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JULY 1988 \$1.95

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Past, Present And Future

BUDGET MUSCLECARS
9 Hot Hatchbacks
Shoot It Out On The
Road And Track

SPECIAL REPORT
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Perform Surgery Inside
Your Body

**SABRE SAW
SECRETS**
15 Tips From
A Pro





FORD BEATS CHEVY AGAIN --BIGGEST LEAD EVER.

**BIG FORD PICKUPS TOP CHEVY
IN SALES FOR 11 STRAIGHT YEARS.
IT'S BUILT HI-TECH AND TOUGH--
FOR UP TO \$815 LESS!**

Ford has been America's best-selling full-size pickup 11 straight years—and last year beat runner-up Chevy by 131,000 pickups—Ford's biggest winning margin ever!*** There are lots of reasons why:

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BIGGEST BOX, MORE PAYLOAD

You get a larger, wider, deeper pickup box from Ford. And Ford payloads exceed Chevy by up to 270 lbs.

\$815 LESS THAN CHEVY*

Big Ford pickups were first with rear Anti-lock brakes, and offer multiple-port fuel-injected engines,



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\$215 MSRP

COMPARE FORD TO CHEVY*

Ford F-150 LWB XLT Lariat— 5-Speed Equipment Package 507A \$12,046	Chevrolet C-1500 LWB Silverado 5-Speed, comparably equipped \$12,861	Ford Advantage \$815 less
---	---	-------------------------------------

No charge items on Ford manual transmission packages include:

Radio, AM/FM Stereo	Bright Low-Mount Mirrors
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Argent Rear Step Bumper	Tinted Glass
Sliding Rear Window	Tachometer

Package content differs and savings vary in La., Okla., Texas. F-150 prices higher in N.Y. See your dealer for complete details.

standard. F-150 XLT Lariat with option package 507A offers this—and Ford's shape-of-tough styling—for \$815 less than the comparably equipped Chevy!*

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Covers powertrains for 6 years/60,000 miles and body-panel rust-through for 6 years/100,000 miles.†

BEST-BUILT AMERICAN TRUCKS 7 YEARS RUNNING

Based on an average of owner-reported problems in a series of surveys of '81-'87 models designed and built in North America. At Ford, "Quality is Job 1."

*Based on manufacturers' suggested retail prices of F-150 (2WD) equipped with 5-speed manual transmission and Preferred Equipment Package listed compared to MSRP of comparably equipped C-1500 Chevrolet model. Comparisons based on prices available at time of publishing, including destination and delivery charges and excluding title and taxes.

**Based on calendar year manufacturers' reported retail deliveries, 1977-1987. †Restrictions and deductible apply. Copies of this limited warranty are available at your Ford Dealer.

Buckle up—together we can save lives.



BIG FORD PICKUPS

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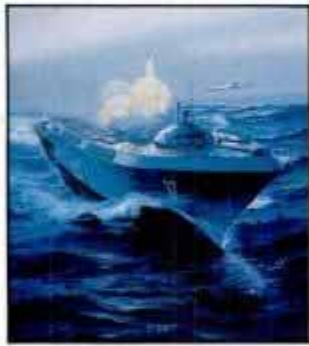
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And that's like getting Purolator Oil Filters FREE... FOR LIFE!



Purolator
FILTERS



56 COVER STORY

The success of the U.S. Navy in the next century lies in the evolution of an integrated battle force working together with advancements in stealth and firepower.

—PM Illustration by Tom Freeman



76 Serious shades



86 Breadwinner

51 Econo commandos



SPECIAL REPORT: FOCUS

91 How To Take Better Photos

92 Improving Your Images

Get more mileage from your photo gear.

93 Fun With Film

Get exotic effects without special gear.

95 One On One

Shoot flattering portraits with simple gear.

96 Focus On Speed

Tips from a professional race-car photographer.

98 Night Shots

How to capture dazzling light displays on film.

99 Shoot The Moon

Easy lunar pics.

100 Inner Visions

Infrared secrets.

102 Developing

Tips at the lab.

103 Fading Memories

Save your shots.



AUTOMOBILES

20 Inside Detroit

Our Motown man brings you the scoops.

26 Imports

From Alfas to Yugos, we track down the inside story.

30 Car Clinic

Got a car question? We've got the answer.

46 Motorsports

We put you on the pole position for the action.

51 Econo Commandos

The world's top pocket rockets in a fight to the finish.

72 National Nostalgia

Now you can rent a classic car.

115 Saturday Mechanic

Finding and fixing water and air leaks.

HOME/SHOP

28 Old House Restoration

Bob Vila drafts some new ideas for some old treasures.

38 Hints From Readers

Simple solutions to common problems.

82 Sabre Saw Secrets

A do-it-yourselfer's guide to the versatile sabre saw.

86 Breadwinner

Mobilize your kitchen with this rollaway baking cart.

107 The Better Home

• Replacing a water heater • Replacing a starter pull-rope • Homeowners' clinic • Appliance clinic

MILITARY

56 Battlecruiser 2000

PLUS FREE POSTER!

Stealth and firepower will revolutionize sea warfare.

SCIENCE/TECHNOLOGY

13 Tech Update

The latest in space, automotive, computers and more.

48 Science

Our magnifying glass gives you a closeup.

79 Micro Machines

How the minute machines of tomorrow will work.

BOATING/OUTDOORS

40 Outdoors

Whatever the season, we cover the gear you'll need.

68 Family Flyers

Five sport sedans for the water clash in our test.

76 Serious Shades

High style gives way to high-tech optics.

ELECTRONICS

25 Electronics

From microchips to megawatts: Understand it all.

50 Audio

Tips and new-products: A treat to your ears.

DEPARTMENTS

4 Editor's Notes 7 Letters 10 Time Machine

123 Worth Writing For 138 Next Month

EDITOR'S NOTES

I ADMIT IT. I'm an old-car nut. There's something about cars of the '40s, '50s and '60s that is simply not there for me in new cars. Call it character. Call it charisma. Call it what you like. For me, old cars have it. New cars don't. My current old-car possessions include a 1957 Ford Thunderbird and a 1969 Chevrolet Camaro Rally Sport convertible. Both have been restored and regularly compete in local car shows although they're not restored well enough to win anything in competition. Even so, we're pretty reluctant to drive them around and risk all the work, time and money we've put into them in the restoration process. So there is the old-car enthusiast's dilemma—what good is fixing up and restoring an old car if you're afraid to drive and enjoy it? Now, here comes National Car Rental with the solution—at least if you're in the Los Angeles or




I drove a 300H and Corvette while . . .



. . . Swan and Frank pushed an MG.

stealth aircraft, it's not surprising that both the Army and Navy are actively investigating land-based weapons systems and seagoing warships with low visible signatures that make them harder for enemy radar to detect. We reported on a new generation of tanks and armored vehicles in our May 1988 issue (page 68). Now, here's what the Navy is doing. Our story, "Battlecruiser 2000," on page 56, describes a whole new surface Navy with ships that are totally different in appearance—and function. The new ships will serve merely as launch platforms for missiles and will probably never even be within sight of an enemy ship or target. The whole operation will be controlled by remote-sensing and computers. A far cry from the classic naval engagements of the past, like Midway and Coral Sea, where great ships clashed head-on with 16-in. guns and planes launched from carriers. I guess that's progress. 'Til next time.


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POPULAR MECHANICS • JULY 1988

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LETTERS

From Woodshed To Would-Be Guest Cottage



WE'VE been sitting on your plans for a woodshed ("Old-Fashioned Woodshed With A Newfangled Look," page 132, Oct. '78) while waiting for our old outhouse to fall down. The raccoons finally made their way through its rotted boards to ravage the garbage cans stored there. And since we had installed indoor plumbing in our nearby summer cabin in the remote forests of the Berkshires, we were ready to replace the outhouse with PM's woodshed. This is how we modified your plans to build the structure you see here: We incorporated raccoon-proof housing for two garbage cans, losing a bit of the wood storage space. We floated the structure on five 6x6 pressure-treated beams on a bed of gravel 1 ft. thick. And we enlarged the shed to 8 x 18 ft. providing us with an 8 x 12-ft. workshop which will eventually be used as an extra bedroom. Thanks for the basic plans to which we added a little inspiration of our own!

KENNETH SCHWARTZ
NEW BERN, NC

Woodshed plans (X802C) are available for \$2 postpaid

PM woodshed plans were modified to include guest room.

from POPULAR MECHANICS, Box 1014, Radio City Station, New York, NY 10101.

Them's The Brakes

Thanks for saving my brakes and maybe my life. Your item in "Car Clinic" (page 28, April '88) answering Gary T. Allen's question about his Pontiac Trans Am parking brake got me to check my '86 Fiero.

Who would have thought it necessary to periodically use your parking brake to keep your rear brakes adjusted? Mine didn't work and my brake pedal had been low when stopping. With a lot of pulling and pumping, the right adjuster started working and after pulling off the rear wheel I got the left to work, also.

I can't believe there's nothing in the service manual to tell an owner that using the parking brake is necessary for rear brake adjustment!

JERRY E. GREEN
FRANKFORT, IN

I checked my Trans Am—it's got 20,000 miles—and sure

enough, the parking brake was useless and the rear discs were coasting. As Mort Schultz warned in "Car Clinic" only the front discs were working! The owners manual doesn't cover the subject and even the factory shop manual is fuzzy about how the park/rear discs work. A jury-rigged affair of springs and weights supposedly keeps things safe. But I wonder how many other Firebird and Camaro owners are driving around thinking they have 4-wheel disc brakes when they only have brakes working at the front.

PRESTON R. HOGUE
DALLAS, TX

Quad's Not First

In "Quad 4: The Inside Story" (page 62, Feb. '88) you referred to the new GM design as America's first 4-valve-per-cylinder engine. But you overlooked the 4-valve Cosworth Vega that Chevrolet sold as a production car in the mid-'70s.

TOM GORE
UNION GROVE, AL

The Quad 4 is, as we said, "the first domestically produced, mainstream multivalve engine." The Cosworth Vega's 4-valve, twin-cam cylinder head came from England. However, we should have further qualified our statement, referring to the Quad 4 as the first "modern" four valve, since several early engines used the idea in a flat-head configuration: Stutz in 1917 and Pierce-Arrow in 1919 are two examples.

1-Man Furniture Factory

My husband, Reno, has been an enthusiastic collector—and user—of POPULAR

MECHANICS since the August 1938 issue. Since he's now age 58, you can see that he has been woodworking virtually all of his life! PM plans, tips and how-tos have seen us through the construction of several houses, boats, yard projects, cabinets, lathe work and years of repairs. Three of his recent projects turned out exceptionally well. Our No. 1 son is delighted with the home desk from the Nov. '86 issue (page 114). Our daughter is thrilled with the classic oak table from July '79 (page 92) and an oak china cabinet that's based on several PM cabinet plans that my husband mentally stored away over his 50-year love affair with your magazine. Our next project is your rolltop desk (page 80, Jan. '76) for our No. 2 son. Many thanks for so many years of pleasure!

NORMA MISSIO
POWELL RIVER, B.C.,
CANADA

Plans for the home desk (Y19), oak table (679A) and rolltop desk (PL-1736) are listed in PM's Plans and Ideas brochure, which is available from POPULAR MECHANICS, Box 1014, Radio City Station, New York, NY 10101, for \$1.95. PM



Table is one of many PM projects built by reader Missio.

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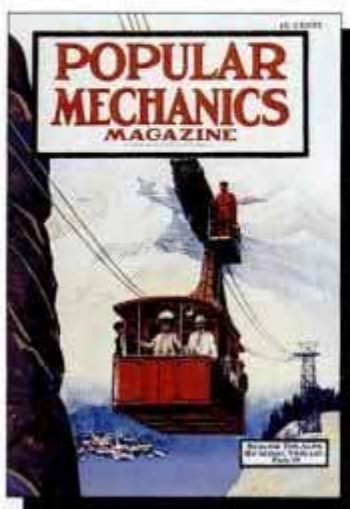
This One



Z9SK-063-WLUE

TIME MACHINE

75 YEARS AGO: JULY 1913



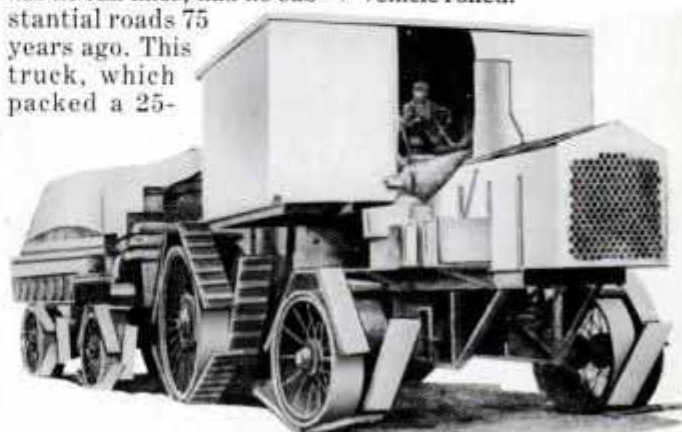
Cliff Climber

In July 1913 PM looked at the easy way to climb the Alps—by aerial cableway. Focusing on safety features of a newly built Tyrolean line, we noted the 1¼-in. steel traction cables, wheels deeply flanged to defy derailment, automatic brakes, wind-swing arresters and backup batteries should hauling motors fail. In addition, in case of total system failure, each car had a canvas basket to lower trapped passengers to the ground.

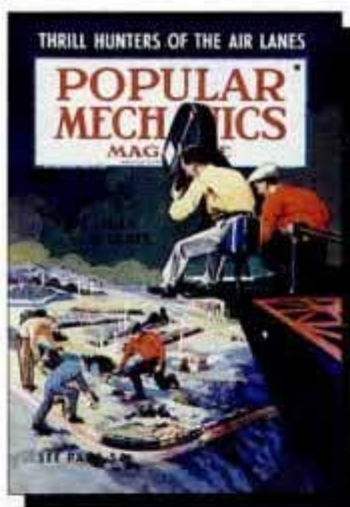
Sand Stomper

The Australian desert, which has no rail lines, had no substantial roads 75 years ago. This truck, which packed a 25-

ton engine, had wheel-planks that were laid down as the vehicle rolled.



50 YEARS AGO: JULY 1938



Movie Model

Fifty years ago our cover featured a model railroad set that was a hobbyist's dream. Laid out over 2400 sq. ft. inside a Hollywood sound stage, the system had 700 ft. of track loaded with switches, crossings, culverts, bridges, signal stations, sidings, towers and cutoffs. On an elevated platform at one end of the stage an operator controlled 15 electrical circuits to start, switch and stop the trains. The mini system served special-effects crews.

Flat-Out Fast

Under construction in 1938, this vehicle held the land-

speed record for 16 years, by far the longest 1-car/1-man reign. In 1939 John Cobb brought the car to 369.7 mph, and in 1947 he hit 394.2 mph. The 3-ton vehicle ran on two 1250-hp engines cooled by ice.



25 YEARS AGO: JULY 1963

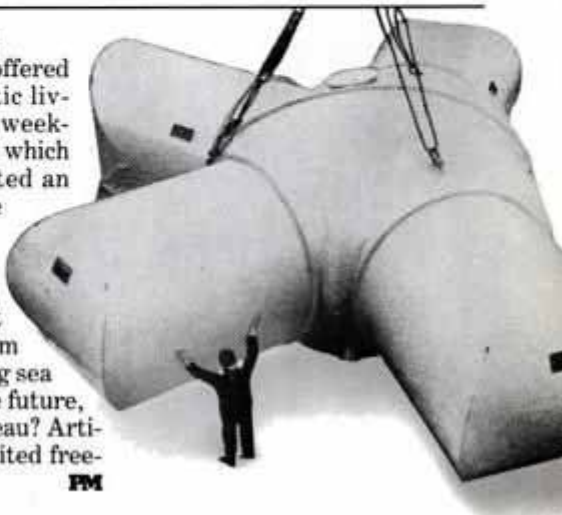


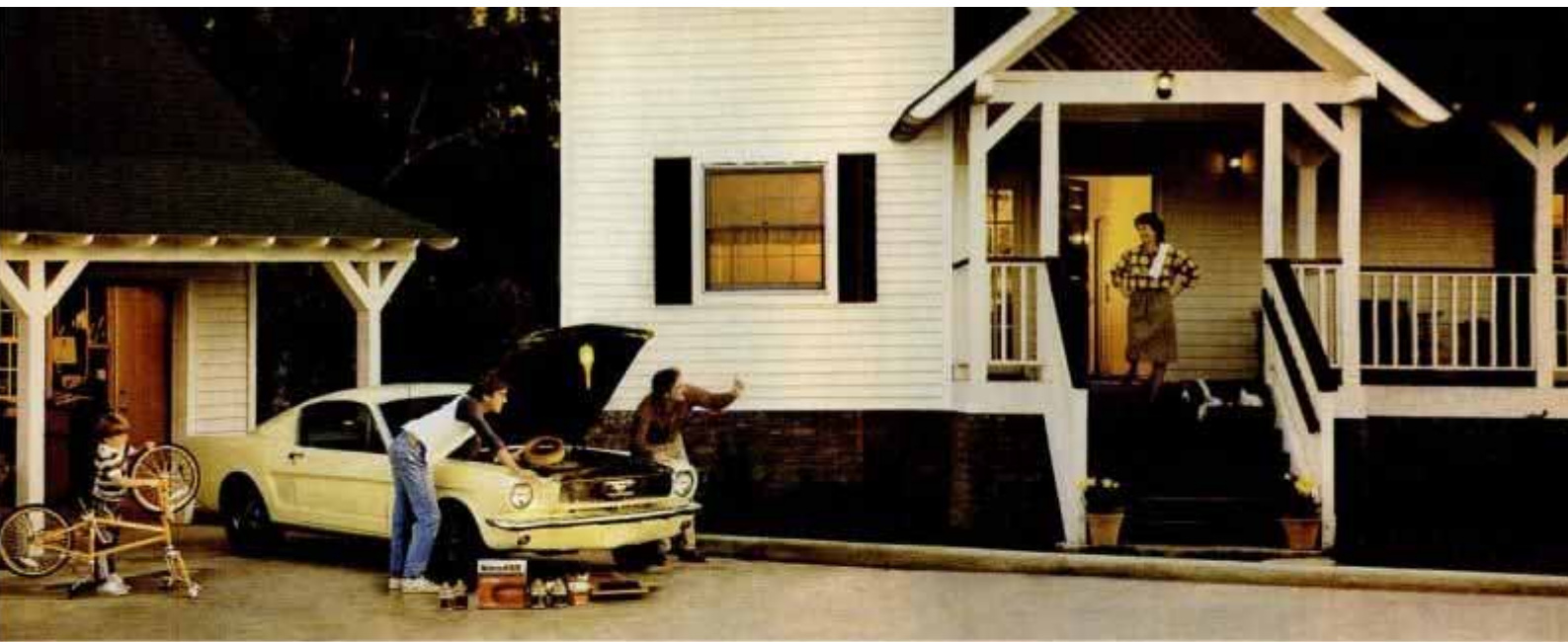
Wet And Wild

Our July 1963 cover showed a jet-propelled hydrofoil Boeing had built for the Navy. The experimental craft featured a fuselage/cabin suspended between two pontoons and hit 60 mph. We compared the flying cat with a plethora of pleasure boats that defied tradition, including a cruiser with a hinged flip-top cabin, an all-open-deck river boat that rode on foam-filled pontoons, and a 28-ft. cruiser with foils that retracted hydraulically.

The Deep Life

Jacques Cousteau offered his vision of aquatic living. He detailed a week-long experiment in which two divers inhabited an undersea module with internal air pressure equal to external water pressure. The next step was a 4-room house for harvesting sea plants and fish. The future, according to Cousteau? Artificial gills for unlimited freedom under water.





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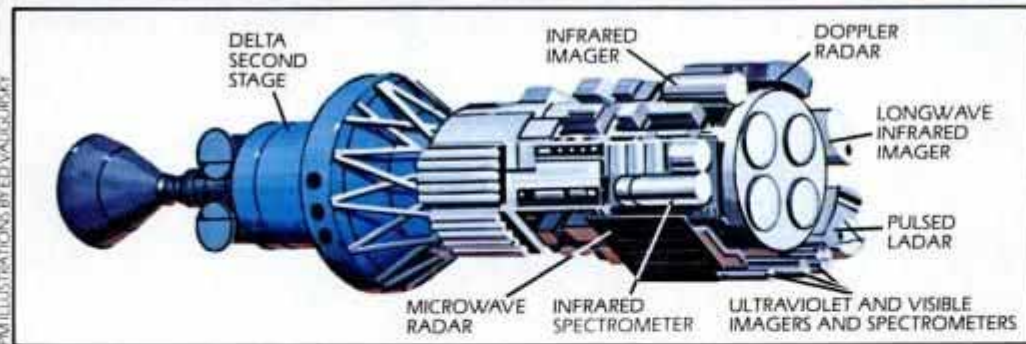
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Smoke Contains Carbon Monoxide.**

© Philip Morris Inc. 1988

Kings: 8 mg "tar," 0.6 mg nicotine av. per cigarette by FTC method.

TECH UPDATE

Space-Based Sensors: Eyes In Sky For SDI



Above, Lockheed-conceived BSTS craft detects heat of ICBMs' liftoff plumes. Mirror in recess guides infrared radiation to concealed array of charge-coupled devices. Functions of external devices are classified. Delta-launched experimental module (left) contains both active and passive sensors, including laser detection and ranging (ladar).

HUNTSVILLE, AL—The Strategic Defense Initiative (SDI) is coalescing into a phase-one Strategic Defense System (SDS) that planners hope to deploy before century's end. Along with hypervelocity interceptors and ground-based monitoring stations, SDS calls for spacecraft bristling with technology for sensing and tracking ballistic missiles.

The boost-phase surveillance and tracking system

(BSTS) has to spot ICBMs before they release reentry vehicles and decoys. Two contractors—Grumman and Lockheed—are now developing designs.

In geosynchronous orbit 22,300 miles above Earth, a BSTS satellite must be able to pick out sudden sources of heat from a field of a quarter of the planet.

An even tougher job will be tracking and identifying reentry vehicles as they are

over the atmosphere. Lockheed and TRW are working up concepts for a Space Surveillance and Tracking System (SSTS) to cover this mid-course phase of missile trajectory. To help the design process, the Defense Department last winter launched via Delta rocket an experimental module festooned with a variety of sensors. At 200 miles above Earth, the spacecraft released test objects to simu-

late both live missiles and decoys, then maneuvered to let the sensors view the objects against space, atmosphere and planet backgrounds.

The increasing dollar amounts slated for sensor development, along with the secrecy sheathing the research, speak to the pivotal role that sensors play in strategic-defense planning.

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



SuperBus negotiates curves more easily than conventional bus. Drivers like front-engine feel.

Tractor-Trailer Becomes Bus

LOS ANGELES, CA—Some commuters are already riding this hybrid vehicle from Orange County parking lots to downtown L.A. The

driver cab is a standard Volvo White tractor model, and a Mexican bus maker has styled the passenger module like an airline cabin. Advantages over conventional buses include substantial savings on maintenance and a fuel-efficiency edge.

Programming Hypercubes

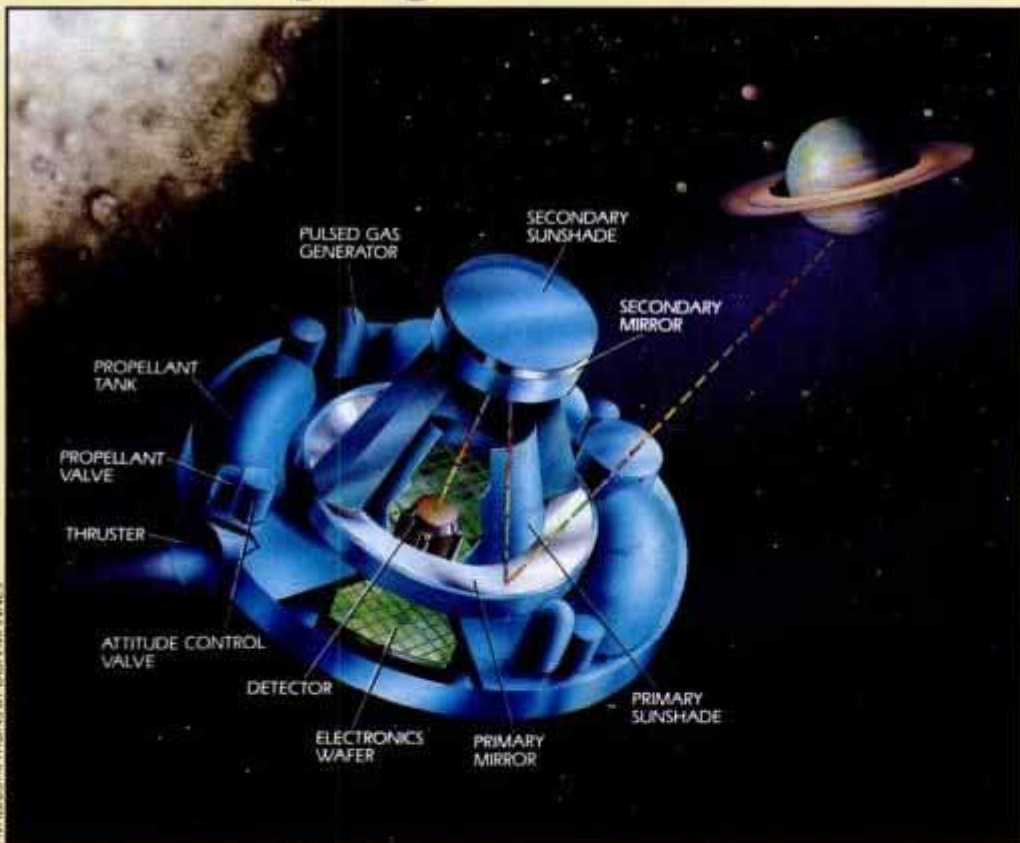
ALBUQUERQUE, NM—This hypercube at Sandia National Labs works 1024 minicomputer-caliber processors simultaneously. Pro-

grammers recently side-stepped a theoretical hurdle to harnessing the machine's full power. The computer now cogitates 10 times faster than once predicted.



World's fastest hypercube.

Earth's Flying Saucers To Probe Planets



Minispacecraft adapted from SDI kinetic-energy projectile design (left) detects radiation from Saturn. Craft is dwarfed by 1970s' Voyager 2 (above).

PASADENA, CA—Ross Jones of NASA's Jet Propulsion Laboratory has proposed using electromagnetic (EM) railguns to launch 10 to 50 small, relatively inexpensive spacecraft every year from low Earth orbit. The 6-in.-wide craft could

perform either flyby or impact missions. Though each vehicle would be limited to only one to three functions, multiple spacecraft could be flown to the same target carrying different experiments. This redundancy could guarantee at least partial success.

One big advantage of EM launch is the extremely high velocities. For example, Jones estimates that a 3-pound spacecraft could achieve an exit velocity of about 22,000 mph, enabling it to travel 750 million miles in two years, aided by additional

on-board propellant. Space scientists could capitalize on EM research already conducted under the Strategic Defense Initiative. Key to the concept's development are instruments insensitive to high acceleration and magnetic forces.

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New Wings For Training Carrier Pilots

LONG BEACH, CA—Starting in 1990, carrier-based fighter and attack pilots will learn the ropes on this 2-place McDonnell Douglas/British Aerospace trainer. The T-45A Goshawk will replace the T-2C Buckeye and TA-4J Skyhawk as the centerpiece for the Navy's new undergraduate jet-pilot training system.

Adapted from British Aerospace's Hawk trainer, the plane has been tailored

for carrier takeoff and landing. Modifications include an arresting hook, strengthened airframe, lateral rather than ventral air brakes, higher-lift wings, and a dual-wheel steerable forward landing gear. The Hawk's single Rolls-Royce engine, developing 5450 pounds of thrust, also powers the Goshawk. It is just under 39 ft. long, with a 31-ft. wingspan.



The first Goshawk flew this spring.

Undergraduate Goshawk pilots will also work out extensively on Honeywell-de-

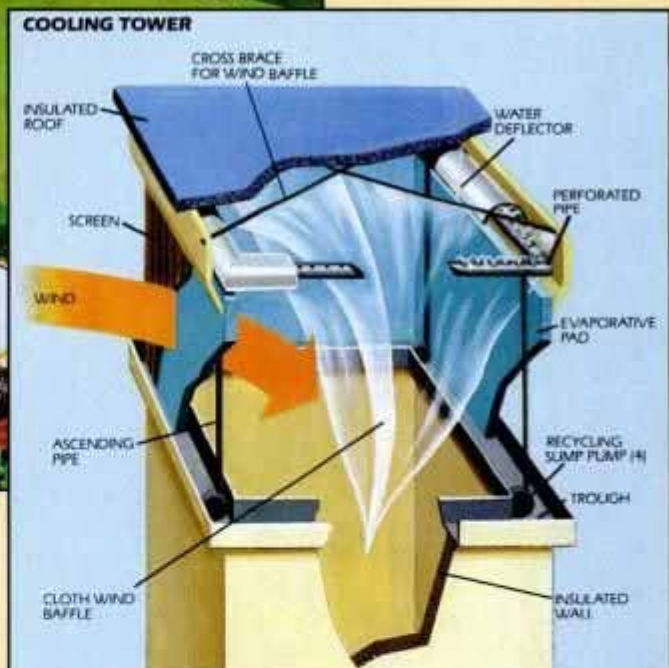
signed simulators. Thanks to the low operating costs of the Goshawk, the overall system is expected to cut the Navy's training costs in half.

BRITISH AEROSPACE PHOTO

Outdoor Air Conditioning In Desert



Hot air enters cooling tower (red arrow), cools and sinks (blue arrow). Detail of tower top (below) shows pump system recycling water to keep pads wet.



PHOENIX, AZ—Simple technology is bringing relief to this broiling desert metropolis. Engineers from the University of Arizona's Environmental Research Laboratory are supervising the installation of 10 30-ft.-high cooling towers in a downtown Phoenix plaza.

The structures recall the Mideast wind towers that deflect breezes over pools of water. The Phoenix towers will work with or without wind, however.

On each side of the tower's top are water-soaked cellulose pads. Sump pumps help distribute water continuously over the pads. As the water evaporates from the pads, the air inside the top of the tower becomes cool and moist. The cool air falls, due to convection, and blows out on to the plaza through double doors at the tower's base.

The pressure drop inside maintains a steady intake of dry air at the top. A cloth baffle captures wind movement from any direction to give this air flow an added kick.

Temperatures outside the doors can be 30° cooler than surrounding areas during summer. Decorating the plaza with plants and sunshades will enhance the cooling effect. The air is more humid, but that's not a problem for a city like Phoenix.

The towers will also work to cool interior spaces, according to project engineer Kathy Kent, if coupled with an updraft exhaust tower. Operating a cooling tower costs about \$5 a month, including water, and the 1/3-hp sump pumps can run off photovoltaic cells. Widespread application will lighten electric utilities' summer loads in hot, arid locales.

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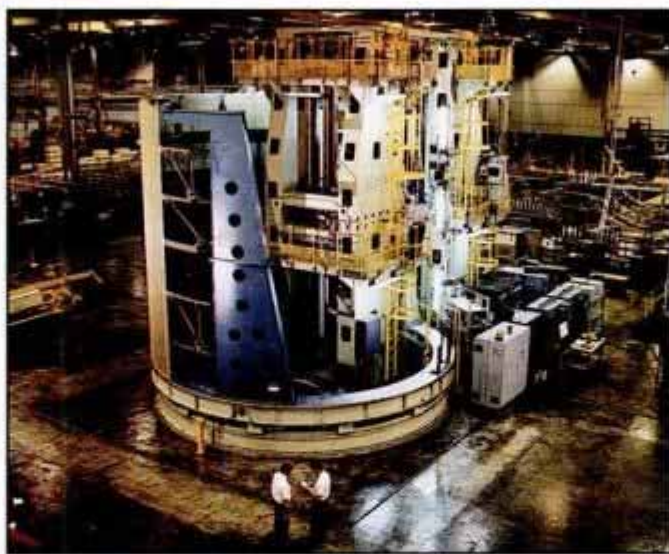
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NASA's Mighty Robot Riveter

NEW ORLEANS, LA—A unique tool assembles the center section of the Space Shuttle's huge external tank. It's a 33-ft.-tall automated riveting machine custom-built by Gemcor Systems and operated by Martin Marietta at NASA's Michoud assembly facility.

Not only is the machine gigantic, but it can rivet on a vertical plane, able to work on high curved sections.

A huge turntable positions the curved sheets of metal that the riveter joins. The machine has two functionally identical upper and lower riveting systems, each with an inner and outer carriage



Ring-shaped positioner moves curved sheets into riveter.

assembly. Both operate independently and can be working at the same time.

Located on the outer carriage assembly is a pneumatically operated automatic

tool changer and a 5-position rivet injection system. The tool changer has an 18-position rotating tool turret containing 12 drill holders and six anvil holders.

The system can automatically select the right size fastener by measuring the thickness of the material to be fastened together. Each riveting assembly has a fiberoptics system to detect missing or misoriented fasteners before injection.

Each system requires a control-station operator and an inner observer.

According to Martin Marietta, the machine can drive 2000 rivets a day when fully operational. The accuracy and quality of the work is expected to save 80 percent on riveting material costs.

Virtual-World Remote Control



MOFFETT FIELD, CA—NASA's Ames Research Center has developed an interactive virtual-environment system for use in space. Controlled by operator position, voice and gestures, the system lets a user explore and interact with a remote site.

A helmet-mounted visual

unit consists of wide-angle liquid-crystal display screens for each eye.

When the user moves his head, a tracking device controls the changes in displayed stereoscopic images sent from remote sensors.

Delivered through headphones, 3-dimensional

sound provides spatially correspondent cues for objects in or outside the field of view. The system also uses speech synthesis and recognition for reporting and response.

For tactile interaction, a user wears gloves with flex-detecting and motion-tracking sensors that transmit the

tele robotically testing pneumatic grasper at Space Station. arm, hand and finger movements to a computer.

Applications being explored include workstations for telerobotics, the management of large-scale integrated information systems, and remote surgery.

Plants Help Purify Sewage

ITHACA, NY—Devised by Cornell University researchers, an experimental facility first runs raw sewage through tanks containing anaerobic bacteria. The microbes absorb toxic substances and digest suspended solid matter, converting the waste to useful methane gas. Effluent from the bacterial tanks then filters through roots of plants grown in shallow hydroponic troughs. The partially treated water is still nutrient-rich and clean enough to nourish healthy plants. Outflow from this stage, once disinfected,



Comparing input with output.

is clean enough to drink. The system generates nursery-quality plants and uses minimal energy.

Building A Better Bobsled



Airflow Sciences engineers craft sled model from clay.

LIVONIA, MI—It's back to the drawing board for the next-generation bobsleds ("Gold Medal Gear," page 72, March 1988). According to sled designers at Airflow Sciences Corp. (ASC), the breakneck pre-Olympic schedule meant the sleds were delivered to the Calgary Winter Olympics before testers could provide good over-track data.

The next step, says ASC's Jim Paul, is the development of two test sleds outfitted with sensors to detect temperature, acceleration, aerodynamic pressure and other factors. Telemetry devices will relay the data to a computer during test runs. Though the two sleds will look identical, one will sport a conventional steel chassis while the other will have ASC's chassis-less fiberglass-composite design.

ASC will pay particular attention to high-frequency vibrations. One issue is whether the sleds perform better when the runners plane smoothly or chatter down the track.

Synthesized Sounds From Saxophone

WEST LINN, OR—Musical engineers continue to forge new hybrids between traditional and electronic instruments. Bringing digital control to this saxophone involved fitting a flex transducer inside the reed, planting an air-pressure sensor at the base of the neck, and replacing the finger keys with electronic buttons. These



features translate performance—lip pressure changes, breath attack and note selection—into digital data. Routed instantly to a synthesizer, the data guide the shaping of sounds. A saxman can even

Cable powers sax's sensors and sends performance data to synthesizer interface (left).

program an onboard micro-computer to doctor his performance data before it leaves the instrument.

Superresolving Microscope

ITHACA, NY—The problem: How to resolve microfeatures smaller than the wavelength of light, without damaging the sample by using shorter-wavelength radiation like X-rays or charged particles like electrons.

Cornell engineers have illuminated such ultratiny objects. The apparatus consists of a superthin aluminum-coated glass tube ending in an aperture $\frac{1}{10}$ th the wavelength of light— $\frac{1}{1000}$ th of a

hair's width. The aperture is fixed at an equally minute distance from the sample, which is lit from below. At such a short object-to-aperture distance, aperture width, rather than wavelength, determines resolution. The technique will yield high-resolution pictures of viruses, molecules and micromachines. **TU**

Sample is scanned and image reconstructed like a TV picture.





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INSIDE DETROIT

BY JIM DUNNE

Ford Escort For 1990

FORD IS testing its planned replacements for the Escort line. This 2-door will be sold by Ford dealers exclusively along with a 4-door version. Mercury dealers will get the 4-door as the replacement for the Tracer that it now imports from Mexico.

The car will be built by Ford in the United States, but much of its chassis design is taken from the Mazda 323. However, Ford will furnish the drivetrain, including engine, transmission and front-drive system.

Note the mask over the rear window and C-post in the photo at right. It covers part of the side glass and the seams of the hatch-door opening. Headlights on this car are of a low-profile type that allow Ford to create a lower hoodline and a lower overall appearance for the car.

Sizing Saturn

GM will build the Saturn in a size halfway between compact and subcompact. That's the plan for the Saturn cars you'll see in late 1990.

Saturn planners have largely abandoned the idea of building a subcompact to compete with the least expensive imports. Instead, the car will be a competitor for Accords, Camrys, 626s and similar models. Three body styles are planned: a 4-door sedan and two 2-door types.

Three New Names

Chrysler will field cars with three new names for 1989—Dodge Spirit, Plymouth Acclaim and Chrysler Imperial.

Spirit and Acclaim are newly designed cars—code-named the A-bodies—that replace Aries and Reliant.



Ford sales mainstay Escort gets all-new skin and Mazda 323 underpinnings for 1990.

The Imperial name has been resurrected to go on Chrysler's new flagship 4-door sedan. Major differences between the Imperial and the current New Yorker are a 4-in. longer wheelbase, a similar stretch in the overall length and an opera window in the C-pillar.

Geo Tracker

The bow-tie badge on the grille of the sport/utility vehicle seen in the photo below says Chevrolet, but the Geo Tracker 4x4 will be built by Suzuki, not General Motors. The 4-place, 4-wheel-drive Tracker is smaller than Chevy's S-10 Blazer, but larger than Suzuki's highly successful Samurai.

Two 4-cylinder engines will be offered, a 1.3-liter for



the base Geo Tracker, and a 1.6-liter ohc all-aluminum performance edition for the premium model.

The hardtop shown here will be joined by a convertible soft-top model in Chevy dealerships sometime late this year or early in 1989. Suzuki dealers in the United States will also get their version—without bow tie—at

about the same time, when they will sell the Tracker alongside the Samurai.

Geo is a new name Chevy plans to use as a marketing umbrella that will cover all its imports, including Sprint and Spectrum sedans. Initially, the Tracker will be built in Japan and shipped here. But in its second year, the vehicle will be produced at a Suzuki plant in Canada.



Chevy will add Suzuki-built Geo Tracker sport/utility entry midway through '89. Hard and soft-top editions will be offered, as well as 4wd.

King Corvette

At Chevy they call it the ZR-1, but it probably will be known by its more dramatic King of the Hill label.

Latest reports on Chevy's 1989½ supercar indicate that the highly complex 32-valve, double-overhead-cam engine won't be repairable at the average Chevy dealership. If something goes, the car will be returned to Chevy's engineering center

(Please turn to page 24)

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- Pioneer Trim Package
- Power Steering
- Intermittent Wipers
- Dual Mirrors
- Rear Step Bumper
- Gauge Group
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- Each game ticket has four multiple choice trivia questions about TV, music, sports, movies and other fun subjects.
- Answer questions by circling the letter in front of your answer.
- Use the four circled letters to spell the "Payoff Word" answer. A "payoff clue" is provided to help you (see Sample Game Ticket).
- Every correctly answered game ticket is worth one "point."
- The goal is to submit an entry with as many points as possible to win prizes (minimum 10 points needed to enter).
- Monthly contests will continue through September 1988. You can enter every month. Or, you can save game tickets for several months to submit a higher point score entry. It's up to you.

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SAMPLE GAME TICKET

• Circle letter to answer question.

1. WHICH CITY IS THE CAPITAL OF MASSACHUSETTS?

- H. Lowell
- D. Haverhill
- B. Boston
- R. Plymouth

2. WHAT IS THE ENGLISH LANGUAGE TRANSLATION FOR THE ITALIAN WORD PIZZA?

- P. Pie
- T. Dough
- S. Delicious
- E. Cake

3. HOW MANY SIDES DOES AN OCTAGON HAVE?

- A. 8
- H. 6
- J. 7
- O. 5

4. WHICH OF THE FOLLOWING IS NOT A PERCUSSION INSTRUMENT?

- Cymbals
- W. Trumpet
- E. Drums
- R. Triangle

• Use circled letters to spell Payoff Word similar to Payoff Clue.

PAYOFF CLUE: UNDERSTAND

PAYOFF WORD: K N O W

• 10 or more tickets needed to enter.
Signature: *John Smith*

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TO PLAY: Every Millionaire Cash Quiz game ticket contains four multiple choice questions and a Payoff Word question. Participants who correctly answer all questions on a game ticket can earn one "point". Answer the four multiple choice questions by circling the letter in front of your answer. Then use the four circled letters to spell the Payoff Word answer in the spaces provided. The "payoff clue" will help you determine the Payoff Word answer. NOTE: There can be more than one choice for the Payoff Word answer. However, there is only one correct Payoff Word answer. The more correct game tickets you submit, the better your opportunity to win monthly cash prizes.

TO ENTER: Game tickets must be answered and signed in ink to be valid. An entry consists of an envelope or package containing 10 or more correctly answered and signed game tickets and a 3 x 5 card with your printed name, address and telephone number. Mail entry to: Millionaire Cash Quiz Entries, P.O. Box 1234, Loretto, MN 55492-1234. YOU MUST add up the number of points (tickets) you have accumulated and print that total point score in the front lower left corner of your entry envelope or package and print your name and complete return address in upper left corner. Entries not valid until received and verified by judges. Total number of correctly completed game tickets sent with entry must equal point score shown on outside of entry or entry is subject to disqualification. Send as many game tickets with your entry as you like (but not less than 10 game tickets), including duplicate (but not reproduced) game tickets.

EVERYONE CAN WIN BONUS PRIZES: Every participant who submits an entry of 10 or more points will receive a bonus prize of \$2.00. Limit one bonus prize per household per month.

MONTHLY CASH PRIZES PLUS \$1,000,000 GRAND PRIZE: \$200,000 in cash prizes will be awarded in each of six monthly contests as described below. The independent judging agency, Promotional Marketing Corporation, Westport, CT 06880, will record the point score of each entry submitted for each monthly contest. A \$50,000 top prize will be awarded to the highest scoring entry each month, the next 10 highest scoring entries will each receive \$5,000, and the next 100 highest scoring entries will each receive \$1,000. Limit one monthly prize of \$1,000 or more per household during the six month contest period. The \$50,000 top prize winners in the six monthly contests will automatically qualify for the \$1,000,000 "Grand Prize Playoff" competition to be held at a site and date to be announced following determination of all \$50,000 monthly winners. The Grand Prize Playoff winner will receive \$50,000 per year for twenty consecutive years without interest commencing 1989. In the event of a tie for any prize, a tie-breaker competition will be used to determine winners.

MONTHLY CONTESTS AND ENTRY DATES: There are 6 separate monthly contests as follows: April,

May, June, July, August and September 1988. To qualify for any monthly contest your entry must be postmarked by the last day of that month and received by the 10th of the month following. The last monthly contest ends 9/30/88. Enter each month or accumulate game tickets and enter any monthly contest you wish. You may submit only one entry to any monthly contest. Monthly winners will be notified by mail within 15 days after the determination of monthly winners.

ELIGIBILITY: Contests open to U.S. residents, AT LEAST 21 YEARS OF AGE. The following persons are ineligible: employees of R.J. Reynolds Tobacco Company, its affiliates and subsidiaries, and of its advertising agencies, suppliers and independent contractors engaged in the development or production of materials for this contest, or immediate families of the foregoing. All entries must be submitted in the name of an individual person and prizes can only be awarded to the person whose name is listed on the entry. Winners will be required to sign Eligibility Affidavit and Release, and must agree to use of their name, address and likeness for advertising purposes without further compensation.

GENERAL INFORMATION AND CONDITIONS: Millionaire Cash Quiz game tickets are available in special packs of WINSTON, SALEM and CAMEL cigarettes. You may also obtain 2 bonus game tickets by sending handprinted request with stamped, self-addressed envelope to: Bonus Tickets, P.O. Box 5699, New Milford, CT 06774. Limit: one request per envelope, person or household per day (WA state residents need not include return postage). All requests must be received by 9/15/88. There are 1,000 different game tickets. Winning requires factual knowledge in sports, music, television, movies and other general knowledge subjects. By entering, participants agree to be bound by these rules and the decisions of the judges which will be final. All entries become the property of R.J. Reynolds Tobacco Company and will not be returned. Participants accept all responsibility for late, lost or misdirected mail. Entries sent with insufficient postage will be disqualified. All federal, state and local laws and regulations apply. Void in VT, MD, KY, AZ and where prohibited by law. No substitution, transfer or exchange of prizes. Taxes are the responsibility of winners. Entries subject to disqualification if game tickets are mechanically copied, reproduced, mutilated, counterfeited, altered, defaced or tampered with, or if containing printing or other errors. Any attempt to forge game materials or to commit fraud will be subject to criminal prosecution. Contest may be cancelled at any time with appropriate notice. For list of major winners, send self-addressed stamped envelope to WINNERS LIST, P.O. Box 5522, New Milford, CT 06774. Questions were prepared and answers verified by the editors of The World Almanac® and Book of Facts. Participant waives any claim or right in the event of any ambiguity or error in a question or answer.

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INSIDE DETROIT

(Continued from page 20)



Bronco II 4-door proto after crash testing.

in Michigan for repair. When the current Corvette was introduced five years ago, Chevy officials promised that it would be world-class. Given the ZR-1's estimated top speed of 170+ mph, with handling capabilities to go with the muscle, the new car's performance will keep the bow-tie publicity people working overtime to find some new superlatives.

Project Crash

Despite the appearance of the crash-test prototype above, Ford has not abandoned its plan to introduce a new 4-door version of its Bronco II sport/utility vehicle in 1990. The wreckage is part of the development that every new vehicle goes through in order to satisfy Federal safety regulations.

This hulk is what remains of the Bronco II body after a high-speed frontal collision into a concrete barrier.

What it suggests, in this instance at least, is that there is more work to be done in reinforcing safety sections of the vehicle's body.

Buckling at the cowl and in the rocker panel are faults that must be corrected in the final Bronco II body. It appears that a previous test of this body was also run, as evidenced by extra target markings that still appear on the sheetmetal. Estimated speed of the vehicle in this crash—30+ mph.

Hope For Fiero?

Rumors abound in Detroit about the future of Pontiac's Fiero, a car that currently has no future at all—not officially, anyway. Nevertheless, stories persist of outside companies proposing a joint venture with General Motors to build a newer version of the 2-seat sports car.

They go like this: The car will be given new exterior styling, a roomier interior and a turbocharged V6 engine.

With those moves taking care of most of Fiero's shortcomings, and also presenting a fresh appearance, the future Pontiac Fiero would sell at a money-making price of \$16,000 or slightly more.

However, industry insiders aren't holding their breath. They think the car is gone forever, the victim of high insurance rates, more competition from overseas, and a general decline in the 2-seat sports-car market.

FM

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ELECTRONICS

BY STEPHEN A. BOOTH

Small But Colorful

IT IS NO small coincidence that downsized electronics products begin arriving on store shelves in time for the warm weather months. Summer's the time when people most appreciate small, portable items as traveling companions for vacations or even daytrips. As pointed out in last month's column ("Electronics," page 28), battery usage continues to rise, and the sales curve plots almost like the temperature on a weather graph. Now, you can add LCD color TVs to the list of portables for which you'll buy batteries.

At this writing, liquid-crystal display (LCD) color TVs are available from Magnavox, Sharp and Sony. In screen size (3-in. diagonal), operation and technology, the three units are quite similar. Another similarity is price: In one word, high. The Magnavox Personal View carries a suggested retail sticker of \$449. Sharp's Crystaltron and Sony's Color Watchman weigh in at \$600. Of course, actual street prices will be lower, but you get the picture. For about the same money you might purchase a 19- or even 25-in. set and still have change for TV dinners. With LCD technology, you're paying for the privilege of taking your living room on the road.

I recently had the opportunity for a hands-on workout with the Magnavox unit. In future columns, I'll report on the Sharp and the Sony (the latter also includes FM stereo radio). For the time being, an examination of the Personal View will serve to explain how color LCD works and the reason for its high price.

Why the cost disparity between these new color TVs

and the black-and-white, 2-in. LCD models that have been around for years and often sell for well under \$100? Color, as you might expect, has something to do with it. But in terms of brightness, contrast and image quality, the new sets stand head-and-shoulders above the older ones, owing to their use of thin-film transistor active-matrix displays.

How they work

The LCD TV's portability owes to the thinness of the screen—only $\frac{1}{8}$ in. thick. Across the $1\frac{1}{4}$ -in.-high \times 2 $\frac{1}{2}$ -in.-wide surface of that screen are (in the case of Magnavox and Sharp) 92,160 picture elements (pixels) that project the TV image. The pixels are arranged in lines, 240 per line from the top to bottom of the screen, 384 per line running from the left to right side of the screen. A color filter layer over the pixels alternates dots of red, green and blue.

Using the active-matrix drive system, each pixel is individually connected to its own thin-film transistor, which transmits the voltage changes that correspond to changes in the moving TV picture. These changes can come every $\frac{1}{30}$ of a second, the frequency of a TV frame.

Because each pixel in the 240×384 matrix is individually addressed, there is no danger of the picture information spilling over into adjacent pixels. This was not the case in older, passive-drive systems, where the picture information had to travel the entire length of the vertical and horizontal lines to address an individual pixel. Voltage leaks along the way would cause crosstalk with adjacent pixels, resulting in poor contrast.



Portable color TV is shown here half actual size.

Other elements that contribute to the sharpness and accuracy of the new LCD TVs is a black matrix mask that separates the individual pixels, the use of improved liquid-crystal materials, and a built-in backlight whose color temp is close to that of natural light (from the Sun).

An active-matrix set is more difficult to manufacture than a passive system: The slightest imperfection or bit of dust means the entire panel must be rejected. This is partly reflected in their high price, which should come down as manufacturing yields improve and as more competitors enter the field.

Built-in versatility

In addition to VHF and UHF reception (through a built-in telescoping antenna or, with an adapter, from external antenna or cable) these color LCD TVs can display pictures from VCR, video camera or other video source. Power comes from a supplied AC-to-DC adapter, optional car battery adapter, or from alkaline batteries (five AA cells for Magnavox and Sharp, four for Sony).

Magnavox cites 2 hours of battery life when the screen is viewed in the lowered position (to use the backlight). With the screen raised (as shown here) to take advantage of ambient light, battery life is 4 hours. I found both specs to be uncannily on target. As the batteries near exhaustion, the picture goes to b&w briefly, then vanishes, and shortly thereafter the audio goes mute.

You can conserve a bit of power by using the supplied earphone instead of the built-in loudspeaker (whose sound quality is as excellent as the picture's quality). But don't count on using ambient light too often. For one thing, it's difficult to angle the screen just right to grab a free ride from a sunbeam. And outdoors, you'll more often than not need the added brightness of the backlight to overcome reflections in the screen. Magnavox, by the way, does offer a sunshade, NiCd rechargeable battery pack, and a more powerful, angled backlight as options. Stay tuned for a viewer's report on the Sharp and Sony models. **FM**

IMPORTS

BY BILL HARTFORD

More Convertibles On The Way



YOUR annual urge for a convertible pops up with the crocuses. Admit it. The little green tips of envy surface—usually in March—when you see those neighborhood kids. They're always the first to throw back the top on that clunker of a convertible. Time to start harvesting color brochures from your local dealers.

Usually, the urge passes. If it didn't, convertibles would be the only cars from the world's automakers. So, June 21st comes and goes, and you've survived again. But look out! In recent years, ever-returning spring has seen more topless models to choose from.

Isle Of Capri

One of the most eagerly awaited soft tops for '89 bears a recycled nameplate: Capri. Lincoln-Mercury promises the car will be an affordable roadster. That means about \$15,000. The Capri, which can be seen in preproduction metal at this year's auto shows, will be built in Australia. The practical part of the package is that it's based on Mazda's highly regarded 323, with its reliable and quick, 1.6-liter,

Mercury Capri, with Ghia styling, Mazda power and reasonable price, will be in production for top-down motoring next spring.



fuel-injected Four. Top Capri will get XR2 designation and a 132-hp hop-up.

Little Lotus

Another anxiously awaited roadster, at least among aficionados willing to go up to \$25,000 for their tanning machines, is the Lotus M100, to be called Elan, another recycled nameplate. Potentially a 150-mph road burner, the lightweight British creation will owe its performance to a weigh-in of 1600 pounds, coupled with 160 hp from the turbo version of its powerplant: Isuzu's 1.6-liter, 16-valve

Four. The Isuzu connection is by way of GM, which now owns Lotus Cars and has Isuzu as a Japanese partner. Lotus will sell the Elan in the U.S. market through a network of about 100 dealers.

The roadster's composite body has a low C_d of 0.32. For scale, just imagine a topless Honda CRX and you'll have an idea of how you'll feel at the wheel.

Stitch In Time

Canvas is in the cards for the tops of some existing hard-tops, too. The Sterling will likely get a power soft top for

'89 and Jag's XJ-S convertible top may be factory-stitched soon. Detroit is as active as the importers, with plans to let the Sun shine into the Buick Reatta and Pontiac Firebird, for example.

No Waiting

But if you've put off the top-down treat for too long and aren't going to wait a sunny day longer, you can find full convertible models among a third of the import manufacturers. Remember, we're talking true topless here—no T-tops or Targas.

Most easily affordable are Alfa, Toyota and VW. The Cabriolets from VW are between \$15,000 and \$17,000 and offer roll bar and back seat. Toyota's Celica is under \$20,000, as are Alfa Romeo's Graduate and Veloce. The loaded Quadrifoglio is \$25,000. Also in that price range is Mazda's RX-7.

Beginning at \$30,000 are Saab's 900 and BMW's 325i. Convertibles from \$40,000 to \$86,000 are from Maserati, Mercedes, Ferrari and Porsche. Sunshine money from \$150,000 up to \$200,000 must be paid for Aston Martin, Bentley and Rolls Royce. Too hot to pop the top? **PM**



Lotus Elan roadster, with 1.6-liter Isuzu Four up front, comes here from England spring '90.

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OLD HOUSE RESTORATION

BY BOB VILA

Restoration Faucets And Fittings

LAST month, we saw that the market for reproduction bathroom fixtures—like pedestal sinks, high-tank toilets and claw-foot tubs—is alive and thriving. This month we'll look at some faucets and fittings that make a period bathroom complete.

Thanks to suppliers in this end of the reproduction business, outfitting an antique bathroom fixture or a new repro model isn't too difficult. And for those of you who only want the real thing, you can always take a chance on a salvaged faucet or fitting.

Antique styles

As I explained in my last column, the advent of indoor plumbing during the Victorian era has simplified the choices in period bath remodeling. In most cases, creating a period bath means, quite simply, taking the fixtures and fittings back to the Victorian period.

Many of the old, quality faucets and fittings were either solid brass or nickel plated. The less expensive chrome-plated brass became popular in the '30s.

Most of you are probably familiar with old-fashioned faucets. One style is the spoke or cross handle faucet, usually made of porcelain or brass. The porcelain handles are labeled **HOT** and **COLD**. Sometimes, the brass handles have porcelain buttons marked **H** and **C** top center.

Another is the lever handle, also found in porcelain or brass. The style of the lever varies. Some are oblong, while others may have a curlicue on the end. Again, the levers are commonly

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



This solid brass lavatory faucet features large porcelain handles, labeled **HOT** and **COLD**, and oversized antique escutcheons.

marked **HOT** and **COLD**.

Many early bathroom sinks didn't have mixing faucets. If you're an old-house owner, I'm sure you're familiar with this situation. These old sinks often have a chain stop between separate hot and cold taps. A common mistake I've seen is for people to assume they can install a reproduction single-spout mixer to this center hole. Usually, the hole is just too small to accept a standard fitting. So you have to drill to make it bigger. If the sink is made out of vitreous china, it's nearly impossible to do this without destroying it. Even if it's cast iron, you've got to be extremely careful not to crack and chip. Fortunately, the reproduction market has made allowances for this situation. Some suppliers offer single-hole mixing faucets that can be used on basins with holes.

You can also find reproduction bathtub fittings that match what you've chosen for your sink. Many of the popular cross- and lever-

style handles are available with mixer faucets and diverters for tub/shower use. Since the holes on the front of a tub have remained fairly standard over the years, you shouldn't have a problem finding a repro fitting to refurbish an old tub.

As far as toilets go, the old high tanks had chains with pulls generally made out of porcelain or wood. Levers on the low-tank toilets were usually porcelain, brass, a combination of the two, or nickel plated. Again, you should have no problem finding suitable reproductions.

The salvage story

For the most part, expect to pay more for reproduction fittings than an original. All purism aside, perhaps the biggest advantage the former has over the latter is that all the pieces are there! If you're familiar with the intricate world of plumbing parts, you know that this is no small matter. A repro fitting is usually easier to install than a salvaged one and, of

course, you have the added bonus of knowing it'll work when you're through.

True, you can find some bargains in salvage yards. But even though a piece may be polished and plated and look great, there's no guarantee that it'll work when you get it home. So unless you know what you're doing when it comes to do-it-yourself plumbing, I don't suggest going this route. If you end up calling in a pro to do the installation for you, there's a very good chance that the labor cost will jack the price of your bargain way over that of a new reproduction.

If you're lucky enough to have the original old fixtures in your bathrooms but don't want the nickel or chrome plate, you can strip them down to the solid brass base by having the plating removed. Although this process is usually cost prohibitive for most folks (I know a shop that typically charges \$200 to strip an average 10-piece faucet), if your old fittings are irreplaceable, it may be an option.

There's always a chance that all the parts to an old faucet set do not have a solid brass base. If that's the case, these pieces must be individually plated to match the rest of the fixture—which will add even more to the cost of this work. Sometimes, you can chip or scratch through the nickel or chrome plate in an inconspicuous spot to see what's underneath.

If you do decide to go this route, unless you want to polish the brass fittings once a week, make sure you have the brass lacquered. Of course, I have heard of some purists who order brass reproductions without lacquer. But unless you're one of

Brass tub faucet with shower riser and head from Chicago Faucet Co.



them, opt for the lacquer or you'll be sorry each cleaning day.

You can also have this process done in the reverse. Have the fittings stripped and then replated with nickel, chrome or even brass. (The latter is done on painted, cast-iron claw-foot tub legs and is usually the most expensive.)

Hand in hand with the high cost of this process is the problem of finding someone who can do this work. Many of the shops that will do jobs like this specialize in plating automotive parts. Look in your *Yellow Pages* under Plating or Metal Finishers.

So, thanks to the suppliers who make

reproduction fittings and faucets available, there's no reason why you can't complete your period bathroom with the right fittings. Just keep in mind that it doesn't pay to skimp on these final details. If you go the first-class route initially and buy top-quality faucets and fittings, you're bound to have less plumbing problems down the road. Make sure you allow for this in your restoration budget. Also, keep in mind that many of the companies in the list below also offer a variety of bath accessories, like towel bars, soap dishes and toilet tissue holders, that further complement this period look. **PM**

Source List

Following is a list of some suppliers of period bathroom fittings:

- A Ball Plumbing Supply, 1703 W. Burnside St., Portland, OR 97209, (503) 228-0026
- Antique Baths and Kitchens, 2220 Carlton Way, Santa Barbara, CA 93109, (805) 962-8598
- Barclay Products Limited, 424 North Oakley Blvd., Chicago, IL 60612, (312) 243-1444
- Bathroom Machineries, D.E.A., Domestic Environmental Alternatives, 495 Main St., P.O. Box 1020, Murphys, CA 95247, (209) 728-2031
- Besco Plumbing, 729 Atlantic Ave., Boston, MA 02111, (617) 423-4535
- The Brass Finial, 2408 Riverton Rd., Cinnaminson, NJ 08077, (609) 786-9337
- Cumberland General Store, Route 3, Crossville, TN 38555, (800) 334-4640, (In TN, [615] 484-8481)
- Decorum Hardware Specialties, 235 Commercial St., Rt. 1A, Portland, ME 04101, (207) 775-3346
- Mac The Antique Plumber Inc., 885 57th St., Sacramento, CA 95819, (916) 454-4507
- Remodelers & Renovators: Supplies For Vintage Houses, 1920 N. Liberty, Boise, ID 83704, (208) 323-1089
- The Renovator's Supply, Inc., Millers Falls, MA 01349, (413) 659-2211
- Restoration Works Inc., P.O. Box 486, Buffalo, NY 14205, (716) 856-8000
- Roy Electric Co., Inc., 1054 Coney Island Ave., Brooklyn, NY 11230, (718) 434-7002
- The Sink Factory, 2140 San Pablo Ave., Berkeley, CA 94702, (415) 548-3967
- Sunrise Specialty, 2204 San Pablo Ave., Berkeley, CA 94702, (415) 845-4751
- Victorian Warehouse, 190 Grace St., Auburn, CA 95603, (916) 823-0374
- Watercolors, Inc., Garrison On Hudson, NY 10524, (914) 424-3327

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CAR CLINIC

BY MORT SCHULTZ

Escort Enigma

MY FAMILY has four Ford Escorts—two 1985s, a 1986 and a 1987. Each has presented us with the same two problems. One is a white emulsion in the crankcase oil that collects on the dipstick despite the fact that oil is changed more often than Ford recommends, and a new filter is installed each time. The other problem occurs after the cars are driven and parked. Water drips from their tailpipes. This has resulted in the mufflers on two of the vehicles rusting through and having to be replaced.

Two Ford dealers label these conditions "normal and harmless," but I am still concerned about these conditions in my Escorts. Can you rescue me?

JOSEPH M. SNYDER
ST. CLAIR SHORES, MI

First, let's let Ford have its say: "There is no problem. A white-brown substance, which is caused by moisture,

burns off when an engine gets hot. So does the moisture coming from the exhaust system. It appears as if Mr. Snyder and his family drive mostly short distances."

The company's position regarding the emulsion build-up is addressed in Technical Service Bulletin (TSB) 85-10-11 as follows:

"A white-brown colored substance may collect on the oil dipstick or inside the fill cap during operation in extremely cold temperatures. The condition is normal and due to the internal vent system of the engine. Care should be taken so it is not misdiagnosed as an internal coolant leak."

The internal vent system is a fixed-orifice crankcase ventilation system and not a positive crankcase ventilation (PCV) system, which features a movable PCV valve.

Escort is one of the few domestically built engines using a fixed-orifice crankcase ventilation system, which is

more common to imports.

TSB 85-16-7 reemphasizes that the white-brown substance can develop in "extremely cold temperatures" and that an accumulation of "moisture condensation" resulting from using a fixed-orifice crankcase ventilation system is the cause. However, this bulletin recommends revising the ventilation system for better results if the engine is not equipped with electronic fuel injection: for example, engines offered prior to the current 1.9-liter powerplant, which came on-stream in 1986. As a consequence, this advice may apply only to your 1985s.

As for the problem of water dripping from the tailpipes, combustion of a gallon of gas may produce as much as a pound of vaporized water, so it's not unusual to have droplets coming from a tailpipe, especially before an engine warms up. What's bothering me is your statement that the discharge is appearing after driving the cars and parking. Does this mean driving the cars a short distance and stopping so the exhaust system is still cold? (It takes longer for the exhaust system to warm fully than it does for the engine.) If short-trip driving is the norm, then some water discharge can be expected. But if discharge occurs after driving the vehicles a considerable distance, it may not be normal.

As you can tell, there are several questions here that only you can answer in order to draw definite conclusions. If the moisture you see dripping from your exhaust, and collecting in the crankcase is actually coolant leaking from the cooling system, then the level in the recovery tank will be dropping to match. If the condition you describe is ac-

companied by a steady loss of engine coolant or overheating, you might want to arrange a meeting with a Ford factory field representative, through your dealer, to have all four Escorts evaluated. I suggest you ask the rep to inspect for internal coolant leaks (unlikely) and to determine if the revised ventilation system described in TSB 85-16-7 is applicable to your 1985 and 1986 models.

Rack And Ruin

My 1985 Subaru station wagon has a leak in the steering rack assembly. The dealer says it will cost \$1000 to repair. Wouldn't you say that a steering rack which goes bad in less than three years is a steering rack that was poorly manufactured? Is there some sort of secret warranty covering this situation?

ROBERT STEBLER
PITTSFIELD, MA

One of the things that is sometimes referred to as a secret warranty is simply a TSB which dealership service personnel fail to implement, either because they don't look for them or because they get lost in the mass of documents service departments receive.

However, your argument in this case is clearly with the dealer. One thousand bucks for repairing or even replacing a steering rack assembly is simply too high. Moreover, in a case such as this, the dealer should present the facts to Subaru and let Subaru decide whether it should bear the cost. This is not the dealer's decision to make.

Subaru does offer a seal kit for overhauling the steering rack. The part number is 31263GA-010, or -000, or -001. Which part number suffix applies depends on wheth-

(Please turn to page 37)

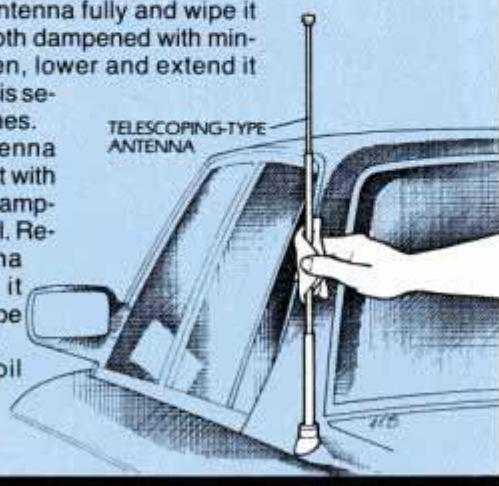
Sound Advice

One way to prolong the life of a power radio antenna is to do what the Delco Products division of General Motors advises. Every two or three months:

■ Extend the antenna fully and wipe it clean using a cloth dampened with mineral spirits. Then, lower and extend it again. Repeat this sequence three times.

■ With the antenna extended, wipe it with a cloth you've dampened with light oil. Retract the antenna and extend it again. Then, wipe the antenna dry.

Don't leave oil on it, or your antenna becomes a dirt collector.



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100's: 14 mg. "tar", 1.2 mg. nicotine; Menthol 100's: 12 mg. "tar",
1.0 mg. nicotine av. per cigarette by FTC method.

An American classic magnificently crafted as
an exactingly engineered die-cast metal replica.

Duesenberg SSJ
A



Shown actual size

© 1987 MGI

Материал, защищенный авторским правом

Beautiful inside and out.

Your model includes a meticulously detailed miniature of the Duesenberg SSJ overhead cam, 32-valve engine. The finish of the car is painted and waxed by hand.



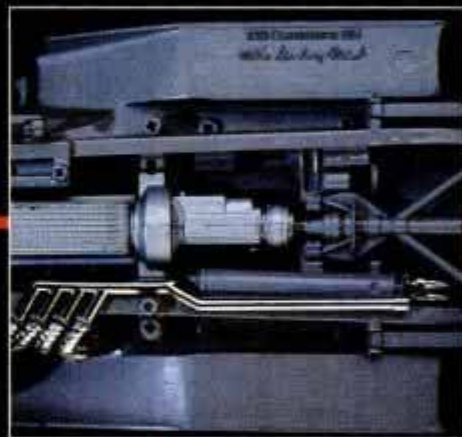
Special touches.

The seats and door panels are real leather. The pedals, controls and instrumentation are detailed. The doors and both sides of the hood open, and the steering wheel turns the front wheels.



Detailed undercarriage.

The SSJ's springs, axles, drivetrain, and frame are all faithful to the original SSJ.



A legend you can hold in your hands.

The Duesenberg SSJ...the most legendary of all classic cars...the fastest, best-handling and most opulent of all Duesenbergs. Only two were ever built, and both are virtually priceless.

And now, a meticulously detailed replica of this fabled classic car—the Duesenberg SSJ—can be yours.

Remarkable attention to detail.

The Danbury Mint devoted over twelve months of painstaking research and development to recreate the Duesenberg SSJ in large 1:24 scale. The resulting model is so detailed, it is virtually impossible, when looking at a photograph, to tell whether it is of the model or the actual car. (Photos here are of the model.)

All the important components—the body, chassis, drivetrain and engine block—are crafted of metal. The seats are glove leather and the tires are genuine rubber.

Each component of this model is individually inspected, then hand-assembled. Note the gleam of the model's finish. It is achieved by polishing each piece of metal, then hand-spraying the paint finish. Finally, and perhaps most remarkably, each car is actually hand-waxed.

Surprisingly modest price.

The Duesenberg SSJ is the stuff of dreams—but the original issue price of this Duesenberg SSJ replica is only \$88.50, payable in three monthly installments of just \$29.50 each. This is an exclusive commission available only by direct subscription from the Danbury Mint; it is not available in any store.

Satisfaction guaranteed.

To reserve a Duesenberg SSJ in your name, you need send no money now. You will be billed in three convenient monthly installments, your first in advance of shipment. If you prefer, you may charge each monthly installment to your VISA or MasterCard account.

If you are not completely satisfied, for whatever reason, you may return your Duesenberg SSJ within 30 days of receipt for a prompt refund or replacement.

Act now to avoid disappointment.

Production of this superb, hand-assembled, hand-finished model cannot be rushed. To avoid disappointment, we urge you to mail the attached reservation application today.

RESERVATION APPLICATION

Duesenberg SSJ

The Danbury Mint
47 Richards Avenue
Norwalk, Conn. 06857

Please
return
promptly.

Please accept my reservation application to the Duesenberg SSJ. I need send no money now. I will pay for my Duesenberg SSJ replica as billed in three monthly installments of \$29.50 each*, the first in advance of shipment.

My satisfaction is guaranteed. If I am not completely satisfied with my SSJ, I may return it within 30 days of receipt for prompt replacement or refund, whichever I wish.

*Plus \$1.25 per installment for Shipping & Handling.

Name _____

PLEASE PRINT CLEAR

Address _____

City/State _____ Zip _____

Check here if you want each monthly installment charged to your: MasterCard VISA

Credit Card No. _____ Expiration Date _____


Signature _____

Allow 8 to 12 weeks after payment for shipment.

F248

BEL TECHNOLOGY DETECTS NEW Ka BAND (PHOTO RADAR)

Don't Be Left Defenseless. Drive With BEL VECTOR 3 Radar Detector.

 Ka Band is the new police radar frequency now in use. And only the new BEL radar detectors are able to detect Ka Band.

Facts You Should Know

The Federal Communications Commission has approved Ka Band for police radar use. And now, many localities in the U.S. and Canada are using Ka Band Photo Radar. But the use of Ka Band isn't limited to picture-taking radar equipment. Standard police radar units can also utilize Ka Band. And as more states quietly introduce Ka Band radar, drivers with only X and K Band radar detectors are left defenseless. Unless they're driving with the new VECTOR 3.



VECTOR 3 comes with everything you see here.

No Quick Fix

Ka Band radar has made X and K Band radar detectors obsolete because existing X/K Band radar detectors cannot be adapted to receive Ka Band signals. While the use of Ka Band has changed police radar, new technology from BEL-TRONICS has revolutionized radar detection.



VECTOR 3 measures only 4.66" L x 3.19" W x 1.095" H.

Greater Detection Range

VECTOR 3 detects X, K, and Ka Band radar. And that's significant. But there's more, it's called Image Rejection Technology (IRT[®]). BEL engineers have incorporated this technology into VECTOR 3. The result is incredible performance and greater detection range of all police radar.

VECTOR 3 Knows

VECTOR 3 is a "smart" travel companion. It warns you when X, K, or Ka Band radar is present with separate audible and visual alerts. It also provides a special audio alert when the radar signal transmitted is Pulsed or Instant On. And for added protection, VECTOR 3 is programmed to advise


VECTOR 3 Remote

The advanced technology and performance advantage of the VECTOR 3 is also available in a remote design for only \$299.95. VECTOR 3 Remote utilizes a compact antenna for easy "under-the-hood" installation. And a very small control panel for discreet positioning in any vehicle.

you should its radar detection circuits ever require adjustment. With VECTOR 3, you'll never question whether radar is present.

At Your Service

VECTOR 3 was designed to make early detection of police radar easy and convenient. You can own the new VECTOR 3 today for only \$279.95. Just call toll-free to order. UPS delivery is FREE. Or ask about our Federal Express overnight service. If not completely satisfied, simply return the unit within 30 days for a full refund (factory direct only). VECTOR 3 comes with a full 1 year warranty on parts and service.

 1-800-341-1401 U.S.A.
1-800-845-4525 N.Y. only
1-800-268-3994 Canada



BEL-TRONICS LIMITED
The Intelligent Choice

*Registered trademark of BEL-TRONICS LIMITED



Compact control panel
is only 3.5" L x 2.5" W x .67" H.

CAR CLINIC

(Continued from page 30)

er the vehicle has front-wheel drive, 4-wheel drive or a turbocharged engine. The price for the kit ranges from \$16 to \$30. Add another \$100 or so for labor.

The price for a new rack from the factory is \$200. Again, add \$100 or so for labor. Even allowing a fudge factor of 20 percent or so, it takes some pretty creative arithmetic to make this add up to \$1000.

Green Light District

Part of the time, the air conditioner in my 1984 Toyota Camry works fine. Part of the time it doesn't work at all. When it doesn't work, the little green light in the center of the a/c ON/OFF button starts blinking. I've taken the car to dealers in Arizona, Maine and South Carolina. Not one could tell me what was wrong or what to fix. Would you like to take a stab at it?

MERVIN OAKES
TRYON, NC

That blinking light is a warning that the a/c compressor has kicked off, which, of course, is why there's no cooling. This computer-controlled a/c system incorporates a speed safety sensor that keeps tabs on the rotational speeds of the compressor and the crankshaft. The purpose is to have the sensor tell the computer to shut off the compressor if a 10 percent or so differential develops between the two. This is a built-in safety feature designed to prevent compressor damage.

There are a number of possible reasons for the kind of problem you're experiencing. One is a worn or improperly adjusted multiribbed drive belt. These belts often are used to run several accessories at the same time. Does the a/c not work, say, when there's a large drain on the alternator? Another is an a/c system that's overfilled and causing a buildup of excessive head pressure under certain types of operating conditions.

Then there's the possibility that a break in the electrical circuit that cycles the compressor is alternately opening and closing. (This kind of intermittent open circuit usually is due to a bad terminal connector.)

Finally, I've seen cases where the a/c has switched itself off because the drive belt has gotten wet, slipped and caused an excessive variation in compressor/crankshaft speeds.

Buck Passing

I purchased a 1987 Chrysler LeBaron GTS which was built for sale in California and, therefore, is set up to meet that state's emissions requirements. I live and drive in Minnesota. Can I have the car switched over to meet Minnesota emissions requirements? The reason for doing this involves fuel economy. My

Dipsy Do

Scott Northrip of Hobart, Oklahoma, has a great way of using flat-sided plastic containers filled with fresh engine oil.

"In overhauling a Chevy 327-cu.-in. V8 engine recently to put in my '57 pickup, I decided I couldn't trust any container I had lying around the house to be 100 percent clean—you know, like an empty coffee can. I needed one to hold oil, so I could coat rod and crankshaft bearings before installing them. Just one bit of grit on one bearing, and there goes beaucoup bucks and lots of time spent working on the engine.

"So I bought a plastic bottle of 30W. I poured off about a quarter of the oil before laying the container on one side. I then used a clean utility knife to cut out the other side. The opening made a perfect size for dipping bearings and, of course, I couldn't have had a cleaner environment. Didn't waste any oil, either. Since the bearings were clean and I was careful not to contaminate the oil, I later poured it into the engine."

We like to coat more than just bearings when assembling an engine. This container is great for dipping the top inch of pistons, with rings installed, before sliding them into the block, insuring scuff-free startup and good ring seating.



friend has an identical car and gets 30 to 32 mpg—I get only 26.

ANDREW LUCACHICK
GHEEN, MN

According to the Environmental Protection Agency, there's no law prohibiting what you suggest. I have to warn you, though, that you're looking at an expensive proposition even if you find someone willing to do the job.

If you consult a dealer, chances are he won't have the know-how. So he'll pass the buck to the manufacturer, who will probably decline. A spokesperson in the engine emissions department at Chrysler told me, "Chrysler's policy is not to suggest methods that will alter the original emissions settings of a vehicle."

Modern emissions control systems aren't just hung onto engines—they're integrated into the fuel-injection and ignition systems, and modifying them usually means throwing out everything and starting over from scratch.

According to the EPA mileage guide, your car is rated at 23 city and 26 highway, assuming it's equipped with an automatic transmission. In other words, you're getting good mileage. **PM**

DO YOU HAVE A CAR PROBLEM?

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

SERVICE TIPS

■ Your 1988 Lincoln Continental may have one flaw—an ignition key that's difficult to turn. There's a solution. Have your dealer cut you new keys using Taurus key blanks. They have larger heads than Continental key blanks and give you more to grab.

■ A water leak from either the left- or right-hand side of the dashboard of 1987-88 Honda Civic sedans could be the result of a skimpy seal where the dash support, floor and kick-panel support board join together. Have a dealer reseal the area according to TSB 88-010.

■ Owners of 1988 Chrysler Corp. cars equipped with 2.2-liter turbocharged engine and automatic transmission may encounter stoptight stalling when using a/c. Warning that "the condition may be difficult to verify," Chrysler has issued TSB 18-015-88, instructing dealers to cure the problem by installing a different engine control computer.

■ A low-speed surge from the 7.4-liter engine of a 1987-88 Chevy or GMC truck with the manual transmission in First or Second gear, that can't be eliminated by prescribed shop manual procedures, should have a new PROM installed in the electronic control module. The fix is described in Chevy TSB 88-162-6E.



HINTS FROM READERS

STOP BURGLARY BEFORE IT STARTS! CALL 1-800-468-2100 TODAY!

You'll receive **FREE** details on the breakthrough **HOME PROTECTOR™ "Wireless" Security System...from BLACK & DECKER.**

Now, whether you're away from home...at work, on vacation, a business trip, or on an errand... you can have **reliable** protection for your home.

Introducing Black & Decker's HOME PROTECTOR System...a state-of-the-art, **wireless** security system that guards your home 24 hours a day, every day. Whether you're home or away. Any effort to enter your home is **instantly** met with a formidable line of defense...flashing lights, a powerful siren, and, with our optional "24-HOUR" telephone monitoring service, a call to the police or anyone you choose... **all within minutes of an attempted break-in!**

State-of-the-Art System Delivers Professional Level of Protection!

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every component...door sensors, window sensors, sirens, even the System Controller itself...capable of functioning **independently.**

The moment a protected door or window is moved the entry sensor sends a coded, audible signal to the Controller Unit, which, in turn, activates the System. Even if the System Controller is destroyed, the rest of the system continues to operate!

LESS THAN HALF THE COST of Most Professionally Installed Systems!

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YES! I want to know more about the break-through HOME PROTECTOR Security System. Please rush my **FREE** Information Package by First Class Mail.

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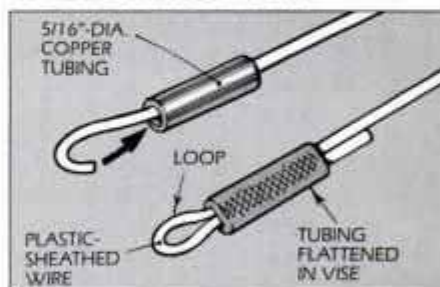
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State _____ Zip _____



BLACK & DECKER®

Clothesline Ends



Plastic-sheathed wire clothesline is a great product, but when I bought some, the dealer was unable to supply me with a way to terminate the ends neatly. To solve this problem, I simply slipped a short length of $\frac{5}{16}$ -in.-dia. copper tubing over one end. Then, I looped the wire over and passed the end back in the tubing. Flattening the tubing in a vise or with locking pliers locks the wire in place.

—Tom B. Gunter

Honing On Steel



Keeping plane irons and chisels in top shape means frequent trips to the whetstone. And, when the stone begins to wear, its hollow shape is transferred to the edge you're sharpening. As an alternative to constantly dressing your stone flat, you can hone your tools on a flat steel plate. The cutting action is provided by a fine abrasive powder such as aluminum oxide or silicon carbide. Spread the abrasive powder on the plate and add a little, ordinary light household oil as a lubricant. Besides doing the job on the bevel edge of the tool, this method works for flattening and dressing the back of the iron or chisel. Both the abrasive powder and honing plate are available from woodworking supply outlets.—Walter Burton

Save Gas, Save Engine with 'POLY'

GUARANTEED LOWEST PRICE (see details below)

The following introduces one of the most fully tested and proven gas saving, friction-reducing engine treatments ever to reach the market!

The Secret is "Poly"

"Poly" is short for polytetrafluoroethylene (TFE), the slipperiest substance known to man. (1981 Guinness Book of World Records). Petrolon Corporation, makers of Slick 50, invented a way to permanently bind this slippery chemical to your engine with one treatment. Just one quart of Slick 50 can reduce engine friction, increase gas mileage and horsepower and reduce engine operating temperature, causing your oil and engine to last longer...plus it reduces metal wear, defraying costly overhauls.

Years of Testing and Use Have Proved it True!

Slick 50 has been thoroughly tested in independent laboratories and out on the road:

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

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

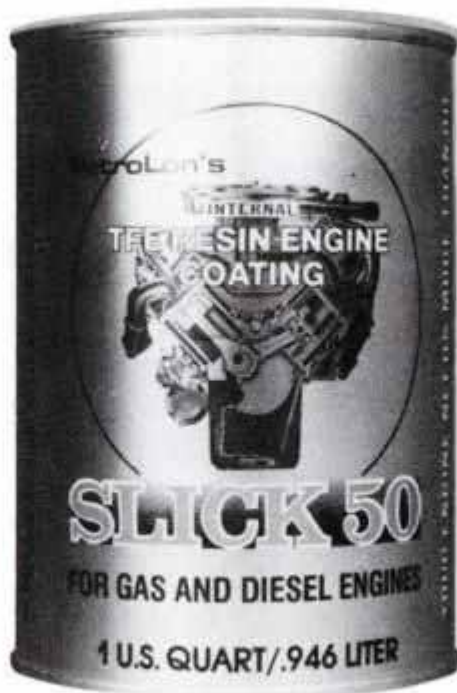
TUV, a German testing laboratory with credentials every bit as prestigious as our Underwriters Laboratories, tested Slick 50 in 1986. They found substantial increases in both gas mileage and horsepower. Their tests showed that these gains were due to a reduction in friction.

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

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

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

Perhaps most dramatic of all is a torture test overseen by the Automotive Services Council for Pennsylvania and shown on 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.

4 Ways Slick 50 Saves You Money

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

1. Increase mileage
2. Increase horsepower (small economy cars and large RV's really need this)
3. Reduce operating temperatures, thus increasing the lubrication and life of the oil and engine.
4. Minimize or eliminate costly overhauls by reducing engine wear

Up to 90% of the engine wear on a car can be caused by lubrication starvation cars experience when first started before the oil begins to circulate. Slick 50 can eliminate this problem for less than the cost of two tanks of gas.

Slick 50 Will Not Affect Your Warranty

Slick 50 is suspended in an excellent grade of petroleum oil which meets or exceeds every manufacturer's engine warranty requirements. In addition, this oil carries an American Petroleum Institute service classification SF-CC-CD.

There's No Risk with Our Money Back Guarantee

Use Slick 50 for 3000 miles. If you don't notice an improvement in engine performance, return your invoice with a short note telling why, for a prompt full refund—no questions asked.

Profit from Selling Slick 50 Yourself

Here's an opportunity to make handsome profits. Having such solid test results from major institutions make Slick 50 easier to sell than many other products. Free dealership information is sent upon request.

GUARANTEED LOWEST PRICE!

If at time of purchase you have seen Slick 50 advertised in a current magazine at a lower price, we will beat that price by \$2.00 per quart.

For purchase or further information call toll-free 1-800-525-8624, ext. 7 (in California 1-800-233-9559) or send to: Progressive Energy Corporation, 255 South Bent Avenue, #B1, Dept. PM788, San Marcos, California 92069.

Yes, I want to improve my car's performance and save my engine—rush me risk free:

One Slick 50 at \$39.95 + \$4.00 shipping and handling. Calif. Residents add 6% Sales Tax.

Give me free shipping and handling for my order of 2 or more at \$39.95 each.

Check C.O.D. Visa/MasterCard
Card # _____

Exp. Date _____

Name _____

Address _____
(Give street address if possible for UPS delivery)

City _____ State _____ Zip _____

PEC
Progressive Energy Corporation

255 South Bent Avenue, #B-1, Dept. PM788
San Marcos, California 92069

CALL NOW, TOLL FREE 1-800-525-8624
IN CALIFORNIA, TOLL FREE 1-800-233-9559.

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OUTDOORS

BY JOE SKORUPA

The Power Of The Prop

PROPELLERS make or break racing boats, but how much do they affect the weekend boater?

Like most boaters, I'm familiar with prop theories and manufacturer's guidelines. This knowledge, coupled with experience, tells me that the right prop makes a boat perform like a finely tuned machine and the wrong prop, especially on a planing hull, robs the rig of fuel, speed and overall performance, or may damage the engine.

But most boaters aren't in it for speed trophies. They're just looking for fish, fun and other pleasant pursuits. How much does prop selection really affect them?

Peak performance

I recently enlisted the aid of technicians at Mercury Marine's MerCabo Test Base, near Boca Grande, Florida, to help answer this question.

We took a look at propping from several different angles. We started with a 16-ft. 7-in. Cajun 168 Sport Espirit



Tucked-under engine makes boat jump on plane, but plow water like a barge unless corrected.

equipped with a 100-horse Merc as our basic test rig.

To establish an optimal standard of operation, we did top-end and 0-to-35 mph acceleration runs propped with a Quicksilver 20-in. pitch (13 $\frac{1}{4}$ -in.-dia.) Laser II stainless-steel prop.

This prop was designed by Mercury to be the ideal match for its 100-horse outboard. (Pitch, by the way, is the theoretical distance a propeller moves forward in one revolution.)

With a 2-man load, the average speed of four top-end runs (two in each direction) was 44.48 mph at 5510 rpm.

Maximum rpm for this outboard with a 1-man load, according to Mercury, is 5600. Using the same format, 2-man load and four runs, acceleration time from 0-to-35 mph was 8.68 seconds.

Now that we knew the performance results of optimal propping, we tried the same runs with other commonly used props.

We chose two smaller ones and one larger, and since most boaters, especially those with outboards, rarely use stainless-steel props, which are about three times more expensive, all of our test props were aluminum.

Radar runs

Running with 17-in. pitch (13 $\frac{1}{4}$ in. dia.), top-end speed was 42.7 mph at 5746 rpm, and hole shot 7.93 seconds. The smaller prop was nearly a second faster in hole shot, but off by a mile and a half in top-end speed.

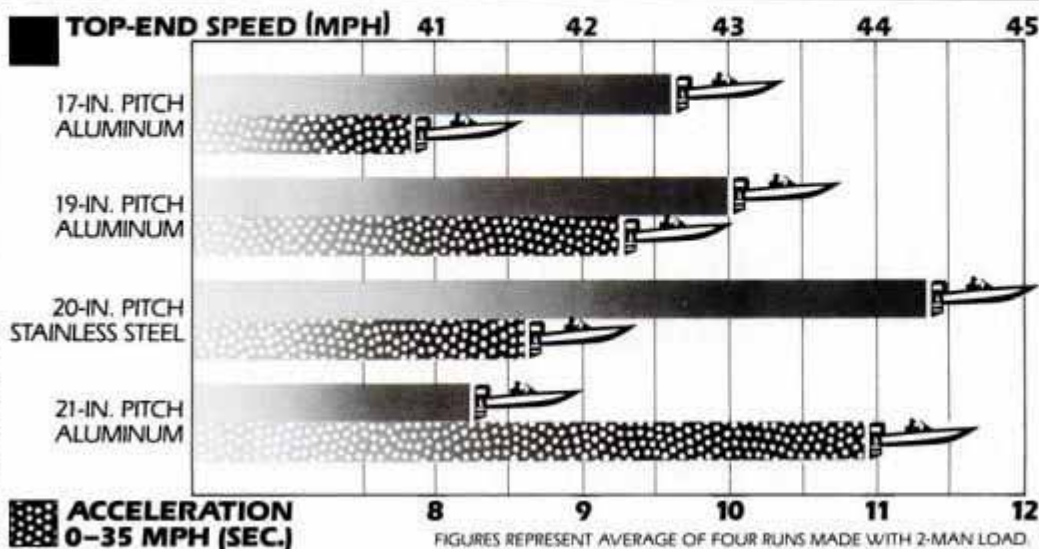
More significant than top-end loss, was the problem of over-revving and prop blow out. In all test runs with the 17-incher, the engine smoothly climbed to about 5000 rpm and then suddenly surged beyond the 5900-rpm mark, causing the prop to break loose and ventilate. This not only robbed power, but vividly demonstrated a problem that would eventually lead to engine damage.

With 19-in. pitch (13 $\frac{1}{4}$ in. dia.), top-end speed picked up from runs made with the 17-incher to 43.0 mph at 5585 rpm, but the hole shot slowed down to 9.3 seconds. Both lagged behind the optimal marks set by the Laser II. Although there was some over-revving and blow out, an experienced driver could throttle back a hair to compensate and ensure a normal, damage-free engine life.

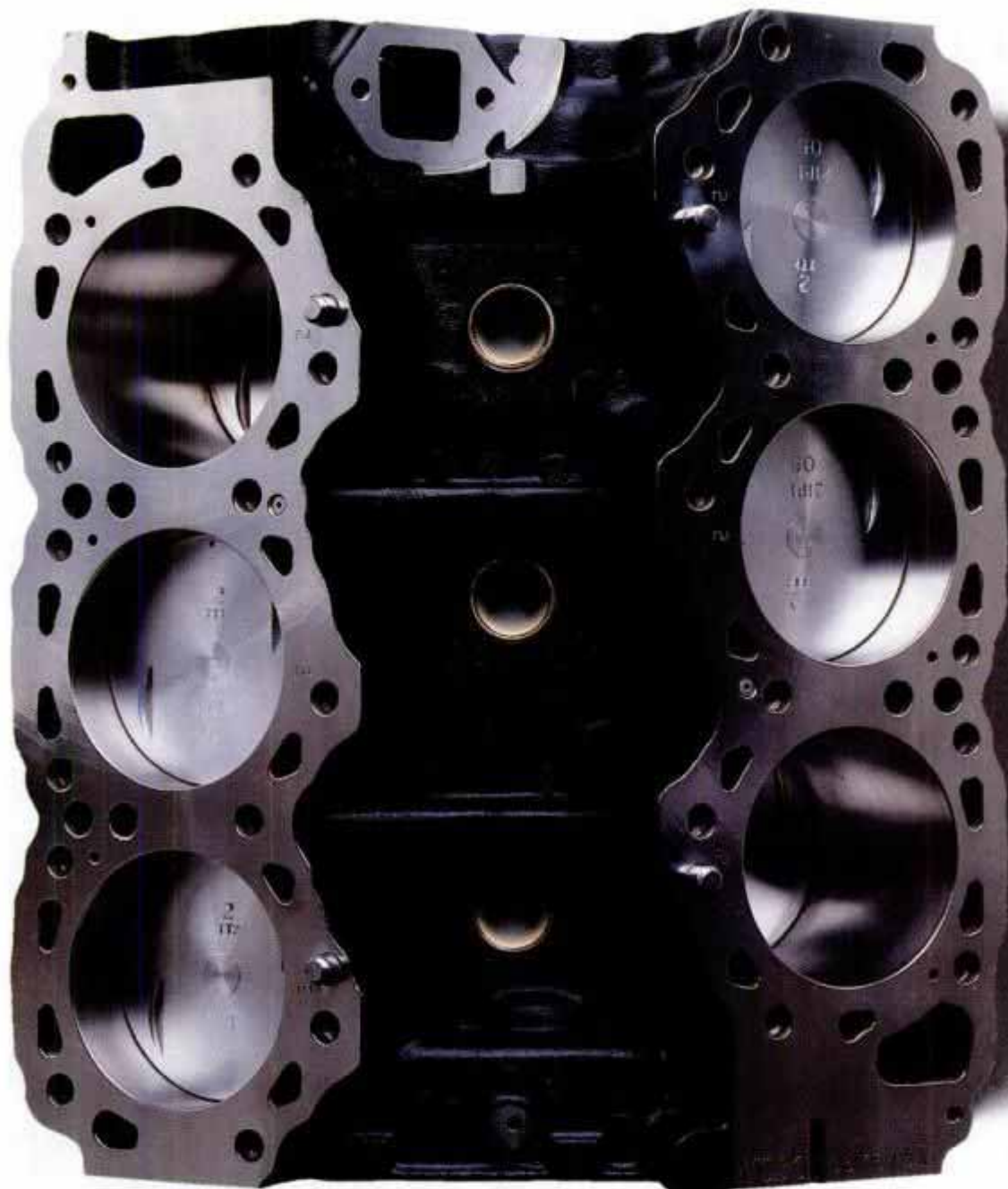
The most dramatic data collected was with the 21-in. pitch. Its top-end was 3 mph slower than the Laser II (41.25 mph at 4900 rpm) and more than 2 seconds slower

(Please turn to page 45)

PROPELLER EFFICIENCY



Optimal data collected with 20-in.-pitch Laser II prop. Divergence of others is dramatic.



You coulda had a V6.

For those of you who can't survive unless you're on a steady diet of mountain passes, logging roads and sand dunes, Nissan offers an engine that will supplement your feeding habits.



is the same one that's made mincemeat of such off-road terrain as the Baja 1000 and the Mint 400.

Our fuel-injected, overhead cam V6.

Boasting 145 horsepower and 166 ft.-lbs. of torque, this 3.0-liter engine

And if your idea of off-roading is occasionally straying up onto a curb, you'll be happy to know that the Hardbody™ V6 is available in our 4x2's, as well.

All of which suggests, no matter what kind of trucking you're into, our V6 will satisfy your craving.

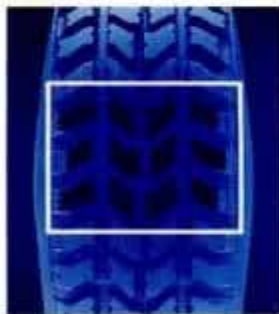


Built for the Human Race.™

The revolutionary Goodyear An entirely new direction in

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

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



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

Existing technology did not meet the challenge.

What was needed was a breakthrough in design.

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

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

Because of this unidirectional tread pattern, the Wrangler MT delivers

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

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

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

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

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

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

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



GOODYEAR

BECAUSE THERE REALLY IS A DIFFERENCE.



**Wrangler MT radial.
tread design. And performance.**



Popular Mechanics

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Guide to Car Care

A collection of *Popular Mechanics* "Saturday Mechanics" articles and "Car Care Guides." You'll learn all aspects of car maintenance, including how to trouble-shoot engine problems, service the drivetrain, repair electrical problems and care for your car's exterior. All procedures are illustrated and clearly explained by experts. 152 pp. (B-1915--\$9.95)



Auto Repair Manual 1982-1988

This 51st edition has been completely revised with the latest in auto repair. It covers 1,900 models with 55,000 essential service specs and 2,500 diagrams and photos. A valuable reference, with more sections on do-it-yourself auto repair than ever before, including fuel and ignition system updates. 1,300 pp. (B-1924--\$21.50)



Basic Car Care

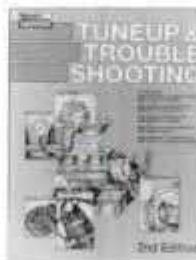
The best basic manual around, with step-by-step instructions and troubleshooting charts, tuneup specs for U.S. and import cars and a complete glossary of car terms. Includes sections on tools and equipment, preventive maintenance,

fuel, starting and cooling systems, brakes, tires, air conditioning and diesel engines. 404 pp. (B-1901--\$16.95)



Bodywork and Painting

Keep your car looking new with this manual for the weekend mechanic. Color photos, diagrams and instructions tell you how to eliminate rust, fix dents, spray paint, repair grills and bumpers, keep interiors clean and bring out your car's lustrous shine—all without expensive equipment. 240 pp. (B-1903A--\$12.95)



Tuneup & Troubleshooting

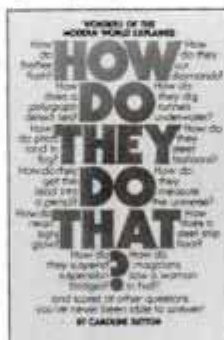
Nearly 300 pages with valuable information on all aspects of tuning your engine, including spark plugs, breaker-point ignitions, compression and vacuum service and lubrication. More than 700 illustrations and 50 pages of trouble-shooting charts. (B-1902--\$14.95)

Good Housekeeping Illustrated Book Of Home Maintenance

Keep up with your home repairs with this do-it-yourself guide. Learn about appliance troubleshooting, laying tiles, adding windows, treating wood rot, renovating furniture and improving home security; plus plumbing, paneling, waterproofing, electrical work and other topics. Contains more than 1,000 illustrations and color photos. 238 pp. (B-1925--\$22.95)

Tips, Hints & Everyday Wisdom

Removing laundry stains, gardening, managing money, staying fit. These are some of the topics covered in this collection of practical tips. For example, to mow a wet lawn coat the mower blades with vegetable oil to keep the cut grass from sticking. 388 pp. (B-1930--\$19.95)



How Do They Do That?

The modern trivia book that explains mysteries of today's world. Among the 150 puzzles: How are underwater tunnels dug? How do magicians saw a woman in half? How does truth serum work? 292 pp. (B-1923--\$8.95)



Undiscovered

Journey to the world of shipwrecks, buried treasures and mythical places. Follow your imagination to Atlantis, the biblical cities of Sodom and Gomorrah, King Arthur's grave, the tomb of Herod the Great and more, as the author uses maps and photographs to describe an undiscovered world. 192 pp. (B-1928--\$16.95)



Tree Identification Book

Ever wonder about that tree in your front yard? Or what your oak table looked like before the wood was cut for lumber? This book, with more than 1,500 illustrations, takes you on a nature walk to identify the shape, leaves, bark and branches of more than 100 trees. 272 pp. (B-1913B--\$14.95)

How The World Works

Einstein's theory of relativity, the big bang, human evolution, gravity, black holes. If you're curious about these and other science topics, this book is for you. Written in an easy style, it provides a fascinating look at our world, from the exploration of DNA and genes to quantum mechanics. 378 pp. (B-1931--\$18.95)

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Let *Popular Mechanics*' informative guide help you change the look of your home with fresh paint, attractive wallpaper and refinished furniture. Learn about exterior and interior paints, brushes and other equipment, painting problems, stripping and refinishing furniture and hanging wallpaper. Detailed instructions and photos. 160 pp. (B-1926--\$8.95)

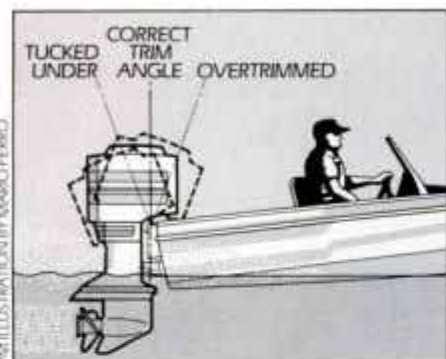


Story of Baseball

Step into the batter's box with this nostalgic look at our national pastime. Read about baseball's early days, Babe Ruth's career, the modern superstars, even the time a midget with a 1 1/2 inch strike zone pinch hit. There are also sections on hitting, pitching, fielding and managing. 148 pp. (B-1929--\$8.95)

OUTDOORS

(Continued from page 40)



Proper trimming gives solid prop bite. Over- and undertrimming rob efficiency.

in hole shot (10.9 seconds). It was, in fact, slower than all the test props, but this was to be expected of a prop with so large a pitch. Under-revving is less a problem than running at hot rpm levels, but it too may be harmful over time.

Analyzing power trim

We did several other hard-data efficiency tests at MerCabo. Most outboards today have power trim, long overdue as a standard feature. But how much does it really affect performance?

Using our basic 100-hp Merc and Cajun 168 Sport Espirit rig, equipped with a Laser II prop, we did radar runs with the engine fully trimmed down, optimally trimmed and fully trimmed out.

Trimmed down, or tucked under the boat, produced a top-end speed of 37.25 mph, more than 7 mph slower than optimal trim. The reason for this is that the hull, although on plane, plows bow-down through the water like a barge.

Acceleration was also affected. Average hole-shot time, with engine tucked under, was 9.44 seconds. As might be expected, the boat popped right up on plane, but then plowed sluggishly.

Hot-rodders love full-trim running with all the high revs, roostertails and top-end speed. What they don't realize is that overtrimming moves the water intakes out of the water and may lead to loss of water pressure and overheating. It also produces a squirrely ride because most of the hull is forced out of the water and stability is diminished.

Unfortunately, the transom angle of the Cajun 168 didn't permit the all-out overtrimming possible on many other boats, so top-end speed loss wasn't as noticeable as it might have been. Hole shot, however, was another story. It took 11.4 seconds to reach 35 mph and over-revving was a real danger.

Everyone wants his boat to perform up to snuff, and when it doesn't, wants to know why. Our test data show that where the engine meets the water, the frontline power delivery of the prop and how it's trimmed, is the first and easiest place to maximize performance. **PM**

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MOTORSPORTS

High Tech At Pikes Peak

IN 1806, U.S. Army Lieutenant Zebulon Pike was leading an expedition across uncharted Colorado territory when he came upon a mountain peak rising from the edge of the plains. He claimed it would never be climbed and left, leaving his name behind him.

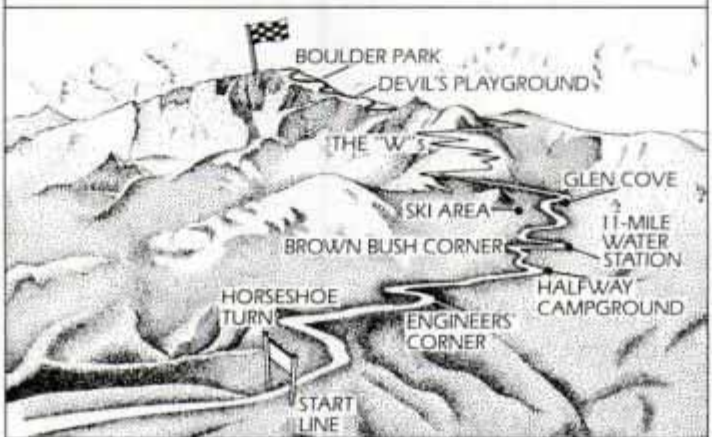
Pike obviously wasn't much of a forecaster. Not only was his peak conquered, by 1900 a track was carved up the side of the 14,110-ft. mountain and the first car reached the top. By 1915, Spencer Penrose, a wealthy resident of nearby Colorado Springs, had enlarged the original trail into a 2-lane highway. A year later, to promote the newly opened gravel road, Penrose organized an auto race. The Pikes Peak Auto Hillclimb was born. It is the second oldest U.S. auto race, predated only by the Indy 500.

The race is still much the same as when the first event was won by Rea Lentz in a time of 20 minutes, 55.6 seconds. The course starts at the 9402-ft. level and runs 12.42 miles through 156 turns on its way to the top. Because of the dramatic altitude change, drivers can experience hot weather at the start and snow or fog at the top. It's no wonder it's called "The Race to the Clouds."

The highway is open to the public, so racers can only



Audi rally ace Walter Rohrl was King of the Mountain in 1987.



Pikes Peak run climbs 4708 ft. in 12.42 miles, with 156 turns.

practice for a limited time in the early mornings during the week before the race. Qualifying takes place on the bottom half of the course two days before the race. In the actual event, each car gets one run up the hill, starting at 1- or 2-minute intervals. Months of preparation go into a race that's over in less than 15 minutes!

Pikes Peak has become steeped in tradition over the years. The Unser family owned the hill for several

decades with a total of 22 overall wins and 15 records, dating to 1934. But despite the participation of famous drivers, it has basically remained a local event.

For years the fastest cars were traditional upright sprint cars—until the mid-'70s, when a group of young off-road racers from California entered rear-engined buggies. Much to the chagrin of the die-hard local racers, the two unknowns—Rick and Roger Mears—started to beat the more powerful sprint cars.

However, the real turning point came in 1985 when French rally driver Michele Mouton, driving a 4wd Audi Quattro Sport, broke the overall record. It changed tradition—the open-wheel cars were no longer fastest and locals were no longer in the hunt.

The Pikes Peak technological revolution started in 1981 when Audi of America entered its Quattro in a new rally car class with U.S. champion rally driver John Buffum at the wheel. He didn't break any records but he did surprise the locals, who couldn't believe a small European car could be so fast.

Audi returned for each renewal of the event after that and managed to be quicker and quicker each year. In 1986 Bobby Unser, driving a Sport Quattro rally car, bettered Mouton's record by 15 seconds, with a time of 11 minutes, 9.22 seconds. It was Unser's first run up the mountain in 12 years.

Audi's success attracted the attention of other European teams, so it was not surprising to see 13 4wd rally cars among the contenders when the combatants assem-



Coyote won open-wheel.

bled last July. Topping the bill was Peugeot, with three cars, while Audi returned with German driver Walter Rohrl.

Heavily sponsored by Camel cigarettes, Peugeot had won the 3-week Paris-Dakar off-road race in Africa before spending \$1 million for its assault on Pikes Peak. The team leased a warehouse in Colorado Springs for two months and rented the mountain for seven days of exclusive testing. The cars were



Turbo problems kept Ari Vatanen's Peugeot from overall win.

specially built for the hillclimb, using lightweight parts and the turbocharged, 4-cylinder, 1775-cc engine was tuned to produce 500 hp. Audi was also loaded for bear. Rohrl's turbocharged, 2110-cc, 5-cylinder engine was rated at 598 hp.

Popular California-based New Zealander Rod Millen, whose 4wd Mazda RX7 has finished second to Audis in several other runs, showed up with a turbo rotary capable of making 550 hp. But for sheer high-tech audacity, Volkswagen was the winner once again, with its fourth twin-engined entry. Previous editions used two transverse-mounted engines, one at each end, but in 1987 VW altered the layout a bit, using two 300-hp turbocharged, 16-valve GTI engines mounted longitudinally.

The only 4wd American rally car to compete was a specially built Oldsmobile entered by local driver Frank Peterson. He built it in 80 days, just in time for the 1986 race, but due to lack of testing—and finance—it has never showed its true potential. Peterson's Olds has a transverse, rear-mounted, 207-cu.-in. V6 Indy engine.

Race day saw a record number of spectators watch the stock cars, production rally cars and open-wheel racers, but the main battle was in the open rally class. Peugeot's Finnish driver, Ari Vatanen, was fastest in qualifying so he got to race after Rohrl.

Rohrl's run was fast—he blew Unser's record, breaking it by 22 seconds. All eyes were glued on Vatanen's nimble Peugeot. It looked good—until halfway, when it started to run ragged as a 50-cent turbocharger hose clip broke and he lost about 200 hp. He still managed to finish second, only 7 seconds behind Rohrl. But Audi had retained its title and a rookie German rally driver had become King of the Hill.

The open-wheel class also provided excitement as two drivers beat Al Unser Jr.'s 1983 record. Bill Brister, in a Chevy-powered Coyote, was first even after failing to qualify.

Despite its defeat, Peugeot is hooked on the race and will likely return in 1988—this year's mountain madness is scheduled for the weekend of July 8-10—to try and break Audi's stranglehold. And the vast media coverage generated in 1987 will probably draw even more rally teams to the fray.

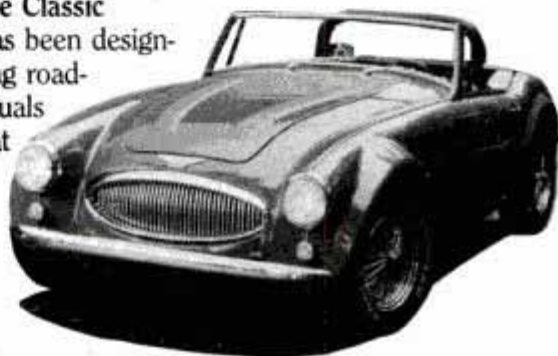
Many Europeans described the hillclimb as one of the best auto racing events they'd ever been to—"the world's best kept secret." Could it be that after 72 years, Pikes Peak has found itself as a technological showplace on the international racing calendar? And if European interest continues to grow, how long will it take for Detroit to wake up to this high-tech showcase in its own backyard?—*John Rettie*

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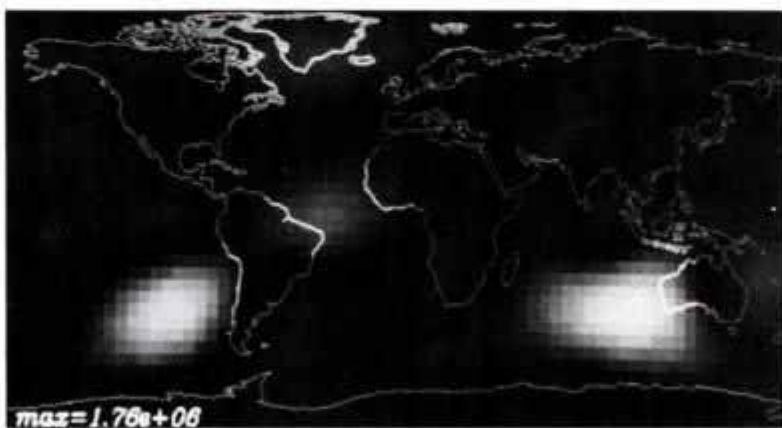
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CAT Scanning Planet Earth

THE technique is well known in the radiology departments of leading hospitals. Computerized tomography, or CAT scanning, combines information from many X-rays crisscrossing within the body to form a 3-dimensional view of a patient's internal organs, bones—or suspicious tumors.

A similar technique—called seismic tomography—is giving geologists the same kind of internal image of Planet Earth.

Cal Tech Associate Professor Robert Clayton, Geophysics Professor Don L. Anderson and graduate students Hua-Wei Zhou and Olafur Gudmundsson are using the Earth's seismic history compiled from nearly 3000 surface stations to develop a picture beneath the Earth's crust. Seismic pressure, or P waves, traveling at roughly the speed of sound reflect and refract off the Earth's internal structures, arriving at widely spaced global monitoring stations at different times and intensities. A computer analysis of the travel-time anomalies between P



Light and dark regions show topographic variations on Earth's core.

waves offers an intriguing glimpse of the world beneath our feet.

A recent Cal Tech experiment involved charting what scientists believe are topographic variations on the Earth's core. Because P waves travel faster through denser material, like sound waves, and cold areas are more dense, P waves can be presumed to travel faster in colder regions and slower in warmer regions. Scientists surmise that rapid changes in P-wave speed around the core indicate areas of varying density—or mountains and valleys. Roughness of the

core may account for millisecond inconsistencies in the Earth's rotation.

Broad-band digital seismometers will someday replace current analog seismographs, completely automating this ongoing Earth scan and improving data accuracy.

Rube Goldberg Award

Rube Goldberg was the cartoon genius who devised comically complex machines to perform the simplest of tasks.

Goldberg's whimsy lives on at Purdue University, where the Theta Tau and Triangle engineering fraternities sponsor a yearly competition to see who can devise the looniest machine to perform the most prosaic chore.

The 1987 task?

Design a machine that will break an egg and prepare it for frying. This year, students had to invent a machine that would moisten a stamp and attach it to an envelope. The winning entry used a model of a mailman being attacked by a dog, a mousetrap and a Bobby Knight doll throwing a tantrum.

The competition is being thrown open to national entries next year. Budding

"Goldbergites" should call Theta Tau's Mike Barrett at (317) 743-2461, or write Mike at 416 N. Chauncey, West Lafayette, IN 47906.

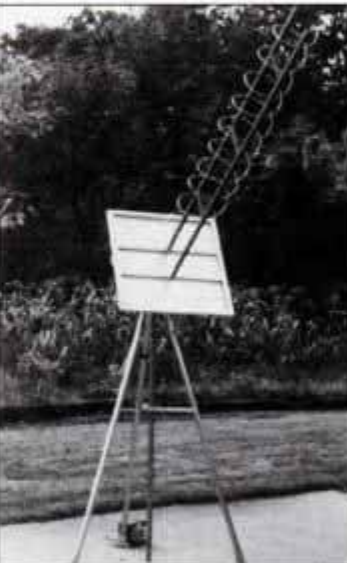
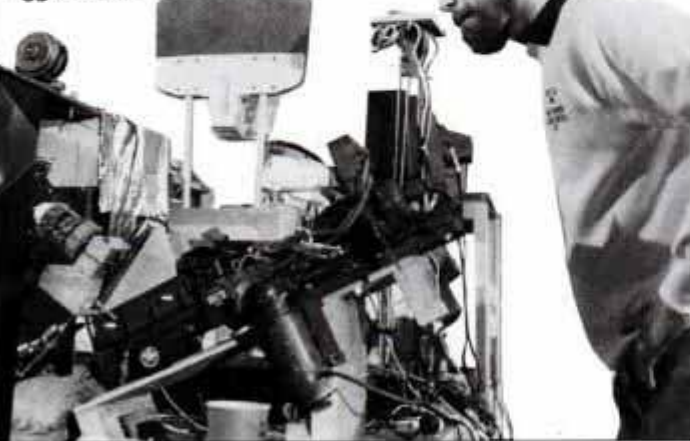
Listening In

It was only a matter of time before true radio telescope technology descended in complexity to amateur levels.

Edmund Scientific's new 400 MHz Radio Telescope kit (\$1200) permits radio source

observations of everything from solar flares to electromagnetic disturbances—and makes a perfect adjunct to an optical device. But it's no toy. The Edmund Radio Telescope comes with a multi-element helical antenna, preamp, demodulator, adjustable time constant integrator, and calibration noise source reference. All told, it's an excellent way to make more of a connection with the changing sky. Write Edmund Scientific Co., Dept. 5554, Edscorp Bldg., Barrington, NJ 08007. **PM**

In the spirit of Rube Goldberg: A high-tech egg smasher.



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... tell us within 30 days and we'll send UPS at our expense* to pick it up and give you a complete full refund!

Once you have your car detailed by a real pro like Robert Palumbo or Mark Kitaoka you won't believe what a great car you owned all along! It's never been so clean inside, it's never gleamed so beautifully outside. (Robert Palumbo actually discovered Malm's when a customer brought him the polish and wax and asked him to use them on his car. The result so impressed Palumbo that he switched to Malm's then and there!) But there's another reason to keep your car shining with Malm's Polish and Pure Carnauba Wax ... it will last longer, and you'll get much more for it when you sell.

The best new car dealers use Malm's too

New car dealers who really care, particularly those who sell cars costing \$30,000, \$45,000, \$60,000 and more, now lightly polish and wax with Malm's before they deliver the car to the customer. They know how important it is to start the buyer off with a shine that can't be matched.

What if your car is over four months old?

By now a dulling imperceptible film covers the paint. Even careful washing won't remove it! That's when you really need the

complete Malm's System. Enhance and preserve the finish this 2-step way. Wash it, then apply Malm's Polishing Cleaner to take away stains, greasy road grime, and small haze-like scratches. Malm's polish won't harm clear coat finishes. You don't have to use the Polishing Cleaner every time you wax. But you should use it the first time and at least once per year thereafter. Unlike many harsh, abrasive cleaners, Malm's is so microscopically fine it can be used straight from the bottle to polish gold or silver. That means if your car is really dull, you can actually use a power buffer! Malm's is so fine it won't leave swirl marks!

All by itself, Malm's Polish will impeccably clean and revive the paint to original showroom quality. Then, for the final touch, protect that sparkling finish with a thin film of Malm's Carnauba Wax and buff lightly. Now you won't believe your eyes ... your car has that famous Malm's "Better than Showroom Shine"! Good for 4 to 6 months. And the

rain will continue to bead up on the finish even though you wash it again and again!

Malm's reader service! Don't fall for these gimmicks and claims!

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Cheap "carnauba waxes" off the shelf. The less they cost, the less real carnauba they contain, and most contain strong abrasives too. A pint will only do your car two or three times. Malm's costs more, but a pint will wax even a big Mercedes a dozen times and more.

Colored waxes. May actually dull the gloss! And think about this: if the coloring dye is strong enough to affect your paint, it could dis-

color your rubber, chrome and glass! Malm's works great on ALL colors!

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Road Warriors

BY FRANK VIZARD

AUTOMOTIVE loudspeakers perform in a violent world. They are routinely exposed to extremes of temperature and humidity. The rear portion of those installed in car doors become wet from moisture trickling down window tracks. And the shocks and vibrations car speakers are exposed to can be strong enough to sever the wiring connections.

To survive in the harsh automotive environment a car speaker must be stronger and more durable than its home audio cousins. Accordingly, autosound speaker manufacturers are turning to space-age materials.

Home hi-fi speakers generally use paper cones to reproduce sound, because paper reproduces audio signals in a natural-sounding way. But car speaker makers substitute other materials to give their products greater longevity.

Perhaps the most frequently used material in car speakers is polypropylene, owing to its resistance to moisture, high temperatures and the debilitating effects of direct sunlight. Polypropylene is flexible enough to reproduce sound. To some, its sound quality is satisfactory, but to others the sound character is brash and not as natural as that produced by paper cones.

In response to these criticisms, some car speaker makers combine polypropylene with other materials to achieve

Titanium and other space-age materials beef up car speakers such as these by MB Quart.

better sound. For example, Blaupunkt's new QL Series speakers use polypropylene cones sprayed with a fine quartz dust that dampens the cone. Different cone materials might have a frequency at which the cone vibrates excessively and creates an unnatural sound. In this instance, the quartz powder dampens that frequency, reducing it to below audible levels. Infinity's new Reference Standard Designer Series speakers mix graphite and polypropylene to achieve the same end.

Not every company opts for polypropylene. JVC, for instance, uses what it calls Cross Carbon, a carbon material that is combined with an acrylic-resin compound. The result is a speaker highly resistant to moisture, heat and direct sunlight.

Another car speaker line comes from MB Quart, a well-known German manufacturer new to the United States. Like many other car speaker makers, MB Quart is using titanium to construct its tweeters or treble-drivers. The increasing use of titanium in car speakers is prompted by two considerations. First, titanium has a very high stiffness-to-mass ratio, which promises longevity. Second, digital sources such as compact discs demand tweeters that can produce extended treble response and handle fast, transient signals.

Insight into the manufacturing process comes from JBL, which incorporates titanium in its new T06 component tweeter. JBL's pro-

prietary process involves high-pressure gases swirled against a pure titanium film to form a dome only 25 microns thick—that is, 25 millionths of a meter. At the same time, an intricate pattern is molded into the dome to improve rigidity without increasing mass.

JBL combines the properties of titanium with a magnet made from neodymium, an aerospace material also being used in many new headphones. Magnetic flux density is one of the critical elements of good speaker performance.

In the past, car speakers often required large magnets to achieve the desired performance. With neodymium, the same performance levels can be achieved using a magnet smaller in size. JBL's T06 tweeter has a mounting depth of only ¼ in.

Such shallow mounting depth gives an installer much more flexibility in speaker placement. Locating tweeters in the dashboard, for example, is now more feasible than it was previously.

It might soon become a necessity more than an alternative. With the increasing number of ragtops hitting the road, the rear-shelf speaker installation so necessary to good sound is being eliminated. Speakers installed in the dash and the doors are going to have to carry the acoustic burden. Thanks to stronger and more durable space-age materials, it will be possible to get big sound out of smaller and shallower spaces. **PM**

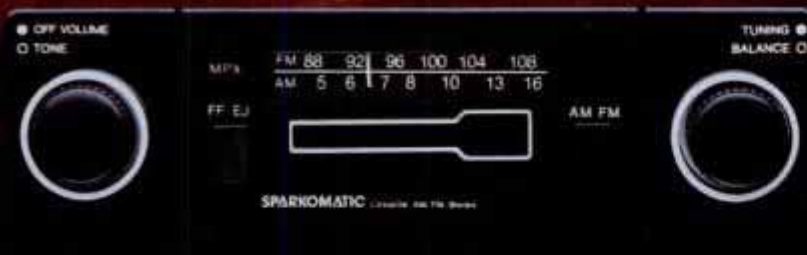


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VOLKSWAGEN GTI 16V

PM
COMPARISON
TEST

ECONO COMMANDOS

The world's top pocket rockets in a fight to the finish.

BY RICH TAYLOR, Contributing Editor; PM Photos by John Lamm

ECONO Commando Recipe: Take one lightweight, 3-door front-drive hatchback. Revitalize wimpy econobox engine with a double dose of horsepower. Blend in slick-shifting 5-speed transaxle. Add sporty bucket seats and leather-wrapped steering wheel for flavor. Stir in fat, sticky tires, alloy wheels and a stiff suspension. Season with airdam and spoiler. Paint to taste, preferably Hot n' Spicy Red. Serves one grinning driver and as many as three happy passengers.

To get the most from this recipe, it should be savored on a curvy mountain road. Every one of these mini hot rods chases down apexes like a terrier after a squirrel, but unlike many high-performance sports cars, they're never scary or intimidating, nor are they uncomfortable or cramped. Driven with elan, they can hold their own with any 2-seater this side of a Corvette, yet fold down the rear seats, and you can pack in a couple of bicycles. Best of all, these 30-mpg cruisers aren't on the Insurance Enemies List.

We found winding roads in the San Gabriel Mountains, and performed our track testing at Los Angeles County Raceway. As usual, we sampled all the cars in a back-to-back taste test, and came up with a consensus: These Econo Commandos are uniformly terrific. All nine are about the same size, performance and all fun to drive.

The biggest difference is in price. The most expensive is nearly *twice* the price of the cheapest—\$16,050 versus \$8592.

COMMANDOS



ISUZU I-MARK TURBO



CHEVROLET SPRINT TURBO



FORD ESCORT GT

whisker over 16 seconds, at 84 mph. It's both quicker and faster, for example, than such hot 2-seaters as the Fiero GT, Toyota MR2 or Mazda RX-7. It also has excellent brakes, and pulled .82G on Pomona's skidpad.

Though the current Golf has been with us for three years, it still holds together remarkably well. The nose has been modernized with Eurostyle aero headlights, and the Scirocco-style bucket seats, 4-spoke steering wheel and analog instruments are conservative and thoroughly functional. The GTI is a beautiful compromise—a hot performance car, yet with genuine room for four adults.

Volkswagen Golf GT

What VW now calls a Golf GT used to be the GTI, until the 16-valve engine was introduced. The GT costs a substantial \$3000 less than the new GTI, but of course, you don't get the same equipment levels. VW saves money by using rear drum brakes instead of discs, less expensive 185/60R-14 tires, no power steering and a single-overhead-cam engine rated at 18 hp less than the 16-valve version.

Naturally, this adds up to quicker acceleration for the GTI—an impressive 1.3 seconds 0 to 60 and 5 mph in the quarter-mile.

However, in other areas of performance the GT holds its own. Though the GTI has a bigger footprint, its extra 55 pounds—all in the front end—tend to negate the extra adhesion. As a result, the GT was .02G faster around the skidpad than the GTI, matched it in the slalom, and beat it by a car length in braking.

Overall, we like the GTI best, because its potent powerplant most truly fits the Econo Commando recipe. But the GT is the better buy, with satisfying performance for \$3000 less.

Honda Civic DX

Our Best Buy in this group is Honda's all-new Civic DX. The \$9572 Civic DX is an unadorned econobox, thousands of dollars less than any commando except the little Sprint Turbo.

Volkswagen GTI 16V

The GTI, progenitor of this entire class of cars, continues to be our favorite Econo Commando. And when you figure it costs more than a 140-mph 5-liter Mustang or Firebird GTA, it *should* be good. The GTI is nothing more nor less than Volkswagen's familiar Golf 3-door, fitted with 4-wheel disc brakes, quicker ratio power steering, Pirelli P600

205/55VR-14 tires on wider wheels, and most importantly, an innovative double-overhead-cam head with 16 valves that raises the output of the time-honored 1.8-liter Four to a rambunctious 123 hp.

If you've been raised on big V8s, that may not sound like much, but in a 2300-pound package, it's enough to boot the GTI from 0 to 60 in just over 8 seconds, with quarter-mile times in a



Mirage Turbo: Potent New Contender

The Mitsubishi Mirage Turbo wasn't available when we assembled our Econo Commando fleet for testing, but we'd be remiss if we didn't at least mention this new minitiger.

Clad in sleek new sheetmetal, the hottest member of the Mirage family (or Colt clan, if you happen to be buying from Chrysler Corp.) roars to

market with a heady 29-percent horsepower increase over its far from tepid predecessor.

A new port-injected 16-valve twin-cam cylinder head accounts for the increased output, which totals 135 hp at 6000 rpm, with 141 lbs.-ft. of torque at 3000 rpm, tops in the Econo Commando class.—T.S.



MAZDA
323 GTX



VOLKSWAGEN GOLF GT

This is one of the few truly pretty cars in this class—graceful, clean and modern. While other manufacturers are still selling economy boxes first brought to market in the '70s, Honda has brought out an all-new Civic every three years.

Not only is the exterior state of the art, but Honda also has the best interior ergonomics this side of Mercedes-Benz. Drive a mile in this Civic, and you'll be as familiar with it as your own front hall. We sorely missed a tachometer, but otherwise the ergonomics are without flaw, and everything from the single-post headrests to the futuristic 2-spoke steering wheel seems like the perfect solution to that particular design challenge. The Civic is made from inexpensive materials, but it appears expensive and substantial, not cheap. That's good design.

Honda's engineering is equally impressive. The engine uses a unique 16-valve head, with a single overhead cam. Honda was a leader in switching to MacPherson strut suspensions more than a decade ago. Now Honda's leading the way in switching back to classic double wishbones for better handling and ride.

At the track, the Civic did remarkably well, considering it was running on cheap Dunlop SP 23J 175/70R-13 tires. It beat the Golf GT, Le Mans and Escort GT at the dragstrip, had the second-best braking performance behind the Escort, was second on the skidpad with an excellent .83G and won the slalom—pretty impressive for an unpretentious econobox running on so-so tires. Add another 13 hp from the Si engine that will be available in 1989, and this inexpensive Civic would have walked away with this test in every category. Even so, you can't find a better new car in this class for under \$10,000.

Mazda 323 GTX

On paper, the GTX looks overwhelming: a double-overhead-cam, 16-valve 1.6-liter engine, turbocharged and intercooled to produce 132 hp, one of the



PONTIAC LE MANS GSE

hottest in this class. Full-time 4-wheel drive for maximum traction. Disc brakes at all four corners, all-independent suspension and every conceivable gizmo, from 7-spoke alloy wheels to yellow-on-black aircraft-style gauges and ultra-adjustable bucket seats.

At 2600 pounds, the GTX weighs a good deal more than it should—about 300 pounds more than the regular hatchback.

Mazda engineers blame the additional components of the 4-wheel-drive system. No matter, the slightly pudgy 323 still put up the best quarter-mile numbers, and did 0 to 60 in a zippy 7.4 seconds. The GTX was only a hair behind the first-place Civic in our slalom, and posted .82G on the skidpad, using Bridgestone Potenza RE86 185/60R-14 tires. The only time the GTX showed its weight was in braking, where it ended up near the back of the pack.

The GTX has excellent performance, and it's a joy to drive at normal highway speeds. But if you start to push it, you'll find it's a handful to drive fast.

It has too much roll in the corners, hints of torque steer under acceleration, handling that edges out toward nervous when you get near the limit of adhesion and enough turbo lag to be irritating.

Taken all together, this is a difficult car to drive fast and not as much fun as you'd expect it to be. At \$15,000, it's also difficult to perceive as a bargain.

Pontiac Le Mans GSE

The Le Mans is a Korean-built Opel Kadett, now "commando-ized" with a 2.0-liter engine and all the zoomy ingredients of the hot-rod recipe. It's a surprisingly nice little car and very reasonably priced.

It won our fuel economy test by over 2 mpg, returning an excellent 25 mpg despite Boy-Racer driving by our demon test crew.

It beat the Golf GT and Escort GT in acceleration and finished mid-pack in the slalom, though it was last on the skidpad, at least partially due to its slippery Uniroyal Rallye 340/60 185/60HR-14 tires.

The Le Mans GSE is very different in appearance from other econoboxes—rounded and bulbous, rather than boxy and square. A rear wing, aero rocker moldings and body-color wheels give it a cute, racey look. The interior is finished in a perky gray tweed, which seems very European and appropriately sporty. The seats are Recaro copies that rank with the best in this class (notably those in the GTI), and the white-on-black analog gauges are excellent. The controls are very German in feel, with easy-to-use ergonomics.

Compared to the low roofs of most Japanese small cars, there's plenty of headroom. The Le Mans interior also measures considerably larger than the other cars in this group.

Thanks to the extra punch of the new 2.0-liter engine, the Le Mans

COMMANDOS

GSE is a good deal more fun to drive than its milder editions. Although there's still plenty of body roll, it can be thrown about with confidence and is devoid of hidden vices. Two small improvements that would help: more precision in the shift linkage and less steering assist.

This is a surprisingly comfortable small car in every way, and Daewoo is already delivering build quality the equal of Japanese competitors. The Le Mans GSE is a pleasant surprise, all-round.

Ford Escort GT

The Escort is the best-selling car in America—and the world. The GT has the H.O. version of the 1.9-liter engine, a swoopy aero package which successfully modernizes the aging hatchback and an interior obviously inspired by the SVO Mustang and Ford's other Euro-look interiors. The overall feel is very high-tech and



TOYOTA FX-16 GT-S

modern, which is amazing when you think that this car was designed when Lee Iacocca was still at Ford.

The Escort GT is much better than you'd expect for such a dated design. It's big and roomy inside, and except for the rather old-fashioned seats, comfortable and easy to drive. It finished a resounding first in our braking tests, but midpack on the skidpad and last in the slalom, despite its excellent Goodyear Eagle GT 195/60HR-15s. Even with the H.O. engine, it's the slowest car in this class,

with quarter-mile times over 17 seconds. The engine is also very noisy and thirsty.

Overall, the Escort GT is one of the least expensive cars in this group, and much nicer than you might expect.

Its aging design has been cleverly updated to remain competitive, and all it really needs are better seats, more sound insulation and another 20 hp. Everything else is just fine. Like the Volkswagen Golf GT, this is a perfect example of a design that's been steadily refined and improved over a decade, until it's better than ever.

Isuzu I-Mark Turbo

General Motors owns one-third of Isuzu, and the I-Mark is identical to the Chevy Spectrum. It's a pleasant little car, but one with very little personality. It's hard to remember what the car was like, an hour after you've driven it. The

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)
Chevrolet Sprint Turbo	\$8240/ \$8592	L3, SOHC turbo, intercooled 61.00/1000	70 @ 5500 rpm/ 107 @ 3500 rpm	front/ front	5-speed manual	88.4/ 2245	144.5/ 3670	60.2/ 1529	F:52.6/1336 R:51.2/1300
Ford Escort GT	\$8977/ \$10,365	L4, SOHC 113.50/1860	110 @ 5400 rpm/ 115 @ 4200 rpm	front/ front	5-speed manual	92.2/ 2392	169.2/ 4298	65.9/ 1674	F:54.7/1389 R:56.0/1422
Honda Civic DX	\$8195/ \$9572	L4, SOHC, 16-valve 91.09/1493	92 @ 6000 rpm/ 89 @ 4500 rpm	front/ front	5-speed manual	98.4/ 2499	156.1/ 3965	65.6/ 1666	F:57.1/1450 R:57.1/1450
Isuzu I-Mark Turbo	\$10,699/ \$11,658	L4, SOHC turbo 89.74/1471	110 @ 5400 rpm/ 120 @ 3500 rpm	front/ front	5-speed manual	94.5/ 2400	157.4/ 3997	63.5/ 1613	F:54.7/1389 R:54.3/1328
Mazda 323 GTX	\$12,999/ \$15,097	L4, DOHC turbo, intercooled, 16-valve 97.45/1597	132 @ 6000 rpm/ 136 @ 3000 rpm	front/ all	5-speed manual	94.5/ 2400	161.8/ 4110	64.8/ 1645	F:55.1/1400 R:56.1/1425
Pontiac Le Mans GSE	\$9000* \$11,000*	L4, SOHC 121.00/1998	95 @ 4800 rpm/ 118 @ 3600 rpm	front/ front	5-speed manual	99.2/ 2520	163.7/ 4158	65.5/ 1664	F:55.1/1400 R:55.4/1407
Toyota FX-16 GT-S	\$10,968/ \$12,773	L4, DOHC, 16-valve 96.83/1587	110 @ 6600 rpm/ 98 @ 4800 rpm	front/ front	5-speed manual	95.7/ 2431	160.0/ 4064	65.2/ 1656	F:56.5/1435 R:55.7/1415
Volkswagen Golf GT	\$10,385/ \$13,255	L4, SOHC 108.60/1780	105 @ 5400 rpm/ 110 @ 3400 rpm	front/ front	5-speed manual	97.3/ 2472	158.0/ 4013	66.1/ 1680	F:56.3/1429 R:56.0/1422
Volkswagen GTI 16V	\$12,995/ \$16,050	L4, DOHC, 16-valve 108.60/1780	123 @ 5800 rpm/ 120 @ 4250 rpm	front/ front	5-speed manual	97.3/ 2472	158.0/ 4013	66.1/ 1680	F:56.3/1429 R:56.0/1422

*Estimated

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

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

styling is clean and neat, never gaudy, and the alloy wheels are cute. Otherwise, this could be a generic Japanese econobox for an insurance company safe driving ad.

The interior has GM-style buttons around the instrument binnacle, and a nice 3-spoke steering wheel. The interior is attractive—our test car was finished in gray—and compares nicely with the new Honda Civic for stylishness and functionality.

Under the hood, the I-Mark has a turbocharged 1.5-liter engine and conventional econobox chassis. It's perfectly acceptable, though the engine is annoyingly noisy even at highway speeds.

In our testing, the I-Mark returned excellent fuel economy, yet tied with the Volkswagen GTI for acceleration, just behind the winning 323 GTX. It also has good brakes, and finished third in the slalom. It was near last on



HONDA CIVIC DX

the skidpad, thanks to the Bridgestone Potenza RE88 P185/60R-14 tires and gobs of understeer.

The I-Mark has zippy performance, a pleasant interior and innocuous styling. The price is right in the middle of the Econo Commando pack, and both Isuzu and Chevrolet dealers should be willing to deal.

Toyota FX-16 GT-S

The FX-16 is built in the joint-venture NUMMI factory in Fremont, California, and when it was launched two years ago we expected great

things. However, this has become one of the few Toyota models which isn't selling well. This seems attributable to the car's basically generic econobox styling and a fairly substantial price tag (though it ranks behind both VWs and the Mazda).

And even though it's equipped with one of the sweetest engines in this group, the FX-16 isn't as lively an all-around performer as its GT-S trim suggests. Understeer is nothing short of massive, and the steering is the group's slowest.

The FX-16 was next to last in our skidpad tests, midpack in the slalom and disappointing in braking.

The twin-cam, 16-valve, 1.6-liter pulled through the quarter-mile nearly as quickly as the GTI, but the FX-16 doesn't approach the awesome all-around competence of the VW.

Besides its excellent engine, the best part of this Toyota is its obvious assembly quality—proof that American workers can produce a car as well built as any in the world.

(Please turn to page 119)



TEST RESULTS

CURB WEIGHT (lbs.)	STEERING TYPE/TURNS LOCK-TO-LOCK	BRAKE SYSTEM FRONT/REAR	FUEL ECONOMY (EPA city/PM test)	ACCELERATION 0-60 MPH (sec.) 1/4-MILE (sec. @ mph)	BRAKING 60-0 MPH (ft.)	700-FT. ¹ SLALOM (mph)	SKIDPAD ² 200-FT. CIRCLE (G)	CARGO ³ VOLUME (cu. ft.)	EPA ⁴ INTERIOR VOLUME (cu. ft.)
1565	rack-and-pinion/3.3	F:8.4-in. disc/ R:7.1-in. drum	37/ 22.10	8.5 16.53 @ 80.91	167	54.79	.78	18.4	74.4
2258	power rack-and-pinion/3.04	F:9.2-in. vented disc/ R:7.1-in. drum	24/ 15.33	9.8 17.08 @ 78.81	131	57.89	.79	16.4	102.4
1993	rack-and-pinion/3.87	F:9.5-in. vented disc/ R:7.1-in. drum	33/ 22.10	8.9 16.75 @ 80.99	142	60.10	.83	16.9	85.0
1923	power rack-and-pinion/2.88	F:9.0-in. vented disc/ R:7.1-in. drum	28/ 22.78	8.2 16.21 @ 82.30	148	59.84	.78	16.9	101.6
2600	power rack-and-pinion/3.01	F:10.2-in. vented disc/ R:9.7-in. disc	21/ 20.53	7.4 15.60 @ 85.96	162	60.04	.82	11.0	88.0
2058	rack-and-pinion/3.5	F:10.1-in. disc/ R:7.9-in. drum	27/ 25.00	9.2 16.87 @ 80.55	143	58.18	.77	13.4	107.6
2365	variable ratio power rack-and-pinion/4.1	F:9.6-in. vented disc/ R:9.5-in. disc	25/ 21.84	8.3 16.42 @ 82.68	181	59.22	.78	14.1	86.0
2212	rack-and-pinion/3.80	F:9.4-in. disc/ R:7.1-in. drum	24/ 21.03	9.5 16.93 @ 79.50	142	58.00	.84	17.9	86.9
2267	power rack-and-pinion/3.17	F:9.4-in. vented disc/ R:9.4-in. disc	22/ 19.60	8.2 16.20 @ 84.05	158	58.16	.82	17.9	86.9

3. Number indicates maximum cargo volume as determined with rear seatback in normal position.
4. Number indicates maximum interior volume as determined by EPA calculations.

BATTLECRUISER 2000

In the coming century, a lethal combination of stealth and firepower will revolutionize warfare on the high seas.

BY NICK NICHOLS; PM Illustrations by Tom Freeman

"No profession is more wedded to the folklore of the past than the armed services."—Winston Churchill

THAT esteemed son of Britannia might have added that none of the armed services is more heavily shackled to tradition than the U.S. Navy. Who else in this age of high-tech mania would have recommissioned that venerable emissary of "gunboat diplomacy," the *USS New Jersey*?

Touting a different diplomacy, recently retired Vice Adm. Joseph Metcalf III told PM, "Institutions die hard, and the U.S. Navy is a very mature bureaucracy." Not that he isn't an advocate of putting more ordnance to sea, far from it—it's the *type* of ordnance that Metcalf's concerned with. The admiral feels that recent technological advancements in weaponry and command, control and communications (C³) systems have yielded an opportunity to completely reevaluate "the way we do business," from surface ship design and construction to strategy and tactics.

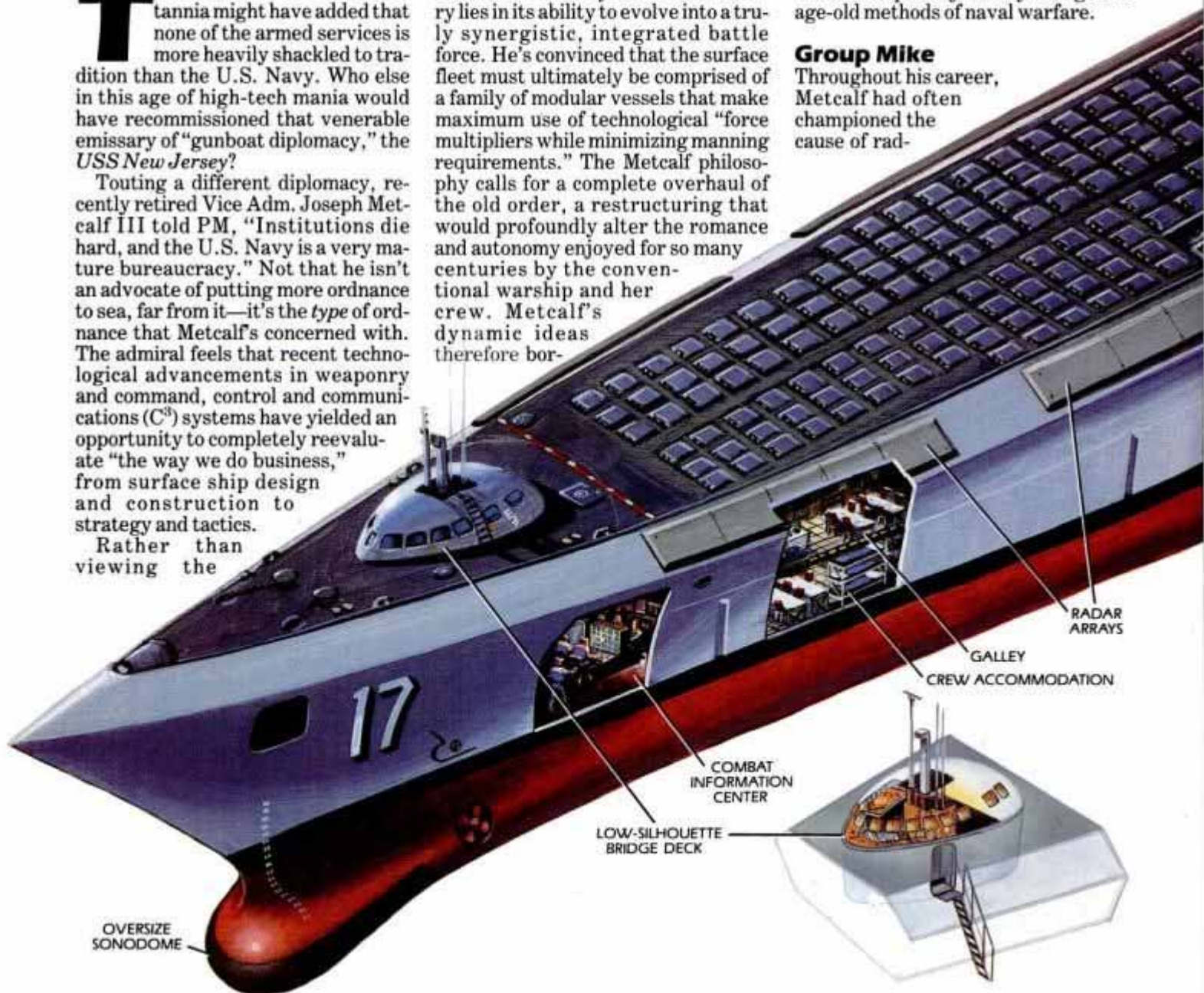
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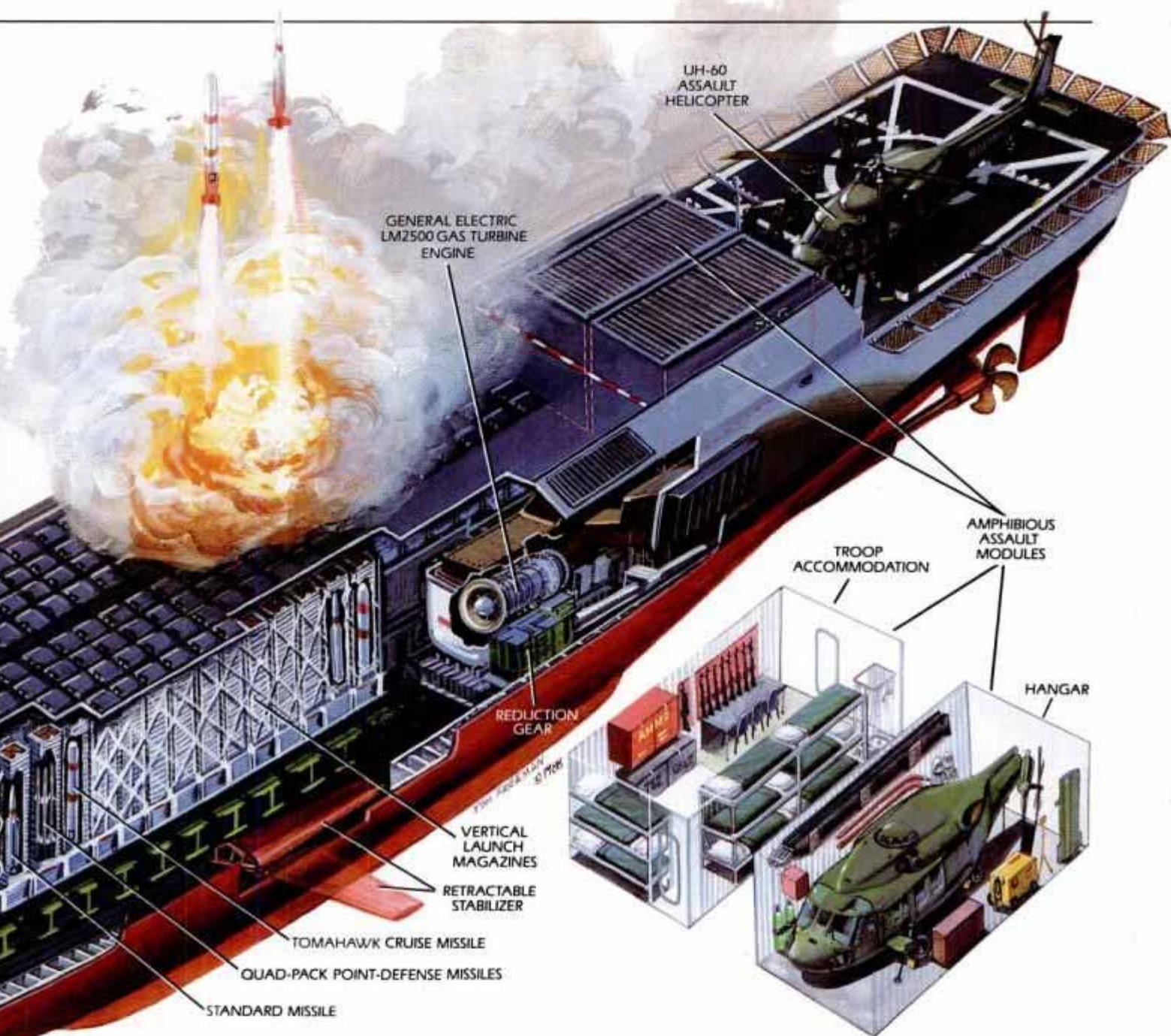
surface fleet as a collection of self-contained, floating arsenals (as typified by today's martial leviathan, the aircraft carrier), Metcalf believes the success of the Navy in the next century lies in its ability to evolve into a truly synergistic, integrated battle force. He's convinced that the surface fleet must ultimately be comprised of a family of modular vessels that make maximum use of technological "force multipliers while minimizing manning requirements." The Metcalf philosophy calls for a complete overhaul of the old order, a restructuring that would profoundly alter the romance and autonomy enjoyed for so many centuries by the conventional warship and her crew. Metcalf's dynamic ideas therefore bor-

der on heresy in the eyes of hidebound traditionalists. In short, the maverick mariner is instigating a revolution! And the focus of this revolution is an unusual ship that just may change the age-old methods of naval warfare.

Group Mike

Throughout his career, Metcalf had often championed the cause of rad-





ical departure from orthodox doctrine, and in his influential preretirement job as Deputy Chief of Naval Operations for Surface Warfare, he finally found himself in a position to do something about it.

The project that took shape in late 1986 under Metcalf's guiding hand was aptly christened the Revolution at Sea initiative, and a supervisory work/study group was established to oversee the various phases of the broad-based research effort. Fiercely loyal to their progressive leader, this body of officers adopted the phonetic-M title of "Group Mike" in recognition of Metcalf's personal commitment to the project.

Group Mike's innovative ship is the physical manifestation of Metcalf's preoccupation with "putting maximum ordnance on target." More im-

portantly, the admiral sees his visionary vessel as the heir-apparent to the primary strike role currently filled by the aircraft carrier.

"We're almost to the point where we're going to be able to eliminate manned aircraft from the naval scenario altogether," explains Metcalf. "Before long, both offensive and defensive duties in the fleet are going to be handled by missiles of various types."

For example, the offensive task of deep interdiction—presently the exclusive turf of carrier-based aviators—can be more efficiently fulfilled by precision-guided, long-range cruise missiles, according to Metcalf.

The admiral hints that anti-aircraft/antimissile laser weapons will soon be numbered among the ship's defensive armament.

Conceived as a means to get more ordnance on target more accurately, the stealth ship of tomorrow will carry multiple magazines of vertical launch missiles. Perfected on baseline-two ships of the Aegis cruiser series, the vertical launch system brings a variety of smart missiles to bear on different targets in a complex battle environment. The future variant of the Tomahawk cruise missile will strike land targets more than 1350 miles away. Updated Standard surface-to-air missiles will defend the ship and her battle group from air and missile threats. Antisubmarine rockets (ASROCs) will knock out submarines. Salvos of smaller missiles will help defend the ship. Marked by a low silhouette, supersensing radar arrays, and carrying remotely piloted surveillance aircraft, the ship of tomorrow will also incorporate mission-specific modules in the stern to accommodate amphibious assault teams, SEAL units or even X-wing fighters.

BATTLECRUISER 2000



A vertical launch Standard surface-to-air missile aboard contemporary cruiser *Lake Champlain* leaves magazine in less than a second.

PHOTOS BY BRIAN E. WOLFF

Critical volume

The revitalized surface fleet, as outlined by the Revolution at Sea studies, will be fashioned around three significant pieces of advanced hardware: the AN/SPY-1 Aegis radar system, a mix of modern missiles, and the missiles' Vertical Launch System (VLS). The first element in the triumvirate, Aegis, is already in service with the fleet, mounted on the *USS Ticonderoga*, and on more advanced sister ships like the recently launched *Lake Champlain*. This isn't the ultimate platform for the highly sophisticated radar, but budgets being what they are, it'll have to do for the time being, allows Metcalf. What is needed, he reasons, is a follow-on to the *Ticonderoga* dedicated primarily to carrying the missiles—a ship conceived in the image of Metcalf's "maximum ordnance" doctrine, one that incorporates the Vertical Launch System to accomplish this goal.

So what will Joseph Metcalf's ideal surface warrior look like? The answer to this question is largely couched in the parameters of modern naval warfare—a 3-dimensional "up, out and down" formula.

The area embraced by these elements is called "battle space," and its physical size is dictated by the range of the weapon systems being utilized at a given point in time. Hence, this spatial battleground is constantly expanding. The battle space in which Metcalf's high-tech warship will have to operate is defined as being 15,000 ft. up (the practical ceiling of surface-to-air missiles), 1350 miles out (the current operational range of cruise missiles) and 1500 ft. down (the engagement depth of

contemporary attack submarines).

In meeting this triple threat, Metcalf envisions a streamlined seafarer armed with a mixed bag of missiles: SM-2 Standard surface-to-air (up), Tomahawk cruise (out), and the anti-submarine rocket, or ASROC (down). Martin Marietta, maker of VLS, is working on a cluster of small ship-defense missiles called Quad-Pack. All of the missiles would be prepackaged to plug into universal VLS cells (about 274 of them!) arranged in a solid bank running nearly the entire length of the hull. This impressive assortment of firepower would be directed by the Aegis system, either nestled belowdecks aboard this missile platform or mounted on another ship. The grinning admiral admits, "If I had my way, this ship would be ordnance from stem to stern. If someone wanted to put something else on board—office space, paper manuals, or a signalman's flag bag—he'd have to prove to me that we need it."

Enter JMS dreadnought

Metcalf's hard line on giving ordnance stores "priority one" cuts right to the heart of the matter, for the single immutable caveat that must be embraced by every ship designer worth his salt is that the most precious commodity aboard any vessel is volume—every square centimeter of space must be applied to the ship's defined use. As far as Adm. Metcalf is concerned, the defined use of a warship is "to go in harm's way, to survive and to put ordnance on target." Anything that doesn't contribute directly to the achievement of these ends is superfluous and counterproductive.

"Everything we put into our ships is worth nothing if it doesn't contribute to putting ordnance on target. That's why we have ships at sea! That's why we have a navy!"

The admiral calls his creation the "Future Strike Cruiser," but taking the vessel's iron-fisted arsenal of multimission missiles into account, his Revolution at Sea colleagues have unofficially dubbed the powerhouse JMS dreadnought (JMS, of course, for "Joe Metcalf's Ship"). In keeping with Metcalf's definition of a warship, the FSC has one job in addition to delivering sledgehammer blows—to survive those of the enemy—or better still, to prevent their being delivered in the first place. The best way to accomplish this is to reduce the ship's radar profile and heat signature—in other words, to create a stealth ship.

Addressing the physical profile issue, Metcalf says all of the structures that protrude above the deck have got to go—including the bridge and conning tower.

"The bridge," Metcalf contends, "has no relevance to the modern warship. It's a glaring anachronism. It was originally designed in Adm. Dewey's day to allow the captain to watch the fall of his shot, but the vast expansions of battle space has rendered it obsolete."

Many of the command functions traditionally conducted from the bridge have already been transferred to a sophisticated electronic nerve center called the Combat Information Center, or CIC. Because of the need to collocate the CIC with the bridge, it is currently situated topside—a vulnerable spot for such a critical facility.

Metcalf would like to shift the remaining bridge functions to the CIC, which could be nestled snugly and safely in the very bowels of the ship. In his opinion, there is no rational reason to do otherwise.

Future nerve center

The CIC of the Future Strike Cruiser would house a master control console encompassing all of the equipment necessary to sail and fight the ship: powerplant controls and monitoring devices, rudder controls, communications equipment, weapons controls, radar and sonar monitoring stations, navigational controls, large-screens that monitor the threat environment, and so forth. The data required to accomplish these varied tasks would be presented to the officer of the deck via a mutually redundant array of plasma displays, video monitors, and low light level/infrared vision systems. Navigating in the open ocean would be deftly handled by computers linked to the NAVSTAR satellite-based global positioning system (which will be in place within the next five years).

Ship's operations

Long-range remotely piloted aircraft would extend the ship's sensor capacity well over the horizon—using television, infrared imaging and laser range-finding.

Maneuvering the ship in restricted waters, or when conducting underway replenishment—the primary reasons for the existence of the conning station—could be adequately performed by a 4-man position placed in a blister molded into the deck above the CIC. The conning station, would be equipped with fly-by-wire controls and TV monitors. This position would never be manned during combat, as all activity would then be focused in the CIC. All of the functions related to maneuvering the vessel would also be imbedded in a remote control unit to allow them to be performed by an officer standing on the deck.

Both of these control units—the CIC and the secondary conning station—would be hardened against electromagnetic pulse (EMP) damage and enclosed in a container of some ballistic material to act as a spall liner, providing added protection against projectiles and shrapnel. Battle stations and quarters would be further safeguarded against NBC (nuclear, biological and chemical) attack.

The hull of the Future Strike Cruiser would, for budgetary reasons, have to be derived from an existing design.



Lake Champlain's Capt. Ralph Martin, standing, directs combat information center aboard present-day cruiser, which will also be the nerve center of tomorrow's Navy.

Metcalf leans toward that of the *Spruance*-class destroyer (the base design of the *Ticonderoga*), but some critics feel the growth potential of an aluminum hull based on 20-year-old technology is too limited for such a long-term project. The more recent *Arleigh Burke*-class hull would be more to their liking, as its appearance marks a return to all-steel construction. As luck would have it, the *Burke* was designed around the AN/SPY-1 Aegis radar system, while Aegis was fitted to the *Spruance* as an afterthought. Further, the *Arleigh Burke* hull incorporates numerous survivability and sea-keeping features which render it capable of fighting longer and in less forgiving seas than that of the *Spruance*.

In either case, the gunwales of the hull selected for the FSC would be lowered closer to the water line, their upper edges meeting a turtle-backed deck ringed with radar sensors.

Making it go

Propulsion of the Future Strike Cruiser is an area of concern which promises major leaps in technology. In the near term, Group Mike anticipates continued use of the gas-turbine powerplant currently found aboard ships of the *Ticonderoga* class. But for the future, Group Mike is recommending the integration of an inter-cooler regenerative system (ICR) for a number of reasons. First, such a system can be placed directly under the deck, where intake and exhaust can be accomplished without any cumbersome ducting. By comparison, conventional gas-turbine power-

plants are situated in the bottom of the ship, their heavily insulated ducting consuming up to 20 percent of the total hull volume.

Since the ICR recycles exhaust before expelling it into the atmosphere, no stacks are required—only flush-mounted deck grates. The stealthiness of the craft is further enhanced by the fact that the propulsion system's exhaust approaches ambient temperatures, resulting in a significantly reduced heat signature. These attributes serve to underscore the ICR's most impressive statistic of all: This system offers a potential increase in efficiency of 30 percent over the conventional gas turbine it would replace. This equates to a commensurate expansion of operational range—or if you prefer, a third of the volume normally used for fuel storage could be allocated to additional weapons stores, mission-specific equipment, or other flexible applications.

The ICR concept is very attractive, indeed, but Group Mike is not satisfied to rest on its laurels—it wanted to look a bit further down the road as well. After all, this is to be a revolution. Group Mike's Ship Operational Characteristics Study points out that the Navy is currently pursuing experiments in superconductivity, research that could feasibly yield a truly revolutionary propulsion technology by the turn of the century. Group Mike's Capt. Lee Gunn elaborates: "Electric drives and superconductivity were made for each other. If the cryogenic support necessary for superconductivity has not evolved into a

(Please turn to page 120)

FAMILY FLYERS

Five sport sedans for the water clash in a battle of big-boat luxury and hot-rod speed.

BY JOHN WOOLDRIDGE; PM Photos by Skip Gandy

COMES A TIME for every boatman when he wants to trade up to a bigger boat. It's a natural urge, and when it strikes, your demands become sharply focused. You want a smooth ride and room for a cabin below. You want handling like a roadster and the speed of one, too. And, finally, you want sleek styling and sophisticated fit and finish.

In other words, you want a family flyer

—a small cuddy-cabin boat with big-boat features and feel.

The PM test team decided to take a look at these cruisers at the Miami International Boat Show, where we picked up five of today's hottest models right off the exhibit floor. We brought them to MerCruiser's test base, near Boca Grande, Florida, and put them through a battery of tests. All were equipped with MerCruiser's gutsy,





**PM
COMPARISON
TEST**

Test fleet at cruising speed, from the top:
Century 4500 CLX, Chris-Craft 245 Limited,
Cobalt Condurre 223, Celebrity 250C/CT
and Chaparral 2350 SX.

FAMILY FLYERS



330-hp, 7.4 Litre Bravo One propulsion system. Here's what we found.

Cobalt Condurre 223

The family flyer our test team would most like to trade up to is the Cobalt Condurre 223, a rare boat that looks as hot as it performs.

The test winner set a blistering pace in all performance categories. Hole-shot and top-end speeds were eye-popping. Even more impressive were its G-force-generating performance-course turns.

Total cabin volume, sleeping pad space and cockpit area, however, were middle of the pack, and total

stowage space was dead last.

But this boat exudes style and luxurious comfort. The Condurre's fiberglass exterior and flowing lines were second to none. Accessibility to controls and visibility of gauges were superb. Helm features we especially liked were weather-resistant toggle switches and engine-hour counter.

Cabin appointments are as plush as they are in the cockpit. Overall, the Condurre looks and rides like a waterborne Mercedes.

Chaparral 2350 SX

Sporty looks, superb layout and brisk acceleration make the Chaparral one

of the test-fleet leaders. Hole-shot times (second) were blistering and tracking was exceptionally tight in turns, but slower top-end speeds (fourth) held back its performance-course ranking.

Deck space was well behind the fleet, because Chaparral chose to maximize the cabin, where the 2350 SX led all comers, as it did in stowage. Features we especially liked were a minigalley and third-largest V-berth.

Fit and finish, second only to the test winner, was precise and clean.

Performance gauges were easily read. But status gauges were partly obscured, as was forward view, caused by a mid-level windscreen and high-mounted wiper motor.

But overall, the Chaparral is a head-turning, smooth-handling day cruiser with room for overnighting.

Celebrity 250C/CT

The Celebrity achieves high marks for comfort, performance and a distinctive teak-trimmed design.

At speed, the Celebrity finished third in acceleration and top-end, and a remarkable second on the performance course.

Like other test boats, the Celebrity sacrifices cockpit area (ranked fourth) for cabin space (ranked second). Be-

TEST PARAMETERS

Each boat was propped and tuned by MerCruiser and equipped with MerCruiser's Bravo One propulsion system, based on the GM 454-cu.-in. V8 block, producing 330 hp (list price: \$11,500). Speed and timing figures are the result of averaging four test runs for each boat with two adults aboard and matched fuel loads. Performance course began from a dead stop and included full-throttle and 90° and 180° turns.



OVERALL RANKING/MAKE/MODEL	1. COBALT CONDURRE 223	2. CHAPARRAL 2350 SX
LOA/Beam/Weight/Fuel Capacity	22'3"/96"/3700 lb./60 gal.	23'3"/102"/4120 lb./70 gal.
Deck Area (sq. ft.)/Ranking	55.5/3, plush and cozy, with large sunpad	48.38/5, adequate seating for four
Stowage (cu. ft.)/Ranking	34.45/5, extra spaces would be appreciated	56.56/1, copious and well thought out
Cabin (cu. ft.)/Ranking	110.91/4, beamy but low headroom	149.09/1, a pleasure to be in
Top End (mph)/Ranking	57.38/1, leader of the pack, aggressive and smooth	54.19/4, off the leaders, but not by much
Acceleration 0-35 mph (sec.)/Ranking	8.58/1, jumps off the line, immediate planing	8.64/2, a whisker off the pace, skiers take note
Performance Course (sec.)/Ranking	38.1/1, superb blend of control and speed	40.4/3, superb cornering and control
Sleeping Pad (sq. ft.)/Ranking	37.85/4, comfortable but not for long weekends	40.0/3, large enough for two and comfortable
Fit-and-Finish/Ranking	Unmatched craftsmanship, luxury and style/1	Clean detailing throughout/2
Price As Tested	\$29,150	\$30,996
Address	Cobalt, P.O. Box 29, Neodesha, KS 66757, (316) 325-2653	Chaparral, P.O. Drawer 928, Industrial Park Blvd., Nashville, GA 31639, (912) 686-7481
Bravo One's stout upper-drive allows for a drag-reducing lower unit.	High marks for tightly clustered instruments, engine-hour counter and wheel-position indicator.	Solid seating, but some gauges are obstructed. High-mounted windshield wiper motor can be annoying.

lowdecks layout was outstanding, with the fleet's roomiest sleeping pad.

Visibility from the helm seat is superb, but a metal plate jugged into the backs of our legs and raised mounting bolts assaulted bare feet.

Fit and finish was judged high, yet flex was a problem on the foredeck and the louvered doors tended to rattle and bang.

Still, the Celebrity was our fleet's most consistent boat, ranking no lower than fourth across the board.

Century 4500 CLX

Designing a big-boat feel into a sporty package was Century's aim with the 4500 Sport LX. The Century has the largest cockpit, third largest cabin and second roomiest sleeping pad and stowage areas.

The boat is certainly fast enough for cruising and skiing, but it finished well off the pace in all the performance categories.

Fit-and-finish ranking was also back of the pack. Details that need attending to include exposed fasteners, shaky windscreen and pedestal seats, and a weak sliding door latch.

Instrument groupings were readable at a glance. We particularly liked the proper mounting of wipers.

The roomy cabin has a number of



CHRIS-CRAFT 245 LIMITED

standout features, including a convertible dinette and minigalley.

Chris-Craft 245 Limited

Clean aerodynamic lines and contemporary design features are the hallmarks of the 245 Limited.

In addition, it's a straight-ahead waterscorcher, nearly besting the leader in top-end speed. Less satisfying were the hole-shot and the performance-course results, where power-draining cavitation resisted all our efforts to neutralize it.

Among the Chris-Craft's best features is a well-layed-out deck. Back-of-the-pack rankings in cabin size,

stowage volume and sleeping pad area are the result of the large cockpit. Forward visibility is superb, as are sightlines for dash instruments. Engine controls are competition-style and take some getting used to.

Despite its name, this Chris-Craft is far from limited. It's a real rocket in the straightaways, with a superb fit and finish.

All of our family flyers incorporate advances in performance and design that weren't available a couple of years ago. They're faster and more luxurious than ever before, making this an ideal time to trade up to any boat in the fleet. **PM**



3. CELEBRITY 250C/CT	4. CENTURY 4500 CLX	5. CHRIS-CRAFT 245 LIMITED
22'5"/96"/3900 lb./72 gal.	23'3"/102"/4250 lb./75 gal.	24'4"/102"/4750 lb./74 gal.
52.5/4, snug for passengers, superb at helm	70.6/1, spacious plus large sunpad	68.24/2, wide open comfort, with enormous sunpad
48.28/3, thoughtful side pockets and foot boxes	49.74/2, room for everything	46.52/4, adequate and not that far from leaders
141.29/2, plush with outstanding headroom	120.05/3, midsize but lots of amenities	106.74/5, large cockpit compromises belowdecks
54.25/3, swift enough for thrills	53.75/5, last in an exceptionally fast fleet	56.75/2, a straight-ahead rocket
9.36/3, all-around solid performer	10.4/4, adequate for all watersports	10.99/5, heavy hull gives sluggish hole shot
38.27/2, exceptional feel and responsiveness	41.9/4, skittered somewhat in tight corners	42.76/5, good feel, but excessive cavitation in turns
47.69/1, clever arrangement can accommodate family	40.19/2, plenty of room to stretch out	33.69/5, smallest in the fleet
Despite overall care, certain glitches need work/4	Minor details bring down overall ranking/5	Somewhat spartan, but better detailing than most/3
\$28,379	\$27,360	\$29,930
Celebrity, P.O. Box 394, Benton Industrial Park, Benton, IL 62812, (618) 439-9444	Century Boats, P.O. Box 15488, Bay County Indus. Park, Panama City, FL 32406, (904) 769-0311	Chris-Craft, 101 Riverfront Blvd., Bradenton, FL 34205, (813) 747-4100

Adjustable wheel and digital instruments are a nice touch, but unwieldy seat mountings diminish comfort.



Gauges readable at a glance. Proper windshield wiper mounting a pleasure, but helm seat wobbles.



Unobstructed gauge sightlines are superb, but competition throttle and clutch takes getting used to.



National Nostalgia

Return with us now to those
thrilling days of yesteryear . . .



THOMAS WOLFE told us we couldn't go home again, and it's hard to argue with this premise. On the other hand, if you want to turn the calendar back just for a while, it's hard to imagine a more effective time machine than a car from your target era.

This is particularly true if the target era is the '50s, when men were men, girls were cheerleaders and cars were peculiarly—even spectacularly—American. An age of innocence, interpreted in tail fins, chrome frosting and the throb of big-inch V8 engines. Install

yourself in a '57 Chevy convertible, dial up an oldies station and watch the decades melt away.

Then again, you might yearn to visit the dawn of the American sports car consciousness, when quirky little

British roadsters shaped a whole new concept in automotive fun. An Austin-Healy, perhaps. Or a Triumph TR-3.

Obviously, there are practical limitations to this plan. Unless you happen to be a collector, chances are you don't have access to a machine that'll transport you across the time warps. Which is why we look upon National Car Rental's California Classics as something more than your garden-variety rent-a-car promotion.

It's true that National's oldies program is self-serving in that it's aimed at stimulating membership



One of the most desirable of all '50s classics, this 1957 Chevy Bel Air convertible is a big favorite in the National Car Rental California Classics headquarters at L.A. airport.

National Nostalgia



rolls of the company's Emerald Club, a frequent renter program similar in concept to the airline bonus plans.

Still, regardless of its reason for being, the Emerald Club gives rent-a-car customers an opportunity to drive something well removed from the vanilla offerings that make up most rental fleets.

The original National Car Rental California Classics fleet got its start a year ago in Los Angeles, at the company's Los Angeles International Airport facility. Although the fleet started out with a mixture of coupes and convertibles from America's golden era—the '50s and early '60s—it has since been purified to an all-convertible collection. And a tempting collection it is, including a number of 2-seat Thunderbirds (1954-'57), late '50s Corvette roadsters, several Chevy Bel Airs, a rare '54 Buick Wildcat, and three '59 Cadillacs—to name just a few.

National's fleet of British roadsters, established last December, is based at the firm's San Francisco airport headquarters, and includes some

National's San Francisco classics include (left to right) a 1947 Morgan Plus 4, a '53 MG-TD and a rare '37 MG-TA. The '57 Ford Fairlane (inset, top) is from National's L.A. collection. Opulent dashboard (below) belongs to 1962 Chrysler.



cars that are rare by any standards. Foremost under this heading is a 1937 MG-TA roadster, forerunner of the MGs that more or less launched the sports-car era in this country.

Public response at both the Los Angeles and San Francisco facilities has been so positive that National has added oldies operations at its outlets in San Diego, Las Vegas and Palm Springs, California. And as we went

to press, plans were underway to set up several fleets in Florida. Target cities in the Florida plan are Fort Lauderdale, Fort Meyers, Tampa, West Palm Beach, Orlando and Miami. Save for San Francisco, all the fleets will follow the L.A. formula.

Although there are oldie car rental operations of a local nature here and there around the country, clearly the magnitude and scope of the National plan eclipses anything attempted before now. And it's creating some interesting ripples throughout the collector car community.

Stocking up several fleets in a short time means that National's buyers can't be too fussy about how much they pay for a car. And from an investment point of view, they don't really have to be. Although National frequently pays well beyond premium prices for its topless classics, the company is in the luxurious position of purchasing cars that will only appreciate in value—the exact opposite of the standard fleet car. And while they're appreciating in value, they're simultaneously generating profits.



The other side of this is that National contributes to a rapid escalation in prices for cars of this type and time. In a collector segment that's already hot, National is big enough to send values skyrocketing.

However, for the guy who simply wants to visit America's golden automotive age—rather than actually own a slice of it—the question of prices is academic. His stake in the dream machines is the daily rental rate—\$49.95 (\$59.95 for the San Francisco cars)—plus 30 cents per mile, fuel and extra insurance (optional). There's also Emerald Club membership, which has a \$50 initiation fee.

These aren't what you'd call rock-bottom rates. On the other hand, these cars are hardly what you'd call basic rental transportation.

One cautionary note. Generally speaking, National's policy regarding these cars is first come, first served, and what you see is what you get. We don't take issue with this.

However, we do suggest that you take a good look at what you get before you leave the lot. In the course of

One of National's most prominent collectibles is a 1962 Chrysler 300H (top). This immaculate musclecar once belonged to singer Karen Carpenter. Jaunty little Nash Metropolitan (above, right) was short on muscle but won our cuteness award.



developing our story, we drove a number of cars from the Los Angeles and San Francisco operations. We emerged with a conviction that many of the cars have developed one or more of the idiosyncrasies one associates with old age in automobiles.

For example, in San Francisco (where almost all the cars are right-hand drive) we found that the time-honored complaints against classic

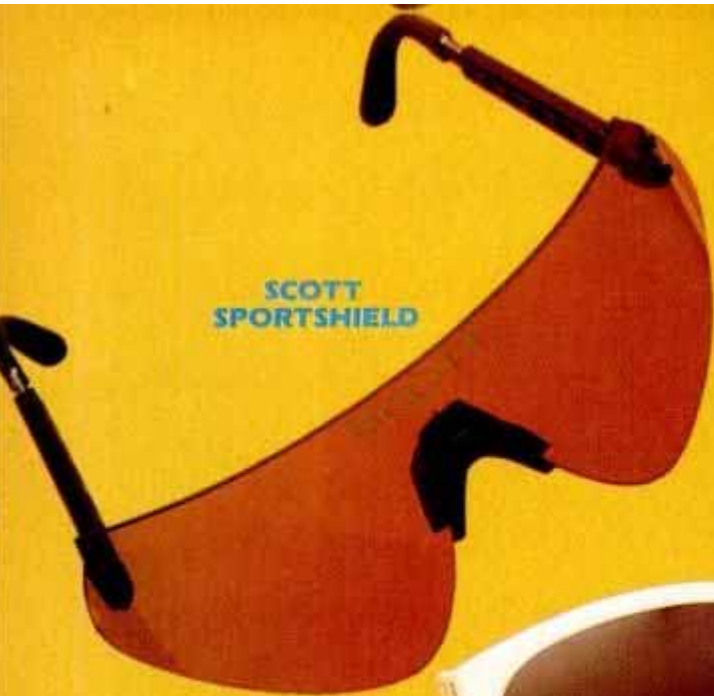
British sports cars—cramped driving positions, rubbery steering, a tendency to overheat—hadn't gone away in the years since these cars were made. Our favorite car in the San Francisco fleet—a sweet little 1937 MG-TA—developed a fuel-feed problem and quit running in the exact middle of the Golden Gate Bridge.

We didn't encounter anything quite so dramatic in Los Angeles, but many of the cars had small deficiencies—a power window that wouldn't roll down, for example, or balky throttle response, or a radio that wouldn't work—that could detract from the time machine experience.

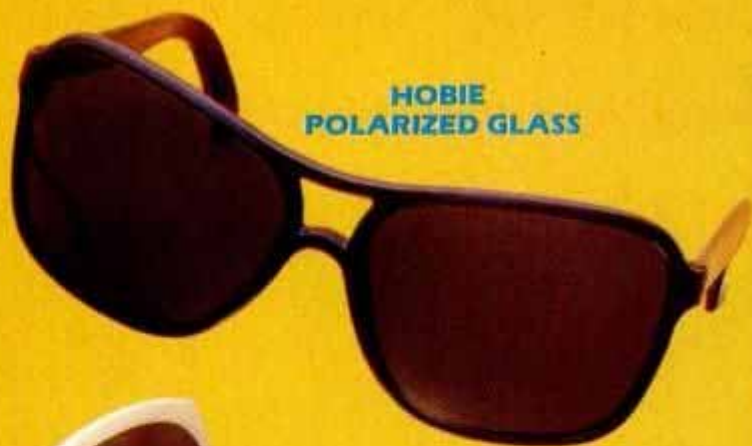
The message here—one that National makes no bones about—is that these are old cars, and nothing produces automotive infirmities so effectively as age.

But a quick checkover will tell you whether the car's basic systems are working. And then you can be on your way to enjoying another characteristic of age in automobiles—particularly automobiles whose tops fold down: They can be magic.

PM



SCOTT
SPORTSHIELD



HOBIE
POLARIZED GLASS



VUARNET FOLDING
GLACIER GLASS



SERENGETI
DRIVERS



RAY-BAN CATS
GLACIER GLASS

SERIOUS

High style gives way to high tech as new performance sunglasses become sophisticated optical instruments.

BY CHRIS CASWELL; PM Photos by Bill Ashe

SHADES ARE COOL. Always have been, always will be. You wear them because they make you feel as cool as Gen. Douglas MacArthur, Don Johnson or the Blues Brothers.

But looking through a glass darkly has new meaning

today. Appearances are less important than protection. Researchers have discovered that ultraviolet (UV) rays, the band bordering the visible spectrum of sunlight with the shortest wavelength, damages the eye faster than any other kind of light.



CARRERA
BOEING SHIELD

BOLLE IREX

GARGOYLES
LUNAR GRAY

VUARNET
NAUTILUX

REVO VENTURES

PHOTO BY JAP GANDY

SHADES

Exposure to UV light can cause pain, temporary loss of day vision (often referred to as snow blindness) and temporary loss of night vision. Cumulative effects can be more serious, such as cataracts, pterygium (a sight-reducing growth) and even blindness.

Modern sunglasses do much more than cut down glare and squinting. They protect the eye and react to light in ways that rival the sophistication of a camera.

Choosing a pair of sunglasses, never an easy task when image was the only criterion, has become considerably harder. Today's shades are fitted with a variety

of high-tech, ophthalmic lenses that have distinctive light-reacting features and specialized uses. Prices are higher, too, and run from \$25 to \$225.

Why should you spend that much for sunglasses when a \$5 pair can be found in the local drugstore? Because old-style dark glasses, colored discs, actually do more harm than good. They block glare but allow the eye to open up to direct UV exposure.

The first thing to look for in sunglasses, then, is 90 percent or better UV blockage. Here are some other important things to keep in mind.

SERIOUS SHADES

Lens construction

Sunglasses can be made with either glass or synthetic lenses. Glass lenses are scratch resistant, nonwarping and can be distortion free. Synthetic lenses are light, virtually shatterproof and generally less expensive.

The most common synthetics used are polycarbonate and Lexan, both of which can withstand a shotgun blast at 15 yards without shattering.

Polycarbonate lenses are used, for example, by Gargoyles in its Lunar Gray (\$72) model, which is also mirrored. Mirroring is accomplished by applying a thin metallic coating to the lens, which reflects some light as a buffer against glare.

Constant-density lenses, made either of glass or synthetics, have a uniform, fixed color, such as the amber of the Bolle Irex (\$90) model, the frames of which have side lenses to block out incidental light and wind for skiing and other fast-moving sports.

High-tech lenses

Photochromic lenses, such as those on the Serengeti Drivers (\$95), have the camera-like ability to automatically adjust their density in relation to the Sun. In full sunlight they darken. Removed from sunlight they fade.

The photochromic effect is caused by silver halide crystals in the glass that react to the presence of UV light and adjust from light to dark within a few minutes.

Double-gradient lenses, such as those on the Vuarnet Nautilux (\$80),

offer two different filters within the same lens. The darker (blue) filter appears strongest at the top and bottom of the lens, while the lighter (green) filter is strongest in the middle.

Dark blue filters appear high, to absorb direct glare from the Sun, and low, to absorb direct glare from the water. The mid-lens is a lighter green to allow nearly true colors to be seen.

Also ideal for water sports are polarized lenses, as on the Hobie Polarized Glass (\$68). Polarized lenses are made by sandwiching a layer of polarizing material between two pieces of plastic or glass. The polarizing material is a thin synthetic membrane constructed with its crystal molecules aligned in parallel lines.

Lightwaves travel in a random direction until they're reflected off a surface, such as water, and become directional, causing a hot spot of intense glare. Polarized lenses filter out this glare by aligning crystals in vertical lines, which tends to act like a venetian blind. The effect on the water is to eliminate much of its glisten and to allow boaters and fishermen to actually see below the surface.

Sport-tech features

By combining several features into one lens, the Revo Ventures (\$150) are cutting-edge, sport-tech sunglasses ideal for skiing. Revo uses as many as 25 lens layers to achieve its unique combination of tinting, mirroring and polarization.

Light, mask-shaped sunglasses,

with adjustable temple arms, such as the Scott Sportshield (\$60), are a recent innovation for skiers. The Sportshield features a 1-piece Lexan lens that has a light amber tint designed to enhance vision in snowy conditions.

One of the toughest tests for sunglasses is mountaineering, where the thin atmosphere filters little of the Sun's rays. Ray-Ban's Cats Glacier Glass (\$74), with G-31 Gray Full Mirror lenses, has several sport-tech features especially designed for the carabiner set, including temple arms fitted with movable leather shields to block out peripheral light.

To cope with the cramped stowage spaces of hikers and climbers, Vuarnet makes a Folding Glacier Glass (\$80), which has gray mirrored glass lenses and a collapsible frame that fits in a compact, hard-plastic case.

An even tougher-test than mountaineering is flying. UV light is so strong at high altitudes that pilots can experience nausea, headaches and severe pain due to its effects. The Boeing Shield from Carrera (\$180-\$225) not only absorbs 85 percent of visible light and 100 percent of UV rays, but its tough, gray wraparound lens blocks out incidental light from all directions.

Color shifting

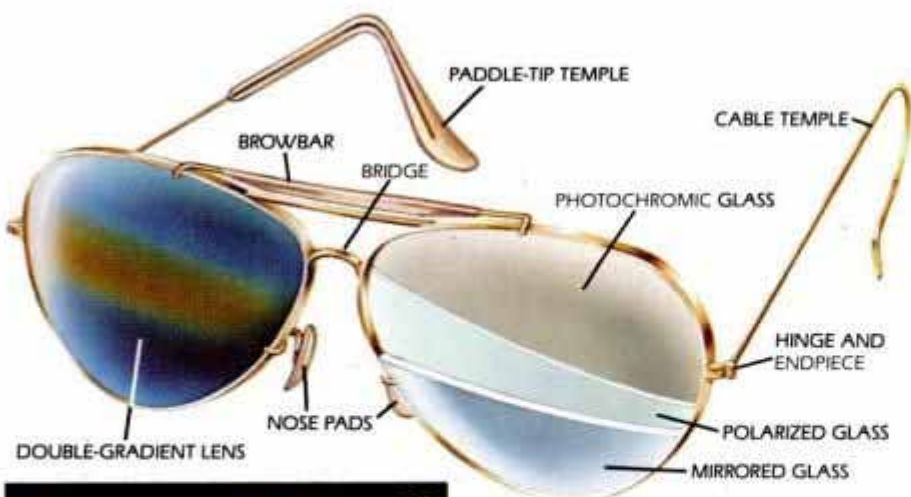
Tests have shown that the eye is least sensitive to the color blue, which is why a bright blue light bulb often seems to have a halo around it. Blue light, unfortunately, is easily scattered by moisture or dust in the air, causing a loss of depth perception on hazy days. For this reason, many sport-specific sunglasses absorb all or most of the blue light.

Black and gray lenses are considered neutral, because they transmit all colors evenly, while green shifts colors only slightly. All other tints shift colors dramatically, such as brown, which absorbs a large percentage of blue light, and yellow, which only transmits colors your eye sees sharpest.

But there is a delicate balance between removing undesirable colors and creating more problems than are solved. Major color shifts may alter a driver's perception of traffic lights, for example, and headaches and eye strain may result.

No doubt there are many other sport-tech features on the market, interchangeable lenses, protective brow pads and others, but in the end, after you analyze all the features, your best bet is to pick up a pair of sunglasses you like, look around and then believe your own eyes.

PM



Composite sunglasses (above) with two different temple earpieces and lenses, illustrate a variety of sport-tech elements. Curve of visible light (left) shows relative strength of colors allowed through sunglass lenses. Mid-chart colors are easiest to distinguish, so they're transmitted in greater strength. UV light, on left, and infrared, on right, are kept to a minimum.



FUTURETECH

MICRO MACHINES

With minute gears, rotors, stators and circuitry, machines of tomorrow will work from the inside out—fixing computers or combating cancerous cells.

BY WILLIAM HOFFER



AT&T technicians (left) use a photolithography mask aligner to create micromachines above. The gear (top)—300 microns in dia.—is shown next to a human hair. Tiny calipers (middle) and a micro gearbox (above) are also feasible.

SUPPOSE THAT, early in the 21st century, physicians discover an obstruction in your heart, a blood vessel clogged by a cholesterol deposit. In this marvelous world of the future the doctor simply injects a microscopic substance into your body, which travels to your heart, locates the obstruction and destroys it quickly and painlessly.

A new wonder drug? No, it is a machine, complete with gears, driveshafts, pulleys, switches, sensors, actuators

and other mechanical components (perhaps in a configuration yet to be conceived) and driven by an on-board micro-computer. The machine's specifications are mind-boggling: Its rotary engine can spin at half the speed of sound and reach that velocity from a standing start in one-tenth of a millisecond. Yet it is so small that the unaided eye cannot see it and, since it costs less than a penny to produce, it is disposable.

The cholesterol-chomping micromachine exists only as a

MICROMACHINES

twinkle in the scientific eye, but the first few prototypes of micromachines are now a reality. This leads to the conclusion that researchers are on the brink of a breakthrough that may well transform (and shrink) the entire mechanical world.

The key concept is this: The manufacturing techniques of the semiconductor industry can be applied to the production of machines. Intricate techniques such as photolithography, chemical etching and metal deposition are applicable to the mechanical world as well as the electronics world. In other words, the electronics revolution of the 1970s and '80s can be copied, and even surpassed, by the micromechanical revolution of the 1990s and beyond.

The new wave

"We are talking in terms of a revolution," according to George A. Hazelrigg, PhD., of the National Science Foundation, in Washington, D.C. "People are walking around with bug eyes, thinking about what the future holds. Let me show you."

Hazelrigg reaches into his desk drawer for a glass slide on a piece of paper. A tiny speck is barely observable.

"That is a rotor, made at MIT. And it is a fairly large one, because we don't have to work too small as of yet. This rotor measures about 200 microns across. There's no reason you can't take it down in size by a factor of 10. Keep in mind that we still haven't got these things to run, but the design parameters are boggling."

Although there are many and wondrous variants to the process of producing a microelectronic circuit, the basic technology is well established, and is similar to the development of a photographic plate. Technicians begin with a base, called a substrate, usually a silicon crystal. Upon this substrate they deposit a layer or layers of working material, usually silicon, that is sensitive to an electromagnetic radiation source, such as X-rays or electron beams. The silicon is covered with a mask, or pattern, irradiated and then treated chemically to etch away unwanted material, leaving the desired pattern of silicon. The process has been highly refined by experience, enabling technicians to produce multilayered assemblies in intricate patterns. Vast libraries of software aid in the mass production of integrated circuits constructed to precise microspecifications.

The building process

Micromechanics is an attempt to etch out basic mechanical parts that are capable of motion relative to one another. The first step is to remove a completed part from the substrate, an advance unnecessary for the production of microelectronics but critical to micromechanics.

Mehran Mehregany, an MIT graduate student and a consultant to the Robotics Systems Research Dept. of AT&T Bell Laboratories in Holmdel, New Jersey, devised a method to do this, basically by turning over the assembly and etching away the substrate from behind. Using this process, a team of engineers (Bill Trimmer, Ken Gabriel, Ken Orlowsky and Nick Ciamata) at AT&T produced a prototype, free-standing gear 300 microns in diameter (a human hair is about 100 microns thick) and 50 microns across.

"We made a gear because it is a structure people know," explains Trimmer. "It may be that there is a better struc-



ture to use on such a small level, but we don't know that yet." Having made the gear, the group advanced to the next logical step, which was to tie together two or more components into a mechanical system. They soon realized, says Trimmer, that "hand assembly is a problem."

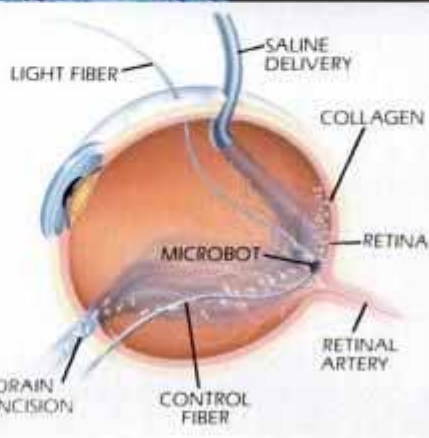
At the micro level it is more prudent to build products with no assembly required, and several laboratories have attacked this challenge by the use of so-called sacrificial layers. For example, Richard S. Muller and his colleagues of the University of California at Berkeley built a pin joint, composed of a hub and a rotating member. The assembly was constructed in layers, separated by sacrificial layers of silicon dioxide. When the structure was complete, the



silicon dioxide was etched away, freeing the rotating member. After that success, they built more elaborate devices, including an entire machine—a system of gears, slides and a spring made of polysilicon—that is smaller than the width of a human hair.

"It doesn't make much sense to build a micromachine if you have to put a big motor on the front of it," notes AT&T's Gabriel. "Right now we're tackling the basic problem of the power source. At the moment, electrostatic power appears to be the cleanest and most advantageous, but hydraulic and pneumatic power sources are also possible, and the choice, in the end, may depend a lot upon the specific application."

(Please turn to page 121)



A retinopathy procedure of the year 2050 might involve a microbotic walker teleoperated by surgeons outside the body. Equipped with a rapid-spinning wire cutter, the device would crawl on articulating legs to the work site inside the eye and use the cutter to remove collagen buildup from the retinal surface.

ILLUSTRATION BY PAUL COCHRAUER

Sabre Saw Secrets

A do-it-yourselfer's guide to the versatile sabre saw.

TEXT AND PHOTOS BY ROSARIO CAPOTOSTO, Contributing Editor

THE SABRE SAW'S unique design and versatility have made it one of the most popular portable power tools in use today. Do-it-yourselfers like the tool's user-friendly design and relatively safe style of cutting. Professional tradesmen find sabre saws valuable for use both in the workshop and at the job site.

However, the sabre saw's most outstanding features are its ability to make curved cuts and, when fitted with the appropriate blade, cut a wide variety of materials including wood, metal, plastic, brick, leather and ceramic tile, to name a very few.

Sabre saws, also known as jigsaws or bayonet saws, are available in many different models from several tool manufacturers. Prices start at about \$25 and go up as high as \$250. A good-quality sabre saw in the \$50 to \$75 range would suffice for most active do-it-yourselfers.

Regardless of the saw model, they all operate basically the same way. A motor-driven gear assembly powers a shaft up and down. A blade clamp, attached to the end of the shaft, holds the saw blade securely.

Sabre saw specifics

Sabre saws are typically rated according to amperage, blade speed and stroke length—the distance the blade travels.

Generally, the current rating is a good indication of power. The more amps a tool draws, the more powerful it is. Most sabre saws range between 2 amps and 4½ amps. The speed that the blade moves up and down is meas-

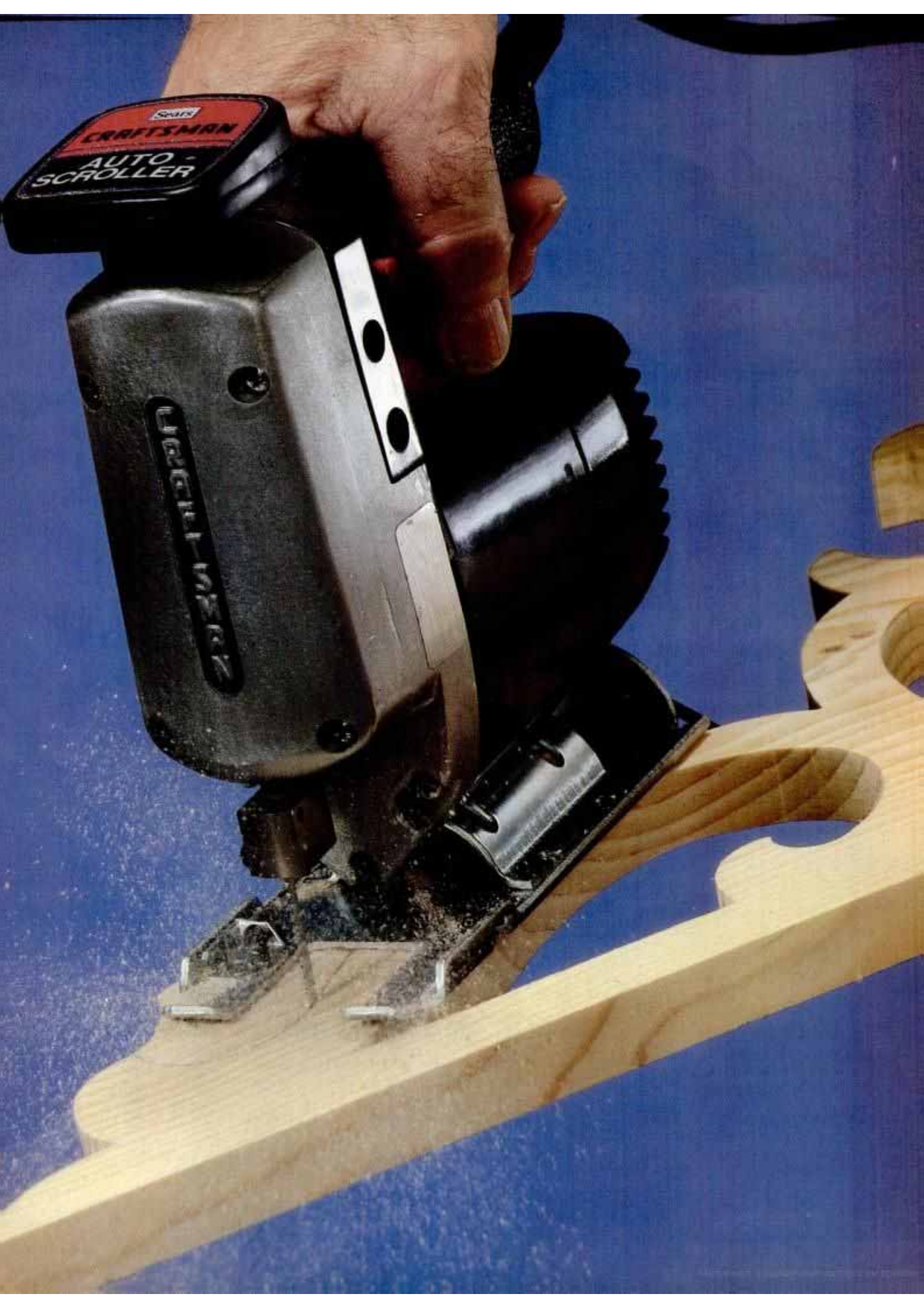
ured in strokes per minute (spm). Sabre saws are available in single-speed, 2-speed and variable-speed models. A variable-speed sabre saw operates from 0 to about 3200 spm. This feature allows you to adjust the blade's speed, and therefore, cutting efficiency, to the type and thickness of the material being cut.

Blade stroke length ranges from ½ in. to about 1 in. depending on the saw. The longer the blade stroke, the more saw blade teeth that will be doing the actual cutting.

Most sabre saws cut with a straight up and down reciprocating action. Other saws offer orbital-action cutting. The blade cuts into the work at a slight angle on the upstroke and then moves away from the work on the noncutting downstroke. Orbital action means faster cutting with less chatter and increased blade life since there's no friction on the downstroke. Most orbital-action sabre saws feature a 3- or 4-position switch for selecting the desired cutting motion from straight reciprocating through various degrees of orbital action.

Another worthwhile feature found on some sabre saw models is a scrolling mechanism. This allows you to rotate the blade 360°—while cutting—to gain superior control when sawing intricate scrollwork and highly detailed shapes.

Other convenient features worth looking for include electronic speed control, ball-bearing blade guides, a built-in sawdust blower, large, stable base, blade wrench storage and a base insert that minimizes splintering. Also, check out the latest models—the new cordless sabre saws.



Sabre Saw Secrets

Saw blades

Sabre saw blades are available in a wide variety of styles, shapes and sizes for cutting virtually every material. The blade you choose depends on the type of material being cut, speed of the cut and smoothness required. The blades are listed according to their designed cutting purpose and the number of teeth per inch (tpi). As with most blades, the more teeth a sabre saw blade has, the smoother and slower it will cut. Fewer blade teeth produce a rougher, faster cutting blade. Blade lengths typically range from about 2½ in. to 4 in. Specially made blades, up to 12 in. long, are also available.

To cut sharp corners and tight curves in wood, try a narrow scrolling blade. For ultrasmooth cuts, use a taper-ground blade that has no-set teeth. Saw directly up to a perpendicular surface with a flush-cutting blade. The blade is offset so that the teeth extend to the front edge of the base. Woodcutting blades commonly range from 3 tpi (very rough cut) to 14 tpi (smooth cut). Metalcutting blades range from about 14 tpi to 32 tpi.

For extra durability, try bimetal saw blades. These blades feature tough high-speed steel teeth welded to a resilient spring-steel blade.

There are also a couple of *toothless* blades that are worth mentioning. A carbide-grit blade is available for sawing a variety of very hard, abrasive materials such as ceramic tile, slate, steel, plaster, brick and fiberglass, to name a few. The blade is made up of thousands of tiny tungsten-carbide particles bonded to an alloy-steel blade. Another valuable toothless blade is the knife-edge blade. Use it to cut rubber, leather, cork, vinyl, cardboard and foam rubber.

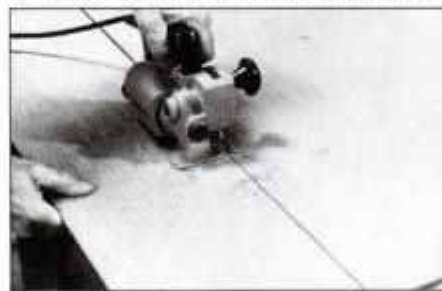
Most sabre saws accept a standard ¼-in. straight-shaft blade. However, some saws will only accept blades with a specially shaped shaft. While this type of saw works well, the blades are often a little difficult to find. Standard straight-shaft blades are sold at virtually every hardware store, home center and lumberyard.

Sawing basics

A sabre saw is most often used freehand to make curved and straight cuts. For more precise straight cuts, run the saw against a straightedge guide. Since a sabre saw cuts on the upstroke, any splintering that results will appear on the top surface of the



Cut out sharp inside corners in stages. First saw into the corner, back out the blade and then come back and make the finishing cuts.



To ensure straight freehand cuts, use a relatively wide blade and support the workpiece close to the line of cut with two 2x4s.



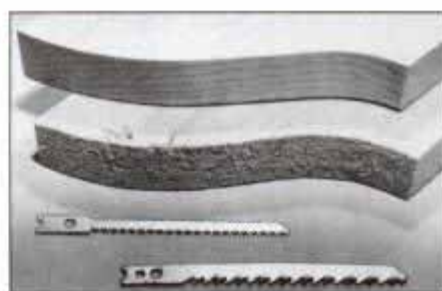
To make a plunge cut in the center of a board, tilt saw on its nose, start motor and then slowly lower the rear end of the tool.



Some saws have a tilting base to cut bevels. Use a straight board to guide saw. Block clamped to guide supports saw at the start.



A flush-cut saw blade allows the saw to cut right up to a perpendicular surface. It's best to start the cut with a standard saw blade.

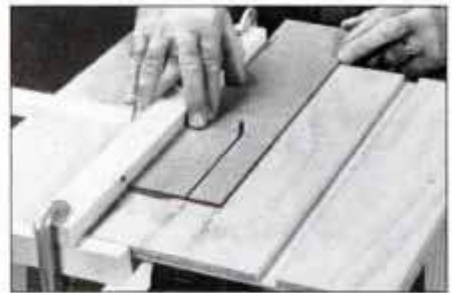
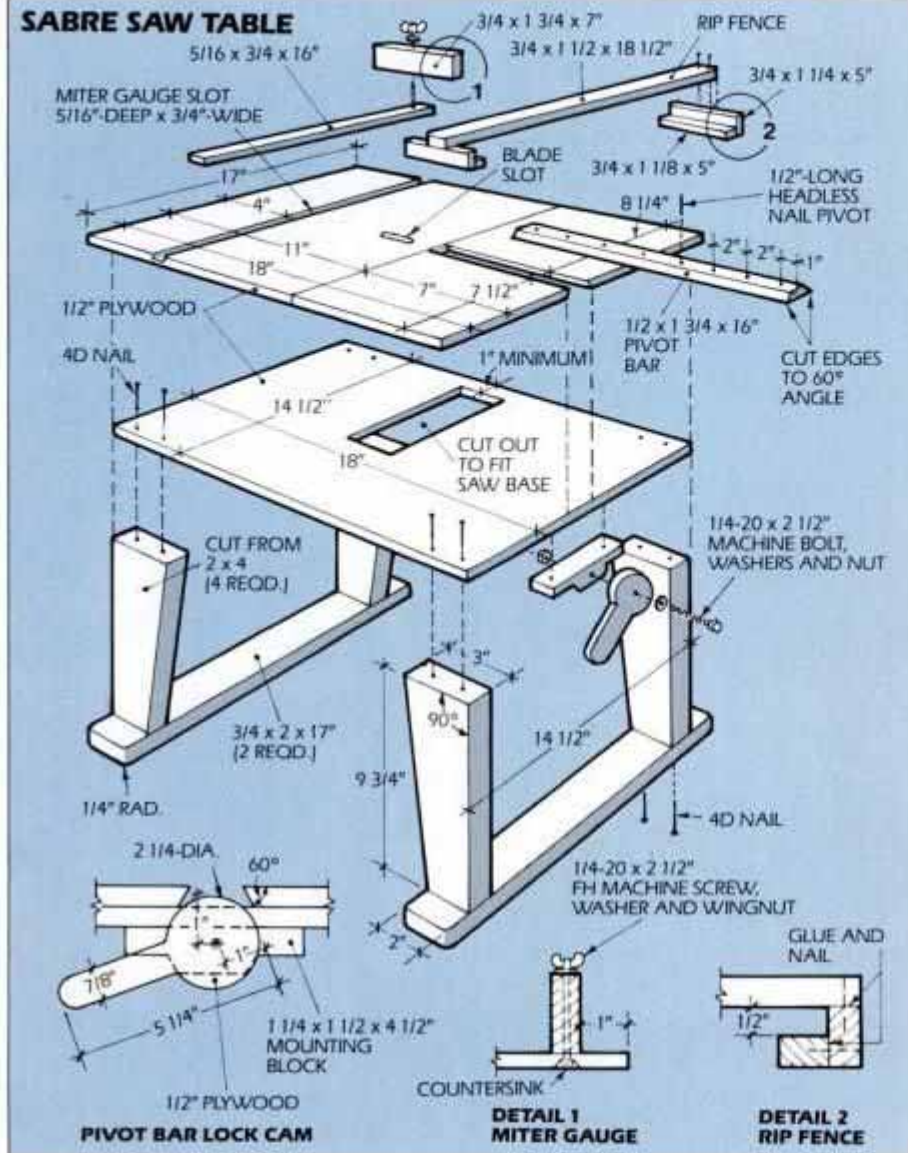


Fine-tooth blades give smoother cuts. Top board was cut with a 20-tpi, taper-ground blade. Lower board, with a 6-tpi saw blade.



Here's a sampling of sabre saw blades, (l to r), 14-tpi scrolling, 12-tpi scrolling, 10-tpi taper ground, 6-tpi rough cut, 10-tpi flush cut, 24-tpi metal cutting, carbide grit and knife-edge.

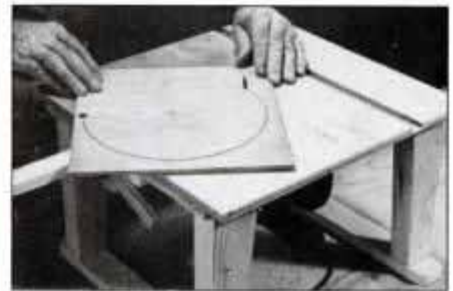
SABRE SAW TABLE



Shopbuilt table converts the portable sabre saw into a stationary tool. For accurate rip cuts, clamp the wood fence to the tabletop.



Execute square and angled crosscuts with a miter gauge. Gauge slides in a 5/16-in.-deep x 3/4-in.-wide slot that's routed in the tabletop.



A sliding pivot bar adjusts for cutting circles from about 5 in. to 36 in. dia. Note that a blade access hole is bored in the work first.

workpiece. Whenever possible, saw the work with its good side facing down. If this isn't possible, there are alternative methods to reduce splintering. Use a fine-cutting, taper-ground blade on a saw fitted with a base insert and advance the saw slowly. Another trick is to score the line of cut with a sharp utility knife prior to sawing. Vermont American makes a reverse-tooth saw blade (model No. 30018) that cuts on the *downstroke* to eliminate top surface splintering.

When cutting curves freehand, use a narrow scrolling blade. Steer the blade slowly and tangent to the line. Try to avoid the common error of applying side pressure to steer the blade. The best way to handle sharp, inside corners and angles is to first saw into the corner, back out the blade and bypass the corner to continue along the cut line. Then, come back

later to clean up the corner.

Metalcutting is done at a slower blade speed than woodcutting. When sawing thin metal, it's important that at least two teeth of the blade make contact with the edge of the workpiece. Otherwise, the cut will be extremely rough and the blade teeth may be sheared off. Check the blade package for the type and size of metal it's designed to cut.

A sabre saw is especially useful for making plunge or pocket cuts in the middle of a board. Tilt up the saw on the front edge of its base so that the blade clears the workpiece. Start the saw and then slowly lower the rear of the tool until the blade cuts through the work. It's important to keep a firm grip on the saw with *both* hands. The photo shows the plunge cut being made with one hand on the saw. This was done for photo clarity only.

Guided saw cuts

Although it's used freehand a majority of the time, a sabre saw can make precise cuts with the help of various jigs and straightedge guides. Some saws come with a T-shaped rip guide that is adequate for some small cuts. But, an easy-to-make straightedge guide provides a better way to ensure straight, accurate cuts. Make the guide from a straight piece of wood such as a rip of plywood. Clamp or nail the straightedge guide to the work and run the saw along it. The distance from the guide to the line of cut must equal the distance from the blade to the edge of the saw's base.

To eliminate the need to measure from the line to the guide, make a customized cutting guide from two pieces of 1/4-in. plywood or hardboard. Glue and nail a 1 1/2-in.-wide plywood strip

(Please turn to page 105)



Breadwinner

Mobilize your kitchen with this rollaway baking cart built of pine with Corian top.

BY NEAL BARRETT

BACK IN THE DAYS when baking was a daily chore for many households, it wasn't unusual for the kitchen to feature a specific area for preparing, kneading and rolling out the dough. Today, homemakers all over the country have rediscovered the art of baking as a way to produce high-quality breads and pastries for family and friends to enjoy.

Our baking cart not only complements this growing interest by providing the extra work and storage space that baking requires, but is designed as an independent rollaway unit that fits neatly into any kitchen layout.

Featuring classic detailing in an updated format, our baking cart is compatible with both contemporary and traditional kitchens.

The No. 2 common pine construction means you won't have to search far afield for material and the simplified joinery only requires the most common power and hand tools, pipe clamps and a table saw.

This piece and other space-saving projects are all featured in *The Breathing Room Book*, available from Western Wood Products Assn., Yeon Building, 522 S.W. Fifth Ave., Portland, OR 97204, for \$1.95.

Making the panels

The sides, back, bottom, shelf and partition are all made by gluing 1x4 stock edge to edge. Crosscut the stock for each panel slightly oversize. Apply glue and use pipe clamps above and below the panel to help distribute the pressure evenly. Make sure the panel is flat when clamped up. After the glue has cured, scrape off any excess and glue up the remaining panels in the same way.

Use a belt sander to smooth the panel surfaces. Secure each piece to your workbench with clamps or between bench dogs for this operation. You can also toenail the panels to your worktable. Use small finishing nails placed at the panel ends and set below the surface. Keep the sander moving at all times to avoid gouging the panel and use minimal pressure.

Next, mark the finished panel dimensions on each piece and lay out the cutting lines. Double check that the layouts are square and to exact size. Clamp a straightedge to the panels for guiding your circular saw (photo 3).

Rip 1x4 stock to 1/2 in. thick x 3 in. wide for the side and back cleats. Crosscut to length and secure to the panels with 3d finishing nails. Don't use glue to avoid humidity changes possibly cracking or warping the panels.

The fluted legs

Crosscut the 1x4 leg stock to exact length. Then, construct a jig to hold the pieces for routing the flutes. Cut a piece of 3/4-in.-thick stock to 8 in. wide x 34 in. long for the jig base. Secure a piece of scrap stock cut to the same length as the legs to one side of the jig base (photo 5). Then attach two end blocks to the base so the leg stock will be supported on three sides. Fasten stop blocks to the end pieces for limiting the travel of your router. These are positioned so the flutes begin 2 3/4 in. in from each end. The spacing of the stop blocks is determined by the size of your router base.

Install a 3/8-in.-dia. corebox bit in your router and adjust the depth of cut to 3/16 in. Adjust the router edge guide attachment to cut the center flute. After this flute has been cut on each leg piece, adjust the guide to cut an outer flute. When this cut is completed on all pieces, simply reverse the stock for the third flute.

Rip a 45° bevel along one edge of each leg piece. Assemble the legs by first placing one piece in your vise

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



1 Edge-glue 1x4 boards for panels. Alternate clamps above and below. Be sure panels lie flat when clamps are tightened.



2 After glue has cured, scrape off excess and belt-sand panels smooth. Keep the sander moving with even pressure.



3 Mark panels to exact size for cutting. Clamp each panel to the worktable and use a straight board to guide the saw.

Breadwinner



4 Select the best face of side and back panels and nail cleats in place. Don't use glue to avoid cracking or warping of the panel.



5 Leg fluting jig holds leg pieces in place and limits router travel. Use a $\frac{3}{8}$ -in.-dia. corebox bit and router edge guide.



6 After ripping a 45° bevel on one edge of each leg piece, apply glue and nail pairs together with 4d finishing nails.



7 Use glue and 4d finishing nails to secure legs to back. Attach one leg to each side and glue and nail sides to rear legs.



8 After nailing $\frac{3}{4}$ -in.-sq. strips across cart front, nail strips around bottom edge of sides and back to support bottom panel.



9 Glue and nail $\frac{3}{4}$ -in.-sq. strip to upper back edge. Then secure the corner blocks with 3d finishing nails and glue.

with the inner edge of the bevel in line with the benchtop. Partially drive several 4d finishing nails in the beveled edge of the adjoining piece so their points poke through. Apply glue and press the second piece in place on the first. Drive the nails, set the leg aside to dry, and complete the remaining legs in the same manner.

Assembling the case

Attach two legs to the back with glue and 3d finishing nails. Attach the front legs to the sides in the same manner and then join the sides to the rear legs. Tie the cart front together by attaching the $\frac{3}{4}$ -in.-sq. strips across the front at the top and bottom. Then, install the ledger strips around the inside bottom edges of the case for

supporting the bottom and attach the strip at the top edge of the back. Toenail the spreader to the rear top strip and secure it at the front by nailing through the front strip.

Next, install the bottom to the bottom strips with glue and 3d finishing nails. Cut and install the corner blocks (O) and attach the drawer side guides to the blocks with glue and 4d finishing nails. Attach the drawer support strips to the drawer side guides. Then, install the front and rear drawer supports (Q and R).

The $\frac{3}{4}$ -in.-sq. strips on the cart bottom serve as dividers for tray storage and for holding the partition. After attaching these strips, slide the partition in place. Secure it by nailing through the cart bottom and through

the drawer support strips. Then, install the shelf cleats and shelf.

Constructing the top

Use a miterbox to cut the 1x4 stock for the cap (T and U) to exact length and secure the pieces to the cart with 6d finishing nails. Use glue on the miter joints and nail through each joint to ensure a tight fit. Then, cut and install the cap spacer (V) over the center spreader as shown in the drawing.

Rip 2x3 stock to $1\frac{1}{4}$ in. thick \times 2½ in. wide for the top blocking (W and X). Cut each piece to length and clamp in place on the cart. Secure the blocking with 2-in. No. 8 fh screws.

To make the dentil molding, first crosscut a length of 1x12 stock to at least 36 in. long. Install a $\frac{1}{2}$ -in.-dia.

Key No. Size and description (use)

A	2	$\frac{1}{2}$ x 21½ x 27¼" pine (side)
B	1	$\frac{1}{2}$ x 27¼ x 29½" pine (back)
C	1	$\frac{3}{4}$ x 22¼ x 28½" pine (bottom)
D	1	$\frac{1}{2}$ x 22¼ x 20¾" pine (partition)
E	1	$\frac{3}{4}$ x 19 x 22¼" pine (shelf)
F	4	$\frac{1}{2}$ x 3 x 17½" pine (side cleat)
G	2	$\frac{1}{2}$ x 3 x 24½" pine (back cleat)
H	6	$\frac{3}{4}$ x $\frac{3}{4}$ x 22¼" pine (support strip)
I	8	$\frac{3}{4}$ x 3½ x 27¼" pine (leg)
J	2	$\frac{3}{4}$ x $\frac{3}{4}$ x 30" pine (front strip)
K	1	$\frac{3}{4}$ x $\frac{3}{4}$ x 28½" pine (top back strip)
L	1	$\frac{3}{4}$ x $\frac{3}{4}$ x 27" pine (back strip)
M	2	$\frac{3}{4}$ x $\frac{3}{4}$ x 21½" pine (side strip)
N	1	$\frac{3}{4}$ x 2 x 20¾" pine (spreader)
O	4	$\frac{3}{4}$ x 1½ x 4¾" pine (block)
P	2	$\frac{3}{4}$ x 4¾ x 22¼" pine (side guide)

MATERIALS LIST—BAKING CART

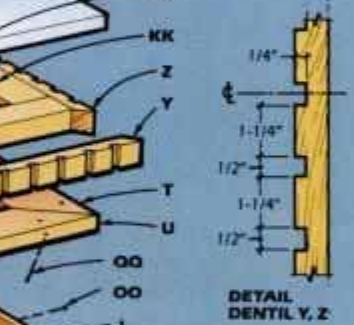
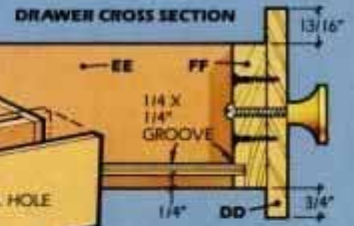
Q	1	$\frac{3}{4}$ x $\frac{3}{4}$ x 24½" pine (drawer support)
R	1	$\frac{3}{4}$ x $\frac{3}{4}$ x 23" pine (drawer support)
S	2	$\frac{3}{4}$ x $\frac{3}{4}$ x 21½" pine (drawer support)
T	2	$\frac{3}{4}$ x 3½ x 24½" pine (short cap)
U	2	$\frac{3}{4}$ x 3½ x 31½" pine (long cap)
V	1	$\frac{3}{4}$ x 3½ x 17½" pine (cap filler)
W	2	1½ x 2½ x 29½" pine (blocking)
X	3	1½ x 2½ x 17½" pine (blocking)
Y	2	$\frac{3}{4}$ x 1½ x 31" pine (long dentil)
Z	2	$\frac{3}{4}$ x 1½ x 24" pine (short dentil)
AA	1	$\frac{1}{2}$ x 1½ x 17½" pine (trim)
BB	1	$\frac{1}{2}$ x 2½ x 14½" pine (trim)
CC	1	$\frac{3}{4}$ x 14½ x 34½" Corian (top)
DD	1	$\frac{1}{2}$ x 5½ x 24¾" pine (drawer face)
EE	2	$\frac{3}{4}$ x 3½ x 22¼" pine (drawer side)
FF	1	$\frac{3}{4}$ x 3½ x 22¾" pine (drawer front)
GG	1	$\frac{3}{4}$ x 3 x 22¾" pine (drawer back)
HH	1	$\frac{1}{4}$ x 21¼ x 23¾" plywood (bottom)
II	4	2½-in. resilient tread caster Shepherd No. SD-9319
JJ	1	drawer pull Colonial Bronze No. 171
KK	20	2" No. 8 fh screw
LL	4	1" No. 10 fh screw
MM	16	1¼" No. 8 fh screw
NN	4	¾" No. 3 rh screw
OO		1" wire brad
PP		3d finishing nail
QQ		4d finishing nail
RR		6d finishing nail

Misc: 120- and 220-grit sandpaper, glue, 40 steel wool, polyurethane varnish, mineral spirits.

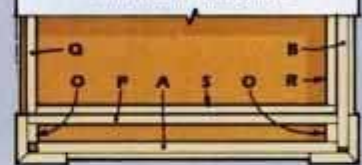
BAKING CART

24-1/2" DEEP X 31-1/2" WIDE X 33" HIGH

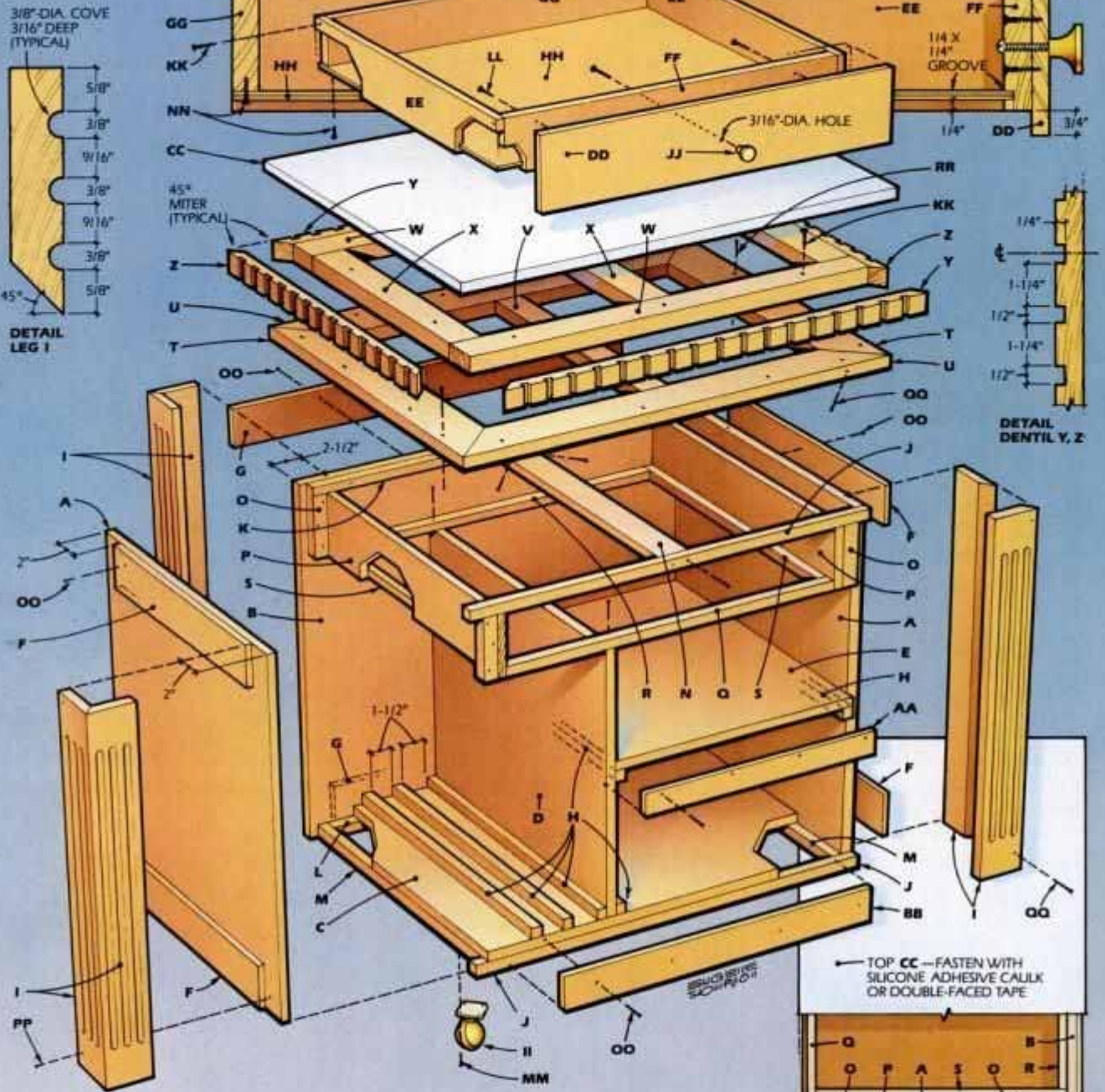
DRAWER CROSS SECTION



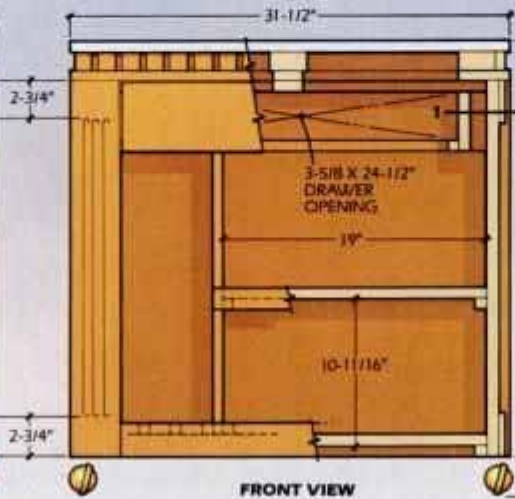
TOP CC — FASTEN WITH SILICONE ADHESIVE CAULK OR DOUBLE-FACED TAPE



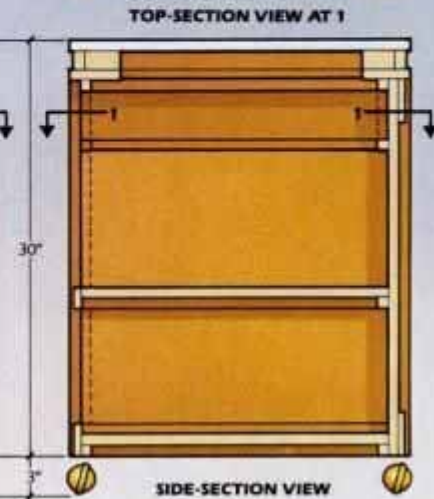
TOP-SECTION VIEW AT 1



SIDE VIEW



FRONT VIEW



SIDE-SECTION VIEW

Breadwinner

straight bit in your router and rout $\frac{1}{4}$ -in.-deep dadoes across the face of the board leaving a $\frac{1}{4}$ -in. space between each dado. Make sure that the workpiece is clamped firmly to the bench and use a straightedge clamped to the stock to guide your router. All four lengths of dentil molding are ripped from this board. Cut at least 17 dados across the 1x12 stock to accommodate the long front and rear pieces.

Rip the dentil molding to $\frac{1}{4}$ in. wide. Use a miterbox to cut each piece to length and attach to the top blocking with 4d finishing nails and glue.

Cut and apply the trim strips (AA and BB) as shown in the drawing. Turn the cart upside down and mark and bore pilot holes for screwing the casters in place. Install the casters with $\frac{1}{4}$ -in. No. 8 fh screws.

Making the drawer

Cut all parts for the drawer to exact size. Use a dado blade mounted in the table saw to cut the grooves in the drawer sides and front that contain the drawer bottom. Join the sides, front and back with 2-in. No. 8 fh screws. Slide the bottom in place, check that the drawer is square and screw the bottom to the drawer back with $\frac{3}{8}$ -in. No. 3 rh screws.

Cut the drawer face to size and attach to the drawer front with 1-in. No. 10 fh screws. Bore the hole for the drawer pull and install.

Finishing the cart

Set all nails and fill. Then, sand the entire cart with 120- and then 220-grit sandpaper. For a durable natural finish, apply three coats of polyurethane

varnish, thinning the first coat 30 percent with mineral spirits. Sand lightly and dust off between coats. After the final coat has dried, rub the cart with 4/0 steel wool for a satin finish.

We topped off our baking cart with a $\frac{3}{4}$ -in.-thick piece of Corian for attractiveness and durability. This material is available at building suppliers and through kitchen and bathroom cabinet showrooms. You can usually get it cut to size. Attach the Corian to the cart with silicone adhesive caulk for a permanent installation. For a top that can be removed at a later date, use double-sided tape.

Other options for the top include plastic laminate glued to a particle-board or plywood panel, or a slab of marble or granite for that authentic pastry-rolling surface. **PM**



10 Cut drawer guides to size and attach to the corner blocks. Then, install the drawer support strips to the sides, back and front.



11 Use 3d finishing nails to attach strips to the cart bottom. These act as spacers for holding trays and the case partition.



12 Slide partition in and nail up through bottom. Secure top edge by nailing through front and rear drawer supports.



13 After cutting 1x4 cap pieces to length, nail in place on cart. Use glue and nail through each joint with finishing nails.



14 Cut the $\frac{1}{4}$ -in.-thick spacer blocking to length and clamp in place. Secure to cap assembly with 2-in. No. 8 fh screws.



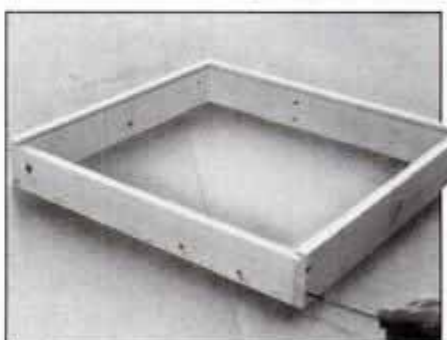
15 Begin the dentil molding by routing $\frac{1}{2}$ -in.-wide dadoes across 1x12 stock. Board clamped to work guides router.



16 Set table saw fence to rip $\frac{1}{4}$ -in.-wide strips of dentil molding. Miter pieces and install with finishing nails and glue.



17 After cutting drawer components to size, cut $\frac{1}{4} \times \frac{1}{4}$ -in. groove in sides and front with dado blade mounted in table saw.



18 Screw sides, front and back together and slide the bottom in. Secure bottom to back with $\frac{3}{8}$ -in. No. 3 rh screws.

SPECIAL REPORT

Focus

How To Take Better Photos



Special Effects

How to get them without special gear.

Tips From The Pros

How to shoot portraits, auto races, fireworks and the moon.

Infrared Magic

Get dazzling images with special films.

Picture Processing

Getting the best from your local lab.

Photo Preservation

How to display, store and restore your photos.

Improving Your Images

Armed with a camera bag full of tricks from the pros, you can get more mileage from your photo gear.

BY STEPHEN A. BOOTH, Photography Editor

MASTER THE possibilities. . . This advertising slogan for a credit card should apply to your photography efforts as well.

You don't have to look far to find good photographs. Open your morning newspaper to the sports pages and you're likely to see dramatic shots of runners sliding into base or race cars angling for position on the corners. Magazines are chock full of color portraits, special effects photos or images of aesthetic or scientific interest.

Certainly, most of these pictures are taken by professional photographers. Compared to amateur photogs, the pros have more experience, greater amounts of sophisticated equipment and, quite often, access to the best locations from which to take a photograph.

There's another difference, too, and it's got to do with attitude.

Most of us have a household camera that we use for social occasions. We're pretty content to snap the shutter and take what the camera delivers. Yet with just a bit more forethought and effort, these everyday images can be improved. Instead of having just a visual record of a subject or event, you can have a record that's visually exciting. Think about it: Most of the photo opportunities available to the pros are available to the casual snapshotter, too, whether at a family picnic or a trip to the ballpark.

For this reason, POPULAR MECHANICS assembled a list of popular photo situations, and assembled a roster of professional photographers to share their tips for making the best of these situations. We angled the list toward summertime shooting opportunities. That's why you'll learn how to photograph fireworks instead of snowflakes,

auto racing instead of ice hockey.

To give you your best shot, we also asked our pros to devise their tips for the type of equipment casual photographers are likely to own. Accordingly, all of the photo situations presented here can be handled with a 35mm SLR camera and popular lenses. Most of the shots are also within reach of simpler point-and-shoot compact cameras.

Who are our pros? Regular readers will probably know Armand Ensanian, who writes our "PM Photo Tip" and teaches what he practices at colleges in the New York area. George Schaub also teaches photography—but only at night. Daytime, he's the executive editor of *Popular Photography* magazine. And if you follow auto racing, you're probably familiar with the byline of John Lamm, who writes and photographs for *Road & Track* magazine.

You'll find out more than just how to take a pretty picture in this Special Report. If you want to explore creative photography, there's an article on how to use films. And to make the most of your efforts, we'll also show you how to deal with your processing lab, and how to preserve your efforts for future generations.

PM

PM PHOTO BY J.R. ROST



Fun With Film

Here's how to bend the rules to get exotic effects without special gear.

BY GEORGE SCHAUB

You can get a soft, grainy effect similar to Impressionist paintings if you overexpose high-speed slide film and make an enlarged print.



FM PHOTO BY GEORGE SCHAUB



FM PHOTO BY JON SCHAUER

Daylight films shot in artificial light suggest warmth, romance or nostalgia.



PC/ANNO/CD/PP PHOTO

Instant slide film, used in this microscope photo, yields offbeat prints.

WHEN someone mentions special-effects photography, your first reaction might be to reach for some exotic filters. But you don't have to. One way to delve into the magic of special effects photography without filters or a home darkroom is to use ordinary film in extraordinary ways—in some cases breaking the

rules of good photography. Though some of the films we'll discuss are made for special purposes, all are available in 35mm format.

The first effect we'll explore involves shifting the color in pictures—without the use of color filters. Sunlight contains all the colors of the visible spectrum which, when mixed together, produce white light. Artifi-

cial light sources are deficient in some of these wavelengths. The eye and brain correct these differences and allow us to see natural colors regardless of light source, but films can do no such thing. That's why color slide film is available in both daylight- and tungsten-balanced varieties. The tungsten type contains a built-in blue bias to give true colors when pictures are made under artificial light.

When daylight films are shot indoors they record all the deficiencies of artificial light, yielding images that are warm—or yellowish-red. This effect can impart a nostalgic glow to scenes, one that comes in handy when you want photos to have a sentimental mood, as in the portrait shown here. In some cases, slides gain an old-fashioned, sepia-toned look.

Conversely, tungsten films shot outdoors have a definite bluish cast, one that gives a cold though not stern feeling to pictures. Try this technique with landscapes made on quiet, misty mornings, or to exaggerate the frigid feeling in shots of fields of snow.

Another rule you can break is the one that says you shouldn't shoot color under mixed light sources. Mixed means scenes lit with artificial light and daylight, such as a room with all the lights turned on and sunlight streaming through the window. You can use either daylight or tungsten film to shoot this scene. With daylight film you'll get the true color of the sunlight and a yellow glow from the lamps. With tungsten you'll get natural colors around the lamps and a cold blue light streaming through the window. Tungsten films include Ektachrome Tungsten 50 and 160, Fujichrome 64T and Scotch Color Slide 640T.

A film's graininess is determined by its ISO rating. The lower the rating or speed, the finer the grain. However, you might want to exaggerate grain for a more pictorial effect, as some professionals do. Aside from its textural qualities, extreme grain can also break color into its complementary components, an effect that gives enlarged prints the look of a pointillist painting created by an Impressionist artist such as Seurat.

The easiest way to get a high-grain effect is to start with a film that already has inherently high grain, such as Agfachrome 1000 or Scotch Color Slide 1000. But you should expose these films at even higher speeds, such as ISO 2000 or 4000 (a gain of one or two stops, respectively). There is a limit to how far you can push these films—a 1- or 2-stop push is best. Be-

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Fun With Film

yond that, color and sharpness rapidly deteriorates.

After you shoot, inform your lab that you want the films push-processed for the ISO rating you shot at. Any lab that offers in-house E-6 slide processing can provide this service. If you can't find such a lab, get an ESP-1 mailer from your Kodak dealer: This will get you a 1-stop push from any Kodak lab. Though you might not see the results when you first look at the slide, projection or enlargement printing will tell the tale, as in the floral still life shown here.

If you want to go for the grain in black and white, pick up a roll of Kodak's Recording Film 2475. Originally intended for low-light surveillance photography, this superhigh-grain film has a speed rating of ISO 3200. You don't have to push the speed: When enlarged, your picture will look as if it were printed through a gritty texture screen.

You can also get offbeat effects with Polaroid's line of 35mm instant slide films. Unlike ordinary slide films, you don't send them out for processing. Once exposed, you develop the film in Polaroid's manual Auto-Processor (\$131) or motorized Power-Processor (\$275).

These Polaroid films were designed for special applications, such as the photomicrography shot seen here. But soon after release, photographers began to explore their creative possibilities. The two color films, PolaChrome and PolaChrome HC (for high contrast), are unlike any color film you might have encountered before. Each is actually a black-and-white film that is overlaid with a single layer of primary-color filter stripes. PolaChrome renders muted colors, while PolaChrome HC gives a splashier, almost wet-paint look.

These films are made primarily for projection, but when we misuse them by making prints, the color-forming stripes read as color *patterns*. The effect resembles, but has a different character from, the results of pushing and enlarging high-speed slide film. Prints made from PolaChrome slides have been compared to those of antique color processes, such as turn-of-the-century autochromes. This is no coincidence, as the color-forming system in the film is actually an updated version of that used in the earliest forms of color photography.

In the past, when you wanted to create a graphic, high-contrast b&w photo, you were in for a lot of work. With Polaroid's PolaGraph slide film,

all you need do is load and shoot. The result resembles a pen-and-ink drawing, with blank whites, hard blacks and little or no gray tones in between. You can get the positive slide printed on color positive paper for a right-reading picture, or on any regular paper to reverse the tones. PolaLith, a negative version of this film, can be printed on regular paper for graphic, high-contrast positive prints.

Perhaps the oddest member of the group is a PolaBlue. This slide film gives results that resemble architectural blueprints. When used to photo-



Prints made from PolaGraf instant b&w slide film can resemble pen-and-ink drawings.

graph everyday scenes, it creates stark abstractions in blue and white. The slow speed of this ISO 8 film makes it impractical for handheld shooting, so use a tripod and cable release. Or, shoot it to make copies of existing prints using a tripod and copy-board setup. Ditto for the PolaChromes: Use them to copy prints or other slides for interesting effects.

For an easy but offbeat effect, try shooting Ilford's XP1, a b&w print film that can be processed in C41 color print chemistry. You can expose it at its rated ISO 400 speed or anywhere from ISO 200 to 1600—and mix speeds on the same roll. When processed in non-XP1 chemistry, the prints can take on a blue, green or even sepia tint.

PM

One On One

How to shoot flattering portraits with proven techniques and simple gear.

BY ARMAND ENSANIAN

MOST amateurs are really portrait photographers. Think about it: Pictures of friends or relatives predominate in our photo albums.

Portraiture attempts to project an individual's character on 2-dimensional film. This is a formidable task. You not only have to be concerned with technical matters, but also with the pose and attitude of your subject. Let's talk intangibles before technicalities.

The more formal you make the portrait session, the more likely you are to intimidate your subject. If your subject becomes intimidated, he or she will become inhibited, and reveal little inner personality to the camera. For this reason, you should keep the atmosphere casual. Make your subject comfortable by striking up a conversation before and while shooting. Downplay the technical aspects of the shoot by preparing your gear well in advance—and above all, make sure you're familiar with it.

The best portraits should emphasize the subject. Keep the background simple, or out of focus. Short telephoto lenses (70mm through 135mm) used at larger apertures (lower *f*/stop numbers) will blur backgrounds for greater subject emphasis. Point-and-shoot compacts with tele lenses (or adapters) set to about 70mm make nice portrait cameras when shooting between 6 and 10 ft. Shooting with slow films, such as ISO 25 or 50, ensures larger lens openings.

Another reason to shoot with telephotos is to minimize facial distortion. Long lenses flatten the field. Shoot large-nosed people head-on at the longest focal length possible.



For portraits use a telephoto lens to blur the background and emphasize the subject.

Keeping the camera's film plane parallel to the subject also minimizes body distortion. Shooting down on the subject will produce distorted, tapered bodies. Center the lens on your subject. Kneeling for full-length portraits keeps the camera centered and parallel.

The best kind of lighting for casual portraits is diffused daylight, such as

that available on bright but hazy days, or in the shade, or through a white curtain.

Study your subject's face to locate shadows such as under the chin or around the eyes. If the contrast between shadows and highlights is too great, use a large piece of white cardboard to soften the shadows. Aim this reflector to bounce light from the light source to the shadows. Electronic flash set to 1/2 or 1/4 power can also be used to fill in shadows (most flash manuals describe fill-in techniques), and many point-and-shoot cameras allow fill-in flash.

Lighting is greatly dependent upon your subject's physical attributes. Large round faces need sidelighting to thin them out. Thin faces need head-on illumination to bring them into proportion. Position your subject accordingly, or use reflectors to direct light to specific areas of the face.

Subtle changes in body positioning can alter personality. People photograph much more aggressively when leaning toward the camera. Confidence is also emphasized when the subject looks over the shoulder and directly into the lens. Tilting the head slightly to the side enhances femininity. Double chins can be eliminated by tilting the subject's head back then raising the camera and shooting from above (parallel to the face) for a head-and-shoulders portrait.

Your subject will be more relaxed when sitting or leaning. If hands are included in the picture, use props to keep them busy. Make sure that you don't cut off limbs at the joints.

Highlighting the hair will help separate your subject's head from the background—and add a touch of flattery. A small flash unit, connected to the camera with a long PC cable and positioned above and behind the subject, will do the trick. For more glamorous pictures of women, place the flash directly behind the head. Natural backlighting works too, but in all cases, be sure to meter light reading directly off the face.

Medium-speed color print film, such as ISO 100, produces softer contrast portraits than those shot with slide films. Unless the background is heavily backlit, expose as usual with auto cameras. With manual cameras, meter off a gray card held in front of the subject's face (or off the face itself) for accurate exposures. Compose vertically, if you can, and fill the frame with as much of the subject as possible for tightly cropped portraits. **PM**

Focus On Speed

Tips from a professional race-car photographer can put you on the inside track.

BY JOHN LAMM



From public access area, Canon T-90 and 300mm lens got Paul Newman at work and play.

MOST RACE fans don't have the amount of equipment a press photographer carries—or the passes that give access to the prime photo locations at most race tracks. So for this story, we covered the Detroit Grand Prix and Trans-Am race

using only the passes a spectator can get.

How easy it is to photograph from these locations varies from track to track. At oval courses, from small dirt tracks up to Daytona or the Indianapolis 500, you can get some pretty photos from the infield or the stands, but



Panning at $\frac{1}{30}$ second keeps most of Newman's Nissan 300ZX turbo sharp, but adds enough blur to suggest speed.

A slow, $\frac{1}{15}$ -second exposure creates an Impressionist rendition of Williams-Honda Grand Prix car at speed.



you won't have the kind of access available at a road-racing course. The same applies to drag racing.

Road racing provides more photo opportunities, mainly because cars turn left and right, go uphill and down, and you can see them from a variety of angles. Tracks laid out on city streets, as at Detroit, are more difficult to photograph because of the necessary concrete barriers and debris fences. But some of these tracks sell what is generally called a superphoto pass. It's \$100 or more, but offers access to locations the general public can't reach.

Regardless of where you stand, you'll need some basic equipment. Begin with a 35mm SLR body with a motor drive or power winder. Your most important lens is an 80 to 200mm zoom. Second would be a slightly shorter lens, a 35 to 70 or 35 to 105mm model. Third on the list is a 300, and after that add a 400 or 500mm lens. You might economize by coupling a zoom to a 2X teleconverter.

To prevent camera shake, you'll need a tripod when you're using lenses of 300mm or more, but learn to handhold your shorter lenses. Brace yourself against a steady object when possible.

The question of which film to use depends on whether you prefer slides or prints. Either way, you'll need a variety of film speeds. Slow films will do nicely for the pretty pan shots, but you'll need faster speeds for the longer lenses, especially if your maximum aperture is $f/4.5$ or 5.6 .

If you are shooting print film, take about 40 percent each of ISO 100 and 200, and 20 percent ISO 400. Slide choices for a bright sunny day include Kodachrome 64 for general use, and about 20 percent Kodachrome 200 or Fujichrome 100 for the longer lenses. If it's cloudy, I'd choose Fujichrome 100 for the brilliance of its colors, and push it one stop to ISO 200 if more film speed is needed. When taking pictures late in the day, I'd add Kodachrome 200 to my list. For extra insurance against inadequate light (or slow lenses) you might pack a roll or two of high-speed print (ISO 1000 or more) or slide film (ISO 400 or 1000).

Enough about equipment and film. Now it's time to use them. Most racing photos are of the three basic types shown here. We'll call them panning, stop action and overall.

Panning is the most commonly used, and really quite simple. You want to capture the movement of a race car as it rushes past you or

around a corner. Here's all you do. Pick the angle at which you want to shoot the car. Get the car in your viewfinder well before that point, follow it along and press the shutter release when the car is at the desired angle. Follow the car *smoothly* for a second or two after you've shot.

To show the car sharply front to back, shoot at $\frac{1}{125}$ th of a second. Try slower speeds, even down to $\frac{1}{15}$ th, for the different, often beautiful, effects of speed blur. (We shot Paul Newman's Nissan 300ZX turbo at $\frac{1}{30}$ second, and the Williams-Honda Grand Prix car at $\frac{1}{15}$ second.) Try panning when the cars are on straight stretches, but also get them in corners, particularly sweeping turns where you are on the inside.

To stop a race car, especially with a telephoto lens, use shutter speeds of $\frac{1}{250}$ th or faster. Pick the spot you want to shoot and watch for a few laps. See where the cars are working—you'll be freezing the action, but you don't want the car to look like it's just parked on the track. So try to find a place where it looks like it's a bit out of shape, as in a turn.

Now, frame the scene in your viewfinder, but don't start shooting until you've done a few dry runs to follow the car through the scene. Although you're not taking a pan shot, you should still follow the car into the scene, snap the photo, and follow it out again.

(This doesn't apply if you are using a long lens on a tripod aimed at a corner to stop head-on or going-away action.)

The overall shot can be a pan or a stop-action photo, but the point is to show what the environment around the track is like. Usually, short lenses and wide-angles are best for this.

You want to come away from the race with memories on film, and that means getting both the cars and the surroundings. We caught Paul Newman clowning on a moped at Detroit, and we wouldn't leave a race at Long Beach without a shot at the Queen Mary.

It would be a mistake to go to a race and just do one of the three types of photos we've suggested. Take some record shots, then some slow-shutter-speed pan photos, and pick up the overall pictures as you go along. And don't be afraid to experiment. The pros do. Take a lot of film to one event and make notes as you try different photos and films, so that when you see the results you can know what to do, or not do, the next time. **PM**

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Use long exposures to capture a fireworks display as it cascades down.



Night Shots

Summer puts on a show when the Sun goes down. Here's how to shoot fireworks or Ferris wheels.

BY GEORGE SCHAUB

SUMMERTIME presents many opportunities to photograph dazzling displays of light at night. Whether it's carnival rides at the county fair, or fireworks on the Fourth of July, you can create colorful pictures with a minimum of equipment and a few simple techniques.

Either daylight- or tungsten-balanced films can be used to shoot fireworks or neon. Tungsten films will give a cooler look to the colors. Daylight films will give a warmer rendition. For fireworks, you'll want long exposure times to capture the falling light trails, so use ISO 200 or 400 color print or slide film. Also, use a lens with a focal length between 100 and 200mm to fill the frame. Zooms work well here.

There's no practical way to make exposure readings of fireworks. For that reason, the techniques we'll ex-

plore require you to work in the manual exposure mode, according to the speed of the film.

We've all seen shots of fireworks where the colors seem to flow down through the sky. Most of these are made with exposure times of 1 second or longer. To make these shots, mount your camera on a tripod, set the shutter on B (bulb), open the shutter when you see the first hint of color in the sky, then close it after a second or two. If your camera does not have a B setting, set the shutter speed for 1 or 2 seconds. To avoid overexposure, set the lens aperture to $f/16$ with ISO 400 and $f/11$ with ISO 200 film.

If you can't use a tripod, you might try handholding the camera. To reduce the risk of vibration-induced blur, you'll have to use faster exposures. You won't get the streaming effect as the pyrotechnics drop from the sky—just the initial burst.

Once again, exposure times are approximate. Try $1/30$ second at $f/2.8$ with ISO 200 film, $1/30$ second at $f/4$ with ISO 400, and $1/60$ second at $f/5.6$ for ISO 1000 or higher. These are still relatively slow speeds, so steady your camera as much as possible. With auto-everything compacts, you really can't control exposure. These cameras will expose for the preponderant darkness of the sky. On newer models, override the automatic flash. On older ones, trick the camera by covering the metering eye—and even the flash—with black tape. Shoot only ISO 400 or faster films.

Amusement parks and carnival rides are also great subjects for getting fantastic colors on summer evenings. Though you can use the long exposure technique for creating abstractions of swirling motion, you can rely a bit more on the in-camera meter for your exposure settings. Keep in mind that you have to meter the highlights and midtones in order to get a proper reading. If you include too much of the dark sky in the scene, you might overexpose your film.

The best way to take readings is to approach your subject, take the reading, lock it in or set it manually, then recompose the scene and shoot. If you have difficulty taking a closeup reading, start at $1/60$ second at $f/4$ with ISO 400 film, and bracket up and down.

High-speed films come in very handy for these more terrestrial night-light shots, as they allow you to use even faster shutter speeds to capture the action. Of course, you can switch to a slower shutter speed to gain a higher aperture (f /stop number) if you want increased depth of field.

Flash can also be put to good use when photographing rides, particularly when your child is being spun around at dizzying speeds. Though your shutter speed may be locked at a slow synch speed, such as $1/60$ or $1/125$ second, the burst of light a flash gives out can be as short as one ten-thousandths second in duration. If you time the shot just right, you can capture the look of glee on your child's face as he or she goes whizzing by.

A great time to shoot carnivals is just after the Sun goes down. At that time of the day, there's still enough ambient light to capture details in parts of the scene that later will become obscured by darkness. Meanwhile, the lights will have come up enough on the rides and games to give a true sense of place to the scene. **FM**

Shoot The Moon

Fascinating lunar photos are within your reach with a few tricks of the trade.

BY ARMAND ENSANIAN



To create this multiple exposure, use a zoom lens to shoot Moon, then evening skyline.

THE MOON, our closest galactic neighbor, photographs well on its own or when juxtaposed against Earth's landscapes, as in the multiple exposure shown above. You can reach it with a compact point-and-shoot camera, but SLRs offer more options.

A simple zoom or telephoto lens in the 200mm range will show crater detail when coupled to your SLR with an inexpensive 2X teleconverter lens. Even an inexpensive telescope will yield sharp closeups. An eyepiece adapter fits the scope to replace the camera lens—and even works with some binoculars.

With long lenses, vibration will be more of a problem than optical resolution. Mount your camera (and telescope) on a tripod. For really sharp pictures, use a locking cable release instead of the camera's own shutter release button, and load the camera with slow ISO 25 slide film.

Next, set the lens aperture at $f/16$ for a telephoto lens. Lock the shutter open on the B (bulb) setting while

holding a piece of black cardboard in front of the lens. ISO 25 film at $f/16$ requires a $\frac{1}{2}$ -second exposure—slow enough to expose by hand with the cardboard. After you've returned the cardboard to cover the lens, advance the film. Repeat the process for each frame, and try longer exposures (1 or 2 seconds) if you like.

Because telescopes do not have aperture rings, you'll have to expose differently. If your SLR has an aperture-priority metering mode, take your exposure-time reading directly from the camera and manipulate the cardboard accordingly. If your camera lacks this feature, do a series of time exposures. Start at $\frac{1}{2}$ second then double the time with each frame until you reach 8 seconds.

By the way, if you don't want to use the hand-exposure method, load a faster ISO 400 slide film, set the aperture at $f/16$ and vary shutter speeds between $\frac{1}{30}$ and $\frac{1}{125}$ seconds ($\frac{1}{60}$ to $\frac{1}{2}$ second with a telescope). Keep in mind that the higher-speed film will add graininess to your picture.

Nightscape with the Moon are easily shot as multiple exposure photos. You'll need a tripod and ISO 200 slide film. An SLR fitted with an 80- to 200mm zoom and 2X teleconverter is ideal. Telescopes won't work well.

To create the picture seen here, you'll have to run the film through the camera twice. The first set of exposures is for the Moon, the second for the landscape. Here is the procedure.

Open the camera back, fire the shutter, then load the film. Use a pen to mark the film sprocket hole that is positioned over the film advance sprocket. Close the back and run off a few frames. With the zoom set to maximum and the aperture at $f/11$, take a series of Moon exposures from $\frac{1}{2}$ second to $\frac{1}{250}$ second. Be sure to keep the Moon in the upper half of the frame. Repeat the exposure series until the film runs out.

Rewind the film—but leave some leader out of the cassette. Reload, aligning the marked hole with the sprocket, and advance the film to the frame that begins your Moon shots.

You can shoot your nightscape in another location or at another time. Set the aperture at $f/5.6$ and the focal length of the lens anywhere you want—just remember where the Moon is positioned in the frame. Vary your time exposure with each shot, beginning at $\frac{1}{2}$ second and working down to 8 seconds. If your camera lacks a shutter speed dial, vary the film-speed setting. Begin at ISO 200 and move to 100, 50, 25 and even 12 or 6.

You can shoot the Moon with an autofocus point-and-shoot camera, but you'll have to trick the camera first.

Although the Moon reflects light brightly, autocompacts will meter for the preponderantly dark sky and set exposure accordingly, overexposing the Moon. To trick the camera, use ISO 25 slide film, but before you load it, cover the cassette's DX coding (the series of silver and black boxes) with tape. This will force the camera to expose for ISO 100 film, underexposing the ISO 25 slides sufficiently to prevent washing out the Moon.

Because compact cameras have short lenses, the Moon won't appear large or detailed in your pictures. Set the lens for the greatest focal length possible, and try to use a tele-adaptor lens. Capture the Moon when it's low in the sky—and visibly larger. Since the Moon will be small in the frame, tell your lab there are Moon shots on the roll. To fill the frame, try the double-exposure nightscape technique described above.

PM

Inner Visions

Infrared photography lets you see things through different eyes.

BY ARMAND ENSANIAN

THERE is more to light than meets the eye. Visible light is only a small part of the giant radio dial of energy that can expose film. The panchromatic color and b&w we normally use are only sensitive to the lightwaves we can see. But beyond this spectrum lies the form of electromagnetic radiation known as infrared.

Specialized infrared films allow us to picture the world through an entirely new set of eyes. Infrared light (IR) behaves very differently than its visible neighbor. Objects that normally reflect light might be totally nonreflective to IR, whereas other

subjects indistinguishable to panchromatic films pop right out of an IR photo. IR pictures of paintings or documents often reveal clever coverups and forgeries undetectable to the naked eye. You can have a lot of creative fun with IR films—even with a simple point-and-shoot camera.

IR films are available as b&w prints or color transparencies for about twice the price of conventional films. Eastman Kodak provides b&w High Speed Infrared Film 2481 as well as color Ektachrome IR Film 2236. Both can be ordered from Kodak dealers in 35mm and must be kept in the freezer compartment of a refrigerator until

used. Allow film canisters to reach room temperature before opening, and for best results load your camera in total darkness. Store exposed IR film in the freezer if you're not going to develop it right away.

IR b&w is ideal for dramatic shots of clouds and sky, and for cutting through haze. Pollutants that reflect IR are easily detected. Leafy plants also reflect lots of infrared under the right light. This renders plants as white with b&w film, and as varying shades of red and magenta when color IR film is used with a red or orange filter. Camouflage detection with color IR film was once very popular, since many paints and fabrics reflect IR differently than visible light. It is still very popular with creative photographers because of its false color effects. Color variations within the subject, impossible to get with filters alone, are possible with Ektachrome IR film. It all depends on the color of the filter you use in front of the lens. For true IR photography (shown here in the aerial photo) a medium-red filter is used to block violet, blue and red lightwaves—to which the film is also sensitive. For more offbeat photos, experiment with a variety of filters—or none at all.

If you have ever wondered what that little red dot near your focusing scale is for, it's for IR photography. Without correction, long IR waves would focus behind the film. When using IR films, simply focus normally, note the subject distance on your focusing scale, then move the distance measurement over to the red dot. Autofocus SLR cameras will require manual focusing if available. Try to shoot at the smaller aperture openings (*f*/8, *f*/11 or *f*/16) for best results—especially if you can't correct for focus. Compact, autofocus point-and-shoot cameras with lenses shorter than 40mm should work fine without focus compensation.

Exposure bracketing is a must with IR since most light meters are not very sensitive to it. *Use the supplied film data sheet as a guide to set film speed.* ISO 50 is a good starting point for both b&w and color IR films exposed through a red filter. If you just want to have some fun with colors, shoot IR with an auto-everything compact, with or without filters. The camera will read the film as ISO 100, producing acceptable results. Try placing different-colored filters or gels in front of the lens and electric eye for unpredictable effects.

A popular expectation is that IR



Infrared lightwaves are invisible to the eye, but Ektachrome IR Film 2236 detects how objects absorb or reflect it (above). Compared to conventional film (right), IR reveals unusual color shifts—green sky, black water, red vegetation.



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films can illustrate differences in temperature. It is true that heat radiation is part of the IR spectrum, but IR films are made to work with the shorter IR wavelengths and not the longer heatwaves. A hot iron does emit enough short IR waves to be used as a light source in total darkness, but it will require very long exposures.

Hot appliances, engines, castings, and other objects between 500° F and 1000° F emit lots of IR and can be shot in total darkness. No filter is required here, but a tripod and locking cable release are helpful.

It will take some experimenting and a roll of film to zero in on the exposure. Start with 10 seconds at f/8 and double the exposure successively for 10 frames, making the last exposure a whopping 86 minutes long. At such high temperatures, use a telephoto lens to put distance between the heat source and the camera—and yourself.

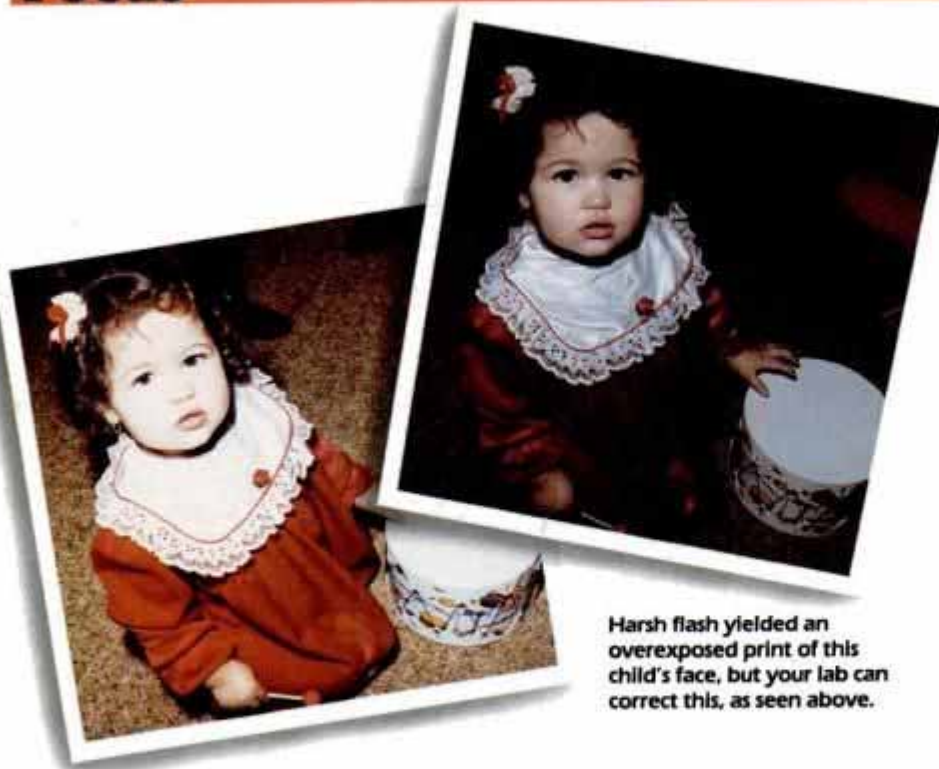
As with visible light photography, IR films need enough light reflecting off a subject to produce an image. At night there's not enough IR light available to shoot in total darkness. You'll need an artificial light source, such as a flash or flood light. Filters are not necessary in the dark.

Unobtrusive dark red lamps placed in a room emit plenty of IR light. And electronic flash units are rich in IR. All you need to do is cover the flash head with enough red gel, plastic or acetate to block most of the visible light. A bit of a red glow should be all that remains. Autofocus point-and-shoot cameras, with flash head covered as above, are well-suited for close-range picture taking in the dark. B&w film works best with living subjects, color with hot items.

Infrared photography requires little, if any, additional equipment to start exploring. In fact, b&w IR photography is as easy to get into as ordering the film. Conventional b&w processing at home or at any lab will produce good results. IR images do tend to be a bit grainy due to their thicker emulsions. Be sure to tell the lab that it is IR to minimize their handling the cassette in light.

Color IR film has one drawback. It is not readily processed because it requires the old E-4 chemistry. If you can't get E-4 processing in your area, American Photogroup (611 Dwight St., Springfield, MA 01101) will handle color IR films sent by mail. Send the film in a lead-foil pouch and by overnight mail to minimize risks from light or heat damage.

PM



Harsh flash yielded an overexposed print of this child's face, but your lab can correct this, as seen above.

Developing Strategies

Be aware of the services—and service—your photo processor can provide.

BY GEORGE SCHAUB

NEXT TIME you drop off a roll of film at your local photo shop, ask about the type of services you can obtain. Photography is an interchangeable medium. Once you have a negative, slide or print, you can get it made into any other format—or size.

For example, a color negative will get you a color print (from wallet to poster size). But you can also convert it into a color slide, or even a black-and-white print. Color slides can get you color prints, color negatives, b&w prints or enlarged color slides. If you only have a print (such as one you found in an old family album), you can get a new print from the old one.

Not every lab performs every service. Most rely on a network of other photofinishing sites to provide services they don't. Although it's useful to know what services your photo outlet can deliver, it's more important to

be aware of the *level* of service your lab *should* deliver for conventional developing and printing.

Generally, we accept whatever the lab gives us. If colors are off, or the print is too dark, we allow the lab to blame our technique or equipment.

In fact, when it comes to color and b&w prints about the only thing a lab can't fix is a poorly focused picture. But if faces come out green, if prints are cast in a warmish light because daylight color film was shot indoors, or if flash shots are washed out, a little extra effort on the part of the lab can make the final picture turn out right.

If you're like most people, the roll you send in for processing contains a variety of subjects photographed under diverse lighting conditions. Though modern printing machinery accommodates for these changes and corrects printing accordingly, many labs still have equipment that is

geared mainly to normal negatives—ones exposed in daylight with an overall balance of colors and tones. These printing machines also have channels—specific filter packs balanced for the more popular brands of color films. When your images don't match these preprogrammed conditions, the operator still has the option to input more or less exposure or to shift the color balance to normalize what labs call oddball negatives. If the lab doesn't take the time to do this, you might get less than optimal prints.

For example, let's say you've taken a picture of your child sitting on a red rug. When the automatic printing machine views the negative, it sees a large field of red and tries to balance it out in the print. The result is untrue colors on the rug, and a child with a purple face. This is known as subject failure, and it can be corrected.

Pictures made with flash can also present a problem. If the flash is too close to the subject or too powerful, the face often prints in a highly overexposed fashion as in the example shown here. All the operator has to do is print one button darker to get a well-exposed face. This will sacrifice the darker tones in the print (notice the carpet), but at least your principal subject will turn out right, as shown in our second example.

So much for printing. What about quality control when your exposed film is developed into negatives or slides?

For the most part, today's color negative processing is standardized and mechanized and should yield good results—barring glitches in the processing machinery. If your negatives appear off-color, or if you see streaks and scratches spaced randomly throughout the roll, chances are you're looking at a lab-related problem. Unfortunately, poorly developed film (color, b&w, even slides) can only be salvaged, not made right. You're lucky if you get an image at all.

Of course, if you've used outdated film, left the roll in your car's overheated interior, or if the inside of your camera is filled with beach sand or other grit, you should be honest enough to accept the blame. But when film *develops* properly but *prints* poorly, insist on corrected prints.

Insist firmly. Labs hate to remake prints. Once you let the lab operators know that you know they can do a better job, they might pay more attention the first time around. **PM**



Modern processing (right) salvaged much of the original quality of this poorly stored 32-year-old print and its negative.

Fading Memories

Careful storage and display can keep your precious images from disappearing.

BY STEPHEN A. BOOTH, Photography Editor

IT'S SAD BUT TRUE: The photographs to which we entrust our memories are neither immortal nor immutable. They can develop partial amnesia, where a color fades or changes, or chronic loss of memory, where the entire image vanishes progressively. This is especially true of prints that are left out for display, particularly color prints. But stored prints, even negatives and slides, are not immune to the ravages of time and the environment.

You can slow nature's aging process and extend the life of your photos by thoughtful display and storage. And although you cannot reverse damage already done, there are photo processing techniques that can salvage what's left of a disappearing image, and perhaps restore some semblance of the original.

As good as they are, the dyes used in color films do fade, and the papers

and gels used for prints, negatives and transparencies do deteriorate. Fading comes in two forms. Balanced fading is a matter of color *quantity*. The cyan, magenta and yellow dyes that make up the image diminish equally in relation to one another. The colors are no longer as rich as before, but they're still recognizable as correct. Unbalanced fading is a matter of color *quality*, and objectionable to most people. If one color has deteriorated out of proportion to the others, the tonal balances will be altered and appear unnatural. For example, normal flesh tones might turn boiled-ham pink or sickly yellow-green.

Light, heat, humidity, air pollutants and certain chemicals are harmful to color photos. Store developed images in a dark, cool, dry and preferably airtight environment.

The ultraviolet radiation in sunlight and fluorescent bulbs will bleach

colors (incandescent light is less damaging). If a photo is permanently displayed, it should be framed and located away from direct lighting. Glass will filter some ultraviolet, but plastics sold for this purpose are better.

Heat and humidity, together or separately and especially in combination with chemical fumes, will accelerate the deterioration of a photo. This can happen even in dark storage. Moreover, humidity can breed damaging mold. This means attics, basements and garages are not the ideal repositories for your photos.

If you have to compromise, a warm and dry location is better than a damp one—even if it's cool. Airborne pollutants are difficult to avoid—and they'll damage otherwise-stable black-and-white photos. Besides automobile and industrial emissions, harmful fumes emanate from gas stoves, paints and solvents, mildew inhibitors and insecticides, even unfinished and unaged woods, newly finished woods, and glued-wood products.

This brings us to storage materials. Some contain harmful substances. Avoid cardboard, high-sulfur paper (used in inexpensive black-paper albums), brown paper bags, and any plastic made from polyvinyl chloride or polystyrene. Don't let ink or glues anywhere near your photos. Film manufacturers recommend display and storage products made from acid-free papers, polyethylene, polyester, cellulose acetate, acrylic plastics, glass, aluminum, stainless steel or enameled materials. Be wary of anything not billed as photo-safe.

There's hope for that faded portrait you might find in an old family album. If the negative's in good shape, routine reprinting should yield a sharp new print. But if the neg has deteriorated, you'll need customized service. If the neg isn't totally spoiled, the lab can reconstitute key elements such as the flesh tones in a portrait.

This kind of custom processing was used for the photograph shown here, and it's expensive—\$30 to \$40. Making a new print from an old print runs \$10 to \$20 more, but it won't be as sharp as one made from a negative. Moreover, you can't restore color or detail that's no longer on the original, unless you commit to costly retouching and painting by hand. If you want to spare *your* posterity from this expense, store your photos well and make duplicates for cold storage while the negative or slide is young. **PM**

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to another wider strip (about 5 in. or 6 in. wide). Then, guide the saw along the edge of the narrow, top strip to trim the bottom strip to the proper width. To use the guide, simply align its edge with the line of cut, clamp it in place, as shown, and make the cut.

A sabre saw is also quite handy for making lap joints. For edge-lap joints, make a simple U-shaped jig out of plywood, as shown. The inside dimensions of the jig depend on the width of the saw's base and the size of the notch you need to cut. The jig controls the saw to form the width and depth of the notch. Then, make several freehand cuts in the middle of the notch. Use a chisel to break out the waste in the notch, as shown.

End half-lap joints are made by attaching a plywood plate to the saw's base. This shortens the blade's stroke length and determines the depth of

cut which should equal one-half the thickness of the stock. Nail or clamp a board to the workpiece, as shown, to guide the first saw cut and establish the shoulder of the joint. Then, make several freehand cuts through the waste area. Use a chisel to break out the waste and trim the joint smooth.

To ensure accurate guided cuts, use a set-tooth blade, not a taper-ground blade. Also, check that the saw's blade holder and ram shaft have no side play.

Shopbuilt saw table

Convert your sabre saw to a stationary power tool by building the saw table according to the plans provided. The table features a 17 x 18-in.-wide work surface, miter gauge, saw fence and circle-cutting jig. The saw is mounted to the underside of the table. The saw blade protrudes from the ta-

ble's surface and allows you to guide the workpiece with two hands.

Note that the 1-in.-thick tabletop is formed by two layers of 1/2-in. plywood. The top layer is made of three pieces of plywood. This is necessary to form the dovetail-shaped pivot-bar groove. The pivot bar houses a 1/2-in.-long pivot point that is cut from a finishing nail and ground to a sharp point. Bore eight 1/16-in.-deep holes in the pivot bar to house the pivot point. In order to cut perfect circles, the pivot point must align exactly with the front edge of the blade's teeth.

The pivot bar slides in the groove and is held in place by a wood handle, called a pivot-bar lock cam, that's situated under the bar. Note that the lock cam is bolted off-center to create a cam-action lever. Therefore, when you turn the handle it wedges against the bar and holds it securely. **PM**



Metalcutting blades are similar to hacksaw blades. Small teeth ranging from about 14 tpi to 32 tpi. Cut metals at slow speeds.



A straight wood strip, tack-nailed in place, ensures straight cuts. Note that strip extends beyond board to align saw at start of cut.



Break out the waste with a chisel. The two parts lock together and form a clean, invisible joint, as shown in the right foreground.



To obtain clean, chatter-free cuts in sheet metal, place it between pieces of cardboard or 1/4-in. plywood. Support work on 2x4s.



Customized-cutting guide requires no measuring. Simply place edge of guide on the line of cut. Saw blade will cut along guide edge.



Cut end half-lap joints with a short blade. Wood plate under saw's base controls depth of cut. Strip nailed to work guides first cut.



A tungsten-carbide-grit blade will cut ceramic tile, slate and other very hard, abrasive materials. Apply slow, steady pressure.



Form edge half-lap joints with this U-shaped jig. The jig guides the saw for the two outside cuts. Interior kerfs are made freehand.



Using a chisel, break out the waste and scrape the joint smooth. Assembled half-lap, shown at right, forms a clean, strong joint.

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BUCKLE UP FOR SAFETY

How To Replace A WATER HEATER

BY MERLE HENKENIUS; PM Illustrations by George Retseck



LIKE all things mechanical, water heaters do break down. And, when it's time to have yours replaced, you can expect the installation charge to equal, or exceed the cost of the heater itself. The good news is you can remove your old heater and install the new one yourself.

Garden-variety water heaters with 5-year warranties can cost as little as \$125. A permit to do the job and an inspection may be required in your area, but don't let that intimidate you. Just keep in mind the \$120 to \$160 you'll be saving by doing it yourself.

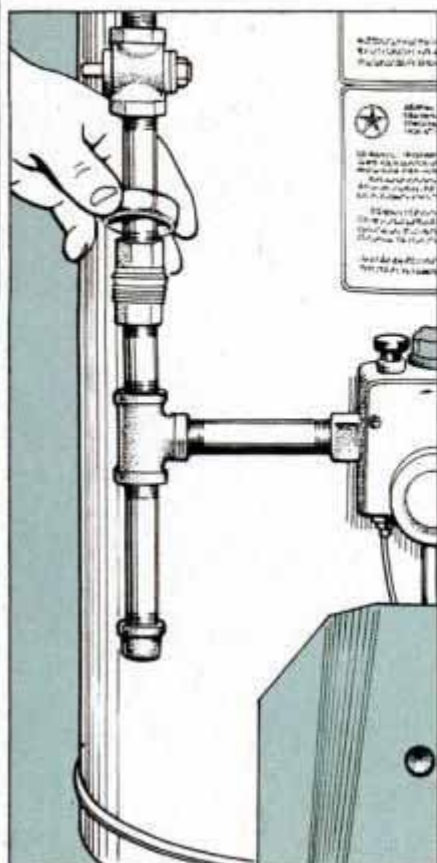
When to replace a heater

Strictly speaking, a water heater need not be replaced until its tank begins to leak. An inoperative heater with a sound tank *can* be repaired. However, if your unit is several years past its warranty, it's probably unwise to invest more than \$50 in repairs. There's no way of knowing how long the tank will last and you'd probably be better off replacing the entire unit. Remember, if the manufacturer loses faith in the heater after five years, there's probably a good reason to do so yourself.

Regardless of the age of your heater, if the tank develops a leak, replace it soon to avoid major water damage.

Choosing the right heater

As you shop for a new water heater, you'll find a confusing array of brand names, efficiency ratings and warranties. There are many more brand names on the market than water heater manufacturers. This means that more than one brand name is being manufactured by the same company. If you're looking for a standard heater with a 5-year warranty in the \$125 to



1 After turning off gas valve, loosen the union below the valve and disassemble the piping that connects to control valve.

\$175 price range, then you'd probably do best to ignore the brand and simply shop for the best price.

The real differences occur when shopping for extended-life and high-efficiency heaters. Extended-life heaters may feature dual anode rods. These are magnesium rods that retard tank corrosion by acting as electrolytic sacrifices. Instead of your tank corroding, the anode rods cor-



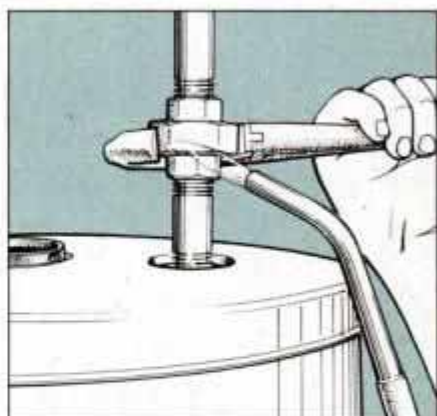
2 Attach a garden hose to the drain valve. Open the T&P valve or the hot-water taps in your house and drain the tank.

rode. While all heaters have at least one anode rod, having two can greatly increase the time before tank corrosion creates a serious problem. Extended-life units may also feature fill tubes designed to keep sediment from collecting on the tank bottom and, if your choice is electric, they may have heavier heating elements.

Other extended-life water heaters with 10-year warranties are virtually the same as ordinary units warranted for five years. In this case, you're simply betting with the manufacturer that the heater will actually last 10 years. It's at least a \$70 wager that may or may not pay off.

High-efficiency heaters have foam insulation instead of fiberglass. The extra R-factor involved is particularly valuable if you use your hot water only a few hours a day as do most working couples. They may also have two anode rods, an antisediment fill tube, and a modified burner assembly.

Base your decision on as much technical information as you can get and



3 Disconnect iron water pipes by loosening unions with pipe wrench. Stubborn unions may require heating with torch.

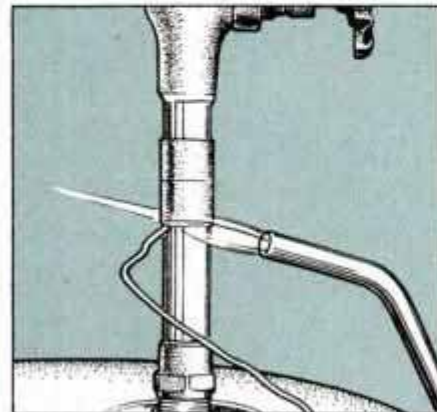
pay close attention to the estimated energy cost printed on the sticker on the heater. You can expect to spend over \$400 for the best of these models.

Removing the old heater

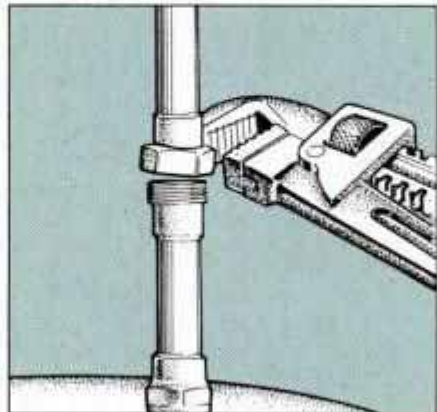
If you have an electric heater, shut off its circuit breaker or remove its fuse at the main panel. Remove the cover plate near the conduit entrance on the heater cabinet. Remove the wire nuts and disconnect the wires and ground connection. Undo the box connector that secures the conduit to the cabinet and pull out the wires.

If you have a gas heater, shut the gas valve by turning it to its cross-line position. Most codes require this valve to be within 3 ft. of the heater's control valve. Loosen the union below the valve and disassemble the piping that connects to the heater (Fig. 1).

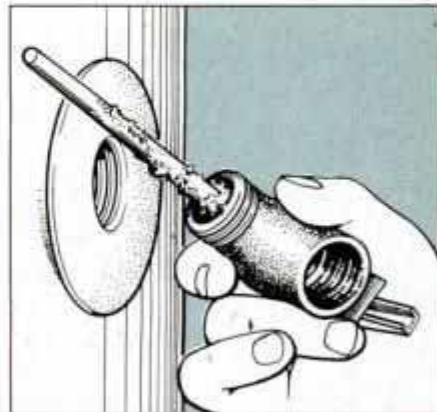
With the energy supply disconnected, shut off the water inlet valve and attach a garden hose to the heater's drain valve (Fig. 2). Then open the T&P (temperature and pressure)



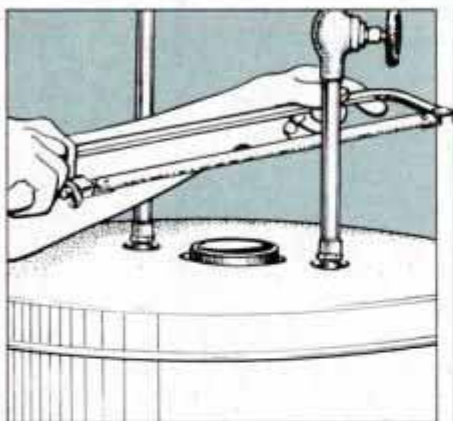
7 After soldering length of copper pipe into adapter and threading into tank, use sweat coupling to join to existing pipe.



8 Copper pipes can also be reconnected with a brass union. Solder the bottom half to the stub before threading into heater.



9 A clogged T&P valve means that the one you install should be checked periodically by lifting the manual release lever.



4 Copper pipes can simply be cut with a hacksaw. Leave pipe stubs in place for use as handles when carrying the tank away.

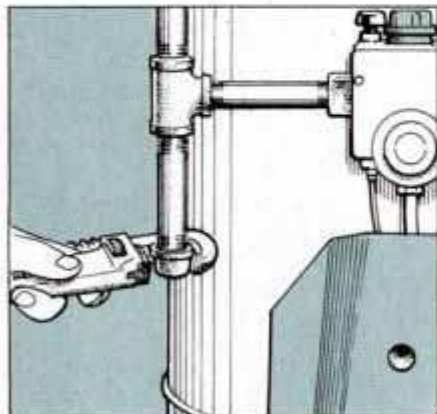
valve at the top of the heater and drain the water into the nearest floor drain. If yours is an older model with no T&P valve, open the hot-water faucets in your home.

If your heater is not electric, then the next step is to disconnect the exhaust flue. In most cases, the flue will be fastened to the flue hat with sheet-metal screws. Simply remove the screws and lift off the flue piping.

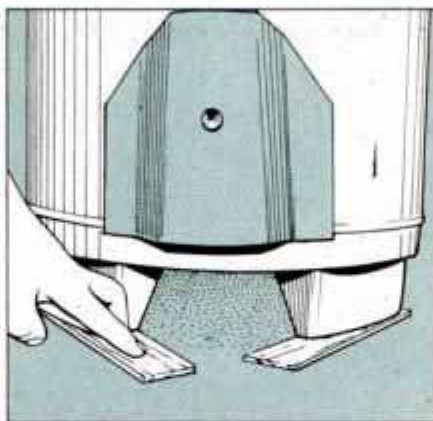
Removing the water pipes

If your heater is supplied by iron pipes or you have copper pipes that are connected by unions, loosen the unions to disconnect the pipes (Fig. 3). You can also simply cut copper pipes with a hacksaw or wheeled pipe cutter (Fig. 4). Leave the pipe stubs connected to the heater to use as handles when carrying the old heater out of the house.

After the water heater is completely disconnected from its energy source, piping and flue, grasp the pipe stubs and rock it side-to-side to move it.



10 Before lighting pilot on gas heaters, loosen bottom cap to remove trapped air. Then, allow gas in the room to dissipate.



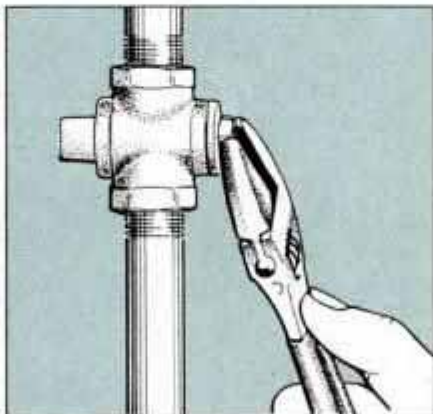
5 If the new tank is installed on a sloping floor, level the heater by shimming under the legs with wood shingles.

Connecting the new heater

If the floor is level, simply slide the new heater under the water pipes and align it properly. If it's to be positioned near a floor drain, as many are, then you'll need to shim one side of the heater to compensate for the sloping floor. Use short pieces of cedar shingles or strap iron to shim the legs so the unit is plumb and secure (Fig. 5).

When connecting the water inlet and outlet pipes, it's generally okay to duplicate the type and configuration of fittings that existed on your old heater. If, however, you live in an area that has prolonged high humidity or your water has a high concentration of dissolved mineral salts, and your pipes are copper, it's advisable to connect the heater with dielectric unions. Because the fittings on the heater are iron, a direct copper-to-iron connection under these conditions can significantly increase the rate that the iron corrodes.

A dielectric union consists of a threaded iron half, a brass half and a



11 Gas valves often leak after being operated. After gas is turned on, tighten stem nut on the back of the valve a half turn.

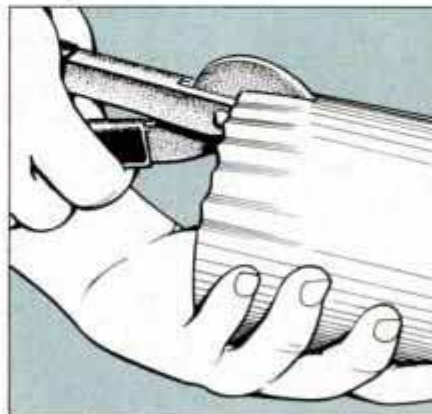


6 This dielectric union uses a rubber washer and a plastic insert to keep the brass upper half from contacting the iron half.

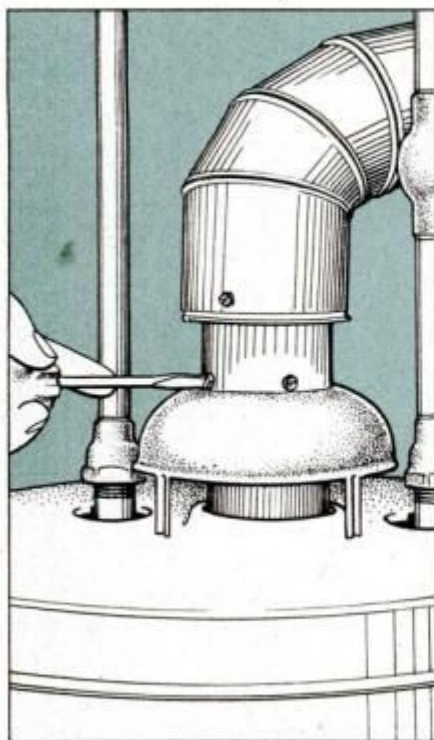
threaded iron collar (Fig. 6). Separating the two halves is a rubber washer. A plastic insert separates the iron collar from the brass. With this union you can join copper to iron without any direct contact between the metals. If you're unsure as to whether this union is necessary in your locality, check with your local building code authorities or a plumber.

If no dielectric unions are required, then the connection is simple. Measure between the existing pipes and the heater fittings and cut two pieces of copper pipe to length taking into account the shoulder depth of the adapters. Then, flux an end of each pipe stub and insert them in the adapters. Solder them on a fireproof surface. Never solder an adapter after threading it into the cold-water inlet as you may melt the plastic fill tube.

When the adapters have cooled, wrap three layers of Teflon tape clockwise around the threads of the male adapters. Thread them into the heater fittings and tighten. Then,



12 If you end up with two female ends on flue pipe, crimp one end with a crimping tool or with needle-nose pliers.



13 If necessary, use a vent increaser to connect the heater's 3-in. flue hat to a 4-in. vent. Secure joints with sheetmetal screws.

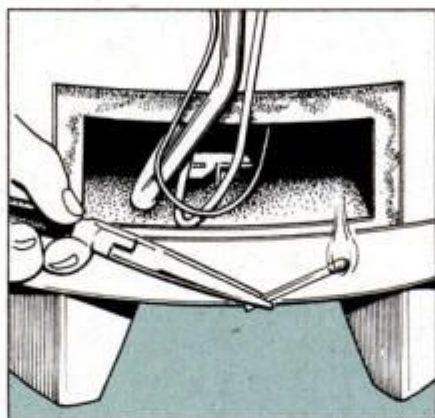
clean and flux the remaining pipe ends and join them with copper sweat couplings (Fig. 7). If you can't raise the existing pipes high enough to slide the couplings in place, use slip couplings which have no center stops. Slide the slip couplings over the pipe stubs before threading the adapters in place. As an alternative, you can use brass unions in place of the sweat couplings (Fig. 8).

If yours is an older home with galvanized iron pipes, simply thread an appropriately sized galvanized nipple into each fitting and join the nipples to the existing pipes with galvanized unions. Apply pipe compound to the threads of each connection. Avoid any temptation to use black iron nipples or fittings as they'll rust in short order.

Installing a T&P valve

Today, every heater must be equipped with an approved temperature and pressure relief valve. Should the control mechanism on a heater stick in the On position, this valve will bleed off the excess steam pressure. Check the T&P valve on your old unit for sediment buildup. If it's clogged, then make a point of checking your new valve periodically to ensure safe operation (Fig. 9).

The critical thing to look for when



14 A wooden match held in a long pair of pliers is best for lighting the pilot. Press pilot button and slide match into heater.

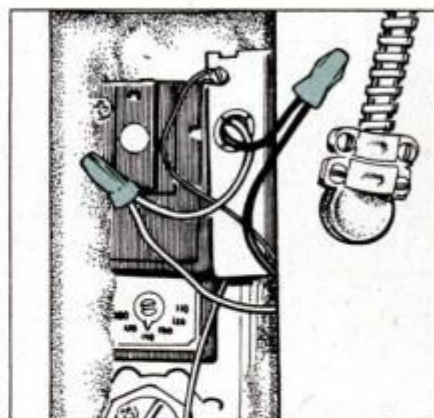
buying a T&P valve is its psi rating. Check the rating on your new heater first, and buy an appropriate valve.

To install the valve, simply coat the threads with pipe compound and thread the valve into the heater opening. You may find the heater opening on the side or the top. Most codes require that you install a drain pipe that extends from the valve to within 3 in. of the floor.

Connecting the gas

Make sure you use only black iron pipe for the gas line. Compounds in the gas can cause the zinc coating on galvanized pipe to flake away and enter the control valve. In many cases you'll be able to use the nipple/fitting arrangement from the old heater. If not, thread an appropriately sized nipple into the control valve and thread a 1/2-in. tee to it. Thread a second nipple into the top of the tee and attach the bottom half of the union. Then, thread a short nipple into the bottom of the tee and install an iron cap on the open end. Finally, tighten the union. Typically, pipe compound is used on all gas joints. However, Teflon tape does the job and ensures that no compound particles work their way into the control valve.

Turn the gas on and check for leaks by brushing a solution of warm water and liquid dish detergent on all the joints. If bubbles appear, turn off the gas, take the piping apart, and start over. When all the joints are tight and the gas is on, slightly loosen the cap on the nipple below the tee to bleed air out of the line. Then retighten (Fig. 10). Because gas valves can leak after they've been used, tighten the stem nut on the back of the valve a half turn (Fig. 11).



15 On electric units, secure conduit with an approved box connector. Connect wires with wire nuts and secure ground.

Next, install the flue pipe. Most new heaters have 3-in.-dia. flue hats, but many codes require 4-in.-dia. pipes. If so, install a step-up adapter on the flue hat to accommodate the larger pipe. Join all connections with sheetmetal screws (Fig. 13).

If your old flue pipe is sound, you can simply reinstall it. New pipe usually comes with its snap seam apart. Simply cut it to length with tin snips. Use a hacksaw to cut pipe with a closed seam. If you end up with two female ends, form a male end with a flue pipe crimping tool or needle-nose pliers (Fig. 12).

Connecting the electricity

Chances are, the existing electrical wires can be reconnected just as you found them in the old heater. Your old wiring will need to be replaced, however, if it doesn't meet your local electrical code. The wires leading from the ceiling or wall must be encased in flexible or rigid conduit and fastened to the heater with an approved box connector. You may find that a separate disconnect box may be required in your area.

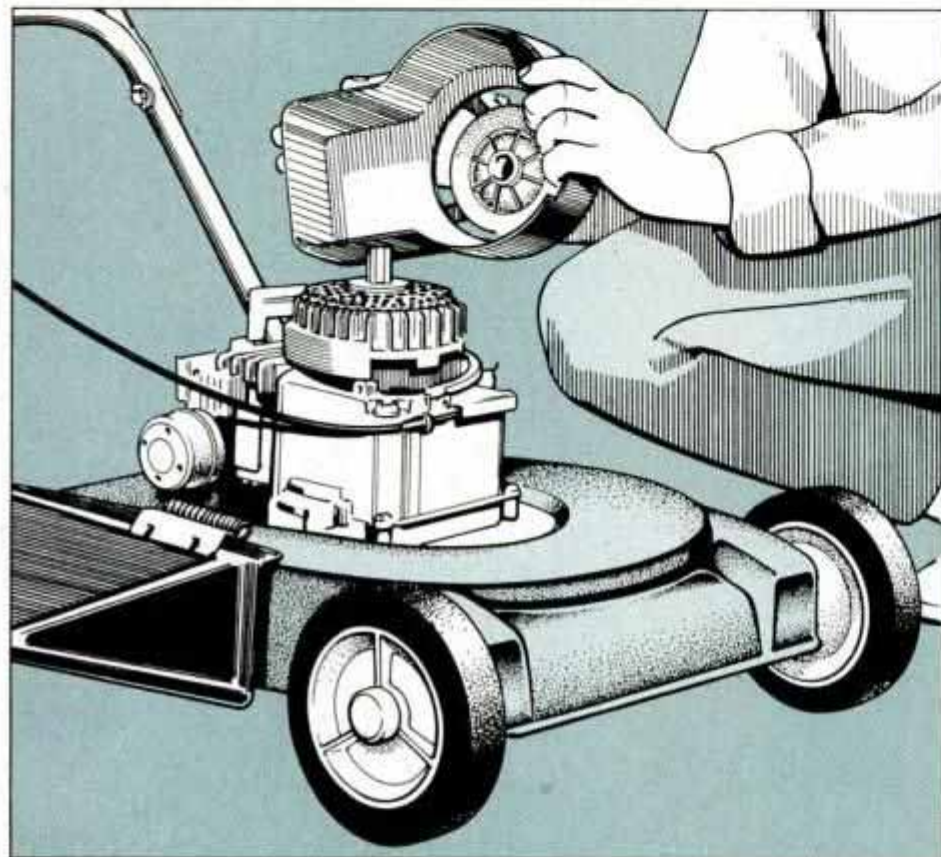
Fish the wires into the cabinet and secure the cable with the box connector. Join the black wire to the black lead and the white wire to the white lead with approved wire nuts. Then screw the ground wire to the green terminal in the cabinet (Fig. 15). Finally, make sure that the heater thermostat is covered with insulation and replace the cover plate.

Before turning the power on, fill the tank and bleed all air through the hot and cold faucets in your home. Never energize a dry heating element in an electric tank. It will burn up in a matter of seconds.

FM

How To Replace A STARTER PULL-ROPE

BY MORT SCHULTZ, Contributing Editor; PM Illustrations by George Retseck



1 To reach the starter mechanism on Briggs & Stratton engines, first remove the throttle cable clip on the housing. Then, ground the sparkplug and remove the housing.

LET'S FACE IT. Without that pull-rope wound and waiting, even the best maintained small engine becomes a useless lawn ornament. And don't think that electric-start engines are immune. If this system fails, you must rely on the pull-rope to get the job done.

All ropes wear-out eventually. The wise homeowner will keep an eye on the condition of the pull-rope so it can be replaced *before* it breaks. The following rope replacement procedures cover most of the pull-rope starters found on Briggs & Stratton and Tecumseh engines.

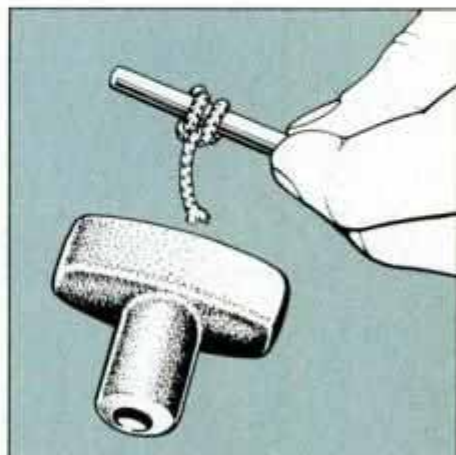
Varying engines and applications require different length ropes, so, make sure you get an exact replacement. To protect against unraveling, burn both ends of the new rope and use a cloth to wipe them smooth while they're still hot.

Briggs & Stratton starters

First, disconnect the sparkplug cable from the plug. Use a jumper cable with alligator clips on each end to ground the cable to a metal part of the engine. This is a precaution against accidental starting.

Next, unscrew the securing clip that holds the throttle cable to the housing. Remove the housing bolts and take off the housing (Fig. 1). On the underside of the housing you'll find the starter assembly.

Cut the rope near the handle, pry out the metal rope retaining pin and remove the old rope (Fig. 2). Pull the remaining rope out of the starter as far as it will go. Then, while holding the pulley in place with your thumb, pry the knotted end out of the pulley and cut off the knot (Fig. 3). Remove the rope and slowly allow the pulley to return to its unwound position.



2 Cut the pull-rope near the handle, pry out the metal retaining pin that secures the rope. Untie and throw away the rope end.

Tie a knot in one end of the new rope. Turn the pulley counterclockwise as far as it will go, back it off two turns and thread the unknotted end through the hole in the pulley while holding the pulley in place with your thumb (Fig. 4). Then, pull the rope through the hole in the housing. Stretch the rope tight to engage the knotted end and slowly allow the pulley to rewind the rope (Fig. 5). Thread the other end of the rope through the handle and tie it to the rope retaining pin.

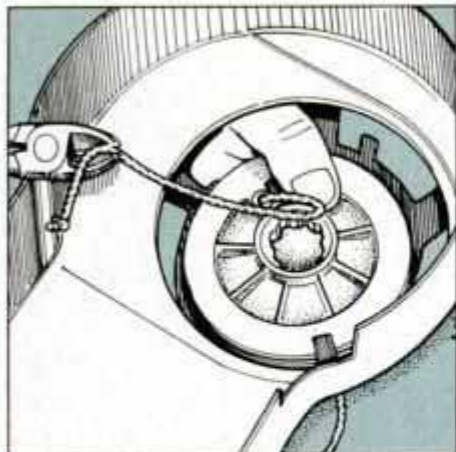
Tecumseh pull-starters

Many Tecumseh engines feature a starter that's similar to the type found on Briggs & Stratton engines. You can use the above procedure as a guide for replacing the rope on these models.

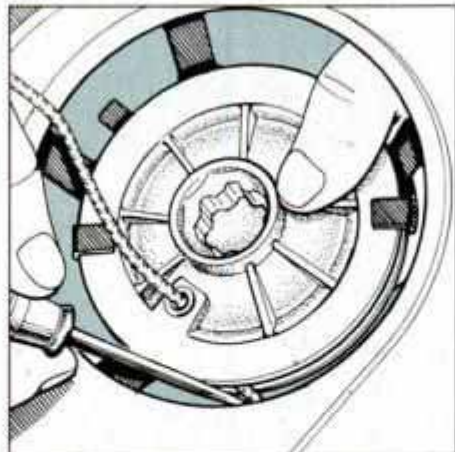
Other Tecumseh engines make use of side-mounted vertical-pull starters. The following describes the procedure for the most common side-mounted starters manufactured over the past eight to 10 years.

Ground the sparkplug cable as described for the B&S engines. Then, remove the gas tank by prying back the retaining clips and sliding the tank upward. Unbolt the air filter and remove the housing (Fig. 6).

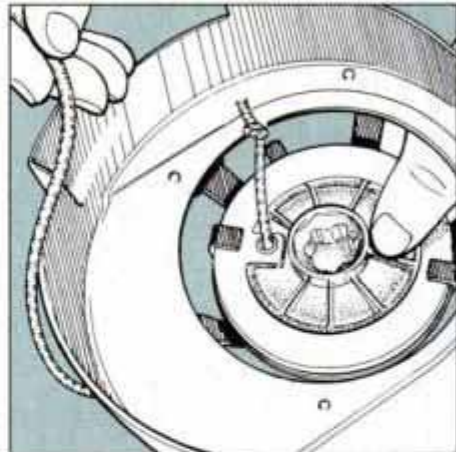
You'll see the starter assembly mounted in a bracket that's secured to



3 After stretching the rope out from starter, hold spring in place, pry out the end and cut off the knot. Remove the old rope.



4 After knotting one end of the new rope, hold pulley with spring tensioned and thread rope through hole in the pulley.



5 Thread the rope through the housing and stretch it tight. Then, slowly allow the pulley to wind up and resecure the handle.

the engine side (Fig. 7). Check the bracket for a notch in the center of the upper edge. This notch facilitates removing the old rope without disassembling the starter. If your unit lacks this feature, simply shape an ap-

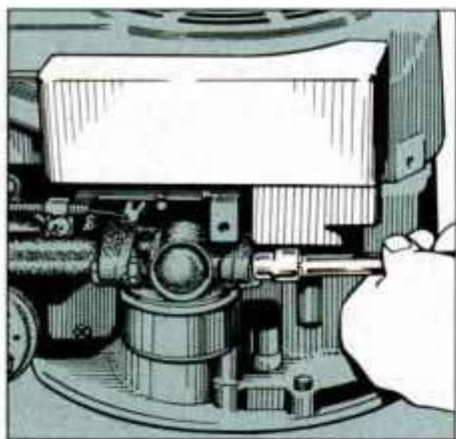
proximately 1/4-in.-deep x 1/2-in.-wide notch by carefully breaking away the bracket material with a pair of pliers.

Next, pull up on the rope until the staple that secures it to the pulley is centered in the notch. Hold the pulley

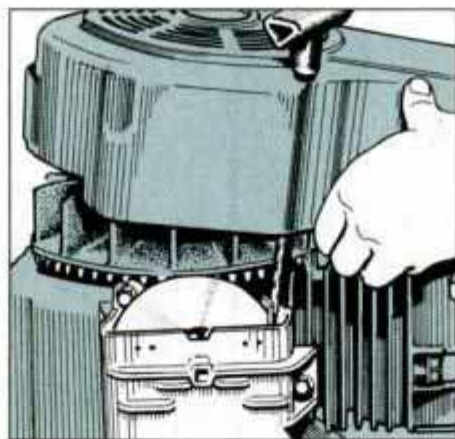
in position and use a narrow-blade screwdriver to pry the staple out (Fig. 8). Then, pull out the remaining rope. Hold on to the pulley when unwinding the rope. When it's free, wedge a large screwdriver between the bracket and pulley to hold the pulley in place with the spring tensioned.

Remove the rope from the handle by prying out the staple in the handle stem. Thread the new rope through the handle, tie a knot in the end and pull it tight (Fig. 9).

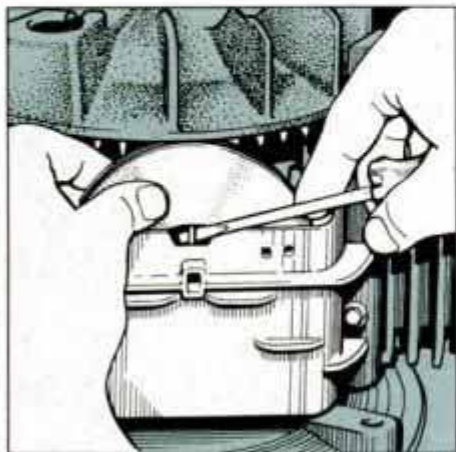
Feed the other end through the housing. Turn the pulley as tight as it will go. Then, back it off while looking down into the pulley until you see the rope hole. It should be about 180° from the old staple position. Line this hole up with the notch and wedge the pulley in place. Thread the rope under the wire rope clip, through the hole and out the side of the pulley (Fig. 10). Tie a knot in the rope end, pull it tight into the pulley cavity and let the rope wind onto the pulley. **PM**



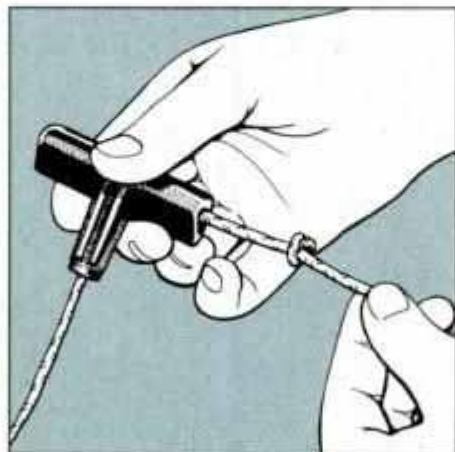
6 To remove the housing on Tecumseh engines, first unbolt the air filter and slide off the gas tank. Then remove housing bolts.



7 Lift the housing off the engine, pull out rope and set housing aside. The starter assembly is mounted on the engine side.



8 Turn pulley until staple appears in notch on mounting bracket. Remove staple with narrow-tip screwdriver or awl.



9 After removing old rope from the handle, thread new rope through, knot the end and pull tight to seat rope in handle.



10 With spring tensioned, pass rope through housing, under clip and through hole in pulley. Knot end and pull snugly.

Homeowners' Clinic

BY NORMAN BECKER, P.E.

Water Tempering Tank

My electric water heater, although well insulated, is costly to operate. I have a wood stove that keeps the basement at about 70°F. Would locating a prewarming tank about 3½ ft. away from the stove and tied to the water heater be a good idea?

JOE MINER
WHATLEY, MA

An uninsulated water tempering tank that acts as a reservoir for your water heater is a good idea—especially if the incoming water is very cold. Assuming that the prewarming tank has a 40-gallon capacity, then for every 1° F rise in water temperature that you achieve, you'll save approximately 100 watts. If the water entering the prewarming tank is 45° F and it's heated to 60° F before entering the water heater, then you'll save about 1.5 kilowatts.

Another advantage of a prewarming tank used in conjunction with an electric water heater is that it will increase the overall supply of available hot water. An electric hot-water heater typically has a low recovery rate in comparison to an oil- or gas-fired unit. The recovery rate is the number of gallons the unit will reheat in 1 hour. The recovery rate for electric hot-water heaters is about 18 gph whereas it's about 40 gph for a gas-fired unit and about 120 gph for an oil-fired unit. A higher recovery rate will enable you to have more hot water over a given period of time.

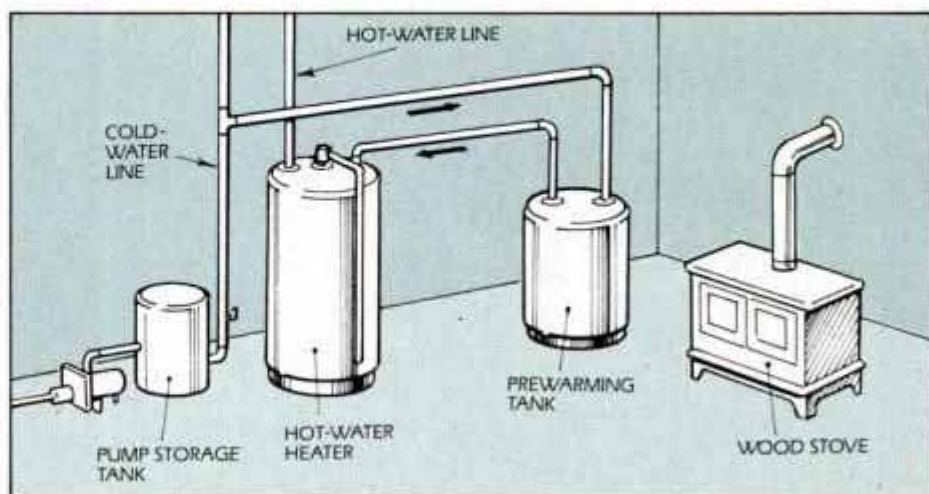
Of course, there is a tradeoff with this system. You'll probably have to throw another log on the fire.

Ultrasound Versus Insects

For the past two years, we've been harassed by carpenter ants that are nesting in the joints around our masonry chimney. Spraying the area with insecticide resulted in a few dead ants, but the destructive action persists. Do you think that high-frequency sound would exterminate them?

ELSIE LEE
ANN ARBOR, MI

Carpenter ants nesting in the roof sheathing and rafters around the chimney is a fairly common problem.



You can save on water-heating bills by taking advantage of wood stove heat. Place prewarming tank near stove and connect so cold water is warmed before going to heater.

These insects thrive on damp, rotting wood, often found around masonry chimneys because of faulty flashing and leaky joints.

I checked with the National Pest Control Assn. and was told that there are no indications that ultrasonic devices will work on any insect.

Although there haven't been any studies conducted with ants, tests have been made with cockroaches. The ultrasonic devices were found to have no observable effect. Several years ago, the Environmental Protection Agency tested a number of devices and concluded that they are not effective against insects.

Spraying surfaces with insecticides intended for consumer use will not destroy the colony. There are effective insecticides that will do the job, but they're only available to professional exterminators.

I suggest that you hire a licensed exterminator to correct your problem. After the nest is gone, repair any damaged wood and seal all open joints in the area.

Condo Humidity

I need advice on how to deal with a humidity problem. I close my condominium apartment for a few weeks at a time. When I return, I find a bad case of mold and mildew. I'm considering getting an electric dehumidifier to solve the problem. Is there a better solution?

FRED RODRIGUEZ
McALLEN, TX

Whether or not a single dehumidifier will be adequate for your purpose depends on the configuration of your apartment.

If you have a number of rooms, you'll probably need more than one dehumidifier because the partitions will interrupt air circulation between the rooms. You can substitute a fan for one of the dehumidifiers if it's positioned so that air is moved from a moisture laden room to one with a dehumidifier.

Dehumidifiers are usually equipped with an overflow control that shuts the unit off when the reservoir is filled. To make sure that the units keep working, run a hose from each one to a sink or toilet.

If your condominium apartment is centrally air conditioned, then a good cost-effective solution is to install a humidistat in parallel with the air-conditioner thermostat ("Homeowners' Clinic," page 139, July '87).

With this system, whenever the humidity builds up beyond a preset limit, the air conditioner will be activated even if the temperature in the apartment is not high.

This will remove excess moisture from the air throughout the apartment. **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

Oven Needs Adjustment

I need some information on how to adjust the oven temperature control dial on my Tappan electric range. The element stops heating long before the correct temperature is reached. It's almost impossible to bake anything.

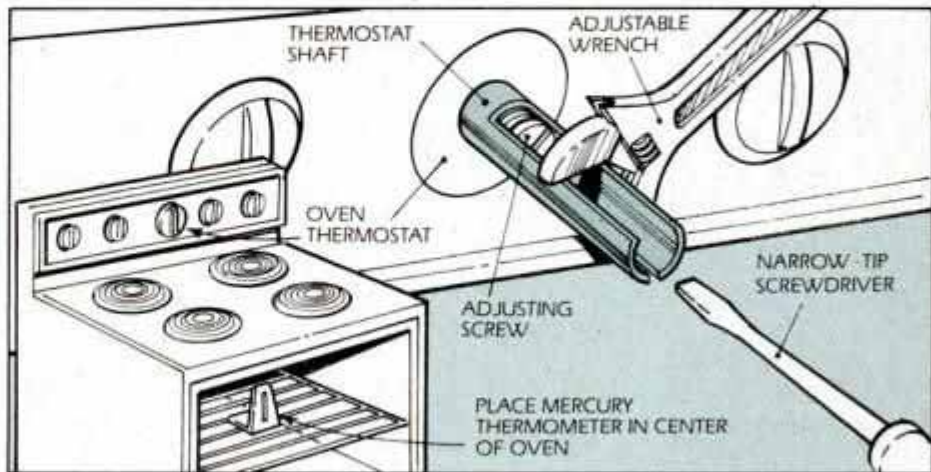
KENNETH D. PATRICK
ROSEVILLE, CA

To check the oven temperature and recalibrate the thermostat, you'll first need to buy a quality mercury oven thermometer. These are available at larger hardware stores or your local appliance repair and parts store and cost about \$8 to \$12. Place the thermometer in the center of the oven on the second rack. Make sure the range clock isn't set on the COOK-AND-HOLD feature which will maintain an oven temperature of only 150° F. Also, check that the minute timer is in the Off mode.

Now, set the selector switch to PRE-HEAT and the thermostat knob to 400° F. After the oven cycles once and the element is off, set the selector switch to the BAKE position and allow the oven to cycle two more times. After three complete cycles, record the lowest oven temperature by checking the thermometer at the end of the Off cycle. Then, note the highest temperature by checking the thermometer at the end of an On cycle.

Compute the average oven temperature by adding the highest and lowest readings and dividing by two. The result should be between 390° and 400° F. If it isn't, you'll need to recalibrate the thermostat as follows:

With the oven still set at 400° F, remove the thermostat knob. Hold the stem with a small adjustable wrench to keep it from turning. Use a narrow-tip screwdriver to adjust the screw in the center of the stem. Turn the screw clockwise to increase the oven temperature, or counterclockwise to decrease it. One-quarter turn results in a change of 45° F. After adjusting, recheck the average oven temperature. It may take several tries to get the temperature just right. If the thermostat doesn't respond to adjustment or the oven doesn't cycle, you'll have to replace the thermostat.



To adjust temperature dial, use a mercury oven thermometer to measure actual oven temperature. Then, recalibrate the dial by holding the shaft while turning the adjusting screw.

Needs Help

My 20-year-old central heating and air-conditioning unit contains a Honeywell electronic air cleaner, model No. F37A. When I tried to order replacement electronic collector cells from my local parts supplier, I was told that Honeywell no longer supplied these parts. They recommended that I have them rebuilt by a local technician.

I believe I can handle the job myself but cannot find a source for the .003- to .005-in. high-voltage collector wires. Do you know of a company that can supply me with what I need?

JOHN S. EVANS
WILLIAMSBURG, VA

A company called Air Cleaning Specialists of California may be able to help. The address is 180 El Camino Real, Millbrae, CA 94030. The toll-free number outside of California is (800) 633-4007. Interested readers living in California should call (800) 972-4227. This company stocks a variety of parts for older Honeywell air cleaners. It's also a factory service center for various other electronic air cleaner manufacturers.

Unfortunately, the company no longer stocks new cells for your air cleaner. However, if they're able to rebuild your old cells, total cost for shipping, parts and labor will run about \$150 to \$200. If you prefer to replace the collector wire yourself, Air Cleaning Specialists can supply it.

Replacing Contacts

I have a Hotpoint stove with plug-in type elements. Due to arcing, the contacts are burned. How can I have new contacts installed?

E. CHARLES McDUFFEE
MONTGOMERY, AL

Send your elements to South Eastern Range Replacement Parts Manufacturing Co., 301 South Linwood Rd., Gastonia, NC 28052. The toll-free number is (800) 438-8364. Include a note stating your name, address and phone number, and instructions to replace the burned contacts.

The company may have the parts in stock or be able to make them. If so, they'll call and inform you of the repair costs.

When you remove the elements, disconnect the power and check each of the sockets carefully. If you notice burned spots or pitting, you'll have to install new sockets before installing the repaired elements.

For The Record

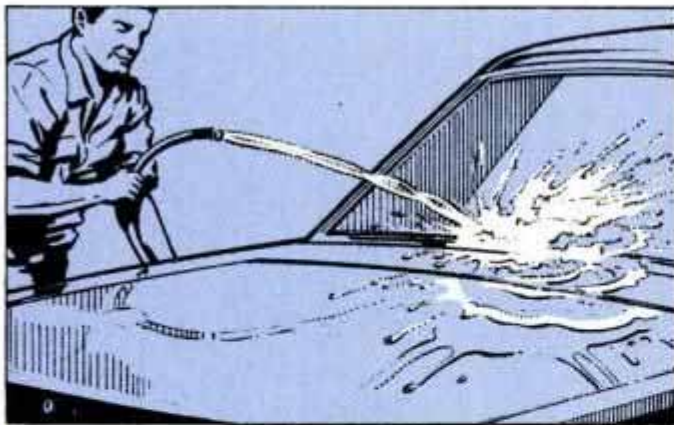
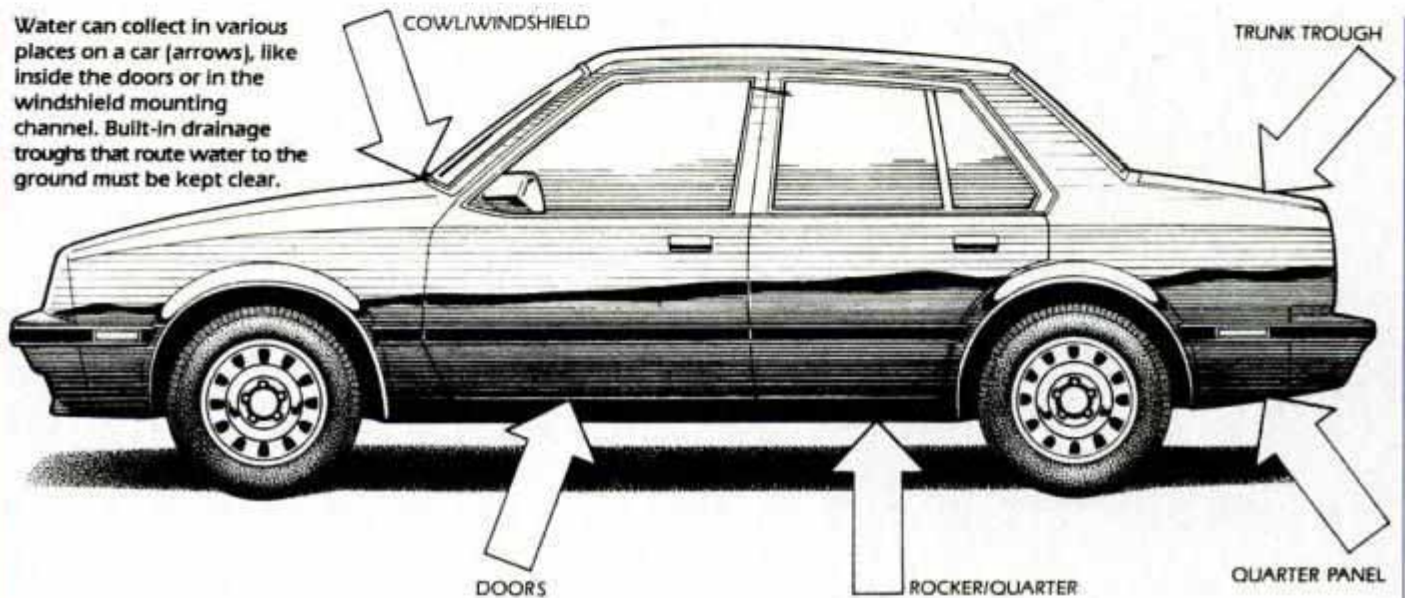
Our wires got crossed when we offered the toll-free number for ordering Montgomery Ward appliance repair manuals ("Appliance Clinic," page 132, Dec. '87). The correct number is (800) 323-1965.

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

Finding And Fixing WATER AND AIR LEAKS

BY MORT SCHULTZ, Contributing Editor
PM Illustrations by Fred Wolff

Water can collect in various places on a car (arrows), like inside the doors or in the windshield mounting channel. Built-in drainage troughs that route water to the ground must be kept clear.



Flooding a suspected area is first step in hunting for a water leak.



You, or a volunteer may have to get into the trunk to pinpoint leaks.

WATER that gets into your car makes a mess and can lead to long-term damage. Leaks start when your car's drainage system gets clogged, if seam-sealer between body panels crumbles or if weatherstripping around doors and windows wears out or tears. Weatherstripping damage can also create cold-air leaks.

Considering the dozens of potential

openings, how do you find the one that leaks? With a lot of patience, a little luck and a few down-home tools, such as a garden hose and towels.

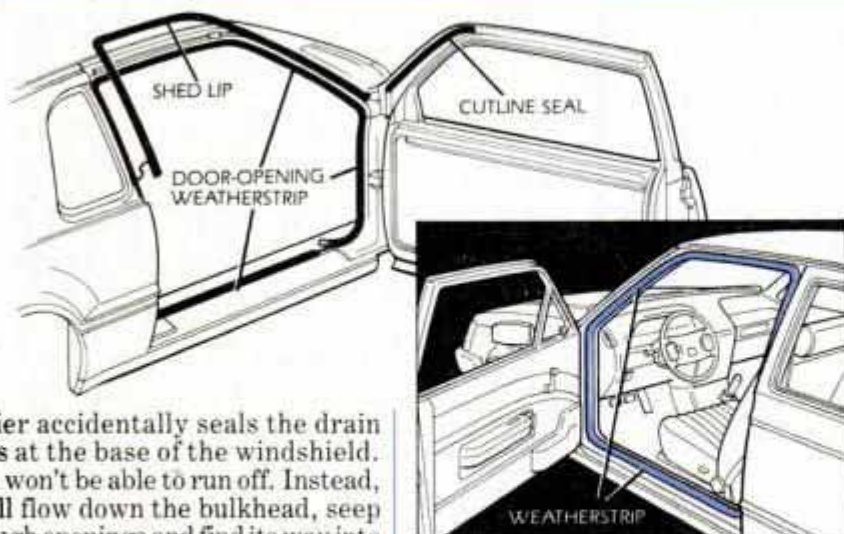
Natural drainage

A car's drainage system consists of holes and dart-shaped openings in the lower part of the windshield, in the cowl, at the base of doors and under rocker/quarter panels. When it's

functioning properly, the system disposes of the water that sneaks behind the vehicle's skin.

But if the drain holes and darts get plugged, water can run into the interior, accumulate in small enclosed areas and cause rust.

Drain holes and darts frequently get blocked when the car is being repaired. Suppose that in the course of replacing a cracked windshield the



glazier accidentally seals the drain holes at the base of the windshield. Rain won't be able to run off. Instead, it will flow down the bulkhead, seep through openings and find its way into the car under the dash.

Another example: Suppose you get a leak after a body shop straightens the front of the car following an accident. The mechanic may have failed to reinstall the shields over the large drain holes on the left and right sides of the cowl, giving falling autumn leaves a resting place. Instead of then being able to run off through cowl holes, water may seep into the car.

Did a leak develop soon after you had the car rustproofed? Maybe drain holes and darts in the door and quarter/rocker panels have been blocked. To be sure they're open, poke them with an awl.

But, remember, if the rustproofing is applied thickly, and is still as gooey as it's supposed to be, it will probably

Limousine-type door (left) requires more sealing than full-frame (above).

melt and block the holes again on the next sunny day.

Also, over the years, drain holes and darts in doors and quarter/rocker panels can get clogged with sediment or leaf fragments that wash down with the water. It takes a few minutes to reopen them with a probe and thus insure that rust won't develop because of water trapped between the panels.

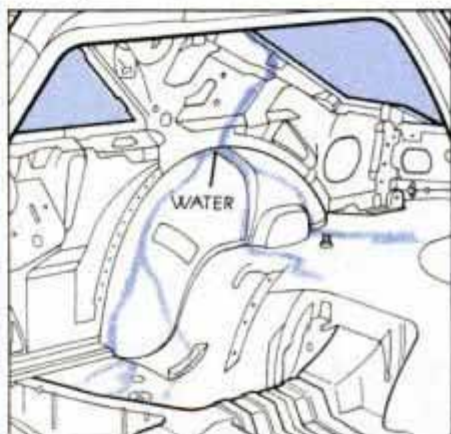
Whither weatherstripping?

Rear-wheel-drive cars are much more susceptible to damage to weatherstripping and seam-seals than front-wheel-drive cars. The stress on fwd vehicles by the pulling action of the

transaxle is absorbed by structural members in the engine compartment—not by doors, windows and sheet-metal joints as with a rear-wheel-drive powertrain.

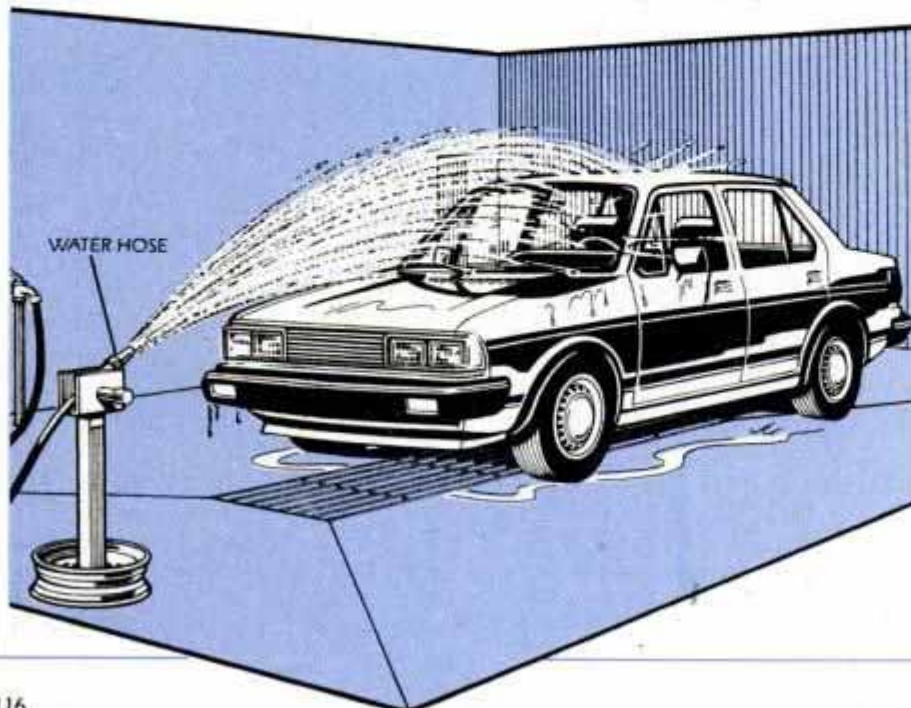
Depending on the style of door—full-frame, limousine or frameless—there are a number of things to keep in mind when tracing a leak that may be the result of damaged weatherstripping.

A full-frame door has a frame around the glass that seals the door to the body. A limousine door is the same as a full-frame door except that the top of the frame is extended and beveled to allow the door to become an integral part of the roof. (Limousine-type doors are found on other cars besides limousines.) Frameless doors, which are characteristic of



The entry point for rainwater can be a long way from where it puddles in the car.

When working alone, set up a holder for water hose to keep water playing on car.



hardtop, T-roof and convertible models, lack frames around the windows.

With one exception, full-frame and limousine doors are weatherstripped the same way. That exception is the extended top frame member of limousine doors, which requires shed-lip and cut-line seals.

The shed-lip seal is a pliable flap along the front and top of the door frame opening that blocks water and air. The cut-line seal is located along the edge of the door to fill this cavity.

To determine if there's a water and/or air leak through weatherstripping of full-frame and limousine doors, first examine the material for tears, which can usually be repaired with silicone rubber sealant.

Next, gently pull on the weatherstripping to see if it has separated from the metal at some point. If it has, use rubber cement or liquid butyl sealer to resecure it.

To determine if weatherstripping is worn, put a crisp dollar bill on it, close the door and pull. If there's no resistance, weatherstripping is worn in that spot, but don't be too fast to replace it. Worn weatherstripping can often be salvaged by cleaning the metal under the weatherstripping and placing a piece of double-sided polyethylene foam tape between the metal and the weatherstripping.

Note: Repair materials can be obtained from auto parts and hardware stores or car dealers.

Sound advice

There are several other points to remember about full-frame and limousine doors:

- Spraying weatherstripping with silicone lubricant every six months will keep the material supple and prolong its life, often for as long as you own the car.

- Door alignment affects the performance of weatherstripping. If a door loses alignment, something that usually happens only after an accident, you'll get air and/or water leaks. A misaligned door, which can often be resquared by shimming and re-securing hinges, is apparent if the space between the door and B-pillar on one side of the car is wider than the corresponding space on the other side of the car.

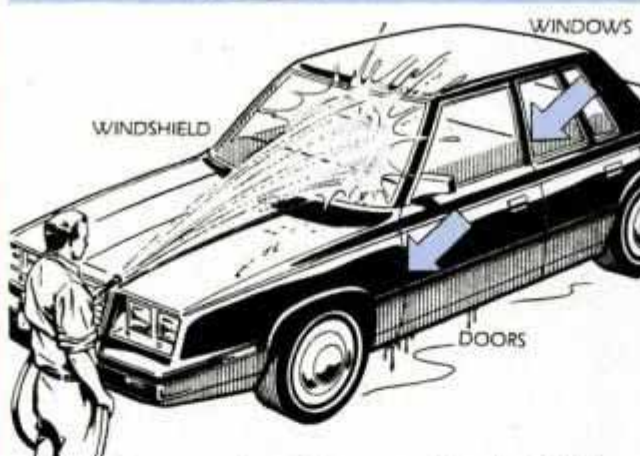
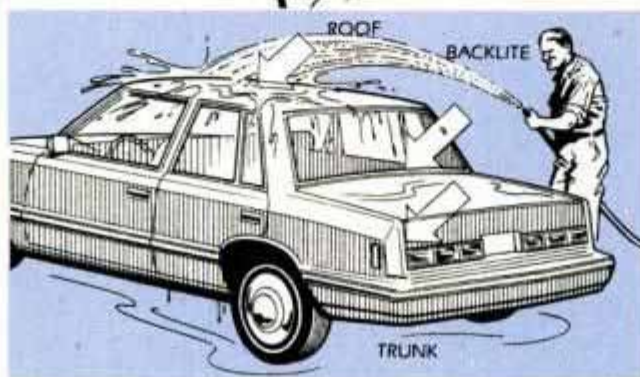
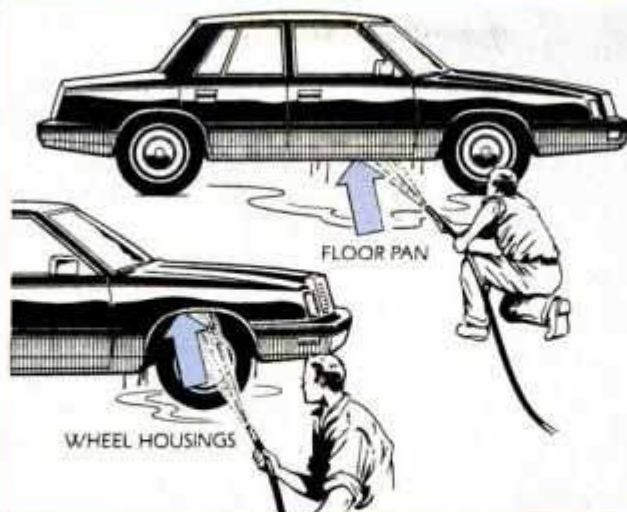
- Wind noise can result if there is an irregularity in the surface of the door opening, such as a lump of solder or plastic body putty.

Use a chisel or sandpaper to smooth the area.

- Three potential leaks around windows of full-frame and limousine doors are the flocked-run seal in the channel that surrounds the inside opening of the door, and through inner and outer belt-line seals.

You can see at a glance whether inner and outer belt-line seals are doing their jobs. They should hug the glass.

The flocked-run seal is another matter. Suppose there's a water leak around a window during a gale-driven rain or when the car is going through a



Try dividing your car into eight zones to help pinpoint leaks. Don't rush, as water may take time to show up inside.

car wash. Air can also leak into the car if this seal is worn.

You can't examine the flocked-run seal visually to see if it's worn. Instead, cut a length of foam tape to size, roll down the window, and insert it into the window channel under the seal. If the leak disappears, you've eliminated a troublesome spot.

Frameless doors of hardtop, T-roof and convertible models rely on secure weatherstripping on the body flange and body trim to stop leaks. Door alignment is even more important on these models.

Water test

Once you're confident the drainage system is clear and the doors and windows are doing their job, where else can water be entering the car? To find out, do a water test. Divide the car into eight zones and investigate one zone at a time. Be patient. It may take a long time for water to begin dripping during the test, so don't give an area just a quick spritz. Keep water flowing onto each spot for at least 20 minutes.

Keep in mind that water can be deceiving. Its point of entry doesn't always correlate directly with the wet spots. For example, a soggy carpet on the front floor could be caused by damage in the sunroof channel. Instead of rain falling on your head, as you might expect, it will take the path of least resistance which could be from the sunroof channel, down the windshield pillar and onto the floor.

Zoning the car

What you can anticipate finding in each zone is as follows:

Floor pan—If water leaks through the floor pan, making carpets soggy, the cause is loose or missing fasteners, such as brake-line clips, torsion bar bolts, seatbelt bolts, loose or missing floor pan grommets and seal-seam gaps in floor pan panel joints. Tighten fasteners and seal them with auto body caulking, buy grommets for empty holes (seal them, too) and apply caulk to body seams and spot-weld joints. Just pulling

up the carpet can reveal plenty, since floor pans are just as prone to rusting away as exposed panels like fenders.

Wheel housings—Water leaking into the car through wheel wells will show up on the floor near A-, C- and/or D-pillars, or in the trunk, depending on which housing has the leak. Tighten fasteners, such as rear seatbelt bolts and shock-mounting bolts, and reseal panel seams.

Doors—Although you've already checked weatherstripping and door alignment, there are other possible leaky spots. If water is showing up on

the floor near doors and pillars, there may be a gap in a pillar seam, or perhaps loose hinge bolts or loose grommets around the A-pillar wires that pass from the engine compartment to power window motors.

Windshield—You can pinpoint leaks around the windshield by having an assistant with a mirror and flashlight sitting in the front seat. As you concentrate water on the zone, he can see if it drips down the bulkhead.

If there is a leak, make sure left and right cowl drain holes are clear and a shield covers each. Look for missing or loose grommets in the bulkhead. Tighten fasteners holding parts to the bulkhead, such as relays and the air conditioning/heater plenum.

That leaves the windshield itself. As mentioned before, drain holes at

using a windshield molding trim tool. Don't make do with something like a screwdriver—chances are you'll crack the glass. Slide the tool under the molding until it hits a clip. Then, twist the tool gently until the molding pops off the clip.

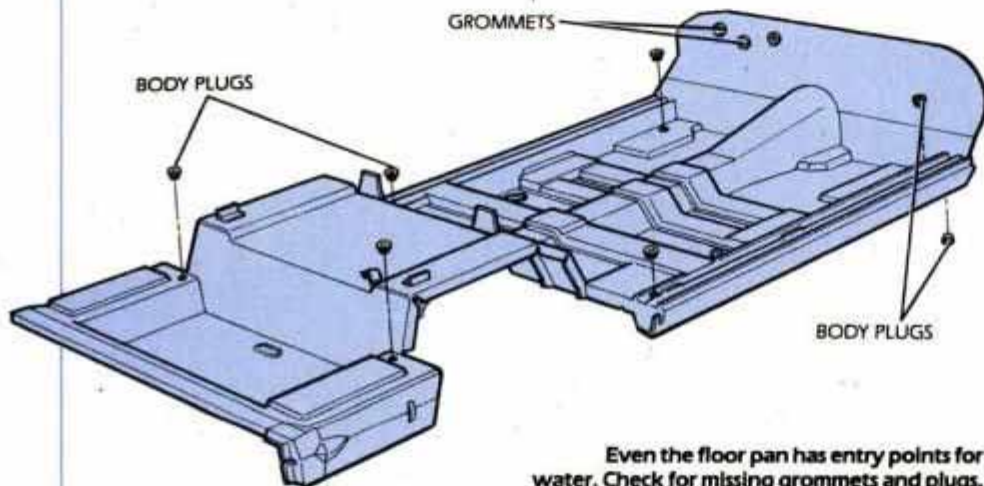
After all moldings have been taken off, count the number of clips and buy new ones from an auto glass shop. Don't reuse old clips. They're not tight enough the second time around.

Put new clips in the same positions as the old ones, lay down a wide bead of windshield sealer (don't leave any gaps), place the molding over the clips, and press down until in place.

Backlite—Leaks from gaps in backlite sealer will necessitate removing moldings and resealing from the outside. But before going through this



Wind flutter in trim can be located by temporarily taping down suspect pieces.



Even the floor pan has entry points for water. Check for missing grommets and plugs.

the base of the windshield could be clogged if you've had the windshield replaced. Otherwise, small gaps could have developed in the sealer around the windshield. If so, there's a chance you can reseal these from *inside* the car using a urethane sealer such as one manufactured by 3M (part No. 3M08609). It comes in a cartridge for use with a caulking gun.

Apply the material around the entire perimeter, but remember: *on the inside*. It won't work if you put it around the outside molding and could cause a problem, requiring removal of the molding to reseal the windshield.

Don't get windshield sealer into the clips. It'll make removing the trim almost impossible to do without damage, and if you haven't found the leak (or need to replace the windshield at some point later on), you might wind up replacing the trim.

If an inside-the-car resealing effort isn't successful, remove the molding

trouble, make sure the deck lid seal (that's the weatherstripping on the top lid inside the trunk) is firmly in place and gutters are secured to the body of the car.

Yes, gutters. Water can leak



A mirror and a flashlight will come in handy for restricted areas like the dash.

through a separation between a gutter and C-post, for example, and wind up inside the rear of the car.

Trunk—If you find water in the trunk, first check weatherstripping. Then, tighten and apply sealer to all rear-end fasteners, such as taillight screws, license plate housing screws, and bumper or shield fasteners. Check gutter-to-body integrity and seal taillight and backup light assembly moldings with auto body caulk.

Windows and roof—Water test windows in case you missed something before. Then, test the roof. Water found in the car after the roof has been given a going-over can be entering through gaps between a gutter and the body or a gap in pillar weld joints. If the car is equipped with a sunroof, suspect that. If sunroof channels were not equipped with drain tubes and sealed tightly at installation, remove and reseal properly.

Wind tips

Here are two tips that may save time in locating the source of a wind noise:

- As you test drive the car with the windows tightly closed and the heater/air conditioner/vent system off, have an assistant press a towel against each window. If a wind noise disappears or changes pitch, you've got the area pinpointed.

- If the source of the wind noise seems to be outside the car, retract the radio antenna and drive the car. If the noise hasn't disappeared, tape small sections of molding with pressure-sensitive waterproof tape. Drive the car. Has the noise stopped? If so, remove the molding, fill its hollow back with auto body caulk and reattach the strip securely to the body. When moldings have been tested, turn your attention to headlamp and taillight pieces and the grille. Patience pays.

ECONO COMMANDOS

(Continued from page 55)

Chevrolet Sprint Turbo

The Suzuki-built Sprint holds together better visually than any other microcar since the Austin Mini Cooper. It's cute, inside and out. The materials are obviously inexpensive, but assembly quality and finish are excellent. Our test car had charming red and gray tweed upholstery, with a gray dash, nice white-on-black gauges, and GM pushbuttons on the instrument binnacle.

There are even surprisingly comfortable bucket seats. You could squeeze in four people, but this is essentially a 2-person car, with a surprising capacity for luggage.

The Sprint is *small*—just 12 ft. long, and 1565 pounds, soaking wet. In normally aspirated tune, its 48-hp, 3-cylinder engine is pretty anemic. The turbo boosts output to 70 hp, however, which is enough to run 0 to 60 in 8.5 seconds and the quarter-mile in 16.5 seconds at 81 mph. That's impressive for an engine that's smaller than some of the powerplants Suzuki puts in its 2-wheelers.

The Sprint was underwhelming in the corners and in our handling tests, but it would be a mistake to expect more from 12-in. wheels wearing merely adequate tires (Bridgestone RD401s, size P165/70R-12). Driving fast it's a bit of a handful, thanks to short wheelbase and stiff suspension. It's a blast to throw around for a few miles, but you soon tire of the rather choppy ride, buzzy engine and chassis vibration.

There's no question that the Sprint Turbo has plenty of *joie de vivre*. Like so many of Suzuki's sporty small cars, most of which we never see in this country, it has style, it's fun around town, and it's just slightly outrageous. Nevertheless, \$8500 for this car is a lot of money.

The Bottom Line

As we noted at the outset, this stimulating class of cars—fuel misers that somehow discovered steroids—covers a broad price range. And there are temptations from the top of the price list on down.

Our consensus is that the GTI continues to embody a level of all-around performance the others would like to match, but miss in one way or another. But that's an opinion undiluted by economic realities. If you develop a dollar-value weighting factor, you're likely to form an entirely different opinion.

And that means you'll just have to drive them all, or at least all of them that make sense to you. **FM**

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BATTLECRUISER 2000

(Continued from page 67)

practical option by the time the FSC is in the pipeline, we will have at least created a system that can make use of it later on. If it is available," he concludes, "it will be a perfect marriage."

All in the family

One of the most appealing aspects of the Future Strike Cruiser is an endowment that didn't even occur to Metcalf—rather, it was the product of Capt. Gunn's ship characteristics analysis. After entertaining various design configurations, Group Mike concluded that it would be possible, in fact highly desirable, to adapt the hull to accept modular inserts of various types. The entire hull would be fitted with hard points and chocks to mount VLS cells, but a certain area would be additionally arranged to mate with containerized modules, such as auxiliary fuel tanks, antisubmarine warfare (ASW) equipment, and so on.

The original idea for this plug-in design arose from a desire to upgrade the ship's habitability during peacetime through the installation of berthing modules that could be easily replaced by weapons for combat duty. It wasn't much of a mental jump to recognize the logical extension of this brainstorm: The modular concept also lends itself to the substitution of any number of self-contained, special-purpose mods. For instance, a special operations SEAL team (replete with all its associated gear) could be "pre-packaged" for integration into FSC—so too, a unit equipped with remotely piloted reconnaissance vehicles or an amphibious assault team.

This alternative use of space would produce a family of vessels built on a common hull—a very cost-effective approach to ship design—while affording the capability of tailoring every ship to a specific mission. Such a flexible configuration also facilitates extended growth potential.

At this point in time, the future of Metcalf's revolution is far from being assured—if the old salts have anything to say about it. And, as it was Metcalf's enthusiasm, energy and personal commitment that were largely responsible for this revolutionary concept, some skeptics suggest that his retirement will stall the program like a ship without a rudder. Metcalf refuses to accept this verdict. He simply states, "Resistance to change is the enemy." Adm. Metcalf has charged those who follow in his wake to drive on, in hopes that his ambitious Revolution at Sea will not be rendered into just another Evolution at Sea.

FM

MICROMACHINES

(Continued from page 81)

The material of choice thus far is silicon, for the simple reasons that it has properties of weight, strength and elasticity that compare favorably to steel, and is the most extensively studied material known to man. But other materials such as aluminum and tungsten are also under scrutiny.

AT&T's Gabriel cautions conservatism when contemplating the future ramifications of micromechanics. "The applications will probably be fairly mundane," he declares. "The first person who worked on microprocessors probably didn't envision them winding up in ovens or dolls."

Microjobs

But it is impossible for others to contain their speculative enthusiasm. Anita M. Flynn, of MIT's Artificial Intelligence Laboratory, waxes more poetic.

She details a few possibilities:

■ Is there a suspicious O-ring on a Space Shuttle solid rocket booster? Send a crawling robot to check it out.

■ Suppose there is a break in an underground electrical circuit. Send in a gnat robot to measure the conductivity between each leg. When it locates the open circuit, the robot extends itself across the fault and reestablishes the connection.

"It can just stay there forever," says Flynn, "as an autonomous piece of wire."

■ Picture airborne gnat robots, flying over a farmer's field, using infrared sensors to determine which sections are in need of water, then swooping down to activate the irrigation system accordingly.

■ Have a security problem at the warehouse? Employ an airborne army of sentry robots to detect disturbances.

■ Want to clean barnacles off of a ship? Use millions of gnat robots (like "scrubbing bubbles") to munch away in tandem.

The preliminary calculations of the price for micromachines are as breathtaking as the theoretical performance specs. It currently costs about \$400 to produce the wafer that serves as the construction base for microelectronic circuits.

"Put a million of these motors on a wafer and they don't cost anything," Hazelrigg says.

"Today you buy a device with a million transistors in it and you don't even think about it. You put it on your wrist and it tells you the time. Maybe someday we'll make a mechanical variant of it that would fit inside a button and cost a penny."

Difficulties ahead

While researchers remain confident that micromachines will become a reality, they are wary of promoting premature enthusiasm, for problems still confront them.

Simply removing the completed machine from the substrate has proved difficult. Cooling leaves residual stresses within silicon that are not apparent in electronic microstructures, but can cause free-standing micromachines to warp. Another difficulty, says Hazelrigg, is, "we don't know the properties of materials on this scale because we've always dealt with things big enough to see. Materials, metals especially, are crystalline in structure, and many of the properties of the metals are determined by the interstices between the crystals. Now we're getting down to a scale where it's perfectly feasible to make devices out of a single crystal and we don't know the properties. We don't know how to test for them."

Then there is the question of lubrication. In a macromachine, operational surfaces never touch one another. Rather, they hydroplane upon oil (or other lubricant). But the design parameters for a micromachine may call for a clearance of only two mean free paths of a molecule (the mean free path is the average distance a molecule travels before it smashes into another molecule), leaving only enough space for a few atoms of lubricant. At that level, will individual atoms, instead of lubricating, act like grains of sand? No one knows.

What will be the effects of vibrational forces upon micromachines that are spinning at millions of rpm?

And how about heat? On a microscopic scale, will heat cause fragile parts to warp?

There is one further problem that dogs the early research work, illustrated when a scientist left home one morning carrying a 300-micron gear ensconced in protective wrapping within a shoebox. He tripped on his threshold and the shoebox went flying. "There is a 300-micron gear somewhere in his front yard," Hazelrigg says. "If you drop one of these things, you'll never find it. Perhaps we are creating a new science called microarchaeology. Hundreds or thousands of years from now people will sift through sediment to find these micromachine parts and speculate on what we were doing."

Despite the problems, micromechanical researchers radiate a uniform optimism. It may take a decade or two to iron out the difficulties, but there is general agreement that we now stand upon the threshold of the micromechanical age. **PM**

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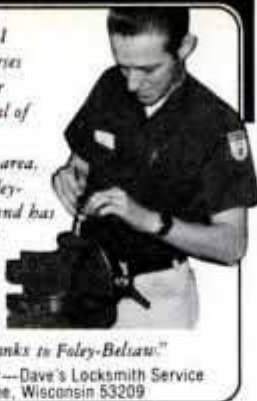


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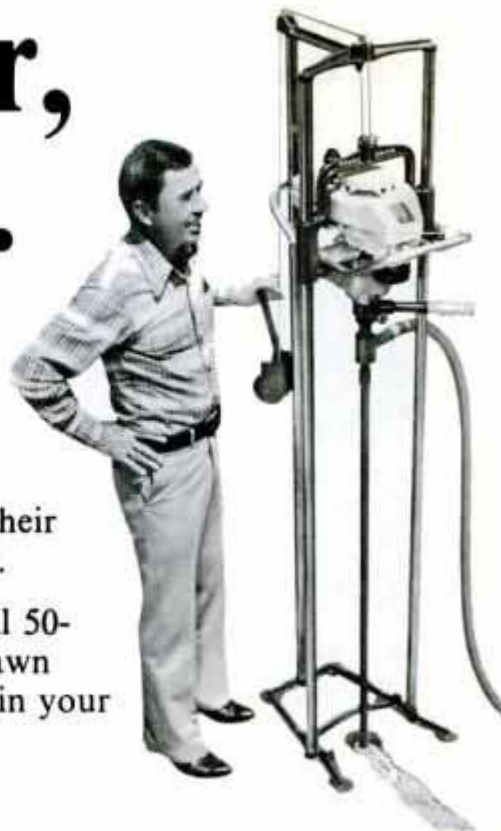
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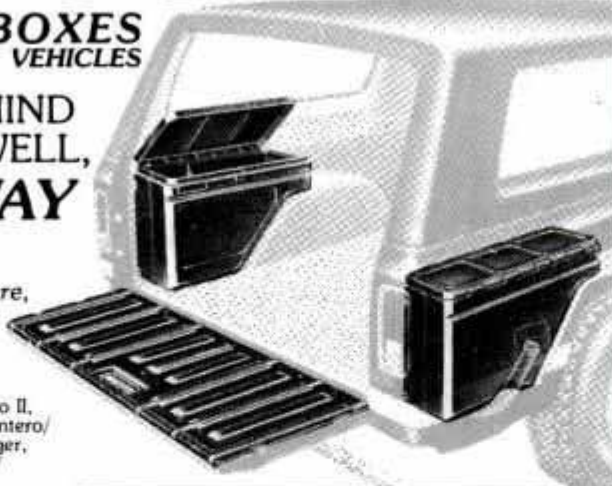
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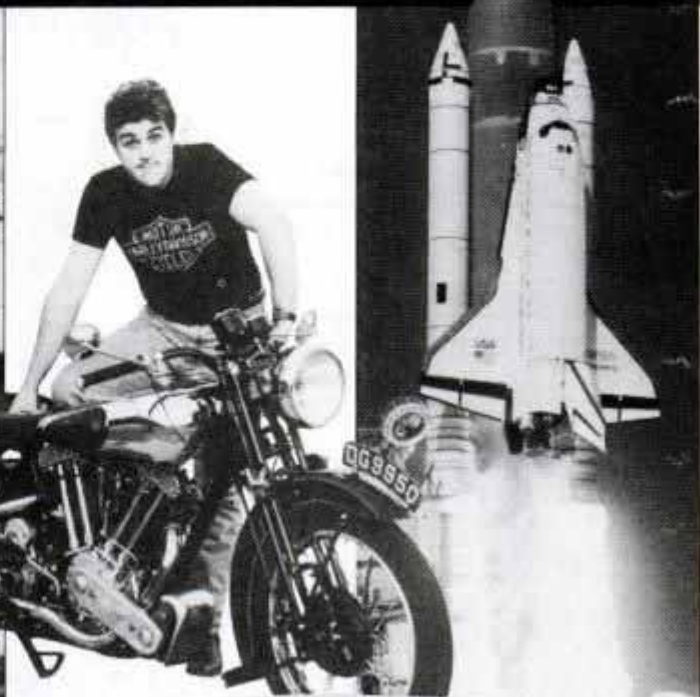
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