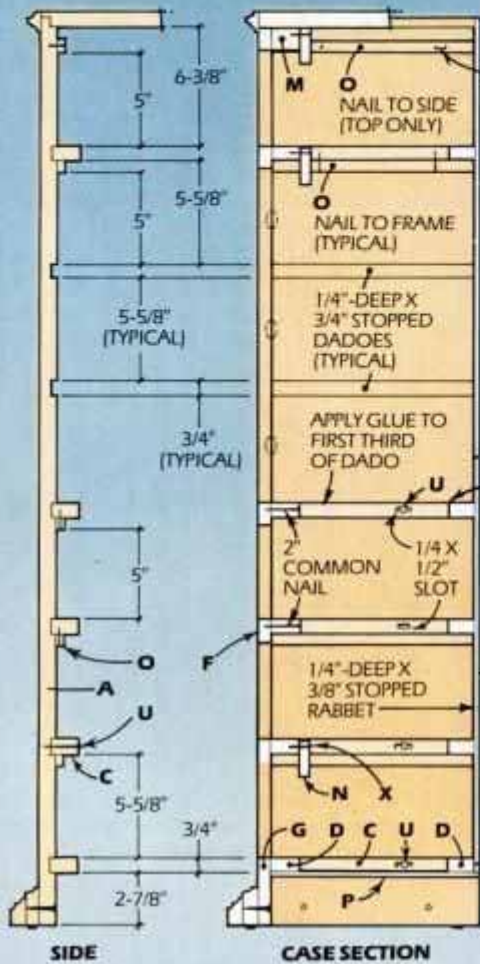


8 Use radial saw and dado blades to cut tenons on frame members. Clamp stop-block to fence to ensure identical cuts.



9 Bore mortise holes in frame parts on drill press. Clamp fence with stopblocks in place to limit board travel.

TALL CHEST 13-1/2" DEEP X 22-1/2" WIDE X 49" HIGH



MATERIALS LIST—TALL CHEST

Key	No.	Size and description (use)
A	2	3/4 x 12 x 48 1/2 mahogany (side)
B	1	3/4 x 12 x 19 1/2 mahogany (top)
C	14	3/4 x 1 1/2 x 11" poplar (frame rail)
D	14	3/4 x 1 1/2 x 17" poplar (frame rail)
E	1	1/2 x 3/4 x 18 1/2" poplar (strip)
F	7	3/4 x 1 1/4 x 18" mahogany (facing)
G	1	3/4 x 3/4 x 18" mahogany (facing)
H	1	1/2 x 18 1/4 x 45 1/2" plywood (back)
I	1	3/4 x 1 x 21" mahogany (molding)
J	2	3/4 x 1 x 12 1/2" mahogany (molding)
K1	1	3/4 x 2 x 21" mahogany (molding)
K2	1	3/4 x 2 x 22 1/2" mahogany (molding)
L1	2	3/4 x 2 x 12 1/2" mahogany (molding)
L2	2	3/4 x 1 1/2 x 13 1/2" mahogany (molding)
M	1	1 1/4 x 1 1/2 x 2" poplar (block)
N	7	1/2 x 3/4 x 2" poplar (drawer stop)
O	14	1/2 x 3/4 x 10 1/2" poplar (cleat)
P	1	1/2 x 11 1/2 x 18" plywood (bottom)
Q	7	3/4 x 5 1/2 x 18 1/2" mahogany (drawer front)
R	14	1/2 x 4 1/4 x 11 1/2" poplar (drawer side)
S	7	1/2 x 4 1/4 x 17 1/2" poplar (drawer back)
T	7	1/4 x 11 1/2 x 17 1/2" plywood (drawer bottom)
U	14	2" No. 10 rh screws and washers
V	6	1 1/2" No. 10 fh screws
W	6	1 1/2" No. 8 fh screws
X	7	1 1/4" No. 10 panhead screws
Y	16	3/8" No. 4 fh screws
Z*	7	drawer pulls

Misc: 2" common nails; 1 1/4" finishing nails; 1" brads; 3/4" brads; No. 0 joining plates; 3/8"-dia. furniture glides; 120- and 220-grit sandpaper.
 * No. SB720 2 1/2" brass drawer pulls available from Constantine's, 2050 Eastchester Rd., Bronx, NY 10461; (800) 223-8087.

NOTES:

- CUT WITH OGEE FILLET ROUTER BIT
- CUT WITH COVE-AND-BEAD ROUTER BIT

these pieces together—back to face—and hold them with masking tape.

Next, cut the molding pieces to length and miter their outside corners. Glue and clamp the top molding in place. Then glue, clamp and screw the bottom molding to the case (Photo 14). Once the moldings are installed, attach the drawer stopblocks to each frame and install the spacer cleats that keep the drawers from tipping downward when opened (Photo 15). Note that the cleats are nailed to the bottom of the side frame members, not to the side panels, except at the top. The top cleats do get nailed to the side because the wood movement

problem is avoided by making slotted expansion holes for the nails.

Drawers

These drawers feature overlapping fronts, joined to the drawer sides with dovetails. The backs are secured to the sides with corner dado joints. The bottoms fit into simple grooves. All these rabbets, dados and grooves are cut on a table or radial-arm saw with a dado blade installed.

Cut the stock for the drawer fronts to size, then cut a rabbet completely around the inside surface of each piece. Cut the 1/2-in.-thick stock to size for the sides and the backs, then cut

the rabbets on the ends of the back pieces and the dados on the ends of the side members.

We cut our dovetails using a router jig that is comprised of a template and a dovetail router bit (Photo 16). Setup and cutting procedures will vary depending on the jig you use, so refer to your operating manual for instructions on cutting these joints.

When the dovetails are complete, cut the grooves for the bottom panel in the front and sides of each drawer. Then cut the bottom panels to size and bore the clearance holes for the drawer pulls through the drawer fronts. Next, install a 1/8-in.-rad. beading bit



10 Slide all drawer frames into their dados. Then mark on frame edge exactly where frame facing boards should stop.



11 Cut frame facing to length and clamp in place. Then tap frame nails into back of facing to create alignment dimples.



12 Join frames to sides with hide glue. Apply glue to front third of joint. Back is held with screws in slotted holes.



13 Use a router table, or a table saw with a molding cutter head, to cut the base and top moldings for the case.



14 Cut base molding to size. Bore pilot holes for screws that join molding and case. Clamp together and drive screws.



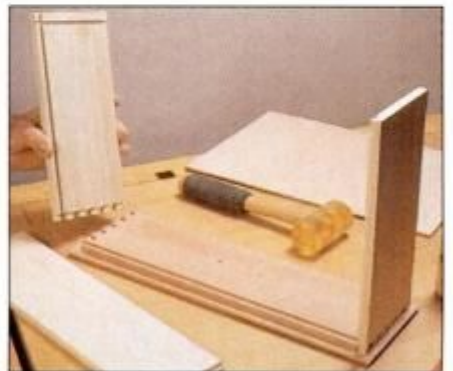
15 Cut drawer spacer cleats to size, then nail them to bottom edge of frame members, not to the case side.



16 Cut dovetails by hand. Or use router template. Just align template, according to maker's directions, and rout.



17 Cut outside bead on drawer front with router table. Hold backup board against workpiece to prevent tearout.



18 Check the fit of all drawer parts before assembly. Then apply glue to the joints, slide the parts together and clamp.

in a router table and shape the edges of the drawer fronts. Make the cross-grain passes on the ends first, holding a backup block against the trailing edge to prevent any tearout (Photo 17). Use the same bit to round over the top edges of the drawer sides.

Sand all the parts smooth and remove the dust. Then assemble the drawers with glue (Photo 18) in this order: Fit one side onto the front, then the back onto the side, followed by the second side onto the back and then onto the front. Slide the bottom panel in place, then attach it with nails driven into the bottom edge of the back piece. Also drive a couple of brads into the box dado joints at the rear of all the drawers.

Finishing

Finish sand the entire cabinet with 220-grit sandpaper and ease all sharp corners. To obtain the rich, deep mahogany tone, the cabinet was first given a coat of Behlen's Solar Lux Medium Red Stain (Photo 19). This is a nongrain-raising stain formulated for spray application. If you're brushing by hand, like we did, it must be mixed with a retarder to slow the drying rate. We added 1-part retarder to 6-parts stain.



19 Apply stain to drawer fronts with clean, soft cloth. Retarder is added to stain to keep lap marks from showing.



20 Apply filler to stained surfaces. When filler reflection begins to dull, wipe off across the grain with a coarse cloth.

Next, seal the stain with a wash coat of shellac—mix 6-parts alcohol with 1-part 3-pound-cut, white shellac. Apply full-strength shellac to the inside of the cabinet and to all the surfaces of the drawers except, of course, the outside of the drawer front.

Then mix a natural paste wood filler with burnt umber Japan color, to match the color of the stained piece, and spread on the filler (Photo 20). Let this filler dry until it starts to become dull, then wipe it off—working

across the grain—using a burlap cloth. Once the bulk of the filler is removed, wipe lightly in the direction of the grain with a clean, soft cloth.

After letting the piece dry, apply a wash coat of shellac. Then let the shellac dry and lightly sand the surface to remove any small imperfections. We finished up by applying two coats of Behlen's Clear Gloss Brushing Lacquer. When the finish is complete, install the back panel and drawer pulls and you're done. **PM**

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Viewing Habits

A modified cherry clothes press for watching TV in bed.

By Rosario Capotosto, Contributing Editor

● It's difficult to think of a home appliance that has made—and continues to make—a bigger impact on our lives than the television. The myriad sensibilities that come through this electronic eye may entice or irritate, but usually—in one way or another—they do compel. The box itself—especially many of today's flat screen, flat-back models—is another story. Many people consider the tube unattractive or, at the very least, not something they want staring back at them 24 hours a day. And while most of us may have come to grips with this Orwellian box in the family room or den, it can still seem out of place in the bedroom.

In the hopes of putting a better face on your bedroom TV, we designed this traditional clothes press. It can accommodate a full-size TV and VCR while still boasting plenty of room for tape storage. Plus, it has three spacious drawers for clothes or linens. And, we used special cranked hinges that swing 250° instead of the usual 180°, so the doors can open almost flat against the cabinet sides.

The joinery techniques required for this piece run the gamut from mortise-and-tenons, to dowels and plate joints, to traditional dovetails and dados. So you'll have a chance to hone a number of different skills before you apply the finish.

Just a word of caution before you begin: This piece was dimensioned to hold the basic 20-in. television. Recent RCA, Sony and Hitachi models should all work well. But no matter which brand or model TV you have, be sure to measure it before you start building—and, if necessary, alter our dimensions to suit your particular needs.

Case construction

Start by cutting the stock to size for the door, side and top rails and stiles. Note that one door stile is slightly wider than the others to allow for a rear overlap where the two doors meet. Use a dado blade in a table saw to cut the panel grooves in the rails and stiles (Photo 1). Be sure to fabricate the door and case members separately, because the grooves in the case members are centered while those in the door members are off-center and of a different dimension. However, since the top frame members are grooved the same as the side

frames, cut these grooves with the same dado setup. You should also be aware that our plans show ¼-in.-wide grooves used to seat the plywood panels in the case sides and top frame. Hardwood plywood commonly measures slightly less than ¼ in. thick, so check the thickness of your plywood and size the grooves accordingly.

After the grooves are cut, lay the door rails and stiles facedown on the table saw and cut a ¼-in.-wide setback on the face of the grooved edges. This allows space for the bead molding that will be applied later.

Next, mark the mortise locations on the stiles and use a drill press to bore overlapping holes to remove most of the mortise waste (Photo 2). Then follow up with a sharp chisel to square the corners and smooth the walls (Photo 3).

To cut the tenons, adjust the dado blade to make equal depth cuts on both faces of the side frame rails. Be sure to clamp a stopblock on the miter gauge fence to ensure identical repetitive cuts (Photo 4) and to form a haunch on all the tenons to fill the groove holes (Photo 5). Readjust the cutter height, as required, to make the tenon cuts on the ends of the doorframe rails.

Temporarily dry assemble the case side frames and use a ¼-in.-rad. rounding-over bit to ease the corners that will be visible (Photo 6). Also, hand sand the groove edges with a felt-lined sanding block. Disassemble the frame, and then cut a rabbet in the rear stiles to recess the back panel. Cut the 1-in. setback for the doors in the front stiles.



When the cabinet is closed it reveals the tasteful lines of a traditional clothes press. But inside, it has room for a full-size TV and two VCRs.

Lead photos: J.R. Rost
How-to photos: Rosario Capotosto
Technical art: Eugene Thompson
Photo stylist: Gabe Henick

Next, cut the plywood insert panels to size and sand the faces. Dry assemble the frames again, to check the fit of the panels (Photo 7). When satisfied, use hide glue and clamps to assemble the side frame parts. Then, make a simple jig to guide your router and cut the stopped dados and rabbets in the case sides (Photo 8). A stopblock nailed at one end of the jig will control the router's travel. Square the ends of the dados with a chisel.

Now, fabricate the maple frames inside the cabinet. Begin by cutting the stock to size, and use a doweling jig to bore the holes for the dowel pins (Photo 9). Note that the VCR-compartment frame receives a half-lapped crossmember that supports a vertical dividing panel. When all the parts are cut, glue and clamp them together. Check each assembly for square, then set them aside to dry. After the glue is set on the VCR shelf, cut a groove in the crossmember—and a dado in the frame parts above—for the compartment divider panel. Assemble the frame and panel that form the top of the case and the TV support slab.

Then dry assemble all the crossframes with one case side lying on the bench. Add the other side and check everything for fit. When satisfied, cut



This cabinet not only hides the TV, it also features two false drawers with drop-down lids, which can house a single VCR and plenty of tapes or two VCRs.

the plywood back panel to size and temporarily tack-nail it in place. Then, measure the length of the cherry edge banding at each crossframe location. (In theory, they should all be identical, but discrepancies do creep in, so it's best to measure and cut each to fit its space.) Disassemble the case. Glue and clamp the strips in place on the frames and the TV slab.

Assembly of the case is best handled in two stages. You'll need eight bar or pipe clamps, two 7-ft. cauls and four more cauls that are about 1 ft. longer than the width of your workbench. Begin by laying one side of the case on your bench. Apply hide glue to



1 Cut stock to size. Then cut panel grooves in cabinet and door rails and stiles using dado blade in table saw.



2 Cut joint mortises in stiles by boring overlapping holes on drill press. Marked tape on surface guides spacing.



3 Clean out all mortises with sharp chisels. Make sure that mortise walls are pared smooth and square to edge.



4 Cut rail tenons using dado blade on table saw. Wood fence and stopblock on miter gauge ensure identical repeat cuts.



5 Closeup shows configuration of joint. Haunch on tenon is required to fill gap in groove above mortise.



6 Temporarily dry assemble side frame, making sure parts are square. Then round over inside edges with router and bit.



7 Assemble frame and panels using slow-setting hide glue. Add second stile only after all other parts are joined.



8 Cut shelf dados using a router and simple jig made of scrap lumber. Block at end of jig stops router travel.

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all the rabbets and dadoses, then coat the mating edges of the crossframes with hide glue as well. Slide all the frames into position and lift the second case side into place. Do not glue the second side to the frames. Install the cauls and clamps, check for square and let the glue dry (Photo 10). When the glue has set, invert the assembly and apply glue to all the joints on the second side, then reinstall the clamps.

Cut the parts for the VCR-compartment divider to size and assemble them. Then, slide this assembly into place and secure it with glue and screws. Also, at this time, add the horizontal rails that help to stiffen the



9 Lay out dowel locations in support frame members, then bore dowel holes using portable drill and doweling jig.

TV shelf, and tack-nail the back panel in place so you can bore pilot holes for the screws used to attach it permanently. Bore these holes at 6-in. intervals around the perimeter and into each crossframe. Then remove the back, countersink these screwholes, apply glue and attach the back with the case lying flat down on your workbench.

Case doors and drawers

Cut three pieces of stock—slightly oversized—for the door panels, and mark the correct planing direction (with the grain) on each board. Then, using a plate joiner, cut the joining



10 Glue and clamp case together. Clamps can bear directly on case, or be attached to cauls and workbench as shown.



11 Use plates or dowels to join stock for door panels. Locate plates or dowels clear of area that will be beveled.



12 Apply glue to slots, plates and mating edges, then clamp. When dry, smooth panel surface with hand plane.

slots—three per edge—in all the mating boards. When this is done, glue and clamp the boards together, keeping all the grain lines pointing in the same direction (Photo 11). Once the glue is dry, use a sharp hand plane to reduce the thickness of the panels to approximately $\frac{5}{16}$ in. (Photo 12).

Dry assemble the doorframe members and measure the space between the grooves to establish the size for the door panel. Reduce the height dimension by $\frac{1}{16}$ in. and the width by about $\frac{1}{4}$ in. to allow for expansion. Cut the panel to size, then set up a high auxiliary wood fence on your saw's rip fence. Tilt the blade to 10° for making the bevel cuts that create the raised-panel effect (Photo 13). Also use an elevated featherboard to steady the panel. Be sure to make the crossgrain cuts first to prevent tearing out the wood fibers at the panel corners.

The next step is to cut the bead molding that surrounds the door panels. Use a $\frac{1}{4}$ -in. bullnose bit in a table-mounted router. First, make a pass on the edge of both board faces. Then, use a $\frac{1}{16}$ -in. slotting bit to extend the width of the bead (Photo 14). Rip the finished $\frac{5}{16}$ -in.-wide beads on the table saw and miter their ends to fit the doorframes.



13 Cut panel bevels on table saw using high auxiliary fence and elevated featherboard as safety precautions.



14 Cut bead molding on router table with two different bits: a bullnose bit first, followed by a slotting bit.



15 Attach bead to frame members, then glue and clamp frame together. Do not glue panel into groove—it should float.

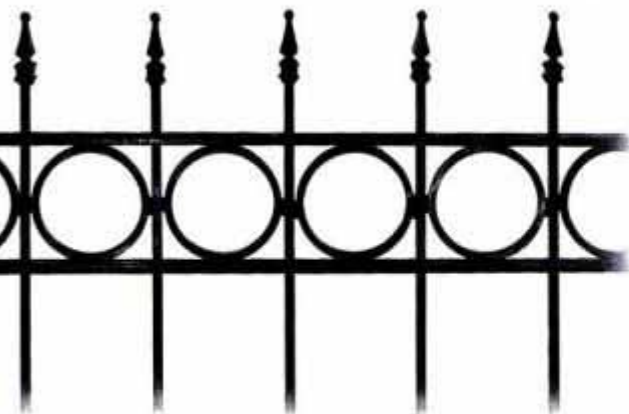


16 Cut hinge mortises using router with guide bushing and two scrap wood jigs—one for door surface, one for door edge.

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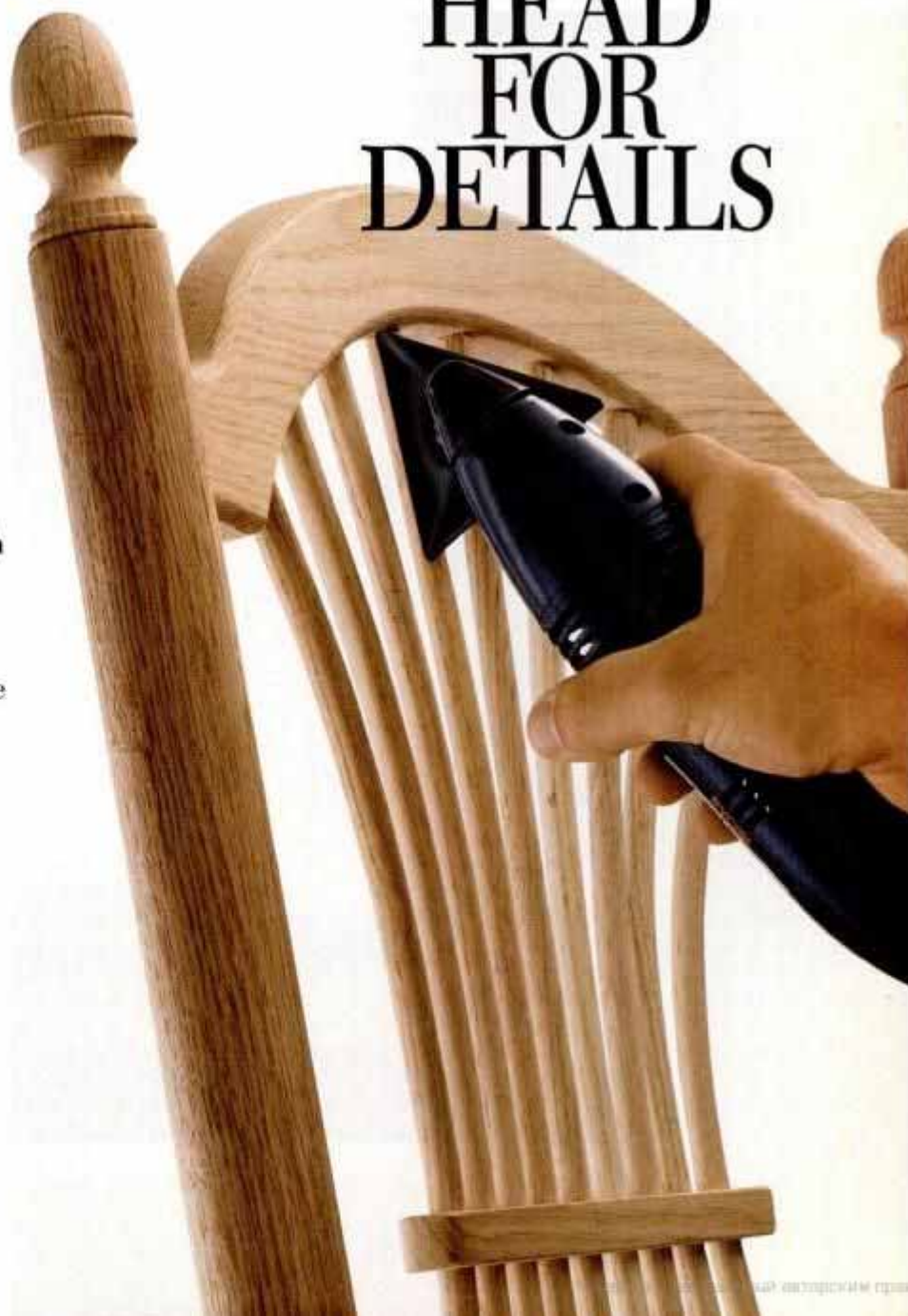
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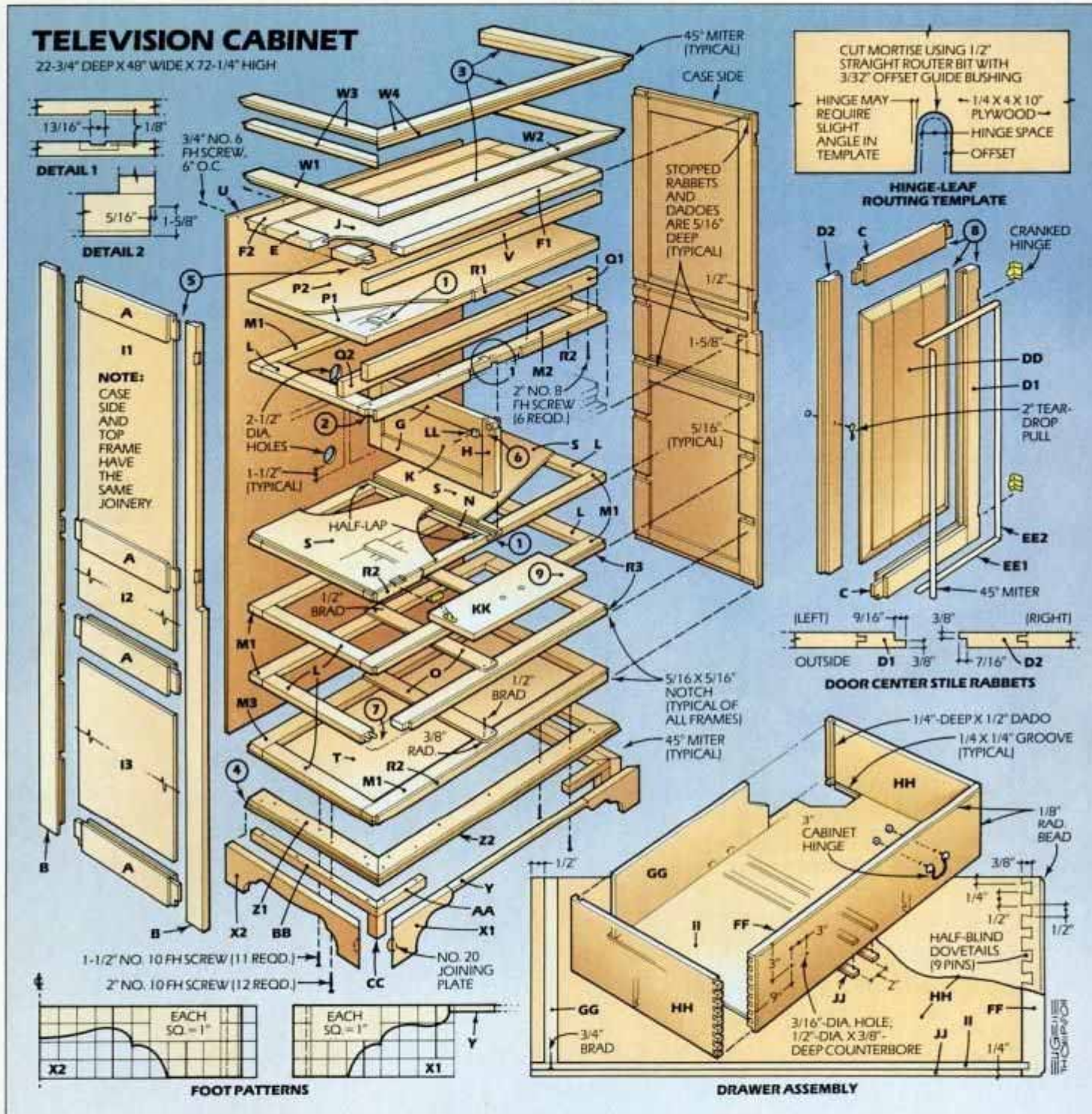
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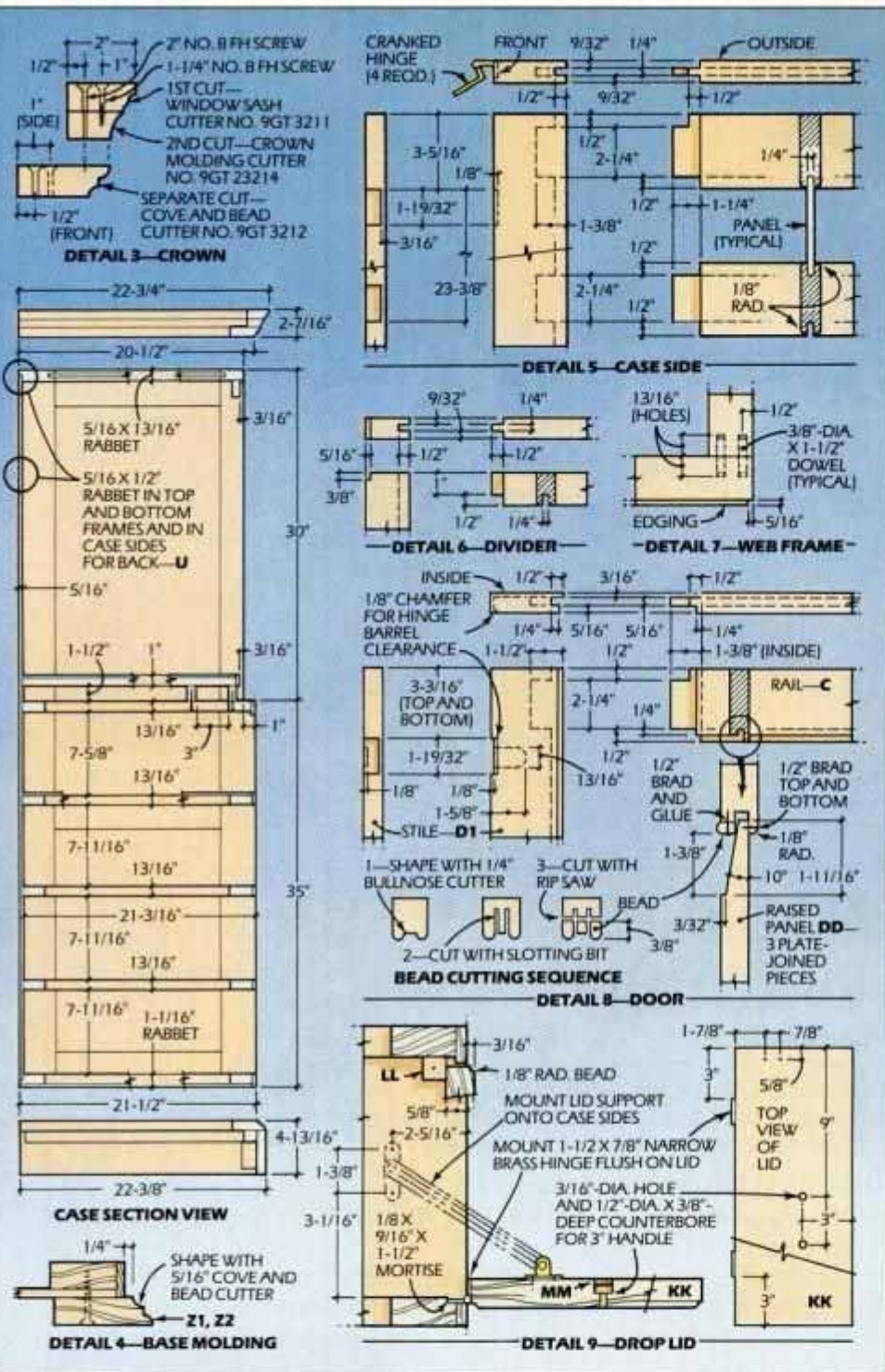
Use a 20-gauge brad, with a clipped-off head, to bore pilot holes in the bead molding. Then install the bead, while the door is still dry assembled, with a slight amount of glue and some 1/2-in. 20-gauge brads. Do not apply glue to the mitered ends of the bead molding because the frame members must still be taken apart. We didn't bother to countersink the brad heads. A 20-gauge brad is so fine that once the piece is stained and finished, the brad heads are nearly invisible. You should be careful, howev-

er, not to nick or dent the molding when hammering the brads flush.

Disassemble, finish sand and wipe off the dust from all the door parts. Then apply glue to a stile and two rails. Insert the panel and add the second stile (Photo 15), being careful to avoid getting glue on the panel. It must be allowed to float so it can expand. You can, however, drive a small brad near the edge of the upper and lower rails. Locate the brad in the center of the length of the rail. With the panel thus fastened, its expansion

will be equalized on both sides of the brad.

Clamp the parts together and when dry install the cranked hinges. To do this, it's necessary to cut mortises on the edge of the rear of each door. Use a simple plywood template and a router with a guide bushing to make these cuts (Photo 16). Note that the long leaf on the cranked hinge that we used was slightly angled relative to the barrel. This didn't affect its performance, but did require a matching angle in the template cutout. Be sure to



MATERIALS LIST—TV CABINET

Key	No.	Size and description (use)
A	8	$1\frac{1}{2}$ " x $3\frac{3}{4}$ " x $17\frac{1}{2}$ " cherry (rail)
B	4	$1\frac{1}{2}$ " x $3\frac{3}{4}$ " x $6\frac{1}{2}$ " cherry (stile)
C	4	$1\frac{1}{2}$ " x $3\frac{3}{4}$ " x $18\frac{1}{2}$ " cherry (rail)
D1	3	$1\frac{1}{2}$ " x $3\frac{3}{4}$ " x $29\frac{1}{2}$ " cherry (stile)
D2	1	$1\frac{1}{2}$ " x $3\frac{3}{4}$ " x $29\frac{1}{2}$ " cherry (stile)
E	2	$1\frac{1}{2}$ " x $3\frac{3}{4}$ " x $17\frac{1}{2}$ " cherry (rail)
F1	1	$1\frac{1}{2}$ " x $2\frac{1}{4}$ " x $43\frac{3}{4}$ " cherry (stile)
F2	1	$1\frac{1}{2}$ " x $3\frac{3}{4}$ " x $43\frac{3}{4}$ " cherry (stile)
G	2	$1\frac{1}{2}$ " x $1\frac{1}{2}$ " x $18\frac{1}{2}$ " cherry (rail)
H	2	$1\frac{1}{2}$ " x 2 " x $7\frac{1}{2}$ " cherry (stile)
I1	2	$\frac{1}{4}$ " x 16 " x $24\frac{1}{2}$ " cherry plywood (panel)
I2	2	$\frac{1}{4}$ " x $9\frac{1}{2}$ " x 16 " cherry plywood (panel)
I3	2	$\frac{1}{4}$ " x 16 " x 21 " cherry plywood (panel)
J	1	$\frac{1}{4}$ " x 16 " x $38\frac{1}{2}$ " cherry plywood (panel)
K	1	$\frac{1}{4}$ " x $5\frac{1}{2}$ " x $18\frac{1}{2}$ " cherry plywood (panel)
L	10	$1\frac{1}{2}$ " x 2 " x $16\frac{1}{2}$ " maple (rail)
M1	8	$1\frac{1}{2}$ " x 2 " x $43\frac{3}{4}$ " maple (stile)
M2	1	$1\frac{1}{2}$ " x 2 " x $43\frac{3}{4}$ " cherry (stile)
M3	1	$1\frac{1}{2}$ " x $2\frac{1}{2}$ " x $43\frac{3}{4}$ " maple (stile)
N	1	$1\frac{1}{2}$ " x 2 " x $20\frac{1}{2}$ " maple (crossmember)
O	3	$\frac{1}{2}$ " x $1\frac{1}{2}$ " x $20\frac{1}{2}$ " maple (guide)
P1	1	$\frac{1}{4}$ " x $19\frac{1}{2}$ " x $43\frac{3}{4}$ " fir plywood (shelf)
P2	1	$\frac{1}{4}$ " x $19\frac{1}{2}$ " x $43\frac{3}{4}$ " cherry plywood (veneer)
Q1	1	$1\frac{1}{2}$ " x $1\frac{1}{2}$ " x $43\frac{3}{4}$ " cherry (support)
Q2	1	$1\frac{1}{2}$ " x $1\frac{1}{2}$ " x $43\frac{3}{4}$ " maple (support)
R1	1	$\frac{1}{2}$ " x 1 " x $43\frac{3}{4}$ " cherry (edge band)
R2	3	$\frac{1}{2}$ " x $1\frac{1}{2}$ " x $43\frac{3}{4}$ " cherry (edge band)
R3	2	$\frac{1}{2}$ " x $1\frac{1}{2}$ " x $43\frac{3}{4}$ " cherry (edge band)
S	2	$\frac{1}{4}$ " x $20\frac{1}{2}$ " x $21\frac{1}{2}$ " cherry plywood (platform)
T	1	$\frac{1}{4}$ " x $21\frac{1}{2}$ " x $43\frac{3}{4}$ " plywood (panel)
U	1	$\frac{1}{4}$ " x 44 " x 64 " cherry plywood (back)
V	1	$1\frac{1}{2}$ " x $1\frac{1}{2}$ " x $43\frac{3}{4}$ " cherry (rail)
W1	2	$1\frac{1}{2}$ " x $2\frac{1}{4}$ " x $22\frac{1}{2}$ " cherry (molding)
W2	1	$1\frac{1}{2}$ " x $2\frac{1}{4}$ " x $46\frac{1}{2}$ " cherry (molding)
W3	4	$1\frac{1}{2}$ " x $2\frac{1}{4}$ " x $22\frac{1}{2}$ " cherry (molding)
W4	2	$1\frac{1}{2}$ " x $2\frac{1}{4}$ " x 48 " cherry (molding)
X1	2	$1\frac{1}{2}$ " x 4 " x $8\frac{1}{2}$ " cherry (foot)
X2	2	$1\frac{1}{2}$ " x 4 " x $22\frac{1}{2}$ " cherry (foot)
Y	1	$\frac{3}{8}$ " x $1\frac{1}{2}$ " x $29\frac{1}{2}$ " cherry (filler strip)
Z1	2	$1\frac{1}{2}$ " x 3 " x $22\frac{1}{2}$ " cherry (molding)
Z2	1	$1\frac{1}{2}$ " x 3 " x $46\frac{1}{2}$ " cherry (molding)
AA	2	$1\frac{1}{2}$ " x $1\frac{1}{2}$ " x $8\frac{1}{2}$ " maple (cleat)
BB	2	$1\frac{1}{2}$ " x $1\frac{1}{2}$ " x $21\frac{1}{2}$ " maple (cleat)
CC	2	$1\frac{1}{2}$ " x $1\frac{1}{2}$ " x $2\frac{1}{2}$ " maple (corner block)
DD	2	$\frac{1}{4}$ " x $16\frac{1}{2}$ " x $24\frac{1}{2}$ " cherry (panel)
EE1	4	$\frac{1}{4}$ " x $\frac{3}{8}$ " x $16\frac{1}{2}$ " cherry (bead)
EE2	4	$\frac{1}{4}$ " x $\frac{3}{8}$ " x $23\frac{1}{2}$ " cherry (bead)
FF	3	$1\frac{1}{2}$ " x $7\frac{1}{2}$ " x $43\frac{3}{4}$ " cherry (drawer front)
GG	3	$\frac{1}{2}$ " x $7\frac{1}{2}$ " x $42\frac{1}{2}$ " poplar (drawer back)
HH	6	$\frac{1}{2}$ " x $7\frac{1}{2}$ " x $20\frac{1}{2}$ " poplar (drawer side)
II	3	$\frac{1}{4}$ " x $20\frac{1}{2}$ " x $42\frac{1}{2}$ " lauan plywood (drawer bottom)
JJ	6	$\frac{1}{4}$ " x $1\frac{1}{2}$ " x $20\frac{1}{2}$ " maple (guide)
KK	2	$1\frac{1}{2}$ " x 7 " x $21\frac{1}{2}$ " cherry (drop-down front)
LL	2	$\frac{1}{2}$ " x $\frac{1}{2}$ " x $\frac{1}{2}$ " cherry (stop)
MM	4	$\frac{1}{8}$ " x $\frac{1}{2}$ "-dia. cherry (plug)

Misc.: $1\frac{1}{2}$ " No. 8 fh screws; 2" No. 8 fh screws; $1\frac{1}{2}$ " No. 10 fh screws; 2" No. 10 fh screws; $\frac{3}{4}$ " No. 6 fh screws; $\frac{1}{2}$ " brads; $\frac{1}{4}$ " brads; No. 20 joining plates; 2 Brainerd No. 1085 $5\frac{1}{2}$ " lid supports; 8 Garrett Wade (161 Avenue of the Americas, New York, NY 10013) No. A 34.02 C 3" cabinet handles and 2 No. A 48.02 2" tear-drop pulls; 4 Stanley No. CD 5300 $1\frac{1}{2}$ " x $\frac{1}{2}$ " brass hinges; 4 Armor Products (Box 445, East Northport, NY 11731) No. 78090 cranked hinges; 120- and 220-grit sandpaper; glue; stain; sanding sealer and polyurethane.

check the hinges you buy—before you make the mortises—and follow suit if necessary. And always make some test cuts in scrap stock before you cut the finished mortise on the doors.

To make the drawers, first cut the stock to size, then set up a router dovetail template and cut the half-blind dovetails in the drawer sides and front (Photo 17). Follow these by cutting dados in the side members for the back boards and by cutting the grooves for the bottom panel in the sides and front boards. Next, shape

the bead around the front with a router, bore the holes for the handle hardware and sand the inside surface of all parts. Assemble the pieces with glue and clamps, check for square and set aside to dry. Complete the drawers by attaching the guide strips to the bottom panels.

Case moldings

The crown molding is fabricated from three narrow boards shaped on a table saw fitted with a molding cutter. To build it, glue together the top and

middle strips with a $\frac{3}{8}$ -in. offset. Then attach an auxiliary wood fence to the rip fence on your table saw. This will allow you to adjust the fence properly when making the cove cut. You should also use a raised featherboard to keep the work on a true course (Photo 18).

Cut the first profile with the window-sash cutter, then switch to the cove cutter. Adjust the fence and cut the second shape. The bottom member is shaped with a cove-and-bead cutter, then is glued and screwed to

WOODWORKING GUIDE

the top assembly. To obtain smooth, non-forced molding cuts, make several incremental passes. Don't try to cut the whole profile in one pass. Miter the corners (Photo 19) and attach the crown to the case top with screws and glue.

Cut the stock for the case feet to size and miter the ends. Then, cut the curved profiles on a band or scroll saw. Lay out the miter faces to receive a single joining plate and cut the slot using a plate joiner. If you don't have a plate joiner, just use a spline set into a saw kerf groove.

Cut the backing cleats for the feet to size and attach them to the case with glue and screws. Then attach the feet, beginning with the front ones. When both front feet are installed, apply glue to the side feet, miter joints and the plate slots, then insert the joining plates and slide the side feet in place (Photo 20). Clamp to the cleats until dry.

We finished this cabinet with a coat of Behlen's Virginia Cherry Master-Gel Stain, followed with three coats of Minwax Semi-Gloss Polyurethane. We finished the drawers—except for the outside of the fronts—with a single coat of sanding sealer. **PM**



17 Cut drawer stock to size then lay out and cut dovetails using router and jig. Code mating pieces to avoid mismatches.



18 Cut crown with molding head in table saw. Use featherboard and pushstick to keep stock firmly against fence.

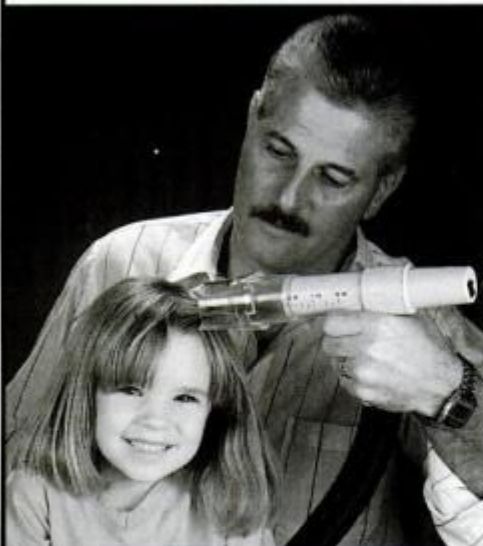


19 Join crown molding parts with glue and screws. Then support back side of assembly with scrap block. Cut miters.



20 Cut case feet to shape and join to mounting cleat. Then glue and screw to bottom, using plate to reinforce corner.

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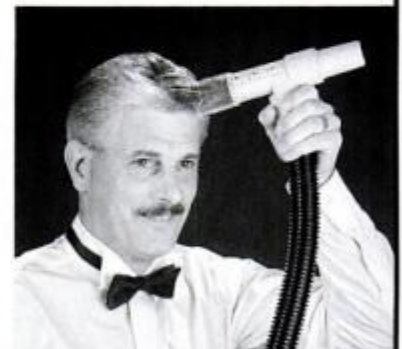
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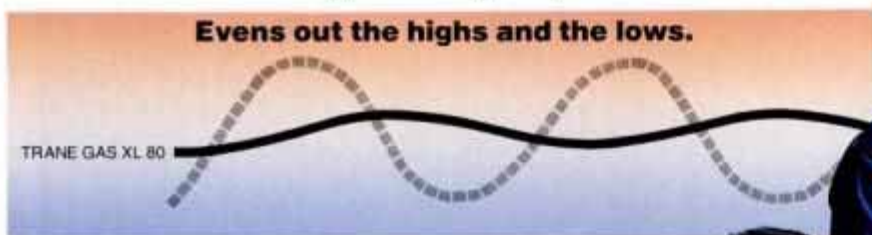
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CAR CARE

CAR CLINIC

BY MIKE ALLEN,
Associate Automotive Editor

Keeping Up

I had the valve seats refaced on my old Nova after a couple of them burned. I decided to replace the exhaust valves after I got the heads back from the machine shop. I then spent the entire weekend with a rented valve spring compressor reassembling eight valves because I couldn't get the keepers to stick into the little grooves in the valve stem.

To add insult to injury, two of the darned things came apart as I was turning the engine over with a wrench to check the valve lash. I had to go and buy new keepers because the old ones flew off into a far corner of the garage where I couldn't find them.

How are you supposed to get these things to stay back together? How can I be sure the ones I do have back together stay that way? And do I have to pull both heads again to fix the ones that dropped in? I can pull the valve back up with my fingers, but it won't stay there while I try to reassemble the spring, retainer and keepers.

JOHN EPPLER
COLD SPRINGS, MI

My first rule on cylinder head work is to leave all of it to the machine shop.

My second rule is to replace all of the valve keepers—they're cheap.

There's a secret to assembly. Use a dab of assembly lubricant or wheel-bearing grease to stick the keepers to the groove until you release the valve spring compressor.

Then cover the valve spring area with a couple of clean shop rags, and smack the top of the valve stem a couple of times with a plastic- or brass-headed hammer. This will seat the keepers—or not—and the valve spring, retainer and keepers will pop off. The shop rags will keep them in the vicinity, instead of embedded in your eye or off in some dark corner.

You can avoid pulling off the head and the expense of a new pair of head gaskets (never reuse a head gasket



that's been torqued, even if the engine hasn't been run) by using an air hold. This can be purchased or rented at most auto parts stores. I made one by welding a 1/4-in. pipe nipple to the metal shell of an old spark plug. Compressed air, routed into the cylinder through the air hold, will keep the valve shut while you reassemble the top end.

Steamy Situation Update

Thanks to the several hundred people who wrote in concerning a letter from

James Gianotti about the fogged-up windows in his VW Golf ("Steamy Situation," page 74, Aug. '92). I suggested he replace his heater core.

Since then, VW has issued a recall campaign, as a number of late-model VWs have had heater-core failures. If you have a syrupy smell, a windshield-fogging problem or any evidence of heater-core leakage, see your dealer immediately. Eventually, all owners of affected vehicles should be contacted by VW, but if you're not sure, call your dealer.

Getting 200° F ethylene glycol

CAR CARE

sprayed on your ankles is no fun. Get this looked into right away.

All Charged Up

I am part owner of a hunting camp located in northern Pennsylvania. We have a large generator for our electrical needs, and it's started by four 12-volt batteries. But the camp is often left unattended for months at a time, and the batteries go flat, especially in the winter.

I was hoping to use a solar charger, but the area gets limited sunlight due to many tall trees. WESHOOVER
WOODWARD, PA

First off, if those four batteries are wired in parallel, isolate them from each other while you're gone—the battery that self-discharges fastest will suck the others down with it. Batteries will normally self-discharge at a rate of about 1% per day.

Keep the terminals and battery tops clean and grease-free. The moisture that the dirt attracts will conduct a few microamps constantly, discharging the battery faster.

I've had limited luck keeping batteries charged with solar chargers. They work in the summer when the days are long and sunny. But winter's short days and overcast skies reduce their effectiveness. Couple that with tree cover—even the leafless branches of winter—and you may not keep your charge. Try putting a solar charger up on a pole or a rooftop and simply string wire to the batteries, even if it's a hundred feet or so. With solar chargers available at RV dealers and mass merchandisers for \$30 to \$50, it's worth a try.

Sailboaters use a very small wind-powered generator that hangs from the mast to keep their batteries charged, so you might try looking at the marina or ship's chandler. These things are not cheap, however.

Don't Settle For Less

Settle an argument for us: What is the more harmful for a 4-cylinder engine, to be driven 5 mph under the speed limit or to maintain the legal limit up to a speed of 65 mph?

I maintain that going slower is not saving the engine, and that it makes

(Please turn to page 102)

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SERVICE TIPS

• 1989 and later Suzuki Swift owners with crunching noises might look into a revised 2nd-gear synchronizer assembly, as well as switching to GM Synchronesh Transmission Fluid (GM PN12345349) to improve shifting. Replacing the 2nd-gear synchro will entail removal and disassembly of the transmission, however.

• If your 1992 Cadillac Brougham 5.0-liter has a clicking noise at idle when the engine is cold, it might be the plastic covering the torque converter scraping on the flywheel. Cadillac suggests trimming the plastic cover with a knife to prevent contact.

• Does your 1988-1990 GMC Sierra pickup smell like hot transmission fluid or smoke after carrying a heavy load? Seems that the transmission fluid can get hot enough to burp out of the dipstick tube.

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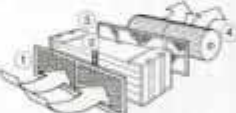
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CAR CARE

for an unsafe situation by not staying up with the flow of traffic.

JIM WHARTON
HAMLET, IN

There's not any appreciable difference in the potential lifespan of an engine if you drop back 5 mph—everything else being the same. Even a small 4-banger, with proper maintenance and frequent oil changes should outlast the chassis.

There's good reason to drive any car on the expressway at the fastest legal speeds periodically, to reduce carbon and sludge buildup. Admittedly, with modern fuel injection and gasoline additives, an "Italian tune-up" isn't as compelling as it once was—but there's no damage to be done by getting the engine perking.

For the sake of the peace of mind of other drivers, maintaining pace with traffic is safest.

PM

DO YOU HAVE A CAR PROBLEM?

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

Gobble, Gobble

● With Thanksgiving looming ahead, I'm probably going to cause a few divorces—but here goes.

I was replacing the brake pads on a very neglected Volvo last week. The brake fluid looked like cappuccino (brown and muddy) from dirt and particles in suspension. I was planning on bleeding the brakes, but I'm reluctant to pump gritty brown brake fluid from the reservoir through the system to flush it. Besides, when you push back the pistons to install the new pads, there's never enough room in the reservoir for the fluid that's being displaced.

So I used a rubber turkey baster to suck the excess fluid from the reservoir. In fact, I added some clean fluid to the reservoir, and then used the baster to flush the plastic reservoir a couple of times.

Brake fluid is toxic—so don't even think of using that baster on the turkey afterward. It is also good at removing paint, so keep it away from your fender.



ILLUSTRATION BY GUY LE BOUTANN

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MAINTENANCE BASICS

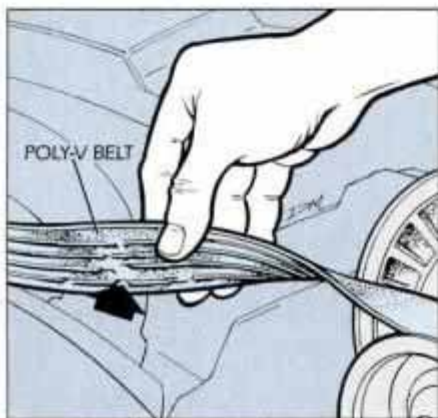
DRIVEBELTS

BY DON CHAIKIN,
Contributing Editor

● Though the fan belt is gone from just about every car these days, your car still has other belts under the hood. These drive the alternator, air-conditioning compressor, power-steering pump and water pump.

Some drivebelts are single V-belts riding in a deeply grooved pulley. Some are poly-V belts with several grooves and ribs riding in matching grooves in the drive pulleys.

On some engines, belts may be used



Check the undersides of all belts by twisting the belt along its entire length.

to drive more than one accessory. Many new cars use a single belt for all the accessories.

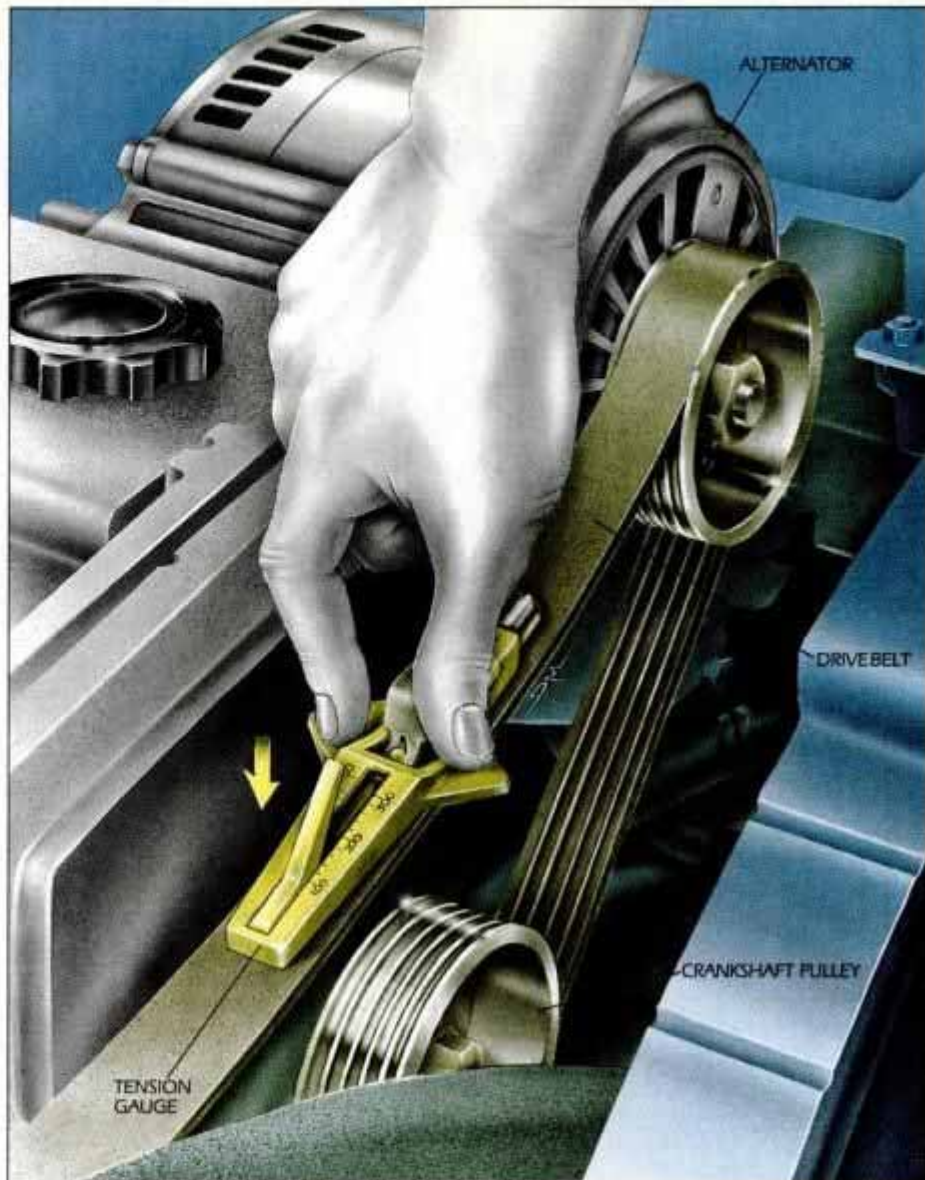
Regardless of the type or number of belts under your hood, they should be inspected at least four times a year.

- Inspect the sides of V-belts for glazing, cracks and tears.
- Check the ribs of poly-V belts for breaks in the ribs, cracks and missing chunks of rubber.

Any damaged belt must be replaced, but it's good practice to replace any drivebelt after four years. Even if the drivebelt appears to be in good condition, it may be weak internally.

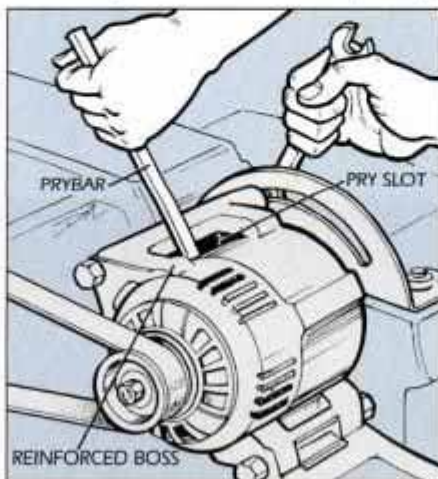
- Replacement belts should match the original belt in size and thickness.
- New poly-V belts must have the same number of ribs as the original.
- Check the tension of all drivebelts using a belt-tension gauge.

Inexpensive, simple-to-use gauges are available at auto parts stores. The distance between pulleys on today's engines is too small to accurately



judge a belt's tension by merely pressing it between two pulleys.

All drivebelts have a provision for tensioning the belt. However, it may



All accessories have a tensioning provision including reinforced sections and pry slots.

not be obvious at first glance. When several accessories are driven by a single belt, there may be only one adjustment. Either only one of the accessories can be moved in its bracket, or there is a separate idler pulley which does not drive anything, but serves only to tension the belt. On cars with a single belt, the tensioner may be spring-loaded and automatic. If the belt is too loose or too tight, replace the tensioner.

Many accessories or their brackets have special tabs or slots for a wrench or a ratchet drive specifically for moving the accessory. If you must pry on an accessory, take care to pry only on the appropriate, reinforced section or you may damage it.

Do not overtighten a belt. Too much belt tension accelerates wear of the accessory's bearings and shaft. Too little tension allows the belt to slip in its pulleys.

FM

HOW IT WORKS

LIMITED-SLIP DIFFERENTIAL

BY DON CHAIKIN,
Contributing Editor

● Whether your car, truck or minivan is front-wheel drive, rear-wheel drive or all-wheel drive, it uses a differential to split the engine's power between the left- and right-side drive wheels. All-wheel-drive vehicles also use a differential between front- and rear-drive axles.

The problem of getting power to wheels on opposite sides of the car is complicated by the fact that as you drive around even the gentlest of curves, the wheels on the outside of the curve have to travel farther than the wheels on the inside of the curve.

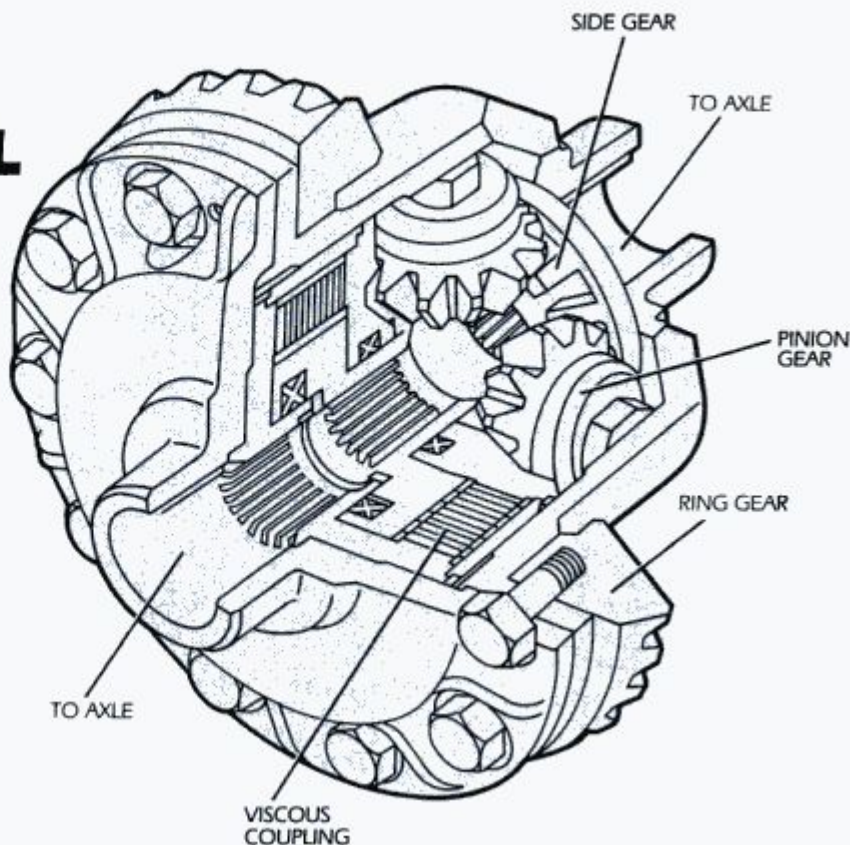
Vive la difference

To compensate for that difference in outer and inner wheel speed, your car uses a differential. This component typically consists of a ring gear, which has a carrier or cage solidly attached to it. In the carrier or cage are the two so-called side gears—one for each drive axle—and two or four small idler pinion gears.

Power from the engine drives the ring gear via a gear on the end of the driveshaft. As the ring gear rotates, so does the carrier.

Under ideal and simple conditions, if the car is moving in a perfectly straight line, both drive wheels are rotating at the same speed. As the ring gear turns the carrier, the carrier rotates the two side gears along with it, splitting the engine's power between them. As these side gears rotate equally, the two constantly meshing pinion gears go around with the carrier, but do not rotate between the side gears.

However, as the vehicle goes around a curve, the wheel on the inside of the curve goes more slowly than the outside wheel. As this happens, the respective side gears inside the differential rotate at different speeds, which causes the pinion gears to rotate between the side gears. The ring gear and the carrier rotate at the average speed of the outside and inside wheels.



A viscous coupling limits slip by forcing side-gear plates to churn in heavy silicone fluid.

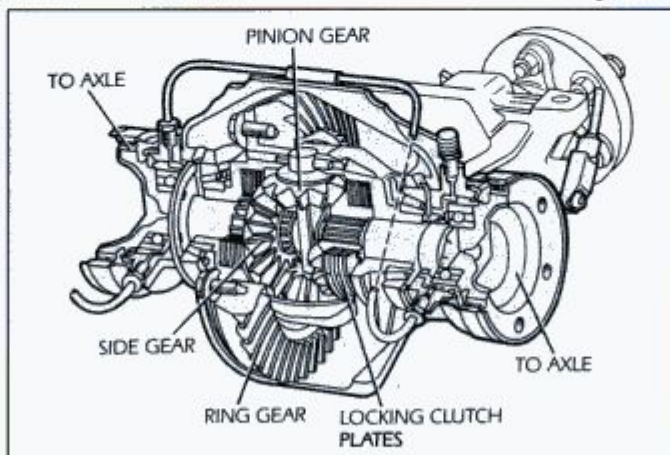
Slip-slidin' and spinnin'

Since the engine's torque is equally split between both drive wheels, as long as they both have equal traction the system works fine. However, if one of those wheels is on a slippery patch and the other is not, the wheel on the slick spot requires very little torque to spin—and since the laws of physics dictate that force takes the path of least resistance, most of the engine's power goes to the slipping wheel. Therefore, it's possible that not enough power will go to the wheel that has traction to get that wheel to turn at all.

This wrinkle in the system is corrected by a limited-slip differential. While some carmakers use a viscous coupling (see How It Works, page 114, Nov. '91) in the rear differential, and many makers of awd vehicles use a viscous-coupling center differential, carmakers typically use a simple clutch-and-spring system in limited-slip differentials.

Clutch packs are mounted behind each of the axle's side gears and springs between the side gears force the gears against the clutches. While the springs allow enough slippage to permit driving around a curve, in slippery conditions they keep the side gears against the clutches with enough pressure to make those gears spin at the same speed. If one wheel begins to slip, the friction of the clutches ensures that the slipping wheel does not receive all of the engine's power.

One refinement on this basic concept is the locking differential. Here, hydraulic pressure clamps the clutch plates against the side gears, locking them mechanically, ensuring an even torque split, regardless of the road conditions. **PM**



In this locking differential, hydraulic pressure forces clutch plates against the side gears, ensuring traction at both drive wheels.

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L

CAR CARE

NEW PRODUCTS

IMPROVE YOUR CAR

Rear-End Foglight

To keep the traffic behind you as aware of you as you are of the traffic ahead, consider auxiliary lighting for the back end of your car or truck. This red halogen rear-mounting foglight from Cibié is bright enough to be seen in fog, heavy rain and snow. The lens diffuses the beam so the light projects a 120° arc. The light's mounting base swivels 105° so the light can be aimed directly behind you, regardless of your vehicle's rear-bumper shape. The Cibié rectangular, rear foglight costs \$89.20. For more information, contact Cooper/Wagner Lighting, 922 Roosevelt Pkwy., Chesterfield, MO 63017; (314) 532-8150.



Laser Detector

More police are using laser speed guns to monitor traffic speeds, and your trusty radar detector will not alert you to them. The Passport 1000 from Cincinnati Microwave detects traffic laser units and warns you to watch your speed in the same way your radar detector does. The Passport 1000 comes with a windshield mount, coiled power cord and power plug for your car's cigarette lighter. The unit is smaller than 3 x 5 in. and less than 1 in. thick, so it can fit into your pocket. Passport 1000 costs \$99. From Escort Division, Cincinnati Microwave Inc., Fields-Ertel Rd., Cincinnati, OH 45249; (800) 433-3487.



Oil-Filter Cutter

After taking your old engine oil to the recycling center, it's environmentally counterproductive to toss your used oil filter out with the trash. Instead, cut the metal can off the filter so you can throw it in with your other recyclable metal after cleaning. And you can then inspect the inside of the filter for early signs of serious engine problems. Tiny flakes of bronze indicate

bearing or bushing wear; metal dust and grindings may mean grinding shaft gears. If you use a hacksaw to cut the can off the filter, you might mix in the metal sawdust from the can with the oil-filter trappings. A better method is to use this special filter cutter, No. 910-81031, from Speedway Motors Inc., 300 Van Dorn, P.O. Box 81906, Lincoln, NE 68501; (404) 474-4411. The cost is \$45.

All-Season Performance

Michelin, the radial-tire pioneer, has three distinctive new all-season tires. The MX4 offers wet-weather grip and long tread life for subcompacts and midsize cars. Prices range from about \$45 to \$90 a tire. The MXV4 (\$60 to \$120 per tire) has been configured to give a quiet ride and improved grip to luxury sedans. The most aggressive of the new tires is the XGT4 (\$55 to \$100). Its unusual triangular tread blocks are designed for excellent grip and responsive handling. All are available in a variety of sizes and aspect ratios. From Michelin Tire Corp., P.O. Box 19001, Greenville, SC 29602; (803) 458-5000.



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FM

SATURDAY MECHANIC

CHECKING YOUR TROUBLE CODES

BY PAUL WEISSLER

● They all laughed when you opened the hood of your late-model computer-controlled fuel-injected car. They know that only the cognoscenti at the dealership have been inculcated with the secret codes that hide the darkest secrets of your engine's operation. They know that only with thousands of dollars worth of inscrutable test gear, covered with flashing lights and arcane symbols could the furthest depths of engine management be probed. How dare you attempt to repair your car armed with little more than a Radio Shack voltmeter?

They're wrong. It's true that well-trained pros use computerized "scan"

testers (starting at \$750) and oscilloscopes with gas analyzers (around \$35,000) to locate the tough problems, but most repair shops just look for the trouble codes generated by the engine computer's self-diagnosis system. You can do that yourself—without the pros' expensive equipment.

Looking for trouble

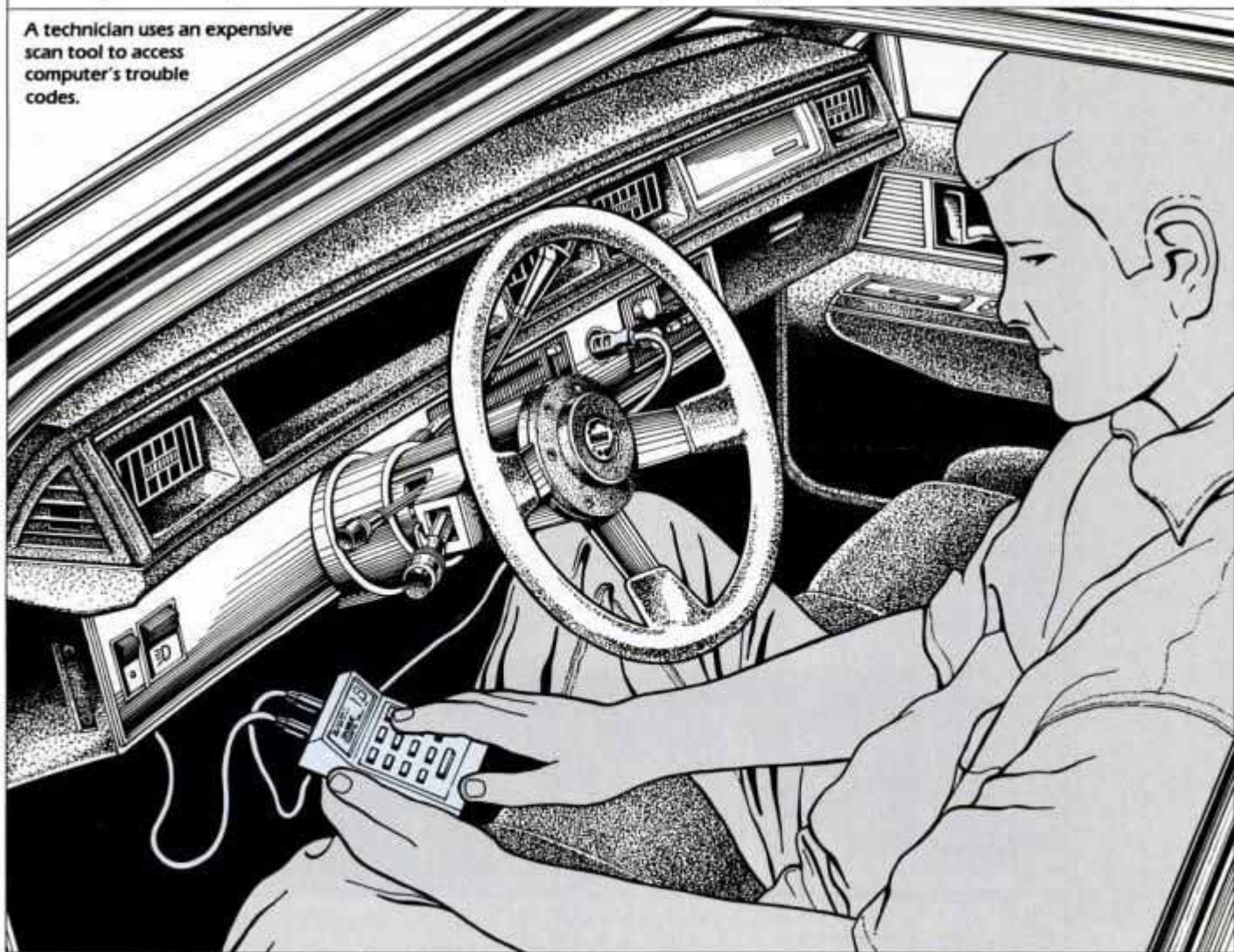
Besides managing your engine, modern automotive computers also monitor themselves, their sensors and the systems they control. When the computer detects a problem within its purview, the problem is logged into the computer's memory and assigned

a code number. And while at one time only General Motors' systems provided easy access to those trouble codes, today every make of car does.

However, there is no industry-wide standard for trouble codes, you can't use one maker's trouble codes for another car. For example, while Code 44 on GM cars means an oxygen-sensor problem, it means no trouble in the computer system on many Nissan products.

With a quality repair manual—either from the factory or from an aftermarket publisher—you can get the trouble codes and know what each one means. Better manuals also provide a

A technician uses an expensive scan tool to access computer's trouble codes.



precise procedure for you to check out the code—using equipment you probably already have, such as fused jumper wires, computer-safe test lights (about \$10 each) and digital volt-ohmmeters (as little as \$30 for the basic-but-good model).

The manual is also your source for the location of various computer-system parts—including the computer itself. You'll find most computers under the dash or behind a kick pad, but some are under a passenger's seat and still others (most Chrysler and some General Motors) are under the hood. So the parts-location illustrations in the manual are important.

Pinpointing problems

General Motors led the industry with its under-dash diagnostic plug and the CHECK ENGINE dashboard light. Other makers soon followed, and the POWER LOSS light on Chrysler products in the mid-to-late 1980s and the SERVICE ENGINE NOW on some GM cars serve the same purpose. Import companies and Ford were late to adopt the CHECK ENGINE light, but still have provided trouble codes.

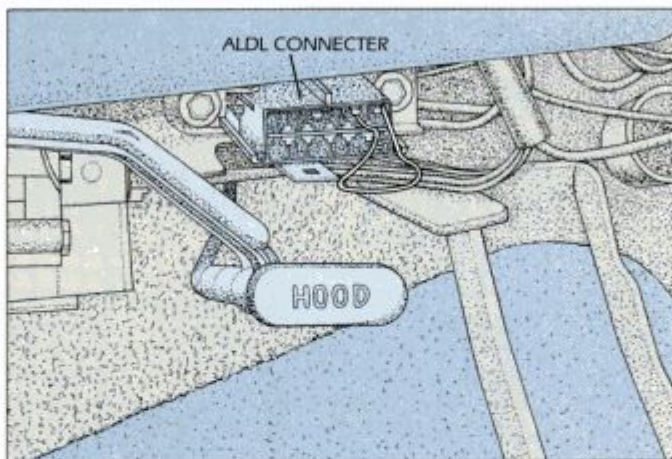
If your car is equipped with a CHECK ENGINE light or the equivalent, wait for the light to go on and stay on for a few seconds, to be sure the computer has logged a trouble code. Some computers also log codes for intermittent problems and may even briefly flash the CHECK ENGINE light at the time they're logged.

What you'll need

Before you attempt to access your car's computer, understand that if you follow the test procedures improperly, you may damage some very expensive components. Don't say we didn't warn you!

Before you begin, be certain that you have the correct service manual or information for your specific vehicle. Simply connecting a jumper wire incorrectly can be enough to do electronic damage. Now, properly armed and warned, here is what's needed to access the memory of your late-model car's computer and see if there are any trouble codes:

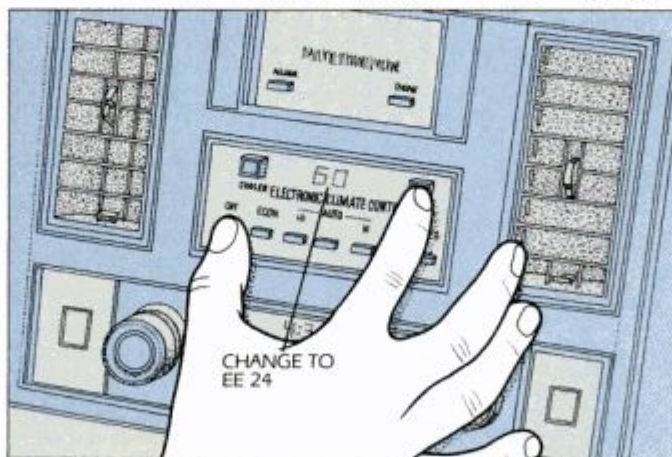
• **General Motors**—With the



Shorting two pins of the ALDL connector will send a General Motors' computer into its self-test mode.

ignition on, bridge the diagnostic plug's end terminals—possibly using a paper clip—that have a white/black and a black wire. The CHECK ENGINE light should flash, or pulse, out a code starting with 12 (light pulse, brief pause, then two light pulses). This means "no ignition signal to the computer," which is correct since the engine isn't running. This is a simple check of the self-diagnosis capability. Then the light will pulse all codes detected, with a moderate pause between each one. It may repeat the codes twice. All the GM trouble codes are two digits each.

In addition, Cadillac and Cadillac-built front drives—Buick Riviera/Reatta and Olds Toronado—provide a digital readout of trouble code information on the Fuel Data Center. With the ignition on, simultaneously press and hold the OFF and WARM(er) buttons on the a/c panel. After all the panel indicators light up, release the buttons. On most models, any intermittent engine codes (with the letter E as a prefix) are displayed first, fol-



Enter the diagnostic mode by simultaneously pressing the off and heat buttons on the air-conditioning panel.

lowed by current trouble codes (prefix EE). The service manual also can lead you into a more comprehensive diagnosis, all without the use of special testers.

• **Chrysler**—(Note: Since most pre-1991 Jeeps and the Eagle Premier do not have Chrysler-designed computer systems, the following procedures are not applicable to those vehicles.) Without starting the engine, cycle the ignition key on and off, on and off, then on again. The POWER LOSS or CHECK ENGINE light will pulse out the codes. A No. 55 (five pulses, pause, five pulses) indicates that the test is over.

• **Ford**—Only models equipped with the EEC III or EEC IV engine computers (check your car's underhood tuneup decal) have self-diagnostic capabilities. In addition, Ford did not install a CHECK ENGINE dashboard warning light until later EEC IV cars.

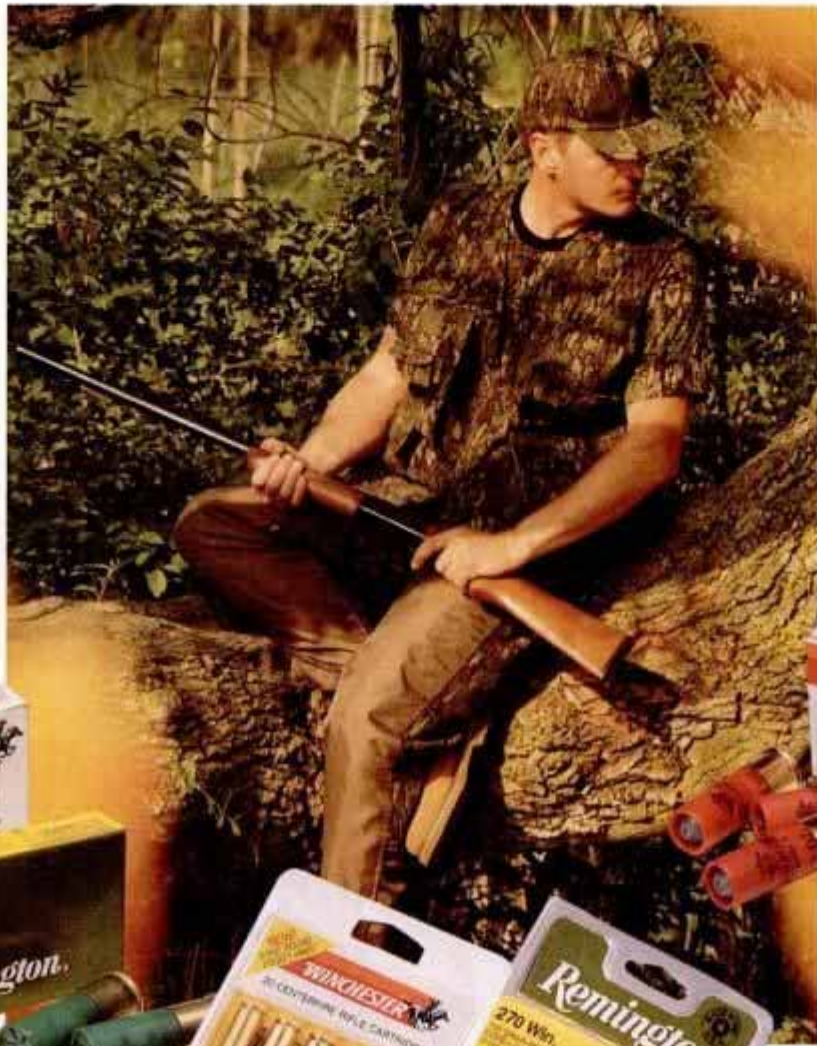
If your car has an EEC III system (mid-1980 to 1983), you will need a vacuum gauge. A manual vacuum pump makes the job simpler, but is not necessary. Connect the vacuum gauge between the emissions' diverter valve and its solenoid. Then with the engine fully warmed and idling, apply 20 in. or more of vacuum to the Manifold Absolute Pressure (MAP) sensor's vent neck for 1 minute. If you don't have a vacuum pump, attach a hose to a vacuum source on the intake manifold. Release the vacuum and the self-test will run automatically.

All the codes will be pulsed out by the jumping needle on the vacuum gauge. First the needle will pulse an engine number equal to half the number of engine cylinders (twice for a 4-cylinder, four times for a V8 and so on). Early in the test, engine vacuum and idle speed will rise, and after about 2 minutes, both will fall. Then the needle will pulse out any trouble codes. A Code 11 (pulse, pause, pulse) is a pass.

If your car has an EEC IV computer, you must locate two underhood diagnostic connectors. One has five terminals, the other only one. Hook up a jumper wire and

(Please turn to page 112)

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CAR CARE

an analog voltmeter to the connectors and the car battery as directed by your manual. The engine should be cold and not running, but the ignition should be on. The voltmeter needle should flick the engine cylinders code during the test, and any trouble codes or Code 11, which means no trouble code found, at the end of the test.

You can also test for cylinder balance on EEC IV-equipped cars with sequential port fuel injection. See the service manual procedure following the engine-running test.

Many 1991-1992 Ford models have 3-digit trouble codes, in addition to the 2-digit ones.

• **Toyota**—If the CHECK ENGINE light goes on with the engine running, connect a fused (under 10-amp) jumper from a test terminal, often labeled "T," or "TE-1," to the "E-1" terminal (electrical ground) of an underhood plug. The engine must be off; ignition on. The dashboard warning light will pulse out any codes and keep repeating them. If the light just blinks once every quarter-second, there are no codes stored. To check the control unit of the automatic transmission, use the same underhood plug—the

OVERDRIVE light will do the pulsing.

• **Honda**—If the CHECK ENGINE light goes on, find a 2-terminal connector under the right side of the dash. Bridge the connector's terminals and the CHECK ENGINE light pulses out the codes. Single-digit trouble codes are displayed by a series of short blinks. For double-digits, it's longer pulses for the first digit, short ones for the second (three long pulses followed by one short is 31). Late-model Accords do not have a CHECK ENGINE light. On these cars, you must pull back the carpet under the dash on the passenger's side, turn on the ignition and watch an LED on the computer body itself blink out the trouble codes.

• **Nissan**—Depending on the model, your car may use one of several self-diagnosis systems. However, they are all accessed—with the ignition on and the engine off—by one or two LEDs on the side of the engine computer, found either under the dash or the passenger's seat depending on the model. Older models have one red and one green LED. Newer models just have a red one.

A mode-selector screw next to the LED(s) on most models allows you to

choose from several diagnostic features. Turn the selector screw fully clockwise and wait for the LED to flash. The number of times indicates test mode. Then turn the screw fully counterclockwise and wait again. When you're in the trouble-code mode, any codes will pulse out. Where two LEDs are used, the red pulses the first digit, the green the second (two red pulses and one green equal Code 21). On units with just one red LED, long pulses are for the first digit, short ones for the second.

Decoding

Knowing the trouble codes does not necessarily mean you know what the trouble is. For instance, a code indicating a problem at the oxygen sensor may mean the sensor or its wiring is bad. But it may also mean that there is too much, or too little, oxygen in the exhaust for the computer to correct the situation—possibly indicating a disconnected vacuum hose or leaking fuel injectors.

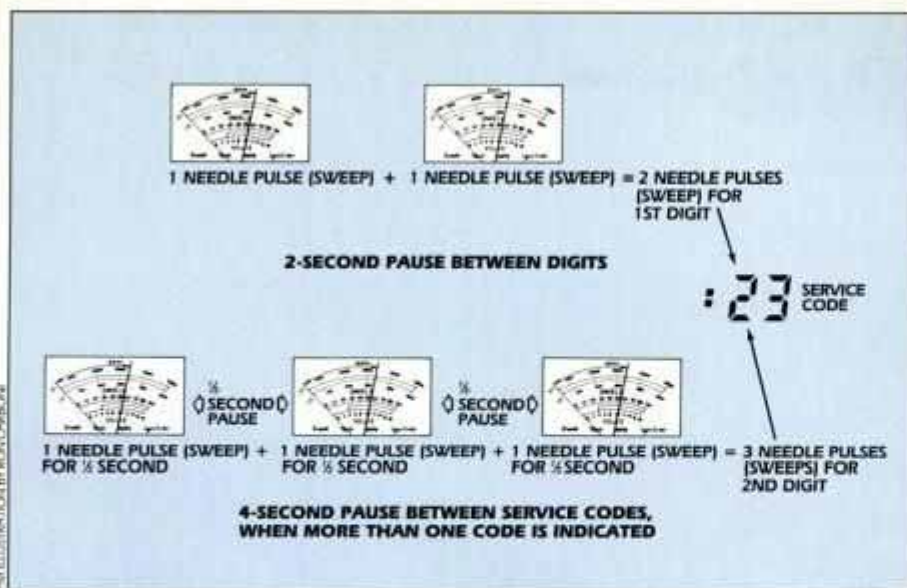
Mechanical problems seemingly unrelated to the computer may also precipitate a trouble code. For example, if the thermostat sticks open,

Trouble Codes

- | | |
|--|--|
| 11 Pass | 45 Thermactor air upstream during self-test |
| 12 Rpm not within self-test upper rpm limit band | 46 Thermactor air not bypassed during self-test |
| 13 Rpm not within self-test lower limit band | 51 -40° indicated ECT-sensor circuit open |
| 13 D.C. motor did not move (2.3/2.5/1.9L CFI) | 52 PSPS circuit open |
| 13 D.C. motor does not follow dashpot (2.3/2.5/1.0L CFI) | 52 PSPS did not change states |
| 14 PIP circuit fault | 53 TPS circuit above maximum voltage |
| 15 ROM test failed | 54 -40° F indicated ACT—sensor circuit open |
| 16 Rpm too low to perform fuel test | 55 Key power circuit low |
| 18 Loss of tach input to processor-SPOUT circuit grounded | 57 NPS circuit failed open |
| 19 Failure in EEC reference voltage | 61 254° F indicated ECT—circuit grounded |
| 21 Indicates ECT out of self-test range | 63 TPS circuit below minimum voltage |
| 22 Indicates MAP/BP out of self-test range | 64 254° F indicated ACT—circuit grounded |
| 23 Indicates T.P. out of self-test range | 67 NPS circuit failed closed—A/C on during self-test |
| 24 Indicates ACT out of self-test range | 67 NDS circuit open—A/C on during self-test |
| 25 Knock not sensed during dynamic response test | 72 Insufficient MAP change during dynamic response test |
| 29 Insufficient input from V.S.S. | 73 Insufficient TP change during dynamic response test |
| 31 EPT/EVP below minimum voltage | 74 BOO switch circuit open |
| 32 EVP voltage out of static limit | 75 BOO switch circuit closed—ECA input open |
| 32 EGR valve not seated (PFE) | 77 Operator error (dynamic response/cylinder balance test) |
| 33 EGR valve not opening | 78 Power interrupt detected |
| 34 Insufficient EGR flow (1.9L, 2.3L T/C EFI/2.3L, 3.8L CFI) | 81 AM2 circuit failure (OCC test) |
| 34 EVP voltage above static limit (SONIC) | 82 AM1 circuit failure (OCC test) |
| 34 Defective EPT sensor (PFE) | 84 EVR circuit failure (OCC test) |
| 34 Exhaust pressure high/defective EPT sensor | 85 CANP circuit failure (OCC test) |
| 35 EPT/EVP circuit above maximum voltage | 87 Fuel pump test failed (OCC test) |
| 41 EGO sensor circuit indicates system lean-no EGO switch detected | 89 CCO circuit failure (OCC test) |
| 42 EGO sensor circuit indicates system rich-no EGO switch detected | 91 EGO sensor input indicates system lean (cylinders 5-8) |
| 43 EGO lean at W.O.I. | 92 EGO sensor input indicates system rich (cylinders 5-8) |
| 44 Thermactor air system inoperative (cylinders 1-4 dual EGO) | 94 Thermactor air system inoperative (cylinders 5-8, dual EGO) |
| | 98 Hard fault present,***FMEM MODE*** |
| | 99 Idle not learned, ignore codes 12 and 13 |

Warning! Your trouble codes will probably vary from these Ford codes—but this list is typical of what you might see on your vehicle.

CAR CARE



Count needle swings on an analog meter to determine the trouble codes on some Fords.

coolant temperature is abnormally low, and the computer may be tricked into concluding that coolant temperature is normal but the coolant-temperature sensor is defective.

It is critical, therefore, that you have the proper manual for your car. The right manual will lead you through the diagnosis very specifically, step by step, until you pinpoint the problem.

Turning off the light

After you've fixed the problem, you must turn off the CHECK ENGINE light and clear the computer's memory of the trouble. The procedures for clearing the codes from memory vary—check your manual.

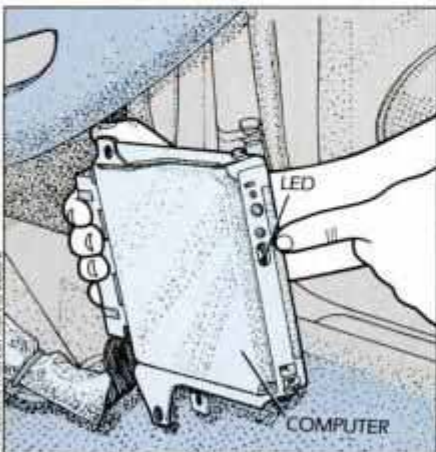
However, it may be necessary to disconnect the computer by either pulling its fuse or disconnecting the battery for about 30 seconds. Be aware that you also lose any fuel and ignition running adjustments the

computer has made (along with the radio station preselects). It can take up to 100 or so miles of driving for the computer to remake those adjustments. Until it does, your car may not perform well, even though all problems were repaired.

There are some nonengine computers that require a specific procedure to clear a code. These systems have backup circuits to hold the code even if the car battery is disconnected.

One alternative to an expensive scan tool is to use your laptop computer and a software package called Diacom. Diacom connects the parallel port of your computer to the diagnostic connector of your GM, Ford or Chrysler product. Depending on the capabilities of your car's on-board computer, you can read trouble codes or monitor many vehicle functions in real-time, or trap them in memory for later perusal or printout. Call Rinda Technology at (312) 736-6633.

Low-cost computer testers for do-it-yourself use are perhaps one to three years away, but when they come, they'll enable you to do an even better job. Right now there are a few simple devices on the market in the \$30 to \$40 range, but basically they consist of nothing more than a connector, a fused jumper wire and an LED, boxed with a short manual that has the breakdown of the codes and some short instructions on how to perform the tests. They work—but they're no substitute for an inch-thick factory shop manual and a certain amount of common sense. In the meantime, learn to use the engine computer self-diagnosis and you'll do more than you ever thought possible. **PM**



This Nissan's computer must be removed from under the dash to see the LED flash.

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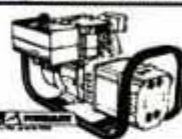
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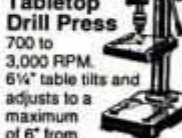
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8 HP Tecumseh engine has cast iron sleeve. Two 120 V and two 240 V outlets. Item# 16425
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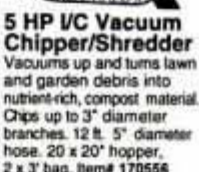
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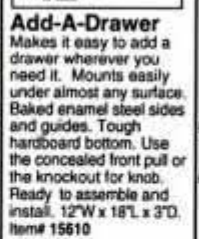
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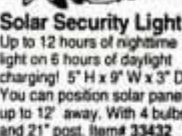
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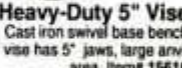
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BOATING

THE FIRST EFI STERNDRIVE

BY JOE SKORUPA, Boating/Outdoors Editor



● Here's an exercise in marine industry logic that's interesting to follow:

Stern drive engines are based on automotive engines. True enough.

Automotive engines are equipped with EFI. Equally true.

Therefore, stern drive engines are equipped with EFI. As Wayne and Garth would say, "Not!"

Not until now, that is. OMC Cobra recently debuted the marine industry's first EFI stern drive at its testing center in Stuart, Florida. And as exciting as this development is to boating, I couldn't help but think: It's about time. EFI has been a standard feature on cars for the past 10 years. It's been gradually spreading through outboard lines for the past four or five. Why did it take stern drives, which are based on technologically familiar Detroit iron, so long to come up to speed?

The answer is lack of incentive. Back in the 1970s, the Big Three car builders weren't exactly thrilled to expand into EFI, either. But two things forced their hand: 1. Government regulations mandated better fuel efficiency and lower emissions levels, and 2. Aggressive import builders invaded the United States and forced the Big Three to radically

upgrade technology and virtually everything else about the car business.

Unfortunately for the stern drive market, it has neither of these incentives. Although the situation may change in the future, to date, the marine industry remains free of government-mandated performance standards and emissions controls. And, unlike cars and outboards, aggressive import builders haven't fully cracked the stern drive market, yet. Stern drives, in fact, are in the unique position of being dominated by a single builder that holds an estimated 80% of the market. That builder is MerCruiser, and from the evidence available, the absence of competition has apparently produced the absence of stern drive EFI.

One of the ironies of this situation is that MerCruiser's sister division, Mercury, actually introduced EFI to the outboard industry in the late '80s. So, although the company theoretically had the means to develop an EFI stern drive earlier, it's clear that MerCruiser chose to wait. From a corporate point of view, this decision didn't hurt MerCruiser's market dominance, but it did leave the door open for someone to jump through. That someone was OMC Cobra.

Bite of the snake

Without doubt, EFI is a technological advancement for stern drives. Why? Do you like getting better gas mileage? Do you like the engine to start every time you turn the key in the ignition? Do you like feeling that the engine is hard-wired to the throttle instead of connected by a bungee cord? Even Wayne and Garth couldn't mess up these questions.

Here's how the system works: To achieve the improved levels of performance, the OMC Cobra EFI uses a multiport injection system that atomizes the fuel entering the manifold. To get the fuel to the injectors, the system uses two electronic pumps. The first, a low-pressure unit, draws fuel

(Please turn to page 116)



OMC's new EFI stern drives are based on 5.0-liter and 5.8-liter Ford engines.

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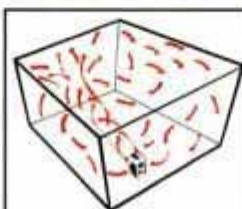
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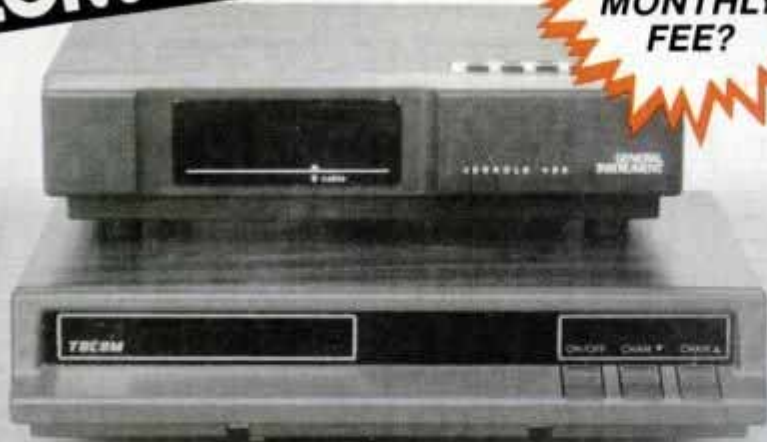
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BOATING (Continued from page 114)

from the fuel tank and sends it to the fuel vapor separator. The second, a high-pressure unit, transfers the fuel to the combustion chambers. OMC's unique water-cooled fuel vapor separator makes the EFI engine compatible with current boats by cooling the fuel and eliminating the need for a return line to the fuel tank or for a tank specially designed for EFI.

The brains behind the EFI system is OMC Cobra's familiar Spitfire electronic engine management unit, which monitors and controls fuel delivery, spark advancement, temperature, torque loading and other important aspects of engine operation. The Spitfire computer works in conjunction with the EFI electronic engine control module, which is called the EEC IV. Integrating these units, according to OMC engineers, was the most difficult part of the EFI development process.

The OMC Cobra EFI sterndrives are based on 5.0-liter and 5.8-liter Ford V8 engines. Why Ford and not ubiquitous GM blocks? Reportedly, Ford was more cooperative during the difficult process of integrating the Spitfire and EFI brain boxes. GM, on the other hand, traditionally likes to keep everything on a tight leash. Perhaps the difficulty in getting full cooperation from GM may be one reason why MerCruiser has been slow with its own EFI development. Perhaps not.

Whatever the reason, there are rumors that Merc is going to unveil an EFI sterndrive in the fall using a 502 GM block. This will probably be a premium-priced, high-performance engine. While this is welcome news for MerCruiser aficionados, it's interesting to note that EFI arrives as non-premium standard equipment on the OMC Cobra V8s. OMC's price point for EFI- and non-EFI-equipped sterndrives in the same power range will be exactly the same. Eventually, according to OMC, non-EFI sterndrives will be eliminated from this engine class and a new era will dawn in sterndrive power.

New Stable-V hull

As interesting as the OMC Cobra EFI was during its recent introduction, the design of the runabout in which it was tested was every bit as newsworthy. The boat was the new Four Winns 210 Horizon Sunsport and, together with the EFI sterndrive, it provided the most carlike ride available on the water. The reason for this is twofold: 1. The EFI engine starts like a car with a simple turn of the ignition key, and 2. The 210 Horizon (21 ft. 6 in. long, 7 ft. 6 in. wide and a 20°

deadrise) has a Stable-V hull that hugs the water the way a sports car hugs the road.

Currently available in Horizon bowriders and Sundowner cuddies, the Stable-V hull uses the integrated swim platform as a functional surface component on the hull. It does this by extending pod-like structures down from the swim platform to just above the water level. The pods surround the engine's outdrive aft of the transom, similar to a tunnel-hull boat, and they break free during normal straight-ahead running. Another visible element of the design is the hull step, which is just forward of the tunnel.

Aside from these obvious elements, however, there's a lot you can't see in the Stable-V design. Designer Tom Wenstadt, who developed the hull during a period of two years, talks about engineering concepts like the hull's progression of deadrise, the center of lift, the prismatic coefficient and other murky matters. While these concepts are no doubt essential, it didn't really start to make sense to me until Wenstadt compared the pods to dragster wheelie bars.

Like dragsters, boats have a tendency to lift their front ends during acceleration. However, when the 210 Horizon's front end starts to lift, the Stable-V pods come into play and hold the hull down like a wheelie bar on a dragster. This makes for exceptionally level and efficient hole shots.

Carl-like ride

The Stable-V pods also come into play during hard-cornering maneuvers and prevent the boat from rotating excessively on its side. To test this, the Four Winns engineers challenged me to perform some high-speed, wheel-lock turns. I happily obliged. What I found was that no matter how sharply I spun the steering wheel at speeds up to 50 mph, the 210 Horizon smoothly held the turn without sliding, going over on its side or blowing out the prop. Equally important, since the pods remain above the waterline, the hull provides a fairly smooth ride in rough chop.

Needless to say, I was impressed by the Stable-V's performance, which gets its name from the fact that it has great side-to-side stability and is particularly well-mannered in all situations. But what really intrigues me about the concept is that when you combine the innovative Stable-V with the state-of-the-art OMC Cobra EFI sterndrive, you get a ride that's the closest thing on the water to the feel of a car on the road. Pleasure boaters have been waiting for this experience for a long time.

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DETROIT SPY REPORT

BY JIM DUNNE, Detroit Editor

1994 Cadillac De Ville

● This view of the 1994 Cadillac De Ville sedan shows major changes, though the overall look of the car is similar to the current model. Traditional styling is carried over in the eggcrate texture of the grille and the Series 60 rear fender skirts.

Note the plastic bumper that replaces the bright metal bumper of current models. Major body changes include a more rounded appearance overall and a sloping hood.

Cadillac is expected to offer a version of the new Northstar V8 engine in the De Ville line, to boost horsepower to the 250 level.

Troféo 4-Door

Oldsmobile will have a new V8 engine ready for this 4-door sports sedan when it makes its debut as a 1994 mod-



1994 Olds Toronado-replacement Troféo will receive 4.1-liter version of Cadillac Northstar V8 engine.

el next fall. While the Toronado replacement will continue with front-wheel drive, Olds will use a 4.1-liter version of Cadillac's Northstar engine for the new car.

This prototype, undergoing tests in Michigan, carries a heavy disguise at the C-post and a brow atop the hood. Black paint covers other styling details, including an upright, reverse-curved backlight.

1994 Explorer Facelift

Ford enjoys a huge lead in sales for its sport/utility Explorer over the competition—and it intends to keep that lead. Next year, Explorer will get a front-end freshening to change the grille appearance from that of a light-



truck to more of a sedan (station wagon) look. The changes will be restricted to an upscale model, one that will compete in the \$25,000-plus price range of the Jeep Grand Cherokee. Look for more detail in the grillwork,

a completely new front bumper, relocation of parking and running lights and a fancier appearance overall.

Small Cadillac

Cadillac and other GM divisions may be planning a new car—one with rear-wheel drive—that will sell at the low end of the Cadillac price lineup. The plan is to compete with the growing number of smaller Japanese luxury models

that sell in the \$25,000 to \$30,000 range. And, since all of Cadillac's competitors use rear-wheel drive, the GM luxury car division will be competing head on against the imports. Cadillac's plan is to build a 5-passenger midsize car, powered by a V8 engine driving through the rear wheels. Olds and Pontiac are interested in sharing the Cadillac design. What's hold-

ing up the project? GM's recent cost-cutting moves leave little room for the addition of a new rear-drive platform.

V8 Imperial?

Chrysler's plans to build a V8-powered Imperial as the eventual top model (above the New Yorker, due in mid-1993) in its new LH line face two obstacles.

First, altering the chassis to accept the bigger engine. The LH cars were designed around two variations of the same V6 block.

Second, and probably more expensive, is the problem of coming up with the right engine for the job. None of Chrysler's current car lines use a V8, which means one of the company's two pickup truck V8s—318 or 360 cu. in.—would have to be pressed into service.

Chrysler's product planners regard V8 power as essential for a prestige nameplate like the Imperial. But if



Segment-leading Ford Explorer 4x4 gets a more carlike grille treatment and a completely new front bumper for next year.

the adaptation is too costly, the Imperial project will probably be dropped.

Ford's V8 Engines

Ford's 4.6-liter V8 will quickly spread to other vehicles in the stable. Versions are already in the Crown Vic, Grand Marquis and Town Car. The 32-valve high-performance version is being introduced in the '93 Mark VIII. Thunderbird and Cougar will get the sohc 220-hp edition next year. Finally, Ford will install the same engine in its newly designed 1995 Mustang.

Lead-Acid Power

GM has chosen lead-acid batteries for its 1995 Impact electric car. It may be old-fashioned in design, but the lead-acid is a proven battery that should hold no surprises when the Impact hits the road. "We chose what's available now," a GM engineer explains. "We have to be ready for 1995, and can't wait to develop a new battery." This decision allows GM to build all of its electrical parts to work with a familiar and dependable power source.

Electrifying Price

Chrysler's electric van is a "zero emissions" vehicle, but its price is sky high. Chrysler plans to charge customers \$100,000 to \$120,000 for its electric full-size van. Yes, Chrysler designers explain, the van uses a current Dodge Ram Wagon body and chassis. That keeps the cost down.

But the batteries are expensive. And the cost of building special heaters, air conditioners, power-steering pumps and brake boosters jacks up the price. At \$100,000-plus, electric utility companies are likely to be Chrysler's only electric van buyers.

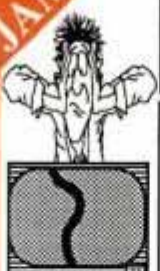
Future Battery

Among the batteries for an electric car of the future is a nickel-metal hydride type being developed by a group that includes Ford, GM, Chrysler and Ovonic Battery Co. of Troy, Michigan. According to its backers, the Ni-MH battery will last the lifetime of a car and deliver twice the energy for its size—that means double the mileage. It is also claimed that the battery can be recharged to 60% of its capacity in 15 minutes, and delivers the same performance—top speed, acceleration—as a lead-acid battery.

While the Ni-MH battery has been mass produced in small sizes for portable computers and telephones, the large size needed for automobiles has not been built. This is the goal of the new consortium—perfect Ni-MH for mass production. Developers are careful to give no hint of the ultimate price of the Ni-MH battery. **PM**

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ELECTRONICS

SMART CREDIT CARDS

BY FRANK VIZARD, Electronics Editor



● From a technical point of view, the credit cards people carry are pretty stupid. Basically, they're nothing more than pieces of plastic with a magnetic strip on the back.

Now consider the smart credit card: It is the same size and shape as the credit cards people already use. The only difference is that the smart credit card has a small, gold electronic chip embedded in the plastic. This is the card's brain.

Smart cards have been used in Europe for some time and for a variety of purposes. In Ireland, for example, people buy a Telecom Eireann Call-card for a set fee and then use it to make telephone calls. As you make each call, the charge is electronically subtracted from the total value of the card. When you've used up your "units," the telephone will no longer accept your card. Then you simply buy a new one.

Despite its popularity in Europe (114 million are used each year), smart cards are only beginning to be used in the United States. One of the first places Americans will see smart cards is at the local supermarket. Leading the way is Super Valu Stores Inc., which plans to install a smart card check-out system at 200 of its stores nationwide.

The Vision system, as it is called, was developed by Advanced Promotion Technologies with financial services provided by Bank One. The Vision terminal measures only 16 in. long and 9 in. high. This compact console features a touch-sensitive videoscreen that shows videos of store specials. Also on-screen is an electronic

One smart credit card can replace many because the gold IC chip holds three pages of data.



register showing the price of individual items being purchased.

Next to the videoscreen is a printer for producing receipts or special discount coupons. Finally, there is a card reader—you just put your card in the slot—that allows you to charge your purchases. The keyboard is for entering a personal identification number which prevents unauthorized use.

Another application of smart card technology is in government assistance programs. In St. Louis, Missouri, and Dayton, Ohio, pilot projects using smart cards and terminals

from Oki America Inc. and National CacheCard Co. are underway. In this instance, smart cards are used as replacements for welfare checks. Monthly benefits are stored on a smart card, which recipients then use to purchase goods or medical services. The government saves on paperwork, but more importantly, smart cards can't be stolen like welfare checks.

Similarly, the U.S. Department of Agriculture is interested in using smart cards for the estimated 23 million Americans using food

stamps. Instead of paper coupons, aid recipients would get a smart card with the dollar amount of their entitlement stored in memory. Here again, the considerable savings in administrative paperwork and food stamp fraud—estimated at \$36 million per year—justifies the use of smart card technology.

Because the IC chip on the smart card can contain the equivalent of three pages of typewritten information, the smart card can also be used to consolidate accounts. For example, a car-rental card, telephone charge card and a gas card could be all contained on one smart card. If nothing else, a multiple-use smart card will make your wallet thinner since you'll have fewer cards to carry around. **PM**



Vision supermarket check-out system with videoscreen uses smart card technology.

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MOTORSPORTS

FORTUNES OF WAR

BY TONY SWAN, Automotive Editor



● For every champagne-soaked victory circle celebration you've ever seen on TV, there are 10 tableaux of desolation that never make the small screen. Frustrated drivers, gloomy crews, broken race cars—like the victory circle antics, they provide an unmistakable index of where Lady Luck has been spreading her fickle favors.

Make no mistake—luck is the random variable of racing. When it deserts you, bad things start happening, even if your team is among the best. You could ask Scott Sharp, whose Camaro has led almost every race on the 1992 SCCA Tide Trans-Am Tour. But with two events left to run, the defending series champion was trailing teammate Jack Baldwin.

Even better, though, you could ask Tommy and Bobby Archer. After establishing themselves as top contenders with regular Kenwood Fast Five qualifying spots and a stunning 1-3 finish at Detroit, the Archers found that Lady Luck's limited attention span had shifted.

In particular, it had shifted away from the Dodge Daytona powerplants. The Archers had excellent durability with their 305-cu.-in. (destroyed from 318) Dodge V8s during the early part of the season. Although these engines lack the decades of development enjoyed by the Chevy and Ford V8s, they were comparatively bulletproof—until midseason.



Starting from the back of the Lime Rock grid due to tire problems in qualifying, Tommy Archer (3) worked his way past the Mustang of Jerry Clinton (14) to pursue defending champ Scott Sharp (33). But a broken spring perch, incurred on Lime Rock's tricky uphill (top), put Archer on the sidelines.

When the Trans-Am Tour hit its intense heart-of-schedule stretch, the Archers ran into engine problems. Specifically, they experienced sever-

al failures due to broken connecting-rod bolts. One of them put Tommy on the sidelines when he was leading at Watkins Glen. Another took Bobby out of the hunt early in the Road America round at Elkhart Lake.

"We were surprised," said Tommy, "because these engines are basically very tough. What it really comes down to is development. We got a late start, and we're confident that what we've learned this year will help us with our engine program next year. But in a series as competitive as this, you can't afford any nonfinishes."

While this string of races effectively took the Shellzone/POPULAR MECHANICS Daytonas out of contention for the championship, the Archers continued to have some highly respectable outings.

Bobby ran a solid fourth at Lime Rock, Connecticut, then followed that with second place in a wild show at Trois Rivères, in Quebec. In that same race, Tommy had a shot at the win, running nose-to-tail with eventual-winner Baldwin through a melee of spinning cars on the last lap.

But the oily surface that had provoked the other spins put Tommy into a pirouette of his own, costing him six positions in the finishing order.

"Maybe I should have played it safe," he said. "But like we said at Long Beach, we're in this to win. Nobody remembers second place." **PM**

a prototype on the market.

Soldiers themselves are often modeled by toy manufacturers. A marvelous grouping of toy soldiers from the period between the World Wars is on display, complete with radio operators, medical personnel, a cook and even a pigeon handler. From the Vietnam era, a GI Joe doll rides the waves of imagination in his pontoon boat. POPULAR MECHANICS cover art illustrates his real counterpart using a newly developed night-vision scope. Another PM cover on exhibit is dedicated to the women war workers of WWII, with Rosie-the-Riveter types finishing off the glass nose cone of a B-17 Flying Fortress.

One of my favorite images in "Irresistible Force" is a photo of a Canadian soldier in France during World War I. He sits in a narrow, muddy trench reading a copy of POPULAR MECHANICS with a big grin on his face. The photo confirms why we had difficulty locating PM issues from that era for the exhibit. During the war, POPULAR MECHANICS told readers that if they dropped their old magazines in a mailbox, they would be shipped to servicemen overseas.

Wars are important to the spread of technical knowledge in many ways. Servicemen often learn how to use new technologies, bringing mechanical skills back to civilian life after the war and applying them to do-it-yourself projects of all types. Often, too, surplus war items find their way into the hands of civilians, inspiring all kinds of innovative uses. We've included one of the more whimsical recycling projects from World War I—a PM contest to see who could come up with the best use for thousands of left-over trench helmets. (The winner used them to protect young melon plants from frost.)

Yet for all the whimsy of the toys, we hope we've reminded visitors of the consequences of war. PM pictured some children playing soldier, and some donning real gas masks. Some dads built the "Sink-Em!" battleship game for their kids, while others engaged in "The World's Biggest Chess Game" on the high seas of the Pacific. Last year, desert camouflage hit the market in time for kids to emulate their parents in Desert Storm.

"The World War was the most terrible event civilized man has ever witnessed," wrote inventor Hiram Percy Maxim for PM in 1936. "If another breaks out, and nations take advantage of all the amazing developments since 1918, what are the consequences likely to be?" Fifty-six years and an eternity of technology later, that same question still nags us. **PM**

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HOW TO RESTORE AN OLD CAR

Part 4: Paint Work

BY RICH TAYLOR, Contributing Editor; PM Photos by Jean Constantine

● You'll remember that last month we restored our 1967 Camaro convertible back to the "roller" stage. This means the car is finally sitting on its wheels once again, with the chassis and unibody essentially complete and awaiting only the finish paint work. But there's more to a show-car finish than just firing up the spray gun and turning everything Matador Red.

Even though most of the body panels on our Camaro are new, they still required a surprising amount of bodywork to bring them up to spec. Dings, dents and distortions seem to be inevitable during shipping and handling.

We had already sprayed the uni-



Our Camaro as it rolled out, Matador Red at last (top). Back at our shop and equipped with Rally Stripe, SS emblems and rear spoiler (above).

body inside and out with Dupont 1615 self-etching primer to protect it from surface rust. Running our Campbell-Hausfeld dual-action sander lightly over the surfaces using 100-grit paper instantly showed high and low spots.

The next step was to sand the bad spots down to bare metal, then fill

them with body filler. I mix only a small amount at a time and throw the remains away, bowl and all. This avoids contaminating the next batch of filler with residue from the previous batch.

Auto-body men call filler "cheese," because it is greenish-yellow and the proper time to start working with it is just after the catalyst has kicked off and the filler has the consistency of Swiss cheese. I start by using an "English file" sold by The Eastwood Co. This is a body file with a turnbuckle to adjust it to either concave or convex surfaces. It's perfect for rapidly cutting down filler.

Some auto-body men like to slather
(Please turn to page 127)



Rich uses an English file to shape body filler on the rear deck. This is a tricky area where many different body surfaces meet.



Rich mixes body filler in a disposable paper bowl before adding another layer to smooth multitudinous door dings.



Ken Barnes uses a DA sander on the inside of the trunklid prior to priming and painting.

large areas with filler, then sculpt it back to shape. I prefer to build up dents a small amount at a time. The sequence that works for me is English file, DA sander with 100-grit paper, DA sander with 220-grit paper, then hand sanding with 220-grit paper wrapped around a sanding block.

The most precise tool for discovering and measuring imperfections is still the human finger. Running your hand over the surface will detect bumps and hollows you can't see.

The most difficult areas on our Camaro were the weld seams where the quarter-panels meet the rear deck and the top edge of the quarter-panels where they meet the top molding. The weld seams in the door openings, floor and trunk were not filled at the factory. We brought them up to a reasonable appearance, then brushed them with seam sealer to



It's not enough to clean areas to be painted, you must also clean areas where dust can blow onto fresh paint.

duplicate the factory look.

Modern catalytic paints are extremely toxic. We entrusted the finish coat to our friends at Sharon Auto Body, where they have sealed spray booths and clean-air respirators to protect both themselves and the environment. This stage of the project is like a jigsaw puzzle. We brought them the unibody, doors, trunklid, rear spoiler, hood, front fenders, front upper and lower valence separately.

Master craftsman Jim Young started by filling small sanding imperfections with Evercoat 417 glaze. Then he scuff-sanded each part with red Scotchbrite pads to give the paint a good bonding surface. Over this he sprayed PPG Kondar primer/surfacer. This was block sanded using 180-grit paper, reprimed, then sanded again with 320-grit paper on a DA sander.

Before the pieces of the body could be put together, the edges had to be sprayed with Matador Red. Sharon Auto Body used Glasurit 21 Line, a single-stage urethane enamel. Not only did they spray around all the edges, they put a light overspray on the body panels. This is useful for detecting any small imperfections.

With the edges painted red, we could now carefully assemble our Camaro. We installed the trunklid, doors, front fenders, front valence and hood. Once the bodywork had been put together and adjusted for even edge gaps all the way around, the whole thing was given a final sanding with 320-grit paper on a DA.

In the paint booth, the interior was masked off with brown paper and tape, along with the wheel wells and the area under the body. Fifteen minutes before applying the finish paint, we had the body sprayed with a catalyzed sealer. And then, after six months of work and anxiety, in a matter of hours our dull-gray project metamorphosed into a Matador Red Camaro convertible. We rolled it out of the paint booth beautiful enough to bring tears to your eyes.

Back home, we installed the rear spoiler and front airdam. Then Jim came by and masked off the white

(Please turn to page 128)



Wearing a respirator, Ken sprays "yellow death" onto finished doors using our TP-77.



Ken masks wheel wells and chassis before putting on a protective coat of Dupont 1615 self-etching primer.



Edges painted! Matador Red overspray on primer helps locate imperfections and will be sanded off before finish coat is applied.

Rally Stripe that distinguishes an RS Camaro. Back in 1967, the Rally Stripe was applied by hand, and there are no specifications for it. We used the width of the RS fender emblem as our logical width, scuff-sanded the stripe area then sprayed it white. We removed the tape about 20 minutes after painting to minimize pulling at the edges.

We used a variety of spray paints from D&R to finish off our car. The trunk took No. 19003 green/aqua spatter paint, the wheels required Rally Wheel paint and the firewall, dashboard and interior trim took No. 19001 semigloss black. Since all these areas had already been primed, it was a simple—though surprisingly time consuming—matter to scuff sand, clean, mask off and spray these areas.

Wouldn't you know it. I stood back to admire our bright-red Camaro and noticed a discrete, but still undeniably noticeable, dent right in the center of the front upper valence. It was too

subtle to see in flat finish primer, but all-too-evident in gloss red. The hood hinges also had primer overspray that made them look disreputable.

We still had the original valence that had come on the car, which turned out to be heavier and more accurate than our new replacement. It had to be sandblasted, bodyworked, primed and painted and reinstalled on the car. Then both fenders, the valences and the hood had to be readjusted for fit. Camaro hood hinges were raw steel when they left the factory. We sprayed them flat black for a neater appearance before reassembling the nose of the car.

Spray painting a car is easy. Getting it ready to paint is hard. It requires the most meticulous kind of handwork, and you simply cannot skimp. Modern-day materials are also frighteningly expensive. We paid well over \$1000 for paint alone. On the other hand, the materials are such a small part of the total cost of a restora-

tion it's foolish not to buy the best.

Next month, we'll show you how we detailed the exterior of our Camaro with new chrome and trim and installed the diabolically complicated "hideaway" headlights. At that point, not only will our car be red, it will truly look like a real 1967 RS/SS Camaro convertible. **PM**

SOURCE LIST

The following is a list of some of the suppliers for this project:

- Auto Body Specialties, P.O. Box 455, Middlefield, CT 06455; (203) 346-4989 (Body parts)
- Campbell-Hausfeld, 100 Production Dr., Harrison, OH 45030; (513) 367-3130 (Air compressor and air tools)
- Chevrolet Division, General Motors Corp., 30007 Van Dyke Ave., Warren, MI 48090; (313) 492-8855 (Engine and transmission)
- Coker Tire, 1317 Chestnut St., Chattanooga, TN 37402; (800) 251-6336 (Reproduction old-style tires)
- Daytona Mig, 1821 Holsonback Dr., Daytona Beach, FL 32117; (800) 331-9353 (Mig welder)
- D&R Classic Automotive, 31 W. 208 Diehl Rd., Suite 107, Naperville, IL 60563; (708) 369-2030 (Camaro restoration parts)
- DTS, 22250 Scheman Rd., Warren, MI 48089; (800) 521-0628 (Rear axle ring and pinion)
- Eagle Equipment Co., 23 Wetherill Place, Plainville, MA 02762; (800) 535-0016 (Lift)
- The Eastwood Co., 580 Lancaster Av., Frazer, PA 19355; (800) 345-1178 (Specialized restoration tools)
- Gearbox Grannies, 3944 Indian Ripple Rd., Dayton, OH 45440; (513) 429-5642 (Even more specialized restoration tools)
- General Motors Service Parts Operations, 6060 W. Bristol Rd., Flint, MI 48554; (800) GM USE US (Body, suspension and trim parts)
- Goodyear Tire and Rubber Co., P.O. Box 9125, Akron, OH 44305; (216) 796-2490 (Contemporary tires)
- Kanter Auto Products, 76 Monroe St., Boonton, NJ 07005; (800) 526-1096 (Springs, shock absorbers)
- Minisport, Jackson Hill Rd., Sharon, CT 06069; (203) 364-0311 (Complete auto restorations)
- OEM Glass, P.O. Box 362, Route 9 East, Bloomington, IL 61702; (800) 283-2122 (Auto glass)
- PST, P.O. Box 396, Montville, NJ 07045; (800) 247-2288 (Suspension bushings, antiway bars)
- Sharon Auto Body, Route 343, Sharon, CT 06069; (203) 364-0128 (Finish bodywork and painting)
- TIP Sandblast Equipment, P.O. Box 649, Canfield, OH 44406; (800) 321-9260 (Sandblaster, bead blast cabinet, paint sprayer)
- Wurth USA, 93 Grant St., Ramsey, NJ 07446; (800) 526-5228 (Fasteners, ie. nuts and bolts)

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less than \$600.

We used our TP-77 to spray chassis black, primer and even finish paint onto noncritical areas. We could have painted the whole car with it, but we didn't quite dare on such an important project. We did just paint our car hauler using it, however, and we'll surely use it to paint our next restoration project. This inexpensive air turbine produces a finish that equals the best that professionals achieve in a \$100,000 paint booth.

—R.C.T.



ability to the seating, which seems to have been designed by an origami master. Both the second and third rows of seats can be folded or reclined in several configurations, creating a surprisingly spacious cargo bay. Another unique touch is the Expo's four car-style hinged doors.

The smaller 5-passenger Expo LRV is clearly not designed for large families. But for its size, it too can swallow a surprising quantity of stuff.

Both of the Expos scored high marks for routine serviceability.

Where these two vehicles really shine, though, is in all-around performance. Although neither of their 4-cylinder sohc engines makes much horsepower, low curb weights pay off in lively acceleration, brisk transient response (note their slalom times) and good fuel economy.

Our LRV Sport, equipped with a 5-speed manual transmission, fared particularly well in our instrumented testing. Both Expos are available with 5-speeds, as well as awd systems.

Incidentally, the Expo is also available through Plymouth and Eagle dealerships, where it's known as the Colt Vista or Summit Wagon, respectively.

Pontiac Trans Sport SE

The Trans Sport and its GM counterparts (Olds Silhouette and Chevy Lumina APV) have come to be known as the "Dustbusters." Call us crazy, but we have a hunch the nickname has something to do with the styling, which people seem to either love or hate. The same polar reaction ran down the middle of our test crew.

Assessed on the carlike scale, the Trans Sport still gives something away to the Caravan, as well as to the

new Quest and Villager. The test crew consensus was that it feels a tad more trucklike than the Caravan, and a fair percentage had the usual discomfort concerning the exact whereabouts of the invisible extended snoot.

But we're here to tell you that this is a much better Trans Sport than its predecessor, for two reasons. First, there's now a 4-speed automatic

tional powertrain is like night and day. Our test data tells the story.

The other compelling Trans Sport feature continues to be the adaptability of its seating. With all three rows of seats, the Trans Sport is a roomy, comfortable people-hauler. Or you can click the seats out and create a veritable cargo cave.

While the adaptability gap has closed in this area, the GM minivans are still tops.

Toyota Previa LE

The Previa's flowing exterior design emerged as the favorite of our test crew. It's a look that'll be contemporary for a long time—good looking at rest, even better looking in motion.

We liked the good driver sightlines that go with the extensive glass areas, and the midship engine location (beneath the front seats) provides exceptionally positive handling.

However, the 4-cylinder engine is also one of Previa's weak points. Peak power is no better than adequate in a vehicle as heavy as this, and extracting all the power entails excessive noise.

The Previa's interior is pleasant, and there's all sorts of neat stuff available here—such as dual sunroofs, separate rear passenger air conditioning and a built-in beverage cooler. Besides its all-around comfort, the seating is moderately convertible for extra space—though some of the other vans do a better job. And even though there are too many stalks sticking out of the steering column, the general control and instrument layout is both functional and distinctive.

All in all, the Previa stacks up as an exceptionally well-built vehicle with enduring good looks. Just don't expect the heavy-load performance some of the other vans can deliver. **FM**

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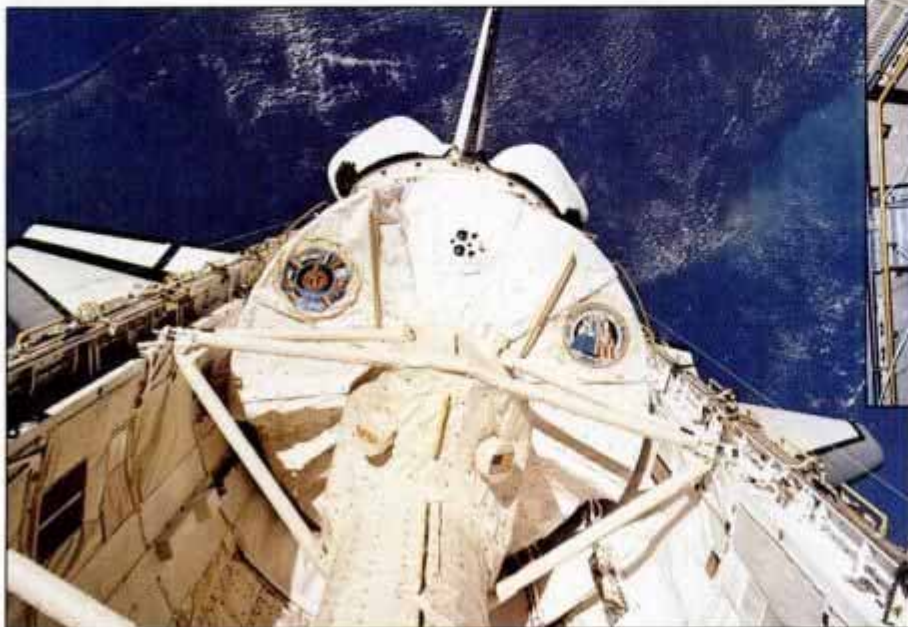
General Motors Parts

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SCIENCE

EXPLORING MICROGRAVITY

BY ABE DANE, Science/Technology Editor

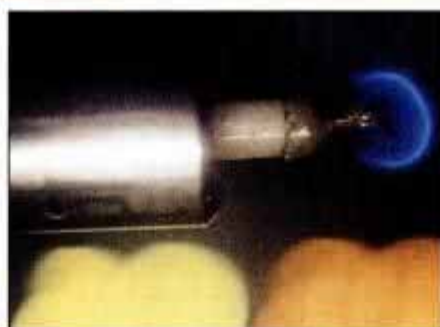


● When scientists lose the familiar tug of gravity, problems that they figured out centuries ago suddenly become baffling all over again. They enter a weird new world where they no longer know what will happen if you light a candle or put water on to boil.

That's quite a comedown for people accustomed to being able to predict how an airplane will fly without so much as building a scale model beforehand. Yet, it's also an opportunity to blaze fundamental new trails and to get an entirely different perspective on what they already know—or think they know.

But until recently, this research has been sporadic, crammed in whenever astronaut schedules and spacecraft payload space permit. That changed this summer with the launch of the first United States Microgravity Laboratory aboard the Space Shuttle *Columbia*. The 14-day flight was not only the longest yet by a Shuttle, it also marked the first time that an entire mission had been devoted to exploring the orbiter's microgravity environment. (It's microgravity rather than zero gravity because in the Shuttle's low orbit there is still acceleration from atmospheric friction.) Crew training, on-board facilities and mission profile could all be custom tailored.

Most of the work was done in a cy-



inside USML-1's Spacelab module (top), candle shows microgravity combustion (above), cylindrical Spacelab module cradled in the orbiter's cargo bay. Reached via a tunnel from the crew compartment, it provided space for new apparatus



Bonnie Dunbar prepares ampoule for CGF, while Lawrence DeLucas mans glovebox.

that enabled the seven astronauts to try things never before tried in orbit.

Experiments were chosen for their potential to provide broadly useful answers to basic questions about microgravity. This, too, was a departure from past practice. "Ten years ago, what everybody wanted to do was go into space and make a product or find an application—like 'let's go into space and grow crystals so we can sell them,'" says Joel Kearns, program manager for microgravity solidification research and biotechnology at NASA. "That's not really the focus right now. One of the reasons is that everybody figured out how expensive it is to get in space, and then also how little we really know about the basic theories that would determine whether this stuff will work."

Much of this theory is in the realm of fluid dynamics, since the behavior of liquids on Earth is so dominated by



Negative-pressure device tests ways to mitigate long-term effects of microgravity on humans.

gravity that it's hard to measure the other forces at play. For example, surface tension, which is a relatively minor factor on Earth, becomes a major player in space. Because of it, the easiest shape for a globule of water to assume in space is that with the smallest surface area—a sphere. Such spheres were studied in the Drop Physics Module, one of three major new instruments aboard USML-1.

The Drop Physics Module used a pair of movable syringes to deploy globules of liquid into a chamber. There, acoustic drivers were used to manipulate the drops through a variety of experiments, including spins, splits and the creation of one drop inside of another.

Another aspect of fluid dynamics that is fundamentally different in space is convection. On Earth, water heated from the bottom rises to the surface, then cools and sinks, creating a simple rotating current. In space, this buoyancy-driven convection is replaced by other flows, which are much harder to predict.

The Surface Tension Driven Convection experiment explored these phenomena by focusing lasers and an infrared imager on a cylindrical test cell filled with silicone oil. The results should help in future efforts to grow crystals and perform other delicate operations with fluids in space.

Such efforts made substantial progress in a third new piece of apparatus called the Crystal Growth Furnace. According to Kearns, the CGF marked "the first time the U.S. has built a furnace for this type of high-temperature science that has worked." Similar German and Japanese devices have lacked the CGF's precision, which makes it easier to compare its results with terrestrial data. The 720-pound CGF centers around a moving furnace module, which applies a precisely controlled sequence of temperatures to each sample. Test ampoules containing materials to be crystallized are automatically loaded under computer control. On USML-1, the ampoules contained a variety of semiconductor materials with potential applications in high-speed computing, infrared detection and optoelectronics.

In all, more than 30 investigations kept USML-1's crew of seven working in 12-hour shifts throughout their two weeks in orbit. It's too soon to say much about the scientific results of the mission, but it can already be rated as one of the Shuttle's most successful to date. Nearly everything worked the way it was supposed to, and the data should keep scientists busy for years to come. **PM**



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30 SECONDS OVER TOKYO

(Continued from page 37)

crash-landed—two crewmen died in one of those crashes and their three fellow airmen were captured. One of them was executed and another died in captivity. The 16th aircraft landed safely in Russia, and its men were taken prisoner because the Russians had not yet declared war on Japan. That crew later escaped.

As the survivors began to find one another in the mountainous Chinese country, it was clear to Doolittle that most—indeed, possibly all—of the aircraft had been lost and some of his men had likely been injured, killed or captured. After examining his own wrecked bomber, he became despondent. He had led his mission to failure, he thought, and possibly charges would be brought against him. Never has a mission commander been so wrong in his assessment.

When Doolittle got to Chungking, he learned that, rather than being court martialed, he had been promoted two grades to brigadier general. Four weeks later President Roosevelt awarded him the Medal of Honor. Every raider received the Distinguished Flying Cross.

The Doolittle attack sent a charge through two disparate populations and produced distinctly opposite results. America went nuts. Our boys had stuck it to the bad guys right on their own front porch. We'd bombed Tokyo, for crying out loud! Tokyo!

And while the physical destruction wrought by those bombs was relatively minor, the negative psychological impact on the Japanese and subsequent actions by their military were significant. The military leaders had assured the population that they were untouchable, utterly secure. When Doolittle's raiders blew those assurances to smithereens, the generals were humiliated. Their reaction was to put forward a naval plan designed to lure the troublesome American carriers out into the open, and then destroy them. The plan went awry—for it triggered the Battle of Midway, during which the Japanese carrier force was crippled.

So, in a very real sense, Doolittle's raiders were the first ripples of what became the tidal wave that defeated Japan. Doolittle returned to Tokyo one more time before the war's end. Then a 3-star general, he was aboard the battleship *Missouri* in Tokyo harbor when a delegation of officials climbed up the gangplank and signed the papers of surrender.

Just shy of 96, Jimmy Doolittle lives quietly with his son in California. He hears from his raiders regularly. Forty are still alive.

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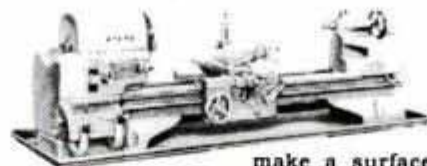
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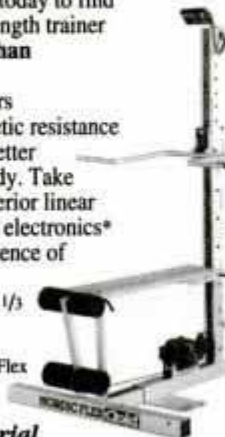
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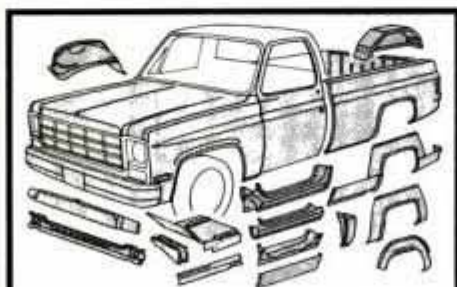
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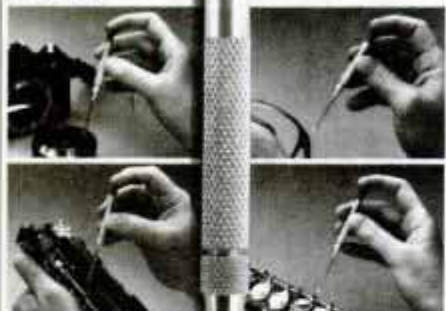
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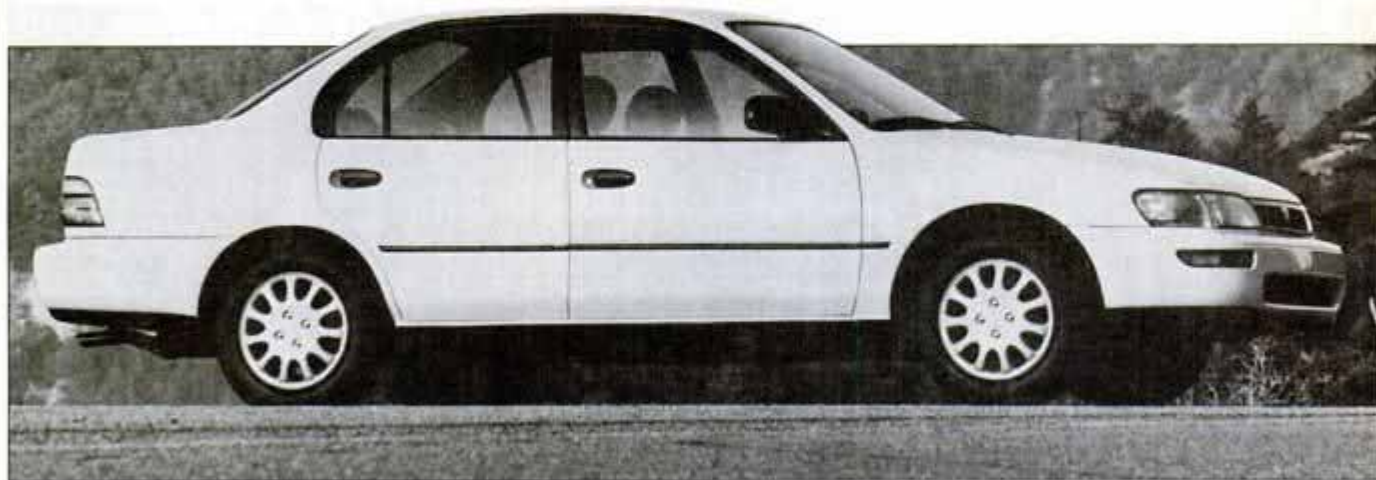
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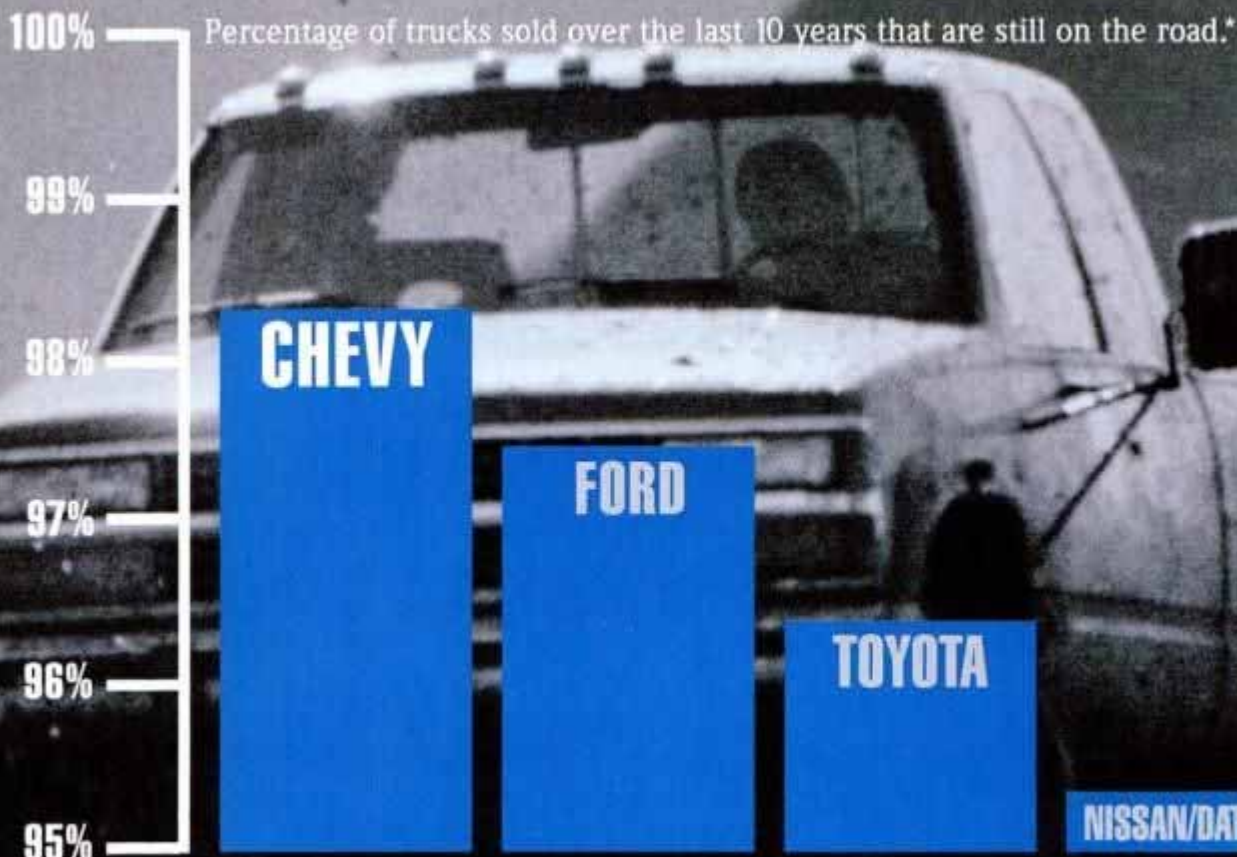
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