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SPECIAL SECTION

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Four-wheel drive, rear anti-lock brakes and peace of mind come standard.

The new Electronic 4-Wheel Drive Ford Aerostar with rear anti-lock brakes makes peace of mind a new standard feature for you and your family. That's because this Aerostar gives you improved traction and control in all kinds of weather.

Full-time traction and more controlled braking.

Aerostar's sophisticated 4-wheel drive is a full-time system which electronically senses

road conditions and adjusts the amount of power given to each set of wheels accordingly. The rear anti-lock brakes are designed to prevent rear wheel lock-up and help you make straight stops.

Powerful 4.0L V-6, standard.

Advanced technology isn't all there is to the Aerostar story. In addition to its standard 4.0L V-6, the new 4WD Aerostar offers attractive styling, a comfortable interior and impressive capability. Put this all together and you've got a

Buckle up—together we can save lives.



vehicle that gives you not only peace of mind, but pride of ownership, too.

Transferable 6/60 powertrain warranty.

Covers you and future owners on major powertrain components for 6 years/60,000 miles. Ask to see a copy of this limited warranty at your Ford Dealer.

Best-built American cars and trucks.

The best-built American cars and trucks are built by Ford. This is based on an average of

consumer-reported problems in a series of surveys of all Ford and competitive '81-'89 models designed and built in North America. At Ford, "Quality is Job 1!"

New 4 WD Ford Aerostar

Have you driven a Ford...lately?



This One



Q186-DXL-KLKJ



Run the river without taking a bath.

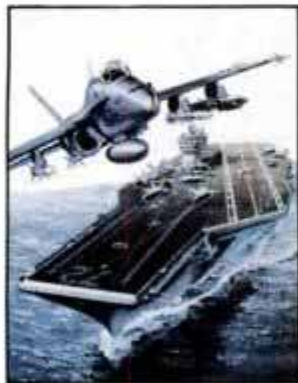
Whether you're up to your axles in water, mud and snow.
Or chasing that yellow line mile after quiet mile.
Your Safari AWR light truck radials will outrun the pack.
At a price that cleans up the competition.

A good deal on
a great tire.



Popular[®] Mechanics

MARCH 1990
VOLUME 167
NO. 3



49 COVER STORY

The most formidable fighting machines in the world.

—PM Illustration by Tom Freeman



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EDITOR'S NOTES

IN LIGHT OF the rapidly unfolding events in Panama, our cover story could not have been more timely. It's ironic that, as tensions between the United States and the Soviet Union lessen, there are still almost comical "heads of state" somewhere in the world declaring war on us. It reminds me of the Peter Sellers movie, "The Mouse That Roared." Unfortunately, there is no comedy involved when American lives are lost shutting down the



Michael, me, Bill and Mario.

Gen. Noriegas of the world. Let's all hope that such incidents become less and less frequent. Unfortunately, there's no guarantee of that happening, so it's imperative that we maintain a very strong, very fit defense posture into the foreseeable future.

As you read this, there are five or six PM readers sitting down right now to write me a letter protesting against the printing of our cover story, "Show Of Force," and accusing me of being a warmonger. Nothing could be further from the truth. In fact, I am a peacemaker. But I've never seen peace break out by letting a small-time bully beat you up. And so, Adm. Edward Martin's article is extremely apropos. Retired Adm. Edward Martin, USN, knows what he's talking about. Recently retired as Deputy Chief of Naval Operations (Air Warfare) and previously Commander of the U.S. Sixth Fleet, Adm. Martin is one of the most gentlemanly persons I've ever met. Just don't kick sand in his face. The U.S. Navy's newest supercarriers truly are rulers of the sea. And Adm. Martin's piece certainly does them justice, as does the beautiful John Batchelor wall poster also in this issue. . . . I recently had the pleasure of presenting the Mechanic Of The Year Award, on behalf of the Automotive Parts & Accessories Assn., to Bill Tabony of Gretna, Louisiana. Bill, who works at the Sears auto store in Gretna, has been an auto mechanic with Sears for 27 years and received the award for scoring highest in the entire U.S. among volume retailer mechanics who took last year's certification tests administered by the National Institute for Automotive Service Excellence (ASE). More than 5000 other mechanics competed for Bill's award so it's quite an accomplishment. On hand to help me with the presentation in Chicago was racing legend Mario Andretti and son Michael, an up-and-coming legend. Congratulations to Bill and all the other mechanics who help keep our wheels rolling. . . . Speaking of awards, I call your attention to our new awards program, The POPULAR MECHANICS Design & Engineering Awards (page 68). We'll be recognizing excellence in the many editorial areas that we—and you—are involved with. Check the announcement to see how you can participate. . . . Longtime Contributing Editor Bob Vila hosted public television's popular show, "This Old House" for 10 years. Now Bob is moving on to a new show, "Home Again With Bob Vila." The show will feature affordable repairs, renovations and how-tos that almost anyone can do. Watch for Bob's new show this spring in your area. Till next time.

Gen. Noriegas of the world. Let's all hope that such incidents become less and less frequent. Unfortunately, there's no guarantee of that happening, so it's imperative that we maintain a very strong, very fit defense posture into the foreseeable future.



Contributing Editor Vila


Joe Oldham

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Editor-in-Chief
Joe Oldham

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Bill Hartford

Graphics Director
Bryan Canniff

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Thomas Klenck, associate editor
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Norman Becker, Rosario Capotosto,
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contributing editors

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Automotive

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Mike Allen, assistant editor
Michael Lamm, Rich Taylor,
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Abe Dane, editor
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Robin LaSalle, asst. production editor

Art

Alan Andresen, Tom Kane, Suzanne McCreight
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Editorial Offices

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FREE RADAR REPORT:
Traffic Radar: How it works, and why it gets wrong readings. For your free copy, call us toll-free at 1-800-543-1608.

Radar Warning Breakthrough

Digital Signal Processing (DSP) allows new ESCORT to warn you of traffic radar much sooner than previously possible

When we introduced the original ESCORT in 1978, its superheterodyne technology provided an incredible increase in warning distance. One magazine said we "struck panic into the whole radar detector industry."

Our new ESCORT will have the same effect.

History repeats itself

Since 1978, we've continued to advance the science of radar warning, and our original ESCORT and PASSPORT have won test after test. But we've never stopped working to develop another breakthrough to redefine radar detection again. And now we've done it.

Incredible new technology

Our all-new ESCORT provides an incredible increase in detection distance. And it's only a fraction of the size of the original ESCORT. The key is Digital Signal Processing (DSP), an incredible computer technology.

DSP is used by NASA to create detailed space photos from blurry images. It's used to deliver sharp images of internal tissue from medical scanners. It's used by military radar to distinguish enemy from friendly aircraft.

And now we're using DSP to find radar signals too weak to be detected by conventional technologies.



The heart of ESCORT's DSP circuitry is a custom version of the Motorola DSP 56000. This 20 MHz 24 bit parallel HCMOS processor is capable of 10.25 million instructions per second, and is also used in Steve Jobs' new \$10,000 NeXT computer.

How it works

The new ESCORT's DSP circuitry samples incoming radar signals 50,000 times a second, slicing them into discrete bits of information. This information is digitized and continuously analyzed by an incredibly fast signal recognition computer. The end result is remarkable.

Breakthrough performance

ESCORT's advanced signal processing provides an incredible increase in sensitivity on both bands. Quite simply, this means that the new ESCORT picks up radar signals further away than was ever before possible, even distant instant-on radar signals. And its advanced City/Highway circuitry lets you optimize ESCORT's warning system for either driving environment.

"The new Escort packs ultimate sensitivity into a small package. Nothing else even comes close, and no wonder... No analog device can hope to match this performance."

BMW Roundel December 1989

Intuitive warning system

ESCORT's warning system keeps you fully informed. Upon radar contact, ESCORT's alert lamp glows and its variable-pulse audio begins a slow warning. Simultaneously a bar graph of Hewlett Packard LEDs shows radar proximity.

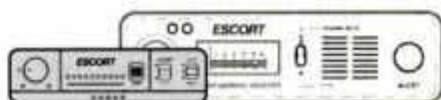
As you get closer, the audio pulse quickens and the bar graph lengthens. You'll understand ESCORT the first time you use it.

No compromise design

We've spared no expense in making ESCORT the best equipped radar detector ever. A photocell adjusts the visual display for the light level in your car (there's also a Dark mode for more discreet operation).

ESCORT's adjustable volume and Mute switch let you adjust the audio level, and we've added a new "AutoMute" that automatically turns the volume down after the initial alert.

ESCORT's aluminum housing, finished in non-glare black, provides ruggedness that will last for years and years, unlike plastic housings. And ESCORT comes complete, period.



The new ESCORT is only 7/8" high and 3 1/4" wide.

All accessories included

For installation, ESCORT comes with both visor clip and windshield mount. For power connection, we supply both a coiled and a straight cord to plug into your car's lighter. There's also a cord for permanent wiring into your car's electrical system, if you prefer.

We even include a leather carrying case, which fits easily in a coat pocket or briefcase, so you'll always have ESCORT with you.

Test-drive ESCORT at no risk

For more information, or to place an order, just call us toll-free. We only sell direct from our factory to you, and we guarantee your satisfaction.

After you receive ESCORT, if you're not completely satisfied within 30 days, just return it. We'll refund all your money and your return shipping costs. There are no hidden charges.

With the new ESCORT, we've revolutionized radar detection again. But don't take our word for it. Order today and see for yourself.

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New Anti-theft System

Escort comes with a tiny "Digital Key" to put on your keyring. When you first receive your Escort, and then about every two months, you'll use your Digital Key to "unlock" your Escort.

For someone who doesn't have the proper Digital Key, your Escort simply won't work.

So while your Escort is valuable to you, it's of little value to a thief.

Our new Digital Key security system will help keep your new Escort yours.



Actual size cutaway of Digital Key

Aerovantage.™
 Because aerodynamic cars need aerodynamic wipers.

Vented bridge lets air flow through

Silencer bushings provide quieter operation

Fits domestic and import cars

The wind can play havoc with windshield wipers on today's cars. Lifting them off the glass. Anco Aerovantage has been aerodynamically designed to fight wind lift. Giving you the advantage of a quieter, cleaner wiping blade.

ANCO
 CLEARLY THE LEADER

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Advertising Offices

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224 West 57th St., New York, NY 10019
 John A. Pagliaro, New York Manager
 (212) 649-3135
 Edward W. Baker - (212) 649-3141
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Chicago

1 South Wacker Dr., Chicago, IL 60606
 (312) 984-5190
 Alan R. Perry, Western Manager
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Detroit

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 Laurence E. Lantzy - (313) 649-2981
 Donald C. Schulz - (313) 649-2981

Los Angeles

3000 Ocean Park Blvd.
 Santa Monica, CA 90405
 Austin C. Sass, West Coast Manager
 Alfred R. duPont - (213) 450-8881

Direct Response Advertising
 Barbara Jones, Manager - (212) 649-3139

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 Sophie Gronowicz - (212) 649-3167

Production Manager
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Advertising Production
 Patricia A. Tanner - (212) 649-3164

Reader Service Department
 Norah I. Golad, Manager - (212) 649-3128

Published by The Hearst Corporation:

Frank A. Bennack Jr., President
 Randolph A. Hearst, Chairman
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 K. Robert Brink, Exec. Vice President
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PM HOTLINES

COMMUNICATE WITH US

We're trying our best to make it easier for you to communicate with us. Here are four ways you can do it.

HOTLINE PHONE NUMBERS

Special telephone numbers here at Popular Mechanics allow you to call our editors directly and easily. They're activated once a week, on Wednesdays, from 3 to 5 PM EST. All the editorial staff hotline phone numbers are listed here.

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Steven Willson, editor (building, home remodeling) (212) 265-7538
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Frank Vizard, editor (212) 265-7581

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Joe Skorupa, editor (212) 265-7596

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 Mike Allen (technical and design, care and maintenance) (212) 265-7536

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Abe Dane, editor (212) 265-7740

GENERAL

Joe Oldham, editor-in-chief (212) 265-7503
 Bill Hartford, managing editor (212) 265-7518

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You can call the PM computer any day between 6 PM and 8 AM (only) EST. The number is (212) 582-8369. Once you're on line, you can leave messages for specific editors, or direct inquiries and comments to a specific department. The department bulletin board also allows you to share your thoughts with other readers who call in.

New users will get an identification number and password that allow them to access the system. Simply set your communications software to 8 bits, no parity and one stop bit (B-N-1), and set the baud at 300 or 1200. If you're asking a specific question, allow a week before calling back for our answer.

FAX MACHINE

You can fax written mail to us if you have access to a fax machine. Our fax number is (212) 586-5562 and is available 24 hours a day.

The Fine Art of Nature



- 23K gold border
- Actual size: 9 1/4"

- Limited edition plate

A pair of handsome Ring-necked Pheasants tread gently upon the newly fallen snow. The female carries herself with regal aplomb, while the male boldly displays his richly colored plumage, as if in defiance of winter's sameness.

Now, renowned wildlife artist Jim Killen captures the beauty of this scene on flawless porcelain, with the introduction of his breathtaking collector plate, "Ring-necked Pheasant." Absolute in its authenticity—and brilliant in its execution—"Ring-necked Pheasant" is a true masterpiece, offering beauty to equal nature's own.

Adding to its significance, "Ring-necked Pheasant" premieres an important new series of collector plates entitled *North American Game Birds*. Each issue will feature a dramatic Jim Killen original, portraying a different, well-known upland game bird in its natural habitat. Each 9 1/4" plate will be embellished with 23K gold, hand-numbered on its reverse, and accompanied by a same-numbered Certificate of Authenticity, attesting to its place within the edition limited to a total of 14 firing days.

Ring-necked Pheasant

As an owner of "Ring-necked Pheasant," you will have the right—not the obligation—to acquire each issue in the collection, as presented to you. And, there is absolutely **no risk**, because The Hamilton Collection **100% Buy-Back Guarantee** assures that you may return any plate within 30 days of receipt for a full refund.

Because "Ring-necked Pheasant" boasts the credentials of major artist, aesthetic appeal, and popular theme, this dynamic issue could someday join the company of bird-subject plates which have appreciated in value by as much as 3900% after the closing of their editions.

Strong competition to acquire "Ring-necked Pheasant" is anticipated, and you are urged to respond promptly, since applications will be processed in order of receipt.

© 1989 HC

Respond by:

March 31, 1990

Limit: Two plates per collector

Accept my reservation for _____ (1 or 2) "Ring-necked Pheasant" at \$37.50 (plus \$2.48 shipping and handling) each, payable in two equal installments of \$ _____ (\$19.99* for 1 or \$39.98* for 2 plates).

I need send no money now. I will be billed \$19.99* per plate for my 1st of 2 installments, prior to shipment.

Ms. Mrs. Mr. **MZM1 QE LA**

Name _____

Address _____

City _____

State _____ Zip _____

Signature _____

*CA, FL, and IL residents will be charged the appropriate sales tax. All applications must be signed and are subject to acceptance. Shipments made to the U.S. and its territories only.

The Hamilton Collection

9550 Regency Square Blvd., P.O. Box 44051
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LETTERS



Good Cue For PM Project

YOUR pool table project in the December '89 issue ("Rack 'Em Up," page 74) is a terrific design. I would offer a small suggestion for the construction, however. I've put together a table or two and have found that to seal and smooth the joints between the slates, beeswax works really well. I use a small butane torch and a cake or two of beeswax and melt it into the cracks. You can use a hair dryer to ensure a good flow. Then use a razor-blade scraper to get a smooth surface between the slates. This way you won't have to mix plaster of Paris, which will shrink after it dries so you'll have to do it again. By using beeswax, you will also avoid the sanding that is necessary with plaster of Paris.

NICK L. NAPIER
BEDFORD, IN

Full Speed Ahead

Racing 1990 "America At Speed" in the January issue (page 81) is a super feature! Certainly one that should be repeated annually (at least the schedules for CART and NASCAR races). Thanks for the special section.

DAN AMEY
HOCKESSIN, DE

Your article "Top Fuel Technology" (page 98) in the Racing 1990 special section offered an interesting insight into the technology behind big-bucks racing for all of us "recliner racers." However, you miss one sign of the times as you spirit us into the '90s. You repeatedly refer to the crew chief as a "he." In your photo, the top fueler is driven by Dick Lahaie and the crew chief is Kim Lahaie...as in daughter Kim Lahaie.

As bad as we hate to admit it, it's not a man's world, so come on, give the women a break when you can. It only stings a little.

GARRY C. GARNER
CORPUS CRISTI, TX

Your article on "Top Fuel Technology" was well written and informative, but in the photo on page 98, you showed a screw-type supercharger and called it a Rootes-type. Also, top fuelers use 2.90:1 rear-axle gears, not 2.70:1 as you had stated.

CLIFF MORGAN
PHOENIX, AZ

You're right, Cliff. The screw-type blower shown uses vanes with a tighter pitch than the Rootes unit. As for the gears, the NHRA re-

cently restricted the rear-axle gear ratio to 3.20:1, as we said, to keep speeds below 300 mph.

Double Trouble?

The article on oil tankers in your Nov. '89 edition ("America's Oil Tanker Mess," page 51) gives a number of views about the merits of building tankers with double bottoms or double hulls. However, you did not quote the American Petroleum Institute on this controversial subject. API's Task Force on Oil Spills, composed of senior executives of major U.S. petroleum companies, has concluded that: "Double bottoms may prevent minor pollution in vessel groundings, but probably increase the risk of major pollution in large vessel incidents. When the double bottom of a tanker is pierced, the vessel will sink deeper into the water because of flooding of the empty double bottom hulls."

V. KENNETH LEONARD
TRANSPORTATION DIRECTOR
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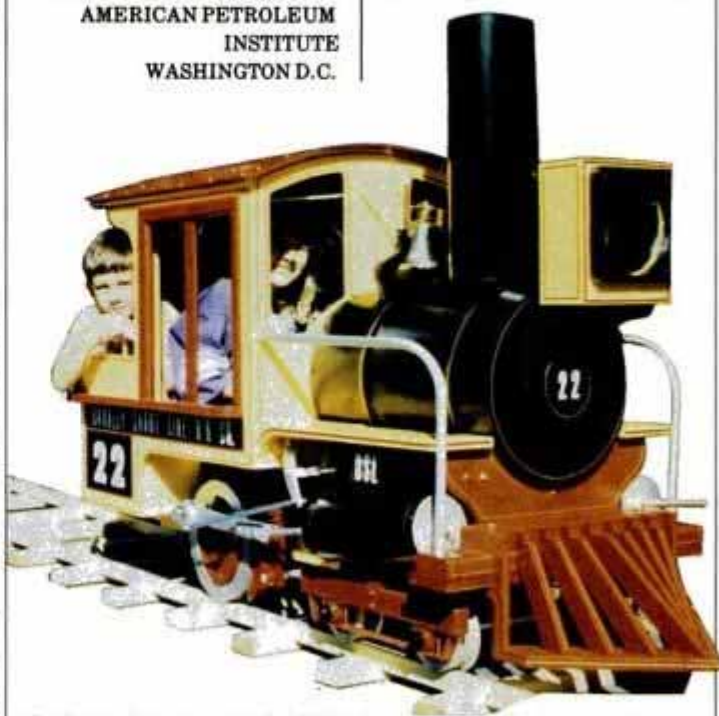
Golden Oldies

I see that I'm not the only PM reader who holds onto vintage issues. In your "Letters" column in December (page 8), you showed the Sidewalk Classic built by Michael Irene Sr., who looked back and found the project in the Nov. '63 issue. Well, soon after, in the August '65 PM (page 118), you featured an old-time steam engine, with the complete plans shown in the magazine. This was my choice to build for my grandchildren and I completed the project last summer. I followed the plans, but changed the colors, since here in the West we tend to favor Union Pacific yellow.

RAY BARKLEY
KAYSVILLE, UT

Readers who may not have held onto the train project issue (or weren't born yet), can get a photocopy of the story for \$5 from POPULAR MECHANICS, P.O. Box 1014, Radio City Station, New York, NY 10101.

PM



Car batteries are power for PM train project built by Ray Barkley.

LESABRE

American quality has never looked better.

Its styling is newly refined. Its value is legendary. This is the 1990 edition of the full-size Buick LeSabre.

According to one measure—the J.D. Power and Associates 1989 Initial Quality Survey—Buick ranks among the most trouble-free American brands. And that same study ranked the 1989 Buick LeSabre as the most trouble-free American car.*

In addition to giving you less to worry about, the 1990 LeSabre offers you more to enjoy. Including a standard 165-horsepower 3800 engine for smooth, confident power.

Spaciousness for six passengers. Four-wheel independent DynaRide suspension. Even air conditioning is standard.

The 1990 LeSabre: an outstanding automobile, because it offers you outstanding quality. See it now at your Buick dealer.

For more information call 1-800-441-5372.



The Great American Road belongs to

BUICK

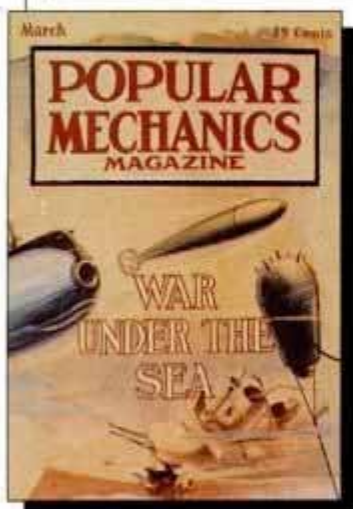


© 1989 GM Corp. All rights reserved. LeSabre is a registered trademark of General Motors Corporation. *J.D. Power and Associates 1989 Initial Quality Survey covering November and December, 1988, based on owner-reported problems during the first 90 days of ownership.



TIME MACHINE

75 YEARS AGO: MARCH 1915



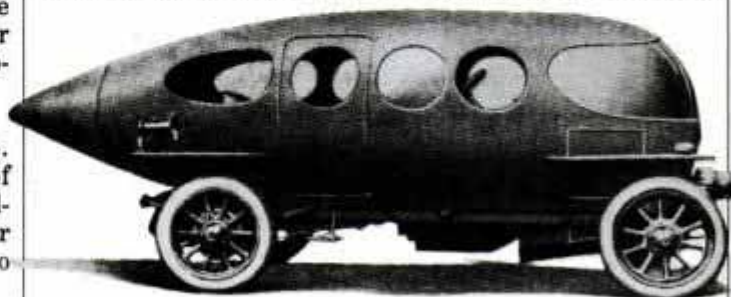
Deep Threat

Merely a curiosity a few years earlier, submarines took a more lethal shape in wartime. In one stunning hour, a lone German sub destroyed three British armored cruisers, sending the world's navies scrambling for new tactics. Behind the upheaval were subs with the range and seaworthiness to hunt far out to sea alone. Some predicted the end of military surface ships, but already the desperation of war was hatching ways to counter the new scourge.

Early Aerostyle

Before wind tunnels, form sometimes had a hard time following function, and aerodynamics was more or less a hit-or-miss proposition. Some rudimentary princi-

ples were beginning to emerge, however. The addition of a teardrop-shaped shell, for example, was found to raise the top speed of the car below from 50 mph to 80 mph, without other changes.



50 YEARS AGO: MARCH 1940



Day Of The Destroyer

As if in answer to the cover story of 25 years before, the article leading off our March 1940 issue began: "Days of easy hunting are over for the submarine." What followed was an in-depth treatment of the convoy system for protecting shipping, and of the destroyers that enacted it. With their shallow draft and their high top speed, destroyers could dodge torpedoes, and then hunt down submarines with depth charges.

Preview Of The Moon

A 38-ft. concrete replica of Earth's only natural satellite drew crowds to the new Griffith Observatory in Los Angeles. Simulating the view from a future spacecraft, the display was based on photos taken from the 100-in. telescope at Mount Wilson. A sculptor, astronomer and architect collaborated on the project, which incorporated some 650 known features of the lunar surface. Visitors looked down on the completed model from a windowed

gallery, while a light on a circular track above mimicked gradations of the lunar day.



25 YEARS AGO: MARCH 1965



Water Rocket

With spring around the corner, we offered up a project to make the days go quicker and brighten summer's promise. Our tiny 3-point hydroplane boasted the same setup as the machines that held all the major water speed records, but it could be built in the corner of a garage for \$25. Weighing 74 pounds, it fit easily into a station wagon. And a 14-hp outboard was all that was needed to propel the diminutive water skimmer at 33 mph.

The Peaceful Atom

Radiation's mysterious power to transform materials was the subject of an enthusiastic compendium titled "The Wonderful World Of Irradiated Miracles." Heat-shrink

plastics and wood composites were among the wonders radiation could produce. The portable food irradiator below is still a controversial part of radiation's promise. **FM**



Interplak cleans circles around your ordinary toothbrush.

The Interplak® Home Plaque Removal Instrument is one of the most important advances in home dental care since the invention of the toothbrush.

It doesn't look like an ordinary toothbrush. And it doesn't work like one.

After using the Interplak instrument just once, you'll be able to feel the difference immediately. Your mouth will seem fresher. Cleaner.

It cleans teeth nearly plaque-free.

Clinical studies show that manual brushing removes only some of the plaque that builds up daily on your teeth.

But those same studies show that the Interplak instrument cleans teeth nearly plaque-free and reduces gingivitis to improve the health of your gums. And the more plaque you remove, the more you reduce the risk of early gum disease and tooth decay.

Nothing fights plaque better.

Unlike manual and electric toothbrushes that only clean back and forth,



Interplak tufts clean plaque from between teeth and under the gums.

or up and down, our ten tufts of bristles rotate 4200 times a minute.

And they reverse

their direction 46 times a second to literally scour off plaque and stimulate your gums. When the tufts reverse direction, the bristles extend fully to clean deep between teeth and



under your gumline. And because the bristles are four times softer than the softest toothbrush, they're no more abrasive than manual brushing with toothpaste.

Ask your dentist about the benefits.

Dental professionals across the country have enthusiastically endorsed the Interplak instrument and they've recommended it to their patients. It's even accepted by the American Dental Association.

It's easy to use, cordless, and it recharges itself every time you place it in its stand. Plus you can buy color-coded, interchangeable brush heads for the whole family.

Ask your own dentist about the benefits. Or for more information and a retailer near you, call toll-free 1-800-334-4031. The Interplak Home Plaque Removal Instrument from Bausch & Lomb.

A new way of brushing your teeth, with extraordinary results.



INTERPLAK®
HOME PLAQUE REMOVAL INSTRUMENT

Interplak is Acceptable as an effective cleaning device for use as part of a program for good oral hygiene to supplement the regular professional care required for good oral health.
Council on Dental Materials, Instruments and Equipment, American Dental Association.



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You serve part-time, usually one weekend a month, plus two weeks a year. So you can continue your education and pick up some valuable lessons from us. The kind of education that comes from experience.

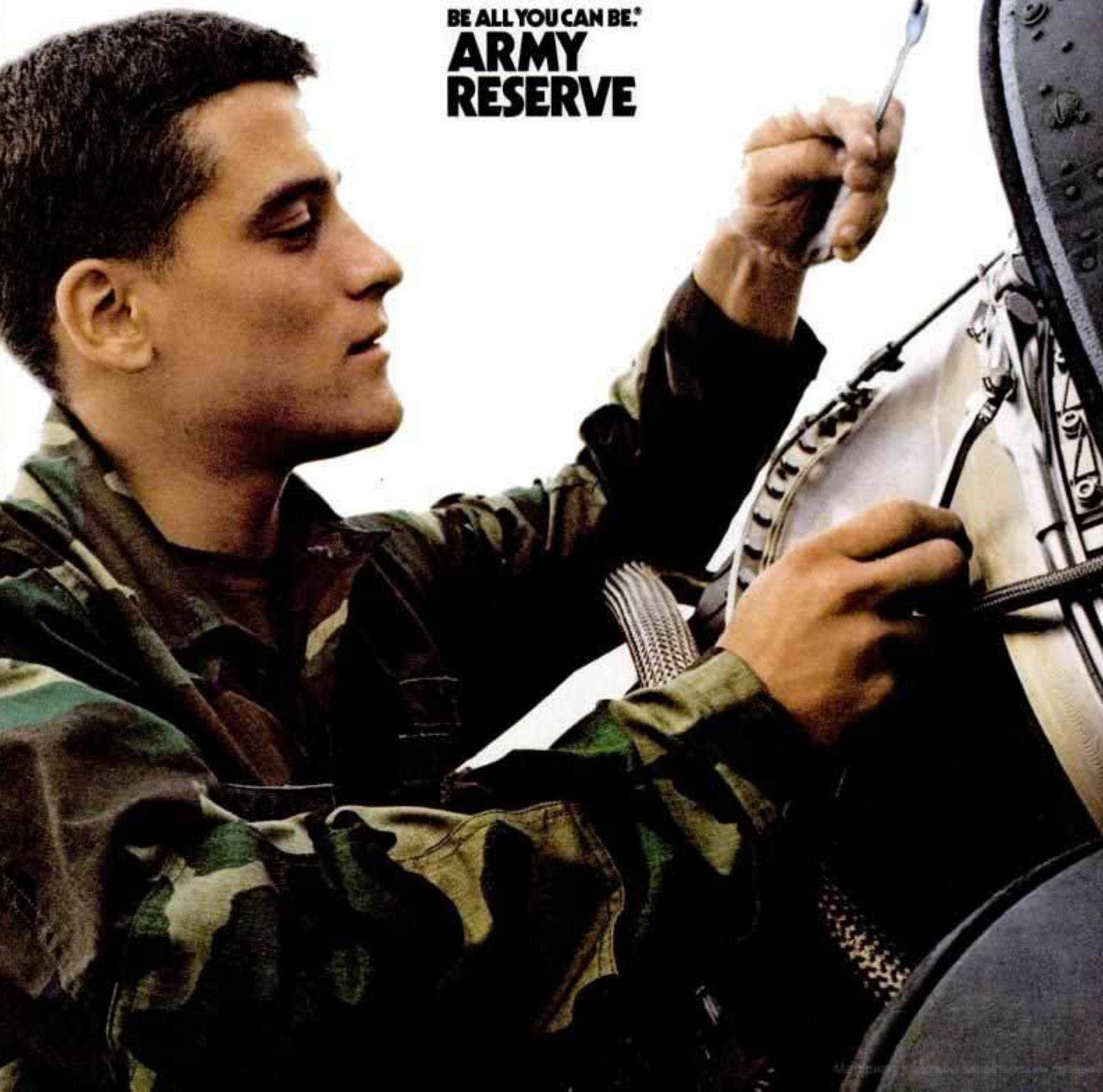
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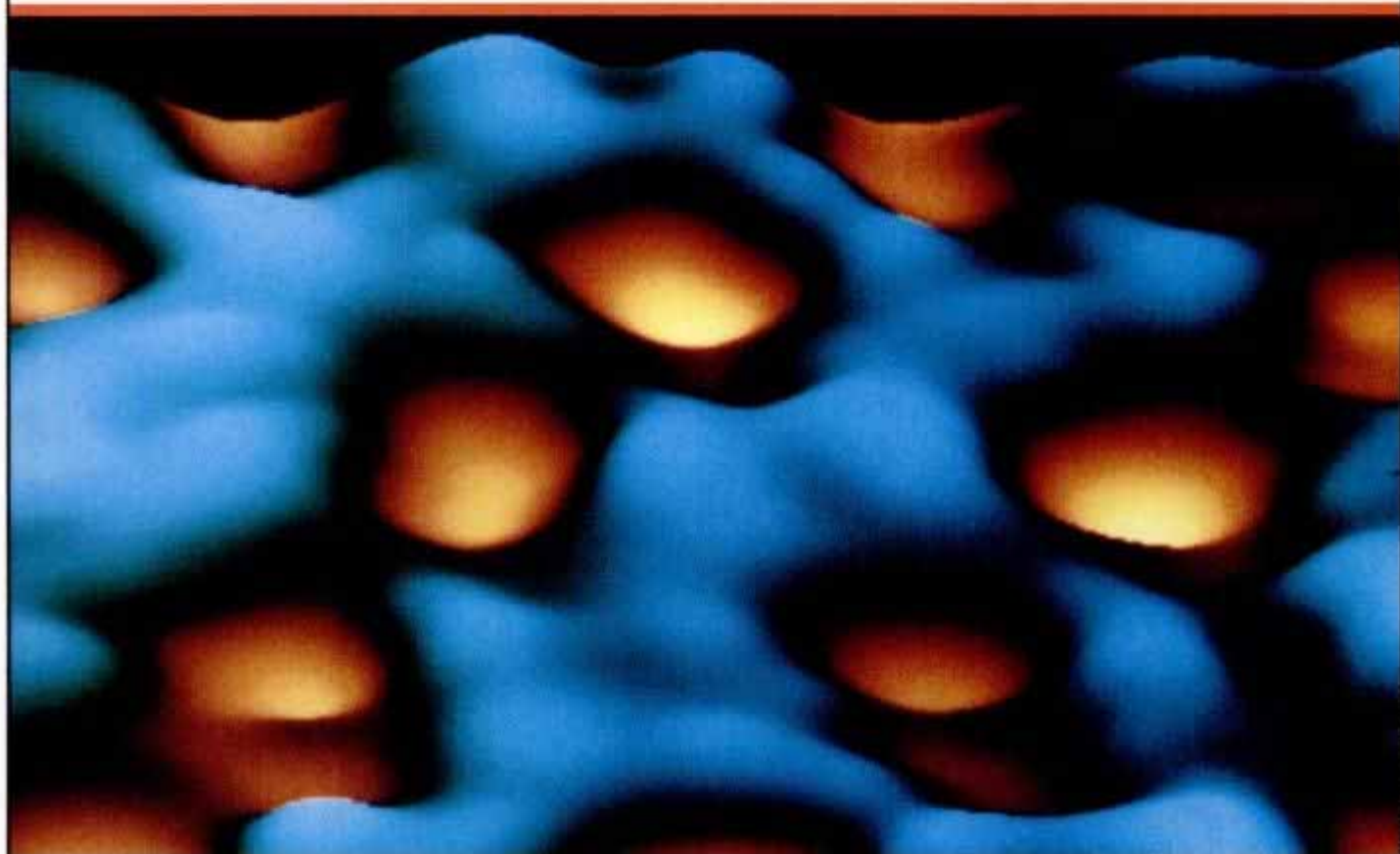
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TECH UPDATE

News Of Tomorrow's Technology Today



NATURE MICROGRAPH

Scanning Tunneling Microscope Reveals Code Of Life

ALBUQUERQUE, NM—For the first time ever, scientists have produced photographs of the individual chemical base pairs making up the rungs of the helical DNA ladder. These rungs contain the genetic instructions for every detail of every living thing on Earth.

Produced with a Scanning Tunneling Microscope (STM), the photographs bring scientists one step closer to a more efficient technique for determining the order of DNA base pairs. By speeding the ongoing effort to catalogue the entire human genetic code, such a technique will help explain causes of cancer and other genetically related diseases.

Invented in 1982, STM works by passing a current from an ultrafine probe to the

surface of the material being photographed. The size of the current depends upon the distance between the probe's tip and the specimen. The probe moves back and forth to keep this current at a constant level, and this movement is what provides details of the surface structure.

Until now, STM has been used mainly by physicists and electrical engineers to study surfaces of semiconductor crystals and other nonbiological materials. But the new DNA photos, produced by chemists at the University of New Mexico, show that STM can be a powerful tool for the study of proteins and other complex biomolecules.

Editor: Abe Dane
Contributors: Mike Fillon, David W. Freeman, John Rhea, Paul L. Ruben

Glowing orange areas in scanning tunneling micrograph reveal the placement of base pairs in DNA. Never before have these basic constituents of the genetic code been seen.

Highlights This Month

- **Stealth News**—Latest photos and Pentagon reports of new F-117A role.
- **Future Thrills**—New amusement park concepts foreshadow a hair-raising tomorrow.
- **Army Firepower**—A new crop of high-tech assault rifles takes on the venerable M-16.
- **Aviation First**—Persistence pays off for student builders of human-powered helicopter.
- **Lifesavers In Space**—NASA seeks Space Station escape pods to avoid disaster in orbit.
- **High-Tech Juice Drive**—World's first 5-speed automatic transmission debuts in Japan.
- **Hypersonic Dogfighters**—Future Air Force missiles will use ultrafast air-breathing propulsion and bank-to-turn steering.

Stealth Comes Into Focus

TONAPAH, NV—As we go to press, the first trickle of what is expected to become a torrent of new information on the F-117A Stealth Fighter is just becoming available.

Civilians staking out Nellis Air Force Base here continue to take better and better photos as daytime training flights become more common. And the Pentagon has stated that the plane has car-



F-117A Stealth Fighter, shown here over Nevada with T-38 chase plane, may actually be intended for high-precision bombing missions, rather than air-to-air combat.

ried out a successful surgical strike against Gen. Manuel Noriega's forces in Panama.

The mission suggests that the craft may be intended for attack duty, rather than the air-to-air combat role envi-

sioned for the F-117A earlier.

The new photos reveal a number of details including an arresting hook, and what may be retractable radio antennas on the plane's underbelly. With broader

operations bringing the plane more and more into the public view, the Pentagon is expected to release more detailed information soon. Watch this space for word of further developments.

21st Century Fun

ATLANTA, GA—The amusement park industry gathered here at its annual convention late last year to view the thrills of tomorrow. One of the more radical concepts was a giant marble chute, with riders carried inside the marbles. A free-wheeling inner sphere keeps riders upright. Closer to reality, the Waikiki Wave has a free-pivoting, 48-person gondola suspended on rotating arms mounted on 50-ft. towers. Spun by two independent motors, the arms cause the gondola to undulate wildly and unpredictably. Dramamine, anyone?



Looking like some sinister outgrowth of an astronaut training program, the Waikiki Wave will shake, rattle and thrill future amusement park visitors, if developer Vekoma International has its way.

Army Rifle Trials Begin

FORT BENNING, GA—The Army has embarked on a 7-month testing program to see whether improved technology can produce a rifle twice as effective as the current M-16A2. PM was on hand for the first day of tests at the specially refitted

Bruckner Range here. With \$2.7 million worth of new computerized moving targets spread over rugged terrain at ranges between 25 and 600 meters, the Bruckner range is designed to duplicate a real battlefield as closely as possible.

In keeping with this idea, test subjects exercise vigorously before firing, and wear a strap-on heart monitor that reports back to scorekeeping computers. If targets are not hit within a few seconds, the sound of return fire blasts over loudspeakers above the firer, in an effort to keep him as jumpy as possible.

The four rifles, produced by Steyr Mannlicher, AAI, Colt Industries and Heckler and Koch, incorporate advances in ergonomics, projectile design and firing mechanisms. If, at the end of six months, any of the guns proves twice as effective as the baseline M-16, it may be fielded as early as 1995.



Steyr ACR prototype (above) fires flechettes in 3-round salvos. Sensors in arches next to pop-up target (right) trace paths of bullets that miss.



The All New Cub Cadet. Now There's Every Reason On Earth To Own One.

Innovation. It's what makes us what we are. Introducing the advanced new garden tractor of the '90's.

Just look at the remarkable features it offers you.

Tilt steering and a single-lever adjustable, cushioned seat provide comfort and convenience. A powerful, automotive battery improves starting and offers longer life. A large, 5 gallon capacity, saddle-style fuel tank keeps you cutting longer. Streamline hood and side panels are molded from dent-resistant, rustproof materials, for lasting beauty. Dual halogen headlamps increase visibility for dusk and night time operation.

And the extraordinary backlit dash panel has indicators that continuously monitor every vital operating condition.

Toughness. It's our hallmark—the heart of every Cub Cadet garden tractor.

Model 1862 starts with an 18 H.P. twin-cylinder Kohler engine. Transfer that power through the perfectly balanced drive shaft, into the hydrostatic transmission. Handle rough terrain with a cast iron front axle that offers improved stability and a 30% tighter turning radius.

Mount it all on a full-length, welded, twin-channel steel frame.

There's no doubt about it. It's a Cub Cadet.



Exhilaration. It's like a Sunday drive with the top down.

Experience the smoothness of the powerful twin engine. Touch the control of the hydraulic deck lift. Turn the wheel, and sense the fingertip power steering. Adjust the seat and tilt the wheel until you're perfectly comfortable. Flip on the

headlamps, and take your new model 1862 Garden Tractor for a spin. It's a kick! It's truly a tractor for all reasons.

Common Sense. When it's a Cub Cadet, it's backed by our network of over 1600 independent dealers. Our factory trained dealers sell, service, and stand behind every Cub Cadet tractor. And we stand behind them, with a 2-year limited residential and 1-year limited commercial warranty.

Innovative engineering, state-of-the-art technology and the quiet assurance of a dedicated Cub Cadet dealer.

It all adds up to make Cub Cadet garden tractors *the* sure bet.



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Tough Tractors, For Your Little Corner Of The World.

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CAL POLY/LOREL KEIRO SAKI PHOTO



Unofficial first flight of *Da Vinci III* was carried out in Cal Poly gymnasium. They flew again one month later before National Aeronautic Assn. witnesses to make the achievement official.

Man-Powered Helo Airborne

SAN LUIS OBISPO, CA—After eight years of work, students at Cal Poly have achieved the fine balance of light weight, strength and aerodynamic efficiency needed to get a human-powered helicopter off the ground. Now officially recognized by the National Aeronautic Assn., the flight lasted 6.8 seconds and took the spindly craft 7 in. into the air.

Named *Da Vinci III*, the copter is similar to ones used

in previous attempts by Cal Poly (See "Tech Update," page 15, May '88). A 100-ft. rotor is pulled around by propellers at each end. Pedaling spins the propellers by unwinding Kevlar thread from their shafts. The latest *Da Vinci* includes guy wires to limit rotor flexing.

Although still far short of the requirements, the Cal Poly group hopes eventually to claim the \$25,000 Igor I. Sikorsky prize.

Sound Analyzer Decodes Knee Damage

SAN ANTONIO, TX—Previously nothing more than a source of anxiety, the creaks and clicks of a bum knee may now be put to use in diagnosing the problem. With a computerized joint-recording system of his own design, University of Texas rheumatologist I. Jon Russel has begun to decode the language behind these unnerving sounds.

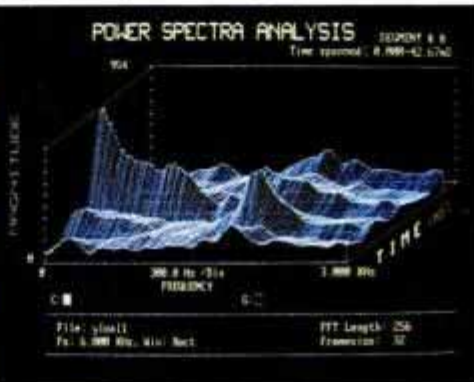
His technique, called acoustic arthrography,

involves a specially designed chair with a tension bar that precisely controls the speed and range of knee movement. Sounds picked up by a

sensitive microphone held near the knee are fed to a recording device and a small IBM computer. The computer produces a graphic read-

out of the knee's acoustic signature and compares it with a database of signatures linked to specific problems.

The technique will not replace conventional orthopedic procedures such as arthroscopy and surgery. Instead, acoustic arthrography is most likely to be used in screening candidates for these more invasive treatments to determine whether and how they should be used. Future modifications to the equipment should allow acoustic arthrography to be used on elbows, shoulders and hips, as well as knees.



Dr. Russel records knee sounds (left), producing graphic. Hilly terrain indicates osteoarthritic knee. Healthy knees are smoother.

UNIVERSITY OF TEXAS HEALTH SCIENCE CENTER PHOTO

Escape Pods For Space Station

NEW YORK, NY—Consistent with the renewed imperative for fail-safe design

following the *Challenger* disaster, NASA is soliciting proposals for vehicles that

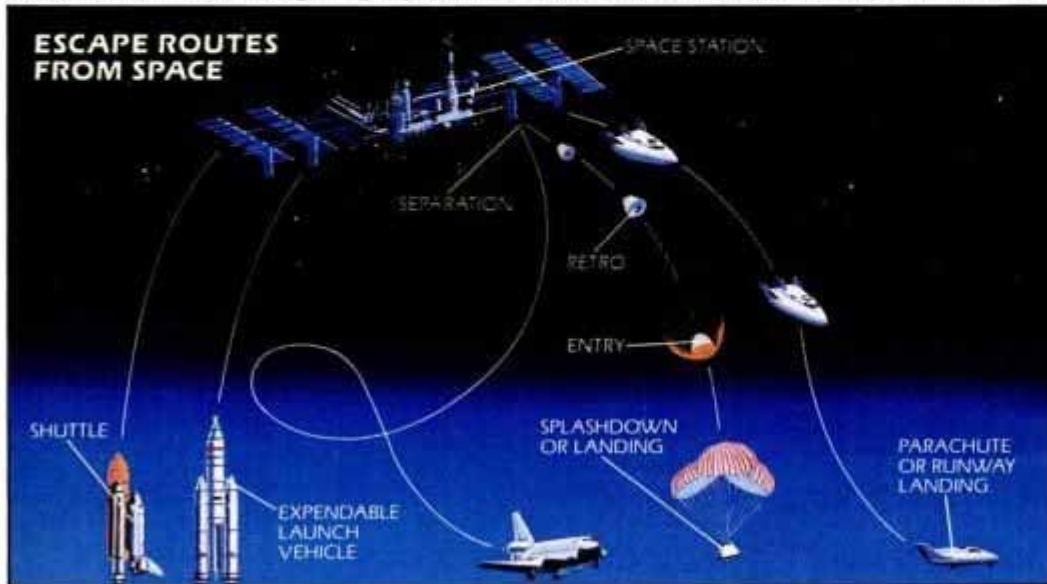
could evacuate Space Station *Freedom* in the event of an emergency.

The request for proposals calls for a craft that would be

moored at the Station, and would have the ability to get astronauts to a medical facility on Earth within 24 hours of a decision to launch. It would also have to have a lifespan of 30 years and require minimal maintenance. Because of stringent reliability requirements, the designs under consideration are based primarily on already proven technologies.

Situations where the vehicle might be called on include grounding of the Space Shuttle, which would leave *Freedom* without supplies, a catastrophic failure of Space Station systems, or a sick or injured crew member.

Crew-recovery vehicle would be carried to Station by expendable booster or Shuttle. Designs include winged gliders and ballistic capsules.



PM ILLUSTRATION BY ED VALIGURSKY

Better car care is easy,
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Sale ends March 10



COPPER PLUS SPARK PLUGS
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many U.S. cars and light trucks.
Sold in 4-, 6-, and 8-packs only.

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for your used one,

contico "WORKBOX"
TRUCK TOOL BOX

For full- or mid-size trucks. Durable polyethylene construction. Won't rust, dent, chip, peel or crack.

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RubberQueen

TRUCK BED MATS

Custom-fit rubber bed mats to fit many short- and long-bed trucks. Mfr. may vary.

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TAILGATE MAT
PROTECTOR...SALE 16.00



SALE

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For light-duty trucks.

Popular sizes for many pickups, vans, and RVs. Carry out. Installation available in stores with service.

TRUCK TONNEAU COVER

Vinyl truck bed cover protects cargo and enhances appearance. Velcro closure. Sizes to fit most popular short- or long-bed trucks.

EVERYDAY
LOW
PRICE

49⁹⁷



new truck or a fresh start
stop at Kmart.

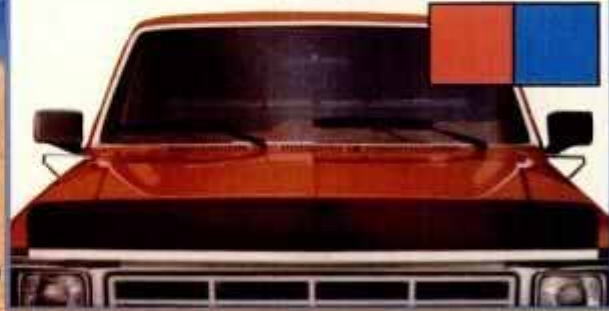


RubberQueen DEFLECTA-SHIELD

**BUG AND STONE
DEFLECTOR**

Smoke, red, blue, or clear bug deflector for many pickups and vans. With brackets. Mfr. may vary.

SALE
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**HALOGEN
TRUCK LIGHTS**

Rectangular amber or clear lights with wiring and switch.

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RubberQueen KENCO

**CUT-TO-FIT
RUNNING BOARDS**

68" extruded running boards for most pickups and vans. Style and mfr. may vary.

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96" RUNNING BOARDS...84.97

**DURANGO
TRUCK TIRE**

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8.75R16.5LT*	79.97
9.5R16.5LT*	88.97
31x10.50R15*	95.97

*Not available in all stores.
▲ Based on white letter.

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SONY.

ES-R11 AM/FM AUTO REVERSE CASSETTE

PLL quartz tuner, seek function, preset tuning (12 FM and 6 AM), and 6-watt output.

SALE

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SPARKOMATIC

SR38 AM/FM CASSETTE WITH EQUALIZER

Deluxe stereo with night illuminations, 5-band equalizer, and 4-way fader.

SALE

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SPARKOMATIC

9440 THREE-WAY SPEAKERS

120-watt peak power, 3/4" woofer, surface mount.

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Whistler

WHISTLER WH-425 RADAR DETECTOR

Low-level signal monitoring alert-to-pulse signals. Power on LED. City mode LED. X and K band monitoring. 6-segment LED array.



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ROAD ALERT 50 SECURITY SYSTEM

Ideal for car, van, RV or hotel. Activated by change in room pressure.

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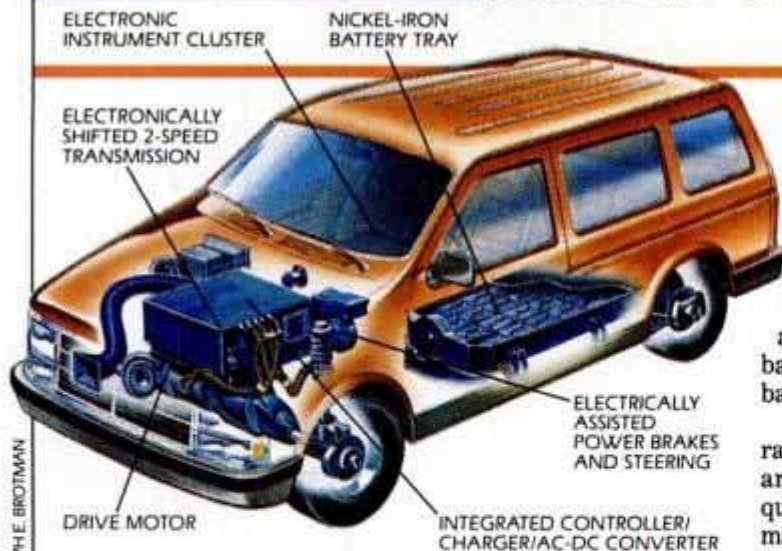
49⁹⁷



K mart Car Care Sale begins February 25 and ends March 10 at most K mart stores across the U.S.A.



Kmart
The Saving Place



Based on a Chrysler minivan, the TEVan is jacked up to accommodate a slide-out tray of nickel-iron batteries. The basic front-wheel-drive layout, suspension and brakes are retained.

power steering, optional air conditioning, 4-year battery life and an automatic battery watering system.

Although G-Van's 60-mile range and 52-mph top speed are modest, they are adequate to do the jobs of an estimated 40 percent of the vans in commercial fleets. The G-Van will be sold and serviced through GM dealers in the U.S. It is hoped that reduced fuel and maintenance costs will make up for the \$32,000 sticker price. More exciting from a technological standpoint was the minivan-based TEVan displayed at the same conference and scheduled for production in about three years. Using advanced nickel-iron batteries holding 30 percent more power per unit of weight, the vehicle has a 73-mph top speed and a range of 100 miles.



NASA vacuum chamber is used to simulate low-Earth-orbit environment on Freedom panels.

Panel Test

CLEVELAND, OH—Concerns that space plasma might short out the high-voltage solar panels on Space Station *Freedom* have been allayed by vacuum chamber tests at NASA's Lewis Research Facility. Inside the chamber, two arrays were exposed to a solar simulator and to a wide range of ion densities. Lockheed will use the data from the tests to arrive at an optimum final design for the panels.

Electric Van Enters Production

TEANECK, NJ—As a proof of its belief that the technology exists for commercially viable electric vehicle production, a partnership of automotive companies and electric utilities has unveiled an electric van that should be rolling off the assembly line this May. A more advanced variant, offering far superior performance and range, was also displayed, and is scheduled for production in about three years.

Called the G-Van, the first of the vehicles uses technology taken from the GM Grifon, a British design that has logged over 7 million miles in fleets around the world. Remarkable more for its practicality than for exotic technology, the G-Van will use a standard GM body and chassis, and an upgraded lead-acid battery system. It does, however, include some noteworthy technological flourishes, including electric

TV Camera Guides Mortar

HUNTSVILLE, AL—Fiberoptic smart weapon technology has now found its way into a mortar projectile that soldiers can fly to within 1½ ft. of a target by remote control. Now under development by Boeing, the Fiber Optic Mortar Projectile (FOMP) is fired from a standard 120-millimeter mortar. A 2-way fiberoptic data link unwinds from a bobbin on the back of the projectile-like line from a spin casting reel. Soldiers monitor the projectile's flight on a battlefield TV screen, and select a target. Then they order the mortar to deploy its wings and fire a small rocket motor. An automatic tracking system guides the projectile from that point until its high-explosive antitank warhead is delivered to the target.

The very high kill proba-



High-speed photograph shows FOMP projectile deploying control wings in flight tests. Illustration delineates path of shell from firing, to ignition of rocket for subcloud flyout, to terminal guidance toward selected target.

bility yielded by the FOMP approach contrasts sharply with conventional mortar firing techniques. These require soldiers to fire initial rounds according to rough estimates of the target's location, then home-in based on corrections radioed back from forward observers. Accuracy was seldom better than 100 yards, and moving targets were nearly impossi-

FOMP ATTACK SEQUENCE



ble to hit. In addition to the quantum leap in accuracy, the FOMP extends mortar range from about 2½ to 5 miles.

Expected applications include long-range engagement of massed enemy armor and infantry units. Strategists believe the need for enhanced capability in these areas will grow stronger as easing East/West tensions

lead to reductions in the NATO forces available in the event of war in Europe.

Scheduled to undergo flight tests throughout this year at White Sands Missile Range in New Mexico, the projectiles should be ready for production in 1991. Boeing expects the Army to buy at least 50,000 of the 3-ft., 35-pound, projectiles at \$20,000 apiece.



Engineer places sample of sine wave composite in screw jack testing machine to see how it would absorb energy in a crash.

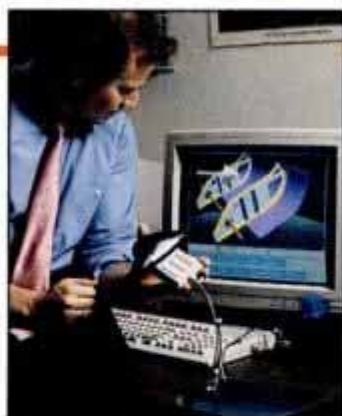
Crashproof Composites

ATLANTA, GA—Composite materials, already a boon to aircraft designers because of their light weight and high strength, may now be tailored to protect crew members in the event of a crash. To this end, engineers at Georgia Tech are studying how different-shaped samples of graphite epoxy com-

posite behave in a 60-ton press. In one series of experiments, the material was fashioned into a sine wave web, or corrugated, shape. Such a shape would normally fail suddenly, but by machining small flaws, known as failure initiators, into the samples, the engineers were able to make them deform gradually, reducing peak load. The corrugated shape easily incorporates into airframes.

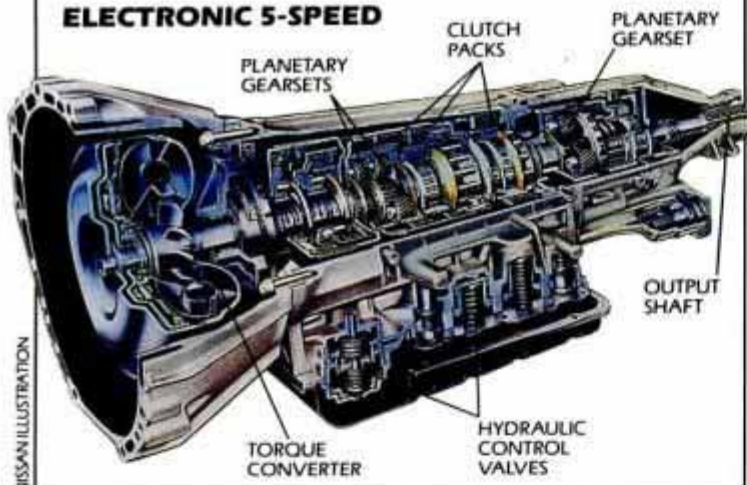
Building Planes On Computer

LOS ANGELES, CA—Northrop is evaluating a computer input device that enables designers to rehearse the assembly of aircraft before a single part is made. The tool is a refinement of an earlier concept called the Data Glove, which fit over the hand and controlled movements of a simulated hand on screen. The FlederMouse, as the new device is called, has similar abilities, but eliminates the need to don and precisely position the glove before use. A cursor follows the mouse's



Northrop designer uses FlederMouse to simulate the assembly of an aircraft wing on computer. movements and can be locked onto graphically represented parts. These can then be moved anywhere on screen. It may enable manufacturers to do without expensive engineering mockups.

ELECTRONIC 5-SPEED



5E-AT fits a third planetary gearset into tapered section leading to the drive shaft, producing a unit no bigger than earlier 4-speeds.

First 5-Speed Automatic

TOKYO, JAPAN—Automatic transmissions continue to shed their slush-box image with Nissan's introduction of the first juice drive with five forward gears. The electronically controlled unit fits into the same space as the company's earlier 4-speed E-AT, and has so far been installed only in Cedric and Gloria models sold in Japan.

Called the 5E-AT, the transmission was created by adding a third planetary gearset to the fourth gear of the E-AT. The additional gear allows Nissan to use a very low 3.857:1 first gear

ratio for quick acceleration. It also makes it possible to use a relatively high 3.90:1 final drive ratio for better mileage in overdrive.

Perhaps the most interesting feature of the transmission is an electronic learning control operating its internal clutches. To prevent variations in shift timing resulting from wear, the system monitors engine speed and adjusts clutch pressures to produce shift timing in accordance with histories stored in memory. Nissan has announced no plans to market the 5E-AT in the U.S.

Hypersonic Air-To-Air Missile

EGLIN AFB, FL—The Air Force is working on a lightweight air-to-air missile capable of hunting down targets at five times the speed of sound. Known as Have Dash II, the program is intended to develop technology for a new generation of dogfight missiles to be used on the Advanced Tactical Fighter, and possibly to replace the Advanced Medium Range Air-to-Air Missile (AM-RAAM) now being tested. Adapted from the classified Have Dash I intended for stealth aircraft, the new missile will have a composite

shell capable of withstanding the 900°-1200° temperatures produced by air friction at hypersonic speeds. Unlike present fin-steered missiles, Have Dash II will be asymmetrically shaped with a flat bottom that enables it to turn by banking.

Recoverable vehicles used in early testing will be powered by rocket motors, but eventually the missile will use an air-breathing propulsion system offering a better power-to-weight ratio, higher speeds and longer range. Flight testing will begin early in 1992.



Concept of Have Dash II hypersonic missile shows asymmetrical flat-bottom design that permits bank-to-turn steering.

225 horsepower at 4200 rpm. 300 ft. lbs. of torque at 3200 rpm. Gas-pressurized struts up front. Quadra-Shock system in the rear. And four patches of extra fat rubber on the pavement. Mustang GT. Grab onto the five-speed and make your move. It's a kick in the tranny.

Best-built American cars.

The best-built American cars are built by Ford. This is based on an average of

consumer-reported problems in a series of surveys of all Ford and competitive '81-'89 models designed and built in North America. At Ford, "Quality is Job 1."

All 1990 Mustangs are equipped with a driver air bag supplemental restraint system.

Ford Mustang GT

225 horses are bound to kick something.



Buckle up—together we can save lives.

Have you driven a Ford...lately?



FREEWHEELING

BY TONY SWAN, Automotive Editor



Chevy's New Aerocops

WE DON'T expect you to be happy about this, but it may be of interest to know that the next time you see those familiar red lights flashing in your rear-view mirror, chances are those lights will be mounted atop a Chevrolet Caprice.

And as we motor into the '90s, chances are also good that the Caprice beneath those lights will look much like the one shown here.

If we were odds-makers, we'd call this at least a 75-percent certainty, based on Chevy's impressive record in the cop car business. Although Ford has been getting more visibility with its Mustang pursuit cars, Chevy's Caprice is and has been America's police workhorse for well over a decade.

While the shape of Chevy's new full-size sedan—the first new Caprice since 1977—is certainly contemporary and compelling, the real reasons for police preference lie elsewhere. Cop car requirements include four doors, plenty of horsepower, a good-sized trunk—to accommodate emergency equipment—and plentiful interior volume, for radio gear, radar

units and, of course, the occasional rear seat passenger.

The old Caprice had all this, and the new one promises to deliver as well, a judgment based on a recent afternoon at Firebird International Raceway near Phoenix, Arizona. Chevy showed its new Caprice in cop clothing, a Camaro similarly attired—made to challenge Ford's Copstangs—plus a cop-spec Caprice powered by a Corvette engine.

As you'd expect, all three cars were set up with stiffer-than-stock suspensions. Other goodies in the cop car inventory include a heavy-duty generator, extra radiator capacity and extra battery capacity. Not to mention lights and an electronic siren capable of an incredible range of sounds.

Experimenting with the audible and visible reminders of authority tend to distract the driver from a vehicle's dynamic properties—that's right, it's *fun* playing cop for a day—but we eventually found time to concentrate on the cars' handling. The new Caprice is certainly more nimble than its stock counterpart, but it's



no sports car. It didn't take long to get into terminal understeer, and recovery in slalom maneuvers was sluggish.

The Camaro was a completely different story—taut, responsive and dead level in hard cornering. It was easy to get the rear end to kick out, and to steer with the throttle once oversteer was achieved. It reminded us of our Nelson Ledges-winning Mustang cop car of two years ago (see "Hot Pursuit," page 57, Nov. '88).

However, from the point of view of all-around police work, the Corvette-engined Caprice was clearly made up of the right stuff. The combination of performance suspension components and torquey Corvette power made the old Caprice fast and agile.

Chevy doesn't have this available in the new Caprice as yet, but it's coming.

ZR-1 Puzzle

Speaking of things relating to Corvettes, here's one you can assemble for yourself. It's a jigsaw version of the Corvette ZR-1 cutaway poster by our friend David Kimble, who is generally regarded as America's top technical illustrator.

You may recall the Corvette Indy poster that Kimble produced for PM a couple years back (Sept. '88, page 66), and you've probably seen other samples of his masterful work elsewhere.

The puzzle is poster-sized
(Please turn to page 22)



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FREEWHEELING

(Continued from page 20)

—15 in. × 21 in.—with 529 pieces, and is tough enough to challenge jigsaw mavens, as well as Corvette aficionados. It's available for \$19.95 through Cygnet Enterprises, 27 Upland Way, Verona, NJ 07044.

Autorock

Whatever its executives may think about contemporary music in private, Ford Motor Co.'s public position seems to be that rock and roll is here to stay.

Ford made this position clear with its recent \$250,000 contribution to the fledgling Rock 'n' Roll Hall of Fame, currently gestating in Cleveland, Ohio.

The contribution was based on the many commemorations of Ford products in tunes such as *Little Deuce Coupe*, *Mustang Sally*, *Hot Rod Lincoln*, *Little Cobra* and others.

The hall is budgeted for almost \$50 million, and reportedly has some \$40 million in hand. Construction is scheduled to begin this fall, with the opening due sometime in 1992.

No word yet on whether GM will similarly support the melodic immortalization of its products.

Accidental English

If you've ever filed an accident report, you will probably sympathize with the anonymous writers quoted below.

The quotes, excerpted from real traffic accident reports, were collected by Richard Lederer in his new book *Anguished English*.

The book (Doubleday Dell, \$5.95) is an anthology of misinformation and bloopers assembled from a variety of sources—student essays, newspapers, official reports of one kind and another—and is hilarious from end to end.

We offer a few of the choicer accident report morsels herewith.

- "Coming home, I drove into the wrong house and collided with a tree I didn't have."
- "In an attempt to kill a fly, I drove into a telephone pole."
- "I had been learning to drive with power steering. I turned the wheel to what I thought was enough and found myself in a different direction going the opposite way."
- "An invisible car came out of nowhere, struck my car and vanished."
- "I pulled away from the side of the road, glanced at my mother-in-law, and headed over the embankment."
- "The pedestrian ran for the pavement, but I got him."
- "I had been driving for about 40 years when I fell asleep at the wheel and had an accident."
- "I was on my way to the doctor with rear-end trouble when my universal joint gave way, causing me to have an accident."

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Escort	112.9	106.8
Cincinnati Microwave		
Passport	114.1	107.9
Clutra Trapshooter		
RD-3170	113.4	110.8
Falcom 15-0900		
Snooper D-4000	109.4	108.8
Kraco KR-16	102.7	104.7
Masco PH222	101.5	94.8
Maxxon RD-25	108.3	106.9
Radio Shack Microdot		
Road Patrol XX	107.6	106.0
Uniden PC60AL	113.1	108.8
Whisper Spectrum 2	115.9	110.4
Average unit	110.1	106.3

Source: Road & Track, Nov. 1990
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OLD HOUSE RESTORATION

BY BOB VILA, Contributing Editor



CEDAR SHAKE & SHINGLE BUREAU PHOTO

Wood Shakes And Shingles

THE CROWNING glory of an old-house restoration is a new roof of wood shakes or shingles. The standard roofing material of Colonial times continues to be used today in many parts of the country. Originally, the type of wood used was dependent on what was available locally. For example, red cedar was plentiful on the West Coast, swamp cedar in the mid-Atlantic states, white cedar in New England and cypress in the South. Today, you'll still find a variety of woods used to make wood shakes or shingles, such as red and white cedar, white pine and oak.

If it's installed and maintained properly, you can expect a wood roof to last a long time. Although 25 to 30 years is a good minimum, I've seen

some 70-year-old roofs that are still functioning properly. Understanding what's involved for installation and maintenance will go a long way in helping you decide if a wood shake or shingle roof is the right choice for you.

Ventilation is key

One of the secrets of a successful wood-roof application is adequate ventilation. Because of the nature of the product, air must be able to circulate underneath it to prevent moisture buildup and its resultant rot. Historically, an open-sheathed roofing system was used, which accomplished this objective very nicely.

Today, this is still the preferred method of installation. But keep in mind that the rough, uneven nature of shakes demands some extra protection. When installing shakes, the open sheathing should be interwoven with felt

paper so that the tips of the shakes are up underneath the felt. This provides extra protection from driving winds and rain, but still allows adequate ventilation at all times. The felt paper interweave is usually not necessary with shingles, since they lie flat. If an open-sheathed roof isn't a practical option for you, the shakes or shingles should be attached to horizontal furring strips that allow an inch or so of air to move between the bottom of the shingles or shakes and the plywood or solid sheathing.

Another important factor is allowing for the natural expansion of the wood. If space is not left for this and the shingles or shakes are butted up close together, you're likely to get a failure, or crack, in the nail line.

To ensure that enough space was left between each piece, some of the old timers used to soak shingles and install them when they were

A wood shake or shingle roof can add the finishing touch to any restoration roofing project.

wet and at their largest. (I don't recommend doing this today, though, since wet shingles are very slippery and hard to handle.) Usually, leaving approximately a ¼-in. space or keyway between each shingle (a bit more, about ½ in. should be left between shakes) is enough to allow for any movement.

How the shingles are actually fastened is also an important factor to success or failure. Ideally, a shingle should hang on its nails. The nailheads should be driven so they are just flush with the shingle surface. Don't dimple it or sink the nails in. If you do, you risk punching a hole which will allow the shingle to lift right off the roof. Two nails should be used per piece, placed about ¾ in. from each side, 1 in. above where the butt line for the next row will be. (Covering the nailheads like this helps prevent them from rusting and staining the roof surface.) The seams shouldn't line up for three courses, preventing water from wearing a channel or path in the roof.

In some cases where an existing wood roof has failed, the best solution is replacement. Sometimes if the pitch of the roof is not sufficiently steep, the life expectancy will be diminished. In any case, when reroofing, it is always best to strip existing shingles first.

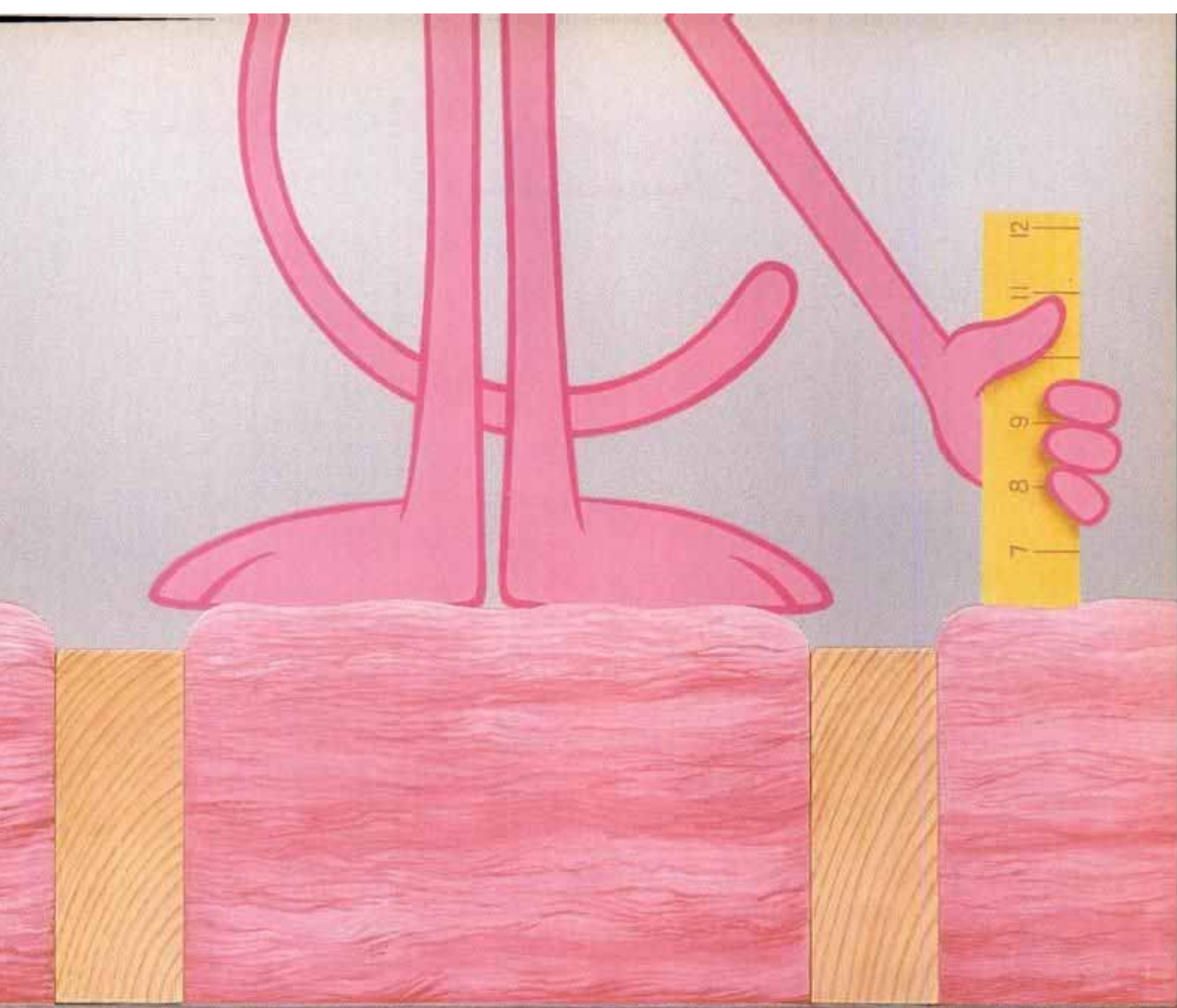
Also, always check local building codes before reroofing to see what requirements there might be in terms of products used.

Moisture is culprit

Going hand in hand with the proper installation of a wood shingled roof is its maintenance.

(Please turn to page 26)

Contributing Editor Bob Vila hosted public television's "This Old House" for 10 years.



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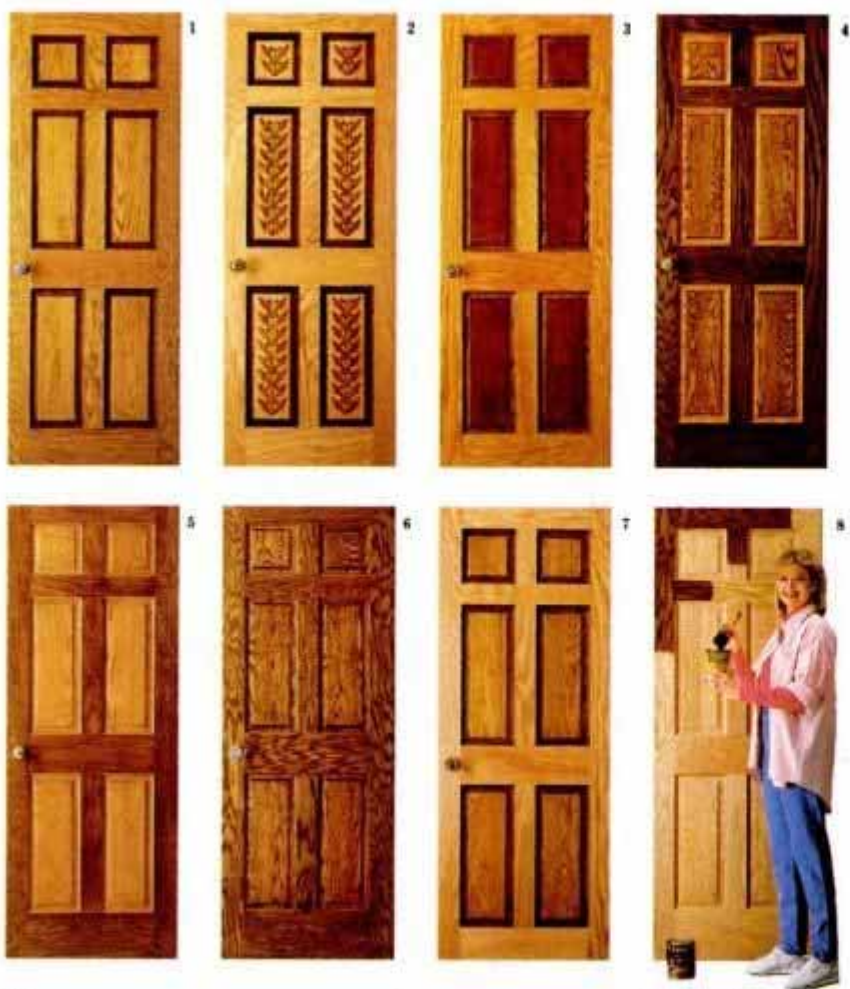
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OLD HOUSE RESTORATION

(Continued from page 24)

nance. Due to the nature of the material, the prime concern is preventing moisture from rotting the wood. Aside from making sure there is adequate ventilation for the wood to breathe, it's also important to keep the roof surface clean. Make sure no trees overshadow or rub against it. At least once a year the surface should be brushed free of debris, which accumulates moisture and holds it close to the wood.

Geography plays a major role in this moisture control. The more humid the cli-

mate, the more likely you are to have problems with moisture. To combat this, it's a good idea to treat the shingles with a clear wood preservative and fungicide—applied with a garden sprayer—every two to five years. Make sure the product you choose does not seal the wood—this will ultimately destroy the roof by trapping moisture inside the shingles. Remember, your ultimate goal is to keep the wood breathing.

If you live in a dry and arid climate, choose an oil-based product to help replenish what's lost to the weather. No matter where you live, be careful not to use an organic oil, like linseed. Although

these oils go into the wood beautifully, they attract fungus which, of course, can ultimately destroy the wood.

You can buy CCA pressure-treated shingles today. If you live in an area where you get lots of hot, humid weather, they are an excellent idea. Fire-retardant shingles are also available. Check with your local building inspector to see if they are required where you live.

Repair and replacement

Occasionally, it's necessary to replace a defective or badly cracked shingle or shake. It's fairly easy to do. First, finish cracking the shingle and remove the broken pieces. Then, carefully reach up under the row and cut off the nails with wire cutters or a hacksaw. Push up a new shingle that's the same size as the old (you may have to do some trimming) underneath the row until it's about 1/2 in. too long. Then carefully toenail the shingle in place by driving two nails—at a 45° angle—just below the butt line of the shingle course above. Set the nailheads, then drive the replacement shingle flush to its neighboring shingles using a wood block and hammer. This should move the nailheads underneath the course above.

If a shingle is sound but has cracked slightly, it's possible to *under shim* it with a piece of waterproof material (for example, 30-pound felt or galvanized metal) to prevent leakage. Simply cut a piece of this material larger (but shorter) than the shingle that's cracked and place it underneath it. The weight of the shingle will hold the repair material in place.

Finding replacement shakes and shingles shouldn't be difficult. A home improvement center normally will carry a variety of wood shingles, but plan on buying a bundle—no one will sell you just three or four. If you're having trouble finding a match for a specialty or restoration-type shingle, the folks at the Cedar Shake and Shingle Bureau [515 116th Ave. N.E., Suite 275, Bellevue, WA 98004, (206) 453-1323] should be able to help you find what you're looking for.

If you decide to add a new wood roof and are having the work professionally done, make sure the roofers you hire have worked with these materials before. Many times, you'll find it's the older carpenters who have the experience installing these systems.

Also, there are some good publications available to guide you through this project. The Cedar Shake and Shingle Bureau's "Design And Application Manual For New Roof Construction" is available from the above address for \$1. "How To More Than Double The Life Of Your Roof, Care And Preservation Of Your Cedar Shake Or Shingle Roof" is available for \$5 from the Cedar Guild, P.O. Box 249, Lyons, OR 97358, (503) 897-2541. (The Cedar Guild welcomes questions about all cedar products.) **PM**

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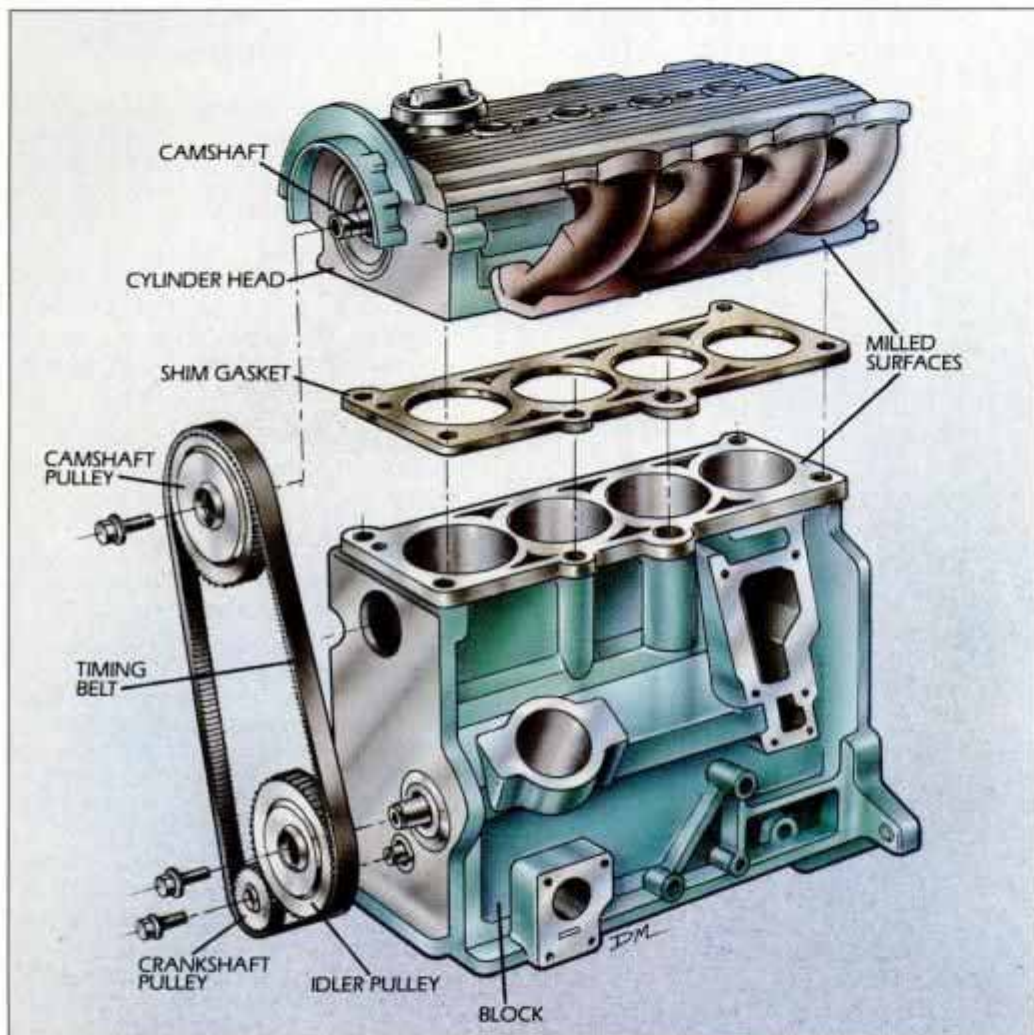
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CAR CLINIC

BY MIKE ALLEN, Assistant Auto Editor



PM ILLUSTRATION BY DON MANNES

Timing Is Everything

I BLEW THE head gasket in my VW Rabbit. No big deal, the motor had plenty of mileage on it. The head was warped pretty badly, and by the time the block and head were milled straight, the total removed metal was way over VW's recommendation. I knew this could increase compression and I'd have to use super premium gas, but the dealer says I'll still have problems. I've done this before on big V8s, with no problem.

ALLEN MICHAELS
ONTARIO, CA

Pushrod engines have their camshafts in the block, not

the head. Changing the compression ratio is no big deal. But overhead-cam engines have a chain, or in the case of your VW, a rubber timing belt indexing and driving the camshaft from the crank.

So? Changing the center-to-center distance between the crank and cam also changes the cam timing, which will have a considerable effect on engine performance. Your VW won't have any problem with valve/piston clearance regardless of how wrong the valve timing is (although this is not true of other ohc engines—if you're tinkering with some other en-

gine, beware). But performance may not be what you expected, especially if you expected the extra compression to perk things up.

The VW engine can't really stand a lot of extra compression with the standard fuel-injection setup—you'll have detonation problems. See if you can scrounge up a shim gasket—a head gasket that's thicker than the stocker. Depending on the design, it'll be either an asbestos/steel sandwich like the original, or a sheet of soft copper. Try to find one thick enough to restore the original relationship between the head and block.

You're treading on thin ice here—you'll probably be able

to make it work, but find a machinist or engine builder who understands what he's doing, as there are some other subtleties. For instance, retarding the cam timing a tad—3° for a start—will increase top-end power, while advancing it the same amount will fatten up the bottom end. You can use offset Woodruff keys or a slotted cam sprocket to move timing around to your taste, but get the basic timing right first.

Stick 'Em Up

The cloth headliner in my 1982 car is separating from the insulation in spots. Is there any type of adhesive that I can spray into these areas to reattach it?

LOUIS B. VERGEZ
GRETNA, LA

Go down to your local auto parts store, one that caters to the body shops in town. The counterman will be able to show you several 3M products—spray, brush or squeeze-tube—intended for attaching interior trim and headliners.

If the bulge is spreading from the edges of the panel, remove the trim in the affected area. Pull the bulged area apart, and spray the adhesive in evenly. Give it a minute to tack, and smooth the bulge out from the center to the edge. Replace the trim.

If the bulge is in the center, and if it's close to the edge, pull the headliner apart until it does go to the edge, and proceed as above. If not, you have a couple of options.

Cut the liner with a razor blade, and spray the adhesive into the slice. This works better with vinyls, especially if you can hide the cut in the pattern.

Fix small bulges in fabric liners by poking a pointed
(Please turn to page 30)

The smartest call you can make in spark plugs is NGK. At least, that's been the thinking for some time at



Nissan, Rolls-Royce, Saab, Honda and now BMW. In fact, a majority of auto-makers worldwide.

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for their street and racing requirements.



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CAR CLINIC (Continued from page 28)

stick through the weave until the hole is big enough for the nose of a squeeze-tube of adhesive. Apply the adhesive sparingly in a circle around the hole, and squeeze the adhesive away from the hole with your fingers. When it has dried, use a stiff brush to rearrange the fibers and close up the hole.

Clean up overspray and all the goo on your fingers with lacquer thinner.

Toxic Avenger

Some camping friends of mine asked me how to prevent their pressurized water system from freezing. I didn't stress the fact that they must use a special non-toxic RV antifreeze, so they used ordinary automotive antifreeze. Is there any way the system can be made safe for drinking water, or do all the lines and the tank have to be replaced?

DARYL BOOTS
WEST POINT, NE

The ethylene glycol used in antifreeze is mildly toxic. In fact, I recall a scandal a few years back when a winery in Germany was adding it to its product to improve the taste. So, small concentrations of it shouldn't be a problem.

Drain the tank into a bucket. Always dispose of used antifreeze in an environmentally responsible manner. After you've gotten out all you can, park the trailer where the few ounces left won't kill the lawn or be lapped up by the fam-

ily dog. Connect the garden hose to the tank inlet and flush for a half-hour or so.

Replace the drain plug. Leave the faucet(s) on, and continue to flush for a few more hours. Cycle the flush valve on the toilet a few times every hour or so. Turn off the faucets and fill the system. Repeat this process in a day or two.

If there's no characteristic sweet taste left to the water after this, you're okay. But next year, use the correct chemicals.

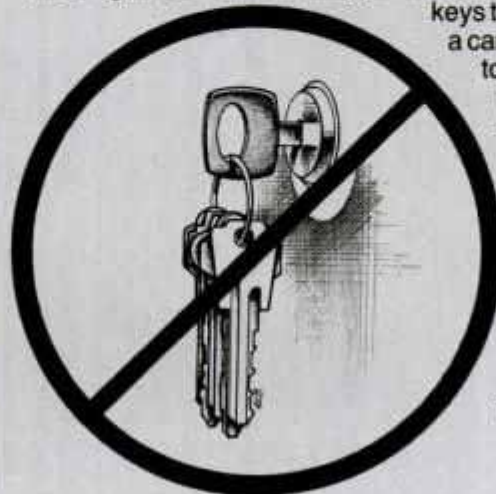
Timing Is Everything, Part II

I replaced the distributor on my Chevy because the bushings were worn out. I

Lighten Up!

Reader Al Kamishlan, a locksmith, sent in this tip: "Tell your readers not to use a key ring with more than a few keys on it in the ignition of their cars. Some lock mechanisms are pretty fragile, and the cylinders can actually pull out. Besides, the extra weight will wear out the lock mechanism prematurely."

He's right. So I immediately picked up my own car keys and removed: two keys to a house I no longer own, a key to a car that I have up on blocks, the keys to the PM motorhome (which we returned to Winnebago months ago), two small ornamental brass medallions and a Swiss Army knife. No wonder I've had to replace the lock on my pickup twice.



Al also cautions people not to use bent or severely worn keys, as they also are pretty hard on the lock mechanism. Guess I'll have to stop using those keys as screwdrivers.



PM ILLUSTRATION BY ADOLPHE BROTMANN

...OR NOT?"



WHEN YOU JUST CAN'T WAIT TO GET STARTED.

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was sure that the No. 1 cylinder piston was at top dead center when I reinstalled the distributor, and the distributor rotor was pointed right at the contact for No. 1 cylinder as I slipped it in. Checking the timing with the engine cranking shows the spark is coming at the correct time—but the darned thing just backfires and spits at me!

What did I do wrong?

JIM 169

(From the PM Hotlines electronic bulletin board)

The distributor rotates once for every time the crank rotates twice—so the crank will show TDC two different times, once for TDC on the compression stroke—which shows where it's supposed to be when the plug fires—and once at TDC on the exhaust stroke—which is where you've set the distributor for the plug to fire.

Rotate the crank until it shows TDC. Remove the distributor clamp, and the cap. Pull the distributor out until the gear clears without turning the body of the distributor. Rotate the shaft 180°, push the distributor back down and clamp it.

The Ties That Bind

I replaced the brake shoes on my Cavalier, and, less than 8000 miles later, the outer pads are almost completely worn, with the inner pads showing little wear. The original shoes went 20,000 miles

with no evidence of this uneven wear.

Both wheels had the identical problem, and I can't find any information that will tell me what I did wrong.

RAYMOND OSTROWSKI
PHILADELPHIA, PA

Your Cavalier uses a single-piston caliper that requires the caliper itself to be free to slide back and forth a few thousandths of an inch every time the brakes are applied. A lot of vehicles use this system, and your problem is a common one.

The bolts that the single-piston caliper slides on must be free and clear of corrosion, or the pads won't return after the brakes are released. The constant friction wears them out. Sometimes, the opposite problem occurs—the caliper won't move at all, and the inner pad does all the work.

Whenever you replace the pads, or, more often if necessary, disassemble the sliding caliper, wirebrush the appropriate areas, replace any hardware that's corroded, lubricate with lithium grease or antiseize compound and reassemble.

I recommend replacing the pins every time you replace the pads. Be sure not to get any grease or greasy fingerprints on the pads or disc surface. **PM**

DO YOU HAVE A CAR PROBLEM?

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

SERVICE TIPS

■ Improved cold driveability on '89 Celica All-Tracs results from a revised ECU, which entered production in October 1988. These ECUs (PN 89661-20361) may also be used on 1988 All-Tracs and should be returned to Toyota for remanufacturing. TSB 003

■ LeSabres, Electras and Rivieras with the 3.8-liter engine may show an intermittent SERVICE ENGINE SOON light, accompanied by a stored code 44 or 48, even though engine operation is within normal limits. Water splashing onto the O₂ sensor lowers the temperature, and the new chip allows the sensor temp to be out of the specified temperature range for a longer time before setting a code. According to TSB 88-6E-8, a revised Mem-Cal chip will prevent the light from coming on until there is an actual problem.

■ Using Nissan's abrasive-coated brake pads may make it unnecessary to machine brake rotors, as the abrasive coating will grind off irregularities within the first 500 miles of normal operation. TSB 82-094

■ Ford TSB 88-21-9 specifies that pipe sealant with Teflon be used when reinstalling flywheels on 4.9L light truck engines. The shop manual doesn't specify what type of sealant should be used.

ELECTRONICS

BY FRANK VIZARD, Electronics Editor

Your Video Robot

CAMCORDER operation is getting simpler all the time. That's the only conclusion you can make after examining the new Canon H660 camcorder. Why? Because cumbersome manual operations have been automated, leaving you free to concentrate on moviemaking.

Here's the list of things you don't have to worry about anymore provided you own the Canon H660, its E640 sister unit or what's bound to come from imitators in the future.

■ **Framing**—The H660 uses an auto-framing circuit to maintain a constant image size as your subject moves toward or away from the camera. Let's say you want to keep an upper-body shot of the subject as it moves around a room. The H660 memorizes the desired subject size and automatically adjusts the focal length of the zoom lens as it tracks. The upper body of the subject stays in the frame no matter what its distance from the lens.

■ **Two-Subject Focusing**—Let's say two subjects are situated so that only one at a time can be in sharp focus. A focus memory records a specified focus setting for each subject and then recalls it at the touch of a button. This feature makes it easy to switch the focus smoothly between two subjects in the same frame.

■ **Quick Zooming**—A zoom memory feature makes it possible to automatically shift to a specific focal length at the push of a button. This means that you can prefocus to a spot where you expect action to occur, and put this focus setting into the memory so you can zoom there quickly when action occurs.

This capability is particularly useful at sporting events. For example, you might set the zoom to quick-focus on a slide at home plate. You'll use the quick-zoom feature in conjunction with the H660's Sports Finder. This is

a magnified viewfinder that lets you follow the action with your eye away from the eyecup. With this expanded field of view, you can anticipate when action will enter the H660's field of view, rather than be taken by surprise.

■ **Closeups**—Automatic focusing occurs as close as 1.9 ft. That's less than two camcorder lengths away (the H660 is about a foot long). Objects right against the lens can be focused manually.

The H660's effectiveness as a video maker is not solely due to the automation of functions that were manually controlled previously. The H660's microcomputer measures light conditions in 15 separate zones to assess overall conditions for proper exposure. This light evaluation system is combined with a 2-field auto metering system that detects backlighting or excessively bright spots. By compensating for these problems automatical-

ly, the H660 videotapes the subject without washouts or flaring.

The H660 also offers a few features that can lend a bit of style to your video productions. You can add written titles or illustrations simply by shooting the image and storing it in memory. The stored title or illustration may then be superimposed on your movie in normal or reverse video, in any of eight different colors. A range of 16 thresholds lets you use low- or high-density images as titles or special effects. You can also choose between opaque and see-through titles. The latter is a stencil-like effect that lets the background video show through the lettering. In addition, there's a character generator that lets you produce and superimpose two lines of 16 characters each.

Additional features are similar to those on other Canon camcorders. Most no-

table is the 180° rotating viewfinder that makes long shooting spells and odd-angle shots less strenuous than they might otherwise be. Also included is a wireless remote control that lets the videographer get into the production. The infrared remote has a range of up to 16 ft. Four high shutter speeds let you record fast action with a minimum of blurring.

All of these features make the Canon H660 an easy camcorder to use. Picture quality is generally excellent, thanks to the use of the superior Hi8 video format. In the Hi8 format, the luminance signal is expanded to increase horizontal resolution to about 400 lines. In addition, the frequency deviation range is increased for an improved signal-to-noise ratio that results in a smoother, more

(Please turn to page 37)



ELECTRONICS

(Continued from page 32)

natural tonal gradation.

The H660 did exhibit a noticeable tendency to change red-orange colors into pure oranges, however. Sunsets, for example, appeared on tape as mostly orange, although the eye recorded red as the dominant color. Similar results were noticed with red-orange bits of cloth. However, deep unmixed reds were recorded faithfully. Red is the most difficult color for video systems to reproduce accurately, and, as such, is a good barometer of a camcorder's capabilities.

The 3.3-pound H660 costs \$1949 and uses both Hi8 and standard 8mm videotape. Nearly identical to the H660 is the E640 (\$1749), which uses only standard 8mm videotape. The E640 does offer an 8x zoom lens while the H660 features a 6x zoom lens. Both use a 1/2-in. 360,000-pixel CCD image sensor and record for up to 2 hours in the standard mode.

Whither Nintendo?

While Sega and NEC have introduced advanced videogame systems that use 16-bit microprocessors, Nintendo has backed off from offering a 16-bit system. The company believes its current 8-bit technology still offers untapped possibilities, mostly on the nonvideogame front.

Gamesters should know that Nintendo is considering a phone link that would allow players to compete via modem in nationwide competitions. Nintendo also intends to acquire Archer Communications. Archer is the developer of QSound, a psycho-acoustic audio system that claims to be able to produce surround-sound effects from a standard stereo signal. Providing the acquisition takes place, surround sound could be the next big videogame feature.

Nintendo seems interested in more than just games. The company has inked a deal with Fidelity Investments, a Boston-based firm, to offer such financial aids as portfolio management, real-time trading of securities and other market information to the approximately 20 million owners of Nintendo's videogame systems. This information will be transmitted by telephone. A special modem and controller needed for the service will be marketed by Nintendo later this year for about \$200. Fidelity Investments will supply the required software. Nintendo's appeal lies in the fact that it now controls two-thirds of the videogame market in the U.S.

Nintendo also is having discussions with AT&T regarding the possible use of its videogame system as a foundation for the creation of shopping and travel services. Nintendo's game system already is being used in this manner in Japan. In the future, videogame systems may do more than simply entertain. **PM**

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while fat drippings drain through a tray shielded from heat for virtually smokeless cooking. The unique design keeps the stoneware cool enough to handle. Plus, clean-up is a cinch since all parts except the heating unit are dishwasher safe. Instruction booklet with recipes included. UL listed; 5-year limited warranty; made in the USA. **\$59.98** (\$7.00) #A1936.

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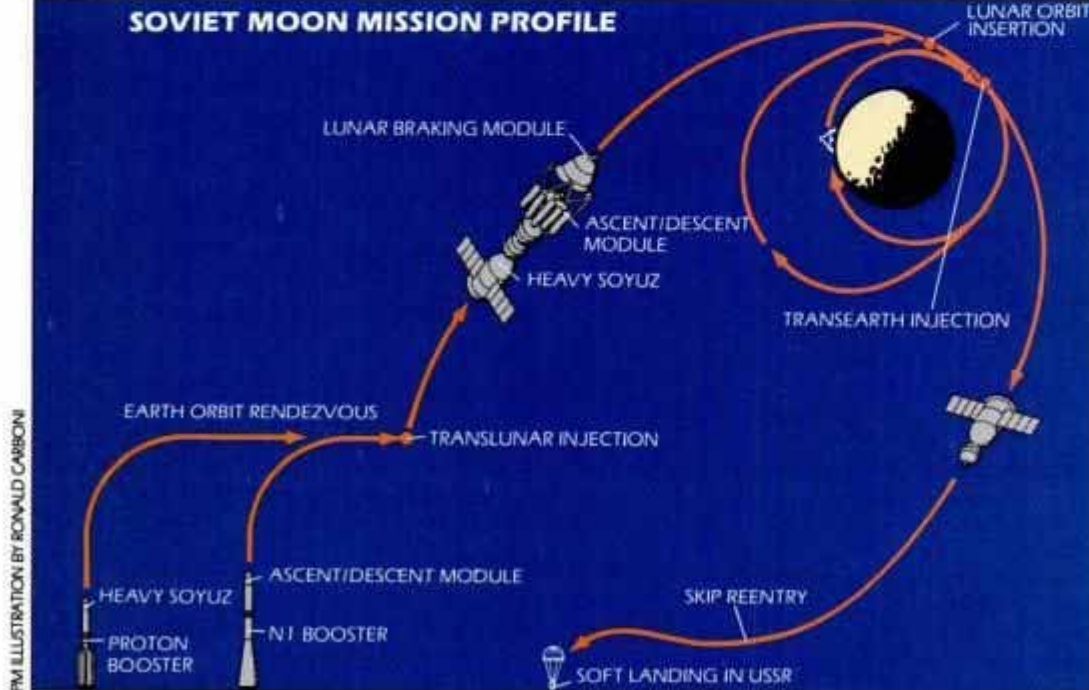
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SCIENCE

BY ABE DANE, Science/Technology Editor

SOVIET MOON MISSION PROFILE



PM ILLUSTRATION BY RONALD CARBONI

LOR profile sent one cosmonaut to the surface, while the other orbited above in Soyuz. Safe return depended on rendezvous of lander's ascent stage with Soyuz—suggesting Soviet guidance systems were highly sophisticated.

life support needed to carry the full crew all the way back to Earth. The engines and fuel necessary to break such a multipurpose vehicle free of lunar gravity for the return voyage would have exacted a substantial weight penalty for the outbound leg.

NASA seemed to stumble on the benefits of LOR almost by chance. Ultimately, LOR was chosen because it placed the emphasis on precision guidance systems, an area where the U.S. was strong, rather than on booster development, where the Russians had enjoyed an early lead. It thus seems serendipitous and puzzling that the Soviets should have chosen the same approach.

Divergent paths

In other respects, however, the two programs differed. Most obvious is the Soviet decision to use two separate rockets to boost the two cosmonauts and their lunar spacecraft into Earth orbit. This was necessitated by the fact that the Soviets didn't have a booster large and reliable enough to get men and equipment into orbit. The solution was to send the cosmonauts up first aboard the time-tested Proton booster, then have the rest of the gear catch up with them atop a new booster called the N1.

Another difference, and one relevant to a debate that still goes on today, is the Soviet's decision to automate most of the flying, leaving as little as possible to the Cosmonauts' discretion. Some have said that NASA's insis-

The Moon Mission That Wasn't

SELDOM IS history rewritten so abruptly. But with the remnants of the aborted Soviet-manned Moon program recently unearthed in a Moscow museum, there can be no doubt about it: There really was a race to the Moon, and NASA won. Critics who suggested that the Soviets were too practical to compete with what they saw as American technological grandstanding were wrong.

Although the Russians staunchly denied it, they too saw the importance of a Moon landing as a demonstration of worldwide technological leadership, and went all out to beat us to it.

As the wall of silence and disinformation that surrounded the massive Soviet effort crumbles, a rich trove of information is coming into view. It presents a fascinating instance of parallel technological evolution. Two countries chose the same goal, and then each bet all its

marbles on a different way of reaching it. Needless to say, they ended up in vastly different positions—leaving a legacy that remains represented in the space programs of each country to this day.

Discovered by a delegation of M.I.T. aerospace engineers touring the Moscow Aviation Institute last November, the completed Soviet lunar lander and return-to-Earth module finally clarifies a shifting cloud of evidence and speculation that has long surrounded the question of whether the Soviets really were trying to get to the Moon.

Soviet similarities

The Soviet approach is striking both for its similarities and for its differences next to *Apollo*. Like NASA, they settled on a lunar orbit rendezvous (LOR) as the most efficient way of reaching the Moon. The agreement here is especially noteworthy for the fact that it was not at all the

obvious approach to take.

LOR required bringing along a whole separate life-support system aboard a specialized lunar lander. The rendezvous itself was also exacting and risky. If the crew of the lander failed to link up with the orbiting mother ship for the ride home, they were out of luck.

The advantage was that you didn't have to actually land on the Moon with a craft that had the heat shields and



Soviet lunar craft was found by accident in Moscow museum.

M.I.T./PROF. JACK L. KERBER/PHOTO

tence on letting many aspects of the flight depend on the astronauts' piloting skills was based on romantic and outdated notions left over from aircraft. But as it turned out, the Russian approach was fraught with technological difficulty. Sergei Korolev, who headed the Soviet Moon effort, declared in frustration that manned flights would be only a tenth as difficult as the fully automated ones.

The showstopper

In the end, though, it was trouble with the giant N1 that undid the Soviets. James Oberg, an aerospace engineer and Soviet space expert who compiled some of the earliest and best evidence of the Soviets' lunar ambitions, has pieced together an account of the N1's development that jibes well with the latest information now trickling out of Russia.

Going all out to keep pace with NASA, the Soviets gambled on "all-up" testing of the whole rocket at once, rather than more cautious incremental testing of individual components. NASA took the same chance on *Saturn*, and it worked out, but for the Soviets it was a disaster—four out of four flights between 1969 and 1972 ended in failure, and the launch complex was destroyed by explosion twice. After limping along until 1974, the program was abandoned, displaced by Earth-orbit activities as the focus of Soviet space research.

A shocking discovery

The failure of the N1 was ironic not only because it represented a squandered lead in rocket design, but also because, as the recent M.I.T. trip discovered, the Soviets had completed a surprisingly advanced lunar landing and return craft by 1968. Thus, the Soviets tripped on what was not necessarily the highest technological hurdle. "I believed there was a Moon race," says Professor Laurence Young, a member of the recent M.I.T. delegation. "The shock to me was that they had completed the spacecraft."

Edward F. Crawley, another M.I.T. professor, says "The lunar landing craft bears a similarity to the Soyuz, but is distinguished by having both descent and ascent propulsion stages and four extendible landing legs."

Professor Young pointed to the lander's three gimbed and throttleable rocket motors, and what appeared to be a surface mapping radar as features that exhibited an unsuspected level of sophistication. Even so, it remains baffling how the Soviets planned to bring it in for a landing under the control of only one pilot. Even with two crewmen, landing the American lunar module was a tremendously taxing procedure.

However much of a marvel the Soviet lunar craft may be, it was useless without the N1. And indeed the lack of such a

heavy booster limited the whole Soviet space program. Although hailed by many as prudent and farsighted, the Soviet's decision to make Earth-orbiting space stations the focus of their manned program was actually not a decision at all. Without more powerful rockets, the Soviets were confined to Earth orbit.

The disappointment felt by the Soviet engineers who devoted so much effort and ingenuity to a spacecraft that not only never flew, but was never even acknowledged to exist is easy to imagine. Lev Kamanin, an aide to the Air Force committee in charge of the program, expressed it well in a journal entry quoted

in an obscure Soviet publication this summer: "Dec. 21, 1968—*Apollo 8* flies to the Moon. For us, the holiday is darkened with the realization of lost opportunities and with sadness that today the men flying to the Moon are named Frank Borman, James Lovell and William Anders, and not Valery Bykovsky, Pavel Popovich or Alexi Leonov." The poignancy of these words is only heightened by the new revelations about the advanced state reached by the Soviet lunar program, and by the realization that had things gone a little differently, the same feelings might very easily have been expressed by an American. **PM**



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DETROIT SPY REPORT

BY JIM DUNNE, Detroit Editor



Chevy's Ultimate Corvette

WHAT Corvette enthusiast wouldn't want a ragtop version of Chevy's 380-hp ZR-1 hyper Vette? The bow-tie boys say this hot little number doesn't fit into current production plans. But that could change depending on a strong demand from enthusiasts.

This one-off early prototype



1991 Pontiac Grand Prix

has been spotted prowling the streets of Detroit. A special DR-1 badge on the rear fascia signifies the sole member of the ZR-1 convertible driver's club—Don Runkle. Runkle is now GM vice president in charge of advanced vehicle development, and he proves the old axiom that rank has its privileges.

Runkle's roadster started its life as a standard L98 Corvette convertible that received the official ZR-1 treatment—LT-5 engine,

special body panels and other details.

1991 Grand Prix

It's facelift time for Pontiac's Grand Prix line. The sheet-metal surgery will take place on the 1991 lineup even though the model isn't that old, having been introduced two years ago as an '89.

The Prix will continue the strong Pontiac family resemblance with the traditional split grille. The headlight area will get a revised look with even more emphasis on the cat's eye shape. The headlights themselves will be smaller in size and there will be three set into each housing per side.

The total effect will be a more aggressive front end, well suited to Pontiac's continuing "excitement" advertising theme.

Lumina Goes Turbo

It's turbocharging versus supercharging as Chevrolet unleashes a turbo Lumina SS to do battle against Ford's supercharged Thunderbird in the \$25,000 class. Motivated by the same 205-horsepower, 3.1-liter, intercooled turbo V6 that resides in the engine bay of Pontiac's Turbo Grand Prix, the Lumina SS has a tough-looking stance with fat 50-aspect ratio, 16-in. tires. The suspension also will be refined to handle the boosted power output. The choice of transmissions will be limited to GM's 4-speed automatic, at least for the '91 model. Chevy Caprice: Flagship gets first styling change in 14 years.

Staying Power

How did Chevy get away with cranking out the same old Chevy Caprice look from 1977

to 1989 for its full-size flagship sedan in an industry where styling changes cycle in at an average of 4- to 6-year intervals to keep buyers interested? True, there was a minor facelift in '81, but it was minor indeed. In the same period, Chevrolet brought out three freshly styled intermediate-sized cars—Malibu, Celebrity and Lumina. But the Caprice, instead of lying down and dying for lack of interest, continued to show strength on the sales charts. Its secret? Staying power by virtue of its traditional American size, performance and value for the money—a basic market principle that Chevy planners apparently forgot on some of their other car lines. And now—the electronic muffler. The folks at Walker are hard at work on an electronic muffler for cars. We first reported on this in our June '89 issue ("Tech Update," page 13). The unique device works by counteracting the exhaust rumble of the engine, and it does it without baffles, resonators or packing materials. The system uses a couple of electronic sound generators and speakers. As the engine produces exhaust noise, the sound generators set up a similar sound through the speakers that is completely out of

(Please turn to page 42)



Chevy's Lumina gets a turbo V6 and a bulging hood to house it.

Quality is Job 1.



Profile in quality #10: Engineering.

Shown here is the 3.8 Liter Supercharged engine. It represents sophisticated high performance engineering. The Supercharged engine, available in the Ford Thunderbird Super Coupe and Mercury Cougar XR-7, is one example of Ford's constant exploration and development of new technologies. When quality is job 1—you don't do it any other way.

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its flagship, the Allanté, with features that are on the cutting edge of safety technology. But no amount of hardware will ever be a match for bad driving conditions combined with bad drivers. Two automotive writers found that out the hard way when Cadillac let them loose on snowy roads in northern Michigan to be impressed with the car's highly advanced antilock braking and antispin traction control systems (see page 69 in this issue for "True Grip," which describes the Allanté traction control system). They were impressed, all right, but not the way Cadillac had in mind.

In the first incident, the journalist lost control, slid through an icy corner and plowed into a snowbank. No one was hurt, but the Caddy's front end came away a bit rearranged with part of the fascia and air dam bashed in. The second incident was even more spectacular. Here, the driver ignored an icy patch, skidded through a turn, ran off the road and had a close encounter with a tree, head-on. Again, there was no injury as the driver's side airbag inflated. But the entire front end was wiped out. We won't mention the bruised egos or the explaining to the Cadillac PR department. The lesson is obvious. It's not nice to try and trick Mother Nature, no matter how advanced your technology.

Wild In The Streets

Viper, Chrysler's wild-looking, high-performance, 2-seat sports roadster took to the streets for its first test drive last December. Neighbors in the vicinity of Chrysler's engineering center outside Detroit caught a glimpse of the first prototype Viper on its maiden voyage. Development continues on the sportster as engineers still wait for the green light to put it into production, and that's expected to happen within a year.

Originally, the Viper was supposed to have a V10 under its hood. But the prototype seen plying Detroit's freeways was powered by a Chrysler 360 V8. "Just something to get it out of the garage," one Chrysler insider confided to PM. Viper's most radical styling cue, the peekaboo exhaust pipes that snake out from the front fenders, will definitely be on the production car.

Going To The Cats

Ford liked Jaguars so much they bought the company—or rather, controlling interest in Jaguar. But Ford's top executive, Red Poling, will continue driving a Lincoln, and not a Jag, as his personal transportation machine. "I'll stick with what I've already got," Poling told PM. Meanwhile, Ford's headquarters in Dearborn, Michigan is seeing a sprinkling of new Jaguars in parking lots and test tracks. "We'll help (Jaguar) with testing and technology," Poling says, "but we don't plan any huge increase in sales." **PM**

SPY REPORT (Continued from page 40)

phase with that of the engine. The two waveforms (sounds) combine in the muffler to cancel each other out. Compared to a conventional muffler, the electronic version is lighter in weight and has less back pressure, which translates into more power and better fuel economy.

Chrysler Takeover?

The rumor mill in Detroit was humming with reports as early as last December that Chrysler was a target for a takeover by "a European carmaker" with a small presence in the U.S. That description fit a number of overseas companies, but Fiat seemed to be the most logical plotter, considering its huge assets and reputation for foreign investment. Also, Fiat has been itching to reestablish sales in North America. Two other suspected Europeans were Renault and Volkswagen, with Renault being the more natural of the two because of its past association with American Motors, now a Chrysler division (Jeep/Eagle). In a separate move last fall, Chrysler was trying to sell off two subsidiaries—a move that could have put a damper on a possible outside takeover.

Saturn Changes Orbit

When General Motors launched its Saturn car project five years ago, the company announced the mission of the program

was to compete against "the best of the imports." At that time, it was believed that Saturn would be a low-price, entry-level car that would sell for about \$7000 (today's prices). Well, things have changed. By current accounts, Saturn will probably sell in the high \$9000 range to start and push \$14,000 for a fully loaded model. The car's designated import targets also have changed to more upscale machinery. The '91 Saturn will now compete against higher priced Corollas and Civics, as well as Camrys and Stanzas. One big reason for the Saturn upgrade is the dramatic change in the small-car market since the Saturn project was announced. Higher priced, larger subcompacts have seen a big jump in sales.

Breathe Easier

Asbestos is being phased out of brake pads and shoes. Right now, only 50 percent of replacement brake pads and shoes contain asbestos material. Within three years, 90 percent of these products will be asbestos-free, according to Tenneco Automotive. The EPA has mandated that new cars must have asbestos-free brakes by the 1994 model year, and replacement pads and shoes must follow suit by September, 1996.

Allanté On Ice

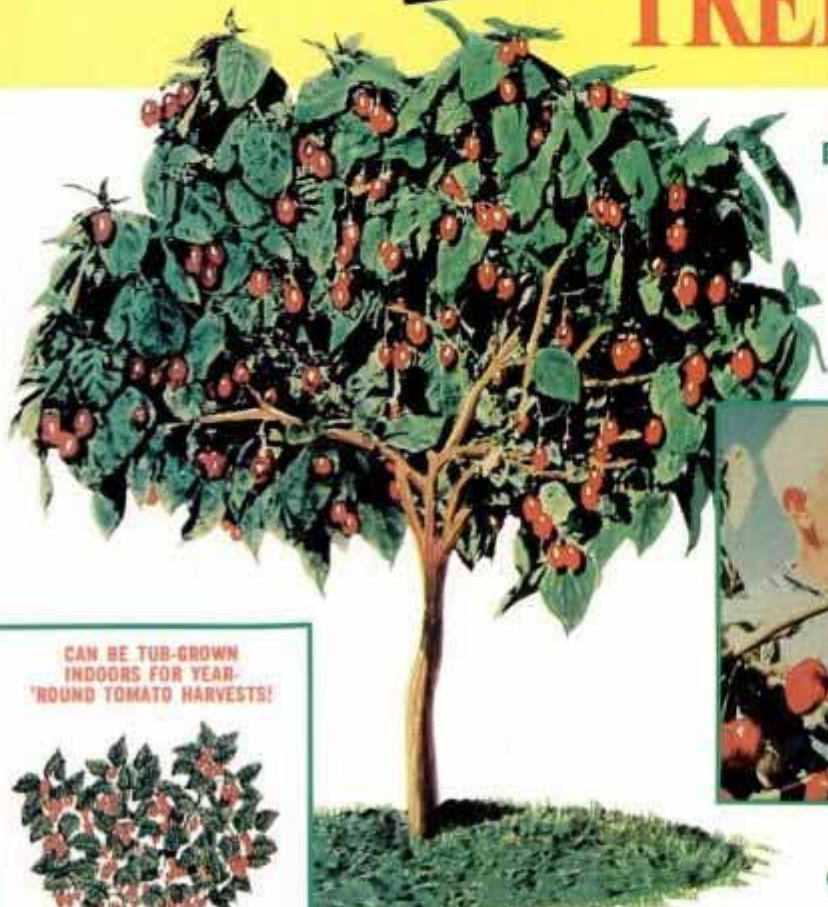
There's no question that Cadillac packed

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GROWS INDOORS OR OUTDOORS . . . YOU PICK BASKET AFTER BASKET OF RIPE, TASTY TOMATOES . . . ONE BUMPER CROP AFTER ANOTHER . . . 5 TO 7 MONTHS A YEAR . . . YEAR AFTER YEAR!

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"Ripening in New Zealand from late April to early November, the tree tomato (or Tamarillo) has a very long fruiting season. Its wide range of culinary uses make it a valuable winter and spring fruit . . . a welcome addition to the menu."

"Although introduced into New Zealand many years ago, it is only in recent years that the tree tomato has become better known for its many uses. It is now much sought after, and its popularity is indicated by the high price realized for it on local markets . . . Under suitable conditions the plant will produce from 40 to 60 lbs. of fruit annually."



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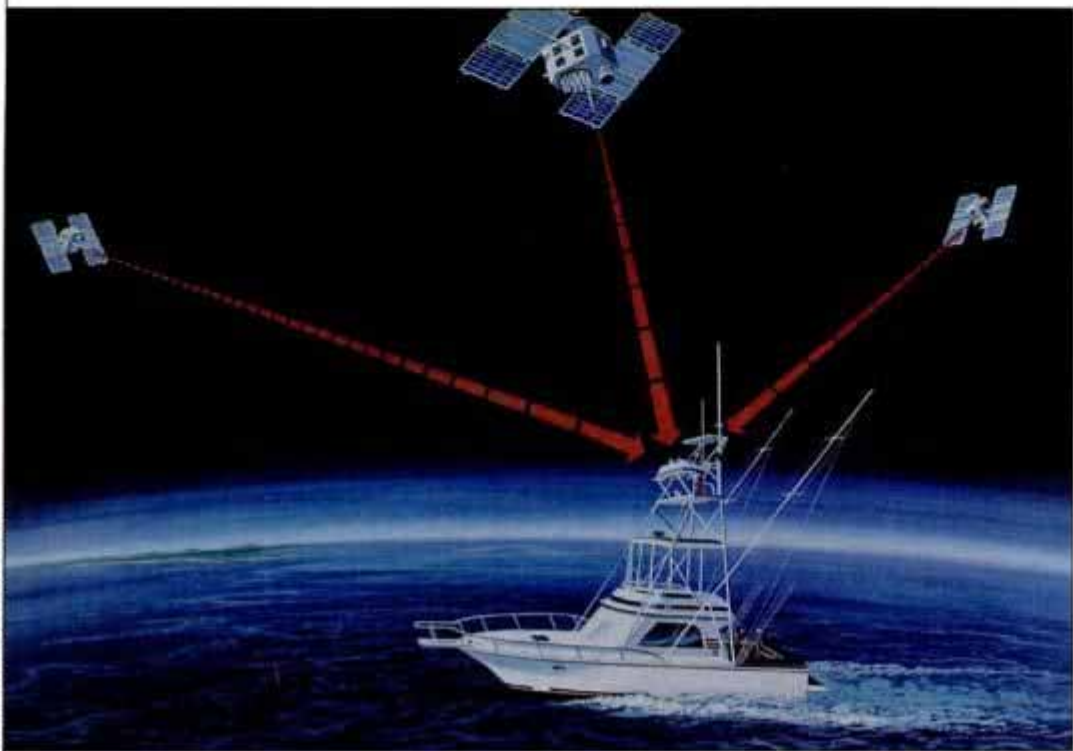
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BOATING

BY JOE SKORUPA, Boating/Outdoors Editor



PM ILLUSTRATION BY DEAN ELLIS

Navigation In The GPS Age

EVER GET the feeling that somebody is jerking your chain? Just when my record and cassette collections reached a thousand, technically advanced CDs came out and I'm now forced to replace albums and tapes at twice the cost.

If this isn't bad enough, I understand that the next breakthrough, DAT (digital audio tape), is already in the wings and may make CDs obsolete. By changing formats every couple of years the music business stands to make a fortune. Does anyone doubt some genius is already working on a miracle replacement for DAT?

Offshore fishermen and long-distance boaters are in a similar situation. Just when they've fully outfitted their boats with current electronic equipment—loran units, for near-shore navigation, and Sat/Nav units, for open-ocean use—news breaks that

these systems have been superseded and will be ultimately phased out.

But, unlike the world of music, sophisticated electronic navigation systems, based on radio transmissions from satellites, are dependent upon the government for implementation. This means that very little is going as planned, and that all previous announcements are subject to later revision.

GPS in orbit

After a long period of research and development in the 1970s, a number of governmental agencies—principally the Department of Defense (DOD)—began busily overselling the prospects and advantages of a satellite-based radionavigation system called GPS (Global Positioning System).

In 1984, for example, a Federal Radionavigation Plan was issued that reaf-

firmed that GPS was the intended replacement for the current satellite navigation system, known as Transit, and it will be operational in 1988. It also stated that loran, a land-based radionavigation system, will be phased out as soon as GPS receivers are widely available and prices reduced.

Unbounded governmental confidence inspired electronic equipment manufacturers to swiftly develop GPS-compatible navigation instruments and adopt a similarly overstated tone.

Consider this example from the literature of a leading-edge electronics firm: "Once it is complete, GPS will be a navigator's *dream come true*, a single uniform radionavigation aid providing worldwide, continuous, 24-hour, all-weather position fixes with a high degree of accuracy and reliability." Another company declared, "ships and boats will be able to steer directly into port

even in dense fog."

Can civilian marine navigators expect this kind of miracle performance from GPS? Only in their dreams.

Inside GPS

No one disputes that when GPS is up and running it will be a tremendous advancement over the present system of Transit satellites, which is used by current Sat/Nav instruments. Or that it will be more sophisticated than loran.

Offshore navigators are very aware that loran positioning is only possible near shore and its signals are affected by thunderstorms. They also know that at certain latitudes, Sat/Nav units can go for long periods between position fixes. The problem is that there are only seven active Transit satellites and their spacing isn't uniform. Also, Transit satellites orbit at only 700 miles above the Earth's surface, which often makes it difficult to find a satellite high enough above the horizon.

GPS improves on the Transit system in a number of ways. When fully operational, the GPS orbiting pattern will include 24 satellites, which are called Block IIs. The pattern calls for 21 active satellites and three orbiting spares.

These satellites will orbit about 10,900 miles above the Earth's surface and be spaced so that users will have at least four satellites in view at all times. This will be achieved by placing four satellites in each of six orbital planes 60° apart. (Each circumpolar plane crosses the equator at a 55° angle.)

Why does it need four satellites to achieve a position fix? An accurate latitude/longitude fix for boaters can

(Please turn to page 46)



The Ultimate Fish Finder:

There are more than a handful of interesting gadgets around designed to help you catch fish. Not to mention the numerous secrets fishermen have shared over the years.

But if you really want to catch fish, knowing where they are is only part of your problem. Getting to where they are completes the equation, and that's where Evinrude® outboards come in.

To begin with, our outboards are designed with the specific needs of the fisherman in mind. That's why our gear case water intakes resist plugging in weeded areas.

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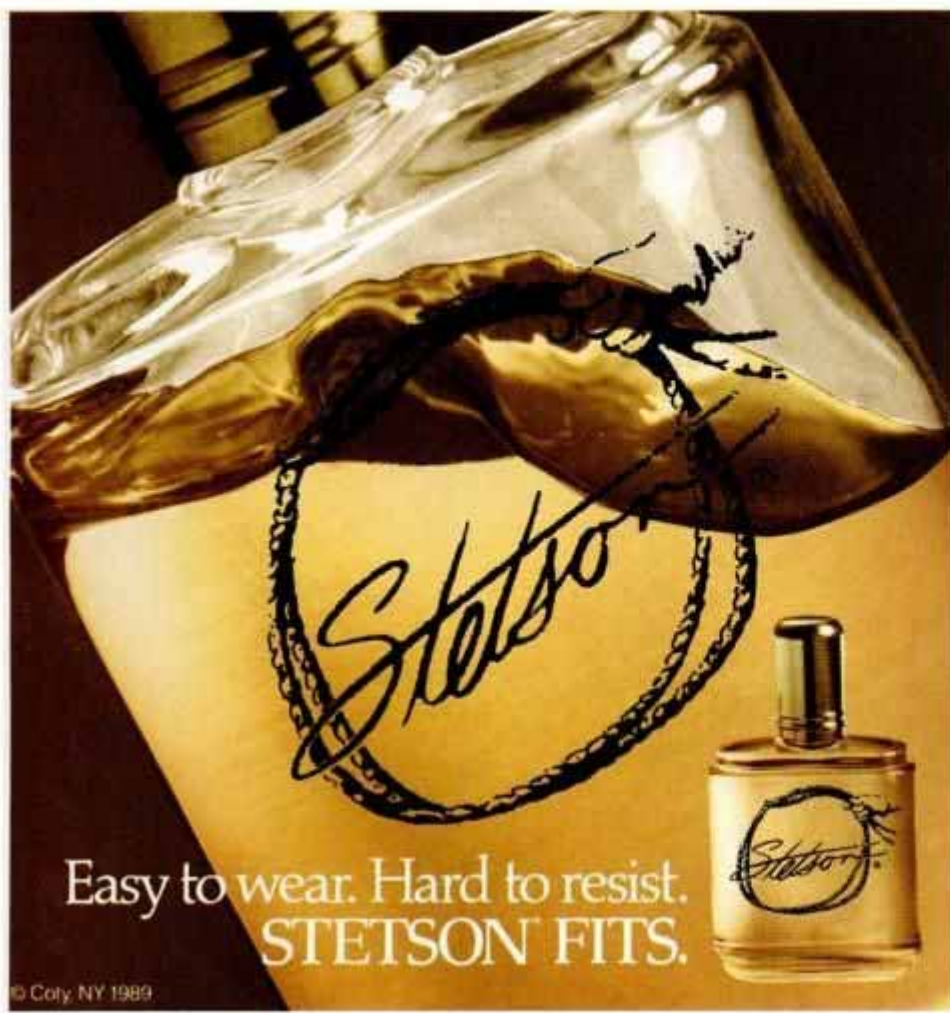
a fish, you've got to have a few moves up your sleeve. So thanks to fuel-injection starting, you can always count on starting up fast. And with our patented VRO²™ oil injection system, we'll keep your outboard running smoothly no matter how many fish you're after.

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BOATING (Continued from page 44)

be made using just three satellites—one each for latitude and longitude and the third for an accurate fix on an atomic clock (to compute position, the receiver must make extremely accurate time-of-arrival measurements for the satellite messages).

The fourth satellite gives GPS a 3-dimensional positioning capability. In other words, it's used to determine altitude. Who needs 3-D information? Aviation pilots.

Challenger setback

So far the biggest glitch in the government's ambitious GPS plan is in meeting target dates. The tragic explosion of the Space Shuttle *Challenger*, in 1986, set back satellite deployment several years. The Shuttle program was grounded and attempts to use Titan and Delta rockets failed. The DOD ultimately decided to develop an alternate launch vehicle for GPS and the result was the Delta II.

The first Block II/Delta II launch took place early last year. Since then a total of five GPS satellites have been deployed. Based on the current rate of satellite deployment and several other factors, electronics industry predictions target mid-1991 as the operational date for round-the-clock, worldwide, 2-

dimensional GPS use for boaters.

Unfortunately, this date may also be a dream, because it's based on the assumption that boaters require fewer satellites than pilots (they don't need to know altitude). Just 12 properly positioned Block II satellites would give boaters worldwide, full-time coverage.

The problem is that the DOD is bunching them together (as opposed to evenly spacing them). This is done to develop strategically placed 3-dimensional windows for online tests. Due to bunching, it's predicted it will take at least 18 satellites to provide full navigational service to boaters. The marine electronics industry believes this pattern will be achieved by mid-1991.

The DOD, on the other hand, predicts that full operation of the system will occur in 1993. This refers to 24-hour, worldwide, 3-dimensional operation, and it implies successful deployment of 21 active satellites and completion of the testing phase, which is far from over. The 1993 date is five years later than the original prediction and, of course, it isn't written in stone. (Interestingly, during GPS testing, the entire system is designated "unhealthy" and is unavailable for accurate position fixing. This means that even when all satellites are flying, the system can't necessarily be counted on. Such a shutdown, for limited win-

dows currently in use, occurred last September 20 through October 4.)

The biggest problem with GPS, however, isn't technological, but human—the human capacity to commit acts of warfare. Theoretically, GPS is capable of providing continuous, worldwide, 3-D position fixing to within 10 meters. This is the exact information required by guided missiles and is 99 percent of the reason the DOD is willing to spend \$500 million per year on the program.

To deny such accuracy to hostile foreign users, GPS satellites will transmit two levels of service: full service to the military and a deliberately degraded service to civilians. GPS service to civilians will be accurate to within 100 meters with a 95-percent confidence level. It isn't 100 percent because random errors will be added without notice.

To many boaters, this level of GPS service is far from a dream come true. In fact, cynics point out that a system that isn't 100 percent certain is actually 100 percent uncertain. Remember the claim about steering directly into port in a dense fog? How would you like to do it knowing that unpredictable errors are introduced unannounced for undesigned periods of time?

GPS in the loran age

Since the initial period of rosy expectations for GPS, as exemplified in the 1984 Federal Radionavigation Plan (FRP), the situation has changed considerably. The 1986 FRP, for example, stated that GPS may not supplant the loran navigation system in the foreseeable future. The 1988 FRP stated that loran may not be replaced at all.

The reason for the turnaround is that there are currently about 500,000 loran users and the number is expected to grow rapidly. Fishermen and boaters can purchase loran units for as low as \$300. Current prices for GPS units, which are ultimately expected to drop by half when the system is fully operational, are in the \$3000 range.

The final irony for the vast majority of boaters—those who travel within 200 miles of shore—is that loran accuracy is somewhat greater than civilian GPS (ranging from 30 meters to 100 meters) and far more repeatable (returning to a location previously recorded in the loran unit), which is one of loran's most important functions.

So in the end, most boaters will continue to use the loran system despite full GPS deployment and be better served. The danger is that the loran system (recently turned over to the Coast Guard) may someday be discontinued and compel boaters to use the more expensive, less accurate civilian GPS system. Will this actually happen? Nothing's for certain, but weren't albums and cassettes replaced by CDs?

PM

Light On Your Feet

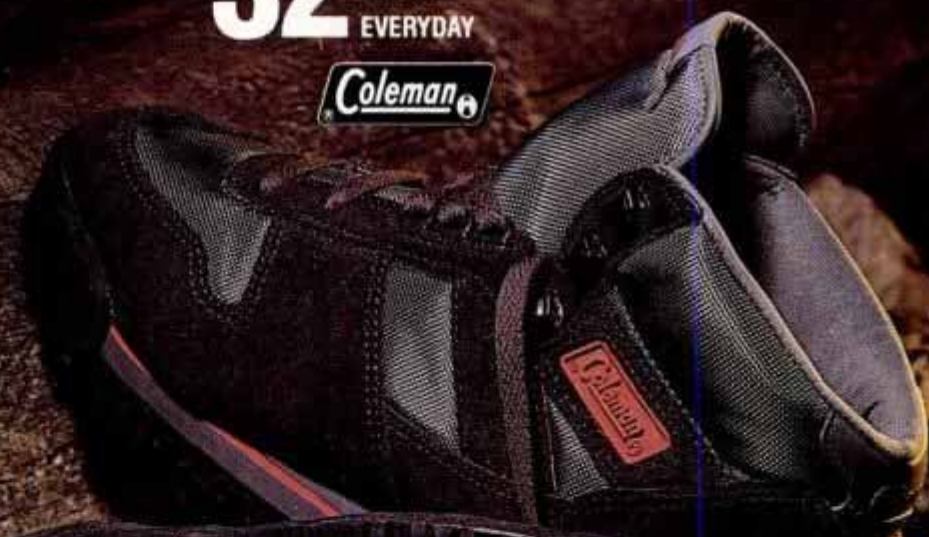
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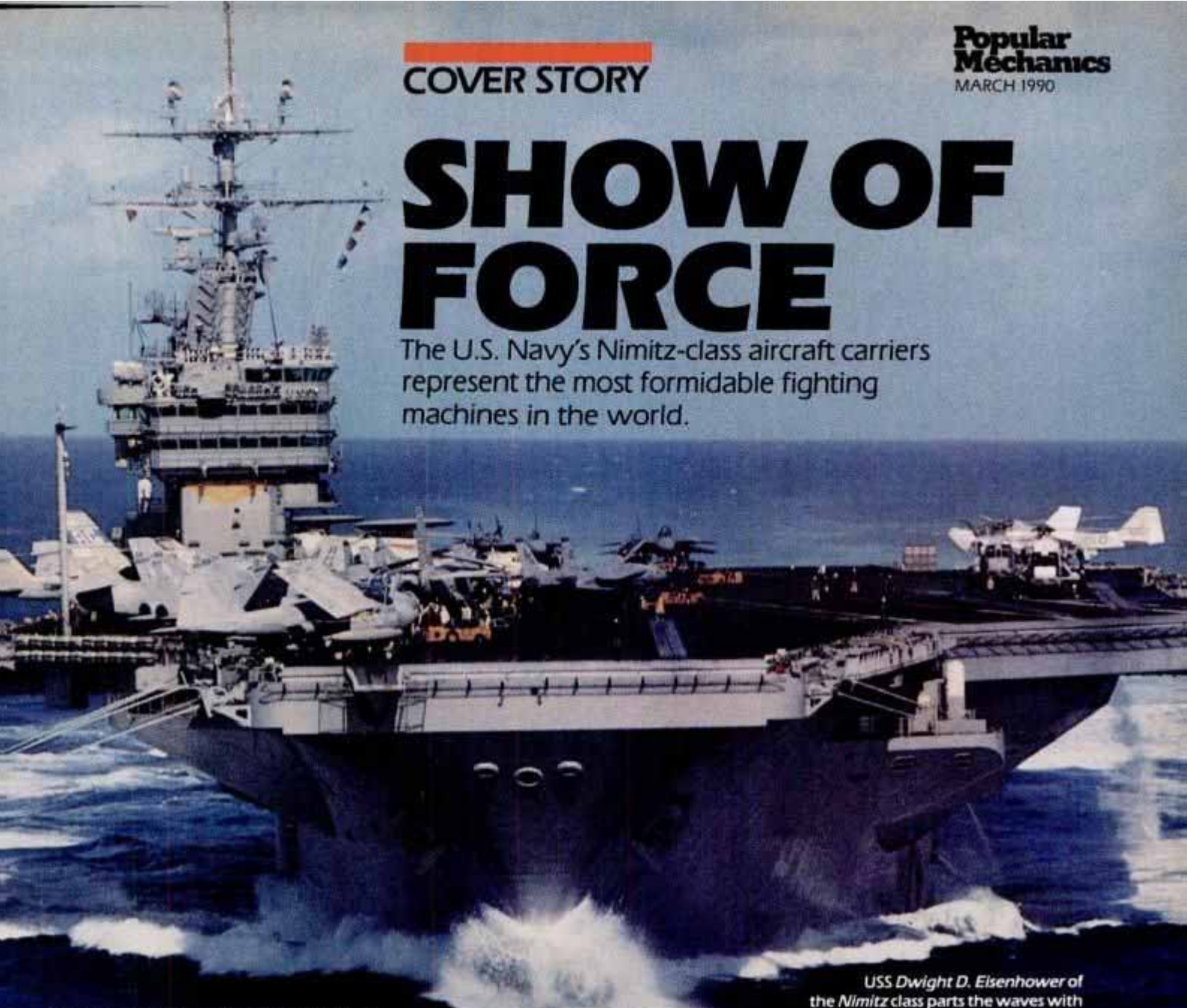
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SHOW OF FORCE

The U.S. Navy's Nimitz-class aircraft carriers represent the most formidable fighting machines in the world.



USS Dwight D. Eisenhower of the Nimitz class parts the waves with a full complement of aircraft on deck.

BY VICE ADM. EDWARD MARTIN,
USN (Ret.), and TIM COLE

USS *Theodore Roosevelt* remains at anchor off Naples, Italy, its 1052-ft. profile dominating the hazy horizon of an April afternoon. *TR*'s deck bristles with aircraft—A-6 Intruders, E-2C Hawkeyes, C-2 Greyhounds, F/A-18 Hornets, S-3 Vikings, the mighty F-14A Tomcat. Even at rest, *TR* reflects a sense of pride and dormant power, quietly doing the job of defending international sea lanes and protecting our national interests around the world.

Shift the scene 24 hours later and several hundred miles away in the east-central Mediterranean and *TR* is ablaze with energy. F-14s, F/A-18s and A-6s catapult in rapid succession from the deck, accelerating

from a standing start to 150-170 knots in 2 to 3 seconds. Four aircraft per minute launch from each of four steam catapults. As launches continue from the two bow catapults, aircraft begin to land, being recovered less than 1 minute apart on *TR*'s angled flight deck. The flight deck is alive with a choreography of airplanes, sophisticated equipment and people. Every activity—on the carrier and off for hundreds of miles in every direction—is closely monitored by a complex system that includes sailors at computer consoles and tough, agile deck crews, who haul fuel lines, chock and chain aircraft, hoist missiles and load bombs. Belowdecks, thousands more make the ship operate with the precision of a fine watch. The carrier is doing what it does best: operating aircraft, ready for any contingency.

High up on the bridge of *TR*, 10 stories above the flight deck, her commanding officer, Capt. Dayton Ritt, simplifies his ship and mission, "We're a big floating airport. I can take my ship anywhere in the world to execute orders from the national command authority."

Some aircraft carrier commanders can't say that. *TR* and her sister ships of the Nimitz class have twin multimegawatt nuclear reactors which propel these 97,000-ton behemoths at speeds in the 30-knot range. Yet, these reactors require refueling only once every 13 years. Thus, the Nimitz-class carrier becomes the ultimate expression of aircraft carrier design and technology—technology that has gradually evolved since Eugene Ely flew a Curtiss pusher off the converted deck of the USS *Birmingham* on

SHOW OF FORCE

Nov. 14, 1910. Since then, the ability of the aircraft carrier to take the fight to the enemy has altered global, political and military affairs. America's maritime strategy of forward defense—stamping out brushfires before they become full-scale conflagrations, preparing to fight and win large-scale wars if need be—is built around the awesome capability of this new and improved state of the art.

The *Nimitz*-class aircraft carrier has been described as the most technologically complex entity that mankind has ever assembled in one package. A young landing signal officer emphasized its capability to POPULAR MECHANICS as *TR* completed the recovery of more than 80 aircraft one stormy night: "We can launch our aircraft, recover them at night, in any weather, with radars and communications completely shut down to conceal our position. There's no other navy in the world that can do what we do."

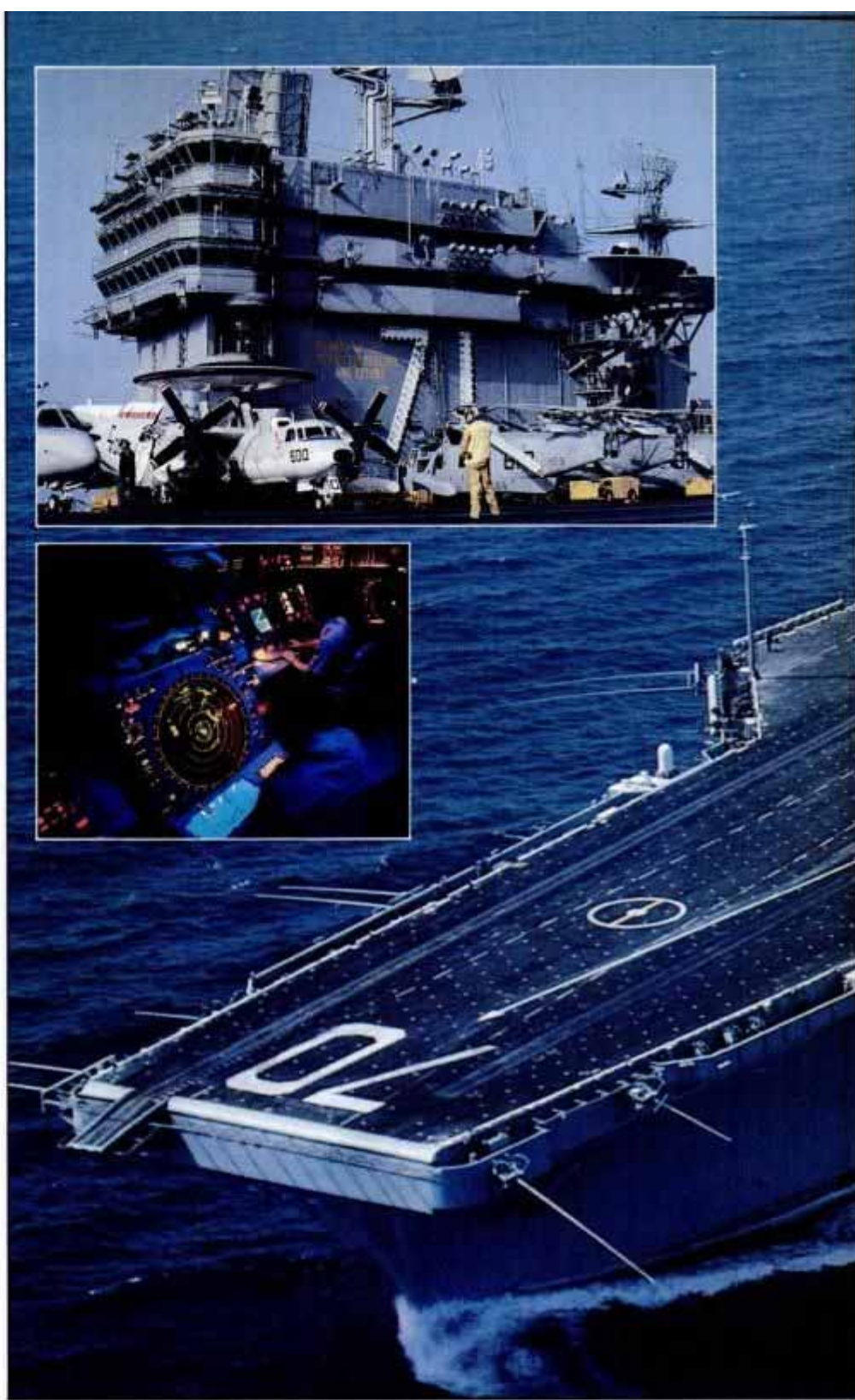
To learn more about America's mightiest carriers, POPULAR MECHANICS traveled to the Mediterranean to observe carrier flight operations and to discuss the unique capabilities of the *Nimitz*-class supercarrier. The USS *Abraham Lincoln* is the latest of this class currently operational. The forthcoming additions of the *George Washington*, *John C. Stennis* and *United States* will give this nation an unmatched capability to deter aggression, and, if necessary, to wage war—thereby maintaining the peace in a volatile world.

Powerplant factors

What does the *Nimitz* class have that other carriers don't? Start with the propulsion system. The *Nimitz* class is powered by twin pressurized-water nuclear reactors (USS *Enterprise*, CVN 65, our first nuclear carrier has eight much-less efficient reactors). *TR*'s state-of-the-art reactors heat pressurized water, which in turn heats a separate water loop and turns it into high-temperature, high-pressure steam. The steam drives the ship's main-propulsion turbines, generators, auxiliary machinery and provides steam for the catapults.

The benefits of nuclear power extend well beyond *TR*'s ability to dash for years at high speed without refueling. Interior space that otherwise would go toward bunker fuel now can be put to use to store jet fuel, more weapons and other consumables.

Statistics alone give an impressive picture of the *Nimitz* class: Height from keel to mast top, 24 stories; flight-deck area, 4.5 acres; combat load displacement, 97,000 tons; number of spaces, more than 4000; weight



of rudders, 65 tons apiece; weight of anchors, 30 tons each; weight of propellers, 66,200 pounds each; number of crew, 6200; meals consumed daily, 18,600; average crew age, 19½ years.

TR has everything it needs to sustain its complement of aircraft—jet repair facilities, metal bending shops, airframe repair bays, even an electronics shop where complex motherboards for microprocessors are resoldered.

"Making a *Nimitz*-class carrier function smoothly depends greatly on the experience gleaned from previous carriers," says Capt. Mike Concan-

non, a carrier veteran currently working at Naval Sea Systems Command in Washington. The position of the island relative to length overall is considered ideal on the *Nimitz*. Earlier carriers, with the island too far forward, couldn't clear the decks fast enough. "It's nice to have all that real estate forward," Concanon says.

The size and position of the four aircraft elevators—two forward of the island on the starboard side, one aft of the island on the starboard side, and one on the port stern quarter (each the size of two average city dwelling lots)—also were developed from



A day in the life of a *Nimitz*-class carrier: Catapult launches an F-14 Tomcat (right). Air operations are monitored from sky cap's cupola at flight-deck level (above right), tower atop island [upper left] rising 10 stories above deck, and by radar operators in control room belowdecks (left).

years of trial and error aboard preceding carriers. The *Nimitz* elevators, unlike elevators aboard some prior ships, can all be operated during launch and recovery, a crucial element in speeding up what can be an extremely tough process.

Making arrests

The *Nimitz* flight deck is designed around the catapults and arresting gear critical to the launch and recovery of aircraft. Each of the four catapults are approximately 300 ft. in length and are driven by high-energy steam operating in two parallel cylinders

against a piston in each cylinder. These are interconnected to a shuttle that attaches to the aircraft. At the end of the launch stroke, the pistons are slowed by a spear-shaped conical device entering a water brake. While the details of the catapults are classified, according to Concannon, "They're reliable, stout, common-sense devices." And he adds, "No other navy has been able to duplicate our arresting gear, which is also very rugged and dependable." Again, the arresting system's precise design is classified. Essentially, however, each of the five 2-in. wires (or cross-deck

pendants, as they are officially called) is attached at each side of the landing area to hundreds of feet of wire cable and wound through a series of sheaves belowdecks. The sheaves connect to a hydraulic ram that is pulled by the force of the landing aircraft. The metering of the hydraulic fluid is varied to provide a constant and even slowing of the aircraft.

"Improvements in our arresting gear have given us extra flexibility. With these newer systems, we can recover aircraft at much heavier weights," Concannon says. "That means we can land with more fuel and

SHOW OF FORCE

U.S. NAVY PHOTO



ordnance aboard, saving the taxpayers' money. Or, we can recover with a tailwind, which gives the captain considerably more flexibility in maneuvering the ship."

Making TR go

Everyone aboard an aircraft carrier knows that it is the pilots, bombardiers, radar intercept officers and other flight crews who get all the glory. But *TR* and her sister ships would be dead in the water without the legions of highly skilled young men who toil on her flight deck. It requires over 6000 men working 18-hour days under arduous conditions to operate these ships—reactor operators, engineers, electricians, cooks, barbers, technicians in virtually all disciplines, medics, seamen and ordnancemen. They all make a precise contribution to the functioning of this complex mobile city—a city where mistakes can quite easily claim lives.

This complex blending of men and machinery into an effective fighting force of gargantuan proportions culminates in the often delicate application of force. Aircraft carriers can be used as altogether effective instruments of national policy—not necessarily destruction.

Operating in international waters and launching aircraft in international airspace, the carriers are not subject to the whims of politicians, or the

kinds of pressures our land-based forces must contend with when operating from nations other than our own. Our carriers are sovereign U.S. territory capable of rapid and flexible mobility. They don't need permission from often hostile governments to launch airplanes, nor must they overfly friendly or unfriendly countries to reach a target.

Aircraft carriers have been the centerpiece of America's foreign and military policy since the Battle of Midway in World War II. Whenever our country's credibility is at stake, whenever our allies are threatened, the first question the President asks is, "Where are the carriers?" In fact, of the more than 227 world crises since World War II, carriers have been involved more than 220 times.

Critics suggest that the sheer size of our aircraft carriers makes them vulnerable. Navy planners concede that it would be difficult to escape a well-placed nuclear warhead. But aircraft carriers are less vulnerable than land bases because they're mobile. "Hell," says Vice Adm. Richard M. Dunleavy, "with the proper intelligence, practice and with a little luck with the weather, we can disappear out there. We shut down our radar and radio emissions, go completely without communications, and time the Soviet surveillance satellites. Last year, nobody knew where we

USS Abraham Lincoln, shown here shortly after christening, is latest of Nimitz class.

were for nine days during an exercise in the North Atlantic."

Also, a vital capability that has evolved in our carriers is their defenses. While carriers provide the awesome striking power of our Navy, rarely, if ever, do they operate alone. The carrier battle group usually consists of 5-9 ships including *Aegis* missile cruisers, destroyers, frigates, missile ships and submarines. All are electronically linked to provide sensor capability and combat information out to many hundreds of miles above, on and under the sea. In addition, the carriers are well armed against close-in adversaries that might have eluded outer defenses. Each carrier is armed with the *Sea Sparrow* missile capable of knocking down high or surface skimming targets and the automatically directed *Vulcan Phalanx* close-in cannons.

"Most of us think the size of the *Nimitz* class is optimum for overall requirements for the foreseeable future," says Dunleavy. "However, the shape of the box may change. For example, is the island really necessary? Can we lower the silhouette of the ship to make it less observable to radar and other sensors?"

In the end, the size and type of aircraft drive the design of the ship. The upcoming A-12 and the Advanced Tactical Aircraft, both now under development, will influence future carrier design. Superconductivity may also change the aircraft carrier of the future, Dunleavy says. Electromagnetic catapults may replace the reliable, though heavy, steam catapults.

Regardless of what lies over the horizon, the *Nimitz*-class aircraft carrier—"these national treasures," as *TR*'s Capt. Ritt calls them—will be a fixture in the fleet well into the next century, preparing then as now to sail in harm's way. **PM**

Sea smoke swirls around bow of *Abraham Lincoln* as she prepares for aircraft launch with blast deflectors raised.

PM PHOTO BY PH2 DENNIS TAYLOR/U.S. NAVY





THE BIG THREE

We test the patriarchs of the endangered species *Luxus Americanus*.

BY TONY SWAN, Automotive Editor

WE'VE BEEN hearing a lot about luxury cars recently. Some of the names are familiar—like BMW, Mercedes and Jaguar. And some are totally new to us—specifically, names like Lexus and Infiniti.

But very rarely have any of these names been American. The luxury-car limelight has fallen almost exclusively on imported makes during the past couple years, while once-

proud U.S. nameplates like Cadillac, Lincoln and Chrysler seem to have acquired a sort of country-cousin status versus their peers from other lands.

We decided it was high time we took a look at how the traditional American luxury makes are responding to the increasingly formidable challengers vying for a piece of the high-roller marketplace.

The timing of this decision was

dictated, at least in part, by the recent resurrection of one of the great old American nameplates, the Chrysler Imperial. And since the Chrysler marketing plan is to challenge the other American luxury makes—the Cadillac Fleetwood and Lincoln Town Car—an all-American revue made even more sense.

Something else that made sense was to put most of the test emphasis

THE BIG THREE



CADILLAC BROUGHAM

PHOTO BY HUMPHREY SUTTON

Brougham of Elegance

Cadillac's ultratraditional Brougham is a perennial favorite with New York limousine drivers. Powered by 350-cu.-in. V8, the Brougham was the quickest of the Big Three.

on how these cars behaved in traditional luxury-car assignments. Although we did run all three through our standard instrumented test battery at Raceway Park in English-town, New Jersey, we were much more interested in how these cars stacked up as high-end people haulers operating in an urban environment. Accordingly, most of our impressions are based on several days of living with the cars in Manhattan—the Big Three in the Big Apple.

Lincoln Town Car

Although we were a long way from a consensus on this who's who of American big cardom, the new Lincoln Town Car emerged as a sort of grudging first among equals. We can't call it superior in all respects, particularly in contrast to the venerable Cadillac. But all the testers felt that the Town Car's new exterior is an appealing update on this traditional American automotive theme.

There's more to it than mere good looks, of course. The Town Car's new aero lines reduce drag—the C_d rating has gone from a barnlike 0.46 to 0.36, not exactly world class but certainly much more respectable. Although reducing drag is always helpful at the gas pump, it didn't produce much effect in fierce New York City traffic.



PHOTO BY BILL ASKE

However, a more important benefit of the aero improvements is reduced wind noise. This was a priority of the design team, and it has paid off with a level of operating quiet that's exemplary in the luxury-car class.

We were also impressed with the Town Car's powertrain, although this is hardly new. We've been fans of the Ford 5.0-liter V8 for a long time now. It's smooth, torquey and fully capable

of hustling some 4000 pounds of luxury car in an acceptable hurry—very helpful in New York City.

The V8 mates to a 4-speed overdrive automatic, which is also an established item, something that can be said for the entire rear-drive chassis. New equipment includes automatic load-leveling air springs at the rear and a speed-sensitive variable-assist power-steering unit.



LINCOLN TOWN CAR



The Town Car showed impressive workmanship, with an excellent level of fit and finish inside and out. Our test car was upholstered in supple cream-colored leather, and seating was generous with a good range of adjustability. Airbags are provided for both the driver and front seat passenger. Instrumentation is digital and minimal, but readily readable, something that's true for all three cars.

The Town Car's handling drew a mixed review. With practice, the big Lincoln could be herded through city traffic a good deal quicker than the Cadillac, though traffic-running isn't what these cars are all about. However, the Town Car's good transient response was completely offset by the total absence of steering feel. There is simply no sense of what the front wheels are doing when the steering



Although exterior and interior are all new, Lincoln Town Car's rear-drive chassis remains unchanged. Town Car also features airbags for driver and front seat passenger.

wheel is turned, even though steering effort does increase along with speed. This is, in our view, a serious flaw.

A couple other flaws held our Town Car enthusiasm in check. Tops on this list are the rear edges of the front doors. Instead of a straight up and down line, the rear edge of the door is curved toward the front of the car, like a bow, leaving sharp points at top and bottom that can put a nasty bite on your shins.

Not so serious but thoroughly irritating is the interlock between the transmission and door locks. When the car is put into motion, the doors automatically lock. This is okay, except that there's no automatic unlock function, something that's very annoying for a driver who needs to open the rear door frequently.

Where the Town Car scored big, though, was in curb appeal. Pull up to the Water Club or Regine's in this baby and doormen in Camelot uniforms come running. The Town Car definitely says class to a lot of people, most of whom will expect a big tip.

Cadillac Brougham

While the Town Car is basically unchanged beneath its slick new skin and interior, this patriarch of all Caddies has resisted change of *any* kind. This is the classic Cadillac sedan of se-

THE BIG THREE

TWO
TOWNS
DISANGELI
ESTERIO



CHRYSLER IMPERIAL

IMPERIAL

Chrysler Imperial's more compact dimensions were handier in traffic. New air-spring suspension gives smooth ride and acceptable handling.

dans. It's as close to a throwback of the land yachts of the '50s as you'll find as we enter the '90s. Incredibly, this chassis was actually *downsized* in 1977 and has remained essentially unchanged since then, replete with vinyl roof, tufted pillow leather upholstery, and plentiful power from a big push-rod V8 engine.

The concept of big in this regard has evolved, of course. The 500-cu.-in. monster motors of yesteryear have given way to today's 350 (a new option for 1990). Still, torque is plentiful and for all its 4300-pound bulk—this is the biggest production car made in America—the Brougham emerged as the quickest player in this threesome. Again, this helps when you're trying to achieve some sort of operational parity with the Manhattan taxi fleet.

Though it wasn't quite as nimble, the Caddy's subjective handling seemed equal to the Town Car, largely because of better steering feel.



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)
Cadillac Brougham	\$37,530/ \$39,298	V8 OHV 350/5733	175 @ 4200 rpm/ 400 @ 2000 rpm	front/ rear	4-speed auto	121.5/ 3085	221.0/ 5614	76.5/ 1942	F: 61.7/1568 R: 60.7/1542
Chrysler Imperial	\$26,045/ \$28,745	V6 OHV 201/3294	147 @ 4800 rpm/ 183 @ 3600 rpm	front/ front	4-speed auto	109.3/ 2776	203.0/ 5156	68.9/ 1750	F: 57.6/1463 R: 57.6/1463
Lincoln Town Car	\$27,986/ \$33,646	V8 OHV 302/4942	160 @ 3400 rpm/ 280 @ 2200 rpm	front/ rear	4-speed auto	117.4/ 2982	220.2/ 5593	78.1/ 1984	F: 62.8/1595 R: 63.3/1608

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

IM PHOTO BY HUMPHREY SUTTON

IM PHOTO BY BELLASHE



Like the Town Car, the big Cadillac's ride quality was equal to Manhattan's worst streets, and we expect the traditional body-on-frame construction will be able to absorb lots of punishment before serious squeaks and rattles show up.

Our test car was devoid of the latter, although it didn't score quite as well in the exterior fit-and-finish ratings as its rival from Ford. We found seams that didn't mate up quite the way the designers intended, and plastic panels at the rear that showed hints of warpage. On the credit side of the ledger, interior space is nothing short of abundant, making the ins and outs that go with a New York night on the town a piece of cake.

Pluses and minuses notwithstanding, though, the real appeal of this car is that it so faithfully reflects a luxury-car tradition that's increasingly scarce. Get in, shut the door and suddenly it's 1965, with the addition of superb audio systems.

Or dress up in black tie, have your lady put on that little black dress, the tight, short one, and some high heels, and take her to dinner at Delmonico's. It's a place where the old wealth of New York feels at home, and so will you when you pull up in a Cadillac Brougham.

Chrysler Imperial

Chrysler's marketing goal for the Imperial revival is to challenge the other two cars in this test. However, the plain truth is that this car simply isn't in the same class as its rivals. Riding a stretched New Yorker unit-body chassis, the front-drive Imperial is smaller than the Town Car and Cadillac in virtually every dimension.

There are benefits in reduced di-

mensions, of course. The Imperial is handier to handle around town, and a bit less expensive to run. On the other hand, if we accept the traditional American parameters of automotive luxury—power and imposing size—the Imperial doesn't measure up.

This is not to say that equipment and amenities are lacking. The Imperial includes antilock braking and a



driver's airbag in its safety inventory. It gets power to the pavement via a sophisticated, electronically controlled 4-speed automatic transmission and rides on Chrysler's new air suspension system (optional).

We found that this system managed to level out Manhattan's ups and downs quite effectively, and also delivered decent handling. The Imperial was quickest in the slalom portion of our formal track testing, and also felt a good deal more nimble around town.

Inside, our test car was tricked out with spiffy Mark Cross leather upholstery (optional), an 8-way power seat with 2-position memory function for the driver, power mirrors, central locking, automatic climate control, a premium AM/FM sound system—in short, all the items you need to keep you happy between stops in traffic.

Although curb weight was much lower than Cadillac and Lincoln, Imperial finished third in acceleration runs.

We were also favorably impressed by the Imperial's engine performance. Chrysler's new corporate 3.3-liter V6 provides the power, and even though it's not in the same torque category as the bigger V8s, it's agreeably willing.

Lincoln performed respectably in slalom, despite absence of steering feel.

The downside of the new engine is excessive induction noise at full throttle, and it takes vigorous full throttle to make the Imperial run with the New York rat pack.

But the major shortfall has to do with size. And the most telling manifestation of the shortcoming showed up quickly. We pulled up to the front door of the 21 Club and the doorman looked at us as if we didn't belong there. Almost as if we were driving a plain Chrysler New Yorker or something. For a long time now, the Lincoln Town Car and the Cadillac Brougham have represented the gold standard in Manhattan limousine transportation. It's likely to be a long time before the Imperial displaces the establishment. **PM**

TEST RESULTS

CURB WEIGHT (lbs.)	STEERING TYPE/TURNS LOCK-TO-LOCK	BRAKE SYSTEM FRONT/REAR	FUEL ECONOMY (MPG EPA city/PM test)	ACCELERATION 0-60 MPH (sec.) ¼-MILE (sec. @ mph)	BRAKING 60-0 MPH (ft.)	700-FT. SLALOM (mph)	SKIIDPAD ² 200-FT. CIRCLE (G)	EPA CARGO VOLUME (cu. ft.)	EPA PASSENGER VOLUME (cu. ft.)
4283	Power recirc. ball/ 3.2	F: 11.7-in. vented disc/ R: 11.0-in. drum, ABS	14/ 11.5	10.1 17.1 @ 72	136	45.6	0.67	19.5	128.0
3570	Power R&P/ 2.9	F: 10.1-in. vented disc/ R: 10.0-in. drum, ABS	17/ 16.6	12.3 18.9 @ 67	143	52.8	0.62	16.7	121.1
4025	Power recirc. ball/ 3.4	F: 11.0-in. vented disc/ R: 10.0-in. drum, ABS	17/ 12.0	11.0 17.7 @ 68	148	50.2	0.68	22.0	117.7

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

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THE NEWEST OUTDOOR



▲ **Bigger is better.** With 230 horsepower and 385 lbs.-ft. of torque, this mammoth 454-cubic-inch V8 is like no other engine available today. It has the power to make grown men tremble and bring Ford owners to their knees.



▲ **A new set of wheels.** Styling doesn't stop with the sheet metal. It continues right down to the wheels. From the new 454 SS chrome mags to our available 4x4 aluminum wheels, we have style that rolls on and on.

▼ **Protecting your favorite sport.** No matter which sport truck you choose, Chevy's got you covered. With a 3-year/50,000-mile Bumper to Bumper Plus Warranty that protects nonpowertrain components 2 years longer than Ford.*

*Except tires, which are covered by their manufacturer. A deductible applies after 12 months or 12,000 miles. See your Chevrolet dealer for terms of this limited warranty.



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▼ **The name says it all.** Chevy 454 SS. 7.4 liters of fuel-injected V8 muscle. The most powerful 1/2-ton pickup in the world. A truck so intense, it only comes in black. And with its sport suspension, the Chevy 454 SS turns corners as quickly as it turns heads.

454



▼ **The wild side.** The one-of-a-kind Chevy Sportside? Available in 2- or 4-wheel drive with up to 5.7 liters of grunt under the hood. The 5-speed manual transmission is standard.

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SS

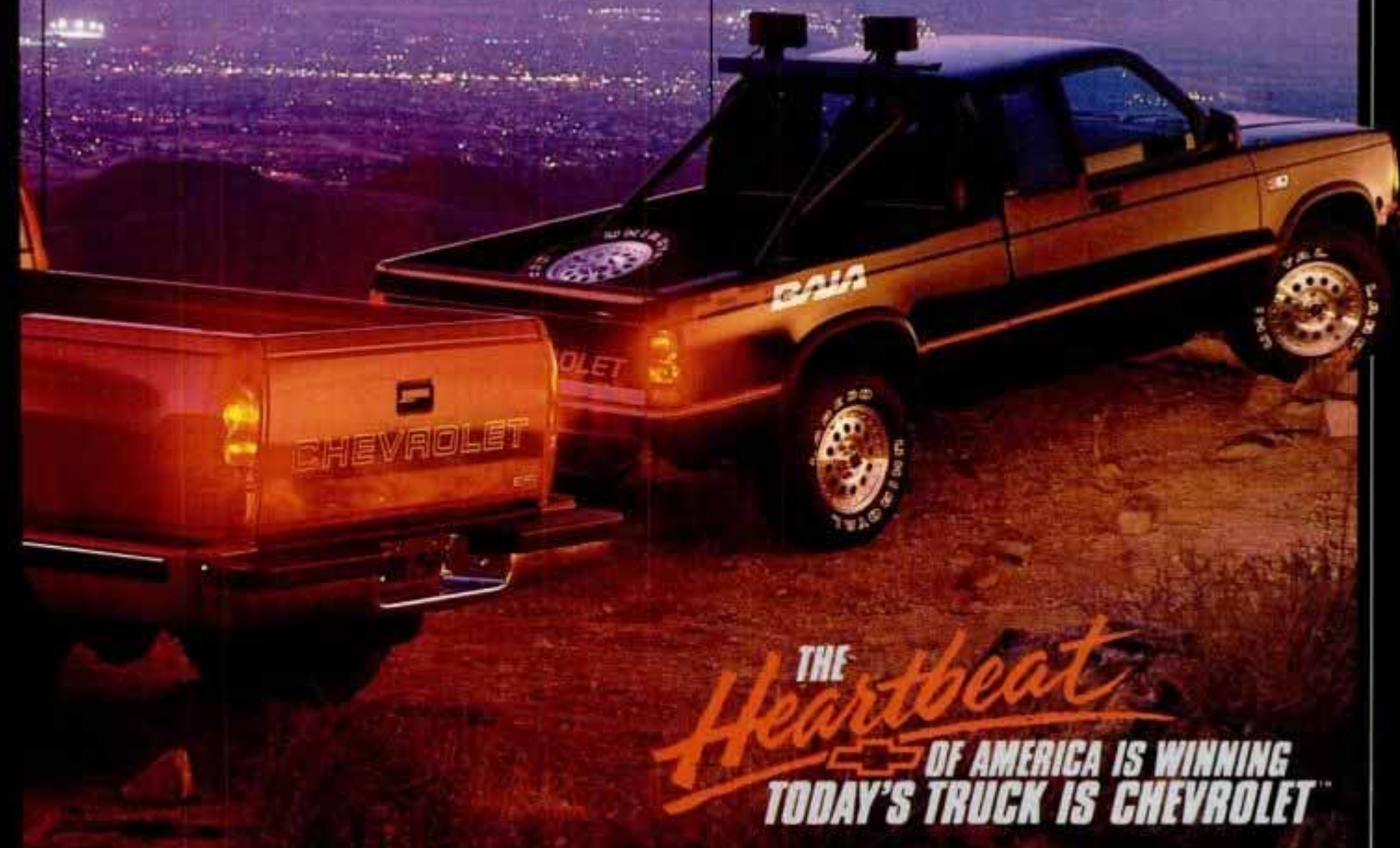


Cameo

▲ **Enhance your image.** S-10 Cameo. With the biggest available engine in its class, a newly available 5-speed manual transmission, special ground-effects styling and monochromatic paint, it makes a statement coming and going.

▼ **Play dirty.** S-10 Baja. This truck has all the toys. Insta-Trac™ 4-wheel drive, a 4.3 Liter Vortec V6, light bar,** grille guard and more. Inspired by the 1988 Class 7 off-road champion, S-10 Baja takes our message to the street: "Nobody's winning like The Heartbeat of America!"

**The light bar on S-10 Baja is not a roll bar. The support will not protect you in an accident.



THE
Heartbeat
OF AMERICA IS WINNING
TODAY'S TRUCK IS CHEVROLET™

ANNOUNCING THE

Popular Mechanics

DESIGN & ENGINEERING AWARDS

Sometimes, an idea is so good that it demands special recognition. The idea might be a new product that simply does a job better, or it might be a totally new concept in planetary exploration. When we run into such an idea, we often feel the need to recognize it in a special way. Somehow, just telling you about these exceptional new designs in our regular pages doesn't seem quite enough. So we're starting something new: The Popular Mechanics Design & Engineering Awards.

Each year, our editors will review and select their choices for the most significant new products in each of their areas of expertise – new cars, new trucks, car care, boating, outdoors, home remodeling and maintenance, shop tools and equipment, science, technology, aerospace, electronics and photography.

Because of the wide range of areas we cover editorially, to us a "new product" can be anything from a sparkplug to a stealth bomber. Our awards will reflect this wide range of diverse interests. The criteria for selection will be left up to our experts in each PM department. It could be a new innovation in materials, a design that no one ever thought of before, or an improvement on something that has existed for years. There might be five, or eight, or no, awards in any given area. Our editors will make their selections in the latter part of the year and we'll announce our choices to you in our January 1991 issue.

One last thing. We'd like *your* help in getting this important program going. So if you'd like to nominate a new product or new design for an award anytime in 1990, by all means, we'd like to hear from you. Call us on the PM Hotlines, write or fax your nominations to the appropriate editor. Who knows? Maybe one of your selections will receive an award.

Joe Oldham
Editor-in-Chief



TRUE GRIP

The new traction control systems optimize adhesion under all conditions. Here's how they work.

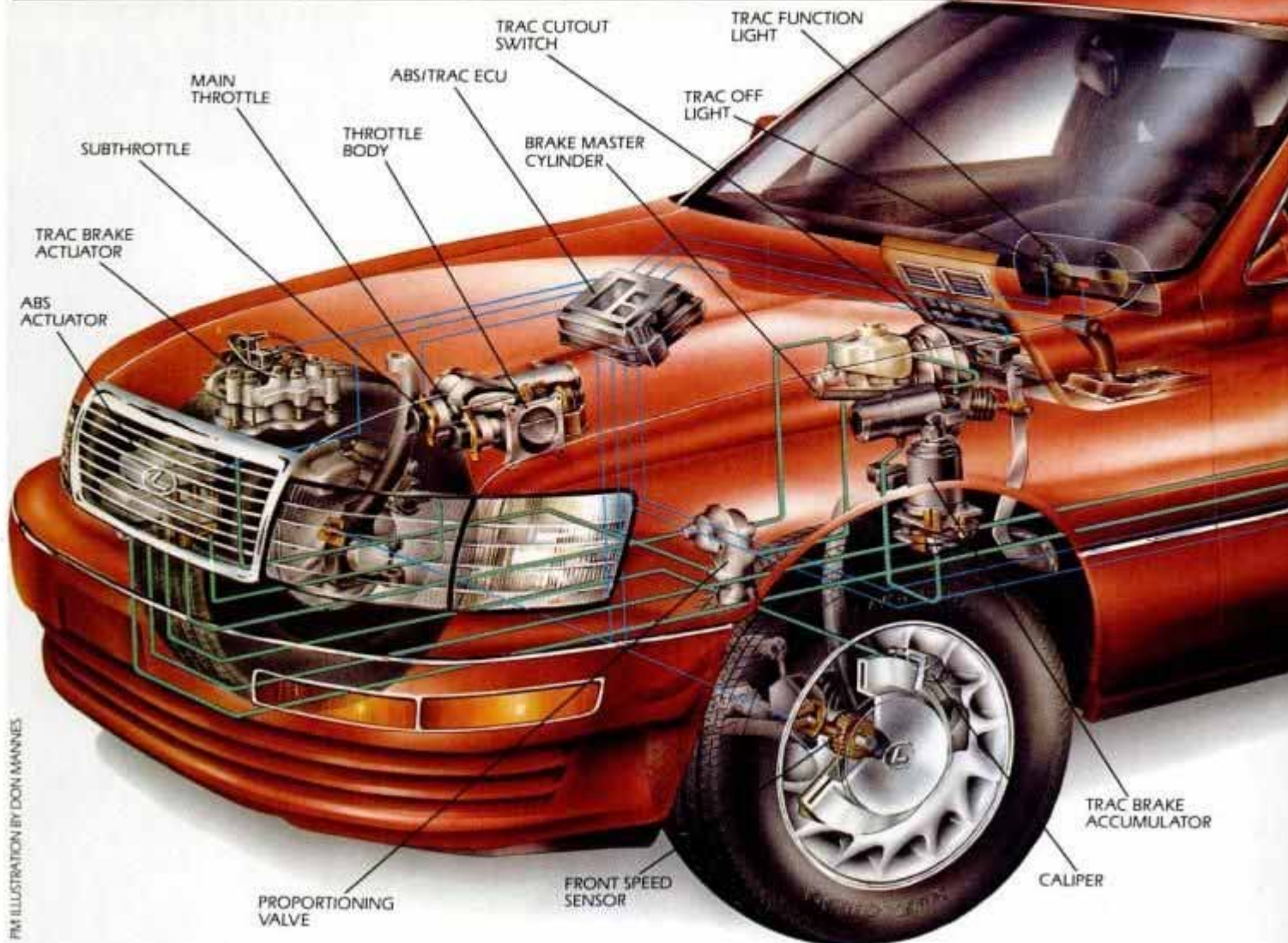
BY PAUL STENOQUIST
PM Photo by Humphrey Sutton

YOU HAVE TO move. Right now. So you hammer the throttle. The tires spin furiously, clawing at loose dust and gravel. The car begins to fishtail un-

der you. You dial in some opposite lock, back off a little, feather the throttle. Slowly, the car begins to take hold and accelerate. But you're going nowhere fast. No fun. And if a 60-ton truck is bearing down on you at 60 mph, a lack of traction can be downright deadly.

Automakers from Munich to Michigan agree. And they're doing something about it. For 1990, a number of new cars are available with traction control systems that regulate wheelspin through computer controlled application of brakes and/or adjustment of engine

TRUE GRIP



FM ILLUSTRATION BY DON MANNING

power whenever traction is lost.

Thus, traction control does more than provide quick getaways. It will also help save your backside if you drive over a patch of ice with one wheel or if one driving wheel loses bite during cornering. We'll look at Cadillac, Lexus and BMW systems.

Cadillac

It comes as no surprise that Cadillac is first among domestic automakers to offer traction control. It's also no surprise that this relatively expensive technology is offered only on the flag-ship fwd Allanté roadster.

Developed by Bosch, the Cadillac system includes four wheel-speed sensors (the same sensors used for ABS control), a microprocessor, a hydraulic plunger unit, a hydraulic pressure accumulator, two mini master cylinders (in addition to the standard master cylinder), and a fuel-injection-system interface. During driving or acceleration, the traction computer constantly monitors data from the front-wheel sensors as well as sensors on the two nondriving wheels.

The sensors on the nondriving wheels provide an indication of vehi-

cle speed and keep the computer informed about differences in wheel speed due to normal differential action caused by cornering.

Should a loss of traction occur, the speed of the drive wheel with less traction increases suddenly and significantly. The computer compares the speed of the drive wheels to the reference velocity for the nondriven wheels and almost instantly recognizes the abnormal increase in wheel speed, indicating loss of traction. It then sends a signal to the hydraulic plunger unit to activate a mini master cylinder, which takes pressure from an accumulator and delivers pressure pulses to the brake caliper on the slipping drive wheel. The duration or width of these pulses is increased until the slippage is regulated to approximately 10 percent of wheel speed.

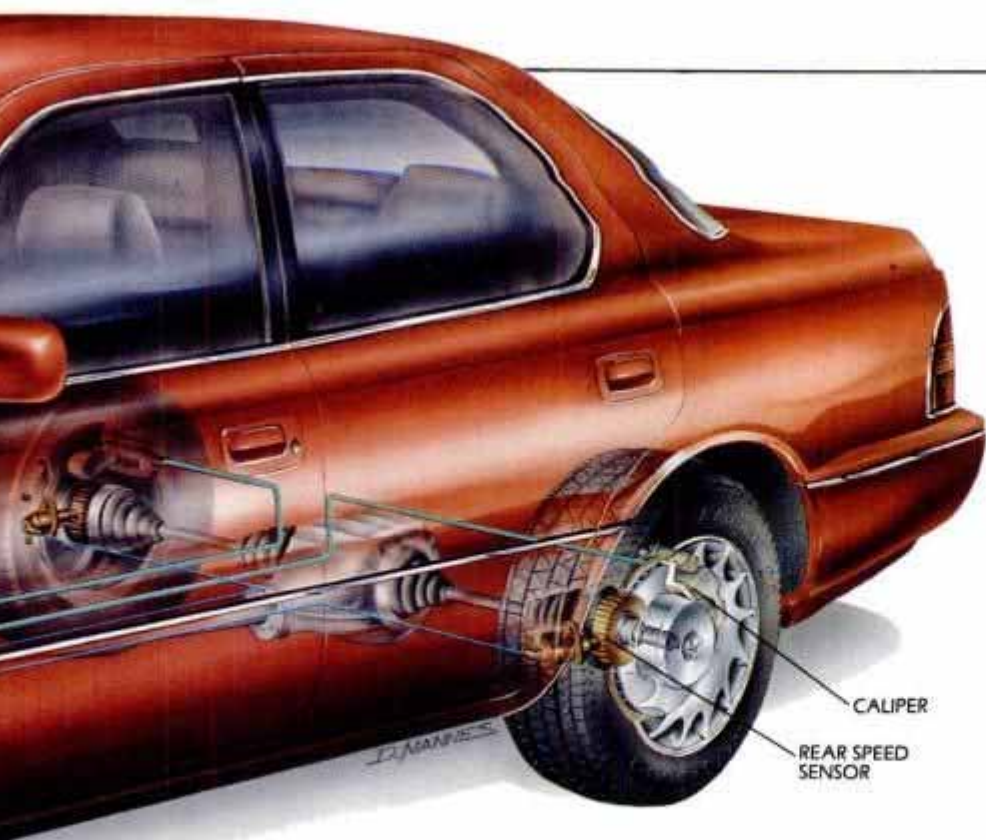
As brake pressure is applied to the slipping wheel, proportionately more torque is delivered to the other driving wheel. This is the result of normal differential action. And this is why traction control can do a better job of optimizing traction than even the best driver can accomplish manually.

Consider what happens to a car

without any type of traction control if one drive wheel is buried deep in slippery snow and the other drive wheel is on dry pavement. In this scenario, the wheel in the snow spins out of control while the other wheel doesn't turn at all, held by the tractive force of road against tire. With traction control, the spinning wheel is braked. Because the differential now meets more resistance at the axle of the slipping wheel than at the axle of the wheel on dry pavement, it directs more torque to the wheel with traction. A limited-slip differential will do the same but won't be any help where the dry wheel hits a slimy spot 2 ft. farther down the road.

Meanwhile, the wheel-speed sensor keeps signaling the computer, allowing constant adjustment of hydraulic modulation and regulation of wheel slippage. Brake pressure pulses are applied approximately 10 times per second. If both drive wheels lose traction, the computer will modulate hydraulic pressure to *both* drive-wheel brakes.

Should wheel slippage at one or both wheels continue beyond 3 seconds, the computer will begin to re-



LEXUS LS 400 TRACTION CONTROL

Lexus LS 400's traction control (TRAC) is typical of the new microprocessor-controlled systems. In rear-wheel-drive Lexus, the ABS/TRAC computer (ECU) constantly monitors front- and rear-wheel velocities, with sensors at each wheel. (ECU also modulates brake pressure to front and rear callipers, through proportioning valve, while braking.) When rear wheels overspeed the fronts, the TRAC actuator, using hydraulic pressure stored in the TRAC brake accumulator, will apply the otherwise conventional rear callipers hard enough to prevent wheel speed differences greater than 10 percent. On lengthy patches of slippery surface, the TRAC computer will close off the secondary subthrottle butterfly valve electrically, reducing horsepower dramatically even if the main throttle is wide open.

duce engine power by shutting off fuel to engine cylinders. After the first 3 seconds of brake modulation, the fuel supply to one cylinder is gradually leaned out, then shut off. If brake modulation continues, an additional cylinder will be cut out every 3 seconds until the car is running on only four cylinders.

By reducing power, stress on the drivetrain, transmission, brake system and engine is reduced. Without control of engine power output, the traction control system could only remain active for a short period of time. When traction control is active for 2 seconds, a dashboard light is illuminated, signaling the driver that he's operating in slippery circumstances.

Lexus

The Lexus traction control system, called TRAC, is optionally available on the LS 400 Sedan.

Because Lexus is a rear-drive automobile, control functions act on the rear wheels. Another readily apparent difference is that the Lexus system is driver selectable. A console-mounted switch allows the driver to disable traction control when he wants to. There are occasions where

spinning the tires actually generates more motion than controlled slip.

Some other differences between the Lexus and Cadillac systems are not so immediately obvious. Rather than using separate microprocessors for ABS and traction system control, as Cadillac does, the LS 400 manages both from a single ECU. Like the Cadillac system, Lexus traction control reduces engine power and applies drive-wheel brake pressure to prevent wheel slippage. Unlike the Cadillac system, Lexus immediately begins to reduce power when traction problems are detected by the ECU.

The Lexus system differs also in the way it reduces engine power. Rather than cutting out cylinders, TRAC utilizes a second valve in front of the main throttle valve. When engine power reduction is required, this subthrottle closes in response to signals from the ECU.

BMW

The Munich maker calls its traction control system Automatic Stability Control (ASC). Found only on the top-of-the-line 750iL 12-cylinder sedan (availability will be extended to the 535 model later this year), ASC is

new for the 1990 model year.

ASC relies fully on control of engine power to prevent wheelspin. This, of course, requires rather precise regulation of throttle. This precision is possible because the big Bimmer utilizes fly-by-wire engine throttling. In other words, there is no direct link between the accelerator and the fuel-injection throttle.

Like the other traction control systems, ASC utilizes four wheel-speed sensors to determine when wheel slippage occurs. Because the BMW is a rear driver, the rear-wheel sensors are the ones that will report any increase in wheel speed and the front-wheel sensors serve as the baseline indication of vehicle speed and current differential action.

If the ASC computer recognizes a traction problem, it overrides any demands for more throttle that may be coming from the driver and controls engine output to keep those drive wheels pushing right near the limit of adhesion. To cushion any abrupt changes in power flow, ignition timing is also regulated as the throttle opening is changed. If wheel slippage continues after the throttle opening has been reduced to the minimum value for a given road speed, the ignition timing is further retarded to reduce engine power. Should both of these measures fail to prevent wheel slip, ASC can briefly discontinue engine operation until the wheels have regained traction. Because all of these control events happen in milliseconds and are continued only until traction is restored, they are virtually imperceptible to the driver.

A really sophisticated feature of the BMW system operates when you get off the throttle. It regulates engine braking during deceleration to prevent wheel breakaway on poor traction surfaces. When rear-wheel breakaway occurs on deceleration, MSR opens the throttle slightly and adjusts ignition timing to minimize engine braking, restoring traction.

Like Lexus, BMW allows you the option of turning off the traction control system with a dashboard switch. BMW quite correctly points out that traction control isn't always desirable and lists conditions when the old right foot and your very own built-in, seat-of-the-pants control unit are superior to electronics. The occasions are while driving in snow with rear-wheel chains and when starting off or driving uphill on an extremely poor frictional surface. And our favorite: When driving "enthusiastically" on road surfaces with varying traction.

Apparently, it's okay with BMW if we have fun from time to time. **PM**



EYES ON THE UNIVERSE

The first of four huge space telescopes will be launched by NASA this month.

BY WALTER SORRELLS

AFTER THE SHUDDER of the rockets has ceased and their glow has receded into the dark smear of the planet below, the ponderous craft will settle into orbit, point its great eye out at the endless night and begin the slow task of learning to see. It will take months to learn. Months before the distant stars begin to shine. Months before the hazy planets begin to resolve. Months of learning, of calibration, of testing. But then, the great eye will see—deeper, farther, more clearly than anything that has come before it.

The craft is the Shuttle-borne Hubble Space Telescope, the greatest optical telescope in history. Once fully operational, its probing eye will stare into the infi-

nite darkness, seeking out the timid smudges of light we hope will help us unravel the mysteries of the universe. Mysteries such as how galaxies, stars and planets are formed. Where did our planet come from? How did the universe come into being? And with the help of Hubble's cyclopean eye, we will begin to understand.

Unfortunately, Hubble has one grave limitation. It is blind to almost all electromagnetic radiation outside the visible spectrum. Outside the grasp of its instruments, giant galaxies spew gouts of hot X-ray emitting material into the void. Neutron stars are rocked by thermonuclear quakes. Dark clouds of hot gas gather and form into stars. Distant quasars spit gamma rays with such violence that their vestigial fury may be seen across trillions of miles of space.

But to Hubble, all of this is invisible.

Recognizing that the sky yields its mysteries grudgingly, and from all parts of the spectrum, NASA has assembled plans for a program of orbiting telescopes to blanket the remaining wavelengths.



Borne aloft by the Space Shuttle, the four satellites of the Great Observatories program will increase the depth and breadth of the visible universe by an order of magnitude. They are (from left to right): SIRTf, AXAF, GRO and Hubble.

These massive telescopes are collectively labeled the Great Observatories. Hubble, scheduled for launch on the Space Shuttle *Discovery* this month, is only the first of four that NASA plans to hurl into space by the end of the century.

Following Hubble on June 4, will be the Gamma Ray Observatory (GRO) which will probe the highest extreme of the spectrum, searching out the most explosive sources of energy in the universe—galactic cores, supernovas, quasars. In 1996, the third of the Great Observatories, the Advanced X-ray Astrophysics Facility or AXAF, will seek to answer questions about phenomena such as black holes, novae and neutron stars. With luck, the last of the four observatories, the Space Infrared Telescope Facility or SIRTf, will go into orbit before the next century begins. SIRTf will hunt for the cool gaseous regions where stars are being born, and for small, unignited suns called brown dwarfs.

Each of the four observatories will break new ground, and will do so on several fronts. But that is not

all that distinguishes them from earlier instruments. "They all maintain a more or less long-term presence in space. They have the capability of being serviced. And they're an enormous step up in sensitivity—typically by factors of 10 both in effective area and spectroscopy," says Allen Bunner, Program Scientist for GRO and AXAF. Indeed, it is increased sensitivity which is the hallmark of the telescopes in the program. In plain language, the more sensitive the telescope, the farther it can see. The angular resolution of Hubble, for instance, is .1 arc seconds. This means it can resolve images 50 times fainter and seven times farther away than any ground-based optical telescope. As a result, the area of the visible universe will increase in one herculean leap by 350 times.

In large part, the higher resolution is due to the lack of atmospheric distortion. In the visible spectrum, the atmosphere diffracts light rays which, while causing the pleasant twinkle of stars to the naked eye, limits the range of even the best telescope.

GREAT OBSERVATORIES

In the infrared, gamma-ray and X-ray spectra, however, astronomers face even greater problems. The infrared spectrum offers only a meager handful of windows through which astronomers can view the sky—and even those are full of the infrared noise produced by our own heated atmosphere. In the high-energy spectrum, the situation is even more difficult. Gamma and X-rays are blocked entirely by the atmosphere.

What will we see?

As stars and galaxies form, they grow hotter and easier to see in the visible spectrum. With the precise resolution of its 2.4-meter primary lens, Hubble can make extremely precise spectroscopic surveys of astronomical phenomena such as supernovas. It will, for example, spectrographically identify elements produced in the later stages of supernova SN 1987A, a star which exploded in the Large Magellanic Cloud in 1987. The result may show the origins of heavy elements which form the building blocks of our universe.

Perhaps the strangest of the four observatories is the Gamma Ray Observatory, which will fly shortly after Hubble. GRO, a great lumpy satellite weighing over 35,000 pounds is not a telescope in any conventional sense. Rather, it has four instruments that peer into different parts of the gamma-ray spectrum.

In the heart of GRO's largest instrument, the Yugo-sized Energetic Gamma Ray Experiment Telescope (EGRET), a 900-pound block of sodi-

um iodide crystal squats swathed in tantalum sheeting. As high-energy gamma rays slam through the tantalum and into the giant crystal, a pair of charged particles is produced. This electron-positron pair shoots through EGRET at the speed of light, emerging through one of 36 spark chambers which records the reaction.

The first mission of EGRET and its partner instrument, the Imaging Compton Telescope, will be a one year, all-sky survey of the gamma-ray spectrum, yielding the first detailed picture of the gamma-ray sky. It will reveal important data about quasars, supernovas and our galactic core.

"The survey is going to provide detection limits down to a factor of 10 to 20 times better than any existing observations," says Donald Kniffen, GRO project scientist.

Because X-rays are so energetic, they are absorbed rather than reflected by relatively flat surfaces like those on the Hubble or SIRTf mirrors. As a result, AXAF employs an unusual optical device known as a Wolter Type 1 grazing incidence mirror. This employs two sets of cylindrical mirrors nested within each other like bottomless waste baskets of different sizes. An X-ray enters the telescope parallel to the mirror sets, and glances off one of the first sets of six mirrors (which have a slight paraboloid figure) at a very shallow angle. The X-ray then caroms off of a corresponding mirror (this one a hyperboloid) in the second set, which channels the photon toward the focal plane. These odd mirrors will allow AXAF

to see eight times farther than the Einstein Observatory (HEAO-2), which had previously been the most powerful X-ray telescope.

Prime targets for AXAF are quasars. Little is known about them beyond the fact that they are extraordinarily violent sources of energy. Though only about the size of our solar system, quasars throw off more energy than all the stars in our galaxy combined. Despite their inexplicably high energy output, only a handful have yet been located.

This will change. Because they are extremely bright in X-rays, "AXAF will find quasars like gangbusters," says AXAF Project Scientist Dr. Martin Weisskopf.

Among the deepest astronomical mysteries are those associated with the birth of galaxies. Generally, these phenomena are hidden by galactic dust, leaving crucial questions unanswered. At what point did galaxies form? Do black holes provide the energy for the highly energetic so-called active galaxies? What is happening at the center of our own galaxy?

"There's a ubiquitous interstellar dust that apparently plays a very fundamental role in star formation itself," says Dr. Fred Gillett, acting program scientist for SIRTf and an astronomer at the Kitt Peak Observatory. This dust forms a floating cosmic slush blocking out radiation in the visible and higher spectra. Only the last of the four observatories, SIRTf, will allow us to study the shrouded realms where galaxy formation occurs.

Using its powerful, cryogenically cooled 1-meter class primary mirror, SIRTf will focus a broad range of infrared radiation on its bank of sensitive instruments. SIRTf's infrared camera, utilizing advanced arrays cooled to a mere fraction of a degree above absolute zero, will pierce much of the primeval dust, giving us our first images of protogalaxies and forming stars.

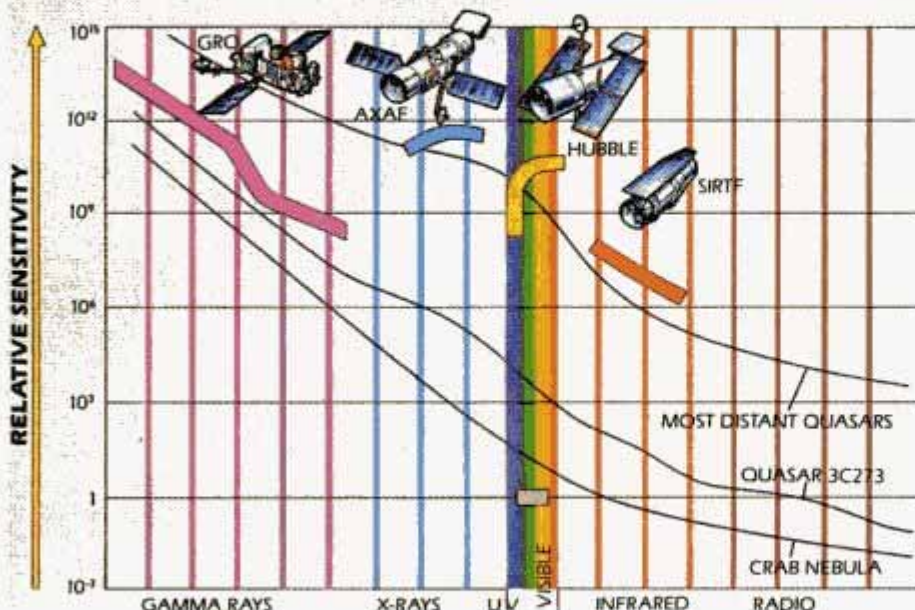
Synergy

But it is not just as individual observatories that Great Observatories will make their mark. "What we're trying to do," says Hubble's Program Scientist Dr. Edmund Weiler, "is cover the electromagnetic spectrum from gamma rays to infrared. You learn different things about the same object by looking at it from different angles."

What secrets will these brawny new telescopes uncover?

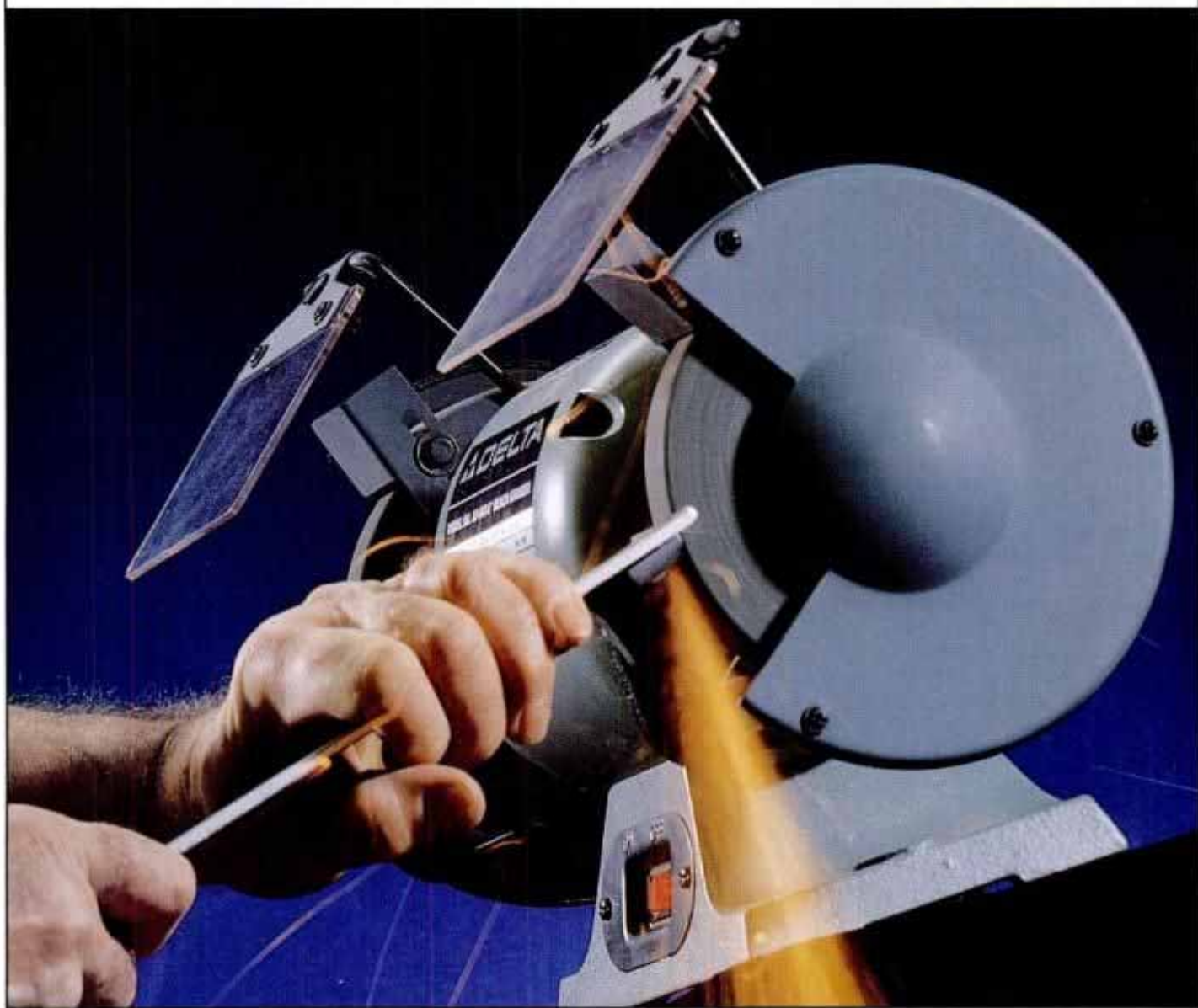
According to Dr. Weisskopf, "It is very safe to predict that once we get them up and going, we will see a revolution in our understanding of the universe."

SENSITIVITY ACROSS THE SPECTRUM



The Great Observatories cooperate to capture radiation from gamma rays to infrared. The most distant quasars are within range of all but GRO. And all four can see nearer phenomena, yielding full-spectrum views of objects such as quasar 3C273 and the Crab Nebula.

JOURNAL



TOOL TECHNIQUES

BENCH GRINDER BASICS

How to harness this versatile, 2-wheeled abrasive machine.

TEXT AND PHOTOS BY
ROSARIO CAPOTOSTO,
Contributing Editor

IF YOUR metalworking tools are limited to a hacksaw and a few files, you're missing out on one of the most useful tools around—the bench grinder. Once you've had one in your workshop for a while, you'll probably find it indispensable for performing a wide variety of jobs around the home and shop.

Woodworkers have long recognized the grinder as a fast and efficient machine for shaping bevels prior to honing. And, it's an excellent tool for putting the finished edge on cold chisels, shears, axes and other cutting tools.

In addition to keeping your tools sharp, the grinder is *the* tool for removing burrs from castings, dressing rough-sawn metal and handling general metal shaping. A wide variety of

interchangeable abrasive wheels are available in different grades and types to suit specific applications.

However, this versatile tool isn't limited to ordinary grinding operations. Substitute a grinding wheel with a wire wheel, and you're ready to remove rust, scale and paint. Or switch to a buffing wheel for polishing metals and plastics.

As with any other power tool, it pays to familiarize yourself with both the principles of operation and the various accessories available so you can safely achieve the intended results. Once you know how the tool works and which wheels you should use on specific jobs, all that's necessary is a little practice to refine the techniques of grinding, shaping, cleaning and polishing.

The Grinder

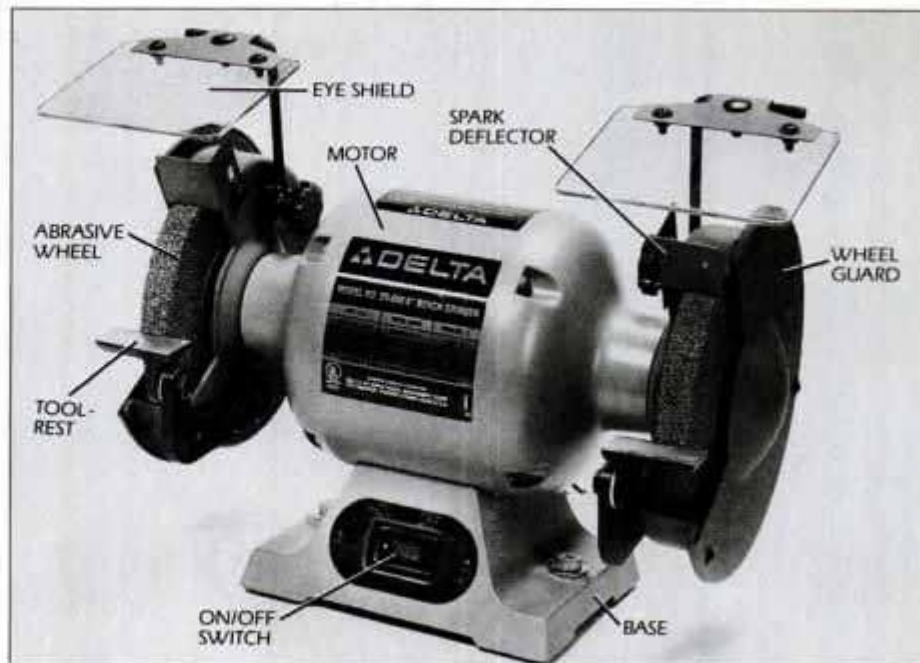
COMPARED TO most other machines, a grinder is the essence of simplicity. It's basically an electric motor with shafts on each end where the wheels are mounted. Each wheel is secured by a nut and the nut pressure is distributed on the wheel by large washers (Photo 1). To keep the nuts from loosening, the direction of each shaft thread is opposite to the wheel rotation—the lefthand shaft has a lefthand thread and the righthand shaft has a righthand thread.

The size of the grinder is designated by the diameter of the wheel that can be used. Grinders are generally available in 5-, 6-, 7- and 8-in. sizes. Motors range from ¼ to 1 hp with no-load speeds from 3400 to 3800 rpm. Unless you plan to use your grinder for extra heavy-duty work, a 6-in. model will be satisfactory.

When selecting a grinder, first check to see that the motor housing doesn't protrude beyond the circumference of the wheel. If it does, the length of straight work passed across the wheel will be severely limited. Also, make sure that the toolrests are adjustable both in terms of angle and distance from wheel. Toolrests should be kept about ⅛ in. from the wheel



1 Tighten wheel mounting nuts with hand pressure on wheel—never overtighten. Keep washer and wheel face free of debris.



The typical grinder has two wheels driven by a central motor. Safety features include wheel guards, spark deflectors and eye shields. Toolrests are adjustable.

(Photo 2). Then, turn the grinder on and let it run for a minute or so. A well-balanced motor with true shafts will run quietly and smoothly.

Safety standards require wrap-around wheel guards that cover all but a 90° segment of each wheel. The outer covers of the wheel guards are

easily removable for changing wheels. On top of the wheel guards you'll find adjustable spark deflectors (Photo 3) and each wheel will have a shatterproof eye shield. Don't, however, rely on the eye shield alone for eye protection—always wear safety goggles when using the grinder.



2 Position adjustable toolrest no more than ⅛ in. from wheel. Right-angle position shown produces a square ground edge.



3 Adjust the spark deflectors to within ⅛ in. of the wheel to prevent sparks from flying out over the top of the wheel.

Wheels

THERE ARE two manmade materials commonly used in grinding wheels: aluminum oxide and silicon carbide. Aluminum oxide is the choice for grinding high-speed steel, carbon steel, malleable iron and wrought iron. Silicon carbide is best suited for cast iron, tungsten carbide, brass, bronze, aluminum and glass.

Wheels are available in grain sizes of 10 to 1000 grit, and this range is divided into four categories: coarse, medium, fine and very fine. When

selecting a grain size, remember that a coarse wheel will cut faster than a fine wheel, but will leave a rougher surface.

The *grade* of the wheel refers to the hardness or strength of the bonding agent that holds the grains together and is indicated in a range from A to Z. Grades A to H are called soft, I to P medium and Q to Z are rated hard.

As a rule, soft wheels are used on hard materials and harder wheels are used on soft materials. Softer wheels are especially useful for grinding cutting tools because the dulled grains

readily fall away exposing fresh, sharp grains. This reduces heat build-up. A medium-grade wheel (K) is suitable for general-purpose grinding.

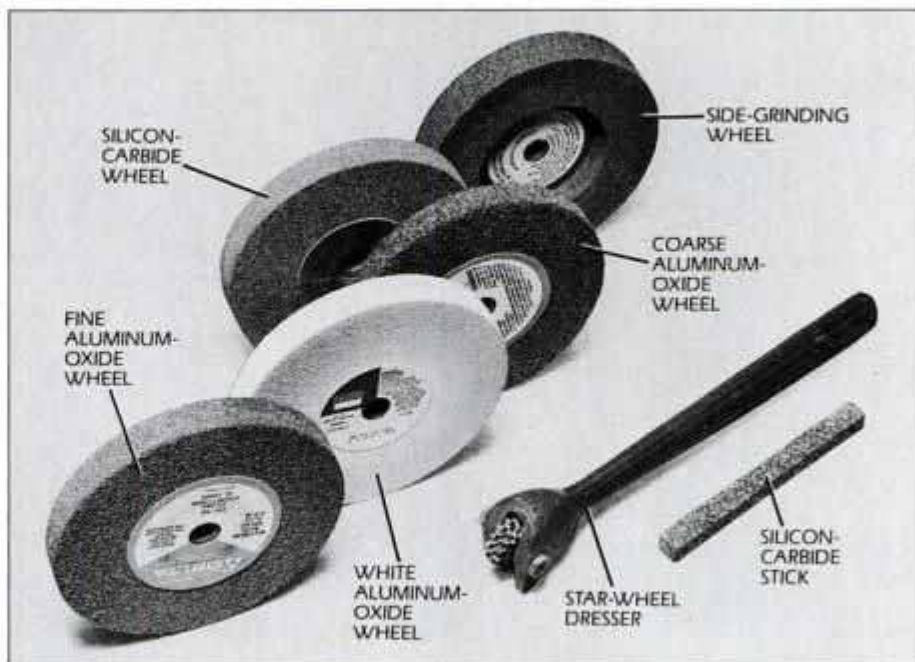
The *structure* of a wheel refers to the grain spacing or density and ranges from 1 to 15. A low number indicates dense spacing and is appropriate for hard, brittle material. Soft metals, however, tend to clog a dense wheel and are better worked with a more open-grained wheel. Also, wide grain spacing results in a coarser finish than close spacing. Tool grinding is best done in the 5 to 8 range.

The material that holds the grains together in most wheels is a vitrified, glass-like bonding agent. Industrial wheels and cutoff wheels may have a different bonding agent.

All of the above characteristics are encoded on the side of most wheels such as 9A 60 J8 V5. The A stands for aluminum oxide (the 9A in this case stands for one manufacturer's white aluminum-oxide wheel). If the letter were C, the wheel would be silicon carbide. The 60 refers to the grain size, J indicates a medium hardness grade, and 8 stands for medium density. The V indicates vitrified bonding and the 5 is a manufacturer's symbol.

A new grinder usually comes with a pair of general-purpose, aluminum-oxide wheels—a 36 grit for rough work and rapid stock removal, and a 60 grit for fine work and sharpening. You might add a 100-grit wheel for finish grinding and a silicon-carbide wheel for touching up carbide-tipped tools. Side-grinding wheels permit safe use of the wheel side when a flat-ground surface is required. And, for trouble-free sharpening of chisels and plane irons, choose a white aluminum-oxide wheel for fast, cool cutting.

When a grinding wheel is worn out of shape, or becomes dull, loaded or glazed, it must be trued and dressed



Most wheels are made of aluminum oxide or silicon carbide. Side-grinding wheel permits flat grinding, and star-wheel dresser and silicon-carbide stick keep wheels in shape.

(Photo 4). Truing is performed with a star-wheel dresser which removes material from the wheel until it runs true (Photo 5). Dressing is done to clean and restore the sharpness of the wheel face and is accomplished with a silicon-carbide stick (Photo 6).

Always check a wheel for cracks

before mounting it—a damaged wheel can fly apart and cause serious injury. After a visual inspection, lightly tap the wheel side at four points near the circumference with a screwdriver handle. A good wheel will produce a clear metallic ring. If the sound is dull, discard the wheel.



4 This wheel is partially clogged and needs to be dressed. If wheel clogs often, it may be too hard for the material being ground.



5 Use a star-wheel dresser to true face of wheel that has worn unevenly. Heavy sparking indicates more pressure is needed.



6 To clean and restore the sharpness to a dull or clogged wheel, pass a silicon-carbide stick over the rotating wheel.

Techniques

TO SHAPE the bevel on chisels and plane irons, first set the tool rest so the tool contacts the wheel at the appropriate angle. Then, with the blade firmly on the toolrest, grind the bevel with a continuous, smooth side-to-side motion and light pressure (Photo 7). If a discoloration appears on the edge, excessive heat has drawn the temper and the tool won't stay sharp for long (Photo 8). The solution is to grind away the affected area and regrind the bevel (Photo 9). Always



7 To shape a hollow-ground bevel on a chisel, first set the toolrest angle. Index finger under toolrest guides chisel across wheel.



8 Discoloration on this chisel indicates overheating that has drawn the temper from the steel. Edge won't stay sharp during use.

keep a bowl of water on hand to cool the edge as the grinding proceeds.

Drill bits and lathe skew chisels are best sharpened on the side of a side-grinding wheel. Special grinding jigs like these benefit from shopmade jigs secured to the toolrest bracket (Photos 10 and 11).

Both jigs are based on a 1/2-in.-thick plywood platform that takes the place of the toolrest. Shape this piece to suit your grinder and cut a 1 1/4-in.-deep notch for the wheel. The platform is secured to the toolrest bracket with 1x4 right-angle stock.

To flat grind the bevels on a skew chisel, first make a guide block to attach to the platform. Cut compound

angles on each side so the chisel will meet the wheel side at the correct angle. We used a 78° bevel angle with the tool tilted 10° from vertical. Center the block on the plywood platform and secure with nails and glue.

To make the drill bit sharpening jig, attach a 1/2-in.-sq. guide block to the right side of the wheel notch so it's positioned at 59° to the wheel side. Then, lay out guidelines at 47° to the wheel, spaced about 1/8 in. apart. Place the bit against the guide block so the cutting edge is horizontal. Let the edge contact the wheel and immediately rotate the bit 1/6 of a turn while shifting it to align with the guidelines. Then, sharpen the other edge in the

same way (Photos 11 and 12).

Smoothing rough-sawn metal is another common job for the grinder. Set the toolrest at right angles to the wheel and pass the stock gently across the wheel edge (Photo 13). Smooth edges on round stock by grinding a bevel on the edge. Set the toolrest at 90°, hold the stock at an angle and rotate it clockwise (Photo 14).

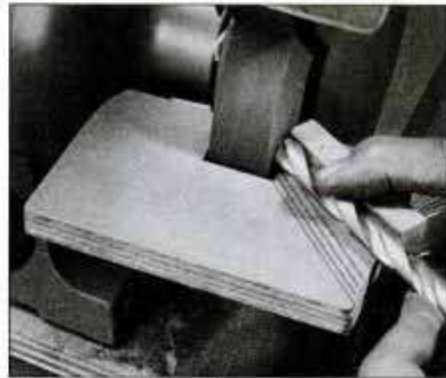
To smooth the edges of glass, remove the toolrest and hold the glass below the center of a silicon-carbide wheel and shape the edge freehand (Photo 15). The grinder is an excellent tool for deburring iron castings and removing rivets when disassembling garden tools (Photos 16 and 17).



9 To regrind an overheated tool edge, set toolrest to 90°. Grind beyond discoloration. Then, reset toolrest and reshape bevel.



10 Sharpen flat-ground bevel of lathe skew chisel on side-grinding wheel. Jig keeps blade positioned for uniform bevel.



11 Use jig attached to toolrest bracket to sharpen drill bits. Guide block, set at 59° to wheel side, properly aligns edge of bit.



12 Finish sharpening bit by rotating bit clockwise 1/6 turn while shifting it to guidelines positioned at 47° to wheel side.



13 To smooth hacksaw marks in metal-working, first set toolrest to 90°. Support work on toolrest and feed against wheel.



14 Bevel round stock by supporting it on a level toolrest and rotating the stock clockwise while moving across wheel face.



15 Use a silicon-carbide wheel to smooth glass. Remove toolrest and guide work freehand below wheel centerline.



16 Silicon carbide is also recommended for grinding cast iron. Avoid heavy pressure that may overheat and damage wheel.



17 Riveted tools like this garden shovel can be disassembled for repair by grinding away the rivet heads with a coarse wheel.

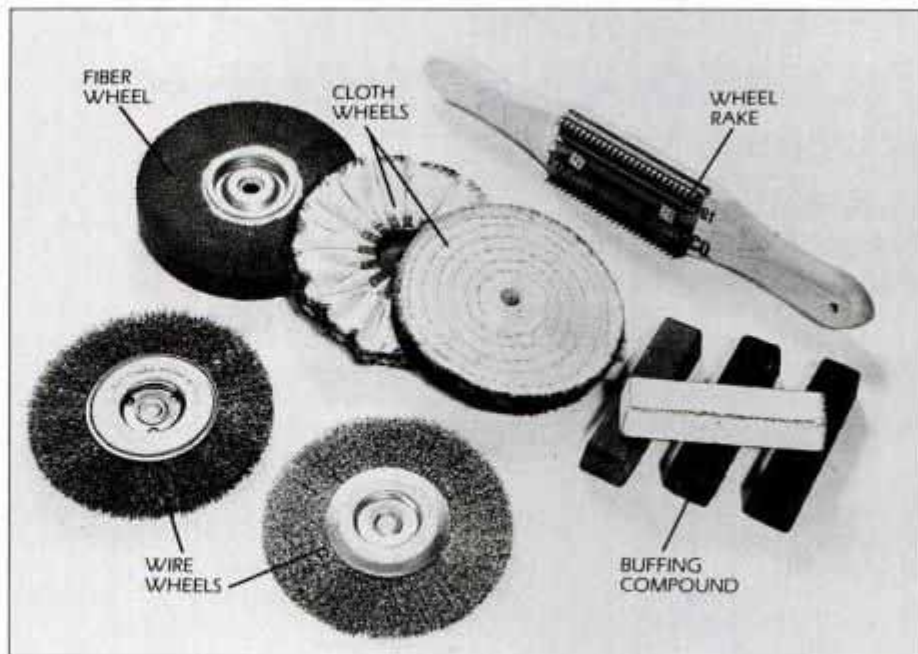
Cleaning & Polishing

TO CLEAN rusty, corroded metal or remove paint, simply remove one of the wheels and install a wire brush wheel. These come in coarse or fine grades. Use the coarse wheel for heavy cleaning jobs and the fine one for delicate work where a satin finish is required (Photo 18). Fiber wheels are available for light-duty tarnish removal. When cleaning edged garden tools such as shears, hold the edge away from the rotating wheel, not directed into it (Photo 19).

To polish metal and plastics, you'll need a cloth wheel and buffing compound. Cloth wheels are either tightly sewn, or loose, where the layers of fabric are secured only at the hub. The tightly sewn wheel provides a stiffer edge, but the loose wheel allows you to polish tight curves.

Buffing compounds are very fine abrasives and come in a range of grades. Jewelers rouge is the finest grade and should be used on precious metals and when the highest gloss is desired. For chrome, use slightly coarser white pumice compound. Tripoli is a medium grade compound and, for the coarsest buffing, choose emery buffing compound.

To polish, first install a buffing wheel and, with the grinder turned



Wheels for cleaning and polishing include wire wheels, fiber wheels and cloth wheels. Cloth wheels are impregnated with buffing compound before use and cleaned with a wheel rake.

on, hold the buffing compound against the wheel to impregnate the cloth with abrasive (Photo 20). Then, bring the workpiece up to the lower area of the wheel and apply gentle pressure (Photos 21 and 22).

To keep your cloth wheels in shape, have a wheel rake on hand for removing caked compound (Photo 23). **PM**

Source List

Bench grinders and accessories are available from mail-order suppliers as well as local hardware and tool dealers. Following are sources for more hard-to-find items:

- Woodcraft, 210 Wood County Industrial Park, Parkersburg, WV 26102
- Garrett Wade, 161 Avenue of the Americas, New York, NY 10013
- Sears Tool Catalog, Sears Tower, Chicago, IL 60684



18 Use a coarse wire wheel to remove rust and scaling paint. Fine wire wheels mar less and produce a satin-like finish.



19 To remove tarnish on garden shears and other tools, use a fiber wheel. Always hold tool cutting edge away from wheel rotation.



20 Prepare cloth wheel for buffing by pressing compound to wheel edge while grinder is running. Avoid heavy application.



21 Use a cloth wheel loaded with white (pumice) compound to polish chrome. Always hold work to lower section of wheel.



22 Use a loose cloth buffing wheel for reaching into confined areas. Jewelers rouge is appropriate for precious metals.



23 Wheel rake is used to dress the edge of cloth buffing wheels. It removes caked compound and trims frayed edges flush.

THE BETTER HOME HOMEOWNERS CLINIC

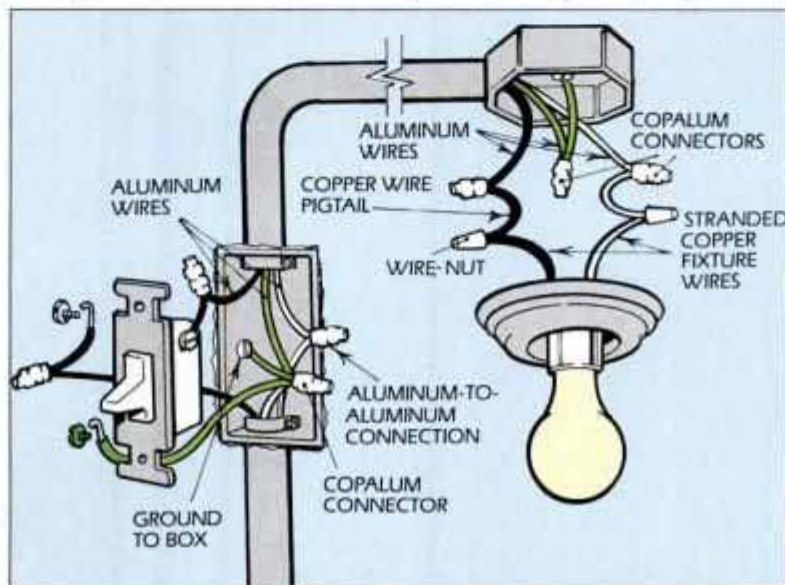
BY NORMAN BECKER, P.E., Contributing Editor

Aluminum Wiring Hazard

We bought our home in 1985 and plan to add several new electrical circuits and to install new light fixtures and ceiling fans into already existing circuits. The problem is that all circuits, switches, light fixtures, receptacles and appliance connections were wired with aluminum wiring components.

We know we must replace failed switches and receptacles with ones that are approved for use with aluminum wiring, but we don't know what to do about installing new copper-wired fixtures in existing circuits. A friend warned us that connecting copper to aluminum wiring could create a fire hazard. Is this true?

ROBERT HUTCHINS
RALEIGH, NC



Connect existing switches, outlets and fixtures to aluminum wiring with copper pigtails and specially designed Copalum crimp connectors.

Aluminum wiring is a potential fire hazard. Between 1965 and 1973 about 1.5 million homes were wired with aluminum, which at the time was approved by the National Electrical Code. Later, it was found that dangerous overheating in 15- and 20-amp branch circuits, at some connections between aluminum wires and outlets, switches, fixtures and appliances, resulted in fires.

Correcting the problem does not require rewiring the house. You can replace switches and outlet receptacles that are unmarked, or marked AL/CU, with devices that are marked CO/ALR. Or, you can use existing switches and outlets provided you attach short copper pigtails to the ends of the aluminum wires and to the devices (aluminum-to-aluminum splices are an exception). It's also necessary to connect light fixtures and appliances with copper pigtails.

Because of the potential for a fire, it is important that copper wire pigtails be attached to aluminum wires with specially designed connectors (Wire-Nuts can be used, however, at copper-

to-copper connections, such as at light fixtures). The Consumer Product Safety Commission recommends using a compression-type crimp connector with heat-shrink insulation. These are called Copalum Compres-

sion Connectors. They, and the crimping tool used to install them, are made by AMP, Inc., Copalum Program, MS 140-13, P.O. Box 3608, Harrisburg, PA 17105.

The connections are best left to a licensed electrician who is equipped to work with them and has been trained by AMP, Inc. For more information, and the name of an AMP-certified electrician, call the Product Information Center at (800) 522-6752.

Duct Dust

Several years ago, we had a furnace installed and started getting a great amount of dust every time it was on. We had the same company that installed it check it, but were assured everything was okay. After a couple of years, we asked someone else to check it out. It was discovered that a return air duct had been laid over the dirt floor in the crawl space with no cap, and all the dust was being brought into the house. Other than taking the ducts down to remove the dirt, is there anything we can do?

It's a year-round problem because

the central air conditioning uses the same ducts.

ROGER DUNCAN
HANCOCK, MN

All warm-air furnace systems must have a filter in the return duct to trap dirt and dust in the airstream. The filter prevents airborne particles from getting into the air supplied to the rooms. There could be several ways that the airstream that enters the room picks up particles. The filter may be dirty, it may not be the correct size or it may not have been installed properly so particles slip past it. Or, you may not even have a filter. If none of the above cause the problem, you might have an electrostatic filter installed in the return duct. These filters are effective in removing dust and dirt from the air.

Although the end cap on the return duct in the crawl space was finally installed, you should also seal the joints between the duct sections with duct tape. Open joints could be a source of dust entering the airstream. Also, the portion of the return duct in the crawl space should be insulated as an energy-saving measure. **PM**

Service Tip

The U.S. Department of Housing and Urban Development (HUD) has published three informative booklets. "House Buying" (Item 163V) tells you how to shop for, inspect and finance a house. "Home Buyers Vocabulary" (Item 161V) lists and defines commonly used home-buying terms. "Homeowner's Glossary Of Building Terms" (Item 162V) defines terms used in home construction, repair and maintenance. The booklets cost about \$1 each from the Consumer Information Center, Pueblo, CO 81009, Attn.: R. Woods.

DO YOU HAVE A HOME-MAINTENANCE OR REPAIR PROBLEM?

Just ask Norman about it. Send your question to Homeowners Clinic, Popular Mechanics, 224 West 57th St., New York, NY 10019. While letters cannot be answered individually, problems of general interest will be discussed in the column. For more home-repair and maintenance help, get PM's Home Care Guide, \$2.45 postpaid. Send your order(s) to Popular Mechanics, Box 1014, Radio City Station, New York, NY 10101.



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THE BETTER HOME APPLIANCE CLINIC

BY STEVE TOTH,
Contributing Editor

Keeps Latching

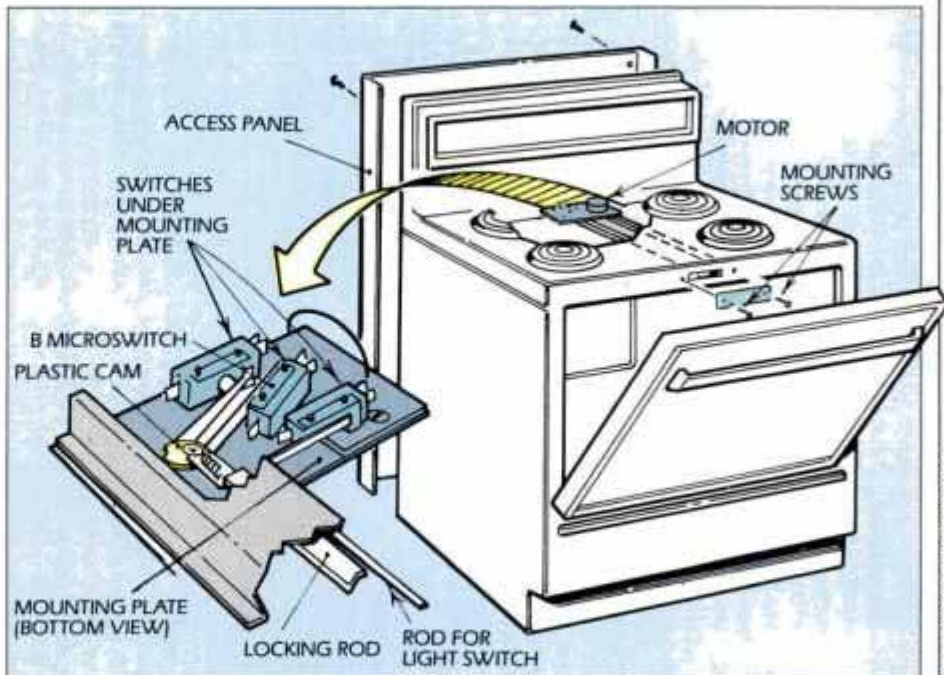
My Tappan self-cleaning electric range model No. 31-252326/01046-1407048 has a problem with the motor that operates the latching mechanism. When I turn on the self-cleaning dial, the motor keeps running, latching and unlatching the oven door. It appears that the motor operates a cam that in one cycle touches three different microswitches. Are one of these the problem?
M. SESKIN
BROOKLYN, NY

From all symptoms, I suspect the middle microswitch or the B switch, as it's called, is the culprit. When power is applied to the motor, it turns a plastic cam. The cam pushes a flat metal arm that is attached to a microswitch. When the motor completes half of its cycle in the 30-second run time, it changes the position of the arm on the B switch. This removes power from the motor and latches the door. The switch is not operating as it should. The arm on the switch may be bent, or the contacts inside it may not be opening.

To replace or fix the switch, disconnect power to the range, and remove the rear access panel. The three microswitches are mounted in the center, near the top of the range's back, under a metal plate attached to the locking mechanism channel.

Now, go to the range's front and open the oven door. Remove the two screws which hold the front of the locking mechanism to the range's front. Now go to the range's back and slide the mechanism back 3 to 4 in.

If the switch arm is bent, straighten it with a pair of needle-nose pliers. If the arm is broken or the switch otherwise defective, remove the two screws that hold it to the mounting plate. Be sure to reattach the wires on the new switch to the correct terminals. Next, push the locking mechanism back into position. To get the pushrod for the light switch back through the hole in the range front, guide it through the hole with a small screwdriver. Push the mechanism forward to get the hook for the latch-



To repair or replace the B microswitch, remove the back access panel and the front mounting screws. Slide the mounting plate assembly out the range's back.

ing mechanism through the slot in the front panel.

Before installing the rear access panel, check that no wires have come loose from the microswitch. Order the microswitch from a White Consolidated Industries parts or service company in your area. It's part No. 695T106P02 and costs \$18.

Gas Range Parts

Are parts still available for a Grand gas range, model No. 850, serial No. 41561? I need springs for the oven door and have to replace the extension that leads from the pilot light to the top of the burner.
ED KOLLER
CLEVELAND, OH

The Grand Gas Range Co. was purchased by the Glenwood Range Co. many years ago, and parts are no longer available from the company.

However, Macy's Texas Stove Works (5515 Alameda Rd., Houston, TX 77004) specializes in repairing old gas ranges. You can send them the parts and ask them to match them or send them a photo. Another option is to photocopy the parts by laying them on a copier and covering them with a white towel. In the letter to Macy's, include your name, address and phone number, and the make and model numbers of the range.

Needs Gasket

I have a chest freezer that's about 40 years old. It's a Hotpoint model No.

2FK120B, serial No. CPV235868. The gasket for the door is shot. Would it be possible to find a new one?

V.C. TOMBERLIN
MORGANTON, NC

A replacement door gasket for your vintage freezer is still available. The Hotpoint replacement part number is WR24X5083, and it costs about \$45, plus tax and shipping. Call the G.E./Hotpoint Answer Center at 1-800-626-2000 for the location of your nearest parts center. **PM**

Service Tip

With microwave ovens becoming more popular, many people are wondering if they can use metal in them. Check the manufacturer's instructions. Some older brands cannot be used with metal while some new ones can be used with aluminum foil or frozen food trays.

Use approved containers and increase the cooking time. Food takes longer to cook in uncovered foil trays because microwave energy enters only from the top, and not all around, as with glass cookware. Above all, prevent metal from touching the oven walls. This could cause damage from arcing.

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



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NEW PRODUCTS

SPRING GREENING

Whip your yard into shape with new outdoor power equipment.

BY ROY BERENDSOHN,
Assistant Home and Shop Editor

Steady Speed

Honda's HR215 21-in. cut mower is the industry's first walk-behind with hydrostatic drive. Just set the throttle lever at full speed and adjust pressure on the bale handle to control the drive speed. It's powered by a 4-cycle 4.5-hp engine and has a top-opening 2.4-bushel grass catcher and an aluminum deck. It costs \$740 at outdoor power equipment dealers. For some more information and details,

write to American Honda Motor Co., Inc., 100 W. Alondra Blvd., Los Angeles, CA 90024.



Close-Quarter Mower

To reduce hand trimming after mowing, this 46-in. mower's front-mounted deck and rear-wheel steering allows it to cut close to trees, flower beds, under fence rails and into and around corners. It has a 7-in. turn radius and a traction-assist mechanism to shift weight from the deck to the two front soft-

track tires. Its 17-horsepower, 4-stroke engine and hydrostatic transmission are one assembly, with one oil reservoir for easier servicing. Two foot pedals control drive speed, from 2.5 to 5 mph, forward and reverse. It costs about \$4900 at John Deere dealers. For more information about this mower, contact John Deere at 1400 Third Ave., Moline, IL 61265.



Stand Up/Lay Down

Stand up this chipper/shredder and feed in branches or lay it down and rake into its 18-in. x 22-in. hopper. A safety interlock prevents it from running without the hopper fastened. Powered by a 120-volt, 10-amp motor, its heat-treated steel blades chip branches up to 1 1/4 in. dia. and blow the mulch into a 2.5-bushel high-tensile-strength nylon bag. It costs about \$300 at outdoor power equipment dealers. Write Flowtron, 2 Main St., Melrose, MA 02176.

Automatic Mixer

This 21-in. 2-stroke mower holds 2 quarts of gas and 36 ounces of oil in separate tanks and mixes them at the proper ratio. The manufacturer says it carries enough oil to cut a typical lawn all season, and the 5-hp engine shuts off automatically if oil level is low. Its deck is magnesium alloy. The mower costs about \$770 at most outdoor power equipment dealers. Write Lawn-Boy, Plymouth, WI 53073.



Twice Tilled

This counterrotating tiller churns the soil forward, retilling it as it goes, to quickly break down even hardened soil, its maker says. The self-propelled chain-drive tiller features a 4-stroke, 5-hp Briggs & Stratton engine, handle-mounted controls and a front counterweight. It tills a 17-in.-wide path up to 8 in. deep and has a 7-position depth stake. As a safety measure, it does not till in reverse, and its tines are covered with a hinged guard. It costs about \$750 at outdoor power equipment dealers. For more information about this tiller, write Poulan/Weed Eater, 5020 Flournoy-Lucas Rd., Shreveport, LA 71129.

Cuts Closer

Trim right next to flowers and other delicate plantings with this cordless string trimmer. Weighing 2.6 pounds, it cuts a 6-in. swath and runs about 45 minutes on a full charge. Recharge it overnight. Its monofilament line is .080 in. dia., the same heavyweight line used in gas-powered trimmers. The line is replaced as a snap-in cartridge, and the five cartridges that come with it should last about half a season. Called Clipquik, it costs about \$35 at hardware stores and home-centers. For more information, write to Poulan/Weed Eater, 5020 Flournoy-Lucas Rd., Shreveport, LA 71129.



No Cord Cuts

Designed to eliminate cord cuts and tangles, this hedge trimmer is powered by a 5-pound 12-volt lead/acid battery that hangs off your shoulders and hip with adjustable straps. Fully charged, it cuts up to 1000 sq. ft. of hedge and recharges overnight says Black & Decker. The battery is protected while recharging with a built-in, 20-amp circuit breaker. The 16-in.-long bar can cut in either direction and severs branches up to 3/8 in. dia. It costs about \$95 at hardware and department stores. For more information, write to Black & Decker, 10 N. Park Dr., Hunt Valley, MD 21030-0748.



Rough Rider

You can clear weeds and brush on rough terrain with this mower because its 38-in. sickle bar pivots to follow ground contour. Capable of slicing through a 1/2-in.-dia. sapling, its induction-hardened steel knives are individually replaceable. Power transfer from the 4-stroke, 4-hp engine is by belt and chain drive. Other features include bar-tread tires, handlebars mounted in rubber sleeves to damp vibration and a vibrating grass diverter to push aside the growth that has been cut down. It costs about \$1279 (\$180 extra for key start) from Troy-Bilt Manufacturing Co., 102nd St., Ninth Ave., Troy, NY 12180, (800) 828-5500.

Safe At Home

The two 20-tooth blades on this 3-wheeled edger move back and forth to reduce the danger of rocks thrown by spinning blades. The 42-pound edger is powered by a 1-horsepower, 2-stroke engine, and its blades stop immediately when the engine is switched off. A 32-in.-long handle is adjustable, and the blades cut from 1/2 in. to 2 3/4 in. deep. It costs about \$550 at outdoor power equipment dealers. For more information, write to RedMax, 540 Frontage Rd., Suite 362, Northfield, IL 60093-1210.



Hybrid Hauler

The Kawasaki Mule 2010 is a 4-wheel-drive hybrid. Powered by a 540-cc fan-cooled, 4-stroke overhead valve engine and automatic transmission, its top speed is 22 mph. The Mule weighs in at 1065 pounds and, with a

flip of a switch, can change to 2-wheel drive. Turning radius is 14.8 ft. While pulling 1000 pounds, it can carry 600 pounds of cargo in its 11.3-cu.-ft. capacity, hand-crank-operated dump bed [a hydraulic lift kit is available from the dealer]. It costs about \$6495 at Kawasaki dealers. For more information about the Mule 2010, write to Kawasaki Motors Corp., USA, 9950 Jeronimo Rd., Irvine, CA 92718-2016.





Lawn Sophisticate

Snapper's 12-horsepower, 33- and 41-in. LT12D riding lawnmowers are designed with comfort and ease of maintenance in mind, their maker says. The blade-height lever is located for easy reach, and nine blade settings adjust for grass from 1 to 4 in. tall. Their 6-speed, disc-drive transmissions can be shifted on the go. No tools are necessary to remove the hood or adjust the polyurethane seat. The 33-in. model costs about \$2100 and the 41-in., \$2200 at Snapper outdoor power equipment dealers. For more information and details, write to Snapper Power Equipment, McDonough, GA 30253.

Portable Power

You can work beyond the range of extension cords with this portable electric generator. Powered by a 4-stroke engine, the 54-pound generator measures 11 in. deep x 15 in. high x 15 in. long and produces 120 volts at 11.7 amps or 12 volts at 10 amps. It costs \$700 at outdoor power equipment dealers. Write Yamaha Outdoor Power Equipment, 6555 Katella Ave., Cypress, CA 90630.



One-Stop Tool

The Green Machine 1900 replaces individual equipment with a power head and six attachment tools. A .85-horsepower, 2-cycle engine is mounted on an aluminum shaft with an adjustable handle. With a 3-in. string trimmer head it costs about \$190, with a 3-in. trimmer/brush cutter or a blower, \$230, an edger, \$260, and a snowthrower or cultivator, \$290. It's sold at outdoor power equipment dealers. For more information, contact The Green Machine, HMC, P.O. Box 560, Long Beach, CA 90801-0560; or 20710 S. Alameda St., Long Beach, CA 90810.



Pickup And Go

Attach the Navi-Hoe to a 1/2-ton or larger pickup and drive to where you want to dig. Weighing 850 pounds, it consists of a hydraulic boom and 12-in.-wide bucket, stabilizers, controls, seat, hydraulic pump and mounting hardware. The truck's engine, at idle, powers its hydraulic system. The boom swings 160° side to side and digs to 72 in. deep. The boom, seat and controls can be centered on the bed or to the left or right side. It costs about \$7000 from Navi-Hoe dealers. For more information, write to Navi-Hoe at Full Vision, Inc., P.O. Box 647, W. Hwy 59, Newton, KS 67114.



Tight Control

This 4-wheel-steering, 42-in. tractor has a 12-in. turning radius. Its manufacturer says it tracks truer than other all-wheel-steering tractors because its computer-generated steering mechanism ensures the rear wheels follow the front, eliminating rear-wheel skidding. It's powered by a 14-horsepower twin-cylinder engine hooked to a single-speed transaxle and a 7-speed cruise-control lever. It costs about \$2400 at White Outdoor Power Equipment dealers. For more information, write to White at P.O. Box 361131, Cleveland, OH 44136.



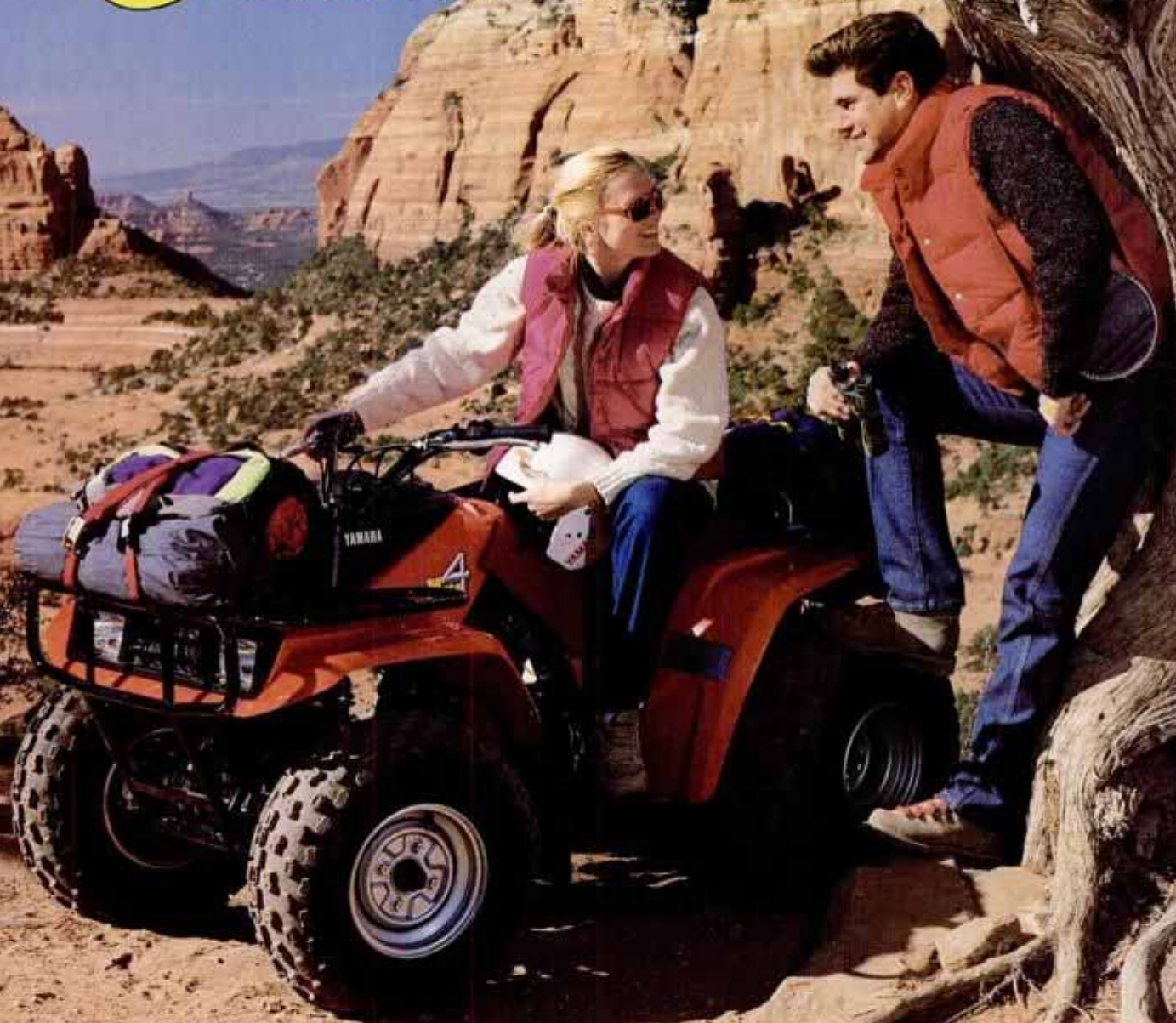
Deep Deck

The 4 1/4-in.-deep mower deck and blade configuration on this lawn tractor create a vacuum that stands up grass for a neat cut and better discharge. The deck pivots with the front axle to prevent scalping, and cutting height is infinitely adjustable from 1 to 3.5 in. A quick-hitch mounting system lets either the twin-blade 38-in. or the triple-blade 44-in. deck be removed without tools. With a 12.5-horsepower engine and 38-in. deck, it costs about \$3000, and a 16-horsepower engine and 44-in. deck, about \$3700 at outdoor power equipment dealers. For more information, write to Simplicity, 500 N. Spring St., P.O. Box 997, Port Washington, WI 53074-0997.

PM

SPECIAL SECTION

High-Tech Outdoors



A PM GUIDE TO THE BACKCOUNTRY'S HOTTEST GEAR

- High-Performance Clothing And The Latest Miracle Fibers
- New-Age Backpacks And Cutting-Edge Accessories
- Next-Generation Tents And Sleeping Bags
- **PLUS:** Breakthrough Equipment For Snorkelers And Divers

BRAVE NEW WORLD

High-tech fabrics, cutting-edge camping equipment and new-wave underwater gear for outbound adventure.

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

GETTING AWAY from it all was never like this. Location: the blue-sky country of Sedona, Arizona. Camp sites: high-altitude ridges, ponderosa-pine forests and cool-water canyons. Red-rock monuments were everywhere. Sunsets blazed each night in wide-screen technicolor. Ah, wilderness.

But as spectacular as the scenery was, the high-tech outdoors gear chosen for field testing was equally

impressive. In fact, a U.S. Forest Service Ranger came by as the PM test team set up camp one day and jotted down notes for his next equipment requisition order.

The truth is that backcountry gear has come a long way in the past couple of years. Today's outdoorsman uses electronic instruments that measure altitude and weather conditions, cooks with multifuel stoves fitted with heat exchangers, overnights in sleeping

bags lined with space-age fabric and keeps warm and dry in clothing made of the latest high-tech textiles.

Outward bound

ATVs are one of the best-kept secrets in outdoor life. Three-wheelers were banned a year ago (the government justly deemed them inherently unsafe), but bigger, safer, more versatile 4-wheelers are still great utility vehicles for those who like to go riding



Wild things for the outdoor life include: high-tech textiles, from Patagonia and L.L. Bean (inset photo above), XPD heat exchanger cooking unit from MSR (inset photo above right), Snuba (inset photo right), an underwater breathing system for noncertified divers, Yamaha's YFM250 ATV and North Face's VE-23 tent (below).



out to where the wild things are.

We tested a new Yamaha 250-cc YFM250 4-wheeler by driving it fully loaded with several hundred pounds of equipment up red-rock moonscapes and near-vertical grades. The 5-speed workhorse is equipped with reverse and both high and low gear ranges. The rugged YFM250 retails for \$3449.

Perhaps the biggest story in outdoors gear is high-tech clothing. The problem is that you need a computer

printout to keep up with the latest breakthroughs in Cordura, Gore-Tex, Hydrofil and dozens of other specialized fabrics. It took us awhile, but we finally figured out the difference between the high-tech and the hype, and concluded there's never been a better time to outfit for the outback.

After we broke camp in Sedona we headed for Key Largo, Florida, to test new-wave snorkel and scuba equipment, another hot area for innovation.

Dive computers, metal detectors and underwater communicators are among the latest high-tech gear.

Getting away from it all means different things to different people. But, no doubt, all outbound adventurers have at least one thing in common—the urge to heed, in some way, the universal call of the wild.

PM

NEW-FRONTIER FABRICS

A guide through the maze of chemistry's latest miracle fibers.

BY TIM BANSE; PM Illustrations by Gary Ciccarelli

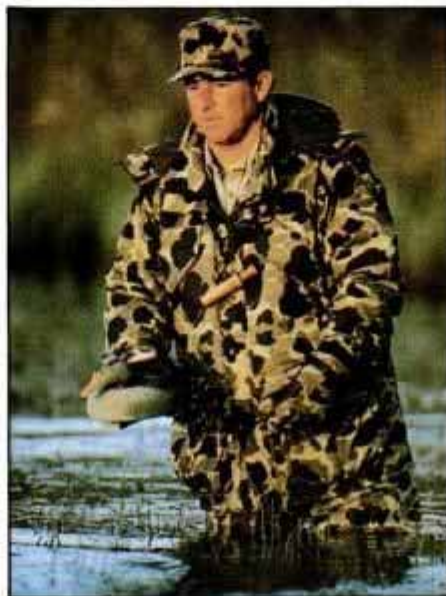
THE PROBLEM OF being miserable in cold, wet weather has been solved. At least that's the claim made by today's high-tech textile mills. Modern outdoors clothing is woven with fabrics that are waterproof, breathable and toasty-warm even in the most adverse conditions. If you buy and wear the right clothes, apparently, you can comfortably ignore a sleet storm.

Unfortunately, this modern miracle has created a new problem of its own. We counted more than 200 fabric names during research for this article. Without carrying a computer printout, how can a person confidently walk into a store and buy the best garment for his needs?

Cracking the code

Buyers of outdoors clothing—and this includes everyone from hunters to campers to football season-ticket holders—are confronted with clothing racks filled with names like Hydrofil, Versatech, Quallofil, Ultrex, HighTrek and dozens of others. Some of these come directly from chemical labs like DuPont, Allied, Amoco and 3M. Some come from fabric companies that purchase fibers and make hybridizations. And still others come from clothing manufacturers that market proprietary names.

The best way to demystify this puzzle is to separate fabrics into three basic categories: 1. shells, 2. waterproof/breathables, and 3. insulation/linings. The shell is simply the outside layer that holds the garment together.



Outdoor clothing using Gore-Tex membrane repels water droplets, but expels perspiration vapor.

er. It's constructed from synthetic or natural fibers or both. Depending on the mill, the shell may be coated or bonded with a semipermeable laminate or membrane.

No doubt the most fascinating question regarding high-tech fabric is: How can a single garment keep rainwater and wind out while allowing perspiration to escape and keeping body heat in? The answer is that waterproof/breathable fabrics are semipermeable membranes, coatings or microporous fabrics capable of differentiating between body-generated vapor and outside drops of water.

Gore-Tex, from W.L. Gore, is probably the most well-known, high-tech outdoors fabric. It is actually a thin film with 9 billion microscopic pores per inch. Each of these pores is 20,000 times smaller than a drop of water, yet 700 times larger than a water-vapor molecule. This means that rain drops are too big to penetrate while vaporized perspiration is easily expelled. When Gore-Tex is bonded with an outer shell you end up with a breathable but totally waterproof, windproof garment.

Microfine, from DuPont, is also microporous, but it isn't a separate membrane or layer. It is a fabric that achieves water repellency and vapor breathability through the density of its weave.

Sympatex, which has the same characteristics as a microporous membrane, is actually a *nonporous* membrane. It achieves breathability through hydrophilic chemistry, which diffuses perspiration along water-attracting regions in the solid membrane.

The same effect can also be achieved by certain coatings. These differ from membranes in that they are spread in liquid form and cured on the shell. Thickness is critical. The coating must be applied as thinly as possible or the water vapor will be trapped inside. If it's applied too thinly, pinholes allow water droplets to migrate inward. MicroTec, from MicroPore, is a microporous coating. Aqua-Guard, from Rotofil, is a nonporous coating. Helper finishes, such as Zepel, are often combined with coatings to induce water to form in large droplets and more easily run off the shell.

Being wet is bad enough, but being cold and wet is insufferable. A good

Light on your feet (from left to right): Vasque Clarion II Hiking Oxford (\$72) and Vasque Clarion II Hiking Boot (\$79), both of which come with removable insoles; L.L. Bean Winter-Sports Sneaker (\$49); Rocky Stalker (\$130) and Hi-Tec Sierra Lite (\$50).



PM PHOTO BY BILASHÉ

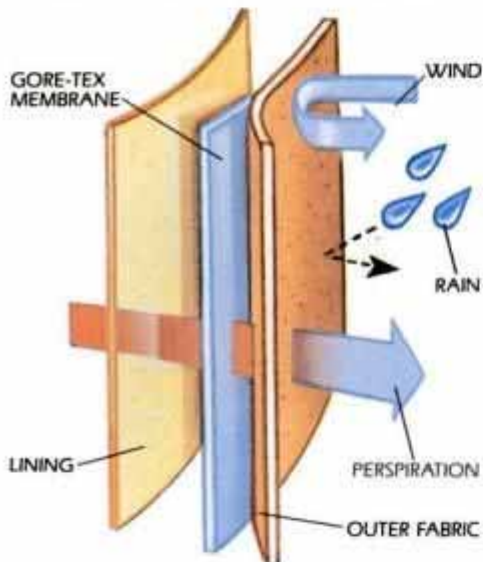
lining eliminates this misery by providing insulation and a degree of moisture management.

Insulating fabrics slow down the natural process of air warmed by body heat migrating outward to the cold. But high-tech textiles, such as DuPont's Thermolite and 3M's Thinsulate, not only combine high heat retention with minimal bulk, but do so even when wet.

Another kind of insulating fabric is composed of fibers that are hollow. Dead air is trapped inside and insulates while the surface area wicks perspiration away. Fabrics that fall into this category are DuPont's Coolmax, Thermoloft, Quallofil and Thermax.

Long underwear, the ultimate warm-weather item, should wick perspiration away from skin, transfer it to outside layers of clothing and provide insulation. To accomplish this,

INSIDE GORE-TEX



HIGH-TECH TEXTILES



WINTER SNEAKER



High-performance clothing pictured in illustration (right) is from Cabela's, Helly-Hansen and L.L. Bean. Gore-Tex (top) was first waterproof/breathable system. Ultralight Winter-Sports Sneaker (above) is from L.L. Bean.

High-Performance Fabrics

Bion III, Bradford Industries, a solid polyurethane film that achieves breathability through hydrophilic chemistry. Can be used as a laminate or coating. Abrasion resistant. Found in outerwear, rainwear, gloves and boots.

Caprolan, from Allied, nonshrinking, durable nylon base that's highly abrasion resistant. Used in rugged outdoor, packs and luggage.

Cambrelle, from Faytex Corp., a tough, nonwoven shell fabric using a nylon core. High rate of absorption and breathability. Resists odor, abrasion and piling. Found in boots and shoes.

Coolmax, from DuPont, a hydrophobic polymer with 4-channel fiber. Great evaporation and wicking capacity. Found in bodywear, sport socks, shoe liners and used for low insulation.

Condessa, from Amoco, also known as Propex III. A shell fabric woven of polypropylene. Used in boots, shoes, rugged outdoor, luggage and packs.

Cordura, from DuPont, was originally used in tires. This tough nylon shell fiber is often blended with other fabrics to soften it. Found in boots, shoes and rugged outdoor, as well as backpacks and luggage.

Entrant, from Toray Industries, is a soft, microporous polyurethane-coated fabric that allows moisture to pass in only one direction. Used as a shell fabric in outdoor and rainwear.

Gore-Tex, from W.L. Gore, a thin, microporous membrane bonded to shell material. It was the first technique to create breathable rainwear. New soft and stretch blends are now found in socks, jeans, gloves, hats and sweaters, in addition to ubiquitous outdoor and rainwear applications.

High Trek, from DuPont, a yarn blend comprised of 55-percent Orlon, 20-percent Hollofil and 25-percent wool. Soft, warm and itch-free, also transports moisture away from body. Insulates even when wet. Found in sweaters, socks, hats, scarves and gloves.

Hydrofil, from Allied, hydrophilic copolymer nylon insulation fiber with rapid wicking ability. Used in thermal underwear, socks, gloves and jacket liners.

Kodofil, from Kodak, a lightweight, tubular polyester insulating fiber. Found in outdoor and sleeping bags. Similar to the softer Kodosoff.

Microfine, from DuPont, the first microfiber of 100-percent nylon. Weaves in water repellency, wind protection and vapor permeability without need for a coating or laminate. Very soft. A shell

fabric of wide application in outdoor.

Microsoft, from DuPont, a microporous fiber with a sanded, suede finish. A weatherproof shell fabric used in lightweight outdoor.

MicroTec, from MicroPore, a microporous fluoropolymer coating that can be used on most synthetic and some natural fibers. Waterproof and breathable. Found in outdoor and rainwear.

Quallofil, from DuPont, a hollow fiber with four channels. Soft and downlike, it maintains loft and insulation qualities through repeated washings. Found in winterwear and even sleeping bags.

Super-Microft, from Teijin America, a weave of polyester yarns that has microcrimps in fibers that create a soft, natural feeling. Water repellent. Used as a shell for down pants and jackets.

Supplex, from DuPont, a lightweight, multifilament nylon. Waterproof and noticeably softer than ordinary nylons. Often blended with natural fibers for outdoor shells.

Symptatex, from Akzo, a nonporous, polyester waterproof/breathable membrane. Laminates to any material and found in shoes, boots, hats, gloves and outdoor.

Thermax, from DuPont, a hollow-core polyester knit that insulates and promotes wicking. Found in thermal underwear, socks, hats and gloves.

Thermoloft, from DuPont, a fine, hollow polyester fiber interlocked with a binding fiber. A mid-loft insulation found in outdoor and winterwear.

Thermolite, from DuPont, a thin-fill insulation similar to Thermoloft. Found in outdoor and some lightweight sleeping bags.

Thintech, from 3M, a nonporous free-standing membrane with hydrophilic tendencies. Used as a laminate layer or insert in outdoor and rainwear.

Thinsulate, from 3M, insulation constructed of 65-percent olefin and 35-percent polyester. Found in everything from outdoor and gloves to boots and hats.

Ultrex, from Burlington, 3-part system of Supplex, microporous inside coating and water-repellent finish: A waterproof/breathable shell fabric found in outdoor and rainwear.

Versatech, from Burlington, a polyester microfiber with waterproof/breathability built in due to the dense weave. Found in outdoor and rainwear.

Zepel, from DuPont, a fluorochemical finish. Effective through multiple washings. Does not inhibit breathability. Used on outdoor and rainwear.

Duofold uses a 2-layer system combining Thermax and wool. The Thermax layer feels soft next to skin and enhances wool's natural warmth and tendency to wick moisture away.

Not too long ago hiking boots were as heavy as a pair of bricks. Not anymore. Supertough Cordura, from DuPont, now replaces leather in upper panels to reduce weight. Microporous membranes and water-wicking insulations, equally lightweight, do their magic to keep feet warm and dry. And Vibram soles, developed by the Army for humping jungle trails in Vietnam, offer good traction and seem to last forever. The result? Rugged boot weighing just 2 pounds.

Hype versus high tech

It's impossible to be familiar with every single fabric, fiber and proprietary brand name. Several new ones, in fact, seem to appear every day. However, there is a way to shop for high-performance clothing and find the garment you need.

First read the hang tag and determine whether the waterproof/breathable component is a membrane or a coating or a microporous weave. Membranes do a slightly better job managing moisture and may last longer. Coatings, on the other hand, tend to be softer and more supple. Microporous weaves, becoming widely used, may be the wave of the future.

Next, check details of construction. Because water tends to seep in at the seams, quality garments tape their seams. The best designs eliminate shoulder seams altogether. Also crucial for keeping out water are flaps behind zippers and closure cuffs.

Waterproof/breathability makes good sense if you anticipate spending extended periods in a driving rain, but it may be overkill for alpine skiing, where you might be better served by waterproof shells.

Some manufacturers tend to confuse buyers by inventing proprietary names. The main thing to remember is that searching tags and labels for primary fibers is the best way to separate high tech from hype. **PM**

Clothing for illustrations and photography:
Cabela's, 812 13th Ave., Sidney, NE 69160, (800) 237-4444

Columbia Sportswear, 6600 N. Baltimore, Portland, OR 97203, (503) 286-3676

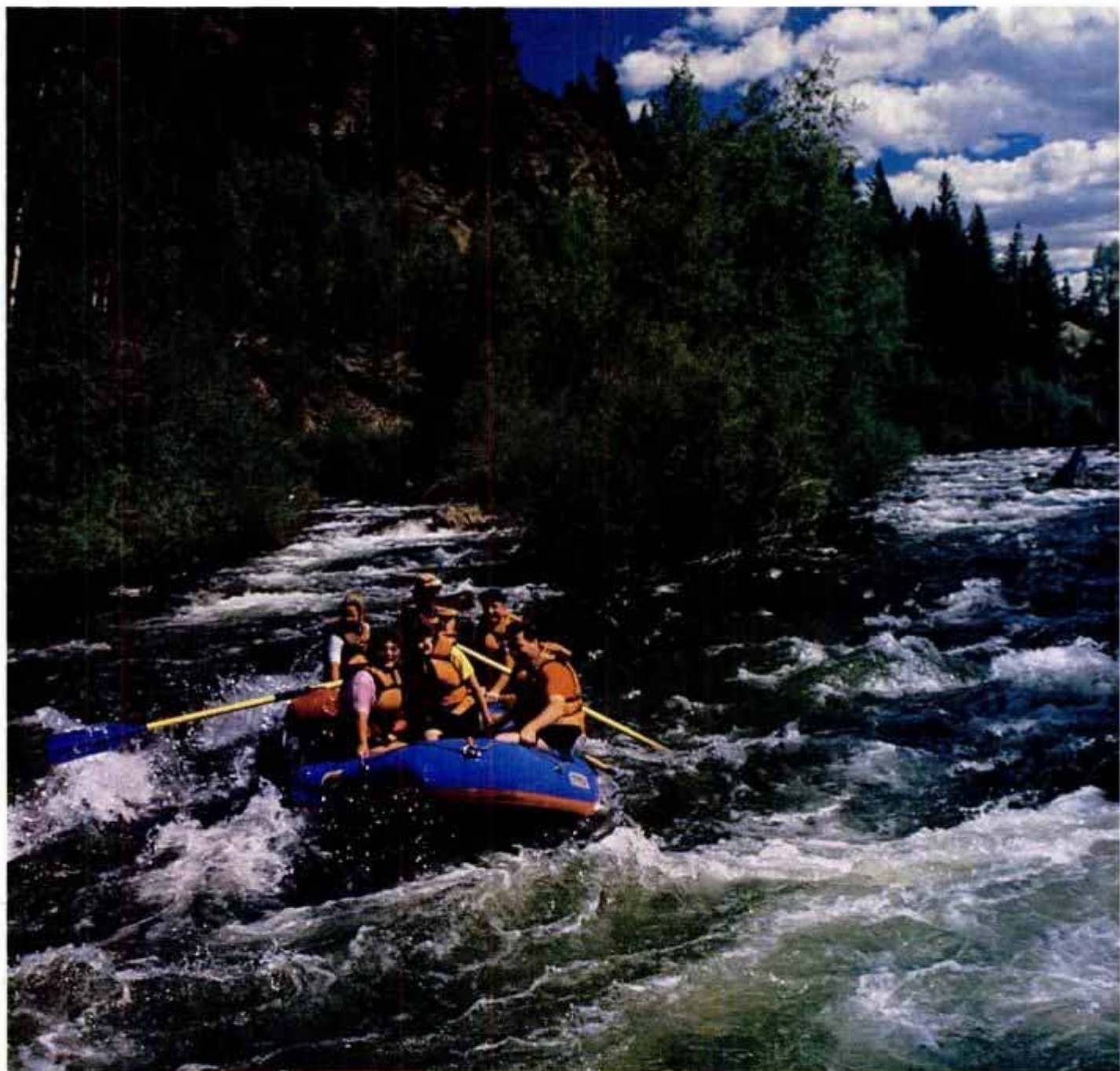
Helly-Hansen, P.O. Box 97031, Redmond, WA 98073, (206) 883-4313

L.L. Bean, Casco St., Freeport, ME 04033, (800) 221-4221

Patagonia, P.O. Box 8900, Dept. 055C, Bozeman, MT 59715, (800) 523-9597

Wrangler, P.O. Box 21488, Greensboro, NC 27420, (919) 373-3400

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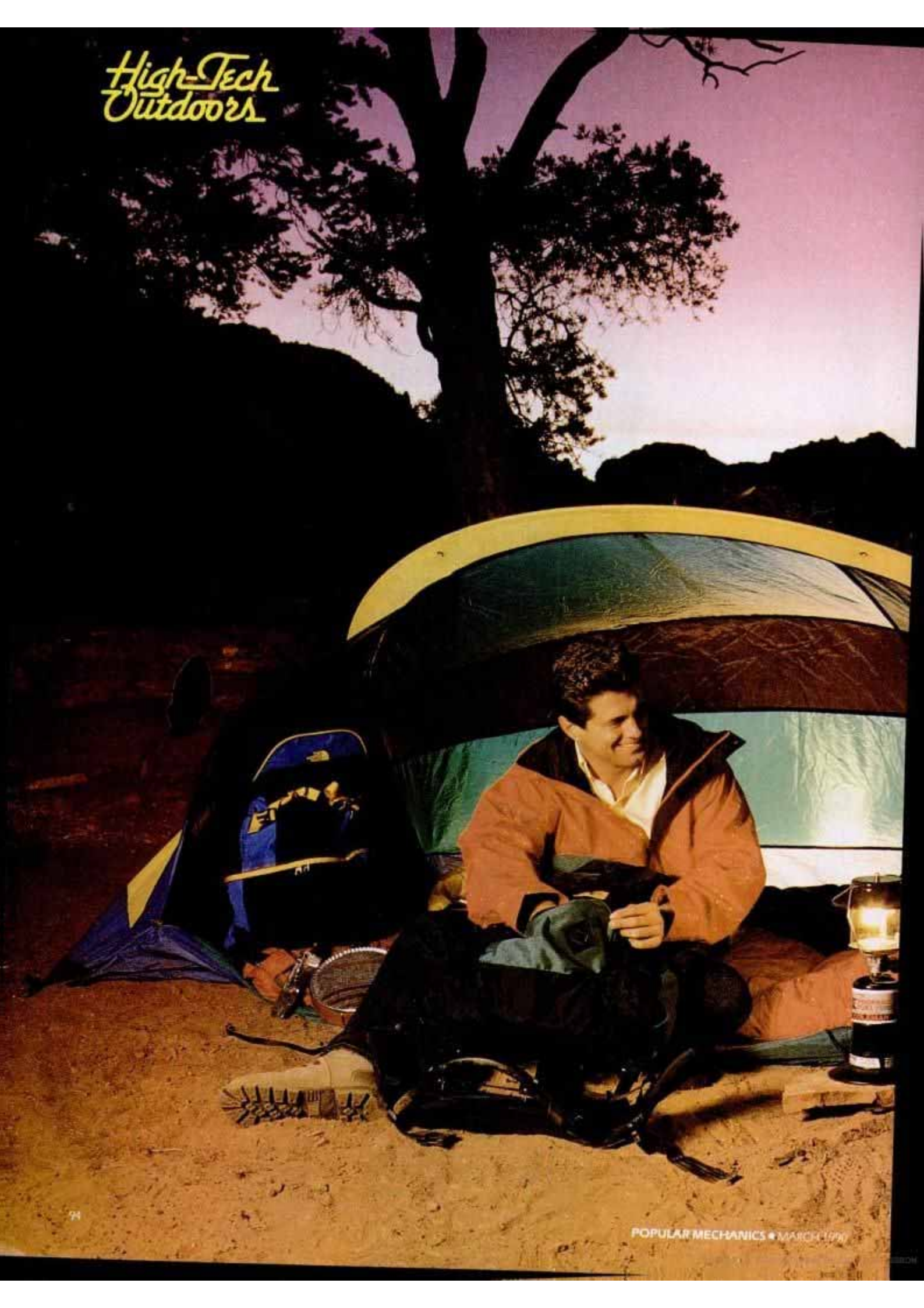
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*High-Tech
Outdoors*



CUTTING-EDGE CAMPING

The latest innovations in backcountry gear.

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

GOING OUT into the wild doesn't necessarily mean going native. In fact, most backcountry adventurers are equipment-intensive sportsmen who understand that getting away from it all ultimately means bringing a great number of things with you.

So, it's not surprising that rugged individualists welcome the current trend in high-tech camping gear. Space-age alloys and composites, introduced over the past couple of

years, have produced lighter, stronger, more compact equipment, while outback accessories have been radically transformed by advanced electronics and cutting-edge designs.

The compleat camper

In some ways, the biggest problem facing today's outdoors outfitter is narrowing down the options. The PM test team inspected dozens of innovative backcountry items before settling on a manageable group. After four days of field testing in Sedona,

Arizona, here's what we found.

Since few outdoorsmen enjoy camping in Arctic or monsoon conditions, the 3-season Aerie tent, from Kelty, is designed to take full advantage of good weather. An open-air effect is achieved by unzipping the entire front panel, which transforms the freestanding shelter into a high-tech lean-to. To let in even more air and light, a mesh panel runs the full length of the back wall.

When conditions worsen, a rainfly



Overnight adventurers fire up MSR's multi-fuel-burning Whisperlite Internationale stove (right) fitted with the XPD heat exchanger. Kelty's Aerie 3-season tent provides wide-open space for North Face's Alpine Dancer internal-frame backpack (far left) and Kelty's external frame Cirque R.

High-Tech Outdoors

fits over the ripstop-nylon tent and also doubles as a front awning. The 6-pound 4-ounce Aerie, which sleeps two in a rectangular space measuring 37.2 sq. ft., retails for \$255.

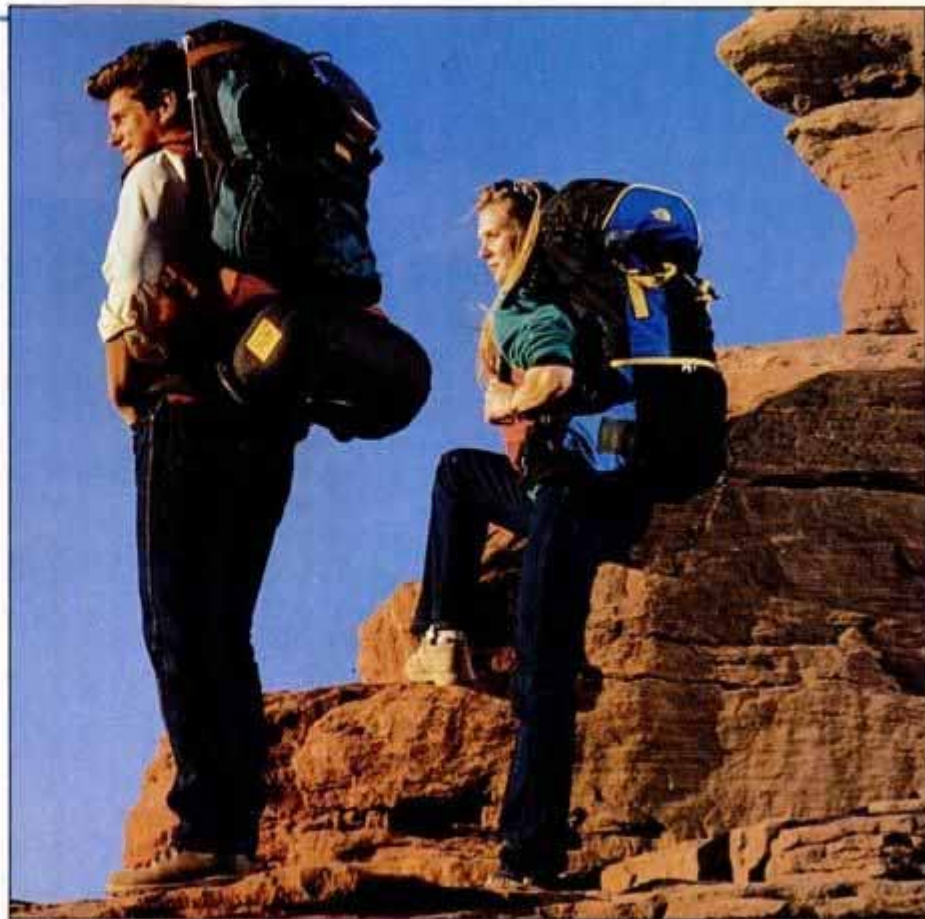
Internal frame or external, which makes the better backpack? The answer is both, because each has its own strengths. For example, the internal-frame Alpine Dancer (\$195), from North Face, has a narrow, snag-free profile and is superb for climbers. It weighs 5 pounds 2 ounces and has an obstruction-free volume of 2.3 cu. ft. The top pocket is removable and doubles as a fanny pack.

The wide-profile, external-frame Cirque R (\$165), from Kelty, is an ideal hiker's pack. The frame enables a sleeping bag to be securely lashed outside the 5-pound 8-ounce pack and the extra width (volume is 2.7 cu. ft.) allows the designer to incorporate handy side pockets.

In the bag

Sleeping bags may not be the most high-tech pieces of gear, but some are better than others and the one the test team liked best was the 4-season Unimog (\$275), from North Face. This semirectangular-cut, down bag is tapered, but doesn't constrict the lower body like a mummy bag. Its temperature range is down to zero.

Two items that worked well with the Unimog are the Air Lift II mattress and Spider Mat pad gripper, both by Basic Designs. The Air Lift II (\$49) measures only 4 in. x 8 in., rolled up and weighs just under 2 pounds. It features a multichambered design that enables it to inflate even if individual tubes need repair. To eliminate sliding on uneven ground—caused by nylon bag on nylon mattress



—the nonslip Spider Mat (\$10) wraps around the mattress and secures with Velcro tabs.

Most outback stoves deliver heat, but none do it as efficiently as MSR's (Mountain Safety Research) WhisperLite Internationale and XPD Cooking System. The Whisperlite Internationale (\$54) is an innovative *multifuel* stove that burns white gas, kerosene, Coleman Fuel and Chevron Blazo. But the real breakthrough is the XPD (\$46), which consists of two rounded stainless-steel pots and a corrugated-aluminum heat exchanger that traps and efficiently channels hot

Backpacking with the external-frame Kelty Cirque R (left) and internal-frame Alpine Dancer, from North Face.

stove gases. With concern about quality of drinking water running high in the wilderness, the Deluxe First Need (\$50), from General Ecology, is a welcome solution. The 15-ounce water purifier effectively filters out waterborne bacteria and protozoa, parasitic cysts and most chemical pollutants. This includes giardia.

Finally, no backcountry adventure is complete without interesting gadgets and gizmos. The two we selected are Ultimeter, from Peet Bros., and Liquipak, from IAO. The multifunction Ultimeter (\$165), a combination altimeter, barometer and thermometer, is a marvelous aid in topographic-line navigation and a key to forecasting the weather. Liquipak, which comes in a variety of sizes, is a flexible alternative to a canteen. The water belt unit (\$20) holds up to 1 liter, fits around the waist and is ideal for day hikes.

Modern technology is often thought to be the hallmark of civilization. We found that many new pieces of high-tech equipment were actually born to be wild. **PM**

Roughing it with (clockwise from far left): Deluxe First Need water purifier; Ultimeter, a combination altimeter, barometer and thermometer; the XPD heat exchanger; Air Lift II mattress; Spider Mat sleeping-pad gripper (center); Liquipak flexible canteen.





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High-Tech Outdoors



UNDERWATER ADVENTURES

Reef testing new-wave snorkel and scuba gear.

BY PIERCE HOOVER; PM Photos by Stephen Frink

NOT LONG AGO, the deck of a dive boat looked like a scene from an old frogman movie. Everyone was dressed in black rubber suits, masks, fins and wore unpainted steel tanks on horse-collar BCs (buoyancy compensator devices).

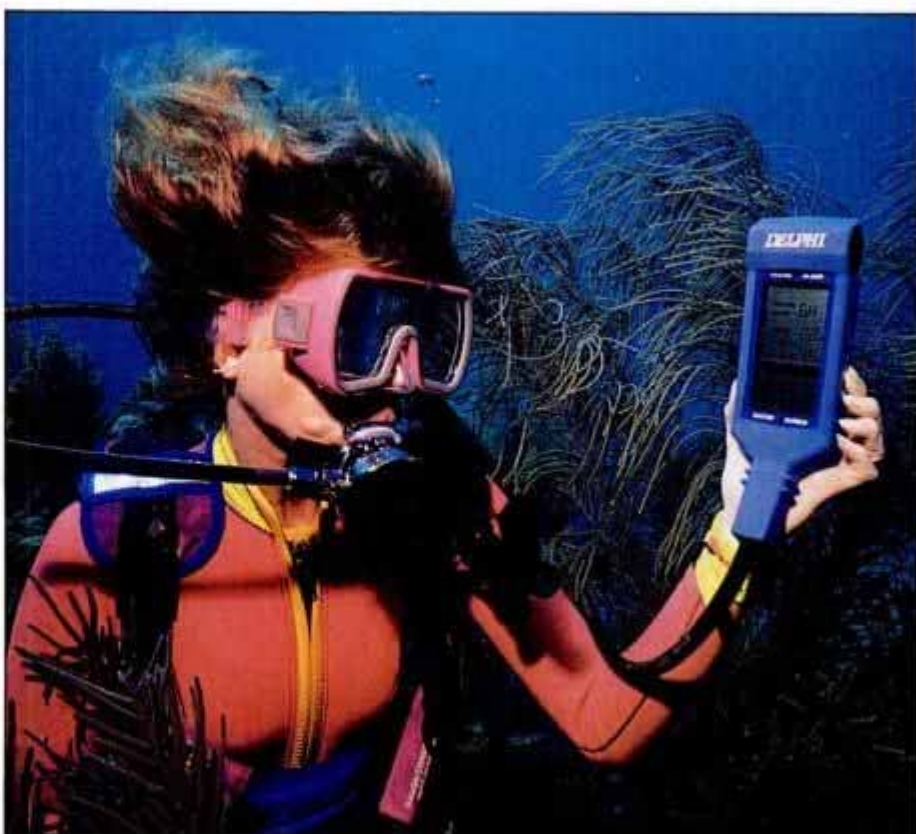
Today, that same boat looks more like a snack bar at a skateboard park with divers decked out in lime green suits, hot pink fins and fuchsia masks. And beyond bold colors, current new-wave gear is compact, lightweight and more technically advanced.

But divers have seen dramatic advances in equipment before. My closets, for one, are filled with highly touted gear accumulated over several seasons of buying. Some items were really big news when they first hit the market and now draw only amused chuckles from fellow divers when worn at a dive site.

This is definitely not the case today. In fact, the first problem facing the PM test team was narrowing down the innovative gear to a manageable group. In the end, the equipment selected ranges from computers that combine functions of gauge monitoring and dive-table calculation to a treasure-hunting metal detector to a raft-mounted breathing system that opens the underwater world to thousands of first-time divers.

On the reef

Our test site was Florida's John Pennycamp Reef State Park, a colorful world of coral gardens and sunken wrecks that's just a short boat ride off Key Largo. This immense, protected reef is filled with a variety of underwater locations that are ideal for both



The Snuba, a floating scuba tank with air hoses (opposite), enables noncertified divers to explore coral gardens and play with moray eels (top right). Divers breathe through second-stage mouthpieces and tow the raft as they swim. Treasure hunter (inset opposite) scans an old wreck with new Pulse 8X metal detector. The Delphi (right), by Orca Industries, is a next-generation dive computer.

High-Tech Outdoors

snorkeling and diving adventures.

No snorkeler likes to get saltwater in his or her mouth, but until now it came with the territory. The new Impulse snorkel (\$44), by US Divers, solved the problem with an annular-valve baffle system set on top of the snorkel barrel. It prevents water from reaching the mouthpiece while underwater. A purge valve drains the tube upon resurfacing.

We were impressed with the Impulse's dry-mouth capability, but decided to give it a torture test. We put a garden hose in the top of the tube, put the mouthpiece in place, and turned on the water. The water was pushed out the side vents and we were able to breathe normally. Use the Impulse once and you'll be hooked.

We coupled the Impulse snorkel with a US Divers Scan mask, which is neutrally buoyant and made of soft silicone. It has an extrawide face plate to increase peripheral vision and retails for about \$90.

Rad fins

Fins are fins, right? I dug into my closet and brought along a number of the recent breakthrough fins to the test site. These included black rubber

fins with straight blades, rocket fins with sculpted vents, a pair with silicone blades and a set shaped like spaceship wings fitted with 1-way scupper vents. Fins aren't just fins.

After a day of testing, it wasn't

New-wave underwater gear (above, clockwise from top left): Expandable Plana Avanti fins, from Mares. Impulse snorkel, with baffle system that prevents water entry, and silicone Scan mask (center) are both from US Divers. Aqua Vox enables divers to communicate. Omega Reef Runners are good on land and in water. Weekender 35, from Kodak, is waterproof and disposable. Casio Alti-Depth measures depth and altitude.

hard to determine that the new Plana Avanti fins, from Mares, were the pick of the litter. The Plana Avanti (\$79) offers a noticeable improvement in kicking power and efficiency, thanks to twin flexible rubber strips running the length of the blades. The strips enable the blade to expand during the kick stroke to displace more water.

Most scuba divers who wear large open-back fins couple them with neoprene booties. For snorkelers, however, we found a good option in the lightweight Reef Runner shoe from Omega. It has a nonskid sole joined with a nylon upper. It's as comfortable on land as it is in water and costs about \$35.

One final item for snorkelers is the new Weekender 35 (\$13.95) underwater camera from Kodak. It's a fixed-lens, 24-exposure, 35mm, disposable that's waterproof to 15 ft. It can be dropped off for development at any location that does regular Kodak developing. We developed a roll and the prints were tack sharp.

Down under

An exciting world exists just 20 ft. beneath the water's surface, but unless you're a certified diver it may as well



PHOTO BY ROBERT BOVA

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be 200 ft. However, an innovative new device, called Snuba, opens up that world to anyone.

The Snuba system uses a conventional scuba tank cradled in an inflatable raft that's easily towed by underwater explorers. Divers are connected to the tank with low-pressure lines coming from a first-stage regulator and breathe through second-stage mouthpieces.

The result is that the Snuba system leaves the diver free of all equipment except a few weights, a lightweight harness to hold the regulator in place, and a mouthpiece.

The raft is made from the same materials as life rafts and has a plexiglass window built into the bow so that divers can paddle to the dive site and preview the underwater scene. A unique pressure gauge that monitors the first-stage regulator accompanies one of Snuba's two mouthpieces.

Certified divers can rent Snuba without supervision, but others will need a half-hour training session, which has been approved by national dive associations, and be accompanied by an instructor using conventional gear. Currently, Snuba is available through a network of rental programs. If it were for sale, the rig would cost about \$2700.

The test team found Snuba to be more fun than anticipated. The harness allows divers to effortlessly tow the raft, which acts like a topside warning to boaters.

How much adventure can you have at just 20 ft. below the surface? During testing at John Pennycamp, we visited elkhorn coral reefs, two old wrecks and fed a 4-ft. moray eel. Snuba is a true user-friendly breakthrough that should enable thousands of beginners to take their first breaths underwater.

Deep thrills

Certified divers who go deeper than 20 ft. will want to try the new Genesis 80 air tank from Sherwood. The lightweight and compact Genesis 80-cu.-ft. cylinder is nearly 7 in. shorter than a standard aluminum 80-cu.-ft. tank and 4 pounds less.

In addition to the 80, Genesis makes 65-cu.-ft. and 100-cu.-ft. tanks. They range from \$330 to \$455, depending on volume.

The company that started the dive computer revolution, Orca Industries, has just introduced the Delphi (\$649), a second-generation unit that bases bottom time on calculated nitrogen levels in the body. It reads tank pressure to calculate air consumption and remaining bottom time, and is also the first dive computer pro-

grammed for decompression diving intervals.

Speaking of underwater electronics, the latest sport-tech watch from Casio, the Alti-Depth (\$99), is water resistant to 100 meters and contains a depth gauge and altimeter, plus all the usual stopwatch functions. We dove with it and took it up in an airplane. In both instances, it proved to be very accurate.

If you're tired of looking at fish and would rather search for buried treasure, instructor Carl Fismer, of the Spanish Main Treasure Co., in Islamorada, Florida, has a gadget for you. Over the past couple of years, Fismer has found about \$20,000 in silver coins and 50 gold pieces. How? Using the new Pulse 8X underwater metal detector, from JW Fisher. This electromagnetic sensor can locate coins buried 16 in. deep and can also be set for dry-land use. Cost is \$895.

Fismer admits that he's dug up more beer cans than coins, but he still prefers a unit like the Pulse 8X without a discriminator feature that filters out clutter. The reason? He once found 200 silver coins in an area that a discriminator would have discounted. The lesson, Fismer says, is to dig up every find.

Talking like flipper

Commercial divers sometimes use underwater communications systems consisting of a full face mask and an electronics package that channels conversations through a transducer and receiver. Sport divers rarely use the systems because they're bulky, hard to use and very expensive.

Florida inventor Mike Benjamin decided a better way to communicate underwater was to imitate dolphins and whales. He studied the mammals and came up with Aqua Vox, which mates to a regulator and creates an air chamber for divers to speak into. The chamber contains a bullet-shaped element that channels sound and transfers it from air to a liquid medium.

The test team tried Aqua Vox and it worked, but not without a little practice. Exhaust bubbled from the regulator can drown out the sound, so you learn to speak when your partner isn't exhaling. Also it works best when you look directly at the person you're speaking to. Once you get the hang of it, you can have underwater conversations at distances up to 20 ft.

Electronic underwater communications systems cost several thousand dollars, which makes Aqua Vox a bargain at \$99. Now, thanks to Mike Benjamin and Aqua Vox, I guess you could say that even underwater talk is cheap.

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FIRSTHAND DRIVE REPORT

'90 Nissan Pathfinder 4-Door

BY RICK TITUS, West Coast Editor



THE BATTLE for market supremacy in the sport/utility division is fast becoming a war. What was once a peaceful segment dominated by the Jeep Cherokee is a hotbed of new models.

Of the current crop, Nissan has one of the winners in its new 4-door version of the Pathfinder. Recent studies have shown that 85 percent of all sport/utility vehicles are 4-doors, so Nissan put a high priority on the new design.

Conceived and executed at the Nissan Design International studio in San Diego, California, the new Pathfinder was developed around a standard 3.0-liter, 153-hp multipoint fuel-injected V6 engine. It's offered with either 2- or 4-wheel drive and is available with either a 5-speed manual or 4-speed automatic.

Ride and handling are the new Pathfinder's strong suits. The use of progressive-rate 5-link coil springs in the rear gives the 4-door Pathfinder a luxury-vehicle ride, by sport/utility standards. The torsion bar front suspension works well in both on- or off-road sit-

uations, but is clearly tuned for on-road ride and handling.

Four-wheel disc brakes, with a mechanical rear-wheel antilock system, provided the Pathfinder with the means for rapidly hauling itself to a halt. Repeated hard brake use revealed little sign of fade or off-center pull. We also give high marks to the decreasing power-assist steering, which was light at low speeds, yet precise at higher speeds.

Get the revs up

We found the engine a bit sluggish on the bottom end, requiring several seconds of flat-to-the-floor acceleration before really gaining its lung. Once driven to the middle of the tachometer, however, it proved smooth and lively. The highly developed corporate 3-liter V6 got several intake manifold and fuel-injection mods in an effort to improve its low-end torque and overall driveability, all of which conspires to give the Pathfinder an impressive 3500-pound towing capacity.

The external design intent was to minimize the cosmetic

impact of four doors while emphasizing the ease of rear-seat entry. To that end, the new Pathfinder's designers were very successful. It clearly requires a second glance to spot the rear doors. The C-pillar concealed door handles do a great deal to assist in this objective. As for ease of rear-seat entry, we found the Pathfinder at least as good as any, but still a little awkward on step-in. Once seated, however, both the rear seats and the leg space are fine.

We found both the base XE and the high-line SE to be nicely appointed. Fit and finish quality for the interior matches that of Nissan's Maxima, which is to say, quite high. A complete AM and FM stereo cassette audio system with four speakers is the standard, with system upgrades readily available. Nissan made an extra effort to provide excellent interior air circulation

and designed a split rear window in both rear doors that allows approximately 60 percent of the glass to roll down—no small feat considering how small the new rear doors are. The back seatrest folds down, in either halves, or in total. When everything is folded down, the cargo-carrying floor space is nearly doubled. The dashboard and the working controls are all well placed, with driver-adjustable shock absorbers and automatic locking front hubs standard.

The Pathfinder's lovely body lines are rather abruptly interrupted with the addition of the externally mounted rear tire rack. Though socially acceptable among sport/utility vehicle owners, we couldn't help but wonder how much more attractive The Pathfinder would have been with the spare mounted under the floor. There is a space-saving spare tire option that mounts the spare just inside the rear gate.

Even at its \$18,000 base price, with fully loaded models selling for around \$22,500, we still suspect that Nissan will break its 1990 sales goal of 30,000 units. The sport/utility segment might well be a marketing battleground, but there are bound to be some very satisfied customers enjoying the spoils of war. **FM**



Pathfinder features cockpit-adjustable shocks.

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A one quart treatment of Slick 50 will bond slippery "poly" to your engine for a minimum of 50,000 miles. Unlike some temporary products on the market, Slick 50 does not need to be added every time you change your oil. By reducing engine friction, Slick 50 increases gas mileage and horsepower and it reduces wear, defraying costly overhauls.

Slick 50's Credentials are Impressive

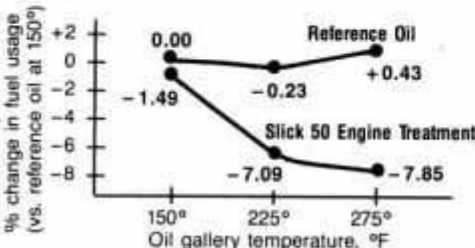
"Slick 50 does reduce engine heat and ordinary wear, and our informal tests indicated that it will improve gas mileage by about two or three miles per gallon . . . Slick 50 does exactly what Petrolon claims it does." *Consumer Digest* (Mar/Apr 1982, p. 35)

In 1989, the premiere engine and lubricant testing lab in the U.S. tested Slick 50. This EPA recognized lab conducted a strictly controlled experiment using industry standard ASTM procedures. Results showed Slick 50, compared to a standard reference oil, reduces engine wear by more than 50%. Be cautious of those Poly treatments that cannot back up their claims with such solid evidence.

In a fuel usage test conducted by this same prestigious lab, results showed that Slick 50 (compared to a standard reference oil at 150°) reduced fuel consumption in the test engine by 7.09% at an oil temperature of 225° and 7.85% at 275°. Once warmed up, most cars operate within the range of 225° to 275°.

Especially interesting is the fact that fuel usage with just the reference oil increased (see graph) as the oil got hotter than 225°. This is due to the well known fact that oil gets thinner at higher temperatures, causing increased friction (and wear) in your engine. However with Slick 50, fuel usage actually decreased, showing that Slick 50 produces its greatest friction reducing benefits at higher temperatures, which is exactly when your engine needs it the most.

As with any lab test, these results may not translate exactly the same percentagewise for every engine under every type of driving condition in the "real world." However, the conclusion for these test cases is clearly that Slick 50 does reduce engine wear and does increase gas mileage.



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start them, before the oil has a chance to circulate. Up to 90% of engine wear can be caused by this starvation. You receive all these benefits for less than the cost of two tanks of gas (\$39.95).

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TUV, a prestigious German testing laboratory, tested Slick 50 and found substantial increases in both gas mileage and horsepower. 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.

The Cranfield Institute, known worldwide for its work in tribology (the study of friction), concluded a five-year study on Slick 50 in 1989. Results showed Slick 50 does indeed coat metal surfaces, dramatically reducing friction and extending the life of metal.

Perhaps the most dramatic of all is the torture test seen by thousands of viewers on NBC TV station KPRC. A Lincoln Town Car was treated with Slick 50. During the broadcast, the oil was drained and the car was driven without the oil plug for about 30 minutes. The water temperature never rose and the engine sustained no apparent damage.

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Change oil and filter and substitute one quart of Slick 50 for the last quart of oil. (Add two quarts for engines with oil capacities of seven quarts or more.) Slick 50 is excellent for turbo-charged engines, aluminum block engines and rotary engines.

Slick 50 will work with all petroleum based oils and synthetics compatible with petroleum based oils.

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By reducing friction, Slick 50 does all of the following:

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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 drastically reducing engine wear
5. Easier starting (important in cold weather)
6. Since lubricating lead is being removed from gas, and unleaded gas is poor in lubricating qualities, this extra lubrication of Slick 50 on valve systems and guides is a real bonus.
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FIRSTHAND REPORT

Yamaha WaveRunner III

BY CLIFF GROMER



NEXT-WAVE personal watercraft are here. When the weather was still warm enough for hot in-water action, we got a wet-and-wild ride on boating's first 3-person wavebuster. Yamaha's WaveRunner III seats a skipper, first mate and second mate (providing total weight is at 450 pounds or less).

Measuring 117.7 in. in length, the WaveRunner III is big. It's not as massive as the QE-2, but it's large for a personal watercraft (PWC). It tips the scales at 454 pounds. Yamaha's next largest craft, for example, the new WaveRunner LX, weighs only 379 pounds. It's shorter, too, at 109 in.

Extra mass and size, naturally, translate into stability on the water, at rest and underway. This was immediately evident during test sessions.

At first, riders may miss

some of the nimbleness of the smaller WaveRunner models, but the ride is certainly more comfortable and secure. Comparing a full-size car to a compact is an analogy that comes to mind.

Interestingly, the WaveRunner III is a splashy craft and kicks up more spray than smaller models. Getting wet, of course, is part of the PWC game, so this isn't a problem. The increased spray is probably caused by the craft riding lower in the water due to its added weight.

A new V-shaped hull, on the other hand, is a distinct improvement over Yamaha's flat hulls of the past. To beginners it may seem slightly more tippy, but novices gain confidence quickly and seek new levels of performance. The WaveRunner III provides it with instant steering response and snappy turns. Gone are the wide arcs and skids.

What does it take to push this large craft and 450 pounds of passengers? Under the handlebars is a big 633-cc, 50-hp, 2-stroke engine that delivers 50 hp at 6000 rpm. The jet-drive unit, with its axial-flow, single-stage pump, packs 496 pounds of static thrust.

Power to maneuver

This adds up to quick acceleration and 38-mph top speed with a single rider. Also, it means plenty of punch to kick out the tail in power spinouts and other high-action maneuvers. (Note that Yamaha and other PWC manufacturers could easily tune existing engines for considerably more speed, but the industry purposely stays below the 40-mph plateau.)

Among the best new features on the WaveRunner III is Yamaha's oil-injection system, which eliminates the hassle of mixing and shaking

the infamous gas/oil cocktail. A well-positioned oil gauge and electronic gas gauge keep riders posted on feeding time. Plus, a fuel pump image flashes when the level drops to a quarter of a tank. There are about 2 hours worth of thrills and spills at full bore with the WaveRunner III's 10.6-gallon fuel capacity.

Another standout feature of this new-wave PWC is reverse gear. This makes docking chores simple and offers riders a new dimension of fun—riding backward.

Three storage compartments accommodate a variety of gear. A self-draining ice chest is found beneath the seat, a water-resistant cylinder (for wallet and papers) is found astern and the last one is just in front of the handlebars. A fire extinguisher is also located under the seat.

Other features include Yamaha's trademark visible spout, passenger grip handles, bow eye and tow cleat, nonskid decking, protective bumpers all around, tool bag, rpm limiter and 1-year limited warranty. Price of the WaveRunner is \$5365.

Clearly, Yamaha saw a trend coming when it designed this big PWC. Since the Callaway Gardens introduction, Bombardier debuted its own 3-person watercraft, the Sea-Doo GT.

Perhaps the most important thing about 3-person watercraft is that they open up PWCs to the world of waterskiing. Now an observer can ride along.

The new emphasis by Yamaha, and other PWC manufacturers, is on family fun, multiple-passenger cruising and extended-trip adventures. The new Yamaha WaveRunner III delivers in all categories. **PM**

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Roll Top Desk—Nostalgia buffs will especially appreciate the always popular roll top desk for both home and office. It's antique style is cherished by many. Make one yourself in fine cherry and take pride in this charming heirloom. You build it as two separate units, a base and a roll top. (PM-1736—\$6.95)



Covered Gate—Designed in 1927 for a house on the California coast, this gate has withstood the test of time. Build it for your own yard, and it will be welcoming guests into your home for years to come. Choose all-heart redwood lumber for the gate for weather resistance, and fasten all joints with brass or stainless steel screws. (PL-2122—\$5.95)



Redwood Patio Furniture—Six durable pieces made of heartwood redwood, built to withstand exposure to heat and moisture, resist warping and fulfill specific needs. The barbecue cart has two drawers, a maple cutting board and a broiler pan on the food preparation side and a built-in ice chest and bottle storage rack on the other side. The chaise lounge can be adjusted either to a reclining position or placed flat so several people may sit. Four additional pieces are included. (PM-1013—\$6.95)



Model SS United States—The glorious, record-breaking flagship of the U.S. Merchant Marine. No passenger ship has ever matched her top speed. The professional quality model is drawn in detail on 3 full-size blueprints. Over 2-ft. long; made of wood and metal. (PM-1200—\$9.95)



HydroRunner—Taking to the water will never be the same after you blast the throttle in this 40 miles-per-hour personal watercraft. Powered by a 28-hp outboard, this sleek tri-hulled machine measures 8 1/2-ft. long with a 4 1/2-ft. beam, and weighs 200 pounds. Plans contain six blueprint sheets and a detailed photo-illustrated book. (PM-1810—\$15.95)



Bookcase Wall—A floor-to-ceiling dream project that makes your living or family room seem larger. The shelves are 12-inches deep, and the five cabinets can be adjusted to any width. Great for storing or displaying your fine items. (PM-1008—\$6.95)



Two-Bay Garage—A spacious 2-car garage with a studio and loft above. This 22x28-ft. building has the space to handle all your garage needs. The studio area features three windows and the garage doors open to a spacious concrete slab floor. What makes this garage so special is the second floor—you can make it an ideal studio, an office, planning center, or even a small apartment or guest room (with a few modifications.) (PL-390—1 plan: \$18.50; each additional plan \$16.00)



Sidewalk Classic—Powered by an automobile battery (with built-in charger) and generator, this bright red replica of an open roadster rolls along at a safe, quiet 5 miles per hour. Buy the parts at your hardware or automotive store. It's great for everyday fun on the sidewalk and sensational in parades. (PL-1227—\$6.95)



Wheel Horse—This sturdy three-wheeler is pushed powered, either by its rider or by the rider's friend. It's constructed of plywood and pine and is great for ages 3 and up. Easy-to-follow, step-by-step illustrated instructions. (S-2510-2—\$4.95)



Router Bench—Turn your router into a powerful tool. This simple bench contains two drawers for bits and small accessories and a movable fence on the work surface to guide your work along the table top. You make the table as tall as you like, and the top measures 18 3/4" x 23 3/4". Plan contains full-size pattern and cutting and assembly instructions. (S-1625—\$5.95)

AUDIO

Sound Options

BY FRANK VIZARD, Electronics Editor



ADD Toyota and Hyundai to the growing list of car companies that offer premium sound systems developed in conjunction with leading audio firms. Not surprisingly, there's a topnotch sound system for the new Lexus LS 400, Toyota's ultimate luxury car. More surprising are the quality sound systems available for the Toyota Celica and Hyundai Sonata.

The base system in the LS 400 comes from Pioneer, and it is characterized by the number of speakers involved and their positioning. The most noticeable speakers are the tweeters, mounted far forward in the corners of the doors where no-draft ventilation windows used to be in days gone by. Since the tweeters are mounted very high, the dispersion of high-frequency sounds is very directional, and closer to passengers' ears. Lower down in the front doors are 4½-in. midrange speakers. A second pair of 4½-in. speakers is installed in the rear doors.

Deep bass is provided by an 8-in. subwoofer installed in the rear package shelf. This subwoofer is powered by its own 25-watt amplifier. The other speakers in the system

are powered by the amplifiers built into the AM/FM cassette receiver. Ten watts is supplied to each of the remaining four channels.

An optional compact disc changer with 6-disc capacity is available for the Pioneer system. The CD changer is trunk-mounted.

Nakamichi, meanwhile, is supplying the premium sound system for the LS 400. Speaker locations remain the same. The difference from a spec-sheet standpoint is principally one of power. Continuous average power to the door speakers is 14 watts per channel. The subwoofer amplifier is capable of 70 watts of continuous average power. A CD changer is also available.

A hush-up

Advocates of high power in car audio systems may think both systems somewhat anemic at first glance. High power, they would declare, is required to overcome the road and engine noise inherent in the automotive environment. The Lexus, however, is an exceptionally quiet vehicle, so high power isn't as big an issue. With the windows rolled up, the power provided by either the Pioneer or Nakamichi systems is more than ade-

quate for the situation.

The Lexus team should also be commended for its attention to sonic details. The LS 400 is equalized differently, depending upon whether the interior of the car is leather or cloth. Leather reflects sound, while cloth tends to absorb it. FM diversity tuning, in which the best signal from two antennas is picked for listening, is also included.

The sound of the Pioneer and Nakamichi systems is audibly different. While both are good, the overall tone of the Nakamichi system made it clearly superior. The Pioneer system has a tendency to sound a little bright, something that can be alleviated

Sound systems for Lexus LS 400 come from Pioneer and, as an optional upgrade, Nakamichi (left). Dash-mount controller is uncluttered.

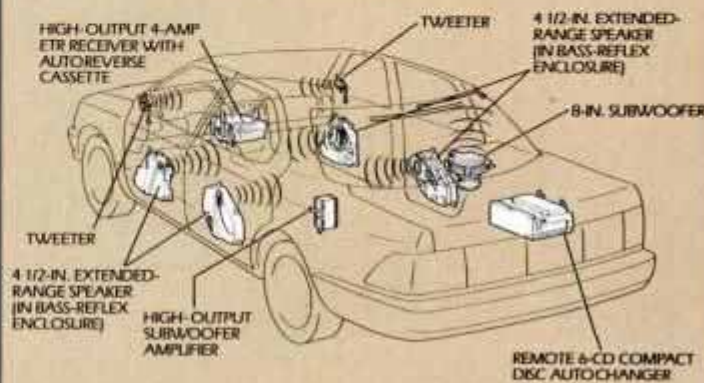
somewhat by cutting back on the treble control and boosting the midrange control. Both the Nakamichi and Pioneer cassette receivers utilize separate bass, midrange and treble controls—a welcome though not very common feature in other products. The sense I get is that the Pioneer system could easily be made to sound better, but suffers somewhat by its association with Nakamichi. Marketing concerns seem to dictate that the difference between the two systems be substantial enough to justify upgrading a potential buyer to the Nakamichi system. The difference is in perceived sound quality. Nonetheless, the Pioneer system is still quite good.

Celica solutions

Toyota employed a third audio supplier to develop the sound system for its new Celica. Fujitsu Ten, a long-time maker of car audio products, actually faced an engineering challenge tougher in many ways than that for the Lexus teams.

From an acoustical standpoint, the most challenging of

LEXUS LS 400 AUDIO SYSTEM



LS 400 uses a cleverly designed, multiple speaker/amp installation.

the Celica variations is the hatchback. The lack of a rear package shelf does not make for easy positioning of woofers and subwoofers for bass response. Utilizing research derived from the use of a grid of 240 microphones placed inside the car, Fujitsu Ten adopted an approach they dubbed the System Ten.

Deep bass is supplied by two 8-in. subwoofers installed in the front doors. Normally, subwoofers installed in the doors would produce an unacceptable resonance. But Toyota used special sealing methods, including a unique double labyrinth seal at the base of the window glass, to turn the door into a big loudspeaker enclosure. The subwoofer itself is also partially enclosed so it acts like a ported enclosure.

This enclosure-within-an-enclosure design helps generate a great deal of bass. The subwoofers are powered by an independent amplifier installed under the front passenger seat, pumping 18 watts power to each channel.

As in the Lexus, tweeters are positioned in the far, forward corners where the window meets the door. The mid-ranges, each 5 inches in diameter, are positioned at each end of the dashboard. Each tweeter/midrange gets 11 watts of continuous average power. In the rear, two 6½-in. full-range speakers are located on either side of the rear seats. Tweeters are positioned directly behind the rear seats in the rear shock towers.

The amplifiers for all the speakers except the subwoofer are built into the AM/FM cassette receiver. Like the Lexus, the tuner utilizes FM diversity tuning. Also included is a CD player featuring 4x oversampling and the ability to play both 3-in. and 5-in. discs.

The sound quality of the System Ten is surprisingly good, particularly since the Celica is not a luxury car. Given the sonic difficulties posed by hatchbacks, Toyota and Fujitsu Ten deserve praise for a job well done. Praise goes to the Lexus team as well. If a good sound system is part of the buying decision for a new car, then Toyota's Celica and Lexus offerings deserve top consideration.

Hyundai's new song

Also deserving consideration is the new sound system found in Hyundai's Sonata GLS. For this car audio system, Hyundai turned to Polk Audio, a Baltimore loudspeaker company, and Alpine, the well-known car audio electronics maker.

Offered as a \$1450 option, the Hyundai/Polk system consists of a 160-watt, 4-channel amplifier, a cassette receiver, a compact disc player and an array of 12 speakers governed by Polk's SDA crossover matrix. The Alpine amp is derived from the company's 3520 aftermarket model, while the CD player is based on the Alpine 5905 aftermarket unit. The

cassette receiver—which includes Dolby B and C, 18 presets and other attractions—is based on the Alpine 7385.

The key to the system, though, is the SDA crossover matrix. SDA stands for Stereo Dimensional Array. What SDA does is produce two different signals, the normal stereo signal and a signal that is the opposite of interaural crosstalk distortion. Crosstalk occurs when the sound from the right channel reaches the left ear and vice versa. SDA produces a cancellation signal timed to reach your ears at the same time as the undesirable crosstalk signal, thereby sonically eliminating it. The result is truly audible in the Sonata GLS. There is a sense of wider imaging and none of the stereo-coming-from-a-hole effect often experienced in cars.

Keep It Clean

Adequate care of audio and video equipment keeps gear performing at its best and helps induce longevity. One piece of equipment needing more care than most others is the tape recorder. Dirt on the record and playback heads will seriously impair a tape recorder's performance. Fortunately, there are plenty of head cleaners on the market and most people seem to be aware of them.

Fewer people, though, are aware of the audible distortion that can be caused by the build-up of magnetic fields on the recorder's heads. This build-up occurs with each pass of the tape over the heads. Over time, the distortion caused by the magnetic field build-up may reduce the signal by 2 to 5 dB, particularly in the midrange between 1.5 KHz and 12.0 KHz. Noise may also increase by as much as 9 dB in the low to midrange portion of the spectrum, between 75 Hz and 9 KHz.

Demagnetizers do exist to solve this problem. Generally, there are two types available. The oldest is shaped like a wand and is cumbersome to use. More convenient is the cassette demagnetizer, which requires a battery.

A new approach to demagnetizing tape heads comes from Trackmate, an Irish company founded by transplanted Americans. Trackmate has developed a combination cassette cleaner/demagnetizer that doesn't require batteries, and poses no apparent threat to speaker coils.

At the heart of the product is a Field Discharge Chip (FDC). The FDC is permanently charged and captured in a ceramic matrix housed inside a gold cartridge. As the cleaning brushes move back and forth over the tape heads, the motion generated by the swishing brushes causes the FDC to move as well. The motion of the FDC sweeps the magnetic field away in about 15 seconds. List price is \$15. Trackmate also produces a line of care products for video cassette recorders, computers and compact disc players. **PM**

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REPLACING YOUR CLUTCH

BY PAUL STENQUIST

YOU'RE IN HIGH GEAR on a slight incline, and you push the throttle floorward to maintain cruising speed. The engine roars—and the car slows. Or maybe every time you engage the clutch, the car tries to shake your teeth out of your head. Or there's a rattle in the clutch housing. Maybe it's time to crawl on that creeper and slide under the greasy side.

Installing a clutch disc and pressure plate is a relatively straightforward job once you've managed to remove the transmission. Exploded view shows relationship of parts in a typical transmission.

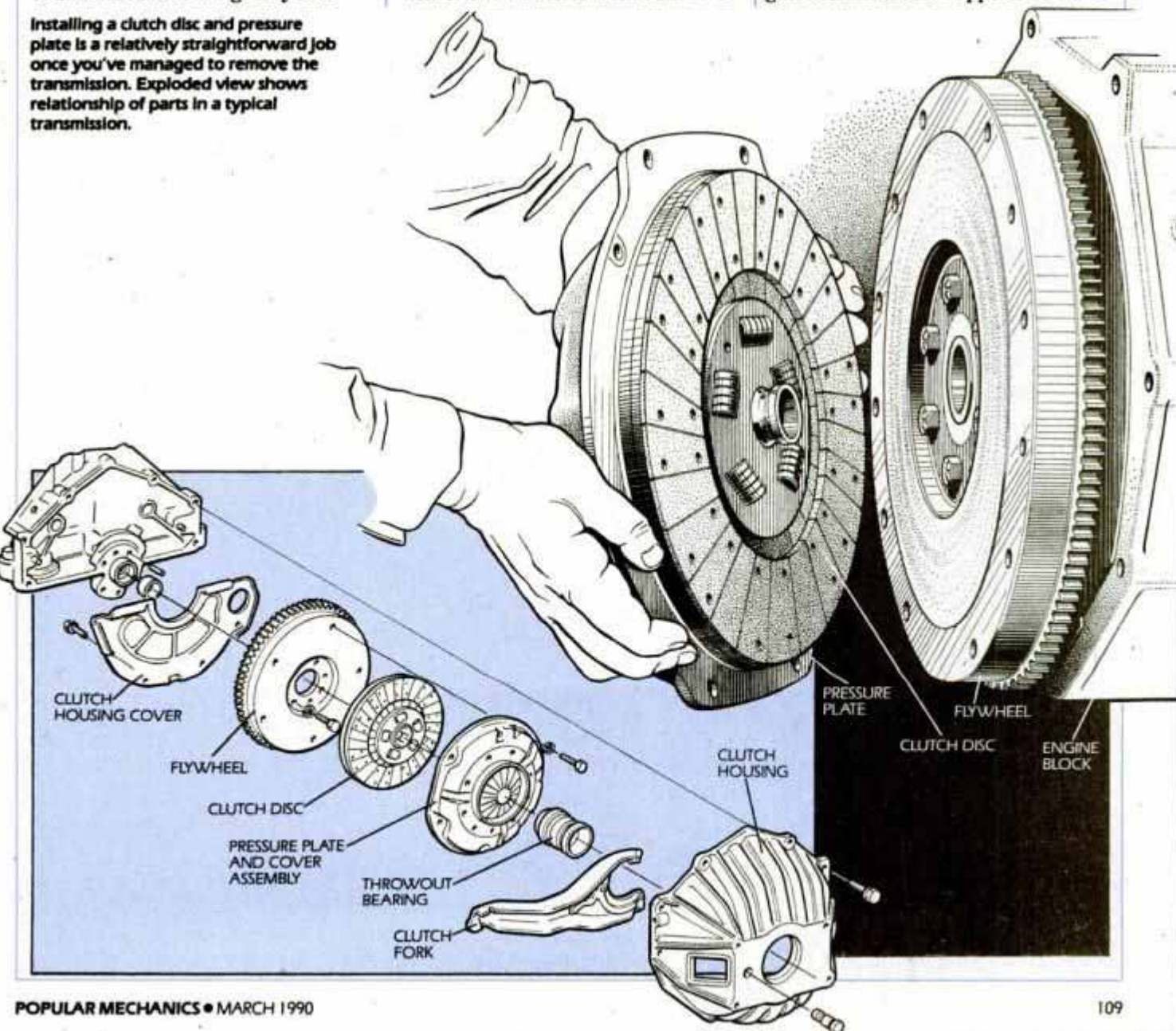
What's going on here?

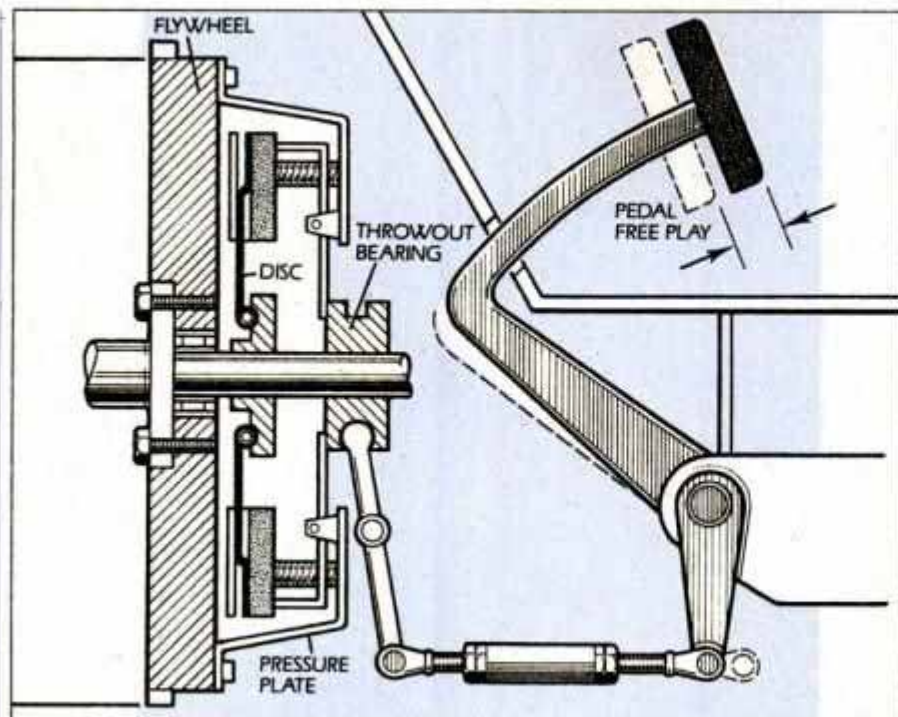
A manual clutch connects and disconnects the engine and transmission so that you don't have to turn off the engine to stop or change gears. Handy, isn't it?

The driving member is the engine flywheel/pressure plate assembly. The driven member is a clutch disc with friction material bonded or rivet-

ed to both sides of a wavy spring. The wavy spring softens the shock of engagement. The disc's hub has a series of coil springs around its perimeter. These damp the torsional vibrations of the crankshaft.

The transmission input shaft passes through the hub of the clutch disc and on to a pilot bearing in the engine crankshaft for support. The disc





1 Pushing forward on levers of lever-type pressure plate disengages clutch.

can move forward and backward on the input shaft splines.

A pressure plate contained in a stamped steel housing is bolted to the flywheel. This plate is forced against the flywheel by coil springs or a diaphragm spring when you take your foot off the pedal. When it's forced against the flywheel (which is rotating with the engine, of course), the clutch disc is squeezed between the two and carries the rotation to the transmission input shaft.

The pressure plate is released by a lever that pivots on the bell housing, which is bolted to the back of the engine. The inner end of the lever is fitted with a bearing, called the throwout bearing. The throwout bearing allows release of the clutch while it's rotating.

On a clutch that locks by means of coil springs, the throwout bearing releases the clutch by means of three levers that pull the clutch plate away from the clutch disc. A lever-type clutch is illustrated in Fig. 1. On a clutch that locks by means of a diaphragm spring, the diaphragm itself is pushed in or out by the throw-out bearing. A diaphragm-type clutch and the other clutch system components are shown in the lead illustration.

On many rear-drive cars, the actuating mechanism is a mechanical linkage. On most domestic front-drive cars, the clutch is usually linked to the clutch pedal by means of a cable. Oth-

er cars use a hydraulic cylinder and slave to actuate the clutch (Fig. 2).

Common clutch failures

Clutch slippage is the most common problem associated with manual transmission drivetrains. Slippage can be caused by improper clutch

adjustment, a worn clutch disc, a warped pressure plate or flywheel, an oil-soaked disc, insufficient pressure plate spring tension, or a newly installed disc that has not seated. A temporary slippage problem may result when a disc is overheated.

Clutch grab or chatter is probably the second-most common complaint. This is exactly what it sounds like: A grabbing and chattering that occur when the clutch engages. These symptoms are most often the result of oil or grease that's accumulated on the friction disc.

The symptoms can also be caused by a burned or glazed disc, worn transmission input shaft splines, loose engine mounts, a warped pressure plate or flywheel, or burned resin on the pressure plate or flywheel. A misaligned clutch housing can also cause clutch chatter.

A clutch that fails to release will not allow you to smoothly shift gears. On cars with a cable-type clutch linkage, a damaged cable may be the culprit. On cars with a hydraulic linkage, a leak is a distinct possibility, as is a failed cylinder. On all cars, consider broken engine mounts, a faulty pilot bearing, a warped clutch disc, binding input shaft splines, or a disengaged release fork as possible causes.

A rattle can be caused by weak retracting springs, a loose release lever, oil in the friction disc damper or worn damper springs.

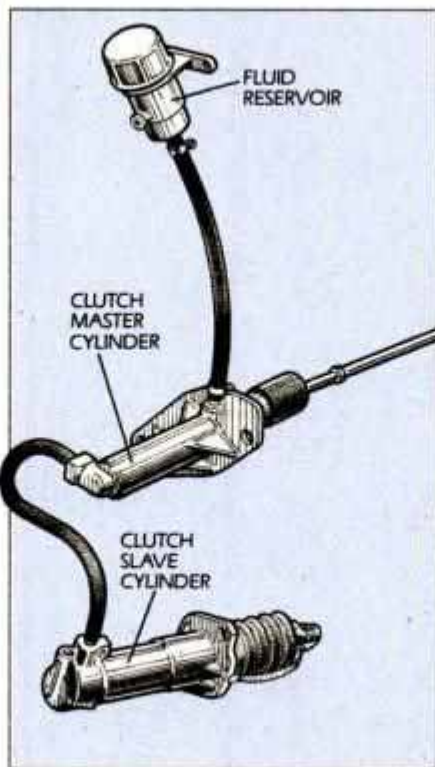
A whining or screeching sound that you hear only when the clutch is released (pedal down) is almost always the result of a defective throwout bearing. A throwout bearing noise heard when the clutch is engaged (pedal up) is caused by incorrect release fork position or a weak or missing clutch linkage return spring.

Obviously, we can't cover every possible complaint on every car. So, as always, you'll need the manual specific to your vehicle to get you through diagnosis and repair.

Clutch adjustment

A properly adjusted clutch should provide about 1 in. of free travel with the pedal at rest. A lot of recently produced cars, particularly those with cable linkage, have a self-adjustment mechanism. On these cars, the slack in the linkage is automatically taken up as the clutch wears. When the clutch wears to the point where the linkage has too much free play and the clutch can no longer be disengaged, the disc must be replaced.

A lot of early front-drive cable link-



2 Hydraulic linkage uses pressure from master cylinder to move slave pushrod.

age systems require that you periodically lift the clutch pedal up against its stop. This releases the adjustment pawl, allowing spring pressure to lengthen the cable and correct the freeplay adjustment. Carefully inspect a cable linkage system before condemning the clutch.

Cars with mechanical linkage usually include an adjustment rod at the release lever. To adjust, back off the locknut and turn the adjusting nut to take up slack in the linkage until you have 1 in. of travel at the pedal. Don't forget to tighten the locknut when you've finished.

Cars with hydraulic clutch systems frequently provide an adjustment point where the master cylinder actuating rod joins the clutch pedal assembly. To adjust this type of linkage, loosen the locknut and turn the pushrod until the freeplay is correct. Retighten the locknut.

Some car manufacturers, including Toyota, provide a specification for pedal height. On these systems, the pedal height should be adjusted before the linkage is adjusted. Pedal height adjustment is usually accomplished by means of a jackscrew on the pedal assembly.

A hydraulic system that operates sluggishly or fails to disengage the clutch can be bled in a manner similar to bleeding brakes. You'll find a bleed screw on the slave cylinder.

Most makers of cars with hydraulic clutch systems provide a specification for slave-cylinder pushrod extension. If the pushrod doesn't fully extend, causing the clutch to remain engaged, the hydraulic system is at fault. The usual cause of a hydraulic failure is a fluid leak. The usual fix is replacement of the offending component: master cylinder, slave cylinder or tubing.

Nailing down a diagnosis

If you suspect that your clutch is slipping and have already checked and adjusted the linkage, start the car,

shift to high gear, and rev the engine to 1500 rpm. Then, with both parking and foot brakes applied, lift your foot from the clutch. If the engine dies, the clutch is not slipping.

To confirm a disengagement failure, start the engine, push the clutch pedal all the way to the floor, count to five and attempt to shift in and out of Reverse gear. If the shift lever binds or the gears grind, the clutch is not disengaging.

Clutch disc and pressure plate removal

On front-drive cars you have to remove the transaxle assembly to replace the disc and pressure plate. It's possible, but no fun.

4). This can be purchased quite inexpensively at an auto parts store.

When servicing a clutch, take normal precautions to prevent breathing asbestos fibers. Most mechanics wear a painting mask. If the inside of the clutch housing has to be cleaned, use water. Never brush or blow dry dust off of the housing.

When you're certain that a clutch problem is not the result of broken engine mounts, transmitted noises or faulty linkage adjustment, mark the driveshaft rear U-joint caps so they can be reinstalled in the same position. Position a drain pan under the trans rear seal. Unscrew the rear U-joint nuts, slide the driveshaft forward until the rear joint can be

disengaged from the pinion flange, then pull the driveshaft off of the trans output shaft. Some gear lube will run into the pan, so be sure to refill the trans later.

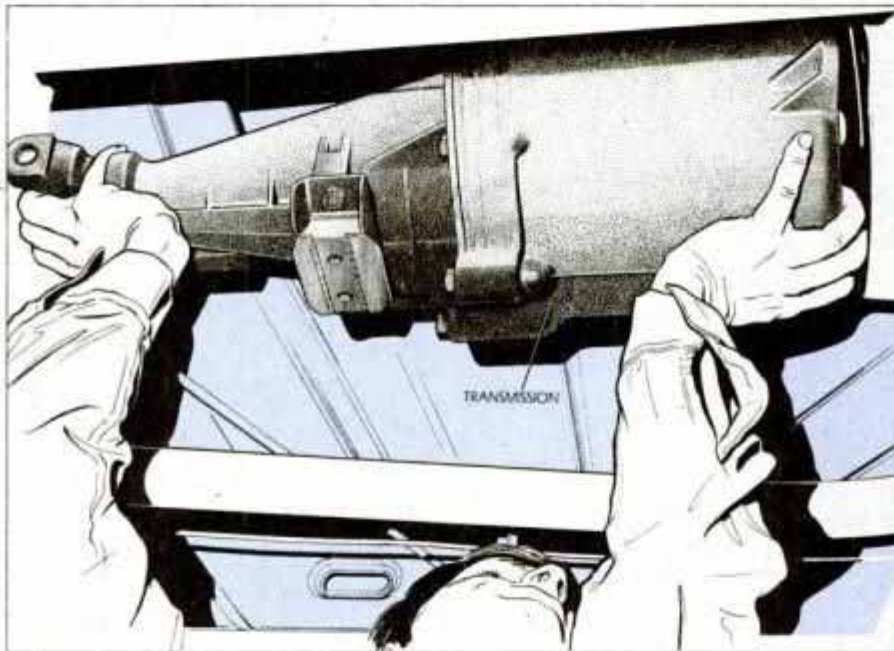
Locate a jack under the rear of the engine oil pan where it won't interfere with the clutch housing removal. Drop the trans rear cross-member by unbolting it from the rear trans mount and the body or frame unit. Shift the transmission to Neutral, and disconnect the shifter linkage.

Then, back off the clutch adjustment until the release linkage can be disconnected from the fork.

Time to pull out the trans. With trans jack in place or with a helper supporting the tailshaft, remove the four bolts that secure the transmission to the bell housing. Pull the trans toward the rear of the car so that it disengages the clutch disc. Then, lower the trans to the ground when the input shaft finally clears.

Remove the starter if it bolts to the clutch housing. Then, examine the clutch housing. If it has a dust cover opening that is large enough for clutch removal, you won't have to remove the housing. If it doesn't, use a long extension and a universal socket to remove the clutch housing bolts.

With housing and/or dust cover re-



Some aluminum case manual transmissions can be muscled down if you're a brute.

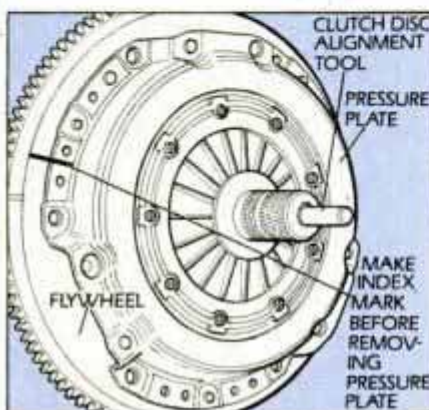
On rear drivers, you still have to remove the transmission to service the clutch, but it's a little simpler than pulling a transaxle. Below, we'll provide a general game plan that covers most rear drivers. Check your service manual for specific instructions.

You'll have to get the car well up off the ground. Follow all jacking recommendations as outlined in your service manual. Use proper jackstands or ramps and a level, paved surface. Block the wheels.

If your car has a trans with an aluminum case, you can probably muscle it down yourself (Fig. 3). However, it won't be easy. If your trans is a cast-iron unit, you'll definitely have to rent a transmission jack for the job. For any clutch replacement job, you'll need a clutch disc alignment tool (Fig.

moved, mark the pressure plate cover and flywheel with a punch, so that they can be reinstalled in the same position if you reuse the pressure plate. Then, gradually loosen the pressure plate bolts half a turn at a time, working from side to side to prevent cover distortion. Check for a leaking transmission input shaft seal or engine rear main seal.

Examine the clutch disc. If it shows anything other than normal wear, the pressure plate should be replaced along with the disc, and the flywheel will probably require resurfacing. We recommend changing the pressure



4 Use clutch disc alignment tool to position disc in respect to pilot bearing or bushing while you tighten pressure plate bolts.

plate and resurfacing the flywheel when the clutch disc is serviced. If you do intend to reuse your pressure plate, there should be no signs of checking or cracking. Evidence of extreme temperature, such as black and blue marks, are also grounds for replacement.

Before removing the flywheel from the engine, check runout with a dial indicator. Use a magnetic base to mount the indicator on the engine. Apply forward pressure so that the crank is seated on its thrust bearing and turn the flywheel. The indicator should show no more than 0.003 in. total runout. Inspect the flywheel for excessive discoloration, gouging or heat cracks. Replace a flywheel that shows even minimal heat cracking or checking (Fig. 5). Have your machine shop resurface a steel flywheel to remove minor imperfections.

Checking housing alignment

If your clutch problems cropped up after the engine or clutch housing was replaced, or if your car has been plagued with clutch problems since new, the condition could be the result

of a misaligned clutch housing.

To check clutch housing alignment, mount a magnetic-base dial indicator on the flywheel. Position the indicator so that the tip of its shaft rests on the machined edge of the transmission flange mounting surface at the rear of the clutch housing. Making sure that the crank remains in its full-forward position, rotate the flywheel and note high and low readings. There should be no more than 0.008-in. runout.

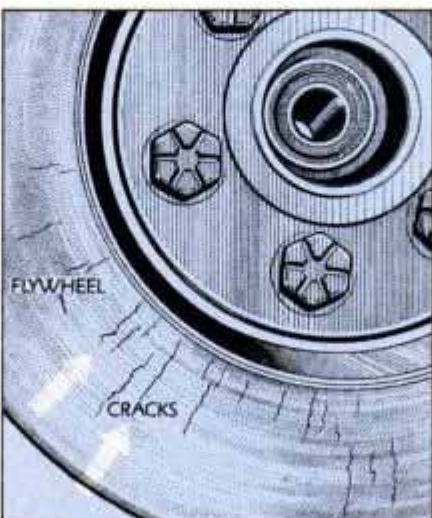
If runout exceeds this figure, mark the points at which high and low reading occur to determine which way the housing must be relocated. Relocate the housing toward the point of the low reading by replacing the standard dowel pins with offset dowel pins. These are available through most dealer parts departments.

Once you're sure that the bore runout is okay, check the rearward-facing machined surface of the housing to make sure it is square to the back of the engine block. To do this, mount the indicator on the flywheel, perpendicular to the rear face of the housing. Then, making sure the crank is seated forward, rotate the flywheel.

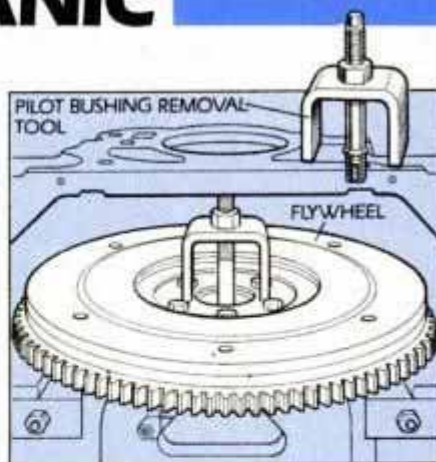
If the reading varies by more than 0.005 in. or more, cut pieces of shim stock and insert them between the housing and engine block as required. Each piece of shim stock used should be located at a bolt. Cut a slot in the shim stock so that it can be slipped over the partially loosened bolt.

Bolting it back together

Before installing the new clutch, check the pilot bearing or bushing in the back of your crankshaft. If it's a sealed bearing, it should turn freely. If it's a bushing, it should not show



5 Never reuse a flywheel that shows signs of heat cracking or checking.



6 You'll need a special tool to remove and replace pilot bushing or bearing.

much wear. Lightly coat a bushing with multipurpose grease before re-assembly. If a pilot bearing doesn't turn freely or if a pilot bushing shows signs of wear and out-of-round, it will have to be replaced. To remove either, you'll need a special tool (Fig. 6).

Install the flywheel using a thread-locking compound on the bolts. Torque bolts to spec in an alternating cross pattern. Position the clutch disc on the pressure plate assembly. The protruding side of the clutch disc hub must face the rear of the car. This is critical to correct installation.

While holding the disc in place, install the pressure plate assembly. The pressure plate bolts are shouldered and cannot be replaced with ordinary bolts. If they show signs of distress, they should be discarded.

Hand tighten the pressure plate bolts. Insert the pilot shaft of the alignment tool through the clutch disc hub spline and into the crankshaft pilot bearing. You'll have to move the alignment tool around and jiggle it to engage the pilot bearing. Make sure the tool bottoms in the pilot bearing before continuing.

Once you're sure that the alignment tool is in place, gradually tighten the pressure plate bolts. Work from side to side, and keep checking to make sure that the alignment tool doesn't bind or fall out of the pilot bearing. Once the pressure plate assembly has been torqued in place, remove the alignment tool. Lightly lubricate all contact areas of the clutch fork and the part of the release bearing that contacts the fork with multipurpose grease. Don't lube the input shaft.

Install the transmission, dust cover, crossmember and driveshaft. Lube all moving parts of the clutch release linkage, and reconnect. Adjust the linkage as described above to provide 1 in. of freeplay when the clutch pedal is at the top of its travel. **PM**

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RICK BRUSH,
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AVIATION

Sounds Of Silence

BY FRED MACKERODT, Contributing Editor



PHOTO BY MELVIN NIDELMAN

Tests aboard Piper Aztec proved Bose headset's electronics were effective against low-frequency noise.

SINCE THE Wright brothers' first flight, noise has been synonymous with airplanes and aviating. From the romantic whistling of the wind in the wires to the pounding away of aircraft engines, pilots have always been subjected to the ravages of noise.

Aviation pioneers Dick Rutan and Jeana Yeager surmounted some major obstacles in their 1986 9-day, non-stop flight around the world. One of these was noise.

At one point, they related the sound in the cockpit of *Voyager*—with both engines pounding away inches from their ears—to that of being in a phone booth lying on its side and being dragged down a cobblestoned street behind a Mack truck with no muffler.

Early test flights of the *Voyager* pointed up the problem. Both pilots suffered measurable hearing loss during these preparatory test flights, and Rutan developed

a condition known as tinitis, a ringing in his ears which has remained with him to this day. Chronic tinitis is a common complaint of pilots.

Flight surgeons who administer physicals to pilots will tell you that hearing loss is a given with anyone who has spent any appreciable amount of time in the cockpit. Dr. Stephen Ferrard of Hillsdale, New Jersey, a pilot himself for 50 years, points out that a lot of pilots he examines, especially the ones who fly general aviation airplanes, have measurable hearing loss that can be traced to being around airplanes.

In addition to causing hearing loss, cockpit noise also affects flying safety. It causes fatigue, which leaves pilots less able to handle the everyday chores of flying, not to mention the inevitable emergencies. It also affects communications, both within the cockpit and without. A recent study by the FAA of

air traffic in the heavily traveled northeast corridor cited cockpit noise as a special

danger seriously affecting controller-pilot communications. This is especially true of helicopters, where the noise levels tend to be very high. Choppers also operate in very tight environments where clear communications are all the more important.

New headset

Enter the new Bose noise-canceling headset. The company, a leading supplier of audio components, was already developing the headset when the *Voyager* flight was planned.

Bose jumped at the chance to have the headset used by the *Voyager* crew, and it is credited with bringing the two aviation pioneers through their 9-day ordeal with no measurable hearing loss. Bose has now put the headset on the market.

The Bose headset employs the latest in sound-muffling technology, including a double ring of super-soft cush-

NOISE CANCELING HEADSET



Sound pressure servo system in earcups converts unwanted noise to antinnoise. Gel cushions block sounds in higher frequency ranges.

BOSE ILLUSTRATION

ions made of silicone gel and a layer of foam inside a clear polyurethane skin that blocks out the majority of the high-pitch noise, above 1000 Hertz.

Antinoise

How effectively a headset removes high-pitch noise is a function of how closely and tightly the earcups surround the ear. But this new headset goes a big step beyond blocking out high-pitch noise—which every good low-tech headset should do. It removes low-pitch noise (between 30 and 700 Hertz) by actually creating a noise to cancel noise.

The revolutionary headset uses microphones on the earphones that monitor sound at the user's ear. According to Bose, this measured sound is compared with the sound the user wants to hear—either a communication signal from a radio or, if no signal is provided, silence.

The difference between the existing and the desired sound is then processed to create a signal opposite in frequency to the unwanted noise. A law of physics states that a sound wave that interacts with an equal, out-of-phase sound wave will be canceled. The antinoise of the correction signal, when reproduced by the speaker in the earcup, cancels the unwanted noise, leaving the desired sound.

In-flight test

Sounds complicated. Does it work? Unequivocally yes. I tried the Bose headset in a number of different aircraft, including my own Aztec. A switch controls the noise-canceling feature, and when that switch is turned on, the effect is uncanny.

After a momentary pause, while the headset is measuring the ambient noise, virtually all of the low-level rumble is sort of washed away. You still know the engines are working, but their sound level is reduced dramatically.

I put the Bose headset to the ultimate test in an airplane owned by my friend, Bob Mason—a 1956 Cessna 310, the aircraft that made Sky King famous. Mason's vintage airplane has to be one of the noisiest flying machines in existence. The exhaust from its twin 240-hp Continentals exits from dual 5-in. exhaust stacks which are on top of the wings. These stacks at one point are as close as 3 ft. from the pilot's ears.

With the noise-canceling feature off, the Bose headset removed about 50 percent of the Cessna's roar. Turned on, it knocked out about 90 percent of the noise, even at full takeoff power. Pilot-to-pilot and radio communications were clear as a bell.

The one big drawback of the Bose headset is its price—\$965.

However, like anything else, the price will probably come down in time,

putting the new headset more within the reach of private pilots.

New entries

Competition from a number of companies is already putting downward pressure on prices. Telex Communications introduced its \$900 ANR (for active noise reduction) headset in February. Sennheiser Electronic, a West German microphone manufacturer, will bring out a lightweight noise-canceling headset this April. The Sennheiser headset doesn't surround the ears, thereby having little effect on high-frequency sounds, but cancels out low-pitch noise

with a system similar to that of Bose. Noise-cancellation technology is also being studied for use in other applications. Bose is looking at headsets for race cars and for military and industrial applications. Don Gauger, Bose's manager of communications products, also sees the possibility in the future of noise canceling headsets for audiophiles.

If nothing else, the advent of this new technology points out the need for at least some kind of ear protection while flying. A good economy priced headset is great for starters. And even a cheap set of ear plugs offers a lot of protection. **FM**



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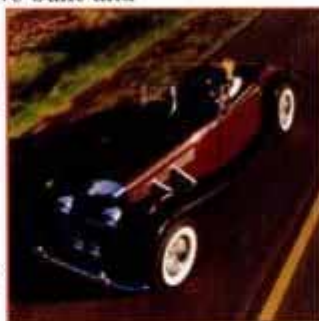
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Improving Your Images

BY STEPHEN A. BOOTH

WITH ALL the automation in today's 35mm cameras, and all the advances in 35mm films, it's sometimes easy to forget that there was a time when photographers set shutter speed and aperture manually, metering the light with great care according to the limited exposure capabilities of relatively slow-speed films.

Today's color print films have wide exposure latitude. Your metering can be off as much as four f/stops but you'll still get an acceptable photo. The film, processed under computer control in a minilab, is forgiving of errors. It has to be. Automated, point-and-shoot cameras sometimes get fooled by complex lighting situations. Trained photographers could adjust for difficult lighting conditions by fine-tuning their exposures manually.

If you're nostalgic for those hands-on days, or, if you simply want to retain creative control of your photographs, then you'll want to experiment with Kodak's line of Ektar color print films.

The Ektar series comes in three film speeds: ISO 25, 125 and 1000. Kodak recommends them for critical photo situations—the type where photographers usually go with a transparency film, such as Kodachrome. Ektar brings to



This golfing-action photo, shot in late-afternoon sunlight, was made on Kodak's Ektar 1000 print film with a shutter speed of $1/1000$ second at f/4. Notice the fine grains of sand, and the detail in shadow areas.

the print world much of the acclaimed beauty of that classic slide film—the deeply saturated colors, the superfine grain, the punchy contrast. It also brings the critical exposure requirements of transparency film. Unlike conventional print films, Ektar does not offer lots of forgiving exposure latitude. Metering must be precise. Accordingly, Kodak recommends—strongly—that its Ektar films be used in single-lens-reflex cameras with manual control, rather than auto-everything snapshooters.

This recommendation applies particularly to the slow-speed ISO 25 Ektar, an arty film that also benefits from the help of a tripod. Ektar 1000, a high-speed film, has a bit more exposure latitude—as you might expect from a film that will be used either for action photography, or with long focal-length lenses, or where light conditions are iffy.

Though all the Ektars are intriguing, we've concentrated on the ISO 1000 because its applications probably match the photo-making interests of PM readers.

High-speed print films in the ISO 1000 range have been around since the early 1980s. Most people probably perceive them as a last-resort type of film, for times when you must have a picture, whatever the quality. The early ISO 1000's were extremely grainy. Shadow areas blocked up—losing detail and often taking on a murky cast of brown or blue.

As you might suspect from the sample photos here, Ektar 1000 has changed all that.

Grain is almost unbelievably fine. Shadow areas retain detail. Color tone under contrasty light conditions has a wider range than earlier films of this speed. Accordingly, this film will let you get photographs that would have been difficult before.

For example, compared to an ISO 100 film, the extra 2 to 3 stops of speed permit you to handhold a camera. With an ISO-100 film, shutter speeds would be so slow as to require the use of a tripod, to prevent motion-induced blurring. The same applies if you are using a telephoto or a zoom lens. Their long focal length restricts the light reaching the film, thereby requiring the use of larger aperture (lower f-stops). But depth of field becomes constricted at large apertures: Slight movement by the subject might put it out of sharp focus. Again, the high speed of an ISO-100 film permits you to use a smaller aperture, for greater depth of field, or, a faster shutter speed to capture action. The photo of the young boy, shown here, was shot with Ektar 1000 at $1/125$ second and f/2.8. With an ISO-200 film, the shutter speed would have to have been a relatively long $1/15$ or $1/30$ second—to slow to snare a constantly on-the-go child.

What's the bottom line? Ektar 1000 has proved itself an outstanding high-speed print film. It would be right at home during an indoor ballgame, or a cloudy day at the track, with long lenses, or with subjects that just won't sit still.

Pick Any Number

After all this talk about critical exposure, there's now a film that doesn't care what ISO speed you set.

Polaroid, best known for its instant films, now has entered



Ektar 1000 comes through with flying colors in this photo, taken in the shady light of an autumn afternoon. Exposure was $1/125$ second at f/2.8. With ISO 200 film, a $1/15$ to $1/30$ -second exposure would be needed—too slow for a constantly moving child.



Canon's EOS-1 is an autofocus SLR with 1/8000-second shutter, and manual control features aimed at pros and serious amateurs.

the conventional film market with a novel approach to 35mm-print photography. The company's OneFilm is an ISO 200, medium-speed formulation whose wide exposure latitude helps it work in a wide range of lighting conditions. Instead of offering a choice of 100, 200, 400 and 1000 films, Polaroid will offer just the one. The concept? People have enough things to worry over without agonizing over the correct film for the job. The idea isn't new—ISO 200 has long been the utility fielder of print film. All Polaroid is doing is stating this in black-and-white.

Flash News

It will take a while before we've got enough hands-on experience with Canon's new EOS-1 (\$1850) to deliver an in-depth report. So for now, we'll just announce its arrival and its reason for being.

Advanced and professional photographers have been slow to accept the new breed of autofocus, single-lens-reflex cameras. This has something to do with the automatic focusing, and a lot to do with the automation of everything else. All so-called AF cameras also are automatic-exposure cameras. The on-board computer takes decision-making, and creative control, out of the user's hands.

With the EOS-1, Canon is giving that creative control back to the human behind the viewfinder. Yes—it still has a genie inside. But the genie can be custom-programmed to do the photographer's bidding—virtually anything that an all-manual SLR can do, and then some.

The EOS-1 offers a choice of five light-metering systems and six autoexposure modes. It's got a 1/8000-second shutter and automatic bracketing, which means that the motorized film advance will make three images of the same subject at three different exposure settings determined by the photographer.

Among other pro features, there's a 1/8000-second shutter and an \$1850 price tag. Stay tuned for more details. **PM**

PM Tips For Better Pictures



PM PHOTO BY ARMAND ENSANIAN

YOU CAN push your film to get a photo in low light. All you do is shoot at twice to four times the film's ISO rating. Longer developing time yields a grainy but usable image, as seen above. Most B & W print and E-6 slide films can be pushed. Color print film cannot and Kodachrome should not. Be sure to shoot the whole roll at the same speed, and tell your lab to push-process the roll for the ISO rating you used.

—Armand Ensanian

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MOTORCYCLES

Gentleman's Express

BY BILL HARTFORD, Managing Editor



A CAR'S ENGINE isn't visible unless the hood is up, so why should a motorcycle's powerplant stand naked before every observer? Full-coverage bodywork clothes Honda's new PC800 Pacific Coast without revealing any clue to the engine type or layout.

Motorcyclists have a long-standing reputation as technophiles, so you might wonder why Honda has chosen to conceal every mechanical bit of the Pacific Coast short of the exhaust system. The answer is simple enough: Honda wants to expand sales beyond the traditional enthusiast buyer pool.

The Pacific Coast greets its widely divergent marketing goals with a futuristic, sculptured shape. The fairing's front portion carries forward a family resemblance from the Gold Wing series machines, and, accordingly, provides reasonable weather protection. At the back end, the plastic shroud-

ing bulges out to form an easily accessible trunk, and the instruments nestle under a hooded panel.

Easily removable panels allow access to the engine oil dipstick and permit spark-plugs to be changed with no further disassembly. Sturdy steel tubing guards for the engine cases and rear body sections are concealed behind plastic covers. If the bike goes over, only the small sacrificial panels need be replaced.

Peel away this Honda's skin and things get even more friendly. The concealed power source turns out to be an 800-cc water-cooled V-Twin, tuned for a broad powerband and a torquey reply whenever the throttle is goosed. Vibration is controlled by a combination of offset crankpins and rubber mounting at the frame attachment points. Engine noise has been all but eliminated, with just enough of the V-Twin rhythm coming

through at idle to let you know that there's a bit of soul lurking deep in the basement. Low-maintenance demands on the owner are assured by a shaft final drive, electronic ignition, hydraulic valve adjusters and an 8000-mile oil change interval.

Slow-speed maneuverability is improved by positioning heavy components down low on the frame, so the Honda engineers located the gasoline reservoir below the seat. The traditional gas tank up top is no more than a cosmetic shell. Fuel capacity (including reserve) is just 4.2 gallons, though. We averaged 51 mpg at a brisk highway cruise.

Though the cover-up panels of the Pacific Coast conceal nearly every bit of evidence to the contrary, this Honda is anything but low tech. Dual disc brakes up front are shrouded in plastic, but they are both powerful and reassuring in use, partly due to the antidive mecha-

nism fitted. The rear trunk opens easily with the pull of a single remote lever and remains in the raised position thanks to a small gas strut. The suspension, though thoroughly conventional in design, is graciously compliant.

What makes any motorcycle a worthy long distance companion is cabin comfort, and the Pacific Coast excels in this department. The seat is low and wide, there is room for all but the tallest riders to stretch out and the fairing effectively blocks wind from reaching your chest and hands. Wind buffeting intrudes at helmet level, though. We'd take some simple hot-air ducting in the bargain, too, as long as there's that radiator up front to make this possible. Considering the \$7698 price tag, an electronic cruise control might be thrown in as well.

As a lifestyle statement, the Honda Pacific Coast speaks of culture and refinement like no other cycle in recent memory. Any other motorcycle, even with a TV celebrity or billionaire jet-setter in the saddle, simply underscores the rider's desire to swim against life's mainstream current. Without giving up the flavor or pleasure of travel on two wheels, the Pacific Coast defines a proper Gentleman's Express in the 1990s. **PM**



Gas strut holds the trunk lid in the open position.

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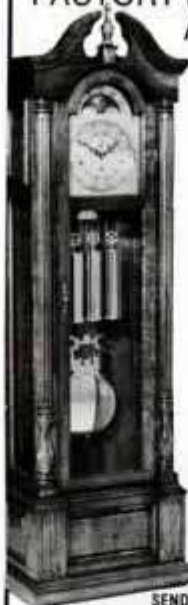
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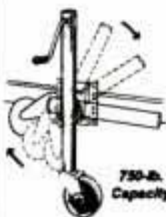
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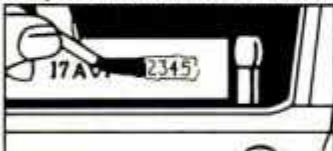
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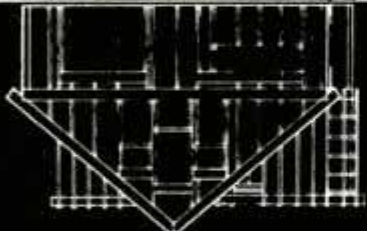
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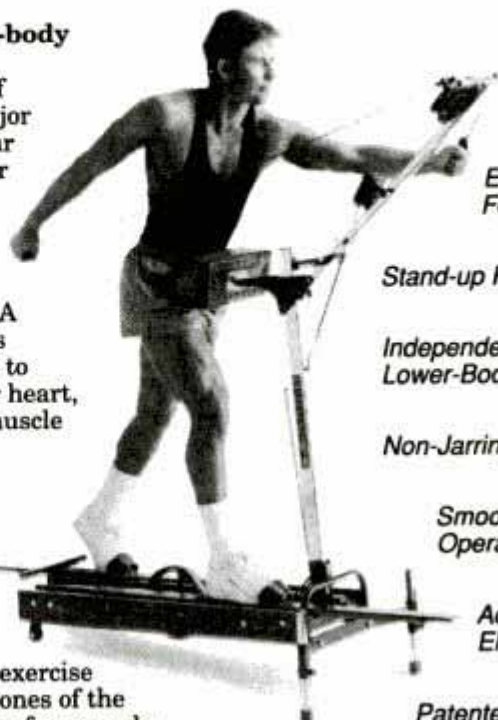
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Two brochures from Wolman® Deck Care Products, "Treat your deck to a longer life" and "Treat your deck to the rich warmth of natural wood"—show how to restore and protect pressure-treated and natural wood from the harmful effect of water. Free

718 1990 SPORTBOATS

New for 1990 from Chris® Craft Boats are the all new Concept '90 Sportboats. Full color catalog features 14 of the Sport and Fishing boats in the 31 model line. Catalog includes details and specs. Free

719 CLASSIC CAR PLANS

Kidmans offers seven different detailed plans for 2/5-2/3 scale collector cars for children and adults. All designed to be easily built from inexpensive recycled parts. Optional 12V rechargeable power. Great shop project. Brochure \$1.00

720 COMPLETE FISHING BOAT PACKAGES

Fisher Marine's complete factory-rigged top quality aluminum fishing boat systems include: Mercury or Mariner outboard, full accessories, bottom line locator, MotorGuide electric, and drive-on trailer. Catalog and nearest dealer. Free

721 QUICK CHARGING

Charge your rechargeable batteries twice as fast with the Eveready Quick Charging Rechargeable battery system. Rechargeable batteries are a convenient and economical way to power any device. Pamphlet explains how rechargeables will work for you, and includes a \$1.00 coupon on a rechargeable battery purchase. Free

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SOUND ADVICE is an audio cassette tape containing 20 of the most common noises your car can make. Listen to this tape and identify the noise your car is making so you can fix it yourself, or aid your mechanic in fixing it. From POPULAR MECHANICS. \$7.95

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724 POPULAR MECHANICS "PLANS AND IDEAS CATALOG"

Hundreds of ideas for the do-it-yourselfer. Plans for storage and mini-buildings, furniture, toys, hovercraft, outdoor furniture, just about everything. \$2.00

725 COLD FACTS ABOUT WINTER STARTS

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726 THE PROTECTION YOU NEED

Protect your home with AT&T's Security System 8000, custom designed for the right level of wireless protection for your family and property. The self-monitored system offers a variety of protection services, and is professionally installed. Free brochure

727 LIFETIME FINISH

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