SPECIAL 90th ANNIVERSARY ISSUE

FEBRUARY 1992 $1.95

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90 YEARS

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E A WAKE-UP CALL? TAURUS SHO

H A THOUSAND POUNDS OF STEEL? PROBE GT

ING AS TOO MUCH FUN? ESCORT GT

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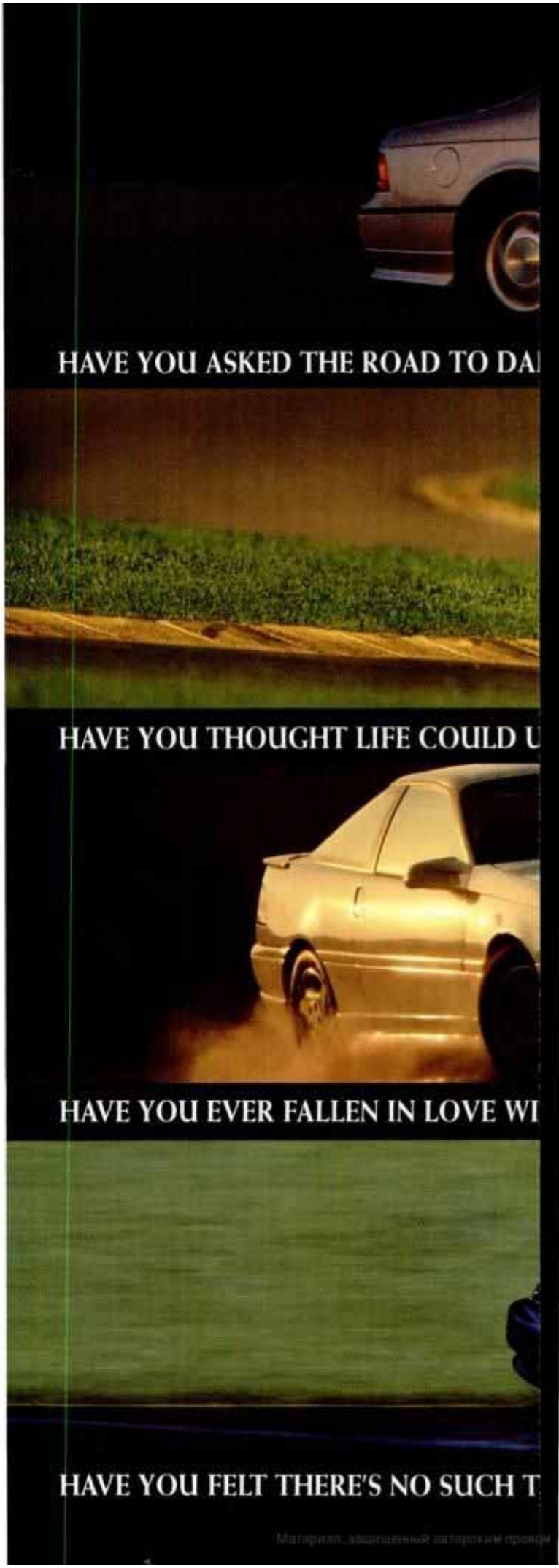
Ford

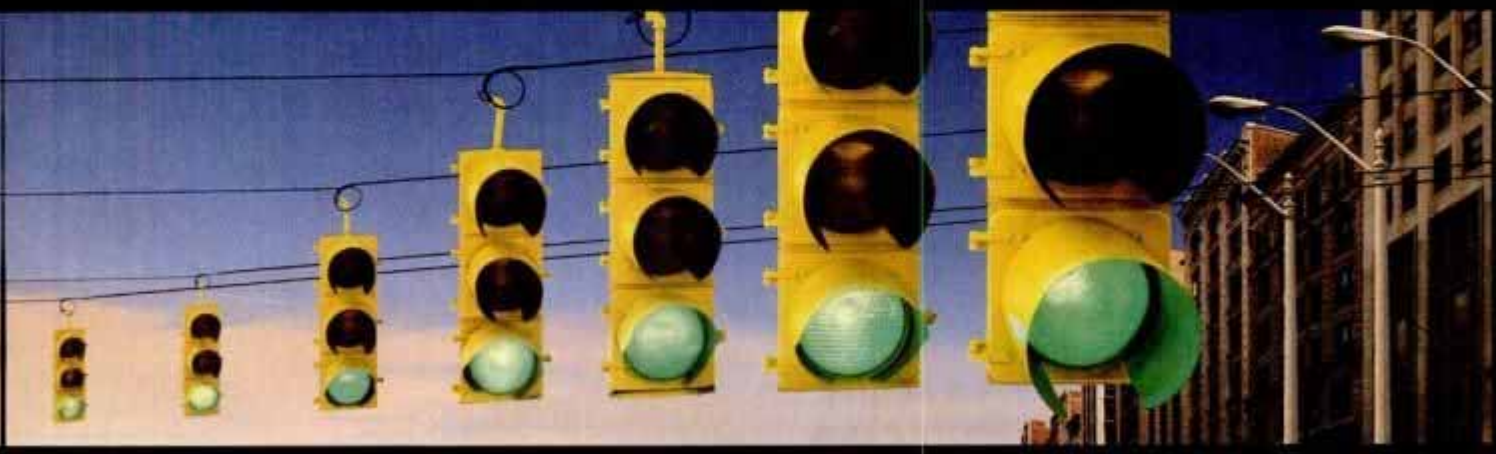


HAVE YOU NOTICED HOW MORE CARS ARE BECOMING MORE BORING, ALL CATEGORIES AND STATISTICS, TOTALLY FORGETTING WHY A SPORTS CAR IS DRIVEN? FORGETTING THE POWER OF A CAR SHOULD BE FELT LONG BEFORE YOU TURN IT ON. IT'S SOMETHING FORD STILL OFFERS, ALONGSIDE ALL THE TECHNO-ENGINEERING. SOMETHING THAT SAYS REAL FAST THAT AMERICA'S LOVE AFFAIR WITH THE CAR ISN'T OVER. AND LATELY, COULDN'T WE USE A LITTLE MORE OF THAT?

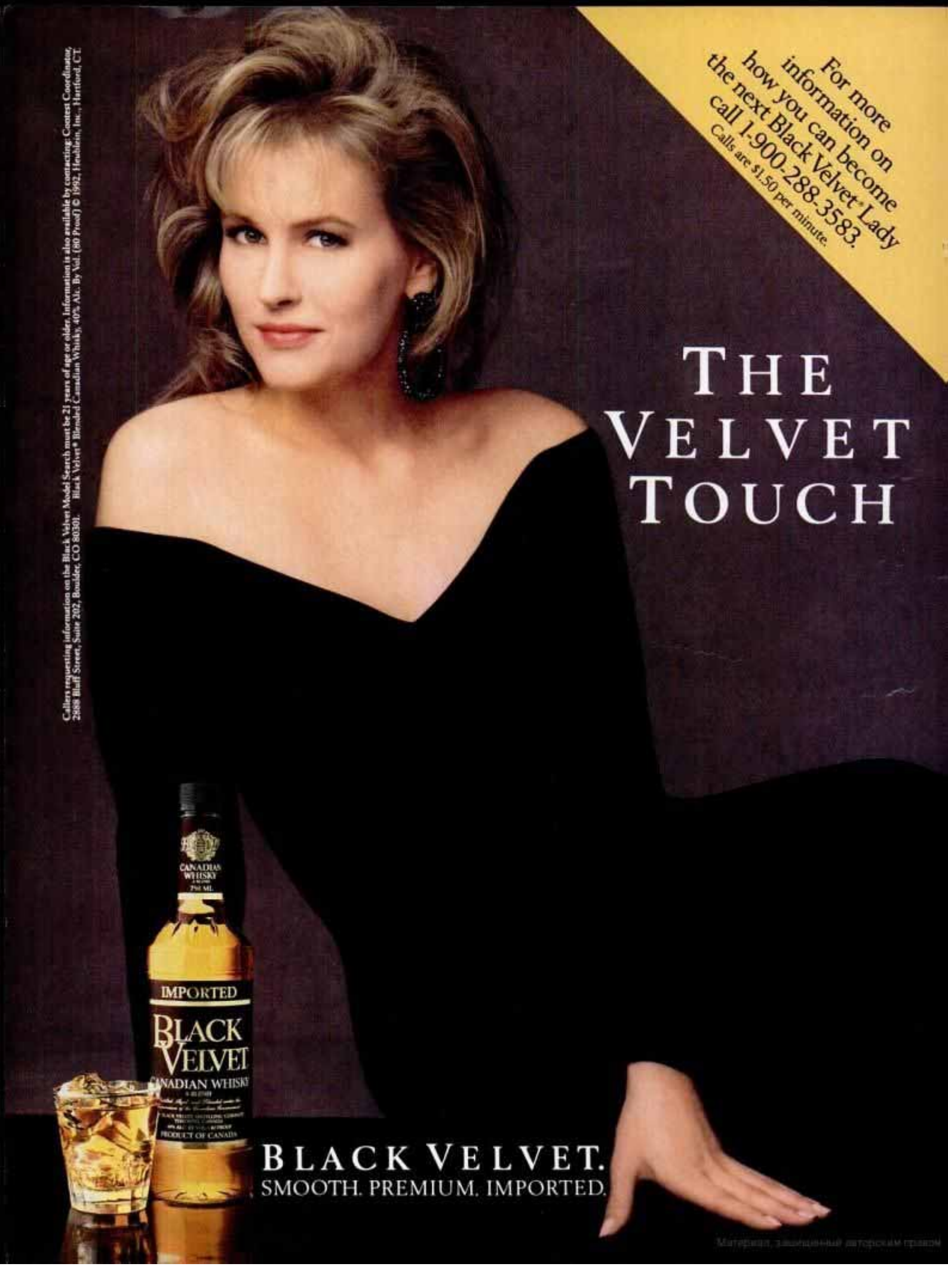
HAVE YOU BET THE MOON YOU COULD BEAT IT TO THE CORNER?

HAVE YOU MADE A CITY DISAPPEAR?

HAVE YOU ALWAYS HATED LONG GOODBYES? MUSTANG GT CONVERTIBLE



HAVE YOU WISHED ALL THE LIGHTS IN THE WORLD WERE GREEN?



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Popular Mechanics

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VOLUME 169
NO. 2

90 YEARS

83

26 COVER STORY

67 SPECIAL SECTION

PM cover illustration by John Berkey

EDITOR'S NOTES

HENRY FORD MUSEUM & GREENFIELD VILLAGE PHOTO

● Mary Seelhorst is a remarkable person. Mary is curator of the "Possible Dreams: POPULAR MECHANICS and America's Enthusiasm for Technology" exhibit at the Henry Ford Museum & Greenfield Village in Dearborn, Michigan, which will open February 29. In that position over the past two years, Mary has read—and, I think, memorized—every issue of POPULAR MECHANICS from January 11, 1902 to this one. Right now, at this point in time, there is no one, *no one*, on the face of this Earth who knows more about the content of POPULAR MECHANICS than Mary Seelhorst. So when I wanted a piece written for this special 90th anniversary issue on how 90 years of POPULAR MECHANICS has chronicled, and even influenced, the changes that have taken place in America since 1902, I turned to The Source—Mary Seelhorst. Mary's article is not so much a history of POPULAR MECHANICS as it is an essay on how our society has changed, how we have changed as a people, in 90 years. Mostly, the piece is illustrated with covers and pages from POPULAR MECHANICS because we were there every step of the way—illuminating, explaining and enlightening our readers about the world around them. It's kind of like what we try to do in every issue even today, plus have a little fun along the way. Come along with Mary for a look back at the dreams we shared and the people who made them happen. One of those people is Dan Coleman. Now a vice president with our parent company, Hearst Magazines, Coleman was with POPULAR MECHANICS for more than 30 years, the last 10 as publisher. I asked him to add his reminiscences to Mary's essay, and I think you'll agree when you read our special anniversary section that they add a special touch to this look back at PM's heritage. . . . **Every four years,** a wonderful thing happens. No, not the presidential elections—the Olympics. People from almost every country in the world gather together in peace and good will to share the experience of athletic competition. Our contribution is a special section this month which covers some of the inside stuff you won't get on TV. Like how our U.S. athletes utilize the latest in sports science and sports medicine to develop training regimens that push the human body—and mind—to its limits. Science/Technology Editor Abe Dane and Electronics Editor Frank Vizard combined to develop our special section which starts on page 26. . . . **Speaking of special sections,** we have one more for you this issue. It's February and that can only mean one thing around here—boats. We've got all the new models, engines, gear and everything else you usually find in our annual Boating '92 special. Till next time.

Mary Seelhorst

Dr. Steve Johnson, left, director of sports science for U.S. Skiing and our Abe Dane.

Joe Oldham

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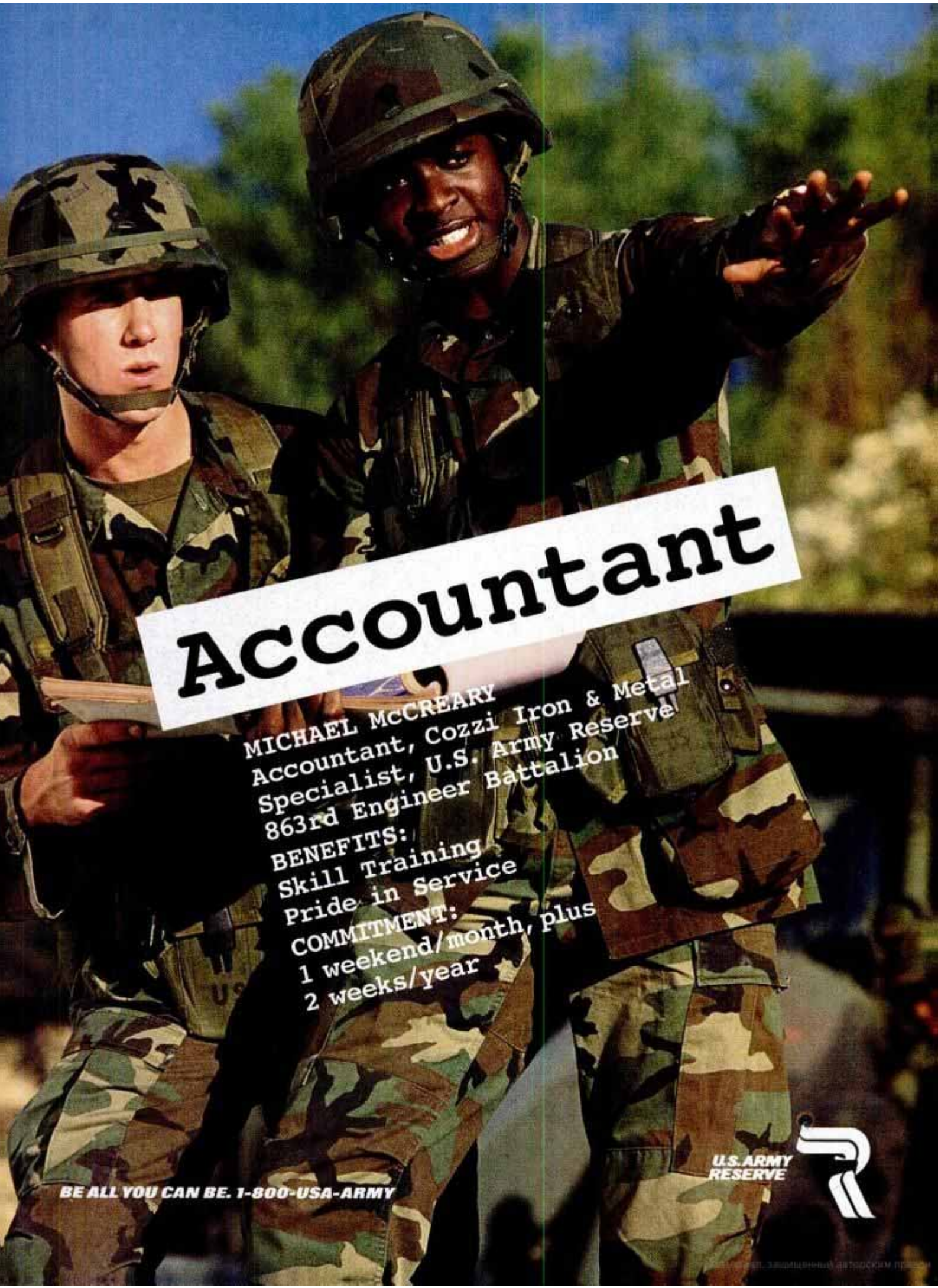
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LETTERS

In The Black

Thanks for your cover story on the Department of Defense's so-called black programs. I agree that some programs should remain classified. After all, we don't want to give away all our secrets to the Saddam Husseins of the world. On the other hand, as a taxpayer, I feel that I should be given sufficient information to know, at least generally, where my tax dollars are going. LEO VECCHIONE
CLIFFWOOD BEACH, NJ

Hot Dogs Or Sushi?

The debate over which cars are better, American or Japanese, degrades both sides. I own both an American (Chevrolet) car and a Japanese (Honda) car, and I find that both cars are dependable. Any car is only as good as the person driving it. Pedal-to-the-metal, stop-and-go drivers will wear out and/or break any car, imported or domestic. If we took the time to check the fluid levels, tires, brakes, belts, hoses and so on, we just might find out that any car can be dependable. JUSTIN MILLER
BESSEMER, MI

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

My first new vehicle was a 1987 Chevy S-10 pickup. I had transmission problems every 3000 miles and fabric fatigue within the first year. After 1500 miles, the a/c compressor made a lot of noise. After 13,000 miles, steering wheel bolts fell out. After 43,000 miles, the fuel injectors burned out and the computer brain failed. I also experienced problems with the a/c-heater fan motor, electrical fires at the fusebox, door handle springs and casting breakage. In addition, too much voltage from the alternator caused all the lights to burn out repeatedly. I now drive an American-built Nissan from Tennessee that is fabulous and has 22,000 troublefree miles. What a difference.
GLENN E. MILHOUS SR.
EL MONTE, CA

I own a 1978 Chevy Malibu with 238,000-plus miles on the odometer. I also own a 1985 Dodge D-100 with 126,000 miles and a 1982 Buick Regal with 101,000 miles. I bought my first car in 1953 and have never owned a lemon. The Japanese propaganda machine is working real well. It tries to make people who don't buy its cars appear to be freaks, and a large part of the brain-dead American public is falling for it.
DENFORD L. HARPER
ATTALLA, AL

Shot To Pieces

A reader from Stamford, Connecticut, recently wrote that "the need for handgun control is overwhelmingly obvious." The residents of Connecticut should be aware of what would happen in their state if the firearms industry is legislated out of existence. The state would: 1. Lose all the corporate taxes paid by firearms companies, 2. Lose personal income taxes paid by their employees, 3. Have to pay unemployment benefits to those employees, 4. Lose taxes and jobs from other companies that supply goods and services to the firearms industry. Here in Ohio, everyone feels an economic pinch when there is a slump in the automobile industry. Those who live in Connecticut should know who butters their bread.
JAMES L. VANIMAN
TROTWOOD, OH

The Glock 17 handgun is a beautifully designed piece of machinery that does well what it is supposed to do, and is a marvel to look at. In this day and age of criminal violence against women and the elderly, coddled by our degenerated legal system, we need more guns in the hands of decent and mature citizens instead of depending on the state to protect us. POPULAR MECHANICS is about beautiful and efficient machinery, and the Glock 17 pistol is in that category.
ROBERT YORK
PENSACOLA, FL

C-17 Correction

The piece on the new C-17 aircraft was inaccurate. Operational Air Force pilots will not have to restrict reverse thrust with leading edge slats down. A minor change in the material covering the slats will eliminate the restriction.
COL. M.R. GALLAGHER
SCOTT AFB, IL

On Track

The May 1932 issue of PM had plans for the 1831 De Witt Clinton train. At the time, I was a senior in high school taking a course in machine shop. So I decided to start building the train. By the time I graduated, I was able to finish the frame, the main wheels and the crankshaft for the engine. After college, I was off to Air Force Flying School. Twenty-five years in the service further delayed the project. I finally finished the engine 56 years later. Now I've started on the tender.
LT. COL. JESSE A. TOBLER
USAF, RET.
SHELTON, WA

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Overall, today's Dodge trucks, gas and diesel, can deliver more payload, towing and horsepower than Ford, Chevy or any import.* Period.

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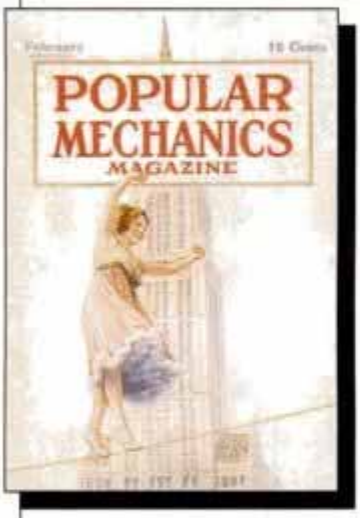
TIME MACHINE

75 YEARS AGO: FEBRUARY 1917



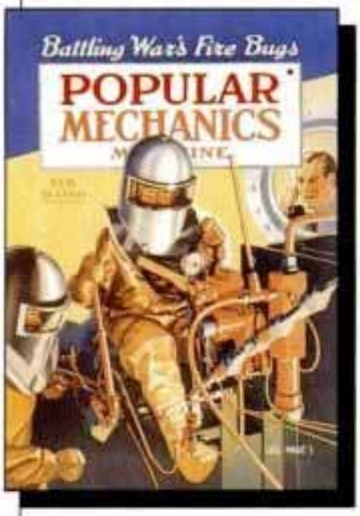
Sky Walker

Highlighted by the "Cathedral of Commerce"—the 780-ft. Woolworth Building—the New York skyline was taking shape. Cheap steel, reliable elevators and a roaring thirst for office space were turning Manhattan into a man-made canyonland, as concerns about crowding and sunlight deprivation hadn't yet begotten zoning and setback laws. The new buildings inspired daredevils, like the Ziegfeld girl who walked a tightrope 250 ft. above Broadway.

Ack-Ack Aweigh

Nothing changed naval warfare faster than the appearance of naval aviation in World War I. Shipboard anti-aircraft artillery began appearing as hasty retrofits to existing vessels. Among the first were shrapnel-firing 3-in. guns, mounted almost vertically and tended by a 7-man crew perched on a rotating platform. Popping off 30 rounds per minute, the guns were rapid for their day. But they lacked effective fire control and couldn't keep up with agile airplanes.

50 YEARS AGO: FEBRUARY 1942



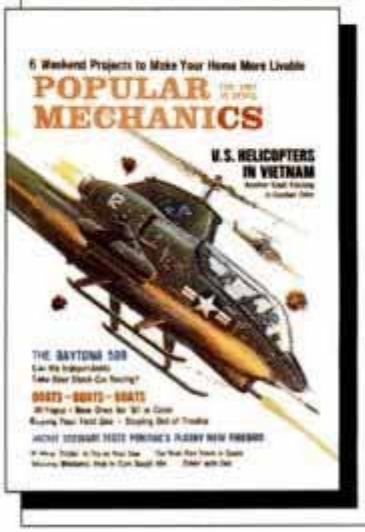
Seven Miles High

At 35,000 ft., the B-17 Flying Fortresses claimed territory all their own—with technical problems to match. Wispy air density shorted out engine ignitions. Ball bearings froze in their own grease. Paint shrank and shed like dandruff. To counter these glitches, Boeing reproduced high-altitude conditions in a cold compression chamber. This is where crews in horsehide suits and aluminum helmets tested vulnerable systems—including their own bodies.

Face Of Fear

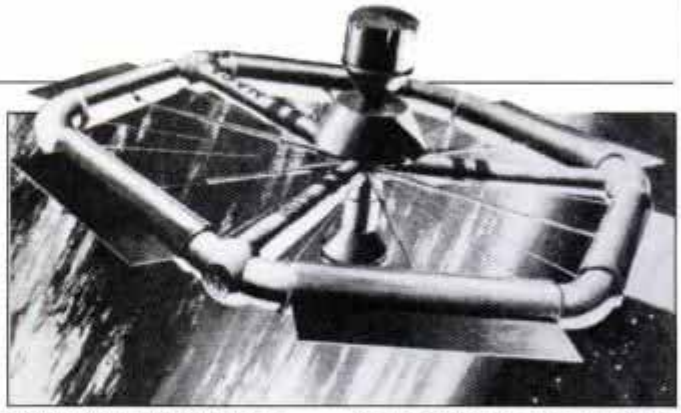
During World War II, Curtiss cranked out flocks of P-40 Warhawks between 1940 and 1942. Strapped for airpower, the RAF had ordered the Tomahawk version by the thousand, and sent them up against Germany's new Messerschmidt Bf 109F's in the Middle East and North Africa. No match for the Messerschmidts in raw speed, the P-40 Warhawks could still outmaneuver their adversaries in a dogfight. They also took well to a shark-mouth paint job.

25 YEARS AGO: FEBRUARY 1967



King Cobra

The combat helicopter came of age in the Vietnam War, as Army choppers did everything from medevac to machine-gun assault. Small but nimble, the beloved and versatile Huey handled the attack role during the early years. But in '67, its hatchet-faced descendant—the Huey Cobra—arrived on the scene. Unleashing a lethal mix of grenade, rocket and cannon fire, the mean Snake quickly took the spotlight as the premiere offensive threat of the war.



Five-Year Mission

We celebrated the 5-year anniversary of John Glenn's orbit by predicting the space program's next five years. Our calls? 1968: Air Force astronauts live in Manned Orbiting Laboratory for a month. 1969: We land on the Moon. 1970: We sink research lab beneath lunar soil. 1971: We launch orbiting space station. 1972: We build lunar radio-telescope. **PM**

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TECH UPDATE

News Of Tomorrow's Technology Today

PM ILLUSTRATION BY PAUL DIMARE

Future Ships Could Swim Like Fish

LAWRENCE, KS—Fish have known it for 400 million years: The easiest way to slice through water is to flap a tail. Now man is catching up. Seeking efficiency and stealth for marine craft, engineers are looking seriously at fishtail propulsion.

At the University of Kansas, Ronald Barrett has already demonstrated a 9-in. proof-of-concept vehicle. Wiggling at a frequency of 22 swipes per second, a submerged tail drives the little model at 0.6 knots. The motion comes from piezoelectric ceramic strips, which expand and contract in response to an alternating current. Lined up at 45° angles along the tail's sides, the strips can be triggered independently to control pitch, yaw and roll.

Barrett sees two major applications for what he calls solid-state aquatic vehicles. Navies could exploit noiseless propulsion and fishlike behavior to have small underwater robots sneak up on hostile ships. Surface vessels could take advantage of the drag-reducing eddies touched off by the oscillating tail, for a big boost in efficiency over conventional screws. Scaled up, a 100-ft. tail could push a ship at 30 knots.

Meanwhile, Massachusetts Institute of Technology engineer Michael Triantafyllou is already designing a 5-ft. robot sub with a tail that is driven by hydraulically activated pulleys.

Twin piezoelectric fishtails, oscillating out of phase to minimize yaw, could drive future tanker.

Editor: Abe Dane
Assistant Editor: Greg Pope
Contributors: Lisa Bulich, Mike Fillon, Bob Scheier

Highlights This Month

- **Water Bearer**—Floating aqueduct could slake California drought.
- **Weather Eyes**—Planes' new sensors spot wind and see through storms.
- **Grand Slam**—Army's superdoor is faster than a speeding bullet.
- **Jets Strip Jets**—Water guns peel paint from aircraft.
- **Shot From The Blue**—Huge gun to launch payloads from barge.
- **Armed Forces**—Robot limbs evolve for strength and grace.

(More Tech Update on page 14)

Aquatic Aqueduct

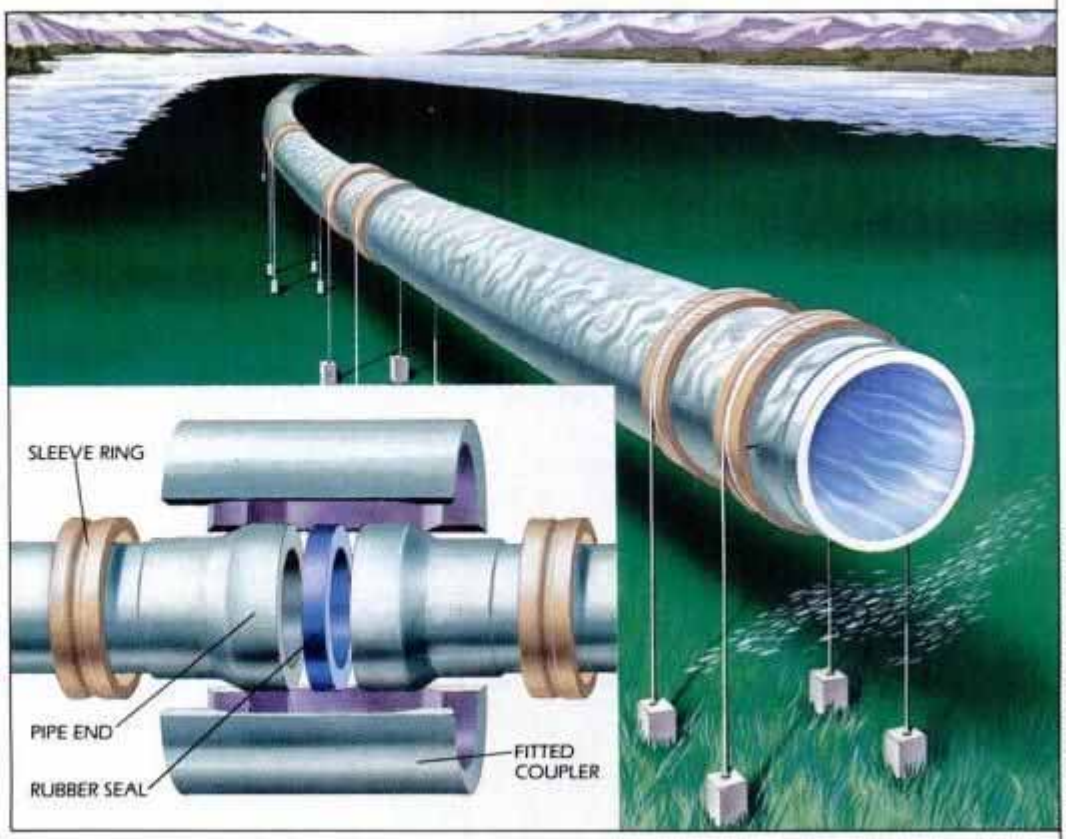
SITKA, AK—Thirsty Californians might someday sip Alaska's glacial water, courtesy of the world's longest aqueduct. Engineers have been exploring the possibility of a 1700-mile subsea water pipeline between an Alaskan river and Lake Shasta in Northern California.

Built of conventional steel buried in concrete, the project could cost $150 billion and take 15 years to complete. But engineering concerns Kaempen Technology and Advanced Offshore Concepts advocate a lighter tube made of a fiberglass-plastic composite for as little as $20 billion over 10 years.

Such a pipeline would take advantage of the fact that fresh water is less dense, and hence more buoyant, than salt water. The tube would float underwater, anchored to the sea floor by cables. Unlike steel, fiberglass resists rust and salt corrosion. And a mechanical coupling system, says Kaempen, could connect lengths of pipe with a seal tighter than welded steel.

To deliver 4 million acre-ft. of water annually would require land-based pumping stations every 150 miles. But the Coriolis effect, by which the Earth's rotation deflects ocean currents, may help push the water along and relieve energy demands.

Despite strong opposition from environmentalists, the proposal continues under scrutiny by both California and Alaska officials.



PM ILLUSTRATION BY ADOLPHE BROTMAN

Floating offshore aqueduct is constructed from lengths of composite tube mated mechanically.

PM ILLUSTRATION BY ED VALIGURSKY

Decoys lure anti-radiation missiles away from radar units.

Radar Missile Decoy

CHINA LAKE, CA—Enemy missiles that home in on Air Force ground radar may soon get sent on a wild-goose chase by radar decoys.

Developed by ITT-Gilfillan, the decoys consist of three antennas that put out strong signals aimed at incoming anti-radiation missiles, or ARMs. The missiles lock onto the decoy signals and crash into a safe impact area (inevitably dubbed "the ARM pit").

The decoys will help upgrade the Air Force's Tactical Air Control radar units and enable weapons controllers to continue radar-tracking targets during an attack. Testing begins this month.

Spy Drone Uncloaked

SAN DIEGO, CA—Flight tests are scheduled to begin this month on the recon tool of the late 1990s, the BQM-145A Medium-Range Unmanned Air Vehicle.

Self-guided, the drone will carry the Advanced Tactical Airborne Reconnaissance System, or ATARS, for the Air Force, Navy and Marines. During a recon mission, ATARS sensors will collect imagery, then beam it to processing stations on its return trip.

The Mach-0.91 vehicle will drop from the wing of an F/A-18 or blast from the ground via booster.

Production plans call for at least 500 vehicles.

TELEDYNE RYAN PHOTO

Built by Teledyne Ryan, 18-ft. UAV has 700-mile cruise range.

(More Tech Update on page 16)

The ultimate housewarming gift.

Give your home the gift that will last for years: a big help in lowering your energy bills.* And more warmth and comfort throughout the cold winter months.

All it takes is CertainTeed Fiber Glass Building Insulation.

Since most American homes are underinsulated, there's simply no better way to meet the latest Department of Energy recommendations than with CertainTeed. CertainTeed is thermally efficient, offers consistent quality, and will last for the entire life of your home. No wonder so many professionals choose it. To find out how much insulation your home should have, see your local CertainTeed building materials retailer, and ask for the one thing your home and family will appreciate for years: CertainTeed Fiber Glass Insulation. Or write CertainTeed, P.O. Box 860–PM, Valley Forge, PA 19482.

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*Savings vary. Find out why in the seller's fact sheet on R-values. Higher R-values mean greater insulating power.

Insulate now with CertainTeed Fiber Glass Building Insulation and you can get a free RoadPal™ Air Pump. Offer limited; expires March 1, 1992. See store display for details.

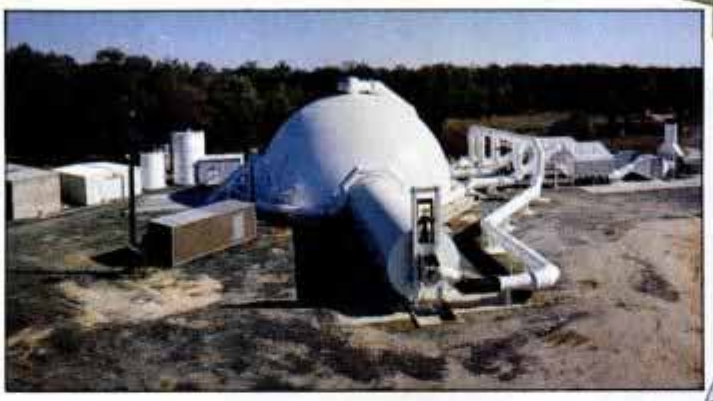
World's Fastest Door

ABERDEEN, MD—A super-guillotine slams the door on the Superbox, the Army's new armor-testing facility at Aberdeen Proving Ground. The door takes a mere 50 millionths of a second to close.

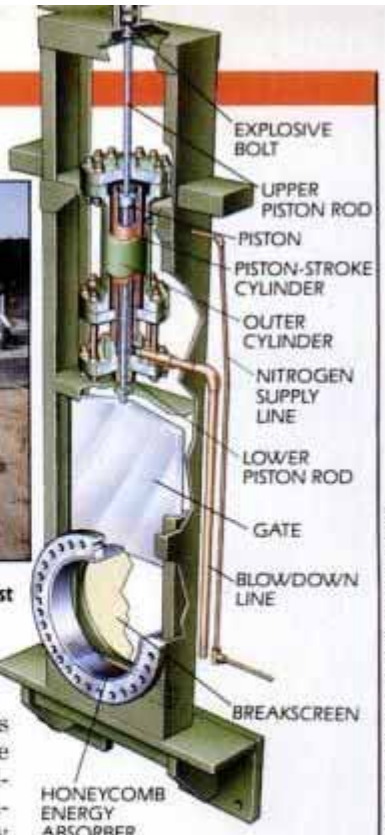
Here's how it works. The door's gate is raised, and nitrogen is pumped in to pressurize a piston connected to the gate. Only an explosive bolt prevents the piston from moving under this pressure.

Then the gun pulls up outside the Superbox and fires at a test vehicle within. As the round passes through the open door, it shatters a breakscreen. This sends an electrical current to the explosive bolt, which blows, letting the door slam shut before the blast wave reaches it.

Why the need? The machine must contain radioactive toxins which are released when depleted-uranium rounds slam into tanks inside the Superbox. Since an airtight gate wouldn't be as fast, blowers pull any leakage from around the door into a filtration system. Idaho National Engineering Laboratory designed the door.



Army's 84-ft.-dia. Superbox features ultrafast door to contain blast waves that could carry toxic uranium particles.



PM ILLUSTRATION BY HANK IKEN; U.S. ARMY PHOTO

PM ILLUSTRATION BY PAT RUGGERO

corners and curved areas with handheld jets. But the process still stands to cut labor costs in half.

Meanwhile, the Air Force will put its Large Aircraft Robotic Paint Stripping (LARPS) facility at Tinker AFB in Oklahoma. The centerpiece of the system will be a huge hydraulically powered robot that travels on an automated guided vehicle.

Guided by sensors, the machine will train high-pressure water on broad fuselage and wing areas. It will pepper sensitive areas with flecks of dry ice to avoid water infiltration. The facility, to be built by USBI Co., is scheduled for installation in 1995.

Waterjets Strip Jets

NEW YORK, NY—Old paint may be hard enough to strip away, but aircraft paint, designed to withstand ultraviolet radiation and rapid temperature changes, is especially stubborn.

To make things even tougher, environmental regulations make chemical removal forbiddingly slow and expensive. But aircraft operators believe that high-powered waterjets will wash away the problem.

The German airline Lufthansa is now building a cavernous twin-bay aquastripping hangar at its maintenance facility in Hamburg. Remote-control devices incorporating six rotating jets will remove more than a square yard of paint per second. The paint-tainted water passes through a treatment plant and is reused three times.

The automated equipment can only handle about 70% of the plane's surface area, so workers will have to pry into

LUFTHANSA PHOTO

LARPS robot (top) will scour paint from large jets for the Air Force. Lufthansa is testing waterjets on commercial airliners (above).

(More Tech Update on page 18)

THE CAR THAT STUNNED THE AUTOMOTIVE WORLD

Corvette STING RAY

CHEVROLET

Presented by Chevrolet Motor Division
in association with
Franklin Mint Precision Models.

The definitive die-cast replica
of the first Sting Ray.

Crafted in 1:24 scale of 113 separate parts.

Shown approximately actual size
of 7⅛" L. Scale 1:24.

The interior is highly detailed, down
to the realistic instrumentation.

The 1963 Corvette Sting Ray. America's dream machine. The sports car that stunned the automotive world with its revolutionary design and performance.

Now, Chevrolet Motor Division, in association with Franklin Mint Precision Models, presents the definitive die-cast re-creation of the 1963 Corvette Sting Ray.

Here is a precision-engineered model, authentic in all its detail. From the distinctive split rear window to the chrome-plated wheels.

There is also a wide array of operating features: the steering wheel and road wheels actually turn. Doors open and close. Even the hood lifts to reveal the powerful 327 cubic inch V-8 engine. It's the definitive model of the Corvette that stunned America. The price, just $90.

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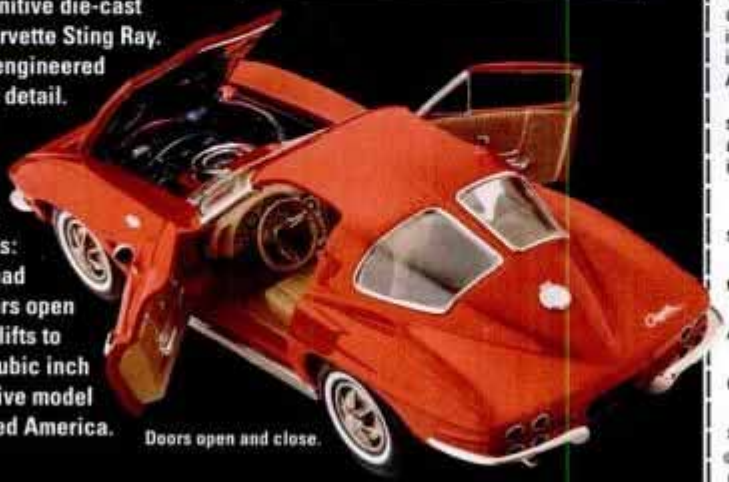
If you wish to return any Franklin Mint Precision Models purchase, you may do so within 30 days of your receipt of that purchase for replacement, credit or refund.



Doors open and close.

Please mail by February 29, 1992.

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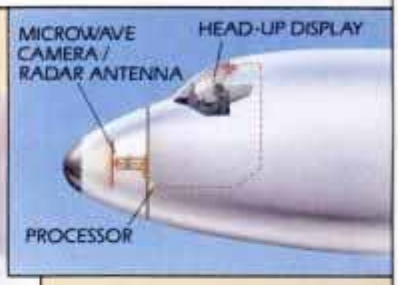


PM ILLUSTRATIONS BY DON MANNES; NASA PHOTO

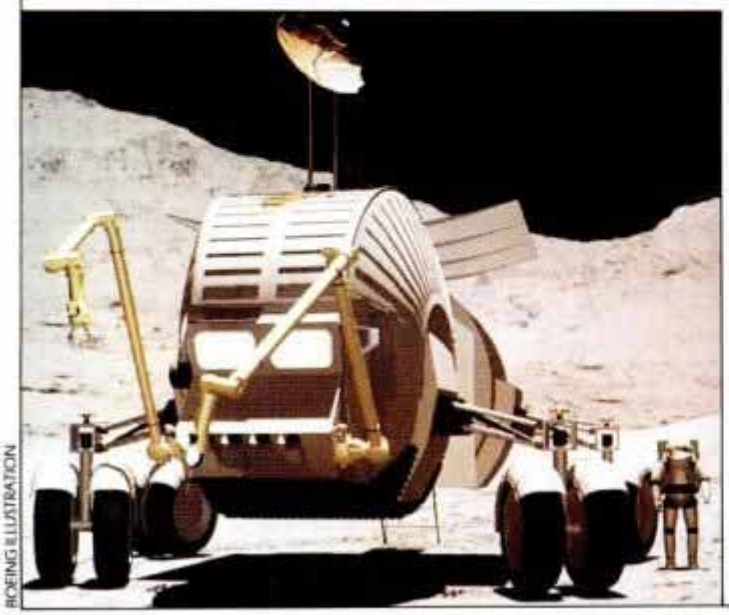
Head-up display (above) is fed by microwave camera (top right). NASA-Langley's wind-shear detector (right) seeks shifting raindrops.

NEW YORK, NY—New sensors will soon be helping airline pilots to navigate through—or around—bad weather.

Several avionics firms are developing passive microwave and millimeter-wave cameras that can be integrated with a plane's weather radar antenna. Like infrared cameras, the sensors would "see" through fog, rain or smoke to pick up natural emissions from buildings, runways and so on.

TRW has high-resolution millimeter-wave sensors that will also allow stealth aircraft to prowl through bad weather without turning on their radar. Thermo Electron Technologies is combining a compact microwave antenna with chips that would convert the sensed data into a head-up video image.

Meanwhile, NASA has equipped its Boeing 737 research jet with two forward-looking sensors that detect wind shear—a violent shift in wind direction near the ground. A radar unit looks for sudden changes in rainfall direction, while an infrared camera picks up associated temperature changes. In addition, Lockheed is flight-testing a shear-detecting laser radar. All airliners must have wind-shear detectors by 1994, under a mandate from the FAA.



BOEING ILLUSTRATION

Moon Buggy 2000

HUNTSVILLE, AL—If NASA targets the Moon for serious exploration, the golf-cart-style lunar rovers of the Apollo era just won't cut it. Instead, Boeing is proposing a huge, pressurized vehicle that will allow astronauts to work in shirtsleeves.

The 9-ton aluminum machine would feature all-wheel independent drive and steering, with a reinforced undercarriage and meteoroid-proof body. Two manipulator arms could drill and collect samples while the astronauts stay inside. They could venture out, however, through an air lock that would also serve as a radiation shelter in solar storms. The vehicle is designed for 2-person, 14-day missions.

Conceived by the same Boeing team that designed Space Station *Freedom*'s habitation modules, the rover borrows space-station technology. It could even be operated remotely, sent to explore ahead of a manned mission with which it could rendezvous later.

Pressurized lunar rover designed by Boeing would wield twin manipulator arms and provide solar-storm shelter.

(More Tech Update on page 20)

If You Don't Use Genuine Toyota Parts, You May Not Be Such A Popular Mechanic.

The wife says, "Let a professional fix it." You prefer to do it yourself. And if you don't use Genuine Toyota Parts, you may find yourself in a rather awkward situation.

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Take our oil filters, for example. They have an anti-drainback valve which doesn't allow oil to drain back once the engine's been stopped. This permits instant lubrication when you restart your engine.

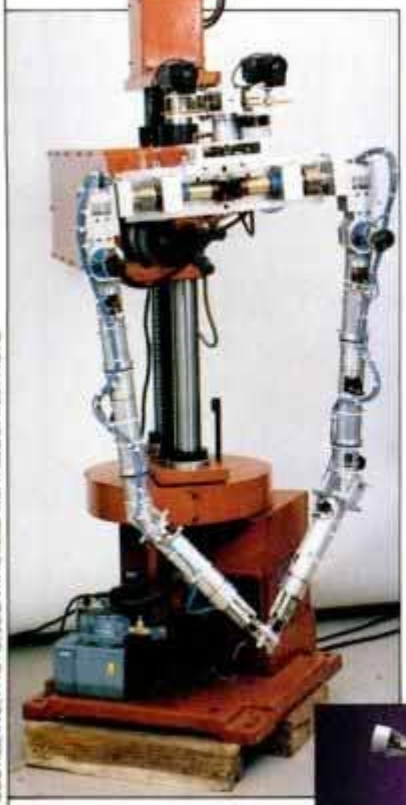
You'll also know exactly where to go for the right part. Right away. For a price that's right on the money. And that's your Toyota dealer.

So insist on Genuine Toyota Parts. It could possibly be the best thing you can do for her Toyota. And your popularity.

PARTS & SERVICE

"I love what you do for me."

TOYOTA



ODETICS, INC. PHOTO: SCIENTIFIC RESEARCH ASSOCIATES PHOTO

botic base. For added dexterity, the shoulders expand, and the neck and lower body can bend independently.

Meanwhile, Odetics, Inc., has developed a powerful compact manipulator. Weighing only 150 pounds, the arm can lift 50 pounds, or carry 20 pounds with a 55-in. reach. That's far better than the capabilities of current industrial robots. In addition, the arm's joints feature dual motors, introducing fault tolerance.

Both machines were developed for the Jet Propulsion Laboratory under NASA small-business grants.

State-Of-The-Art Arms

PASADENA, CA—Two new robotic-arm systems are demonstrating unprecedented agility and strength.

Scientific Research Associates has incorporated two cooperating articulated arms and stereo vision into a standard industrial ro-

Odetics arm (above) and SRA robot (top left) approximate human abilities.

PM ILLUSTRATION BY ED VALIGURSKY

Barge-borne supergun would launch experimental payloads.

Supergun At Sea

PHOENIX, AZ—The superartillery technology that obsessed Saddam Hussein may reemerge in its original incarnation—as a device to send experimental payloads into the upper atmosphere.

Orbital Transport Services believes it can reassemble the modified 16-in. guns of Project HARP, the High-Altitude Research Program of the 1960s. Mounted on an ocean barge, the supergun would fire a projectile to altitudes above 100 miles.

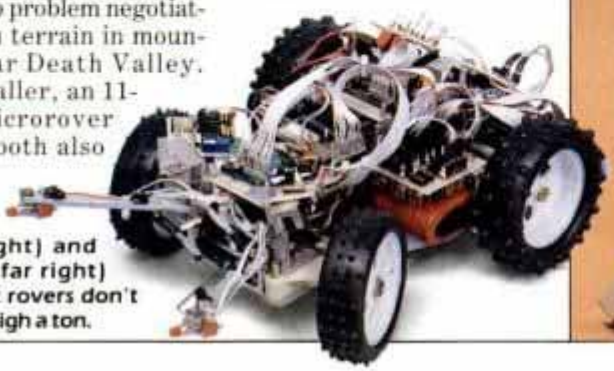
The system's appeal would be the short period between launches. Experimenters who use sounding rockets often have to wait for years between shots.

Midget Robot Rovers

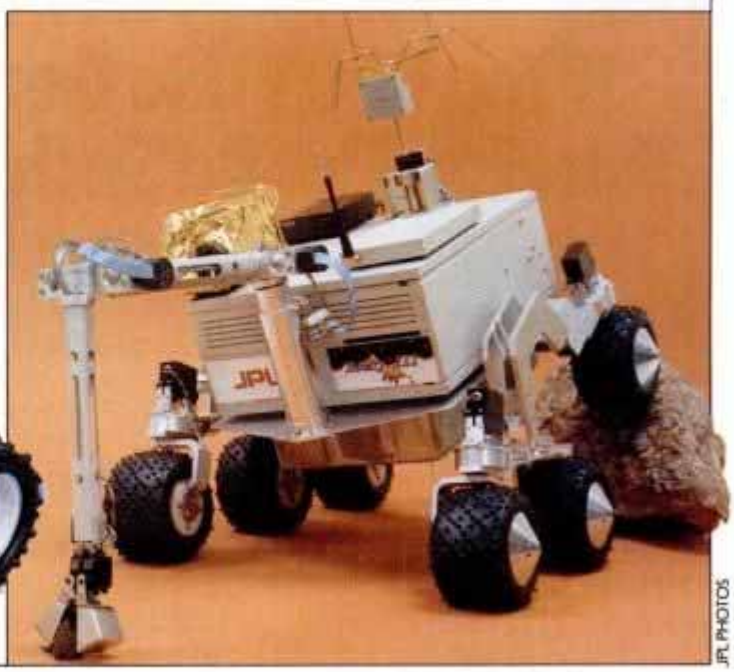
PASADENA, CA—Along with its car-size unmanned Mars rovers, NASA's Jet Propulsion Laboratory has come up with rolling robots no heavier than dogs or cats.

Weighing in at 52 pounds, Rocky III resembles a personal computer on wheels, but had no problem negotiating rough terrain in mountains near Death Valley. Even smaller, an 11-pound microrover named Tooth also performed well recently.

The midget machines would carry miniature TV cameras, micromechanical sensors to test atmosphere and soil, and small seismometers. They represent the cheapest way yet to explore the Moon or Mars. TU



Tooth (right) and Rocky III (far right) prove that rovers don't need to weigh a ton.



JPL PHOTOS

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Apply our Connoisseur's Choice® Cleaner and Protectant products to fight moisture and sun. Their Mink Oil ingredients rejuvenate old, weathered and brittle vinyl, rubber and leather surfaces, making them soft, supple and pliable again. Connoisseur's Choice leaves a super slick, shiny surface which repels dirt, grime and water damage. Try the C.C. duo on finished wood surfaces, too!

In between Liquid Glass and Connoisseur's Choice applications, use our specially formulated Wash Concentrate to restore the sparkling clean finish. W.C. cleans without dulling surfaces with a hazy film the way abrasive and alkaline-based cleaners do, and it gives the added benefit of extra protection against acid rain damage.

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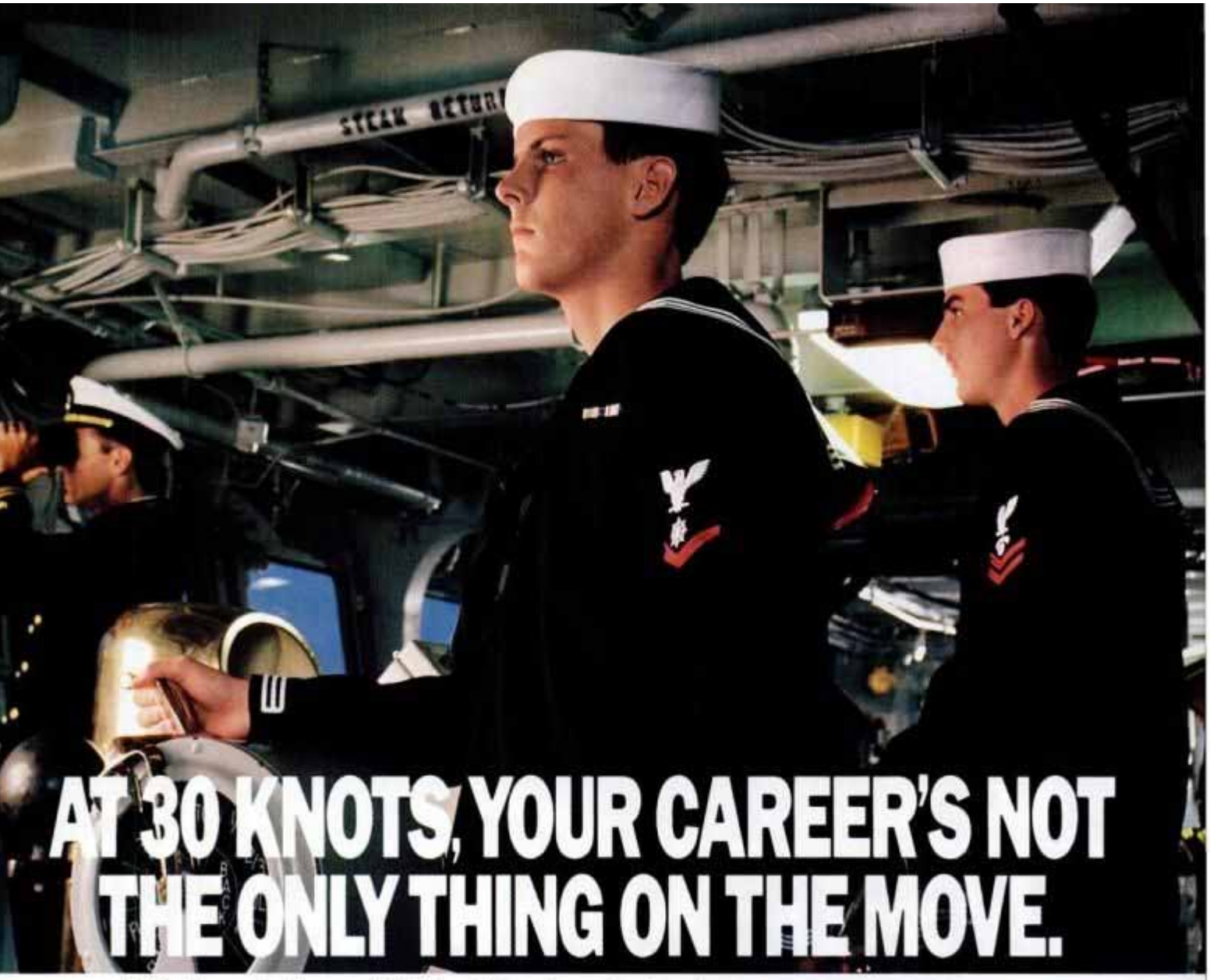

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Popular Mechanics
FEBRUARY 1992

SATURN

A home run for the home team.

BY MICHAEL LAMM, Contributing Editor; PM Photos by Mike Gaspar

● The Saturn wasn't really planned to be a rival for the Honda Accord, America's best-selling passenger car. The original targets were two smaller imports—the Honda Civic and Toyota Corolla.

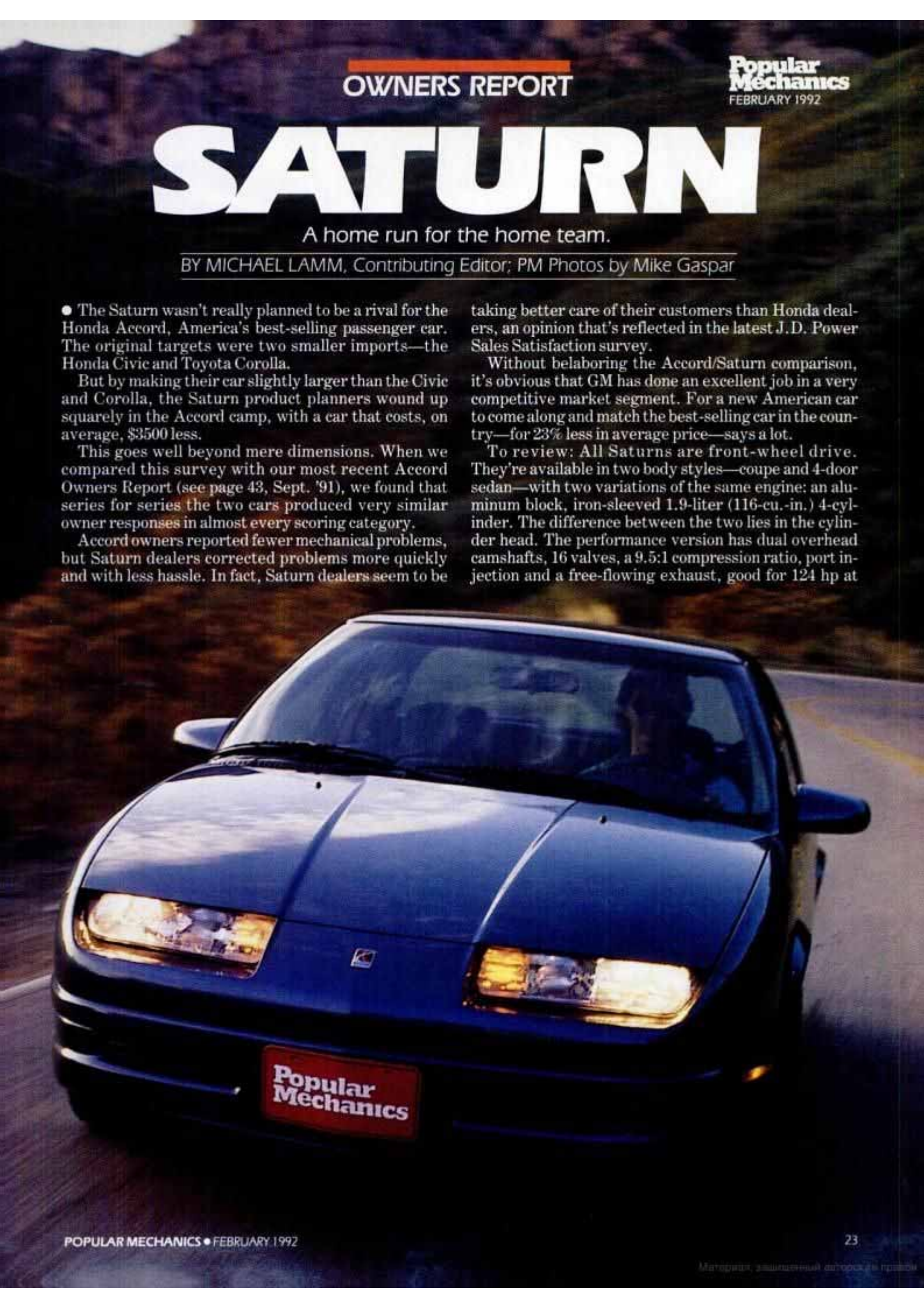
But by making their car slightly larger than the Civic and Corolla, the Saturn product planners wound up squarely in the Accord camp, with a car that costs, on average, $3500 less.

This goes well beyond mere dimensions. When we compared this survey with our most recent Accord Owners Report (see page 43, Sept. '91), we found that series for series the two cars produced very similar owner responses in almost every scoring category.

Accord owners reported fewer mechanical problems, but Saturn dealers corrected problems more quickly and with less hassle. In fact, Saturn dealers seem to be taking better care of their customers than Honda dealers, an opinion that's reflected in the latest J.D. Power Sales Satisfaction survey.

Without belaboring the Accord/Saturn comparison, it's obvious that GM has done an excellent job in a very competitive market segment. For a new American car to come along and match the best-selling car in the country—for 23% less in average price—says a lot.

To review: All Saturns are front-wheel drive. They're available in two body styles—coupe and 4-door sedan—with two variations of the same engine: an aluminum block, iron-sleeved 1.9-liter (116-cu.-in.) 4-cylinder. The difference between the two lies in the cylinder head. The performance version has dual overhead camshafts, 16 valves, a 9.5:1 compression ratio, port injection and a free-flowing exhaust, good for 124 hp at



Owners praised Saturn's classic white-on-black analog instruments.

Saturn's seats and roomy interior were high on the list of best-liked features.

Owners liked the power of Saturn's dohc 16-valve Four, but criticized noise levels.

5600 rpm and a very flat torque curve.

The garden-variety version has a single overhead cam, eight valves, a 9.3:1 c.r. and throttle-body injection. It develops 85 hp at 5000 rpm and 107 ft.-lb. of torque at 2400 rpm.

There are two transmission choices—an electronically controlled 4-speed automatic or a 5-speed manual. Final drive ratios—4.06:1 for the manual, 4.133:1 for the automatic—are the same for both engines.

SUMMARY OF 1991 SATURN OWNERS REPORTS*

Total miles driven:	**2,349,536**	**Handling:**		Poor	1.0	Brakes	8.9
Average miles driven:	**6299**	Excellent	77.5%	**Comfort opinion, rear seats:**		Shift linkage	7.9
Purchase price:		Good	20.9	Excellent	31.7%	Air conditioning	5.9
Average	$11,744	Average	1.6	Good	50.3	Transaxle	5.9
Range	$7995-$15,100	Poor	0.0	Average	15.1	**Did you repair it yourself?**	
Why did you choose the Saturn?		**Braking:**		Poor	3.0	No	95.0%
Price/value	51.9%	Excellent	66.1%	**Specific likes:**		Yes	5.0
Styling	50.0	Good	30.2	Styling	62.7%	**Dealer repairs satisfactory?**	
Made in U.S.	32.1	Average	2.9	Handling	45.2	Yes	86.5%
Operating economy	14.8	Poor	0.9	Economy	41.2	No	13.5
Quality/workmanship	11.0	**Overall performance:**		Comfort/roominess	24.3	**Dealer service opinion:**	
Standard features	10.2	Excellent	67.9%	Price	23.7	Excellent	70.6%
Avg. mpg, city/hwy.:		Good	30.7	Power/performance	19.2	Good	23.9
5-speed manual	28.9/35.5	Average	0.8	**Specific dislikes:**		Average	4.4
4-speed automatic	26.5/32.7	Poor	0.5	Rattles, noises	20.1%	Poor	1.1
Body style choice:		**Control layout:**		No complaints	13.2	**Number of vehicles owned:**	
4-door sedan	88.6%	Excellent	73.0%	Automatic shoulder belts	12.3	This vehicle only	24.5%
Coupe	11.4	Good	25.4	Upholstery material	9.9	Two vehicles	47.3
Model choice:		Average	1.6	Insufficient power	7.2	Three vehicles	17.2
Saturn SL (base)	11.1%	Poor	0.0	Drips from rain gutters	5.7	Four or more	11.0
Saturn SL1	28.9	**Instrumentation:**		Rear headroom	5.4	**Principal driver:**	
Saturn SL2	48.6	Excellent	72.6%	**Suggested changes:**		Female	51.9%
Saturn SC (coupe)	11.4	Good	26.1	Reduce rattles and/or noises	18.1%	Male	44.3
Engine choice:		Average	1.3	No changes	10.6	Equal	3.8
Dohc 16-valve Four	60.0%	Poor	0.0	More powerful base engine	10.6	**Age distribution of owners:**	
Sohc 8-valve Four	40.0	**Driver sightlines:**		Different upholstery fabric	9.6	Under 29	26.6%
Transmission choice:		Excellent	66.5%	Airbags	8.5	30-49	45.9
4-speed automatic	52.9%	Good	31.7	Improve automatic belts	8.2	50-plus	27.3
5-speed manual	47.1	Average	0.8	**Mechanical trouble?**			
Engine power:		Poor	0.3	No	73.6%	**Based on your experience, would you buy a Saturn again?**	
Excellent	52.9%	**Comfort opinion, front seats:**		Yes	26.4	Yes	83.4%
Good	39.3	Excellent	63.5%	**What type of trouble?**		Maybe	13.7
Average	6.8	Good	33.7	Sunroof sticks, balky motor	16.8%	No	2.9
Poor	1.0	Average	1.8	Electrical problems	8.9		

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

In our survey, 60% of the owners chose the more potent dohc Four. Of the owners who complained about acceleration—about 7%—most had chosen the sohc with an automatic transmission. Surprisingly, both engines delivered virtually identical mpg.

All vertical body panels are plastic, with a sturdy steel space-frame underneath. The hood, roof and decklid are sheet steel. The big advantage of plastic bodywork is its resistance to rust and small dents. It's also easier to replace and lends itself to less-expensive styling changes.

Like its imported competitors, the Saturn comes loaded with standard equipment. Saturn offers A and B option packages, but relatively few other extras. Antilock brakes with rear discs cost $895 and were ordered by 18.3% of our respondents. Those who have ABS reported good performance, with no pedal feedback.

The Saturn's electric sunroof, a $530 option, gave the most trouble of any component. Some 17% of our owner group cited snags with sunroof cables or bad switches. These and other problems were repaired under warranty.

When it came to warranty or other work, our owners returned exceptionally high praise for their dealer service departments. Dealer repairs were satisfactory in 86.5% of all cases, compared to 75% for the Accord.

The Saturn's price/value ratio was the main reason for buying. Styling ranked a strong second, with "Made in America" not far behind.

Performance also got generally good marks. The Saturn SL2 sedan and SC coupe are equipped with a sporting suspension that includes front and rear antiroll bars and more aggressive spring and damping rates. All models have variable-assist power steering. Thanks to these features and good chassis design, the Saturn scored well in ride, handling, steering and braking with most owners.

On the downside, 20.1% mentioned rattles and noises. A number of owners wished for airbags, which won't be available until 1994. There were also complaints about the automatic shoulder belt.

The all-important survey question —based on your experience, would you buy a Saturn again?—generated a rousing 83.4% yes. That's only four percentage points behind our all-time best, the Lexus LS 400, and less than one point behind the Acura Legend.

Given the fierce competition at the smaller end of the automotive marketplace, it was clear going in that Saturn was going to have to try harder than most to succeed. And it seems that's just what Saturn is doing. **PM**

Styling was what most owners liked best about their Saturns. Rust- and dent-resistance and easy replacement of the car's plastic body panels also drew praise.

EDITORS REPORT

The Dividends Of Homework

● It's not always easy to get excited about American small cars, but the Saturn has been a happy exception. In testing (see Saturn Showdown, page 21, May '91), on the street and even on the racetrack (see Motorsports, page 110, Dec. '91), it's been consistently impressive, and we're not surprised the owners like their cars.

We *are* surprised—pleasantly—at the early performance of the Saturn dealer body. Fast, reasonably priced, low-hassle service is rapidly becoming the key to getting ahead in today's car business. Thanks largely to Acura and Lexus, good dealer service has become a buying priority, and customers simply won't put up with the old you-can-maybe-have-it-back-next-week approach. Saturn has obviously done its homework on this score, and judging by our survey it's paying dividends.

The car itself is exceptional in two respects—performance and interior volume. The dohc 16-valve version of Saturn's new 1.9-liter aluminum engine provides snappy acceleration, even when it's mated with the 4-speed automatic transaxle, and our fuel-economy experiences with the car largely parallel the numbers turned in by our survey group.

We also agree with those owners who disliked the 85-hp 2-valve version of the engine: sluggish describes it best, and we strongly recommend the 16-valve edition.

The new car's handling is, to us, its most impressive trait. Saturn did its homework here, too, carefully dissecting and analyzing nimble little hot rods like the Acura Integra before developing the chassis. The result is exceptionally crisp turn-in and transient response.

The ultimate proof of Saturn's chassis development program came last fall, when Peter Farrell won the IMSA Firehawk Touring Class driver's championship for Dave Rosenblum's Valvoline/ICY team. This series is for street stock cars, and for an all-new car from an all-new manufacturer to win the first time out is rare.

Not everyone wants to go racing, of course, and for most drivers comfort and convenience are more important than agility. The Saturn gets some mixed marks on this score. It's roomy —the design team's use of interior space rivals something from Honda —and the seating is excellent. Controls are well marked and located, and driver sightlines are good.

On the other hand, the trade for crisp handling is more ride harshness than you'd find in a competing Japanese car. There's also substantially more engine noise, something Saturn is working to fix in '92 models.

These are not insignificant criticisms in a car that's going to see a lot of family duty. Nevertheless, we think the Saturn's virtues—excellent handling, lively engine performance, superb brakes, resilient plastic body panels, roomy interior, thoughtful design for routine serviceability—far outweigh its faults. —*Tony Swan*

THE TECHNOLOGY OF THE OLYMPICS

Our athletes use sports science to go for the gold.

BY FRANK VIZARD

● The differences in gold, silver and bronze medals in the Olympics are measured not just by the color of metal but in hundredths of a second and in millimeters. At the Olympic level, athletic performance is near-perfect and improvements are incremental.

Yet, these incremental improvements are what separate winners and losers. Taking an athletic performance up a notch is to enter an elusive landscape with few signposts. Increasingly, technology is being used to help U.S. Olympians take the final step on the road toward perfection.

Much of the technology used to improve the performance of our Olympic athletes is developed in Building 22 on the grounds of the U.S. Olympic Training Center in Colorado Springs, Colorado. Nestled within sight of Pikes Peak, Building 22 houses the Sports Science Division of the U.S. Olympic Committee (USOC).

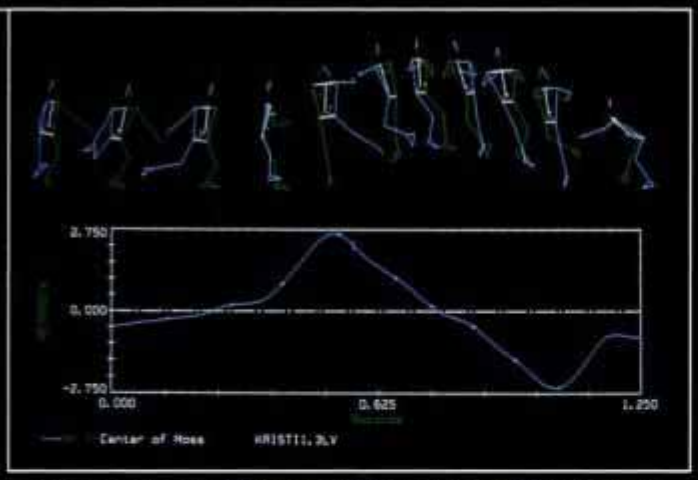
Under the direction of Dr. Jay Kearney, and staffed by many former Olympians, the Sports Science Division uses a multidiscipline approach involving departments for biomechanics, physiology, psychology, computer science and engineering. Yet compared to the sports science efforts of other countries like Germany and Russia, the U.S. effort is understaffed and underbudgeted.

Despite the lack of resources, a Tom Swiftian approach that stresses ingenuity is yielding impressive results, especially in the so-called high-technology sports like bobsled, luge and cycling. And while all these projects are coordinated in Building 22, a lot of other work is done by researchers at the Olympic Center in Lake Placid, New York, individual sports associations, and by corporations and individual volunteers who lend their expertise and technical facilities.

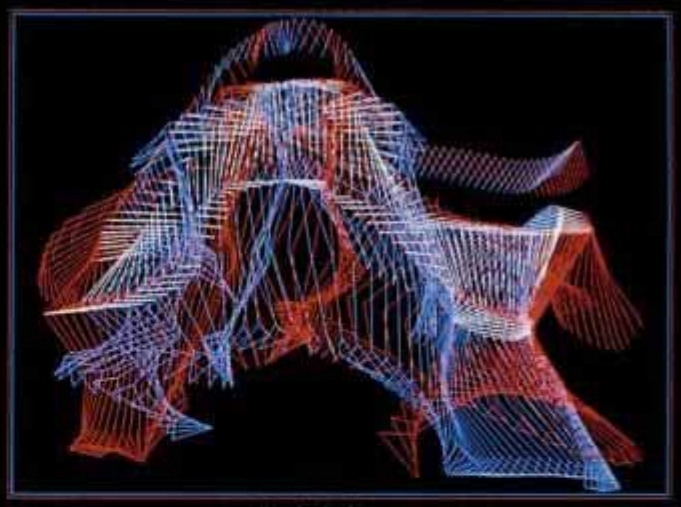
Two of the most helpful tools being used to improve athletic performance are the personal computer and the video camera. Coaches have been videotaping athletes for a long time, but now they are able to view body motion in a more subtle fashion, thanks to the personal computer.

Using software de-

HEINZ KLEIMEIER/SPORTS ILLUSTRATED PHOTO



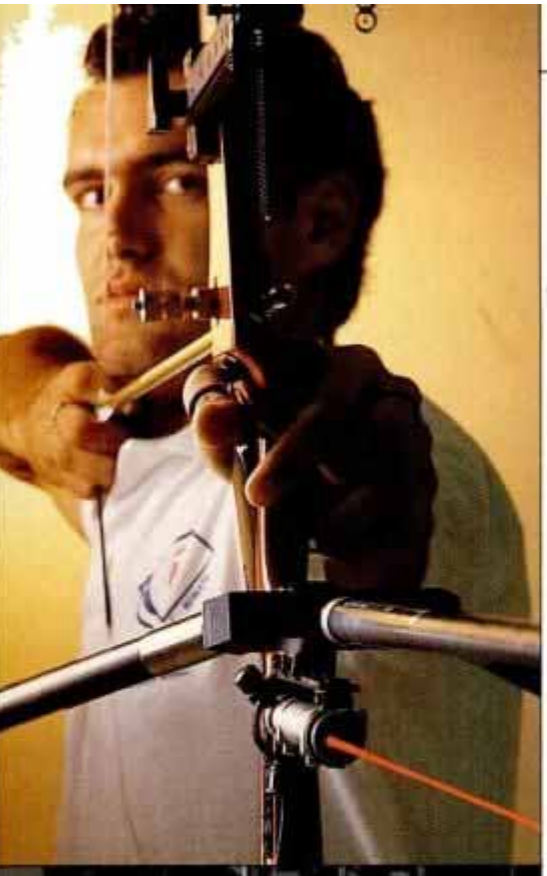
A videotape of an ice skater's performance is converted to a stick-figure (above) or a full-motion (right) display on a personal computer for closer analysis by coaches.

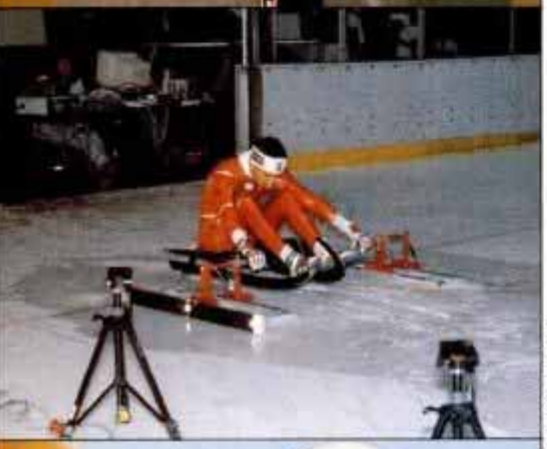


Triple Axel

veloped by Peak Performances Technologies, Inc., of Englewood, Colorado, an athlete's videotaped performance can be displayed on a personal computer screen as a series of graphic images. For example, a video of an ice skater leaping and turning in midair can be displayed as a series of stick figures. By looking at an athlete in this manner, it's easier to note the position and angles of arms, legs and torso during the jump. A graph showing the athlete's center of mass or balance can also accompany the stick-figure display.

Similarly, a computer graphic can also be generated to show the complete body motion of a skater doing a triple axel, for example. What coaches are looking for is a certain "signature trajectory" that is matched up against an optimum performance like that of former Olympic skater Scott Hamil-





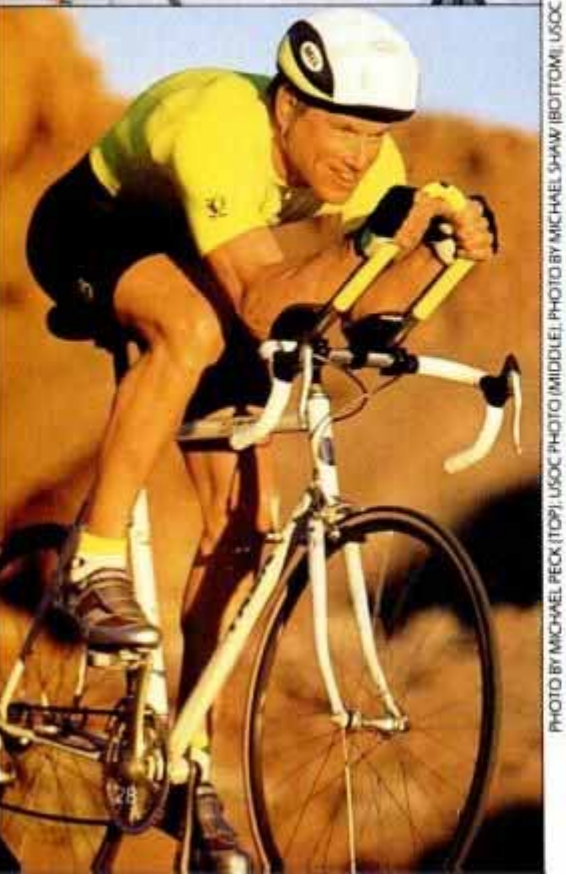


PHOTO BY MICHAEL PECK (TOP); USOC PHOTO (MIDDLE); PHOTO BY MICHAEL SHAW (BOTTOM); USOC PHOTO (RIGHT)

ton, for instance. This technique can be applied to any sport.

While computer science now reaches across the breadth of Olympic sports, some measuring devices are sport specific. Lugers, or sliders as they call themselves, are using special handles on their sleds to measure the horizontal and vertical forces being used at the start of a run. By working on techniques that eliminate the vertical force, sliders can start quicker and go faster.

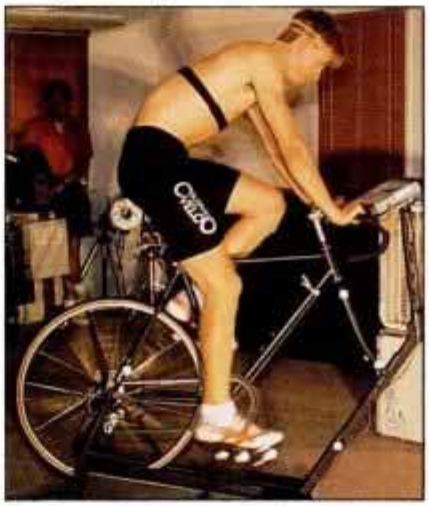
Archers and shooters of every stripe, meanwhile, are using lasers attached to their weapons to improve their aim. Cyclists are using "force pedals" that analyze their pedaling motion and the subtle twisting and turning movements of the foot that may cause variations in performance. And in the bobsled, teams are using simulators that react to changes the driver makes during a run.

Perhaps the area being investigated by the most people is drag, defined as the amount of resistance an object experiences as it moves through air or water. In kayaking and canoeing, for example, researchers—led by Eric Haught, a scientist who normally does most of his work for the NASA space program—have redesigned the men's single kayak with an eye toward drag reduction. The Eagle II kayak has 2% less drag than the Eagle I—a boat paddled by Greg Borton for a gold medal in the 1988 Olympics. The decrease in drag theoretically translates into an increase in speed of 2 boatlengths over 1000 meters. Additional speed in all kayaking and canoeing events may be provided by an as-yet secret paddle design that not only reduces drag but also increases lift for faster propelling.

Drag reduction is also critical to the success of the bobsled team. Working as most countries do with a sled of Italian design, the U.S. team nevertheless has made substantial modifications. The front cowl now extends to within 3 in. of the driver instead of 1 ft., thereby reducing drag 3.8%. Filler material along the upper inside of the crew cavity further reduces drag 5.3%. Adding dimpled patches to the helmets and slightly reshaping the rear end of the sled reduced drag by another percentage point. A 10% reduction in drag translates into a speed increase of 0.1 second—a big improvement when you remember the U.S. 4-man bobsled team lost a bronze medal by 0.02 second in the 1988 Olympics.

Sliders will also be using new aerodynamic tricks to reduce drag in the luge. Designed with the help of 3M Corp., sliders will be wearing a new helmet lens that provides better "look-down" viewing while optimizing airflow. 3M also worked with coaches to develop a new spiked glove that is better able to transfer energy from the wrist to the fingers during the start. Wind-tunnel testing and a new system of better balanced weights were also developed with the aid of 3M.

High technology yields better athletes. A laser attached to a bow lets an archer shoot straighter (top left). Lugers grip special handles to measure vertical and horizontal forces at the start (middle left). Aerobars create a more aerodynamic shape for bicyclists' bodies (bottom left) while force pedals analyze their cycling motion (right).



Old bicycling records should be shattered by minutes, rather than just the typical seconds, thanks to a new drag-reducing innovation called aerobars. A U-shaped bar that's mounted over the center of the handlebars forces the rider to tuck his arms closer to his body. This change in body position creates a smoother airflow around the cyclist. Aerobars, not used in the 1988 Olympics, have already been credited for some spectacular victories—most notably, Greg LeMond's come-from-behind victory in the 1989 Tour de France.

New research is even allowing .22-caliber bullets to fly straighter. Called UltraMatch, the ammo being used by Olympic shooters uses more refined gunpowder particles and the bullets are made to closer tolerances. The problem with standard ammo is that if bullets don't seal uniformly in the back when they're fired, they don't go straight. UltraMatch bullets fly straighter and provide a tighter spread in events where a 10-bullet cluster must be fired across a 10mm target, for example.

Not every innovation developed by sports scientists automatically leads

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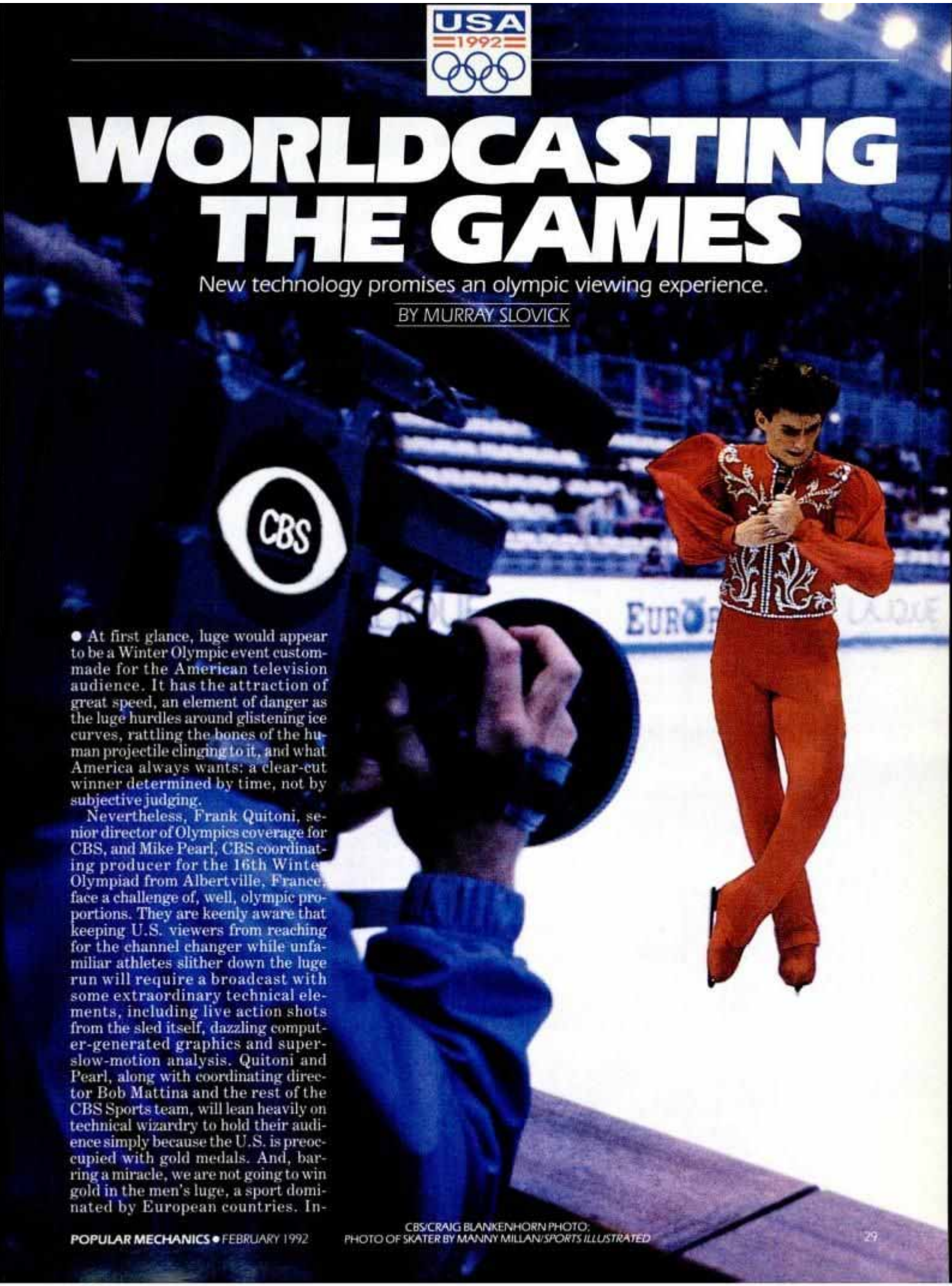
WORLDCASTING THE GAMES

New technology promises an olympic viewing experience.

BY MURRAY SLOVICK



● At first glance, luge would appear to be a Winter Olympic event custom-made for the American television audience. It has the attraction of great speed, an element of danger as the luge hurdles around glistening ice curves, rattling the bones of the human projectile clinging to it, and what America always wants: a clear-cut winner determined by time, not by subjective judging.

Nevertheless, Frank Quitoni, senior director of Olympics coverage for CBS, and Mike Pearl, CBS coordinating producer for the 16th Winter Olympiad from Albertville, France, face a challenge of, well, olympic proportions. They are keenly aware that keeping U.S. viewers from reaching for the channel changer while unfamiliar athletes slither down the luge run will require a broadcast with some extraordinary technical elements, including live action shots from the sled itself, dazzling computer-generated graphics and super-slow-motion analysis. Quitoni and Pearl, along with coordinating director Bob Mattina and the rest of the CBS Sports team, will lean heavily on technical wizardry to hold their audience simply because the U.S. is preoccupied with gold medals. And, barring a miracle, we are not going to win gold in the men's luge, a sport dominated by European countries. In-

CBS/CRAIG BLANKENHORN PHOTO;
PHOTO OF SKATER BY MANNY MILLAN/*SPORTS ILLUSTRATED*

deed, apart from figure skating, ice hockey and perhaps Alpine skiing or speed skating, most Americans consider many of the cold and frosty sports of the Winter Olympics boring. When did you last experience the thrill of victory in the biathalon (a combination of rifle marksmanship and cross-country skiing) or the Nordic combined (ski jumping and cross-country skiing).

Boring, in TV Land, translates into low ratings, and low ratings means less advertising income, which is real bad news when you've spent millions for the rights to broadcast the event as CBS has. So the folks at Black Rock, on 57th Street in New York City, are counting on new television technology to take you right onto the course, let you see what the athlete sees, hear what he hears—in short, give you the kind of closeup feeling you cannot get from standard camera positions and standard telephoto lens shots.

What was once marginally interesting is now visually arresting, or so TV executives hope. Networks are armed with new, special tools to do the job. One big tool is a remote-controlled camera, described by Quitoni as "about the size of a lipstick case," which could be put on a luge sled, for example, as it races down the course. These thumbsize cameras are manufactured by Toshiba, and are 2-piece units with a tiny lens assembly in the "head unit" connected by cable to a second small box, called the CCU (camera control unit) containing the electronics, which can be as far as 100 ft. away.

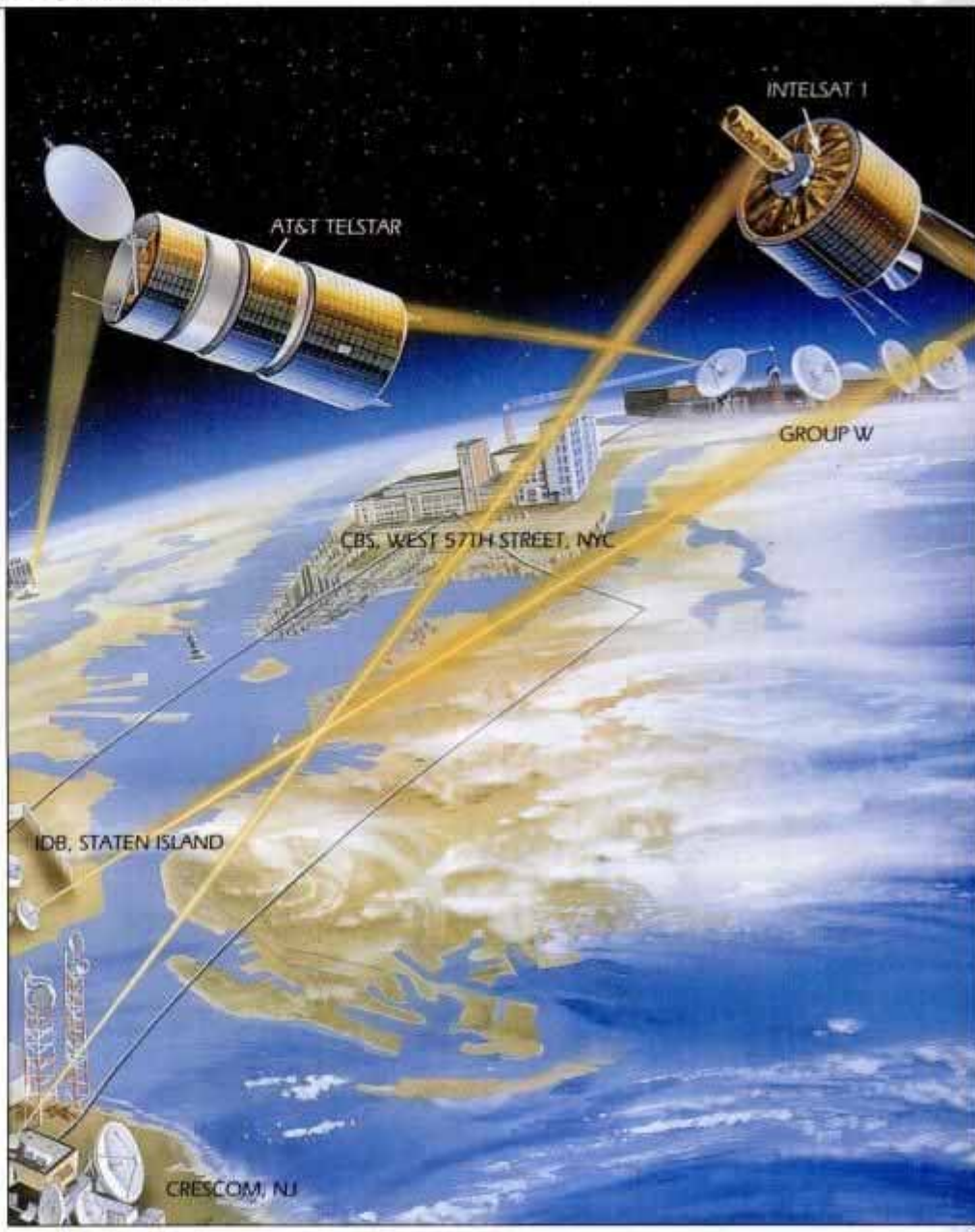
The tiny $3500 cameras are completely self-contained, using 12-volt battery power, and receive instructions and transmit video signals via RF microwave transmission. If you follow sports on TV, you've probably seen previous versions of the small Toshiba cameras in use: at the net in the U.S. Open, on stock cars and aboard America's Cup boats.

The newest model of the superminicamera, available for use in Albertville, is dubbed the IK-M40A. Toshiba says its tiny CCD pickup is capable of delivering surprisingly high resolution—460 lines—and features improved signal-to-noise performance. The camera will be modified with special shock mounts to withstand the vibration and centrifugal forces of the luge run. It may also be equipped with a remote-controlled pan/tilt device so the director can change the camera's field of view.

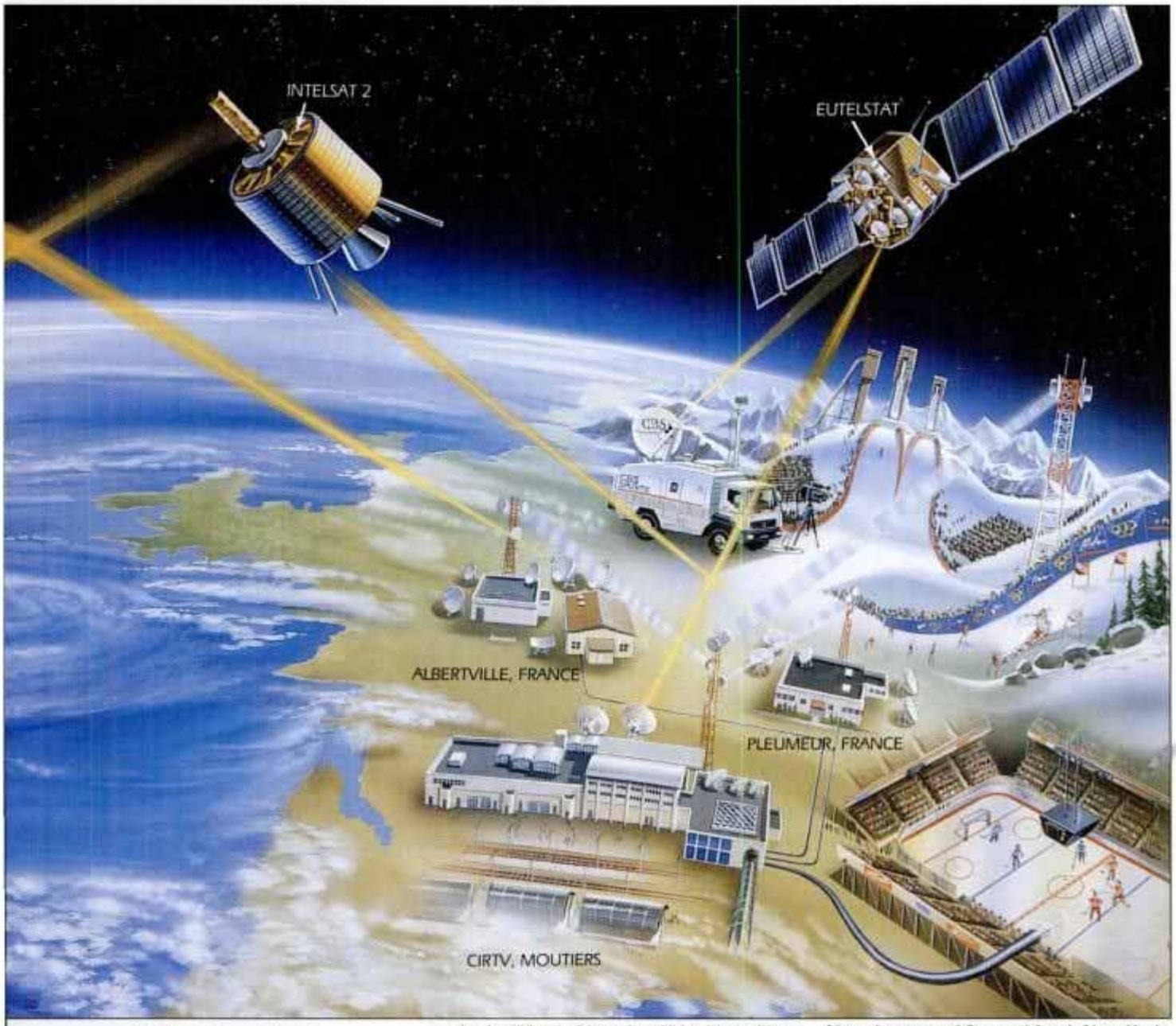
The camera also has a high-speed electronic shutter to capture fast-moving action. Shutter speeds vary from the standard $^1/_{60}$ second all the way to $^1/_{10,000}$ of a second.

Seeing what the camera sees is no easy task. Since the microwave video signal from the small Toshiba camera requires line-of-sight connection to the receiving unit, CBS needed to set up signal links on the turning, twisting luge run. The CBS engineering team decided to send the camera signal via radio waves to a hovering helicopter above the course, which, in turn, will transfer the signal to the broadcast center. All of this depends, of course, on the cooperation of the weather. Neither miniature video cameras nor helicopters work well in a blizzard. If the high-tech system cannot be used, standard backup coverage is planned.

Cold weather will also prompt CBS to use unmanned, remote-controlled cameras that reduce the need for shivering cameramen. Mattina says robotic cameras will be placed in stationary positions at the new $30-million Olympic bobsled course at La Plagne (the cameras will be imbedded in the course itself) and on the 90-meter ski jump at Courchevel to let viewers see the jumper from unique angles. The network also plans to put microphones on the lip of the ski jump. The whoosh of the jumper going airborne "sounds like an airplane taking off,"



Toshiba's tiny lipstick camera will deliver big pictures.



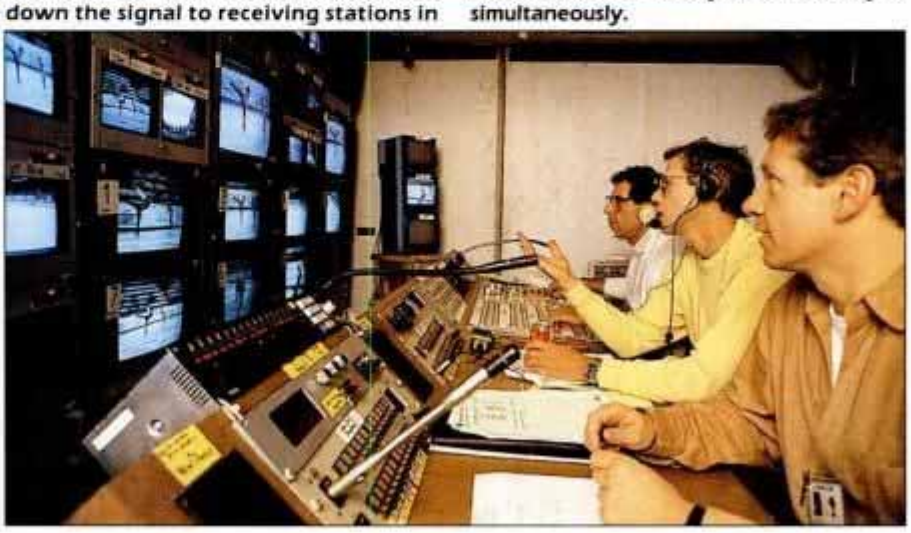
says CBS producer Pearl.

As many as 25 unmanned Hitachi Denshi HV-C10 cameras, which are new-generation, higher-resolution versions of off-the-shelf industrial video products, may be used at the Games. The cameras employ three ½-in. CCD imager chips generating 680 TV lines of horizontal resolution and measure 6 in. long, 4 in. wide and 4 in. high without a lens. The bayonet-mounted Fujinon or Canon zoom lens for the HV-C10 adds another 3 in. to the length dimension. CBS's Mattina says special housings have been built for the cameras to protect them from the ice, snow and cold. Also, a new camera mount has been designed for the minicameras so if there is a problem, they can be changed in a couple of hours. The camera's signal is sent by coaxial cable to a mobile video-editing van at the sports venue.

From the editing van, the video and

(Please turn to page 120)

At the Winter Olympics, CBS will use fiber-optic cable, microwave or satellite transmissions from each venue depending upon local conditions. The video signal is then relayed from the broadcast center in Moutiers to satellite uplink stations in Albertville and Pleumeur. The satellites bounce down the signal to receiving stations in New Jersey and Staten Island, New York. From there, it is relayed by fiberoptic cable to CBS studios on West 57th Street in New York City. Another fiberoptic link brings the signal to Group W for satellite transmission to the rest of the country. Below, technicians look at a variety of camera angles simultaneously.



CHEVROLET CAPRICE CLASSIC

The 1992 Caprice has come a long way since it became America's best-selling full-size car. Yet it still retains the traditional values that got it there. Rear drive. Full-perimeter steel frame. V8 power. ♦ But there's much more. It's roomy, quiet, smooth, comfortable, aerodynamic and has a long list of standard safety features. And its corrosion protection is unsurpassed. It's really no wonder that the new Caprice has received such a warm reception. Obviously, it's the new standard for affordable,

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full-size luxury. And one well within your means.

1992 Caprice Features:

• Standard Bosch 4-wheel anti-lock brakes (ABS). • Driver's-side air bag. • Standard air conditioning. • Delco stereo. • Full-coverage, no-deductible, 3-year/36,000-mile Bumper to Bumper Plus Warranty for 1992 models.* • 24-hour Roadside Assistance for 1992 models. See your dealer for details.

THE HEARTBEAT OF AMERICA IS WINNING.™

THE MECHANICS OF SKIING

Guiding a pair of knife-edged composite boards down an undulating slope at 80 mph, the machinery of man is taxed to the limit.

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

● Hunkered down in a bullet-like tuck, the downhiller's drag coefficient is shaved to a slick .28. By holding this wind-tunnel-honed position, he slices through the air at 80 mph with only 18 pounds of resistance. The powerful extensor muscles of his hips and thighs flex and relax in phase with the pounding corrugations of the snow, while his upper body barrels down the slope unperturbed.

To gain some sense of the marvel of this mechanism, consider that most carmakers can only wish for drag coefficients better than .30, and that fully active automotive suspension systems are only now emerging from the laboratory. But that's just the beginning. Watch what happens when he enters a turn.

Approaching a gate, he breaks out of his tuck, more than tripling the aerodynamic forces working against him. Extensor muscles tighten in his right thigh, concentrating weight on his right ski, while hip flexors retract his left ski off the snow. Balanced thus on a beam of flexible composite 2½ in. wide, he drives his right shin forward against the stiff cuff of his boot and swings his hips to the left. The ski rolls onto its sharpened steel edge and bites into the snow, its flared forebody bending upward to carve an arcing path across the hill.

Lateral g-forces build as the ski claws around the turn. He leans farther inward to counter them, keeping his center of gravity precisely in line with the combined centrifugal and gravitational forces. Arms are deployed slightly to fine-tune the delicate balance. Constant adjustment of his course is accomplished through

Using The Forces

Red vectors show the forces all skiers must master. Pulling straight down from his center of mass, gravity holds him to the snow and propels him along the slope. Perpendicular to that, centrifugal force drives him outward away from the gate. Resisting both are the vertical and horizontal reaction forces, representing the snow's support of his outside ski and the lateral adhesion provided by digging in the ski's edge. The resultant force line passing up through his shoulder describes the path along which the combined centrifugal and gravitational forces oppose the combined reaction forces. Green lines reveal geometry of body segments.

Flexible Flyer

Luxembourg's Marc Girardelli, who has won the overall World Cup championship four times, provides a model of modern slalom. Note the smooth, direct course of his upper body in contrast to the radical movements of his skis.

changes in ski edge angle, controlled by contractions of his massive hip muscles and refined by smaller movements at the knee.

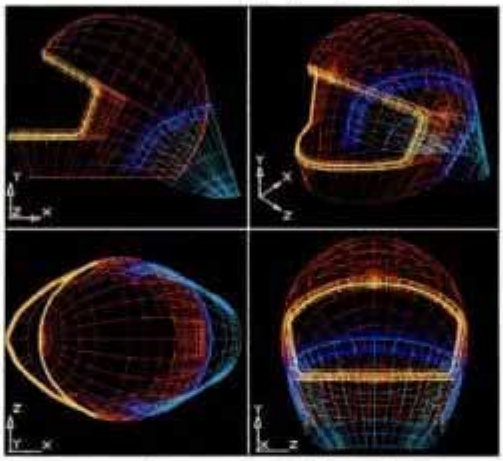
At the most extreme point of the turn, where gravity comes into closest alignment with centrifugal force, he carries as much as 2½ times his weight on his outside leg. The power output of his straining muscles approaches 1400 watts.

As the forces near the limits of his strength and of the ski's lateral adhesion, he widens his turn radius until he is aimed toward the next gate. The sideforces subside, and he pulls back into his tuck.

The whole process has taken less than 2 seconds. In that time, a torrent of visual and tactile cues has been processed, millions of neurons fired and hundreds of muscles tensed and relaxed. The result: A gracefully curved line inscribed in the snow, with energy losses to skidding and air friction kept to a minimum.

Survival of the fastest

The object of alpine ski racing is simple: To win, a racer must convert altitude into speed, potential energy into kinetic, more efficiently than his competitors, while taking the most direct line feasible through the gates. Yet in practice, there is nothing simple about it. "Of all Olympic sports, it is perhaps the most complicated," says Olle Larsson, program director at the Rowmark Ski Academy in Salt Lake City, Utah. High speeds and a rugged mountain environment introduce a flood of ever-changing variables.



Cad/Cam may improve speed-skiing helmets.

Responding to this challenge, modern racing technique builds on a long chain of improvements in equipment, and on an evolutionary process in which each year's winning styles are analyzed and copied.

In 1968, the last time France hosted the Olympics, local boy Jean-Claude Killy swept all three alpine events—slalom, giant slalom and downhill. His style capitalized on two key advances: fiberglass skis and stiff, plastic boots. Since then, these technologies have evolved in step with advances in technique.

Unlike their predecessors, modern skis flex to follow the curvature of a turn. Rather than skidding around gates, skiers today rely on their skis' natural tendency to bend when set on edge. This arises from the fact that skis broaden slightly near the tip and tail—a characteristic called sidecut—so that edging makes them arc up at the ends and sag in the middle. Once the ski is forced into this curve, the skier rides it around the turn, distributing his weight for maximum lateral adhesion and minimum forward friction.

In recent years, refinements in flex patterns, matched with more pronounced sidecuts, have produced skis that are capable of turning more sharply. This is particularly important in slalom, where the gates are closest together. But it has also affected giant slalom and the new super G event by allowing skiers to make very brief turns that carry their cen-

OLLE LARSSON ILLUSTRATION (TOP); SSPEP PHOTO

ters of gravity on a more direct line.

As equipment improves, top coaches strive to find ways of exploiting it. "A great coach has the eyes, and he can spot the energy leaks," says Dr. Steve Johnson, director of sport science for the U.S. Ski Team. But at the highest levels, the margins between victory and defeat are so small that they often defy human perception. More and more, coaches are shoring up their instincts with science.

I met Johnson last winter at a clinic for the U.S. Ski Team in Vail, Colorado, where this trend was made clear. Sponsored by Visa U.S.A., the event applied a variety of high-tech tools to the problem of winning Olympic gold medals.

Elements of style

Under scrutiny were several crucial aspects of racing form and human function. The most basic of these is biomechanics, which uses simple laws of physics to shed light on highly complex patterns of movement (see lead illustration). To help coaches pick up subtle nuances of technique, a team under the direction of Dr. Charles Dillman set up a system to produce 3-dimensional computer models of the skiers.

Using a pair of synchronized video cameras, Dillman's group took stereoscopic footage of each racer's passage around a slalom gate. Afterward, technicians viewed each frame of video on a PC and marked the body's joints with a mouse. Processing with special software yielded animated sequences of digitized stick figures (see "The Technology Of The Olympics," page 26, for more detail).

Although painstaking to generate, the stick figures permit exact measurement of the angles between body segments, and can isolate very specific aspects of form. Also, the computer can analyze a sequence of figures to find points where a skier loses speed or skids out in a turn. As a result, coaches can pinpoint the mistakes behind minute losses of energy. "It's like magnifying the performance with a microscope," commented one coach.

Bill Johnson practices transition from low tuck to turning stance in Calspan wind tunnel. The training helped him win a gold in '84.

Airpower

While biomechanical finesse may be the key to winning slower events, it takes a back seat to aerodynamics in the downhill. Dr. Michael Holden, a certified ski instructor and staff scientist at the Calspan labs in Buffalo, New York, has addressed this aspect of the sport for several years by training members of the U.S. team in a low-speed wind tunnel.

"The concept is to view a ski racer like a dart," says Holden. That approach proved itself in 1984, when Bill Johnson became the only American ever to win a gold medal in the Olympic downhill. According to Holden, Johnson's wind-tunnel-tested low tuck was so formidable in the straightaways that other countries took to designing rougher, twistier courses to prevent him from using it.

The skier-as-dart parallel is even more apparent in speed skiing, where racers wearing leg fairings, streamlined helmets and airtight, form-fitting suits plunge at speeds up to 139 mph. At those speeds, spills commonly result in second-degree burns from friction against the snow.

Debuting as a demonstration event at Albertville this year, the sport requires athletes to be perfectly attuned to aerodynamic forces. Skiers usually begin to plane a fraction of an inch above the snow around 110 mph. Thus, the only way to retain control is by keeping a clean, symmetrical tuck.

To boost the U.S. team's chances, a nonprofit consortium of high-tech companies called the U.S. Performance Engineering Program is developing a new helmet, which they hope will improve safety and aerodynamics. Although it won't be tested until shortly before the Games, Cad/Cam and fluid-flow analysis should give it a leg up on current handmade models.

With this merging of synthetic streamlining aids and the human form, the line between man and machine grows ever subtler. But the comparison of the two remains just as illuminating—and just as vital to competitors going for the gold. **PM**

U.S. SKIING/CALSPAN PHOTO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4
5
Winston
Cup Series
Popular
Mechanics

COMPARISON TEST

FAST AND FANCY

Cadillac's new Seville STS challenges Lexus LS 400, Infiniti Q45, BMW 525i and Lincoln Continental.

BY TONY SWAN,
Automotive Editor
PM Photos by Roy Attaway

● Beyond the issue of the new Cadillac Seville's capabilities, this test raises another question: What are the ideal traits of a luxury sport sedan? As we drove this quintet over the course of a week-long evaluation, we pondered this question more and more.

We think it's fair to say that BMW set the standard for this class of cars. But it's clear that the original concept has generated interesting interpretations. In the end, it's a matter of personal tastes. Each of these cars has its own personality, and each excels in one or more traits.

The group

While there are certainly some other cars a luxury sport sedan buyer might add to his or her shopping list, this group represents the cars that Cadillac sees as direct competition for the new Seville in general and the Seville STS in particular.

Conspicuous by its absence is an entry from the Mercedes-Benz 3-series, which falls closest to the Seville range in price and is on Cadillac's list of Seville competitors. We think the new V8-powered 400E, nominally a member of the 3-series family, is closer to the mark, but at $55,800 it falls into a different price category. In any case, caught in the midst of model-year turnover, M-B was unable to supply us with a test car.

There are also commonalities that we have refrained from detailing for each car. For example, all the cars had airbags as standard equipment, and all had antilock braking.

Cadillac Seville STS

We've been enthusiastic about this new-breed Cadillac since our first encounter, and a week of intense hands-on did nothing to diminish that enthusiasm. Quite the contrary. Not only is the STS (Seville Touring Sedan) contemporary in style and appointments, its performance is now a match for

Agility, tasteful interior and exterior styling are Seville STS strong points. OHV V8 provides good low- and midrange acceleration.

any of the cars in its class.

This is a bigger car than its predecessor—3 in. longer on the wheelbase, about 13 in. longer overall and almost 2.5 in. wider.

It's also worth noting that the Seville shares no body panels with the new Eldorado, something that could not be said for the previous generation. Only the windshields are interchangeable. The design team put all this dimensional increase to good use inside the car, which is roomier in almost every category, particularly rear-seat legroom, improved by 3.5 in. Front-seat travel has also been increased, but we'd still like to see more front legroom.

The smell and feel of the perforated leather upholstery lends the right note of luxury, and the redesign of the multiadjustable power front seats provides the lateral support you'd associate with a car that aspires to BMW territory.

This also goes for the general layout and trim of the interior. Classic analog gauges (the standard Seville employs electronic displays), a clean, uncluttered dashboard and thoughtfully designed, well-located controls suggest European origins. The striped Zebrano wood trim lends a note of distinctive elegance.

Like the interior, the outside of the STS projects an international character that's refreshing. In Touring Sedan trim, the car is devoid of exterior ornamentation, with body-colored moldings, mirrors and grille. It's also sleeker than its predecessor—0.33 Cd versus 0.38.

What we like best, though, is this car's performance. Cadillac's 200-hp 4.9-liter aluminum pushrod V8 is no match for the Japanese V8s in terms of top end (a moot point here—the Seville's computer limits top speed to 112 mph), but its torque provides lively acceleration.

More important, in our view, is the handling. The chassis team targeted increased rigidity, something that's reflected in the heftier front frame rails and crossmember. In STS tune, the all-independent strut suspension offers stiffer damping, higher spring rates (the rear spring is a transverse composite leaf, à la Corvette), a rear antiroll bar and a heavier front antiroll bar. Front and rear tracks have been expanded by an inch, and the new 16-in. alloy wheels are mated to 225/60HR-16 Goodyear Eagle GA tires.

Behind the bigger wheels are bigger brake rotors, and stopping power is impressive.

Both Seville models are equipped with Cadillac's Computer Command Ride System, which automatically adjusts damping on a basis of vehicle speed, acceleration (or deceleration) and lateral loading. While we prefer systems that offer the option of driver adjustability, this one works very well indeed. The STS, a front-wheel-drive car, surprised us with its agility, winning the slalom run and scoring near the front of the group in the other instrumented test areas.

What this all adds up to is a new kind of Cadillac, with an exceptionally high fun-to-drive index. It puts an all-

Faithful readers will note some alterations in this data panel. We've substituted leg-, hip- and headroom dimensions for the amorphous EPA interior-volume index. We've also included turning-circle numbers. Look for these statistics in all future test results.

SPECIFICATIONS AND DIMENSIONS

MANUFACTURER/ MODEL	BASE PRICE/ PRICE AS TESTED	ENGINE/ DISPLACEMENT (ci/cc)	ENGINE HP, NET/ TORQUE (ft.-lb.)	ENGINE/ DRIVE LAYOUT	TRANS-MISSION TYPE	WHEEL-BASE/LENGTH (in.)	TRACK FRONT/REAR (in.)	WIDTH/ HEIGHT (in.)	HEAD-, LEG-, HIPROOM, F/R (in.)	CURB WEIGHT (lb.)
BMW 525i	$34,900/ $38,140	L6 DOHC 24V 152.1/2494	189 @ 5900 rpm/ 181 @ 4700 rpm	front/ rear	4-speed automatic	108.7/ 185.8	57.9/ 58.9	68.9/ 55.6	F: 36.9/41.7/54.3 R: 36.4/34.2/56.9	3561
Cadillac Seville STS	$37,975/ $40,086	V8 OHV 298.5/4894	200 @ 4100 rpm/ 275 @ 3000 rpm	front/ front	4-speed automatic	111.0/ 203.9	60.9/ 60.9	74.4/ 54.0	F: 37.6/42.8/55.2 R: 37.9/39.5/57.6	3721
Infiniti Q45	$42,000/ $42,000	V8 DOHC 32V 274.2/4494	278 @ 6000 rpm/ 292 @ 4000 rpm	front/ rear	4-speed automatic	113.2/ 199.8	61.8/ 61.8	71.9/ 56.3	F: 38.2/43.9/55.2 R: 36.3/43.9/56.4	3950
Lexus LS 400	$42,200/ $46,255	V8 DOHC 32V 242.1/3969	250 @ 5600 rpm/ 260 @ 4400 rpm	front/ rear	4-speed automatic	110.8/ 196.7	61.6/ 61.6	71.7/ 55.3	F: 38.6/43.8/57.5 R: 36.8/34.3/57.4	3759
Lincoln Continental	$30,335/ $31,134	V6 OHV 231.9/3802	160 @ 4400 rpm/ 225 @ 3000 rpm	front/ front	4-speed automatic	109.0/ 205.1	62.3/ 61.1	72.7/ 55.6	F: 38.7/41.7/56.5 R: 38.4/39.2/56.5	3628

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

Big, comfortable and roomy, Lincoln Continental rates high on value. Handling, power of 3.8-liter V6 keep it out of sport-sedan territory.

LS 400 suspension is tops in ride quality, soft for slaloms. Power of 4.0-liter dohc 32-valve V8 is smooth and quiet. Superb interior.

American spin on the luxury sport sedan concept, with the added enticement of a price advantage over its Japanese rivals. For buyers considering one of the other cars in this group, particularly the Lexus or Infiniti, we think the STS is a must-see.

Lexus LS 400

Since its introduction, the LS 400 has generated tons of verbiage, and you'd have to work hard to interpret any of it as negative. You certainly won't find any negatives here. Conceived as the first offering of a division dedicated to "the relentless pursuit of perfection," the LS 400 is about as close to perfect as materials and technology can make it.

Its dohc 32-valve 4.0-liter aluminum V8 is supremely smooth, quietly potent and economical (by luxury-car standards) in the bargain—no guzzler tax here.

It's hard to imagine an interior more comfortable, more richly appointed or beautifully finished than this one. The LS 400 is cathedral quiet at almost any speed, all the better to listen to the superb sound system.

Consistent with this spirit of polished hedonism, the chassis is tuned to provide exemplary ride quality, as well as excellent straight-line stability. Braking is on a par with the best, fade-resistant and powerful. Handling is devoid of nasty surprises.

But that area—handling—is where the issue of sport-sedan preferences comes into play. Our LS 400 test car was equipped with the basic steel-spring suspension, which we've found to be a bit more responsive than the

TEST RESULTS

STEERING TYPE/TURNS LOCK-TO-LOCK	TURNING CIRCLE (ft.)	WHEELS/ TIRES	BRAKE SYSTEM FRONT/REAR	FUEL ECONOMY (MPG EPA city/hwy.) PM test	ACCELERATION 0-60 MPH (sec.) ¼-MILE (sec. @ mph)	PASSING[1] ACCELERATION 40-70 MPH (sec.)	BRAKING 60-0 MPH (ft.)	700-FT.[2] SLALOM MPH	200-FT.[3] SKIDPAD (lateral g)	PM[4] SERVICEABILITY INDEX
Pwr. recirc. ball/ 3.5	37.7	15 × 7-in., alloy/ 205/65R-15	F: 11.9-in. vented disc/ R: 11.8-in. disc, ABS	17/25 **23.2**	9.2 16.94 @ 83.4	17.1	145	58.4	**0.79**	8
Pwr. rack & pinion/ 2.65	40.0	16 × 7-in., alloy/ 225/60HR-16	F: 10.9-in. vented disc/ R: 11.0-in. disc, ABS	16/25 19.8	7.7 15.97 @ 85.0	16.3	134	**60.9**	0.78	8
Pwr. rack & pinion/ 2.6	37.3	15 × 6.5-in., alloy/ 215/65VR-15	F: 11.0-in. vented disc/ R: 11.5-in. disc, ABS	16/22 17.9	**7.1** **15.37 @ 90.3**	14.3	133	55.8	0.77	6
Pwr. rack & pinion/ 3.3	36.1	15 × 6.5-in., alloy/ 205/65R-15	F: 10.8-in. vented disc/ R: 11.4-in. vented disc, ABS	18/23 19.5	8.0 16.18 @ 87.6	**14.2**	146	56.7	0.74	5
Pwr. rack & pinion/ 2.7	38.4	15 × 6.5-in., alloy/ 205/70R-15	F: 10.0-in. vented disc/ R: 10.0-in. disc, ABS	18/25 19.3	8.9 16.73 @ 81.3	17.9	**129**	56.3	0.68	5

3. G-force generated during steady-state travel around a 200-ft. diameter circle. Chart number is an average of best cw and ccw. **4.** Based on 12 basic maintenance functions.

optional air-spring setup. But even so, it's on the soft side compared to the BMW, Infiniti and Seville STS.

Toyota's tradeoff here is for ride quality, leaving aggressive handling to the superb new Lexus SC 400 coupe, which offers a much more sporting setup.

Infiniti Q45

If you prioritize power as an essential of sporting luxury, here's one that'll ring your chimes. The Q45's superb 4.5-liter dohc 32-valve alloy V8 provides *serious* thrust when you tramp on the throttle. Even though it's harnessed to the heaviest car in this group—close to 2 tons—it's easily the quickest.

We attribute its leisurely passing times to gearing and a slow kickdown in the 4-speed automatic transmission. Aside from that aberration, this is one potent hunk of refinement.

There's lots of space inside this big car, and space equals comfort. Roominess also applies to the seats, though they lack the lateral support we associate with sport sedans. Interior fit and finish is consistent with the excellence you'd expect in this group. We should note, though, that as a subjective response, our test crew preferred the Lexus interior trim and styling to the more subdued Q45.

The Q45's handling produced the most polar range of responses in this group. Our test car lacked the optional ($2800) Touring Package, which includes Infiniti's active suspension and 4-wheel steering. Even so, the multilink suspension is stiffer than the LS 400, and the car can be herded down a mountain road quicker.

On the other hand, it's not too difficult to provoke the Q45 into oversteer. We certainly wouldn't call it tail-happy, but hooking up all that power requires care.

Infiniti Q45 offers subdued, roomy interior and aggressive suspension tuning. Muscle of Q45's twin-cam 32-valve 4.5-liter V8 engine was the favorite of the test crew.

BMW 525i

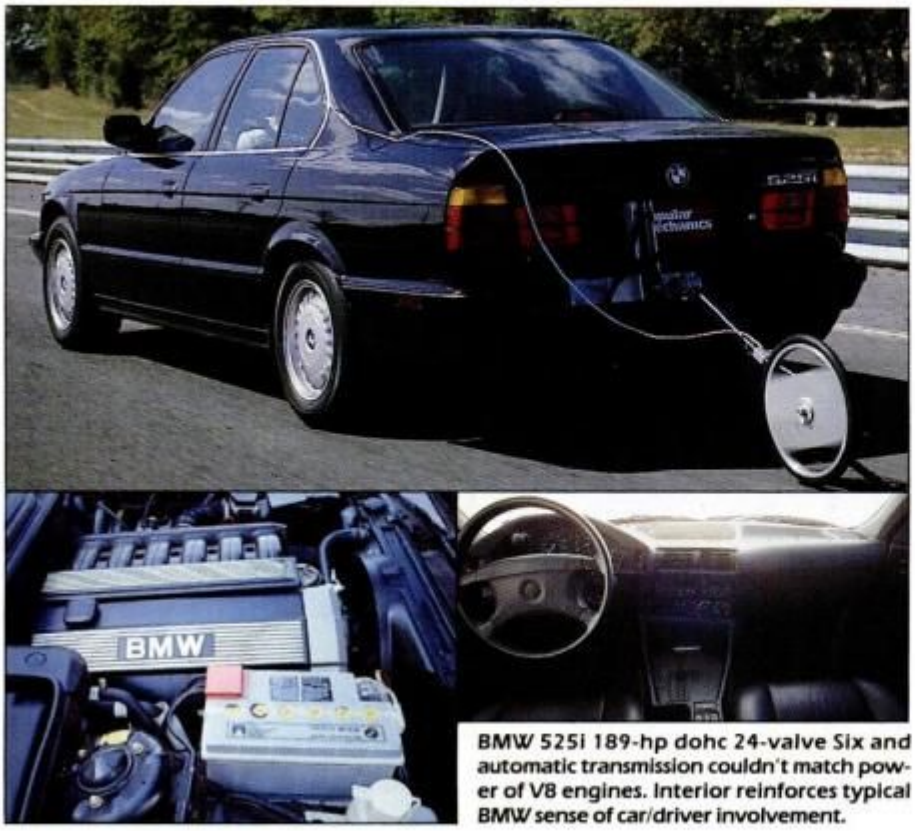
BMW built its reputation on sedans that handle like sports cars, and in this sense the 525i is eminently true to its breed. Although it spots most of the other members of this quintet a bunch of horsepower, its excellent chassis puts it on an equal footing when it comes to the twisty bits.

That BMW magic comes through inside the car, as well, with beautifully bolstered seats, highly legible analog instruments and a padded, leather-wrapped steering wheel that tells the driver precisely what the front wheels are doing. Although the 525i had the only recirculating-ball steering system in the group, and a relatively slow ratio, it was the best of the bunch in terms of road feel.

Like its BMW brethren, the 525i is satisfying to drivers who like the sense of involvement that goes with knife-edged handling. When the road begins to wind, it inspires a sense of confidence and man/machine rapport none of the other cars quite match.

But the powertrain just isn't as fast as the chassis. The dohc 24-valve straight Six, bumped to 3.0 liters and 189 hp last year, doesn't produce quite enough go-power when it's mated with an automatic transmission. Even though the 4-speed auto offers three different shift modes, it soaks up too much of the engine's relatively limited power.

We recommend a 5-speed with this setup (the only car here that offers one). Of course, the 209-hp 3.5-liter 535i is an even better solution. Just bring another $6000.



BMW 525i 189-hp dohc 24-valve Six and automatic transmission couldn't match power of V8 engines. Interior reinforces typical BMW sense of car/driver involvement.

Lincoln Continental

The Continental may be one of Cadillac's chosen targets in the marketplace, but it is not a sport sedan. It lacks the power and handling, for all the sophistication of its suspension, to be considered as such.

But for the driver who's not in a hurry, the Continental offers plenty—a roomy, comfortable interior, lots of standard equipment, plush ride quality, stylish, distinctive good looks and a price that undercuts this group by thousands of dollars.

In terms of dynamic properties, we were very impressed by the big Lincoln's stopping power. But the big attraction here is value. This is an outstanding luxury-car buy. **PM**

Admittedly, the new Ford van conversion did start with a distinct advantage.

It's a better van to begin with.

The new Econoline van is the only one that begins with body-on-frame construction.

Not bad for starters. But only the beginning.

Everything about the 1992 Econoline makes it absolutely clear: this was designed to be the highest-quality van Ford has ever built.

Now, the most conversion-ready full-size van has a new aerodynamic shape, new user-friendly instrument panel, even a new chip-resistant primer. Along with unsurpassed trailer-towing capability, you now get improved ride, handling and steering.

Ford Trucks. The Best Never Rest.™

What's more, the first driver air bag in a full-size van* supplements your safety belt. Rear anti-lock brakes are standard.

A Ford Econoline van conversion really does give you so many distinct advantages.

But then, it began with one.

Ford

*All models except E-350. Air bag effectiveness depends on wearing your safety belt, so always buckle up. "Best-Built" claim based on an average of consumer-reported problems in a series of surveys of all '81-'91 models designed and built in North America. Sales by Division.

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

QUICK-CHANGE ARTISTS.

We believe that every hour spent in the shop is precious time.

That cutting a perfect curve on a quality saw should be part of the pleasure.

And that blade changes are a rude interruption of enjoyment and productivity.

We kept little things like blade changes in mind when we designed these saws to make sure they spend more time working than being worked *on*.

We figure that every quality feature we build into every tool we make will show up on the work that comes out of your shop.

You'll find Delta quality shop tools at your local Delta machinery dealer or at leading home center and hardware stores.

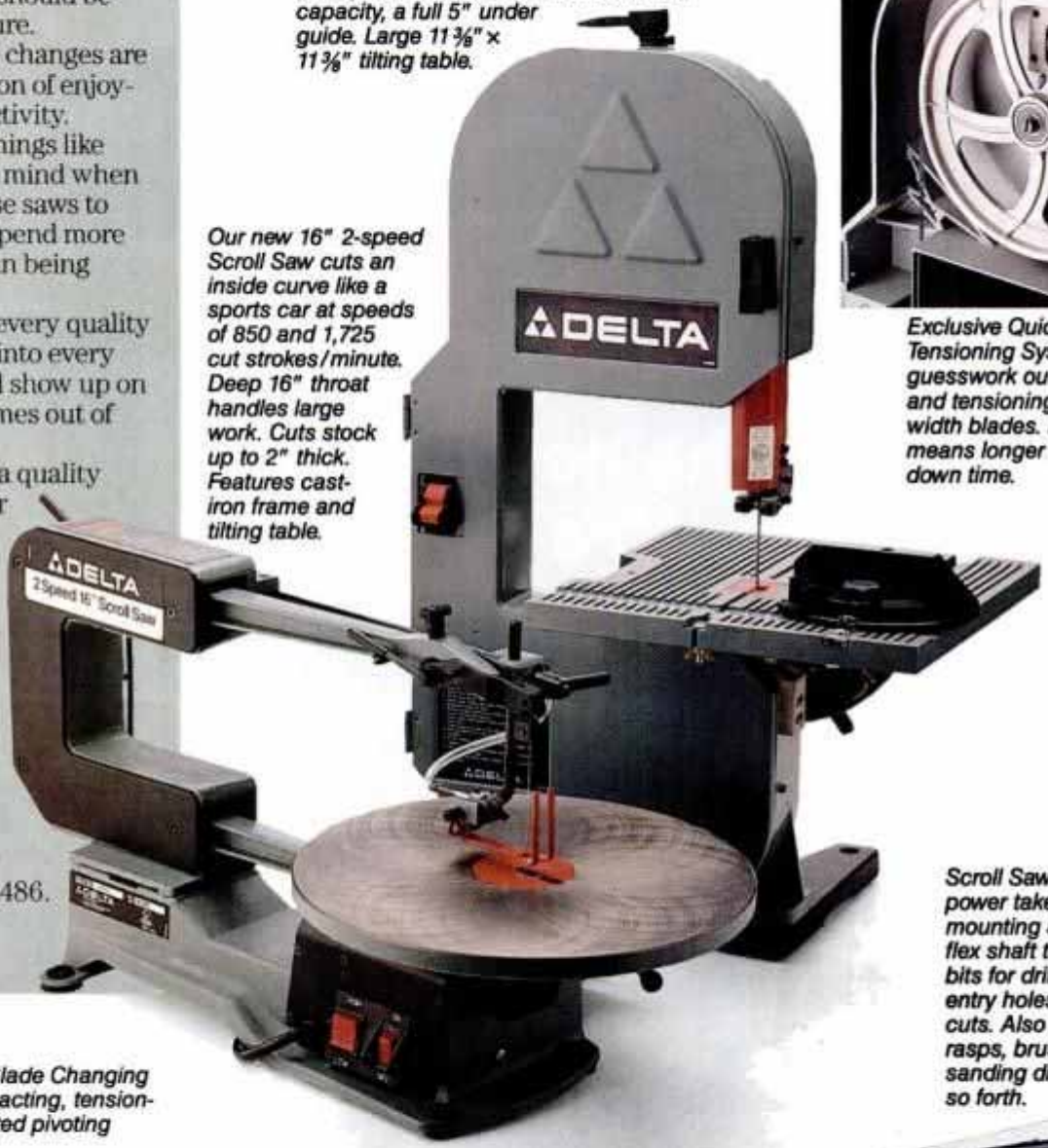
Call toll free and we'll give you the details on the store nearest you.

Delta International Machinery Corp., 800-438-2486. In Canada, call: 519-836-2840.

The new Delta Bench Band Saw. Two-wheel design minimizes blade flexing and reduces blade breakage due to metal fatigue. Hinged wheel cover for fast, easy blade changes. Provides 7 ½" blade to frame capacity, a full 5" under guide. Large 11 ⅜" × 11 ⅜" tilting table.

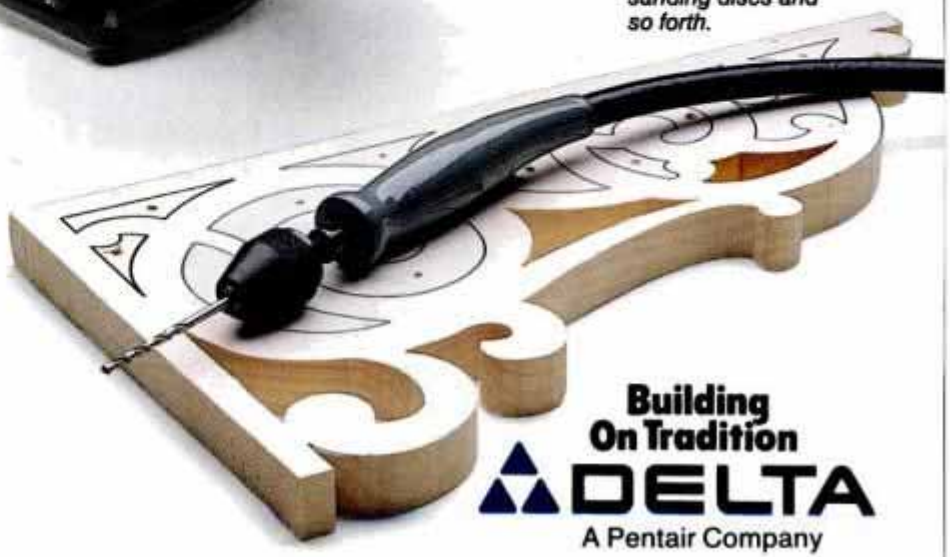
Exclusive Quickset™ Blade Tensioning System takes the guesswork out of adjustment and tensioning for different width blades. Proper tension means longer blade life, less down time.

Our new 16" 2-speed Scroll Saw cuts an inside curve like a sports car at speeds of 850 and 1,725 cut strokes/minute. Deep 16" throat handles large work. Cuts stock up to 2" thick. Features cast-iron frame and tilting table.



Scroll Saw has unique power take-off for mounting accessory flex shaft that powers bits for drilling blade-entry holes for internal cuts. Also powers rasps, brushes, sanding discs and so forth.

It's a snap. Quickset™ Blade Changing System features instant-acting, tension-release lever with patented pivoting chucks and wrench.



Building On Tradition

DELTA

A Pentair Company

SHOP TECHNIQUES

VENEERING

To capture the beauty of expensive hardwoods–without the expense–use veneers.

TEXT AND PHOTOS BY
ROSARIO CAPOTOSTO,
Contributing Editor

● Some woods are simply more attractive than others. And, like anything of real value, these woods are often too special to be used just anywhere. It's often uneconomical—and wasteful—to build a piece of furniture from an expensive solid wood, such as rosewood, for example. The solution is to use the prized wood only where it's seen—with veneers.

Although today's mass-produced furniture utilizes veneering for economic reasons—with the result that a veneered piece is often seen as less than best quality—veneering is a well-respected facet of traditional woodworking. As well as making good use of materials, veneering broadens the spectrum of design possibilities. Decorative woods normally unfit for solid construction, such as burls, or cuts from a stump or crotch of a tree, now become part of the woodworker's palette.

A veneer is a thin sheet of wood, often $^{1}/_{28}$ in. thick or less, that's glued to a core called the ground. The ground can be solid lumber or a panel, such as plywood or particleboard. When applied to solid wood, the grain of the veneer runs parallel to the ground. On plywood, the veneer runs at a right angle to the surface. Veneers are usually applied to both faces to prevent warping, and a less-expensive veneer is often used on a hidden side. In some cases, crossbanding veneers are placed at right angles under the surface veneers to act as reinforcements.

Veneers usually come in a bundle with each slice in sequence as it came from the log. Because each piece displays a similar figure, they can be assembled to form regular patterns. Examples include: book matching, where two adjacent veneers are opened like pages in a book; diamond matching, where four square, diago-

nal-grain veneers are cut and assembled; and slip match, where veneers are glued up edge to edge as they came from the log.

The veneer grain pattern results, in part, from how the veneer was cut. Rotary-cut veneer is made by peeling a layer of wood around the circumference of the log. These veneers have broad grain patterns similar to fir plywood. Flat-cut veneer is made in parallel slices, and has a grain pattern similar to ordinary flat-sawn wood. Quartered veneers are sliced at right angles to the growth rings on a quarter section of log. Rift-sliced veneer is similar and is used on oak to produce striking ray patterns. Half-round slicing involves an off-center rotational cut that produces a series of consecutive veneers (Photo 1).

Standard veneer comes in a variety of species and is sold by the square foot (Photo 2). Pieces vary from 4 to 12 in. wide by up to 7 ft. long. Veneers from burls, crotches and stumps are smaller. Flexible veneer is a special type that has a paperlike backing, and is used for low-cost furniture and renewing old surfaces (Photo 3). For the quickest application, Red Devil offers Wood Works (Photo 4). This is a thin, real-wood veneer with an adhesive back.

1 Various log cuts (clockwise from top left): flat, rift, half-round and quartered. Plywood panel underneath is rotary cut.

2 Fine-figured exotic veneers include (from left): padauk (India), Carpathian elm burl (Europe) and benge mottle (Africa).

3 Standard burl veneer (left) features typical deformed surface. Flexible veneer of same species comes flattened.

4 Types of veneer (clockwise from top left): paper-backed flexible, adhesive-backed, poplar crossband and standard.

Handling Veneers

Veneers with irregular grain are usually very bumpy or wavy, and must be flattened before they're cut. Use a plant mister or old spray pump dispenser to lightly dampen each side of the veneer. Then, sandwich it between several layers of kraft paper and two pieces of ¾-in. particleboard or plywood. Apply pressure to the stack with heavy books or bricks for 24 hours. Then, replace the paper and repeat the process until the veneer lays flat and the paper no longer absorbs water (Photo 5).

Use a sharp utility knife or a veneer saw to cut veneer. A veneer saw is better than a knife for cutting with the grain because the knife may split the wood (Photo 6). However, either tool handles crossgrain cuts. To prevent tearout at the end of the cut, wrap masking tape over the edge on the cutline (Photo 7).

When the edges are to be joined, it's best to true them after cutting the pieces to size. Sandwich the veneer between two pieces of narrow straight stock and then clamp the stack to a wider board on your bench. Use your plane on its side to trim the edge true (Photo 8).

5 To flatten deformed veneer, dampen it with water mist and press between absorbent paper and weighted particleboard.

6 Use the edge of a straight board to guide veneer saw. Saw is better than utility knife for cutting with the grain.

7 Use a utility knife to make clean crosscuts. A piece of masking tape wrapped at the end of the cut prevents tearout.

8 To accurately true veneer edges, sandwich veneer between boards and clamp to wider board that supports plane.

Hammer Veneering

One of the traditional methods for applying veneer is called hammer veneering. While this technique has been largely superseded by clamping with today's modern glues, it does have a few advantages. First, the size of your work isn't limited by clamp or press size. And, the veneer is always visible so it's easy to make sure parts are aligned. Finally, hammer veneering is relatively fast. Unfortunately, the process can be messy and the work requires practice.

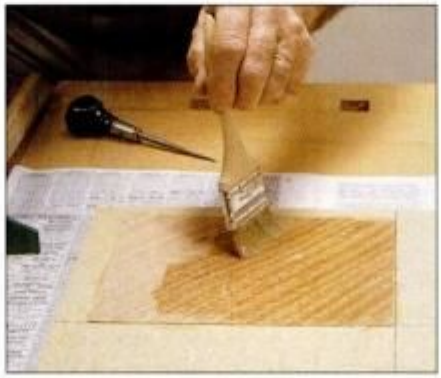
Hammer veneering gets its name from the veneer hammer. However, this tool is a hammer in name only. It's actually slid over the veneer surface to distribute pressure. The process uses hot animal glue that comes in flake form. It's mixed with water and heated in a glue pot or double boiler on a hot plate. You can use hammer veneering to apply either a single veneer, or a grouping as our example shows. In addition to previously mentioned tools, you'll also need a scraper to clean the finished panel, and an electric iron for reheating glue that's cooled too quickly (Photo 9).

Once the pieces are cut, and the glue is mixed and heated, apply glue to the ground with a brush (Photo 10). Then, place the veneer upside down on the glue-covered area, and apply glue to the bottom veneer face (Photo 11). Note that the top surface of the veneer will have glue on it. This helps the hammer slide freely as you press the veneer in place. When the bottom side is coated with glue, flip it over and position it on the ground. Place the hammer on the veneer, apply pressure and move the hammer across the surface to force out the excess glue (Photo 12). Avoid pulling the hammer across the grain.

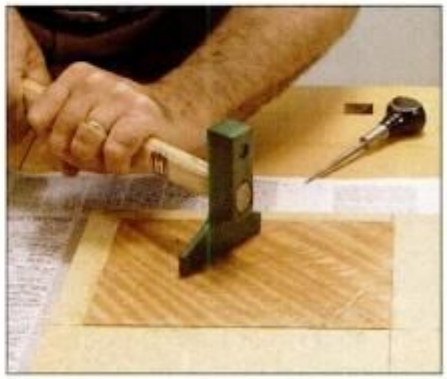
If you're butting sections together, use a chisel to scrape away excess glue along the edge of the applied veneer (Photo 13). If the edges of the applied veneer have distorted and are no longer true due to glue absorption, use a utility knife and straightedge to trim them straight. Also check that the new joint line created by two adjacent pieces is true before adding the next piece. Use a utility knife and straightedge to trim the edge (Photo 14). If any areas have not adhered to the ground properly, use an electric iron set at moderate heat to soften the glue (Photo 15). After all the pieces are in place, use a sharp cabinet scraper to clean the surface of excess glue (Photo 16). Then, carefully sand the panel smooth.

9 Tools for hammer veneering include veneer hammer, saw and utility knife, scraper, glue pot, glue and electric iron.

10 After cutting veneers, begin hammer veneering by brushing hot animal glue onto ground. Work one section at a time.



11 Place veneer upside down on the glue and brush hot glue on the underside. Then, turn veneer over and place in position.



12 Press hammer on veneer and stroke firmly with the grain. Excess glue on veneer face helps hammer slide freely.

13 Before applying the next veneer section, use a chisel to scrape away glue that has squeezed out along the joint edge.

14 Use a utility knife and straightedge to true joint-line edges that may have expanded due to glue absorption.

15 Use a household electric iron set at moderate heat for remelting glue in areas that may have become unstuck.

16 Remove surface glue and smooth veneers with a sharp scraper. Then, finish smoothing the panel with sandpaper.

17 Apply two coats of contact veneer glue to both the ground and the back of the veneer. Then wait until glue isn't tacky.

18 Paper sheets between veneer and ground allow alignment. Contact glue takes hold as sheets are pulled away.

19 Press down the veneer firmly with a small roller. Work from middle toward ends to avoid creating air pockets.

Contact Veneering

Contact veneer glue is easy to use because it's fast, makes a relatively good bond and doesn't require clamping. First, cut the veneer so it overhangs the ground about ½ in. on all sides. Apply two coats of glue to both the ground and the back of the veneer. Allow both coats to dry until they are no longer tacky (Photo 17).

Next, lay two sheets of paper on the ground so that they overlap at the center. Position the veneer on the ground, and then withdraw one of the sheets allowing partial contact to be made (Photo 18). Use a roller to apply gradual pressure as the second sheet is withdrawn. Never press too close to the paper sheet to avoid trapping it. Follow with a thorough rolling before trimming the excess (Photo 19).

Pressure Veneering

Pressure veneering is done with ordinary carpenter's white or yellow glue. In addition to clamps, you'll need two ¾-in. plywood or particleboard cauls cushioned by pieces of ¼-in. hardboard. Use 2 × 3 stock for crossbearers and shape a $^1/_{16}$-in. crown on one edge of each so that when the clamps are tightened at the ends, pressure will be uniform across the entire length of the piece. To spread the glue on medium to large surfaces, use an auto-body resin spreader or short-nap roller. A brush will do for small areas. Other special needs include a veneer roller, wax paper and veneer tape (Photo 20).

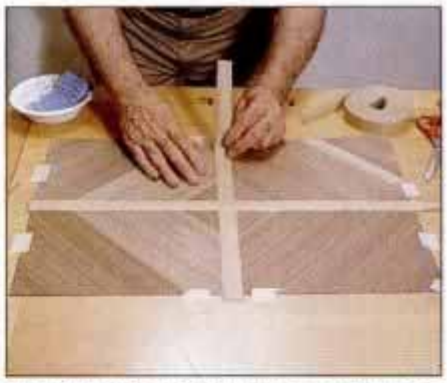
Begin by carefully butting veneer pieces together and temporarily taping them down to keep them from shifting. Then, apply the veneer tape to the seams on the finish side of the veneer to join the pieces into a single sheet (Photo 21).

Before applying any glue, make sure you have your clamps, crossbearers, cauls, hardboard and wax paper ready. Set up the lower crossbearers, caul and hardboard on scrap stock on your worktable so there's room for your clamps. Then, spread an even coat of glue on the ground only—not on the veneer (Photo 22).

Position the veneer on the ground and use the veneer roller to drive out any air pockets (Photo 23). Lay wax paper over the veneer so it won't stick to the top caul and clamp the work between the cauls and crossbearers. Tighten the center clamps first so that pressure moves from the panel center out to the edges (Photo 24). Let the glue dry overnight. To remove the veneer tape, wet with a damp sponge and lift it with a chisel.

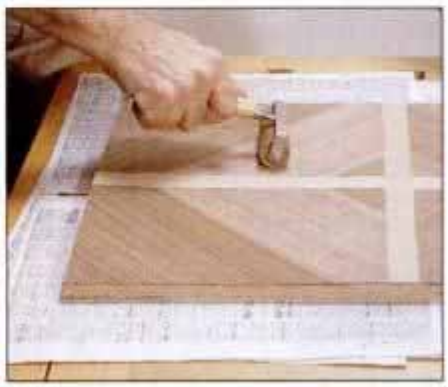
To pressure veneer curved surfaces, the top caul must be curved to match the shape of the ground. The easiest solution is to band saw the curved ground, and then use the waste half as the top caul. Apply glue, lay the veneer on the ground and apply pressure with a roller (Photo 25). Lay wax paper over the veneer and cover this with six layers of newspaper to act as a cushion. Then, install the clamps (Photo 26).

20 Pressure veneering uses standard trimming tools, carpenter's glue and applicator, roller, veneer tape and scraper.



21 Hold veneer pieces in place with masking tape while veneer tape is applied to joints. Moisten tape with sponge.

22 Apply glue to ground only. Plastic spreader makes good glue applicator. You could also use a short-nap roller or brush.



23 Lay veneer onto ground and apply pressure with roller. Work from center outward to avoid trapping air pockets.

Building a press

If you do veneer work on a regular basis, consider building a small veneer press (Photo 27). This easy-to-build fixture will handle panels for door and drawer fronts, plus other small-scale work up to 18 × 24 in.

While we built the press with fir, any strong, clear wood such as maple or oak would be suitable. Begin by cutting all parts to exact size. Then use a marking gauge and square to lay out the open mortise-and-tenon joints for the three main frames, and the lap joints for the bed pieces. Cut the joints on a band saw.

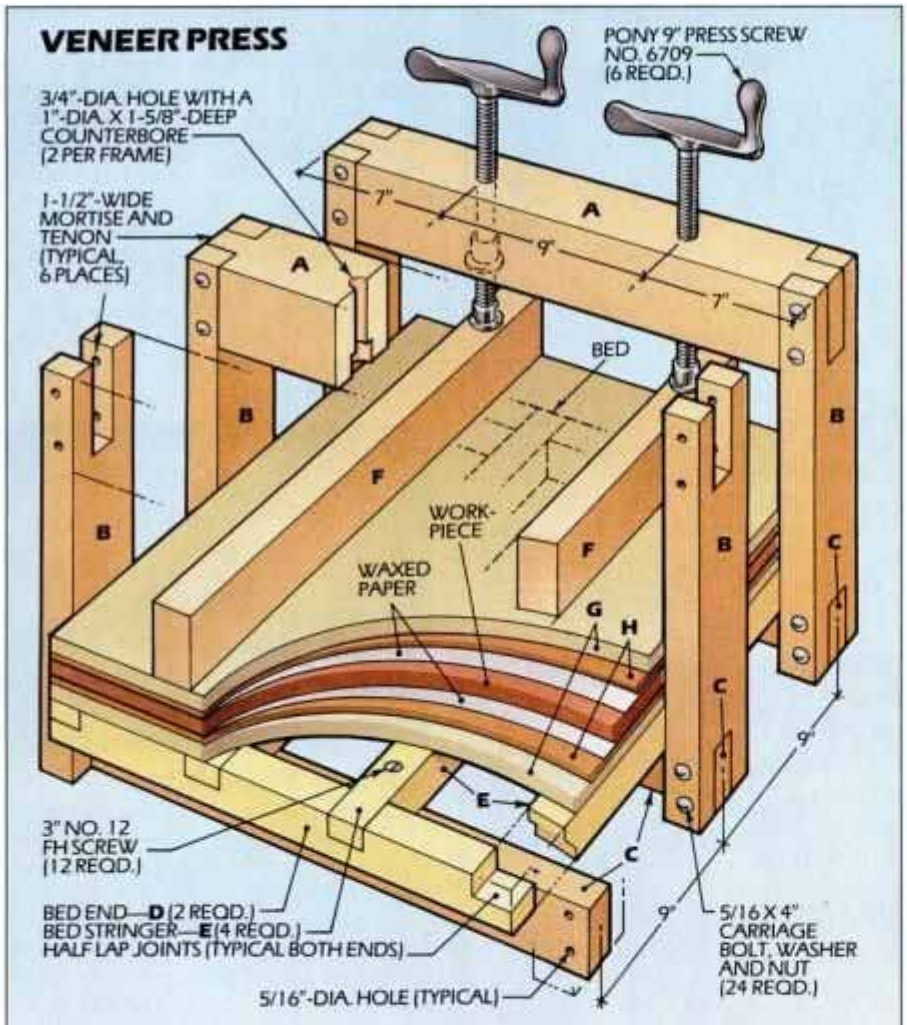
Lay out the press screw hole centers, clamp the first piece to the drill press table and bore the 1-in.-dia. × 1⅝-in.-deep hole first. Without removing the work, change to a ¾-in. bit and finish the hole. After boring all the press screw holes, assemble and clamp the frame members together. Check for square and bore the carriage bolt holes through the joints.

Assemble the bed pieces with glue and clamp until dry. Install the press clamps and secure the bed to the frames with screws. For a press with greater depth capacity, lengthen the frame sides to 18 in. and use Pony No. 6712, 12-in. press screws. **PM**

SOURCE LIST

Veneers, press clamps and veneering supplies available from:

- Constantine, 2050 Eastchester Rd., Bronx, NY 10461.
- The Woodworkers Store, 21801 Industrial Blvd., Rogers, MN 55374.
- Wood Works adhesive-backed veneer manufactured by Red Devil, Inc., 2400 Vauxhall Rd., P.O. Box 194, Union, NJ 07083.



PM ILLUSTRATION BY EUGENE THOMPSON

MATERIALS LIST—VENEER PRESS

Key	No.	Size and description (use)
A	3	3½ x 3½ x 23" fir (frame top)
B	6	1½ x 3½ x 15" fir (frame side)
C	3	1½ x 2½ x 23" fir (bottom frame)
D	2	1½ x 1½ x 18" fir (bed end)
E	4	1½ x 1½ x 24" fir (bed stringer)
F	2	1½ x 2½ x 24" fir (crossbearer)
G	2	⅛ x 18 x 24" plywood (caul)
H	2	⅛ x 18 x 24" hardboard (pad)

Misc: ⅝" × 4" carriage bolts, nuts and washers; 3" No. 12 fh screws; Pony No. 6709 press screws; glue; waxed paper.

24 Sandwich panel between plywood cauls and clamp. Slightly crowned crossbearers distribute pressure evenly.

25 Cut veneer slightly oversize and place onto glue-coated ground. Apply pressure by rolling from the center outward.

26 Use cutoff from sawing curved ground to act as caul. Several sheets of newspaper over veneer help even out pressure.

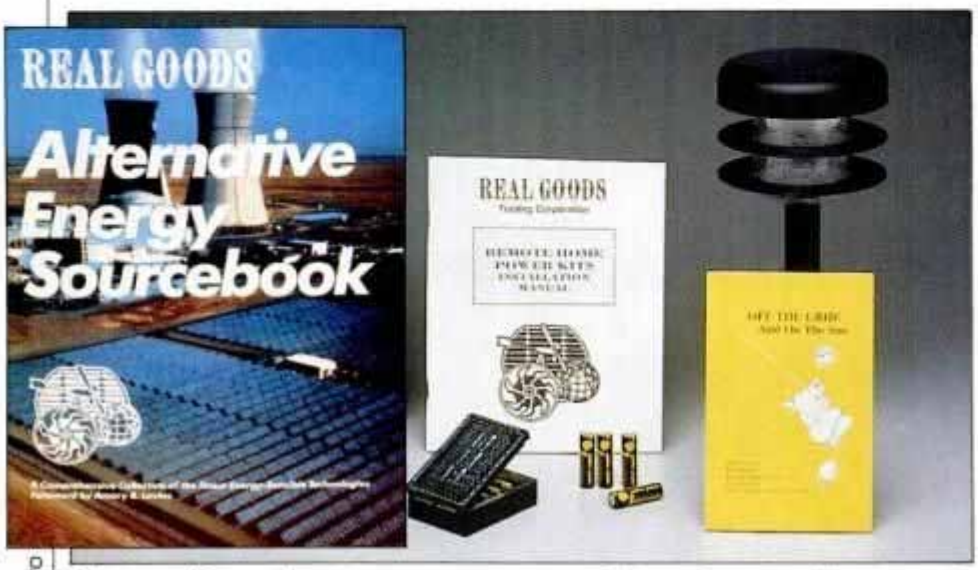
27 For frequent veneering, a shopmade veneer press is handy. This one accommodates work up to 18 × 24 in.

HOME IMPROVEMENT

PRODUCTS FOR A CLEANER ENVIRONMENT

Home products that reduce waste and conserve natural resources.

BY ROY BERENDSOHN, Assistant Home Improvement Editor



PM PHOTO BY ROSARIO CAPOTOSTO

Green Goods

The *Alternative Energy Sourcebook* is the most comprehensive catalog we know of for solar-powered and low-voltage devices. More exactly, it is 300-plus pages of photovoltaics, engine and wind-driven generators, hydraulic water rams, batteries, light bulbs and green consumer goods. The product mix takes in the unexpected, encompassing wood-fired water heaters and low-voltage appliances, such as fans, blenders and a microwave oven. Its cost ($14) is refundable on $100 purchases, and if you let the company know you passed on the catalog to a friend, you'll get free revised Sourcebooks. Also, free seasonal catalogs (much smaller in scope) are available. Contact the Real Goods Trading Corp., 966 Mazzoni St., Ukiah, CA 95482; (800) 762-7325.

Clean & Green

Earth Rite cleaners are made from fruits, vegetables and grains. They are 100% biodegradable and nontoxic. The containers are a blend of virgin and recycled plastic, and are also recyclable. A variety of cleaners are available for everything from bathrooms to laundry. Except for the 2-quart laundry bottle, they come in 22-ounce spray or squirt bottles and cost $3 to $5 at supermarkets and hardware stores. Write Magic American Corp., 23700 Mercantile Rd., Beachwood, OH 44122.

Solar Night Light

This motion-detector/security-light is solar powered and is activated by either heat or motion, its manufacturer says. Its bulb is designed to last five years. Because it's solar powered, you mount it where needed without additional wiring. To increase its flexibility in locating it, the solar module can be detached from the light and mounted up to 14 ft. away (by using the extension cord that's included). Its battery capacity is supposed to be large enough so the light could operate for two weeks without sun. It costs about $170 at hardware stores, home centers and Sears. Contact Siemens Solar Industries, 4650 Adohr Ln., Camarillo, CA 93010.

Spring Thoughts

Putting aside winter thoughts for a moment, you might give some attention to these two organic fertilizers, one for your lawn and the other for your garden. A 25-pound bag of lawn fertilizer (about $17) is a 10-1-4 blend containing 10% nitrogen, 1% phosphate and 4% soluble potash. A 20-pound bag of 5-5-5 garden fertilizer (about $15) contains 5% of the aforementioned nutrients. The fertilizers are slow-release types and do not need to be watered immediately, says their manufacturer. They are sold at hardware stores and garden supply centers. Write to Koos Shore, 4500 13th Court, Kenosha, WI 53141.

PM PHOTO BY ROSARIO CAPOTOSTO

Waste-Water Watcher

Mini Flush, its maker says, can reduce a toilet's water consumption by as much as 77%. It uses a full tank of water to start the flush, but interrupts the flow when the tank is half-empty. By using the water subject to greatest hydraulic force, this reduces the volume, but not the pressure, of each flush. It's designed to be quickly installed and should fit most toilets. It costs about $17 at hardware stores and building supply centers. For more information, write Mini Flush, 3810 Prospect Ave., Suite B, Yorba Linda, CA 92686.

Safety Sealer

This nonflammable, low-odor silane sealer cleans up with water and protects concrete, wood and stucco surfaces. And, according to its manufacturer, it's transparent and paintable. Silane-type sealers are among those recommended by the Portland Cement Association (not a specific endorsement of this product). Because you can apply this sealer right out of the jug, it is easier to use than other commercial-grade sealers. It comes in 1- and 5-gallon containers, $15 and $45, respectively. It's sold at home centers and masonry supply stores. Write Pakmix, Inc., 873 Western Ave., Toledo, OH 43609.

PM PHOTO BY ROSARIO CAPOTOSTO

Second Life

Newspaper that would normally find its way into landfills gets a second life as Easy Grass, a mulch-seed-fertilizer mixture for reseeding a lawn's bald spots. It contains tall fescue, Bermuda grass and sun/shade grass seeds. To use it, scratch the patch to be seeded to a ½-in. depth, apply the Easy Grass and spray the patch lightly with water twice a day for three weeks. A 1.5-pound bag costs about $6 and a 5-pound bag costs about $10 at home centers and lawn-and-garden stores. For more information, write American Environmental Products, Inc., 11300 Rockville Pike, Suite 1203, Rockville, MD 20852.

See The Light

This compact fluorescent light bulb has a rated life of 10,000 hours and uses 75% less energy than incandescent light bulbs, its manufacturer says, which should translate into about $50 saved in electricity over the bulb's life. When the bulb begins to burn out, a circuit shuts it off to prevent annoying fluorescent flickering. It's available in 7-, 11-, 15- and 20-watt sizes, and each size emits the light equivalent of a 25-, 40-, 60- and 75-watt bulb, respectively. It costs about $25 (all wattages). It's sold at hardware stores and home centers. For more information, write Osram, 110 Bracken Rd., Montgomery, NY 12549.

PM PHOTO BY ROSARIO CAPOTOSTO

Compost Helper

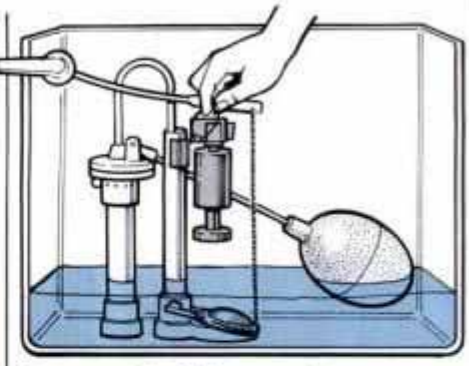
This device captures vegetable scraps that have been ground up in a garbage disposer, so you can save them for the compost pile. Called the Kich'n Komposter, its 115-volt motor spins a strainer that separates the scraps from the waste-water stream. It installs under the kitchen sink. To remove the scraps, unclip the lid, lift the strainer out and shake them into a container. It costs about $143 from Carbco Industries, 240 Michigan St., Lockport, NY 14094.

Recycling Is In The Bag

To avoid using virgin plastic as a means to dispose of garbage, these bags are made from 80% recycled plastic. The plastic comes from residential recycling programs and industrial scrap and waste. This prevents 50 million pounds of plastic a year from being incinerated or disposed of in landfills, the bags' maker says. Depending on bag size and the number of bags per container, they cost between $2 and $2.50 at grocery and hardware stores. Shown are 13-gallon (left) and 30-gallon sizes. For more information, write Webster Industries, 58 Pulaski St., P.O. Box 3119, Peabody, MA 01960.

An Organic Spike

This new line of tree and tomato fertilizer spikes is made from such things as bone meal and sunflower seeds, and the containers are 100% recycled paperboard. According to the company, these spikes reduce the problem of runoff from surface-applied fertilizers and are released slowly into the soil. A pack of five tree and shrub spikes costs about $5, a pack of 12 costs about $11 and a pack of tomato spikes costs about $2 at lawn and garden stores. Contact, Weatherly Consumer Products, P.O. Box 1750, Lexington, KY 40593.



PM ILLUSTRATION BY ED LIPINSKI

Retrofit Water Saver

This toilet retrofit device cuts water use 60% by using less water for liquid waste than for solid waste. To install, first measure the water-tank level. Next, adjust its threaded shoe per the instructions. Snap Pop Flush on the overflow tube, and hook it to the trip arm. To use it, flush as normal for liquid waste, hold the handle down momentarily for solid waste. It costs about $15 at hardware and plumbing supply stores. For more information, contact Pop Flush, Inc., P.O. Box 1150, Vancouver, WA 98666; (800) 457-7660.

PM PHOTO BY ROSARIO CAPOTOSTO

Eco Energy

Eveready improved its Energizer alkaline battery by eliminating nearly all the mercury in it—it's 99.9% mercury-free. The battery's package uses 16% less material than previous designs, and this allowed the company to reduce the battery's corrugated shipping boxes by 30%. It also uses recyclable paper in its packaging and nontoxic water-based ink on the battery label and casing. It comes in sizes from AA to 9-volt, and an Energizer D-cell costs about $1 to $1.25 at drug stores and department stores. Write to Eveready Battery Co., Checkerboard Square, St. Louis, MO 63164.

Finishing Plant

Livos offers a line of plant-derived furniture finishes, stains, paints and household cleaners. By avoiding petroleum-related chemistry, these goods are safer and less likely to produce allergic reactions than other products, says their manufacturer. Shown is furniture polish (about $8), Leinos-citrus thinner ($6 and $10), Glivo liquid wax ($7 and $15), Beikos bee ointment ($15) and Bilo floor wax ($13). All the prices listed are rounded to the nearest dollar. For a look at these and the company's other products, write for a free catalog to Eco Design, 1365 Rufina Circle, Santa Fe, NM 87501. PM

TOOLS

APARTMENT TOOLBOX

TEXT AND PHOTOS BY MERLE HENKENIUS

● At first glance, it might seem like apartment dwellers would have little need for home-improvement tools. But as anyone in the tool-rental business will tell you, this is not always the case. There are all kinds of projects that can't or won't be handled by the owner of the building. These include everything from touchup painting and wall repair to assembling bookshelves and patio furniture. And, of course, many household tools can do double duty in the garage. In short, a simple, well-planned toolkit is a good idea, even when you don't own your own home.

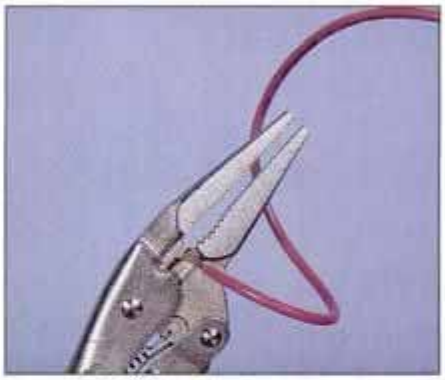
Toolbag—While metal or plastic toolboxes are affordable and come in a variety of sizes, we suggest a toolbag instead. The one shown here is designed to hold masonry tools, but it has several advantages as a general-purpose bag as well. A bag takes up less space in a closet or under a bed, and, its sides expand to hold a growing collection of tools. Finally, a bag won't scratch floors or dent walls when it's carried from one project to the next. A mason's toolbag (about $45) may cost more than a toolbox, but its heavy construction will provide years of service.

Hammer—As your hammer will take on a wide range of tasks, it's best to buy a general-purpose, 16-ounce model that has a curved claw. The curved claw provides maximum leverage when pulling nails, and the medium-weight head handles both trim and rough carpentry. Hammers with hardwood handles are generally less expensive, but steel or fiberglass handles will last longer. These always come with specially shaped grips, which provide better control. You can expect to pay $16 to $24 for a good general-purpose hammer.

Handsaw—When choosing a handsaw, look for a short model to fit inside your toolbox or bag. Of the many types available, a 10-point crosscut saw is a good general-purpose compromise. The handsaw we chose is the Stanley Short Cut. This 15-in. saw (about $17) is designed to be stored in a toolbox, and features an aggressive tooth configuration. Unlike ordinary handsaws, the teeth on the Short Cut saw have two cutting edges. This, along with a thin kerf, makes for fast cutting on both the up and down strokes. Remember to keep the saw

The Stanley Short Cut saw has primary and secondary teeth with both sides of each tooth sharpened for a faster cut.

A 4-in-1 combination file/rasp has coarse and fine cutting surfaces on both the flat and half-round sides of the tool.



Needle-nose locking pliers reach into tight areas and grip work tightly. This model has a convenient wire cutter.

in the sheath that it came in. If your saw doesn't have a sheath, you can make one out of cardboard.

Cordless drill—When it comes to light-duty electric drills, cordless models beat the rest hands down. For versatility, you'll want a drill with a ⅜-in. chuck, variable-speed or 2-speed ranges, and a reversible motor. The low-speed range is used for driving screws and starting precise holes. Use the higher speed for standard hole boring. A cordless drill can also be used as a nut driver and lightweight buffer or grinder. We chose a ⅜-in., 2-speed, reversible model that costs about $49.

Level—Whether you're adjusting the legs of a refrigerator or starting the first roll of wallpaper, you'll need a level to do the job right. We chose a 2-ft. aluminum level with a traditional flat base and a thin top edge to make it effective as a straightedge guide. The model shown has one side graduated in inches and the other in millimeters so it can serve as a rule, and it sells for just under $8.

Tape measure—For measuring your home projects, choose a retractable tape measure that's at least 16 ft. long and ¾ in. wide. A tape with every 16 in. highlighted helps when you're locating studs in a finished wall. Our choice is a 16-ft. model with a thumb lock that keeps the tape from retracting when in use. There is a wide range of measuring tapes on the market, and you can expect to pay about $12 to $16 for a good one.

Stud finder—While inexpensive magnetic finders work on walls with plenty of nails, they're less successful if the drywall is glued in place. And, if your walls contain metal lath, a magnetic stud finder is useless. A better choice is an electronic density sensor. These handheld units are easily calibrated to the wallboard's density, which makes them sensitive to the denser structural members. All you do is slide the unit across the wall until all of its indicator lights appear. You'll find two types of electronic stud finders. The less-expensive version (about $12) requires manual calibration, while the better model we used (about $20) is self-calibrating.

Utility knife and putty knife—A utility knife will find many uses such as slicing through shipping cartons or trimming wallpaper. Choose a model with a blade that can be retracted when the tool's not in use. You might also buy one that stores extra blades in a drop-away slot at the back of the handle. The model shown does both, and costs around $7.

Putty knives aren't made for cutting. Instead, you'll use them to scrape loose paint along windows and to apply fillers such as window glazing and wall compounds. Look for a putty knife that has a sturdy handle and a slightly flexible blade. A knife with a chrome-plated steel blade will resist corrosion. A good putty knife is always worth the $3 or $4 investment.

Combination screwdriver—When it comes to screwdrivers, a multipurpose combination model will give you more for your money. While there are several good brands available with different bit selections, we chose a model that handles four of the most common types of screws. Our combination screwdriver has two reversible bits. One has two sizes of Phillips-head drivers, and the other, two slot-head drivers. Whatever type you buy, make sure the blades are hardened steel. Expect to pay between $6 and $10 for a combination screwdriver.

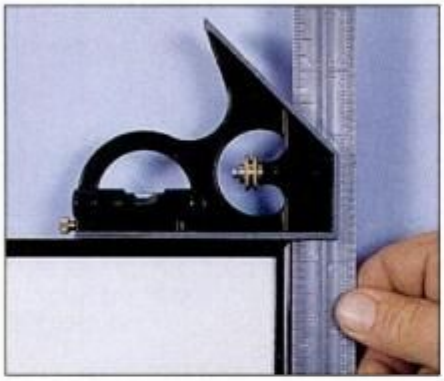
Adjustable wrench—Sooner or later, you'll have to undo a nut or bolt, and pliers simply aren't the right tool for the job. The economical solution is an adjustable wrench. For most apartment chores and light automotive work, an 8-in. wrench will do. Avoid the cheap versions if you want the tool to last. A good adjustable wrench will cost between $12 and $15.

Staple gun—A staple gun will come in handy in a dozen or more ways. You might use it to frame textile wall hangings, refasten furniture coverings or install weatherstripping. The range of quality can vary, but look for a unit that will drive from ¼- to $^{9}/_{16}$-in. staples. Also choose a model that has a dual-leverage release and hardened-steel drive components. The model we chose costs about $22.

Combination square—The most versatile square to own is a combination square (about $14). It has a removable head and a sliding rule. Not only is it useful in checking for square, but its combination head is designed to gauge 45° and 135°. By itself, the 12-in. rule serves as a scale and straightedge, and the head contains a spirit level for checking level and plumb. With the head tightened on the rule, it can be used to mark lines parallel to a board edge by drawing the head along the edge of the board while a pencil is held at the end of the rule. With the rule loosened, the square can be used as a depth gauge.

4-in-1 file—This combination file and rasp has a flat side and a half-round side. Each side has a coarse rasp at one end and a file at the other. This design allows you to handle coarse or fine stock removal on flat and concave surfaces. You can use this tool to do all kinds of trimming from enlarging the lockset hole in a door to trimming the edge of a laminated countertop. A 4-in-1 file normally costs under $9.

Miniature hacksaw—In many respects, a small hacksaw is a better choice than a full-size model for the apartment dweller. This tool will cut everything a standard saw can, and will reach into tighter spaces. With care, it will also make cleaner cuts,



The versatile combination square has a built-in spirit level. It's handy when a large level would be too cumbersome.

A reversible cordless drill is best for light-duty hole boring and screwdriving. This model recharges in 3 hours.

An electronic stud finder measures the density of the wall to determine the precise position of structural components.

and its smaller teeth help to reduce binding. Best of all, you'll invest little more than $2 for the tool.

Locking pliers—There are many types of pliers to choose from, but if you're going to own just one pair, you're likely to get the most use from the locking variety. These can be adjusted to lock on and tightly grip your work, so constant hand pressure isn't required. The most useful model is the needle-nose version with a built-in wire cutter. Expect to pay about $11 for the 6½-in. model shown.

Trim paintbrush—In addition to disposable painting items such as pan liners, plastic dropcloths and roller covers, you'll need a good trim paintbrush. This is the best tool for painting the edge around a window sash or the molding around a ceiling. Look for a brush in the 1½- to 2-in. category. The bristles can either be natural or synthetic—but if synthetic, the ends should be frayed for smoother application. You'll also want a long handle for better control. A good trim paintbrush costs between $5 and $8.

Pry bar—The last item on our list is a small flat pry bar or nail bar. It is useful in removing baseboards and trim, and is also handy when removing nails. In general, anywhere you need to lever something up or around, a pry bar is a welcome sight. Many 12½-in. models are available for about $8. **PM**

BOOK REVIEW

THE COMPLETE GUIDE TO BARRIER-FREE HOUSING

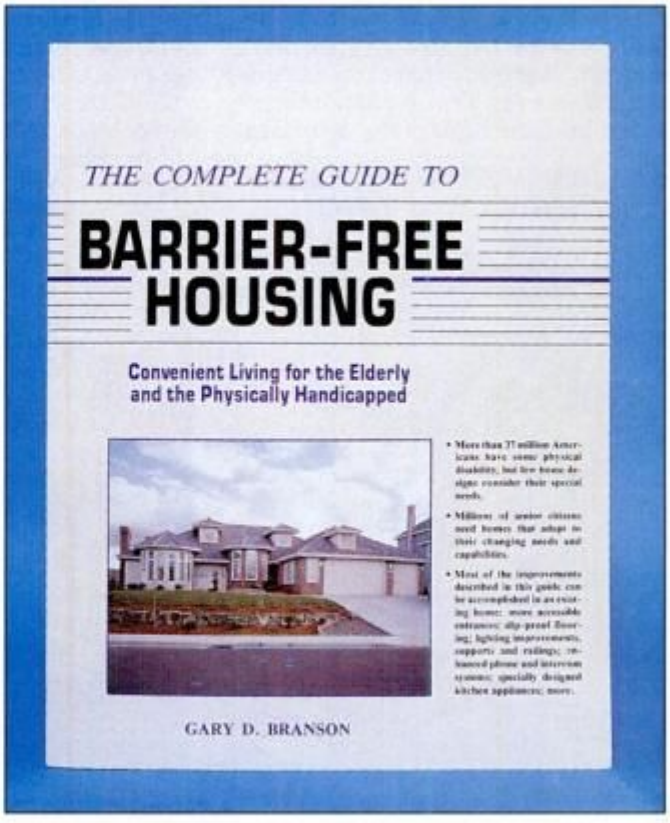
● According to author Gary Branson, an estimated 43 million people suffer a physical handicap that affects their ability to perform normal, everyday activities around the home. This book addresses the subject with specific instructions for making any home accessible—or barrier-free—to a handicapped individual.

However, the book goes far beyond discussing where to install ramps and how wide to build hallways so that the wheelchair-confined population can move around with greater ease. Branson, an expert writer with many years of experience in the home-building industry, introduces a comprehensive overview of tips and ideas for making all types of handicaps just a little easier to deal with. Each section is filled with suggestions, such as making the kitchen countertop contrast in color with the floor to aid the visually impaired, or installing D-shaped handles on cabinets to help those with diminished hand strength.

The first five sections of the book are devoted to the main areas of the home and include: the exterior; entries, stairs and halls; the bathroom; the kitchen; and closets and storage. Also discussed are ways to control air quality, and how to build in a way that reduces typical day-to-day maintenance. Each chapter is followed by a concise checklist that summarizes all the points covered.

There's an appendix that includes specific dimensional information for making various areas of the home accessible to wheelchair users, plus actual floor plan designs. Also included is a comprehensive list of organizations, support groups and information sources relevant to the subject of the handicapped and their environment. This paperback costs about $15, and is published by Betterway Publications, Inc., P.O. Box 219, Crozet, VA 22932.

—Rosario Capotosto



PM PHOTO BY ROSARIO CAPOTOSTO

HOMEOWNERS CLINIC

BY NORMAN BECKER, P.E., Contributing Editor

Fireplace Backsmoking

I recently moved into a brand-new condominium that has a factory-built fireplace. Every time I use the fireplace, smoke fills the room rather than flowing up the chimney. Once the fire gets going, the chimney draws properly and pulls up the smoke. I don't understand why there's a problem. Can you help?

ANNE MORILLON
COLUMBIA, MD

The problem is probably caused by a negative-pressure condition, also called depressurization, that exists in your house. This is a fairly common phenomenon in new construction, as opposed to houses built 20 years ago. To conserve energy, new homes are better weatherstripped and caulked, and are tighter than older homes.

All homes have a ventilation rate. That is the number of times the enclosed air volume changes in an hour. Air enters and leaves the house through various windows, doors and minute gaps. The typical house built 20 to 30 years ago had an average rate of .4 to 1 air changes per hour. Many new houses have an average rate of .1.

Depressurization results when more air in the house exhausts through fans and vents to the outside than flows in. The greater the exhaust and the tighter the building, the greater the depressurization.

Also, because warm indoor air is lighter than colder outside air, it tends to leak into the attic through an access door or ceiling hatch, and then flows to the outside through vents.

When the damper is opened, there is generally an onrush of incoming air. In some cases, the rush of air is so intense it blows ashes into the room. To eliminate this, you must equalize the air pressure between indoors and out. Do this by cracking open a window or door, preferably on the side of the house on which the wind is blowing. If you open a door or window on the opposite side, more air will be drawn out of the house—creating an even greater negative pressure.

Snow Melt In Roof Valley

We have a metal roof on our house constructed with a valley that collects the heavy snowfall. What can we do to encourage the snow to slide off? Can we put in heat tape or paint it with plastic?

WANDA KENNEDY
NIKISKI, AK

I'm not familiar with a plastic that can be painted on a roof that will help. Heat tape, however, will work. The valley on a pitched roof has a shallower pitch than the sides, causing snow to drift in there.

The tapes should be placed across the valley in an X or Z shape. It is important that the screws holding the tape-retaining device not be screwed into the bottom of the valley.

Mildew In Attic

I have mildew on the inside of my unheated walk-in attic. At one end of the attic, there is a crank-out louver window, and there are two roof vents on one side of the roof. I'd appreciate your reply.

NAME WITHHELD
LATROBE, PA

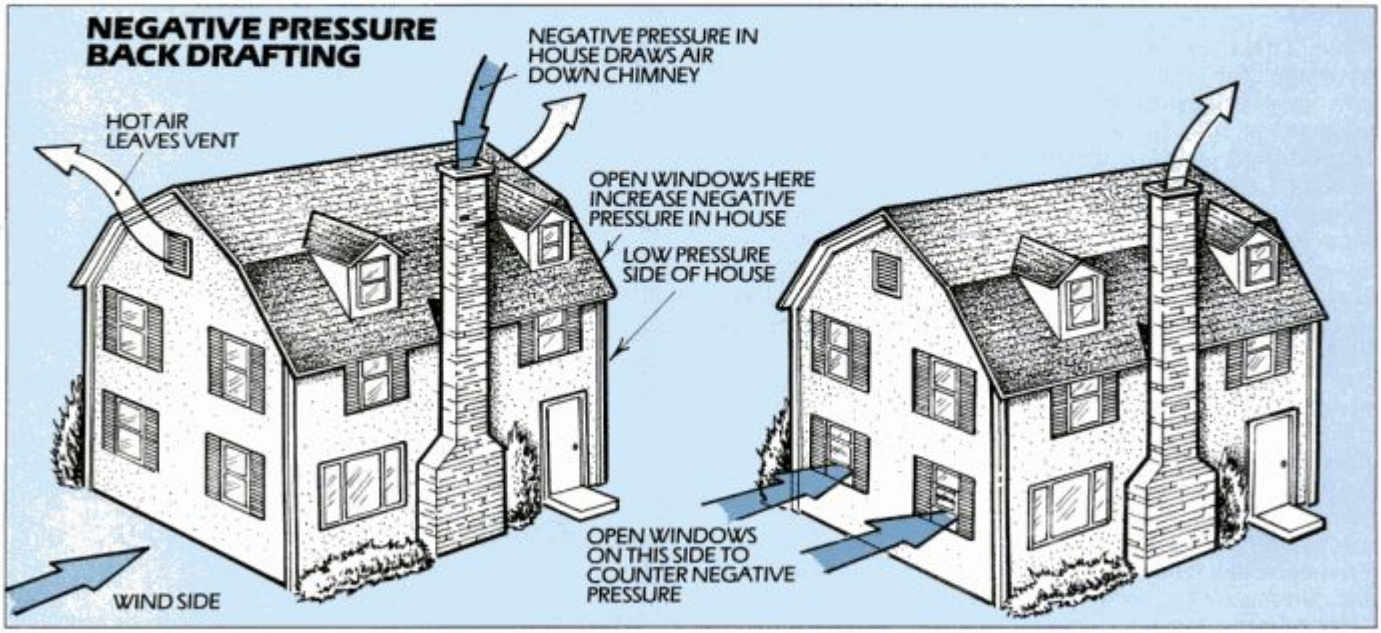
Mildew on the attic side of the roof sheathing is caused by a moisture buildup on the surface, which in turn is the result of inadequate attic ventilation. Mildew, which shows up as dark spots on the roof sheathing, will not cause the roof deck to deteriorate. Once the attic is adequately vented, mildew stops growing.

The louver window should not be closed during the winter months—nor ever. Even if the totally unobstructed attic ventilation opening satisfies the recommended formula of 1 sq. ft. of opening for every 300 sq. ft. of floor area, the distribution of the vents may not provide adequate air circulation.

You will improve the overall attic ventilation if you install a gable louver at the other end of the attic. **PM**

DO YOU HAVE A HOME-MAINTENANCE OR REPAIR PROBLEM?

Just ask Norman about it. Send your question to Homeowners Clinic, Popular Mechanics, 224 West 57th St., New York, NY 10019. While letters cannot be answered individually, problems of general interest will be discussed in the column. For more home-repair and maintenance help, get PM's Home Care Guide, $5.95 postpaid. Send your order(s) to Popular Mechanics, Box 1014, Radio City Station, New York, NY 10101.



PM ILLUSTRATIONS BY ED LIPINSKI

Tight construction coupled with air venting to the outside causes negative pressure (suction) in a house. To relieve this, open some windows.

HOME IMPROVEMENT

INSTALLING A 3-WAY SWITCH

TEXT AND PHOTOS BY MERLE HENKENIUS

● Having to walk across a room to turn off a light is one of life's relentless little annoyances—especially when it means fumbling back through a darkened room. The solution is to install a pair of 3-way switches. These allow you to control a light from either end of the room, hall or staircase.

While 3-way switches are routinely installed in new construction, they are often lacking in older homes. The good news is that most homeowners can handle this electrical upgrade themselves, and often for less than $30. The job involves fishing a 3-wire cable—usually through the attic or basement—to connect the switches.

Because there are dozens of installation variables that can affect your particular job, we've chosen to describe a complete installation that includes a ceiling-mounted light fixture where none existed before. In other words, the fixture, boxes and switches are new. Our example also shows power brought from an existing light fixture located elsewhere in the home, and all the new wiring runs through the attic space.

Assessing the Job

Before starting, take a few minutes to assess the easiest and most economical routes for the new wire. Use a stud finder—electronic density sensors work best—to reveal any structural obstacles. In most cases, you'll find stud spaces open from floor to ceiling, with access barred only by the top or bottom wall plates. These plates are easily bored through from the attic or basement.

You'll also need to locate the simplest access to 120-volt power. While our installation takes power from another light fixture, you might also pull power from a switch or, code allowing, an outlet receptacle.

To take power from an existing fixture, the power must first go to that fixture, where it's then controlled by the switch through a 2-wire switch loop. To test the fixture, turn off the light switch , remove the fixture and use a voltage tester to determine which cable is hot. If neither is hot, the power is originating at the light switch.

You can also tell if there's power at the fixture by looking at the wiring. If the color coding appears cross wired, with an incoming black connected to an outgoing white, then the power originates at the fixture.

1 Bore ¾-in. holes through top wall plates to access the stud spaces that correspond to the new switch-box locations.

2 Use a drywall saw to cut switch-box openings in the drywall. Keep the openings several inches away from the studs.

3 Feed a fish tape from the attic to the switch openings and attach the appropriate cable to the tape's hooked end.

Switch preparation

First, determine the switch locations so they each fall in a stud space. Then, enter the attic or basement and bore a ¾-in. hole through the center of the wall plate over the appropriate stud space (Photo 1).

Use plastic self-mounting, cut-in boxes for both the switches and the light fixture to avoid the task of fastening the boxes to studs and joists. Hold the switch boxes in place and trace lightly around them with a pencil. Position the switch boxes roughly 46 in. from the floor and several inches from adjacent studs. Then, use a drywall or keyhole saw to make the cutouts (Photo 2).

Stringing cable

Run 14/2 cable w/g (14-gauge, 2-wire cable with ground) from the existing ceiling box to the new fixture location. From there, fish another 14/2 cable w/g to the first switch-box opening. Fish 14/3 cable w/g (3-wire cable with ground) from the first switch-box opening, across the joists in the attic or basement, into the stud space of the second switch-box opening, and then through the opening.

To fish the cable through the walls, we used an inexpensive fish tape, which is rigid enough to feed through small openings. Feed the tape from one opening to the next, fasten cable to the tape's hooked end and pull the cable back through. In some cases, you can simply push the cables through the stud spaces without the fish tape (Photos 3 and 4).

After the cable is fed through the box openings, staple it to structural components where possible. You won't be able to fasten it to wall studs, but use plenty of staples in the attic or basement (Photo 5). Your local code will probably require at least one staple every 4 ft. along a framing member, and one within 18 in. of every box. When running across joists, either bore through them and pass the wire through the holes, or staple to the bottom of the joists. In the latter case, nail 1 × 2 furring strips along each side of the cable to protect it.

Tapping into power

To bring power from the existing light fixture, shut off the fixture's circuit and loosen the fixture mounting screws. Then, suspend the fixture by its wires to gain access to the connections. Feed the new fixture's cable into the existing box, and strip 6 in. of sheathing and ⅝ in. of wire insulation (Photo 6).

To connect the cable to the existing circuit, join the white neutral wire with the neutral wires already in place, using a twist connector. Then, join the new black (hot) wire to the black incoming-power wire and the white wire going to the existing fixture's switch. This existing white switch-loop wire will probably be coded with black tape or paint. Join the new ground wire to the existing ground wires and replace the fixture (Photo 7).

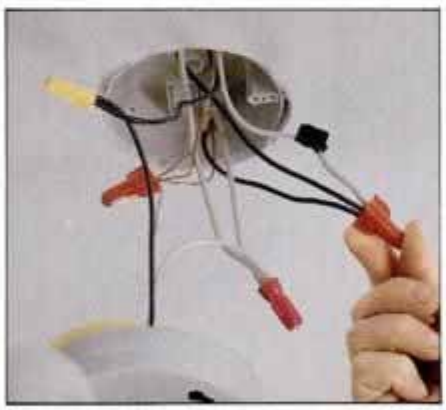
Wiring the new fixture

Hold the ceiling fixture box in position so it's centered between the joists, and trace around it with a pencil (Photo 8). Then cut the hole ¼ in. inside the line (Photo 9). Strip the 14/2 cable that's bringing power to the new fixture as described. Feed the wires into the box, and secure the box to the ceil-

4 Return to the attic and pull the fish tape up to draw the new cable through the hole bored through the top wall plate.

5 Staple all the cables that run along the joists. Protect cable running across joists with furring strips on either side.

6 Feed new 14/2 cable into an existing fixture box that has power coming to it. This cable will bring power to the new fixture.



7 Join the new neutral (white) and hot (black) wires to the neutral and hot wires from the existing power supply cable.

8 Hold a cut-in box to the ceiling and trace around it with a pencil. Center the box location between the ceiling joists.

9 Cut ¼ in. inside the pencil line for the ceiling box opening. This ¼-in. inset supports the fixture box flange.

ing by pressing it into its opening and tightening the screws (Photo 10). Fasten the incoming neutral (white) wire to the neutral lead of the fixture. Join the ground wires with a grounding (green) pigtail. Fasten the other end of the pigtail to the box or to the green lug on the mounting bracket.

Join the incoming hot (black) wire to the white wire going to the first switch. Because this wire is now hot, code it with a piece of black tape. Finally, join the black wire from the first switch to the black fixture lead (Photo 11). Then install the fixture with the appropriate bulb (Photo 12).

Wiring the switches

With the cable fed through the box openings, strip the ends, feed the wire into the switch boxes and install the boxes (Photo 13). Begin wiring the first switch by coding the white wire from both the cable that connects the switches (14/3) and the cable from the fixture (14/2) with black tape. Then, fasten the white wire from the fixture to the dark (common) terminal on the switch (Photo 14). Next, fasten the red and white wires leading to the second switch to each remaining terminal on the first switch. Join the two black wires with a connector. Join the grounds together and connect them to the green switch lug with a green, insulated pigtail.

To wire the second switch, join the black wire to the dark (common) terminal, and the red and white wires to the other terminals (Photo 15). Finish by connecting the ground wire to the green lug on the switch. Finally, install the switches and coverplates, and turn on the power. **PM**

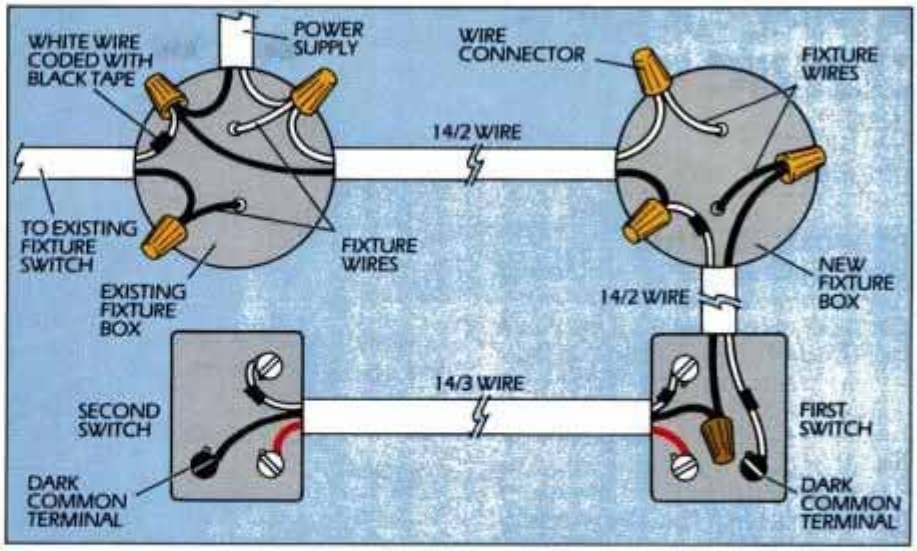
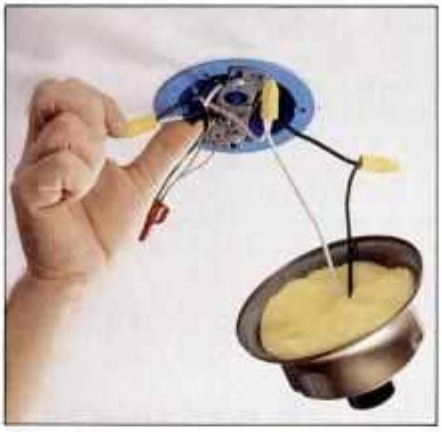


Diagram shows new fixture box (upper right) controlled by two 3-way switches. Power comes from an existing light fixture (upper left). Ground wires are omitted for clarity.

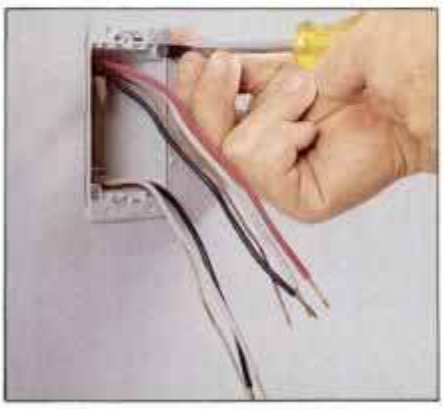
PM ILLUSTRATION BY GEORGE RETSECK

10 After removing cable sheathing and stripping ends of wires, feed wires into box. Then, mount the fixture box.

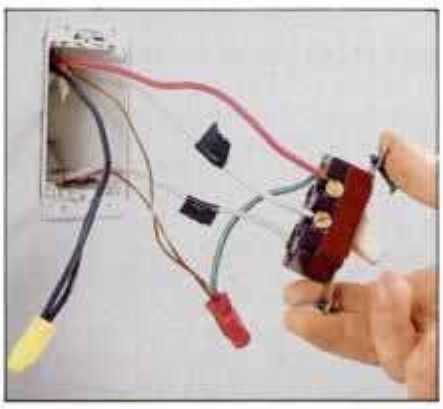


11 Join the neutral to the neutral fixture lead, hot to white switch loop, and black switch loop to black fixture lead.

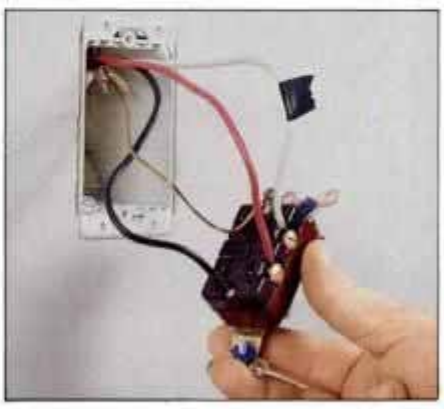
12 When the wiring is done in the new fixture box, install the fixture, an appropriate bulb and fixture globe.



13 Pull the cable from the fixture, and the cable connecting the switches into the switch boxes, and mount the boxes.



14 When wiring the first switch, the white wire goes to the dark (common) terminal. Code the wire with black tape.



15 At second switch, the black wire goes to common terminal. Connect red and white wires to remaining terminals.

APPLIANCE CLINIC

BY STEVE TOTH, Contributing Editor

Odorous Washer

I have a problem with water standing in my Kenmore dishwasher. After washing dishes, it leaves a very bad odor. The drain hose is connected to a Kenmore waste disposer. Water does not appear to be flowing back from the disposer. The dishwasher pumps almost all of the water out during the drain cycle, and only ½ in. of water is left in the machine. Can the water inlet valve be leaking?

JERRY DEWBERRY
NEW HOPE, AL

Assuming that you have an older-model Sears dishwasher (with a 587... model number), and because of your odor complaint, it's unlikely that the inlet valve is leaking.

I suspect that drain water is getting back into the machine from the disposer or a clogged drain. I suggest you install a one-way check valve on the discharge port of the pump.

You'll need to buy the following parts at your nearest Sears parts and service center: drain hose, part No. 5300809930; clamp, part No. 5300808186; check valve, part No. 5300809937. Together, the parts cost about $20.

To install the check valve, first disconnect the power to the washer, and remove the lower access panel. Place a pie pan under the drain-hose connection on the pump. Remove the clamp holding the drain hose to the drain port, and wiggle the hose back, catching the water in the pan. Next, push the check valve on the drain port, making sure the side marked TOP is facing up, and that the end of the valve is positioned at a 90° angle to the floor.

Now, push the new drain hose over the check valve and fasten both with the clamp. Fasten your existing drain hose over the end of the new drain hose and clamp it in place.

Can It Be Saved?

I recently acquired an old Sunbeam Mixmaster Model 9, serial No. S299385. The speed control has become erratic. I took it apart and discovered that a resistor had burned out, and a capacitor tested defective. The resistor has no markings, but the capacitor has C31AD08MFD160VAC printed on it. Several authorized repair centers have told me that parts are no longer available for that mixer. Can you help?

PAUL PARSEKIAN
HOBOKEN, NJ

A speed control is no longer available for your early 1950s Sunbeam Mixmaster, but all is not lost.

First, clean the contact points on the speed control switch with fine emery cloth. Carbon deposits and dirt can build up on these, causing erratic operation. Then, using needle-nose pliers, bend the contact arms so the points are closer together.

Lastly, replace the bad resistor and capacitor—both of which are still available. The 142-ohm ceramic resistor is Sunbeam part No. 18390, the capacitor is part No. 2065. They cost about $3 each.

Parts can be ordered from any Sunbeam authorized repair center, or you can contact the regional parts center: Sun Appliance, Norfolk, VA 23502; (800) 347-4197.

Peeled Dishwasher

The inside skin of my dishwasher peeled and left a bare spot down to the metal. Can it be repaired?

DOROTHY DREERY
ALLPORT, PA

Frigidaire does make available a porcelain repair kit which can be used on the inner surface of your dishwasher. The porcelain repair kit is Frigidaire part No. 8950102. It costs about $35 through your nearest authorized Frigidaire parts distributor. For more information, call (800) 451-7007.

The kit contains a tube of RTV compound and instructions. Basically, you clean the area to be repaired using a file or emery cloth, then smooth on the compound. It may take several coats to build up the surface to its original height.

Needs Top Burner

I have a Ma-Gee gas range, model No. V1008696, that needs a top burner, model No. 5711. Can you help?

PAUL NYSTROM
SEYMOUR, CT

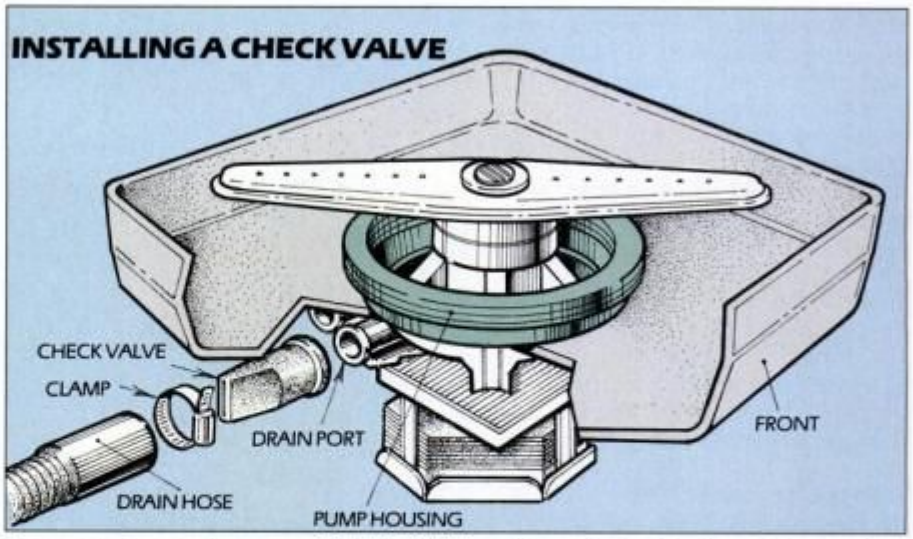
Contact Boston Stove Co., P.O. Box 1002, Reading, MA 01867; (617) 944-1045.

Bad Cat

I own a Shetland quartz space heater, model No. SHD-01A. Recently, my cat broke the 21-in. heating tube, and I've exhausted all avenues trying to find a replacement. I have not been able to contact the Shetland Co. I would appreciate any help.

RONALD LEE GRAF
ATHERTON, CA

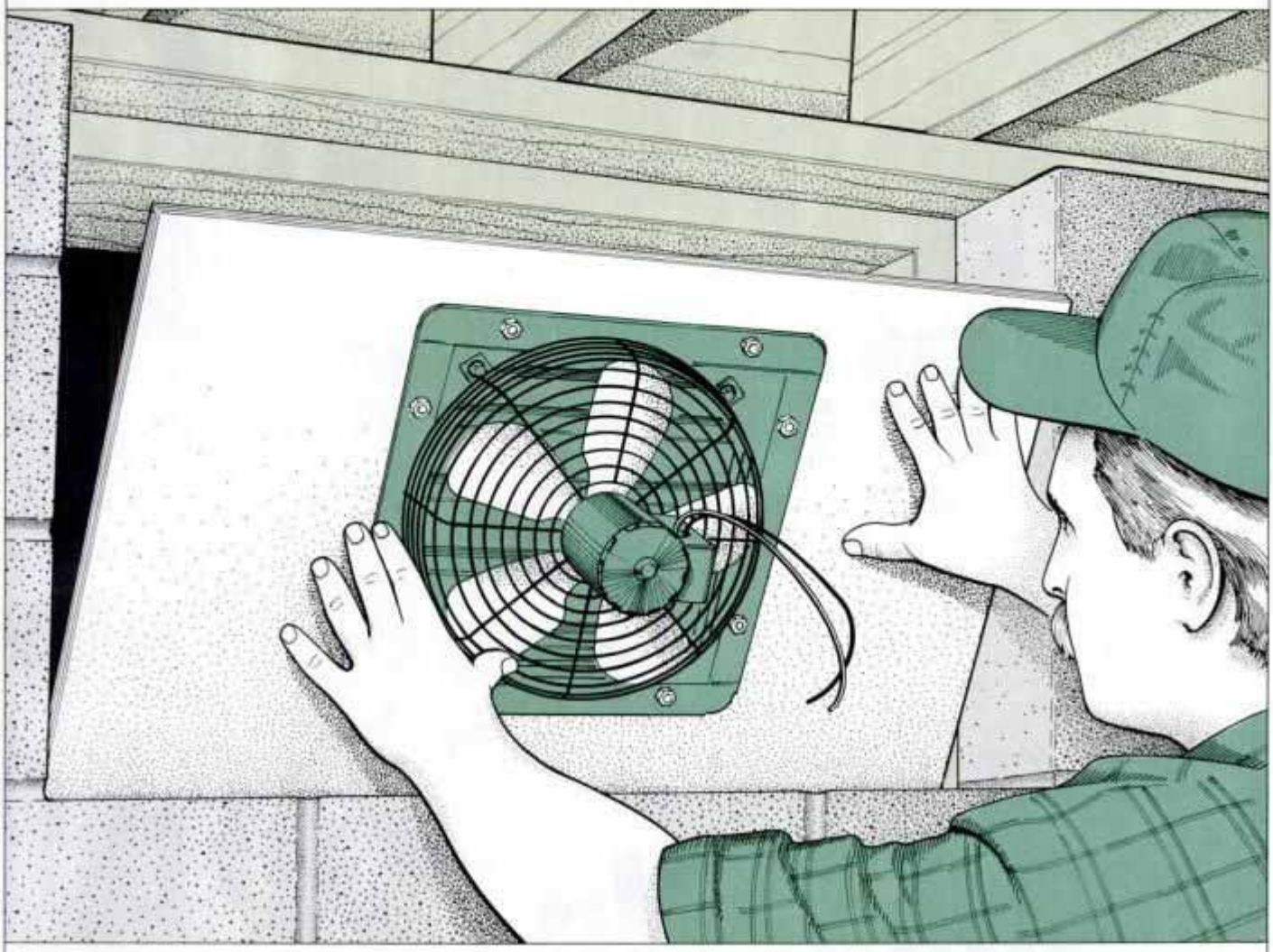
The Shetland Co. went out of business several years ago. The only parts available for the Shetland quartz heater are the heating tubes—and only in the 21-in. sizes. You can buy a new heating tube from Tensor Corp., 100 Justin Dr., Chelsea, MA 02150; (617) 884-7744. It costs about $10, including postage. **PM**



PM ILLUSTRATION BY ED LIPINSKI

To install a check valve, remove the drain hose, slide on the check valve and a new short length of hose, then clamp the hose and valve together.

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



HOME IMPROVEMENT

INSTALLING AN EXHAUST FAN

BY MERLE HENKENIUS; PM Illustrations by George Retseck

● If your workshop is in the basement, and you're tired of paint and chemical odors from your handiwork seeping into the house, you should consider installing a ventilation fan. The installation is pretty simple if your basement has a window. And, it's pretty inexpensive too. The total cost should be about $100.

We chose a 10-in. Dayton exhaust fan, which comes mounted in its own steel frame and is equipped with a fan guard and weighted shutter. The shutter remains closed against outside air until the fan is turned on. We paid about $80 for the fan, with an additional $20 for electrical hardware. Keep in mind that this is not an explosion-proof fan. To create an effective explosion-proof environment is too expensive for a home shop. Work with highly combustible materials should be done outdoors.

If you want to work with milder solvents, start the fan well before you open the solvent container. Then, open an opposing window or door slightly to allow cross-ventilation. This should keep the vapor concentrations within safe limits.

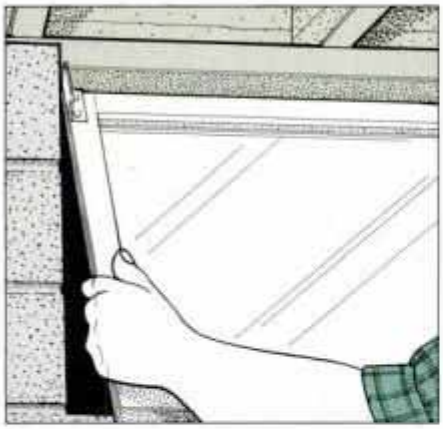
The advantage of a window installation, where the fan is mounted in a plywood panel, is that you won't need to punch a hole in your basement wall. The disadvantage is that you'll lose some daylight. We consider the tradeoff worth it. Our basement has finished walls, but an exposed ceiling. It also has wood-frame windows, with 17-in.-high × 30-in.-wide openings. You'll need to size your fan to the window's clear space.

Mounting the fan in the window

Begin by removing the window from its opening. Most basement windows tilt out (Fig. 1), though some steel models will require removing several security clips first. In any case, remove the window and measure the opening from the first step in the frame, or measure the window itself. Then, cut a ⅝-in. exterior plywood panel to fit the opening. Test fit the panel in the frame (Fig. 2).

With the panel cut, center the fan on the panel. Trace around the fan's shutter housing (Fig. 3), and bore holes at the corners of the fan outline. Using a sabre saw, cut along the outline, starting at a hole (Fig. 4).

Next, prime and paint the panel on both sides and edges (Fig. 5). Use two



1 Begin by removing the basement window. Either tip it out of its frame, or remove its hinges and security clips.

2 Cut a ⅜-in. exterior plywood panel to fill the window opening, and test fit it. This panel will support the fan.

3 To mark for the fan cutout, center the fan on the plywood panel and trace around the fan's shutter housing.

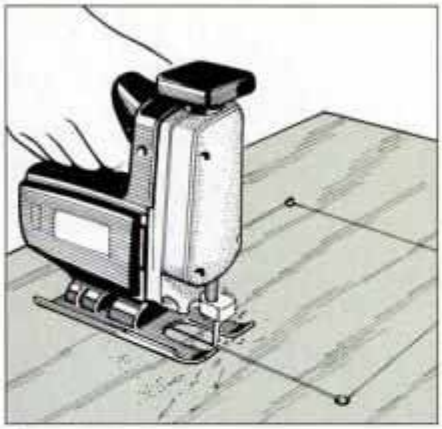
coats of an exterior-grade paint, and set the fan in the panel. Bore the fan's mounting holes. The fan mount has eight prepunched mounting holes, so all you need to do is bore through the plywood (Fig. 6). Then, secure the fan unit to the panel with ¼-in.-dia. bolts (Fig. 7). Caulk the exterior seam between the shutter housing and panel to make the assembly weathertight (Fig. 8). Then, set the panel and drill its perimeter to accept the mounting screws. Finally, secure the panel in the window frame with 1-in.-long No. 6 wood screws (Fig. 9).

Wiring the fan

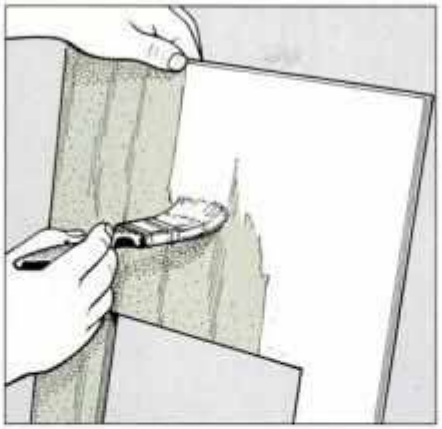
The NEC (National Electrical Code) requires wiring mounted on the surface of a wall to be encased in conduit. In our case, that meant running rigid conduit from the ceiling to the switch and flexible conduit from the switch to the fan motor.

However, our ceiling was unfinished, so we used plastic-sheathed cable (Romex) attached within the floor joists with plastic-sheathed cable staples. Don't staple the Romex to the bottom of the joists. If you install cable on the bottom edge of the joists, you need to encase it in conduit.

Begin by mounting a metal switch



4 Bore holes in the corners where you will make the fan cutout. Cut from hole to hole with a sabre saw.



5 Prime panel faces and edges. Then, give all surfaces two coats of exterior-grade paint to protect them from the elements.

6 Place the shutter housing in the panel. Bore holes for the mounting bolts through the prepunched holes in the housing.

box on the wall and running thin-wall rigid conduit to the ceiling level (Fig. 10). Then, run flexible metal conduit (sometimes referred to as Greenfield) from the switch box to the fan motor. You'll need metal box connectors to join the conduit to the switch box and the fan motor.

Feed 12/2 cable w/g (12-gauge, 2-wire cable with ground) into the switch box from the ceiling (Fig. 11). Next, run a pair of separate No. 12 insulated wires, with a separate insulated ground, from the switch box to the junction box on the fan motor. Use twist connectors to join the motor leads to the switch wires (black to black, white to white), and clip the ground wire to the box (Fig. 12). Then screw the cover on the box (Fig. 13).

At one time, it was considered sufficient to use the metal conduit as a means of grounding the fan motor. This is no longer the case, however, and that's why we specify grounding the motor box with a separate insulated ground wire.

Strip the sheathing from the cable in the switch box and fasten the ground wire to the box with a grounding clip. Next, join the two white wires with a twist connector. Join the two black wires to a single pole switch and

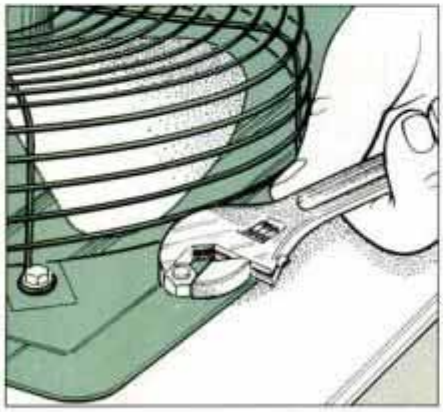
mount the switch in the box (Fig. 14).

When pulling cable from the conduit to the power source, bore the center of each joist when moving across the joists and staple the cable when moving along a joist. Drive a staple every 4 ft. and within 8 in. of the box.

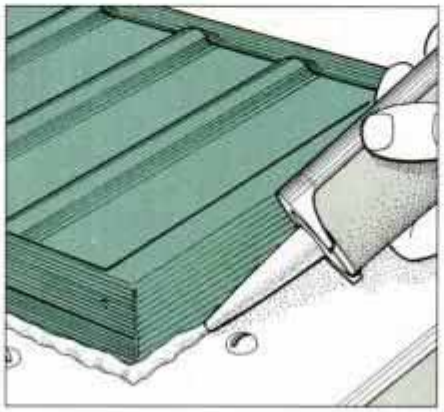
Your source of power may be a ceiling light, receptacle or junction box, wired with 12-gauge cable to match the fan wiring. In the case of a ceiling light, one of the switch-loop wires may be white, but should be coded black with tape or paint.

In our case, the simplest access to power is a ceiling-mounted junction box near the window, which contains two 12/2 cables w/g. We simply removed the coverplate and fed our new cable in through a knockout. Once inside, join the new wires to their like-colored counterparts using twist connectors. Join the black wires together, and join the white wires (Fig. 15). If the box is metal, you'll need to ground it too. Attach the ground wires and a green insulated pigtail wire together with a twist connector. Attach the free end of the pigtail wire to the box using a clip connector.

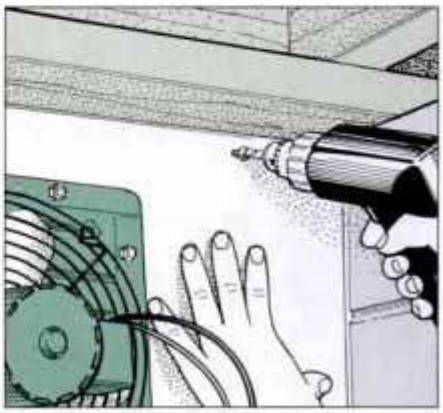
Finally, replace the box's coverplate and turn your fan on for a test. Complete the job by reattaching the coverplate over the junction box. **PM**



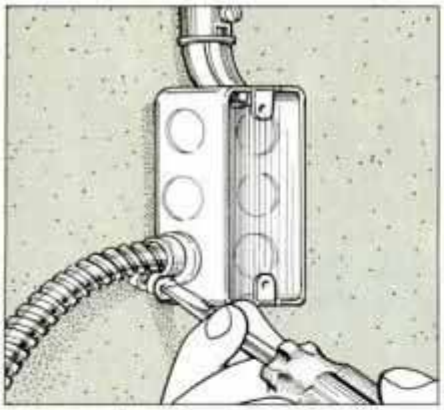
7 Use eight ¼-in.-dia. bolts to secure the fan unit to the panel. Try not to nick the bolt heads' plated coating.



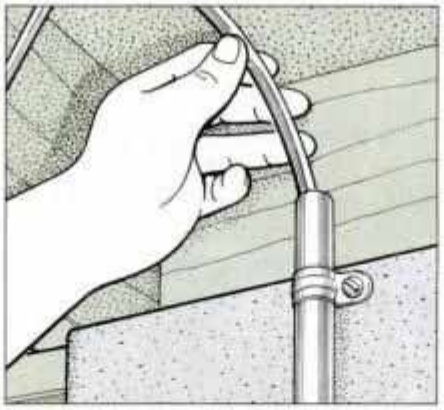
8 To make the panel weathertight, seal around the shutter housing with a good quality exterior-grade caulk.



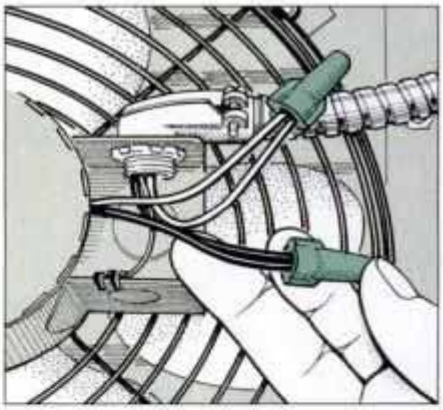
9 Drive No. 6 wood screws through the plywood into the window frame. If necessary, install weatherstripping first.



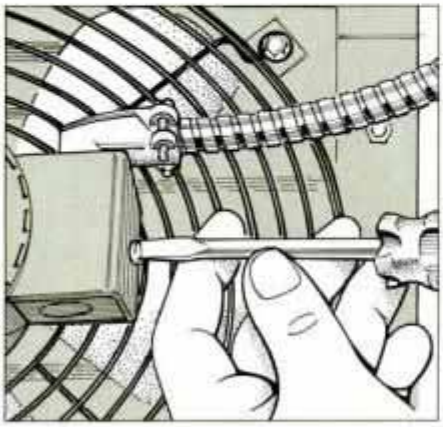
10 Attach switch box to wall. Run conduit to both sides of box, then fasten both types of conduit with box connectors.



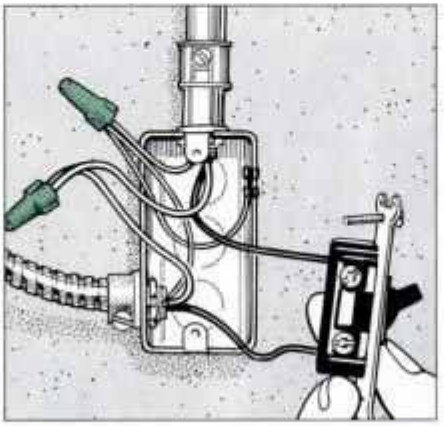
11 Feed 12/2 cable w/g (12-gauge, 2-wire cable with ground) through the conduit and into the switch box.



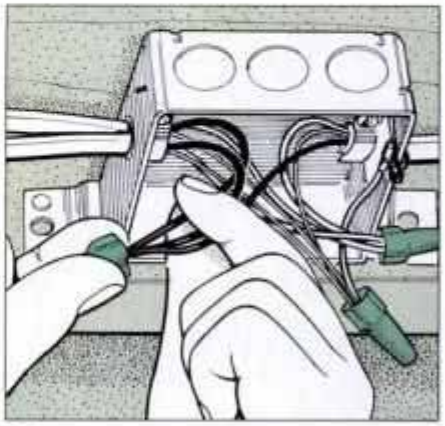
12 Connect the motor to the switch with two No. 12 wires and a ground. Join like-colored wires and clip the ground to box.



13 With the wires tucked inside the box, replace the motor junction-box cover and screw it in place.



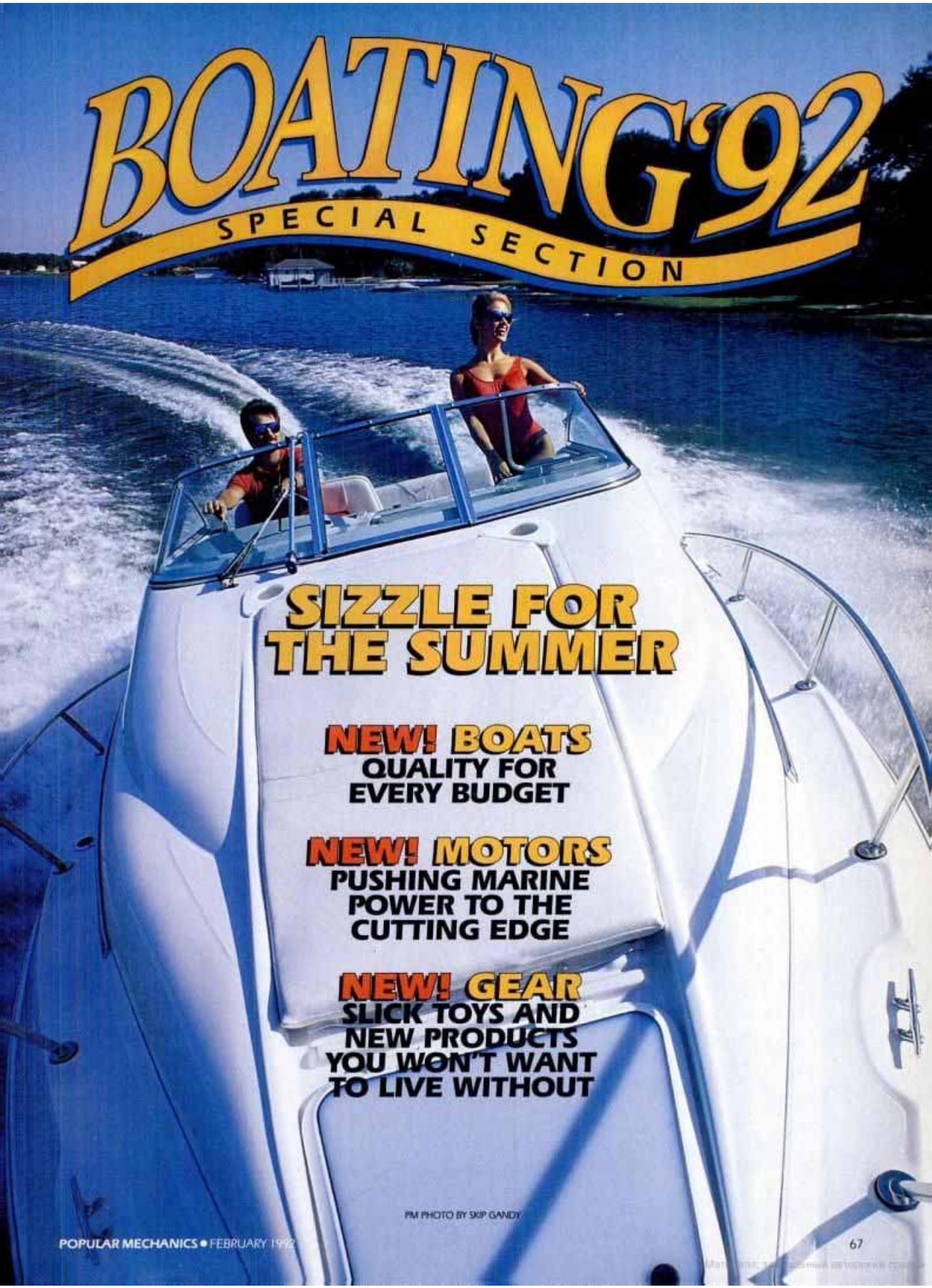
14 Attach the black wires to the switch, and join the neutral wires and the ground wires. Clip a grounding pigtail to the box.



15 Join like-colored incoming wires in the ceiling junction box. Use a grounding clip and pigtail to ground the box.

BOATING '92

SPECIAL SECTION



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BOATING '92

SUNSATIONAL

Changes in cosmetics and beneath the skin redefine the American pleasure boat.

BY JOE SKORUPA, Boating/Outdoors Editor

● Most people I meet don't seem to think that testing boats is one of the toughest jobs around. I can't imagine why. Sure I spend most of the winter in sunny Florida and my schedule is filled with fishing, diving and scorching the water in hot boats. But like everything else, people don't know the whole story until they walk a mile in another person's deck shoes.

Unlike a growing number of other American industries, U.S. boating leads the world in design, construction, durability, efficiency, high-tech advancement, units sold, international market share and every other important category. Covering the waterfront is no easy task when there's so much to cover.

And if this weren't enough, U.S. boating's vitality isn't limited to boats. Marine engines, gear, accessories, equipment and everything else associated with waterway fun is dominated by American companies—with one or two exceptions.

While the continuing recession has adversely affected boating's bottom line, as it has every

other segment of the economy, product development refuses to slow down. In fact, this year's major intros—in boats, engines and gear—are more exciting than ever.

Boatbuilders are advancing along two fronts in 1992: redefining individual details and exploring the possibilities of integrated design. The ingenious Cajun XPT bass boat, for example, has as many uniquely built-in features as a Swiss Army knife. While the head-turning Chris-Craft Caper, with its freshly derivative styling, reminds us that sport boating is meant to be fun.

Bold, new technology dramatically transforms outboards and sterndrives this year. OMC's Quiet Rider, with its breakthrough trim and mounting system, enables an outboard engine to be fully enclosed and integrated into a Eurostyle boat. While the much-anticipated Yamaha 7.4-liter Hydra-Drive features a trailblazing hydraulic clutch and a cluster of other advancements.

The makers of high-tech gear have been busy this year, too. Microprocessor technology reaches a new threshold in the Magellan NAV 5000, which is a mini-GPS unit that tracks five satellites and fits in your hand. And there's good news for the environment from Racor, which introduces an affordable air/fuel separator that's a simple but elegant solution to preventing unnecessary fuel spills.

As you can see, there's a great deal of territory to cover in boating, and it keeps me pretty busy. In fact, I'm usually so busy testing boats this time of year at dealer meetings and boat shows that I have little time to go boating for fun. Life can be tough, but there's a bright side, too. All of this hard work gives me a good overview of what's new for '92.

Age of integration

When the design team at Regal Marine, in Orlando, Florida, approached the problem of creating a 26-ft. fast family cruiser, they started out with a blank sheet of paper and came up with a classic. What I especially like about the 8½-ft.-wide Regal Valanti 240 is its clever and functional use of space. Seating, for example, is outstanding, with a wide helm seat, an aft bench seat and a unique portside lounger. On the surface, this may not seem radical, but precise use of space and superb placement add up to the most comfortable cockpit in its class.

Other features impress me, too, such as the molded-in fender stowage rack, the recessed sunpad on the sloping foredeck, the built-in stern stowage compartment, the easy-to-reach cooler compartment, the hideaway

REGAL VALANTI 240
With one of the most intricate molds in its class, the Regal Valanti 240 builds in a stern storage station (below right) and a hinged aft deck sole for engine access (below left).

PM PHOTOS BY SKIP GANDY


BAJA BANDIT

swim ladder, the functional bow pulpit and the plexiglass-covered chart table. All of these features, by the way, are integrated into the deck mold, which is the best and most difficult method of construction.

Impressive, too, are the galley, stand-up head, and generous sleeping space. However, to me, the most unique feature is the hydraulic engine access. Press a button on the dash and the aft cockpit sole and all of its molded-in features rise up. I'm not talking about a simple engine cover here. The entire aft deck is hinged and opens wide enough to fit a team of mechanics inside. This feature and the entire boat (base price $42,920) are concepts whose time has come.

Cajun, the innovative Louisiana builder of fishing boats, bills its new 1800 XPT as the ultimate family bass boat. To me, it's the Swiss Army knife of boating. There are so many pullout, flip-up and hideaway features on this ingenious boat that if you don't carefully study the owner's manual, it will probably take you months to figure the boat out.

Here's a list of my 10 favorite 1800 XPT trick features: 1. Self-contained generator for battery charging, 2. Tilt-up floor section that closes off the space between the twin consoles, 3. Removable trolling motor with its own storage compartment, 4. Reinforced guard to protect the bow eye, 5. Reversible bow hatch lids that have deck carpeting on one side and seat pads on the other, 6. Snap-on pads to turn the rear casting platform into a sun deck, 7. Ski pylon that twists and locks into place, 8. Rear platform extender that flips forward to cover the seatwell, 9. XPT (extra-pad tunnel) hull that has a wide planing pad and a small tunnel to deliver smooth water to the prop, and 10. Aluminum grid and composite transom that's strong enough to withstand a Scud missile attack. Not too shabby for an 18-ft. boat.

The Cajun 1800 XPT is sold as a package boat with a custom trailer, 150-hp Yamaha outboard, trolling motor, radio/cassette player and fishfinder for $18,995.


GODFREY MARINE HURRICANE 240

Space is the ultimate luxury, and no design offers more of it than a deck boat. Last year, these wide-bodied day cruisers entered a new era with the introduction of the revolutionary Wellcraft Genesis. This year, Indiana-based Godfrey Marine takes the concept a step further with the Hurricane 240.

The difference between deck boats and pontoon cruisers is that features are *added* onto aluminum platforms while they're *built* into fiberglass decks. This is certainly the case with the 24-ft.-long, 8½-ft.-wide Hurricane 240. Like the Valanti 240, this V-bottom has beautifully molded-in features and outstanding seating—a bucket seat at the helm, a big L-seat aft and a semicircular bench forward.

However, what truly separates the Hurricane 240 ($16,195) from its deckboat brethren is its sharply raised helm, which wisely has walkaround side decks. This not only provides excellent driver sightlines, but enough space below to fit a berth and an enclosed head. Other notable features include an outside galley and copious stowage space. The Hurricane 240, and other similar models, may well become the niche boat of the '90s.

Another boat attempting to carve out a unique niche in the market is the Eddie Bauer 1900 SRB Special Edition from Maxum Marine. If a partnership with the outdoors outfitter Eddie Bauer worked for the Ford Explorer, why not for a Maxum bowrider? The answer is it probably will, because the feature-laden runabout is an attractive boat in itself.

This 19½-ft. craft, like all Maxum boats, is an upscale package that's

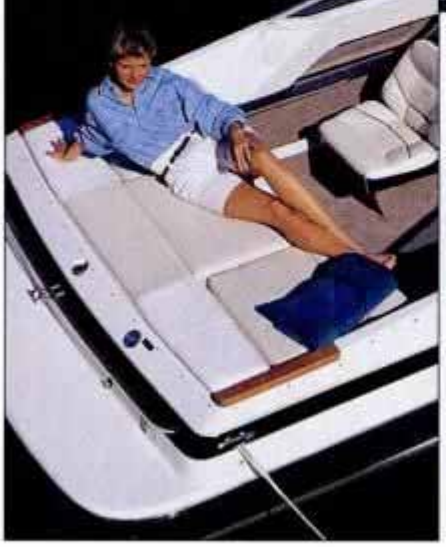
CHRIS-CRAFT 156 CAPER

equipped with full dash instrumentation, 175-hp V6 Merc sterndrive, radio/cassette player, canvas cover and everything else you'd expect from a premium boat.

The Eddie Bauer Edition trim level includes custom colors and emblems, specially monogrammed upholstery, in-dash depth sounder, premium tonneau cover and a $125 Eddie Bauer gift certificate. Personally, I'd like to see the concept taken beyond cosmetic styling, but the boat itself is a winner, and Maxum gets credit for taking a first step into a bold new area of design. Price is $16,495.

Even more daring in conceptual design is Chris-Craft's personal-watercraft-size Caper runabout. Low-to-the-water, sporty fun boats like this used to be abundant in years past. Today, the youth-oriented, 16-ft. 8-in. Caper ($10,500) has the market practically all to itself.

Comparison to the Mazda Miata is inevitable. Equipped with a zippy 60-hp Johnson or Evinrude outboard, curvilinear contours, bright colors, head-turning style, seating for five and little else, this is clearly a fun-in-the-sun niche boat. But boaters in this niche will go crazy for it.



Details, details

God or the devil is in the details, depending on your point of view. Boaters love hard-to-construct, built-in features. Hate isn't exactly how builders think of them, but it's close. The new 22 Tradition, from Kansas-based Cobalt, is a perfect example.

Cobalt designer Peter Granata pushes beyond the conventional boundaries of functional style every chance he gets, and often this means personally clearing up manufacturing stumbling blocks. To complete the im-

BOATING '92

age of a classic, handcrafted runabout, which the 22 Tradition indeed is, Granata wanted the dash panels made of a machine-tooled aluminum, similar to that used in old wooden boats. Dash builders said it couldn't be done, but after a personal visit to the plant, Granata helped the builder figure out a way to do it. The result is a distinctive touch that helps make the reverse-transom 22 Tradition one of the most elegant boats of 1992.

Other standout features are the bow scuff plate, built-in fender storage, pullout trash receptacle, teak swim platform and trim, and too many others to list. Base price for the 22 Tradition is $39,993.

As with the Hurricane 240, space is a major feature of the 237 Quest, made by Four Winns. Although only 22½ ft. long, this center-console fishing machine is a full 9 ft. wide. The generous beam, in addition to providing exceptional seaworthiness, enables the 237 Quest to build in features not usually on boats in this class, such as a walk-in head beneath the console, transom rigging station, transom gate, tackle drawers, washdown system and more. Capable of handling up to twin 200-hp Johnson or Evinrude outboards, the 237 Quest's base price is $30,400 with a single OMC 200-hp outboard.

Surely one of the most innovative boats of the year, and probably the decade, is the 190 Eurosport, by Sunbird, of Columbia, South Carolina. What makes this boat unique is that it was designed specifically to accommodate the revolutionary OMC Quiet Rider enclosed outboard.

To give the outboard room to trim within its own profile, rather than up and out as in conventional systems, Sunbird developed an engine mounting design that uses parallel aluminum tubes connected to two full-length stringers. In effect, the boat

has no true load-bearing transom—an industry first.

Perhaps the most revolutionary aspect of the 190 Eurosport ($10,700 for the complete package) is that it doesn't *look* revolutionary. In fact, it looks like a well-designed affordable family bowrider with a typical Euro-style integrated swim platform. Here's one boat where cosmetics and components beneath the skin are redefining the American pleasure boat.

High-concept packages

The volume boat company of the 1980s, Bayliner, has a new competitor with the recent introduction of the Excel line of affordable family package boats. A division of Wellcraft, from Sarasota, Florida, Excel begins its first year with 18-ft. and 20-ft. hulls that come configured as closed-deck and bowrider runabouts, and, in the bigger hull, a small cuddy cruiser. Power is supplied by Yamaha outboards or Volvo-Penta sterndrives.

What makes the Excel line unique is that a carefully picked committee of designers and engineers spent two years hammering out manufacturing details so that the finished line could be produced inexpensively, in great volume and with built-in quality. I haven't tested these boats yet, but I've seen them at boat shows and they're quite impressive. Ultramodern contours and an unmatched attention to detail bode well for the success of this product line. Prices range from $10,600 to $15,000.

Wrapping up my overview of what's new for '92 is another boat that had an auspicious debut, the 24-ft. 4-in.-long Baja Bandit. I first saw this sexy sport boat powered by the high-tech ZR-1 Corvette engine. That's right. This is the boat that became last year's custom dream machine known as the Wette Vette. And while you can't equip your Bandit with America's most exotic engine, you don't need to. As equipped with a Mercury big-block sterndrive, the Bandit ($30,900) is a 70-mph screamer.

And speed isn't the only standout feature on this high-performance sport boat. The creamy gelcoat, plush upholstery and macho good looks are among the finest in the business.

So, that's a quick glance at the best and brightest boats of 1992. For in-depth coverage of these and other models, look for comparison tests and other feature stories in upcoming issues. I guess that means I have to schedule another round of boat tests in sunny locales. On second thought, my job isn't so tough after all. **PM**

AQUA POWER

The hydraulic clutch, an inside outboard and a peek at engines of the future.

BY JOHN WOOLDRIDGE, Contributing Editor

● You're not likely to see boating's top technical aces lauded on a glitzy TV show named "Engineering Tonight" or featured on a slick all-video cable network dubbed "ETV," but without the products of these mechanical wizards our life on the water would be considerably less enjoyable. Their achievements, both individual and in team efforts, help make boating more comfortable, more efficient and, most importantly, safer.

Nowhere is this more true than in marine propulsion. For 1992, advances in outboard, inboard and sterndrive engines include improvements to existing models and, in a few significant cases, real breakthroughs that will influence the way we boat well into the next century.

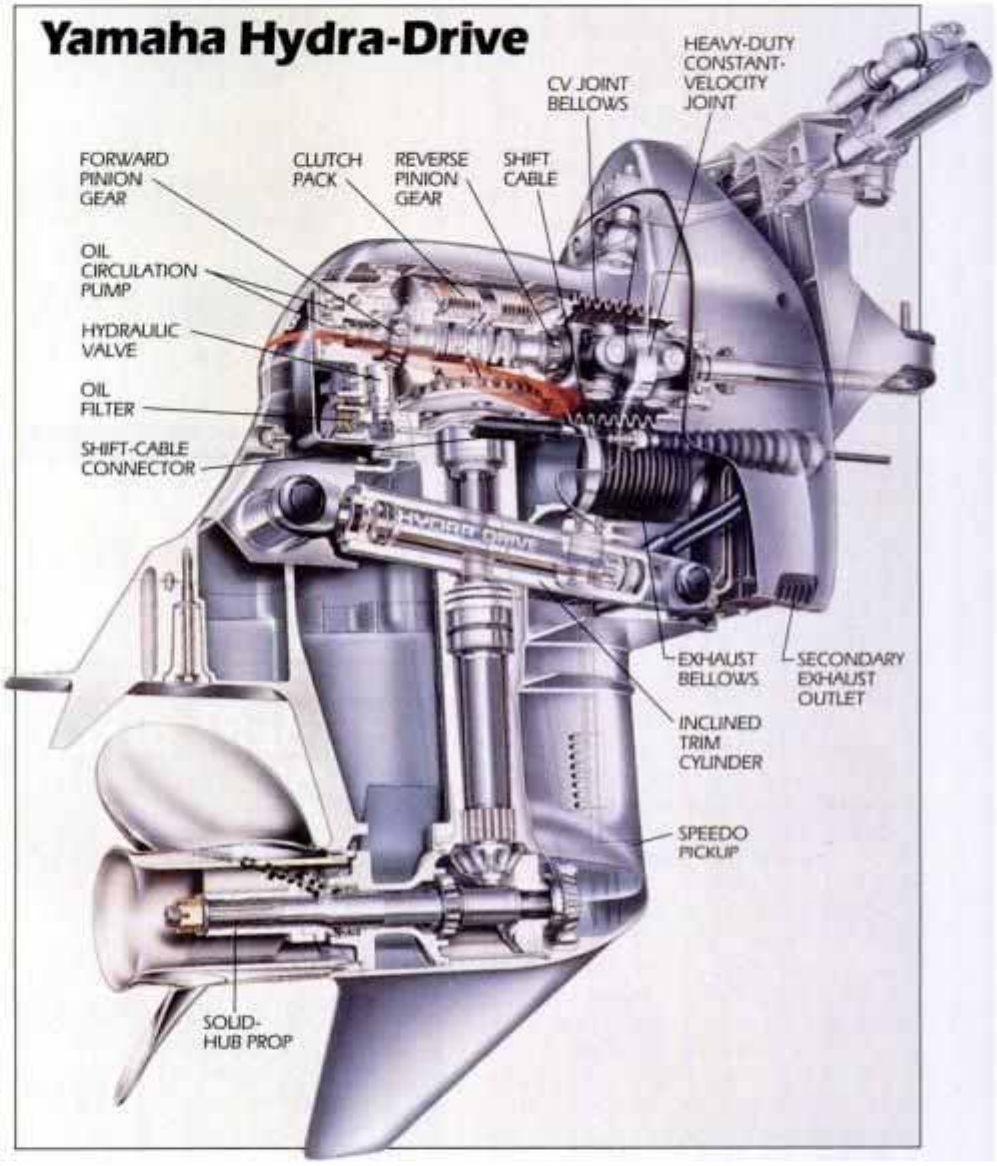
Award-winning designs

Without doubt, one of the major breakthroughs of 1992 is the Yamaha Hydra-Drive, which features the marine industry's first successful hydraulic clutch. The smooth-shifting Hydra-Drive has earned both a 1992 POPULAR MECHANICS Design & Engineering Award and an Innovation Award from the International Marine Trades Exhibition & Conference.

Crank the ignition on a Hydra-Drive-equipped boat and you'll quickly discover why it's an award winner. First, you'll hear the powerful rumble of a 7.4-liter V8 engine. Then, when you slip the throttle into gear, you *don't* hear the shudder of an induced engine stall and the clanking engagement of a conventional cone or dog clutch. Unlike other sterndrive units, Hydra-Drive power is delivered with shockfree smoothness.

At the heart of this system is a hydraulic clutch, located in the upper gear-case housing between the engine and the vertical driveshaft. It employs a series of discs in a pressurized hydraulic bath that functions like an automatic transmission in a car. Power is transferred through crown gears to the vertical driveshaft.

Since this isn't a direct mechanical connection, a certain amount of torque loss occurs, but Yamaha compensates by increasing torque at the point of power delivery through a new line of solid-hub props. The new props are connected directly to the propshaft, minus the conventional power-robbing rubber gasket.



The benefits to boaters from the hydraulic clutch and solid-hub prop are many: better acceleration and top-end performance, better midrange fuel economy and improved durability due to elimination of the mechanically punishing cone or dog clutch.

Two other Hydra-Drive components are of equal interest. These are the Silent Power and the Cathodic Protection systems. Yamaha's Silent Power system dissipates another power robber—back pressure—by venting the exhaust below the waterline and effectively smothering the noise. The Cathodic Protection system creates an electrical current that balances the flow of electrons normally associated with destructive galvanic corrosion. This kind of active anti-corrosion system may well become an industry standard later in the decade.

The trailblazing OMC Quiet Rider is another 1992 PM Design & Engineering Award winner. This unique engine represents an entirely new concept in outboard power—the inside outboard.

Light weight, ease of maintenance and minimal impact on cockpit space have always been hallmarks of out-

board engines. But there's a tradeoff—the exposed engine is noisy and limits what designers can do with the transom. With the introduction of the Quiet Rider, OMC eliminates the negative aspects of the tradeoff with an enclosed-outboard design.

The key component of the Quiet Rider is a unique pivoting bracket that enables the engine to trim/tilt within its own profile, something no other outboard can do. The hydraulic-assisted, aluminum-alloy bracket allows a complete range of trim from -7° to 14°. Tilt angle reaches 52°, where the entire lower unit rises above the bottom of the boat. This is ideal for beaching, anchoring and mooring.

A sealed cowling and air-induction system helps muffle the 90-hp V4's growl, as does the engine cover that opens to reveal fuel lines and a fuel fill. With the engine integrated into the boat, Eurostyle contours are now possible for designers.

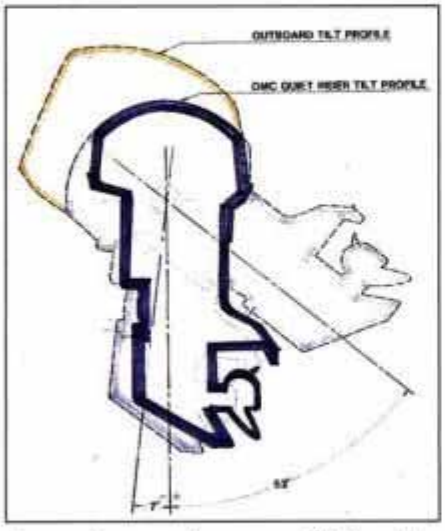
The first boat to feature the Quiet Rider, Sunbird's Eurosport 190, fully capitalizes on the styling potential. (See "Sunsational" on page 68.)

OMC engineering data shows that the Eurosport 190 has sound-level readings at the driver's ear of approximately 75 decibels while cruising in the 3000- to 3500-rpm range. These readings remain under 80 decibels up to 4000 rpm, or slightly below 40 mph. Since noise levels inside a car at high speeds can range from 80 to 90 decibels, you begin to realize the benefits of the Quiet Rider system, which actually tests quieter than some sterndrives.

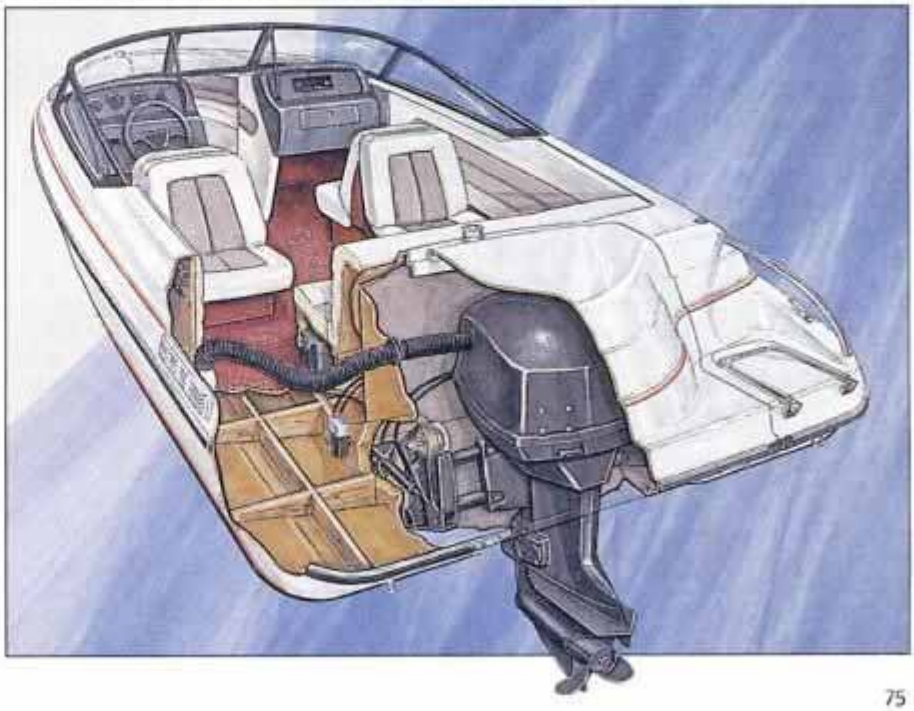
King Cobra strikes

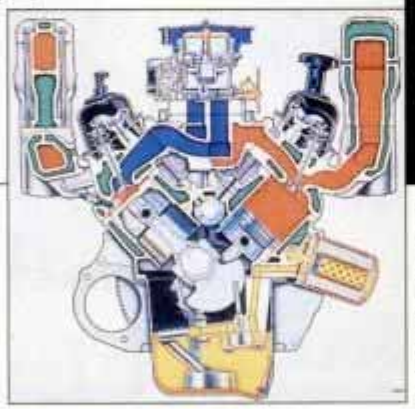
Small-block sterndrive aficionados, take note: OMC's latest collaboration with Ford begins with a revamped 5.8-liter V8 that was designed specifically for the marine market. The new King Cobra 351 High Output uses components adapted from the proven GT-40 racing machines, which made Ford a power in such durability races as the 24 Hours of LeMans. The new engine is capable of producing 20% more power than a standard 351 OMC Cobra engine.

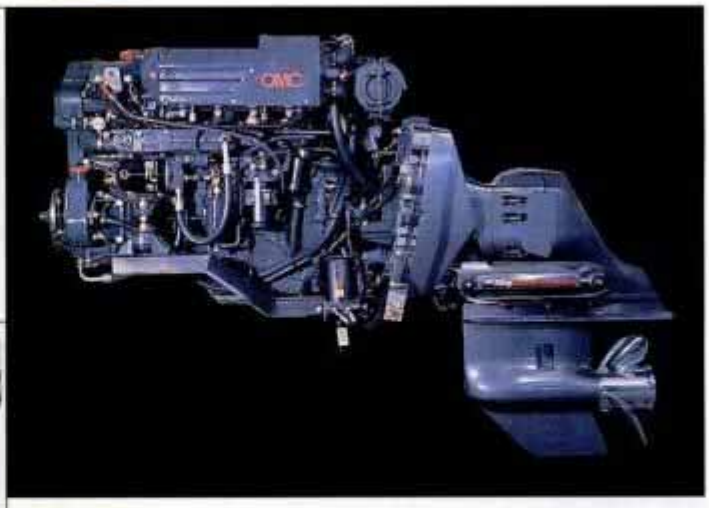
New tech trio from Mercury: 2.5-liter 150-hp XR-6 (top left), Quicksilver Rideguide Outboard Power Steering Kit (above), and Mercruiser 350 Magnum Tournament Ski.



Because it rotates its own profile (above), the OMC Quiet Rider can be mounted beneath a sound-muffling engine cover (right), which is fed by an air-induction hose. Note Eurostyled stern.







Two from OMC: 1. King Cobra 351 HO uses a 5.8-liter V8 Ford block (left), and 2. King Cobra Diesel (above) uses a turbocharged monoblock.

Computer-designed and enlarged ports promote freer breathing. A redesigned cam adds higher intake lift and quicker exhaust. In the block, fully skirted hypereutectic pistons add strength and stability for high-rpm operation, while the reshaped combustion chamber improves fuel-burn efficiency.

OMC engineers added a stronger, more hydrodynamically efficient lower gear case for better control at higher speeds, as well as integral water inlets and a new high-volume, gear-driven water pump to improve engine cooling characteristics.

For owners of performance cruisers, OMC turned to Austria's Steyr-Daimler-Puch for cutting-edge technology in the form of an advanced turbocharged monoblock diesel (block and head are cast as a single piece). This unique casting process allows for a smaller, lighter engine with fewer components than a conventionally cast engine.

Weighing in at just 970 pounds, the Cobra Diesel cranks out 205 horsepower at 4300 rpm. For comparison, OMC's standard 5.8-liter Cobra sterndrive produces 210 hp between 4000 and 4400 rpm, and tips the scales at 976 pounds.

Innovative features on this diesel include a high-pressure, 2-stage fuel-injection system that's modulated by an overhead camshaft, an electronic engine management system and turbocharger.

Interestingly, for those who go where no boater dares to take a prop, OMC has introduced a family of Johnson/Evinrude jetdrives from 35 hp to 105 hp. This is good news for skinny-water enthusiasts, because the units have features identical to those offered on propped engines using equivalent powerheads, such as VRO oil/gas mixing.

The stainless-steel and aluminum-alloy jetdrive unit draws water up through a screened intake on the bottom and forces it out a rear-facing nozzle at high pressure. A hinged reverse gate pivots up to divert pressure forward to achieve reverse thrust. These nonprop engines are ideally suited for running in save-the-Manatee country.

Black projects from Merc

The special needs of waterskiers are addressed in the introduction of MerCruiser's new 350 Magnum Tournament Ski. Based on a 5.7-liter GM block, this high-output model utilizes an aggressive high-lift camshaft with

Green Machines: Life Under The EPA

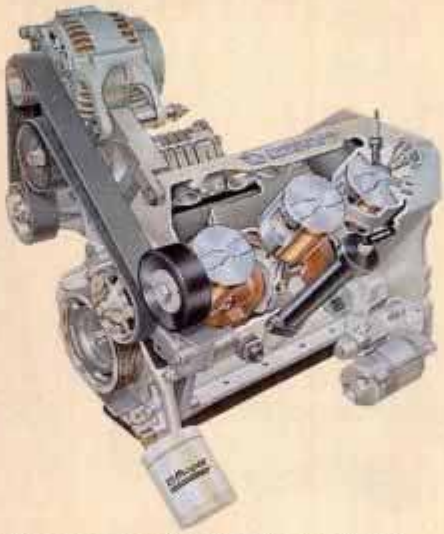
● By the time this issue reaches print, the Environmental Protection Agency will have made its recommendations concerning marine engine emissions. The thrust of the much-delayed decision, however, was revealed in the late fall when information emerged that indicated the study would identify off-road and marine engines as major sources of pollution. In their wildest dreams, marine engine manufacturers were hoping they would remain exempt.

Once the EPA targets marine engines, it will develop guidelines that builders will be compelled to follow, much like what happened to the auto industry in the late 1970s.

How will marine engine manufacturers rise to the technological challenge?

Sterndrive and inboard engine manufacturers may have the best of it. Using emissions-control packages similar to those already in place for automotive engines, such as electronic fuel injection and sophisticated engine function management systems, builders could easily convert existing 4-cycle powerplants into green machines.

Outboard motor builders are not in the same boat, so to speak. Certainly they, too, are looking at catalytic converters, electronic fuel injection and microprocessor management systems, but these can only go so far in outboards. The main problem is in the combustion system.



Chrysler's clean-burning 2-stroke engine may be in Mercury's future.

Part of the fuel charge in 2-stroke outboards is used to clear the combustion chamber of exhaust. This means that before every charge is fired, unburned fuel is jetted directly into the atmosphere. Four strokes, with two extra cycles to play with, are able to close the exhaust port before fuel enters the cylinder.

Mercury Marine, OMC and Yamaha are trying to solve this problem by working with cutting-edge technology developed by General Motors, Chrysler and, most notably, an Australian-based firm called Orbital Engine Co. Orbital, which made headlines several years ago with a pneumatic-assist direct-injection system for 2-stroke engines, is considered the leader in this increasingly important field. Although Orbital's clean-burning 2-stroke engines were intended for use in compact cars, the marine field may actually be where the difficult-to-perfect technology bears its first fruit. Outboards are a natural for Orbital's unique technology, but 2-stroke sterndrives are a possibility, too.

Another possible solution for outboards to meet new EPA standards was spotlighted last year in Honda's clean-burning mid-size 4-stroke. Rumor has it that Honda is in the final stages of testing a new 100-hp outboard, and Mercury, Yamaha and OMC reportedly have 4-stroke projects in the works. The problem with 4-stroke outboards, however, is that there's a severe weight penalty once you start getting into the higher horsepower ranges.

Make no mistake, green machines are coming by the end of the decade and they will profoundly alter the landscape of marine engine technology.

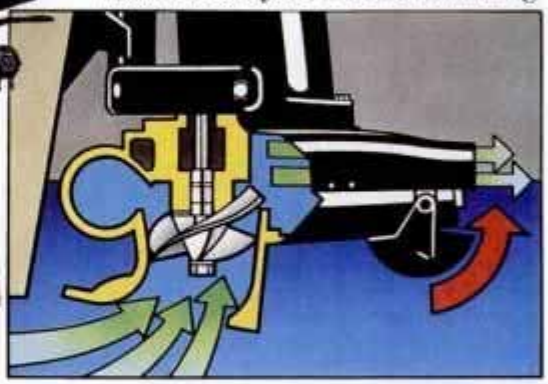
—J.W.

roller hydraulic lifters, which were jointly developed by Merc and GM engineers for increased low- and midrange torque, as well as better top-end performance and longer valvetrain life.

A precision-calibrated, square-bore Weber 4-barrel carburetor promotes an even fuel flow across a wide powerband, and helps the 350 Mag produce up to 265 hp, about 15 more horsepower and 20 ft.-lb. more torque than a standard Merc 5.7-liter Competition Ski V8.

Corrosion protection, especially for sterndrives, is something engineers have been working on for years. As noted previously, the 7.4-liter Yamaha Hydra-Drive features an electronic corrosion-protection system called Cathodic Protection. Merc, too, has its own system, and this year introduces the next-generation unit called MerCathode II.

The system can be purchased as an add-on kit for MerCruiser sterndrives or outboards. The MerCathode II control module, which is mounted on the engine, generates a reverse electrical current to counteract stray galvanic currents that naturally occur when water comes in contact with dissimilar engine metals. The system continues to recommend using a zinc trim tab and bottom bracket cap bolts as additional anodes. If you can't detect the system at work, you know it's working.



An impeller forces water through a nozzle to create thrust in the new line of Johnson/Evinrude jetdrives.

Bass boaters continue to be a major focus for high-performance engines, and this year the men in black have upped the ante in 150-hp outboards by using a block from a model that was introduced last year on a fire-breathing 200-hp engine. The V6 2.5-liter block found on the Mercury XR-6 and Mariner Magnum III adds 11 cu. in. of displacement to the standard 2.0-liter block. The result is an increase in top-end performance and better low-end torque for quick planing. All-new rods, pistons and bearings were specified to handle the increased output.

The 2.5 block is also used on this year's Merc and Mariner 175-hp outboards, which are electronically fuel injected like the big 200-hp models.

Another add-on product to come out of Fond du Lac this year is the Quicksilver RideGuide Outboard Power Steering kit, which improves handling and eliminates steering torque on 70-hp to 200-hp Mercury or Mariner outboards built for the 1989 model year or later.

The interesting thing about this system is that Merc engineers specified a 12-volt pump motor/accumulator that requires no belt-driven pumps on the engine. The only requirement is that your outboard must be equipped with a high-output, 16-amp alternator. In the event of a malfunction, the power-steering cylinder can be overridden by mechanical steering to keep you in complete control of the boat.

Boating, like every other segment of the national economy, is suffering through one of its cyclical downturns, but engineers haven't stopped pushing marine technology to the cutting edge. The product intros may not be as numerous as in boom years, but the ones that made it out of R&D are every bit as important. Perhaps we'll see them soon on "Engineering Tonight." **PM**

GREAT GEAR

Equipment, accessories and toys that you can't boat without.

BY JOHN WOOLDRIDGE, Contributing Editor

● What's new for '92? Quite a lot. Handheld, multichannel satellite transceivers compute position with greater accuracy than ever before. Other electronic instruments expand the underwater view horizontally. One even talks.

Higher performance and greater control typify new personal watercraft. A hot 3-cylinder scooter debuts with snowmobile lineage. Another features innovative trim control.

An elegantly simple air/fuel separator prevents unnecessary fuel discharges. A dual-battery charger shortens downtime between fishing adventures. A fully enclosed trailer protects our prized possessions from road damage and thieves.

Most of us are attracted to boating as a sport, but with all the great new gear there might be a few that are in it just to use the latest gadgets. Boating and toys go hand in hand.

Mini Loran

Smaller is better in electronic navigation. Micrologic's Adventurer ($595) is a portable Loran unit that will fix a position in 45 seconds, store 250 separate 5-character waypoints and secure up to 100 against unauthorized use.

Jet Trim

A twist of the knob on the Variable Trim System and you're in greater control than ever on the Sea-Doo XP ($5899). Racing-style rearview mirrors give the XP a hot look, while the 2-cylinder, 580-cc Bombardier-Rotax rotary-valve engine with twin carbs and a tuned exhaust cranks out 60 hp.

GPS In Hand

Sony breaks the GPS barrier with the smallest, lightest navigation unit on the market. The Pyxis ($1395) is a 1.3-pound, 4-channel GPS. It comes complete with a water-resistant antenna, keyboard and antenna mounting brackets, and cigarette lighter adapter.

Commanding View

Precision optics and advanced flux-gate compass technology converge in Steiner's Commander 7x50 electronic binoculars ($1899). A microprocessor compensates for magnetic variation, to within 1°.

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Beaming Up

Magellan's new NAV 5000 ($1950) takes the handheld global-positioning system (GPS) to a new dimension by tracking five satellites continuously. It gives an accurate 3-dimensional fix in latitude, longitude and altitude virtually anywhere in the world.

Expanded View

Bottom Line's new Stalker Multi-View Sonar ($399) adds sideways-looking sonar to conventional bottom-probing. Computer-enhanced side views eliminate inanimate objects and show only fish. The winner of a 1992 Popular Mechanics Design & Engineering Award.

Holy Bassmobile!

Turn a keyed switch and the top half of the streamlined Bassmobile ($7450) lifts open. Inside, there's a foam liner to cradle your rig and a battery to power lights. A galvanized tubular frame supports the fiberglass shell. It also has a solar-powered circulation vent and an electric jack.

Riding On Air

Mercury Marine now offers Quicksilver inflatables that range from 8½ ft. ($855) to 12½ ft. ($1430). Multiple air chambers and an inflatable keel provide safety and comfort.

Rust Never Sleeps

What would you use to block rust and corrosion, or to loosen seized parts or to protect mechanical and electrical components? A 12-ounce spray can of Corrosion Block ($12.95) does it all. It uses ACF-50 to seal out moisture.

Two Ninjas And A Stealth

Get a grip on MotorGuide's transom-mount Stealth electric trolling motors, which range from the ST200 ($99) to the ST2000V ($299). Backtrollers will appreciate the unique grip handle and two Ninja props.

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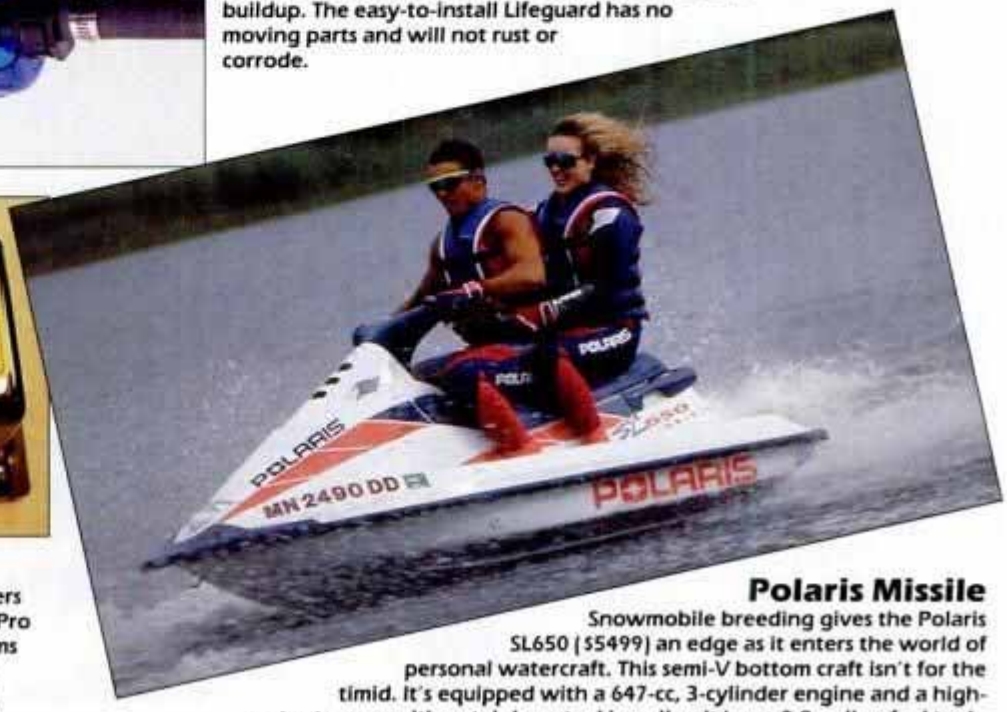
No More Fuel Spills

Put an end to environmentally deadly spills from your fuel tank vent. Installed in your boat's vent line, Racor's Lifeguard Fuel/Air Separator ($85) traps overflow fuel and vapors and returns them to the tank. A relief valve moderates pressure buildup. The easy-to-install Lifeguard has no moving parts and will not rust or corrode.

Overnight Sensation

No more trickle charging, faulty meters or battery cable switching. The Dual Pro Charger ($324), from Charging Systems International, charges two batteries overnight. And since it's waterproof, it can be installed aboard your boat.



Polaris Missile

Snowmobile breeding gives the Polaris SL650 ($5499) an edge as it enters the world of personal watercraft. This semi-V bottom craft isn't for the timid. It's equipped with a 647-cc, 3-cylinder engine and a high-output pump with a stainless-steel impeller. It has a 9.8-gallon fuel tank.

Voice Of The Deep

Now your depth sounder can talk. Depth Talker ($199) connects to virtually any existing digital, video or liquid-crystal fishfinder, and calls out bottom depths. Programmable functions include volume, time intervals and depth changes. Depth Talker features a weather-resistant Mylar speaker and an auxiliary jack for remote speakers.

Airing It Out

Go self-contained with a new OMC Express inflatable boat. Manufactured especially for OMC by Groupe Zodiac, the line consists of an 8½-ft. Express 260 ($875) and a 10-ft. Express 305 ($1095). Both are built using Zodiac's computer-controlled, hot-assembly bonding process, and feature a tapered, upswept bow.

Environmental Defense

Omega created the Polarteck Pullover ($80) with waterproof yet breathable nylon shoulder yokes for protection from the spray. For increased protection, layer it with an Environmental Defense Jacket ($180). PM

Precious Metal.

Buckle up, America!
*Excludes other GM products. †Based on truck registration data model year to date. **Rear-wheel anti-lock brakes operate in 2WD only. ††See your Chevrolet dealer for terms of this limited warranty. Chevrolet and the Chevrolet emblem are registered trademarks and Chevy is a trademark of the GM Corp. ©1991 GM Corp. All Rights Reserved.

• *Most available 1/2-ton power.* • *Standard anti-lock brakes.*** • *Two-side-galvanized steel and standard base-coat/clear-coat paint for superior rust protection.* • *3-year/36,000-mile Bumper to Bumper Plus Warranty. No deductible.*††

Chevrolet. The best resale value of any full-size pickup.** Let's face it, you get what you pay for. And a Chevy retains more of its original value than any other full-size pickup. So, while you're out there making a buck, America's best-selling truck† is working hard to help you keep it. Chevrolet. The trucks you can depend on. The trucks that last.

The Heartbeat Of America Is Winning.™

Popular Mechanics 90 YEARS

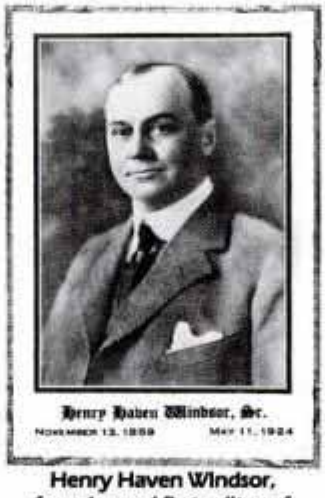
BY MARY SEELHORST

POPULAR MECHANICS' 90-year history resulted from the dream of one, the efforts of many and the enthusiasm of multitudes. As its visionary yet pragmatic founder, Henry Haven Windsor, stated on the publication's first anniversary, "Readers of the first issue of POPULAR MECHANICS searched in vain for the usual announcement of the great things the new paper was to accomplish. All they found were the two lines:

'Tells you how to do things.'
'Written so you can understand it.'

These mottoes have steadily been adhered to and always will be." True to his word, the magazine's mission has changed little over the past 90 years.

His fledgling publication hit the newsstands in 1902, during a time of unprecedented invention and discovery. To many people, the recent technological news must have seemed like fairy tales. The Italian, Guglielmo Marconi, had just sent a message across the Atlantic through the air. In France, Marie Curie had recently discovered a previously unknown substance—radium—that emitted mysterious rays. Around the world, experimenters were flying large gas-filled bags called dirigibles. Meanwhile, several Americans were racing to become the first to liberate a heavier-than-air flying machine from the bonds of Earth, and inventors of horseless carriages—steam, electric and gasoline—pushed the machines to their limits. The dreams of the ages were rapidly becoming the realities of the 20th century.



Henry Haven Windsor, founder and first editor of POPULAR MECHANICS magazine.

Windsor had already published a handful of technical journals for men who were engaged in mechanical trades. But his new magazine was to be different, "a magazine of education," whose readers "need never be at a loss for entertaining things to talk about." Published as a weekly for nearly two years, the magazine was at first a montage of technical tidbits culled from other publications and supplemented with Windsor's own commentary.

Most magazines of the day were sparsely illustrated, but POPULAR MECHANICS featured a large photograph or illustration on every cover, plus numerous photos and diagrams

throughout. A great many weekly covers featured the architectural and engineering wonders of Chicago—PM's home in those years—while other covers depicted mechanical novelties and technological feats from around the world. Windsor believed that pictures were essential to the story he wanted to tell. It was a story about the world in which his potential readers lived, where hands-on thinking—building, trying, testing, fixing, listening—was at least as important as, if not more important than, words.


POPULAR MECHANICS

Oddest of Chicago's Odd Bridges

The Windy City, Chicago, was PM's home in 1902.

Windsor organized the magazine to assist readers with particular interests. The latest technological news always appeared in the front half of the magazine, where headlines such as "Electric Trolley Car" and "How Wireless Telegraphy Works" caught the eye of first-year readers. The back half of the magazine consisted primarily of how-to tips, plus some educational projects for boys, beginning with the series "Easy Electrical Experiments For Boys."

The entertainment value of new technology was not lost on Windsor. Jokes, cartoons and poems with mechanical themes appeared regularly. Women as well as men, he thought, would find things of interest in his paper. The famous actress Lillian Russell endorsed the magazine in its first year: "I read POPULAR MECHANICS because I find so many things in it that are interesting and of help to me. It is the only one of those kind of papers that I can understand."

Within a year, POPULAR MECHANICS' weekly circulation had expanded from a few hundred to 20,000. Circulation continued to grow. By 1909, circulation was 200,000 a month and still growing. In 1911, the magazine assumed the 6½ × 9-in. format it was to keep for many years, each cover featuring a full-page color painting of some technological theme.

But as Windsor began to get feedback from his new readers, the orientation of the how-to columns slowly shifted toward a middle ground: away from highly technical tips and toward farm and home hints that were of more general interest, away from elementary projects for youthful novices and toward a wider variety of skill levels encompassing amateurs of any age. Advertising—once primarily for tools, engines and instructional books—began to reflect a growing audience of general consumers. By the end of PM's first decade,


POPULAR MECHANICS

An Illustrated Weekly Review of the Mechanical Press of the World

PM's first cover, like many to follow, used an illustration.

pitches for cereals, razor blades, patent medicines, motorcycles and other consumer goods joined the fattening advertising section. POPULAR MECHANICS was rapidly becoming an American institution.

PM was the first general-interest technical magazine to include how-to information as part of its technical lore, and it was the first to be so heavily illustrated. The appeal to readers was undeniable. Other magazines were soon founded in the same genre, while *Popular Science*, PM's predecessor in the coverage of general-interest science and technical news, added how-to topics, more photos and bright covers in 1915.

Before the days of minute technical specialization and the dominance of large research labs, PM often promoted experimentation and entrepreneurial efforts in mechanical fields. In 1924, the effort took a more direct route in the form of PM's Industrial Award Plan, in which the magazine publicized specific industrial problems submitted by companies offering cash rewards for the most satisfactory solution. And PM has since kept up its tradition of direct involvement in the technological world. Examples include continuing contests promoting reader ingenuity; PM sponsorship of various tests and trials, particularly in the automotive field; continual adaptation of how-to information to changing technologies and changing times; and the annual Design and Engineering Awards.


POPULAR MECHANICS MAGAZINE

$112,600 FOR YOUR IDEAS

PM has always encouraged reader ingenuity.

While some magazine policies have continued, others have changed as American society has changed. For example, even longtime readers may be surprised to know that until the 1940s, it was PM policy to avoid naming the manufacturer of any product featured in the editorial pages in order to avoid even the appearance of any conflict of interest between editorial integrity and advertising profit—a policy that is almost totally inconceivable in today's consumer-oriented world.

Shortly before his death in 1924, Windsor had introduced the Industrial Award Plan with a statement that captured the essence of the American technological ideal—the possible dream: "Every one has inventive ability because every man, woman and child at some time or other has ideas which they put to use to save time, abolish drudgery, or add to their own happiness."


POPULAR MECHANICS MAGAZINE

A 1924 request for new ideas drew many responses.

Whether our dreams encompass only our

Mary Seelhorst is curator of the "Possible Dreams" exhibit at the Henry Ford Museum & Greenfield Village. Dan Coleman was with PM for 31 years, including 10 years as publisher. He is now a vice president with PM's parent, Hearst Magazines.

Wings For Windsor

● PM was always in the vanguard when it came to reporting on airplanes, and their fascination did not escape Mr. Windsor. He was one of the first to purchase a company plane—a Grumman Mallard—and learned to pilot it himself. Over a period of about 20 years, the hours he logged in this amphibian took him from the lakes of Maine to the California coast. His biggest problem was flying it in and out of Chicago's Lake Michigan: The lake would go from complete calm to 4-ft. waves in just a matter of hours. It became great sport for employees to rush down to the beach when they heard Henry was returning from a trip just to watch the Mallard bounce from crest to crest. Then they'd bet on how long it would take him to taxi in to shore.

—Dan Coleman

own backyard or the entire solar system, Americans continually strive to build a good life and a better world. For 90 years, POPULAR MECHANICS has fueled its readers' dreams of the future while satisfying the realities of their present.

What were the dreams of generations past? How have they been achieved, abandoned or redirected? Let's take a look back at some of the topics PM has covered with particular enthusiasm throughout this most technological of centuries.

Rages Of The Ages

Flying Fever
1902-1919

Now I know why the birds sing when they fly through the air.—Mrs. Van Deman, first woman to fly in America, January 1910 issue

The dream of flight had obsessed mankind for eons. Yet, at the dawn of the 20th century, only unpowered vehicles had graced the skies. But aeronauts the world over were not content to forever submit to the vagaries of wind and weather in unnavigable balloons and gliders. Many experimenters believed that emerging technologies held the promise of powered, controlled flight.

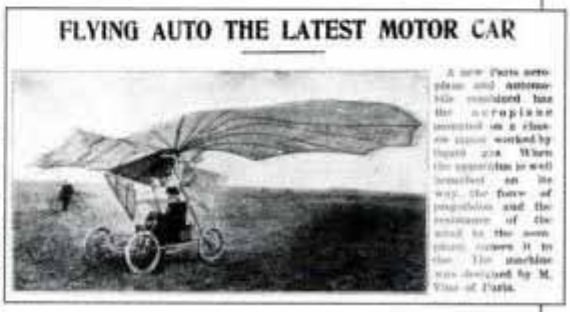
As there were no aviation experts, no manufacturers, no schools for the new science, hopeful pilots had to design, build and learn to fly their own ingenious devices by trial and error.

Dirigibles often competed in early aerial exhibitions.

As flying mania gripped America, a fledgling POPULAR MECHANICS reviewed and debated the form and function of the new machines.

A bewildering array of designs were proposed, some outlandish, others triumphant. Dirigibles, those large, cigar-shaped bags of gas, were the first to fly. Readers of PM's 1902 issues discovered that the Brazilian aviator Santos-Dumont had circled the Eiffel Tower in one—a feat quickly eclipsed by Englishman Stanley Spencer, whose airship, "looking like a bottle-nosed whale," had sailed 30 miles against the wind. PM reported that although Spencer was seen off by cheering crowds in London, some witnesses "were thrown into a turmoil of astonishment, and in some districts they were thoroughly frightened."

Public fear abated as more vehicles took to the skies, but skepticism about the usefulness of aviation reigned for many years. Readers of POPULAR MECHANICS and other technical publications were likely far more interested and optimistic than most. One article defended the much-ridiculed attempts of Professor Samuel Langley to launch a heavier-than-air craft across the Potomac River in 1903, stating: "Inasmuch as it took Professor Langley 15 years to get his model in running order, it is by no means to be understood that because of one or two, or half a dozen, unsuccessful attempts. . .the machine or the principle is a failure." Yet even the generally optimistic PM had not been so gracious at first. After Langley's first failed attempt, PM had reported, "While the machine refuses to fly in the air, it readily sinks itself in the water, and it is believed that by adding a sufficient amount of cord, it could be made equal to the best government submarine torpedo boats."


FLYING AUTO THE LATEST MOTOR CAR

The flying car—a dream that's been around since 1906.


Working Drawings of the "Demoiselle"

SANTOS-DUMONT'S Remarkable Aeroplane

Price Postpaid $2.00

Complete plans for the construction of the wonderful aeroplane offered to the public for the first time.

The set comprises seven large blue prints, showing every detail of construction, accompanied by a description of how to build.

POPULAR MECHANICS COMPANY

Build a real airplane? Sure, with 1910 PM plans.


POPULAR MECHANICS

Building First Airship for St. Louis Aerial Races

The "Junior," a Monster Aluminum Vessel in Course of Construction at San Francisco

The mostly negative press given to Langley's two failures overshadowed a modest feat performed only a few days after his second attempt, when two brothers from Dayton, Ohio, achieved the first successful heavier-than-air flight at Kitty Hawk, North Carolina. They did not encourage press coverage, and it was 1908 before the Wright brothers were mentioned by name in POPULAR MECHANICS, when it was noted that: "The secrecy regarding the Wright brothers' airplane (sold to England) caused many American aeronauts to be skeptical of its suc-

cess." Perhaps the lack of press attention was fortunate, for it allowed them to develop their design in private, patent their invention and demonstrate it to the world in a triumphant display of control and power at LeMans, France, in August 1908.

But their success was not without incident. In September 1908, a passenger of Orville Wright's, Lt. T.E. Selfridge, was the first aviator killed in an airplane wreck. The PM editorial reporting the incident noted, "The sacrifice demanded by science for success is often death, and it is unreasonable to expect that man's persistent effort to conquer the air should be triumphantly advanced without the blood price which always has and always will be inevitable."

Perhaps the first aerial conquest generally recognized as of any practical value was described in the October 1909 issue of PM, "I begin my flight, steady and sure, toward the coast of England. The moment is supreme, yet I surprise myself by feeling no exultation. Below me is the sea. . . . The motion of the waves beneath me is not pleasant. I drive on." Louis Bleriot had crossed the English Channel in a monoplane of his own design. An accompanying editorial noted, "Just what Bleriot demonstrated was that Great Britain is no longer an impregnable fortress."

Bleriot's phenomenal flight touched off a debate in the pages of PM and elsewhere over the possible use of the airplane in war. Capt. Richmond P. Hobson, of the House Committee on Naval Affairs, contributed an essay taking the conventional viewpoint, "The aeroplane has come like the torpedo and the submarine, but the battleship remains and will continue to remain king."

Ever-present danger was part of the thrill in 1911.

Such an outpouring of reader opinion followed that Windsor quickly published a rebuttal by Victor Lougheed, author of a popular new book, *Vehicles Of The Air*, noting, "History is full of examples in which one power has succumbed to another because the opponent was more alert, and quicker to grasp the significance of the latest developments in war machinery." Yet, perhaps the most telling comment was in Windsor's summary of reader letters: "Many contend that the aeroplane is destined to revolutionize warfare—perhaps make war, the war of blood and destruction, obsolete, and thus prepare the world for a millennium of peace." It was not the first, nor the last, such technological dream.

"The Fallacy Of The Dirigible" was explored in 1912.

In 1910, the popularity of the aeroplane soared. Dozens of public exhibitions featuring contests and stunt flying were enthusiastically attended. Men and women signed up for flying lessons. Records were broken regularly. Even before the airplane had been tested in war, innovators were developing peacetime applications—America's first airmail was carried by Earle Ovington in a Bleriot monoplane in 1911, and a London publication staged a now-familiar scene reported in a 1914 POPULAR MECHANICS: "Pictures of royal yacht made from aeroplane."

Do-it-yourselfers could participate in the rage with PM's glider plans of 1909. Detailed instructions for building Santos-Dumont's tiny "Demoiselle" monoplane followed in 1910—plans he had left unpatented in order to promote interest and experimentation in aviation. But PM warned, "It is necessary to possess some mechanical skill and ability, and plenty of common sense. In presenting the plans, we trust that no one of our readers will start to build unless he possesses these qualities, especially the latter, without which he will never be able to accomplish anything." Evidently some readers possessed enough of whatever it took, attested by several published letters and photos showing off readers' gliders and airplanes.

With war on the horizon in Europe, some hopeful flyers would soon direct their aviation ambitions to military service. The desire of nations to gain a technological advantage proved a powerful impetus for rapid development of the airplane, and it was during the war that pilots and manufacturers once and for all proved their abilities.

Bleriot buzzed an astonished French couple in 1909.

Of all the notable American airplane manufacturers, Glenn Curtiss stands out for his long string of accomplishments. As a young motorcycle builder and racer, Curtiss learned to design and build efficient and powerful engines. He built a reputation in the aviation field beginning in 1904 with the lightweight engine developed for Capt. Thomas Baldwin's dirigible. Curtiss's company, by the way, advertised its airship engines in PM. Curtiss soon learned to fly, and became one of America's most dashing aviators. Through a series of partner-

ships, he proceeded to develop some of America's most famous planes, including the first plane to take off from and land on a battleship, several very successful hydroplanes, and the famous JN-4, or "Jenny," in which most WWI American and Canadian pilots trained. After the war, the NC-4 (Navy-Curtiss) would make history in 1919 as the first plane to cross the Atlantic Ocean.

Shortly after WWI, a PM editorial commented: "That the development of the plane has been tremendously advanced by reason of its varied service in the war is apparent. Just how many years, under peace conditions, would have been required to bring the art to its present stage is uncertain." While public enthusiasm for the airplane continued on after the war, nothing would quite match those early days of wonderment—when PM's enthusiasm was ahead of the pack.

Electricity Wins
1917-1934

No story in fiction can match the rise of electricity in the 20th century.—July 1934 issue

Closer to home, a quiet revolution was taking place across America. Slowly but surely, electricity was coming to cities, homes and farms.

While its existence had been known for centuries and its principles understood for decades, electrical heat, light and motive power had until the 1910s been applied mainly to industry and to the homes of wealthy urbanites. Its increasingly widespread use depended in part on the development and construction of large, interconnected power grids—supply systems that could manage flowing electrons like water systems managed flowing water, providing an ever-ready supply across the peaks and valleys of demand. In its first decade, POPULAR MECHANICS had reviewed the construction of numerous powerplants across the country and around the world.

Power companies promised freedom from drudgery.

But the other half of a successful electrical equation was demand—creating and maintaining widespread markets for products that used electricity. As American industry geared up for wartime production in the late 1910s, demand for electricity soared. After the war, domestic applications advanced rapidly. Throughout the '20s and '30s, dozens of PM articles with titles like "High Voltage Brings Super Power Age" and "This Electric Home Runs Itself" supported the widely shared notion that electricity was essential for life in America's modern age.

The first place many people experienced modern electrical wonders was in public places, especially in large cities. "Electrical Bootblacks Give Shoe Shines In New York" read one headline of the early 1920s, while another noted, "Equipment Is All Electric In Big Canadian Cafe." Electricity was reported to have been chilling drinks, pumping gasoline, heating vests and floormats, sharpening knives, cutting hair and serving lunches. Many city streetlights were converted to electricity, and soon electrically lighted advertising signs, once a novelty, flooded streets and showrooms with shining words and images.

As more and more homes were connected to electrical powerlines through the '20s, power companies and other manufacturers promoted appliances that would feed on the flowing electrons. The 2-page photo spreads that PM had inaugurated in 1913 to feature domestic aids and appliances began to fill with notices of new electric dishwashers, fans, lamps, floor buffers, mixers and knife

Dramatic electrical displays were used at the 1933 World's Fair.

grinders. Nearly always these items promised to provide a better life, with such titles as "New Ways To Avoid Home Drudgery," and "Time And Money-Saving Tools For Woman's Workshop In The Home." Children too could enjoy the pleasures of electricity with electric trains and toys of all descriptions.

Yet despite the promised savings, electrical appliances were still too expensive for many Americans. PM offered plans for electric exercising machines, a washing machine and even a hair dryer assembled from a purchased vacuum cleaner and toaster. Some articles cautioned readers about the dangers of electricity. "It's Easy To Dodge Electric Shocks (If You Know How)" claimed a 1927 headline—with a bit of macabre humor created by its odd juxtaposition to a photo of Sing Sing prison's electric chair. The remainder of the article, however, focused on the more common, domestic variety of voltage.

A housing boom following World War I prompted the design of many new, primarily suburban, homes that were completely electrified from the first. Around the country and internationally, power companies sponsored all electric homes open for public viewing. PM reported on a model home —"the perfect home"—erected in 1926 in Paris as

A Buffalo reader built a hair dryer from a vacuum cleaner.

PHOTOS FROM HENRY FORD MUSEUM & GREENFIELD VILLAGE

the American exhibit in the International Exhibit of Household Appliances and Labor-Saving Devices. "It is expected to astonish the French housewives, to whom many of the every-day electrical and mechanical household appliances used in this country are unknown."

In reality, it probably would have astonished the residents of millions of American rural households, who lagged far behind city residents in acquiring domestic electrification. In 1930, nine out of 10 farm families still had no electricity. Power companies expected users to foot the initial bill for erecting powerlines, and the costs to rural residents were prohibitive.

Michigan farmers learn about electrical power in 1929.

The Ideal Electric Home featured the best 1927 gadgets.

PM reported that enterprising farmers could find in electricity "a new hired man, through whose help drudgery has been banished." "Electric Hens Hatch Billion Chicks" read one headline on modern incubation methods. Other articles featured electric sheep shearers, milking machines, cream separators and insect killers. Farmers, almost by definition do-it-yourselfers, were shown how to build wind-driven generators that could power storage batteries for limited uses. If a store-bought generator was preferred, the Zenith "Windcharger" generated enough "juice" to run a radio and two lights.

By the mid-'30s, many believed that farm electrification was vital to the future health of the American agriculture industry. Franklin D. Roosevelt's New Deal administration established the Tennessee Valley Authority to electrify large portions of the rural South, and later organized the Rural Electrification Administration. Whether farmer or city dweller, the clear message was that electricity could and would make life better.

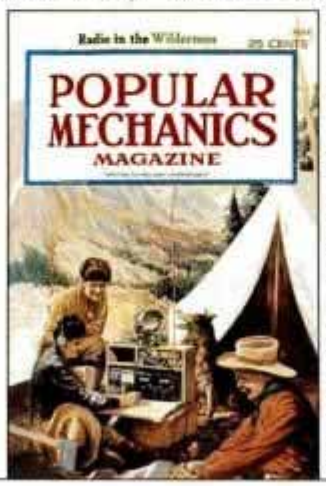
The World Is Radio Mad

1919-1930

Wireless music sends joy in all directions.—March 1920 issue

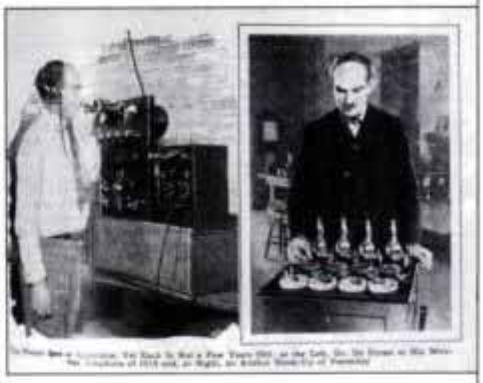
Even as Americans enthusiastically filled their homes with new gadgets in the 1920s, there was one device that stood head and shoulders above the rest—radio.

The principles of radio, or "wireless telegraphy," had been discovered by Guglielmo Marconi just before the turn of the century. Marconi's first transatlantic transmission, of December 1901, was heralded in POPULAR MECHANICS as the beginning of "a new era for civilization." As with aviation, wireless was initially an amateur pursuit, and its developers saw only limited possibilities for commercial use. Unlike aviation however, wireless transmitters and receivers were relatively easy to build once the principles were understood, and using them took no derring-do—just some technical mastery and a knowledge of Morse code. From the first issue, PM presented plans, descriptions and the advice and encouragement of famous radio inventors. Lee DeForest, inventor of the essential "triode" vacuum tube, became a frequent contributor to PM. Voice transmission proved possible in 1907, becoming more common as quality slowly improved. But until the 1910s, the commercial use of radio was mostly limited to code communication from ship-to-shore or vice versa, where telegraphy with wires was impossible.



A radio concert was a novelty in 1925.

Amateurs, however, evolved another idea. Thousands of amateurs had built and used radios since 1901, crowding the limited airwaves with their voices and coded messages. Besides talking to each other, some began to play music and transmit lectures over the air. A March 1920 PM article describing a "phonographic concert" played in Chicago noted that "more than 100 long-distance eavesdroppers in Detroit heard the widely distributed harmony through some 230 miles of space." In November 1920, Westinghouse became the first company to sponsor a station—KDKA in Pittsburgh—to broadcast regular entertainment programming. It was intended as an incentive for people to buy the company's radio receivers. Despite the popularity of amateur broadcasts, many business people thought Westinghouse had made an ill-advised investment.



Inventor Lee DeForest was often featured in PM.

Across the country, people were soon clamoring for the "magic boxes" that could pick up the free entertainment. Manufacturers couldn't keep

Every month, people found more ways to listen in.

up with the demand. Until about 1925 most listeners made their own sets, which were often less expensive and higher quality than the manufactured sets.

Today's parents with computer-crazed children may identify with Windsor's comment of 1922: "What hardly 20 years ago was almost a miracle, to be performed only by experts and scientists, has now become so easily done and understood, that some 60,000 amateurs, chiefly boys in their teens, with antennas raised from barn or ridgepole, daily and nightly pick up messages from points thousands of miles distant." The importance of their contributions was acknowledged by Marconi in his 1925 message to PM readers: "In radio, more than in other forms of science, the amateur experimenter has assisted the professional worker, and many now-famous engineers began their careers as amateurs. I am proud of the fact that I began my radio experiments as an amateur."

POPULAR MECHANICS quickly devoted an entire section to plans and tips for radio enthusiasts, with titles like "Selecting The Proper Vacuum Tube" and "Making Loud Talkers For Radio-Receiving Sets." The rage sparked dozens—indeed, hundreds—of new radio parts companies and radio stations. The world was absolutely, undeniably, radio mad.

PM helped readers buy, as well as build, radio sets.

Even store-bought radios of the early 1920s were complicated affairs, however, consisting of many separate components—detector, tuner, maybe an amplifier, then the battery, aerial, ground connections, plus a headphone or a speaker. About 1925, as more and more mass-produced sets came on the market, PM began to publish such articles as "How To Pick Your New Radio Set," and regular 2-page illustrated features, "Shopping Tips For Radio Fans" and "Latest From The Radio Shops." One headline that appeared in the late 1920s may sound familiar to electronics consumers of today: "Many Radio Receivers Now Obsolete."

In 1925, a POPULAR MECHANICS' cover, normally reserved for scenes more exciting than radio listening, depicted a Radiola III-A receiver being used on a camping trip to the Canadian Rockies. It was part of an "operative experiment, in which a new instrument is tried out under novel conditions and in the face of difficulties possibly hitherto reckoned as prohibitive." Today we might call it a road test. The report noted that the expedition's pack horse had "proved his qualifications as a radio horse by 'broadcasting' the various fragments of the outfit over half a mile of swamp, bog and boulder-strewn mountainside." Of all the adventurers, only the cook wanted to try and repair the radio, but the author noted, "As it is always good policy to humor a camp cook, we let him have his way." Soon the radio was repaired, and the entire camp was enjoying faraway entertainment, having improvised a crude loudspeaker from headphones and a couple of tin cans.

Novelty sets also appeared in PM with ever-growing frequency. "Wireless receiver shaped like human ear;" "Radio set built in bottle in less than 7 hours;" "Radio garter latest fad for wireless fans;" "New Radio-Movie Transmitter." Wait a minute—isn't that a television set?

"It is true that the image may be a tiny, black silhouette, about as clear and exciting as watching the fat gentleman across the street doing his getting-up exercises in a lighted room behind a drawn blind . . . but it does move and live." This was PM's assessment of the art of television in 1928—not the electronic system we are familiar with today, but rather a mechanical scanning version that received a lot of press at the time.

Beginning in 1923, several inventors successfully transmitted pictures with mechanical systems of their own design. One early television engineer often featured in PM was C. Francis Jenkins, an inventor already noted for his motion-picture equipment. Besides experimenting, Jenkins established his own television company to sell kits for television receivers and transmitters, and promised to broadcast regular programming in 1930. But the Great Depression dried up the market and the company folded.

Press coverage of his work kept up public interest in the speculative technology. A 1925 PM article titled "Radio Vision Of The Future" quoted Jenkins at length: "The radio-vision machine, transmitting and receiving living and moving objects, will come to the fireside as a fascinating teacher and entertainer, without language literacy or age limitation; a visitor to the old homestead with photoplays, the

"Radiovision" was tirelessly promoted by inventor C.F. Jenkins.

opera and a direct vision of world activities." Although his system did not come to fruition, Jenkins' vision of television broadcasting in homes across America was finally realized after World War II.

By 1930, radios had been developed that could be plugged into a wall outlet, installed in a car, carried to the beach or harmonized with living-room decor. Radio news, lectures and popular entertainment had become part of the daily experience of millions of Americans. In the commercial arena, radio broadcasting was making air, sea and rail travel safer and more reliable than had ever been dreamed possible.

Yet Henry Haven Windsor expressed perhaps the most ambitious dream of all in one of his last editorials for the magazine. After describing radio's potential to help the nations and races of the world know each other better, he wrote: "Communities live in peace because they know each other. . . . and knowing, make understanding allowances."

"So simple anyone can do it," suggested this 1925 PM plan for building a radio.

Planning The World Of Tomorrow

1930-1950

Housewife of the future hoses down her plastic home.

A better world than we have ever known can and will be built.—Industrial designer Walter Dorwin Teague, December 1940 issue

The stock market crash of 1929 brought an abrupt end to the booming prosperity of the 1920s. While many Americans blamed the shadowy figure of technology for the rising unemployment and other social ills of the day, many others turned toward technology as at least a distraction, and at most a possible salvation, from what became known as the Great Depression.

Throughout the Depression and the World War that followed, PM walked the line between readers' optimistic dreams and their bleak realities. As might be expected, many articles showed readers things they could do to make money—building roadside concession stands or tourist cabins, reusing castoffs, and repairing appliances. Yet the discomfort many Americans felt could not be covered by a fresh coat of paint on the old house, nor patched with a piece of salvaged tin.

Characteristic of the articles addressing the fears of readers was "Machines—Masters Or Slaves?" published in 1932: "Machines, which owe existence to their power to serve human wants, are now accused of turning the tables on man. They are held responsible for unemployment and all the ills which today afflict the world." Through interviews with researchers, engineers, labor specialists and others, the article examined possible causes of, and solutions for, worker displacement. The answers were nearly all reassuring, and ranged from the humorous ("The oyster, in his ignorance and lack of experience, may be more contented than the human being, but who wants to be an oyster?") to the inspirational ("Science is at our service—it can enslave us, or it can free us—but we ourselves must make the choice.").

The clear message to worried Americans was that, despite present problems, technology could ensure a brighter future. Through POPULAR MECHANICS and other mass media, the dreams of America were fed by several streams.

Most obvious of these were the efforts of many manufacturers to encourage consumption by tempting Americans with a cornucopia of goods entirely redesigned in the ultramodern style known as streamlining. The characteristic teardrop shapes of the style had their origins in earlier scientific studies aimed at reducing wind or water resistance of vehicles. Later, streamlined forms were adapted as part of a European and American art and design movement. But in the 1930s, the look was applied to commercial products from toasters to trains.

PM introduced readers to the new profession of industrial designers in 1932 with "Now The Beauty Engineers." Walter Dorwin Teague, one of the most famous of the era's designers, was shown with a scale model of a streamlined car he had designed. While it concentrated on designers' use of new materials and scientific principles in beautifying mass-produced goods, the article did admit that Teague's model was "calculated to win the fancy of people able to write checks big enough to buy its magnified likenesses."

Chicago's "Century Of Progress" fair drew crowds in '33.

WIDE WORLD PHOTO

Many designers believed that science could best improve the lives of people if applied to the products they used every day. One designer already had a proven record of accomplishment. Mechanic, inventor, designer, writer—William B. Stout was the ultimate POPULAR MECHANICS reader. It was Stout

(Please turn to page 94)

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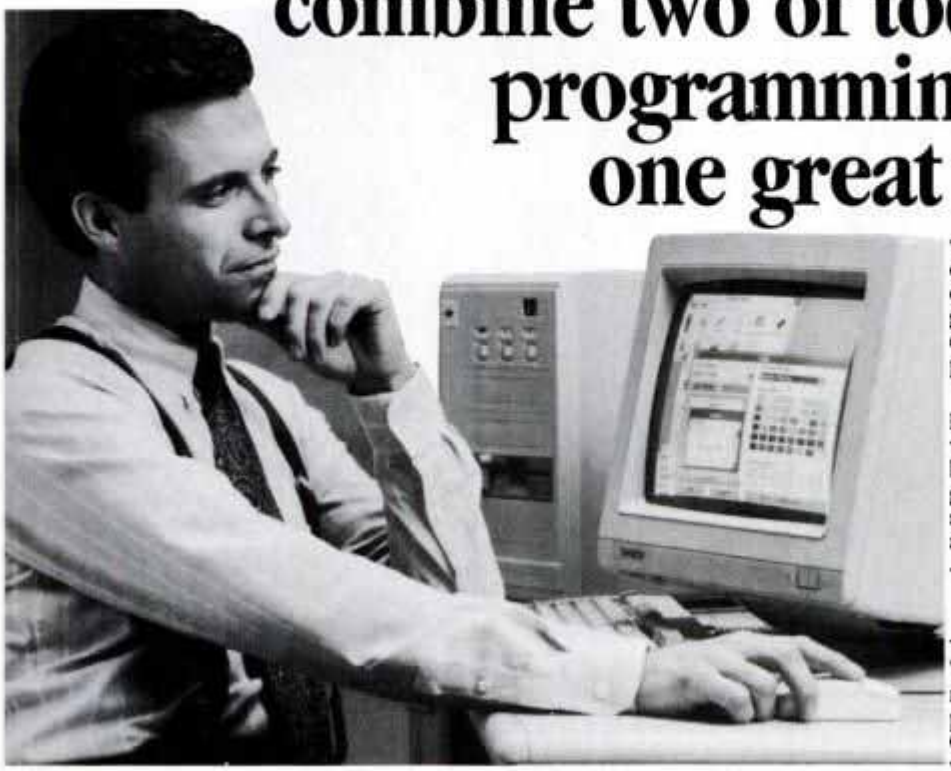

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who, back before most people had seen an airplane, had introduced the concept of the rubberband-powered toy airplane in his syndicated newspaper column featuring mechanical projects for boys. Other careers followed—founding *Aerial Age*, designing motorcycles and working on the WWI-era V12 Liberty airplane engine as chief engineer for Packard. Perhaps his most famous accomplishment was his design of the famous Ford Tri-Motor airplane—the "Tin Goose"—produced in partnership with Ford. But in the 1930s, Stout turned his enormous talents to the design of his ideal motor car. His 1932 essay for PM captured some of his design principles ("Engineering that depends on slide rule and mathematics for creation is doomed to failure."), as well as some of his pet peeves ("If Mr. Public were to judge automobiles by what they do and how well they do it rather than by exterior things, the engineer's dream car would become a reality almost overnight.") A decade later, a prototype of his Scarab, named for its aerodynamic, beetle-like shape, graced the pages of PM. Reportedly a dream to drive, the innovative car was never produced commercially. Perhaps inadvertently, its existence bears out Stout's complaint about Mr. Public. The redesigned minivans that have become so popular in the past couple of years bear a striking resemblance to Stout's Scarab.

Another stream of optimistic thought is found in the numerous articles that encouraged an already prevalent belief in the concept of inevitable, unremitting progress. Chief among these were the dozens of brief articles by inventors, businessmen and scientists published in PM's 30th anniversary issue, with titles like "The Progress Of Medicine," "The Past Assures The Future" and "Education And Progress." The Chicago World's Fair of 1933, covered extensively in PM, was themed "A Century Of Progress." Through spectacular industrial pavilions and futuristic displays, it attempted to link the past to the future across the bridge of modern design.

In 1935, PM pictured the New York City of 1960.

Inventors as well as product designers worked with new materials and industrial processes—plastics, aluminum, nylon, rubber and porcelain enamel—in an attempt to bring the benefits of science and technology to everyone. But with America's entry into World War II in late 1941, these same materials became essential to America's war machine, and were soon in short supply.

"Progress" was the theme of PM's 30th anniversary issue.

As manufacture of durable consumer goods all but ceased, so did the new-product articles always featured in PM. During World War II, the home and shop pages of the magazine often offered substitutes for materials needed for the war effort. Tips on repairing appliances, cars and home items dominated, accompanied by essays describing how industrial and scientific research would help the U.S. win the war.

Immediately after the war, many articles still promoted the comfort and efficiency of modern design. Yet in 1946, "Designs For Better Living" began, "Pity the industrial designer. He must be one dream in front of his competitor, but if he dreams too far ahead, the customers stay away in droves." Through the lean times, designers and manufacturers had learned that despite the promised advantages of modernity, not all Americans were easily persuaded to buy the dreams they made.

Finally, a continuous flood of optimistic predictions appeared in publications of all types throughout the Depression, the war and into the postwar era—predictions for the bountiful and efficient life that would surely follow if America would allow itself to be so redesigned. Some predictions, such as future housewives hosing down their all-plastic living rooms, proved to be possible, but undesirable. Other predictions have so far proven to be impossible—an atomic-powered automobile, for example. Still others—television, interstate highways, chemicals that remove hair, space travel—have all come true.

One prediction deserves special mention. In 1932, Winston Churchill, before his days of fame in World War II, wrote a lengthy piece for POPULAR MECHANICS titled, "Fifty Years Hence." It differed in tone from most predictions of the era's popular press, sensitively assessing the costs and benefits of technological advance, and noting, "We all take the modern conveniences and facilities as they are offered to us, without being grateful or consciously happier. But we simply could not live if they were taken away. We assume that progress will be constant." Then Churchill commented on the possibilities presented by what was then still a theory—atomic energy:

"Tomorrow's Car Today," the Stout Scarab of 1942.

"There is no question among scientists that this gigantic source of energy exists. What is lacking is the match to set the bonfire alight, or it may be the detonator to cause the dynamite to explode. . . . The discovery and control of such sources of power would cause changes in human affairs incomparably greater than those produced by the steam engine four generations ago."

It was the explosion of atomic "dynamite" that in 1945 first demonstrated the atom's vast power to the world. As the atomic bomb hastened the end of the war, American families were reunited and ready for the next great adventure—this time not overseas, nor in the skies, nor in the future, but in their own backyards.

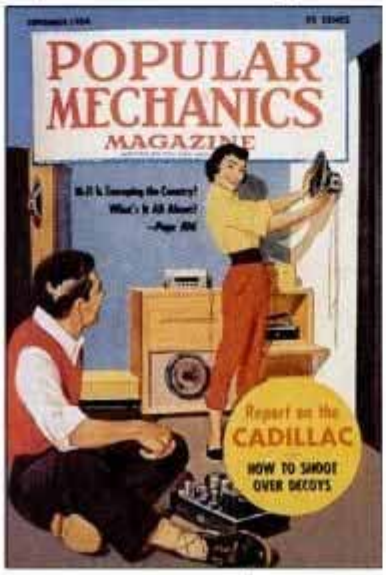
Practicality ruled in '62—even with dream cars.

Building The Good Life

1946-1975

Want a house? Then build it yourself as I did!—Tom Riley, builder of PM ranch house, May 1951 issue

In 1946, after 16 years of economic depression and war, the hoped-for good life finally arrived for many Americans. It was boom time once again—for babies, for the economy and for PM. The magazine's circulation soared almost immediately at the end of the war—from about 750,000 to over 1 million. PM quickly responded to the enormous changes taking place in America with a 2-part punch. First, it made great strides toward becoming a modern consumer magazine. And second, it enhanced its do-it-yourself editorial.



DIY hi-fi was all the rage in September 1954.

The magazine dropped its long-standing policy prohibiting the mention of the manufacturer of any product featured in an article. Advertising was liberated from its separate section and integrated into the editorial pages. And finally, POPULAR MECHANICS distilled the essence of postwar consumerism into its annual housing, auto and outdoor-living issues—each featuring product comparisons, new items on the market and lots of do-it-yourself projects. Features like "Shopping For Tools" and "What's New For Your Home" quickly replaced the fix-up and make-do features of the war years.

The 1951 ranch—one of many PM "dream houses."

Although the magazine still featured the latest in science and technology, it now emphasized domestic life in a way that reflected the desires and needs of its readers. Noting the postwar housing shortage, a 1947 article reported that "the wartime holiday in home building, the postwar shortages of materials and labor and the high costs of both had provoked the most serious housing crisis ever experienced in America." Over their coffee cups, the editors of PM wondered out loud what could be their best contribution to a home-hungry nation. The result was the first of many postwar PM "dream house" plans.

There were also, of course, domestic projects addressing the overriding concern of the postwar era—a possible nuclear attack. Bomb shelters were proposed to fit all budgets and tastes. The ultimate shelter was pictured in a 1953 issue. In the elaborate home of a California contractor, the fully furnished bomb shelter was accessed through an underwater entrance in his swimming pool. Nearly all shelter illustrations were populated with reassuringly happy families.

America's love affair with the automobile—indeed, with personal vehicles of all types—also blossomed. In addition to yearly reviews of shiny new cars and boats, POPULAR MECHANICS published plans and reviewed kits for do-it-yourselfers. Other editorials looked at the products of tinkerers' workshops—autoboats, flying cars, motorized skateboards, one-man submarines and other novel devices.

Live in the suburbs, commute to work—life after the war.

As environmental activists increased America's awareness of pollution and the impending depletion of our natural resources in the '60s and '70s, inventors and experimenters in "alternative" technologies gained renewed respect. A favorite focus of inventive effort during the '60s and the oil crisis of the '70s was the small and efficient commuter cars proposed for the nation's increasing suburbanites.

Letters to the editor, first published regularly in 1949, nearly glowed from the pride with which readers showed off handmade projects displaying their skill and ingenuity. The magazine grew even fatter with seemingly endless ads for tools and materials to build homes, repair cars and pursue hobbies. Several readers dropped a line about the "Hydro Dynamic" boats they built from 1963 plans. One reader described how he built most of it in his basement over the winter, but without gluing the joints: "When the boat was over 90% complete and good weather returned, I disassembled and labeled each part and reassembled and completed the boat in my garage." Another popular do-it-yourself hobby was building hi-fi components, either from scratch or from popular kits like Heathkit and Dynakit. As in the early days of radio, the homemade versions were as good as off-the-shelf models, particularly for self-appointed audiophiles, for

whom listening was more a quest for perfection than it was relaxation. One article, however, attempted the impossible when it promised to "help you select units which fill your immediate needs without becoming obsolete in the wake of future developments." Obsolescence was rapidly becoming a major consumer concern.

It was in electronics articles in particular that a note of skepticism began to appear—a certain weariness from the effort to keep up with all the rapid technological changes of the postwar years. When compared to the optimistic, forward-looking articles of the '30s and '40s, the change is dramatic. Enthusiasm for new products, while still evident, seemed forced at times, as in a 1971 article about cartridge television: "If the array of choices seems to offer hopeless confusion, there's one compensation—its the most exciting confusion to come along in ages."

The Brama family enjoyed their PM Hydro Dynamic for 23 years.

PHOTO FROM HENRY FORD MUSEUM & GREENFIELD VILLAGE

The increasingly widespread use of computers in the 1970s seemed to fuel an undercurrent of worker anxiety about job displacement, reminiscent of workers' worries during numerous technological revolutions that had taken place in the past.

Even concept cars, those ultimate expressions of futuristic industrial fantasy, were treated differently in the POPULAR MECHANICS of the 1960s. "Those Dreams Detroit Built," read one cover, "Have They Changed Your Car?"

The commercial models Detroit changed (or didn't change, as the case may be), however, were soon to become dream cars in their own right, as the face of American technological enthusiasm changed once again.

Recycling The Classics
1975-1992

Restoration fever has captured the American imagination.—Bob Vila, May 1989 issue

Looking to the future has been a hallmark of technological enthusiasm—indeed, of American culture—almost from the beginning. A recent article on bicycle restoration summed up the usual, forward-looking sentiment: "Of course, back when we were growing up there was never any time to look in any direction but straightahead. It only seemed natural that when something as important as a new bicycle was acquired, the old one had to go."

Miss Liberty received a facelift in 1984.

Yet since the mid-1970s, POPULAR MECHANICS and many of its readers have for the first time looked to the past with just as much enthusiasm. Before the '70s, PM's interest in earlier technologies was usually limited to illustrating "progress" ("Twenty Years Ago In POPULAR MECHANICS Contrasted With The Luxuries Of Today," 1923), celebrating technological milestones ("One Hundred Years Of Electricity," 1931) or providing a theme for a retro DIY project ("Period Tables Feature 'Plastic Inlay' Tops," 1953).

Today, collecting, preserving, restoring and using old houses, furniture, tools, bicycles, automobiles, engines and many other technologies have become a national rage. Building new items in a historic style to the smallest detail and preserving hand craftsmanship have also received much attention in the popular press.

Reasons for this phenomenon are many, and occasionally surface on the printed page. Some restoration buffs are in it to satisfy a nostalgic longing for the things of their youth: "After all, that bike probably represented our first exposure to mechanical possessions, a device that needed regular maintenance, occasional repairs and hopefully survived some well-intentioned modifications. From that point on, we were hooked." Yet a convenient and desirable side benefit—for some, the main benefit—is the investment value of a restored piece. Many people who would never dream of restoring a classic car or piece of furniture, nonetheless, avidly acquire fine examples to satisfy a variety of personal or financial ends.

Restoring a piece of lost youth motivates readers.

Sometimes, the interest expressed by hobbyists is in preserving a piece

(Please turn to page 98)

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of technological history, as noted in a 1982 article on restoring old warplanes: "Today, their killing days behind them, warbirds exist as exciting monuments to men and deeds that should never be forgotten." A closely related rationale is found in several stories detailing the efforts of various governments to restore civic treasures and national monuments around the world, despite the enormous problems along the way: "Saving the treasures of the world is getting to be a less complex problem than raising the money to do the restorative work."

The tangible rewards of the end product, however, are often not the most important. Dozens of restoration articles reflect an inspiration deeper and more personal than status, investment or even civic pride: "The steam locomotive is the antithesis of today's microchip technology. It is the spiritual shrine of the days when improving technology simply meant to build something bigger and stronger." While electronic technologies are the locus of much of today's technological development and the invisible brains inside many consumer products, it is hard to say that they have been welcomed with unbridled enthusiasm—even by the interested readers of a normally enthusiastic publication like POPULAR MECHANICS.

WWII aircraft restoration boomed in recent years.

As electronics continues to revolutionize present-day technology, increasing numbers of enthusiasts are embracing older, more familiar technologies for their intangible benefits. Some benefits are as basic as that unearthed by the author of a 1977 article about restoring old steam and gasoline engines: "When asked why they enjoy these engines, most owners mention the sound somewhere in their answers. 'I like to listen to 'em,' said one who started his hobby around two years ago."

Others find that working with hand tools is a respite from high-tech, information-age office work, as expressed by former President Jimmy Carter in a 1984 PM interview: "I really find manual labor a great release—a kind of vacation for me—something that I hungered for when I was in the White House." Carter's craftsmanship has become rather well-known lately. But others have maintained high levels of traditional artisanry in relative obscurity—until recently. Several recent PM editorials have looked at the men and women who have kept the flame: "Some say that craftsmanship died in 1913, when Henry Ford introduced the concept of the assembly line, when quantity replaced quality as the goal of the production team. But, in truth, craftsmanship never died, it merely went underground."

Car care information, for new and old cars, is a PM staple.

As several restoration articles published in the magazine over the years have pointed out, old technology does not necessarily mean simpler technology. Many people enjoy the challenge presented by the intricacies of machines and craftwork for its own sake.

Whether the machines that fascinate us are old or new, meticulously crafted by hand or efficiently assembled in a factory, and no matter what role each of us plays in its production, we would be well reminded, as a 1989 POPULAR MECHANICS article pointed out to its readers, that "The work of the hands is merely the outward manifestation. True craftsmanship is a journey of the spirit."

Themes Through Time

Invisible Rays

Whole nations may cringe before it—but they want it for its advantages and in spite of its dangers.—"Bringing The Atom Down To Earth," November 1945 issue

From X-rays to lasers, POPULAR MECHANICS has covered 90 years of benefits and dangers of the unseen portions of the electromagnetic spectrum, often using language that reflects their polarized potential: "Death ray or life-giving? Magic or science? Mystery or known fact? Dreaded doom or alluring promise?"

"The ordinary light that we are accustomed to makes glass, water and air transparent," informed the January 25, 1902 issue of POPULAR MECHANICS. "But there is another light which does not make glass transparent, but which renders diaphanous every other substance except lead. This is the X-ray." First produced by the German scientist Wilhelm Roentgen in 1895, X-ray's demonstrated ability to make an opaque mass transparent extended our powers of technological belief into the realm of the invisible. A scientist who in 1912 helped select X-ray as one of PM's "Seven Wonders Of The Modern World" put it this way: "The X-rays are wonderful to the majority of us simply because 'they photograph our bones,' but this does not make them wonderful to the physicist. If we had no bones, would the X-rays have received such a heavy vote?"

Marie Curie and her husband Pierre discovered radium.

WIDE WORLD PHOTO

But by 1903, people were becoming aware that the new rays could be harmful as well as

helpful—no bones about it. Rather than abandon a dangerous technology, however, they were generally optimistic about solving its problems by improving the technology. A notable exception was Thomas Edison. In a 1903 issue, one of the first American X-ray experimenters declared, "I am through with X-ray, radium and everything of the kind. . . . I am having all kinds of trouble with my stomach, due, I believe, to leaning over an X-ray machine while experimenting."

The grandaddy of all rays, X-ray, made a 1902 cover.

Soon PM readers saw such improvements as "Protective Glove For X-ray Operators" in 1907, and "Protecting Operators From Treacherous X-rays" in 1910. Since then, a litany of new and improved devices have crossed the pages of PM, even to the "Handy New X-ray Unit" of 1984 —the Lixiscope— which "gives off such low levels of radiation that no screening is needed to protect the doctor or patient."

Radio amazed Popular Mechanics readers in 1903.

Commercial applications of X-rays soon followed. Enthusiasts dreamed up inventive applications as if X-rays could do anything if only given a chance. Some ideas reported in PM proved fruitful, some frivolous: "Photographing An Elephant With X-ray Machine"—to find a swallowed ring (1908); "The X-ray: An Aid In Dentistry" (1912); "X-ray Machine Fits Shoes Correctly And Rapidly" (1920); "X-raying Oilfields" (1947); "Surgical Rays Make Debut" (1984).

A similar pattern—discovery, enthusiasm for benefits, assessment of potential dangers and commercial development—followed with the "popularization" of other invisible rays. Even a ray so common and essential as sunlight did not escape man's assessment. Infrared and ultraviolet, the invisible portions of a sunbeam's light, were not always known or understood. "Life-Giving Rays Of Summer Sun Are Found To Be A Cure For Many Ills" read a 1923 headline. (The same article noted that "Solar energy contains power to operate devices of man.") Yet by 1928, "Beware Of Sunburn" warned: "Sunshine is life, but it also leads to harmful physical effects, despite all that has been said and written about its great curative properties." Manufacturers of the new sunlamps quickly moved to promote the safety of their product, as reported in "Lamp For Health Treatment Removes Harmful Rays."

Bomb shelters mushroomed in popularity.

Later applications of infrared and ultraviolet rays included burglar alarms, germ-killing food treatments, and even interior decoration. "Whether it's for fun or profit, you're sure to get a thrill out of black light, the latest brainchild of lighting science; a magic invisible ray that transforms those 'ugly ducklings' into colorful beauties," suggested a June 1945 project feature.

Lasers were hailed as the latest "death ray" in 1962.

But the military unleashing of another invisible ray was about to change the world forever. Soon PM would observe, "There were three atom bombs and four explosions: New Mexico, Hiroshima, Nagasaki and, the fourth and most shattering of all, the blast that plummeted the minds of untold millions into the strange new world of atomic energy."

Eat Your Oatmeal

● In the days of crystal radio, PM published many stories on its construction and improvement. Readers became very involved in this phenomenon, and were continually submitting suggestions to our editors. One reader discovered that he could amplify the sound of his set by attaching it to the base of the round container in which Quaker Oats Oatmeal was shipped.

Soon thereafter, sales of the product soared. The manufacturer was so impressed at the attention readers paid to POPULAR MECHANICS that he began advertising, and never missed an issue for more than 25 years!

—Dan Coleman

PM Gets Classified

● In the 1930s, POPULAR MECHANICS devoted a substantial amount of editorial space to the discussion of the potential of atomic energy. Every scientist involved was interviewed on a regular basis to provide an update on progress, and the magazine became the leading authority on the subject of nuclear power. So much so, as a matter of fact, that in 1942 Mr. Windsor received an unannounced visit from government officials "suggesting" that he allow nothing further to be published in the magazine on the subject for the duration of the war. Their "suggestion" was followed.

—Dan Coleman

WIDE WORLD PHOTO

Charles Townes, one inventor of the laser.

The atom's tremendous power has frightened us and fascinated us ever since. It has become one of the most hotly debated technological issues of our time. Since that pivotal year of 1945, the magazine has reported on the development of nuclear powerplants, nuclear-powered submarines and ships, and the successes of nuclear medicine. Some proposed projects would today be regarded as foolhardy — for instance, "Atomic Inks For Art" of 1956, or the U.S. government project reported in a 1964 issue under the heading, "How Nuclear Blasts Will Dig A New Panama Canal."

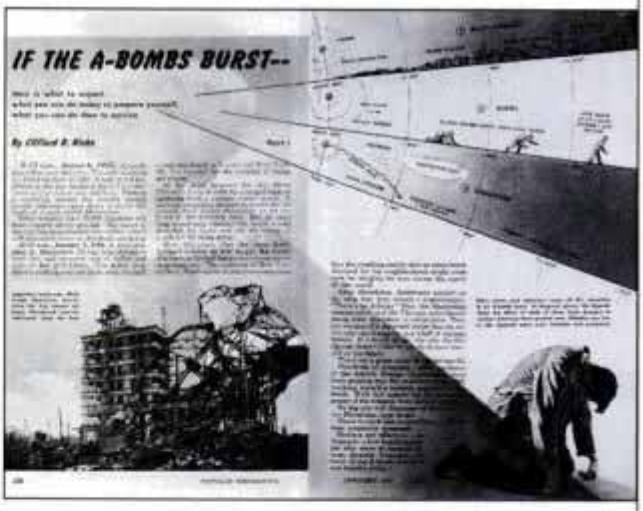
Radio Detection And Ranging was a 1945 surprise.

PM has also promoted radiation-exposure monitors, offered plans for homemade Geiger counters and bomb shelters, and examined the massive problems of nuclear waste management. And when the Atomic Energy Commission constructed a uranium enrichment plant in rural Ohio in 1952, PM even described the social problems that confronted locals trying to cope with the sudden industrial influx.

Many other rays have come to form an invisible backdrop for the 20th-century stage—cosmic rays, microwaves, masers, lasers, radio waves. Naturally occurring rays, like cosmic rays, or those released by radium, have always passed through us whether we knew it or not, as pointed out in a 1980 PM article: "The hard fact is that since humans first appeared on Earth, we have been zapped by constant and unremitting radiation—from conception to grave." Many have been "harnessed" by man, in other words, manipulated for our use.

A laser, for instance, begins life as ordinary, "incoherent" light, which is focused and amplified into a single, coherent beam—light amplification by stimulated emission of radiation. Proposed by physicists Charles Townes and Gordon Gould in 1958, and made to work in 1960, the laser was at first hailed as a possible "genuine death ray" in POPULAR MECHANICS and elsewhere. But how would it be used? The entirely unprecedented beam was sometimes ridiculed as "a solution in search of a problem." Its successful transition into everyday life required some entirely new ways of thinking about tasks we had long accomplished with other various technologies. Many types of lasers now perform surgery, decode music from compact discs, scan the price of our groceries, target our enemies and carry telephone conversations in fiber-optic cable.

Inside the black box: microwave ovens explained.



What happens in an atomic blast? PM tells all in 1951.

WIDE WORLD PHOTO

Atomic clouds ushered in a new era in history.

But even in a magazine as generally optimistic as POPULAR MECHANICS, it is evident that as a society, we have usually—even in our wildest optimism—been aware of potential risks. But it is also apparent that we have continually rebalanced the scales of cost and benefit.

(Please turn to page 102)

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**Applicable sales tax, if any, will be billed with shipment.

Irresistible Force

With magazines like yours, the Russians don't need spies—they can read it all in PM.—Letter to the Editor, August 1984 issue

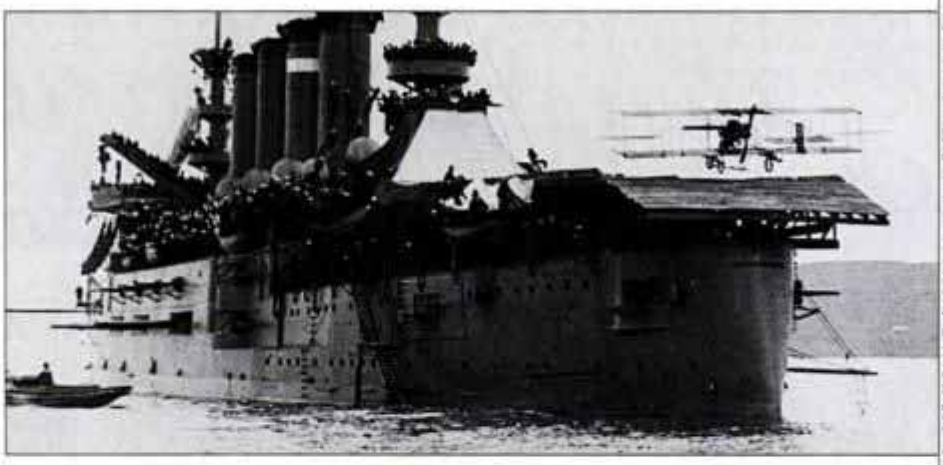
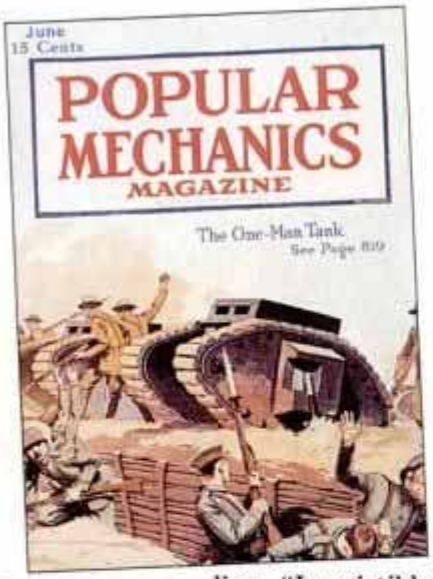


PHOTO FROM HENRY FORD MUSEUM & GREENFIELD VILLAGE

Eugene Ely lands a Curtiss plane on a battleship, 1911.

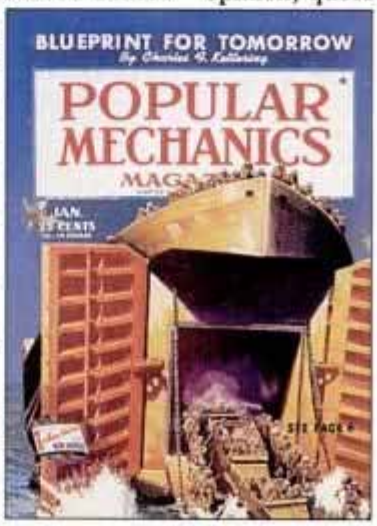
A Canadian in the trenches of France reads PM in 1917.

Since the dramatic, world-altering technological advances of World War II and the postwar welding of scientific research to national defense, many hardware enthusiasts have become accustomed to looking to the military to see the cutting edge of technology. Certainly, POPULAR MECHANICS has mirrored an intense public interest in the machines of war—a fascination that prompted the masterful double entendre of a 1989 headline, "Irresistible Force." Throughout skepticism, censorship, patriotism and criticism, PM has continued to carry the banner of military technology.



A one-man tank for storming trenches in 1918.

Even long-time readers may not realize that before World War I POPULAR MECHANICS' contributors and readers were probably more interested in progressive new military technologies than was the military establishment. The U.S. armed forces were not always as enterprising as they are today. The United States lagged noticeably behind European powers in its pursuit of military advantage through the development and use of such new devices as radio, airplanes, submarines, automobiles, machine guns and telephones.



An odd-looking hull, an innovative purpose, 1944.

POPULAR MECHANICS and other technological press, however, were extremely interested in the possibilities. From the first issue, PM covers often featured new military devices during the long, slow armament buildup prior to World War I—submarines, dreadnoughts, naval guns, torpedoes, an armored car. A 1907 issue sarcastically commented, "The dove of peace seeking an olive branch, whether on land or water or in the air, is liable to be shot to pieces by the target practice of nations professing to hope that they shall not learn war anymore."

Predictions often accompanied descriptions of new war machines. In 1904, PM quoted author Jules Verne, "In the distant future, the submarine may be the cause of bringing battle to a stoppage altogether, for fleets will become useless, and as other war materiel continues to improve, war will become impossible." A German "war-balloon," a large dirigible maneuvered by a 90-hp motor, was described in a 1906 article claiming, "The next war between great powers will surely include conflicts in midair and beneath the sea."

Wilbur Wright was of the same opinion, quoted in 1909 saying, "The future I see for the flying machine is with armies. Every army will have not one, but hundreds of them, carrying three or four men and ammunition, and capable of keeping the enemy continually harassed." But the U.S. Army, after its costly sponsorship of Langley's failed flying machines, was not interested. So the Wrights took their patents to the more receptive governments of France and England. Although Americans had achieved the first flight, other countries soon took the lead in aviation development.

The turnabout was often noted with regret, and sometimes bitterness, in the magazine. Famed aviator Lincoln Beachey submitted an article in 1914,

The flying ambulance was a new idea in 1919.

stating, "The sole thing I wish to accomplish is to instill into the minds of the people of my own country the serious importance of the aeroplane, in order that the federal government may awaken from its coma and see that this nation takes its place in the conquest of the air."

Some of the few military experiments that were conducted were covered by POPULAR MECHANICS. The naval aircraft carrier, for instance, had its beginnings in 1911 when Eugene Ely landed his Curtiss plane on a temporary wooden deck constructed on the USS *Pennsylvania* —and after turning the plane around, took off again.

Not all military articles featured in PM were complimentary.

The wedding of the airplane and the battleship was also an early experiment in what has today become the complex interaction of various technologies in comprehensive weapons systems—each piece used in concert with, and dependent upon, the others. Coordinated systems were a dream of forward-looking innovators during the bloody stalemate of the first World War, as recorded in a 1917 issue, "To combine the submarine's torpedo, the aeroplane and the wireless telegraph into one irresistible engine of annihilation has for months been the dream of a group of inventors, among whom are a few men in the forerank of science."

New technologies were tested in the Persian Gulf.

Heading South

● When the United States was expanding its exploration of Antarctica, one of its prime concerns was providing coverage of the events for taxpayers back home. In the late 1950s, the agency decided to take two (but only two) correspondents to the Antarctic Base Station for this purpose. Representatives of PM and *LIFE* were the only ones chosen, and they had to stay for a 6-week period. When he returned, our intrepid Editor had not only grown a beard to protect him from the weather, but he had accumulated enough material for several features to appear in the magazine. One story that seemed to capture readers' imaginations was a discussion of the mating habits of Adelie penguins. It seems their "marriage proposal" consisted of dropping a pebble in front of another penguin. If the other penguin accepted the pebble, and used it for nest-building, the marriage was on. There was only one problem: It seems that even penguins cannot readily distinguish between males and females. A pebble dropped in front of the wrong penguin often resulted in a fracas that lasted for hours. PM's Science/Technology Editor returned to Antarctica in 1988. It was a different Antarctica and a different editor. The penguins were the same. —*Dan Coleman*

Although peacetime editorials sometimes question the wisdom of military decisions, PM's tone often changes in times of actual hostilities. Technical details, for instance, disappear under censorship as the government battens down the hatch of secrecy. During WWII, the federal government required all publications to avoid reference to several speculative technologies, including radar and enriched uranium. And, although not a war in the conventional sense, Cold War nervousness in the years after WWII prompted even stricter military secrecy. With the recent thaw in East-West relations, PM recently peeked under the Pentagon's veil, following in the footsteps of the "Detroit Spy Report" brand of automotive voyeurism. Only two months ago, "America's New Secret Aircraft" investigated the shadowy outlines of surprisingly radical aircraft being developed in supersecret "black" programs—the same programs that developed the Stealth fighter.

Most post-WWII surprises, however, were overshadowed by the atomic bomb, including the announcement of the world's first electronic computer, ENIAC. Developed at the University of Pennsylvania to perform ballistics calculations for the Army, ENIAC was an example of a WWII trend toward government contracts with independent research and development laboratories.

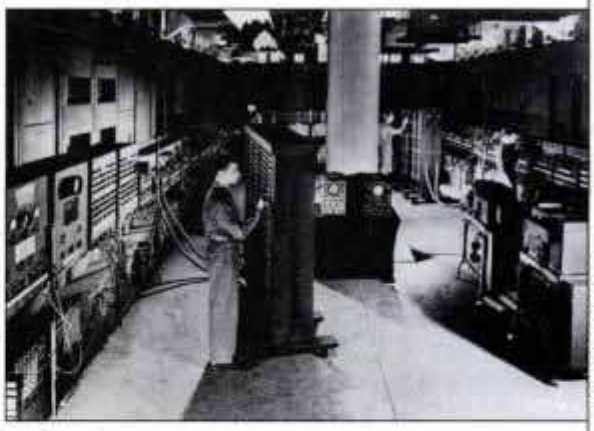
PM did not mourn the passing of "the picturesque lone inventor." "If giant enemy bombers ever dot our night skies," explained PM in early 1941, "we will have reason to appreciate the coordination made possible by these laboratories." Out of this kind of research came significant inventions, innovations and new industrial materials. "They are many-sided research laboratory inventions, in which many men and many minds contributed anonymous parts," PM observed. It was the success of this method of wartime research that led to today's military-industrial complex.

While many different opinions have been expressed in POPULAR MECHANICS, especially in letters to the editor, patriotism and support of government policy have generally been the rule during war. Henry Haven Windsor lashed out against the excesses of "the barbaric Huns" during WWI, and throughout WWII nearly every cover featured a big, bright image of war machines worldwide, large American flags or pitches for war bonds.

WIDE WORLD PHOTO

The Patriot missile launcher was big news in 1991.

J.W. Mauchly and J.P. Eckert Jr. invented ENIAC, a room-size electronic computer.



WIDE WORLD PHOTOS

By comparison, the Korean conflict (sometimes called the "forgotten war") and the Vietnam War received far less attention in general, and less patriotic boosterism.

In the late '80s, many covers noted the Reagan-era boom in defense research with such headlines as "America's Nuclear Stealth Subs," "War Machine!" and "Stealth Tank, Army's Newest Tactical Destroyer." Many, while lauding the advanced capabilities of the weapons, recognized the costs, like this 1989 article, "The $530 million B-2 Stealth bomber joins the B-52 and the B-1 in forming a Strategic Air Command capable of defeating diverse threats. But the American public must decide if the price is just too high." Letters from readers came down both pro and con in healthy and often heated debate. After "Bringing Star Wars Down To Earth" by physicist Edward Teller was published in 1984, one reader wrote in, "He would have us believe that we can engage in nuclear war and still look forward to next month's PM in the mail," while another begged to differ, "Edward Teller's article was like a breath of fresh air."

The proposed Strategic Defense Initiative once again renewed, in some quarters, the old dream that, through technological advancement, war will become impossible. Yet again last winter, Americans watched with fascination the amazing televised technological display in the Persian Gulf. And with the very recent collapse of Soviet communism, another renewal of hope. As congress discusses the possibility of a financial "peace dividend," America may perhaps allow itself to dream the old dream once again.

Man's Quest For Speed

Man likes to go fast.—February 1957 issue

What do you get when you combine a thrillseeker with readily available transportation technology? The 20th-century speed enthusiast. From risk-takers to spectators, from racers to rollerskaters, most Americans have experienced the rush of excitement—and sometimes fear—that comes from watching the landscape flash by. For 90 years, POPULAR MECHANICS has encouraged its readers' pursuit of speed thrills, racing and record-breaking.

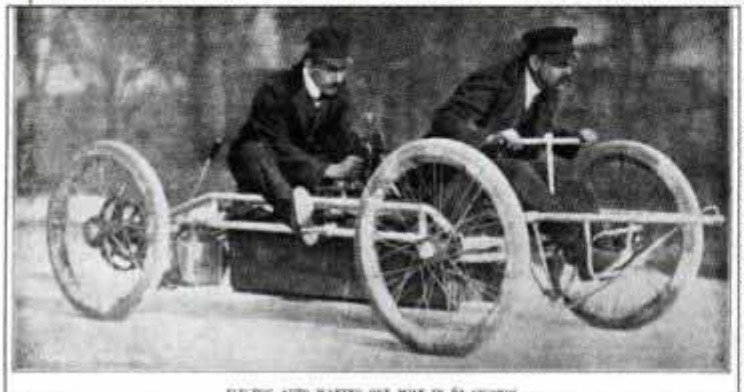
Land speed in particular has been a focal point for speed enthusiasts around the world. Unlike flying, which requires a rather large contraption; boating, which requires a body of water; or rail speed, which requires—well—rails, land speed can be achieved by anything from a sled to a rocket-propelled Bonneville behemoth. An inventor of amusement park rides mused upon the failure of one new device in a 1928 issue of POPULAR MECHANICS. He wrote, "The automobile has completely revolutionized riding devices. People used to be willing to poke along, but now when they go out for a good time, they want it quick and fast."

The cold war of the highway, from mirrors to lasers.

Seeing Without Turning

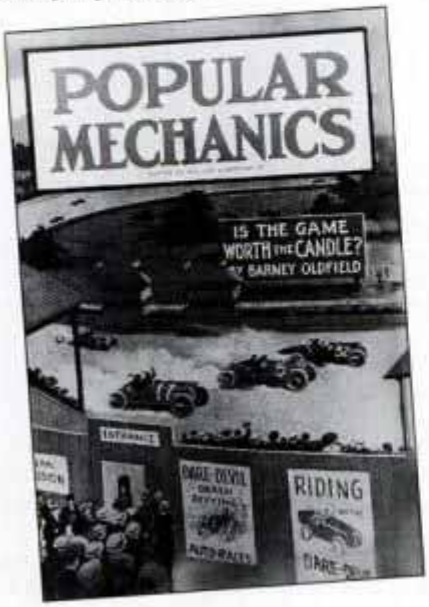
Good times. That is where it all starts for us as children, when swingsets and bicycles first expose us to the rush, the thrill of speed. For the very adventurous youngster, there was the American tradition, the Soap Box Derby. POPULAR MECHANICS often published plans and tips as well as a bit of inspiration for better performance, "Winning the 1947 All-American Soap Box Derby is not just something to dream about—it's going to be done by some boy with ingenuity, initiative, skill, designing ability and a willingness to compete with the best the field has to offer in a spirit of four-square sportsmanship and fair play."

Of course, some speed enthusiasts are just kids who never grow up, as belied by 1968's "Tips To Tuning A Winning Slot Car:" "While wringing out the slot cars you gave the kids for Christmas, you no doubt asked, 'How can I get better performance?'" Since



From the first issue of PM, Riker's electric racer.

its beginning, PM has offered plans for parents to build the dream of fast fun for their kids. A discarded ironing board, for instance, forms the platform for the 1961 "Snow Outrigger Built For Speed." For those who prefer the real thing to toys, PM has provided a host of tips and tricks for hot rodders, drag racers and plain-old everyday drivers.



Barney Oldfield asked some tough questions in 1911.

A long-standing, yet often controversial PM tradition has been to reveal the tricks of the speed cop in the ever-escalating cold war of the highway. As early as 1905, when very few people owned a horseless carriage, PM revealed "How Auto Scorchers Are Caught." It was a complicated procedure involving three officers, a stopwatch and a telegraph. In 1908, the magazine offered what amounted to a tip for lead-footed motorists, "One of the numerous ways by which autoists succeed in foiling the attempts of the police to catch them exceeding the speed limit, is a large reflector fastened to the dashboard of the automobile." It was, in essence, a rearview mirror, the invention of which is often mistakenly credited to Ray Harroun, who used one winning the first Indianapolis 500 of 1911.

Radar, the invisible ray that "sees the unseen," found a peacetime application in foiling speedsters as early as 1947. Soon radar detectors were made available to the driving public, and have been the subject of comparison tests and features ever since. While many articles published in PM, especially during the "Naderism" of the '60s and '70s, emphasized safe vehicles and responsible driving habits, several discussed the flaws of radar speed guns and suggested the use of radar detectors: "Should you be fingered by radar when you are positive you were driving within the law, this basic information on the speed meters and their limitations may be of help in establishing that you were, indeed, within the limit."

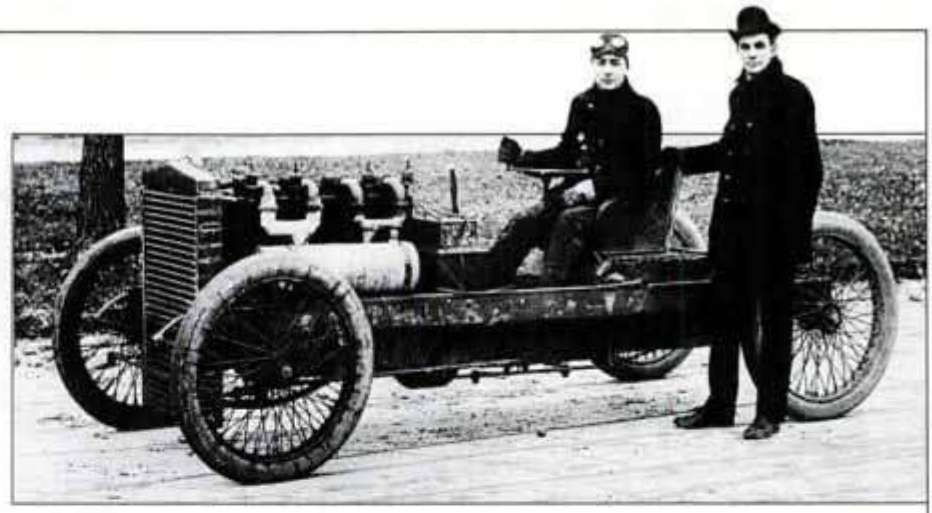


PHOTO FROM HENRY FORD MUSEUM & GREENFIELD VILLAGE

Ford and Oldfield with Ford's 1902 racer, 999.

Drag racing, the ultimate for speed enthusiasts in 1953.

Readers, of course, tend to respond vehemently on one side or another of the debate, often accusing PM editors of assisting lawbreakers. That may all be solved by a 1989 technological escalation: "A new police speed gun that uses a laser beam instead of radio waves could render automobile radar detectors use-

Harry Miller with one of his famous Indy 500 engines, 1932.

Changing Sizes

● One of the most dramatic changes in POPULAR MECHANICS took place in January 1973. Except for the first few issues, PM had been published in a unique size—6½ × 9⅛ in. This size made it immediately recognizable to readers, and perhaps contributed much to its success. However, the size became very limiting to editors and artists competing with the free-flowing layouts of larger-size magazines, and advertisers were complaining ever more loudly at the expense required to produce printing plates for PM's unique specifications. Something had to be done, but to simply increase the page size, with its attendant increases in paper, printing and postage, would have put PM out of business. We couldn't simply cut back on editorial features—their quantity and variety were the hallmark of PM. After many months of discussion, a suitable compromise was arranged: We could have the best of both worlds. We simply stopped thinking in terms of editorial *pages* and started thinking in terms of editorial *area*. In the old size, there were approximately 51 sq. in. of live editorial area per page. In the new (and current) size, there were approximately 70 sq. in. of space. In the old size, 150 pages accounted for 7650 sq. in. That same number of square inches in the new size only used 109 pages. The change brought POPULAR MECHANICS into line with other contemporary magazines, and set the stage for its success in the '80s and '90s.

—Dan Coleman


MOTORSPORTS

THE INDYTECH 500

Computers assist today's Indy 500 contestants.

less, and set the stage for a new generation of countermeasures." Then again, maybe not.

Radar detectors have no use on the oval circuit that has belonged to America almost every Memorial Day since 1911. While there are many auto races, none has been so enthusiastically attended as the "carnival of speed," known as the Indianapolis 500. Pausing only for world wars, the 500-mile race has been run at the Brickyard since 1911.

As a 1976 PM essay pointed out, the Indy 500 has two faces: "With the cry 'Gentlemen, start your engines!' the machines—and the merrymakers—roar to life." The spectacle is unique, and the fans of Indy are famous in their own right. "The Indy 500 is mid-America's annual Woodstock," declared one author. "A.J. Foyt is Bob Dylan."


PM sponsored a record-setting car at Bonneville, 1986.

Foyt, a 4-time winner and one of the most famous Indy drivers of all time, is one of a long list of drivers who made their mark at Indianapolis. Another is Jimmy Clark, whose rear-engine, Ford-powered Lotus won the 1965 race, breaking the long domination by the front-engine Offenhauser-powered roadsters.

Of course, no driver wins the race alone. PM has always covered the men and machines behind the driver. For instance, Harry Miller, one of the most renowned Indy engine designers, was often featured in PM articles of the 1930s: "'You are really driving a racing car yourself,' explains Harry Miller, famous designer. 'Today's automobiles are actually the racing cars of a few years ago, modified to suit your special needs.'" Pit crews, too, have had their day in PM's sun. Brothers Leonard and Glen Wood were featured in "Those Wonderful Brothers Wood," a tribute to the hard work of the top teams. "'The harder you work to prepare a car, the better your chances of winning,' says Leonard, 'but luck has a big part in it, you can be sure of that.'" Factors other than luck and preparation figure into today's battles of wheeled technology. "The speed secrets of the '80s are computers, composites, aerodynamics—and cubic cash. It's no longer enough for a successful racing team to have a fearless driver, a flawless engine and a peerless chassis," noted a 1986 article. "Winning today's high-stakes races can require the services of a full-time aerodynamicist, a consulting computer engineer and an on-staff telemetry technician."

Despite the unabashed enthusiasm POPULAR MECHANICS has shown for the sport, its ever-present dangers are often recounted. One of the earliest was Barney Oldfield's bitter 1911 account of the dozens of preventable deaths and injuries that had already occurred in auto racing's short history: "Racing has had one excuse—the development of the motor car. This, though, was nothing more than an excuse—the real reason for its existence was the blood-hunger of the spectator. In the recent race at Indianapolis, where the crowd's lust was satisfied by a black tangle of shattered men and machines, nine-tenths of the entries were made against the desires of the manufacturers." Oldfield used his PM platform to promote racing reforms. He blamed unscrupulous promoters for ignoring safety at the expense of young and inexperienced drivers.

No automotive sport, however, has proven as dangerous as the attempts to break land-speed records. On the sand of Daytona, the salt of Bonneville and elsewhere, many have optimistically pursued this risky sport. PM asked Mal Hooper, after a successful Bonneville run, "What's on the mind of the driver pushing his racing car toward the 4-mile-a-minute mark on the Bonneville Salt Flats?" His answer: "One out of three smashes up." It was a risk PM anticipated in 1902: "In such a test as will be necessary to try the automobile of the future to its limit, there will be more failures among men than machines."

Yet the dream of absolute speed has been dear to the hearts of men for centuries. "From the day man first put wheels under a platform, he has raced against his fellow men. When that platform became an automobile, he began racing the clock," declared a 1957 is-

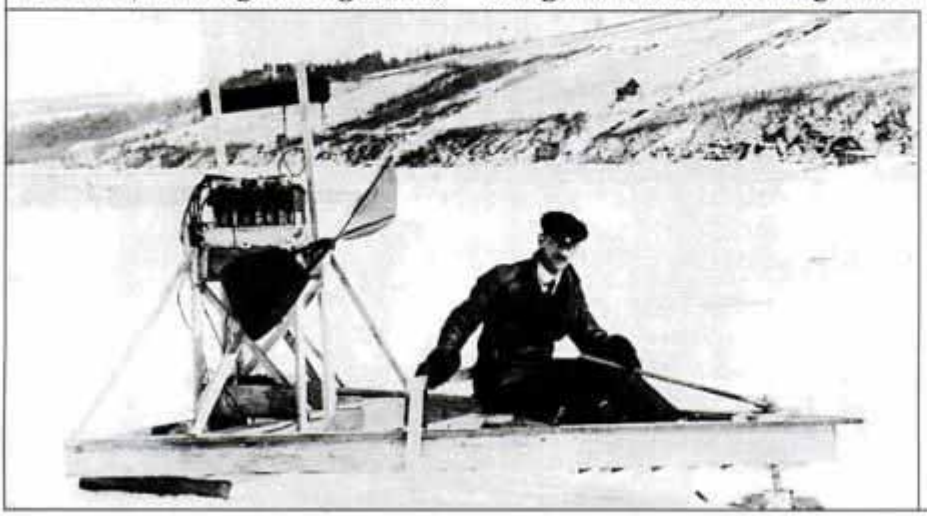

Glenn Curtiss designed a Power Ice Boat in 1909.

PHOTO FROM HENRY FORD MUSEUM & GREENFIELD VILLAGE

(Please turn to page 108)

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sue. And speed has been dear to POPULAR MECHANICS readers and editors since the first issue, where a small, "low-rigged racing frame" was pictured as it hurtled across a 1-mile course in 63 seconds.

It was widely reported that Andrew Riker's little racer had set the world speed record for electric automobiles at the then-astonishing rate of 57.1 miles per hour. A 1957 PM later commented: "A mile a minute, that frightening speed once dreamed of as the ultimate, turned out instead to be only a starting point."

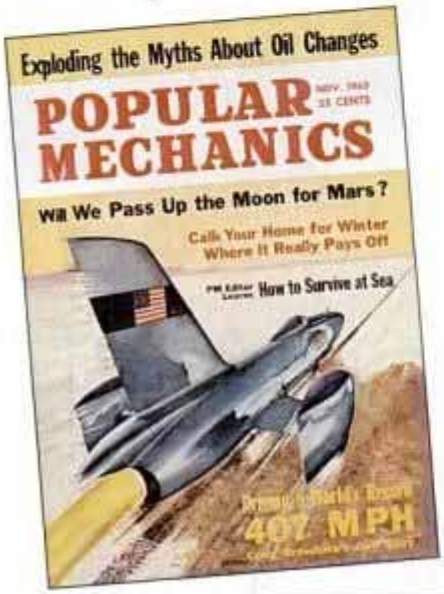
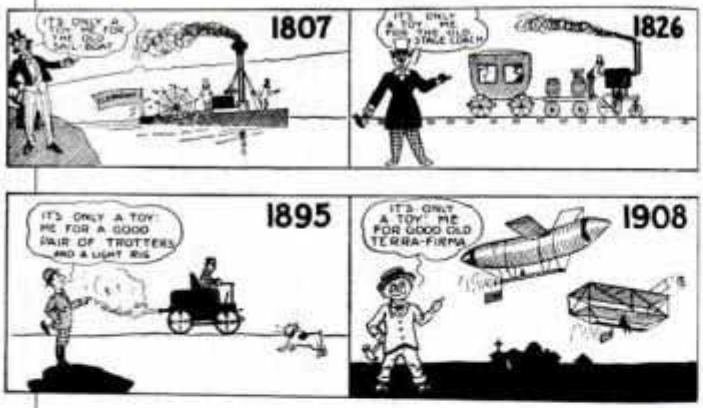


PHOTO FROM HENRY FORD MUSEUM & GREENFIELD VILLAGE

Henry Ford himself snapped shots of the first Indy 500.

As recently as 1986, PM teamed with carbuilder Gale Banks to run a Pontiac Firebird at Bonneville. At 267.615 mph, it became the fastest stock-bodied production car in the world. So why do we do it? "To some men, speed is a compulsion," speculated a 1957 author. "Only overwhelming compulsion can explain why men sacrifice time, money and, not infrequently, their lives for speed." Perhaps the best explanation for breaking speed records is akin to Sir Edmund Hillary's reason for climbing Mount Everest: "Because it's there." Unlike Everest, however, each new record establishes a new barrier waiting to be broken. Each record set could prove to be the final, unbreakable mark. We have not yet answered the question PM asked in 1928, "What is the final goal of speed?" Whatever it is, it may be one of the purest forms of technological enthusiasm known to man.

Craig Breedlove established many new speed records.



"It's Only A Toy" cartoon ridiculed skeptics.

And what of the future? Henry Haven Windsor never intended for PM to be history—any way you look at it. Yet its 90 years of reporting forms a sort of unintentional history, laced with the popular opinion and attitudes that are as important a part of our past as any single technological accomplishment.

Perhaps no technological dream has captured the imagination of so many people across so many centuries as the dream of flight. Within this century, we have flown from the sands of Kitty Hawk to the craters of the Moon. The Moon landing has been perhaps the ultimate statement of our ability to turn our most vaunted of dreams into reality, an almost sacred symbol of our importance that, simultaneously, reminds us of our smallness in the universe as a whole.

POPULAR MECHANICS has cut a broad swath across 20th-century American technological history, recording the domestic and the scientific, the mundane and the sublime, the victories and the defeats, the past and the future of the world.

As we move into the last decade of this century, technological issues are more important than ever. We should remember that our missteps and failures, as well as our achievements, are the direct result of our dreams.

Wherever our dreams take us in the future, POPULAR MECHANICS will continue to cover the adventure as it always has, reporting it as it happens, "Written So You Can Understand It." **PM**

WIDE WORLD PHOTO

The Moon landing —a symbol of our dreams.

MAINTENANCE BASICS

EXHAUST SYSTEMS

BY DON CHAIKIN

Probe rusty spots of exhaust plumbing to make sure corrosion is only on the surface.

PM ILLUSTRATION BY DON MANNES

● A routine inspection of your car's exhaust system—two or three times a year—can do more than keep your car performing properly and quietly. It can save your life. Odorless carbon-monoxide gas leaking into your car can make you drowsy or ill. With time, it can kill you.

Though you need no sophisticated tools to inspect the exhaust, you do need goggles or safety glasses to protect your eyes from falling pieces of rusted metal. Also, you'll obviously want a sturdy floor jack and safety stands to raise your vehicle and allow you to work underneath it.

Always perform exhaust system work when the engine and exhaust are cool. Begin the inspection in the engine compartment, then work your way back under the car.

Under the hood, check the exhaust manifold—there are two if your engine is a V6 or V8, one for each cylinder head—which is the part of the exhaust that bolts up to the engine.

● Look for loose or missing mounting bolts or nuts on the manifold.

● Check manifold mounting flanges for cracks.

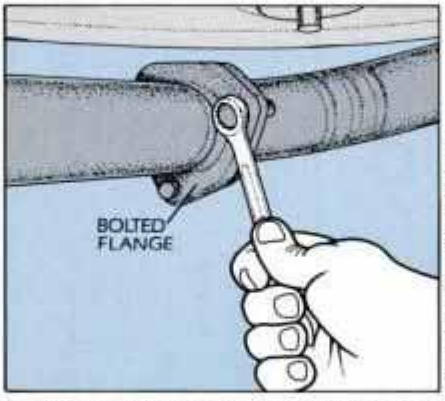
● Check that the gaskets between the manifold and engine are not broken or missing. Carbon stains on the manifold or the engine adjacent to the manifold indicate a leak.

● Examine connections to components of the emissions-control system, including the tubes or pipes from the manifold(s) to the EGR (exhaust gas recirculation) valve. Look for rusted-through holes, cracks and deep dents or kinks.

● See that the oxygen sensor—threaded into the manifold—is properly snugged in and not showing any signs of leakage. Check that its wiring is properly connected.

Next, slide underneath your rig. Be sure that it is properly and securely sitting on safety stands. Then:

● Check the connection at the end of the exhaust manifold. Remember, V-type engines have two manifolds. These connections are often spring-loaded. Be sure that the nuts are secure, and that the springs and the gasket—often a sealing ring—are intact.



PM ILLUSTRATION BY RON CARBONI

Don't force exhaust system bolts. If the nut or bolt is too tight, use penetrating oil first.

● Follow the exhaust pipe from the manifold to the catalytic converter, or primary muffler, on to the connecting pipes, the secondary muffler and finally the tailpipe. Run your gloved hand over each pipe and muffler, feeling for holes, cracks or deep dents.

● Use an old screwdriver to jab at each pipe, connection and muffler. If you can poke the screwdriver through the surface rust, the component should be replaced.

● Check all clamps and hanger brackets. Tighten any loose nuts or bolts. This requires the correct-size box wrench or socket. You may have to treat the nuts and bolts with penetrating oil before attempting to turn them. Otherwise, they may break off.

● Twist and inspect all rubber hangers. Cracked, chunked or broken hangers should be replaced. PM

HOW IT WORKS

SUPERCHARGING

BY DON CHAIKIN

● There really is no great mystery to it. The more air that goes into an engine, the more fuel it can burn. So, everything else being equal, the more air that goes in, the more power that comes out. Superchargers—and their cousin, the turbocharger—are used to cram more air into your engine.

Sucking wind

Engines breathe, or *aspirate*, much the way you and I do—by sucking in fresh air and blowing out the used air. As each piston travels downward in its cylinder, the drop in pressure caused by the moving piston draws air into the cylinder through the open intake valve. All the pistons moving up and down is enough to constantly suck air through the air cleaner, ductwork and intake manifold. But under certain conditions, such as high-speed or high-load operation, the engine could use more air—and fuel—than it can draw in on its own.

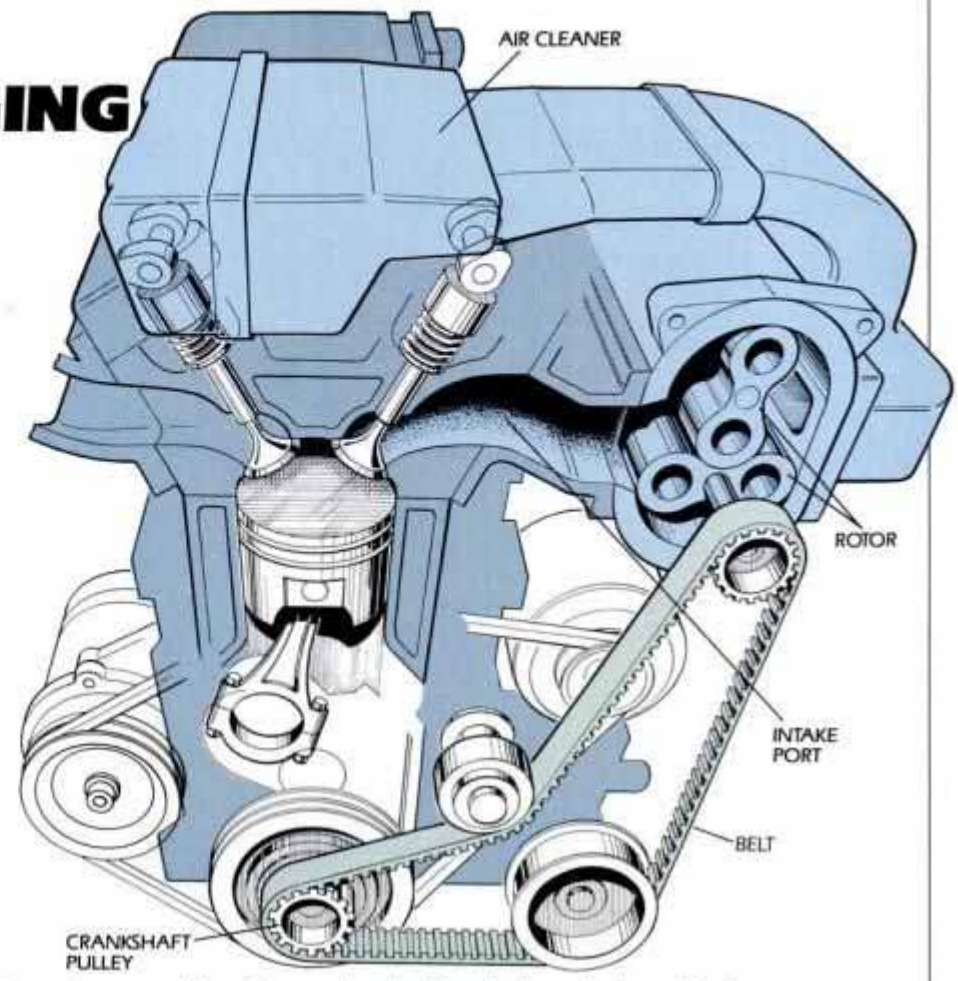
Heavy breathing

To help supply an engine with this larger volume of air, it must be forcefed. This is accomplished by a *forced-induction* device. And with this year's introduction of the Buick Park Avenue Ultra, Oldsmobile 98 Touring Sedan and Pontiac Bonneville joining the Ford Thunderbird Super Coupe and Volkswagen Corrado, a forced-induction system utilizing a mechanical supercharger is gaining popularity among carmakers. Superchargers have been popular for decades with drag racers and hot rodders.

Pumping air

Superchargers are simply engine-driven air pumps. As used in passenger cars, superchargers are belt driven by the engine's crankshaft at a rate faster than the engine speed. Though some engine power is consumed by the supercharger, the gain more than makes up for the loss.

There are various types of supercharger designs, and the most common is the Rootes variety. In this design, engine power drives a shaft which runs the length of the supercharger housing. This shaft is geared to a second shaft parallel to the first inside the housing. Both shafts have lobed rotors that mesh with each other, sort of like very coarse—2- or 3-tooth—gears. The edges of the rotor lobes almost touch the inside of the housing.



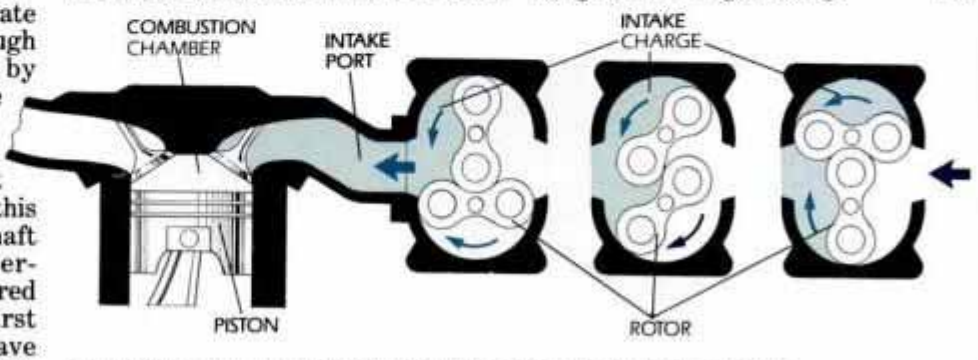
Superchargers, unlike turbos, are directly driven by the engine's crankshaft.

The rotors spin so their lobes separate at the housing's inlet, drawing air into the housing. As the rotors spin away from each other, each carries freshly drawn air trapped between its lobes and the housing. When the lobes meet at the housing's outlet, the meshing rotor lobes force the air into the intake manifold.

The constant spinning of the rotors brings more air into the engine than it can consume, resulting in a buildup of air which pressurizes the manifold. When the individual cylinders' intake valves open, the pressurized air is forced into the cylinders.

To prevent a dangerous buildup of pressure in the intake manifold, a valve controlled by the engine computer opens, allowing the air to recirculate back to the inlet side of the supercharger. This valve also regulates the level of boost.

Since the supercharger is directly connected to the engine by a belt, its boost is immediate at all engine speeds—there's none of the lag associated with turbochargers. This provides better performance at all speed ranges, including cruising. **PM**



Close-fitting counterrotating lobes force extra air into the intake manifold.

PM ILLUSTRATIONS BY HANK IKEN

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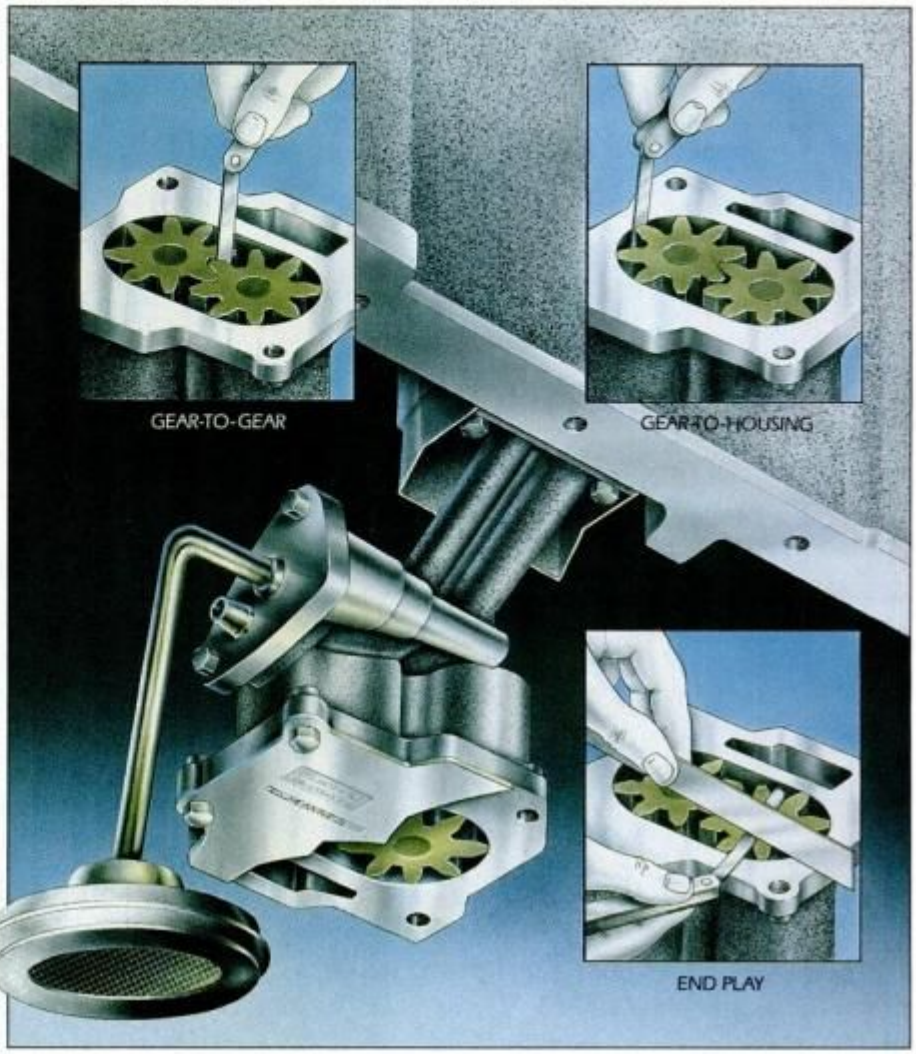
CAR CLINIC

BY MIKE ALLEN,
Associate Automotive Editor



PM ILLUSTRATIONS BY DON MANNES

All Pumped

I recently rebuilt the engine in my pickup, replacing the bearings one at a time without removing the crankshaft. But now the oil pressure is just as low as before I took it apart. The oil consumption is fine—what with new rings and rebuilt heads—but the oil light flickers at idle, and a mechanical oil-pressure gauge shows no more than 25 psi once the oil is warmed up.

I checked the bearing clearances with Plastigage as I installed them, and the clearances are within specifications—although admittedly at the wide end of spec. Do I have to pull the crankshaft and get it turned, or can I shim the bearings about a thousandth?

OSCAR KUCERSA
DALLAS, TX

Don't shim the bearings.

If the clearances are anywhere close, and the journals aren't out-of-round or tapered (not always easy to catch without pulling the crank and miking the journal properly), it's probably not the cause of your low oil-pressure problem.

I trimmed your lengthy letter for publication, but one thing you didn't mention replacing was the oil pump. In fact, you didn't mention the oil pump at all—and I'll bet the thing is just tuckered out.

Drop the pan. Remove the pump assembly from the block. You can check it without removing it, but it'll be easier and cleaner to deal with on the bench.

Check that the pickup is firmly attached to the pump body. Some pickups are simply pressed into place, while others use an O-ring seal. If the pickup doesn't seal well to the pump, it'll suck air and you'll have low oil pressure.

Then, open up the pump and use feeler gauges to check the clearance in three places. (Look in the shop manual for the correct clearances.) First check the end clearance between both gears and the cover. Use a straightedge to simulate the cover, and insert the gauge between it and the gear. If the cover is gouged where the gears ride on it, or the clearance is excessive, replace the pump. If these clearances are okay, check the clearance between the gears and the pump body, and then the backlash between the gears.

Excess clearance, gouges, wear on the idler gear's shaft or loose bushings on the drive gear are all cause to replace the pump as an assembly.

If that all checks out, take a close look at the relief plunger's spring, as well as the bore where the relief plunger rides. If the plunger itself is scored, replace the pump assembly. If the spring is tired, you'll have low pressure, especially at idle. The cheap way is to replace the spring—but if it were my engine, I'd pop for a new pump.

Getting The Lead Out II

I'm enclosing a copy of an article in the local paper by some "automotive expert" who suggests adding 6 ounces of nondetergent oil per tankful of unleaded gasoline to make up for the lubricating qualities of the missing lead my older car needs. But in your December '91 column, you specifically said not to use motor oil, diesel fuel or automatic transmission fluid for this. I've been using 30-weight motor oil for years in two of my cars with no ill effect or valve problems. What's the truth here?

ROBERT CLUBBEDGE
SAVANNAH, GA

The truth is that any gasoline-soluble lubricant will have no effect. The problem with running leaded-gas engines on lead-free is valve recession. At high loads and high speeds, the exhaust valve gets hot enough to be close to its melting point. When it gets slammed down against the valve seat, and then picked back off the seat milliseconds later, minute particles of the seat will actually stick to the valve.

Eventually, the seat erodes to the point where the valve no longer closes completely. As brief as the valve's tenure on the seat is, it's still the period when most of the heat is dissipated to the head. (It's a long way up the stem to the nice cool valve guide.) Ultimately, the valve burns or melts—and you have no compression.

Thanks to a phenomenon that's still not well understood, small concentrations of lead seem to prevent

these particles from being picked off the seat. Lead-free engines have hardened seats and valves that resist recession without depending on this phenomenon. You can have almost any engine upgraded with these higher-quality parts.

Oil, automatic transmission fluid, diesel fuel or other lubricants have liabilities—they aren't intended to be burned in gasoline engine combustion chambers, and can make for fouled plugs, high amounts of carbon deposit and nasty emissions. Also, they can lower the octane rating of gasoline and induce detonation.

As I said in December, cars and trucks used in light-duty service—as distinct from heavy hauling or towing—can be run a very long time sans lead with no ill effect.

Stay Dry

My '85 Chrysler LeBaron GTS 2.2-liter with 31,000 miles pings badly on unleaded regular. Rather than retard the timing or pay big bucks for premium, I'm considering adding a water-injection system.

(Please turn to page 114)

Getting To The Point

CAR CARE TIP

● I was tuning up a friend's car the other day, installing a new set of points. Now *that's* something I haven't done in awhile. I don't think there's a car or truck on the market today that still uses Kettering-style points-and-condenser ignition.

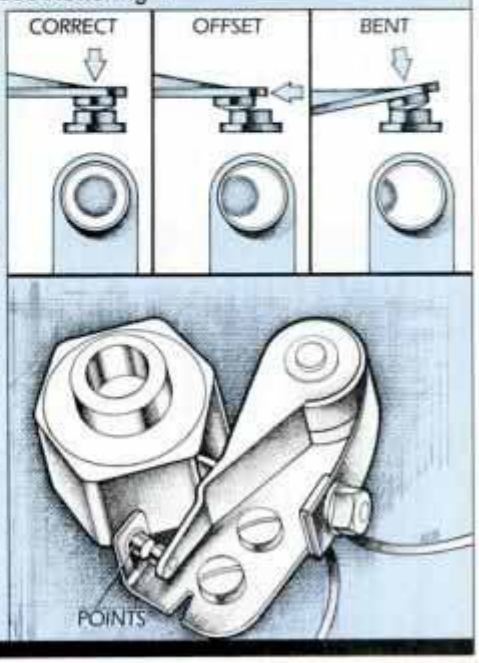
But this old war horse still had some use in it—and there are plenty of stablemates who do as well.

Maybe it's because they don't make as many as they used to, but these points that I was trying to install were *awful*. The two halves of the contacts were misaligned two different ways. They weren't even close to parallel, and only about two-thirds of the surface overlapped.

Of course I noticed this after the parts store had turned out its lights for the weekend.

Not to worry. A few minutes' careful work with a pair of needle-nose pliers had restored them to their proper concentric, parallel relationship.

And be sure to clean *any* new set of points with a clean piece of business card or lintfree cardboard after you install them.



PM ILLUSTRATION BY ADOLPH E. BROTMAN

This supposedly will lower combustion chamber temperatures, remove built-up carbon and reduce the ping.

Will this have any effect on emissions or engine performance? Will this be likely to cause any valve burning precipitated by a chunk of carbon wedging itself in between the valve and seat?

RICHARD SMITH
FAIRPORT, NY

Water injection is a scheme transplanted to the automotive field from WWII-vintage aircraft technology. Water or water/alcohol injection was used, quite successfully, to control detonation in turbo/supercharged aircraft engines for short bursts of extra power in combat situations.

The systems now available for automotive use might have some usefulness in similar circumstances—short bursts of added turbo boost at wide-open throttle.

If your problem is the classic part-throttle ping, water will need to be injected almost continuously, much to the detriment of HC emissions and probably causing massive amounts of sludge buildup.

The water-injection rigs I've tried were awfully touchy to set up properly, and tended to be inconsistent, too.

I think you ought to find out why your LeBaron started to ping awhile ago. It may be carbon buildup, but I doubt it. The increased cranking compression you see with a compression test doesn't really translate to highly increased dynamic cylinder pressures. Either the carbon layer insulates the head from the combustion gases, or the carbon layer is porous enough to damp the beginning of any sonic shock waves in remote corners of the combustion chamber where detonation starts.

Experience says that you probably have one or more of these problems:

- *Dirty fuel injectors.*
- *A malfunctioning EGR system.*
- *Some ignition timing anomaly.*

Find out what's wrong and then fix the problem. **PM**

SERVICE TIPS

- If your '88 or '89 Honda Civic's rear suspension makes a squeaking noise going over speed bumps, especially at lower temps, there's a plastic shim to insert in the trailing arm bushing to keep the bushing's inner section from rubbing on the outer section.

  Coat the shims with silicone lube, and work them into the bushing. Then melt the protruding end of the shims with a soldering iron to keep them in place. TSB 90-017
- 1991 Caddy Eldorados and Sevilles may have a cable between the alternator and battery rubbing on the inboard right-hand drive axle boot, causing a leak. If so, TSB T-91-22 says to reposition the cable and replace the boot. Inspect the joint for wear, and replace if necessary.
- Late-model Acura Integras with a notchy, grating clutch pedal feel may benefit from a new clutch cable, as the older cables sometimes have excess friction. TSB 90-012
- If the windshield washers on your new 7- or 9-series Volvo start wimping out, try blowing compressed air backward through the line, backflushing or replacing the filter in the washer fluid line near the pump. You'll have to remove the air cleaner to access it, according to Volvo TSB 36/707.

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.

SATURDAY MECHANIC

MAINTAINING YOUR CHARGING SYSTEM

BY DON CHAIKIN

● You're still miles from home on a classic dark and stormy night when you realize that the road in front of you is rapidly getting dimmer.

You pull over, and as the engine goes to idle the BAT warning light on the dashboard flickers—just before the engine coughs and dies.

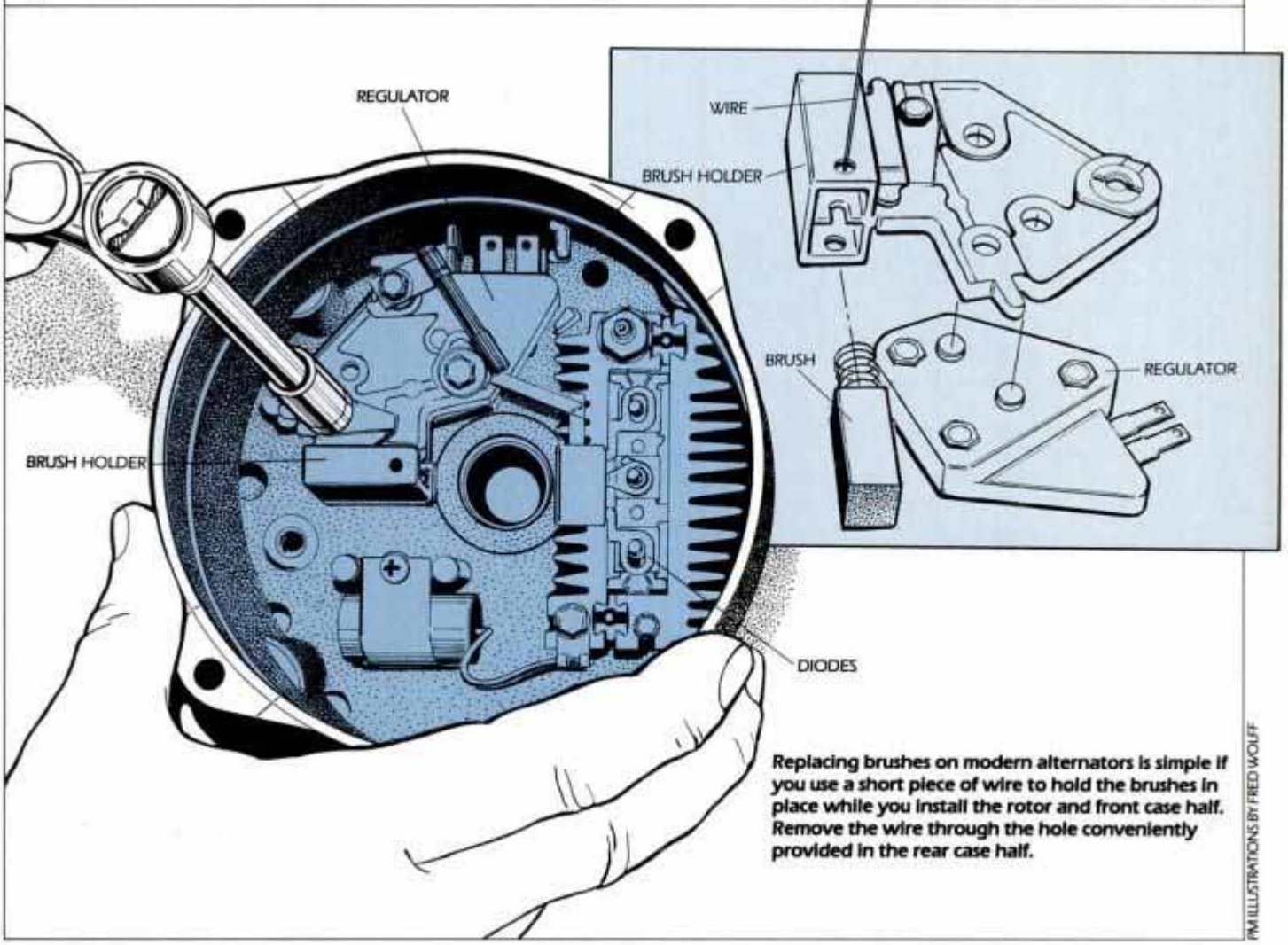
The problem? Something is awry in your car's charging system.

Recharge, please

The electricity that powers the ignition system, fuel injection, computer, lights and accessories all comes from your car's alternator. In addition to all these operating tasks, it also recharges the battery. Whenever the engine is running, the alternator is spinning, making electricity.

The pulley on the front of the alternator drives a shaft-mounted electromagnet, called a rotor. The rotor gets the current it needs to energize its magnet from the battery, through brushes that contact slip rings on the rotor shaft. As this electromagnet spins, its magnetic field induces current flow through tightly wound wire coils surrounding the rotor inside the alternator. These coils are wound around an iron core, and together the windings and core comprise the stator. As engine speeds increase, the current in the rotor increases with it, producing a simultaneous increase in voltage from the stator.

Left unchecked, the alternator would keep producing more and more voltage as engine speed increased. Too much voltage will boil the battery and blow fuses. Too little will not charge the battery or run the accessories. That's where the voltage regulator comes in. The voltage



Replacing brushes on modern alternators is simple if you use a short piece of wire to hold the brushes in place while you install the rotor and front case half. Remove the wire through the hole conveniently provided in the rear case half.

PM ILLUSTRATIONS BY FRED WOLFF

regulator limits the alternator output and prevents overcharging the battery in the process. The regulator operates by limiting the amount of current going to the rotor windings. Though voltage regulators used to be electromechanical devices that used vibrating—and often adjustable—contact points to limit current flow, modern regulators are small, sealed electronic devices that use diodes to control alternator output. In fact, in many late-model cars the regulator is integrated into the alternator.

The electromagnet in the rotor is made of wire windings surrounded by interlocking metal fingers, which are the alternating magnetic poles. As the rotor spins inside the stator, the magnetic poles are constantly reversing the direction of the current flow in the stator. It's this changing of direction that creates alternating current (AC), rather than direct current (DC).

But since your car's electrical system requires direct current, the AC must be converted to DC before it leaves the alternator. This is done by diodes, which act as electrical one-way valves.

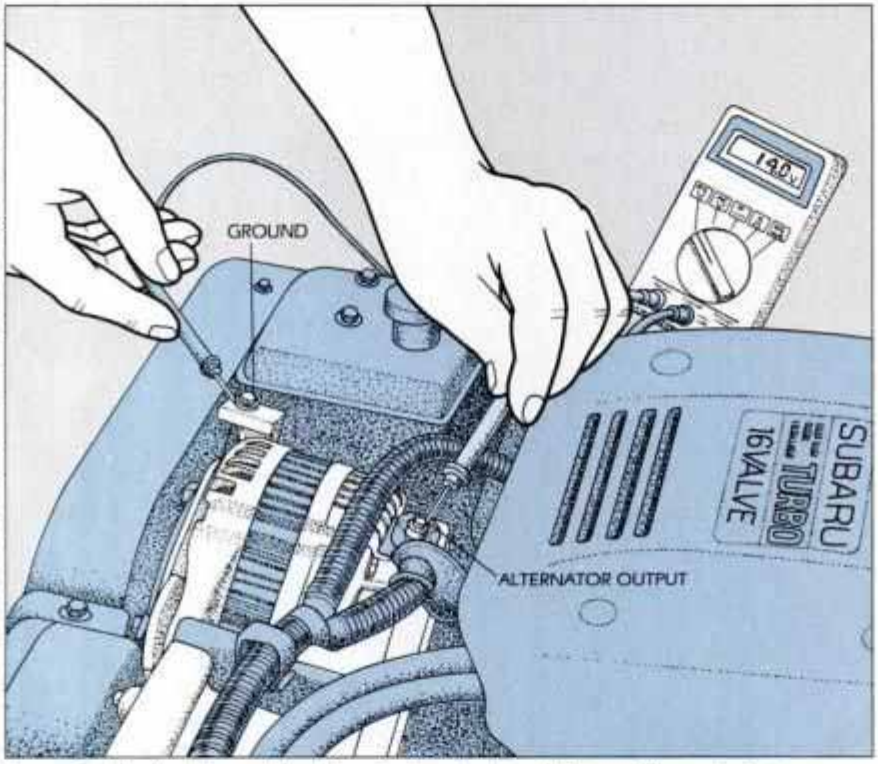
The third component of the charging system is the battery. The battery stores the electricity needed to start the engine and to provide a small amount to energize the alternator's rotor while the engine is running.

Remember, electricity only flows in a complete loop. If there is a problem anywhere in the charging system, the entire system goes down. When you're diagnosing a charging system problem, you must consider the battery, the alternator, the voltage regulator and all of the wire and connections between them.

Battery basics

The battery relies on the alternator to replenish its power, so a weak—or dead—battery may point to a problem elsewhere in the system or could be the cause of the trouble. In any case, it's an excellent place to begin your diagnosis.

Automotive batteries store electricity chemically. The box we generally call a battery is really six smaller cells, connected in series. Each of these smaller cells consists of electrodes immersed in a water/sulfuric-acid solution, called electrolyte. The electrodes are alternating plates of lead and lead peroxide. Nonconducting porous separators between the plates prevent short circuits within the cells. The chemical reaction between the sulfuric acid and the lead plates causes the flow of electrons between the electrodes.



Be sure to check voltage at the alternator's output terminal as well as at the battery.

The chemical reaction that creates electricity also produces a certain amount of lead sulfate, which gets deposited on the electrodes. When the battery is being recharged, the chemical reaction is reversed—the lead sulfate breaks down and rejuvenates the electrolyte.

As time goes on, however, the lead-sulfate coating on the electrodes is too heavy to be broken down completely. Over time, the electrolyte grows weaker and the electrodes become less conductive.

Like other chemical reactions, the lead-acid reaction in your battery slows as temperatures go down. A fully charged battery is at maximum strength when the temperature is about 70° F. A battery that's got enough zap to start your car on a warm spring day may not get the job done when the mercury drops to the freezing mark or lower.

Before checking your battery, ensure that it is fully charged. If the battery isn't a sealed, maintenance-free type, you can check the strength of the electrolyte in each cell. Remove the vent caps and check to see if the electrolyte level is up to the bottom of the fill neck in each vent. If not, add distilled water. Drive the car for a while to thoroughly mix the water with the electrolyte. Then, use a hydrometer to test the specific gravity of the solution. The electrolyte of a fully charged battery should be between 1.27 and 1.29 at about 70° F.

Check the state of the electrolyte in a sealed battery by checking the built-in indicator eye.

Disconnect the battery ground cable and attach the battery to a charger. When the battery charger shows that the current draw is less than 1 amp, the battery is charged. Double check by using the hydrometer. Remember, battery strength is inverse to ambient temperature—do this diagnosis on a warm battery. And any time you're handling a battery, keep in mind that it's filled with acid. Wear eye protection, and flush spilled electrolyte from your skin immediately.

Also remember that a charging battery produces hydrogen gas, which can explode if exposed to a spark. Some manufacturers recommend removing the battery caps to allow hydrogen to dissipate, while others recommend leaving them in place. If you do remove them, cover the holes with a clean shop towel to prevent dirt and foreign objects from contaminating the electrolyte.

With the battery charged and warm, connect a voltmeter to its terminals. The voltmeter should read at least 12 volts. If not, replace the battery. Be sure to turn in the old battery when you buy the new one. The bat-

PM ILLUSTRATION BY RON CARBONI

tery supplier will properly dispose of the battery. Do *not* simply toss out the old battery with the trash. It contains lead and acid, both toxic substances that are very harmful to the environment.

If the battery is putting out more than 12 volts, reconnect its ground strap and disconnect the ignition system, leaving the voltmeter attached to the terminals. Have a helper crank the engine for 15 seconds, while you check the voltmeter. A healthy battery should put out at least 9.6 volts at about 70° F. If not, it is weak and must be replaced.

If the battery passes the voltage tests, clean its terminals and connectors. Use an inexpensive wire brush designed to clean both the terminal posts and the cable clamps. If your car has a side-terminal battery, make sure that the cable mounting surfaces and the attaching bolts are clean and corrosion-free.

Even though the advent of the so-called maintenance-free sealed batteries has greatly cut down on battery corrosion, it's still a good idea to coat the battery connections with white grease or petroleum jelly—after they have been connected—to prevent a buildup of corrosion on the terminals. Clean the surface of the battery with detergent and warm water to remove surface dirt, which, in damp weather, can drain your battery by becoming an electrical path.

Check the other ends of the battery cables. Make sure that the ground strap is intact and that it is snugly attached to the car's chassis or engine and that the mounting bolt is not rusted. Check that the positive cable is secure, intact and connected properly at the starter switch or junction box. Again, be sure that the cable terminal end is solid and that the mounting nut is rust-free and snug.

Alternately speaking

If the battery is good—or if a replacement quickly runs down—suspect the alternator or the voltage regulator.

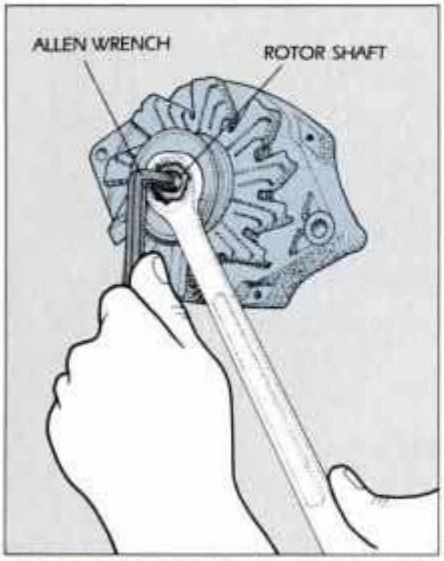
To check those components, leave the voltmeter hooked up to the battery—which should still be holding more than 12 volts.

Start the engine and run it at 2000 to 3000 rpm. With the lights, heater, defroster and other accessories off, the voltmeter should read about 2 volts higher (typically 14 to 15 volts, check your car's specs) than it did with the engine off. If the voltmeter reads *more* than 2 volts higher suspect the voltage regulator.

CAR CARE

With the engine still running at 2000 to 3000 rpm, switch on all the lights and accessories. Now the voltmeter should read about 0.5 volt more than when the engine was not running. If the voltage now is not at least 0.5 volt more than at rest, there's one more test to try before condemning the alternator.

Shut the engine down and disconnect the voltmeter leads from the battery. Connect the voltmeter's positive lead to the BAT terminal on the alternator and the negative to a good ground. Restart the engine, turn on all the lights and accessories, and bring engine speed up to 2000 to 3000 rpm. If the voltage reading still fails to increase by at least 0.5 volt, there is a problem with the alternator. But if the voltmeter now indicates an increase of more than 0.5 volt, suspect the regulator.



Remove the pulley by holding the rotor with an Allen wrench and turning the nut.

Drivebelt basics

Another common culprit in low alternator output is the engine's accessory drivebelt. A slipping belt is all that's needed to reduce alternator speed and output to unacceptable levels. Many new-model cars use a single multi-V serpentine belt to drive all the engine accessories. These belts use a single spring-loaded tensioner to ensure proper tension. If the belt seems slack, the tensioner might be sticking or otherwise defective. Also, check to make sure there are no cracks or missing pieces between the belt's grooves.

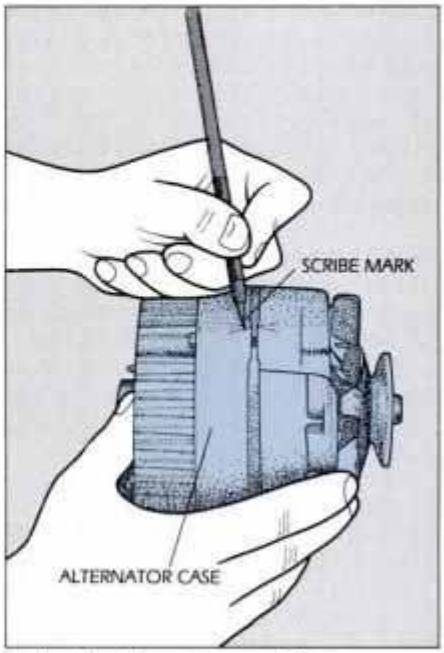
If your alternator is driven by a V-belt, check the belt's tension. Thanks to today's tighter engine compartments and shorter distances between belt pulleys, the only way to accurately check drivebelt tension is with a special gauge, available at auto parts stores. Compare the reading against your car's specs. Also check the belt for glazed sides, cracks and missing chunks. If you haven't replaced the belt in two years, it's a good idea to replace it now, regardless of how good it may look.

If the belt is loose, tighten it. If the belt drives more than only the alternator, ascertain which accessory—or idler—pulley is the one that pivots and adjusts tension. Take care when tightening the belt not to overtighten it. A belt that is too tight accelerates bearing wear in the accessory. Don't pry against the sides of the alternator to tension the belt. Either pry on a special boss on the housing, or look for a tab or hexhole designed to accept a wrench for you to tension the belt.

Next, inspect all the wiring connections. A loose or corroded connection causes voltage drop, reducing the alternator's effective output.

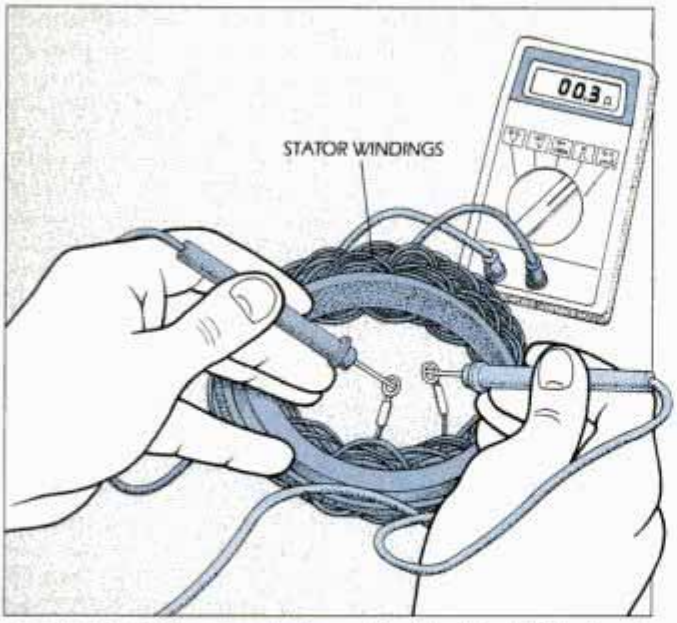
However, if the belt and wiring are good but alternator output is not, the alternator must be repaired or replaced. Or, if the alternator output is higher than it should be (as outlined above), the regulator must be replaced. There are no repairs to be made to a modern, sealed electronic voltage regulator.

If your car does not have the voltage regulator built into the alternator, chances are you'll find the unit either on the firewall or near a strut tower on the fender well, where it may be hidden by another component.

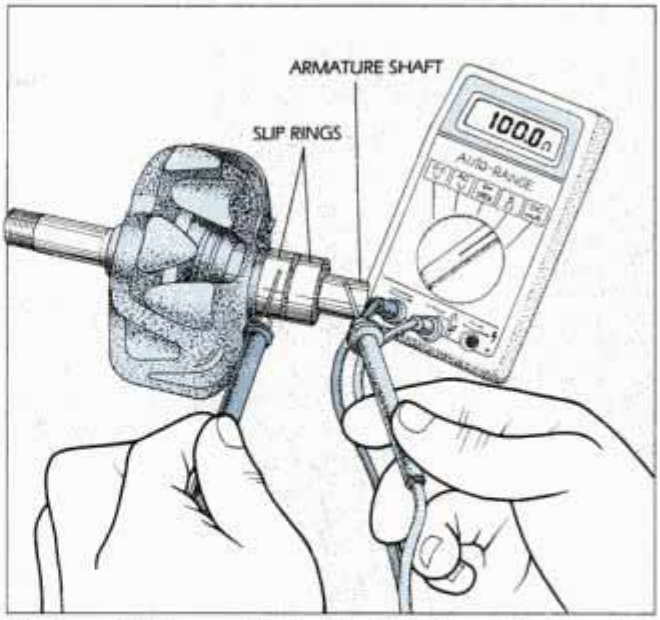


Scribe the alternator case halves to ensure bolting them back together correctly.

PM ILLUSTRATIONS BY RON CARBONI



An ohmmeter is the proper instrument to check for electrical continuity through the stator windings. You should expect to get a low-resistance reading.



Check carefully for possible short circuits between the alternator's slip rings and the rotor itself. Correct readings in this instance should show a very high resistance.

Disconnect the wiring, labeling it if necessary, and remove the regulator's mounting bolts. Clean the mounting surface and bolts before installing the replacement.

However, if the problem is the internal voltage regulator or the alternator, you must disassemble the alternator. Start by disconnecting the battery ground connection. Then, remove and label the wires from the back of the alternator. Next, loosen the drivebelt and slip it off the pulley. Then remove the bolts holding the alternator in its bracket.

Next, mark the mating halves of the alternator's housing, using either a scribe or permanent marker (on a clean, dry surface). Then remove the long through-bolts that hold the housing halves together.

The front and rear of the housing should separate easily. If they need a little persuasion, tap lightly on a reinforced section of the housing with a soft-headed mallet—taking care not to damage the soft aluminum housing. Within the alternator housing, you will find the diodes and the brush holder—possibly along with a resistor and radio-noise-suppressing capacitor—as well as the voltage regulator (on units with internal regulators).

Next, remove the pulley from the end of the rotor shaft. Hold the shaft with an Allen wrench while loosening the pulley retaining nut. With the nut off, the pulley, fan and any spacers slip off the end of the rotor's shaft. Slide the rotor out of the front half of the alternator housing.

Before removing the stator assembly, scribe mating marks on it and on the alternator housing. Then, disconnect the stator winding's terminals from the diodes and slip the stator out of the alternator housing.

Besides checking the rotor for obvious damage—such as a bent shaft—you can test the electromagnet's windings for internal breaks. Connect an ohmmeter to the brushes' slip rings on the rotor shaft. There should be some continuity between the rings. Depending on the alternator, the ohmmeter should read anywhere from 2 to a few hundred ohms. Next, test that there is no continuity between either of the slip rings and the rotor itself.

Inspect the stator windings in the same manner. Connect an ohmmeter between any two of the stator's coil leads—there should be continuity between the leads. Repeat the test with all combinations of the terminals. Next, test between each of the terminals and the stator's iron core. There should be zero continuity.

If the rotor or the stator fails any of the tests, replace the alternator.

If they both pass, test the diodes. Alternators typically have either three or six diodes. Each of the diodes must be tested. If the diodes are individually accessible, simply connect the ohmmeter to both sides of the diode and note the reading. Then, reverse the polarity and note the meter reading. If the diode is good, the meter will show continuity in one direction and not in the other. It may be necessary to unsolder one end of the diodes if they are preassembled.

If the diodes are embedded in a mounting plate, hold the meter probes to the diode terminals and to their joint mounting tab, or first to the terminal marked BAT, and then repeat the tests with the probe held to the terminal marked GND. If any of the diodes are bad, replace the assembly.

While alternator brushes normally last well past the life of the unit, inspect them for cracks, chips and wear. Be sure that their backing springs are good and have the tension needed to hold the brushes against the rotor shaft's slip rings. The slip rings should be regular—not overly grooved—and shiny. Out-of-round, burned or heavily worn slip rings are grounds for a new or rebuilt alternator.

If all the alternator tests prove good, but the voltage regulator is defective, replace just the regulator.

To reassemble some alternators—like GM's Delcotron—you must first depress the brushes fully into the brush holder and keep them there while you slip the rotor shaft back into the housing. To hold the brushes, insert a stiff piece of wire—a straightened paper clip will do—through a hole in the back of the alternator housing and through the holes in the brush holder. After the alternator is reassembled, and you're sure the rotor shaft is spinning properly, slip out the wire. The brushes will pop up against the slip rings.

Reinstall the alternator. Replace the drivebelt and properly tension it. Then, reattach the wiring to the back of the alternator and reconnect the battery's ground cable. PM

PM ILLUSTRATIONS BY RON CARBONI

WORLDCASTING THE GAMES

(Continued from page 31)

audio signals are sent to the 22,500-sq.-ft. broadcast center in Moutiers. Although Albertville is the ceremonial and organizational headquarters of the Games and the site for figure and speed skating, other events are spread out in 13 villages and 10 resorts scattered over 1600 sq. km and connected only by mountainside roads and ski trails. Because of the rough terrain, microwave transmission of television broadcast is not practical. Though for other purposes, such as voice communications, a network of nine transmission towers, placed on mountaintop and other strategic positions, will send signals between Olympic venues. Video stories and segments will be edited at the venues—it would be impossible to edit all material at the broadcast center—and sent via satellite or fiberoptic lines to the broadcast center, La Centre International de Radio-Television (CIRTV), in Moutiers. More than 100 km of fiberoptic cables are in place connecting Meribel, Courchevel, La Lechere, Moutiers, Albertville and Chambery. Twenty-five satellite transmission antennas have also been placed throughout the sites.

CBS's facilities at the broadcast center include eight editing suites, a central control graphics room, two production control rooms and a master control technical area. Sony's Communications Systems Division was selected by CBS Engineering to implement the CBS systems design, so it is not surprising to find lots of Sony products in the mix, such as Sony D-2 digital VTRs and Betacam tape recorders. Portable Beta ENG cameras also will be used by CBS, as will a newly developed super-slow-motion camera.

Once the video signal reaches the CBS broadcast center in Moutiers, the first procedure is to convert it from PAL into NTSC so it can be viewed on your made-for-the-U.S. television. Many of the events of the Winter Games will be shot in PAL, the European broadcasting standard, except for the opening and closing ceremonies, figure skating and ice hockey, which will all be covered by CBS using its own crews and NTSC equipment. The rest of the primary Olympics feed will be controlled by European networks broadcasting in PAL.

The conversion procedure affects directly the quality of what viewers will see at home. As Pearl explains, "A lot of times when you see stuff from Europe you see picture lag, or technically, converter lag, from the PAL to NTSC conversion." He points

out that this is particularly evident in scenes comprised of static and dynamic portions. In the past, a figure skater, for example, would appear clear but the background might be jittery.

Asked if the conversion problem has been overcome to their satisfaction, producer Pearl and director Quitoni both say, "It won't happen this time." Ten new conversion units, manufactured by Vistech and Thomson, operate exclusively in the digital domain, says Quitoni. Pictures coming into the broadcast center in PAL go directly into the converter where they become digital images and come out the other side as jitter-free analog NTSC video ready for transmission.

Where the network plans to really let loose, however, is in graphics created to enhance the aesthetic values of the broadcast. In its opening sequence, for instance, CBS plans to use a 3D representation of the Earth digitized from real pictures, taking the viewer from outer space all the way into the valley of Albertville. This special effect was created for CBS by a computer graphics house using advanced animation techniques.

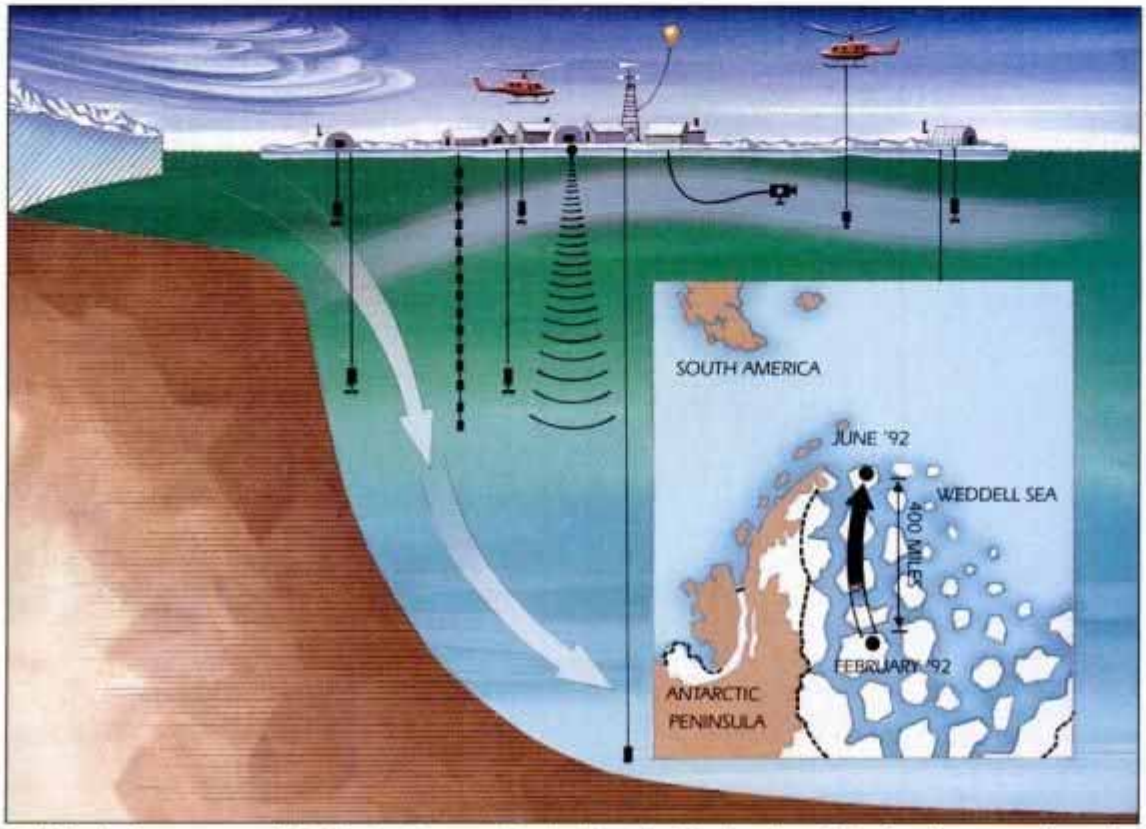
One of the digital graphics tools being used in Albertville includes the industry's hottest character generator, the Chyron Infinit'. In addition to the mundane task of putting high-resolution typography on screen, the Infinit', which is about the size of a personal computer, can also give characters different degrees of transparency, putting see-through artwork on screen, and creating 2-dimensional animation. In the CBS Winter Olympics coverage, you can watch the machine at work presenting figure-skating scores. As each judge of the international panel of judges presses a scoring button on their console, the score will be sent simultaneously to the Olympic scoring computer and to a CBS computer, which will then engage the Infinit' to generate a special effect: The number will appear to glide out from behind the flag of that judge's native country at the bottom of the viewer's screen.

Perhaps the most technically interesting event in the Olympics won't be seen by American home viewers. Europeans will see a new wide-screen, high-definition television (HDTV) signal being transmitted to special viewing stations in Europe. The Olympic Games in Albertville are going to provide the first wide-scale test of Europe's HDTV system, with 8 to 10 hours of HDTV programming everyday—much of it live, and some recorded. Even without HDTV, however, this year's Olympics promises to be entertaining television. **PM**

SCIENCE

GOING WITH THE FLOE

BY ABE DANE, Science/Technology Editor



PM ILLUSTRATIONS BY ADOLPH E. BROTMAN

Ice Station Weddell dangles temperature, salinity, oxygen and current probes. ROV looks up at the ice with TV camera, and acoustic Doppler current profiler pings the depths, while helicopters dip instruments at distant sites.

● Why is the ocean cold? Why is the atmosphere warm? And how will their temperatures change in the future? This month, a team of Russian and American researchers will cast themselves adrift on the unexplored ice floes of Antarctica's Weddell Sea in search of answers.

As you read this, the Russian icebreaker *Fedorov* is plunging through the treacherous wasteland 1300 miles south of Argentina. When it is wedged about 250 miles into the pack ice, it will launch a pair of Bell 212 helicopters to search for a solid sheet of ice about 7 ft. thick and a little less than 2 miles across. Then, the ship will pull up to it and deposit men and equipment to build an encampment of 24 huts, housing scientific instruments and living quarters. After three days, the icebreaker will depart, leaving Ice Station Weddell at the mercy of the currents.

A Russian-supplied bulldozer will plow out an airstrip, and the rest of the station's complement will be delivered aboard Twin Otter turboprops. Then the science will begin.

Perched on the floating ice, 10 Soviet and 10 American scientists will find themselves smack in the middle of some of the most complicated and important climatological interactions on the planet. Air, ice and water meet and exchange energy on a massive scale in the Weddell Sea, affecting the temperature of the oceans and atmosphere worldwide.

Bitter-cold Antarctic winds soak up heat from the Weddell, chilling surface water to the point where it grows dense enough to sink. The resulting frigid current, known as Antarctic bottom water, spreads through the depths of the world's oceans, keeping temperatures there near 0° C. "The Weddell is a primary supplier of the cold waters that keep the oceans cold," says Dr. Arnold Gordon, senior scientist at Columbia University's Lamont-Doherty Geological Observatory and leader of the expedition's American contingent.

These interactions are important because they play a big role in controlling how heat is distributed between the atmosphere and the ocean. The more heat the ocean absorbs, the cooler the air will be, and vice versa. In essence, the ocean acts like a tremendous heat sink, able to either warm or cool the air by absorbing or discharging huge amounts of heat. Which of these two possible effects the ocean will have, and to what degree, is one of the biggest unknowns dogging efforts to predict global warming.

The question is greatly complicated by the presence of ice, which acts as an insulative blanket between air and water. No one knows whether global warming will increase or decrease the size of the polar ice fields. It depends on the action of an ocean layer called the pycnocline, which holds cold water at the surface long enough to freeze.

Bristling with meteorological and oceanographic instruments, Ice Station Weddell will be the first effort to settle some of these unknowns. In its 5-month, 400-mile drift, it will cover ground unvisited by man since 1915, when British explorer Ernest Shackleton's ship *Endurance* was trapped in the ice floes.

Until now, the logistical difficulty of conducting science in the Weddell has prevented anyone from going back. But according to Gordon, basic measurements have already been done in the more accessible parts of Antarctica. "This is the last unexplored piece of the puzzle," he says. **PM**

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BOATING

LIVE-ACTION SONAR

BY JOE SKORUPA, Boating/Outdoors Editor

● Innovation is an important focus of this magazine, so it's never far from my thoughts. Recently, for three solid days, it took center stage as I devoted myself to the subject at the request of the National Marine Manufacturers Association (NMMA).

Each year, the NMMA bestows an Innovation Award at a massive soiree that's officially known as the International Marine Trade Exhibition and Conference (IMTEC). Most of us call it simply, the Chicago Boat Show.

A blue-ribbon panel of experts is assembled each year to declare two IMTEC Innovation Award winners —one domestic and one international. At the most recent awards ceremony, which is something like the marine industry's version of the Oscars, I was one of a handful of judges.

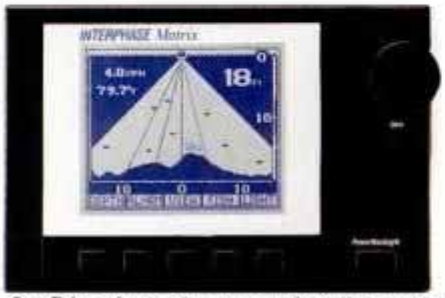
Our job was simple. Separate out of 100 nominees the best from the rest, pare the most promising candidates down to a list of about 10, and then conduct in-depth research into the merits of the chosen few.

As mentioned, this took three days. When the panel assembled for the final vote, the result was unanimous. Yamaha won in the international category for a cluster of advanced systems, including a hydraulic clutch in its high-tech Hydra-Drive (see "Aqua Power" on page 74). And two companies won in the domestic category for a new technology that will alter depth sonar and fish finding forever.

PM ILLUSTRATION BY HANK IKEN

Gulf War tech

The breakthrough sonar technology we singled out at the Chicago Boat Show is found in a unit called the Matrix Fishfinder, which displays information fed to it by a unique component called a phased-array transducer. Since different companies make each of the two key elements that comprise the unit, a joint award was given. The winners are Interphase Technologies, of Santa Cruz, California, and Airmar Technology, of Milford, New Hampshire. Interphase designed and built the sonar unit. Airmar designed and built the phased-array transducer.



See fish swim on the screen of the live-action Interphase Matrix Fishfinder.

What makes this technology exceptional is that for the first time, fishermen will be able to view a wide-angle, live-action display of what's happening below their boat. The heart of this unit is the phased-array transducer, which was inspired by phased-array radar—one of the hottest technologies to come out of the Pentagon's Star Wars effort. Phased-array radar guidance systems were used with spectacular success in the Scud-busting Patriot surface-to-air missile.

What makes the sonar version unique is that for the first time, boaters will have 3-dimensional, instantly updated bottom information. Conventional transducers and sonar units currently display an approximate 20° view that shows fish and bottom contours on a digital screen one row of pixels at a time. Each new column of pixels moves the previous column to the left. The result is that the screen shows a historical image—an image frozen in time—of what the boat's already passed.

In contrast, the phased-array transducer on the Matrix Fishfinder sweeps an area of up to 90° so swiftly

that the information is a virtual sonar snapshot of what's below the boat. Then it updates the information every few seconds so that the image on the screen is virtually live action. The difference between the Matrix and conventional fishfinders, needless to say, is profound.

Phasing in fish

Airmar's phased-array transducer uses multiple ceramic elements (often called crystals) to work together to form a single beam that can be steered plus or minus 45° in increments smaller than 2°. Because the beam can be steered, a total width of up to 105° is possible. Because there's an overlap in each of the beam's increments, resolution and sensitivity are improved to the point where a fishfinder can display the *exact* spatial location of fish and the *exact* size and location of bottom contours.

As mentioned, this highly sophisticated ultrasound technology was previously available only in military, medical and large commercial applications. Interphase is the first consumer company to make use of the Airmar transducer's unique potential.

The Interphase Matrix ($795) dials in its transducer to form a 12° beam angle and sweep it—much like a flashlight beam—across a 90° scanning area. As mentioned, the screen is capable of showing a live-action picture of the bottom, but this is only one of its many display possibilities.

In addition to displaying standard fore and aft scanning, the Matrix can also display port and starboard scanning and horizontal side scanning, which require optional transducers. Conventional pixel-by-pixel bottom histories can be displayed, too.

Like other top-of-the-line fishfinders, the Matrix has supertwist LCD display, 200 KHz operation, speed and temperature displays, resettable distance log, split-screen zoom, bottom lock, programmable alarms, backlit display, waterproofing, adjustable gain and contrast, and many other features.

Key Matrix specs are a display size of 3¼ in. × 4 in., dimensions of 8 in. × 5¼ in. × 3½ in., and a 128 × 160 pixel screen that has a total of 1575 pixels per sq. in.

The Interphase Matrix is the first true advancement in fishfinder technology in years, and it's important not to confuse it with the controversial 3D units from a couple of years ago.

The problem with the earlier 3D display was that it wasn't truly 3-dimensional. It was an electronic sampling of bottom information that was fed to a connect-the-dots software program. In essence, it was a clever way to suggest more bottom detail than the unit could actually record.

A well-publicized marketing campaign for these misnamed 3D units compared their effectiveness to "underwater cameras," and many buyers were tremendously disappointed by what they got. Let me assure these people, and those that remember the highly visible marketing campaign, that the Interphase Matrix unit, which uses the Airmar phased-array transducer, is a giant step beyond the old gimmicky 3D. In fact, although the Interphase Matrix is capable of showing a 3D image, it chooses to concentrate on live-action and 2D modes in order to distance itself from previously generated ill will.

As mentioned, the blue-ribbon committee of experts assembled by the NMMA in Chicago voted unanimously to give a joint IMTEC Innovation Award to Interphase and Airmar for the development of the industry's first live-action sonar. Voting for the Yamaha Hydra-Drive was unanimous, too, which was pretty amazing. The panel of experts had trouble deciding on what to serve for lunch, but when it came to innovative technology the choices were clear. **PM**

AUTOMOBILES

DETROIT SPY REPORT

BY JIM DUNNE, Detroit Editor

The Taurus Dilemma

● Like other successful automotive designs, Ford's Taurus/Sable twosome poses a tricky challenge: How much styling change is enough to keep the cars on the leading edge? And how much is too much?

Ford is already drawing some flak for its 1992 redesign, the first since the Taurus and Sable were introduced in 1986. Although there have been a number of changes inside and out, some critics have been saying the new cars look too much like the originals.

The Ford position on this issue is that change just for the sake of change is something that belongs to another era. Ford's design goal is functional change—revisions that will actually improve the car, as well as update its appearance.

Meanwhile, the designers are hard at work on the next update, which should appear for the '94 model year. The car shown here was spied in Dearborn, Michigan. Its Thunderbird-inspired front end and revised rear end should help quiet some of the same-as-before critics. However, Ford insiders say this design is only a proposal so far, and has yet to be accepted for production.

Chrysler 2-Strokes

Chrysler is continuing to move forward with its plan to put a 2-cycle engine in its small cars. It won't be ready until the 1996 model year, when Chrysler plans to install 50,000 3-cylinder, 2-stroke engines in the small Plymouth and Dodge subcompact sedans.

Chrysler executives aren't saying whether all the problems with 2-stroke exhaust emissions will be fully resolved by production time. But the EPA grants a 4-year grace period to new technology, and Chrysler believes its 2-stroke is just that.

Though the new engine has only three cylinders, Chrysler claims it will produce the power of a Six of comparable displacement. Besides its volumetric efficiency, other 2-stroke advantages include smaller size, lighter weight and fewer parts.

Ford and General Motors are also working on 2-stroke development programs.

Bye-Bye Small-Block

After almost four decades, it looks like Chevrolet will finally replace its evergreen small-block V8 engine. A new, smaller V8—in the 4.2- to 4.5-liter range—is scheduled to make its appearance first in the Caprice line. Look for the new engine to be a knockoff of the new dohc 32-valve Cadillac Northstar V8 that will power the 1993 Allanté pace car at this year's Indy 500.

A single overhead cam valvetrain is expected, with the engine developing 200-plus hp. Match that with an electronically controlled 4-speed automatic, and Caprice's powertrain will be set for at least 10 years.

A Sleeker Subaru

Subaru's Loyale sedan has moved away from the company's tradition of offbeat styling in its most-recent generation. And judging by the '93 prototype shown here, the next generation moves even closer to the midsize mainstream.

With its rounded lines, raked windshield and fast C-pillar, the new Loyale seems to borrow from a number of Japanese sedans, particularly the new Mazda 626 lineup. **PM**

Next-generation Subaru Loyale heads toward styling mainstream.

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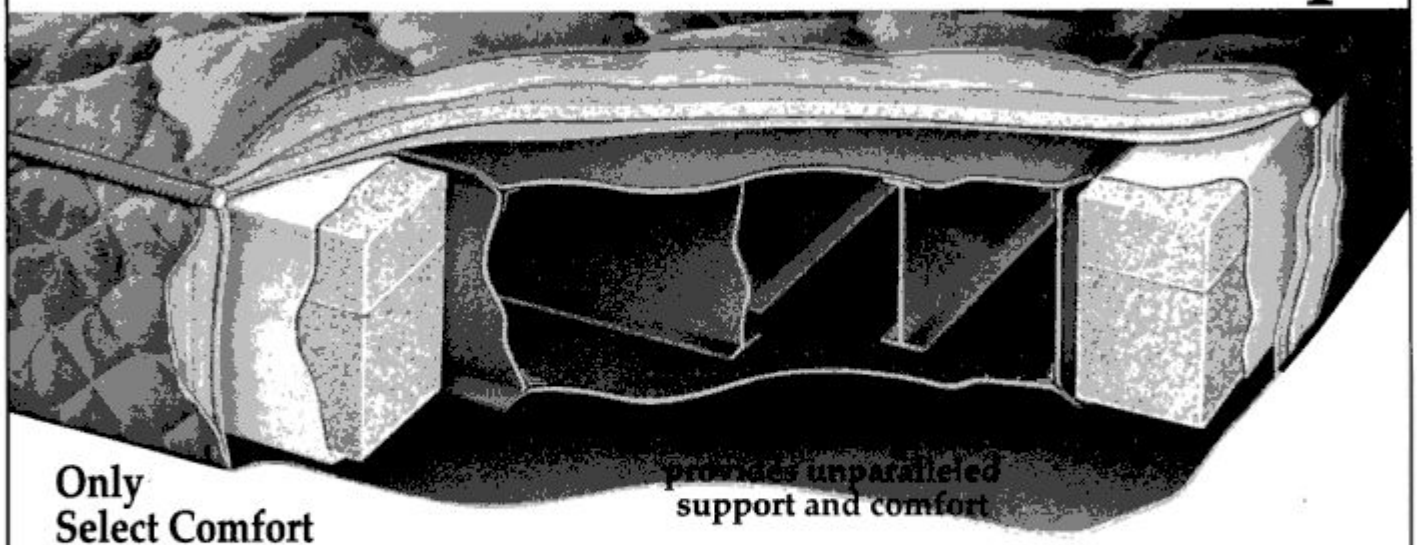

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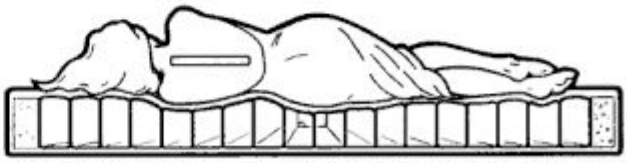

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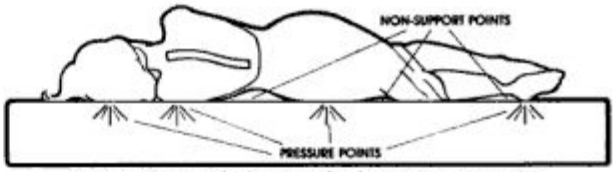
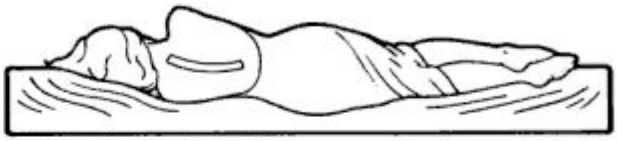


Innersprings polarize your body contours, creating pressure points and uneven support.



Waterbeds rely on displacement and can cause a "hammock effect," bending your spine unnaturally.

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TV STEREO: REAL OR FAKE?

BY FRANK VIZARD, Electronics Editor

● There may be a natural assumption that all TV stereo is the same, but, as it turns out, that's not the case. Worse, there's no easy way to tell by looking at a TV whether or not you're getting stereo—or what can only be described as pseudo-stereo—sound.

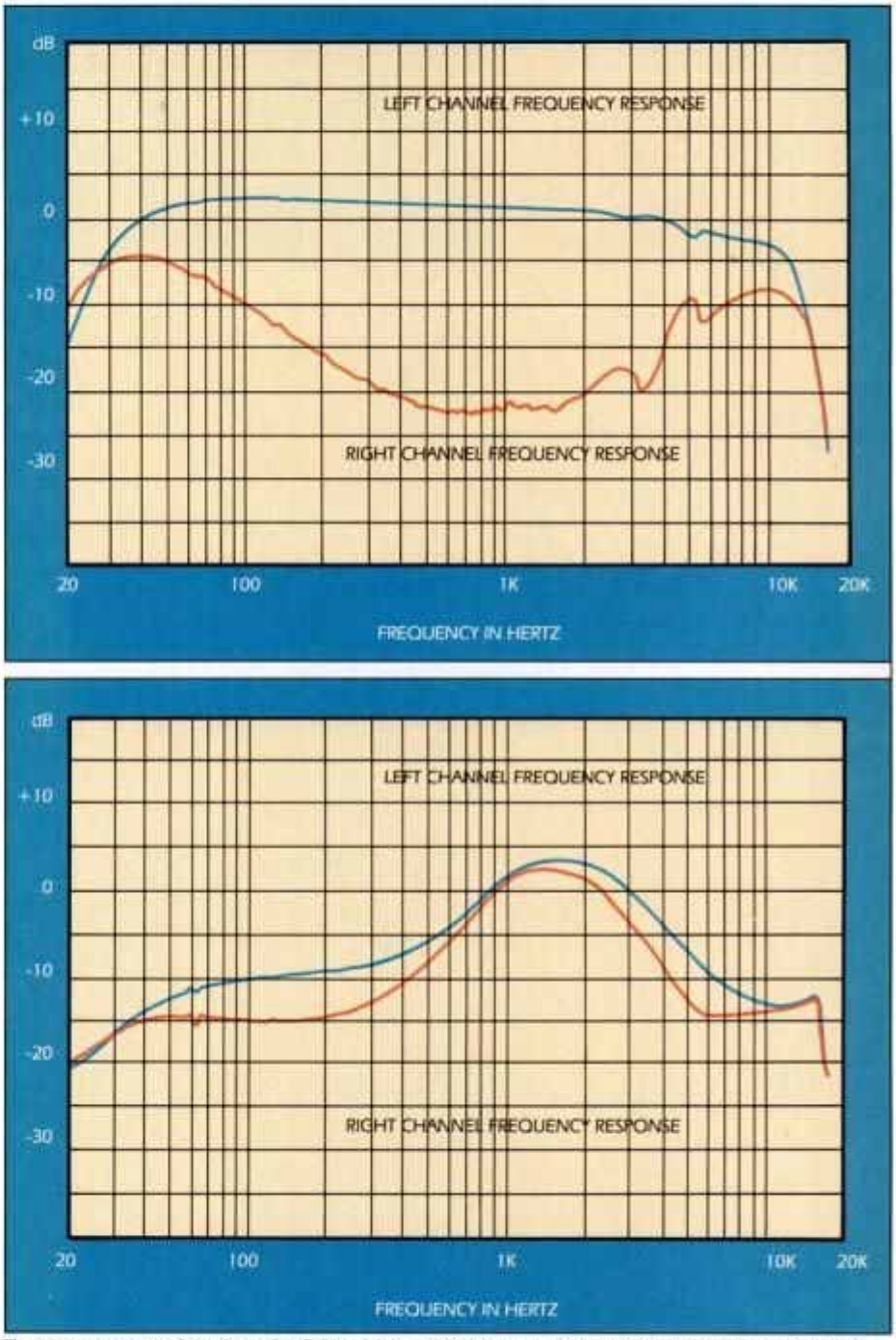
The problem may be that in the vernacular, stereo has come to mean any sound system with two speakers. The truth is that when done properly, stereophonic sound should provide the listener with an illusion of directional realism. This means that if a car is seen moving from left to right across the screen, the sound of the car's engine should be moving from left to right as well. Many TVs claiming the ability to receive stereo broadcasts, perhaps as many as 3 million, don't reproduce sound in this manner.

As initially developed in 1984, all stereo broadcasts were encoded using circuitry developed by dbx. This dbx circuitry is primarily used for noise-reduction purposes. To properly playback the broadcast, TVs need to be equipped with a dbx decoder. Without the dbx decoder, the stereo separation, imaging, noise levels and clarity of the signal can be adversely affected.

As it happens, many stereo TVs made by Magnavox, Sharp and RCA are not equipped with the required dbx decoders. Both Magnavox and Sharp have basically conceded the issue, saying that all future stereo TVs will include dbx decoders. For Magnavox, the future is this spring while for Sharp, the future is next fall.

RCA, however, has dug in its heels, claiming its XS Stereo system—used in place of the dbx circuitry in some televisions—works well. In instances where the speakers are placed close together in a TV cabinet, XS Stereo electronically widens the sound stage so that the sound seems bigger and more spacious than it would be with dbx decoding. Certainly it's true that the closer two speakers are to one another, the less the stereo effect will be heard.

To compare dbx-encoded stereo and XS Stereo, a 4-man listening panel convened at Advanced Product Evaluation Laboratories (APEL), an independent testing authority used by POPULAR MECHANICS. APEL, in fact, first pointed out the discrepancies in TV stereo sound systems.



PM ILLUSTRATIONS BY RON CARBONI

The stereo separation chart for RCA's 20-in. F20706FT model (top) shows a clear separation between left and right audio channels. The nearly identical RCA F20600ET shows a completely different pattern (bottom) due to a different and controversial processing system.

In our test, we used two 20-in. RCA televisions, the F20706FT listing for $499 and the F20600ET listing for $479. Visually, the sets are practically identical. The XS Stereo equipped F20600ET is labeled a "Colortrack" model. The dbx-equipped F20706FT is labeled a "Colortrack 2000" model and has more input/ouput jacks on the

rear panel. The difference in list price between the XS Stereo model and the dbx-equipped set is only $20, but it may be more on larger screen models.

To visually quantify the differences between the two TV sound systems, APEL subjected each model to a standard stereo separation test. These tests showed a marked difference between the two TVs. The F20706FT exhibited a good degree of separation between the left and right audio channels, a pattern similar to most dbx-equipped models. In the F20600ET, the left and right audio channels remained very close to each other across the audio spectrum from low to high frequencies.

In our tests, we duplicated a dbx-encoded stereo broadcasting signal for reception by each television. For the listening portion of our evaluation, we used a variety of test material and movies recorded on laserdisc. The movies were films like "Empire Of The Sun," known for the quality of their stereo sound.

As might have been expected, the F20706FT sounded as good as its separation test indicated. Sounds were localized, and directionality was all you should expect from a stereo TV.

By contrast, the F20600ET did not sound as bad as its stereo separation tests would indicate. Imaging in the XS Stereo system is done by purposely destroying left-to-right separation—that's why the system doesn't look good on a graph. From a listening standpoint, XS Stereo isn't really bad. The soundstage is wider and certainly all the sonic material is audible and understandable. But what you're hearing isn't exactly stereo either. What you're left with can only be described as big mono sound. All audio material appears to be coming from a single point source rather than from different locations on the screen. As far as our listening panel is concerned, there are definitely differences between the two sound systems.

RCA and other television manufacturers, have every right to make televisions utilizing different types of sound systems. Perhaps, as RCA believes, there are situations in which XS Stereo is the better alternative. Yet, with any pseudo-stereo system, you're not hearing the broadcast as it was intended to be heard.

Still, if both stereo and pseudo-stereo sound systems must coexist, then TVs should be clearly labeled to indicate which type of stereo is being employed. Better yet, the industry should agree on a definition of stereo. Certainly, the Colortrack and Colortrack 2000 designations used by RCA to signal the difference in sound systems is far too subtle for most. PM

THE TECHNOLOGY OF THE OLYMPICS (Continued from page 28)

to better athletic performance. The key is how well the athlete adapts to the innovation. In some instances, the technology has been ahead of the athlete's ability. In 1988, for example, a very fast bobsled was developed, but no driver could control it. Likewise, the Merlin canoe used in 1988 had very little drag, but also had poor handling characteristics. This year, Merlin II has slightly more drag but handles much better.

Explaining advances in sports technology is also how sports psychologists earn their money. New technology requires athletes to have a leap of faith that the new technology will help in the long run. This task is made even more difficult since new technology often hurts an athlete's performance during the learning curve.

Sports scientists themselves are learning to get the athlete involved from the beginning. USOC engineers are now developing tiny sensor packs that unobtrusively attach to an athlete's body. The raw data collected by these sensor packs, it is hoped, will provide a few more signposts pointing the way toward the gold. PM

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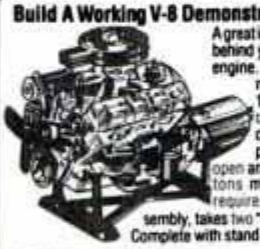

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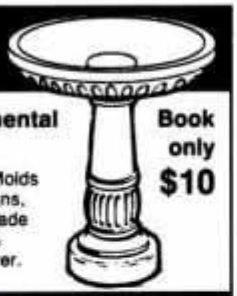

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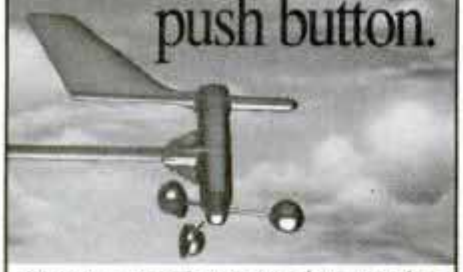

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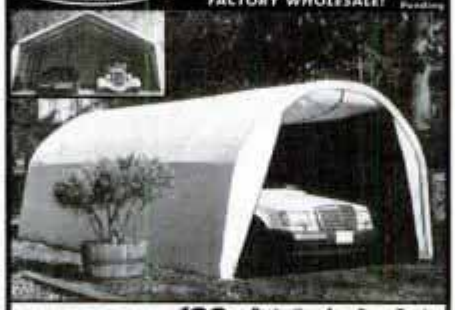

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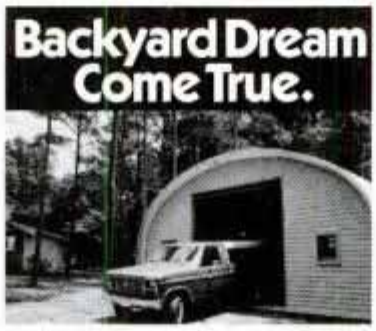

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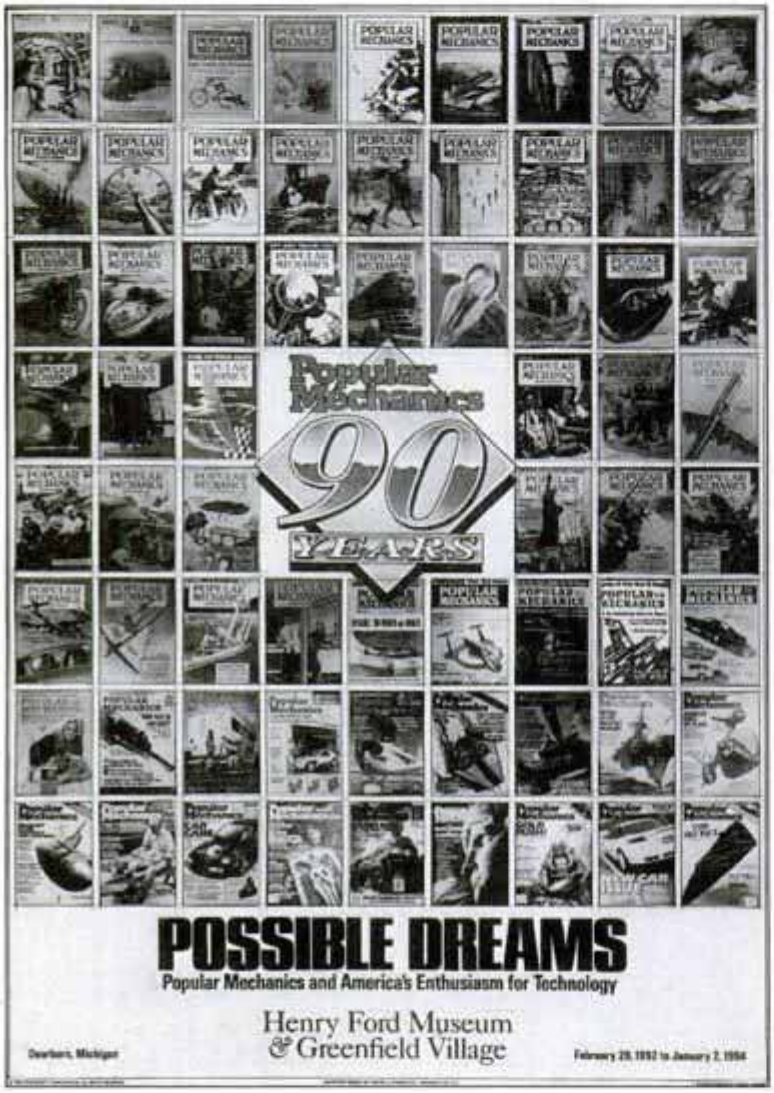

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