

FEBRUARY 1989 \$1.95

Popular Mechanics

PICKUP SHOOTOUT
9 COMPACT HAULERS HEAD TO HEAD

SLEDGEHAMMERS OF THE FROZEN ARCTIC

ATOMIC ICEBREAKERS

Now Nuclear Engines Give These Mammoth Ships More Crushing Power

BOATING 1989

- Great Boats
- Hot Motors
- New Gear

NEW SERIES

HOME & SHOP JOURNAL

- Projects
 - Shop Techniques
 - New Products
 - Tool Tests
 - Home Fixups
- Plus Much, Much More



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A cowboy wearing a tan jacket and a hat is riding a dark brown horse through a snowy, wooded area. He is holding a lasso in his right hand. The scene is captured in a cinematic style with soft lighting and a blurred background of evergreen trees.

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per cigarette, FTC Report Feb. '85

in a low tar cigarette.



This One



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WHY AMERICA'S HAVING A CHANGE OF HEART.



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THE *Heartbeat* OF AMERICA  TODAY'S CHEVY TRUCK™

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Vessels with icebreaking muscle are changing the way men live and work in the frozen North.
—PM illustration by Tom Freeman



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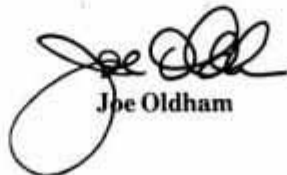
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ASTHE STORY to save the now-famous whales unfolded, a nagging question kept gnawing at me: Why did we have to call in a Russian icebreaker to cut the final swath through the ice to free the whales? Why couldn't we just use one of our own? I asked Science/Technology Editor Tim Cole to look into it. He came back with the rather disturbing answer: We only had two. They were small and old in design. And they were hundreds of miles from the rescue scene. He also told me that he'd found that the Soviet Union has several leading-edge icebreaker ships including a new one that is nuclear-powered and, coincidentally, is the largest ship of its kind in the world. All of this, plus the fact that several people I asked didn't even know how an icebreaker worked (does it *cut* through the ice or *crush down* through it or what?) seemed to indicate that an article was called for. It begins on page 56 and is probably the most comprehensive story ever published on these rather mysterious ships. But I still don't know why the U.S. doesn't own more. . . . **Speaking of ice,** you'll see a lot more than ice if you

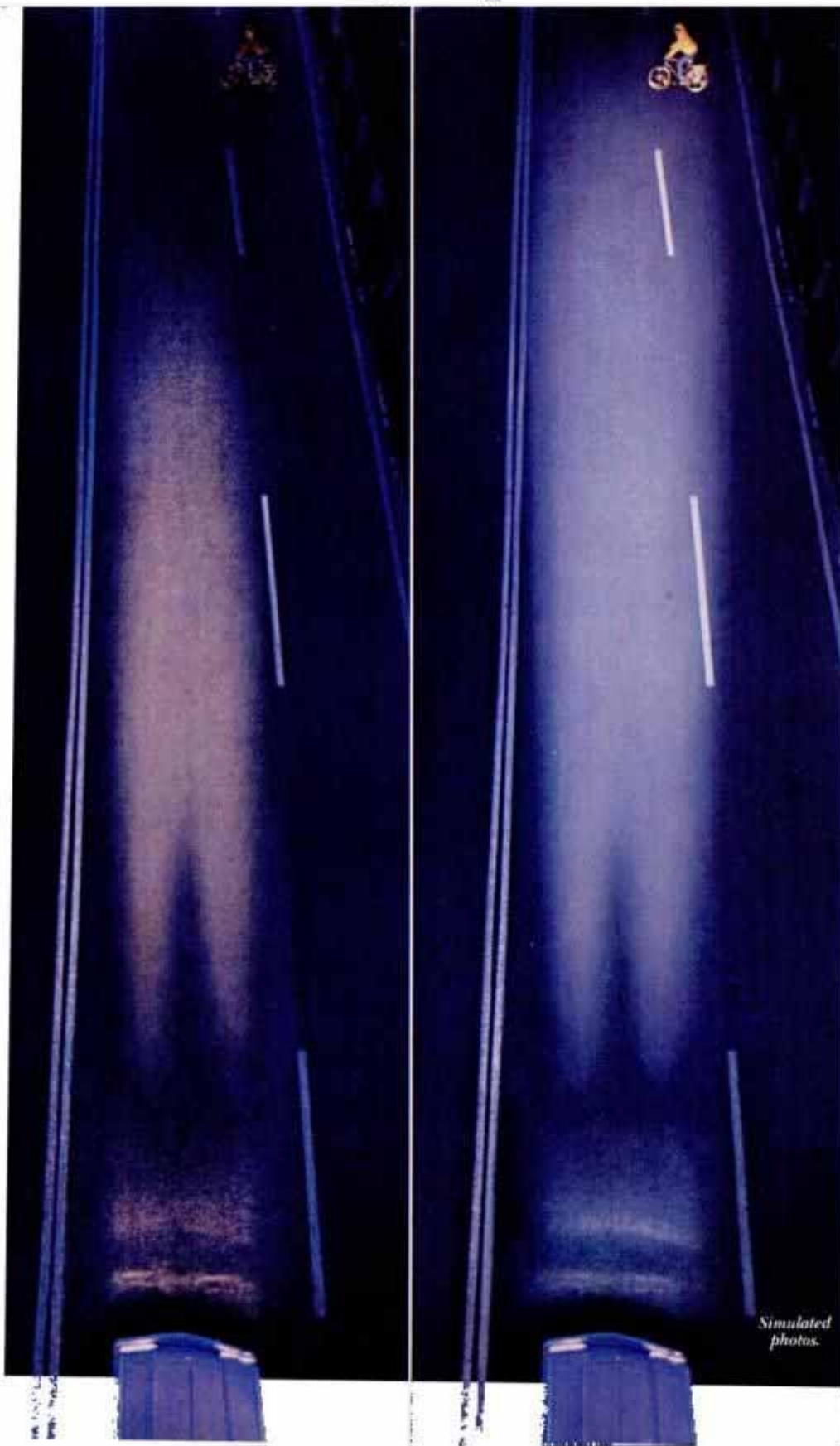


Skorupa handles tough assignment.

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Joe Oldham

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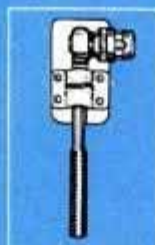
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POPULAR MECHANICS • FEBRUARY 1989

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WATCH FOR THIS MARK

IT MEANS
THE PRODUCT
HAS BEEN
FEATURED IN PM

LETTERS

Flight Plan

AS A REFORMED gyrocopter pilot, I would like to make several criticisms of your November gyrocopter article ("Good Gyration," page 72, Nov. '88). First off, you show the pilot of Kurt Shaw's Wind Ryder flying without a crash helmet. So what if he is entirely enclosed. In the event of a crash the blades almost always hit the ground with tremendous force which often leads to the violent breakage of the main mast right behind the pilot's head. I doubt if the enclosed design would protect him.

The main reasons I gave up gyrocopters was that their high drag and quick rate of descent make emergency landings over obstructed landscape a bit too much of a thrill, especially at the relatively low altitudes where you like to fly a gyrocopter. On the other hand, I have made forced landings into trees with an ultralight aircraft and walked away without a scratch, and very little damage to the aircraft.

So if you fly over open and unobstructed ground, give yourself a thrill and fly a gyrocopter (with helmet). You'll love it! Anything else, stay with a more conventional and crashworthy design.

ROLAND RIEMERS
MAJURO, MARSHALL IS.

PM Posters

Your pullout posters are perfect for the walls in our new Tech 2000 lab. The 7th graders are fascinated with the Shuttle, the 8th graders enjoy the Corvette, and parents at our open house took notice, too. We've laminated the posters for long life.

JOHN FISCHER
TECHNICAL TEACHER
CHESTNUT HILL
MIDDLE SCHOOL
LIVERPOOL, NY



Woodworker's poster and gyrocopters ran in Nov. '88 issue.

Despite its graphic stylishness and accurate information for woodworkers, I won't be hanging your hardwoods poster in my shop. Exotic hardwoods from tropical forests are indeed, as you say, "rare jewels" and we can't continue to encourage the decimation of the rainforests where these trees are cut. Environmental conscience should dictate that PM woodworkers use only the North American hardwoods shown in the poster—hardwoods from trees that are sown and harvested as a renewable resource.

ANGELA B. OLSON
TOUTLE, WA

Grouting Tip

I read with interest your article "How To RegROUT Ceramic Tile" (page 115, Oct. '88). Your discussion of the job was very accurate and complete. I might recommend, however, that your readers consider a good latex additive in place of water when mixing the grout. This will improve the bond strength of the grout, help minimize water penetration, and greatly reduce the possibility of cracking or powdering grout joints. And the

latex additive will eliminate the need for the wet curing technique you mentioned.

RICHARD C. WOOD
LATICRETE INTERNATIONAL
BETHANY, CT

Readers can thank you and Laticrete—a manufacturer of installation materials for ceramic tile, marble and natural stone—for the tip. It's a technique that works, that we use and should have included in our story.

Dutch Treat

I was interested to read about Subaru's Justy using a continuously variable transaxle (CVT) that was developed in Holland and used in the DAF ("Imports '89 Tech Review," page 100, Dec. '88). (I capitalize the letters of DAF because they're taken from the company name.) The company actually recommended changing belts every 50,000 miles, but in my experience, a belt could be used for 100,000 miles. The original DAF belts had several advantages over the new flexible steel belt, including low cost, easy replacement and a get-home ability since the DAF setup used two belts. Two belts provided a power division to the rear wheels which was superior to the so-called limited-slip differential. The DAF was unappreciated in a behemoth-oriented car culture and was an ideal runabout and commuter car that could get 40 mpg. It remains to be seen whether the Subaru achieves such a distinction.

M. HALISTA
MORRISVILLE, PA

We'll also be watching the in-service record of the CVT Justy. So far, it's the only car with CVT sold here. You're right about the initials of the Dutch car: They stand for

Van Doorne's Automobielfabriek. But we choose to go with Daf, just as Saab, for example, uses only an initial capital, which stands for Svenska Aeroplan Aktiebolaget, or the Swedish Airplane Co.

Hot Vette

Your "Motown Muscle" article (page 53, Jan. '89) didn't contain any real performance figures for the ZR1 Corvette. How fast is this car?

ROY TANNER
PISCATAWAY, NJ

The reason we didn't include any hard numbers in our article is that Chevrolet hasn't yet let any magazine perform an instrumented test on the car. However, Editor-In-Chief Joe Oldham did some informal testing on a prototype last June in Arizona. He reports a quarter-mile time of 12.86 seconds at 116 mph, and hit 131 mph in Fourth gear. He says there was still plenty of engine and two gears left, so perhaps Chevrolet's claim of 185-mph top speed isn't far-fetched.

PM Plans

I've read PM for more than 50 satisfied years, but your December '88 issue left me feeling cheated. The cover promises an article on classic toys ("Tiny-Town USA," page 86). But lo and behold, inside, there's nothing but a come-on to sell plans. And at \$6.95! JESSE SKLARIN
MARLBORO, NJ

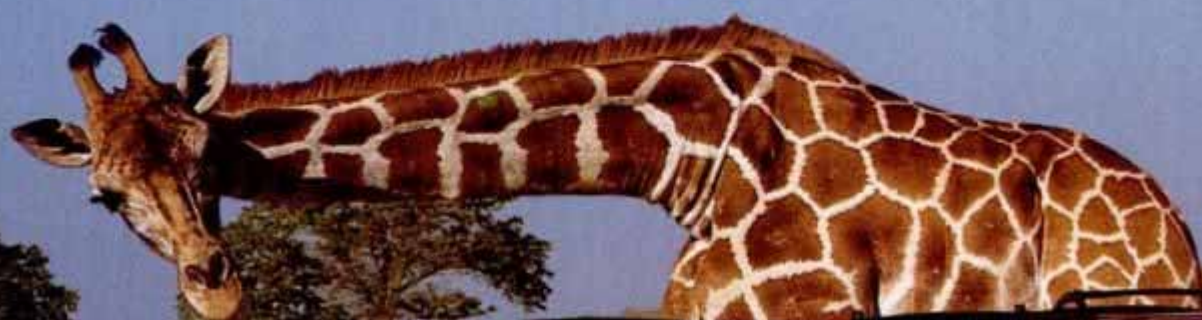
We've been offering plans for many years. Check May '86 and Aug. '88. In that same period, we ran plans and step-by-step instructions for 69 different build-it-yourself projects. Three plan sales articles in three years isn't out of line. We hope you agree and stick with us for another 50 years. **PM**

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*Regular-length model. Extended-length model tows 4700 lbs. when properly equipped. Towing rating is reduced by passenger and cargo weight in towing vehicle.

Have you driven a Ford... lately?



Buckle up—together we can save lives.

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TIME MACHINE

75 YEARS AGO: FEBRUARY 1914



Biker Brigade

In the early 20th century, automotive technology was shaping firefighting into a rapid-deployment operation. Rural road conditions, however, hadn't caught up. In our February 1914 cover story we looked at the motorcycles on which firefighters negotiated unpaved horsepaths or plowed fields, in advance of the main brigade. Partnered with a sidecar, the bikes accommodated up to two firemen and an arsenal of axes, lanterns, hoses and chemical fire extinguishers.

Ice Burner

Along with the gasoline engine, the aerial propeller was a favorite component among early go-fast engineers. Drawing on the popularity of ice yachting, a

Chicago inventor created this speedster, which skated on three blades. The vehicle glided ahead of a 4-ft. airplane propeller, driven by a 12-hp motor. Seating three, the boat achieved 80 mph.



50 YEARS AGO: FEBRUARY 1939



The Power Of Palomar

For our cover story 50 years ago we brought readers inside a masterpiece of Art Deco engineering: the Palomar Observatory. The telescope's 200-in. reflector, a showcase for brand-new temperature-tolerant Pyrex glass, would gather four times the light of any previous mirror. Other marvels included the rubber-wheeled rail trucks that rotated the 2-million-pound dome, and the observation cage suspended inside.

Tube Testing

Television was coming, and we detailed its progress to a public anxious for instant reporting of fast-breaking

news. Demonstrated in New York in 1939, the Iconoscope camera could transmit live pictures with clarity to a receiver several blocks away.



25 YEARS AGO: FEBRUARY 1964



Cheap Thrills

In 1964, a \$2500 sport plane would have thrown the aviation industry into a loop. We flew a prototype developed by Jim Bede. The BD-1 featured honeycomb aluminum construction with fiberglass landing gear, both breakthroughs for private planes. Flaps, fins, wing panels and tips were interchangeable, and the 65-hp engine generated a 112 mph cruise. The plane lowballed its nearest competitor by \$3000 but didn't trigger a downward spiral in plane prices.

Wonder World

An extravaganza celebrating a period of blossoming technology—it was the World's Fair of 1964. We took an advance tour through simulated space-ferry dockings, nuclear fusion demos, animated cave-mannequins, a 12-ft.-high human brain, and other displays. In some exhibits, amusement-ride and cinematographic technology merged to provide a journey into the future, while in others—such as the 700-ft.-per-minute glass elevators—the future was now. **PM**



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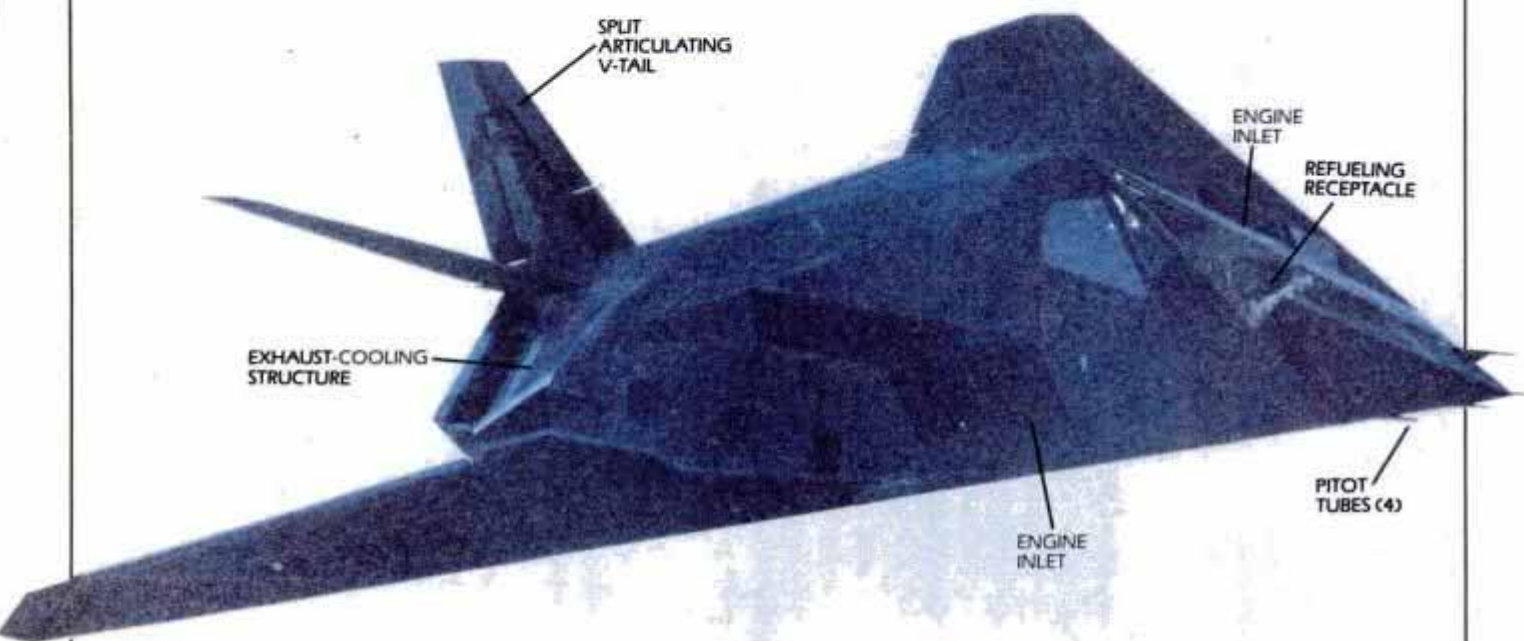
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TECH UPDATE



Stingray-shaped F-117A appears to carry no external weapons mounts, suggesting an internal munitions bay.

AIR FORCE PHOTO

It's Official: Stealth Fighter Is Operational

NELLIS AFB, NV—After almost a decade of concealing its existence, the Air Force has acknowledged that it has 52 F-117As ready for stealth attack missions (see "Our Most Secret Fighter," page 66, Jan. '89). The Lockheed-built plane, first flown in 1981, has been combat-ready since 1983.

Without revealing the plane's operational capabilities, the Air Force released a photograph showing an exterior composed of sharply angled flat surfaces, unlike the smooth contours of the B-2 Stealth Bomber, which was made public on November

22. The angular silhouette scatters radar in different directions, and the reflected radar cross-section changes as the plane banks and yaws during subsonic flight over rough terrain.

Each wing, swept back at about 45°, forms a straight line with the sides of the plane's nose. Wingspan is said to be 40 ft. The plane's tail height of 16 ft. is said to be equivalent to the A-7D, which is used as an F-117A trainer.

Because of the aircraft's unusual shape, experts think it probably relies on an electronic stabilization system.

The F-117A is considered primarily a ground-attack aircraft intended to eliminate high-value bunkers, infrared and radar sensing stations, and surface-to-air missile sites. The Air Force refused to offer any information about the aircraft's mission or munitions, but industry speculation focuses on either the Maverick air-to-ground missile currently in inventory or laser-guided bombs. Maintaining a stealth profile most likely requires that munitions be carried internally.

Designed during the Carter Administration, the Stealth Fighter first entered

public awareness in the form of popular fiction and toy models. But two F-117A crashes—on July 11, 1986, and Oct. 14, 1987—resulting in the loss of two Air Force pilots, focused more attention on the Stealth program.

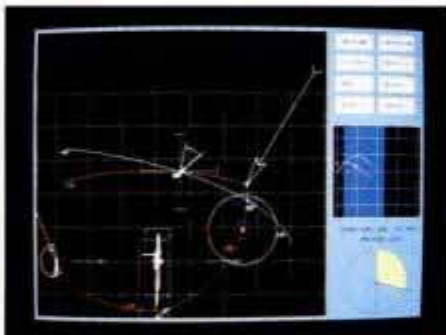
The single-seat plane became public, the Air Force said, because of the need for daylight training flights. It's also hoped that the F-117A can be integrated into combat scenarios involving other aircraft.

Editor: Tim Cole
Assistant Editor: Gregory T. Pope
Contributors: Mike Fillon, Nick Nichols,
Jan Young, Abe Dane

Space Traffic Control

MOFFETT FIELD, CA
—Controls for maneuvering spacecraft in the vicinity of

cles' positions in a modified 3-dimensional perspective based on information from radar and lidar sensors on board the spacecraft. The view is distorted to compensate for the brain's reconstruction of 3-dimensional information derived from a flat surface. Objects out of visible range are magnified. It also has a zoom capability for



Computer graphics show distances.

the Space Station will include this display concept developed at NASA's Ames Research Center.

The monitor depicts vehi-

cles in maneuvering.

The system will allow controllers to direct orbital maneuvers on a spur-of-the-moment basis.



Shuttle-2, designed to fly in the 21st century.

Shuttle For The Future

HAMPTON, VA—NASA is increasingly concerned that the Space Shuttle will be nearly 20 years old by the time the Space Station becomes operational in the late 1990s.

Studies under way at Langley Research Center

point to a second-generation Shuttle that will feature a modular, removable payload pod, wing-tip fins and long-life main engines. A winged flyback booster would replace the external tank-solid rocket booster combo that lofts today's Shuttle.

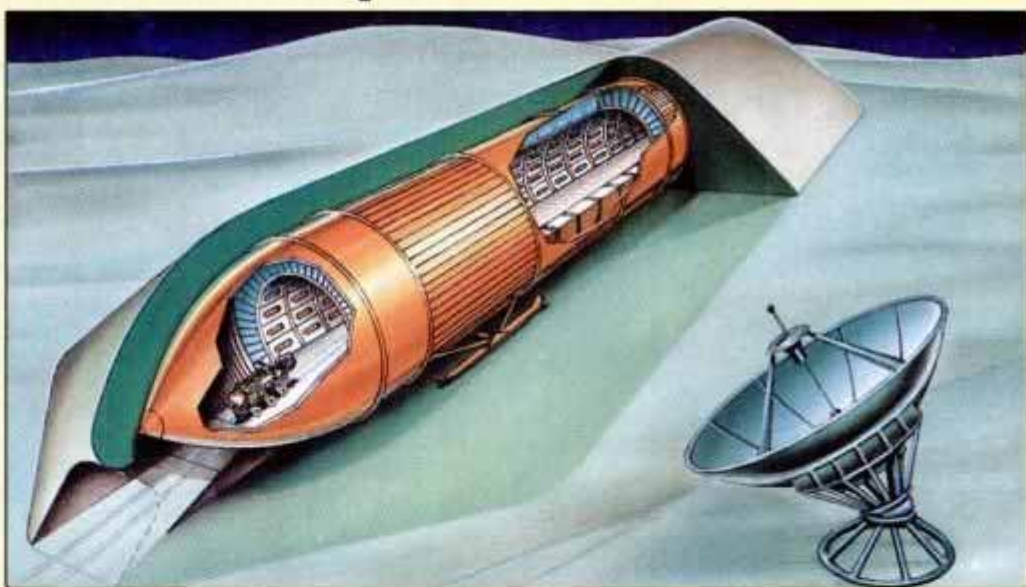
External Tanks Turn Into Space Labs

CITRUS HEIGHTS, CA
—With the Shuttles back in service, private businesses have renewed interest in the external fuel tanks jettisoned by Space Shuttle orbiters after takeoff. NASA will be putting about 40 tanks up for grabs through 1994.

Commercial space firms have proposed the tanks be converted into everything from gamma ray telescopes to orbiting industrial platforms. Typical of how commercial space entrepreneurs are reacting is a proposal by Wickman Spacecraft & Propulsion. The rocket-fuel manufacturer wants to yoke two tanks to create a microgravity research facility in geosynchronous orbit.

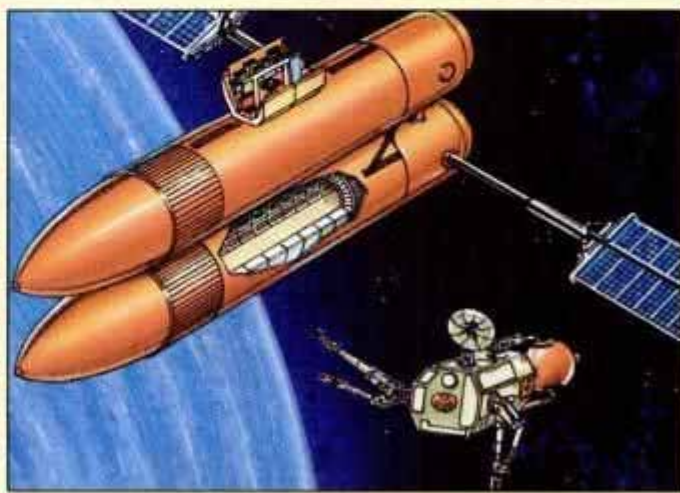
An expendable rocket will launch a robotic vehicle, Astrobot, equipped with manipulators and the experimental equipment. Astrobot will link the tanks, pad the tanks' interiors with insulation and install the apparatus. The vehicle will be able to respond to Earth-base commands and will remain in orbit to monitor experiments.

Meanwhile, Wickman has also expressed interest in landing three tanks on the Moon. Converted and ser-



Roving astrobot (above) will bury lunar tank conversions for insulation from solar radiation. Space-based astrobot (right) will co-orbit with microgravity-lab tanks, shuttling specimens between experiment modules.

vised by a wheeled Astrobot, the tanks would serve as research facilities for processing lunar soil for oxygen, concrete and other necessities. One of the tanks would be outfitted for human habitation prior to establishment of a permanent manned lunar base.

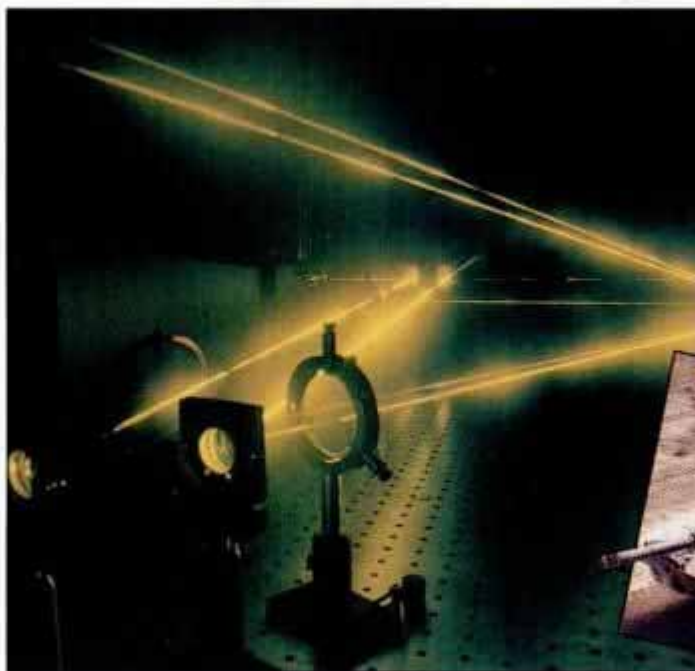


Identifying Tanks In War

STERLING HEIGHTS, MI—As tank evolution continues its course of copycat one-upmanship, target identification systems are growing in importance.

Increasingly, visible-wavelength lasers are the method of choice. Lasers used for rangefinding usually operate in the invisible infrared range for obvious reasons. General Dynamics is experimenting with dye lasers that fire in conjunction with optical crystals which also operate the system's optical computers. In this way, the system uses light, instead of electricity, to process signals.

General Dynamics research strides in battlefield



General Dynamics' electro-optical tank identification technique could be fitted into a fire-control system for an advanced M1A1 version if experiments prove fruitful.

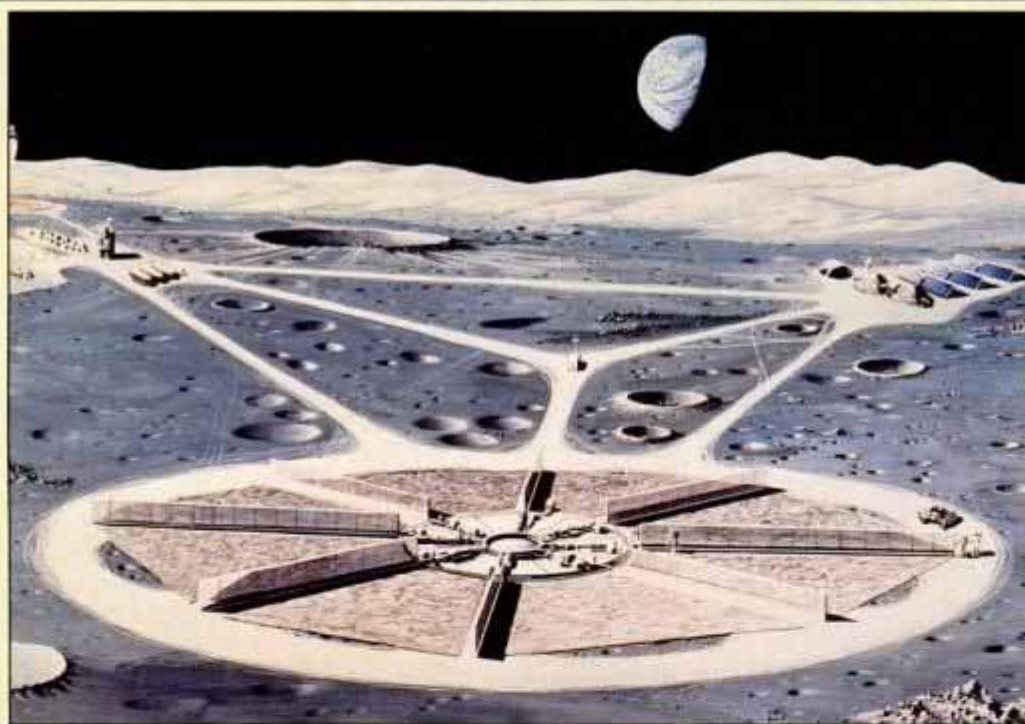
lasers is only one example of the intriguing possibilities that have been presented to military users.

Optic Electronic Corp. has developed an eye-safe laser targeting and ranging system for troop training.

On the defensive side, Perkin Elmer is working on a laser warning receiver to protect against laser-guided weaponry.



GENERAL DYNAMICS/PHOTOS



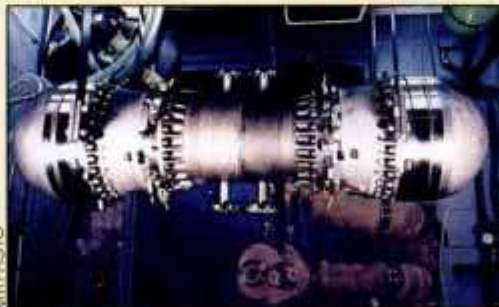
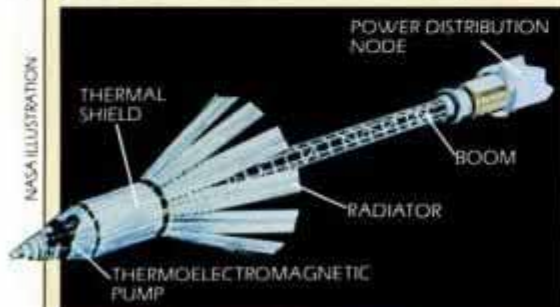
Space Power Needs

CLEVELAND, OH—Options for space power generation continue to multiply. One NASA contractor, Mechanical Technology, Inc., is developing a 25-kilowatt generator based on the Stirling engine. A technology demonstrator model is already functioning.

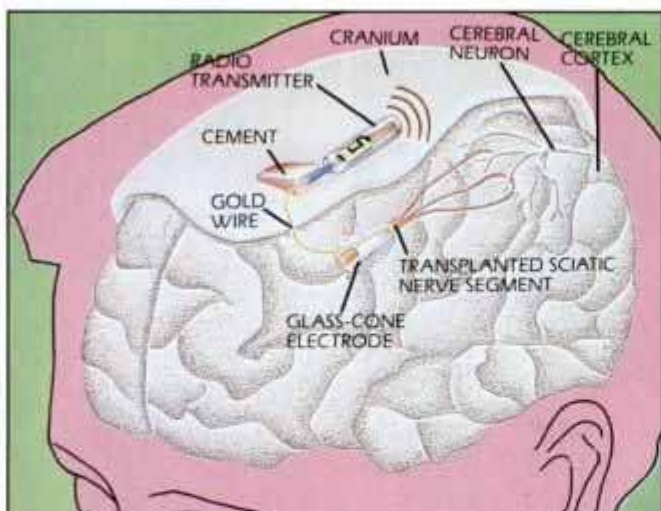
Inside a Stirling engine, gas expands and contracts as heat is added and removed. Pistons inside sealed cylinders are moved by the changes in gas pressure. Stirling's advantages include a lack of wearing parts and excellent efficiency.

Meanwhile, NASA continues to explore the possibility of using small nuclear reactors as orbiting power sources. The SP-100 consists of a small reactor core surrounded by heat-dissipating fins. The reactor and attendant thermal control units are separated from the distribution and control system.

All space-based power concepts have a single design imperative. They must be light enough for easy lofting, yet capable of generating significant wattage for man's future space explorations.



Stirling generators, such as working prototype at right, could form lunar powerplant [above]. NASA's SP-100 relies on nuclear energy to satisfy space power requirements.



Schematic of electrode apparatus, with exaggerated scale.

Spinal Cord Bypass

ATLANTA, GA—Researchers at Georgia Tech are a step closer to restoring movement in persons paralyzed by spinal cord injury.

The key is a glass cone electrode implant that collects signals from nerve cells in the brain. Neural fibers transplanted from the sciatic

nerve in the leg are fitted inside the cone.

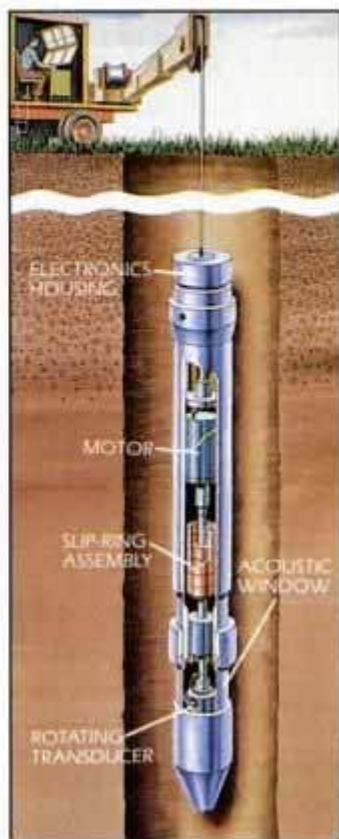
Connected to a radio transmitter installed under the scalp, the electrode broadcasts signals from the motor section of the brain. The apparatus could be used to control muscle electrostimulators in paralyzed humans.

Looking Into The Earth

LOS ALAMOS, NM—An instrument developed at Los Alamos National Laboratory will allow geologists to gain high-resolution pictures of zones miles beneath the Earth's surface.

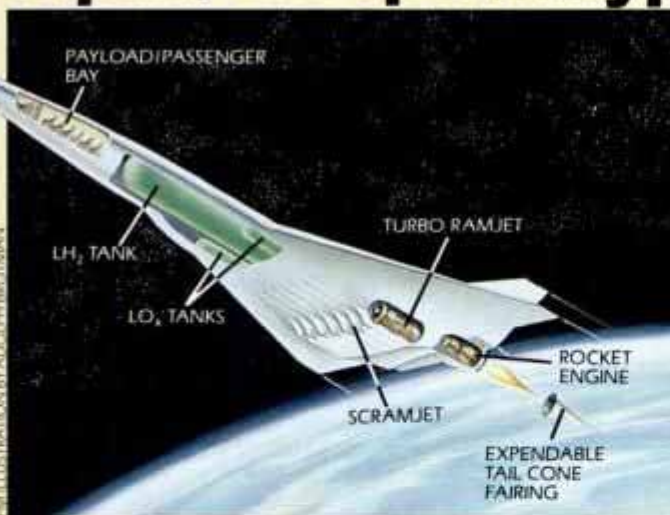
Called a borehole acoustic televiewer, or BAT, the device can be lowered into geothermal wells that radiate temperatures as high as 600° F. Inside, a surface-powered motor rotates a lithium niobate crystal at up to 360 rpm. The crystal acts as both sonar transducer and receiver. A computer housed above the BAT's motor records the data, which can be reconstructed as a 3-dimensional graphic showing fractures and rock stresses.

Besides speeding development of geothermal energy, the device will assist in oceanographic research, oil exploration and earthquake prediction.



BAT can operate at 12,000 ft. The device is about 10 ft. long.

Japan, Europe In Hypersonic Race



Fuji's space plane uses rocket power to achieve orbit (top). Aero AGV (bottom) will speed passengers at Mach 5.

NEW YORK, NY—Spaceplane designs from Kawasaki, Fuji and Mitsubishi may one day achieve single-stage to orbit. The Aerospatiale Avion *Gran de Vitesse* (AGV) will speed high-ticket passengers halfway around the world in a single bound. Both entries in the competition to build faster, higher flying aircraft will travel at hypersonic Mach 5 speeds.

The Japanese aircraft, like the American X-30, are intended to fly hypersonically in the atmosphere using air-

breathing turbo ramjets and supersonic ramjets (SCRAM jets). Conventional liquid hydrogen, liquid oxygen propellant—which will consume the bulk of the aircraft's interior volume—will fuel on-board rockets on the final kick to orbit. In the Fuji version (illustrated), an expendable tail cone shields the rocket nozzle during atmospheric flight.

Aerospatiale's AGV will remain in the atmosphere, but technical hurdles similar to those faced by orbit-capable aerospace planes must be overcome. Current research is focusing on materials that can tolerate skin heat reaching 600° C at higher Mach numbers, turbo-ramjet propulsion concepts and the choice between kerosene or liquefied methane fuel.

Aerospatiale is also studying advanced flight decks that use wide-screen visuals and microprocessor-based instrumentation to speed 21st century travelers.



Air injected at hypersonic speeds combines with fuel in SCRAM jet for hypersonic.

PH ILLUSTRATION BY GERHARD BUCHNER

PH ILLUSTRATION BY ALAN COOPER/PHOTOFEST

PH ILLUSTRATIONS BY ADAM OSBORN/PHOTOFEST

PH ILLUSTRATION BY ADAM OSBORN/PHOTOFEST

Radio ID Tags

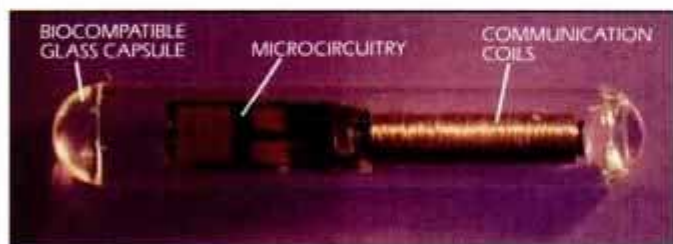
PORT WASHINGTON, WI—Microchips that communicate with a computer by radio-frequency broadcasts are finding widespread use.

The devices' small size and minimal power requirements means they can be encapsu-

lated in inert substances and used in unusual environments. Applications range from signaling tool identification to an industrial robot, to tracking cattle, to protecting paintings and other valuables, to allowing hands-off

entry to secure areas.

One example: An Implantable Transponder from Boulder, Colorado-based Destron/IDI contains an electromagnetic coil and microchip sealed in glass. The chip is pre-programmed with a unique, unalterable identification code. The transponder transmits its ID code when it comes within range of a low-frequency radio signal. The device is entering experimentation in a veterinary setting, implanted by either



Biocompatible RF tag transmits nutritional info to feeding stanchion.

Brain of RF tag is tiny and self-contained.

syringe or scalpel. While RF tags may find increasing use keeping track of farm animals, innovators say the tiny devices may one day perform chores like opening your garage door.

Photonics Shed Light On Diverse Uses

NEW YORK, NY—Engineers are inventing countless ways to replace conventional wiring with light-transmitting glass or plastic, in applications beyond the fibers' well-known uses in telephone trunk lines.

In one recent technology demonstration, West German plastics maker Hoechst AG and fiberoptic network supplier Codenoll Technology Corp. teamed up to outfit a custom-built car with over 100 ft. of plastic optical fibers. The fibers replace the wires that normally connect electrical components such as switches, relays, headlights, sensors and dashboard displays.

The key devices are fiber-optic controller modules, featuring optoelectronic chips that translate light impulses into electrical signals (photo, right) and vice versa.

These modules serve as junctions between the electrical components and the fiber network.

Plastic optical fibers may find increased use in short-distance applications, such as moving vehicles, because they withstand vibrational stresses better than glass.

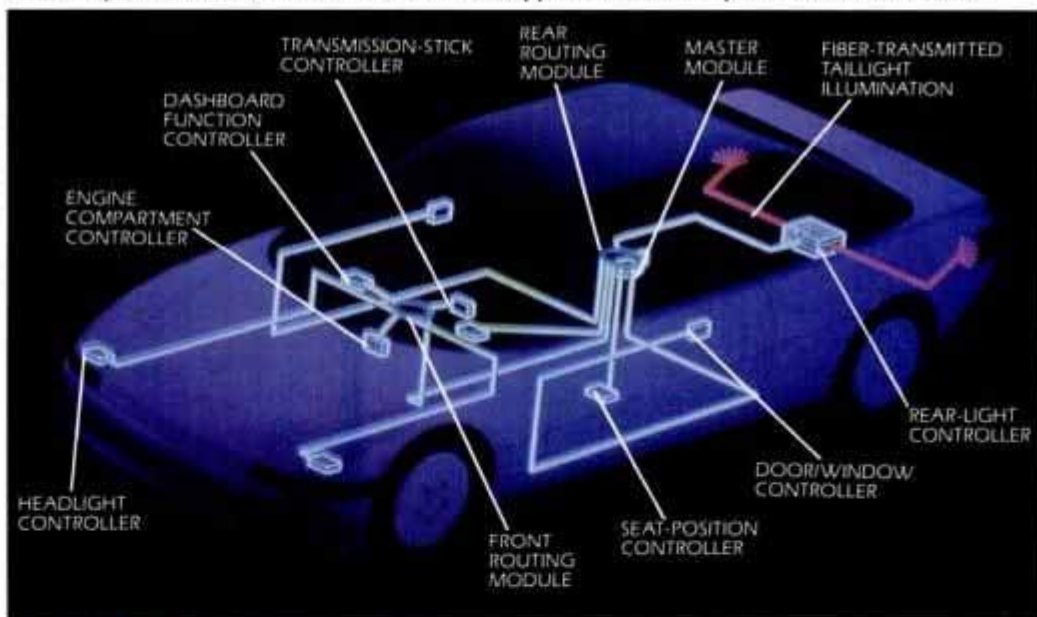
Glass fibers are also finding their way into unusual applications. General Electric has devised a welding system in which a 100-watt YAG

laser delivers its energy via glass optical fibers. An assembly of lenses downsizes the output of the laser to the

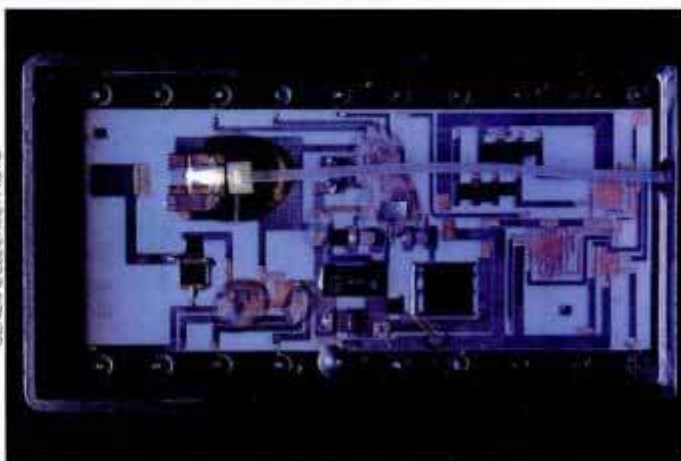
diameter of the fiber without melting the glass.

The technology is being used to heat opposite sides of

a joint simultaneously, resulting in the symmetrical weld necessary for precision composition and fabrication.



Optoelectronics, long an area of advanced research in aviation, are finding uses in automotive and industrial settings.



OUTDOORS

BY JOE SKORUPA

Adventures In Pulling Your Weight



Ford Bronco II eases up slippery launch ramp in 4-wheel drive towing Cobalt Condurre 223.

THRILLSEEKERS go to the farthest corners of the Earth and push their bodies to the limit to prove . . . Well, in many cases, it's hard to say what they prove, other than personal grit.

Is the world a better place because men climb Himalayan mountains without bottled oxygen, popping brain cells as they go? Or windsurf the Arctic Ocean? Or, one of my favorites, carry skis up Mt. Everest and schuss down the highest glacier in the world?

Nevertheless, wouldn't you love to change places with one of these daredevil adventurers? I know I would, but after recently experiencing an action-packed summer of my own, I've come to the conclusion that you don't have to go to Tierra del Fuego or the Siberian Sea to feel the exhilarating thrill of adventure. You can get all the adrenalin rushes and endorphin highs you want right at home. All you have to do is hitch a good-size boat to the family car and pull into rush-hour traffic. I guarantee your blood pressure will

zoom and your knuckles turn white in no time.

Thunder road

I had the pleasure of baby sitting a sporty 22-ft. Cobalt Condurre 223 last summer and trailering it for several hundred miles. I went from Lake George, New York, to the Great South Bay of Long Island to central New Jersey, and various locations in between.

The tow vehicles were all by Ford—Bronco II, full-size Bronco, Aerostar and Econoline Club Wagon.

And although my experiences were often hair-raising, such as the time I drove through enemy territory—New York City—I never had a serious mishap. And although I delayed the start of my vacation by nearly burning out a clutch on a steep boat ramp, I accomplished everything I set out to do.

But, and this is a big but, I always had the *feeling* that something unexpected was about to happen. This was especially true after I banged through a crater-like pothole or heard the slightest hint of unfamiliar grinding in my

limited-slip differential.

I came to the conclusion that I didn't really know the full story of towing and until I did my mind wouldn't be at ease. I spoke about this to the people at Ford and here's what I found out.

Know your vehicle

When the vehicle, hitch and trailer are properly matched and everything's going well, towing seems like a snap. You hardly know anything's behind you. When things aren't going well, you could be in for a bouncing, wandering, nail-biting ride.

Your first consideration for successful towing is the tow vehicle. In the old days, when life and cars were less complicated, you put on a

bumper hitch and drove away. Vehicles, especially cars, had sturdier frames and beefier engines. Today, after the gas crunch of the 1970s, many vehicles have lighter construction and considerably less horsepower. And this is only the beginning.

Some car manufacturers will void your warranty if you tow anything, even a small child's wagon. Bumper hitches are practically obsolete. And many owner's manuals warn that towing heavy loads may damage the suspension, steering column, engine, transmission and brakes.

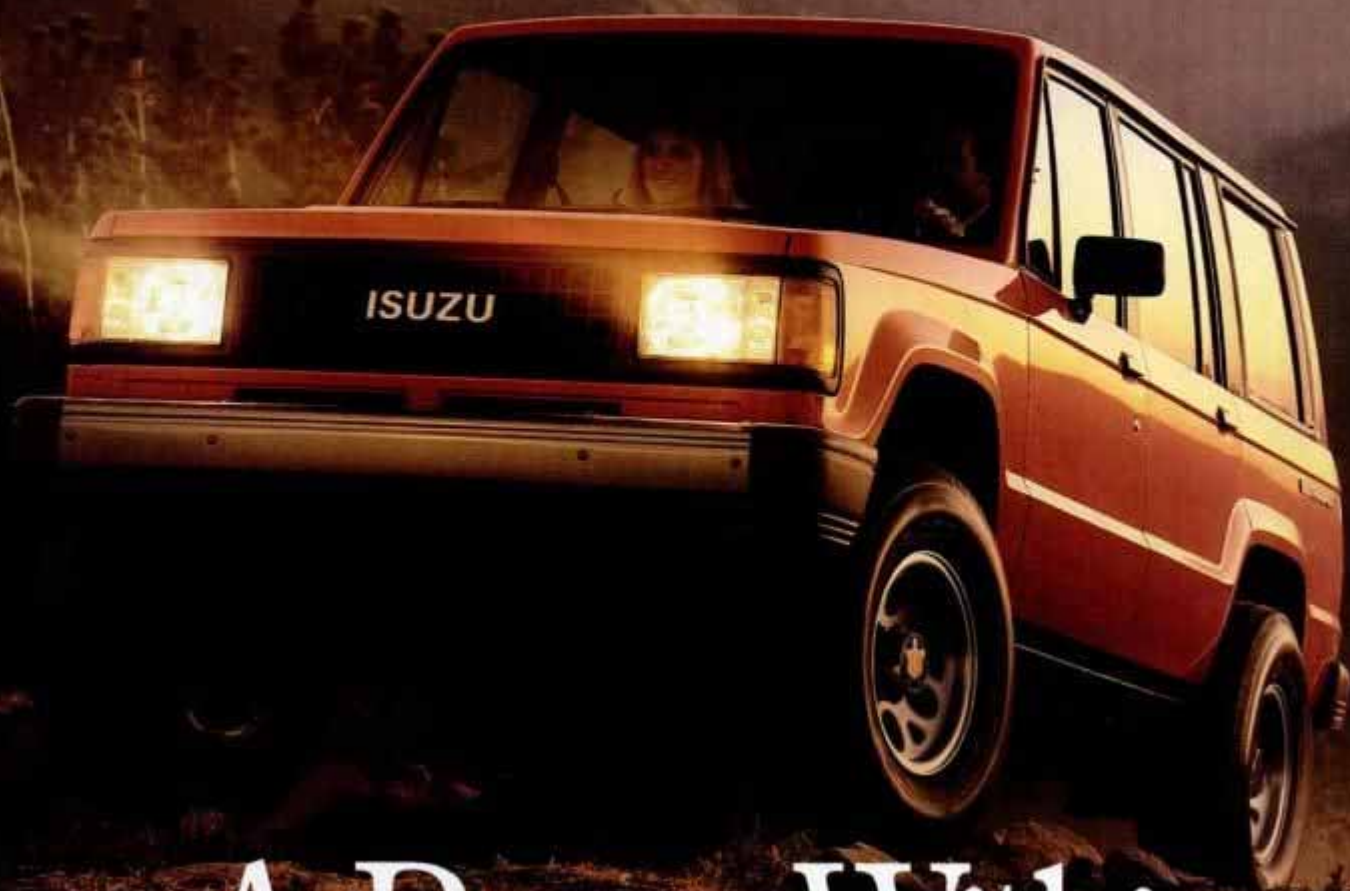
The best way to start on the road to successful trailering is to determine your vehicle's towing capacity (stated in the owner's manual) and your boat-motor-trailer combination's gross weight. In the case of the Cobalt Condurre 223 equipped with a 7.4-liter MerCruiser Bravo, the weight was 3700 pounds. The tandem axle trailer, made by Oklahoma Trailer, was 1100 pounds. Added together the towed load was 4800 pounds. All four Ford vehicles had 5000-pound ratings, so I was well within a safe range, right?

Not so fast. It's important to remember to add the weight of safety gear, sports equipment, personal accessories, fuel (approximately 6 pounds per gallon) and any-

(Please turn to page 20)



Ford Aerostar minivan makes a civilized tow vehicle.



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Jack Bateman,
a Jack Daniel's whiskey maker
since 1956.

From the makers of Jack Daniel's...

OUTDOORS (Continued from page 18)

thing else carried in the boat.

Fortunately, I always travel with a minimum of gear and fuel, but the truth is I was probably pulling about 4900 pounds. Without serious attention paid to carryons, I could easily have become overloaded and damaged the vehicle. To safeguard against this, I plan to go to a public scale next summer and have the load weighed, even if it costs some money. The price will be small compared to the bill I may get for unexpected vehicle repairs if I'm riding heavy.

Complete towing package

Individual vehicle components are the next important consideration. Towing a boat places severe stresses and strains on many systems—cooling, braking, suspension and others. This is even true of rugged sport/utility vehicles, pickups and vans.

The best way to insure that your vehicle can handle these extra demands is to have it equipped with a manufacturer-installed towing package. The package for the full-size Bronco, which costs about \$330 and is similar to that installed on other Ford vehicles, includes a heavy-duty radiator, auxiliary automatic transmission cooler, handling package (rear stabilizer and beefier front and rear shocks), heavy-duty bat-

tery, factory-installed wiring harness, and heavy-duty flashers.

Components that might be included in other factory packages, or individually installed, include auxiliary power-steering fluid cooler, transaxle oil cooler, higher gear ratio, larger U-joint, dual exhaust system to boost engine horsepower, heavy-duty front brakes, heavy-duty wide tires, engine-oil cooler and high-amp alternator.

Trailer, trailer hitch and ball sizes vary according to the load. In the case of my 23-ft. Condure, I used a class III trailer and hitch and a 2-in. ball. This set up is rated to handle up to 5000 pounds. Class I can handle up to 2000 pounds, class II up to 3500 and class IV tows more than 5000 pounds.

Towing tips

In addition to these fundamentals some important tips I picked up from my experience last summer and the guys at Ford include:

■ Automatic transmissions get the nod over manuals. Why? Clutches on manuals get excessive wear while towing. Replacement can be frequent. A manual transmission came installed on my full-size Bronco and I vividly remember one instance where I sat on a boat ramp smelling the clutch lining burn. I even-

tually made it up the unusually steep incline, but not before some very anxious moments.

■ Rear-wheel drive is better than front-wheel drive. All of the Fords I drove had rear-wheel drive, which puts roughly 10 percent more weight on the back wheels than do front drives. I never experienced the sensation of having the trailer weight rob the front wheels of driving and steering traction, which can happen with front drives, and I hope I never do.

■ Four-wheel drive versus 2-wheel drive? Three vehicles I tested had 4-wheel drive, which is a proven asset on slippery surfaces. Relatively few launch ramps I go to aren't extremely slick after a long day of use and 4-wheel drive comes in handy.

■ A vehicle with a separate frame is better than one with unit-body construction, which is a method where the body and chassis are designed as one compatible unit. Unit-body vehicles are made of lighter, more flexible material than full-frame vehicles. They spread stress throughout the body evenly. Three of the four vehicles I tested, the Bronco II, full-size Bronco and Econoline Club Wagon, have full frames. The Aerostar minivan, on the other hand, has a unit-body.

Car or truck

The guys at Ford tell me they can't build enough sport/utility vehicles, trucks and minivans. In fact, as one source put it, they "don't know where the top of the market is." I'm sure there are many reasons for this phenomenon, but I wonder how important the ability to tow figures in this trend?

Automobiles have practically abandoned towing. The list of car manufacturers who recommend against towing throughout their entire line is growing and currently includes: BMW, Mazda, Subaru, Hyundai, and all Chryslers and Pontiacs with turbochargers. Only six cars are rated to handle more than 4000 pounds—Buick Electra Wagon, Cadillac Brougham, Chevy Caprice, Ford Crown Victoria, Lincoln Town Car, and Mercury Grand Marquis.

Three of the vehicles I tested were equipped with the upscale Eddie Bauer special trim and features package, which adds from \$3000 to \$7000 onto the retail price. In the case of the full-size Bronco and Bronco II, this amounted to air conditioning, power windows, cloth upholstery and several other extras. The Eddie Bauer treatment on the Aerostar was positively plush—captain's chairs with lumbar support, trip computer, digital-readout instrumentation,

rear seats that fold down into a bed, radio/cassette with equalizer, rear audio and a/c controls, and more.

Four Fords

The Aerostar (\$12,407 base price) minivan was the most civilized of the four vehicles, with its stylish Eddie Bauer extras (about \$6590). It came with a 3.0-liter V6 engine and an extended length van that adds 28 cu. ft. of cargo volume. New for 1989 Aerostar models is a big 21-gallon gas tank (replacing a 17-gallon tank) for greater cruising range and an underbody spare tire carrier on extended length vans. Although I encountered no towing difficulties with the limo-like Aerostar, I believe its unit-body construction should be taken into consideration if intended for extensive towing.

The full-size Bronco (\$15,900 base), equipped with a 5.0-liter V8, seemed the most sporty of the four, with its touch-drive 4-wheel shifting, dual captain's chairs and color-keyed instrument panel. For 1989, Broncos have added tip-and-slide driver and passenger seats, making access to the back seat easier. The next time I test a Bronco I'll be sure to order an automatic if I plan on doing much towing.

The Econoline Club Wagon (\$15,290 base), equipped with a 5.0-liter V8, was

the most utilitarian of the fleet. It handled four passengers, 2-weeks worth of vacation gear and the Cobalt Condurre, during one towing adventure, without any discernible strain.

If I were forced to choose a favorite, I'd probably pick the Bronco II (\$14,030 base), which combines a sleek, aerodynamic appearance with the grittiness of sport/utility performance. I put more miles on the 2.9-liter V6 powered Bronco II than any of the others and found it to be a smooth-riding, easy-handling tow machine. New features and design elements on '89 model Bronco IIs include wraparound headlamps with integral turn signals and parking lamps, side-window demisters and steering-column mounted automatic transmission shifter. New creature comforts include tip-and-slide, high-backed bucket seats and door trim panels with built-in armrest pads and speakers.

I doubt that unexpected thrills will ever be completely eliminated from towing, but the better informed you are about its affect on your vehicle the better you'll be able to handle situations when they arise. Besides, life wouldn't be worth living without the occasional adrenalin rush, even if it does come from looking back nervously in your rearview mirror.

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BY TIM COLE

Science Education: The Bright Spots

THERE'S an understandable concern over the state of education in America—over science education in particular.

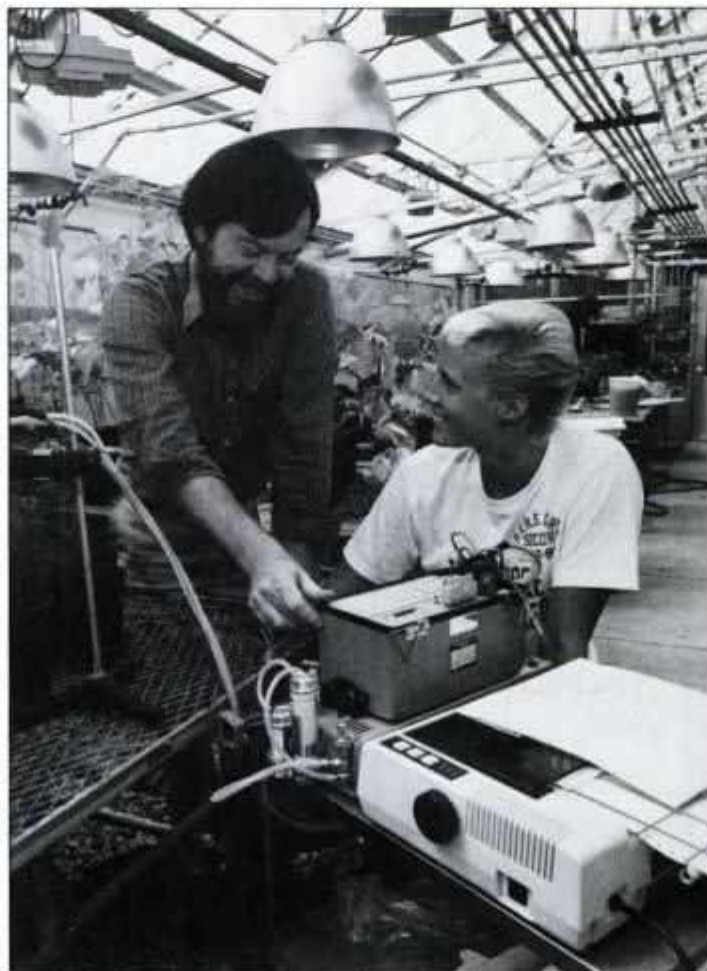
The scales in global economic competition are tipping toward nations that are technologically innovative—like Japan and other Pacific Rim nations. And technical skills in the laboratory, as well as the shop floor, are fostered in the school room.

Moreover, it's becoming clear that America hasn't been cutting it in this vital arena—where, in a very real sense, the future of our country depends. A recent survey conducted by the Public Opinion Laboratory of Northern Illinois University under a National Science Foundation grant showed that 20 percent of American adults think that electrons are larger than atoms, 29 percent think that lasers work by focusing sound waves and, incredibly, 21 percent think that the Sun travels around the Earth.

The consequences of this scientific illiteracy are just being realized in lost productivity. And that's not to mention the loss to what I call our nation's GNI—or Gross National Intellect. A strong GNI has a pervasive influence on America's economic health and military strength—on our national viability in a changed and changing world.



Odyssey of the Mind problem solving.



Scientist helps student in DOE high school science honors program.

Time to give up?

Not really, because there are refreshing signs that America's scientific awareness may be improving. Science museums like Philadelphia's Franklin Institute and the Museum of Science in Boston continue to create

fabulous hands-on opportunities to explore natural processes, physical laws and biological cycles. Settings as diverse as Space Camp in Huntsville, Alabama, and Disney World provide much needed scientific stimulation.

On a slightly differ-

ent scale, there are programs such as Space Science Student Involvement Program (SSSIP), co-sponsored by NASA and the National Science Teachers Assn. (1742 Connecticut Ave., N.W., Washington, DC 20009). SSSIP offers competitive opportunities for young people to create experiments for the Space Station, propose wind tunnel studies, or design a Mars settlement.

Odyssey of the Mind promotes problem-solving skills among preschool to high school students. Contestants from around the world descended on the University of Maryland for the 1988 World Finals of Odyssey of the

Mind, winnowed from 300,000 hopefuls. Their task: To design a submersible vessel with remotely manipulated arms in less than 10 minutes, to use a mousetrap to launch a specially designed paper airplane in 9 minutes, to see who can design and build a balsa wood structure in 8 minutes that will support the most weight.

Odyssey of the Mind (P.O. Box 27, Glassboro, NJ 08028) was founded in 1978 by Dr. Samuel Micklus, professor of technology at Glassboro State College.

"I'm always impressed with the inventiveness and ingenuity of these students," Dr. Micklus says. "I think it's terrific for Odyssey of the Mind to provide an opportunity for young people to realize their potential."

The 1989 World Finals will be May 25-27 at the University of Colorado in Boulder. Six hundred teams—including a squad from the People's Republic of China—will compete in what could be a growing American institution.

Just as significant, six facilities in this nation's network of national laboratories—from Argonne to Brookhaven to Lawrence Livermore to the Fermi National Accelerator—last year hosted 300 high school honors students, who assisted Department of Energy scientists with key projects. Students worked side by side with senior staff members.

Students are selected by their respective state education departments, where more information on DOE's honors program can be obtained. Sure, America has a long way to go to catch up, but the Department of Energy, Odyssey of the Mind, and well-run science museums across the country have given us all a place to begin. **PM**

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The March/April 1982, p. 35 issue of "Consumer Digest" magazine stated, "Slick 50 does reduce engine heat and ordinary wear, and our informal tests indicate that it will improve gas mileage by about 2 or 3 miles per gallon."

One of the country's most respected research institutes reported applying a powerful ultrasonic cleaning process to a Slick 50 treated engine and were surprised at its permanence. "We actually expected the Petrolon Slick 50 TFE Resin coating to also be removed, but later found it was still there."

TUV, a German testing laboratory with credentials every bit as prestigious as our Underwriters Laboratories, tested Slick 50 in 1986. They found substantial increases in both gas mileage and horsepower. Their tests showed that these gains were due to a reduction in friction.

The Federal Aviation Administration has fully accepted a similar product for aircraft—Slick 50 Aircraft Piston Engine Treatment (F.A.R. #33.49). This FAA endurance test-simulated 1400 hours of engine use.

The power technology laboratory at a leading southwestern university stated, "Slick 50 does increase horsepower and decrease fuel consumption in tests done at the university."

The Space Shuttle Columbia uses the chemical "poly" in its gears and bearings because it is the only chemical lubricant which can withstand the heat and corrosive elements of space.

Perhaps most dramatic of all is a torture test overseen by the Automotive Services Council for Pennsylvania and shown on WTVE television. Three cars with 75,000 to 129,000 miles on them were treated with Slick 50. Six months later the oil was drained from each vehicle, and the cars driven without the oil plugs for about a half hour. The water temperature never rose and the engines sustained no apparent damage.



It's Easy to Treat Your Engine

A few minutes before oil and filter change, add the engine flush you get free with each order to clean out the engine. Let the engine idle for 5 minutes. Then drain the oil, change the filter and add the proper amount of oil, less one quart. Add one quart of Slick 50, drive for 30 minutes, and leave it in the crankcase for at least 3,000 miles. As the engine operates, the oil carries the "Poly" between the parts where it is burnished into the pores of the metal.

Only One Treatment Necessary

It's permanent, so you do it only once, not each time you change oil. One quart of Slick 50 will treat all standard 4, 6 and 8-cylinder gasoline and diesel engines.

Works with Most Oils

Slick 50 will work with all petroleum-based oils and all synthetics compatible with petroleum-based oils with the exception of graphite oils. However, once an engine is treated, you can go back to a graphite type if desired.

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Your actual percentages may vary depending on your driving, vehicle condition, weather and geographic location, but no matter what your conditions, Slick 50 can:

1. Increase mileage
2. Increase horsepower (small economy cars and large RV's really need this)
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4. Minimize or eliminate costly overhauls by reducing engine wear

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INSIDE DETROIT

BY JIM DUNNE

Ford LTD Crown Vic, 1991

FORD is preparing a new version of its full-size sedan flagship for introduction in early 1990. Early prototypes of the type shown here illustrate the first step in road testing the new design. Note that the front end, including fenders, hood, grille and bumper, are of a 1991 car, while everything to the rear of the front door post is taken from a current Crown Victoria.

Prototypes are often set up this way in order to speed development of a new line. One of the most important tests on any new car is engine cooling.

Does the shape of the new hood, fenders, bumper and grille opening allow cooling air to reach the engine radiator? If not, then changes must be made early on so that



Ford's flagship sedan will mate aero bodywork to familiar rear-drive platform for the 1991 model year.

Chevrolet Lumina, 1990

This Chevy base coupe is the cousin of the GM-10 cars—Grand Prix, Regal and Cutlass Supreme. Its conservative styling was conceived to prevent overselling the car's potential.

"It's just a coupe, nothing special," explains one Chevy official. "We're saving the pizzazz for our SS model. That one will be different looking, like the Monte Carlo SS."

This model is the Euro-sport Lumina, a replacement

for the Celebrity Eurosport. GM's 3.1-liter V6 engine will be available for the front-wheel-drive layout, with either a 5-speed manual or 4-speed automatic. Basic body and chassis dimensions are similar to those of the other GM-10 cars. Wheelbase will be the same at 107.5 in., while overall length will be just about 198 in.

Escort, 1990

A little of the old, some of the new. Ford is using this cobbled prototype to test drivetrain and chassis parts of the



Chevy's Lumina sedan, set for 1990 debut, rides GM-10 platform.

there is no delay in the public introduction date.

Ford tacked this front on the current Crown Vic for the express purpose of checking cooling efficiency. With this technique, engineers need not wait until complete prototypes are built in order to finish their work. Engine cooling for this car is especially important since Ford will have a new V8, of 4.6-liter displacement, under the hood of the 1991 model.

As the 1991 LTD program moves forward, complete bodies will be tested. While it

is difficult to predict just what the new full-size Fords will look like, you can assume that the present hard lines and sharp creases will give way to more sloping lines and softer curves.

The lower hoodline will also give the new Ford a much more modern appearance. Note that Chevrolet will have its newly designed 1991 Caprice on the road at about the same time that the new Ford makes its appearance. Both cars will feature softer body lines, with a much more pronounced aero shape overall.



1990 Ford Escort is expected to use Mazda 323 mechanicals.

1990 Escort. In this model, the rear window and trunk are disguised to hide Escort's final design.

Reports from inside the company indicate that Ford will use the Mazda 323 chassis as a basis for the new Escort. However, the car will be built in the U.S., and virtually all of its parts, including the engine, will be U.S.-made. While the rear view of the exterior is unremarkable in this prototype, the front end is startling in its newness. Squeezed-down headlights, sloping hoodline and a smoother, more aero finish to the body panels are planned.

Ford plans to build Escort clones throughout the world, creating the closest thing the company has to a world car. The car is important to Ford's overall plans, since it remains the best selling model in the lineup.

Exhaust Tuning

Engine noise is getting a hard listen from Detroit's engineers nowadays. After buyers are satisfied with the usual things about an engine—it runs reliably, it's economical—the question of noise becomes most important. Some folks, sedan buyers mostly, like a quiet engine, one that you hear only during hard acceleration. Others, the kind who buy sporty cars, like to hear a bit of engine rumble.

With these differing buyer proclivities in mind, GM is getting scientific about engine noise. You sporty car drivers will still get your rewarding hollow rumble in the exhaust note. And you sedan drivers who want quiet won't have your favorite tape drowned out.

In some cars there will even be two levels of exhaust music. Accelerate in lower gears—1st through 3rd—and the exhaust tone will be loud. But cruise in 4th or 5th gear and you will barely hear the engine. Noise control will come mostly through the muffler, just as in the past. But the whole drivetrain in newer cars will be tuned, made to cancel out vibrations at certain engine speeds.

Chrysler V6

Admitting that it has been a 4-cylinder engine company for too long, Chrysler will turn that around with a run of new, bigger engines in the coming months. Most important of these is a 3.3-liter V6 that will be ready for the 1990 models next fall. Chrysler plans to build a healthy 300,000 of these engines per year, which could take the company over the 50-percent mark in V6 installations in the coming decade. First use will be in Chrysler prestige sedans and mini vans, including the new-for-1990 Imperial and Fifth Avenue models. For even more performance, Chrysler is planning a 24-valve version of the V6, an engine that could develop up to 200 horsepower.

Aero Mufflers?

With visible portions of the exterior nearing optimum aerodynamic efficiency, designers are looking under the car to improve C_d numbers. And that means more work for muffler designers.

How do you build the tubes and baffles of a standard muffler to fit the streamlined shapes needed under a modern car? A company called AP Parts, in Toledo, thinks it has the answer—a muffler design made entirely of stamped parts. The AP design is simpler, using four parts in all, versus the 10 to 17 parts needed for a conventional muffler. More importantly, the AP muf-

fler can be shaped to fit odd nooks and crannies under the car since it uses no tubes or baffles.

"It fits any shape of the underbody," reports an AP spokesman. "It uses curved passages instead of baffles. Exhaust hits baffles like a wall, and bounces back. That's where we have another advantage."

AP also claims that it can tune the muffler "for luxury car sound, or sports car rattle," all of the jobs that are done by a standard muffler.

We can expect the AP design on two Ford sedans and one Eagle product for next year. **PM**



Radar detectors: Which are really best?

These days every maker says their radar detector is best. Who's telling the truth?

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If you read movie ads, you know how each one finds a short phrase from a review that makes it sound like "the year's best." Well, some detector makers play the same game.

But we won't play games. Below are the overall results of three recent independent tests of radar detectors.

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Uniden	BEL Quantum	BEL
Radio Shack	Whistler	Snooper
BEL	Maxon	Uniden
Whistler	Radio Shack	Whistler
Sparkomatic	Uniden	Cobra
Fox	Fox	GUL
GUL	Cobra	Radio Shack
	BEL Vector	Sparkomatic
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Although each staff of experts used different methods to evaluate the detectors, their conclusions were unanimous: Escort and Passport are winners.

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ELECTRONICS

BY STEPHEN A. BOOTH

Music-By-Wire: Here Comes Digital Radio

THE DIGITAL audio compact disc has been with us nearly six years now. Not long after its introduction, many FM radio DJs began spinning CDs the way they once did familiar vinyl platters.

Broadcasting digital records, though, does not constitute digital radio. Only the music storage source is digital: The FM signal is transmitted to your receiver, then reproduced, in the conventional analog manner. Accordingly, the quality of the sound you receive might vary from what's recorded on the CD—usually for the worse.

It certainly can't be any better than the FM stereo signal which, with a theoretical bandwidth of about 15 kilohertz, ought to be quite good. But multipath and other forms of distortion might degrade the signal, especially as your distance from the transmitter increases. Meanwhile, the broadcaster itself might cheat on its own high fidelity. Some overly ratings-conscious stations alter the frequency response and stereo separation of their



An add-on tuner is needed to receive and decode digital music programs transmitted via cable.

signal in favor of loudness, in order to make it stand out and thereby attract casual listeners roaming the dial.

You'll get no signal distortion, and no commercials, when a music delivery system called CD/8 makes its debut. The service is proposed by a New York company called International Cablecasting Technologies (ICT) and it will use existing cable TV lines to deliver a digitally encoded music signal all the way to your hi-fi system.

Currently, some 50 million U.S. households have the cable hookup necessary to receive music-by-wire. All you'll need to add is a digital tuner, similar in appearance to an AM/FM tuner, to decode the encrypted melodies. The tuner decodes the digital

signal and passes it along to your amplifier in analog form for conventional reproduction through loudspeakers.

According to ICT, the decoder ought to be available for about \$200 from many of the same companies that now sell hi-fi components. The CD/8 service also will cost you money—just the way cable TV service does. Although your cable company will set its own price for the service, ICT is suggesting a \$7.50 monthly fee.

Whatever the amount, what you'll get is eight channels of nonstop, no-talk CD programming 24 hours a day. Channel selections include rock, jazz, classical, oldies, country, easy-listening, new-age, and top-of-the-chart hits. You select the

channel you want through the tuner—but that's not all.

CD/8 also offers a ninth channel as a pay-per-play service, an arrangement similar to that offered by cable TV for special programs. Through this ninth channel, CD/8 subscribers will be able to order from a menu of live musical events, or even order new-album releases (presumably for taping—though ICT doesn't specifically say so). You'll pay for these items à la carte, and the amount will be added to your basic monthly tab. The age of digital downloading finally has arrived.

Although there are other proposals for delivering digital audio by cable, at this time ICT's is the only one that carries a full, 16-bit, CD-quality signal all the way to your hi-fi amp and speakers.

ICT's delivery system conforms to the Philips/Sony specifications for CD. These specs call for 16-bit signal quantization at a 44.1 kilohertz sampling rate, with flat frequency response from 2 Hz to 20 kHz, and 96 decibels of dynamic range and stereo channel separation. Other digital-by-wire proposals would deliver the tunes at sub-CD bit quantization and sampling rates.

ICT uses a proprietary compression and scrambling process to shoehorn this wide-bandwidth signal through a single 6-megahertz-wide cable TV channel.

Late News: Interactive TV Coming This Fall

Think you can out-coach Tom Landry? Call pitches better than Gary Carter? Make your fortune at Vanna's wheel or beat the "Jeopardy" geniuses at their own game? Come this fall, you'll have a chance to put your money where your mouth is.

Interactive programming, which would give TV viewers the option of participating in game shows and other events, is scheduled to begin service on broadcast and cable systems later this year. The 2-way communications service is the brainchild of Interactive Game Network

(IGN), a venture jointly funded by a coalition of broadcast and cable companies.

In order to register your answer to a game-show question or, where legal, bet the ponies without going to the track, you'll need to obtain an add-on interactive console developed by IGN. The console receives questions and instructions from the TV program via FM radio subcarrier (where broadcast) or during the vertical blanking interval of cable telecasts. A signal from the central computer prevents you from responding to a question after it's

been answered on the show.

To submit your responses to the computer "judge" when the game is over, the console plugs into your home telephone jack. A half-hour later, the computer transmits your score to the console and informs you if you've won prizes (if offered).

According to IGN, entertainment sources (including the major sports leagues) are now developing interactive contests to air simultaneously with their programs. Watch this space for news updates on console and program availability.

And that ain't all, folks: In addition to the eight music channels and the payer-play channel, ICT also can transmit 64 data channels for personal computer users. The ICT tuner hooks up to your PC via a conventional RS-232 interface to deliver the various data-retrieval services that will be offered. This means you won't have to tie up the family phone to access these services via your computer's modem.

Despite CD/8's no-talk format, subscribers will be able to get programming information. A toll-free number will yield information about a particular musical selection. Optionally, subscribers can purchase a display module similar to the ones that scroll sports scores in bars and other public places. If you don't want to shell out for the scrolling scoreboard, you can connect the CD/8 tuner to your TV for an on-screen display similar to that provided by VCRs with on-screen programming capability. If the CD/8 tuner is hooked up to a personal computer, the computer's monitor will perform the same display function. As you might expect, both the CD/8 tuner and the optional display module can be controlled by an infrared remote.

For the record, ICT will transmit its music and data signals to the cable company via satellite. Accordingly, the signals remain digital all the way from the CD or data disk to your CD/8 tuner. Of course, any music you might record—even on a digital audio tape deck—will be converted to analog by the CD/8 tuner before recording.

According to ICT, CD/8 should become available sometime this year. Stay tuned for further details.

8mm Video Goes Super

The term Super-8 might summon memories of home-grown family movies accompanied by the whirr of a film projector. Perhaps this is why the video industry has chosen to put the label High-Band on the next generation of improved, 8mm camcorders.

By the time you read this, Canon and Sony will have unveiled a second-generation 8mm technology whose performance will rival the Super VHS format.

According to our sources, High-Band 8mm will deliver nearly 450 lines of horizontal resolution, compared to the 250 lines produced by today's 8mm system.

Contest Time

Once again, Sony is sponsoring a Design-A-Vision competition. This time, industrial design students at U.S. colleges are asked to create an audio or video product for children in the 4 to 12 age group. Deadline is March 31, 1989. For more information, write to Sony Design-A-Vision Competition, c/o Geltzer & Co., 1180 Avenue of the Americas, New York, NY 10036. **FM**

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BY MORT SCHULTZ

Where There's Smoke . . .

NOT BEING able to stop a pickup truck, because the brakes suddenly fail, is frightening. I know, because it happened to me in my 1988 GMC Sierra SLE ½-ton. The cause of the incident, which luckily didn't result in an accident, was a 1¼-in. hexhead bolt lying loose in one of the rear brake assemblies. The bolt had scored the brake drum and damaged the shoes. Do you know of others who have had a similar experience with this truck?

RALPH D. SACHS
PASO ROBLES, CA

I've heard of two others and GM admits there is a problem. The circumstances surrounding these incidents seem to involve brake backing-plate bolts that work

loose, fall into brake drums and cause damage. There is, as yet, no recall, but the National Highway Traffic Safety Administration (NHTSA) has started an investigation. Both GMC and Chevy models may be involved.

Fair warning: If I owned one of these models, I would remove the rear brake drums now to make certain a bolt isn't loose, and reinspect every 10,000 miles. Loose bolts should be replaced with new hardware, and some sort of threadlocking compound would also contribute to peace of mind.

Belt Meltdown

My 1986 Chevrolet Caprice Classic Brougham (305-cu.-in. V8 engine) is driving me nuts. It has busted three air-conditioner belts in 17,000

miles. In each case, the dealer claimed the belt was adjusted properly. Is there a technical service bulletin that covers this? What can be wrong? Is there a cure?

EMERY V. PETERSON
ORLAND PARK, IL

There is no technical service bulletin, so let's start from scratch. Here are questions I would ask concerning incessant drive belt failure:

■ *Is the correct belt being used? Check the engine designation against the part number in the parts catalog for the required belt.*

■ *Is the belt routed correctly? Moving clockwise from the fan/water pump, the belt should be routed around the air conditioner, power steering pump and crankshaft pulleys.*

■ *Are the pulleys true and aligned vertically? Using a bent piece of wire as a pointer, watch for wobble while you rotate the engine with a wrench. If there is misalignment, the belt will appear to be spinning at an angle. Reasons for this are misalignment of one or more pulleys and placement of the belt in a pulley groove it isn't supposed to be in. Some pulleys—the crankshaft and water pump pulleys, for example—have two or three grooves.*

■ *Is the belt adjusted properly? The dealer says it is, but let's make sure. With your engine, a new belt should be adjusted with a belt tension gauge to 140 pounds. If the belt is used, the specification calls for 90 pounds. This business of new and used can be confusing. A new belt is considered used after it has made only one complete revolution. This means that if a mechanic installs a new belt and runs the engine even momentarily, and then adjusts the belt, he should go by the*

used belt specification—not the new belt specification.

■ *Is the belt being damaged by a gouge in the metal on the inside of one of the pulleys or by hitting against a protruding object, such as a radiator hose clamp screw turned the wrong way?*

■ *Is the a/c compressor seizing? A compressor that locks up puts excessive strain on a belt.*

Victimized Computer

The 2.5-liter engine in our 1984 Buick Century was replaced at 12,000 miles. The car, which now has 22,000 miles on the odometer, has developed this problem: During expressway driving, the computer shuts off vacuum to the engine and brakes. The SERVICE ENGINE light comes on, the engine loses power, the air conditioner dies and, most dangerous of all, the brakes lose boost making the car difficult to stop. The dealer has replaced the computer, but this trouble continues. Do you have any ideas?

WILLIAM FRAZEE
PLYMOUTH, MI

Why be so fast to blame the computer? It could be a victim—not the culprit. The computer can't "shut off" vacuum as such, as it has no direct control over it. To make engine vacuum low enough to affect the brakes, either there's a massive leak, or the engine has quit running.

Since you had to have the engine replaced at 12,000 miles, the mechanic making the replacement may have fouled a vacuum line, which could be the reason for your problem. The engine should be examined with a fine-toothed comb for a kinked or cracked vacuum hose.

(Please turn to page 30)

Grease Job

Harken back to your school days and answer this multiple choice question:

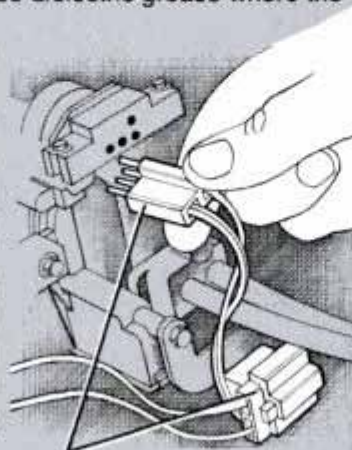
You pull off an electrical connector from a thingamajig and find it coated with grease. You pull off another you-know-what and find it dry of any grease. After cleaning both with electrical contact cleaner, what do you do when it's time to reinstall them?

- (A) Use electrical contact grease on both of them.
- (B) Leave them both dry.
- (C) Grease the greasy one and leave the dry one dry.

The answer is (C). Only use dielectric grease where the manufacturer used it.

Apply grease to the male half before reinstalling them. Leave dry connectors dry after cleaning them.

What's electrically dielectric grease? It's a special grease with high electrical resistance, high resistance to water, and high temperature stability. It's used to prevent corrosion in places where water is a problem. Electrical contact cleaner is usually freon based. Don't use carb cleaner or brake cleaner, or you might melt the connector.



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After this has been done, the possibility of a faulty EGR valve should be considered. A stuck EGR valve could lower engine vacuum slightly, which would be sensed by the engine's vacuum sensor. The vacuum sensor would then send a low vacuum signal to the computer, causing the computer to react by altering the fuel mixture to the rich side. This would cause a loss of power, and a further lowering of engine vacuum as you press down on the throttle to compensate. Eventually the engine will die.

Has the dealer tapped into the vehicle's computer diagnostic system to determine if there is a stored trouble code? A Code 45 is indicative of a rich mixture.

Another possibility for this condition might be an intermittent loss of electrical power to the engine computer, shutting down the entire engine briefly. Let me leave you with one other thought that could be helpful in chasing down the problem. If the dealer can't uncover the reason for your problem, remind him that Buick has a toll-free technical assistance number where factory engineers are standing by to give him a hand.

Far too many mechanics replace the computer when confronted with any unexplainable or intermittent problem, and almost always the computer is not at fault.

Spongy Brakes

After having the brakes in my 1986 Mercury Sable serviced, I noticed that the brake pedal was spongy. I returned the car to the mechanic who bled the system, but the sponginess continues. After such a thorough servicing of the brakes in my Sable, I can't imagine what more could be done to find the source of the problem. We're looking for some more troubleshooting help.

JIM WEBB
JACKSONVILLE, FL

Talk with your mechanic about the bleeding procedure he used. He may not have followed the method necessary for expunging air from the Sable (and Taurus) braking system. This procedure differs from the one used to bleed the brake hydraulic system of other vehicles, including other cars in the Mercury and Ford lineup.

Here's the correct procedure for the Sable/Taurus brake hydraulic system, which incidentally is a crossed system—that is, the right front brake is tied hydraulically to the left rear brake as is the left front and right rear.

Bleed the master cylinder first. Open the bleed screw, depress the brake pedal, but do not pump the pedal. Then, close the screw before letting the pedal slowly return to the raised position.

The Tall & Short Of It

A funny thing happened on the way to the office. The battery in my '84 T-Bird died when I tried to start the engine one morning. I jump-started and stopped by the local service station on the way to the office to pick up a new battery. At lunchtime, I removed the old, dead battery to install the new one.

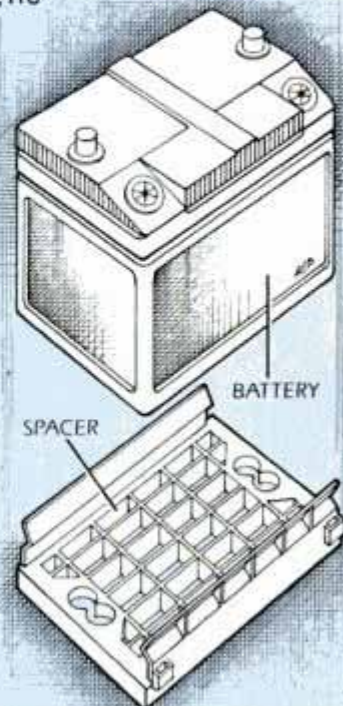
It didn't fit.

Just great, I thought. The so-and-so sold me the wrong battery.

The replacement went back into the trunk, and the deader went back into service. At 5 pm, I jump-started again, but the murderous intentions I harbored probably would have been enough to start the thing without the aid of a generous co-worker's car. Back to the corner service station I sped, rehearsing tart rejoinders about the owner's professional qualifications.

Boy, was I embarrassed when he removed a plastic spacer from the bottom of the battery he had sold me that morning, and nestled it neatly into the battery tray of the 'Bird.

The spacer allows a single part number to fit cars that call for similarly sized but not identical batteries, reducing the establishment's inventory problems—and making it more likely that they'll have a battery that fits your car when you need it.



Wait 5 seconds and repeat the procedure until no air bubbles appear in the bleed-off fluid.

Add brake fluid to the master cylinder to replenish what's been lost during the bleeding procedure. Move on to each wheel cylinder and follow this same procedure.

In case you missed the emphasis, the important points of the procedure are these:

- Do not pump the brake pedal when bleed screws are open.
- Slowly return the brake pedal to the raised position after each bleed screw has been closed.
- Wait 5 seconds after each bleed screw has been closed before repeating the procedure until air bubbles no longer appear in the bleed-off fluid.

Other readers with cars that are difficult to bleed should give this procedure a try.

Also, it may be helpful to use a pressure bleeding system, which uses compressed air to force the brake fluid through the lines continuously.

Stopping to pump periodically gives small bubbles the chance to float back upstream. **PM**

DO YOU HAVE A CAR PROBLEM?

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

SERVICE TIPS

- Let's try to avert a problem before it happens with 1989 Nissan Sentra and Pulsar models. Bring the car to the service department of your dealer and ask that the position of the engine wiring harness be checked as per Service Advisory TSB 88-134. The harness may be too close to the EGR valve, which can get hot enough to melt the insulation and cause a short.
- If the idling speed of the 2.8-liter V6 engine in your 1988 Chevy Cavalier is too high when the engine is cold, the CCC electronic module may need a different Programmable Read-Only Memory (PROM). Details are in dealer service bulletin 88-324-6E.
- You can fail a state emissions inspection with a 1984-87 Dodge Caravan or Plymouth Voyager with a 49-state 2.6L engine unless the provisions of TSB 25-04-88 are applied. This TSB calls for installation of parts contained in an emissions system control package to reduce a high concentration of CO at sea level that shows up during a 2500-rpm test.
- Clicking heard from the front brakes of 1984-88 Escort, Tempo and Topaz and 1984-87 Lynx when brakes are applied is from excessive clearance between the steering knuckle abutment and inner disc brake pad. TSB 88-20-6 has the solution.

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OLD HOUSE RESTORATION

BY BOB VILA

Wood Graining

DECORATIVE painting is coming into its own—again. After years of lying dormant and forgotten under layers of paint and paper, these original *fantasy* or *faux* finishes are being unearthed and re-created by old-house owners.

One of these decorative surfaces that shows up repeatedly in restoration work is graining. In its simplest form, graining is an actual painted re-creation of wood grain. It's a technique that's relatively easy to learn and an inexpensive way to create a durable decorative surface.

Perhaps you've moved into an old house and, during a woodwork stripping project, discovered that what you thought was oak was actually fir grained to imitate this expensive hardwood. Can you learn to re-create and, if needed, restore or repair this surface?

The answer, in many cases, is yes. Like most old-house projects, lots of trial, error and experimentation are a part of every successful job. Add a good deal of patience to this mix and you should be ready to begin.

Graining basics

Graining was commonly used on the woodwork, trim, paneling, doors and sometimes floors in many old homes. A practical finish, graining was a way to imitate the more expensive and often hard-to-get hardwoods on the cheaper and more plentiful softwoods. Although just about any type of wood can be mimicked with graining, I've found that imitating oak and walnut are the most common. So these are the two I'll use as examples.

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



Wood graining can create the look of expensive hardwoods on the surface of affordable soft woods.

There are several basic steps involved in any graining project. Although not a complete how-to tutorial, the following should give you some idea of what's involved in this restoration job. First, like any other paint job, the surface must be primed. This is followed by the application of a base coat. If a faux oak finish is desired, a buttercup yellow might be used. If a walnut grain should be the end result, the base coat can be a light orange.

The next step, applying the translucent glaze coat, is the one that fools the eye. Since this is the layer that is manipulated to create the look of grained wood, the color used must, when applied over the chosen base coat, look realistic. Artist's oils like raw umber, raw sienna, burnt sienna or burnt umber are often used as the colorants in this glaze, which is usually a mixture of varnish,

thinner and linseed oil.

Of course, getting the color just right may take a bit of experimentation. You should always do a test patch before you begin. Applied directly to the wood you plan to grain, any mistakes can be easily removed with a cloth and thinner. Don't worry if it's a little lighter than you want it to be. You'll have a chance to adjust the color again later on.

The consistency of this glaze is also important. If it's too thin, it will be runny and take a long time to set up. On the other hand, you don't want it too thick to work with. Again, experimentation with varying amounts of paint thinner and linseed oil is required on a test patch.

Although both the primer and base coats can be either latex or oil-based, the latter should have an egg shell or semigloss finish. This gives the varnish a smooth surface

to move on. The varnish or glaze coat should be oil-based to allow sufficient time to work the grain. A latex would set up too fast.

Some grainers I know eliminate a lot of this mixing and matching by choosing a readily available premixed stain. Some of the major paint manufacturers' interior oil stains can be used successfully as graining glazes. They are generally used with a generic base coat color, so you only have to vary the color of the graining stain.

If one of the standard premixed colors isn't quite right for the job at hand, a little bit of mixing is sometimes enough to get the exact shade needed. These oil-based stains dry slowly, which allows plenty of time for manipulation. Generally, when the desired grain pattern is achieved, adding a coat of clear varnish to the

(Please turn to page 36)



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OLD HOUSE RESTORATION

(Continued from page 32)

dried surface not only protects your work from dirt, grime and liquid, but also further enhances the color underneath. Although the finished surface usually won't have as much depth to it as it would if it were done the traditional way, the results may be perfectly acceptable to many old-house owners.

Manipulating the glaze

As far as creating the grain in the glaze coat goes, a variety of graining tools and odd brushes can be used. You should be

able to find most of these tools at a good art supply store. Combs made for this purpose are often pulled through the evenly applied oak-colored glaze to create the effect of this hardwood. Varying the pressure as you pull the combs through creates the oak-like patterns. A dry brush pulled over the grain lines while they're still wet softens the look.

One of the biggest problems beginning grainers have is avoiding the light and dark patches that are inevitable if you don't pull the tool or the brush through the glaze smoothly. A little bit of practice with the proper tools should help you achieve this consistency.

Although a wood-like effect can usually be attained with just a single glaze coat, increasing the steps can give a richer or deeper effect. For example, when you're simulating the oak finish, brushing a thinner version of the glaze over the dried grained surface increases the depth of the wood for a richer finish. (Use a special long-bristled brush called a flogger to do this.) Adding this thin over-graining or toning coat creates highlights and gives another chance to adjust the color for the exact finish you want. As a final step, add a coat of clear varnish to protect your new oak finish.

The process is a bit different when simulating the grain of walnut. A flogger is often used to apply the ground coat of glaze. After this ground glaze dries, the distinctive, almost black lines are often hand-painted using a small artist's brush. Soften them with a dry brush for a realistic look. Again, brushing on a thin coat of the glaze as the over-graining or toning coat, with any necessary adjustments in coloration, brings out the highlights and adds very fine detail. A coat of varnish on the dry surface will protect your paint job.

Restoring what's there

If you've got some grained woodwork or wood panels that have never been painted over in your old house, you're lucky! As I said earlier, grained surfaces are surprisingly durable so it's not uncommon to find some in good shape after many years. Sometimes, all that's needed is a good cleaning with a mild dishwashing soap, and water. If the surface has scratches and nicks, carefully touching up these areas with artist's colors and a small brush is sometimes all that's needed. (You'll have to experiment with these colors. Mix them straight from the tube on a palette to try to match the grain.) If the wood is chipped in spots, you'll have to repaint the base color in these places, too. Follow this touchup work with a new coat of good quality, oil-based varnish over the surface. (A polyurethane can look too shiny.)

Although graining is something that, with practice, many folks can master, you have to decide whether or not the project at hand is something you can do. If you choose the professional route, finding a decorative painter who works locally will take some digging. Your best bet is to start with the local historical or Victorian society. They may be able to recommend an expert who works in your area. Be sure you ask to see photos of work they've completed.

All in all, once you understand what's involved in a decorative painting project like graining, the mystery of the fantasy finish is removed. You'll see that creating a faux finish in your old house may be something well within your reach.

PM



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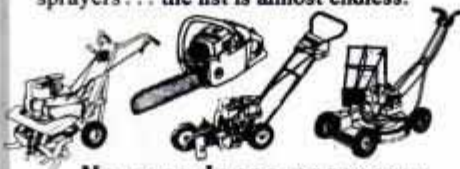
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MOTORSPORTS

BY TONY SWAN

Red, White And Blue Racing

ALTHOUGH the good old boys of NASCAR and the Indy Car guys tend to dominate our attention, thanks in no small measure to the unwinking eye of the TV camera, some of the best racing staged in this country last year took place in near-stock Corvettes.

Conceived when Corvettes were ruled out of the Sports Car Club of America showroom stock endurance championship after winning every race for three years running, the 10-race Corvette Challenge has been successful beyond the dreams of its creators, producing incredibly close competition every time out. Max Jones, a national champion in his own right, summed up the level of competition when he picked up a one-time ride in the Riverside round, third date on the calendar.

"I hadn't had much time in the car, so I didn't really expect to qualify well," he recalled. "But when qualifying was over, I checked my time and found out I was only 1.3 seconds off the fastest time, so I thought, hey, that's not too bad.

"That feeling lasted until I saw the starting grid for the race—1.3 seconds out put me



Some of 1988's closest racing was provided by the Corvette Challenge series. Here Juan Manuel Fangio II (2) and Bill Cooper (36) pace the field at the rain-soaked Mid-Ohio round.

23rd on the grid!"

Bill King, Goodyear's affable public relations director (it's a Goodyear spec tire series), put it this way: "Every time they line up, you've got 35 guys who all think they can win."

As it turned out, at least six of them—Stu Hayner, Juan Manuel Fangio II, Tommy Archer, Andy Pilgrim, Mark Wolocatiuk and Mark Dismore—were correct. Hayner, who has been racing Corvettes for four years, won only once compared to Fangio's three victories, but was a consistent performer all season long, finishing out of the Top 10 just once.

Part of the reason for the high level of competition was the prize money. Good purses and an even better season points fund helped create good starting fields every time out. When the last champagne bottle was emptied, Hayner had pocketed \$142,800 to go with his title, Fangio collected \$115,300 and Tommy Archer \$100,450. That's not Indy-level money, but by showroom stock standards it's double bingo and then some.

Chevrolet has done a good thing here, and congratulations are in order for Doug Robinson and the rest of the bow-tie guys. And if you like close racing, don't miss this series when it comes your way this year.

Bud Bird

Although it's not too surprising that more and more NASCAR Winston Cup teams are moving into the Ford camp, given Bill Elliott's exploits the past few seasons, one particular switch is noteworthy. Junior Johnson, a Chevy stalwart since the early '70s, will field a Thunderbird effort this season, after scoring 114 NASCAR victories and six

Winston Cup championships for Chevrolet since 1971.

The Budweiser-backed Johnson team unveiled its new T-Bird at Charlotte last October, even though they were still officially campaigning a Chevy. Ford is particularly gratified with the Johnson deal since it has no financial stake in the team, aside from engines and technical help. Johnson simply decided he wasn't getting what he wanted from Chevy, and made the switch on his own.

Terry Labonte, who won the Winston Cup championship in 1984 and drove for Johnson last year, will be back to pilot the new Bud Bird in '89.

F1 Power Games

Although Formula One has been just this side of boring



Honda's V10 should top 600 hp.



Junior Johnson (center) and Winston champ Terry Labonte (right).

the past couple of seasons, thanks to the complete domination of Honda-powered cars—the Williams machines in '87 and the McLarens last year—it should be a much different story in 1989.

Due to a rules revision that eliminates turbomotors, the F1 scene will feature an intriguing variety of engines, ranging from V8—the old Ford Cosworth still refuses to die—through V10 to V12, all normally aspirated.

The V10s figure to be particularly interesting, partly because it's not your everyday configuration, partly because Honda is going this route. Renault is also going with a 10-banger, which will feature pneumatic valve operation.

While the elimination of turbocharging brings peak output down dramatically—a competitive F1 engine in 1989 will produce something like 600 to perhaps 630 hp, a far cry from the 1000-plus of the '87 Honda V6—it also makes for a much more technically interesting series, and much closer racing.

For once, Jean-Marie Ballestre and the rest of the F1 rulemakers have come up with something that may actually be what it's supposed to.

MR2 On Steroids

Speaking of engines, here's what the 1.6-liter dohc 16-valve Toyota MR2 powerplant looks like when it's fully race-prepared, whereupon output goes from the 115 of a normally aspirated street engine to a whopping 225.

Toyota didn't do this just to show off. The racing version of the 1.6 will become the official powerplant for Formula Atlantic racers this season, supplanting a veteran Corvair unit.

Toyota Racing Development (TRD), a Toyota subsidiary based in Gardena, California, and Don Preston Racing, Wichita, Kansas, will supply the engines, either race-ready or in kits for independent builders. TRD will supply Pacific division teams, while Preston will supply the Atlantic division.

A ready-to-go engine will sell for about \$14,000, although Toyota plans to help teams that campaigned last year with a \$5300 check to take some of the bite out of the conversion.



Toyota's 16-valve twin-cam 1.6-liter Four is the new power in Formula Atlantic.

Motown's New GP

Yes, there will be a Detroit Grand Prix this June, but it won't be Formula One. In a move that probably startled no one, the Detroit Grand Prix organizers have elected to replace the high-priced F1 circus with homegrown talent, specifically the Indy Car entourage of CART.

Although F1 promises to provide much closer racing this year than in the past few seasons, the level of competition provided by CART has been nothing short of outstanding. While virtually every chassis in the field is made in England, either by Lola or March, CART provides a much more fa-

miliar lineup of drivers, most of them American.

Detroit has also suspended its plans for moving the race from downtown to a proposed permanent circuit on nearby Belle Isle, at least for this year.

While it appears that Formula One Constructors Assn. head Bernie Ecclestone has once again priced himself out of a major venue (the first was Long Beach, California), there may yet be a U.S. F1 race in '89.

At this writing, Road Atlanta and Laguna Seca Raceway, in Monterey, California, were both vying for such an event. **PM**

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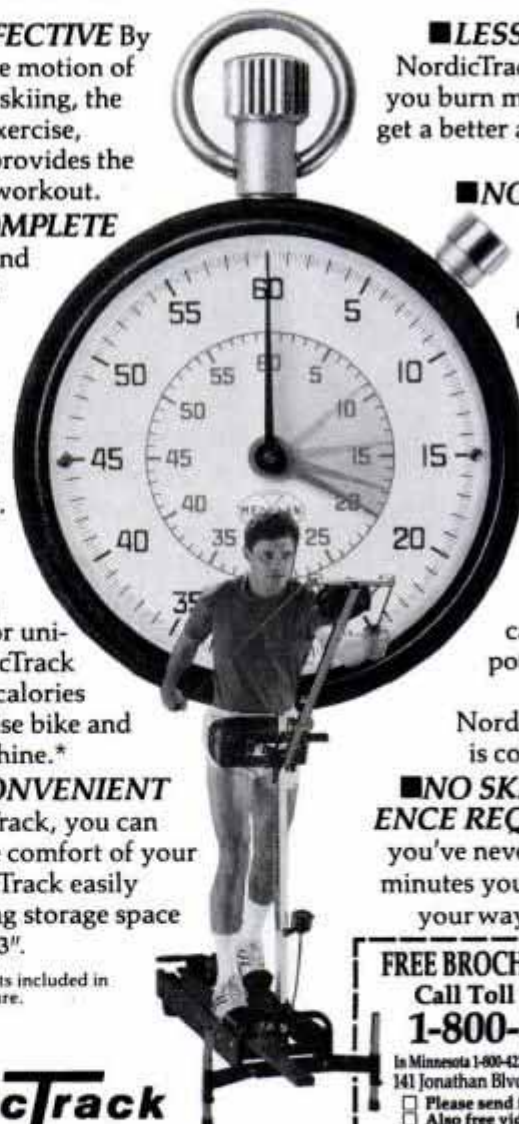
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Fiber Frames For All-Terrain Bikes

BY NORMAN S. MAYERSOHN, Contributing Editor

FORGET all the hype that accompanied the introduction of carbon-fiber composites to bicycle frame construction. The fact is, none of those early framesets took full advantage of composite construction because they were simply built up of round carbon-fiber tubing joined by traditional metal lugs. But here are two new-generation off-road frame designs that take full advantage of the material's characteristics—light weight, terrific stiffness and excellent shock damping.

The use of this technology in all-terrain bikes shouldn't come as a surprise. The absolute freedom of form allowed by carbon-fiber construction can bring a real aerodynamic edge to racing and road bikes (see "Rad Wheels," page 84, May '87). But for dirt diggers, it means even more, an end to the inescapable compromises of metal frames—trading off strength to lower weight or giving up ride comfort to improve frame stiffness.

If you're thinking that all of this aerospace chassis work is senseless overkill for a mountain bike, here's something to keep in mind. Fat-tired, high-handlebar bikes have grown in sales from an elite handful to better than a 50-percent market share. And there are a good many of those offerings selling at \$2000 and up.

The full-bodied machine at



Carbon-fiber monocoque frame from SSDG is strong, aero smart.

the top of the page is a monocoque Formula One bicycle from Stephan & Sharp Design Group (30170 Via De La Mesa, Rancho, CA 92390). Built for a specialized racing environment, it is a spinoff of BMX hardware and a clear indicator of the style we're likely to see soon in other types of production bikes.

Monocoque construction offers a number of minor advantages and one major plus. Among the lesser benefits is

a reduction of aerodynamic drag, on the order of 8 to 10 percent lower than standard round-tubing framework. There's also low frame weight to be considered, claimed to be 2½ pounds. And the torsional rigidity assures that all the energy a rider pushes into the pedals will reach the rear wheel and not be dissipated in chassis flex.

In the long term, the major advance offered by this

monocoque design is really flexibility of design. Working with one basic mold for the off-road models, a buyer's frame can be custom fitted. Location of the bottom bracket and seat post can be shifted almost anywhere in the tub structure to match rider dimensions, and the blend of fiber thickness and materials in the composite may be adjusted for rider weight.

The SSDG monocoque frame, with a selling price around \$900, is for those riders who hate to lose and want every possible edge. By the time the company's full-on ATB comes to market, they'd like to reduce prices by injection molding the bikes from Zytel composite, using a Kevlar film coating for strength.

Another unconventional frame—the MX-Z—is something else entirely, a true ATB rendered in exotic advanced composite materials, and derived from the highly acclaimed Kestrel 4000 road racer. The new 1-piece frame set promises to make life much smoother for the mountain bike clan.

The unique tube layout of the Kestrel MX-Z is made possible by the incredible strength of its fiber construction. Combined with the graphite fiber is a ballistic material known as Spectra, previously used in high-impact applications such as whitewater kayaks and military battle armor. Because

(Please turn to page 118)



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FORD PARTS AND SERVICE DIVISION

Rotary Engine Gets Airborne

BY FRED MACKERODT, Contributing Editor

IT'S INTERESTING to note that the Wright brothers, after inventing the airplane, lent their name to a company that became famous for making aircraft engines, not airplanes. What the Wright brothers came to understand very early on was that once you get an airplane to fly, flight is no longer the challenge. Keeping the airplane flying is. The Wright Co. devoted itself to the development of reliable aircraft powerplants, resulting in the classic Wright radial engines which are still powering DC3s and a lot of other aircraft today.

The opposed 4- and 6-cylinder Continentals and Lycomings used in most general aviation aircraft for the past 40 years have been doing a great job of providing relatively troublefree, reliable flight. However, they're heavy, have a lot of frontal area, are not too fuel efficient, and are getting more and more expensive.

Thus, the search for a better aircraft powerplant goes on. One of the leading contenders is the rotary engine. You'll recall that the theoretical PM Scorpion project airplane design we developed with Burt Rutan ("Wings For Tomorrow", page 70, Aug. '88) had twin rotaries. And NASA has endorsed the rotary as having a lot of promise for aircraft.

But the aviation rotary has had, at best, an on-again, off-again history. Felix Wankel died at the age of 86 last October without seeing the



Aero rotary, with builders Ryusuki Oku and Jim Mederer. Engine exposed (right) shows components in 18-in.-dia. package.

powerplant he invented flying successfully on an ongoing basis.

The last big news we had of a new aero rotary was the Textron-Lycoming and John Deere collaboration to develop one for general aviation. The project died in mid-1987 when Lycoming dropped out because production of general aviation aircraft was in the midst of a serious depression, and liability insurance was soaring out of sight. John Deere was left to pursue other uses for the rotary, such as in stationary powerplants and for powering military vehicles—or so we were left to believe.

Then along came Maurice Brockington. When that Chula Vista, California aircraft designer came up with a

design for an experimental aircraft a while ago, he began searching for an engine. Finding no suitable powerplant for the slick airplane he had in mind, and not wanting to "hang a propeller on a junkyard engine," Brockington developed his own.

He formed BEC Aircraft Engines, Inc. and sought out Jim Mederer and Ryusuki Oku, owners of Racing Beat, a company in Anaheim, California which has been building race-car rotaries since 1971.

Mederer, a former Air Force captain who spent his military career as a maintenance officer working on F4C Phantoms, already had experience building aviation rotaries. He constructed two 330-hp engines in 1974 which

were supposed to go into a 500-mph push-pull aircraft being developed for the unlimited class. The project ran into cooling problems and Mederer lost track of it.

However, Racing Beat jumped at the chance of developing an aero rotary for BEC. That powerplant is shown here.

It is based on the 13B 2-rotor engine found in the Mazda RX-7 sports car and develops 190 horsepower at 6300 rpm on the Racing Beat dyno. Mederer estimates that the engine will swing a



74-in. prop once a gear reduction is found to drop prop speed to the 2700-rpm range.

Mederer expects the engine to be extremely durable. He's shooting for a 3000-hour overhaul interval.

Brockington is about to start durability testing, which will include 200 hours on a test stand and another 2000 in an RV4 kitplane.

He sees the great advantage of the rotary being its extremely compact 18-in. frontal area. He also predicts very low maintenance, confined mostly to changing sparkplugs and filters.

Cruise fuel consumption

should be higher than in a conventional engine of equal power, Brockington says, although he has to wait for the test program to get underway to see how far he can lean the mixture. Without the poppet valves of conventional engines, the rotary leans more aggressively.

While discussing rotary fuel consumption, Brockington mentioned that John Deere was making some breakthroughs in the area of stratified-charge technology for the rotary.

John Deere? We thought that project was in limbo. Far from it, a source close to the project now tells us.

In fact, John Deere is now actively talking to prospective partners in the general aviation business about developing an aero rotary with anywhere from 50 to 3000 hp.

Our source sees the John Deere aero rotary as being smaller, lighter, higher-powered and more compact than conventional engines, along with having better fuel economy and somewhat lower emissions. He also sees the new engine as one of the major hopes for revitalizing the general aviation business.

The rotary project is now in the works at John Deere Technologies International, Inc., in the same plant where the Wright radial engines were made in Woodridge, New Jersey.

Numbers Or Needles?

Analog or digital gauges—which are better instruments for the cockpit?

We recently replaced the needle-type analog turbine inlet temperature gauge in our Aztec with a unit made by Electronics International, Inc., of Hillsboro, Oregon. The TIT gauge in a turbocharged airplane like ours indicates the temperature of the exhaust gases which drive the turbocharger just before they enter the turbine. The gauge is used to lean the air/gas mixture, but its other major function is to let the pilot know when the mixture is getting so lean—and the resulting exhaust gas so hot—that the turbocharger, the exhaust system and possibly the rest of the airplane are about to melt. Temperatures above 1650° F are a no-no, and a special feature of the EI gauge is that it incorporates a flashing red light when things get too hot for comfort. All temperatures are accurate to within 1°, reaction time is instantaneous, and another neat feature is that the gauge also measures ambient temperature. On cold mornings, there's no more guessing whether the engine needs preheat. Just flip on the master, and the EI gauge tells the actual temperature of the machinery in numbers. When it's below 10° F, we need the heat machine.

Analog gauges have their uses. The stack of needle-type gauges that measure the cylinder head temperature, oil temperature and oil pressure in the Az-

tec tell us everything we need to know about both engines at a glance, which is especially useful on the takeoff roll. For years, race-car drivers have aligned gauges to point straight up when everything is working properly.

A friend of ours at Delco Electronics, Tom Goesch, tells us that the deciding factor between analog or digital gauges should be whether you need an absolute number or a general range. A fuel gauge



Digital gauge at bottom shows turbocharger inlet temperature for both engines. One mid-right shows fuel burn for each engine of 13 gph, and Loran-based mpg of 6.62.

is an example where you'd want an absolute number. We'd rather know we have 52 gallons left, than somewhere between a quarter and a half tank. With head temperatures, a range is fine.

Goesch spends most of his time working on the head-up display system being installed in the Pontiac Grand Prix and Olds Cutlass Supreme. This is the system that projects information such as speed indications on the windshield.

The optical technology for this came from the aviation industry, where Delco's corporate partner, Hughes Aircraft Co., has been working on head-up displays for airplanes for years.

Delco took what Hughes knew, simplified the system, and brought the price down into the \$300 retail range.

Now what Delco learned is being recycled back to Hughes and aviation, and is being applied to the development of an affordable head-up display for private airplanes.

What's needed to get people to buy new airplanes is to give them something not available on used airplanes. Rotary power and head-up displays could be two of these things.

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Digital Dustbroom

BY FRANK VIZARD, Contributing Editor

THE USE OF the word "digital" in video has come to signify a variety of special effects ranging from strobe images to picture-in-picture capability. NEC has a different notion. The company chooses to avoid what some might label as gimmicky features. Instead, NEC's VCRs incorporate digital circuitry for improved picture quality.

NEC first introduced digital noise reduction in 1986 but its best and latest effort can be seen in the DS-8000U video cassette recorder. At the push of a button, the digital noise-reduction circuitry inside the VCR reduces distortion such as wavy lines and white flecks of "snow" in noisy videos, whatever the source. These sources include prerecorded tapes, homemade videos, off-air broadcasts and cable transmissions.

The digital noise-reduction circuitry in the DS-8000U works so well it is a wonder that it is not a standard feature in every VCR.

What happens is that the next field of video information is added to the field currently displayed. Because the picture information in each field is nearly identical, the signal power of the picture is in effect doubled.

Both video fields are subjected to video noise, of course. However, video noise is random—it rarely occurs at the same place in each field. So while the picture on the screen has twice the signal power, the video noise increases only by a factor of



Digital circuits in NEC's DS-8000U VCR reduce noise and jitters in videos.

1.4. The result is a visible improvement in signal-to-noise ratios for both the luminance (brightness) and chrominance (color) video bands.

Picture quality is further improved by the inclusion of HQ circuitry—available on many VCRs—to add sharpness and detail to the picture. HQ circuitry generally extends the white clip level by 20 percent, thereby improving definition.

Super Quiet

Although NEC's digital noise-reduction circuitry noticeably improves any video source, NEC engineers were particularly clever to employ it as a feature on a VCR with Super VHS capability. Super VHS improves picture resolution to more than 400 horizontal lines, by expanding the bandwidth from the broadcast standard of 4.2 MHz (330 lines) to 5.4 MHz. Increasing the bandwidth, however, not only increases horizontal resolution but also increases the likelihood of video noise. NEC uses a dual 8-bit system of digital noise reduction that encompasses

the entire 5.4 MHz Super VHS bandwidth to decrease the video noise level.

The digital noise-reduction circuitry in the DS-8000U can be turned on or off as desired. The ON/OFF switch is mostly for the benefit of retail salespeople demonstrating the feature, as there is no good reason not to have the circuitry engaged continuously. There is a 3-position switch that does have greater significance. Level one is appropriate for general use. Levels two and three should be engaged for viewing video sources with correspondingly greater video noise problems. Levels two and three do introduce a noticeable time lag into scenes, however. Speeding objects or sudden movements by actors, for example, produce a trailing effect that seems to elongate the motion.

The NEC DS-8000U is a top-of-the-line VCR listing for \$1500. The inclusion of digital noise-reduction circuitry is not the sole reason for the high price tag. Additional digital circuitry, for

instance, is used to improve freeze-frame and slow-motion modes. The still frames are rock steady. The slow-motion mode, at one-third normal speed, has a lifelike sensation. The DS-8000U also has three different picture-search modes as well as a strobe effect. Hi-fi sound and MTS stereo complement the picture.

Talking VCR

"Yo! Coach! What do I do now?" You might remember shouting that question to the sidelines during your playing days and getting the right answer. Too often, however, the coach isn't around to help you later in life—such as when you're trying to program a video cassette recorder. Video has long been a game without coaches. Now there is one.

Programming a VCR is often unnecessarily difficult. Recognizing this, manufacturers are trying to make this chore easier. On-screen displays and bar-code programming are some of the more recent innovations in this area.

Most of us, perhaps, would prefer to have someone on hand just to tell us what to do. While technicians don't come in the same box as the VCR, Sharp has come up with the next best thing—a remote control that talks to you.

This talking remote control is called "Voice Coach" and it's packaged with Sharp's Optonica VC-G980U VCR (\$800). Voice synthesization is used for three functions: setting the clock, setting the alarm and time-shifting.

Let's say you're time-shifting, for example. Audible instructions work you through the correct procedure one step at a time (the Voice Coach isn't given to

many things in life to remember. With the Voice Coach, programming a VCR isn't one of them.

Gridiron Videogame

One of the first videogames to carry an athlete's endorsement is *John Elway's Quarterback* (\$45), for the Nintendo system. The endorsement by the Denver Broncos passer should tell you what kind of game-plan to expect.

As far as being a realistic reflection of a football game, *John Elway's Quarterback* falls a little short in the manpower department. The offensive and defensive squads field only nine players each instead of the full 11. This translates into a game that is built primarily around the passing attack. Sports cynics might say that this videogame does reflect real life since Elway's team, the Denver Broncos, has historically had a weak running game.

Before each scrimmage, a choice of offensive and defensive plays is flashed on the screen. On offense, you have a choice of 12 plays, including a punting and field goal formation. The emphasis on passing is evident in the playbook. The rushing attack—what little there is—consists of four plays led by the quarterback.

Although it lacks a traditional running attack, *John Elway's Quarterback* is still quite enjoyable. As in the real game, plays are suggested by the coaching staff—meaning the game-cartridge program. Both the offensive and defensive quarterbacks have only a few seconds to "audible" a change of play. Unless a change is made, the play the computer suggests unfolds.



John Elway (above) quarterbacks the plays in your livingroom with his own videogame.

The A and B buttons on the control pad allow the on-screen players to throw, jump or dive as the situation warrants. The on-screen graphics are quite good. Down, yards-to-go, time and score information are displayed across the top of your TV screen.

John Elway's Quarterback can be played in either a one or two player mode. In the 1-player mode, the game cartridge controls the opposition plays. **FM**



Sharp's Voice Coach remote control gives you vocal instructions for VCR programming.

long speeches). When the time-shifting procedure is completed, the Voice Coach tells you what you've done as a final check. A typical sound-off reads like this:

"The VCR timer is programmed to record Channel 7 at 9:05 pm on Tuesday, February 14, until 10:30 pm on Tuesday, February 14, in standard play mode."

Granted, this speech sounds a little wooden but this is about as long-winded as the Voice Coach gets. Pushing the TRANSFER button sends the programming information to your VCR via an infrared transmission.

The VC-G960U is more than a VCR that talks to you. Features include hi-fi sound, MTS stereo, Super VHS capability and a VHS Index Search System that marks each recording start point on a videotape.

The Voice Coach, of course, is what makes this VCR special. There are

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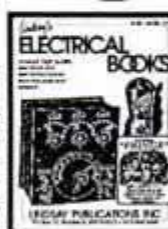


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Little Big Saws

BY JOSEPH TRUINI, Shop And Tools Editor

PORTER-CABLE has recently added two new saws to its line of quality portable power tools. However, the really interesting part is that both saws are scaled-down versions of standard-size tools. They're designed to be lighter, more maneuverable and easier to handle. But, don't be fooled by their size, both of these downsized saws are rated as professional-duty tools.

The Saw Boss is a 6-in. circular saw that, despite its reduced size and weight, boasts the performance of larger and heavier saws. Powered by a 9-amp, 8000-rpm motor, it will cut through 2-by lumber in a single pass—both at 90° and 45°. The depth of cut capacities are 1¹⁵/₁₆ in. at 90° and 1⁹/₁₆ in. at 45°. The Saw Boss weighs in at 8 pounds. That's about 4 or 5 pounds less than a typical 7¹/₄-in. saw.

Other unique features include a sawdust chute that accepts a collection bag or vacuum hose, spindle lock for easy blade changes, and a left-side blade position for greater visibility of the cutting line. To make plunge (pocket) cuts safely and accurately, the saw has a clever depth-stop mechanism. This allows you to preset the depth of cut and then plunge



Saw Boss is a compact, 6-in. circular saw that performs like bigger saws despite reduced size and weight. The 9-amp saw is shown with optional dust collection bag.

the spinning blade into the work with the saw's base held flat down on the work's surface. This method permits safer and more accurate plunge cuts.

The Saw Boss (model No. 345) comes with a 6-in. combination blade, antisplinter base insert and blade wrench for about \$155. A sawdust collection bag (model No. 39334) is available for about \$13.

The second saw, called Tiger Cub, is the world's first compact reciprocating saw. An indispensable tool for rough-cutting framing lumber and plywood, the reciprocating saw is a favorite tool

of carpenters, home remodelers, plumbers and electricians. When fitted with the appropriate blade, it can also cut through nail-embedded wood, composition panels like particleboard, plastics, metal and steel.

The Tiger Cub is powered by a 4.8-amp motor that features all ball-bearing construction and an electronic variable-speed control for blade speeds from 400 strokes per minute (spm) to 2600 spm. It has a full 1-in. blade stroke and the universal blade clamp accepts standard-size reciprocating saw blades. The open shoe design means greater visibil-

ity of the cutting line.

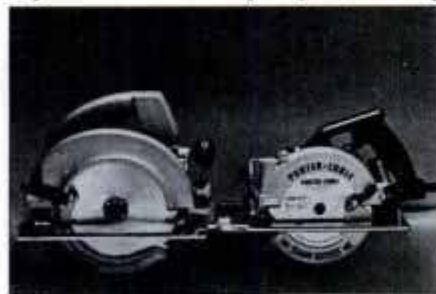
The saw's slim inline design and compact size allows 1-hand use in cramped, confined spaces such as an attic, crawlspace, under a cabinet and between studs, rafters and joists. The Tiger Cub is 13¹/₂ in. long and weighs 5 pounds. That's about 5 in. shorter and 4 pounds lighter than a typical reciprocating saw.

It comes complete with a side handle, blade wrench and steel carrying case that can house the saw with blade attached—a convenient feature. The Tiger Cub (model No. 9647) costs \$185.

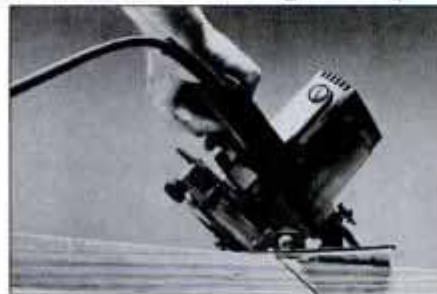
For details on these two saws and the complete line of P-C tools, write to Porter-Cable, Box 2468, Jackson, TN 38302. **FM**



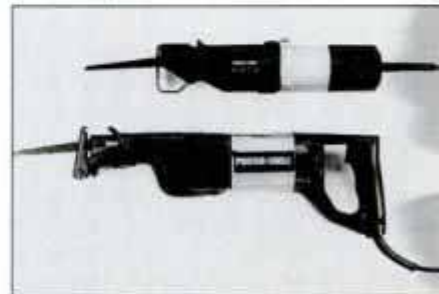
Tiger Cub reciprocating saw features slim, inline design for use in confined quarters. The 13¹/₂-in.-long saw comes with a steel carrying case.



Here's the Saw Boss (right) as compared to a typical 7¹/₄-in. circular saw. Reduced size and weight means greater control.



It may be small, but the Saw Boss can still make big cuts. It can saw through 2-by lumber with blade set at 90° and 45°, as shown.



Compact Tiger Cub (top) is shown as compared to a standard reciprocating saw. Tiger Cub is designed for cutting in tight spots.

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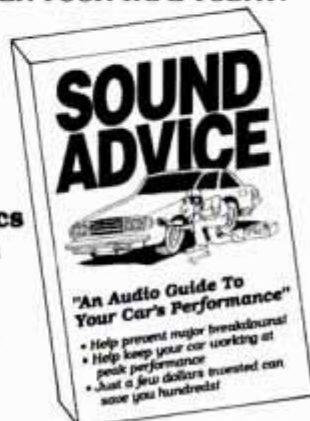
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COMPACT COMMANDOS



**JEEP
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These muscular middleweights
can haul a lot more than cargo.

BY RICH TAYLOR, Contributing Editor; PM Photos by Vic Huber

IT'S A FORMULA that's almost as old as the motor vehicle itself: Big engine + small car = fun-to-drive hot rod. In this case, we're talking about lightweight 2-wheel-drive pickup trucks, crammed to the fenders with 6-cylinder power. The quickest can zip from 0 to 60 mph in 10 seconds, something only musclecars could do until recently.

Unlike those old musclecars, which were pretty 1-

dimensional, these tire-smoking muscle trucks are as well-rounded as most automobiles. They ride, corner and stop with surprising agility. Indeed, they even boast such car-like amenities as ergonomically designed interiors with Recaro-clone sport seats, high-power sound systems, speed-rated tires on alloy wheels, and ABS brakes. Nearly all of them can be ordered with an extended cab that seats four adults at least as comfort-

COMPACT COMMANDOS

ably as in most 2+2 sport coupes.

These trucks are so comfortable and convenient that several of our test crew protested that they aren't real trucks. But where does it say a truck has to have rubber floor mats and vinyl bench seats to carry a load? Despite velour bucket seats and climate control systems, any of these muscular compacts can haul 1500 to 2000 pounds in sturdy double-wall bed. There's also room in each to load the proverbial 4x8 sheet of plywood.

The strongest can also tow up to 5000 pounds, thanks to separate frame construction and lots of torque. Surprisingly enough, 30 mpg is not unreasonable to expect at highway

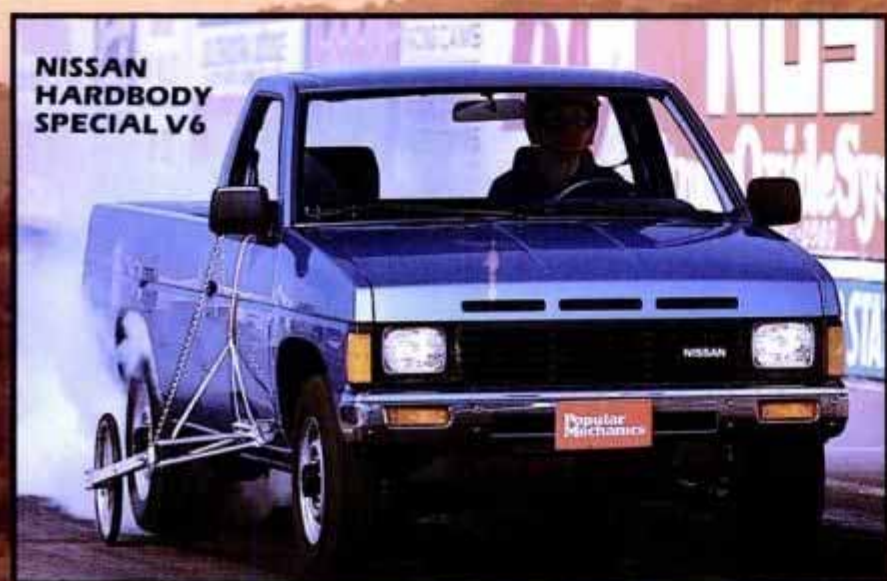
speeds. Again, this is comparable to passenger cars of similar size and price.

Because most buyers will treat them like an especially useful automobile, we tested these muscle trucks with the same standard track tests we use for our passenger car comparisons. Then we spent two days driving them back-to-back over a variety of surfaces—6-lane freeways, city streets and switchback mountain roads. We also spent some time blasting down dirt fire roads, and discovered a pickup's combination of low-speed torque and high ground

clearance is perfect for off-pavement play, even in 2-wheel drive.

Toyota SR-5 V6

When we compiled all our test data plus the votes of our 6-man test crew, one truck emerged as the favorite, but only by the narrowest of margins. Toyota's pickup has been totally redesigned for 1989, and it has edged ahead of competitors introduced as recently as a year ago. It's by far the most civilized of these trucks—one tester summed it up by saying "the Ford was the best truck, but the Toyota was the best car"—from its 7-



Compact commandos grouped clockwise from top left are: Mitsubishi SPX, Mazda B2200 LX, GMC S-15 Sierra Classic, Isuzu Pickup, Dodge Dakota Sport.

spoke alloy wheels to sports sedan dashboard.

The Toyota's styling is sleek and contemporary, with the same rounded aero lines as the new Cressida. The interior seems cut from a much higher grade of materials than those in other trucks, with ergonomically contoured adjustable bucket seats and a padded 3-spoke steering wheel that might have been stolen from the \$25,000 Supra. The controls and analog gauges are convenient and attractive, with a real sense of style that's largely missing from lesser pickups.

The SR-5's smooth 3.0-liter, fuel-injected V6 has plenty of power. It raced to third behind the Jeep and Ranger at the drag strip, a heartbeat ahead of the big-engined S-15. It also had the second-best brakes, and tied for first in both the slalom and skidpad with times faster than most of the passenger cars we test.

Toyota offers the highest payload capacity in this class at 2655 pounds, plus a 5000-pound tow rating. It may be smooth, quiet, comfortable and car-like, but it's also tough. The only drawback is its \$16,000 price tag. In

its defense, it was loaded up with every imaginable accessory. Comparably equipped, the Toyota is competitively priced. Other trucks may excel in one or two specifics, but when it comes to an outstanding combination of truck capabilities and sedan comfort, we'd say Toyota's SR-5 V6 stands alone.

Ford Ranger STX

On the other hand, if you really want to go truckin', Ford's hot-selling Ranger may be the ticket. Our sporty STX was red-on-red, and red hot. It



Grouped clockwise from top left are: Jeep Comanche Pioneer, Nissan Hardbody Special V6, Ford Ranger STX, Toyota SR-5 V6.

COMPACT COMMANDOS

blasted through the quarter-mile behind only the larger-engined Jeep, and no doubt could have been persuaded to hustle 0-60 in under 10 seconds with a little fine tuning. That's moving right along for under 3.0-liters hauling over 3000 pounds. The Ranger also has the best brakes in this class—ABS on the rear to prevent sliding in lightly loaded trim—and tied for first in the slalom as well. It's great fun to drive, with lots of pep, balanced handling and a solid, stable feeling under all conditions.

For 1989, the Ranger has been given an aerodynamic nose, similar to that on Ford's full-size F-series. It's a bit tall and boxy compared to the Toyota, but the Ranger simply exudes strength and brawny machismo. And it is the best-selling compact pickup, so obviously Ford's tough-guy image appeals to a lot of folks. Us included.

Recaro-like adjustable bucket seats, white-on-black gauges and clever interior ergonomics make the STX especially comfortable. But we unanimously hated the fuzzy red upholstery that covers every square



inch of the inside—seats, door panels, even the A-pillars. This ultraswash treatment seems totally incongruous in an otherwise swashbuckling hot rod.

Jeep Comanche Pioneer

Now *this* is a muscle truck. Order the 177-hp, 4.0-liter straight Six, and the Comanche will rip off 16-second quarter-miles all day long. There's nothing technically unusual about this powerplant, but it sure gets the job done—smooth, torquey and strong. The Comanche was more than a half-second quicker than the Ranger in the

quarter-mile, and unusually competent in every other track test as well.

But unlike the Toyota or Ranger, it's a handful to drive fast. Steering feel is too light, and there's a lot of roll in hard cornering. Over bumps, the suspension sets up a pitch and yaw motion that's very disconcerting.

The Comanche is due for an update—boxy lines and an interior distinguished by glitzy mylar trim, idiot lights and poor ergonomics signal time for a restyling, inside and out. On the other hand, it will be tricky to redo the Comanche and retain the essential "Jeepness" that attracts so many buyers.

GMC S-15 Sierra Classic

Also sold by Chevrolet dealers as the S-10, this rugged little workhorse has just about defined the compact truck market for the past six years. The styling still looks good—smooth and straightforward, timeless yet timely. It's one of the most sophisticated shapes around, and as one of our testers pointed out, "the styling is so good, it's hard to judge the size."

The interior is equally timeless. New instruments were fitted a year or two ago, quasidigitals that are neither as functional nor attractive as the analog gauges they replace. Every one of our testers complained about



SPECIFICATIONS AND DIMENSIONS

MANUFACTURER/ MODEL	PRICE LIST/ AS TESTED	ENGINE/ DISPLACEMENT (ci/cc)	ENGINE HP, NET/ TORQUE (lb.-ft.)	ENGINE/ DRIVE LAYOUT	TRANS- MISSION TYPE	WHEEL- BASE (in./mm)	LENGTH OVERALL (in./mm)	WIDTH OVERALL (in./mm)	TRACK FRONT/REAR (in./mm)
Dodge Dakota Sport	\$11,058/ \$13,794	V6, OHV 239/3917	125 @ 4000 rpm/ 195 @ 2000 rpm	front/ rear	4-speed auto	112.0/ 2844	185.9/ 4721	68.4/ 1737	F:60.8/1544 R:59.5/1511
Ford Ranger STX	\$10,749/ \$13,040	V6, OHV 179/2933	140 @ 4600 rpm/ 170 @ 2600 rpm	front/ rear	5-speed manual	125.0/ 3175	192.7/ 4894	66.9/ 1699	F:55.0/1397 R:54.6/1386
GMC S-15 Sierra Classic	\$8,641/ \$13,904	V6, OHV 262/4295	160 @ 4000 rpm/ 230 @ 2800 rpm	front/ rear	4-speed auto	108.3/ 2750	178.2/ 4526	64.7/ 1643	F:54.1/1374 R:54.1/1374
Isuzu Pickup	\$7,299/ \$8,473	L4, SOHC 156/2559	120 @ 5000 rpm/ 146 @ 2600 rpm	front/ rear	5-speed manual	105.6/ 2682	177.3/ 4503	66.6/ 1691	F:56.9/1445 R:55.9/1419
Jeep Comanche Pioneer	\$7,646/ \$10,538	L6, OHV 242/3962	177 @ 4500 rpm/ 224 @ 2500 rpm	front/ rear	5-speed manual	119.6/ 3038	194.0/ 4930	71.7/ 1822	F:57.0/1448 R:57.0/1448
Mazda B2200 LX	\$9,545/ \$10,740	L4, SOHC 133/2184	85 @ 4500 rpm/ 118 @ 2500 rpm	front/ rear	5-speed manual	117.5/ 2985	198.8/ 5050	65.7/ 1670	F:55.1/1400 R:55.5/1410
Mitsubishi SPX	\$10,179/ \$11,853	L4, SOHC 156/2555	109 @ 5000 rpm/ 142 @ 3000 rpm	front/ rear	5-speed manual	116.1/ 2950	188.2/ 4780	65.2/ 1655	F:54.7/1390 R:55.3/1405
Nissan Hardbody Special V6	\$9,549/ \$10,344	V6, SOHC 181/2960	145 @ 4800 rpm/ 166 @ 2800 rpm	front/ rear	5-speed manual	116.1/ 2948	195.5/ 4965	65.0/ 1651	F:54.9/1394 R:55.5/1409
Toyota SR-5 V6	\$12,688/ \$16,240	V6, SOHC 181/2966	150 @ 4800 rpm/ 180 @ 3400 rpm	front/ rear	5-speed manual	121.5/ 3086	193.3/ 4909	66.5/ 1689	F:53.3/1353 R:53.9/1369

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



MITSUBISHI SPX

them. Otherwise, the S-10/S-15 interior is just about perfect—obviously American, but with a very international feeling. The excellent bucket seats would benefit from more adjustability and better support, but they're perfectly acceptable as is. You can drive all day and arrive unkinked.

Sophisticated, well-rounded and balanced are words that could be used to describe not only the GMC's styling and interior, but its performance, too. New last year, the 4.3-liter V6—literally three-fourths of the legendary 350-cu.-in. small-block Chevy V8—has great power and bottomless torque.

Our test S-15 tied for first in both steady state and transient handling tests, thanks to an inherently good chassis, heavy-duty suspension and Goodyear Eagle GT tires. Good looking, powerful, fun to drive and moderately priced—there's not much wrong with this truck.

Mazda B2200 LX

You could say most of the same things about the B2200—it's good looking, well-built, nicely balanced, fun to drive—but with one major exception. There's a big hole where the engine should be.

Now, the largest available powerplant is a wimpy 85-hp 2.2-liter Four

borrowed from the old 626 sedan.

Mazda promises that the new 121 hp 2.6-liter Four from the MPV will soon be available in the B-series. We say why not fit the 158-hp 3.0-liter V6 used in the MPV and 929? This would make the pickup one of the best compact trucks on the market.

Engine aside, the B2200 is a fine truck. Its interior cuts a very good line between car-like luxury and truck toughness, with attractive but durable tweed upholstery, fully adjustable bucket seats, an automotive dash and exceptional sound system. The ergonomics are excellent.

The B2200 looks purposeful and rugged, more similar to the Ranger and S-15 than to other Japanese pickups, but still modern and attractive.

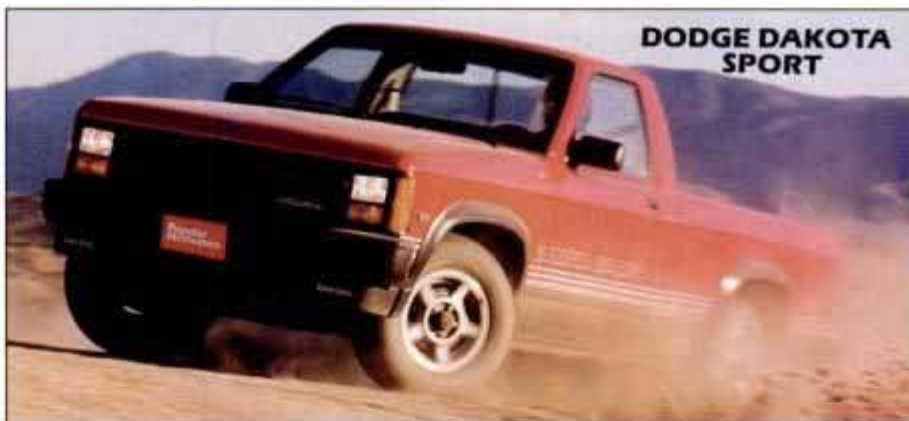
At the track, the B2200 was a mediocre performer not only in acceleration, but in our braking and handling tests, too. Part of the blame must go to the smallish and slippery Japanese Dunlop all-season tires. With a comparable grip on the road, the B2200 would be competitive. All our testers liked this truck and praised its quality, durability, comfort and moderate price. But where's the muscle?

(Please turn to page 122)



Shelby Dakota V8

For 1989, Carroll Shelby is wedging Chrysler's time-honored 318-cu.-in. V8 into the little Dodge Dakota Sport. The 175-hp V8 clips 4 seconds off 0-60 times and adds 8 mph to quarter-mile speed. A stiffer suspension and fat 225/70HR-15 Goodyear GT+4 tires boost skidpad and slalom performance. There's also a 3.90:1 limited-slip differential, an additional frame crossmember, and the usual add-on exterior graphics and aero panels, a charcoal cloth interior and leather steering wheel. The price for this added muscle and panache is about \$1500 more than a Dakota Sport V6. That's a bargain.—R.T.



DODGE DAKOTA SPORT

TEST RESULTS									
CURB WEIGHT (lbs.)	STEERING TYPE/TURNS LOCK-TO-LOCK	BRAKE SYSTEM FRONT/REAR	MAXIMUM AVAILABLE GVWR/PAYLOAD/TOW RATING (lbs.)	AVAILABLE CARGO BED LENGTHS (ft.)	FUEL ECONOMY (EPA city/PM test)	ACCELERATION 0-60 MPH (sec.) ¼-MILE (sec. @ mph)	BRAKING 60-0 MPH (ft.)	700-FT. ¹ SLALOM (mph)	SKIDPAD ² 200-FT. CIRCLE (G)
3270	power recirculating ball/4.2	11.3-in. vented disc/9.0-in. drum, ABS	5930/2550/5900	6.5, 8.0	15/22.05	14.3 18.92 @ 71.44	156	58.52	.76
3133	power recirculating ball/3.5	10.3-in. vented disc/9.0-in. drum, ABS	4580/1700/5500	6.0, 7.0	18/19.89	10.9 17.50 @ 77.16	149	61.94	.78
2648	power recirculating ball/3.5	10.5-in. vented disc/9.5-in. disc, ABS	5022/2000/6000	6.0, 7.5	17/18.41	11.0 17.79 @ 77.90	173	61.94	.81
2665	power recirculating ball/3.4	10.1-in. vented disc/10.0-in. disc	5400/2550/2000	6.1, 7.5	21/23.77	14.3 19.02 @ 71.07	176	60.09	.75
3098	power recirculating ball/3.5	11.0-in. vented disc/10.0-in. drum	4719/1621/5000	6.0, 7.0	16/18.98	9.9 16.88 @ 81.22	160	61.23	.81
2790	power recirculating ball/3.3	10.1-in. vented disc/10.2 drum	4460/1400/1500	6.0, 6.1, 7.5	21/23.38	16.0 19.43 @ 69.50	175	60.52	.74
2825	power recirculating ball/3.4	10.1-in. vented disc/10.0-in. drum	4255/1430/2000	6.0, 7.4	20/21.01	15.2 19.12 @ 70.82	156	61.68	.77
3140	power recirculating ball/3.5	10.2-in. vented disc/10.0-in. drum	5140/2000/5000	6.1, 6.2, 7.5	17/22.81	11.9 17.72 @ 76.68	185	59.84	.75
2960	power recirculating ball/3.6	10.0-in. vented disc/10.0-in. drum	5600/2655/5000	6.2, 7.2	17/21.15	11.4 17.67 @ 77.89	155	61.94	.81

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

ICEBREAKERS!

Delivering cargo—or saving the whales—icebreakers are pulling their weight in the frozen reaches of the Arctic.

BY JOHN FINE

YOU DON'T EXACTLY hear the sound. You feel it.

As the ship mounts the ice and smashes downward in one shuddering, violent crunch, the noise penetrates the ship's thick steel hull and travels all the way to the bridgedeck, enveloping the men at the helm, the throttles, the nav/com center. It's a piercing crash, a desperate thud and a mighty howl—all in one.

She backs off, lurches, heels, summons her strength and thrusts once more. Sensing weakness, she pushes against the ice with the kind of relentless spirit you'd find in a boxing ring. Friction-reducing bubbles hiss from her flanks as the sound resounds throughout the ship.

Free at last.

Until the next pressure ridge. And the next—as the temperature drops to 50° below zero C and the fleeting light casts lengthening shadows on endless white.

Even so, it's business as usual up in the High North, where icebreakers like *Otso*, Finland's state-of-the-art

diesel-electric, carve passageways through once-impenetrable ice, paving the way for the movement of people and cargo to scattered outposts. Icebreakers are changing the way men live and work in the North—opening up huge tracts of land and sea to commercial development, extending the reach into once-forbidding territory at the top of the world.

Indeed, Soviet icebreakers have on at least two occasions gouged all the way to the North Pole. And icebreakers—not solely the means of economic exploitation—are also benefiting wildlife. Last October, it took American ingenuity, Eskimo willpower and Soviet icebreaking muscle to free two young California gray whales ice-bound off Point Barrow, Alaska (see sidebar). The world's attention turned to the ice—and to the machines that break it.

State of the art

Built by Wartsila for Sudoimport, the Soviet ship importing organization, *Taymyr* and *Vaygach* are stupendous

examples of the shipbuilder's craft. The new Soviet nuclear icebreakers are massive. Their overall length is 105.2 meters (480.6 ft.) with a breadth of 29.20 meters (90.3 ft.) and a shallow draught of 8.05 meters (25.8 ft.). From their respective spoon-shaped bows—better to mount and crush ice several meters thick—rise their fat, 7-story superstructures. Below the waterline, a cutting wedge of special high-tensile steel 2 in. thick can be driven forward with a force of 300 metric tons (660,000 pounds). Previ-



Finnish-built Soviet icebreaker *Taymyr*.



U.S.S.R.'s *Arktika* during sail to the pole.



Marking several advances in design and propulsion, Wartsila Marine's *Otso* undergoes Baltic trials. A computer-controlled diesel-electric powerplant instantly adjusts propeller output for changing ice and sea conditions. Fiberoptic switches change rpm or trim from futuristic bridge wings. Soviet icebreakers *Taymyr* and *Arktika* (below left) rely on nuclear power and immense hull form to break ice for long distances. Hauling freight between widely separated Arctic outposts (below right) is the goal.



A Soviet icebreaker leads cargo ships.

ICEBREAKERS!



State-of-the-art diesel-electric powerplants—some relying on superconducting materials—may find use in Wartsila's future icebreakers. An ARCO LNG carrier (top right) is envisioned, as well as a cargo-hauling ice train.



to where people can process them. An atomic-powered icebreaker can work continuously for three years. Of course, it needs normal supplies like food and water, and the crew changes every four months. But a conventionally powered icebreaker with a full amount of bunker oil can work only 30 days before it needs refueling. Everyone in the shipping company is pulling out their hair how to get fuel to the ships," Danilov laughs.

Finnish perspective

The Finnish National Board of Navigation prefers diesel-electric icebreakers. Capt. Raimo Rintala, commander of Finland's newest icebreaker, *Kontio*, explains: "We don't want nuclear ships on narrow and shallow archipelagoes from the standpoint of safety, and we don't need as big a vessel compared to the Russians, who have long distances to navigate. We have the technology to build them, but we operate smaller vessels in these dangerous waters."

ous Soviet icebreakers drew 11 meters, making it impossible for them to work in the shallow water estuaries like the Jenisei River. *Taymyr* and *Vaygach* will sail these rivers with considerable ease.

Aboard each vessel, one pressurized water nuclear reactor turns water into steam that runs two Soviet-built turbines. The turbines are connected to a Siemens main generator. The reactor also powers two auxiliary turbogenerators, two smaller steam generators, and three evaporators for fresh-water production, along with a condenser to recycle the steam-generating plants. Shafted to the engines are three giant fixed-pitch stainless-steel propellers: Each propeller stands 5 meters (16 ft.) high and weighs more than 30 metric tons. The engines that will turn these massive screws through thick Arctic ice develop a total of 50,000 shaft-horsepower.

Taymyr and *Vaygach* have been designed with spacious crew accommodations. Russian crews are often away from home for protracted periods. With accommodations for 138 persons, many features have been incorporated into the Soviet ships to make shipboard life more comfortable. Living spaces on the new Russian nuclear ships are also above the main deck to minimize vibration and noise. A swimming pool, fitness center, movie theater, library, photo lab, sauna and space for leisure activities have all been incorporated into the design. A room to grow fresh garden vegetables has even been added.

"*Taymyr* was our fifth nuclear-powered icebreaker. *Vaygach* is the sixth," says Leonid Danilov, Sudoim-

port's chief supervisor on the nuclear icebreaker project.

The Soviets are committed to nuclear icebreaking, Danilov explains, because of the great distances in the Soviet Arctic. "If you look on a map of the northern part of the Soviet Union, you will see it's very far from industrial centers. Today, the northern area is very important. There are oil and gas fields and precious metals. These raw materials have to be transported

Icebreakers Save The Whales

PPOINT BARROW, AK—The world was watching when two young California gray whales became trapped in sea ice last October off this remote Alaskan oil town. The successful effort to release the leviathans—sparked by a fresh global breeze of environmental awareness—also showcased unique icebreaking technologies.

The Archimedean Screw Tractor, operated by oil rig supply firm Veco Interna-

tional, aroused perhaps the most interest. Transported to the rescue site in the belly of an Air Force C-5B Galaxy transport, the vehicle scampered along on twin-rotating 40-ft.-long pontoons.

As the pontoons turned, raised metal in a screw-like pattern running the length of each dragged the vehicle forward. Used on smooth ice of medium thickness, it helped keep some channels clear, but was sidelined during the final attempt.



Trapped gray whale comes up for air.



Veco's Archimedean Screw Tractor.

Keeping Finland's 22 ports and harbors open, cutting channels through the ice, breaking out, convoying and towing cargo vessels and tankers is a challenge requiring specialized designs. Friction and resistance against the hull present significant problems. Wartsila Marine has found several solutions. *Otso* and *Kontio*, for instance, have a new hull form.

Kontio is 99 meters (317 ft.) long × 24.2 meters (75 ft.) wide with a draft of 8 meters (25.6 ft.). Like *Taymyr* and *Vaygach*, their sloping bows are designed to break the ice downward. The ship's bottom is painted with a special epoxy, called Inertia 160. At the waterline, *Otso* and *Kontio* are surrounded by a 33-millimeter- (2-in.-) thick compound stainless-steel band. The stainless steel not only provides great strength, but epoxy paint on the rest of the hull allows the ship to slip easily through the ice. The hull and stern are made of 22-millimeter-thick steel. Specially designed heavy-duty rudders add to their strength.

"During *Otso's* ice trails, we backed into an ice ridge at a speed of 10 knots to prove to the customer it doesn't break," Henrik Segercrantz, Wartsila's marketing manager, explained.

"With a normal icebreaker, the Inertia 160 wears off first in the waterline area. By putting on a stainless-steel belt, you get a hull that doesn't wear. The belt increases the opera-

tional time between dry-docking."

In addition to the hull, bow configuration and structure, the two new Finnish icebreakers feature Wartsila's air-bubbling system (WABS).

Capt. Rintala explains, "Three big 2000-kilowatt compressors push air through 48 holes low on the hull. Water comes up with the air and lubricates between the ice and hull, reducing friction." The air-bubbling system can also be used to maneuver *Kontio* instead of bow thrusters.

Ships at work

Tests under actual conditions with this new class of ship have proved the effectiveness of Wartsila's hull designs and concepts. *Otso* encountered ridges of ice 15 to 20 meters (48 to 64 ft.) thick on her first trial. Her very first charge penetrated 50 meters (160 ft.) into the ice. *Otso* slipped back off the ice itself without using its engines. The second charge penetrated the thick ice ridge over a distance of 110 meters (352 ft.).

The new ships are also equipped with port and starboard heeling systems that create icebreaking forces in different parts of the hull. In addition, two trimming tanks fore and aft aboard *Otso* and *Kontio* can be filled respectively with 552 and 342 tons of water. Trimming tanks add to the dynamic systems of the vessels, changing the icebreaker's equilibrium.

(Please turn to page 124)

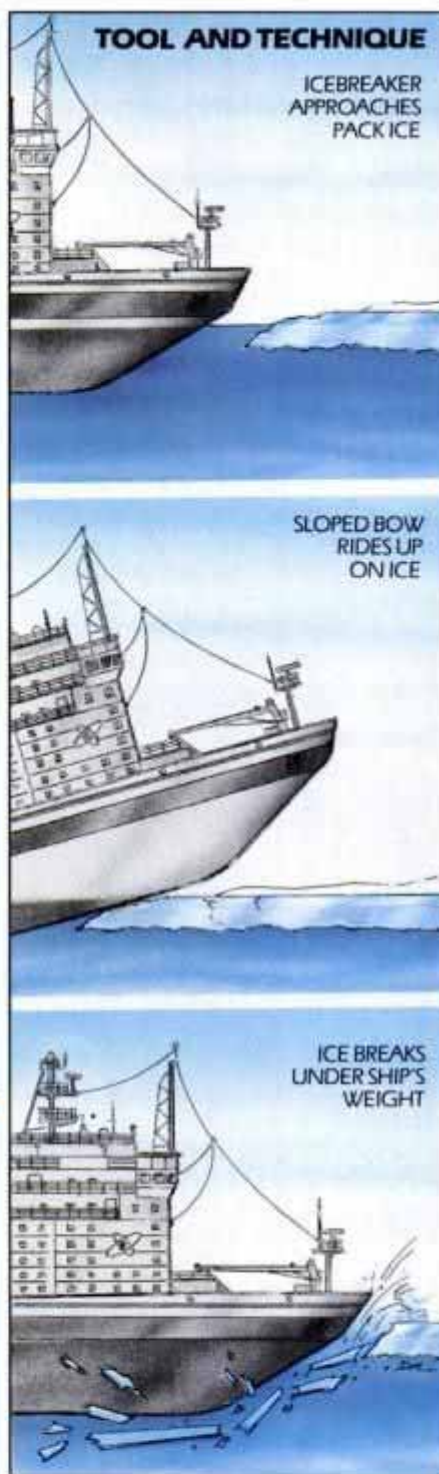
Also in the arsenal: A Sikorsky Sky Crane helicopter swinging a 10,500-pound concrete and steel ice masher. High hopes for a hoverbarge air-cushion vehicle—"that could make cubes out of foot-thick ice," according to one hopeful proponent—were dashed when the machine's rubber skirt deflated on a small pressure ridge.

Of course, the Soviet icebreaking cargo ship *Vladimir Arseniev* and command vessel *Admiral Makarov* did the heavy work to free the whales—at one point cresting a

pressure ridge almost 30 ft. high.

But brains—and heart—as well as brawn earned ultimate victory in this unusual fight for life. Eskimos with chain saws—"thinking like a whale," as one Eskimo elder put it—carved breathing holes for the animals that led them away from shoals. And a couple of simple bubbler devices kept the breathing holes from crusting over in the frigid weather.

In the end, people saved the whales. But some incredible machinery played a part.—*Tim Cole*



TOOL AND TECHNIQUE

ICEBREAKER APPROACHES PACK ICE

SLOPED BOW RIDES UP ON ICE

ICE BREAKS UNDER SHIP'S WEIGHT

BUBBLER SYSTEM



Hull shape, not brute ramming power, has a significant impact on icebreaking potential. A sloping bow allows the ship to ride up on ice, crushing it under the ship's weight. A bubbler system pumps friction-reducing air between hull and ice.



Sikorsky Sky Crane swings into action. The successful *Admiral Makarov* sails toward Barrow.

A PERFECT 10

Here's our choice of the most innovative, trendsetting electronics products for 1989.

BY STEPHEN A. BOOTH, Electronics Editor

WHEREVER ELECTRONICS products make their debut—at trade fairs in Chicago, Las Vegas and Tokyo—PM's electronics staff is always on hand, searching for the items that stand out among the literally thousands introduced. As in past years, our criteria for selecting the top products favors innovation. The electronics item either is the first of its kind, advances the state of the art, or provides a meaningful service to the customer. Among the current crop of products, the only first of its kind is Canon's RC-250 still video camera. Our nine other selections represent enhancements of existing product technology. Their manufacturers have incorporated new features that extend the products' usefulness. **PM**



No More Rain Checks

Sony is well known for ingenuity and performance in electronics products. The company also earns its reputation for designing products according to the way people use them. The CCD-SP7 Handycam Sports camcorder (\$1850) proves the point. Lightweight, portable camcorders lend themselves to active lifestyles—and outdoor activities often are accompanied by rain, snow, salt spray and other elements harmful to electronics. Although it is not submersible, the Handycam Sports shell lets you operate the CCD-SP7 under trying conditions. The 8mm camcorder within is ideal for recording sports action: It couples a 6X power zoom with six shutter speeds, up to $1/4000$ of a second.



Visit A Nightclub—Or Cathedral —From Your Living Room

Digital magic is a fitting description for Toshiba's XB-1000 audio/video integrated amplifier (\$949). On the outside, it looks like a conventional 125-watts-per-channel integrated amp that lets you control 15 audio or video sources (CD, radio, VCRs and so on). Inside, the XB-1000's digital processor can re-create the acoustics of eight locations—including concert hall, stadium and theatrical Dolby Surround—when a pair of rear speakers is added.



Walking Dictionary

Franklin Computer has improved its Language Master Dictionary and Thesaurus. The new LM-3000 model (\$350) displays 80,000 definitions and 470,000 synonyms, and defines the synonyms at the press of a button.



Everything But The Popcorn

Most movies made today feature a Dolby Stereo soundtrack, and an increasing number of movie theaters are equipped to reproduce it. You can enjoy the special sound effects in your living room too, if you route the audio portion of a Dolby encoded videotape through a Dolby Surround Sound processor and a hi-fi system equipped with front and rear pairs of speakers. Akai's VS-A77U-B videocassette recorder (\$779) gets you part of the way there. The VHS Hi-Fi VCR has a Dolby Surround Sound decoder built in—along with a 10-watts-per-channel amplifier to power the rear (or ambience) speakers. In effect, it's three products in one chassis.



Move Your Walls By Remote Control

If you've already got a stereo or hi-fi VCR, the AudioSource SS Two surround sound processor (\$250) will let you extract the Dolby soundtrack from suitably encoded tapes. What's more, the SS Two's built-in 30 watts-per-channel amp will power the sound effects from a pair of rear-channel speakers. The SS Two also imparts concert-hall effects for musical sources, such as CD, and synthesizes stereo sound from monaural sources. You'll adjust the size and acoustics of your "hall" from your easy chair by remote control.



Safe And Sound

You can protect your car from unscheduled joy rides with Sansul's Supernova A-1 security system (\$250). Once armed by remote control with its small, keychain transmitter, the Supernova A-1 monitors up to 10 alarm triggers, including four doors, trunk, hood, ignition, stereo, acoustic and motion/shock sensors. You can even lock and unlock the doors by remote control.



Poolside Conversation

What's the use of a cordless telephone if you can't take it out by the pool? Once again, Sony's got the answer in its water-resistant SPP-S10 Sports Phone (\$199). It can make phone calls through its indoor base unit from up to 1000 ft. away and it acts as an intercom too, so you can call the base unit for fresh towels.



Help!

Some folks call them electronic notebooks, but Pison prefers to call its Organiser II (\$250) a lifestyle-compatible computer. With 32 kilobytes of memory on a 9-volt battery, you can carry a desk full of facts and figures in your pocket.



Volkcomputer

Vendex International didn't invent the personal computer, but its Headstart Turbo 888-XT makes computing more accessible to more people. The IBM XT-compatible offers more than an attractive package price (\$995, including software and monochrome monitor): The built-in Vendex Operating Environment also teaches you how to use the computer. And, if you need more than this headstart, you can call the toll-free PC Coach for personal assistance.



Forget The Film

Canon's RC-250 Still Video Camera (\$800) is the first filmless electronic camera for consumer use. In place of film, the RC-250 records 50 images on a 2-in. magnetic disk, and projects them on your TV screen. The disk is reusable: You can erase the photos you don't wish to keep, and record new ones on the empty frames.



AUTOMOBILES



Sleek fwd Reatta uses Riviera mechanicals, including state-of-the-art touchscreen instrument panel. With 3800 V6 and two seats, it's aimed at up-market buyers.

I BUILT A BUICK

PM goes on-line at Reattaville.

BY MIKE ALLEN, Assistant Auto Editor
PM Photos by G. Photo



THERE ARE 3336 individual spot welds holding a Buick Reatta body together, a fact that acquires a certain immediacy when you've wrestled a 250-pound spot welding machine into place for a thousand or so of those welds yourself. Cars have welds in places where most people don't even suspect there are places. And for a magazine editor who rarely wrestles with anything heavier than a dead-

line, it induced pains in places where I never suspected I had places.

It takes 89 man-hours for the workers at the Buick Reatta Craft Centre, in Lansing, Michigan, to build a Reatta, starting with flat rolls of sheet steel going in one end of the plant, and shiny new cars driving out the other end. My assignment? To work along the line, following one car from beginning to end, and then to drive the car for a few days. Would

GM's claims of one of the best QC (Quality Control) audits in the industry hold up? Or would "my" car drive down the road slightly sideways, rattling and shedding parts.

Punching in—early

I've been through auto plants before. What that usually means is that someone from the public relations staff becomes umbilically attached, leads the visitor through the nicer sections of



Editor Allen attaching VIN number plate to new floor pan.



Reattas ride AGVs several times during assembly.



the plant while giving vague answers to questions, and then takes him somewhere nice for lunch. But on this early (6 am) morning the PR staff is still in bed, and lunch is anybody's guess. Bob Thomas, the Reatta project manager, has a lot of confidence in his workers, or I'd never have the chance to do this.

We start out in the body shop where little pieces of sheet steel are placed in fixtures and welded together

into bigger pieces of steel. I begin with a round of introductions, and an immediate opportunity to begin refreshing my welding skills. These big spot welding machines are *heavy*, and even though they're counterbalanced with cables and pulleys, there's a lot of effort involved in muscling the welding tips into place. Hold the tips at just the right spot, and press a trigger to clamp the tips together. Squeeze another trigger, and a mas-

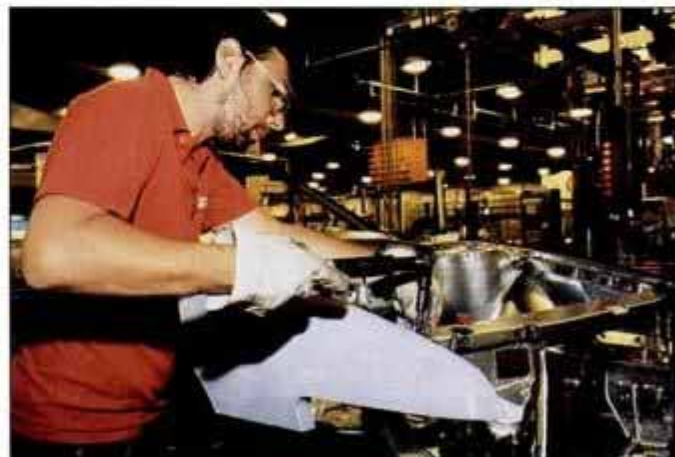
Although a few of the Reatta's welds are done by robot, Editor Allen got ample opportunity to refresh his welding skills while following his car down the line.

sive jolt of electricity passes between the tips, heating the metal between them cherry red and occasionally throwing sparks 30 ft. Then do it again, and try not to flinch.

Reatta production is fewer than 50 cars per day, which means there's



Roof panel is held up by suction until lowered into place.



Plastic front fenders are attached with screws.

I BUILT A BUICK

plenty of time to do a good job. I can't imagine maintaining the 50-car-per-hour (or faster) pace of most other car assembly lines.

By mid-morning break, the skeleton of my Reatta has reached the point where it's too heavy for even two men to carry around. At this point, the barely recognizable floor pan is lifted onto an AGV, an Automatically Guided Vehicle that follows wires set into the concrete floor of the shop. Under computer control, these mobile robots carry the vehicle through the body shop unattended, on through station after station, and ultimately to the paint shop.

Well, at least most of the time. As I watch an AGV move out of the robotic welding station, another empty AGV silently glides across the floor and gently collides with it. Both robots sit mutely until someone notices them.



At last! Allen drives the nearly complete Reatta off the end of the assembly line.

"I hate these things," says my welding teammate, putting down his hammer and punching something into a nearby keyboard. The interloper slinks off, and my Reatta moves on. Bob Thomas commented on this altercation later. "Somebody talked me into putting in those AGVs when we set up this plant. It seemed like a good idea at the time, because it maintained a lot of flexibility, especially in the body shop where there are a lot of parallel operations going on. We could route cars to different stations depending on lots of different things. But we've had a lot of downtime, and they've been a bad investment."

AGVs and a few robots are among the few signs of the '80s in the Reatta plant. In spite of the high quality of in-house stampings, metal finishers use the traditional tools of the trade—pick hammers, spoons and files—to smooth out irregularities before the paint shop. I spent some time relearning the metal-finishing skills I ac-

quired years ago repairing my own race cars. Fortunately, new Reattas need less work than my old Porsches.

Those high-quality stampings are made in a facility (on the grounds) that can change dies (from fenders to door skins) in about 3 minutes, as opposed to the traditional three weeks.

Lunch

Lunch is certainly not the usual PR cloth-napkin affair, but instead consists of two beef-and-napalm burritos purchased from the back of a pickup in the parking lot. There's no bell, no sudden cessation of activity, but the shop just gradually gets quieter for about an hour or so. I do manage to avoid several pinochle games, instead using the time to talk to some of the guys about building cars.

"This plant used to be a drop forge plant," says one veteran. "I spent 15

paint shop is operated as a concession, and the paint isn't paid for until it's on the car and accepted. PPG employs the workers.

The actual painting operation is roboticized, and the cars disappear into a dark tunnel for the spraying. The arrangement works, because Reattas have the best production paint job in my experience, completely devoid of the orange peel that seems to be an industry standard of late.

The next morning sees my Reatta astride another, better-behaved AGV, headed for assembly. It's a hectic morning, installing the wiring, hydraulic lines, interior and instrument panel. No robots here, just people who seem to be able to work quickly and efficiently, talk about cars in general, what it's like to work in the Reatta plant, and baseball—all while lying on their backs and connecting things over their heads.

Their are two watershed points along the line. Installing the engine (from under the car) is done by a 2-man team. And to watch them, you'd swear they were communicating telepathically, because there's no wasted movement, or talk of any sort.

A few hours later, there's the big benchmark—starting up the new car and driving it off the line. Will it start? Will it make gruesome noises? Will Bob Thomas and 400 UAW members tar and feather me and send me back to New York?

But the first twist of the key brings the engine to life. I experience an almost uncontrollable desire to floor the throttle and burn rubber all the way to the street. Fortunately for my job security, there's a pit full of alignment gear and several hours of final detailing before my Reatta rolls out.

Driving

There are several weeks of paperwork and inspections before my Reatta is delivered to PM's Manhattan offices, and I spend a good portion of it thinking up trips to take and calling lady friends to offer them a ride. My Reatta arrives in perfect condition, goes down the road straight, doesn't rattle or shed any parts.

Thanks to Buick and the Reatta Craft Centre for a job well done. They spell it Centre because they want everyone to know that it's not just another car factory, but someplace where the people who build the cars are important.

Bob Thomas refers to them as the people who actually add value to the car as they work on it, as opposed to management types. Judging by the results, it's a philosophy that works. **PM**

years here making axles and differentials. And when GM started changing to front-wheel-drive, there were a lot of guys out of work." GM had closed the plant with no plans to reopen.

But when Buick needed a facility for a low-volume assembly operation, they made the UAW an offer. They needed a base of experienced, skilled workers, and that was available in the Lansing area. But the old-fashioned Hatfields-and-McCoys adversarial relationship between the union and management had to change. Quality control and productivity standards had to improve, because the up-market Reatta was going to sell for \$25,000—plus. It was a 2-way street—Buick was prepared to give the workers a considerable hand in the day-to-day operation of the plant.

Back to work

After lunch I follow the car into the paint shop. There's a unique arrangement between GM and PPG—the

ROUTER BITS

A workshop guide to choosing and using router bits.

BY JOSEPH TRUINI,
Shop And Tools Editor
PM Photos by Brian Kosoff



THERE'S no question about it. The router is a super-versatile, indispensable power tool and is standard equipment in most woodworking shops. However, without a bit, a router is like a Porsche without an engine—nice to have, but not much good.

In last month's issue, we showed how to get the most from your router. Here, we present a closeup look at the various bits that make the router such a versatile, must-own power tool. Router bits are available in hundreds of sizes and styles for shaping, trimming and carving wood and plastics. A vast majority of do-it-yourselfers own a router with a 1/4-in.-capacity chuck. Therefore, router bits with 1/4-in.-dia. shanks are the most common. Note, however, that we also show bits with 1/2-in. shanks that fit larger, more powerful routers.

Router bits are made from four basic



materials: stamped steel, high-speed steel (HSS), carbide-tipped or solid carbide. Stamped steel bits are relatively new and the least expensive. Made from flat steel, the bits are stamped, rolled to shape and then hardened.

Bits made of HSS are popular because they are available in a wide variety of shapes and sizes, relatively inexpensive and can be hand-sharpened in the shop with an aluminum oxide stone. Superdurable tungsten carbide-tipped bits are more expensive than HSS bits, but they hold a sharp cutting edge many times longer. (Some sources say up to 20 times longer than HSS.) Once they do become dull, however, carbide-tipped bits must be professionally sharpened.

Solid carbide bits are used primarily to cut and trim plastic laminates.



Basic bit styles

Router bits come in two basic styles: with a pilot or without. A pilot is simply a noncutting part of the bit that rides against the workpiece edge to control the cut. When using a standard, nonpiloted bit, some sort of guide is ordinarily used to control the cut.

Piloted bits come in two forms. An integral, solid pilot is used on piloted HSS bits. Carbide-tipped bits are fitted with a ball-bearing pilot. The ball-bearing rolls along the workpiece edge as the router is advanced.

Solid pilots, on the other hand, spin at the same speed as the bit. Therefore, when using a solid-pilot bit, advance the router steadily—without stopping—to avoid friction burns on the workpiece edge.

Note that some bits are designed as scaled-down shaper cutters and must be used with the router in a router table. Now let's look at each bit shown.

1. Rabbeting bit—As its name implies, this bit is designed to rout rabbets for rabbet joints. If you build boxes, bookcases, drawers or any kind of cabinet, you should have a rabbeting bit. Rout a rabbet gradually in several passes. Lower the bit slightly

after each pass. The 1/4-in.-shank, carbide-tipped bit shown cuts a 3/8-in.-wide rabbet. A ball-bearing pilot controls the width of the cut. It's \$19 from Zac Products, 34 Renwick St., New York, NY 10013.

2. Half-round bit—This bit lets you rout a half-round shape in the edge of a board in a single pass. The carbide-tipped bit has two flutes that cut a 1/2-in.-dia. bullnose. Use it to shape the edges of drawer sides, tabletops and to form decorative half-round molding. Rout stock thicker than 1/2 in. to create a half-round with bead detail. Since the bit has no pilot, use a straightedge to guide the router. The 1/4-in. radius bit shown costs \$59 from Zac Products, 34 Renwick St., New York, NY 10013.

3. V-groove bit—Milled entirely from solid carbide, this bit cuts V-shaped grooves in wood and plastics. The 1/2-in.-wide cutting head is ground to a



trim overhanging laminate flush with the perpendicular surface. The bit on the left is a bevel trimmer (\$11.65). Note that its flutes are ground to a 10° angle. Use a bevel trimmer after a flush-trimming bit to bevel the edge where two laminates meet at 90°. Contact Bosch, 100 Bosch Blvd., Router Bit Dept., New Bern, NC 28562.

8. Mortising bit—Looking somewhat like a straight bit (No. 4), this ½-in.-dia. bit is designed primarily for routing hinge mortises. A deep slot between the two carbide-tipped flutes promotes fast cutting with excellent chip removal. This makes it especially effective when routing resinous, gummy woods. It's \$10. Contact Bosch, 100 Bosch Blvd., Router Bit Dept., New Bern, NC 28562.

9. Core box bit—This round-nose bit is used primarily for routing flutes in



tion with a dovetail jig or template. You can also rout dovetail-shaped slots, to form a sliding dovetail joint, by simply guiding the router against a straightedge. Note that dovetail joints are cut full-depth in a single pass. Both the bits shown cut ½-in.-wide dovetails with 14° sides. The ½-in.-dia. shank bit (\$16.60) is carbide-tipped. The other bit has a ¼-in.-dia. shank and is made of solid carbide (\$14.30). Contact Freud, 218 Feld Ave., High Point, NC 27264.

6. Double end V-groove bit—Get two bits for the price of one with Vermont-American's versatile double-ended V-groove bit (\$4.50). Made of high-speed steel, it has two cutting points. One end is ground to 45°; the other to 60°. Use it to rout signs, for freehand carving and to form simulated V-groove paneling. Contact Vermont-American, Box 340, Lincolnton, NC 28093.

7. Laminate trimmers—Anyone working with plastic laminate needs a laminate-trimming bit. Shown here are two popular laminate trimmers from Bosch. Both bits are carbide-tipped with ball-bearing pilots. The tall, narrow bit on the right is a ⅜-in. flush-trimming bit (\$14.20). Use it to

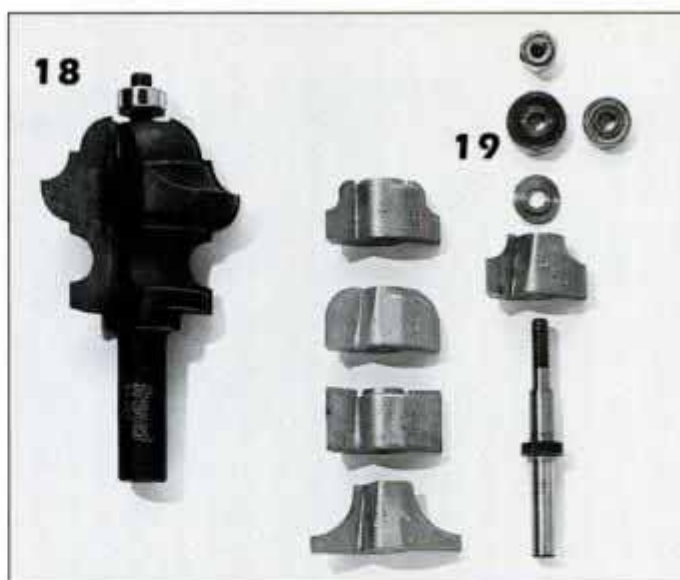
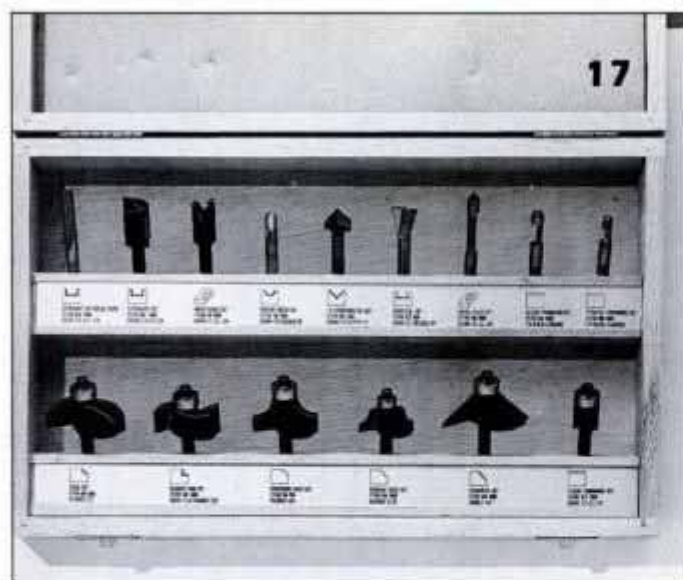
90° angle. Use it to create decorative accents on furniture and millwork. It's also an excellent bit for routing signs. It costs about \$19 at hardware stores. It's also offered in ¼, ⅜, ½ and ¾ in. dia. Contact Freud, 218 Feld Ave., High Point, NC 27264.

4. Straight bits—Nearly every router-bit collection starts with a few straight bits. Shown here are the three most valuable sizes: ¼, ½ and ¾ in. dia. These simple bits are used to cut dados, grooves, rabbets and for certain edge-jointing operations. Each bit has two carbide-tipped flutes for smooth, fast cutting. The bits shown cost: \$9 (¼ in.), \$12 (½ in.) and \$13 (¾ in.). Contact Zac Products, 34 Renwick St., New York, NY 10013.

5. Dovetail bits—With one of these bits, you can rout precise-fitting dovetail joints that rival traditional, hand-cut dovetails. Dovetail router bits are most often used in conjunc-



ROUTER BITS



columns, doors and period moldings. It can also be used to carve signs. To convert it to a cove bit, attach an edge guide to the router's base so that only half of the bit's profile is exposed. The bit features a $\frac{3}{4}$ -in.-wide, carbide-tipped head and costs \$15.60. Contact Vermont-American, Box 340, Lincolnton, NC 28093.

10. Panel pilot bit—This unusual looking tool is a cross between a router bit and a drill bit. It features a self-drilling point, solid pilot and spiral cutting flute. Made of high-speed steel, the bit will bore through wallboard, plywood, chipboard, insulation sheathing and thin aluminum. Then, advance the router to rout out an area. The boring and routing is all done in a single operation. Use it to cut door, window and vent openings. It's available at hardware stores for about \$6. Contact Vermont-American, Box 340, Lincolnton, NC 28093.

11. Chamfer bit—There are several ways to chamfer an edge, but none is quicker or more accurate than using a router. The Freud chamfer bit shown has two large, carbide-tipped cutting edges that are ground to 45°. A ball-bearing pilot controls the bit. The chamfer size can be adjusted by raising or lowering the bit. The bit shown costs about \$30. Contact Freud, 218 Feld Ave., High Point, NC 27264.

12. Stamped steel bits—Economical Dura-Sharp router bits are stamped and rolled from heat-treated, high-speed steel. They're available in 23 different sizes and styles and are sold individually or in 5-piece and 15-piece sets. The bits shown are Roman ogee, beading and V-groove. However, the major reason Dura-Sharp bits are popular is their cost: about half as much as conventional HSS bits. The bits range from \$1.50 to \$5.65 each. The 15-piece set costs about \$35. Con-

tact The Credo Co., 2765 National Way, Woodburn, OR 97071.

13. Door frame and panel bits—Anyone with a $\frac{1}{4}$ -in. router can now mill traditional frame-and-raised-panel cabinet doors easily. The bits shown are for use only with the router mounted in a router table. They include a cove-style raised panel cutter and a ball-bearing piloted coping and sticking cutter. Both are carbide tipped. The coping and sticking cutters are sold in a pair—the one shown and one identical, but inverted cutter—for \$85. The cove-style raised panel bit costs \$70. Contact Zac Products, 34 Renwick St., New York, NY 10013.

14. Keyhole slot bit—Use this unique HSS bit (\$6.35) to cut keyhole slots in the back of picture and mirror frames, small cabinets, and other wall-hung items. Lower the bit into the work to bore a $\frac{3}{8}$ -in.-dia. entry hole. Then, advance the router to mill a recessed slot. The finished keyhole will slide over and lock onto the head of a screw or nail. Contact Vermont-American, Box 340, Lincolnton, NC 28093.

15. Flush-trimming bit—Similar to a ball-bearing piloted flush-trim bit, this solid carbide bit is used to trim plastic laminates flush. The bit features a solid pilot and a $\frac{3}{8}$ -in.-long cutting edge. This style bit (\$9) will cut in tighter spots than ball-bearing piloted bits. Contact Freud, 218 Feld Ave., High Point, NC 27264.

16. Cove bit—For shaping decorative edges and milling moldings, the cove bit is a standard, must-own bit. Cove bits come in a wide variety of sizes and styles. The HSS bit shown has a solid pilot and two flutes that cut a $\frac{1}{2}$ -in.-rad. cove. It costs about \$9. Contact Bosch, 100 Bosch Blvd., Router Bit Dept., New Bern, NC 28562.

17. Router bit kit—Here's a great gift

for any woodworker—including yourself. Freud offers this valuable 15-piece router bit set that contains the most commonly used bits. The set includes a $\frac{1}{4}$ -, $\frac{1}{2}$ - and $\frac{3}{4}$ -in. straight bit, round-nose, V-groove, dovetail, panel pilot, bevel trimming, cove, rabbeting, rounding over, Roman ogee, chamfer and two flush-trimming bits. Six of the bits have ball-bearing pilots. All the bits have $\frac{1}{4}$ -in. shanks and are either solid carbide or carbide tipped. They come in a handsome wooden storage case. The set costs about \$276. That's less than \$18 per bit. For details, contact Freud, 218 Feld Ave., High Point, NC 27264.

18. Multiform bit—Convert your router into a production molding machine with this unique bit. Called the Multiform bit, it's designed to produce standard moldings. In fact, with this one bit you can make 39 different moldings. Twelve of the moldings are made in a single pass. The remaining 27 molding shapes are formed in two passes over the bit. Custom-shaped moldings can also be cut. The bit has a $\frac{1}{2}$ -in. shank and measures $4\frac{1}{4}$ in. long. Use it in a router table only. Priced at \$99, this bit is for serious woodworkers. Contact Freud, 218 Feld Ave., High Point, NC 27264.

19. Arbor shank bit kit—Here's an economical way to start, or add to, a router bit collection. This set includes five carbide-tipped cutters and a ball-bearing piloted arbor. The $\frac{1}{4}$ -in. arbor comes with two bearings, washer and locknut. Simply slide one cutter and a bearing onto the arbor and tighten the locknut. The cutters included are: $\frac{1}{4}$ - and $\frac{1}{2}$ -in. rounding over, cove, Roman ogee and rabbeting. They come in a plastic case and sell for \$73. That's \$14.60 per bit. Contact Vermont-American, Box 340, Lincolnton, NC 28093. **PM**

CARPENTRY BASICS

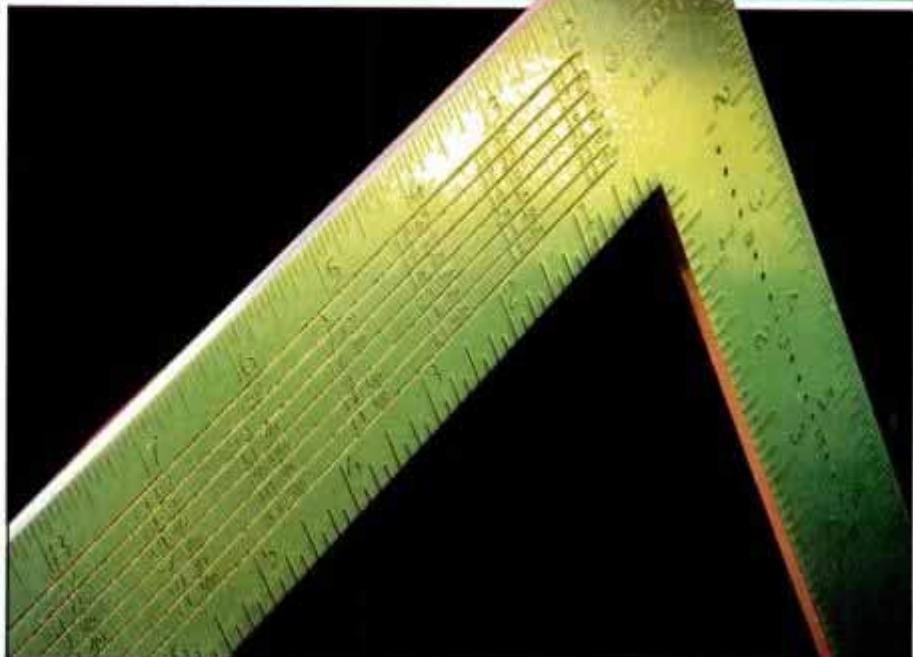
RAFTER LAYOUT WITH A FRAMING SQUARE

TEXT AND PHOTOS
BY ROSARIO CAPOTOSTO,
Contributing Editor

MANY people feel comfortable using a framing square for such tasks as laying out stud locations in a partition wall or marking off joist positions on a backyard deck. But confusion invariably sets in when inexperienced people use a framing square for calculating the proper length and cut lines of roof rafters. This job isn't as difficult as it seems, especially when you consider that just about all the information you need is stamped right on the square itself.

The methods shown here are for measuring *common* rafters. They are the most straightforward members of the rafter family and are, by far, the most often used. They appear in simple gable roofs as well as typical shed roofs, and as such represent the type of work you are most likely to tackle—namely small outbuildings or simple house additions.

The framing square consists of two blades called the *body* and the *tongue*.



The body is the wider and longer blade, usually measuring 2 × 24 in. The tongue is smaller, usually 1½ in. wide × 16 in. long. By aligning the body and tongue—in certain specific ways—along the same board edge, all the cuts required for your rafters can be easily and accurately determined.

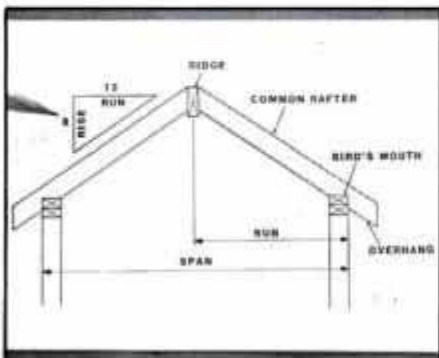
The whole layout system is based on the pitch of the roof you want to build. Photo 1 shows a triangle which is a drafting convention for indicating roof pitch. (The drawing also shows basic roof framing terminology.) The roof pitch is nothing more than the slope of your roof expressed as the relationship between the number of inches of rise—in this case it's 8 in.—and the number of inches of run—which is 12 in.

With your *rise* figure in hand, next

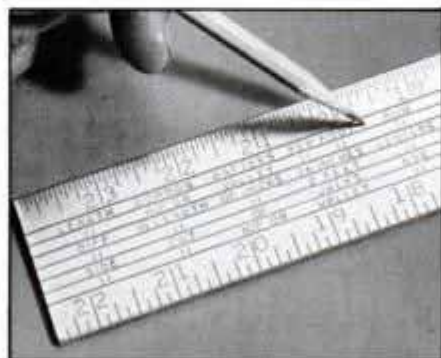
determine the *run* of the roof. In the case of the typical gable roof we show, the *run* is one-half of the *span*—which is the distance between the outside edge of the front and back wall plates.

Once the *run* is calculated, consult the top line of the framing tables on your square. This will reveal the length of your common rafter *per foot of run*, in other words, how long the rafters are for every 12 in. of horizontal run. By multiplying the table figure by the number of feet of run, you end up with the length of the rafter.

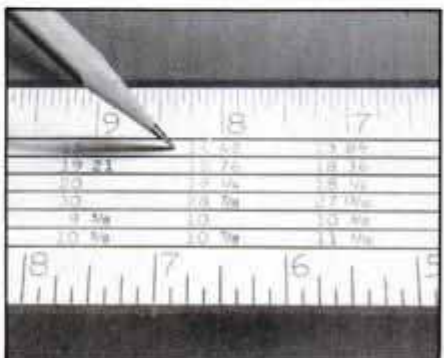
Keep in mind that rafter length is calculated from the center of the ridge board to the outside edge of the wall plates. Therefore, it doesn't include any allowance for a roof overhang. The overhangs—where they occur—are figured separately and their



1 Typical common rafter construction and terminology. Small triangle is drafting convention that indicates roof pitch.



2 One side of square's body has tables for cutting all types of roof rafters. First line gives length of common rafters.



3 To find rafter length for an 8-pitch roof, look under 8-in. mark and find 14.42—decimal is assumed. Multiply it by rafter run.

size should be indicated on the plans. Be sure to mark off any overhang you desire before cutting the rafters.

Once you are satisfied with your layout, cut your first rafter, then use

it as a template for marking others. It's a good idea to begin by cutting only one other rafter and then test fitting it and the template rafter in place. Just tack nail them to the wall

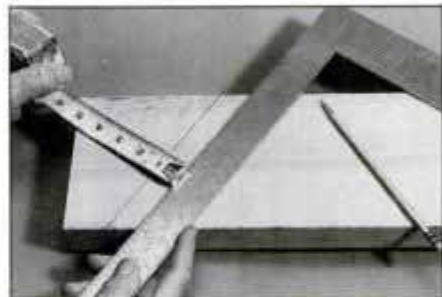
plates and slide a scrap piece of 2x6 stock between their top ends to act as a ridge. If the bird's mouth and ridge joints are straight and tight, you can cut more rafters with confidence. **PM**



4 To establish plumb cut at top of rafter, align 8-in. mark on tongue and 12-in. mark on body with same edge of rafter board.



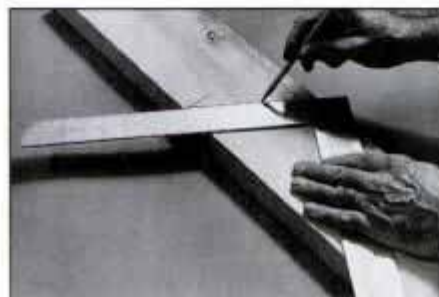
5 Hold square securely and mark plumb cut along edge of square. Mark indicates centerline of ridge board, not cut line.



6 To establish actual cut line at rafter top, deduct one-half of ridge thickness—here it's $\frac{3}{4}$ in.—and mark parallel line.



7 To mark rafter length, measure top edge of board starting at plumb line, not cut line. Mark edge at proper length.



8 To mark second plumb line at bottom of rafter, move the square to the length mark and align tongue and body as before.



9 To mark bird's mouth, hold square perpendicular to plumb line and where length of cutout equals width of wall plate.

NEW TOOL

Power Ratchet



Cordless ratchet comes with plug-in charging base that can be wall mounted or set on workbench. Recharging takes 12 hours.

JUST when you thought you'd seen all the latest tools, someone surprises you. At the most recent National Hardware Show, Black & Decker introduced the Power Ratchet—a cordless, battery-powered ratchet wrench.

It's driven by a 3-cell, 3.6-volt battery that's housed in the handle. Simply depress the ON/OFF button to activate the $\frac{1}{4}$ -in. drive head. A switch on the back of the drive head selects forward or reverse rotation. Unlike a manual wrench, the head can be rotated 360° and locked at the most advantageous position. For final tightening, or to loosen stubborn nuts and bolts, slide the switch to the OFF position and use the tool as a manual wrench.

Power Ratchet operates at 115 rpm and recharges in about 12 hours. It comes in a molded plastic carrying case complete with six sockets ($\frac{1}{4}$ in. to $\frac{1}{2}$ in.), a 3-in.-long extension bar, two socket storage racks, and a wall-mountable, plug-in charger. Optional accessories include metric sockets, hex socket bits and screwdriver bits for Torx, slotted and Phillips fasten-

ers. The Power Ratchet kit (model No. 9050-02) costs about \$70 at hardware stores and home centers.

For details, contact Black & Decker, Box 600, Hampstead, MD 21074.—*Joseph Truini*



Touch of a button spins off nuts quickly. Power Ratchet is useful in tight spots where there's little room to swing the handle.

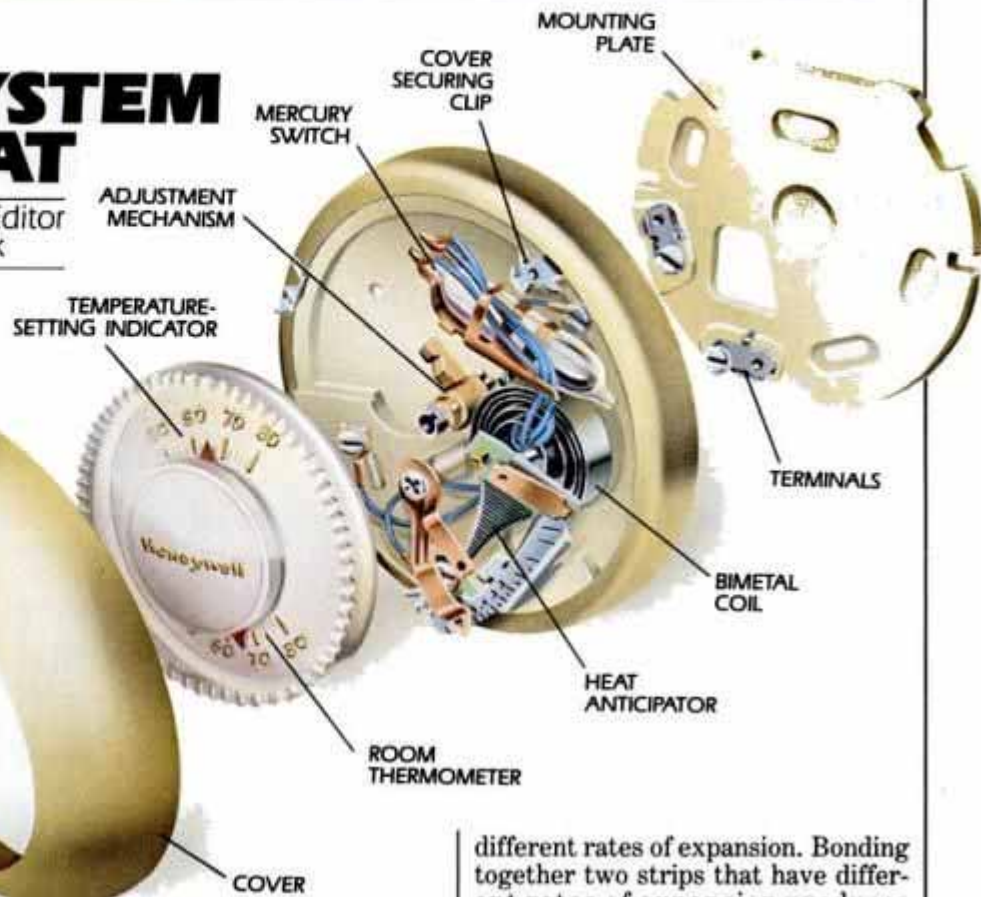
HOW IT WORKS

HEATING SYSTEM THERMOSTAT

BY THOMAS KLENCK, Associate Editor
PM Illustrations by George Retseck

EVER since man moved into the colder climates, access to heat has been of prime concern. Once the quest for fire had been conquered, it only remained to throw a few more logs on when the temperature dropped. It's easy to know when this happens—we start shivering. As technology developed, it didn't take long before some frustrated fire stoker began to wonder whether a device external to our bodies could sense the change in temperature for us—and do something about it.

That device, of course, is the thermostat. And, its simplicity and reliability have made it one of the most taken-for-granted components in a domestic heating system. Without it, you'd have to manually shut the furnace off or turn it on when the room became too hot or too cold.

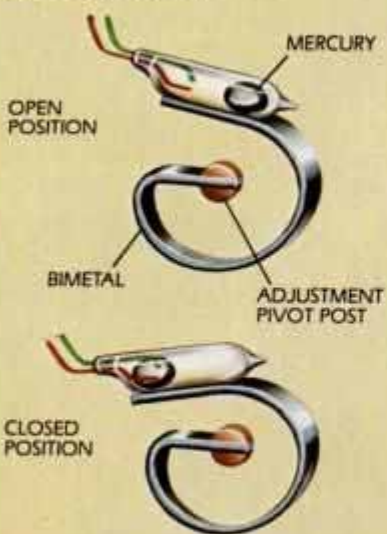


A thermostat performs two distinct functions. First, it reacts to changes in ambient temperature, and second, it sends a message to your furnace when certain conditions are met. An example of a temperature-sensing device is an ordinary mercury thermometer. It signals a change in temperature when the mercury in the glass tube expands or contracts.

Solid metals also expand when heated. And, different metals have

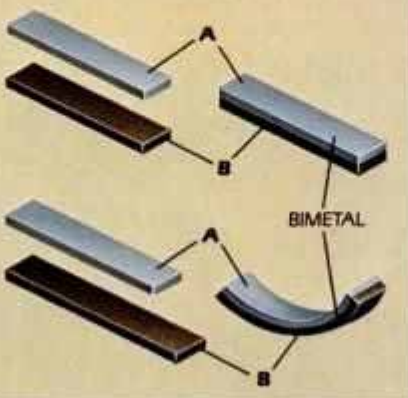
different rates of expansion. Bonding together two strips that have different rates of expansion produces what's known as a bimetal strip. This composite strip will bend as the temperature changes due to the fact that one face reacts to the change in temperature more dramatically than the other. Most thermostats use a bimetal coil to sense temperature changes.

MERCURY SWITCH



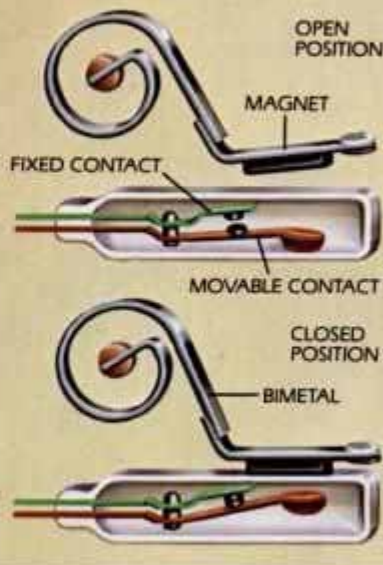
When furnace is off, mercury is away from wires keeping circuit open (top). As temperature drops, bimetal bends and mercury flows over wires to connect circuit (bottom).

BIMETAL PRINCIPLE



Two different metals (A and B) can be the same size at one temperature (above) and different when heated (below). Bonded together (right), bimetal bends when heated.

MAGNETIC SWITCH



Bimetal coil controls magnet position in relation to contact points. As coil bends toward contacts, the magnet draws the movable contact up to close the circuit (bottom).

Once you have a reliable mechanical device that reacts to temperature, the next problem is to get it to turn the heat on and off. Most domestic heating systems are activated by an electric switch that starts the furnace and supplies any other necessary components with 120-volt house current. The thermostat's job is to throw the furnace switch. The task is accomplished by equipping the furnace with a special type of switch called a relay. A relay is simply a switch that can be electrically controlled by another switch. The thermostat contains a low-voltage switch that, when closed, energizes the relay which then sends current to the heating system.

The most common switch mechanism in home thermostats is a mercury switch. A small bead of mercury is encapsulated in a glass vial along with

the ends of the two low-voltage wires that must be connected to close the circuit. The glass vial is mounted on the end of the bimetal coil. When the furnace is on and the room temperature rises, the coil unbends and the vial tilts back. The mercury flows away from the wires and the circuit is broken. When the temperature drops the coil tightens. The mercury flows toward the wires, completes the circuit and the furnace is activated.

An additional type of bimetal-activated switch features contact points to control the current flow. This type of switch has a magnet mounted on the bimetal coil. While the room temperature is warm enough, the magnet remains away from the contacts. As the temperature lowers, the bimetal coil moves the magnet to a position where it can draw the bottom contact

point up to the fixed contact and complete the circuit.

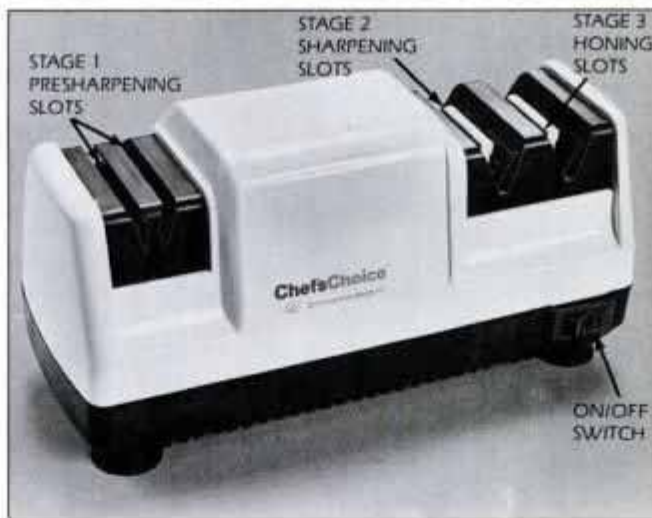
Another mechanism often found on thermostats is a heat anticipator. This device heats the bimetal coil so that the furnace will be shut off slightly earlier than is indicated on the dial setting. In this way, any heat still being delivered from the furnace after it's shut off will bring the room temperature to the desired level. Heat anticipators operate on the principle that heat is generated when there is resistance to electrical flow. Thermostats with fixed heat anticipators use an appropriately sized resistive heater to create enough heat to turn the furnace off slightly before the desired room temperature is reached. Some models feature a variable heat anticipator for fine tuning the point at which the furnace turns off. **PM**

PRODUCT REVIEW

Diamond-Plate Knife Sharpener

FOR THE AVERAGE homeowner, keeping kitchen knives sharp is a next to impossible task, mostly because hand sharpening takes practice, patience and a certain amount of skill. However, now there's an electric sharpener that provides a foolproof way to sharpen knives like a pro.

The sharpener, called Chef's Choice (model No. 100), features a 3-stage sharpening system that utilizes diamond-abrasive discs. The first stage is a 100-grit disc that grinds the edge to a 40° angle. Stage two, a fine 250-grit disc sharpens the edge to a 45° angle. Finally,



Three-stage knife sharpener has two slots per stage for sharpening both sides of blade. Unit has diamond-abrasive sharpening discs.

stage three, a superfine 600-grit diamond disc, set at 50°, hones a razor's edge on the knife. Depending on the condition of the knife, three to six passes through each slot are required.

To ensure that the knife maintains the correct angle throughout the process, magnetic plates in the slots hold the blade as it's drawn across the diamond discs.

The Chef's Choice sharpener costs about \$70 at kitchen supply shops and department stores. Contact Edgecraft Corp., 407 Meco Dr., Wilmington, DE 19804. Or, call toll-free (800) 342-3255.—Rosario Capotosto



First stage is the presharpening slots that grind main bevel and will reshape a damaged edge. Draw knife slowly through slots.



Stage two: sharpening slots. Magnets hold knife at the correct angle. Lift the handle at end of stroke to sharpen the blade tip.



Stage three: final honing for a razor's edge. Make a few slow strokes over disc followed by a few fast strokes to polish edge.

HOME AND SHOP PROJECT

SAVING GRACES

A conservator's secrets for mounting, matting and preserving valuable artwork and precious documents.

TEXT AND PHOTOS
BY KENN OBERRECHT

FOR MOST homeowners, the value of a framed piece of artwork is relative and personal. Even when the value is only sentimental, if the piece is worth displaying in your home it deserves the level of care that will preserve its colors, condition and charm for a lifetime. Presented here are instructions showing how to mount, mat and frame artwork like a professional—at a fraction of the cost charged by custom framing shops. The tools and supplies needed are readily available at artist supply shops and through many mail-order tool companies.

The greatest enemy of artwork on paper—drawings, watercolors, pastels, lithographs, posters and the like—is acid which is found in wood pulp paper products such as standard mat board. Acid attacks artwork, burning highlights and margins, turning whites to brown and fading colors. Artwork that is framed in an acidic environment, will begin showing damage within one to three years. Therefore, anything that comes in contact with the artwork must be acid-free including the mounting and matting materials. You also should seal wood frames with shellac or an acrylic sealer.

In multiple-matted projects, you can use standard mat board for the outer mats



that don't touch the artwork, but be sure to seal the edges of the mat board with shellac or spray the entire board with an acrylic matte finish.

Airborne pollutants, moisture, mold and fungi can also attack artwork. Therefore, the glass must fit snugly against the lips of the frame to help seal out these damaging substances. The mat board provides the necessary airspace between the glass and the artwork. But for pieces framed without a mat board, a special

plastic material, called Framespace, can be slipped onto the edge of the glass to create a space between it and the artwork. Seal the back of the frame by gluing on a sheet of kraft paper.

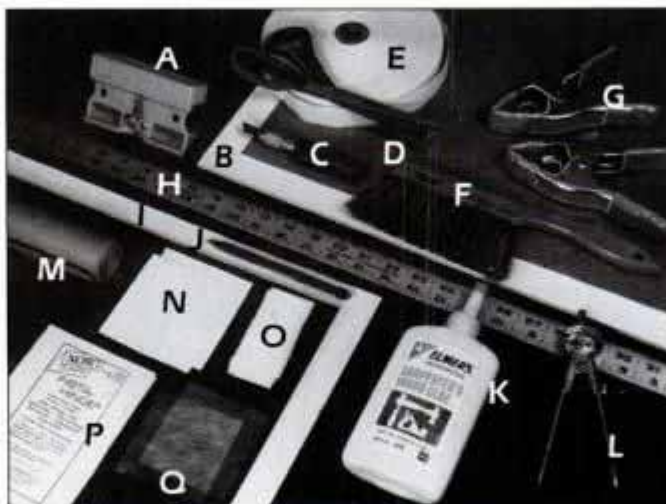
To cut professional-looking beveled mat windows, you'll need a mat cutter—essentially a razor knife with an integral handle and bevel guide. Mat cutters range in price from about \$10 to more than \$50. Some cutters come with an adjustable straight-edge, cutting board and clamps.

If you don't want to pay for specialized equipment and you'll be satisfied with straight-cut, unbeveled mat windows, you can get by fine with an ordinary mat knife, metal straightedge and two spring clamps. You'll also need a large sponge and a piece of 3/4-in. plywood for use as a work surface.

Where to begin

Start by determining the size of the mat window. In most cases, the window is about 1/4 in. smaller than the overall image size, thus, leaving 1/8-in. overlap on each side. There are no hard-and-fast rules regarding the size of the window with respect to the size of the image. You may wish to crop the artwork so that a border reveals a signature or limited-edition series number. These exposed margins usually range between 1/2 in. and 1 in. wide, which means that the windows are cut 1 in. to 2 in. larger than the image.

Next, determine the mat border width. This usually ranges between 1 in. and 4 in. Borders of equal width look fine on most pieces of art, diplomas and certificates. Low-hanging framed artwork often benefits from having a bottom border slightly wider than the top and side borders. Other pieces are enhanced by two or more mats of different colors. The only reliable rule is to do what pleases you. Keep in mind, however, that whenever possible, design the mat and mounting to fit standard-size frames. This



The tools and supplies needed to produce professional-looking framed artwork include: A. mat cutter, B. foamboard, C. mat knife, D. scissors, E. linen tape, F. dust brush, G. spring clamps, H. metal straightedge, I. acid-neutralized mat board, J. pencil, K. glue, L. compass, M. kraft paper, N. blotters, O. rice-paper hinges, P. mounting kit, Q. spun-nylon squares.

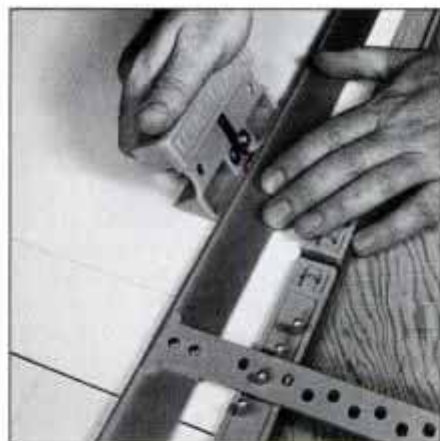
way, you'll avoid the extra trouble and expense involved in ordering a custom-made frame and glass.

Once you've decided on your design, then proceed as shown in Photos 1 through 8. A couple of points to keep in mind are:

■ Since mat cutters are preset at a



1 Trim mat board to size with a knife and straightedge held by spring clamps. Cut $\frac{1}{8}$ in. less than inside frame size.



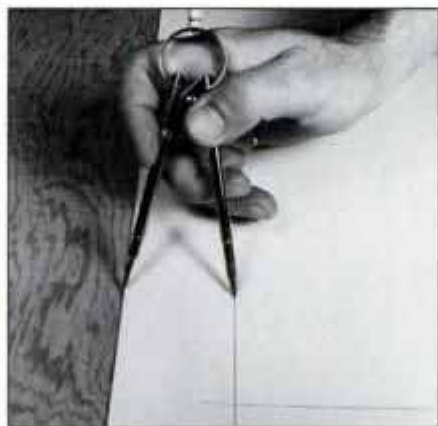
3 Cut beveled mat windows like a pro with mat cutter. Slide cutter along a straightedge that's aligned with layout lines.



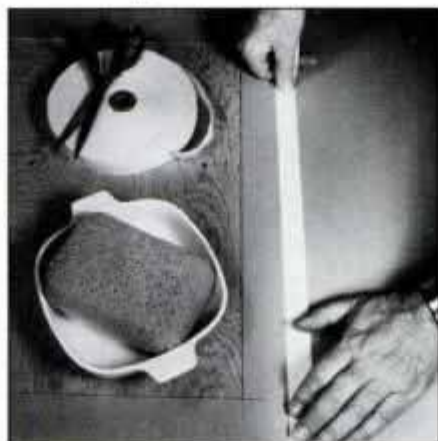
6 Use tissue-covered book to hold art. Moisten hinges and press onto mounting board. Then brush again.

bevel, you'll need to clamp the straightedge about $\frac{1}{8}$ in. outside of the layout lines in order for the blade to cut exactly on the lines.

■ Foamboard—a thin polystyrene sheet sandwiched between two sheets of heavy paper—is an excellent backing material for most framables.



2 Using a compass, scribe layout lines for mat window on the back of board. Mat borders are usually 1 in. to 4 in. wide.



4 Hinge together mat board and mounting board with linen tape. Moisten and then press it down firmly along the seam.



7 Moisten kraft paper, run thin bead of glue on rear edge of frame, then flip over frame and press down onto paper.

Also known as Foamcore, it's sold at artist supply shops.

■ When conservators mount artwork of value, or potential value, they use rice-paper hinges. But since rice-paper hinges are often hard to find and rather difficult to work with, use a product called Insta-Hinge. Sold at frame shops and through some mail-order firms, Insta-Hinge comes with three $1\frac{1}{2}$ -in.-wide \times 24-in.-long strips of rice paper (impregnated with wheat paste and treated with a fungicide), blotters, spun-nylon squares and complete instructions. Each kit contains enough materials to mount 12 items. **PM**

Mail-Order Suppliers

The following mail-order companies carry framing tools and/or materials. Each company offers a free catalog.

■ Brookstone, 127 Vose Farm Rd., Peterborough, NH 03458.

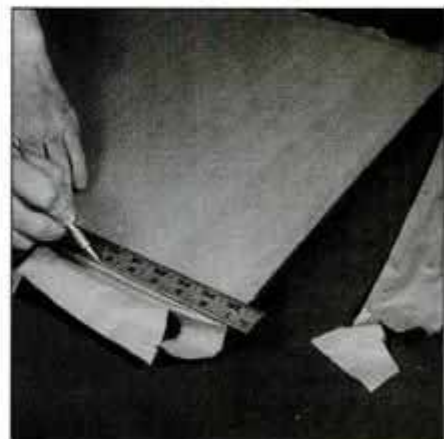
■ Dick Blick, Box 1267, Galesburg, IL 61401.

■ Leichtung, 4944 Commerce Pkwy., Cleveland, OH 44128.

■ Light Impressions, Box 940, 439 Monroe Ave., Rochester, NY 14603.



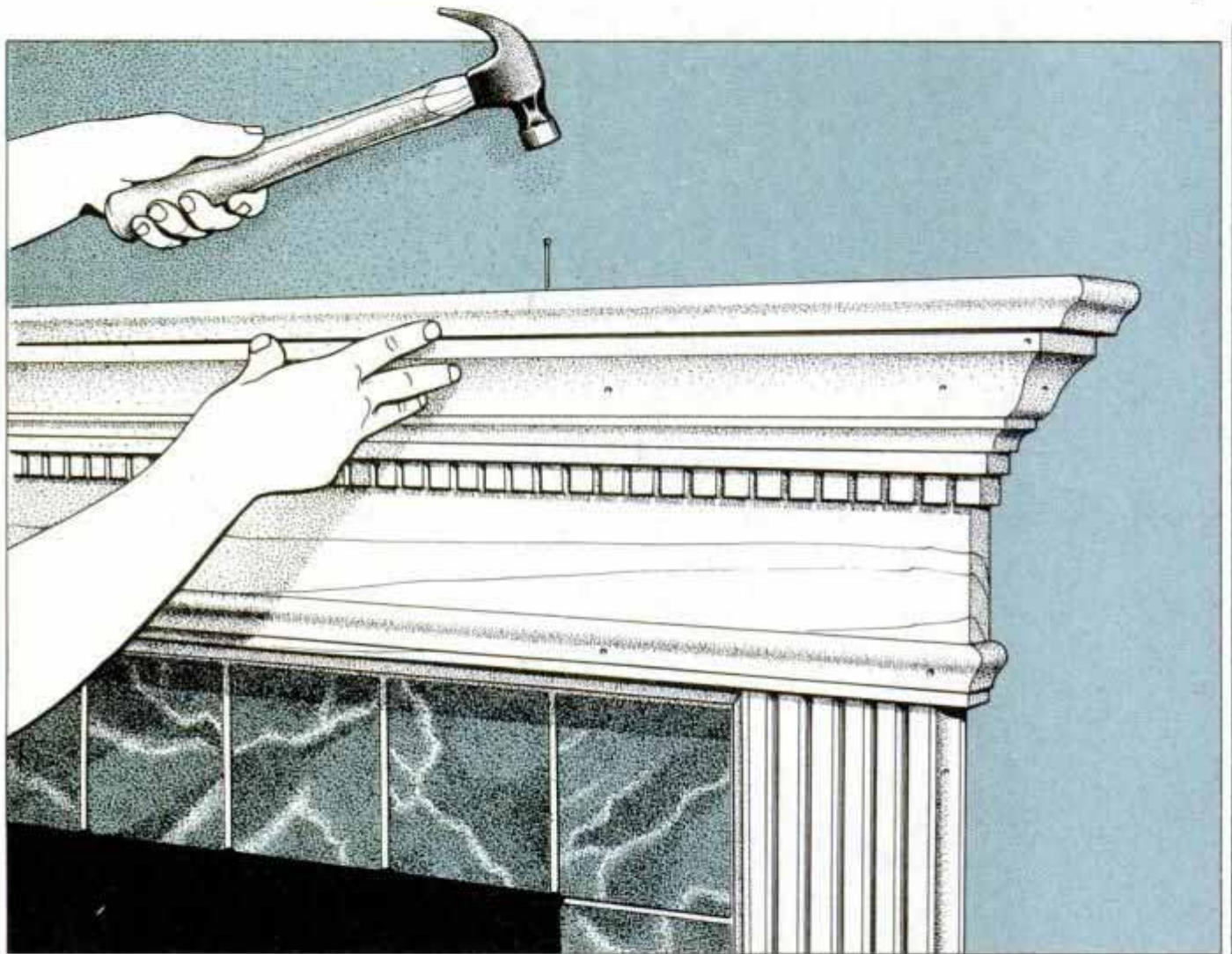
5 Attach rice-paper hinges to top, back corners of artwork. Moisten hinges, press down, then brush again for good adhesion.



8 After glue dries, trim off excess kraft paper with mat knife and straightedge. Make cuts about $\frac{1}{16}$ in. from frame's edge.

How To Build A FIREPLACE MANTLE

BY PAUL BARRETT; PM Illustrations by George Retseck



FOR MANY Americans, burning wood is something more than just another way to stay warm—it's also a way to add a sense of traditional atmosphere to your home on cold winter nights. And, whether you've installed it yourself or not, a built-in fireplace is the ultimate in providing good, old-fashioned warmth.

Many modern installations, however, are plain and unadorned. Although this may be fine for a contemporary setting, a traditionally appointed room demands something special. And, that something is a fire-

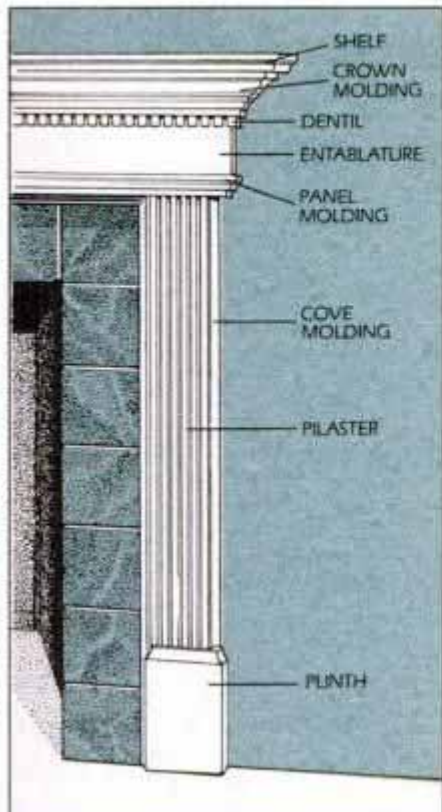
place mantle. While a simple mantle might be nothing more than a shelf, most classic fireplaces are completely framed with woodwork. Even though the design may look intricate, the actual construction is straightforward and simple. Most of the moldings that we used are easily available at any well-stocked lumber yard. You'll also need a router, miterbox, drill and a few ordinary hand tools.

Keep in mind that installing woodwork around a fireplace opening may present a fire hazard. The National Fire Protection Assn. specifies that wood trim or other combustible mate-

rial should not be closer than 6 in. to the fireplace opening. Furthermore, any wood above the opening that projects more than 1½ in. from the wall should not be less than 12 in. from the opening. Local guidelines may vary, so be sure to check with your local building inspector before starting the job. We installed 6-in.-square tiles around the opening so the woodwork would be a safe distance away.

Planning the mantle

The design of a traditional mantle is based on classic architectural elements and each component has a



1 Our mantel design is composed of several traditional elements. The cove, crown and panel moldings are easily available.

name that reflects this heritage (Fig. 1). Pilasters are the vertical column-like components that border the fireplace sides. They connect the base blocks, or plinths, with a heavily ornamented horizontal member composed of the entablature and shelf.

The crown, panel and cove moldings are available at lumber dealers. The dentil blocks are cut from a 1/4-in.-thick lattice strip and the pilaster flutes, plinth coves and shelf-edge profile are cut with easily available router bits.

It's a good idea to make a scale drawing of the mantel based on the

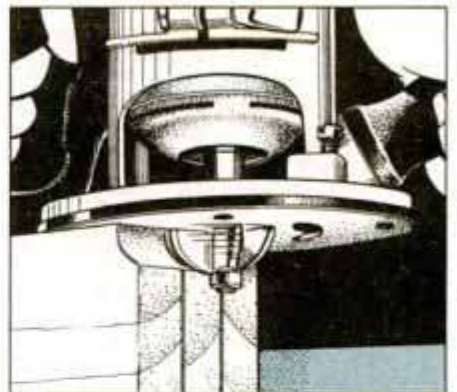


2 After finding the general location of studs by tapping on wall, use a 1/8-in. drill bit and bore holes to find stud centers.

size of your fireplace opening. While most of the component lengths are determined by the size of your fireplace, the widths of the pieces can be varied to suit your sense of proportion. Our opening measured 37 1/2 in. high x 44 in. wide and the dimensions given are suitable for a fireplace of this size.

We planned our mantel to be painted rather than finished clear. This allows the use of less-expensive finger-joined moldings. Also, nail holes, less than perfect joints, and accidental bumps can be easily filled and sanded.

The first step in construction is to locate the wall studs around the fireplace. Tap across the wall with your hammer handle and listen for a solid sound. Then, drill small test holes in an area to be covered by the mantel to locate the exact center of each stud (Fig. 2). Although studs are usually located on 16-in. centers, their spacing may vary around your fireplace opening. Using a 4-ft. level, mark plumb lines on the wall that indicate the stud centers. Then, lay out the positions of all the mantel components directly on the wall. You'll use this layout to cut the components accurately to length.



3 To rout the corner of the plinth, use 1/2-in.-rad. cove bit with pilot. Stock is sandwiced between scrap for easy routing.

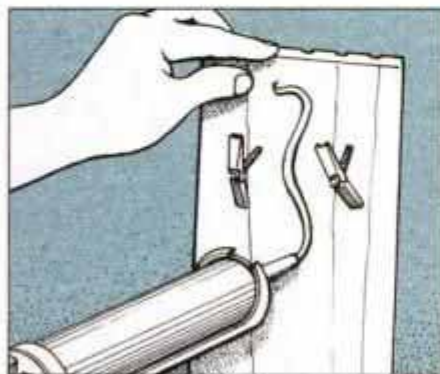
The mantel sides

Prepare the plinths by ripping 5/4 stock to 6 3/4 in. wide and then cross-cutting to 9 in. long. Unless you're using a table saw, it's safest to cut the wood to width before cutting it to length.

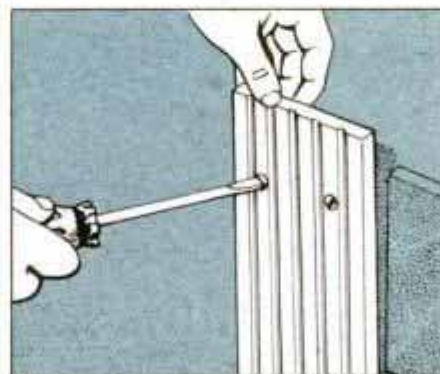
Each plinth has a cove cut across one corner and along the top edge. Use a 1/2-in.-rad. cove router bit with ball-bearing pilot for these cuts. When cutting the corner cove, sandwiche the workpiece between two pieces of scrap stock and secure in your vise. Make sure the edges of all three pieces are aligned. This provides a stable surface for the router and prevents the bit from accidentally turning the corner and removing too much stock (Fig. 3).

When routing the upper edge cove, alternate the direction of the corner cove on each piece so that you end up with a right- and left-handed plinth.

The pilasters are made from 1x6 stock which is actually 5 1/2 in. wide. Choose a board that's relatively free of knots and that's long enough for both pilasters. Then, install a 1/2-in.-dia. core box bit in your router for cutting the flutes. Set the router edge



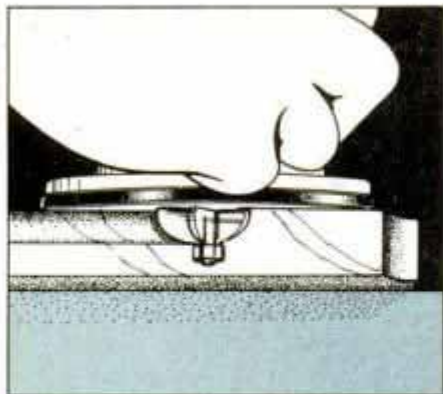
7 Toggle bolts secure pilaster or plinth where no stud is present. Apply panel adhesive sparingly before securing boards.



8 Gently pull back on board to keep toggles from turning as bolt is tightened. Then plug holes with a short 3/8-in. dowel.



9 After cutting the 5/4x10 entablature stock to exact length, sand ends and secure it to the wall with 10d finishing nails.



4 The upper edges of each plinth are routed next. Rout the opposite face on each to make a left- and right-handed plinth.

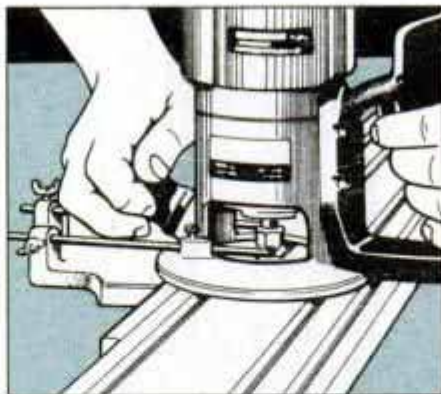
guide to leave a 1/2-in.-wide space before the first flute and rout from both edges of the board face. Be careful to keep the edge guide in firm contact with the board edge at all times.

Then, reset the edge guide to leave a 1/2-in. space from the inside edges of the last flutes and rout the next pair of flutes (Fig. 5). Finally, reset the edge guide and rout the center flute.

After the routing is completed, cut the pilasters to length based on the measurements taken from your wall layout. Use a miterbox to ensure square cuts (Fig. 6).

If you've located appropriately positioned studs for attaching the pilasters and plinths, then secure them—plinths first—with 8d finishing nails. However, if there are no studs, or not enough to secure each piece, then use 1/8-in.-dia., 2-in.-long toggle bolt-type hollow-wall fasteners.

To install the toggle bolts, first bore 1/8-in.-dia. holes through the components at the desired locations. When installing the pilasters, bore the toggle bolt holes on the flat areas of the fluted surface. Then, counterbore 3/8-in.-dia., 3/8-in.-deep holes to accept the bolt heads. Hold the components



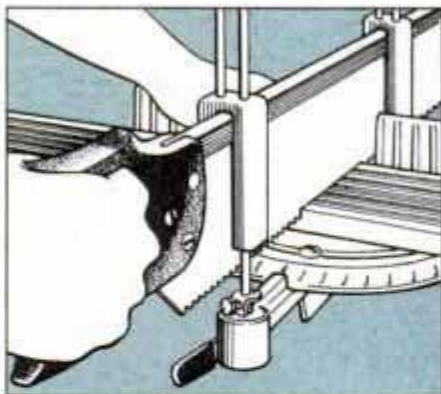
5 Pilaster flutes are routed with core box bit. Router edge guide follows board edge. Space the 1/2-in. flutes 1/2 in. apart.

in place on the wall and mark the bolt positions. Remove the toggles from the bolts, push the bolts through the holes and rethread the toggles. Bore 3/8-in.-dia. holes through the wall at all fastener locations.

Apply a small amount of panel adhesive to the back of each board (Fig. 7), press the pieces in place, and push the toggle bolts completely in so the toggles open on the inside of the wall. Then, while holding the wood away from the wall to keep the toggles from turning, progressively tighten each bolt (Fig. 8).

Plug the bolt holes with short lengths of 3/8-in.-dia. dowel glued in place. Let the glue dry. If the plugs protrude more than 1/8 in., saw them nearly flush to the surface. Use a sharp chisel to trim the remaining waste and sand smooth.

Next, prepare the entablature. Measure the distance between the outer edges of each pilaster, add 2 1/2 in. to create a 1 1/4-in. overhang at each end and cut 5/4 x 10-in. stock squarely to this length. Then, sand the ends smooth. Apply panel adhesive to the back of the board and nail it to the wall with 10d finishing nails (Fig. 9).



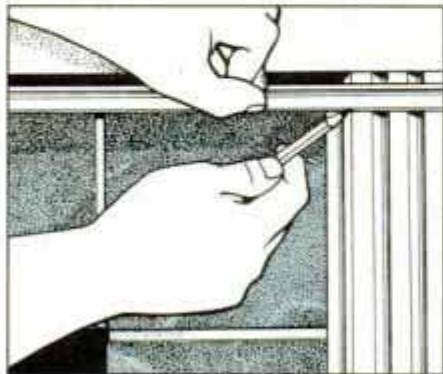
6 After the flutes have been routed on a single long length of stock, cut squarely to length to produce both pilasters.

Applying the molding

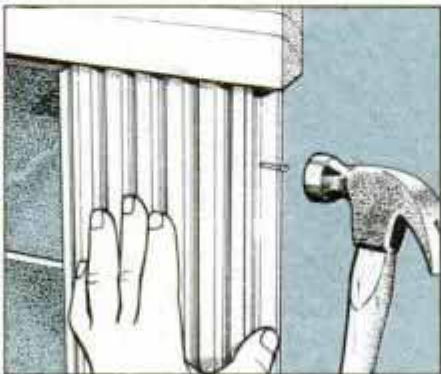
Next, apply 3/4-in. cove molding to the edges of the pilasters and underneath the entablature. Cut the two inside pilaster covers by mitering the top ends to exact length. Nail in place with 3d finishing nails. Miter one end of the horizontal piece of cove molding that will be attached to the underside edge of the entablature. Hold in place and mark the opposite joint (Fig. 10). Cut to exact length and install. Cut the cove molding for the outer pilaster edges squarely to length and install (Fig. 11).

Next, apply the 1x3 frieze board—its actual dimension is 3/4 x 2 1/2 in.—flush with the upper edge of the entablature. This board acts as a base for the crown molding and gives the mantle extra depth. Miter each end of the front frieze board and cut two short mitered lengths to return the frieze around the entablature ends (Fig. 12). Nail the frieze components to the entablature with 6d finishing nails and secure the miters with 4d finishing nails and glue. Keep the nails away from the corners and blunt the nail points to prevent splitting.

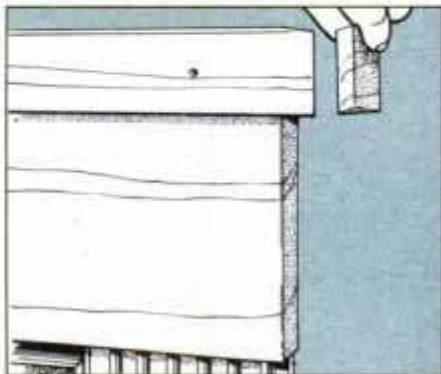
Cut a triangular nailing block that



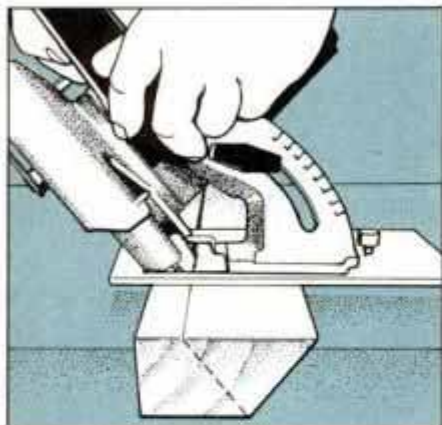
10 With the mitered cove molding secured to inside pilaster edges, mark and cut the cove that fits under the entablature.



11 Cut the cove molding squarely to length and install on the outer pilaster edges between the plinth and entablature.



12 After securing the 1x3 frieze board flush with entablature upper edge, return the frieze to wall with mitered end blocks.

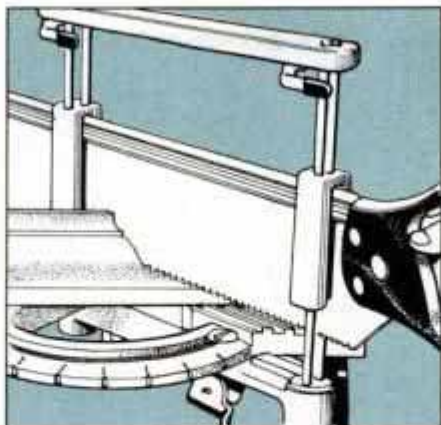


13 Use your circular saw to rip the triangular nailing block from 2x4 stock. Prepare enough to return around entablature ends.

will be secured to the frieze for supporting the shelf. Choose a straight, flat 2x4 long enough to span the mantle plus about 10 in. extra for cutting the short mitered end blocks that return around the entablature ends. Set the base of your circular saw to 45° and rip a bevel along one edge of the stock. Then, measure 2½ in. from the outside corner of the bevel on each end of the 2x4 and use a chalkline to mark the cutting line for the other bevel. Saw to this line from the opposite direction (Fig. 13).

Hold the nailing block in place and mark for cutting the mitered ends. After cutting, nail in place with 6d nails. Then, cut and secure the mitered end blocks.

Because the crown molding is installed at a 45° angle, its mitered corner joints are cut at a compound angle. These joints are easily cut on the miterbox. First set the miterbox for a 45° cut. Then, hold the crown molding upside down and at 45° to the miterbox base and fence (Fig. 14). It's easy to get confused when making these cuts. To avoid error, hold each length to be cut in position and mark



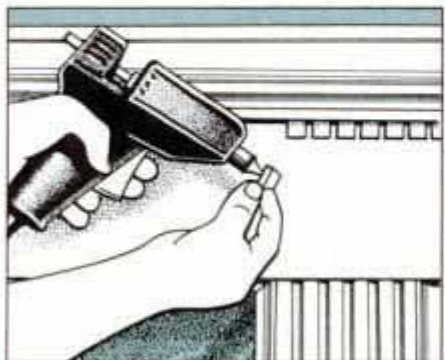
14 After marking crown molding, cut the compound miter by holding the molding upside down and at 45° to miterbox base.

the angle of cut for reference.

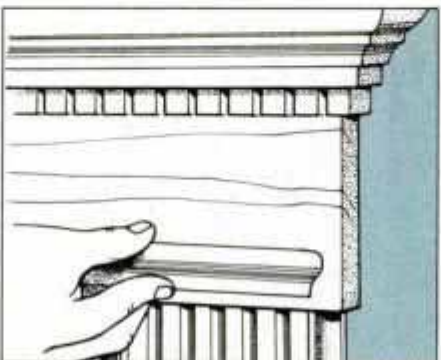
First cut the miter on one end of a length of crown molding that's long enough for the front of the entablature. Then, have a helper hold the molding in place so the mitered edge is accurately aligned and carefully mark the opposite end for cutting (Fig. 15). Secure with 4d finishing nails, maintaining a uniform ¼-in. reveal between the bottom edge of the molding and frieze. Then, cut and install the short lengths of molding that return around the ends.

The dentil blocks are made from a length of ¼-in.-thick lattice that's been ripped to ¾ in. wide. First cut two end blocks 1¼ in. long and install them under the frieze on the ends of the entablature. If necessary, trim these blocks so their ends are flush with the entablature face.

Measure the distance from the outside faces of each end dentil block and divide the space so you get equally sized blocks with uniform spacing. We used ¾-in.-square dentil blocks with ¼-in. spacing. Attach the blocks to the mantle with hot-melt glue applied sparingly (Fig. 16).



16 Divide the entablature length for equally spaced ¾-in.-thick dentil blocks. Secure blocks with hot-melt glue.



17 Panel molding is mitered to exact length and secured with 4d finishing nails. Attach ¼ in. from bottom of entablature.



15 With one end of crown molding cut, hold in place and mark opposite end for trimming. Nail with 4d finishing nails.

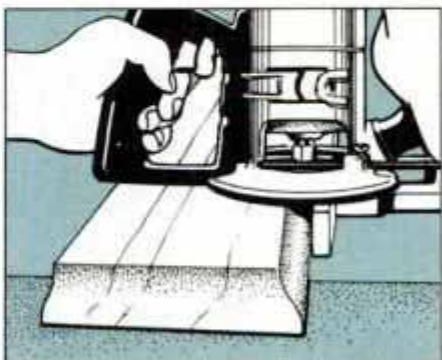
The panel molding is applied ⅜ in. up from the lower edge of the entablature. Miter the ends and nail with 4d finishing nails, and cut and install the short mitered end pieces (Fig. 17).

The shelf is made from ⅝ stock ripped to 5¼ in. wide. This leaves a ½-in. overhang at the front. Cut the stock to length so it overhangs the crown molding 1⅜ in. at each end.

We routed the edge of the shelf with a Roman ogee bit, Bosch No. 85164. Install an edge guide on your router and rout the ends first, then the front edge (Fig. 18). Secure the shelf with 8d finishing nails. Be sure to set the nails back from the edge so they don't break through the crown molding. Then, nail up through the crown molding and into the shelf with 4d finishing nails.

Finishing the Job

Set all nails with a nailset and fill with wood filler. Sand the entire mantle with 120-grit sandpaper and then repeat with 220-grit paper. Prime the mantle with alkyd primer. When the paint is dry, caulk all joints and paint with a quality enamel. **PM**



18 Outer edges of shelf are routed with Roman ogee bit. Use edge guide and rout ends first. Then rout long front edge.

How To Weave A CANE SEAT

BY THOMAS KLENCK, Associate Home And Shop Editor; PM Illustrations by George Retseck

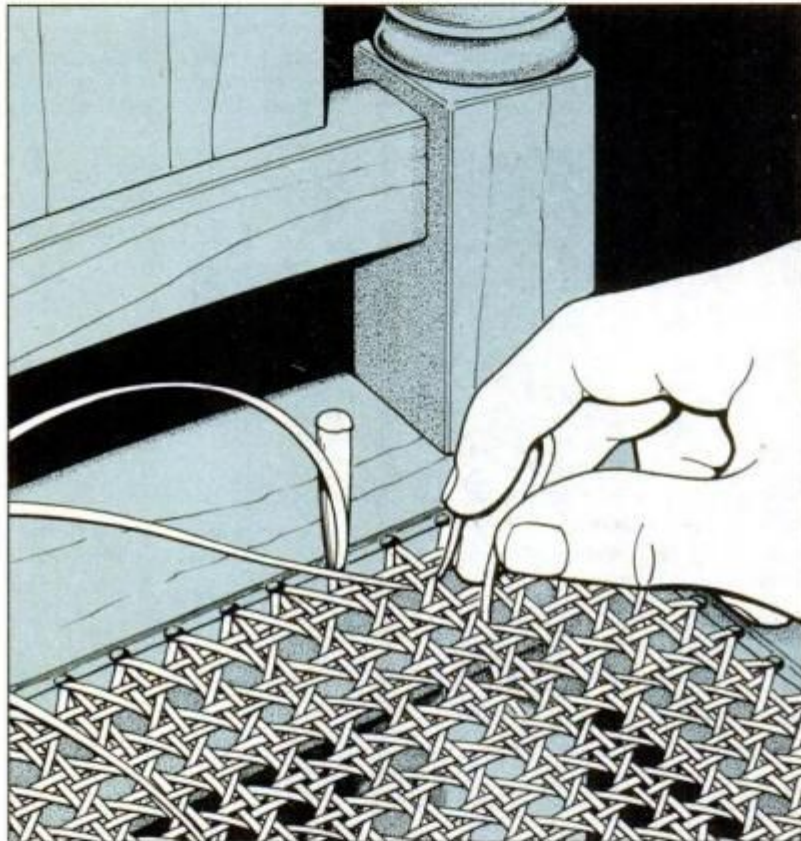
YOU couldn't pass it up. That beautiful antique chair with its intricately woven cane seat. You can tell by looking at it that it's not the prewoven type with a typical spline pressed into a groove that holds the sheet of cane in place. The hands of the artisan were intimately involved with your chair. And, judging by its darker color, you know that the seat wasn't woven yesterday.

And then the inevitable. Years of use have taken their toll and the brittle cane breaks. Well, take heart. Reweaving the seat to its original glory is not difficult. It is time consuming, however—don't expect to get the job done in one day.

Cane is available at craft shops or through mail-order suppliers. Kits generally come with enough cane for two small chairs and instructions. You'll also need about 2-dozen, small, wooden, tapered pegs for temporarily holding the cane ends in place. These can be easily whittled from pine or made from 1/4-in.-dia. dowel. Both cane kits and pegs are also available from The Woodworkers Store, 21801 Industrial Blvd., Rogers, MN 55374-9514.

Starting out

Separate one length of cane from the bundle and coil it so it will fit in a bowl filled with warm water. Clip a clothespin on the coil to hold it together and let it soak for about 15 minutes. As you use each piece of soaked cane, place another coil in the water.



Nearly completed, pattern of seat emerges. Last section of diagonal cane is woven under front-to-back (vertical) rows and over side-to-side (horizontal) rows.

Locate the center holes in the front and back rails. Insert an end of the wet cane into the rear hole allowing about 4 in. to protrude underneath. Then insert a peg to hold the end in place. Always keep the shiny, rounded side of the cane up.

Push the other end down through the front center hole, adjust the tension so the cane can be gently pressed down below the seat frame, and insert a peg (Fig. 1). Then, bend the cane to the hole on the right, pull it through and insert a peg. Carry the cane to the corresponding hole on the rear rail, adjust the tension and secure with a peg (Fig. 2).

Continue across the right side in the same way moving the pegs as you go. Make sure to keep the shiny side

up and maintain even tension (Fig. 3). At the end of a piece of cane, insert a peg and start with a new piece. The side rails of the chair are usually at an angle so you'll reach the rear corner before the right front corner.

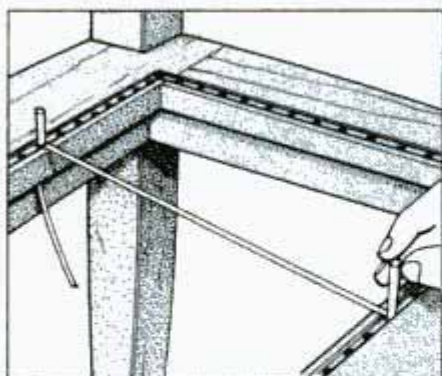
Simply continue weaving down the right side rail. However, you'll have to skip some of the side-rail holes to maintain evenly spaced, parallel lines. Then, finish the left side in the same way starting again at the center of the chair. As you progress down the left side rail, use holes that correspond to the ones you used in the right rail.

Next, install the cane horizontally starting from the rear right corner. (Note: For the sake of clarity, we'll call the side-to-side cane *horizontal* and

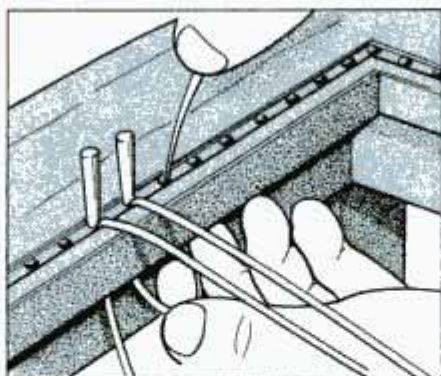
the front-to-back cane *vertical*.) Don't use the corner hole, however, but start with the next hole down. Allow the horizontal cane to lie on top of the vertical cane (Fig. 4). Add a second level of vertical caning that lies over the horizontal caning. Keep these pieces just to the right of the first set of vertical caning (Fig. 5).

If you're running out of pegs to secure the ends, you can tie off these ends from underneath the chair. Wrap each end two turns through an adjacent loop or tie a knot (Fig. 6).

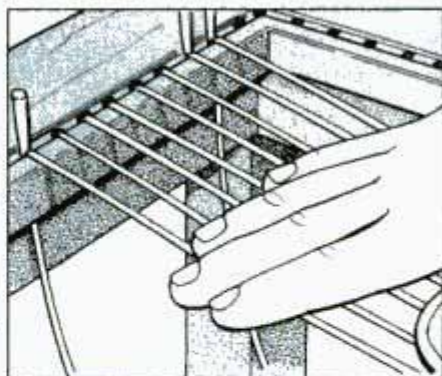
Apply a second row of horizontal cane just below the first. In this step, however, weave the cane over the topmost vertical cane and under the lower cane (Fig. 7). It's faster if you work with one hand above and one



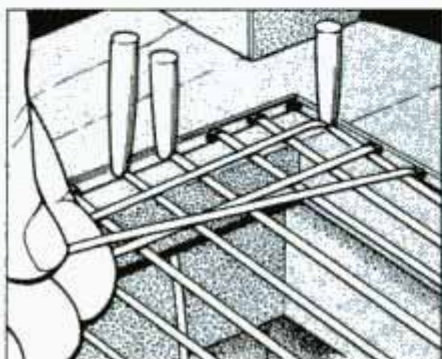
1 Insert the wet cane in the rear center hole and peg. Then, pass cane through front hole, lightly tension and secure with peg.



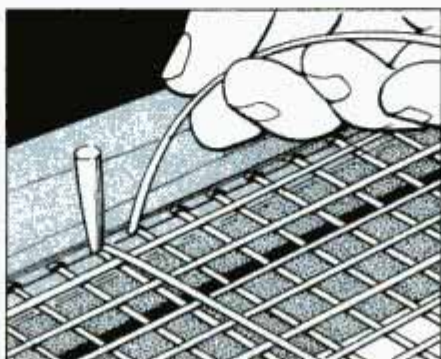
2 When moving from one hole to the next, peg cane and bend under rail. Avoid twisting and keep the shiny, rounded side up.



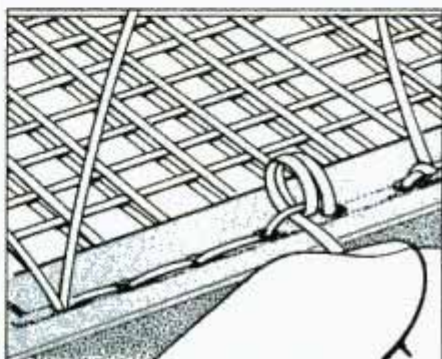
3 Check tension by pressing down lightly with your hand. Correct tension allows cane to be pressed level to underside of rails.



4 Horizontal caning begins in the right rear corner. Lay cane over the vertical cane and progress down side rails to the front rail.



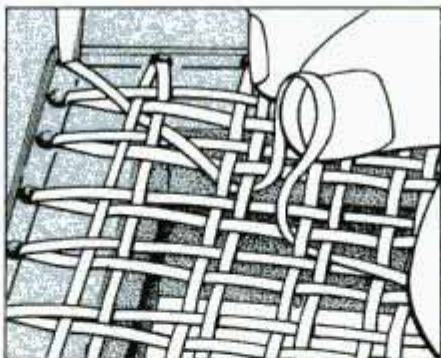
5 Second vertical caning is applied over the horizontal cane. Position this cane just to the right of the original vertical cane.



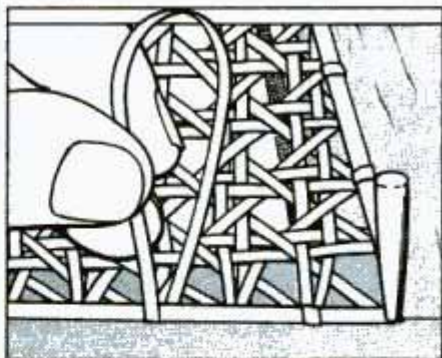
6 The ends of the cane can be tied off underneath the chair. Wind the ends twice around an adjacent loop or simply tie a knot.



7 Next horizontal caning is woven over upper vertical cane and under lower vertical cane. Keep one hand above and one below.



8 The first set of diagonals starts at the right rear corner hole. Pass cane over the vertical lines and under the horizontal lines.



9 After binding cane is pegged at corners, use regular cane to loop over binder and hold in place. Then, tie off all loose ends.

hand below the seat. Weave the cane end through a 4- or 5-in. section and then pull the complete length of cane through. If you find that the cane is drying out while you're weaving, simply moisten your fingertips and run the cane between them.

Diagonal caning

Starting at the right rear corner hole, begin weaving a 45° line that passes under the horizontal caning and over the vertical caning (Fig. 8). When you reach the other corner, pass the cane

to the next right hole and progress back in the same way. If necessary, use an awl to push aside the existing cane in the holes. As you move down the side, some holes will be omitted and some holes may be used twice to achieve parallel diagonal lines. Then, complete the left rear side of the seat.

The opposite row of diagonals is applied in exactly the same way except that the cane goes over the horizontal lines and under the verticals (lead illustration). When it's done, tie off all loose ends.

Binding cane

This cane is wider than the normal cane and is used to cover the holes. It's included in the cane kit. Peg the binding cane in place at the corners and remove any slack. Insert a piece of regular cane into the next hole and tie it underneath. Loop it over the binding cane and back down the same hole. Then, move to the next hole and loop over the binder again (Fig. 9). If the holes are closely spaced you can skip every other hole. Finally, tie off all loose ends.

Homeowners' Clinic

BY NORMAN BECKER, P.E., Contributing Editor

Septic Tank Location

I have a septic tank but I don't know where it is. It was put in a long time ago and there doesn't seem to be any documentation. How can I find it?

BRUCE DEVIDO
ANDOVER, NJ

Try checking with the local health department to see if they have a diagram that shows the location of your tank. If they don't have it, then try the following:

Go into the basement and follow the sewer pipe to the foundation wall. This pipe leads to the septic tank which is probably 10 to 30 ft. from the wall. Now, go to the area outside where the pipe exits the wall and walk in the general direction of the pipe while striking the ground with a heavy, solid steel 5-ft. crow bar.

The top of the septic tank cover (according to proper design criteria) should be 12 in. below grade. Striking the crow bar over solid ground will produce a solid sound. However, when you are over the septic tank, you should hear a hollow sound.

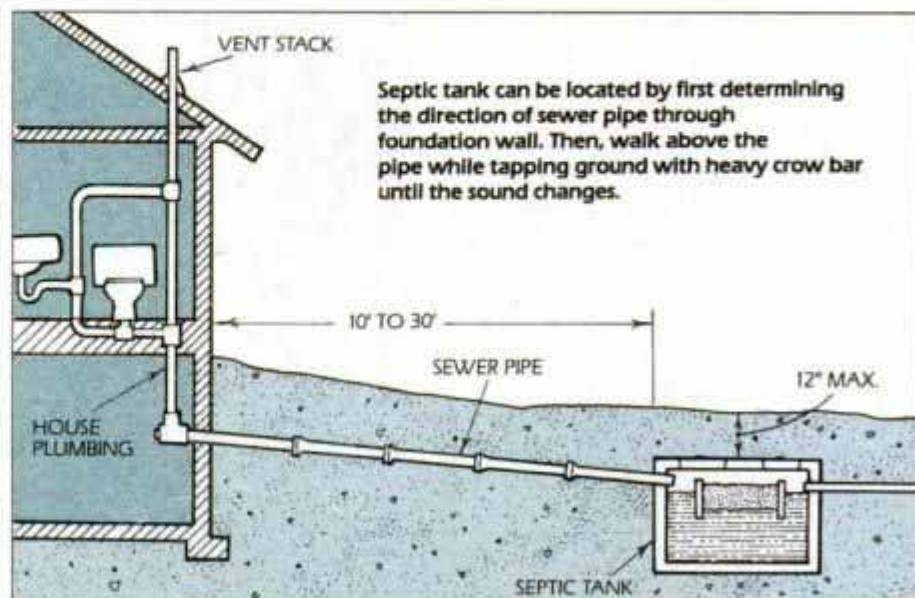
Moldy Corners

Every winter I notice a dark mold that develops in the inside corners of our outside walls. I've tried scrubbing with detergent and repainting, but the condition returns in about two weeks. What's causing this and how can it be eliminated? THOM SPAGNOL
GLENSHAW, PA

The dark mold is the result of mildew buildup. Apparently, those corners are colder than other parts of the wall and, consequently, condensation develops. The moisture accumulation encourages growth of mold spores.

Localized cold spots are usually the result of open joints or a thermal bridge. A thermal bridge is a building component that does not have good insulating value and directly connects an outside wall to an inside wall. Studs and headers can act as thermal bridges.

Most of a wall surface is exposed to warm air circulation which keeps the temperature above the point at which



Septic tank can be located by first determining the direction of sewer pipe through foundation wall. Then, walk above the pipe while tapping ground with heavy crow bar until the sound changes.

moisture will condense (dew point). The corners, however, have virtually no air circulation.

To control the mildew buildup, it's necessary to kill the mold spores. Detergent alone will not do the job. Scrub the area with a solution of detergent, water and chlorine bleach.

Once the mildew has been removed and the area dried, repaint the wall with a quality, mildew-resistant paint. Be aware that this type of paint generally contains fungicides that are poisonous. Do not use it on any surface that may be bitten by a child.

Another solution, although not very practical in this case, is to cover the inside surfaces of the exterior walls with 3/4-in.-thick rigid-foam insulation board, which in turn is covered with drywall. This will raise the surface temperature of the wall above the dew point and thereby eliminate condensation and mildew.

More On Ultrasound

In the July '88 Homeowners' Clinic (page 113), we reported that the National Pest Assn. and the EPA indicated that ultrasonic devices are not effective against insects. Well, reader Edward D. Griswold disagrees—and he wrote to tell us about it:

For at least 12 years I had monthly pest control treatments—inside and

out. Nonetheless, I was plagued with crickets, spiders and moths. During two years of operating an ultrasonic device and after terminating pest control services, I have found not more than 10 spiders and crickets (no moths) and they were either dead or in death throes.

I also conducted a test. I placed a container of sugar water on the garage floor. After I had attracted a stream of ants, I activated a pest controller. Four hours later, there was not an ant feeding.

As an ardent believer in ultrasonic insect repellents, I would appreciate your testing one and reporting your results.

COL. E.D. GRISWOLD
HUNTSVILLE, AL

Since I'm not in a position to conduct a test that would represent a complete sampling of insects and conditions, let's open the idea to other readers. If any of you have used ultrasonic insect repellents, write in and let me know of your experience. We'll publish the results in a future column. **PM**

Do you have a home-maintenance or repair problem? Send it to Homeowners' Clinic, Popular Mechanics, 224 West 57th St., New York, NY 10019. Letters cannot be answered individually, but problems of wide interest will be discussed in the column. For more home-repair and maintenance help, get PM's Home Care Guide, \$2.45 postpaid. Send your order(s) to Popular Mechanics, Box 1014, Radio City Station, New York, NY 10101.

Appliance Clinic

BY STEVE TOTH, Contributing Editor

Globs Up

When my KitchenAid dishwasher model No. KDS16, serial No. 103110604 has finished a load of dishes, there is a big glob of undissolved detergent in the dispenser and small specks of detergent on the dishes. What's going wrong?

EDNA SOHN
ZUMBROTA, MN

It may be that your machine is not getting enough water during the fill cycle, or there could be something lodged in the drain valve that lets the water escape when the unit is filling.

Start the dishwasher and let it go through part of a wash or rinse cycle. Once the tub has stopped filling, check the water level. It should be about $\frac{3}{4}$ in. below the hub of the wash arm. If there is no water in the tank, or you can see the water level going down, then there is probably something stuck in the drain valve. If the water level is low but stable, the inlet valve may be your problem.

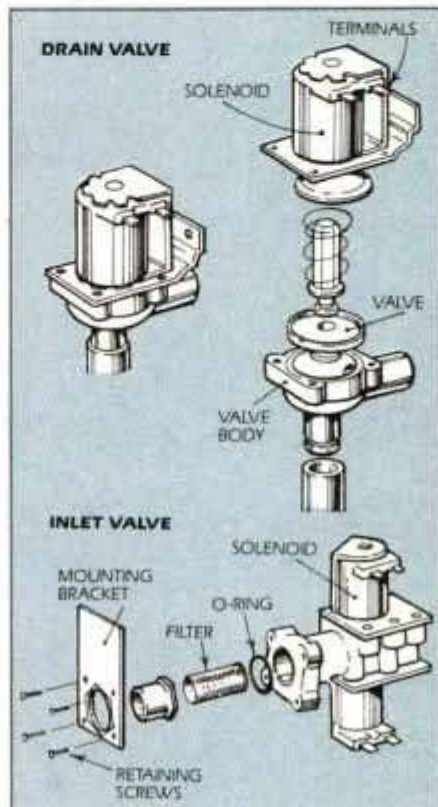
To check either valve, first disconnect the power to the dishwasher. Then, remove the lower front service panel by removing the two screws at the bottom and pulling the panel down and off the machine.

The drain valve is located at the center in front of the motor. Place a pan under the drain valve to catch any water. Disconnect the electrical leads to the solenoid and remove the two hoses. Then, remove the valve from the machine frame.

Look up into the valve and check for any debris that may be keeping it open. Then, reinstall it and test by running through a cycle.

To check the water fill valve, first turn off the water supply. Separate the valve body from the mounting bracket by removing four retaining screws. Remove the inlet screen from the valve and clean it. When reinstalling the screen, note that it must fit tightly in the valve body to prevent debris from passing by and interfering with valve operation. Also, check that the O-ring is properly seated.

After reassembling, turn the water on and check for leaks. Then, run the machine through a test cycle.



For undissolved detergent in dispenser, first check drain valve for obstructions. Then inspect inlet-valve filter and clean.

Washer Won't Rinse

I have a Westinghouse washer model No. L.A.495PXW1, serial No. L.R.F.26641. The first and second rinse do not activate. How can I correct this problem and where can I get a repair manual?

WILSON B. HALL
METAMORA, MI

The most common cause for your problem is timer contacts that are not closing or are burned. To check the contacts, first unplug the machine and remove the control panel to gain access to the timer. Then, use the bar chart on the wiring diagram found on the back of the machine along with an ohmmeter to test the contacts during a rinse cycle.

If the wiring diagram or bar chart is missing, you can find it in the repair manual for your model washer. The manual is Westinghouse part No. L-72SE9951 and costs about \$3.

It can be purchased at any White-Westinghouse parts distributor.

At Wit's End

I have a Frigidaire refrigerator model No. FPC13-200VS with an IMK-4 automatic ice maker. A thin mineral deposit collects on the cube tray that prevents the first two cubes from releasing. The sensing device then acts as if the whole tray of cubes is frozen. The next cycle dumps a tray of partially formed cubes and water and I end up with a block of solid ice.

I've plumbed the ice maker into the softened water supply, tightened the tray, leveled the refrigerator and replaced the tray three times. Nothing works and I'm at my wit's end.

BRUCET. STONEBACK
ALLEN TOWN, PA

Try replacing the ice cube tray with the smaller tray that's used in the IMK-6, -7 and -8 ice makers. This tray will fit your unit and accepts more corrosion before the cubes will hang up. The smaller tray uses the same amount of water as your present tray but will make a greater amount of smaller cubes. The tray is Frigidaire part No. 2832432 and costs about \$12.

Another thing you might try is adjusting the stainless-steel clip on the back of the ice maker housing. This clip catches the tray as it comes around and holds it. When enough torque is built up, it straightens allowing the tray to snap by, which jars the cubes free. By putting more bend in the clip, the tray is held longer and snaps by with greater force. Make sure, however, that the motor drive gear is fully engaged with the cam gear. Otherwise the cam gear may strip. In some cases, you may have to ream out the motor mount holes to get the gears to mesh properly.

Always disconnect the power supply to the refrigerator before working on or removing the ice maker. **PM**

If you have a problem with any appliance, send your question, along with model and serial numbers, to Appliance Clinic, Popular Mechanics, 224 West 57th St., New York, NY 10019. Sorry, but letters cannot be answered individually. Problems of wide interest will be discussed in this column.

SPECIAL SECTION

BOATING'89

NEW POWERBOATS

From Econo Family Packages
To Red-Hot Special Editions

NEW MOTORS

Brainy Outboards And
Breakthrough I/Os

NEW GEAR

Products And Accessories
Every Boatman Needs

PLUS

New-Wave Water Toys

SEA RAY 250
SUNDANCER

JUST ADD WATER

ALL IS NOT QUIET this year on the waterfront. As a matter of fact, you might say it's all revved up with someplace to go. Boating is booming and what was once considered a cyclical fad is now an established, \$17-billion industry.

And, although it's still the middle of polar bear season for most of us, it's never too early to begin making plans for exciting summer days on the water. This is especially true of 1989, a year that will go into the books as the dawn of a new era in package boats, breakthrough sterndrives, new-wave water toys and high-tech gear.

The package-boat explosion reverberates industry-wide, this year, and its impact is enormous. Convenience is the first thing that comes to mind

with turn-key, factory-integrated, boat-motor-trailer units. But look for improved quality control and cost savings as well.

Tricked-out special editions and dedicated fishing machines are equally hot this year. Mario Andretti, Don Johnson and Emerson Fittipaldi lend their fast-lane flare to high-performance boats that look cool and run hot. And the stakes are raised a notch for fishing boats as the mighty Brunswick Corp., parent of Mercury Marine, U.S. Marine and a host of boat builders, forms a new division devoted solely to their development.

Sterndrives dominate the headlines in marine muscle. Major new players and breakthrough designs are the big news. But outboards with

smart electronic systems and friendly bells and whistles can't be overlooked. And an invasion, of sorts, is taking place in big V12s and Euro exotics to supply high-speed, high-status boats with monster power.

The spark of innovation also infuses boating basics, with navigational computers that fit into your hand, fishfinders that look in three directions at once, and modular props with disposable blades. Personal watercraft, the huge success story of the late '80s, are on their way to becoming a splashy world of their own.

If these new boats, motors, accessories and water toys sound like they add up to a perfect recipe for summer fun, then just add water and mix to personal taste.—*Joe Skorupa*

WE'D TELL YOU ALL ABOUT THE REMARKABLE 200HP EXANTE. BUT IT CAN SPEAK FOR ITSELF.

"Cooling system check complete"
"Shift remote control lever to neutral"
"Reduce engine speed"
"Check cooling system"
"Engine oil level is low"
"Oil filter is clogged"
"Fuel level is low"

The Exanté is more than an outboard.

It's a new form of intelligent marine life, able to monitor and diagnose itself. And then tell you, right out loud, what's going on.

At the heart of Exanté is its processor-control computer, Microlink, constantly monitoring the cooling and oil systems. It's the brain that analyzes throttle setting and RPMs as well, automatically adjusting timing for optimum performance.

Which leaves you free to enjoy the thundering power of the motor itself. A 60° V-6 200HP supermotor, the Exanté embodies the finest of Suzuki engineering, starting with dual spark plug cylinder heads, for a clean, more complete burn, to pre-atomized oil injection for long range, full spectrum performance.

The incredible Exanté also comes with Suzuki's factory-backed, 36 Month Limited Warranty, the longest in the industry.

Exanté. It won't tell you fish stories. But you'll definitely want to hear what it has to say.



 **SUZUKI**

**THE POWER
BEHIND BOATING.**

BIG DREAMS IN SMALL PACKAGES

Get ready for boating's new wave—an explosion of boat-motor-trailer units engineered and integrated at the factory.

BY JOE SKORUPA, Boating/Outdoors Editor

CHRIS-CRAFT
334 STINGER
FITTIPALDI
SPECIAL EDITION

PHOTO BY SKIP GANDY



IN THE MOVIE "The Maltese Falcon," a homicide detective asks Humphrey Bogart to spill the beans about the mysterious bird that everyone seems to be after. "What is it?" the hard-boiled cop wants to know. "It's the stuff dreams are made of," Bogie cryptically replies. Not bad, for a private eye.

Dreams. I couldn't help but think of Bogart the other day as I was waiting on the waterfront in fog as thick as pea soup. It was a cool and dank morning, unusual for Bradenton, Florida. As the hours went by and the mist refused to lift, I thought my dream of driving one of the hottest boats in the country—the 334 Stinger Fittipaldi Special Edition by Chris Craft (named for Indy-car driver Emerson Fittipaldi)—was going to be as elusive as Bogie's legendary falcon.

But Florida eventually lived up to its sunny billing and by late morning the Stinger's twin Mercs and I were roaring down the Manatee River past the Sunshine Skyway Bridge, between Passage and Egmont Keys, and out into the Gulf. Dreams, it

seems, sometimes come true.

Special editions, like the Fittipaldi, are certainly among the most exciting boats for '89, but dedicated fishing machines are also hot, and all-in-one packages continue to boom.

The package game

Boaters have always purchased boats, motors and trailers right off dealer showrooms or lots. Now, however, the industry calls this a package and says it's the hottest trend in the

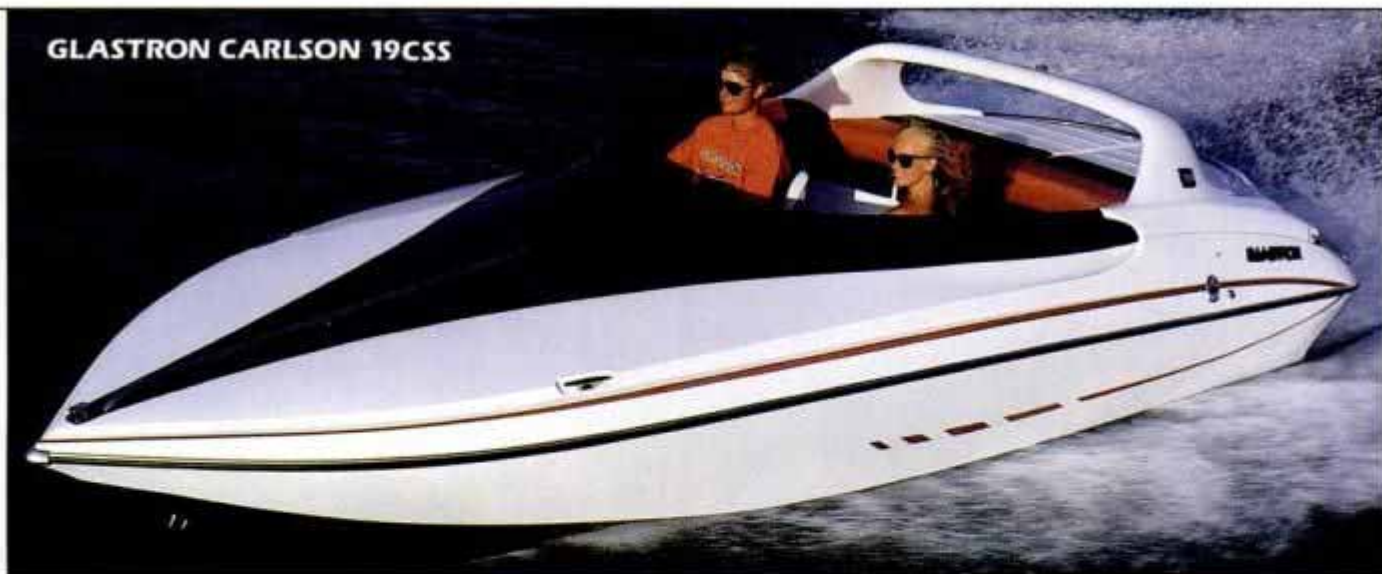
business. What's going on? In a nutshell, the dealer used to do the packaging. Today, the manufacturer does it. And the difference, although not earthshaking, is vast.

Bayliner, Sea Ray and Tracker Marine pioneered boat-motor-trailer packages in the mid-1980s and rocketed to the top of the boating heap. Others soon followed and now every major player has followed.

Here's how it's done. Instead of building a bare hull and asking the



GLASTRON CARLSON 19CSS



SEA RAY 20 LAGUNA

dealer to fill in the blanks, the manufacturer outfits the boat itself. Components are then purchased in bulk and rigging is done at the factory. In addition to cost savings and quality control, optimum equipment match-ups are achieved.

The most immediate impact on the buyer is the convenience of being offered a turn-key purchase with a price tag that includes no hidden costs. Not only are engine and trailer included, but so are radio, swim step, ski-tow eye, instrumentation and other former extras. Consider these fully loaded, affordable packages:

■ Larson All American DC-170, a 17-ft. bowrider with a 130-hp Merc stern-drive, integrated swim platform, stern boarding ladder, radio/cassette, ski-tow hook, suntop, trailer and instrumentation. Price: \$9995.

■ 2001 Arriva, a dedicated 20-ft. ski boat with a Force F-5 150-hp outboard, removable ski-tow post, transom ladder, two ice chests, convertible top, bow cover, radio/cassette, mooring cover, trailer and instrumentation. Price: \$12,995.



WELLCRAFT 26
SCARAB SPRINT



2001 ARRIVA



FUTURE EVINRUDE OWNER IN TRAINING.

Take a good look at the kid up front in the roller coaster, and you just might see yourself. Someone who welcomes with open arms the kind of thing that scares most people silly. Someone who was born for excitement. And who, above all, was born to own an Evinrude® Outboard.

At Evinrude, we know that when you're ready to take off, you want to fly. That's why we built the most powerful outboard you can find today. The Evinrude XP™ 300.

When it comes to speed, acceleration and overall performance, nothing on the water can beat it.

Yet powerful as it is, the XP300 is easy to handle. It has power steering. And counter rotation (in optional dual installations) for effortless maneuvering.

Best of all the XP300 stays out of trouble. Its patented VRO²™ oil-injection system keeps things running smoothly with just the right amount of lubrication. Which is one reason why nothing on the water is as reliable as an Evinrude Outboard.

And when it comes to sheer fun and excitement, we think an Evinrude Outboard beats a roller coaster any day. Hands down. For more information, or the location of an Evinrude dealer near you, call 1-800-255-2550.



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NOT MADE.**



GRADY-WHITE 28 MARLIN



QUANTUM 2000/XB



BAYLINER 1970 CAPRI



LARSON ALL AMERICAN DC-170



CRUISERS BARNEGAT 2530

■ Nissan 200 NP, a 20-ft. pontoon boat with 50-hp Nissan outboard, aerated livewell, helm station with wind-screen, built-in storage, canopy top, trailer and instrumentation. Price: \$9995.

■ Bayliner 1970 Capri, a 19-ft. bow-rider powered by a 125-hp L-Drive with swim step, canvas top, radio/cassette, molded swim platform, built-in and portable ice chests, trailer and instrumentation. Price: \$10,195.

■ Sunbird SPL 150, a 15-ft. bowrider with 48-hp Johnson or Evinrude outboard, swim step, boarding ladder, built-in storage, canvas top, trailer and instrumentation. Price: \$5999.

■ Quantum 2000/XB, a 20-ft. Euro-style fish and ski boat with Force F-5 150-hp outboard, Humminbird fishfinder, MotorGuide trolling motor (which retracts into a hidden compartment), ski-tow post, aerated livewells, depthsounder, radio/cassette, VHF radio, ice chest, convertible top, bow cover, trailer and instrumentation. Price: \$13,995.

In the mid-1970s, the proliferation of jogging, aerobics and other workout pursuits inspired experts to herald the dawn of a new fitness craze. Fifteen years later that craze is a way of life. The same thing, no doubt, will happen with the package-boat trend. In a year or two we'll wonder what all the fuss was about.

Fishing machines

After package boats, but not exclusive of them, the second hottest segment in boating has to be dedicated fishing machines. These special-interest craft draw on two perennially powerful attractions—the love of fishing and thrill of high performance.

Consider Sea Ray's 20-ft. addition to the popular center-console Laguna line, introduced last year. The compact 20 Laguna incorporates such big-boat advantages as a wide 8-ft. beam, cutting board, bait rigging station with sink, forward fishing chair, transom door in the splash wall, bow pulpit and 70-gallon fuel tank.

The 26 Scarab Sprint, by Wellcraft, tosses in equal measures of comfort and high performance with its fishbattling expertise. Built on a proven deep-V Scarab hull, this center-console craft has a padded leaning post seat, forward console seat with built-in cooler, adjustable wave gate aft, special brackets for transom-extend mounting and 80-gallon fuel tank.

Not only are big-boat features moving down the line this year, but vice versa—small boats are moving up. Notable examples are by Grady-White and Boston Whaler, two distin-



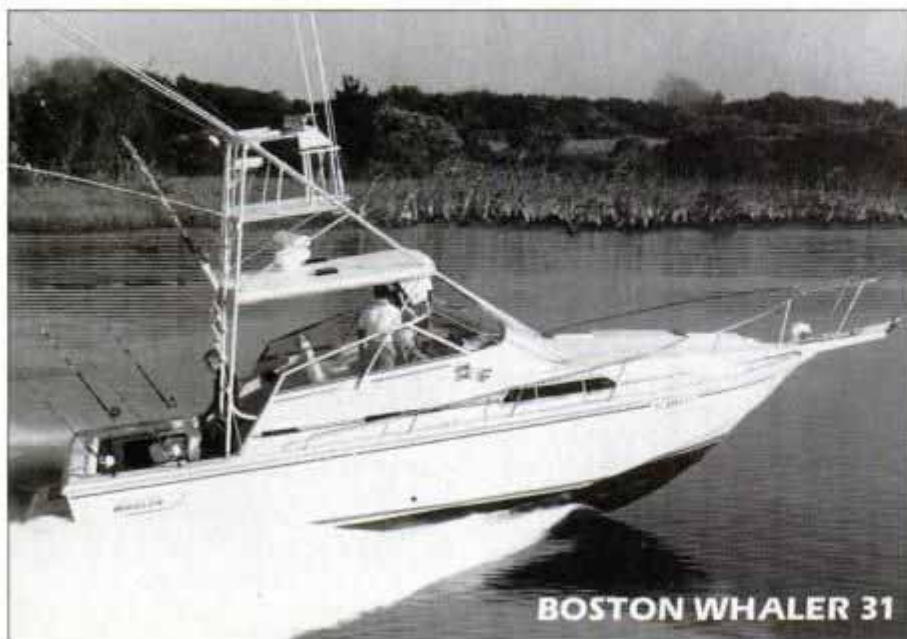
CELEBRITY 259 ANDRETTI



NISSAN 200 NP



DONZI R-21 CUDDY CABIN DL



BOSTON WHALER 31

guished manufacturers with a long tradition in building small bluewater fishing boats.

Since 1977, the largest sportfishing boat in the Grady-White line was a 25-footer. This year Grady-White breaks the 28-ft. barrier with the introduction of the Marlin 28, a walkaround cabin offshore fisherman with an ultrastable 10-ft. 7-in. beam. Although the boat has a Eurostyle cabin and integrated outboard bracket/swim platform, its focus is firmly placed on fish-fighting and seaworthiness with raised sheer lines, flared bow, raised helm station, recessed trim tabs and 60-sq.-ft. cockpit.

Even more dramatic, for a small-boat builder, is the shattering of the 30-ft. barrier. Boston Whaler achieves this with the introduction of the impressive 31 sportfisherman. We're talking big bucks here and big servings of luxury belowdecks and, dare we say it, a big step closer to being a yacht. But if Boston Whaler, a company that started out building un-sinkable little center consoles, can move up the line, why can't we? Dreams, after all, come in all sizes.

But the biggest news in fishing machines this year is the introduction of a major new player—Mercury Powerboats. That's right, boat people now roam the halls of Mercury Marine and beginning this year the new division intends to be a kingpin in fishing boats. The offerings will include boats (names currently used are ProCraft, Fisher and Astro), trailers and, naturally, Mercury or Mariner motors. Look for significant expansion and modification of the 1990 line, when centralized control of the new division is fully implemented.

Special editions

You can't ignore this year's tricked-out muscle machines. And I mean that literally. Wherever I drove the 33-ft. Stinger Fittipaldi, with its flaming red, sculpted hull, heads turned and eyes popped. It makes a bold statement, to say the least.

Chris-Craft offers the Fittipaldi Edition, which includes custom gel coat and graphics, plush appointments and high-performance engines, in both 334 (new this year) and 385 (offered last year) Stinger models.

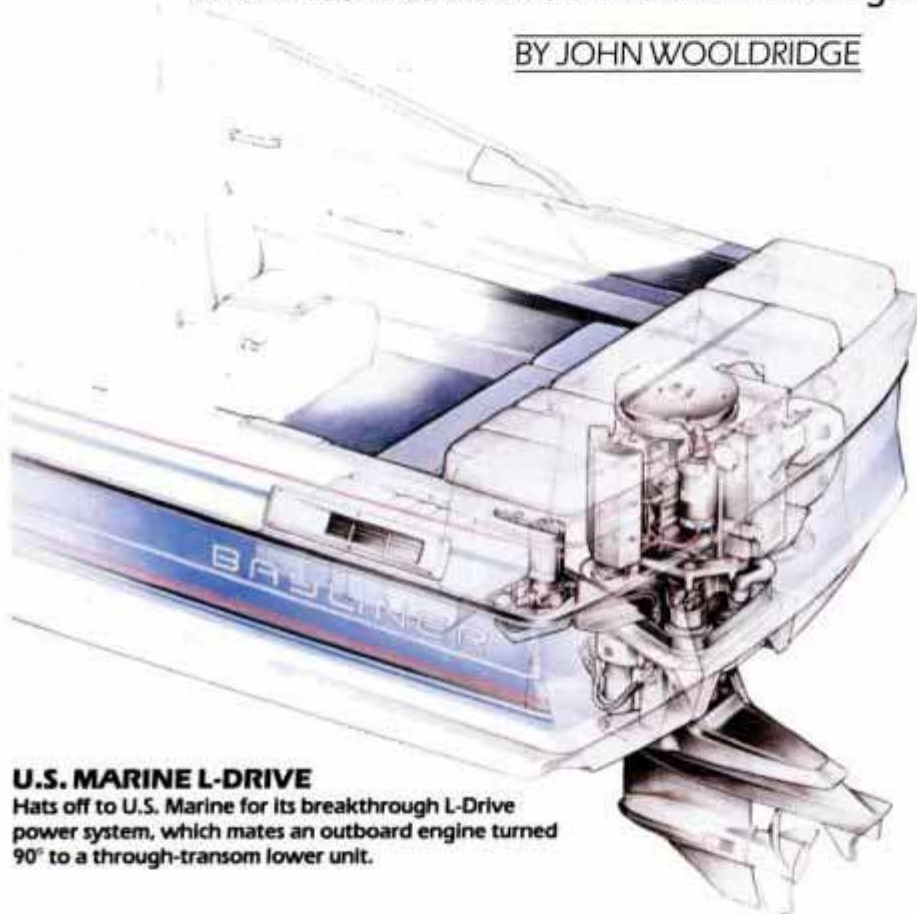
Other builders have also jumped on the special-edition bandwagon. The name of "Miami Vice" star, Don Johnson, is emblazoned across a new customized 43-ft. Scarab Signature Edition. At the time the boat was introduced at a trade show last year, Johnson was dismissed by many as a

(Please turn to page 109)

YEAR OF THE STERNDRIVE

Outboard powerheads move inboard and Detroit blocks add bells and whistles as I/Os dominate new offerings in marine muscle.

BY JOHN WOOLDRIDGE



U.S. MARINE L-DRIVE

Hats off to U.S. Marine for its breakthrough L-Drive power system, which mates an outboard engine turned 90° to a through-transom lower unit.

UNLIKE oil and water, gasoline and water have always mixed. Internal combustion used in inboard-powered boats goes back to the 1880s. Ole Evinrude began hanging outboards off transoms in 1907. And sterndrives (inboard engines with external lower units) have dangled through hulls for at least three decades.

But not since Jim Wynne invented it, in the late 1950s, and Carl Kiekhäfer advanced it, in the early 1960s, has so much attention focused on sterndrives. Two high-stakes players joined the game in 1989, Yamaha and U.S. Marine. And industry statistics confirm that sterndrives are currently the fastest growing choice in marine power.

Lift the engine cover on a stern-

drive and you'll find a powerplant that closely resembles a car engine. Yet adapting it for boating is as challenging as trying to modify your family car for a run up Pikes Peak towing a trailer and boat at 80 mph!

Much higher rpm and horsepower are required to push a boat through water than to run a car on the road. While the engine is running hotter, the heat exchange system of free-flowing air is cut off by a watertight engine box. Temperatures inside the box push cooling and lubricating systems to the limit. The potential for explosion, in the event of fuel line leaks or trapped vapors, is extremely high.

How do modern sterndrives cope with these demands and dangers? To begin with, most sterndrives sold in the U.S. are based on GM or Ford

blocks assembled with components specified by marine engine companies. Typical engines receive brass core and freeze plugs, corrosion-resistant head gasket and cooling system pump, performance intake manifold and a camshaft ground to emphasize low-end torque.

The engines also receive heavy-duty valve assemblies, forged-aluminum crankshafts and pistons, high-flow cylinder heads and high-output oil pumps. These components are added to the block on the assembly line.

What is usually referred to as marinization begins at the marine engine manufacturer. Auto parts unsuitable for marine use are stripped from the uncrated motors. Specially vented external ignition-proof components are added—distributor, alternator, circuit breaker, starter, fuel pump, carburetor flame-arrestor and spill-proof carb. All are designed to minimize explosion hazards.

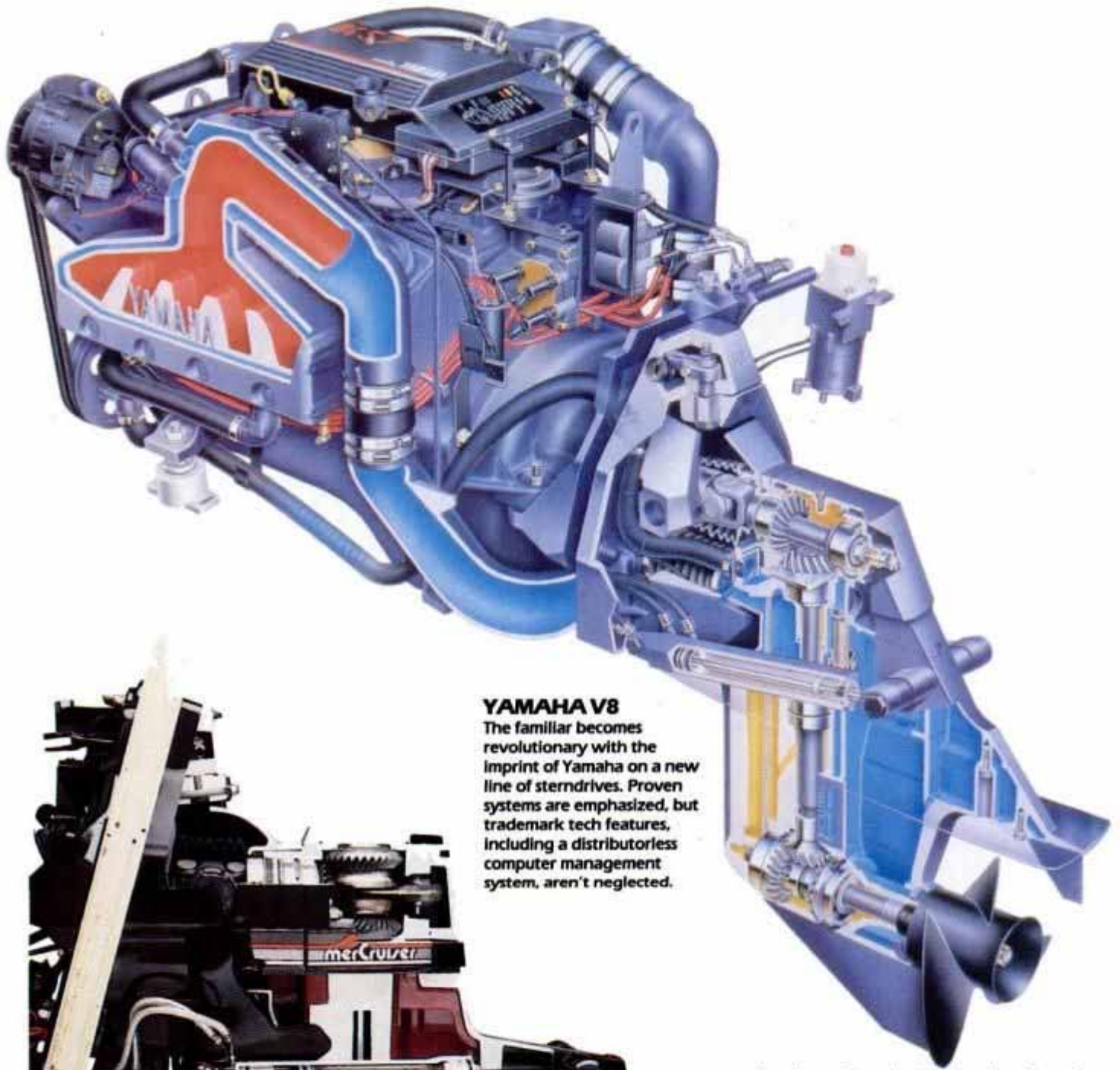
A water-cooled exhaust system is added to control operating temperatures, sealed flywheel housings protect starter from bilge water, and special engine mounts isolate vibration.

Corrosion resistance, naturally, is of prime importance. Multiple stages of cleaning, rinsing, drying, priming, coating and baking are standard procedure. The fully marinized blocks are then cranked, tuned and dyno tested before being fitted to an outdrive. Finally, they're ready to burn up the waterways.

New players

Yamaha kicked off 1989 with a bid to enter the elite I/O club with three new sterndrives based on GM blocks and marinized by Crusader. These units, mated to outdrives made in Japan, are a 4.3-liter, 180-hp V6, a 5.0-liter, 210-hp V8 and a 5.7-liter, 240-hp V8.

These units are more familiar than revolutionary, with some important differences. A notable innovation is a



YAMAHA V8

The familiar becomes revolutionary with the imprint of Yamaha on a new line of sterndrives. Proven systems are emphasized, but trademark tech features, including a distributorless computer management system, aren't neglected.



BRAVO TWO

Where's the beef? Located within Merc's new Bravo Two outdrive, that's where. This rugged lower unit has heavy-duty gears, gearcase housing, shafts and bearings to deliver increased low-end torque.

distributorless ignition and on-board computer system that monitors temperature, fuel flow and gear changes. It then adjusts timing to establish ideal rpm for monitored conditions. In case of overrevving or overheating, it automatically drops engine speed to 2500 rpm.

Other bells and whistles include an external tilt switch on outdrive, dual-belt system for alternator and water-pump, color-coded fluid fills and a 2-gauge instrument package that monitors all systems.

The other new sterndrive player, U.S. Marine, enters the field with a unique technological breakthrough—the L-Drive, best described as an outboard engine mounted inboard (an O/I as opposed to an I/O). The power-head is turned 90° from the centerline,

while the lower unit, which swivels and tilts, extends through a cutout in a specially stepped transom.

If the L-Drive sounds like a space-saver to you, as well as being lightweight, go to the head of the class. But since it requires radical boat modifications—notched hull and special transom cutout—don't expect to see it widely available for some time. Cur-

rently, you can find the 3-cylinder, 85-hp L-Drive on the Bayliner 1770 Capri and the 4-cylinder, 125-hp unit on the Bayliner 1970 Capri.

Not one to sit idly by, MerCruiser raised the stakes by introducing the rugged Bravo Two drive, a beefy variation on its high-performance Bravo One, which debuted last year. The new unit provides more low-end

torque to handle props up to 20 in. in diameter for family cruisers that require less than 45-mph top-end speed.

The gutsy Bravo Two achieves its increased strength by adding heavy-duty gears, gearcase housing, shafts and bearings. It's available in 5.7-liter 270-hp and 7.4-liter 330-hp gas models, as well as two diesel versions.

Volvo Penta, relatively quiet for the past few years, emerges like a sprinter from the blocks in 1989. It has a new offering in the gas V6 category, plans for a V8 in 1990, and a dramatic \$100-million deal with Genmar (owner of Wellcraft, Glastron, Larson, Cajun, Hatteras and others).

Look this year for Volvo's new gas V6, the AQ205 DP (available with either single-prop or duoprop outdrives), and next year for a 7.4-liter big-block V8.

FoMoCo holds the current hot hand in Detroit, so it's not surprising that OMC is adding three new Ford V8 blocks to its Cobra sterndrive line. New this year are 185-hp and 200-hp OMC Cobras based on the 302-cu.-in. V8 block that Ford uses in the ultra-hot Mustang GT.

Also new is the 235-hp Cobra based on Ford's 351-cu.-in. V8 block. Power steering is standard on all three new models and counter rotation is available on the larger two.

Most OMC Cobra engines continue to be based on GM blocks, but don't be surprised to see more Ford blocks in Cobra's future.

Hot outboards

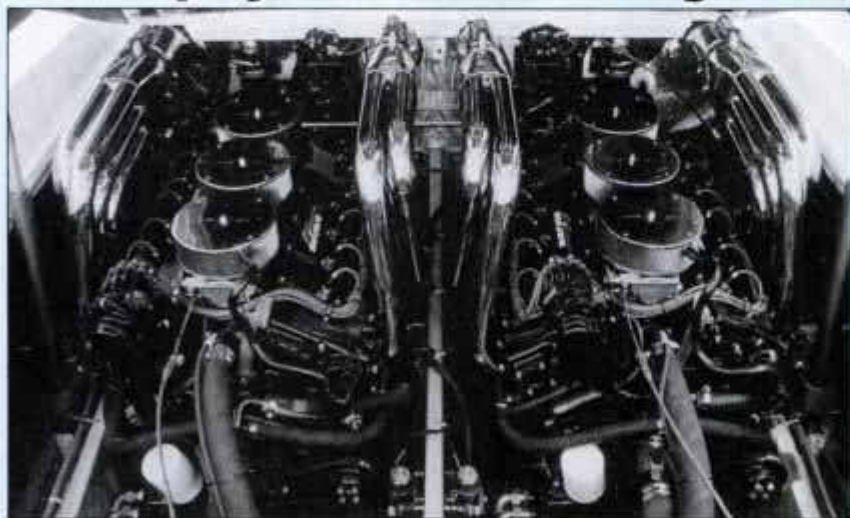
Despite the boom in sterndrives, I/Os have a way to go to catch the popularity of outboards, and it's doubtful they ever will. There are too many high-volume applications—fishing boats, tenders, small runabouts and inflatables, to name a few—where sterndrives can't effectively challenge.

And, as we have seen with the L-Drive (named for David Livingston, president of U.S. Marine, and the engine's primary inventor), advances in outboard technology expand its potential for sophisticated performance.

A good example of outboard innovation is the new 175-hp, V6 Mariner, a dedicated waterski engine. Mariner aimed this one directly at skiers with its 2:1 gear ratio for ski-popping acceleration, 120° throttle travel for precise speed control (most throttles only move 90°) and a jeweled-movement speedo that displays in 1-mph increments with special highlights for key slalom speed ranges.

Both Merc and Mariner share the spotlight for introducing high-tech 115s and lightweight 15s. The 4-cylin-

Powerplay: Euro Exotics & Big V12s



Side-by-side Lamborghini V12s power Wellcraft's Don Johnson Signature Edition.

THE SEARCH is on for the ultimate sterndrive powerplant and it's not just for professional racers. Boatmakers are building these firebreathers for you, if you've got the money and inclination, and they're using the latest in giant-block and monster-cube technology.

Wellcraft is in the forefront of this movement, with its thundering Lamborghini-powered Don Johnson Signature Edition 43 Scarab. This ultralux scorching is powered by twin 630-hp, 9.2-liter V12s that push top-of-the-line MerCruiser Super Speedmaster III or IV racing outdrives. The Lamborghini-MerCruiser combination is considered the most powerful production powerplant on the market.

For those who prefer German efficiency to Italian style, Wellcraft recently debuted a new Scarab Panther with twin Porsche 928 S4s. These high-tech Porsche V8s have 32-valve, liquid-cooled blocks and generate 320-hp to spin Merc Bravo One outdrives.

American builders also produce exotic engines and Donzi recently introduced its new Black Widow with a high-tech concept engine from OMC. The specially modified 351-cu.-in. King Cobra V8 was bored out to 396 cu. in. and equipped with high-performance Second Effort lower unit parts. Standard Cobra V8s are also available.

And home-grown MerCruiser is making waves with its predicted marinization of the celebrated LT-5 engine used in the hot ZR1 Corvette.

But most of the exotic high-performance news comes from across the Atlantic. Deluxe boatbuilder Cobalt is interested in Porsche power possibly for a limited-edition Condure. Ferrari is currently designing and building a boat of its own to handle twin 4.9-liter Flat-12 Boxer engines.

Several other engine makers are also preparing for a European invasion. AMG, the German-based performance-tuning arm of Mercedes-Benz, will soon offer three models of the M-B 5.6-liter V8 for marinization. They will produce from 370 hp to 500 hp. Aston Martin has developed a marinized version of its 400-hp, 5.4-liter V8, but engines are said to be scarce because car demand is so high. And BMW, which entered the U.S. market several years ago and then left it, will soon reappear on the scene with a marinized version of the 5.0-liter V12 engine it uses in the 750iL.

Less-costly big-block engines from GM and Ford will surely dominate the high-performance market, but for high-rollers looking for something exotic, European muscle with 12 cylinders, 32 valves and monster cubes is increasingly available.—J.W.

How to cause a stir without causing a stink.

When Yamaha introduced Precision Blend® oil injection for outboards, it caused quite a stir in the industry.

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Yamaha outboards

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BOATING '89



Merc equipped the 115 with a new smart carburetion system, Concept 2+2, which restricts fuel flow to 2 cylinders at low rpm.



The Johnson GT 175 is a dedicated bass motor, with fuel and oil injection, QuikStart and S.L.O.W.

der 115s are equipped with a high-tech carburetion system, called Concept 2+2, that only fires the top two cylinders below 1800 rpm for optimum efficiency and improved control of fumes. It increases fuel flow with an accelerator pump when more power is required.

The 115s also come with oil injection, loop charging and a through-cowl sight gauge for quick inspection of the integrated 1.45-gallon oil tank.

The 2-cylinder 15s are derived from the "fisherman's friend" series of 8-hp and 9-hp units introduced in 1986. With 16 big cubes of displacement the 15-hp engines have plenty of power at lower rpm. Surprisingly, the engines weigh just 2 pounds more than the 9.9s, at 71 pounds. Other friendly features are a fuel-primer system that replaces a choke, an idle-speed adjuster for trolling and a 1-hand shift/trim/throttle/steer tiller control.

Additions to the Johnson GT and Evinrude XP lines demonstrate the continued vitality of bass fishing. New this year are 100-hp and 175-hp models. The V4 Johnson GT and Evinrude XP 100s come with fuel injection and variable-ratio oil injection. These features are also standard on the V6 175s, which also include QuikStart (automatic control of idle speed based on electronic monitoring of engine temperature) and S.L.O.W. (Speed Limiting Overheat Warning).

The S.L.O.W. engine-limiting system was also added to all Johnson and Evinrude 20-hp to 70-hp engines, and external-mounted trim/tilt switches were added to all T'N'T power trim and tilt models from 40 hp to 300 hp.



Force's new F-5 150 is an inline 5 that offers an innovative weight-saving solution for delivering plenty of low-end torque.

Playing the angles

Ever wonder why V-block engines opt for a 90° V-angle? Primarily, for space savings and because they have a long history of reliable performance. Theoretically, however, the V-shape isn't limited to 90° and as early as the turn-of-the-century builders began to experiment with it.

Suzuki has taken a page from these pioneers with its 90-hp and 100-hp models. These new engines are based on Suzuki's 86.6-cu.-in. powerhead with a 70° V-block. The smaller angle

(Please turn to page 109)



Volvo Penta's new entry in the gas V6 category is the 4.3-liter AQ205 DP, available with either duoprop or single-prop outdrives.

Lasting Attraction

From the first look, you knew the emotion would last. Now long after the initial thrill, the experience is still exhilarating. The Rinker 186 Captiva is built with such quality and precision, you'll never forget why you chose her. Beyond the sporty lines and deep V-hull are precise engine-hull configurations and MerCruiser power, delivering superb performance. It's easy to trailer for weekend outings, yet the deep interior gives you the feel of a larger boat. For these reasons and more, the appeal of the 186 Captiva lasts beyond first impressions to long-term satisfaction.



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Creature comfort is catered to by a snazzy, carry-on marine air conditioner. Style and celestial reckoning are improved by an accurate chronometer that tells time and tides.

And booming personal watercraft, the toys of summer, are becoming increasingly specialized for more fun under the sun.—*John Wooldrige*

Look, Ma, No Hands

Lean into the Powerboard and it will go anywhere you want it to. No tiller or wheel is required. The efficient shape needs only a 5-8-hp outboard. Integral prop guard and motor stop switch are standard safety features. Board only for \$1300.



The Small Chill

Flick on the Carry-On (\$895) portable air conditioner, by Cruisair, and you can pipe 4200 BTUs of cool relief aboard in minutes. It fits almost any hatch, needs only 5½ amps of 115-volt AC, and weighs only 59 pounds.



News At Sea

Raytheon's NCR-300A Navigational Telex (\$1395) receives navigation and safety data usually available only to commercial shipping. It prints hard copy for forecasts, alerts, other vital news.

World In Hand

Mount it or put it in your pocket, the Magellan GPS NAV 1000 (\$3000) does multifunction navigational computing and sat/nav positioning.

Time And Tide

With the stainless-steel Krieger Tidal Chronometer (\$495-\$560) on your wrist you'll know tide time, moonphase, standard time and date at a glance. Keeps boatmen up to the minute.





Go Digital

Conventional compasses swing wildly, but not the KVH Azimuth 100 (\$395). It reads magnetic fields and displays the reading in numerals and points of the compass. Microprocessor and fluxgate sensor are contained in one small housing.



Follows You Anywhere

You can take it with you, if you've got the personal watercraft trailer from EZ Loader, offered in single- or double-bunk models. The double Sea-Doo unit (\$804) weighs 420 pounds and carries a 1200-pound load. Other models are available.



In The Picture

Navigation is easier to visualize with the Trimble Navigraphic, which integrates familiar landmarks with a loran signal. The Navigraphic (\$3995) has a supertwist liquid-crystal display screen and holds up to 50 different routes and 256 waypoints.



Disposable Blades

Ever wish you could just change a blade when your prop gets a bad ding? The Advance-15 (\$149) modular prop allows you to do this and fits most outboards over 120 hp. Available in aluminum in 15-, 17- and 19-in. pitch models. Advance will introduce a stainless-steel version later this year.



Splash And Flash

Ultranautics has a new toy for summer—Sea Flash (\$4495), which is powered by Suzuki's 798-cc, 60-hp engine. The 2-person personal watercraft has a 9-gallon fuel tank, retractable boarding step and top speed of about 35 mph.

Mighty Microchips

Apelco's new XCD 500 (\$699), an LCD fishfinder/plotter and loran C, has four on-screen displays: 1. Fishfinding, 2. Split-screen position plot/fishfinding, 3. Split-screen fishfinding with A-scope, and 4. Navigation/temperature graph.

GREAT GEAR



Say, Octopus
Dive down to 10 meters (33 ft.) and you can still shoot 35mm pictures with the Canon AquaSnappy AS-6, a fully automatic camera with waterproof seals and flash. For \$273 it includes accessory base, sports finder, case, strap and lens cap.



Power To Go

The new Honda EX350 (\$399) portable generator is the strong, silent type. With the power output selector in the 150VA position it runs at 50 decibels, quieter than a normal speaking voice. It's also light, weighing just 19 pounds. It produces up to 350 watts and can run a variety of tools and appliances or charge a battery.



The Smart Shoe

Sneakers always felt right, but the soles were slippery. Now, Omega makes the Sportfisherman Boat Shoe (\$80) with water-dispersing soles and sneaker comfort. It also has a removable orthotic for quick drying, and an adjustable forefoot strap.



One Size Fits All

Give your boat a performance edge with the Sting Ray Hydrofoil Stabilizer, which cuts planing time by forcing the stern up and bow down. The 1-piece Sting Ray (\$80), made of a blended copolymer plastic, fits outdrive and outboard lower units 25 hp to 365 hp.



Catch And Release

The innovative low-profile ski-tow unit (\$35), by Attwood, can handle two ski ropes and swivel 360°. Snap down the chrome cover to hold ropes in place and lift it up to release.



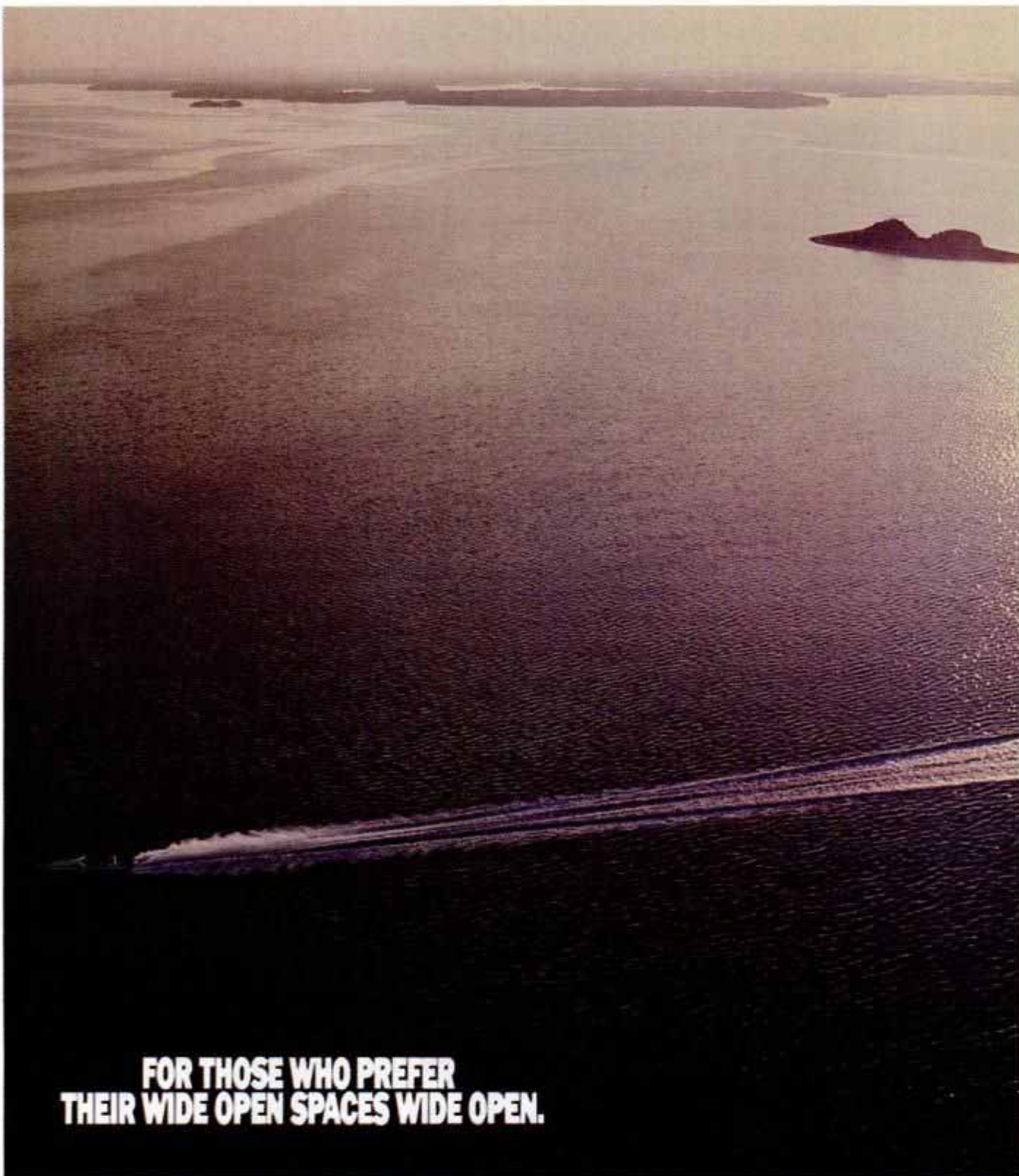
Circle In Square

The compact Focus Speed-Sounder (\$895) from Brooks & Gatehouse displays speed and depth constantly, while offering average speed, trip log, water temperature, anchor watch and depth alarms upon demand.

Spot The Spot

Ever wish you could come within 2 ft. of a favorite fishing hole or relocate an anchor you cut away? Zebco's new Spot Locator (\$20) helps you do this without a depthfinder, batteries or electrical systems. It works by triangulation and only requires the recording of two sighted landmarks and a compass heading.





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BOATING '89



Line Of Sight

Dawn of the smart binocular has arrived with the waterproof 7x50 322BCW (\$420) by Tasco. Features include a size and distance indicator and battery-powered illuminator for dim-light situations.



Points Of View

You can look in five directions, three simultaneously, with the Tournament 360 Scanner (\$740) by Bottom Line. The super-twist 4-in. x 6-in. backlit screen, which has 30,720 pixels for a sharp bottom image, displays viewing directly under boat, forward, aft or to either side.



Picture This

You get the picture when you use the Impulse 3000 Loran C Navigator (\$1050). This navigation computer displays where you are, where you've been and where you're going. Waypoints can be assigned in symbols ranging from a fish or buoy to an anchorage or dangerous waters. **FM**

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BIG DREAMS

(Continued from page 97)

celeb who dabbled in racing. Today, after his recent triumph at the Off-shore Worlds in Key West, Johnson is the reigning Superboat world champion. Perhaps, like clothes, the boat makes the man.

Not to be outdone, Celebrity Boats tapped former Indy-car champion Mario Andretti for a hot new 25-ft. muscle boat, the 259 Andretti. This wavebuster handles up to 730 hp and is available with graphics in Milan Yellow and Venice Red.

Glastron puts a unique spin on the special-edition approach with the debut of the Carlson 19CSS, the first of four projected boats in the Carlson Signature Series named for noted high-performance boat designer Art Carlson. This 19-ft. muscle boat features the sleek, futuristic contours of an exotic European sports car. All external components are sculpted as part of a totally integrated design. Carlson claims the boat's equal focus on hydrodynamics as well as aerodynamics puts it years ahead of the competition. From the revolutionary look of this scorcher, he may be right.

Some boats that deserve special notice don't fall into the previously mentioned categories. The Barnegat 2530, by Cruisers Inc., is such a boat. This 23-footer is a true overnight cruiser that's not only trailerable, but priced about \$30,700.

Another boat of special interest is the Ragazza 21 Cuddy Cabin, the latest addition to the family line introduced last year by Donzi, which was recently purchased by OMC. The R-21CC is a compact vest-pocket cruiser that walks the fine line between plush appointments and affordability. Despite being fully loaded with designer amenities, the price tag is only \$22,295 with a 175-hp OMC Cobra.

Finally, there's a small trend this year in boating we can't overlook—minijets, 9- to 13-ft. runabouts equipped with jet-powered inboards. UltraNautics, the maker of Wetbike, unveiled the 3-person Jetstar 1250, with a 50-hp Suzuki engine. And Kawasaki, maker of Jet Ski, debuted the 3-person Jet Mate, equipped with its 52-hp engine. Interestingly, the Jet Mate is operated by a joy stick, similar to that of a helicopter, which gives it the flare of a personal watercraft in a platform as stable as a boat.

Boating dreams come in all shapes and sizes, from econo family boats to fishing machines to big-ticket cruisers. But regardless of the size of your budget, or what it takes to get your juices pumping, the fleet of 1989 makes it a good year to dream. **PM**

STERNDRIVES

(Continued from page 102)

makes these units narrower and lighter, which is ideal for gaining line of sight over the stern as well as vital room on the transom.

Standard features include power tilt and trim, pre-atomized oil injection and Microlink, a computerized control system that monitors load and throttle setting to adjust timing for optimum rpm.

Also new from Suzuki are the inline twin 15 and the inline 3-cylinder 25. Both are equipped with loop-charging, oil injection and external-mount tilt and trim. The 25 also has pre-atomized oil injection and an overrev limiter.

Force enters the big outboard class with a 150-hp, 5-cylinder engine. The F-5 150 doesn't have oil injection or computerized monitoring systems, but at 340 pounds, the inline Five has a good power-to-weight ratio and with three carbs, plenty of lower-speed torque.

Most of Yamaha's efforts were focused on the sterndrive line, but counter rotation was added to the 130-hp V4 and a factory-integrated dual-station system was introduced for boats needing tower controls. Now both upper and lower stations can feature identical cables and controls.

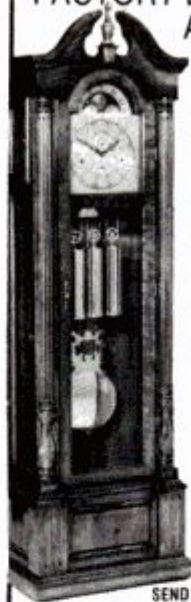
Finally, Nissan and Tohatsu, two companies that market similar Japanese-built engines, broke into the triple-digit power range with the introduction of 120-hp and 140-hp models. Both units are variations of the 4-cylinder, 107.9-cu.-in. block. They feature oil injection, loop charging, over-rev limiter and power tilt and trim.

The year of the sterndrive may well signal the start of the decade of the sterndrive, but only time will tell. We can't ignore the talk that Mercury is planning to build a big-block V6 outboard that may top out at 275 hp. Or that Johnson/Evinrude may be countering with high-performance 225s.

But the biggest rumor moves the spotlight firmly back on sterndrives. According to some sources, Merc is planning a marinated version of the LT-5 engine used in the much publicized ZR1 Corvette. Billed as Corvette's engine of the future, the 32-valve, aluminum-block powerhead, built for GM by Mercury, will be an exciting addition to boating. As of press time, however, no one has actually driven the new Vette and there are whispers that the predicted 390-hp rating may have to be scaled back.

Nevertheless, it's going to be a hot year for engines and a hot year for boats, and there's no better time to head for the water. **PM**

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© by Philip E. Brancato Sr. 1988

Yes, you can make \$1000 a month and more with just a hack saw in your spare time.

Will You Get Rich?

No, you will not get rich, but you can make over \$1000 a month in your spare time and have a ball doing it.

I tried all those "Get Rich" gimmicks that are advertised, that never tell you anything until you've sent them your \$25, and then you find out their gimmicks were not for you. Well, I've tried them all and I'm still not rich.

All I ever wanted was something I could do in my spare time with my hands, make a little money and enjoy myself and not have to buy \$3000 worth of tools or merchandise to do it.

Believe It Or Not

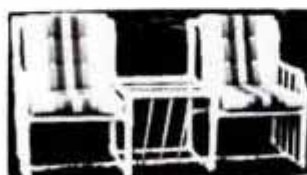
I found the most enjoyable and profitable business working with my hands and the only tools I use are a hack saw and measuring tape. The really nice thing about it is any man, woman or ten-year-old can do it.

What Do I Do?

I make beautiful indoor/outdoor P.V.C. pipe furniture. Such as chairs, lounges, tables, swings, and all kinds of baby furniture out of P.V.C. pipe; and have been for 10 years. P.V.C. pipe furniture is the hottest selling furniture on the market today, because it is unique and beautiful and will not rot or rust and it will virtually last a life time.

Profit Unbelievable!

The fantastic part of this business is the profit.



Just go look at some of this furniture in the stores and see some of the unbelievable prices it is selling for.

A chaise lounge that costs \$62.25 in material and three

hours of work is selling for over \$228 in the stores. I can sell my chaise lounge for anything I think my labor is worth. For once, the big manufacturing companies cannot compete with me or you on prices. You will find you will have more orders than you want!

Where can you buy the P.V.C. Pipe?

You can buy the P.V.C. pipe from any local hardware store to start. Plus I will supply you with the name and address of the largest manufacturers of pipe, fitting, cushions, and table tops who will sell to you at wholesale prices, plus I will supply you with my shop manual and twenty detailed shop drawings with pictures and measurements of twenty different designs.

Do you need my shop drawings

No, you don't need my shop drawings unless you want to save hundreds of hours of trial and error work and thousands of dollars that I had to spend be-

fore I finally found the right design and measurements and tricks to the manufacturing of P.V.C. pipe furniture. I only wish that when I started, I could have bought these shop drawings and I would have gladly paid \$100 for just one of them.

I will pay you!

Yes, I will pay you \$25 for any unique design shop drawing that I can use in my collection and workshop manual.

How do you start?

- 1) Decide if you like to work with your hands to create things and want to make money.
- 2) Can you afford \$14.00 for my shop manual and twenty drawings.
- 3) Send me your name and address along with your check for \$14.00 to:

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Dear Friend,

I made one million dollars in 9 months. You may do better!

My name is John Wright. Not too long ago I was flat broke. I was \$31,000 in debt. The bank repossessed my car because I couldn't keep up with the payments. And one day the landlord gave me an eviction notice because I hadn't paid the rent for three months. So we had to move out. My family and I stayed at my cousin's place for the rest of that month before I could manage to get another apartment. That was very embarrassing.

Things have changed now. I own four homes in Southern California. The one I'm living in now in Beverly Hills is worth more than one million dollars. I own several cars, among them a brand new Mercedes and a brand new Cadillac. Right now, I have a million dollar line of credit with the banks and have certificates of deposit at \$100,000 each in my bank in Beverly Hills.

Best of all, I have time to have fun. To be me. To do what I want. I work about 4 hours a day, the rest of the day, I do things that please me. Some days I go swimming and sailing — shopping. Other days, I play racquetball or tennis. Sometimes, frankly, I just lie out under the sun with a good book. I love to take long vacations. I just got back from a two week vacation from — Maui, Hawaii.

I'm not really trying to impress you with my wealth. All I'm trying to do here is to prove to you that if it wasn't because of that money secret I was lucky enough to find that day, I still would have been poor or may be even bankrupt. It was only through this amazing money secret that I could pull myself out of debt and become wealthy. Who knows what would have happened to my family and me.

Knowing about this secret changed my life completely. It brought me wealth, happiness, and most important of all — peace of mind. This secret will change your life, too! It will give you everything you need and will solve all your money problems. Of course you don't have to take my word for it. You can try it for yourself. To see that you try this secret, I'm willing to give you \$20.00 in cash. (I'm giving my address at the bottom of this page.) I figure, if I spend \$20.00, I get your attention. And you will prove it to yourself this amazing money secret will work for you, too!

Why, you may ask, am I willing to share this secret with you? To make money? Hardly. First, I already have all the money and possessions I'll ever need. Second, my secret does not involve any sort of competition whatsoever. Third, nothing is more satisfying to me than sharing my secret only with those who realize a golden opportunity and get on it quickly.

This secret is incredibly simple. Anyone can use it. You can get started with practically no money at all and the risk is almost zero. You don't need special training or even a high school education. It doesn't matter how young or old you are and it will work for you at home or even while you are on vacation.

Let me tell you more about this fascinating money making secret:

With this secret the money can roll in fast. In some cases you may be able to cash in literally overnight. If you can follow simple instructions you can get started in a single afternoon and it is possible to have spendable money in your hands the very next morning. In fact, this just might be the fastest *legal* way to make money that has ever been invented!

This is a very safe way to get extra cash. It is practically risk free. It is not a dangerous gamble. Everything you do has already been tested and you can get started for less money than most people spend for a night on the town.

One of the nicest things about this whole idea is that you can do it at home in your spare time. You don't need equipment or an office. It doesn't matter where you live either. You can use this secret to make money if you live in a big city or on a farm or anywhere in between. A husband and wife team from New York used my secret, worked at home in their spare time, and made \$45,000 in one year.

This secret is simple. It would be hard to make a mistake if you tried. You don't need a college degree or even a high school education. All you need is a little common sense and the ability to follow simple, easy, step-by-step instructions. I personally know a man from New England who used this secret and made \$2 million in just 3 years.

You can use this secret to make money no matter how old or how young you may be. There is no physical labor involved and everything is so easy it can be done

Here's what newspapers and magazines are saying about this incredible secret:

The Washington Times:

The Royal Road to Riches is paved with golden tips.

Los Angeles Herald Examiner:

We've all got to start somewhere... *The Royal Road to Riches* is the first step in the right direction!

National Examiner:

John Wright has an excellent guide for achieving wealth in your spare time.

Income Opportunities:

The Royal Road to Riches is an invaluable guide for finding success in your own back yard.

News Tribune:

Wright's material is a MUST for anyone who contemplates making it as an independent entrepreneur.

Success!

John Wright believes in success, pure and simple.

Money Making Opportunities:

John Wright has a rare gift for helping people with no experience make lots of money. He's made many people wealthy.

Hollywood Trade Press:

We have never heard of an advertiser offering to pay readers \$20 to try its program. Wright's willingness to do this convinces us that his money secret must really work.

California Political Week:

... The politics of high finance made easy.

Hollywood Citizen News:

He does more than give general ideas. He gives people a detailed A to Z plan to make big money.

The Desert Sun:

Wright's *Royal Road to Riches* lives up to its title in offering an uncomplicated path to financial success.

whether you're a teenager or 90 years old. I know one woman who is over 65 and is making all the money she needs with this secret.

When you use this secret to make money you never have to try to convince anybody of anything. This has nothing to do with door-to-door selling, telephone solicitation, real estate or anything else that involves personal contact.

Everything about this idea is perfectly legal and honest. You will be proud of what you are doing and you will be providing a very valuable service.

It will only take you two hours to learn how to use this secret. After that everything is almost automatic. After you get started you can probably do everything that is necessary in three hours per week.

PROOF

I know you are skeptical. That simply shows your good business sense. Well, here is proof from people who have put this amazing secret into use and have gotten all the money they ever desired. Their initials have been used in order to protect their privacy, but I have full information and the actual proof of their success in my files.

"More Money Than I Ever Dreamed"

"All I can say — your plan is great! In just 8 weeks, I took in over \$100,000. More money than I ever dreamed of making. At this rate, I honestly believe, I can make over a million dollars per year." A. F., Providence, R.I.

"\$9,800 In 24 Hours!"

"I didn't believe it when you said the secret could produce money the next morning. Boy, was I wrong, and you were right! I purchased your *Royal Road to Riches*. On the basis of your advice, \$9,800 poured in, in less than 24 hours! John, your secret is incredible!" J. K., Laguna Hills, CA

"Made \$15,000 In 2 Months At 22"

"I was able to earn over \$15,000 with your plan — in just the past two months. As a 22 year old girl, I never thought that I'd ever be able to make as much money, as fast as I've been able to do. I really do wish to thank you, with all of my heart." Ms. E. L., Los Angeles, CA

"Made \$126,000 In 3 Months"

"For years, I passed up all the plans that promised to make me rich. Probably I am lucky I did — but I am even more lucky that I took the time to send for your

material. It changed my whole life. Thanks to you, I made \$126,000 in 3 months."

S. W., Plainfield, IN

"Made \$203,000 in 8 Months"

"I never believed those success stories... never believed I would be one of them... using your techniques, in just 8 months, I made over \$203,000... made over \$20,000 more in the last 22 days! Not just well prepared, but simple, easy, fast... John, thank you for your *Royal Road to Riches!*"

C. M., Los Angeles, CA

"\$500,000 In Six Months"

"I'm amazed at my success! By using your secret I made \$500,000 in six months. That's more than twenty times what I've made in any single year before! I've never made so much money in such short time with minimum effort. My whole life I was waiting for this amazing miracle! Thank you, John Wright."

R. S., Mclean, VA

As you can tell by now I have come across something pretty good. I believe I have discovered the sweetest little money-making secret you could ever imagine. Remember — I guarantee it.

Most of the time, it takes big money to make money. This is an exception. With this secret you can start in your spare time with almost nothing. But of course, you don't have to start small or stay small. You can go as fast and as far as you wish. The size of your profits is totally up to you. I can't guarantee how much you will make with this secret but I can tell you this — so far this amazing money producing secret makes the profits from most other ideas look like peanuts!

Now at last, I've completely explained this remarkable secret in a special money making plan. I call it "The Royal Road to Riches". Some call it a miracle. You'll probably call it "The Secret of Riches". You will learn everything you need to know step-by-step. So you too can put this amazing money making secret to work for you and make all the money you need.

To prove this secret will solve all your money problems, don't send me any money, *instead postdate* your check for a month and a half from today. I guarantee not to deposit it for 45 days. I won't cash your check for 45 days before I know for sure that you are completely satisfied with my material.

\$20.00 FREE!

There is no way you can lose. You either solve all your money problems with this secret (in just 30 days) or you get your money back *plus* \$20.00 in cash FREE!

Do you realize what this means? You can put my simple secret into use. Be able to solve all your money problems. And if for any reason whatsoever you are not 100% satisfied after using the secret for 30 days, you may return my material. And then I will not only return your original UNCASHED CHECK, but I will also send you an *extra \$20.00 cashiers check* just for giving the secret an honest try according to the simple instructions.

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"As Mr. John Wright's accountant, I certify that his assets exceed one million dollars."
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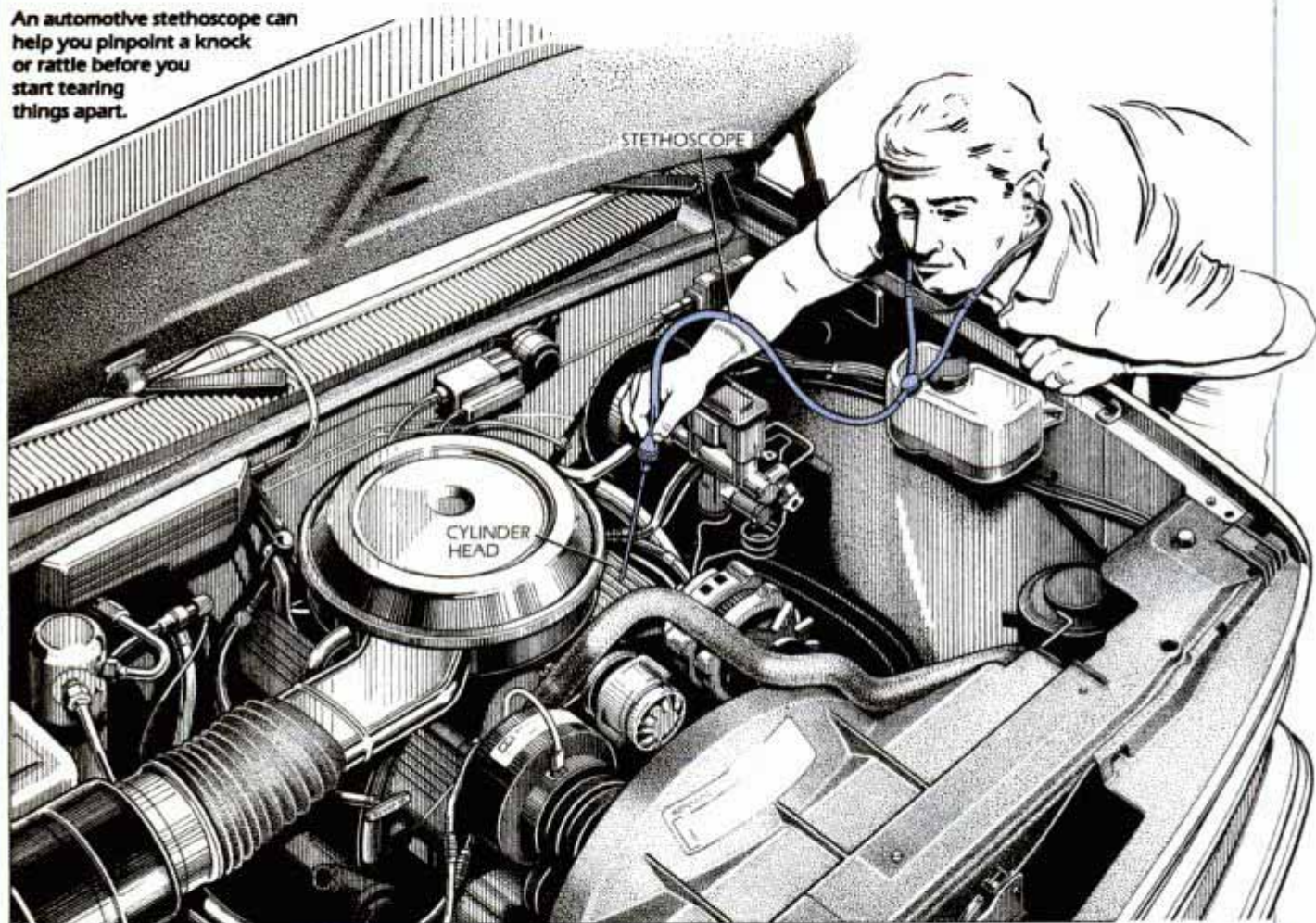
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Knocking Out ENGINE KNOCKS

BY PAUL STENQUIST, Contributing Editor; PM Illustrations by Fred Wolff

An automotive stethoscope can help you pinpoint a knock or rattle before you start tearing things apart.



AT FIRST, you pretend not to hear that dull metallic banging noise pounding out from under the hood. "I'm just imagining it," you tell yourself. But it persists, and as thoughts of dreaded big-dollar repair bills continue to muddy your disposition, you realize you're going to have to *do* something about the death knell. But it's too soon for despair. More often than not, an apparent engine knock proves to be something else. What's more, even a real knock can sometimes be repaired without great expense or difficulty.

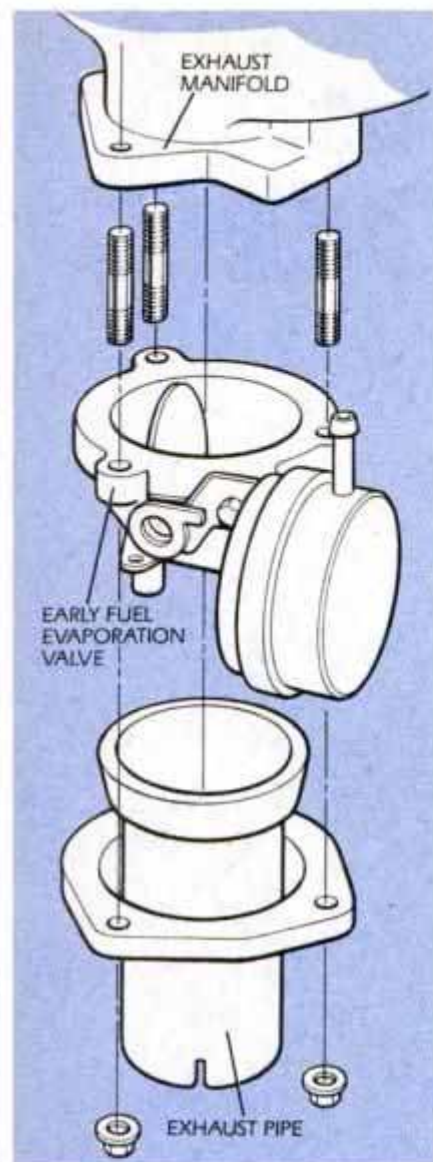
Engine knocks when cold

This type of noise is a banging or dull metallic thud, not a ticking or rattling noise. The sound increases when engine torque is applied, but disappears after 2 or 3 minutes of running time.

One common cause of this noise is a faulty Early Fuel Evaporation (EFE) valve (Fig. 1). On cars so equipped, the valve is located in the exhaust manifold and closes when the engine is cold to divert hot exhaust gases to the intake manifold. If the valve bushings are worn, it may bang against the manifold. When torque is applied,

load increases and exhaust volume is greater. Thus, the banging is louder. When the engine warms up, the valve opens, and the noise disappears.

You can usually determine if the EFE valve or another component is making noise by listening to it through a stethoscope or length of heater hose (see lead illustration). Automotive stethoscopes are available at better auto parts stores. To use the stethoscope you simply touch the probe to the area of the engine or part in question. A hose is used in much the same way: one end to your



1 The Early Fuel Evaporation valve can produce a noise that sounds like rod knock.

ear, the other on the part. When using a hose, take care that you don't touch any sparkplug wires as you might be treated to a high-voltage slap in the head.

When checking for a noisy EFE valve, compare the sound heard at the valve with what you hear at a location on the engine block. If the noise is more pronounced near the valve, it's probably the source.

While a faulty EFE valve is a welcome find when diagnosing a cold-engine knock, the classic cause of this type of noise is a serious one: One or more of the cylinders is too big for its piston. As the piston warms up, it expands and the noise disappears. Increased load causes the piston to slap the walls harder, increasing the noise.

On very old engines, this clearance is the result of cylinder wall and pis-

ton wear. On newer engines, it is more often a manufacturing defect. Manufacturing tolerances are narrow (example: .0007 to .0017 in. for a 1985 Camaro V8) and engines that are out of spec can occasionally slip by.

The solution is not an attractive one, as it calls for disassembly and rebuilding of the engine. That's why some dealers will try to tell you that the noise doesn't matter. And, from their point of view, it doesn't, as the car will probably be out of warranty by the time the condition deteriorates to the failure point.

Eliminating piston slap

If you're determined to repair a piston-slap problem yourself, the best fix is to bore the cylinders and install new, oversize pistons. Ask the machine shop to bore to the minimum oversize that will clean the cylinders. Once the block has been bored, carefully check piston size and cylinder bore size to make sure clearance falls within production tolerance. Cylinder bores can be measured with a snap gauge and micrometer or—as a superior alternative—with a dial bore gauge and a micrometer (Fig. 2). Mike pistons on the skirts about 1 in. below the oil ring or wherever the manufacturer specifies (Fig. 3).

Sometimes, quite similar to the sound of excessive piston clearance is the noise caused by a bent connecting rod. In this case, the engine can sometimes be repaired by merely replacing the rod and its piston with new components, but check carefully for damage to the cylinder wall.

Hone the cylinder before installing the new piston and rod, and compare

ring end gap to the specs found in your service manual. On most cars you can do this job without actually removing the engine block. But make sure you thoroughly wash the honed cylinders with soapy water, rinse and wipe dry, and oil the fresh surfaces immediately. Of course, you must check all clearances, including piston to cylinder, connecting rod bearing and, on V8 and V6 engines, the side clearance between the big ends of the two connecting rods on the journal in question.

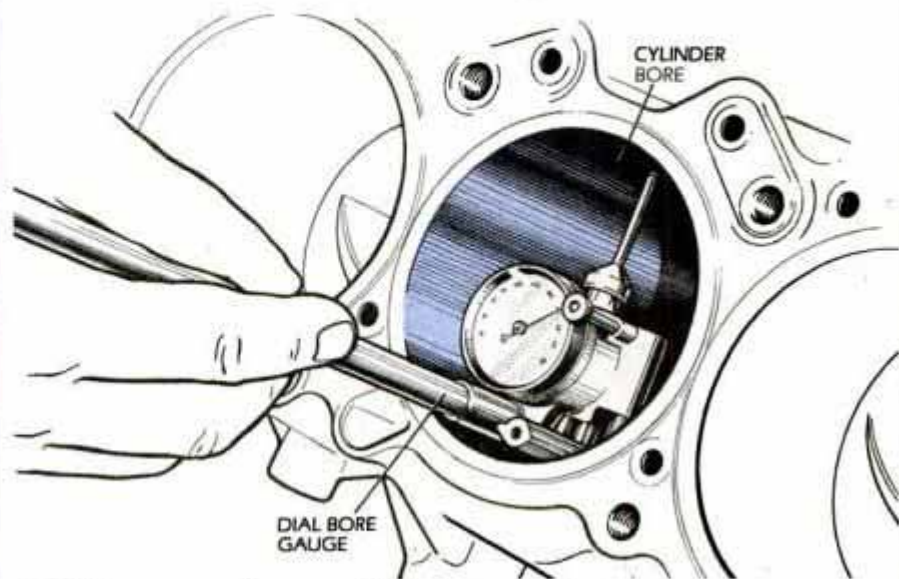
Engine knocks when warm

A heavy engine knock that occurs only when the engine is warm or whenever the engine is running under load can be caused by some relatively innocent problems.

One example comes immediately to mind. It was a 1970 Tempest with high mileage. A distinct knocking noise developed gradually. It sounded like a seriously worn bearing, and it looked like the engine's days were numbered. But a quick check with a stethoscope suggested that the noise was coming from the bell housing area. A trip under the greasy side confirmed this. The cause? Loose torque converter bolts that were easily replaced.

Other causes of a heavy knock include the very common exhaust system throb, caused by an exhaust system component coming into contact with the body or chassis. In many cases, the noise is only heard under load. The cure is simple: relocation of the offending member by means of hanger adjustment.

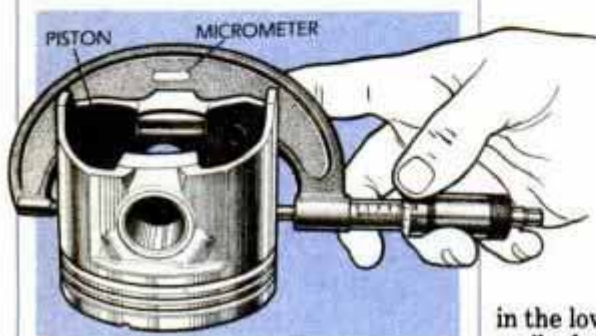
Another possibility is a broken crankshaft balancer or pulley hub.



2 A dial bore gauge will measure cylinder size, taper and out-of-round.

You can usually detect this condition by watching the crank pulley while the engine is running. The runout caused by a loose fit will probably be visible. However, you may have to remove the pulley to confirm the problem. This job is a tough one on most rear-drive cars as it requires removal of the radiator. On some cars you may have to lift the engine. Check your shop manual before attempting to remove the crankshaft pulley on a front-drive car.

On cars with a mechanical fuel pump, a worn pump pivot can produce a muted banging noise that sounds like a much more serious internal



3 Mike pistons on the skirts, opposite wrist pin and about 1 in. from the top.

problem. The condition is fairly common on GM V8 and V6 engines. You can use your stethoscope or length of hose to verify a noisy pump.

Excessive rod bearing or main bearing clearance is the classic worst-case cause. Again, if the engine is new, excessive clearance is a manufacturing defect. If it's an oldy, wear is the culprit.

Diagnosing and replacing worn engine bearings

You can confirm excessive clearance by removing the oil pan and checking clearance with the deformable clearance-checking plastic available at auto parts stores. The most widely available product of this type is called Plastigage. Purchase a size that bridges the maximum clearance spec for your engine. For example, the maximum main bearing clearance for most modern Chevy V8 rod bearings is 0.003 in. Therefore, you would want to use Plastigage that is sized for a 0.002-in. to 0.005-in. range, or thereabouts. To check rod bearing clearance, you simply unbolt the bearing caps, one at a time. (If you intend to remove more than one rod or main cap at a time, you must mark the main

caps and both lower and upper parts of the rods with number stamps. (They are *not* symmetrical or interchangeable, and *must* be installed in their original orientation and location.) With the bearing cap off, pull down on the upper part of the rod to make sure it's seated on the crank. Then wipe the bearing clean and lay the gauging material across the full width of the cap bearing. Reinstall the cap, torquing it to spec. This will compress the plastic gauging material. Do not rotate the crank while the material is in place. Remove the cap and compare the width of the compressed gauging material to the scale on its package.

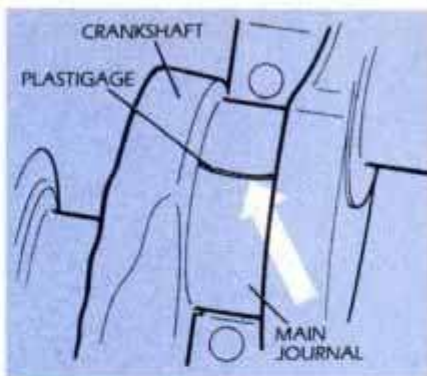
Checking main bearing clearance is the same except that you'll have to push the crankshaft up against its upper bearing halves. To do so, support it at both ends with screw jacks or small hydraulic jacks.

To measure clearance, insert Plastigage in the lower main bearing caps as described above or, if the engine is out of the car, on the crank journal. Torque the cap in place, and compare your reading to the specs in the service manual (Fig. 4). On most engines, specs for front and rear main bearing clearances differ from those for center bearings.

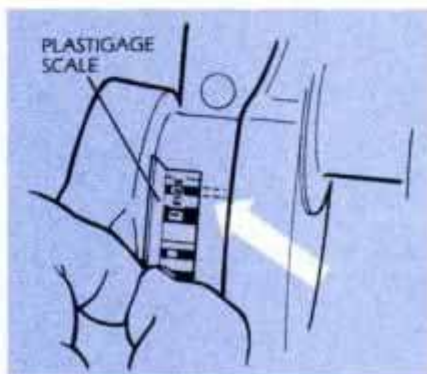
Once you've confirmed that clearance is excessive, you can replace upper and lower bearing inserts with new ones. Undersize bearings are available to compensate for minimal crankshaft wear. However, if the crank is excessively tapered or worn, engine removal and crank grinding will be necessary.

You can sometimes detect excessive crank wear, particularly on the main journals, by looking for ridges at the edges of the part of the journal that contacts the bearing. If the bearings have oil grooves in the center, a ridge will form there when the crank wears excessively. Any ridge that can't be easily polished away, as described below, is cause for concern. To mike the crank, you would have to remove it from the car.

Rod journals can be checked for wear with a micrometer. Simply remove the two caps from a journal (make sure they're numbered) and push the pistons up into the block. If the valves are closed, you may have to remove the sparkplug. Measure the journal and compare its size to the



4 Clean journal and bearing, lay strip of plastic gauging material across journal (above). Torque rod or main cap, remove and measure bearing clearance directly with scale supplied with Plastigage (below).

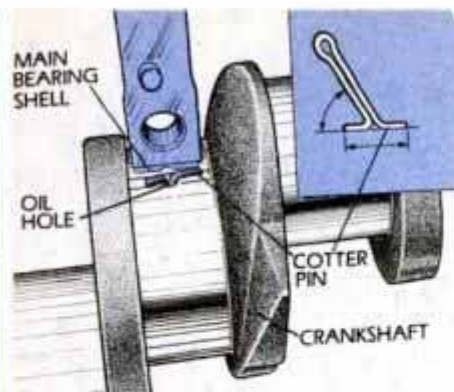


service spec in your service manual. Mike each journal in several spots to determine if it is out-of-round or tapered. For example, the service tolerance for out-of-round on most Chevy V8s is 0.001 in. maximum.

To remove upper main bearings make a tool out of a small cotter pin as illustrated in Fig. 5. Make sure the bent pin lies flush against the crank. Then rotate the engine so that the bent pin contacts the side of the bearing shell opposite the bearing tang. Continue turning the engine until the bearing shell is pushed out.

If crank bearing surfaces are less than perfect, lightly polish them with No. 400 emery cloth and solvent. Push each rod journal's connecting rod or rods and the attached pistons up into the engine, away from the crank. Loop a strip of wet emery cloth over the journal and pull it back and forth in even strokes, using lots of solvent. Make sure you polish evenly, all the way around each journal. To polish main bearings, pass the emery cloth in behind the journal and have a helper rotate the crank as you polish.

Once the crank has been lightly polished, wash it thoroughly with solvent. Use an oil squirt can filled with solvent to flush the crank's oil gallery



5 Insert bent cotter pin in crank oil hole, rotate crank to remove the bearing shell.

bores. Lube the upper bearing half with clean engine oil and rotate it into place with your bent cotter pin. Make sure the bearing tang seats in the block. Check clearance with the plastigauge as described above. If clearance is okay, lube the lower bearing with clean engine oil, reinstall the cap and torque to the manufacturer's specification.

Engine knocks lightly when hot

A faint engine knock that is heard only when the engine is hot can be the beginning of serious trouble in that it is sometimes caused by excessive rod bearing clearance. More often, however, it is the result of a relatively simple problem such as the previously mentioned loose torque converter bolts. Slight exhaust leaks at the manifold can also produce noise that may resemble a knock under certain conditions.

If the noise is extremely load sensitive—if it is loudest when climbing a hill in high gear—it is probably spark knock. The causes of spark knock, include excessive ignition advance, engine overheating, an overly lean condition, combustion chamber carbon accumulation, fuel of insufficient octane rating, an engine hot air or EFE system problem and—most common of all—an inoperative EGR system.

Engine knocks at idle when warm

Noises that are most noticeable at idle may vary from a dull knock to a loud ticking or clattering. An idle knock that is noticeable only for a few seconds and then goes away is often the result of hydraulic lifter bleed-down. This condition is due to wear within the lifter that allows oil to bleed out when the car is parked for a few hours or more. The only fix is lifter replace-

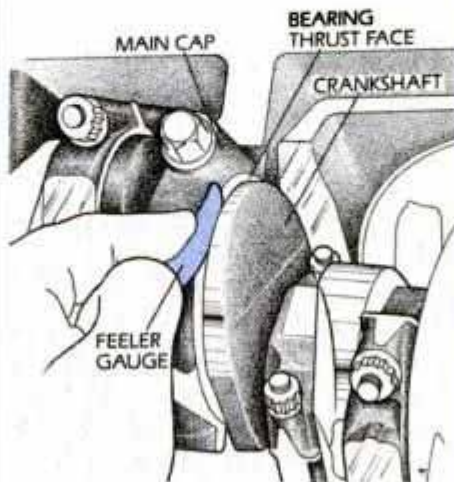
ment. However, the mating of new lifters with an old cam can also cause excessive wear. The best choice is to learn to live with the noise or to replace the lifters and camshaft.

Excessive main bearing end clearance (or thrust clearance) that exceeds specification may also cause noise right after startup. End clearance can be checked by inserting feeler gauges between the crank and crank thrust bearing (the one that wraps around its cap as shown in Fig. 6). Make sure the crank is pushed up tight against the opposite side of the thrust bearing while checking. You can move it forward or backward by rapping with a rubber or wooden mallet. Replacing the thrust bearing is the fix for this problem, but it's best to replace all main bearings along with the thrust bearing.

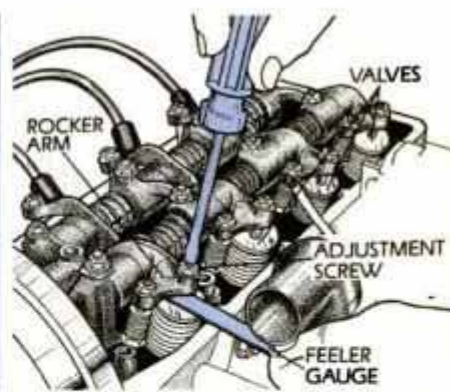
Excessive piston wrist pin clearance will produce a rhythmic clatter when the engine is warm. Sometimes it is most pronounced upon deceleration when the engine is revved in Neutral. Again, if the noise is present in a new engine, it's due to a manufacturing defect. If it becomes a problem in an older engine, the pistons and rods will have to be removed and oversize wrist pins installed.

The most common causes of engine ticking noises at idle include noisy accessory bearings and engine valvetrain problems. If the noise is coming from the valvetrain, you can usually pinpoint it to one side or the other of a V8 or V6 with your stethoscope or hose as shown in the lead illustration.

On engines with adjustable rockers, eliminating a valvetrain noise may be only a matter of adjusting the clearance or "lash" in the valvetrain to approximately zero. To adjust clearance, you simply unlock the adjust-



6 Check thrust clearance between the thrust surface and the crank cheek.



7 Even engines with hydraulic lifters may require occasional valve lash adjustment.

ment screw by turning its jam nut open with a box wrench, setting the clearance with feeler gauges and a screwdriver, and tightening the jam nut without disturbing the clearance (Fig. 7).

Other engines use an adjustable ball-and-socket pivot, but the principle is the same. Overhead cam engines often use shims instead of adjustable rockers, and unless you're willing to invest in a handful of shims and a special tool to sneak them in under the cam, the best you'll be able to do is find the loose ones, and turn the actual adjustment over to a mechanic.

Check your service manual to determine which valves can be set at each crankshaft position. If you don't have a service manual, rotate the engine and watch each valve's pushrod. Turn the crank another 30° or so after the pushrod for the valve being adjusted has dropped to its lowest point, then adjust that valve.

If you can't solve a noisy valvetrain problem by adjusting the valve, you'll have to remove and check parts until you find the offenders. Look for galling or rough spots on rocker arms, worn rocker shafts, bent pushrods (on cam-in-block engines), broken valve springs and valve stem tip wear.

If all valvetrain parts look okay, but valvetrain clearance is obviously excessive on one or more valves, the cause is most likely camshaft and lifter wear. If you replace a cam, you should replace all the lifters as well. Or, on overhead-cam engines, replace the rockers or bucket lifters as required. Then remove and flush the oil pan to get most of the metal shavings out of the engine. Replace the oil filter before starting the engine and change the oil and filter again after running the engine for 15 minutes. Don't allow the engine to idle at less than 1500 rpm when it is first restarted following camshaft replacement.

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What is "Z-7"?

Q. I have noticed on bottles of Pennzoil, the term "Z-7." What is "Z-7"?

F.H., China Grove, NC

A. Pennzoil "Z-7" is a carefully engineered proprietary additive that offers maximum protection against high-temperature breakdown, engine deposits, oxidation and wear. This advanced additive is blended with the highest quality oil base stocks to create a motor oil that protects against high-temperature engine deposits in the piston ring area, as well as combustion chambers. This additive also reduces internal engine friction, resulting in less engine wear and extended engine life.

Changing the Oil and Filter.

Q. If a person only changed the oil filter in their car and added oil as needed, would the oil become useless as a lubricant?

D.M.S., Silver City, NM

A. Yes. Because no filter can remove all combustion by-products, the oil becomes too dirty to function effectively. The only way to remove these by-products is to change the oil and filter on a regular basis.

The recommended oil change interval for severe-service conditions is three months or 3,000 miles, whichever comes first. Most of us drive under severe-service conditions. And that means in most instances, the time limit will come before the mileage limit. Your vehicle owner's manual specifies the correct



By Don Johnson

*Vice President, Product Engineering
Pennzoil Products Company*

oil change intervals for your car under both normal and severe-service conditions.

Turbo Turmoil.

Q. I have been a user of Pennzoil in my gasoline engines for years. I have now purchased a GMC 4000 with a turbo diesel engine. I'm supposed to use an API CD oil. My problem is where to get it. Can you help?

A.C.R., Port Washington, WI

A. We sure can. You'll find the specific API CD oil you need wherever Pennzoil is sold. All Pennzoil Motor Oils are API SG/CD quality rated. For your diesel engine, we recommend using Pennzoil Long-Life SAE 15W-40 Motor Oil in temperatures above 10°F. Please refer to your vehicle owner's manual for other viscosity grades of Pennzoil Motor Oil you can use.

Storage Life.

Q. What is the storage life of motor oil? I stocked up on Pennzoil when

it was on sale. I may have the oil for six months to a year or longer. Will a prolonged storage period like this have a negative effect on its performance or protective qualities?

J.D.M., Byron, IL

A. No. The shelf life of Pennzoil Motor Oil is quite long. If you are storing the product for six months to a year, there would be no problems with the product degrading in any way. The product shelf life is well beyond the 18 to 24 month range.

'69 Dodge.

Q. I have a 1969 Dodge in excellent condition and have never used anything but Pennzoil HD SAE 20W-20 in it. Now, I can't seem to find this grade of Pennzoil anymore. Please advise me on what to use.

H.L., Festus, MO

A. Pennzoil still makes 20W-20. But if you're unable to find it, we recommend using Pennzoil Multi-Vis SAE 10W-30 Motor Oil for your 1969 Dodge engine. This product will provide superior protection and excellent lubrication over a wider range of driving conditions.

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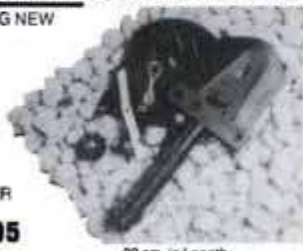
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30 cm. in Length

BICYCLES (Continued from page 40)

Spectra is polyethylene-based, it requires a special plasma treatment to allow the bonding resin to stick to it. It's worth the trouble, though.

Spectra has the best vibration damping qualities among advanced composites, and that means a better ride over rough terrain.

The aerospace engineers who now spend their days designing 2-wheelers at Kestrel (265 Westridge Dr., Watsonville, CA 95076) point out that the MX-Z



Optional Challenge software holds rider's interest with numerous courses, conditions.

frame takes maximum advantage of the anisotropic properties of composites. In other words, they may be made stiffer in one direction than another, depending on the material's orientation, so the fiber alignment in the frame is varied to best control stresses.

A metal frame tube can only be varied in thickness to compensate for the different loads carried by the bottom bracket and head tube, but the composite frame doesn't have to make that sacrifice in weight savings or in impact absorption.

At all points of metal contact, such as the dropouts where the rear axle is positioned, the Kestrel frame incorporates metal receivers for durability. In every other respect, the frame is a 1-piece structure, with continuous fiber coverage over every frame junction point.

As we've seen in so many other carbon-fiber structures, the Kestrel MX-Z manages to combine incredible stiffness with great resilience, and along with the shock-absorbing qualities of the Spectra material allows the rider to go faster over bad surfaces.

Moreover, the frame is impervious to rust and all but indestructible, vital in the ATB market segment and nice to know after you've spent \$1200 on the frame set.

Whichever architecture proves best for building composite bikes, mono-coque or 1-piece frame units, one thing is certain: The days of using carbon fiber as a mere replacement for metal, without regard to its particular strong points, are coming to an end. And quite literally, that will change the shape of bicycle frame design forever.

Brainy Trainer

If winter has you enduring droning sessions at the wind trainer, let a computer put excitement back into the workouts. By using a microprocessor-controlled electronic load simulator, the CompuTrainer allows you to vary riding conditions and keep your head working along with your legs, heart and lungs.

In Manual Control mode, the CompuTrainer (RacerMate, 3016 N.E. Blakely St., Seattle, WA 98105) lets you set the rider inertia weight, road gradient (to uphill or down) and the effect of head or tailwinds. Now, of course the computer jocks couldn't stop there—three pre-programmed road courses are built in and there's a jackpot random setting which changes terrain and wind load with unlimited variation. The handlebar-mounted microprocessor fires off commands to the load simulator at the rate of 50 times per second, so changes are both smooth and realistic.

Okay, that will keep your interest through the first week of cold weather, but what happens when cabin fever really takes hold? Well, you simply step up to the optional RacerMate Challenge interactive software, available for IBM compatibles and Commodore. Now you've got five time trials and five road races, varying in length and difficulty. You can race the on-screen opponent, or store a previous race in memory and race against yourself. Still not enough?



CompuTrainer simulates pedaling load with sophisticated electronic controls.

Then link two CompuTrainers together and race against a real opponent.

With a real competitor at your side, perhaps you could tune up your racing psychology. The screen will display each rider's position, the wind speed, road grade, current and average speeds, miles covered and calories expended.

The CompuTrainer sells for \$595 and the computer software is another \$100. And RacerMate hasn't forgotten the practical side, either. The trainer is a rear-axle-mount design, which means that no adjustment is required for you to go racing electronically. **PM**

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"Well, word got around about how much money I had saved and that opened a whole new world of opportunity. Ever since then I've been like a cat on a hot tin roof! **The first year I did 15 roof jobs. Almost double that the second year, and had a huge backlog.** Most of these were big jobs like the county home, the Chevy-Buick garage, bank buildings, city hall. Big jobs mean big money!

"The business I used to be in had been pretty good to me, but I really had to work both nights and days. **With Pace, business just seems to fall into your lap.** I don't really do any promoting or 'selling'... most of my sales come from referrals, and my phone's ringing all the time.

"What I like to tell people is that Pace offers a fine income opportunity. You can

start working as little as two hours a week and then go full time when your income exceeds your regular job."

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COMPACT COMMANDOS (Continued from page 55)

Mitsubishi SPX

All-new for 1988, Mitsubishi's pickup (also sold by Dodge dealers as the Ram 50) is very similar in appearance to Toyota—sleek and modern, yet tough looking. It uses a lot of the same styling motifs—fender flares, a hood bulge, a wrap-over contour line on the extended cab roof—and to our eyes, is equally good looking. Fit and finish are also above average. Chrome bean-hole wheels supply the only jarring note.

The top-line SPX has a nice interior, with supportive bucket seats, six easy-to-read white-on-black gauges and a handy 2-spoke steering wheel. Our testers criticized the overly zoomy interior styling, the poor ergonomics—controls seem to be scattered everywhere across the dash—and the imprecision of the vague steering and willowy shifter.

Like the Mazda, the Mitsubishi/Ram 50 suffers from a serious lack of grunt. The 2.6-liter Four was second slowest at the dragstrip, clocking in quicker than only the Mazda, and not by much. Mitsubishi builds a terrific 3.0-liter V6 for its passenger cars as well as the Montero (Dodge Raider) sport/utility vehicle, and it's an engine that belongs under the hood of this otherwise fine truck.

Dodge Dakota Sport

We liked the Dakota concept a lot. The idea of a midsize pickup combining the handy size of a compact with the workhorse ability of a full-size truck is very attractive. However, the new-generation Japanese pickups are actually larger in most dimensions than the Dakota—including payloads—and can handily outperform it at the drag strip and the job site.

The long-bed Dakota does stretch out a full 8 ft., which is 6 in. longer than its competitors. It also has the cleverest feature we found in any of these trucks—stamped-in depressions along the box sides to hold 2x6s across the bed to form a convenient rack for plywood or other lumber. Unfortunately, Dodge has given the Dakota all the ambiance of old-time Mopars, a list of attributes that includes too-light steering with no road feel, sloppy handling and a wallowing ride. The interior is unimaginative, and like the Jeep, there's no extended cab option.

The Dakota has excellent brakes with ABS on the rear, but it finished mid-pack in our handling tests. Even with a big 3.9-liter V6, this was one of the slowest accelerating trucks. Carroll Shelby is fitting a V8 to these trucks (see sidebar). We think it ought to be a factory option.

Nissan Hardbody Special V6

Designed in America by ex-Buick stylist Gerry Hirshberg, the chunky Nissan looks like no other pickup. It's distinctive, with brawny individuality all its own. The Hardbody is also built in America, at Nissan's New Smyrna, Tennessee, facility, and has the best fit and finish of any American-built truck in this group.

Disappointingly, the Nissan V6 was near the bottom of the pack in every performance test, coming across as slow and not much fun to drive. The bland interior doesn't relieve this impression, and the truck fails to feel as substantial as its excellent assembly quality leads one to expect.

Isuzu Pickup

Totally revamped for 1988, the Isuzu blends the low-hood aerodynamics of the Toyota and Mitsubishi with the flared fenders of the Nissan. The overall effect is modern, pleasant and clean. The Isuzu returned the best fuel economy, due in part to its superior aerodynamics. We think it's one of the most stylish of all these trucks.

Isuzu pickups have always been underpowered, and this latest one is no exception. Its 2.6-liter Four is rated at 120 hp, and the Isuzu couldn't break 19 seconds in the quarter-mile. Poor brakes and handling also conspired to put the Isuzu near the back of the pack in all our track tests.

It didn't fare much better with our testers. They complained about the poor driving position, difficult-to-use pushbutton controls, notchy shifter, heavy steering and poor ride and handling. Isuzu seems like GM's poor relation, and deserves better.

Conclusion

Compact pickups have come a long way since the first Nissan and Toyota trucks teetered into California 25 years ago. The best of today's trucks—the Toyota SR-5, Ford Ranger, Jeep Comanche, Chevy S-10/GMC S-15—are comparable in every way to passenger cars of the same price, plus they can carry all that stuff people always seem to need to carry.

No matter which truck you choose, we'd recommend you get an extended cab. The extra passenger space and convenience of lockable inside storage will pay for themselves every day. We'd also order heavy-duty or handling suspension, plus the best street tires available.

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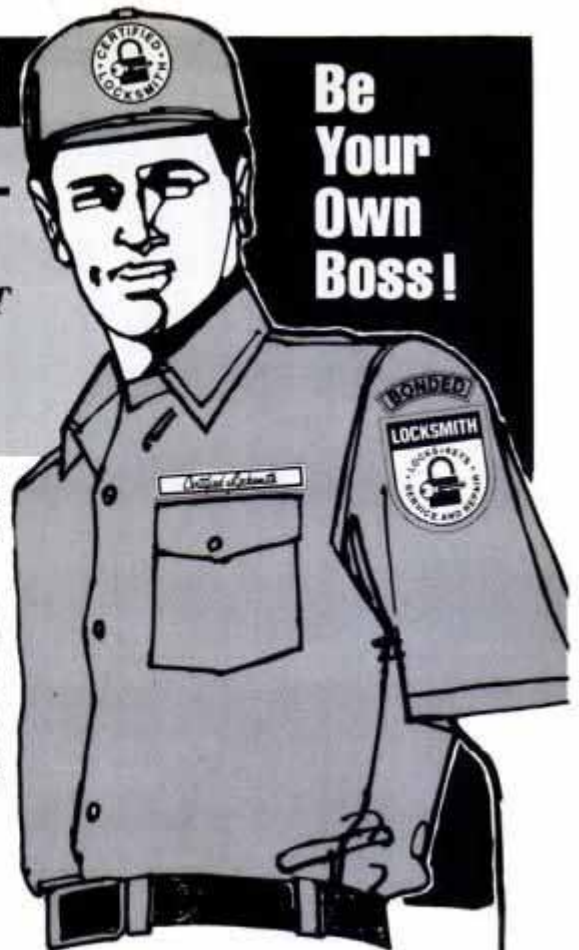
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ICEBREAKERS! (Continued from page 59)

Power plays

The diesel-electric system on the new icebreakers is also of a revolutionary design. Four Wärtsilä Vasa 16v32 heavy-fuel burning diesel engines drive *Kontio* and *Otso*'s twin stern propellers via electric motors. "Each diesel runs its own generator," Capt. Rintala says. "All the energy goes into a common electrical net. Every user—from the kitchen to the propellers—takes what it needs from the net. We can generate 20,400 shaft horsepower."

There are distinct advantages in a diesel-electric system. Eliminating prop torque and power surges during difficult icebreaking exercises relieves engine wear, reducing maintenance costs and downtime.

Otso and *Kontio* use cycloconverters to furnish AC power to the propeller motors. The two synchronous ABB-Stromberg propulsion motors themselves can provide speeds of 110 to 200 revolutions per minute at 8.8 kV. The earliest diesel-electric icebreakers used DC systems. Semiconductors and diode rectifiers made the use of AC generators possible.

A digital signal provides the power reference to the motor's regulating unit. The ship's microprocessors receive a continuous digital signal and a vector microprocessor calculates the output signals for the motor currents, frequency and phase shifts as an icebreaker works in heavy ice. These electronic controls can rapidly change loads on the propellers as ice thickness builds or when resistance outside the hull changes. Computers make adjustments quickly and accurately. Optical fibers are used to transmit control signals and diagnostics.

"We can operate the vessel without anyone in the engine room," says Capt. Rintala. "We control everything here on the bridge."

Arctic research center

Otso's obvious durability and sophistication began with thorough research and development.

"We optimize the icebreakers we build for specific duties. We call it mission-based design," Henrik Segercrantz says, showing off Wärtsilä's Arctic Research Center (WARC) in Helsinki. "There is not one ideal icebreaker. A Baltic or sub-Arctic icebreaker differs from a vessel used in the Arctic. We've invested a lot in research and development. We get direct feedback from actual ships, so we can compare and adjust our model and real scale testing done here."

WARC contains a 77.3-meter- (254-ft.-) long test tank which can produce ice with maximum thickness of 70 mil-

limeters on a daily basis. The 2.3-meter- (7.5-ft.-) deep tank is equipped with viewing windows on the sides and bottom where engineers can study the effects of ice formations on models.

"We have a computer-based system. We give an order to the computer in the afternoon of what kind of ice to create for the next morning," Segercrantz explains. "The model ice has to be scaled down to the model scale for determining bending strength, elasticity, crushing and shearing. With the new fine-grain model ice, we can simulate actual ice conditions, including ridges and pack ice. The models can be different sizes—1:20 or 1:40, for example."

When a model is towed through the tank's ice, various forces are measured including the towing force—the forces on the propellers, thrust and torque, revolutions, blade forces and model motion. WARC experts take their model-based conclusions on the ice and compare their work to actual conditions.

Over the horizon

What's envisioned for tomorrow? Wärtsilä planners are considering Arctic Sea Trains, icebreaking lead ships that tow a series of vessels through the ice, or super cargo container vessels and tankers that have icebreaking characteristics. The future of icebreaking depends on global economics and the politics of nations with polar interests. But external forces can't change one thing. The challenge of navigating in the ice.

"When we go out in the open sea and the ice is drifting, it's hard to find the right way through," says Capt. Soren Fogelstrom, master of the luxury cruise liner *Silvia Regina* operated by the Silja Line. He carries 2000 passengers, along with trucks and vehicles, every day, year-round from Helsinki to Stockholm.

"That's why it's exciting. You're driving at high speed, 20 knots, rushing into heavy ice. Then you're down to 2 knots in just two lengths of the ship. You have to have some tricks up your sleeve."

Tricks, yes, and a passion for challenge that reflects much broader implications. As one century ends and another beckons, there is increasing potential to tap the Earth's last untouched reservoirs of mineral wealth beneath the Arctic. When the price of a barrel of oil goes back up, nations will muster their resolve to discover these new reserves.

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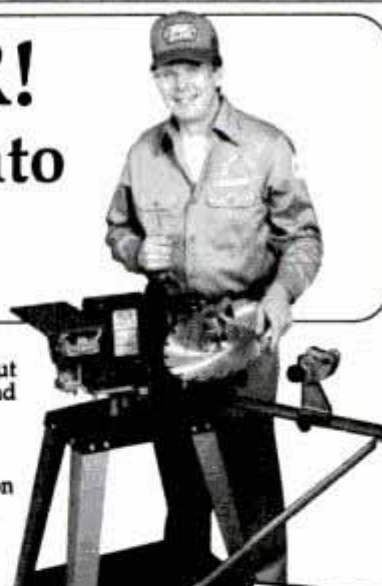
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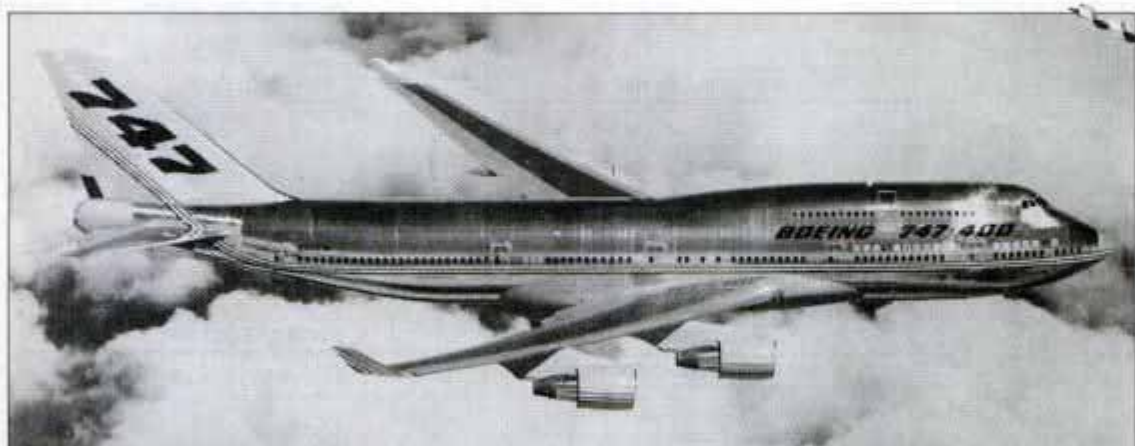
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