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Popular Mechanics

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Improvements in robotics, submersibles and sonar search equipment now promise a wealth of knowledge and natural resources.
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EDITOR'S NOTES

D ID YOU SEE last summer's hit movie, "The Abyss"? Some of the equipment in that movie looked so real to me that I wanted to know afterward if it *was* real. Just a few days later, a diving team off Charleston, South Carolina, announced possibly the most fantastic find in the history of diving—over a billion dollars in gold lying at the bottom just waiting to be recovered. The find, using



GM execs show Saturn in 1985.

high-tech robotic submersible equipment, called further attention to technological advancements in deep-dive equipment. In researching this month's cover story (page 56), Science/Technology Editor Abe Dane found out that "The Abyss" wasn't that far out—or far down. There is research going on in liquid-breathing apparatus and in dive suits that may someday allow man to descend to 15,000 ft. or deeper—a realm that, today, is reserved for steel and glass robots with TV cameras for eyes. . . . General Motors has been trying to build an import-fighting small car for decades. Remember the Chevy Corvair? The Vega? Chevette? There are probably a couple of others I've forgotten on this list of very forgettable cars. About eight years ago, GM's chairman, Roger Smith, decided to try again. But this time, he was going to try a different tack. This time, he'd form a whole new company, The Saturn Corporation, and let it build the car from scratch. In addition to the new car itself, the company would be revolutionary in the *way* it did business. No tons of paperwork; management and union personnel working side by side to solve problems and meet objectives; a manufacturing facility where raw materials came in at one end of the plant and finished cars rolled out the other. Now, on the threshold of its public introduction (Saturn will go on sale this fall), we're in a position to assess whether this new way to make automobiles has worked. Our Detroit Editor, Jim Dunne, takes you inside the car and inside The Saturn Corporation in this month's issue. One thing I can tell you. The concept of what Saturn is as a car has certainly changed. Take a look at the car in the photo here, taken in 1985 at the press announcement of The Saturn Corporation. Then look at the illustrations and photos in the article in this issue (page 43). I, for one, am glad they changed their minds about what Saturn would look like and be. . . . Auto racing continues to be the No. 1 spectator sport in the United States. What's more, many of you participate in racing in one form or another. It's no wonder we get so many letters from readers asking us to devote more space to motorsports. As you regulars know, Auto Editor Tony Swan writes a regular column titled "Motorsports," and we usually have an Indy 500 article in our May issue. But you're right. We've been remiss in not devoting more attention to one of America's favorite pastimes and haven't had a special section on auto racing in a long time. So enjoy (page 81). Till next time.


Joe Oldham

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These surveys, conducted by J.D. Power and Associates, recently measured consumers' opinions three different ways. One survey measured overall *customer satisfaction* with the product and dealer

service after one year of ownership. Another measured *sales satisfaction* with the car, the way it was sold and the way it was delivered by the dealer. And the third measured *initial quality*, based on owner-reported problems during the first 90 days of ownership.

Out of over 150 models surveyed, Buick was the only domestic brand to make the top ten in all three of these surveys.

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J.D. Power and Associates 1989 Customer Satisfaction with Product Quality and Dealer Service™ Buick ranked 10th overall. 1989 New Car Sales Satisfaction Index™ Buick ranked a tie for 3rd overall. 1989 Initial Quality Survey™ Buick ranked 7th overall.

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PM HOTLINES

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

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

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Published by The Hearst Corporation:

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POPULAR MECHANICS is published monthly by the Hearst Corporation, 959 Eighth Avenue, New York, NY 10019, U.S.A. Frank A. Bennack Jr., President; Randolph A. Hearst, Chairman; Harvey L. Lipton, Vice-President and Secretary; Edwin A. Lewis, Vice-President and Treasurer. Hearst Magazines Division: Gilbert C. Maurer, President; D. Claesys Bahrenburg, Executive Vice-President; K. Robert Brink, Executive Vice-President; George J. Green, Executive Vice-President; Mark F. Miller, Executive Vice-President, General Manager; Raymond J. Petersen, Executive Vice-President; Thomas J. Hughes, Vice-President & Resident Controller.

INTERNATIONAL EDITIONS: CARIBBEAN, MEXICO, SOUTHERN HEMISPHERE

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With Foley-Belsaw training, you can soon have the skill and knowledge to **make top money servicing these engines**. Homeowners and business people will seek you out and pay you well to service and repair their lawnmowers, tillers, edgers, power rakes, garden tractors, chain saws, mini-bikes, go-carts, snowmobiles, paint sprayers...the list is almost endless. Better yet, you can **increase your earnings** by selling parts (which are available to you at wholesale cost from Foley-Belsaw) at a 40% profit!



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You may not even know how to change the oil in your car — but if you can read, you can master this profitable trade right at home in your spare time. Lessons are fully illustrated — so clear you can't go wrong. It only takes a few months to complete the whole course — and if you're like most of our students, you can start making money well before you've finished all the lessons!

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*Roger Lee Bailey
St. Marys, West Virginia*

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LETTERS



In-Ground Look

I KNEW THAT the library of POPULAR MECHANICS that I've built up over the years would come in handy some day.

In April of last year, my wife and I decided that we would like to build a deck around our 28-ft. above-ground pool that we had installed the preceding summer. We decided that we would like to have it trilevel, beginning at our backdoor and stepping up to the pool. At this point, I went to my trusty POPULAR MECHANICS magazines. I found several issues with deck stories and I set out to use these ideas to design our deck. To make a long story short, in August we had the finished product. My son helped me with the concrete footings, but the rest of the project was a one-man job. Thanks for what your issues on decks inspired.

KENNETH WEATHERLY
AMARILLO, TX

Readers who want to build to specific plans, or wish to combine the best features of decks that have appeared in PM over the years, will find eight detailed plans offered in the new PM Plans And Ideas brochure. It's available for \$2

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

Basic Navigation

PM's article, "America's Oil Tanker Mess" (page 51, Nov. '89), emphasizes, erroneously, that tanker tragedies can be avoided by throwing money at the problem. An additional one or five steel skins will not avert accidents.

Had the *Exxon Valdez* crew been trained in and used simple horizontal danger angle plotting and other simple paper-and-pencil, position-finding navigation skills, the accident would have likely been avoided.



Nov. '89: Tanker on the rocks.

PM's deck stories inspired design for this 3-level surround for an above-ground pool.

The PINS system and other whiz-bang navigation tools are wonderful aids—until the electronics fail, as they do with great regularity. The bottom line seems to lie with the effective navigation training of people who guide these ocean behemoths—not more steel and electronic Band-Aids.

EVERETT A. ROCKWOOD
CONCORD, CA

Ironsmith

For years I've wanted an iron fence, but was always put-off by the very high cost quoted by professional firms. Now I know that it can be a do-it-yourself project, as pointed out by Bob Vila in PM's "Old House Restoration" story (page 50, March '89). With no prior experience in welding or working with large quantities of raw mild steel, I carefully considered the job at hand and, being reasonably handy around the house, decided to work part-time out of my double garage. I completed my fence in about four months for about \$1000, instead of the \$5000 quoted by the pros. I first welded the nine frames and then fitted the thin uprights (already with welded-on finial) into the frames.

In hindsight, I made many tactical errors, like ordering the steel already galvanized. A lot of extra work had to be done to grind all the welding positions before I could weld successfully. The made-up sections also had to be scoured with a special sol-

vent before applying the various undercoats and paint finishes to ensure a longlasting paint job. All the weld spots also had to be ground smooth with the grinder, and first coated with a special zinc-rich epoxy paint before applying the undercoat and black paint.

The cast-iron finials were also given yet another special undercoat, dipped twice in lacquer-based gold paint and thereafter dipped finally in yacht varnish.

Completing my front garden fence has given me great satisfaction, and proves that the job falls within the scope of any reasonably handy homeowner.

A. J. HANEKOM
CAPE TOWN, SOUTH AFRICA



PM reader's iron fence is pro quality.

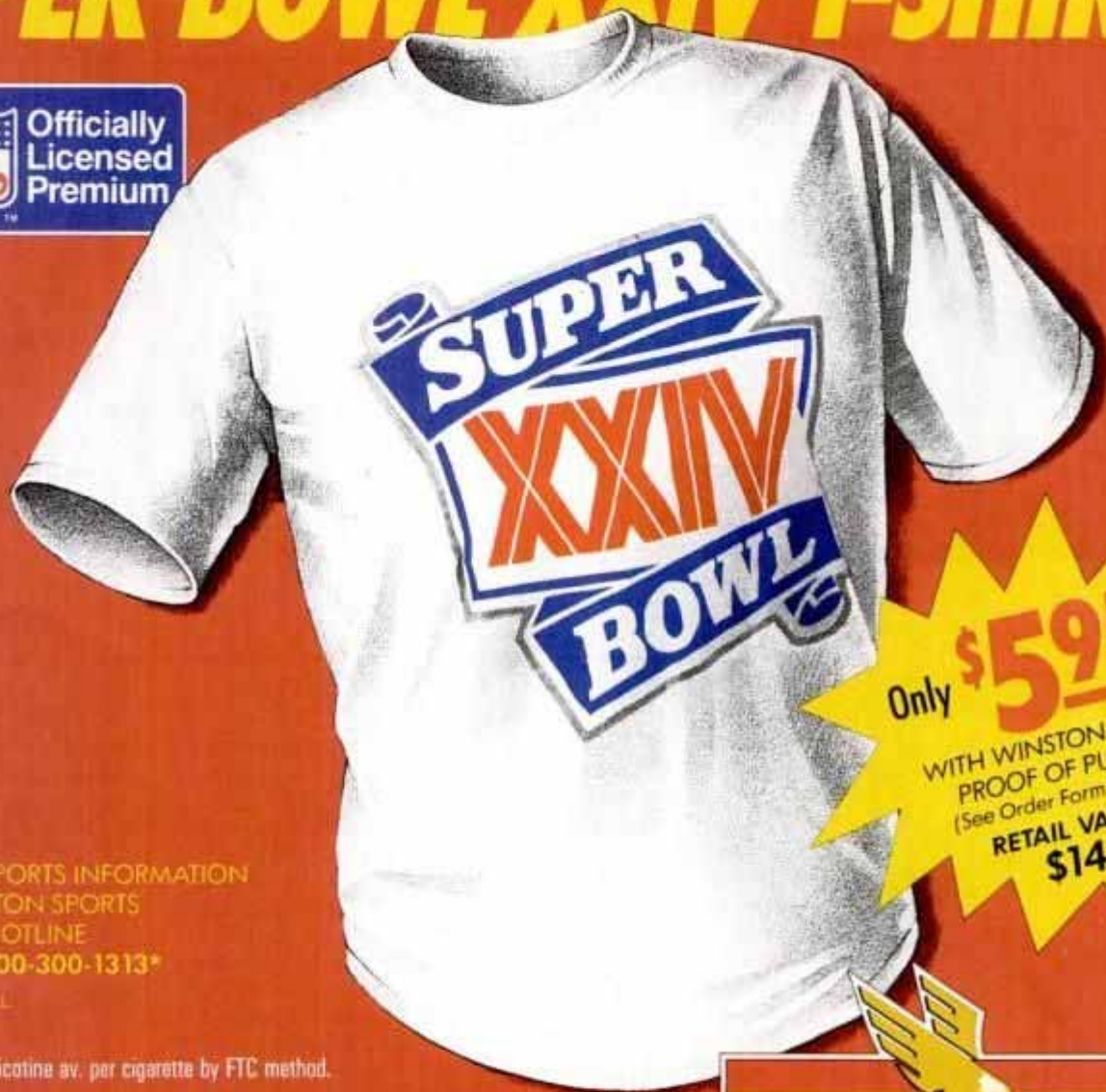
Gradual Intro

I was excited to read that software for personal computers is available for diagnosing car computers ("12 Tools For Fixing Your '80s Car," page 65, Sept. '89). You gave the impression that it had multiple applications. You didn't say it's for only GM models, '81 and newer.

ROBERT F. SKERRETT
DELMAR, NY

Rinda Technologies will make available the Ford and Chrysler Diacom software early this year. **PM**

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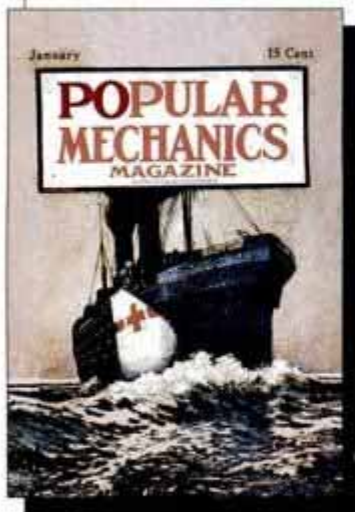


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TIME MACHINE

75 YEARS AGO: JANUARY 1915



Rules Of War

For the third time in four issues, our cover highlighted the escalating European conflict. The hospital ship, distinguished by an illuminated Geneva cross, introduced a treatise on the laws defining civilized war—always a problematic concept. Although the major European powers all agreed to an enlightened code, it often proved unworkable. As we said, "A victory is still a victory—there is no referee with power to award the decision on a foul."

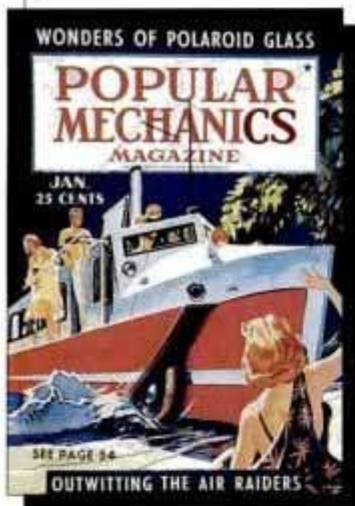
Dawn Of Radio Control

Captivating in both war and peace was the ability of radio and light to guide machines from remote locations. One inventor demonstrated a crewless boat named *Natalia*. Using a new wireless coherer, it steamed 28 miles into open ocean and back, under the control of an operator on land. A more whimsical contrivance, dubbed by Hamilton the *Electric Dog*, was



guided by light. Two selenium cells linked to a steering motor caused the device to follow a lantern held by the operator.

50 YEARS AGO: JANUARY 1940



Amphibious Surfrider

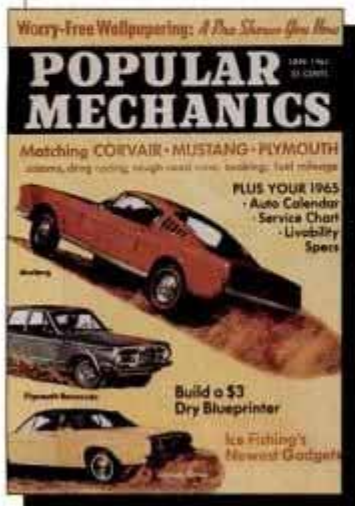
Pleasure seekers hit the beach dry-shod on a combination tour boat and bus, featured on our January cover. Three wheels on its underside allowed it to pick up 16 passengers on land, then wallow out to sea. The front wheels were powered by a 110-hp motor, which could be shifted to drive twin screws. The single, rubber-tired rear wheel was shrouded by the rudder, so that one set of controls could steer the device on land or sea.

Through A Glass Variably

With the startling properties of a new class of Polaroid materials just finding applications, we rounded up ways these now common substances might change our lives. The breakthrough was a flexible sheet with a trillion crystals per sq. in., all lying parallel so they behaved like a single crystal. This polarizing film was the secret to the variable window at right, as well as 3-D movies, windshield glare protection and materials analysis.



25 YEARS AGO: JANUARY 1965



Pony Car Playoff

Our cover story introduced the freshly unveiled Mustang to its rivals, the Chevy Corvair Corsa and the Plymouth Barracuda. All three addressed a ripening market for low-cost, sporty cars. Racer John Fitch matched them in a marathon of tests. Mustang's 271 hp gave it the straightahead edge, but the Corsa's sophisticated suspension surprised Fitch. "A few years ago, no one would have predicted Detroit could—or would—produce such a vehicle," he said.

Flying Jumbo Cat

Apparently on the verge of solving the baffling aerodynamic problems of ground-effect flight, Swiss engineer Carl Weiland envisioned a tandem-airfoil, 3000-passenger catamaran that would skim above the waves at 100 knots. The high lift-to-drag ratio of low-level flight would

mean efficiency somewhere between a ship and a conventional aircraft. A 7-ft. model of the concept flew perfectly. But a 31-footer crashed, and Weiland was out of money. The promise of ground-effect flight may yet be realized on a more modest scale, as we discussed in our July '89 issue. **PM**



Consumer study links small plastic bottle with a closer shave.

Recently, an independent consumer research firm concluded a national study of men's shaving practices. Their findings?

Men who use electric razors use a pre-shave lotion for a closer, smoother shave. And more men use Lectric Shave® than any other brand.

They use it because it works. How it works, on the other hand, requires a bit of explanation.

LECTRIC SHAVE: A HAIR-RAISING EXPERIENCE.

If you were to wake up tomorrow morning and look at your face through a microscope, you'd find your beard hairs lying down flat against your skin (Fig. A).

Convenient for sleeping, not so convenient for shaving. Part of the reason is your pillow. The other is dampness: oils and greases tend to hold the hairs down, much in the way tall grass lies flat when wet.



Figure A. The average man has about 15,000 individual hairs on his face. This is how they naturally behave.

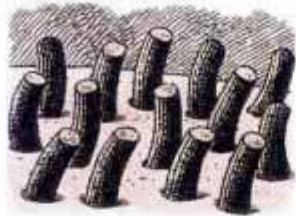


Figure B. Lectric Shave makes the hairs stand up straight, away from your skin. So you shave your beard and not your face.

Now, splash on some Lectric Shave. Within seconds, you'll feel your beard start to bristle up (Fig. B) as Lectric Shave evaporates natural moisture. The hairs dry out; they stand up straight; you get a closer shave than you ever thought possible.

BE KIND TO YOUR FACE. IT'S THE ONLY ONE YOU'VE GOT.

The man pictured above right has put in almost two thousand hours' shaving time. Surprising, but typical. Chances

are, you'll more than double that shaving over a lifetime.

Lectric Shave protects your skin from all those hours of abuse. Its lubricants and moisturizers help the razor glide smoothly over your face. Giving you a shave that's as comfortable as it is close.

ANOTHER WAY TO GET A SUPERIOR SHAVE.

While Lectric Shave can help give you a closer shave, there's always the chance it won't mix well with your brand of cologne.

Unless, of course, you use Lectric Shave Unscented.

This convenient formula has a lighter mix of conditioners, leaving your face clean and smooth. Same great shave, in a formula that will complement any after shave.

Whichever you choose—Lectric Shave Regular, or Unscented—you'll get plenty of close, comfortable shaves in every small plastic bottle.

A BETTER SHAVE IN EVERY BOTTLE.



You'll spend close to four thousand hours shaving in your lifetime. A splash of Lectric Shave could make it a much more pleasant experience.

The sport sedan
that's received
rave reviews from
a family of engineers.
And their families.




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- Corsica LT** ■ Affordable 5-passenger front-drive sport sedan.
- Fuel economy: EPA est. MPG city 24, highway 34*
 - Standard Scotchgard™ Fabric Protector on all seats and doors.
 - New, optional 3.1 Liter Multi-Port Fuel-Injected V6. ■ Soft-ride suspension with front stabilizer. ■ 3-year/50,000-mile Bumper to Bumper Plus Warranty.*

THE *Heartbeat*

OF AMERICA IS WINNING.
TODAY'S CHEVROLET 

Corsica is the proud holder of 30 U.S. government patents—a fitting tribute to its advanced sport sedan engineering. Yet Corsica also was honored as one of *Family Circle's* "Ten Best Cars for Families."

You decide. Is Corsica an unusually practical sport sedan? Or could it just be the most cleverly disguised family car around? When it comes to new ideas, nobody's winning like The Heartbeat of America.



YOU GET A LOT MORE THAN MONEY FOR COLLEGE SERVING PART-TIME IN THE ARMY RESERVE.

Joining the Army Reserve is one of the smartest ways to help pay your way through college. In fact, you can earn over \$18,000 through the Montgomery GI Bill and your Reserve pay during a standard enlistment. And, if you have or obtain a federally insured student loan, you may qualify for a government program that will help repay up to \$20,000 of it for you.

But you get a lot more than just money in the Army Reserve. You get hands on training in one of over 250 skills... skills like modern health care techniques, engineering, foreign languages, criminology and many others.

You get the pride and confidence that come with

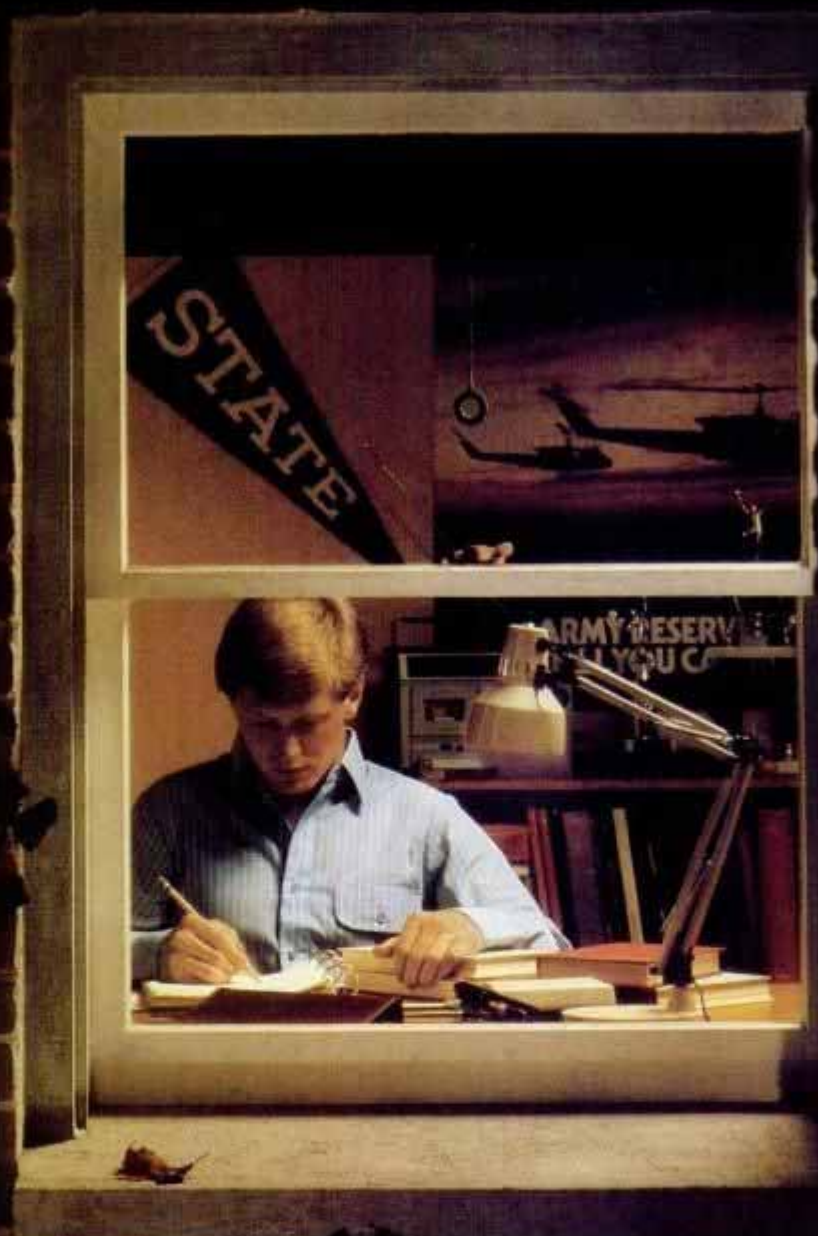
tackling a tough job and doing it well. And service with the Army Reserve can help you develop the maturity and self-discipline it takes to succeed in college and in life.

You also get the satisfaction of knowing you're helping to keep America strong.

Besides completing Basic and Advanced Individual Training, you'll usually serve just one weekend a month in a nearby Army Reserve unit, plus two weeks of Annual Training. Find out more. See your Army Reserve recruiter or call 1-800-USA-ARMY.

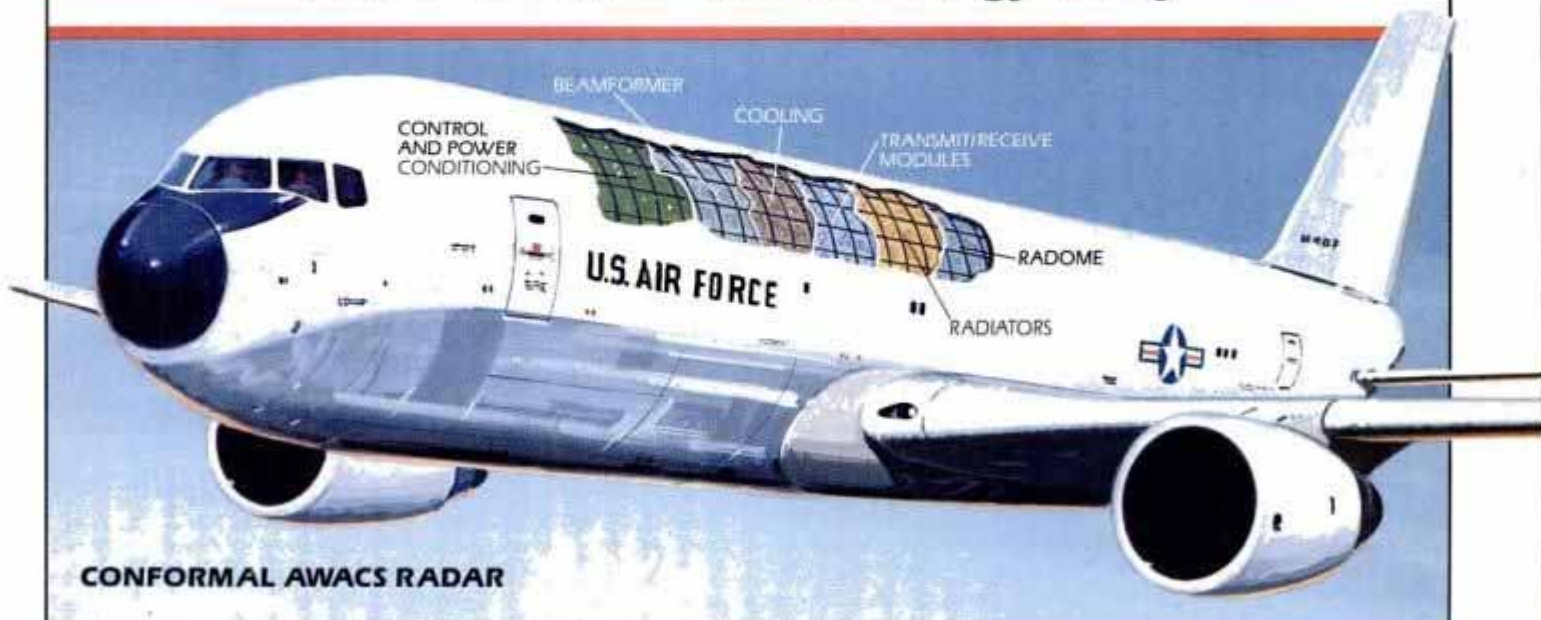
BE ALL YOU CAN BE.®

ARMY RESERVE



TECH UPDATE

News Of Tomorrow's Technology Today

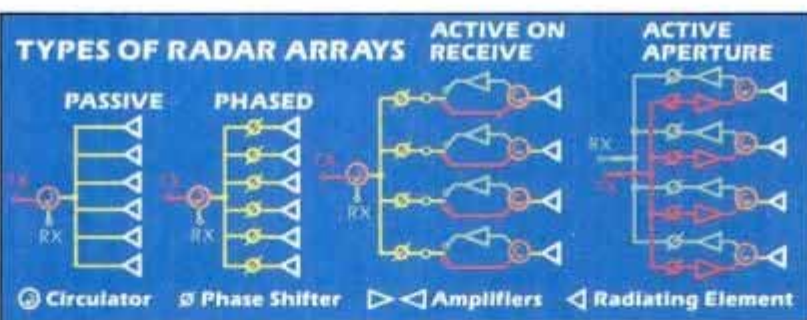


CONFORMAL AWACS RADAR

Arrays Turn Aircraft Skins Into Radar Antennas

BALTIMORE, MD—The Air Force is funding development of extremely powerful radar arrays that could be built into the structure of surveillance planes. Called conformal arrays, or smart skins, they would result in aircraft with better radar capabilities than AWACS, but without the aerodynamic inefficiency of external rotodomes, which cut down on range and time on station.

Creating conformal arrays involves more than just miniaturizing and rearranging components. For example, a design now being pursued by Westinghouse has a fundamentally different architecture than its predecessors. Called an active-aperture array, the new design continues longstanding trends in radar evolution by going another step toward having two completely separate sets of components—one optimized for transmitting radar pulses, the other for receiving them. Unlike even the most modern phased-array antennas, the active-aperture setup has separate am-



Passive arrays are mechanically aimed. Circulator separates transmit (TX) and receive (RX) signals. Phase shifters brought electronic aiming, then transmit (red) grew apart from receive (green), minimizing shared circuitry (yellow).

plifiers and phase shifters for the transmit and receive sides. The result is an antenna that can efficiently produce powerful transmit pulses, and also has a receiving system sensitive enough to pick up faint returns. Also, like phased-array antennas, an active aperture's phase shifters enable it to steer its beam electronically, eliminating the need to move the antenna mechanically.

Westinghouse hopes to demonstrate a simple 4x64-element conformal array within the next two years, and to begin flight tests in about three years.

Editor: Abe Dane
Contributors: Mike Fillon,
Steven M. Shaker

Highlights This Month

- **Tomorrow's Cruise Control**—Self-steering robot tests systems for future cars.
- **Safety At Sea**—Black-box recorder provides clues to marine mishaps.
- **Pollution Prevention**—Metal microwhiskers improve catalyst function.
- **Transcontinental Communications**—Meteor trails replace satellites in networks.
- **Firefighting Tech**—Pneumatic cannon fights fires from the inside out.
- **Next-Generation Avionics**—Mix-and-match electronic modules will be brains for future fighters.
- **Energy From The Moon**—33 kilograms of Astrofuel could power the U.S. for a year.

TM ILLUSTRATION BY RON CARBONE

Self-Steering Robot

YOKOHAMA, JAPAN—Pressing ahead in the struggle to make a computer do what 16-year-old student drivers learn as if by instinct, Mazda engineers have combined a variety of sensors, a video camera and small computers into a self-steering system that can avoid obstacles at 1.5 mph.

The system's road sense comes from a computer module using fuzzy-logic inference software to vary the speeds of motors driving the left and right wheels. The module bases its decisions on range data from eight short-range ultrasonic sensors mounted on the robot's front and sides, and on input from an image processor that interprets longer-range data from a forward-facing, color video camera. The system



Mazda's self-steering robot gropes among obstacles in the Yokohama research center.

enables the robot to move continuously while steering around obstacles, unlike earlier systems which had to stop as they approached them. Mazda hopes to incorporate successors to the system in automobiles early in the next century.

Shipwreck Recorder

LONDON, ENGLAND—Lloyd's Register has built the prototype of a device which serves a function on ships similar to that of the black-box recorders now required on commercial airliners. Designed to withstand temperatures of 1050°C for up to 3 hours, the voyage data recorder can preserve data needed to reconstruct the cause and circumstances of a marine mishap. If heat from a fire grows too intense, springs shoot the recorder over the side, and a radio beacon is activated to aid retrieval.

Inside the insulated container, an endless-loop tape recorder saves up to 54 days worth of data, including hull stresses, the position of the ship's controls, radar data and engine rpm.

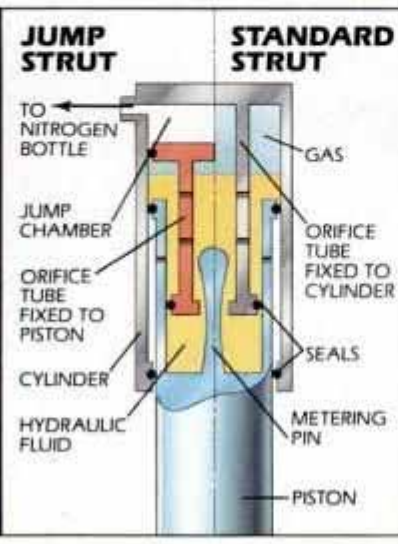


Sealed in its protective vessel, VDR floats free of a wreck, carrying answers for investigators.

Lloyd's believes the device will be useful not only in investigating accidents, but in gathering day-to-day operational data needed to make ships more efficient.



NASA's OSRA research craft will be fitted with a jump-strut nosegear for flight tests at Ames Research Center this fall.



Leaping Landing Gear

FORT WORTH, TX—Jump-strut landing gear, scheduled for NASA testing next fall, could shorten aircraft takeoff distances by more than 50 percent. Now under development by Menasco Aerosystems, the struts use pressurized nitrogen to extend suddenly during the takeoff roll, boosting the plane skyward.

Tests will be carried out aboard NASA's Quiet Short-Haul Research Aircraft (QSRA), which will have a prototype strut fitted to the

nosegear. When activated by the pilot, the strut will boost the nose up, rotating the plane into the proper attitude for takeoff. In later tests, struts may be fixed to the main gear, which would then jump the plane clear of the ground after rotation.

The system takes advantage of the same aerodynamic principles as ski-jump-type launching ramps, but would require no site modifications. In fact, a main use envisioned for it is takeoffs from bomb-damaged runways.

MAZDA PHOTO

PM ILLUSTRATION BY ADOLPHE BROTHMAN

NASA PHOTO

MENASCO PHOTO; PM ILLUSTRATION BY HANK KEN

Microwhiskers Fight Pollution

FLINT, MI—A new process for anchoring catalytic materials on sheets of stainless steel is enabling AC Rochester to manufacture lighter, more durable and freer-breathing pollution-control devices.

Half the thickness of a sheet of paper, the steel replaces conventional ceramic substrates, which were subject to breakage, had less catalytic surface area and produced more power-reducing back pressure in a cata-

lytic converter of a given size.

Earlier problems in applying catalysts to metal were overcome by a technique that grows microscopic whiskers of aluminum crystal on the steel sheets. It involves annealing the metal, which leaves oxygen on the surface, and then subjecting it to a high-temperature firing process. The firing causes aluminum in the stainless alloy to migrate toward the oxygen and form whiskers on the surface. These increase sur-



Metallic whiskers shown in micrograph (left) secure catalysts to metal monolith, shown below conventional ceramic (right).

face area twelvefold and provide purchase for a porous aluminum oxide wash coat, which is added next. Lastly,

the mixture of platinum, palladium and rhodium that catalyzes toxic exhaust gases into CO₂ and water is added.

AC ROCHESTER PHOTOS

Meteors Bounce Messages Cross-Country

NEW YORK, NY—Meteors streaking through the upper atmosphere are coming into widespread use as a way to relay radio messages. Known as meteor burst communications, the technique extends the range of VHF signals to 1200 miles by bouncing them over the horizon off of 50- to 75-mile-high streamers of ionized gas that the meteors leave behind.

Although still not as fast as satellite links, the most pow-



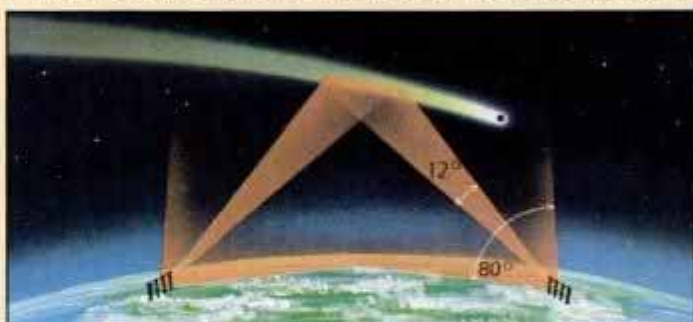
Transtrack keyboard (below) and antenna (above) are fitted to a semitruck. In addition to communications, they provide location reports based on Loran C.

erful meteor burst systems can find a suitable meteor and reflect a highly compressed burst of data off it in a matter of seconds. The systems work by sending out a constant probe beam, which detects a properly sized and positioned meteor. Messages stored in the system are then fired off to a receiving station.

Long-haul truckers have been among the first to use meteor burst, since their routes take them far beyond the range of cellular phones. A system developed by Transtrack, Inc., has already been placed aboard about 50 North American Van Lines trucks for testing.

Military communications is another promising application. If satellites were to be knocked out, or electromag-

Meteors ionize the upper atmosphere, providing a reflective trail for simple truck-mounted communicator (above), or for Broadcom system (below) that zooms in to transmit at 1.6 megabytes per second.



netic pulses from nuclear weapons disabled more powerful radio gear, meteors could keep key officials in contact.

Further advances promise to make meteor burst communications more pervasive. A system developed by Broadcom, Inc., uses adaptive retrodirective antenna ar-

rays to scan broad patches of sky for meteors, then narrow down to a high-intensity transmit beam when one is found. This means that meteors are found quickly, and that data is then transmitted at very high rates, making the transmission of voice, rather than keyboarded, messages feasible.

TRANSTRACK PHOTO

TRANSTRACK PHOTO

PM ILLUSTRATION BY PAUL COOPHALER

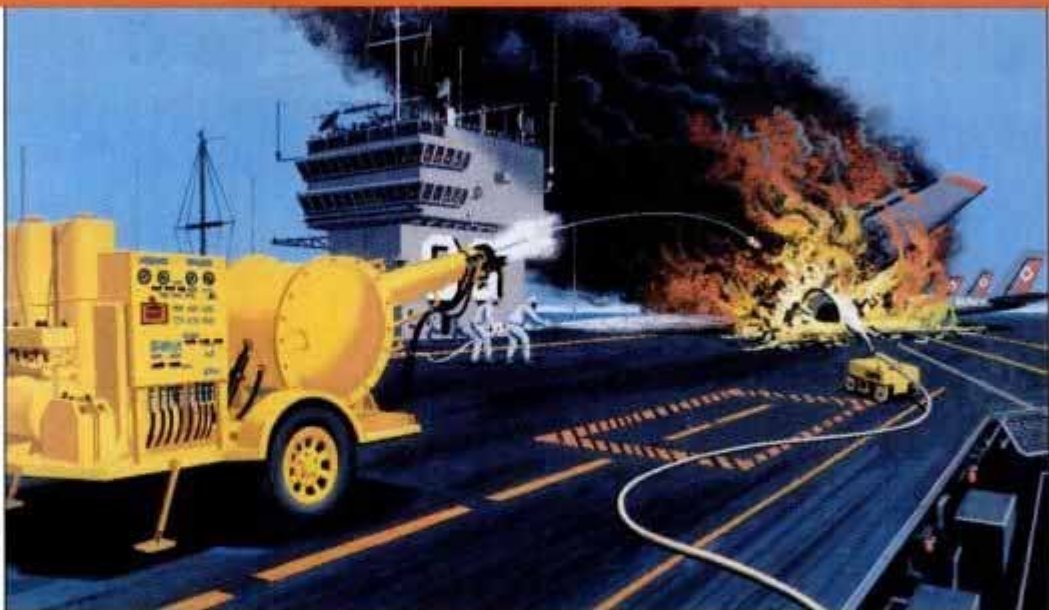
PM ILLUSTRATION BY MARIO FERRO

Long-Range Firefighters

NEW YORK, NY—The Navy is investigating systems that deliver extinguishants to superhot fires while firefighters keep their distance.

One such system, called the Full-Mobility Telerobotic Vehicle Platform, is a remotely operated robot able to carry a hose into hostile environments. Equipped with 4-wheel drive, 360° independent steering and an adaptive suspension that actively controls the height of each wheel, the vehicle is able to traverse rough terrain and maneuver in tight spaces. The Navy expects the first prototype this June.

A more unorthodox approach is embodied in the Land Harpoon, a pneumatic cannon that shoots hose-car-



Artist's concept shows future stand-off extinguishers as they might be used in a carrier flight-deck fire.

rying projectiles into fires as much as 1000 ft. away with extreme accuracy. When compressed air or nitrogen is released into the barrel, a bullet-shaped projectile,

with an appropriate length of hose folded into its after-section, is launched. At a predetermined range, a braking system reigns in the hose, and extinguishant sprays out

through a 360° nozzle on the projectile. Fires can be extinguished far faster from the inside out, so the 10-minute burn-through time of the fluid-cooled hose is enough.

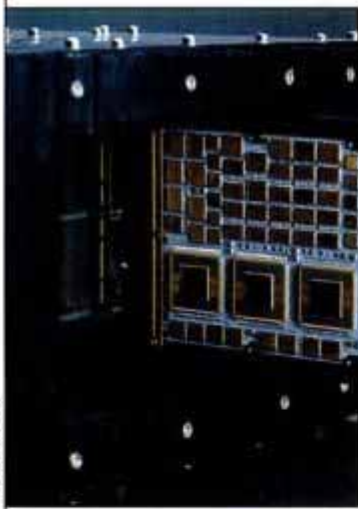
Quick-Change Avionics

ST. PAUL, MN—Electronic systems on next-generation military aircraft may be based on a few basic building-block modules that can be mixed and matched to suit different situations. This common-modules concept is now being developed separately by Unisys, IBM and Texas Instruments for aircraft in-

cluding the Air Force's Advanced Tactical Fighter, the Army's LHX helicopter and the Navy's Advanced Tactical Aircraft. Potential benefits are numerous: Modules can be replaced on the flight line, improvements in electronics can be incorporated without redesigning whole systems and sharing of functions among the modules would allow them to back each other up if damaged.

Unisys has already produced large batches of sever-

al different modules, and a mockup of a liquid-cooled rack to hold them. The 6 × 6½ × ½-in. modules, each containing more processing power than a typical PC, slide into the rack and lock in place with quick-release clamps. On each module, very-high-speed integrated circuits are mounted to ceramic substrates, providing durability and heat dissipation greater than with conventional epoxy circuit boards. The substrates themselves are cooled by contact with the rack.



UNISYS PHOTO

Miner To Harvest Lunar Energy

MADISON, WI—University of Wisconsin scientists are designing a system to gather helium 3, or Astrofuel, from lunar soil. Extremely rare on Earth, this isotope is abundant on the Moon, and 1 kilogram in a fusion reactor could generate as much as 10-megawatt years of electricity.

The most difficult part would be to land an empty ore carrier about the size of the Space Shuttle on the Moon. A mobile miner would

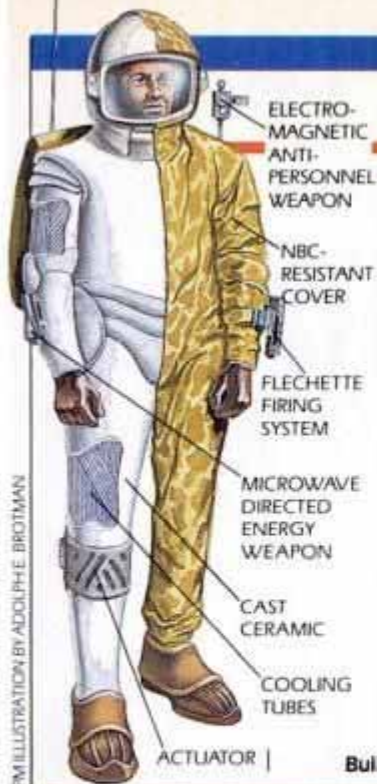
then use a bucket-wheel excavator to dig a 3-meter-deep trench in the lunar soil. Fuel-rich soil would be sieved out, and heated to 700° C by solar reflectors. Thus liquefied, the fuel would have a density suitable for transport back to Earth. While the scheme may seem elaborate, the researchers point out that just 33 kg of Astrofuel, the amount one rover can collect in a year, could produce as much electricity as was used in the U.S. in 1985.



Lunar-mining concept concentrates sunlight to process gathered ore.

FM ILLUSTRATION BY DEAN ELLIS

NASA ILLUSTRATION



ELECTRO-MAGNETIC ANTI-PERSONNEL WEAPON
NBC-RESISTANT COVER
FLECHETTE FIRING SYSTEM
MICROWAVE DIRECTED ENERGY WEAPON
CAST CERAMIC
COOLING TUBES
ACTUATOR

Fighting Exo-Skeleton

PICATINNY ARSENAL, NJ—The Army is studying exo-skeletons armored with cast ceramic to keep the foot-soldier viable into the 21st century. The armor would withstand hits from antipersonnel weaponry, while preserving soldier mobility through a system of powered joints. Protection from nuclear, biological and chemical weapons (NBC) would come from a closed life-support system with a rebreather and an outer cover of self-sealing fabric.

Built-in weapons equip ceramic armor.



Operator reaches into Sensorframe display to work flight controls on simulator.

Hands-In Computing

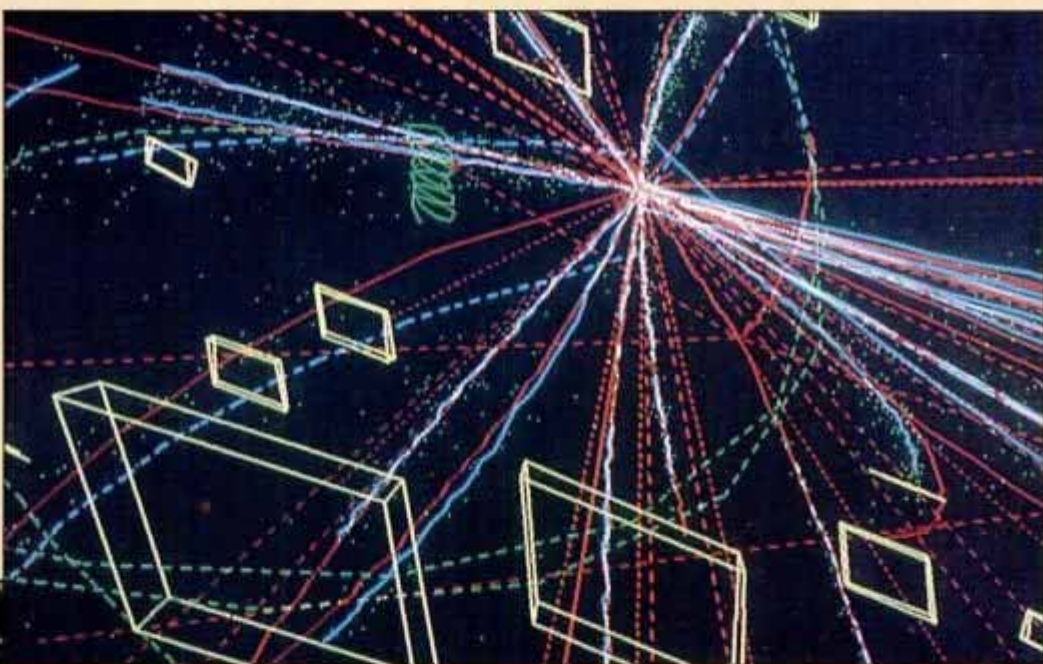
PITTSBURGH, PA—A new computer interface allows users to grab computer-generated images as if they were

real. Now being developed under NASA contract by Sensorframe Corp., the device tracks the user's fingers by shadows they cast when passing between a light source and sensors placed at each corner of the monitor. The resulting input enters the computer through its serial port, and there controls touch-screen-like software. NASA's interest stems primarily from the possibility of eliminating large control panels aboard the Space Station *Freedom*.

Elusive Particles Get To The Heart Of Matter

GENEVA, SWITZERLAND—In a deeply buried, circular tunnel 16 miles long, temperatures 400 billion times that on the surface of the Sun are producing the evanescent Z^0 particle. Discovered in 1983, the particle (pronounced "Z zero") carries the weak nuclear force, which along with gravity, electromagnetism and the strong nuclear force, accounts for the structure of all matter.

Previously only a handful of Z^0 s had ever been produced, but now the Large Electron Positron (LEP) detector at CERN (European Laboratory for Particle Phys-

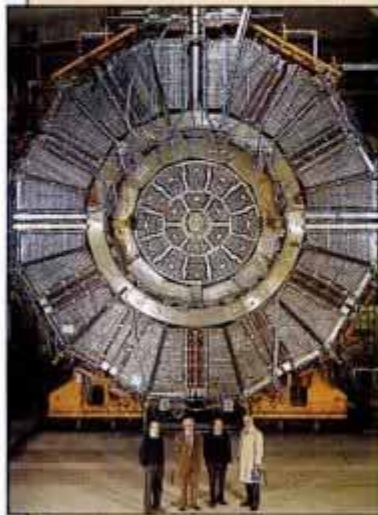


ics) is producing them by the thousands. Inside LEP's 3.7-meter-dia. tunnel, an aluminum pipe surrounded by 5000 electromagnets contains beams of antimatter positrons and matter electrons racing toward each other in opposite directions. With the particles traveling so near the speed of light that their mass is multiplied 200,000 times, the beams collide, annihilating the particles and creating new ones.

The collisions take place in four halls the size of cathedrals, each containing a de-

tor. Named ALEPH, OPAL, DELPHI and L3, each of the detectors takes measurements in a different way. L3, the largest of the detectors, contains as much steel as the Eiffel Tower. It measures the momenta of electrons, positrons, muons and light rays given off by the collision. Now in pursuit of the Higgs Boson, the particle responsible for mass, LEP's scientists are on their way to proving the Standard Model—theories that fit the forces of nature into a single coherent framework. **TU**

Simulated LEP readout (above) shows a shower of Z^0 particles created in a collision that reproduces conditions at the beginning of time. OPAL (below) is one of the detectors where such collisions will take place.



Scientists, standing before ALEPH, LEP's all-purpose detector, give an idea of scale.



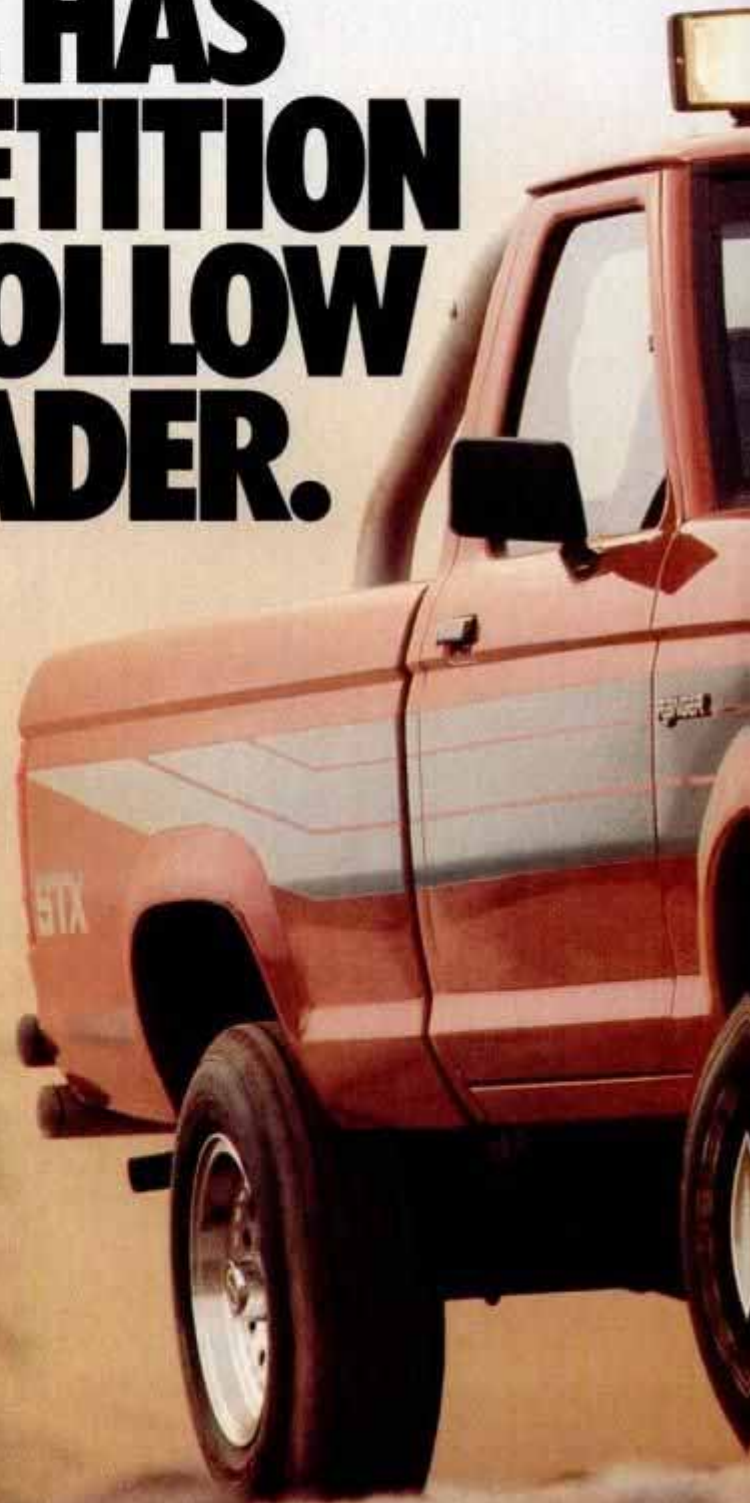
ILLUSTRATION BY ADOLPHE BROTHMAN

SENSORFRAME PHOTO

PHOTO RESEARCHERS, INC. PHOTO

CERN PHOTOS

**WITH A NEW
4.0L ENGINE AND
PUSHBUTTON 4WD,
IT STILL HAS
THE COMPETITION
PLAYING FOLLOW
THE LEADER.**



**THE TOUGHEST
COMPETITION WE HAVE
IS OURSELVES.**

Ford Ranger is America's best-selling compact truck for three years running.* And, try as they might, the competition just can't catch it. And to make matters better for you and tougher for the competition, the 1990 Ford Ranger STX 4x4 now offers an available 4.0L multi-port electronically fuel-injected

engine. And Ford's exclusive pushbutton four-wheel drive is standard. Together they form a combination no one can match.

GREAT FEATURES. STANDARD.

You also get standard features like a five-speed manual over-drive transmission, Twin-Traction Beam front-suspension, cast aluminum wheels, all-terrain tires, anti-lock rear brakes and an AM/FM stereo cassette player.

TRANSFERABLE 6/60
POWERTRAIN WARRANTY.

Covers you and future owners on major powertrain compo-

nents for 6 years/60,000 miles. Ask to see a copy of this limited warranty at your Ford Dealer.

BEST-BUILT
AMERICAN TRUCKS.

The best-built American trucks are built by Ford. This is based on an average of consumer-reported problems in a series of surveys of all Ford and competitive '81-'89 models designed and built in North America. At Ford, "Quality is Job 1."

*Based on model year manufacturers' reported retail deliveries from 1987 through 1989 to date. Optional light bar shown not for occupant safety.



RANGER
BUILT FORD TOUGH



Buckle up— together we can save lives.

DETROIT SPY REPORT

BY JIM DUNNE, Detroit Editor



GM's Taurus Wagon Clone

WHILE WE don't expect to see many of them on the hook as in the spy shot above, we do expect to see a number of Ford Taurus wagon look-alikes rolling out of General Motors plants this fall.

Although substantially bigger than Ford's style-setting wagon, the new GM entries were obviously inspired by the design from Dearborn, with a clean aero shape and sharply raked windshield.

The laydown windshield slope forced GM to make a couple of engineering changes from its current line of B-wagons. Windshield wipers on the new wagons will be exposed, and air-conditioning hardware will reside inside the passenger compartment, rather than under the hood.

Beneath the new sheet-metal, though, there are few

changes. The new skin will ride on the same rear-drive chassis, which dates to 1977. Power will still be from a fuel-injected, small-block GM V8 engine.

Per GM's standard practice, three divisions will share the new wagon, with minor changes in grillwork, taillamp and exterior trim to differentiate Chevrolets from the Oldsmobile and/or Buick versions.

Hybrid Caprice

Observed at GM's New Milford, Michigan, proving grounds, the Chevy Caprice shown below provides only a partial picture of what Chevrolet's big sedan will look like for the 1991 model year.

This prototype is actually a current Caprice wearing a 1991 front-end cap to test cooling characteristics of the revised grillwork.

Look for the rest of the

new car to have a more rounded, aerodynamic appearance, in step with the general industry trend. However, the Caprice's current front-engine/rear-drive body-on-frame chassis will be retained.

Tracing Tracer

Along with the Ford Escort, Mercury's Tracer is set for a



Due for early '90 introduction, Tracer will use Mazda 323 floorpan.

complete redesign, with new cars ready to roll early this year.

A prototype was spotted near Ford territory in Dearborn, Michigan, but production Tracers will still be built at Ford's big new facility near Hermosillo, Mexico.

Like the new Escort, Tracer will be a Ford/Mazda hybrid, using a Mazda 323 floorpan and a Ford-supplied powertrain.

Jeep Tricks

Chrysler executives are congratulating themselves once

General Motors' new full-size wagon for 1991 shows strong Ford Taurus influence. The prototype bears Buick trim on side facing the camera.

again on the acquisition of its Jeep division in the AMC deal.

Although 1989 model year sales weren't quite final as we went to press, it seemed a certainty that the Jeep Cher-

okee would be Chrysler Corporation's single-nameplate sales leader.

This means the Cherokee outsold anything wearing either a Dodge or a Plymouth badge, even though Dodge and Plymouth have long figured as Chrysler's traditional volume divisions.

Not only are the Cherokee buyers more numerous, they're also Chrysler's wealthiest customers, since the Cherokee falls into a luxury-car segment which runs in the middle of the \$20,000 to \$30,000 bracket.



The 1991 front end on current Caprice allows cooling system testing.

Tiny Taillights

Look for smaller, brighter taillights to get increasingly wide use in upcoming new model cars.

You've probably already seen this type of taillight—the light-emitting diode, or LED—on a few imports, and it's expected to dominate the industry by the middle of the '90s.

Dr. Robert E. Levin of GTE Laboratories, one of the largest suppliers of automotive lighting, says that LEDs have many advantages over the traditional incandescent bulbs used for so many decades.

"LEDs produce a red light directly," says Levin, "while the current taillights lose 60 percent of their light passing through the red lens."

Using LEDs results in reduced power demands and increased overall operating efficiency, Levin points out. In addition, since no reflectors are required, LEDs can be fitted just about anywhere on the rear of the car, providing more latitude for the stylists.

"They're only about an inch thick," says Levin, "and are ideally suited for use where space is important."

One natural application is the high-mounted stoplight, which is where some LEDs have already begun to appear. You can look for a domestic use of LED taillights on the 1992 Seville, for one, with LEDs running right across the width of the car's trunk lid.

Lopsided Tires?

During the first century of the automobile, a lopsided tire meant trouble. But in the next century, it may become the norm. Tire manufacturers are working on wheels and tires that have a larger diameter on one side than the other. Sidewalls will be a soft-riding 75 aspect ratio on one side, with a firm-handling 25 aspect ratio on the other.

The idea is to give the driver the benefit of both types of tires. What you'll see on future production cars is 20-in. tires with a low-outside aspect ratio, a combination favored by stylists because it fills up the car's wheelwells.

Using the bigger diameter wheels also allows the use of bigger brake rotors, a big plus for performance cars.

The tire's high-aspect-ratio inner sidewall will be hidden from view.

Detroit manufacturers—GM in particular—who have active-suspension systems under development are particularly enthusiastic about the 20-in. wheels, since they create more space for the complex hydraulic system hardware that goes with active suspension.

Electrocatalysts

With tougher emissions regulations just around the corner, electrically preheated catalysts may be the next step in the clean-air war. Because catalytic con-



COLD REMEDY

Now there's a prescription for helping your car or truck start significantly faster and easier in cold weather: Just add a bottle of Winter Start* to your motor oil.

Last season, thousands of drivers, nationwide, tried this new multi-viscosity oil conditioner and got welcome cold-temperature relief: 27% easier engine turnover, plus 36% better oil flow to engine parts to minimize friction and wear during warm-ups.

(Compared to oil without Winter Start.)*

This season, don't get left out in the cold. Try Winter Start... for a cold remedy that'll really get you going.

For more information, send for your FREE copy of the booklet, "The Cold Facts About Winter Start." The Shaler Co., Box 471, Dept. P010 Waupun, WI 53963, 1-800-777-9870.

If you can't locate Winter Start in your area, write Shaler for your nearest dealer. Or, call 1-800-777-9870 for direct ordering information.

*Results of independent laboratory tests, available on request.



verters don't function well until they're warm, preheating would make it easier to get cars into compliance during the startup and warmup periods.

Initial testing at EPA labs shows a promising reduction of unburned hydrocarbons and carbon monoxide.

In methanol-powered cars, the preheated catalysts all but eliminate aldehyde emissions such as formaldehyde, which has so far figured as one of the biggest drawbacks to this alternative fuel. Automakers are cautious, however. Drawbacks to preheated catalysts include increased cost and heavy drain on batteries. Other problems include

the waiting period required for catalyst warmup, similar to the wait for a diesel glow plug to heat up, and concerns over durability.

Sportier SHO

Tepid sales have forced Ford to look for help with the Taurus SHO. Although the car is one of the hottest sedans available today, with 220 hp from the Yamaha 24-valve V6 engine, the SHO (for Super High Output) has been languishing in showrooms. Ford's plan entails a new grille, new wheels, body cladding and rear-deck spoiler. ASC will handle the styling work. **FM**

OLD HOUSE RESTORATION

BY BOB VILA, Contributing Editor



PRINCETON PLANS PRESS PHOTO

Building A New Old House

IMAGINE many readers of this column are a special kind of old-house aficionado—the kind who doesn't mind spending most weekends getting their hands dirty repairing or restoring one thing or another. But let's face it: Old house living isn't for everyone. There are plenty of folks out there who, although they prefer the look and feel of an old house over a modern one, don't want the maintenance, repair and restoration headaches that generally accompany even the best old-house purchase.

Wouldn't it be great if you could build a new old house—one with all the charm of times past but the conveniences of today? Thanks to a number of companies specializing in historic house building

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

plans, it's relatively easy to do just that.

Of course, how authentic these designs are will vary from company to company. But I suspect that, since living in a new house is obviously okay for anyone interested in this type of thing, the level of authenticity will probably be acceptable, too.

Yesterday's exteriors

There are a variety of historic house plans available today. These include plans for copies of Colonial houses originally built in the late 1600s, 1700s and early 1800s. Generally patterned after homes found in the early Colonies, the styles available include a variety of saltboxes, Cape Cods, gambrels and farmhouses, along with Georgian, Federal, Williamsburg and Dutch Colonials. Plans are also available for a variety of Victorian and Southern-styled homes.

In some cases, the exterior plans are authentic copies of the original old structure. In other instances, they may have been inspired by an old original. The plan catalog should tell you this information. In either case, the design should have an unmistakable feel of the era in question. The aesthetics and proportions, even though scaled down a bit, should be the same.

To re-create an authentic Colonial home, for example, the true proportions and details of the original must be captured. That's why it's so important that the pitch of the roof and clapboard and shingle exposures are copied correctly. And special attention should be paid to the size of any corner boards, facias, soffits, freizes and rake trim. Also important to the overall accuracy of the plan are the size and location of windows, doors and chimneys.

Sometimes kitchen wings, garages and breezeways have

Plans now available for old-house designs yield traditional exteriors like this home, yet boast all the modern conveniences inside that anyone could want.

been added, particularly on some of the Colonial plans, updating the home for 20th century use. Although designed in the same style as the home, so the addition blends in tastefully with the entire structure, they obviously can't be considered authentic.

Intricacies

There are a variety of Victorian home plans available complete with unmistakable period features, like wrap-around porches with intricate detailing, projecting bays and towers, multigabled roofs, and fancy millwork and fretwork.

Inspired by some of the famous architects of the time, like A.J. Bicknell and George F. Barber, the adaptations of some of these designs probably won't matter much unless you're a student of Victorian architecture. Even then, there are some designs available today that claim to be exact duplicates of the original plans. That should be enough for even the most demanding new-house builder.

Today's floor plans

Although the exteriors of many historic house plans would fool many observers,

the interiors would not. Most historic house plans have been updated or modernized to appeal to today's style of living. Some of these changes are welcome ones, like the additions of large modern kitchens, adequate bathrooms and closets. Others are a sign of the times we live in, like larger bedrooms with separate master baths, media rooms and even hot tubs.

In some of the Colonial homes, for example, the interiors are modernized by getting rid of the original structure's low ceilings and steep stairs. Sometimes in these original homes the rooms were *rail-roaded*—you may have had to walk through five rooms to get to the sixth one. To eliminate this inconvenience, center halls are often added to these new plans. Even with these changes, made in the name of progress, new owners can still treat the interiors in a Colonial way. For example, detailing can include chair rails, paneling, wide floor boards and exposed beams to give the home an unmistakable Colonial feel. And, of course, imaginative use of paint, wallpaper and period lighting fixtures and other hardware can go a long way toward creating a more authentic feel for any new house.

Obviously, the level of interior detailing has a significant bearing on how authentic these new homes really are. Some Victorian designs, for example, retain many of the original old features of the structures they are modeled after, like hard pine flooring, detailed moldings and cased openings. If you're a purist (or as much of a purist you can be, considering that you are still building a new house) there are a few designs that claim to duplicate the interiors exactly. Of course, kitchens and baths have been tastefully added to the designs.

If you're interested in building an authentic new Victorian home, there is another route you can take. Many of the old-house plan catalogs from the turn of the century are still available. Fortunately, several publishers are reprinting collections of these plans to make this type of research even easier. (Antiquity Reprints, P.O. Box 370, Rockville Centre, NY 11571 and Dover Publications, Inc., 31 E. 2nd St., Mineola, NY 11501 are two of them.)

If you're set on building one of these old homes, an architect sensitive to your needs should be able to adjust the originally published plan for you and design a set of working blueprints. You should, however, be willing to make some pretty tough decisions. Be sure that any quest for authenticity does not severely undermine your future enjoyment—or resale value—of your new home.

Putting the pieces together

The price of building a new old house will vary from state to state and builder to

builder. In some cases, the costs of building a historic house may be comparable to those of building a similar house of conventional design. Of course, the detail of the structure, like the ornamentation and trimwork that's such an important part of Victorian architecture, can bump up the building costs considerably. So will the complication of construction, like the complexity of a many-gabled roofline and a building that has several angles and bays or a wraparound front porch.

If you decide to take on a project like this, it's very important to choose a builder who is sensitive to your needs. Although any contractor should be able to follow a good set of plans, the one you choose for this project should also have a sense of history and know what details are identified with the period home you're re-creating.

It's also important to find a builder who is enthusiastic about your project. He should be familiar with the reproduction market and be willing to locate the materials you'll need to authenticate the job. For example, he should know where to locate reproduction materials like columns and fancy millwork.

He should also understand the flexibility that such work requires. Often judgments become difficult and time-consuming to make because so many subtle questions of taste always arise during any kind of restoration work. Because time is money, slowing down the work to make these decisions can be frustrating and costly for everyone involved. If you and the builder budget a contingency fund of sorts to carry you over the problem times, the whole project is bound to be more successful.

So, if you love the charm of an old house but want the convenience that comes with a new one, building an *old* new house may be a good choice for you. There are a variety of historic house plans available today that should satisfy most old-house lovers. The level of reproduction detail possible is limited only by the amount in your pocketbook. **PM**

Source List

The following is a list of some old-house plans suppliers and their addresses:

- Bow House, Inc., P.O. Box 228, Bolton, MA 01740, (508) 779-6464
- E. Pollitt, A.I.A., 61 Vista Dr., Easton, CT 06612, (203) 268-5955
- Heritage Home Designers, 650 Krieger Rd., Wharton, TX 77488, (409) 532-0019
- Historical Replications, Inc., P.O. Box 13529, Jackson, MS 39236, (800) 426-5628, [in MS: 981-8743]
- Home Planners, 23761 Research Dr., Farmington Hills, MI 48024, (313) 477-1850
- Princeton Plans Press, P.O. Box 662, Princeton, NJ 08540, (609) 924-9655
- Traditional American Concepts, 321 Dover Rd., P.O. Box 8067, Charlottesville, VA 22906, (804) 973-1709
- W.S. Lockhart, 112 S. Warren St., Timmons-ville, SC 29161, (803) 346-3531

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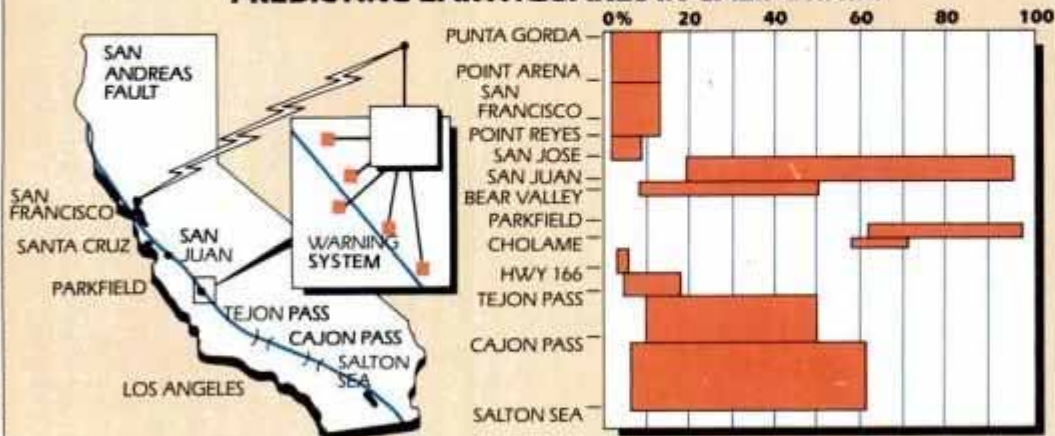
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SCIENCE

BY ABE DANE, Science/Technology Editor

PREDICTING EARTHQUAKES IN CALIFORNIA



Traditional seismic oddsmaking is embodied in graph (near left) of earthquake probability between now and 2003. Early-warning system (far left) is intended for test in Parkfield.

than about 30 to 45 kilometers from the epicenter.

The current version of the program is tailored specifically to work along the San Andreas fault, the 600-mile meeting of tectonic plates that grind past each other at a steady rate of 1/2 in. a year, and last October broke loose with the lurch that knocked San Francisco off its feet. The program could, however, be adapted to work in a variety of locations.

So far, it has been tested only in theoretical simulations. Seismic data from previous quakes were fed into the computer, showing its ability to interpret and respond. Questions remain, however, about whether the system would be able to avoid triggering false alarms when monitoring a steady stream of real seismic data 24 hours a day. To find out, Dainty and his colleagues propose to build a prototype system in the Parkfield area, where it could be tied in to a preexisting sensor network.

If the proposal is ap-

Early Warning For Quakes

SEISMOLOGISTS knew the San Francisco earthquake was coming. They just didn't know when. And since getting caught in a quake is mostly a matter of being in the wrong place at the wrong time, that's the piece of information that would do the most to save lives.

Now a system being developed at MIT raises the hope that seismology may become something other than a waiting game. Our correspondent David Freeman was in touch with the researchers a few days before the October 17 quake struck. He reported that the technology should make it possible to sound a warning anywhere from 10 to 100 seconds in advance—enough time to run for safety, or at least dive under the nearest desk.

The technology is based on an artificial intelligence program in a computer linked to a series of accelerometers placed along a fault line. In a quake, the computer would quickly process information from the sensors to determine the magnitude of the quake and areas likely to sustain damage. Then, warnings would automatically be issued by radio or telephone to businesses and perhaps civil defense authorities in the

regions at risk, and sirens would sound.

Written in the LISP artificial intelligence language, the program is relatively simple, and runs on a standard 386-chip-based personal computer. Developed by seismologist Dr. Anton Dainty and computer programmer John Bullitt, it consists of about 30 "if-then" rules based on what is now known about the way earthquakes develop.

The accelerometers that feed data to the computer are spaced about 3.5 miles apart along the fault line. Measuring about 1 cu. ft. in size, they are mounted on concrete

pads, which in turn are set into the ground, ideally in bedrock to provide the most accurate data.

Wave speed

The ability of the system to provide early warning depends on the fact that the most damaging seismic waves propagate out from a fault rupture at a rate of about 3 kilometers per second. The ruptures occur in such a way that after they've gone on for 10 to 15 seconds, it is possible to know that the resulting quake will exceed 6 on the Richter scale, the point at which serious destruction begins. Thus, some degree of advance warning can reach any area farther



The deadly collapse of Interstate 880 in Oakland provides one example of a situation where early warning might have made all the difference in saving lives.

proved, and trials are successful, Dr. Dainty envisions a larger system that could alert the entire Los Angeles basin area when, as seismologists have long predicted, the Big One strikes.

Saturn V's Successor

Able to hustle 210,000 pounds of payload out beyond the grip of gravity, the Apollo program's Saturn V booster represents in many ways a lost golden age of American rocket science. Last launched in 1973, there has been nothing like it in the U.S. since. It wasn't until late in 1988 that the Soviets were able to match it with their *Energia*.

As NASA and the military weigh a variety of new options for getting heavy payloads into space, one can't help looking back and wondering if they're not trying to reinvent something we already have. As it turns out, however, it's nowhere near that simple. There are two basic reasons.

First, although two complete Saturn V's still exist, along with a small stock of the mighty F-1 first-stage, and J-2 second-stage engines, the technology to make and launch a Saturn V for all practical purposes gone. It's not that NASA has lost the plans, as rumors have suggested, and NASA flatly denies. It's simply that with a technology this complex, you inevitably use it or lose it. As Charles Murray, coauthor of *Apollo: The Race To The Moon*, pointed out in a recent interview, there's no way a librarian can preserve the vast body of know-how involved. The men, the tooling, and even many of the contractors, have dispersed or disappeared. According to NASA deputy administrator J.R. Thompson Jr., it would be cheaper at this point to modify the Space Shuttle into an expendable variant—the Shuttle-C—than to resurrect the Saturn V.

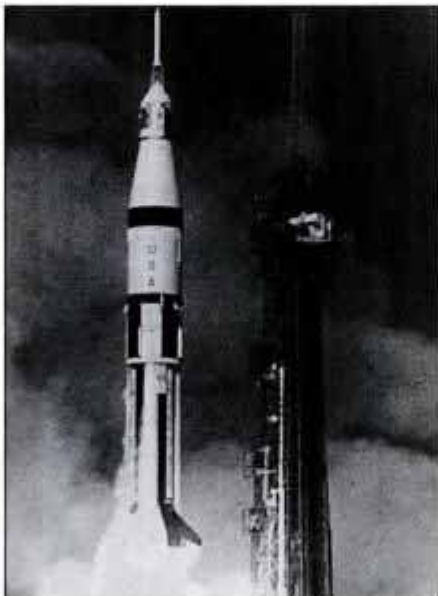
Blast from the past

Second, and more important, is the fact that the Saturn V grew out of a very special set of circumstances and objectives that make it unsuited to the missions now being envisioned. According to Murray, the slogan "waste anything but time" was commonly posted in NASA buildings of the *Apollo* era, representing a spirit of urgency and extravagance that has not been seen since.

In sharp contrast, proponents of newer heavy-lift concepts, base their arguments primarily on economics. Among the concepts is a joint NASA/DOD expendable booster called the Advanced Launch System. Col. John Wormington, Air Force program director for the ALS, says that the old Saturn was optimized to perform like an Indy racer, whereas the ALS will be engineered for simplicity and reliability. "We want to make the launches spectacularly mundane," he says, expressing a

philosophy he believes will lower the cost per pound of payload orbited from over \$3000 to around \$300.

To illustrate, Wormington compares the hugely complex Space Shuttle Main Engine (SSME) with that being designed for the ALS. Chamber pressures will be lowered from 3000 lbs. psi to 2250, turbopumps will put out 37 hp per lb., compared to 100, and specific im-



Saturn V, carrying *Apollo 7*, represents heavy-lift capability that we lost.

pulse (a measure of engine efficiency) will go from 460 seconds to 420. Wormington claims this will lower engine cost from \$55 million to between \$5 million and \$8 million a copy. "It's a design objective revolution, rather than a technology revolution," he says. Thus, the Saturn V is probably the last of a breed—still unsurpassed in many respects, but nonetheless obsolete. **PM**



The 1 1/2-stage ALS concept is one of several ways to restore heavy-lift capability.

LEFT) NASA PHOTO. (RIGHT) MARTIN MARETTA ILLUSTRATION

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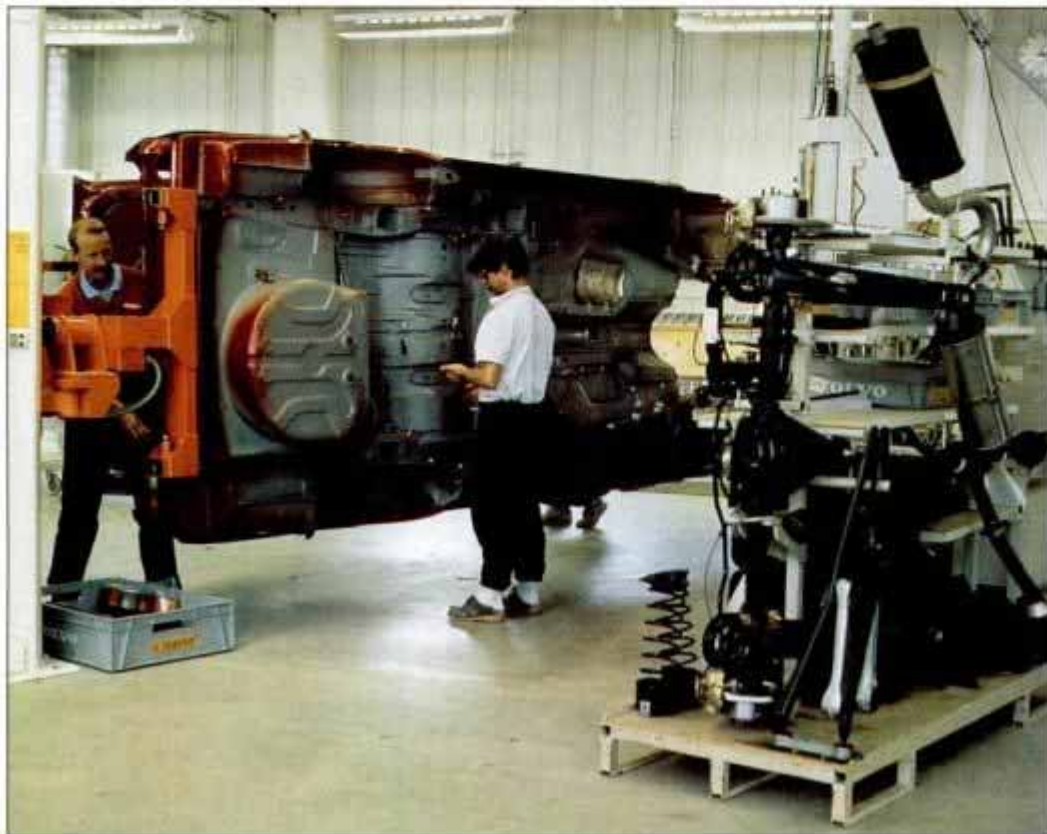
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FREEWHEELING

BY TONY SWAN, Automotive Editor



Uddevalla station-build concept is based on special gimbal that allows workers to rotate car for assembly access.

The Uddevalla File

EVER SINCE Henry Ford made the automobile available to everyman, sociologists have been busy recording the impact of this invention on society.

However, it's only in the past couple of decades that we've begun to record the impact of society on the automobile. And one of the more intriguing chapters in this part of the story is just beginning to unfold in Uddevalla, Sweden, at a new Volvo assembly facility.

What makes the Uddevalla plant unusual is that it runs exactly counter to Mr. Ford's mass-assembly concept. Instead of line workers performing one or two hurried assembly functions as the cars come by, Volvos emerging from Uddevalla are built entirely at single stations, with one team of workers per station.

The problem that Volvo

faces with manufacturing operations in Sweden isn't quite unique, but it does seem to be more pronounced there than in other European countries. As a strongly socialist country, Sweden takes the beneficent view that all its citizens must be provided for.

Since employment isn't a matter of life and death, not all members of the work force are particularly keen on working—not all the time, anyway. Absenteeism and turnover rates in Swedish industry are ruinously high, upward of 25 percent.

Teamwork

When a company is attempting to build a quality product, as Volvo clearly is, this sort of turnover inevitably has a negative impact. It's like trying to operate a football team with new and untried players every few downs. Perform-

ance gets to be spotty, at best. Volvo's response to this challenge is an attempt to create an environment that's not only more interesting to the workers, but more personal as well. Hence, the Uddevalla approach—with hand-picked teams assembling entire cars at a single station.

Mounted on a special gimbal that allows rotation around the car's longitudinal axis for access to the underside, the bare chassis comes to the team along with all the components, fasteners, wiring and fittings needed to complete the car. Some of these items—suspension members, for example—arrive as subassemblies to be bolted in. Others are assembled at the work station and the chassis doesn't leave until it's ready to drive.

Uddevalla is a new plant, running well short of capacity, which means new teams are still being assembled.

Once an 8-member work team has been established and trained, it becomes a semiautonomous unit, with total quality-control responsibilities for the cars it produces. All team members are conversant with a large number of assembly functions—a few are even capable of doing an entire car solo—and when someone's out, the rest of the team has to compensate.

As you'd expect, all this responsibility helps create strong bonds within each team, and something like a family emerges. When someone leaves the team, the remaining members have veto power over new candidates sent to them by the personnel section.

Gearing up

Does it work? Volvo's answer is a cautious yes, so far—cautious because the plant isn't fully staffed yet. But at this point, absentee and turnover figures are less than a third of Swedish norms. Quality—Uddevalla produces 740-series cars—is already up to the level of Volvo's showcase Kalmar facility, and cost of production is only slightly ahead of the more traditional plants. This is expected to come into line once Uddevalla is operating at full capacity.

Full capacity is the zinger, of course. When production hits full-tilt boogie sometime this year, the annualized rate will be about 40,000 units. That's just a good warmup by Detroit standards. When production at Pontiac's Fiero facility slipped to 40,000, they simply closed the plant.

But in the competitive low-volume, high-quality production game, Uddevalla is likely to become a textbook for the entire industry. **FM**

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Ford Mustang GT

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Have you driven a Ford...lately?



OUTDOORS

BY JOE SKORUPA, Outdoors Editor



PHOTO BY GUNNAR CONRAD

A Peak Experience

WE WERE a caravan of 1990 Range Rovers driving from Wyoming to New Mexico along the summit trails of Colorado's Great Divide. And we looked every bit the part—dust-covered vehicles, gear stowed on roof racks, eye-grabbing decals, CB radios, team outfits, the whole nine yards. At times we felt like the Range Rover Great Divide Precision Drill Team—formation parking at campsites, en masse K-turns in gas stations and other curious group maneuvers.

No snivelers

But mostly, as we clawed our way up a rugged mountain pass or entered a magnificent, high-elevation bowl, one of the trip's popular phrases would come to mind—"No snivelers!" And with good reason. This was no trip for acrophobics, or those who didn't want to eat dust from dawn to dusk.

On the other hand, this wasn't an ordinary expedition with a normal group of drivers. This was the first-ever, continuous North-South crossing of an off-road

trail system along the Continental Divide in Colorado. And the drivers were journalists from the U.S., England and Australia. Snivelers? Give us a break!

Why such a grueling trip? First, to promote the extensive off-road trail system open to the public in Colorado. Second, to demonstrate the ruggedness of the 1990 Range Rover. Third, to call attention to the U.S. Forest Service's new Tread Lightly program.

Yes, we're talking off-road ethics here and it should come as no surprise to anyone who reads this magazine that POPULAR MECHANICS has a firm policy supporting responsible and courteous use of outdoor resources.

Cliff Blake, national coordinator of the U.S. Forest Service's Tread Lightly program is encouraged by the fact that Range Rover chose to feature the educational campaign so prominently throughout the Great Divide Expedition. "The answer is education," says Blake. "Some motorized users don't know how to use public lands

correctly. They will, however, if we show them and explain why."

Here's the heart of the Tread Lightly program:

- Travel only where motorized vehicles are permitted. Never blaze a new trail.
- Respect the rights of hikers, campers and others to enjoy activities undisturbed.
- Educate yourself by learning the rules. Then follow them.
- Avoid muddy trails. Damage done in wet season progressively deteriorates.
- Drive responsibly to protect and preserve the environment for the future.

The program's goal, simply put, is to leave no trace.

From Encampment, Wyoming, to Chama, New Mexico, the Great Divide Expedition covered 1123 miles, only 25 percent of which was on pavement, in 13 days. It wound through 32 mountain passes, only four were paved, and crossed the Great Divide 15 times.

I joined the expedition, along with a group of about 10 journalists, for the last four days and 400 miles of the trip. Roads and trails in the mineral-rich mountains of

Southern Colorado were carved about 100 years ago by obsessed gold and silver miners and we passed many of their abandoned mines, camps and ghost towns.

Luxury four-by

If you've never been in a Range Rover, you might ask, why does it cost \$38,000? The answer is that there is simply no other off-road vehicle built like it.

Consider the durability and performance characteristics of these elements: 14-gauge boxed-steel ladder frame, aluminum body (except for hood, tailgate and rear lower quarter panels, which are steel), aluminum 3.0-liter V8 engine, permanent 4wd system with viscous coupling, 4-speed automatic transmission, power steering, leather upholstery, suspension system with an incredible 8 in. of vertical wheel travel in front and 11 in. in rear, antilock brake system (ABS) and other features too numerous to list.

Do these elements add up to big bucks? You bet. Is there a noticeable feel in the Range Rover's rough-terrain ride? You bet there is. Will Range Rovers really hold their value? Check resale prices in your local paper and see for yourself.

As intended, the Great Divide Expedition was a memorable experience for all concerned and Range Rover conquered the high country in high style. I wish I'd been with the group right from the start, but now that I know the route, I'll probably go back someday and do it on my own. And when I do, I'll be sure to Tread Lightly and declare "No snivelers!" in appropriate locations. **PM**

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ELECTRONICS

BY STEPHEN A. BOOTH, Electronics Editor



Sharp's XV-100 LCD projection TV displays a 20- to 100-in. diagonal picture on a scroll-away, glass-bead screen.

In the SharpVision XV-100, the dichroic mirrors act as traffic cops to direct the appropriately colored light to the correct LCD panel. The word dichroic describes the property of a surface to reflect light of one color while transmitting other colors—that is, letting them pass through its surface.

When the illumination from the XV-100's lamp hits the first dichroic mirror, the mirror splits it the way a prism would, then permits blue and green light to pass while reflecting red light to one LCD panel. The next dichroic mirror lets green light pass to an LCD panel, while reflecting blue light to the third LCD panel. Despite this circuitous routing, the different colored lightbeams follow paths that are equal in length. Accordingly, they all arrive at the projector's lens simultaneously.

All of this video magic does not come cheap. The retail price of the XV-100 is \$5200, including its rolldown screen. But the unit is only a projector; No tuner is included. Program material must come from external sources, such as a VCR and its tuner. The XV-100 has input jacks for three sources. According to Sharp, the lamp has a 2000-hour life expectancy, and can be replaced only by a service center. So the dream of flat TV is not unattainable. It's just expensive. **PM**

Writing On The Wall

THE crystal-ball gazers of the electronics world hang steadfast to their vision of a flat-panel TV that will hang from the wall like a painting. Yet like a mirage, this elusive enigma always remains just over the horizon, five years away.

Advances in liquid-crystal-display (LCD) technology are bringing the flat-panel TV within grasp. In fact, you can have a 100-in. TV picture on your wall today—and need not drive a single Molly to fasten it. The picture would appear and disappear at the touch of a button. Meet the SharpVision XV-100, the first LCD projection TV for home use.

The XV-100, from Sharp Electronics, weighs just 30 pounds and measures 21 in. long × 10 in. wide and deep. This does not include the slight protrusion of its 145-265mm f/4.5 zoom lens. At this focal length—about 2x power—the lens can double the size of the image it projects whatever its distance from the supplied glass-bead

viewing screen. For example, at the minimum focus distance of 2 meters (6 ft., 7 in.), the size of the projected image may be adjusted anywhere between 20 and 40 in. diagonally. At the maximum focus distance of 4.6 meters (about 15 ft.), image size may be 50 to 100 in. diagonally. You adjust image size by rotating the lens.

Because the XV-100 is relatively lightweight and portable, and uses a zoom lens to adjust image size, placement in or outside the home is flexible. Additionally, because it uses only a single projection lens, the XV-100 presents none of the convergence requirements of systems that use three lenses to align the beams from separate red, green and blue cathode-ray tubes.

Magic mirrors

Under the hood, the projector looks somewhat like the fun house at an amusement park—a maze decked out with multiple mirrors. Four of these, called dichroic mir-

rors, are responsible for bending and blending the light from three different LCD panels, to create the full-color image displayed.

Through a maze of mirrors, the intense white light of the XV-100's lamp is trained on its three LCD panels. Each of these measures 3 in. diagonally and has about 89,505 pixels (picture elements). Liquid crystals have the property of changing their alignment when subjected to electrical current. Depending on the charge they receive, the crystals in each pixel will either align perpendicularly to the light source to pass light, or they'll line up parallel to it, thereby blocking illumination. The voltage changes correspond to changes in the moving video image.

XV-100 projector weighs 30 pounds and measures 21 × 10 × 10 in. Price is \$5200.



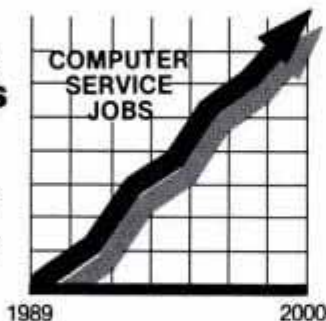
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CAR CLINIC

BY MIKE ALLEN, Assistant Auto Editor

Stick To It

THE OWNER'S manual in my Econoline Van says it should take five quarts to fill the engine—six if I change the filter. But six quarts still leaves the dipstick calling for another quart. The mechanic at the dealership says Ford sometimes uses bigger oil pans. He says to use enough oil to reach the FULL mark, regardless of what the owner's manual says.

MARCO 182
(From the PM Hotlines
Bulletin Board)

The oil level inside the pan should be below the bottom of the crankshaft counterweights, and above the oil pickup screen. This will be determined by the shape of the oil pan. Check to see that the oil dipstick tube is the correct length for the engine. Then compare your dipstick

with another that is known to be correct for your engine. If both dipstick tube and dipstick are correct, this will place the FULL mark at the right height inside the pan.

Fill the engine with enough oil to reach the FULL mark after the engine has run long enough to fill the filter. Your engine may have a different type of oil pan, because Ford installed a different one at the engine assembly plant, or perhaps after the oil pan was damaged in transit and the only handy replacement was bigger.

Shocking Truth

I had the shock absorbers replaced on my '87 Merkur XR4Ti last month. About a week later, a really annoying rattle started, over even minor bumps. I took the car back, but the shop was really

busy, and couldn't replace the rear shocks for a while. I got pretty steamed, and the owner gave me a new pair of shocks, mostly just to get rid of me. It was only a matter of a few minutes to replace the shocks myself, but the noise was unaffected. Now I've got to go back to the shop and tell them I was wrong.

I can't find anything wrong. I even used a torque wrench to tighten the bolts, used Loctite on everything. There isn't anything loose on the rear axle, and the noise seems to come from the left rear shock when you pump the car up and down by hand.

ALLEN STARK
LANSING, MI

Go back with a bigger wrench and tighten the shock mounting bolts.

Merkurs use a shock with an upper and lower bushing. The mounting bolts go crossways through the mounting bracket, through the bushing and then through the other side of the mounting bracket. The bolt must be tightened enough to compress the bracket tightly against the metal sleeve spacer in the bushing. And sometimes that takes a lot more torque than a normal 10 mm 8.8 bolt is spec'd to. Try adding 20 lb.-ft. at a time until the rattle goes away, and then add 20 more for insurance.

Idler

I removed the battery from my car because it's going to be unused for six months. I've moved the battery from the unheated garage to a heated room, but how should I keep it from going dead over the idle months?

IRVING KAHN
NEW YORK, NY

You're on the right track by removing the battery from the car. Keep it in a cool, dry

place—not a damp basement. If the battery is charged, it won't freeze—so you could use a back porch or anyplace dry and out of the weather. Wash the exterior of the battery with a brush and a baking-soda-and-water solution to neutralize any acid, followed by a detergent scrubbing to remove any grease and oil.

Don't get either of these into the filler caps. The idea is to have the surface of the battery clean and dry, as current will leak along the grease and dirt between the terminals and slowly discharge the battery. Prevent corrosion on the terminals themselves by applying grease to exposed metal. I find that Never-Seez, or some other antiseize lubricant, is good, but messier than grease. Don't use oil, as it tends to migrate onto the battery top, and collect dirt.

Periodically charge the battery to keep it at peak capacity, as batteries age much faster when they are discharged. Once every couple of weeks is fine, and a brief charge from a 4- or 6-amp charger should be ample. Don't leave a trickle charger connected permanently. I have a "float" charger, intended to be hooked up and charging full-time, but I don't like to use even that for longer than a day or two.

Be sure the cells are filled to the mark, and don't use anything but distilled water to fill them.

Illuminating Situation

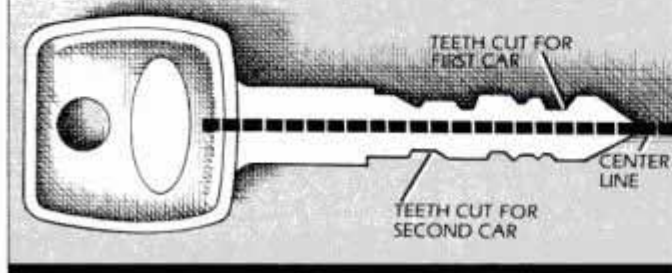
I want to tow a small camping trailer with my new Eagle Premier. The RV dealer wants way too much money to hook up the trailer lights, and says that I'll have to use a switch Velcroed to the brake pedal for the brake lights.

The Eagle dealer says it's

One Size Fits All

Those of us with more than one car will appreciate this tip. Tired of your pants falling down because your keyring looks like it should belong to a night watchman? Late model Fords have double-cut keys, with tumbler cuts on both upper and lower surfaces so it doesn't matter which side is up. Any competent locksmith can cut one face of the key for one car, and the second face for your second Ford car or truck, reducing the number of keys weighting down your jeans by one. Be sure to start with a key blank that fits both locks. The only shortcoming to this whole idea is that you'll have to remember which side is up for the car you're driving—but that sounds like it's not any harder than figuring out which key it is.

IGNITION KEY



because of the "lamp outage module." They don't want anything to do with the whole project.

LEROY NELSON
CHARLOTTE, SC

It used to be that you could simply tap into the wiring harness in the trunk and hook up the trailer lights on most any car or truck. Usually the only real change necessary was to use a heavy-duty flasher relay. Then people started to tow with foreign cars that used a different number of lamps. This required either an adapter box, or extra bulbs on the trailer.

Now we're seeing cars that know whether any of the running lamps are burned out, like your Premier with its outage module. Splicing into the wiring harness could possibly damage the circuitry in the module.

Go back to the dealer, and order P/N 4443972. It's a wiring harness that will plug into the Eagle harness in several places. It has several relays to isolate the trailer lights from the car's lights. You (or your mechanic) will have to drill several holes to route the new wiring, but there won't be any splicing. There's even a provision for backup lights.

Tiny Bubbles

My Cavalier has little drops of water inside the lenses of the headlights on damp days. I've replaced one of them already, and it's a little better, but how can I keep this from happening?

WILLIAM DARLING
GROVER'S MILL, NJ

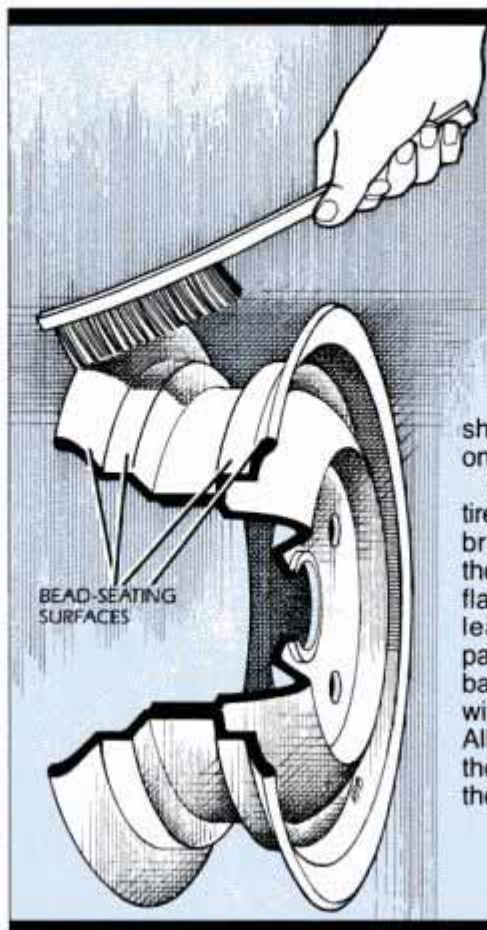
Your Cavalier has headlamps with plastic lenses (nearly shatterproof) and separately replaceable quartz-halogen lamps. There's a rubber seal to keep out running water and insects, but the interior cavity of the reflector is vented to outside air.

A small amount of moisture collecting inside the housing is normal. It will burn off as soon as the lamp's heat warms up the air inside, usually within a minute or two of turning on the lamps.

Take Me Higher

In the November "Letters" column, we responded to a letter from a Mr. Clarke taking issue with the boiling point of radiator coolant being lower at higher altitudes (which was asserted in "All-American Highways," May '89, page 66). He pointed out that modern cars with pressurized radiator caps maintain 13-14 psi inside the radiator, and there's no change in the boiling point, regardless of the altitude.

And we've been getting mail from readers on the topic. Lots of mail.



Rust Never Sleeps

You've mounted up a new set of tires on those old rims you found behind a stack of furniture in the back of the garage. And the next morning they're flat.

Hmmmm...those new tires shouldn't leak—they've never been on the ground before!

What the fellow who mounted the tires should have done first was to wire-brush the surfaces of the rim where the bead sits to remove corrosion and flaking paint. Undoubtedly, the air is leaking through the loose rust and paint. To prevent the rust from coming back, paint the bead-seating surfaces with some sort of rust-resistant paint. Allow 24 hours for the paint to dry, or the rim will bond itself permanently to the tire.

Both we and Mr. Clarke are part right. The actual temperature at which coolant starts to boil is dependent on the absolute pressure inside the radiator—the higher the pressure, then the higher the boiling point of the coolant.

There is a 14-psi difference between the inside of the cooling system and the outside, courtesy of the spring inside the radiator cap. This difference is sufficient to keep the boiling point above your car's normal operating temp, even at the top of Pike's Peak (14,300 ft. above sea level), where the air is only slightly more than half as thick as it is at sea level.

But the absolute pressure inside the radiator is the sum of that 14 psi and the outside atmospheric pressure, normally about 14.7 psi at sea level. That absolute pressure inside the radiator will be lower at higher altitudes where the outside pressure is lower. The bottom line is that the assertion in the May '89 issue that the boiling point goes down as the altitude goes up was correct.

You Can't Do That

I have a 1987 Celica. It runs pretty well, but I was wondering if there is any emissions equipment I could remove for better mileage and power.

JIMMY CLARK
HANSBORO, IN

No.

I thought about leaving my answer as that single syllable, but decided I'd better take this opportunity to remind everyone of two things. First off, it's illegal in many areas of the country to remove emissions control items. Secondly, unlike a generation ago, emissions devices aren't tacked-on—they're integrated into the rest of the engine calibrations. Removing them is more than likely to result in a net decrease in performance.

Short of removing the entire fuel-injection system and replacing it with a brace of carburetors, you're outta luck. And even at that point, you will undoubtedly see a decrease in the mileage to accompany any possible increase in power.

Needed

I own a 1986 Camry with an inaccurate speedometer. I removed it with the intention of moving the needle on the shaft as an inexpensive method of correcting it. I discovered a lever which anchors the mainspring, and by moving the spring to a different notch, was able to change the tension on the spring and correct the error. Neither the local dealer's mechanics nor Toyota's support people knew anything of this.

KURT LARSON
LAKE CHARLES, LA
(Please turn to page 41)

Reach new heights.



Many cars with mechanical speedos do have alternate drive gears available to correct for things like larger tires—but I don't know of any car manufacturers that suggest that the speedometer mechanism be serviced at the dealership level. So I'm not surprised the dealer was in the dark.

But—you say you were going to move the needle on the shaft. Does that mean that the needle didn't sit at zero when the car was at rest? That's not necessarily a problem. Speedometers can have either an offset problem, or a percentage error, or both. Changing the spring tension would have an effect on percentage error, but you'd have to calibrate the speedo at two different speeds over a measured mile to find the exact error.

If the odometer is off by the same number of miles per hour at, say, 30 and 60, you probably have an offset problem. In that case, move the needle. If the percentage of error at two speeds is the same, it's a percent error, and you should move the spring.

But frankly, I don't recommend messing around in there. Find a speedometer shop and get it calibrated properly. Smokeys have heard all of the stories about speedos being off—and the ticket he'll write will probably cost more than the calibration.

Shakin' Street

I have a 1985 Honda Accord. It shakes a little when braking. What can I do to eliminate or reduce this shake?

MARK WALTERS
ARLINGTON, TX

First, be sure that your tires are all on straight rims, that they are round and properly balanced, and the rims are mounted square on the hubs. Mostly you want to eliminate the possibility of any shake from the tires because the problem is probably in the brakes.

Get a good brake technician who knows Hondas to go through the discs and drums looking for out-of-true conditions. You can do this yourself on the discs if you have or can borrow a micrometer and dial indicator. Total runout should be no more than a couple of thousandths. For drums, you'll need a special tool. Tracking down vibrations that appear only under braking is usually pretty straightforward, but too lengthy to discuss here.

Honda discs are notorious for being difficult to machine properly, even on a good disc brake lathe. If you can't get the job to someone who has an on-the-

car lathe, I'd buy new discs.

Too Cool

My '87 Mustang seems to have an idling problem after it's warmed up, but only on cool, humid days. The idle goes up as high as 2000, and if I shut the engine off for a few seconds it returns to normal for a while.

The Ford mechanics have replaced the processor and a lot of other stuff, but they admit they don't have a clue.

MARK BRISETTE
HULI, QUEBEC

Well, if it's only a problem, as you say, on days when the humidity is high, and the temperature is cool—but is still above freezing—then maybe I can help. Carburetor icing happens to fuel injection too.

When cool, humid air goes past the venturi, its temperature plummets rapidly to well-below freezing. Most of the water will turn to ice, and can build up in places like the idle air controller passages, around the edges of the throttle plates, and generally where it's not supposed to be. Shut the engine down, even for a few seconds, and the thin ice will melt enough to drop off.

Look for problems in the thermostatic air cleaner, which pipes preheated air into the system. Also there's a water hose that preheats the manifold near the FI throttle body, so make sure that's flowing hot water in good quantities.

PM

SERVICE TIPS

■ A howling noise under braking on 1988 Eagle Medallions may be quieted by adding six brake shoe silencer pads (PN J1203158) between the rear shoes and the backing plate. TSB 05-52-89 P1770

■ Chevrolet TSB 87-145-6D specifies acceptable internal resistances for distributorless ignition system coils used on Delco Type II/DIS. Measure coils both cold and hot, as resistances may change as the coil warms up.

■ Some 1987 Bonneville with 3.8 roller lifter engines may have a valvetrain clatter on initial startup until the pushrods are replaced with another set (PN 25532162) 0.057 in. longer. This condition may be annoying, but engine durability will not be affected, according to TSB 87-6(Gasoline)-22.

■ Cadillac TSB 87-3-9 applies to Caddy alloy wheels, but the repair procedures involving patching leaks with RTV Silicone apply equally well to any leaky alloy wheel.

■ 1989 Jeep Grand Wagoneers and trucks have revised front wheel toe-in specs, according to TSB 02-57-88. The new specs call for a total toe-in of 0 to 5/32 in., divided equally between the right and left sides of the car. Camber, caster and steering axis inclination remain unchanged.

When it comes to pickups, some buyers set their sights higher. One look at the 1990 Sierra, and you'll see why that suits us at GMC Truck just fine.

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The 1990 Sierra from GMC Truck. It's the one pickup every other truck on the road has to live up to.

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This kind of technology is usually found only in expensive commercial systems. But the Homewatch 2000 is as easy to afford as it is to install and use. We even provide a videocassette, "Homewatch and Home Security," with each unit to help you maximize your home security plan.

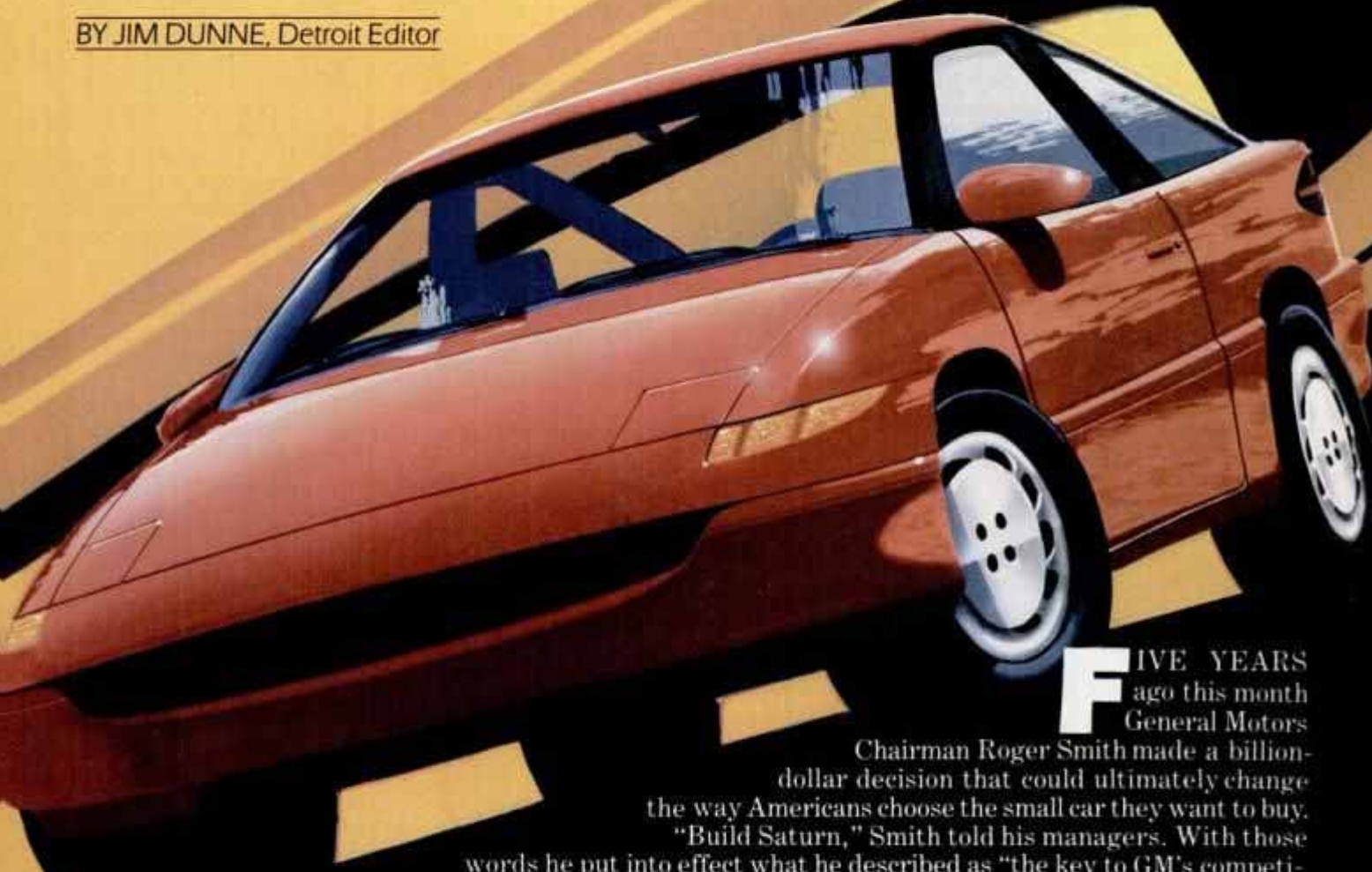
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SATURN RISING

The goal is to totally reinvent the car business.

BY JIM DUNNE, Detroit Editor



FIVE YEARS ago this month General Motors Chairman Roger Smith made a billion-dollar decision that could ultimately change the way Americans choose the small car they want to buy. "Build Saturn," Smith told his managers. With those words he put into effect what he described as "the key to GM's competitiveness, survival and success as a domestic producer."

It's no secret that GM's historically dominant grip on the American car market has been weakening. Imports, especially the small Japanese cars, have been gnawing away at GM's market share for decades. The erosion has been relentless. In the last ten years GM's share of U.S. car sales has dropped from a powerful 45 percent to a tenuous 34.6.

As long ago as 1959, GM began its campaign to fight import market penetration. To understate things a trifle, it's been a war with few victories. Remember Corvair? Vega? Chevette? Built with traditional GM methods, each of these cars failed its mission. Critics say they were overdesigned, or overweight, or too costly to build in the U.S.—or, just not in the same quality ballpark as the imports.

Whatever the reason, GM has been forced to use imports and/or joint venture cars like Geo Storm, Prizm and Metro, or the Pontiac LeMans to fill out its small-car offerings.

From the start, Smith's plan was fairly simple. Create a completely new car

SATURN RISING

Author has spied on Saturn's progress at GM's Milford Proving Grounds through several stages of development, as shown by these heavily disguised prototypes.



company, one that wouldn't be burdened by GM's vast bureaucracy.

It would have to be lean in terms of number of employees, and use the most up-to-date assembly, design and technology. It would have to establish a new relationship between labor and management. Costs would have to be kept to an absolute minimum by stressing efficiency, not only in the way the cars would be built, but in the basic structure and setup of the whole organization.

Today Smith and General Motors are entering the final stages of the Saturn project. A new factory in Spring Hill, Tennessee has been built. It is probably the most modern and sophisticated car-assembly complex in the world. Veteran GM workers have gone through intensive training that focuses on world-class quality. Saturn dealers are readying new showrooms dedicated exclusively to the new make.

Six months from now Smith's vision of the Saturn car will be officially unveiled to the public. Briefly, what you will see is a subcompact car built in two body styles—a 4-door formal sedan and a sporty coupe. Later, a sta-

tion-wagon variant is planned.

The new car is uniquely designed, unlike any other General Motors car. It features a new engine, a hybrid approach to making body panels and styling details that will set it apart from other cars in its class. It will be, according to Smith, "fully competitive with the best of the imports."

In all, GM says it will spend some \$1.9 billion to get Saturn on the road. For that investment, GM hopes to build 120,000 Saturns during the first year, then work up to as many as 240,000 a year.

These production numbers are certainly not record-setting compared to some other domestic plants—Chevy, for example, builds and sells that many Corsicas and Berettas in eight months—but they would prove that Saturn, and GM, can compete against the best of the imports, especially those from Japan.

Like most automobile unveilings, Saturn's details are being kept as secret as possible until the vehicle is ready for sale. However, the attention on Saturn has been so intense that many of the plans and design details have become common knowledge among the Detroit cognoscenti.

From that

information, we've been able to put together a fairly complete description of the car itself, and of its probable performance. We also have a pretty good idea of the price tags Saturns will carry.

Engineering

Technical details are straightforward and contemporary, though not what could be called leading edge. Front-wheel drive, a 1.9-liter 4-cylinder engine, 4-wheel disc brakes and a choice of 5-speed manual or 4-speed automatic transmission. The unitbody construction rides on independent suspension and coil springs at all four corners.

Two versions of the engine will be built, one with a single-overhead camshaft and a performance version with twin cams and four valves per cylinder. Early dyno testing indicates the base engine will be rated 95 hp, while the dohc version will make about 125.

Engine blocks and heads are out of the ordinary in that they are all aluminum alloy and are formed by the lost-foam casting process (see sidebar). Early tests of the engine in prototype Saturn cars indicate that fuel economy will be competitive with some of the better imports in their class. On the EPA schedule, the car is expected to deliver 28 mpg in city driving, 36 on the highway, with a combined average of about 30.

By way of comparison, the 1.6-liter Toyota Corolla is rated at 25/29 mpg for city/highway driving, and the 1.6-liter Honda Civic is rated 33/37.

The competition

Originally designed to compete against Corolla and Civic, the leaders in the subcompact class, Saturn insiders claim that their car will be the biggest subcompact on the road in terms of EPA interior-volume ratings. Wheelbase for the 4-door will be an unusually long 104 in. (Corolla is 95.7, Civic 98.4), while the coupe wheelbase is 99.2 in. Overall length is in the 170- to 175-in. range for the sedan, and only 162.4 for the coupe.

Curb weight is expected to come in at about 2500 pounds.



Sedan has roomy modern look.



Evolution of Saturn's glass post styling can be seen in this series of shots, taken over several months during prototype development. Glass wraps around A- and C-pillars to provide airy, open feeling.

Those specifications run contrary to company claims of subcompact size and edge Saturn upscale toward the compact class, where it would compete with Toyota Camry and Honda Accord. The distinction is important, since it has a very direct bearing on pricing for the new car. When it was first announced in 1985, Saturn's price was forecast for under \$10,000. And that still might be the base price of a bare-bones model. But today's Camry and Accord can run well beyond \$15,000, which would put Saturn in the midrange of car prices, well above the majority of small imports.

Exactly who the competition will be remains a critical question, one that Saturn executives won't answer until later. If Saturn squares off against Corolla/Civic-class cars, the price will be at least \$3000 less than what Saturn would have to command versus Camry/Accord.

The official word from Saturn is that the car started out as a subcompact, but buyers want more room. So the car has grown up to the size of a compact/subcompact. Another reason might have to do with profitability. The bigger a car is, the more opportunity there seems to be for profit.

The final price decision, predictably, won't be made until the eve of introduction.

"We'll look at the competition once more just before making an announcement," says Saturn president Skip LeFauve. "But we don't think our price will drive people away."

You will be able to buy a Saturn car starting next fall at one of the 85 to 90 dealerships planned for major markets around the U.S. at introduction time. At Saturn's insistence, the cars will be displayed in exclusive showrooms, though dual dealerships are expected, which has become standard practice for the establishment of new franchises in the U.S. today.

Wherever the car slots in, Saturn is still expected to fulfill GM's stated intention, voiced by Roger Smith, of producing "an American vehicle that can beat the Japanese in the current small-car race."

"We will be as good as the best

competitors right from the start," says LeFauve. "And we think people, in their hearts, want to buy American. In surveys we've heard 'if you can build a car as good as the imports, we'll buy it.'"

Design

One feature that Saturn officials demanded from the start was a 4-passenger car that presented a look that's different from the standard GM style of today. What they had in mind was a car that could be mistaken for a Japanese make more often than for a Chevrolet.

From the photos of prototype bodies that have appeared in these pages over the past couple years, that effort seems to have been successful. In fact, the styling has more reach than simply matching the Japanese. It actually breaks some new ground, especially in the design of the greenhouse. At the front and rear you see the glass-post look, where glass from the doors appears to butt up against the windshield and the rear window, masking the A and C roof pillars.

By using glass to cover both the front and rear pillars, and by covering the central B-pillar with blackout paint, Saturn designers have created a lightweight appearance for the car, one that creates the illusion of the roof cap floating atop what appears to be all glass supports.

Beyond the obvious differences in the number of doors, styling of the sedan is markedly different from that of the sporty little coupe. The coupe has hidden headlights, while the sedan's are only partially covered. The coupe also has a more rounded beltline that swings upward at the rear while the sedan's belt is more horizontal. Overall, the sedan is much more conser-

vative, with a traditional formal 3-box design, while the coupe is a 2-box fast-back.

Both models use steel and plastic for exterior body panels. Generally, the vertical panels, like doors and fenders, are made of plastic and formed from plastic sheets on heated dies at the Saturn factory. Some curving time is needed to fix the shape. The horizontal panels, those that might bear loads, like the roof and rear deck, are made of standard automotive sheet steel formed on high-production dies.

You can't tell the difference between the plastic and steel body parts by merely looking at them. Both are painted the same color with a new paint process that uses thin coats of color topped by a thick layer of clear coat.

Although most agree that Saturn lines are fresh, few are willing to call the design a trendsetter.

"The glass-pillar look isn't a Saturn trend," says Chrysler design vice president Tom Gale. "It's an industry trend. You see that on other cars already."

"But the plastic body panels are important. They'll cut down on the lead time it normally takes to make styling changes, and that's a plus."

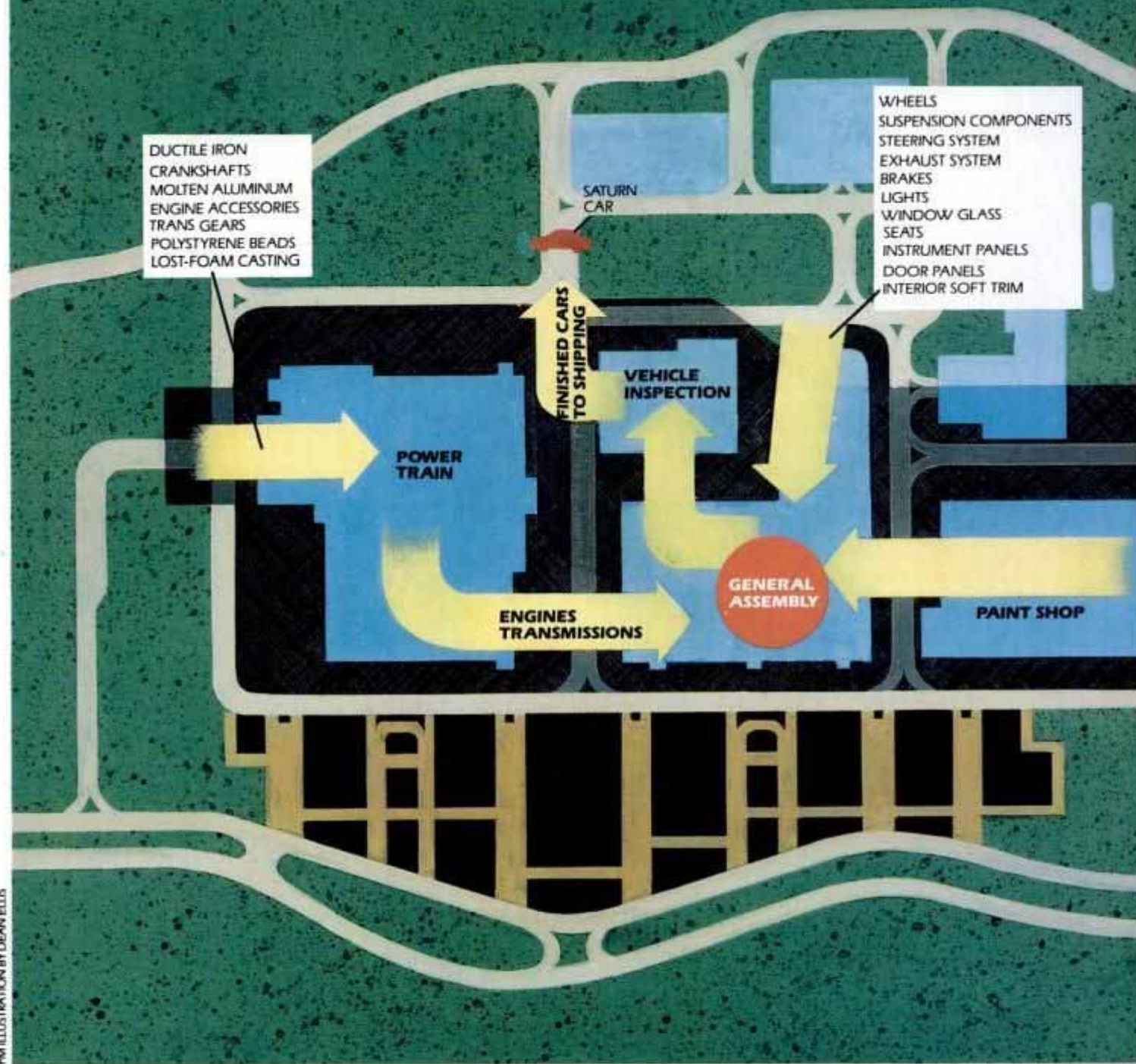
Saturn's chief of manufacturing, Guy Briggs, says that it is also much easier to assemble a car with plastic panels compared to a car with a welded steel body.

"Workers on the assembly line can reach inside the car through holes where the panels are later attached," he says. "The body panels are bolted or glued in place after the interior work is completed. That makes for



Saturn Coupe sports hidden headlights.

SATURN MANUFACTURING PLANT



PM ILLUSTRATION BY DEAN ELLIS

easier work on the line, and better quality overall."

Assembly

How can Saturn build cars that match the quality of the best of the competition? The answer you get from Saturn managers and workers is a deceptively simple one: People.

"Ultimately, people will make the difference," Briggs explains. "Other companies can buy the same technology we have. But the bottom line comes down to the people who operate and maintain the equipment. That's where the difference is."

The Saturn workers are a unique group, and a promising one. All of the factory hands are veteran GM employees who volunteered to come to Saturn. For all of them, the new assignment meant a family move to the Spring Hill area, which was little more than a wide place in the road three years ago, and in some cases even a reduction in pay.

"They come here not with the promise of a bonus, but for the opportunity to participate in design decisions," says LeFauve. "Our workers are taking great risks coming to work here. So there is not a casual attitude

toward business at any level."

Saturn union workers are under a separate United Auto Workers contract, one that leans heavily toward worker participation in running the plant. Line workers, for example, were sent to machine tool builders here and in Japan to oversee—and, in some cases, custom refine—the production equipment they will be using to build Saturns.

You will see other new ideas in production efficiency at Saturn, including just-in-time delivery of parts and materials, an inventory reduction technique that was developed in Ja-



The Lost-Foam Casting Process



SATURN'S ENGINE uses no special new technology, but building the cylinder head and engine block with the lost-foam casting process is unusual. If not unique, for a high-volume production automobile. At the Saturn foundry, the casting process is designed to produce close-tolerance engine parts at a high rate of speed.

The lost-foam process starts with a form fashioned out of polystyrene, a material similar to that used in ordinary carryout coffee cups. The form is the exact replica of the part to be cast. This form is buried in a sand-filled flask with a vent hole protruding. Molten metal is poured into the hole where it vaporizes the polystyrene away.

At Spring Hill, the process starts out with the delivery of crucibles of molten aluminum by bottom-dump semitrucks. The aluminum is unloaded through a launder system to electric furnaces that raise the temperature from the delivered 1300°F to about 1350°-1400°. From there the aluminum goes into a standard casting process where the metal is poured on top of the foam forms.

After 20 minutes, when the metal drops below 750°F, both sand and the casting are dumped out of the forming flasks while the aluminum part moves on to final machining lines. Benefits of lost-foam aluminum castings come from its light weight and the precision of the casting process.

Parker Stroom, the business team leader at Saturn for engine production, claims that he gets excellent dimensional control over



Molten aluminum is poured into sand molds, melting and displacing Styrofoam cores (above). Sand molds are stripped away from cooled aluminum castings (top).

the casting. One result: Parts that are added to the block and head later are in perfect alignment. In addition, there is less need to machine off excess stock because the final part is cast correctly from the beginning.

"We also put a lot of detail in the casting that would normally have to be machined in later," says Stroom. "That includes things like oil return lines and the oil filter pad."

Lost-foam parts are not simply copies of cast-iron castings. "The part has to be specially designed for this process," Stroom relates. "But that gives the engine designer a chance to make a casting that bypasses a number of normal machining steps." —J.D.

pan. Another example is an engine assembly line whose height goes up and down at various stations to optimize specific operations.

In addition, all Saturn employees are walked through the various construction details of competitive models like those from Honda and Toyota. Competitive cars are brought into the Saturn factory where each employee is shown the techniques and quality levels. At one time last spring, the instruction garage contained all of the current Honda models for the workers to inspect.

Saturn is not burdened with multi-

layered job assignments. Taking a page from some Japanese factories, only three worker classifications will exist in the Spring Hill plant—worker, electrician and mechanic. In some GM plants it's possible to find upward of 75 different classifications.

Saturn's offices are also staffed with UAW members, to make certain the idea of union participation is spread throughout the company.

"We want the involvement of the UAW in business decisions," says LeFauve. "There is a real value added when communications flow between management and labor. And the sub-

jects aren't just work rules. They're business decisions, too."

As Saturn draws steadily closer to its production startup next July, an outsider can sense the increase in confidence at the company.

"We'll be every bit as good as the competition from the first car," says Briggs. "And from then on we'll get better."

LeFauve is even more confident.

"The question is not, why buy a Saturn when you can buy an import," he says with a grin. "It should be, why buy a Honda or Toyota, when you can buy a Saturn." **PM**

PONTOON

Gone are the sluggish, spare metal boxes of old. Today's pontoon boats are upscale, stylish and surprisingly fast.

BY TIM BANSE; PM Photos by Skip Gandy



MISTY HARBOR 2000

WARP SPEED and G-force cornering aren't the only measures of performance. Although less demanding than muscle boats, weekend party cruisers have their own set of standards. The best of these boats are adept at leisure exploring, handling extensive passenger lists and accomplishing this with all the comforts of home, such as wet bar, beverage dispenser, entertainment center, TV set and barbecue grill. No other craft on the water fulfills these requirements better than a pontoon boat.

Perhaps the most attractive quality of pontoon boats, especially for the very youngest and oldest members of the family, are their reassuring sense of security. These RVs of the water, even the smallest, barely react to

waves and wake, because of their generous size and stability. Passengers hardly think twice about walking about while underway.

Speed and handling, while not the leading concerns, aren't entirely neglected, either. Many party platforms are quick enough to tow waterskiers and a few rip along at 50 mph. They may not be the most nimble handlers on the lake, especially when docking into the wind or fighting a current. But that's not to say they're clumsy. And while they don't turn on a dime like a semi-V hull, what they lose in handling they gain in extremely shallow draft and rock-solid stability.

With this in mind, the PM test team handpicked a fleet of four pontoon boats representing a cross section of current design trends. They range from a spare fishing model to a radical

speedster, from a high-tech dazzler to a top-of-the-line cruiser as luxurious as Cleopatra's barge.

The fleet was assembled at the Gallatin Marina on Tennessee's cove-studded Lake Hickory, a meandering waterway that rewards weekend explorers with views of pristine wilderness, bluegrass farmland and glittering mansions—many of which are owned by country music stars from nearby Nashville.

All boats were analyzed by the test team in a rigorous fashion, but because they differed so widely in power and size, no head-to-head comparisons were made. What emerged after three days of testing was an overview of leading pontoon boat designs and an appreciation of how well these craft fulfill their let-the-good-times-roll mission.

CRUISERS



HARRIS FLOTEBOTE 280 ROYAL HERITAGE

Godfrey 2600 Sanpan Royale

Do you want a barbecue grill for your pontoon boat? No problem. Color TV? Included. Pump-actuated beverage dispenser? Standard equipment. Entertainment center? Naturally. In fact, the Sanpan Royale's approach to the good life is quite impressive, if not downright overwhelming.

The 26-footer's deck is divided into three areas: 1. bow patio forward of the rail (with gas grill), 2. midship lounge with port dinette table, and 3. L-shaped aft lounge with wet bar, dinette table and helm.

Interestingly, overhead storage compartments with ultrafirm Velcro latches are built into the sunroof. This is an ideal, out-of-the-way location for the TV and a few light objects, such as towels and life vests. Other onboard

amenities include in-dash Lowrance depth finder and pop-up changing room with marine head.

The test team was equally impressed with the Sanpan's stability, cornering and tracking. However, we were disappointed in overall performance, due to the small 50-hp Yamaha outboard motor. We feel most boaters, especially those who appreciate the Sanpan's dazzling array of high-tech features, will opt for an outboard closer to the 100-hp range.

Despite the deluxe approach, some latches didn't quite fit doors and some fasteners inconsistently mixed wing and lock nuts. Also, we would have preferred a more careful approach to marinization of the wiring connectors and fuse block.

On the plus side, the Sanpan Royale represents a unique compromise be-

tween all-out, high-tech luxury and superb dollar value. Minus engine and trailer, retail price is \$11,600. Price for a complete boat-engine-trailer package is \$16,299.

Grumman 20 Fish 'N Funship

In many ways the Grumman Fish 'N Funship is the classic pontoon boat: Aluminum floats, flat deck, side console, aft sunroof, outboard motor and an appearance that quickly declares the twin goals of functionality and affordability. What makes the Grumman unique is that it's also a dedicated fishing boat with an 18-gallon aerated livewell, twin pedestal casting seats, electronic positioning motor and Lowrance fish finder.

Like all pontoon boats, this 20-footer has plenty of room for passengers

PONTOON CRUISERS

and seats nine, but we found the Fish 'N Funship broke ranks with the fleet by sporting few standard amenities beyond ice chest, drink holders and Bimini top. The minimalist helm, for instance, was bare of instrumentation. The payoff for Grumman's spartan approach, as always, is on the bottom line. The Fish 'N Funship retails as a package for \$9875, which includes 50-hp Suzuki outboard with power trim, positioning motor, electronics and a trailer.

Underway, the Grumman demonstrated adequate speed and stability, but two less desirable characteristics were revealed: 1. a wet carpet underfoot and 2. slight flexing caused by independently twisting pontoons. Both problems could be corrected by installing a full-length splash plate between the deck and pontoons, a standard component on the rest of the fleet. A redesign of 1990 model engine boxes is planned by Grumman, which will cut down on turbulence and help solve the wet-carpet problem.

One successful element is the twin-shelf design on the transom, replacing the swim platform. Fishermen will find these useful for installing two 6-gallon fuel tanks, for extended range, and dual batteries, for running electronics and positioning motor. The arrangement also keeps gasoline and



GODFREY SANPAN ROYALE

battery acid as far away from passengers as possible.

As mentioned, the Grumman is a spartan fishing platform, and fit-and-finish was not a strong suit. This was especially evident in the jury-rigged binnacle control mounting with deeply protruding through-bolts, squared corners (instead of rounded) on the coffee table/ice chest, and vibration rattling while underway.

The key to the Grumman's appeal is price and in this area it's easily the fleet leader.

Harris FloteBote 280 Royal Heritage

It's impossible to find a straight line or squared edge on the 280 Royal Her-

itage, which takes curvilinear design to new heights. The Royal Heritage melds the best of upscale aluminum and fiberglass construction into a highly stylized look where every element consists of flowing lines and sweeping curves.

The deck is laid out in two semicircular modules, each comprised of deeply cushioned seats centered around a coffee table/cooler (forward) and pedestal-mounted table (aft). Curvilinear shapes even extend to cabinets, consoles and the sturdy aluminum railing enclosing the deck.

In addition to new-age looks, the Royal Heritage is easily the Rolls-Royce of the fleet. Upholstery is especially soft, smooth and well padded. A

TEST PARAMETERS

Boats were propped, tuned and equipped by manufacturer. Speed and timing data are result of averaging four test runs with two adults aboard and matched fuel loads. Decibel levels were measured at helm in dB-A at idle speed and wide-open throttle (WOT). Fun factor (1-10) is a combination of layout, features, versatility, operational ease and comfort, which is as important to a pontoon boat as top speed is to a muscle boat.



MAKE/MODEL	GODFREY 2600 SANPAN ROYALE	GRUMMAN 20 FISH 'N FUNSHIP
LOA/Beam/Weight/Fuel Capacity	26' 8" / 2515 lbs. / 18 gal.	20' 8" / 1500 lbs. / 12 gal.
Deck Space (sq. ft.)	116.9 sq. ft., functional 3-module layout	101 sq. ft., obstruction-free deck space
Stowage (cu. ft.)	34.8 cu. ft., clever overhead compartments	24 cu. ft., huge livewell
Engine	Yamaha Pro 50, bigger outboard needed	Nissan 50 hp, outboard with power trim
Decibel Level (dB-A) Idle/WOT	60 dB-A/88 dB-A, quiet and smooth running	73 dB-A/95 dB-A, vibration and rattling
Top End (mph)	20 mph, less with several passengers	20 mph, but bare minimum
Acceleration 0-20 (sec.)	8.73 sec., decent time reveals effective design	11.01 sec., slowest in fleet
Fit & Finish	Despite deluxe approach, a few nits to pick	Spartan approach matches affordable price
Fun Factor (1-10)	8, dazzling high-tech features, smooth performer	6, fishing machine with recreational possibilities
Price	\$16,299, complete package	\$9875, complete package
Manufacturer/Address	Godfrey Marine, 22787 County Rd., Elkhart, IN 46516, (219) 522-8381	Grumman Boats, Box 549, Marathon, NY 13803, (607) 849-3211
<p>Marine Aluminum—Most pontoon boats are constructed of 5052 alloy. This aluminum alloy contains 2.2 percent to 2.8 percent magnesium, which contributes to its extremely high level of corrosion resistance. Thickness for sheet or coil aluminum is measured in gauge, which is a percentage of an inch. For most pontoon applications, .050 gauge to .070 gauge is used.</p>	<p>In-dash chart recorder. Fully loaded command console. High-mounted, easy-to-monitor instruments. Comfortable and accessible controls. Plenty of legroom.</p> 	<p>Small, spare unit unencumbered by engine instrumentation. Minimalist approach is acceptable in fishing model. Plenty of room for fish finder and other electronics.</p> 

short list of plush amenities includes stereo stack unit, wet bar, instrument-studded command console, 5-gallon freshwater tank, fold-up changing room with enclosed marine head, fold-down arm rests on sofa-style seats and liquor cabinet. The helm, of course, is fully tricked out with instrumentation and there is enough seating to rival a small-town movie theater. The price also reflects its royal heritage—\$27,300.

Not surprisingly, the Royal Heritage was ultrastable, due in part to its fleet-leading length (28 ft.) and weight (3190 pounds). Despite its size, the Royal Heritage handled effortlessly and ran with surprising swiftness (28 mph). The latter is due to a big, smooth-running 130-hp Yamaha sterndrive powerplant, the only I/O in the fleet.

Fit and finish, as mentioned, is superb throughout. Welds were flawless, structural elements solidly supported and seat frames constructed of durable rotocast.

It was hard to find nits to pick on the Royal Heritage, but there were a few. For example, the heavy plexiglass door on the liquor cabinet sagged somewhat on its hinges. And two design choices were made at the expense of deck space: 1. curvilinear seating modules, although pleasing to



GRUMMAN 20 FISH 'N FUNSHIP

the eye, cut off a lot of usable area, and 2. sterndrive engine, which occupies more space than an outboard.

But this upscale 28-footer has space enough to burn, and luxury-seeking boaters will applaud the final result.

Misty Harbor Model 2000

Our Misty Harbor test machine raised a few eyebrows when it came off the trailer rigged with a Merc 150 outboard. It raised even more when it clicked off radar-gun speeds of 46 mph, nearly twice the speed of the other boats in the fleet. With aftermarket props, the boat scorches the water at 50 mph.

At first glance, it looks similar to

the others, but instead of rounded, barrel-type aluminum floats, the bottom of the Misty Harbor floats are configured like the letter W. Punching the throttle pushes these foam-lined pontoons onto the tips of the Ws, similar to being on plane.

How do these radical pontoons behave at speed? Steering required more effort to conquer torque than the rest of the fleet, but not enough to be aggravating. Tracking is true, cornering is good and, overall, the ride is stable and dry.

In addition to being a speedster, this 20-footer is a functional fishing platform with two bow-mounted pedestal seats and a casting area unhindered by forward rails when the gates are open. Other features include built-in cooler and seating for 10.

Higher speeds demand greater structural support, such as extra bulkheads and crossmembers, so many of the Misty Harbor's noteworthy construction details are hidden. On the surface, the boat is adequately appointed and a significant portion of the \$13,999 retail price, no doubt, is consumed by the big Merc engine.

Since structural soundness and on-deck simplicity are the design goals of the Misty Harbor, it's hard to find a fit-and-finish failing. Perhaps, the biggest overall negative was fuel consumption—150-horses at full gallop work up a big thirst, especially pushing pontoons.

Although this speedster seems to go against the grain of the leisurely pontoon-boat lifestyle, Misty Harbor has carved out a unique niche and many boaters will find the option of speed hard to resist.

Besides hours of tape measure, stopwatch and radar-gun work, our three days on expansive Lake Hickory included some time for fishing, skiing and scenic cruising. It was part of our job to determine if these pontoon boats are truly the versatile, good-time party platforms they're cracked up to be. Our conclusion is they are. Look, somebody had to do it! **FM**



HARRIS 280 ROYAL HERITAGE	MISTY HARBOR 2000
28' 8" / 3190 lbs. / 25 gal.	20' 8" / 2000 lbs. / 18 gal.
117.8 sq. ft., curvilinear design, roomy	109.7 sq. ft., large bow area extends beyond rail
56.9 cu. ft., immense compartments	28.5 cu. ft., stern area can accommodate skis
Yamaha 130 hp, fleet's only sterndrive	Mercury 150 hp, biggest outboard in fleet
70 dB-A/91 dB-A, sturdiness dampens noise	62 dB-A/92 dB-A, predictable whine at top end
28 mph, good speed for large boat	46 mph, fleet speedster, with right prop 50 mph
5.01 sec., surprisingly responsive to throttle	4.6 sec., hole-shot champ
Marvelous craftsmanship and attention to detail	Clean detailing throughout, solid construction
9, luxurious feel, Rolls-Royce of pontoon world	7, ideal for skiing and fishing, on the lean side
\$27,300, complete package	\$12,999, includes engine
Harris Kayot, P.O. Box 264, La Grange, IN 46701, (219) 463-7474	Misty Harbor, 1112 Twentieth St., Humboldt, IA 50548, (515) 332-1222

Superb visibility of high-mounted instruments. In-dash depth sounder and compass exemplify Rolls-Royce approach.



Clean, functional styling can't be faulted, but somewhat on the spartan side. Unobstructed sightlines. More than enough room to add electronics.





MAGNAVOX AZ8390

The addition of digital audio compact disc players puts new demands on portable stereos. The Magnavox AZ8390 (\$380) uses a dynamic boost circuit to handle CD's deep bass.

HI-FI TO GO

The boom box is getting a sonic and stylish upgrade, and moving from the park to the parlor. We try out 12 top portable audio systems.

BY FRANK VIZARD, Contributing Editor; PM Photos by Brian Kosoff

HOW MUCH BOOM is in a boom box? That's a question rattling everyone's ears since one was first shouldered by a dude strutting down the street to a portable beat. Portable stereos, as they are known in gentler society, have since graduated from the cityscape to the picnic knoll, the

college dorm, the vacation home and the land of the guest bedroom.

Respectability for the boom box? Serious hi-fi fans might scoff at such a notion, and with good reason. Portable stereos generally suffer from too much distortion, identifiable by the THD (Total Harmonic Distortion) figure tattooed to a specification sheet.

A THD figure of 10 percent at 1 kilohertz is not unusual. Generally, the THD of quality home hi-fi components is less than 1 percent.

Portable stereos, nonetheless, have adopted a more dignified swagger since their recent association with the digital audio compact disc. The inclusion of CD players has prompted



SONY CFD-454

YORX DP-1515

The loudspeakers of Sony's CFD-454 (\$320) are detachable, for flexible placement that delivers the best stereo effect. Large 4.7-in. woofers deliver good bass from CD, radio or cassette. A subwoofer slot in the base of the Yorx DP-1515 (\$400) enhances bass reproduction from the attached speakers. Tone may be further adjusted with a 4-band graphic equalizer.



JVC RC-X510

A separate subwoofer powered by its own 6-watt amp generates plenty of boom from JVC's RC-X510 (\$320). Up to 20 selections may be programmed on the built-in CD player.

manufacturers to improve the sound of the basic box through more amplifier power and better loudspeaker performance. More watts means less distortion at high-volume levels. And since distortion is most prevalent in the bass region, the new CD boom boxes have loudspeaker sections with larger bass-woofers, subwoofers, or enclosures that are optimized for low-frequency sound propagation.

Trial-by-music

PM listened to a dozen top-of-the-line CD boom boxes to see if they delivered on CD's promise of crystal-clear digital sound. All together, they were a weird-looking crew—some boxy, some sleek, some curvy, and all different sizes. Their specifications and features are listed in the chart accompanying this report.

We were particularly curious about how loudly the machines could be played, without distortion. With CDs, the sound should be clean and the boom should be mean. Any boom box can play *loud*, but the boom must be listenable. To measure the boom, we used a methodology that could be easily duplicated in any hangout—a trial-by-music.

Each boom box was placed on a table at the narrow end of a 12 × 16-ft. room furnished like a typical den or family room, with both reflective and absorptive surfaces. A sound-pressure level meter was aimed at the music source from 12 ft. away—an average listening distance. We measured the "boom" or sound pressure level (SPL) by raising the volume until we heard distortion in the music—either muddy bass, indistinct vocals,

screchy treble or any combination of aural affronts. For our ears-on test, we played classical, jazz and rock selections recorded on CD, specifically, the "Fasch Concerto For Trumpet" by New Orleans artist Wynton Marsalis, "Rockin' At The Regas" by Denver keyboardist Rob Mullin and "Maggie's Farm" by the Irish rock band U2.

Just how much boom each CD boom box generated is indicated in the accompanying chart. The highest SPL figure, 98 dB (decibels), was generated by Sony's CFD-454 model. Most machines generated more than 90 dB while the lowest was 85 dB. To put those numbers in perspective, consider that U.S. Department of Labor noise guidelines state that a 100 dB level is permissible for a 2-hour duration per day while 90 dB is permissible



SHARP GX-CD10

SANYO MCD-950

Sharp's GX-CD10 (\$400) offers programmable CD, three bands of equalization, tape-to-tape dubbing at normal and high speeds, detachable loudspeakers and, as with all the machines, AM/FM. Weighing in at 24 pounds, Sanyo's MCD-950 (\$800) boasts two CD players and tape decks. A tubular acoustic horn atop the unit couples two speakers for enhanced bass output.

HI-FI TO GO



GENERAL ELECTRIC 3-7045

TOSHIBA RT-8089

Subwoofer effect and detachable loudspeakers are standard issue on General Electric's 3-7045 portable (\$320). So is the 5-band graphic equalizer, and CD player with 20 program tracks. Normal and high-speed tape dubbing, and 16 programmable CD tracks, are features of Toshiba's RT-8089 (\$480). Output power is 5 watts per channel, through two fixed speakers.

for 8 hours per day. A level of 90 dB is typical of the noise heard in a car in daytime city traffic. Daytime noise in a typical home averages 60 to 70 dB. Live rock concerts register 120 dB at front-row-center. The threshold of pain is 130 dB.

Handling the boom

Since bass notes generally require the use of large speakers, or woofers, it stands to reason that small, portable stereos would have trouble with the lower portion of the musical spectrum. Boom-box manufacturers use a variety of methods to get big bass from a small package—some of them are quite ingenious.

Sony, for example, uses perhaps the largest woofers practical for a portable, each measuring 4.7 in. in diameter. But large woofers mean the

CFD-454 is not very compact. It's the tallest of all the machines we reviewed, at 11½ in.

Deeper bass is achieved by the Aiwa CA-DW9U even though its woofer size is also 4.7 in. Unseen by the eye is a 4-in. subwoofer speaker firing through a port in the base of the CA-DW9U. A subwoofer is a speaker that handles only the lowest bass notes. The port enhances the output of the small subwoofer, and allows Aiwa to use a smaller enclosure than might be required otherwise. The CA-DW9U winds up being slightly wider and deeper but not as tall as the Sony CFD-454.

The more-compact portable stereos use the same ported-enclosure technique for their woofers, to generate greater bass from a smaller space without a subwoofer speaker. In some instances, as with the Panasonic RS-

DX650 and Soundesign 4955, the subwoofer effect is achieved or augmented by an electronic extra-bass circuit. This boosts low frequencies at low volume levels and reduces them at high volume levels to prevent boominess or muddy bass. The extra bass is controlled by an ON/OFF switch.

The most elaborate subwoofer system used is found in Sanyo's MCD-950 machine. It uses a separately amplified woofer coupled to a passive radiator by a long tube that acts as an acoustic horn. The system, which looks like some kind of acoustic particle-generator that escaped from the lab, supplements a pair of primary full-range speakers. Subwoofer output is controlled by twisting a throttle on the tube into one of three positions, depending on how much bass you want.

Yet another way to manipulate bass output is by using the graphic

SPECS

	AIWA CA-DW9U	FISHER PHD850	GENERAL ELECTRIC 3-7045	JVC RC-X510	MAGNAVOX AZB390	PANASONIC RS-DX650	SANYO MCD-950	SHARP GX-CD10	SOUND- DESIGN 4955	SONY CFD-454	TOSHIBA RT-8089	YORPX DP-1515
Price	\$600	\$800	\$320	\$320	\$380	\$350	\$800	\$400	\$230	\$320	\$480	\$400
Wattage ¹	3.2×2+10	NA	3×2	2×2+6	3.5×2	11×2	NA	4×2	2.5×2	4×2	5×2	5×2
SPL (dB)	96	95	96	92	93	92	97	93	85	98	89	89
Speakers	A	A	A	B	B	A	B	A	B	A	B	B
Subwoofer	Yes	Yes	Yes	Yes	Yes	No	Yes	No	Yes	No	No	Yes
Cassettes	2	2	1	2	2	1	2	2	2	1	2	2
Dubbing ²	N+H	N+H	N	N+H	N+H	N	N	N+H	N+H	N	N+H	N+H
CD Section:												
Number of DACs	2	1	1	1	2	1	1	1	1	1	1	1
Quantization	15-bit	16-bit	13-bit	14-bit	16-bit	16-bit	16-bit	16-bit	13-bit	16-bit	16-bit	16-bit
Oversampling	2×	2×	1×	1×	2×	4×	2×	2×	1×	2×	2×	N/A
Program Tracks	16	25	16	20	24	36	30	20	16	0	16	32
EQ Bands	4	4	5	3	3	5	3	3	3	5	0	4
Batteries (D cells)	8	*	8	8	8	10	**	8	8	8	8	8
Weight ³	16½	15	14½	15½	16	15	24	12	9½	14	12	18
Size(W/H/D) ⁴	26/11/9	29/7/9	26/9/6	23/8/9	26/8/9	28/9/9	29/10/8	25/10/8	25/9/8	27/12/8	25/7/8	24/9/9
Other	EGHI	FGHI		E			CEFGHI		D		H	

(A) Detachable speakers. (B) Fixed speakers. (C) Two CD players. (D) Internal and external microphones. (E) Mixing microphone. (F) Optional surround-sound speakers. (G) Wireless remote control. (H) Timer operation. (I) Dolby B noise reduction.
 *Internal rechargeable battery. **AC operation only.
 1 Watts per stereo channel, plus subwoofer output if applicable. Wattage ratings listed here represent the output at 10-percent total harmonic distortion. Manufacturers are not required to publish power ratings for portable audio equipment. 2 Recording at Normal (N) and High (H) speed. 3 Without batteries, rounded to the nearest half-pound. 4 Rounded to the nearest inch.



SOUNDESIGN 4955

FISHER PH-D850

The Soundesign 4955 is the least expensive CD portable in the group. Yet it offers tape-to-tape dubbing at normal and high speeds, 16 programmable CD tracks, and subwoofer bass. Fisher's PH-D850 (\$800) uses an internal rechargeable battery instead of D cells. A subwoofer reinforces bass production from the detachable speakers, and it has 25 programmable CD tracks.

equalizer included in 11 of the 12 boom boxes reviewed here. Indeed, the extra bass available in the Panasonic RS-DX650 is regulated with the 100 Hz slide control. Other slide controls of the graphic equalizers manipulate the amount of midrange and treble information present in the music. The more slide controls or bands available, the more you can manipulate the sound to your liking.

CD features

Sound quality is only as good as the source material, and the compact disc is the best there is. While there is some variation among the 12 evaluated in terms of the number of digital-to-analog converters (DACs), the quantization and sampling rates—factors that can influence how well a CD player performs—PM found the compact disc performance of CD boom boxes to be competent. Only the Yorx DP-1515 exhibited significant tracking problems. Two models, the Soundesign 4955 and the General Electric 3-7045, had audible machine noise akin to a fly buzzing in your ear when the CD player was first accessed. This annoyance did not affect their play, however.

A look at the accompanying chart will show that not all CD players are created equal—either among this

group, or between the boom-box CD players and conventional home CD players. Let's take quantization, the number of bits in the player's digital-to-analog converter. Most home players use 16 bits or more to resolve the audible range of frequencies from 20 Hz to 20KHz. The boom-box players with fewer than 16 bits do not pretend to handle the lowest and highest frequencies, which might be present only in some classical music. As for oversampling and the number of DACs, most home units today perform at least 2x oversampling and use two DACs. The CD players in the boom boxes are similar to first-generation home players: Very good, but with room for improvement.

Many of the features in home CD players are also available in CD boom boxes, but the mix is often different from machine to machine. Only Sony's CFD-454 lacked programming capability although random shuffle play is available. Some, like GE's 3-7045, offer programmability but not random shuffle play. Audible fast forward and reverse within a track was not always offered either.

Conclusions

Overall, the JVC RC-X510 and Magnavox AZ8390 represent the best values of the group in terms of styling,

sound quality and mix of features at an affordable price. The Panasonic RS-DX650 is also a notable value due to its high power, superb CD performance, detachable speakers and reasonable cost. The much costlier Aiwa CA-DW9U, Fisher PH-D850 and Sanyo MCD-950 are tops in the knock-'em-dead-at-any-price category. It's worth noting that the Fisher unit operates only on its own rechargeable batteries or on AC, and the Sanyo on AC only. Their manufacturers view them more as "transportable" systems than marching bands—and include infrared remote controls for convenience in the home.

Actually, none of these boom boxes is meant for street walking. Every CD player in the bunch is very sensitive to vibration and will skip or stop at the slightest shock. In this regard, this gang is not as tough as it seems. They all do best when they're standing still. If you must parade, stick to cassette or AM/FM radio playing.

On the plus side, all of these machines can double as a CD player for a home component system. CD output jacks allow for easy connection to a component amplifier or receiver. In this respect, CD boom boxes fulfill their promise of good sound while offering flexibility in how they're used and where they're played. **PM**



AIWA CA-DW9U

PANASONIC RS-DX650

A separate 10-watt amplifier powers a downfiring 4-in. subwoofer in Aiwa's CA-DW9U. The detachable speakers are driven by a 3.2-watts-per-channel amp. Remote control is included. You can program up to 36 tracks on a CD with Panasonic's RS-DX650. An extra-bass circuit in the 5-band graphic equalizer enhances low-frequency output from the detachable speakers.



DEEP QUEST

Recent treasure finds foretell an era in which technology will open up the dark world miles beneath the sea and put millions up for grabs.

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

IT WAS JUST a ghost of an image on the TV monitor, a shapeless blossom of multicolored pixels smeared across the screen. But for Tom Thompson and the crew of the dilapidated search vessel *Pine River*, it was the end of a rainbow. After a quest that stretched back almost 20 years and had consumed millions of dollars, they had struck gold.

What flickered before them in the jury-rigged control room was a sidescan sonar readout representing the wreck of the *S.S. Central America* lying a mile and a half below. Lost 130 years before in hurricane-swept waters 200 miles off the Carolinas, the *Central America* had been the *Titanic* of her time, taking with her 425

men and nearly three tons of newly minted gold coins and bars—possibly worth as much as a billion dollars at today's prices.

How Thompson's Columbus-America Discovery Group came to find and recover the ship's treasure is an extraordinary tale, many details of which are just beginning to emerge through a shroud of secrecy that David Graham, editor of *Sea Technology* magazine, quipped "would put the National Security Council to shame." But it is more than a story of the resourcefulness and perseverance of a few men. It is a story predicated on technology. The reason that Thompson chose to go after the *Central America* when he did was that,



for the first time, the capabilities existed to give him good odds of success.

The implications of this fact go far beyond a single trove of gold bullion. Improvements in robotics, submersibles, deep-ocean breathing apparatus and sonar search equipment now promise to bring within reach a wealth of gold, scientific knowledge and natural resources scattered over the vast expanse of ocean floor that accounts for the majority of our planet. "A lot of things that weren't possible before, are possible now," says Robert Stevens, chairman of Continental Shelf Associates, an environmental consulting firm.

As for what the future will bring, Stevens believes

Resting on a plateau at 1700 ft., a massive habitat supports the work of saturation divers and a subsea oil derrick. Liquid-breathing divers head for deeper waters. To the left, an unmanned vehicle goes about its work under computer control. The habitat's support ship, and a towering ocean thermal-energy platform, are key ingredients in this view of our undersea future.



DEEP QUEST

that the *Central America* find just scratches the surface of what the new technologies will be able to do. Although it may have seemed like sheer science fiction, many experts are surprised at how much of the movie, "The Abyss," will soon be feasible.

Mechanizing the deep

One remarkable fact about the still-ongoing recovery of gold from the *Central America* is that it has involved absolutely no human presence below the ocean. This attests to the markedly improved ability of Remotely Operated Vehicles (ROVs) to perform complex tasks and transmit data to operators at the surface.

After locating the wreck in 1986, Thompson's Columbus-America Discovery Group secretly set to work on an ROV called *Nemo*. Although crude in appearance, the 12,000-pound homebuilt device uses leading-edge technologies.

Its modular design allows it to be configured with different combinations of imaging and manipulating equipment for different missions. Among the attachments is a 5-camera boom that transmits realtime, high-resolution 3-D images to the surface. Manipulators include a dustpan-like device that sweeps up objects with a jet of water, robotic arms that transmit tactile feedback to operators on the surface, and an injector that envelopes groups of objects in blobs of fast-hardening silicone so they can be retrieved in exactly the same arrangement as they were found in on the sea floor.

Thompson strongly believes that vehicles such as *Nemo* can do anything divers or manned vehicles can do at far less cost, and without risk to human life. And, indeed, the ROV has demonstrated impressive capabilities at depths thousands of feet greater than any diver can reach. But as robots are becoming better substitutes for humans, humans are gaining the ability to go where only robots could.

Man and the sea

Sending men below about 500 ft. presents daunting physiological and technical problems. The human body evolved to work at atmospheric pressure—about 15

psi. When hydrostatic pressure bearing down on each square inch of a diver's body creeps past about 220 psi, the strain begins to show itself in a bizarre spectrum of effects. Standard saturation diving techniques become inadequate as air becomes so dense that it's physically difficult to breathe, and highly pressurized breathing mixtures begin to transfer normally inert gases to the blood in toxic amounts. Less well understood is a condition known as HPNS (High-Pressure Nervous Syndrome), which strikes unpredictably and may debilitate divers with hallucinations, nausea and convulsions.

The French commercial diving firm Comex has been experimenting with mixtures incorporating hydrogen to counteract these effects. Hydrogen acts as a narcotic, quieting the psy-

chomotor disturbances of HPNS. And since it is the lightest of all gases, breathing effort is reduced. In open ocean trials, Comex divers used the hydrogen/helium/oxygen mix to work for six days at 1700 ft.

With any gas mixture, however, the need to decompress gradually remains a serious obstacle to efficiency. After these dives, Comex's divers needed to spend nearly three weeks locked in a decompression chamber. The reason for this is that at great pressures inert gases in the breathing mixture saturate the blood, and if released too quickly will form bubbles, leading to a potentially fatal case of the bends. But this may have a solution, too.

Breathing liquid

One sure way to prevent inert breathing gases from building up in the blood would be to convey oxygen to the lungs by a different medium. Radical as it sounds, experiments have shown that a liquid fluorocarbon might play such a role.

Research into fluid breathing goes back to 1962, when Dr. Johannes Kylstra of Duke University found that mice could be sustained for hours on a hyperbarically oxygenated saline solution. Soon afterward, it was discovered that biologically inert fluorocarbons could transport far more oxygen, opening up the possibility of supporting human beings. The remaining problem—absorbing CO₂ buildup from the lungs—was solved by Dr. Kylstra in 1976.

The most advanced experiment he performed was filling one lung of an unanesthetized volunteer with salt water. "The diver told me he couldn't tell the difference," says Kylstra. The more efficient fluorocarbon medium was never tried on humans. Although it had worked in a variety of animals, it was thought to be too risky.

Exactly how far a liquid-breathing diver could descend is uncertain. Kylstra says "theoretically any depth would be achievable," but he cautions that anesthetics would be needed below about 3000 ft. to ward off HPNS.

Why go to all this trouble to send a human where a robot can go relatively cheaply? Man's still unparalleled



Under pressure: Divers (top) breathe hydrogen mix while working more than 1700 ft. down. The Newtsuit (above) represents another approach, keeping the diver at sea-level pressure, while preserving much of his dexterity.

dexterity is one reason. As Frank Busby, one of the world's leading experts on submersibles, says, "a man can close his eyes and tie a knot," a task still impossible for a machine. The human advantage was neatly illustrated in Comex's dive, when an ROV monitoring the divers fouled a prop in a nylon rope, and had to be freed by a diver.

Another approach to putting man's unique ability to perceive and react on the bottom is to use a hard suit, which eliminates the need for decompression by maintaining normal atmospheric pressure around the diver. For almost 300 years, a way has been sought to prevent the joints in these rigid-shelled suits from seizing up when exposed to the tremendous loads produced by hydrostatic pressure. A recently developed oil-filled

rotary joint that uses a movable piston to equalize internal and external pressures seems to have the problem licked. The Newtsuit, manufactured by International Hard Suits of British Columbia, uses the joints to give divers 75 percent of their normal mobility. Although present versions of the suit are limited to 1000 ft. by the strength of their aluminum shells, the joints themselves remain flexible to at least 2000 ft. That depth should soon be achievable through the use of carbon-fiber composite shells.

The quest for gold

Of all the technologies aiding our access to the treasures of the deep, the one that has probably advanced most rapidly in recent years has more to do with pinpointing targets than with reaching them. The sidescan sonar rig

that found the *Central America* searched 1400 sq. miles of ocean 8000 to 10,000 ft. deep in 40 days. That's 10 times the area searched a few years ago for the *Titanic*.

Known as the SeaMARK 1A, its capabilities spring partly from a 2-body towing system (see illustration) that decouples the sonar sled, or towfish, from the movements of the ship. Attached to the towfish are a pair of sonar transducers operating at 27 and 30 KHz. At these relatively low frequencies, sonar is capable of long range, but resolution is normally poor. In the case of SeaMARK, however, the tradeoff is minimized by the stability of the towfish and by the use of advanced image-processing techniques. Set to its maximum swath width—5000 meters—the SeaMARK can make out objects about 2 meters across. Focused in on a swath 500 meters across, it can spot a 25-centimeter object 20,000 ft. below.

It was in this high-resolution mode that the Columbus-America group narrowed their list of likely targets to a hit parade of five, one of which turned out to be the *Central America*.

Now, three years later, much of the wreck's treasure has been raised, and it's already clear that their backers will make a handsome profit.

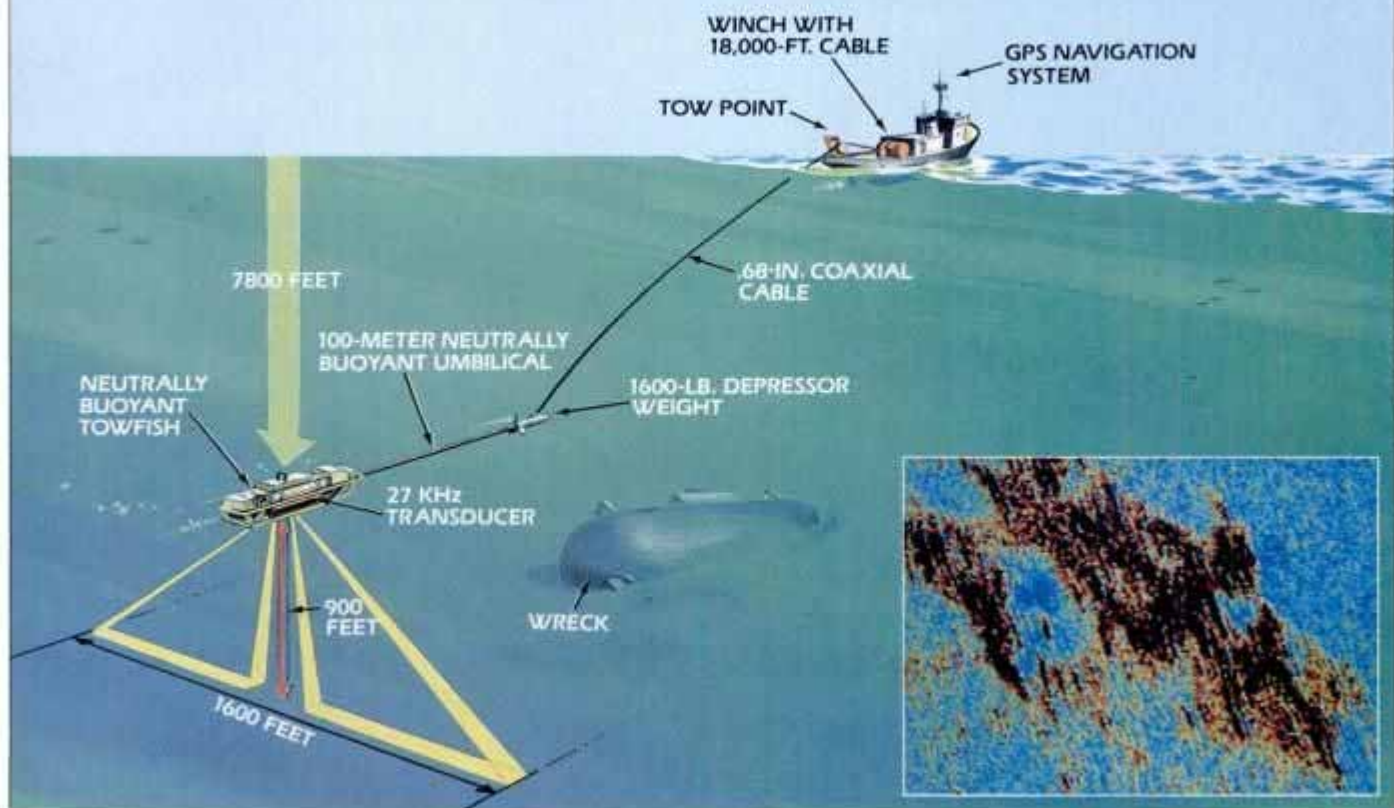
But who knows how many untold millions are still up for grabs 20,000 leagues beneath the sea.

PM

Gold, viewed through *Nemo's* camera, retains luster after 132 years. Search vessel used sidescan sonar with 2-body tow system to isolate transducers from up-and-down motion of ship. The result was an image of the *Central America's* debris field (inset) recognizable by sonar analysis.



HOMING IN ON CENTRAL AMERICA



PM ILLUSTRATION BY FRED WOLFF, 1989 COLUMBUS-AMERICA DISCOVERY GROUP PHOTOS

LONG-TERM TEST CARS

IT'S GOODBYE to some old friends, and hello to some new faces in the PM garage.

Mazda MX-5 Miata

The Miata is the distillation of all that was wonderful about the British sporting roadsters of the '50s and '60s—the Triumph TR-3, the MGB, the Austin-Healey—and the omission of all that was bad: balky starting, heaters that didn't, windows that leaked, tops that leaked more than the windows, marginal handling and intermittent electrical systems.

Our Miata came to us with 113 miles on its odometer, and now with a little over 1033 miles, we have yet to dis-

cover the first flaw. The top, a simple 2-latch manual affair, is child's play to operate—you can do it one-handed, without leaving the driver's seat—and it seals tightly. Controls are also simple and well marked. The simplicity extends to manual roll-up windows, manually adjustable exterior mirrors and no cruise control.

One manually operated item we wouldn't change under any circumstances, even if there was an option of doing so, is the 5-speed gearbox. With its close ratios and short, precise throws, it is an absolute joy to use.

The Miata's 1.6-liter dohc 16-valve Four, adapted from the 323 sedan, is well suited to this application—

strong enough to make the driving fun, economical enough to yield an average 28.4 mpg so far. It can be a bit buzzy inside the car at freeway speeds, but the noise is the kind that brings joy to a driver's heart.

And that's exactly what we expect this car to do in the months ahead.

—Tony Swan

Pontiac Trans Am GTA

The question was, can a high-performance sports car serve satisfactorily as daily transportation? The answer is: Yes, if you're willing to put up with some headaches and annoyances.

On the positive side, you have the car's performance. It's there in

MAZDA MIATA



PM PHOTO BY HUMPHREY SUTTON



PONTIAC TRANS AM GTA

PM PHOTO BY CLIFF GROVER

spades in this 350-cu.-in., fuel-injected roadburner, every time you punch down the throttle. As we said in our first installment, the Trans Am GTA is one of the fastest cars you can buy. Just as exhilarating as the Trans Am's straightline performance is the superb handling and responsiveness built into the chassis.

Now here's the downside.

You can fit a couple of kids comfortably in the back seat, but that's about it. Adults are limited to rides of 5 minutes or less duration. After that, you'll have a screaming basket case on your hands. Capacity for luggage, grocery bags or whatever isn't bad.

Another disadvantage of a high-performance car in daily use—fuel mileage or lack of same. In just under 10,000 miles, we averaged 19.1 mpg.

But here's the real bummer. Own a car like this and, sooner or later, you're going to come out of someplace and find that some moron has tried to steal it.

It happened to us when we had about 3000 miles on the clock. The car was left in a busy supermarket parking lot in midday. We came out 20 minutes later to find the door open and the entire steering column ripped up with wires hanging everywhere. We called the local Pontiac dealer, Sun Pontiac

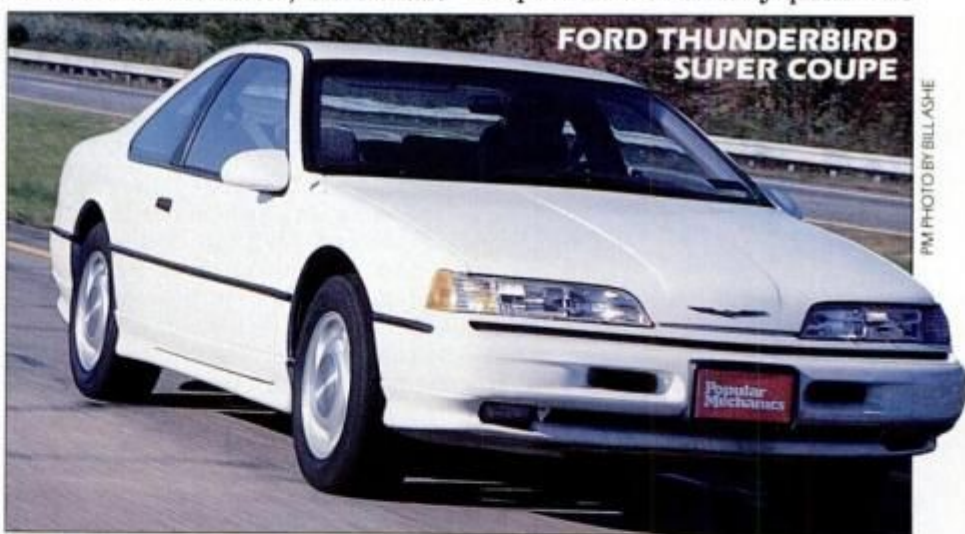
in Wantagh, New York, and explained the situation. We asked to have the car towed in and repaired. The rude person on the other end of the phone told us to call back in two weeks to make an appointment. The next closest dealer was Benjamin Pontiac in Rockville Centre, New York. Mike Reed, the assistant service manager, was very cooperative and courteous. He had the car flatbedded to the dealership that afternoon. For a mere \$711.36, the car was back in service about a week later.

So, should you buy a high-performance sports car to use every day? Hey, how much are you willing to put up with?
—Joe Oldham

Ford Thunderbird SC

At 4500 miles our Thunderbird Super Coupe has lost some of its eye appeal. But we can't blame Ford for this. Rather, we can only wish a pox upon some anonymous mouthbreather who smashed the right side mirror and left a gouge in the door and rear quarter panel. Thank you very much.

The more we live with the T-Bird's supercharger, the more we think this is a sensible installation for a performance car that's likely to see extended duty in urban environments. Engine response is wonderfully quick—we



FORD THUNDERBIRD SUPER COUPE

PM PHOTO BY BILL ASHE



PONTIAC 6000 STE AWD

PM PHOTO BY HUMPHREY SUTTON

LONG-TERM TEST

never tire of watching the boost gauge snap to attention instantly. For all its weight, the Super Coupe is also gratifyingly agile.

Fuel economy continues to range between 15.5 and 21 mpg, though we have yet to make an extended open-road run with the car. That's an experience we look forward to.

—Tony Swan

Pontiac 6000 STE AWD

In the last episode, we mentioned that the 6000 All-Wheel-Drive version was being dropped. Our sources were mistaken, and '90 AWDs should be in good supply at your local dealer.

After an initial few months of good behavior, our car began to have a number of minor, transient electrical problems. It started with the windshield washer fluid level warning on the instrument panel coming on at random. Then one day, the fuel injection occasionally forgot how to idle, stalling the engine anytime the throttle pedal wasn't held down. But when we parked it for an hour, everything was fine again—for a week or so.

We saw sub-20-mpg fuel economy throughout our 9-month test, perhaps the only real disappointment in a real 4-season car.

Aside from these problems, our 6000 has done yeoman service in commuter service. The all-wheel-drive differential lock has never been used, and we suspect few will need to. The sure-footedness in slippery conditions, combined with the ABS brakes, make it a super ride for winter in the Northeast. We hate to see it go.

—Mike Allen

Mazda MPV

Mazda can't quite decide if our MPV is a car or a minivan—and neither can we. It looks like a minivan, but it drives like a car. It's even got a car door on the right side, not a sliding van door.

Using the drivetrain from the 929 sedan, the MPV has plenty of steam,



MAZDA MPV

although the automatic transmission's shifter, located on the steering column, is the vaguest, mushiest, cheapest oar we've seen in a long time. It seems out of character, as the rest of the van—er, car, er, MPV—seems well done indeed.

Our test car came loaded with the usual sinkful of options, stickered at \$16,421.

—Mike Allen

Ford Club Wagon XLT

Our 460 V8-powered Ford Club Wag-



FORD CLUB WAGON

on XLT went through an entire race season hauling around our '89 Saleen SSC Mustang, a 22-ft. Haulmark race trailer, and enough spares to provide logistical support for the overthrow of a Third-World dictatorship. The huge 460 never failed to start, never failed to provide enough towing power, never even whimpered. However, as with any towing vehicle asked to tow a load longer and heavier than itself, we were always constantly aware of the extra weight tagging along.

Mileage in this severe service was 7-8 mpg, climbing to 12 mpg in unladen freeway driving. It did have a distinct appetite for 89 octane or better fuel. The engine pinged badly on 87.

Aside from the melted water hose we mentioned in our last report (Sept. '89, "Long Haulers," page 62), we never had a bit of trouble with this excellent strong-as-a-bull vehicle.

Before choosing it for your tow vehicle, however, be aware of two things. First, it's too big to fit in some

garages, even commercial parking establishments. Second, there aren't too many 460-powered vans around with dual exhausts. Those two pipes interfere with many off-the-shelf tow hitches.

Now that the race season is gone, so, too, is our Ford Club Wagon. Thanks for all the good service.

—Mike Allen

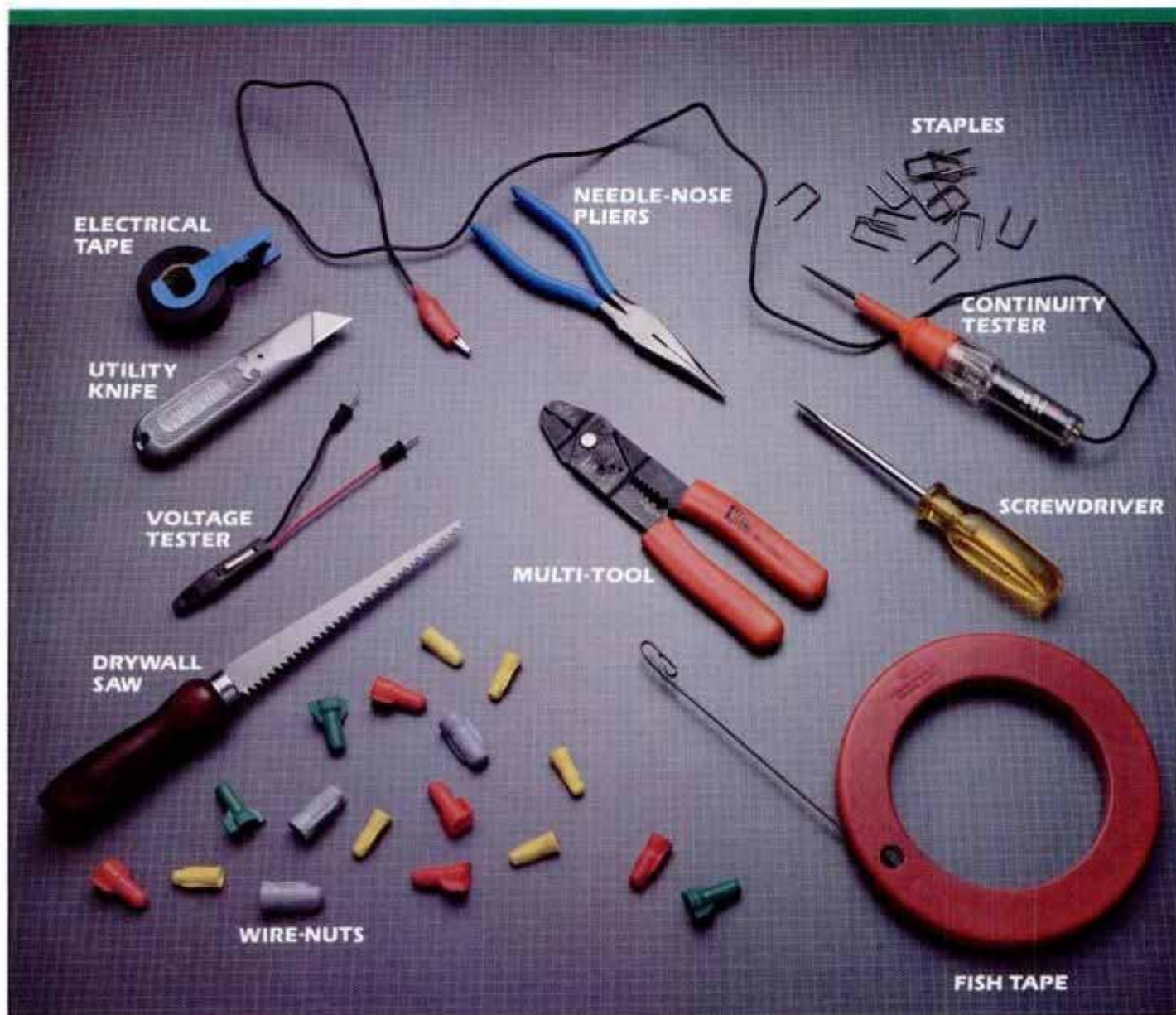
Winnebago Chieftan

Aside from a small fender-bender with an Acura that got the worst of the deal, an auxiliary generator motor with an appetite for oil (1 quart/10-12 hours), and some interior trim that keeps winding up on the floor, this home-away-from-home for our race team has been a real joy to have around. Nobody is confusing it with the Miata—it's built on a truck chassis and it drives like a truck. No surprise there. But after a shift driving the PM Racing Mustang in 100° weather, walking into the Winnie's air conditioning and shower somehow make it all worthwhile. It's going back to the dealer to be sold as a demo, and we're really going to miss it. —Mike Allen



WINNEBAGO CHIEFTAN

HOME AND SHOP JOURNAL



TOOLS BASIC ELECTRICAL TOOLKIT

TEXT AND PHOTOS BY
MERLE HENKENIUS

MANY HOMEOWNERS are intimidated by the prospect of electrical repairs, though they really shouldn't be. When approached safely, and with the proper tools, basic repairs and installations are quite easy

and involve little risk. Bookstores and home centers, and magazines like *POPULAR MECHANICS* abound with information on basic electrical projects, and with a little study, even complicated upgrades are within the reach of most do-it-yourselfers. There is little about electrical work that is physically demanding, but the right selection of tools will make any job easier.

The good news in assembling a basic electrical toolkit is that it will include relatively few tools, with prices often totaling less than the cost of a single service call. (The tools and supplies we show here cost less than \$60.) Your kit may vary slightly with specific needs, but the tools and accesso-

ries included here would make a good starting point for most people. When supplemented by other, more common household tools, you'll be able to tackle most jobs successfully. Of course, any major project will require a permit beforehand and an electrical inspection afterward to conform to local codes.

Voltage tester—A voltage tester consists of two probes joined by a tiny neon light. It is commonly used to determine whether power is present in a receptacle or set of wires, or whether a receptacle is properly grounded. A neon tester is particularly useful in determining the direction from which power originates. For example, does power enter a ceiling fixture first, or

does it enter a wall switch first? When installing a ground-fault circuit interrupter (GFCI), is the outlet location you have in mind at the beginning, middle or end of the circuit? The answers to these questions will be important when extending or upgrading a circuit or fixture.

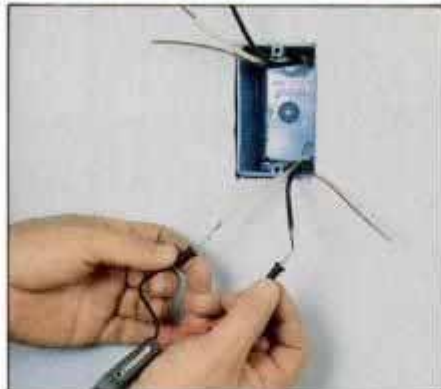
With a neon tester, you'll remove the receptacle, switch or fixture and undo the wires. Then, with the power on, you'll touch the tester probes to the hot and neutral wires from each cable. When the neon light glows brightly, you've found the incoming circuit cable.

Continuity tester—Continuity testers differ from voltage testers in that they have their own power sources. When the alligator clip at one end of the tester is touched to the probe at the other end, a circuit is completed and the battery within the tester lights the bulb in the handle. In like fashion, any device placed between the clip and probe will complete the circuit if it is in operating order. As such, continuity testers are ideal for testing switches, fuses, breakers and lamp sockets. If the device conducts current in the ON position, it's working. If not, it's faulty. As you'll only be checking the circuit created by the tester's battery, you'll need to separate the device from its wiring or power source.

Multi-tools—A multi-tool will be the next most important tool in your bag. With it, you'll be able to cut cables and wires and strip insulation. It's really just a multipurpose sidecutter with a series of slots to match most gauges of wire. By squeezing the handles over an insulated wire and twisting the tool, the insulation is stripped away, leaving the wire intact.

Needle-nose pliers—Needle-nose pliers are useful in bending wires to fit around the binding screws of electrical devices and fixtures. While most new switches and receptacles have stab-in slots as well as terminal screws, you'll still need to bend wires to fit switch and receptacle grounding terminals, as well as many fixture terminals. The job can be done with a standard pliers or even a multi-tool, but is much easier and neater with a needle-nose.

Utility knife—A utility knife is a useful household tool in any case, but is particularly handy when stripping sheathing from electrical cables. In most cases, you'll draw the knife along the center of the cable to avoid damaging the insulated wires at the outer edges. You'll then peel the cable



1 Voltage tester checks which cable carries incoming power. To test, turn off power and remove fixture. Then turn on power and touch tester probes to hot and neutral wires. Tester lights up if current is present.

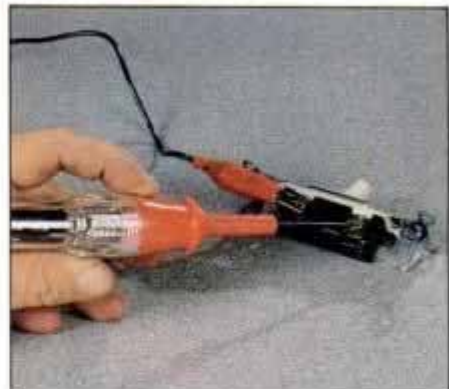


3 Multi-tool cuts cable and strips insulation from wire. To use, just insert wire into proper gauge slot and squeeze the handles together. Then twist tool around wire and pull off insulation.

sheathing back and trim it from the rest of the cable to expose the cable wires. Utility knives are also good for trimming drywall from around outlet boxes.

Drywall saw—A drywall saw might be an unnecessary addition to your toolkit if you'll be only replacing outdated switches, receptacles or fixtures. If you hope to extend a circuit, or cut in new outlet boxes, then a drywall saw is a real time and frustration saver. Unlike its cousin, the key-hole saw, a drywall saw has a rigid blade, allowing you to drive it directly through drywall. In this way, you'll be able to cut outlet boxes without drilling pilot holes. With a drywall saw's coarse cut and narrow set, you'll cut a neat, new box opening in less than a minute.

Fish tape—Fish tape is absolutely necessary if you'll be running new cable within walls, floors and ceilings. Its rigid coil of metal tape can be fed into a wall from the basement or attic, or through an opening cut into a wall. When the tape has bridged the gap,



2 Continuity tester checks if fixtures are working. Shut off power, remove fixture, and attach clip to one side and touch probe to other. If tester lights up, fixture works. NOTE: Switches must be in ON position.



4 Fish tape makes running new wire in enclosed spaces much easier. Just cut opening in wall and feed tape into another opening where new cable is accessible. Then hook cable on end of tape and pull back.

all you'll need do is fasten the new cable to its looped end and pull the tape and cable back through. Its greatest advantage is that it allows you to run cable through finished walls without extensive and costly wall repair.

Screwdriver—Most of the screws you'll encounter in electrical work will require a blade-type screwdriver. Few screws will have Phillips heads. An ideal screwdriver for electrical work will have a large comfortable handle, a 4-to-6-in. shank and a thin, sharp blade. As screwdrivers are the most abused tools in everyone's bag, don't skimp on quality. The bargain-basement models simply won't hold an edge.

Tape, Wire-Nuts and staples—Plastic electrical tape is a useful item in any toolkit, but don't overdo it. It may be used to join soldered wires in low-voltage installations, such as telephone cables and doorbell cables, but should not be used to join wires elsewhere in the house. In fact, all 120- and 240-volt splices should be made with Wire-Nuts and within perma-

nently accessible junction boxes.

You'll find Wire-Nuts in a variety of color-coded sizes depending on the manufacturer. Choose your sizes carefully. When using standard 14- or 12-gauge wire, a yellow nut, for instance, will bind two wires securely together. Three wires will usually require a red nut and four-to-five wires will require yet another color.

When fastening two or more wires with a nut, strip about 1/2 in. of insulation from each wire and hold them tightly so that the ends of each of the wires meet. Then twist the nut over them until it's tight. A loose connection will create heat and will eventually trip a breaker or blow a fuse. Make them tight, with the wiring insulation extending well within the nut.

And finally, you'll need staples to fasten new wires to studs and joists. Place one staple within 8 in. of each outlet box and one at least every 4 ft. thereafter. When fishing new cable through finished walls, this rule may be waived, but you should install the boxes that have fastening clamps that hold the cables firmly within the box itself. **PM**

NEW APPLIANCE

LIFETIME WATER HEATER

TEXT AND PHOTO
BY MERLE HENKENIUS

TANK FAILURE, the universal nemesis in water heater construction, may have just been overcome by State Industries, one of the five major manufacturers in the field. State's new heater has a tank that's built not to rust. In fact, State has enough confidence in its new Duron technology to offer a lifetime warranty on the best of these units.

If this sounds encouraging, it should. By all accounts, the life of a heater is defined by the life of its tank. All other components can be replaced easily and cheaply enough, but when the tank rusts through, the heater is finished. End of story.

The problem with water-heater tanks has always been that they are made of iron to be kept affordable. Heat, water and oxygen, the three constants in a heater's life, will always rust iron, and in short order. To counter this problem, manufacturers line their tanks with a vitrified finish.

This baked-on glass lining is not perfect, however. Pinhole blemishes in the lining allow dozens of points of direct exposure, and rust soon follows. To forestall this rust, manufacturers also install a sacrificial magnesium anode rod within each tank. As the anode rod corrodes, it sheds electrons, which move to the pinholes in the lining and keep the iron from rusting, or shedding its own electrons. A standard anode will be depleted in roughly five years, hence, the standard 5-year warranty. Two anodes, or one heavier anode, allow manufacturers to also offer 10-year warranties. If you're lucky, and your water is not high in mineral salts, your heater will last several years



New water heater has just one welded seam around middle of tank and baked-on plastic coating inside to prevent rust. This design also eliminates need for anode.

past warranty, but that's about it.

To complicate matters, some types of minerals in water react adversely with magnesium anodes, creating a sulfurous odor in the water. In these cases, aluminum anodes are substituted for magnesium. Most manufacturers match the type of anode to the water conditions of the market in which the tank will be sold.

State's new Duron tank circumvents these age-old problems entirely, by doing away with the glass lining and anode altogether. In the process, they've also redesigned the iron holding tank. The tank now consists of two halves of drawn steel, pressed into shape to form two drums. This allows for only one welded seam around the

center of the tank, where the two drums are joined. The tank is then charged with Duron, a high-tech plastic powder, and the tank is superheated and rolled and rotated. This high-temperature firing melts the plastic powder, which then coats the tank uniformly. The result is a stronger outer tank with a flawless plastic coating facing the water. The inlet and outlet fittings are also coated with Duron inserts, so no part of the iron tank is exposed.

State has had its electric models in limited production for several months now and expects to be producing gas models shortly after the first of the year. The best of these models will be offered with lifetime (for as long as you own your home) warranties that include the tank and support components. State is also offering models with lesser warranties, including 15-, 8- and 5-year models. The differences here are primarily in the thickness of the Duron coating. As the Department of Energy has banned the sale of inefficient appliances after January 1, 1990, all models should be economical to operate.

As for price, that's always hard to pin down because manufacturers are prohibited by law from dictating wholesale or retail prices. State, however, cautiously estimates a \$350 wholesale cost, and if we mark that figure up 30 percent, you'd be looking at a \$455 investment on a 52-gallon electric model. While this is somewhat higher than a conventional heater, it's not substantially so. In fact, it starts to look pretty good when amortized over 20 years or more.

Only time will tell, of course, but State may have changed, for good, the way heaters are made, sold and warranted. For the most part, the competition is pretty reserved in its comments. One off-the-record competitor did say, however, that if the Duron process works, the rest of the industry would no doubt move in that direction. As for the rest of us, a lifetime warranty is a lifetime warranty, no matter how it's accomplished. And that's just plain good news. **PM**

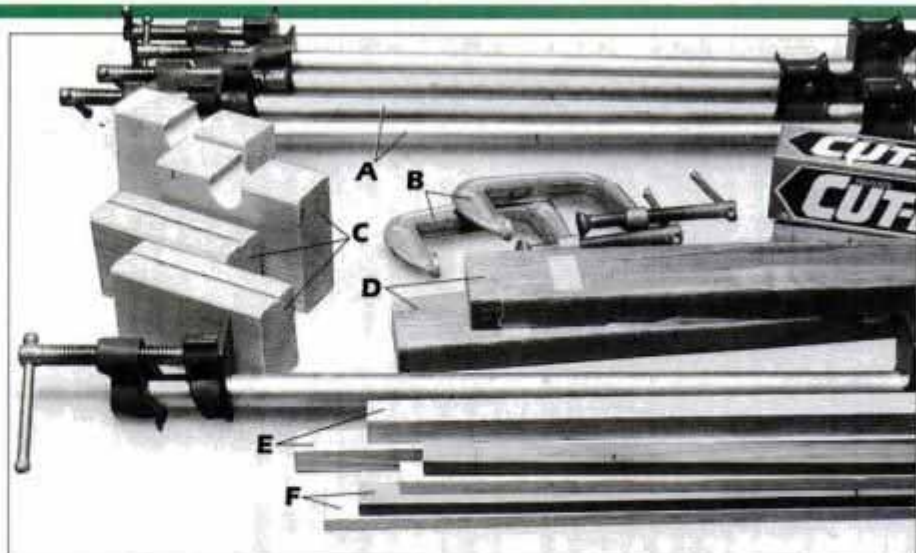
SHOP TECHNIQUES

CLAMPING LARGE PANELS

TEXT AND PHOTOS
BY ROSARIO CAPOTOSTO,
Contributing Editor

ASSEMBLING several narrow boards to produce a wider panel is a very common woodworking chore, especially these days when wider boards are increasingly difficult—and expensive—to obtain. If you want to get the best results, proper stock preparation—surfacing and jointing—is crucial. But equally important are proper clamping techniques. Many times a glued panel will turn out cupped or twisted because of improper clamp placement and the failure to use the proper supporting components.

These problems stem from the fact that the head jaws of pipe clamps have some play in their design. If the clamp is applied to the edge of the board so that the pressure screw in the head



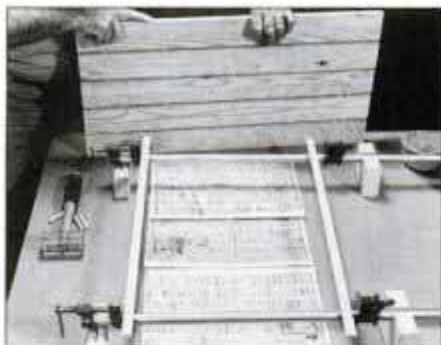
Successful clamping requires plenty of pipe clamps (A), C-clamps (B), clamp supports (C), cross supports covered with wax paper (D), wood clamping pads (E) and spacer sticks (F).

jaw is off-center—relative to the board edge—then the jaw will tilt and tend to make the panel arch in the middle. If the clamps are applied off-center in opposite directions, then the panel will twist.

Off-center clamp placement is only one problem. Pipe clamps also have a tendency to tip over because they have a relatively high center of gravity. This can be very annoying when you are rushing to clamp a joint tight before the glue dries.

All these difficulties can be resolved by using the straightforward clamping system that is shown here. This system uses clamp supports made of 2 × 4 stock to stabilize the head jaws and pipes, clamping pads made of scrap stock to protect the panel edges from clamp damage, cross supports to align the ends of the boards so the panel stays flat and thin spacer sticks that will center the head jaw on the panel edge and help keep the panel flat, too.

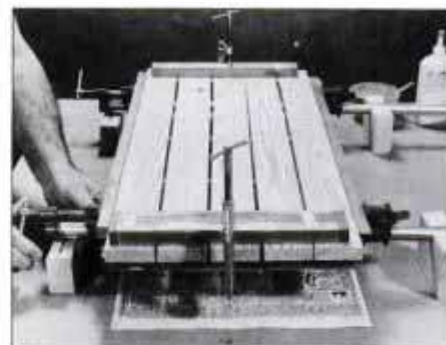
PM



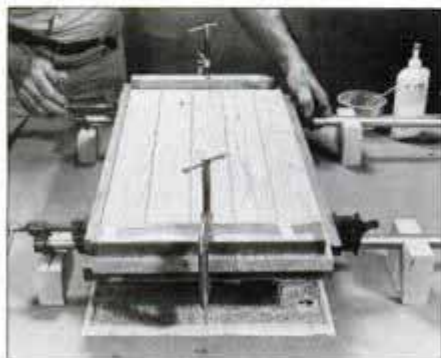
1 Set clamps on support blocks, place spacer sticks of appropriate thickness on clamps, then apply glue to board edges.



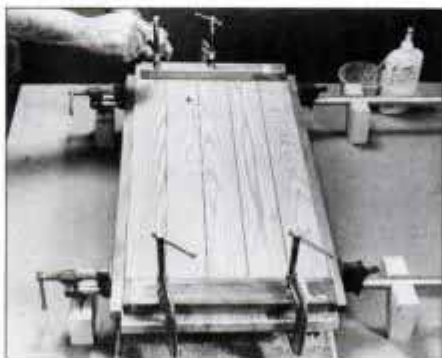
2 Place panel on clamps between clamping pads and tighten slightly. Then lightly clamp cross supports on both sides of each end.



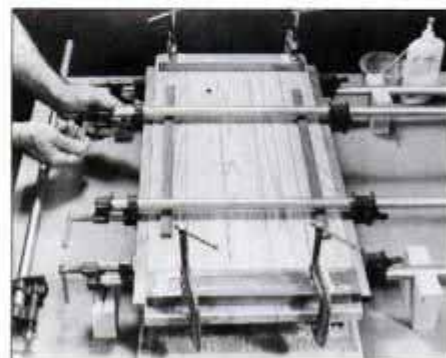
3 Alternately tighten each pipe clamp to close joints. Note that ring direction on board ends alternates to prevent cupping.



4 Continue tightening clamps until joints are closed. Do not overtighten clamps. This weakens joints by forcing out too much glue.



5 Once joints are closed, shift C-clamps to ends of cross supports, and add another C-clamp at each end to bring support tight.



6 Place spacer sticks on panel to support extra pipe clamps and to help keep panel flat. Tighten clamps to same pressure as others.

THE BETTER HOME

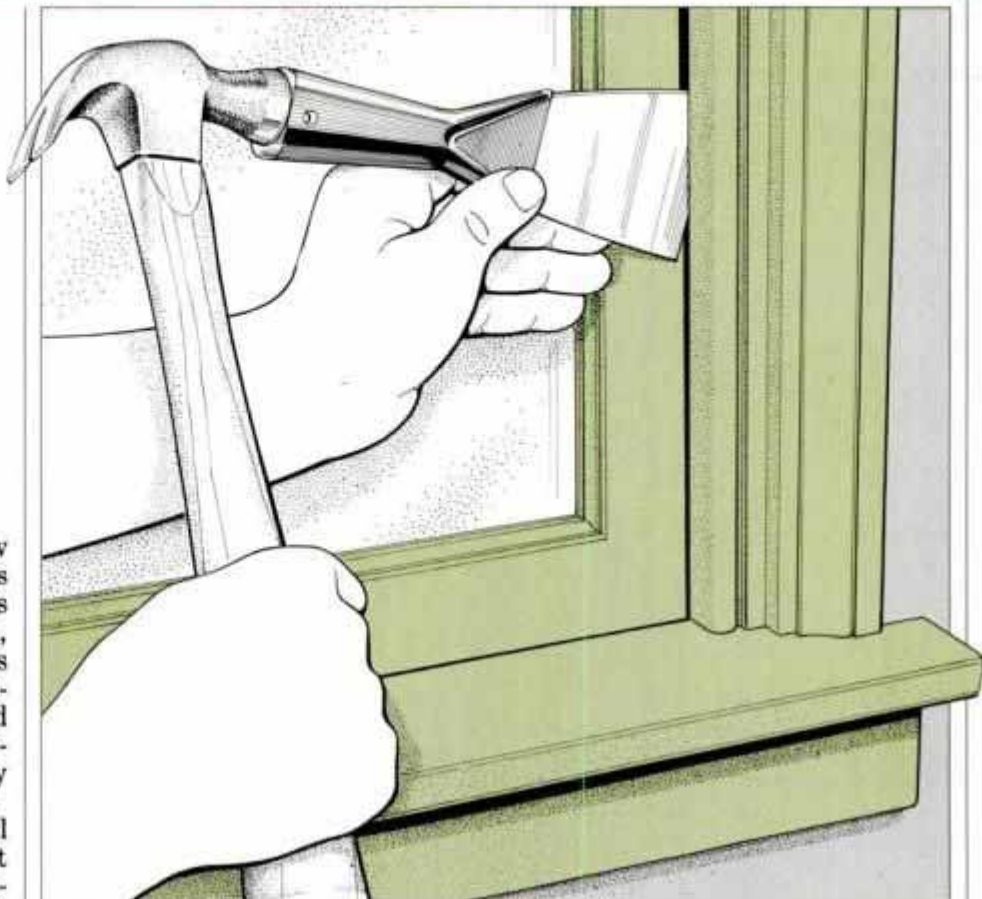
**How To
Maintain A
DOUBLE-
HUNG
WINDOW**

BY ROSARIO CAPOTOSTO,
Contributing Editor
PM Illustrations by
George Retseck

THE WOOD double-hung window with counterbalanced weights—a traditional style for many years—consists of an upper and lower sash, each of which slides up and down in its respective channel. The weights, connected to the sash with a cord and pulley arrangement, control its movement, allowing it to be effortlessly lifted or held in any position.

In recent years aluminum and vinyl components together with spring lift mechanisms have been gradually substituting for wood-and-weight type windows. These newer type double-hung windows rarely need more than a cleaning and lubrication of the channels to keep functioning properly.

But not so with wood windows. As they get older they may occasionally develop annoying sticking problems resulting from paint or dirt accumulation, swelling and/or warping of the wood due to high humidity or direct water seepage under the paint film. And a broken sash cord will cause either jamming during movement or a failure of the upper sash to remain closed or lower sash to remain open.



1 To free a stuck sash, gently tap a wide-blade putty knife between the sash and stop to break the paint seal. Do this all around if necessary.

Typical window problems and solutions are shown in these drawings. More often than not, the simple remedies get the window back to working order. If not, it may be necessary to remove the inside stops, parting strips and sashes to make the corrections. Although these measures are involved, they're not difficult.

Freeing a stubborn sash

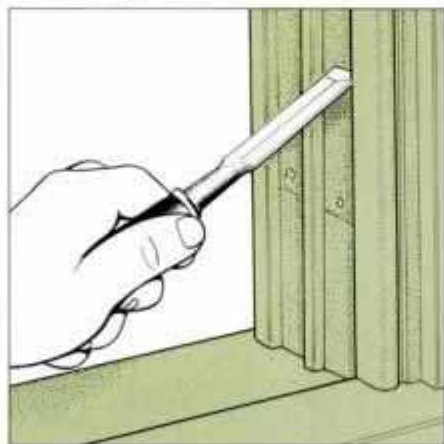
When a window is stuck fast, examine it carefully to determine the cause and

exact location of the problem before attempting the solution. If a paint seal is the cause of the trouble, one of the methods shown in this story will usually free the sash. In any case, avoid using brute force which could result in damage to the sash, the frame or to yourself. Gentle prying or nudging will usually do the trick to solve the problem.

The problem of a sluggish window can usually be traced to paint layer build up. This reduces the gap be-



2 Move outside and force a pry bar between the sash and sill and pry up the sash. Scrap wood pad protects sill.

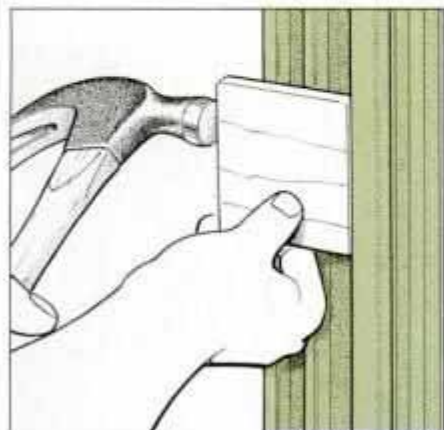


3 Use a wide chisel to shave off dried paint lumps or dirt accumulations from inside the sash channels, stops and parting strips.



4 To create a smoother sash channel, wrap sandpaper around a wood block and sand the edges of the stops and parting strips.

tween the sash and frame members which is necessary for free movement. This problem can be avoided by taking care to sand the old coating before repainting. Pay particular attention to runs and sags which should be leveled off either by sanding or scraping. Light sanding or scraping will also serve to remove built-up grime

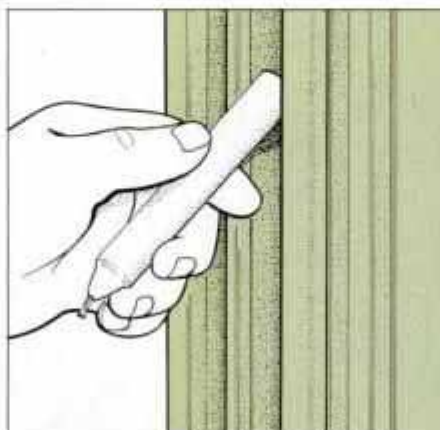


5 A lightly binding sash can be helped by gently tapping a wood block along the stops to slightly widen the channels.

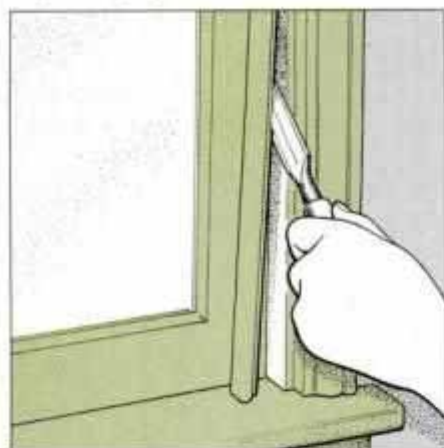
and to widen the gap when moisture has caused a stop or parting strip to swell or warp.

Sash removal

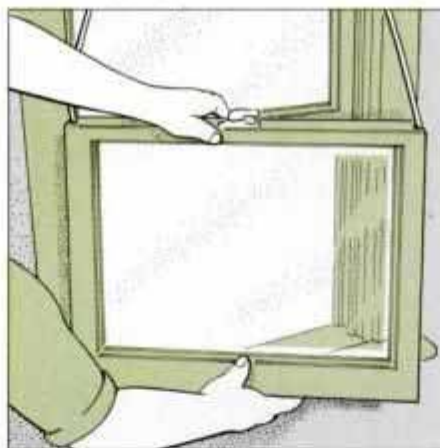
If the previous measures do not solve the problem, it may be necessary to remove the upper or lower sash, or both. This will allow access for plan-



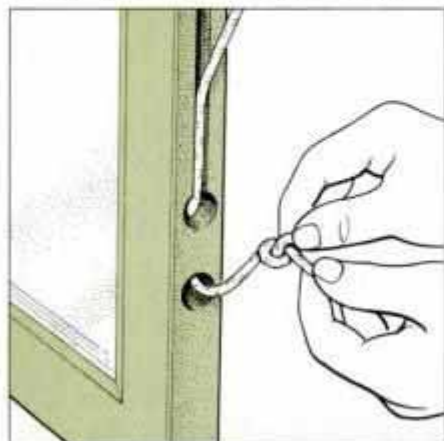
6 Rub a candle or paraffin stick on the edges of the inside stop, parting strip and outside stop to get sash to slide smoothly.



7 To remove inside stop, score paint on joint line with utility knife, use chisel to pry off. Start at bottom of stop, not at top.



8 Once the stop is removed, grip lower sash, then lift it slightly to clear stool trim and swing it out. Stool is attached to sill.



10 Brace sash in place, pull cord knot from containment hole. Undo the knot, free the cord and repeat operation for other side.



11 Use pliers to pull the parting strip out of its groove so you can remove upper sash. Protective wood strips prevent damage.

ing, or for other work such as replacing the weight cords, repairing or replacing stops or for installing replacement window channels.

To remove the lower sash, it's necessary to remove the front stop only. This is usually held in place with a few finishing nails, but paint along the joint lines has the same effect as glue. Use a sharp utility knife to neatly score cut the paint on the joint line before prying the stop molding loose.

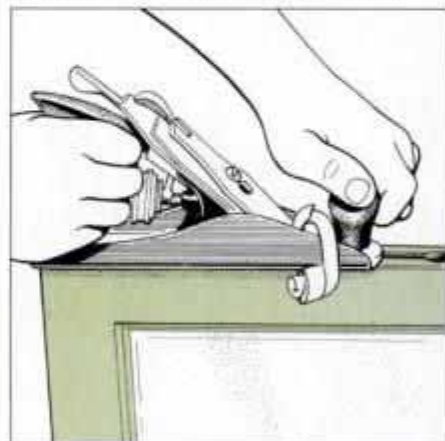
Removal of the upper sash necessitates removal of the parting strip. This, too, is secured with finishing nails but since it's recessed in a shallow groove in the side jamb, it's not removed by prying. Instead, carefully pull it out with pliers. Keep in mind that the blind stop at the rear of the window—facing the outside—is captive and can't be removed to free a sash.

Replacing sash cords

When a sash weight cord needs to be replaced, due to breakage, it's best to replace all the cords in the window at the same time. Otherwise the whole



9 Pull on cord until sash weight hits pulley, then slip nail through cord. This keeps sash from being pulled back into jamb.



12 Hand planing may be required to trim sides of sash for better fit. Planing of inside stops and parting strips may be needed.

process will have to be repeated when another of the old cords breaks, which is a likely possibility. However, instead of using cord, the replacement should be made with long-lasting, durable chain. Although weight-balanced windows are no longer mass produced, sash chain, together with its companion coil and clip-fastening fixtures, is generally available at hardware stores and lumberyards.

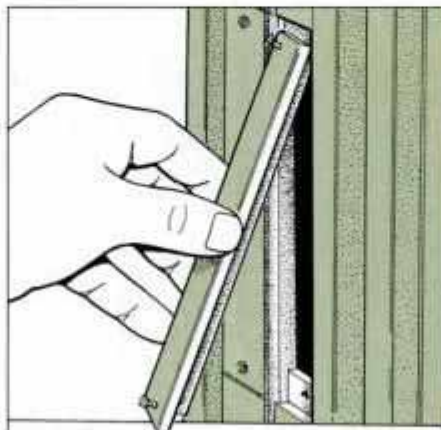
The typical weight counterbalance system has sash weight access panels at the base of the jambs. If your windows don't have these panels, then you'll have to remove the inside casing trim to gain access to weights.

If your windows are equipped with the more modern spring-type lifting devices, the maintenance required usually involves merely adjusting the tension of the spring which is encased in a metal tube. The adjustment is made by detaching the spring case from the jamb then winding or unwinding the spring, as required, to increase or decrease the tension.

If you care to invest the moderate

cost, you can upgrade your double-hung windows with replacement window channels which are designed to replace cord and pulley and spring lift systems. Made of aluminum with a baked white enamel finish—which should never need painting—the replacement product ensures easy sliding windows. A spring-tensioned

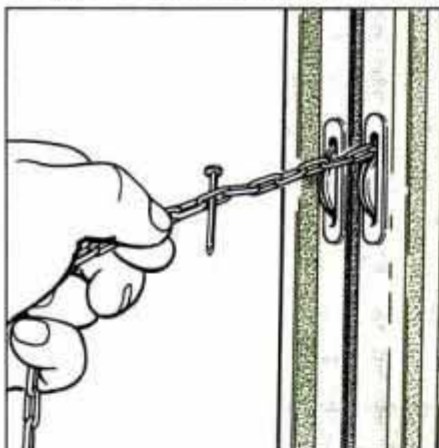
center bead (or parting strip) holds the sash in any position, lets it slide smoothly and still serves as an efficient weatherstrip. Called Window Fixer, it is made by Quaker City Manufacturing Co., 701 Chester Pike, Sharon Hill, PA 19079. Available at home centers and lumber yards, the kit we used cost about \$15. **PM**



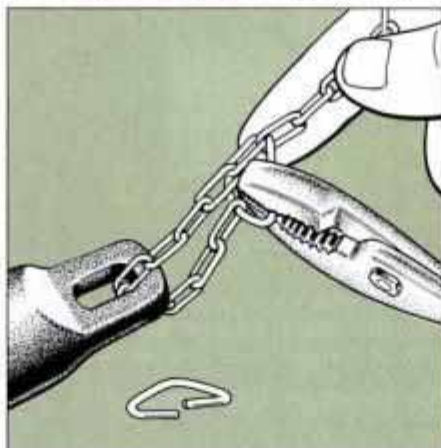
13 Windows with sash weight pocket panels make for easy access. Remove the screws on covering panel to get to weight.



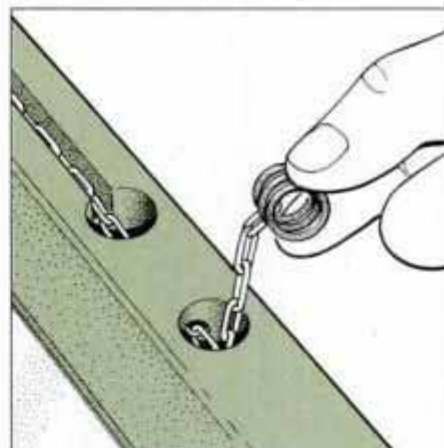
14 Lift weight from opening to replace cord with chain. With some windows, casing trim must be removed to gain access.



15 Feed chain over pulley until lead end can be pulled from access hole. Insert nail through link to keep the chain from falling.



16 Loop the chain through the hole in sash weight. Then secure it with a chain clip (shown) or with a short length of wire.



17 Slide chain into sash groove and out containment hole, then attach end. Push retainer into hole and lift sash in place.



18 Aluminum replacement channels are available for standard-size windows. To install, channels are first fitted to both sashes.



19 Discard window weights, pulleys and parting strips, slide channels and sashes in place, bottom first. Reinstall sash stops.



20 Use silicone spray lubricant to keep sash channels clean and smooth. It works on both wood and metal channels.

THE BETTER HOME HOMEOWNERS' CLINIC

BY NORMAN BECKER, P.E., Contributing Editor

Chimney Condensation

Condensation drips from the damper of my fireplace in the basement when we use the wood stove on the floor above. The stove and fireplace have separate flues. Both flues are contained in a large, open, brick chimney and each is about 12 in. from the chimney's inside walls.

I have patched the chimney cap, bought metal covers for both flues, applied three coats of water sealer to the outside of the chimney, installed a dehumidifier in the fireplace and removed a brick on each side of the chimney top to vent moisture. None of this has worked. Do you have any recommendations?

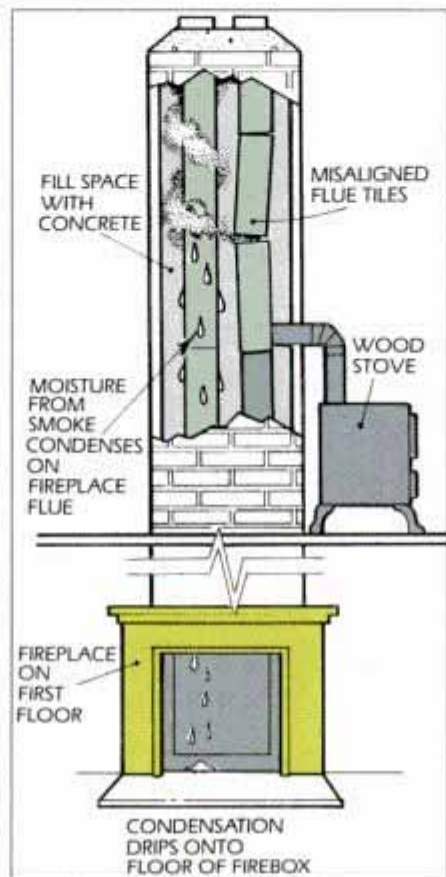
DONALD R. ALEXANDER
FRANKLIN, NC

It sounds like you have a poorly built chimney. There shouldn't be 12 in. of open space between the flue tiles and the inner surface of the brick chimney. That area is usually filled with the rubble from the chimney's construction, such as broken bricks, stones and mortar. The fill provides the flue tiles with lateral stability. Probably your problem stems from one or more open joints between the flue tiles for the wood-burning stove.

Chimney-flue tiles are generally butted one on top of another. A thin mortar bed at each butt joint holds the tiles together. However, it is possible that the tiles are not mortared together or the mortar joints have cracked apart. In that case, a chimney sweep's brushes may have jostled the tiles, opening several joints.

Wood smoke contains water vapor. Some of the smoke is probably seeping through the open joints into the area around the flues. Since the bricks and the fireplace flue are cool, the vapor in the smoke will condense on them and drip down to the fireplace.

To correct the problem, you need to fill the void around the flues with a loose cement mix. This will seal open joints and provide lateral stability. However, I suggest you hire a mason who specializes in fireplaces to correct the problem, because this procedure will considerably increase the weight on the chimney foundation, which may not have been designed to carry such a load.



To stop smoke from seeping through gaps between misaligned stove flue tiles, fill void around tiles with loose concrete mix.

Creosote Removal

Will anything remove creosote from the brick wall behind my stove? Over the past 10 years the streak has lengthened and now reaches the floor.

LYNDA FOWLIE
HARMONY, ME

If the creosote streak is thick, first tap it gently with a small hammer and pry it up with a putty knife. You can try to embrittle the streak, and make it easier to chip off, by applying a dry ice pack to it.

Another option is to make a smooth paste from a solvent (such as benzene, naphtha or trichloroethylene) and an inert material such as talc. Remember when using these solvents to follow precautions printed on the container.

Smear the paste on the stained area with a trowel, allow it to dry and scrape it off. Repeat this as necessary. Afterward, clean the area with water.

Once you remove the streak, that area will be cleaner than the surrounding wall. To reduce the contrast between the streaked area and the wall, wash the entire wall with a cleaner, such as Formula 409, and a stiff bristle brush. Then thoroughly rinse the area.

Contractor Selection

Even do-it-yourselfers need to hire a contractor sometimes. With that in mind, the checklist below will help you get the most from your home improvement dollars and avoid problems on those large projects when you need to hire a contractor. The checklist was supplied by the Office of Consumer Protection, Rockland County, New York.

1. Make a thorough list or plan of the work you want done.
2. Get at least three written estimates, each of which should be based on the same building specifications and materials.
3. Get references from contractors and inspect jobs they have previously done.
4. Before starting, check with the Office of Consumer Protection to see if contractors are licensed and if there are complaints about them on file.
5. Get a written, detailed contract. Changes to the contract should be in writing and signed.
6. Limit your deposit (other than payment for materials) to 15 percent of the total or \$500, whichever is less.
7. The contract should include a 1-year workmanship warranty and include specific start and completion dates. Payment should not exceed the cost of time and materials on work completed.
8. Make sure your contractor gets all necessary building permits, unless otherwise stated in the contract.
9. Protect yourself from liens, in the event your contractor fails to pay a subcontractor or materials suppliers, by adding a release-of-lien clause to the contract. Or, pay subcontractors and suppliers directly.
10. Thoroughly inspect work before making final payment or signing completion certificate. **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, \$2.45 postpaid. Send your order(s) to Popular Mechanics, Box 1014, Radio City Station, New York, NY 10101.

WIRING BASICS INSTALLING A DIMMER SWITCH

TEXT AND PHOTOS BY
MERLE HENKENIUS

MOST OF US think of a dimmer switch simply as an effective way to control the intensity of our lighting. And, while that is its main function, a dimmer can also extend bulb life, reduce energy consumption and eliminate switch interference with radio and TV reception.

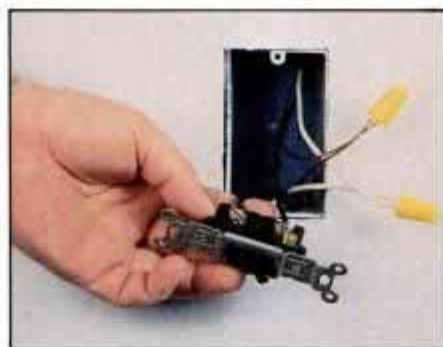
For most applications, a standard 600-watt dimmer switch (\$5-14) will do. Models are available to replace single-pole toggle switches (where one switch controls the lighting), or for 3-way configurations (where two switches control the same light). However, only one dimmer is allowed in a 3-way circuit and don't use a dimmer to control outlets that power stereos, TVs or appliances.

Before starting any work, remove the fuse or shut off the breaker that supplies power to the circuit. Then, take off the switch coverplate, remove the switch bracket screws and pull the switch from the box.

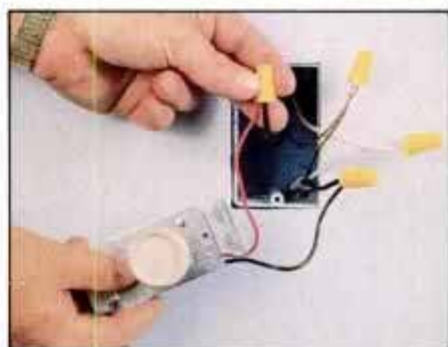
Single-pole conversions

Disconnect the two black, hot wires from the toggle switch by loosening the screws. If your switch has stab-in connectors, remove the wires by inserting a piece of wire into the release openings. Use Wire-Nuts to join the dimmer leads to the black wires. The black lead is usually connected to the incoming hot wire and the red goes to the hot wire that leads to the lighting.

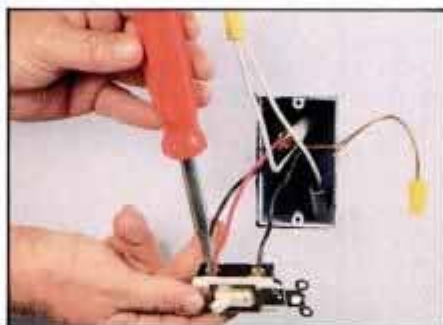
If your switch circuit contains ground wires and the box is metal, join the grounds to the box with a pigtail connection—a short length of wire with one end joined to the ground wires and the other end secured to the box with a screw. This grounds the switch via the connection between its metal bracket and the box. If neither the box or coverplate are metal, then grounding the switch is usually not required. However, if the manufacturer stipulates that the bracket be grounded, or you have a nonmetallic box and metal coverplate, then ground the switch bracket with a grounding clip and pigtail.



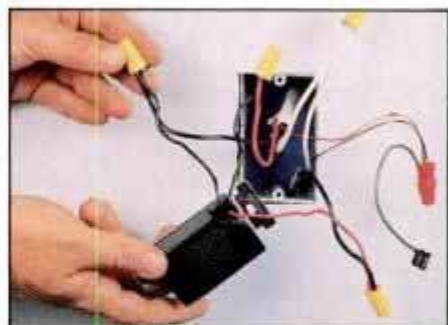
After removing coverplate, pull single-pole switch from box. Loosen binding screws to remove two black, hot wires from switch.



Use Wire-Nuts to join black wires removed from single-pole switch to dimmer switch leads as per manufacturer's instructions.



Pull 3-way switch from box and disconnect wires. Note which wire goes to COMMON terminal. Other wires link remote switch.



Join red lead to wire removed from 3-way switch COMMON. Join other leads to remaining wires. Grounding clip grounds switch.

3-way switches

Two switches that control the same light, are connected to each other with 3-wire cable and each switch has three terminals. The isolated, dark terminal, called the COMMON, receives incoming power in the first box. In the second box, the COMMON feeds the hot side of the lighting cable.

The other black and red wires, called TRAVELLERS, alternate the current between the switches.

To install a 3-way dimmer, disconnect the wire from the COMMON terminal and attach it to the dimmer red lead. Then, join the remaining switch wires to the other dimmer leads and ground switch as described.

FM

HOW IT WORKS

WET/DRY VACUUM CLEANER

BY THOMAS KLENCK,
Associate Home And Shop
Editor; PM Illustrations
by Eugene Thompson

WHILE IT'S SAID that nature abhors a vacuum, it's equally true that most of us wouldn't know how to get along without one—a vacuum cleaner that is. And, there's a model for every purpose ranging from small, handheld cordless units to multimotored carpet cleaners rated in terms of maximum-developed horsepower much like your car.

There are some jobs, however, that even the most powerful household vacuum cleaner can't handle. Picking up nails, small bits of wood and other heavy debris is not only difficult, but can damage an ordinary unit.

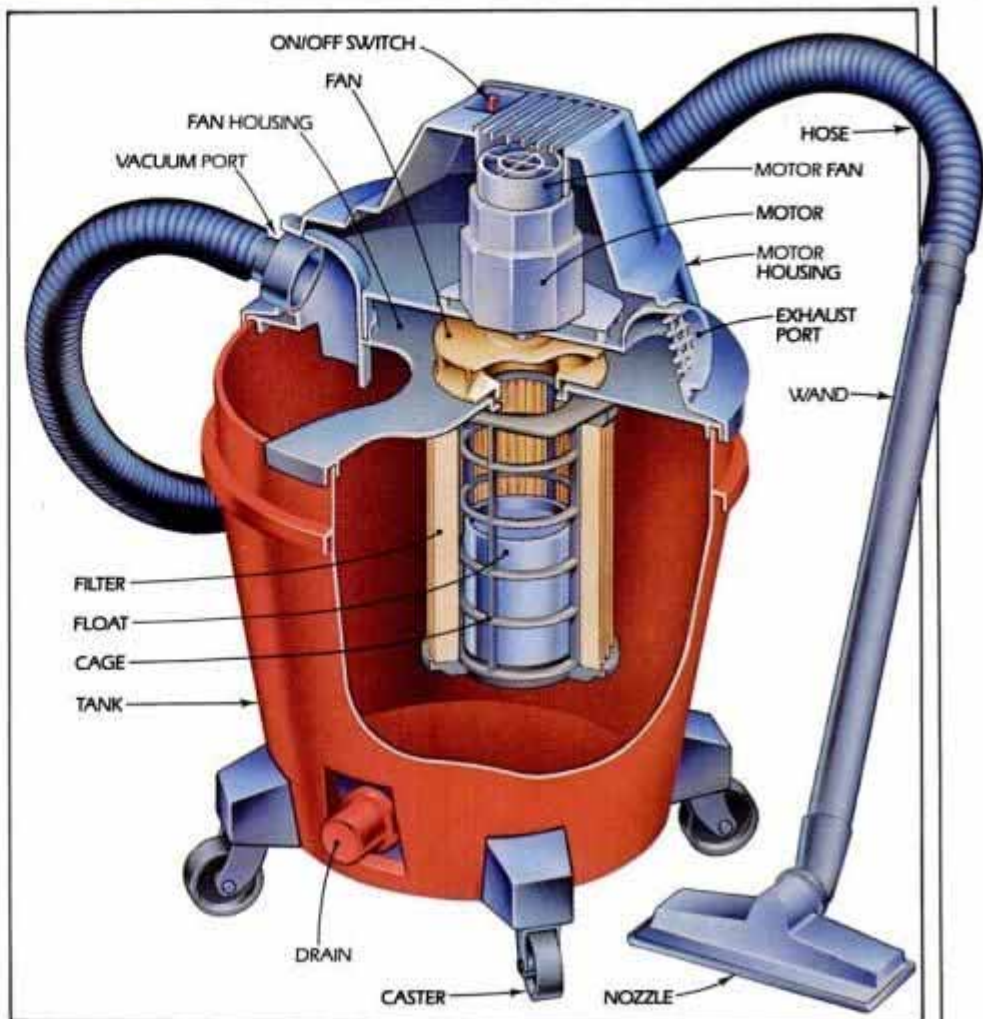
For these jobs, you need a dedicated, high-capacity machine. And, by far the most versatile type is the wet/dry shop vacuum. As the name implies, these units are more than simply oversized household vacs. They're equally at home picking up both dry debris and liquid spills. To get the job done, a wet/dry vac utilizes the same basic principles and components as your household model. The differences lie in how the components are put together.

Vacuum cleaner principles

Actually, vacuum cleaners don't really create a vacuum—an enclosed space completely empty of all air and matter. Rather, they set up a stream of moving air that's capable of carrying small bits of debris. In a standard vacuum cleaner, the particle-laden air is drawn through a porous collection bag that filters out the debris while allowing the air to pass through.

To illustrate the principle, imagine an ordinary household floor fan with a filter mounted on one side. When the fan is running, air circulates through it and any dust is trapped in the filter.

However, simply moving a large body of air through a filter doesn't make a vacuum cleaner. Unless your fan is comparable to a small hurricane, it won't lift dust and debris from



Wet/dry shop vacuums have a large tank and externally mounted motor that's isolated from debris and moisture. High-capacity fan draws air through replaceable filter that traps fine dust. Float in central cage stops airflow when tank is full.

your shop floor. Vacuum cleaners amplify the lifting power of the fan by channeling the air through a narrow hose and nozzle. The smaller the nozzle opening, the greater the suction. At the same time though, reducing the nozzle size reduces the volume of air being drawn and, therefore, the amount of debris picked up.

Vacuum cleaner fans, hoses and nozzles are designed for an optimum compromise between suction and the volume of moving air. To produce enough suction to lift heavy debris and water, and still move the large quantity of air necessary for fast cleaning, wet/dry vacuums have very powerful and effective fans. Some units, called 2-stage vacs, have a second fan mounted after the first to further increase airflow.

The wet/dry difference

Both the household upright vacuum cleaner and the standard canister model operate much like the floor fan and filter example described above.

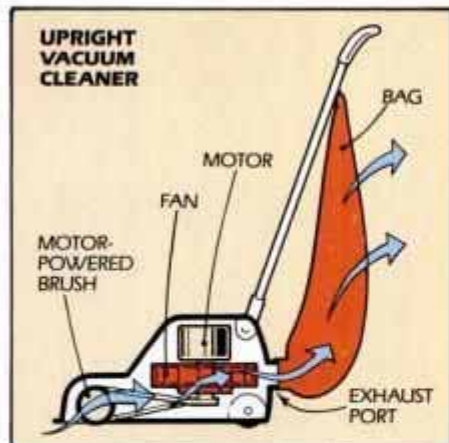
The upright type first draws dust-laden air through the fan and exhausts it into the bag. The air flows through leaving the dust behind. This design can't handle large debris which can jam or damage the fan.

Ordinary canister vacs have the bag in front of the fan and motor. Although you're less likely to damage the fan, excessive dust in the bag can reduce vacuuming effectiveness.

Shop vacuums are similar to the canister type in that the air is filtered before it reaches the fan. These units are capable of handling larger chunks of debris. However, the similarity ends here. Unlike the typical household unit in which the bag serves as a filter, shop vacs have a nonporous collection tank and a separate filter.

As debris-laden air is drawn into the tank, the heavier particles drop to the bottom. The air passes through the filter where the smaller particles are trapped and then moves through the fan and out of the machine.

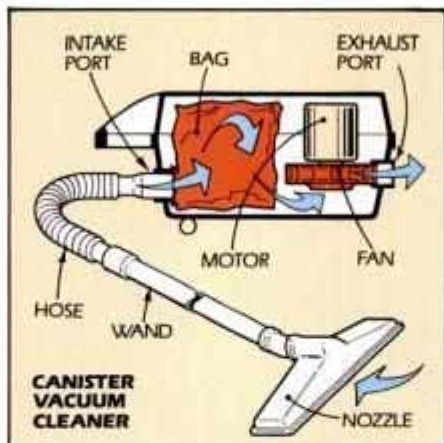
In dry-pickup vacuums, the ex-



UPRIGHT VACUUM CLEANER

Upright vacs use motor-driven brush to dislodge dirt. Debris-laden air travels through fan to bag which acts as filter. Large chunks may damage or jam fan.

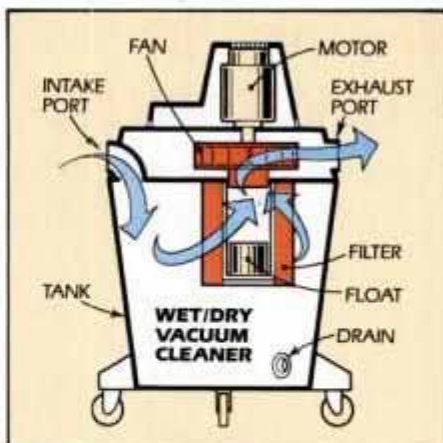
Exhaust air passes by the electric motor after leaving the fan. This airstream also serves to cool the motor. As long as the air is clean and dry, there's no problem. If you try to clean up liquid spills, though, the moisture in the exhaust air could damage the motor as well as create a safety hazard.



CANISTER VACUUM CLEANER

Bag in canister model filters out dirt before air reaches fan. While fan is protected from large debris, liquids can damage bag and moisture may enter electric motor.

Wet/dry vacuums solve this problem by placing the fan in a separate chamber. The motor is isolated from the air being drawn through the machine and has its own dedicated cooling fan mounted on top. In addition to protecting the motor from moisture, this arrangement also keeps any dry



WET/DRY VACUUM CLEANER

In a wet/dry unit, waste falls to bottom of the tank. Fine dust is filtered before air moves through fan and exhaust port. Airstream bypasses external motor.

debris that might pass through a broken filter from entering the motor.

When vacuuming water, a float valve rises with the water level and blocks the airflow when the tank is full. To empty the tank after a wet cleanup job, simply open the drain valve at the tank bottom. **PM**

TOOL TEST

BAND SAW BLADE

UNTIL RECENTLY, a 1/8-in.-wide blade was the smallest I'd ever used on my band saw. Now Sears has come out with a really narrow blade that is only 1/16 in. wide. I tried it and I like it.

The blade is 80 in. long and comes with a pair of self-lubricating guide blocks that must be substituted for the metal ones on the saw's upper guide assembly. The blade and blocks are sized to fit most former and current Craftsman 12-in. band saws.

Test cuts were made in both softwoods and hardwoods in thicknesses up to 5 in. with excellent results. The blade stayed on course and the cut edges turned out smooth. This was surprising because I had anticipated some drifting of the blade when sawing thick stock.

Unfortunately the instructions failed to mention that the lower guide blocks should be moved apart so they do not touch the blade, and that the lower and upper back-up bearings should be adjusted to touch the blade. This will keep it from being pushed back by cutting pressure.

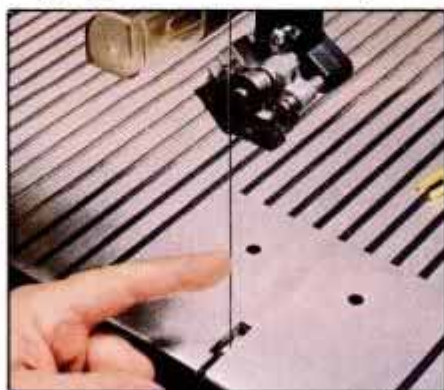
This 20-teeth-per-in. blade is listed in the Sears Jan. '90 Power & Hand Tools catalog. It's priced at \$6.99 plus shipping. —Rosario Capotosto



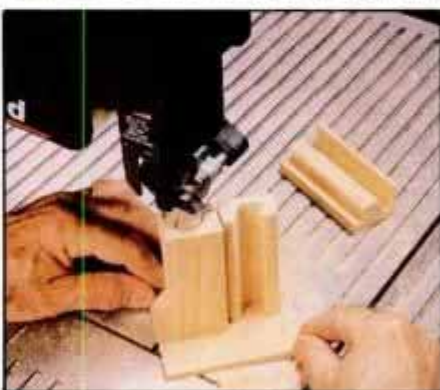
New 1/16-in.-wide band saw blade comes with two special plastic blade guide blocks. Blocks reduce heat and thus wear on blade.



Remove metal guide blocks from saw and replace with plastic blocks. Blade will form its own seat in blocks to prevent twisting.



If your saw has no tension scale for 1/16-in. blade, adjust blade by feel. Deflection should be 1/4 in. with moderate finger pressure.



Blade can cut curves with diameters as small as 1/8 in., as shown on this finger grip drawer pull. Note smoothness of cut.

NEW PRODUCTS HOME ENHANCERS

Fifteen new home-improvement products.

BY ROY BERENDSOHN, Assistant Home and Shop Editor



Big And Strong

Made of 18-gauge stainless steel, Elkay's contemporary Gourmet sink is strong and spacious, with overall dimensions of about 8 in. deep x 20 in. wide and 53 in. long. The model shown is equipped (left to right) with a soap/lotion dispenser, a spray nozzle, uni-

lever faucet and hot-water dispenser. The ribbed drain board can be located on the sink's left or right side. The sink, alone, costs about \$850 at kitchen and bath suppliers. For more information on this sink and its accessories, write to Elkay Manufacturing Co., 2222 Camden Court, Oak Brook, IL 60521.



Landscape Light

Designed to give years of reliable service, this 12-volt landscape light uses a halogen lamp for clear illumination and little color distortion. Its bulb is protected by a clear acrylic lens housed atop a heavy-walled aluminum base that's coated with a baked-on, mar-resistant polyurethane powder finish. Its exterior wiring is Teflon coated for weather resistance. The LS1276-7 costs about \$109 at lighting centers. Contact Thomas Industries, Residential Lighting Div., P.O. Box 7849, Louisville, KY 40207.

Hazard Test

With LeadTest, you can detect lead in dishes, paint, metal objects, plumbing and soil in levels as low as five parts per million, its manufacturer says. To check for lead, you moisten an item with distilled white vinegar—that's included in the kit—and then dip or rub a test strip into the vinegar. The strip turns red if lead is present. The kit costs about \$10 at hardware stores and home centers. Write to Verify, Inc., 1185 Chess Dr., Suite 202, Foster City, CA 94404-1109.



Concrete Reconditioner

This concrete patch is more durable than others, its maker says, because its high concentration of polymer makes it bond tighter and be more resilient once cured. Mix the powder and latex polymer and use it as a skim coat or to fill holes. The 30-pound size shown costs about \$40, and the 7½-pound size, about \$13. It's sold at home centers and paint stores. Write to Mr. Mac's, 11 Creek Ridge Rd., Greensboro, NC 27406.



Space Saver

Hang the Millex ironing board on a door's back or front and it's out of the way. To use it, just fold down the 17-in.-wide x 43-in.-long board. It installs without tools—snap the door hooks to the frame and hang it. The ironing board features steel construction with an epoxy finish. Its blunt end, a European design, makes for faster ironing, the manufacturer says. It costs about \$37 at home centers. For more information, write to Millex Inc., 800 John Watts Dr., Nicholasville, KY 40356.



Almost Natural

One-Coater paint brushes hold more paint and spread it easier than other synthetic brushes, their maker says. The brushes' polyester filaments have a texture like natural bristles, and more surface area than other synthetic bristles. The lifetime-guaranteed brushes can spread oil or latex paints and come in widths from 1 to 4 in. The 3-in. brush shown costs about \$8 at paint stores. Write EZ Paintr, The Newell Group, 4051 S. Iowa Ave., Milwaukee, WI 53207.



Radon Control

Laid over a crawlspace dirt floor, Enkavent radon-control matting intercepts radon gas and channels it to a vent pipe. It consists of a stiff, but porous, mat of nylon filaments backed by polyester fabric. It's sold in 2-roll bundles (each roll is 18 in. wide x 50 ft. long) and costs about \$300. Installed, to retrofit a 1700-sq.-ft. crawlspace. For information, or to locate your nearest supplier, write Akzo Industrial Systems Co., P.O. Box 7249, Asheville, NC 28802.

Child Safe

Safe-let blocks a child's probing fingers from twin-receptacle outlets by covering the opening with a pair of smooth plastic, spring-loaded covers. The covers slide shut when a plug is removed, and they block drafts from uncovered outlets. They're sold in a range of colors for \$4.25 at electrical distributors. For information, write to Molvan Enterprises, 55 W. Beaver Creek Rd., Unit 8, Richmond Hill, Ontario, Canada L4B 1K5.



Papered Panels

Weyerhaeuser's line of decorator panels combines the ease of paneling with the look of wallpaper. The 4-ft. x 8-ft. panels consist of a wallpaper mounted on 1/8-in. lauan plywood. The paper is treated with a clear coating so it's washable. To install, cut the panels with a utility knife or saw and fasten them with adhesive. The panels cost about \$15 each at home centers, and come in about 40 styles. For a free booklet on plywood paneling, send a self-addressed, stamped envelope to the Plywood Paneling Council, 1633 Broadway, New York, NY 10019.



Trackless

These folding bath doors are hung from the wall and don't require hard-to-clean tracks to slide in. Their polycarbonate, plastic door panels come in clear or bronze tint, and their bottom edge slants to drain runoff into the

Compact And Versatile

Designed for small homes, the gas-fired Integra is both forced-air furnace and water heater. It also functions as an air conditioner when hooked to a compatible condenser. About 24 in. wide and 75 in. high, it fits in a closet. It costs about \$1500 installed (plus condenser) and is sold by heating contractors. For more information, write More-Flo Industries, Inc., 18450 S. Miles Rd., Cleveland, OH 44128-4296.



tub. The door frames are available in white, almond and black. They are available to fit tub-opening widths from 51 in. to 84 in. and shower widths from 20 in. to 48 in. The door shown costs about \$140 at home centers and plumbing supply houses. Write Lyons Industries, Inc., P.O. Box 88, Dowagiac, MI 49047.

See-Through Bifold

Wing's new La Door combines bifold compactness with the elegance of a French door. It's sold in 24-, 30- and 36-in. widths and has stile and rail thickness of 1 1/2 in. It's made of clear Ponderosa pine that's smooth sanded so it's ready to paint or stain. Available at home centers, it's offered with panes divided by brass (shown), about \$175; or a single glass pane V-grooved to look like individual beveled lites, about \$195. For more information about Wing's new La Door, contact Wing Customer Service, P.O. Box 38347, Dallas, TX 75238.



Computerized Flooring

For a precise fit between pieces, Tarkett uses computerized routers to cut the ash and oak for its parquet flooring. They're available in a variety of sizes, grades and styles, in individual pieces and stapled-together panels. Finished samples are (left to right): Marie Antoinette, about \$8.50; Herringbone, \$7.50; Fountainebleau, \$16; Woodstone, \$9.50 (cost per sq. ft., select grade, unfinished oak). They're sold at Tarkett wood-floor suppliers. Contact Tarkett, Box 300, Route 9, Riverview Rd., Johnson City, TN 37605.



It's A Snap

You need few tools to install this closet organizer. Most of its steel and plastic parts just snap together to yield a sturdy structure that



allows a lot of air circulation. The steel shelf planks are coated with durable polyurethane paint and are roll-formed for extra rigidity. There are four sizes, for closets 3-6 ft., 4-6 ft., 5-8 ft. and 8-10 ft. They cost about \$55, \$80, \$90 and \$145, respectively, and are sold at hardware stores and home centers. Write the Stanley Works, 195 Lake St., New Britain, CT 06050.



Hot Stuff

The cast-iron Winter Warm fireplace insert can heat a 1500-sq.-ft. area, and is 78.3 percent efficient, its maker says. One interesting feature is a thermostat-controlled fan that drives air past the door's removable glass

panel to keep it from getting soot-covered. It comes in three enamel colors, sand (shown), bronze and black, that cost about \$2500 each. A plain black model costs about \$2300. They're sold at Vermont Castings Dealers. Write Vermont Castings, Prince St., Randolph, VT 05060. **PM**

TOOL TEST
**NEW PLATE
JOINER**

TEXT AND PHOTOS BY
ROSARIO CAPOTOSTO,
Contributing Editor

IF YOU'RE thinking of switching your woodworking joinery methods from dowels to biscuits, consider Black & Decker's Elu 3380 joiner/spliner. I used it to join a variety of test joints, with excellent results.

The Elu's cutting action is unique. While most plate joiners cut their biscuit slots by plunging into the work, the Elu pivots. This makes it more comfortable to hold when cutting slots in awkward situations. The 12-tooth, carbide-tipped blade cuts to a depth of $\frac{7}{8}$ in. and trims stock up to $\frac{13}{16}$ in. thick (Photo 1). Cutting depth is controlled by an adjusting knob and graduated scale that's marked for the three standard biscuit sizes (Photo 2).

I liked being able to operate the tool on either surface of its right-angle base. Both its surfaces, the shoe and blade guard, provide rigid support.

Slots are cut into the face of a 45° miter by attaching a miter guide to



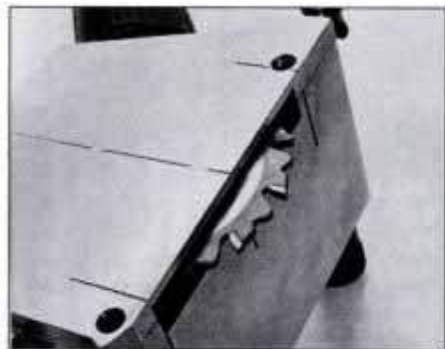
Black & Decker's Elu 3380 plate joiner comes with fence and miter guide (inset).

the blade guard (Photo 4). For fine positioning, the blade can be adjusted side to side in the blade guard. Large adjustments are made by positioning the joiner's fence. The fence helps you accurately cut a row of slots, or spline grooves, in a board's face.

The Elu's ON/OFF switch is a good safety feature. It must be held down to operate the tool. For neater work

in plywood, the joiner comes with an antisplintering blade insert.

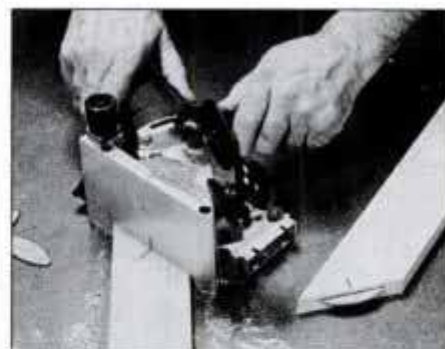
The 3380 has a 5-amp motor and comes with a metal case, fence, miter guide, blade insert, side handle and two wrenches. It costs about \$335 at Black & Decker tool dealers. Write Black & Decker, U.S. Power Tools Group, 10 N. Park Dr., Box 798, Hunt Valley, MD 21030. **FM**



1 The carbide-tipped blade projects through the shoe to cut slots or grooves. Blade guard is perpendicular to the shoe.



2 Adjust the blade depth by turning the knob. Numbers 8, 10 and 12 on depth guide match three biscuit sizes: No. 0, 10 and 20.



3 To cut slots for frame miter joints, lay the tool on the blade guard and align the mark on the shoe with that on the workpiece.



4 Use the miter guide to cut box miter slots. The blade is off-center on the mitered face so it won't break out back of stock.



5 The Elu cuts a row of biscuit slots in a board's face, a handy capability for designs that call for face-to-edge joints.



6 In an operation similar to cutting a row of slots, the joiner is held down and pushed forward to cut spline grooves.

THE BETTER HOME APPLIANCE CLINIC

BY STEVE TOTH,
Contributing Editor

Stopping And Starting

What could cause my Kenmore washer model No. 110.72625100, serial No. C53673806 to continually stop and start during the spin cycle? It does this periodically. Eventually all the water is removed from the tub, but the clothes are still too wet and there is evidence of soap suds.

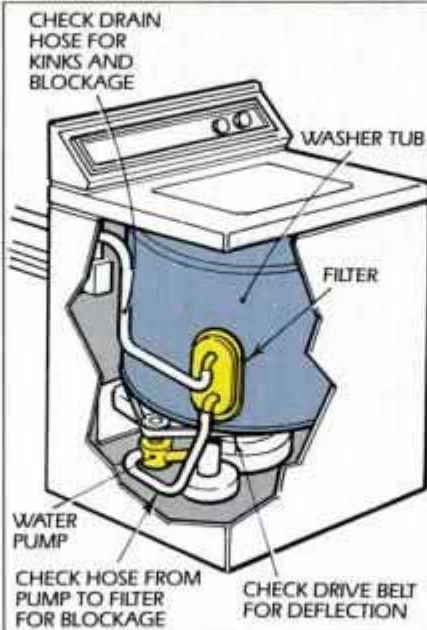
CARMEN DEL GAUDIO
STORMVILLE, NY

Sounds as if your washer may not be pumping all the water out of the tub during the 2-minute drain period before it goes into the spin cycle. When this happens, the water that's left is spun around the tub. The pressure of the water activates the water level switch, causing the spin solenoid on the transmission-mounted control magnet to deenergize. This causes the tub to stop spinning momentarily. As the water falls to the bottom of the tub, the spin circuit is again activated and the tub spins again.

It will take some investigation to find the problem, but something is preventing all the water from pumping out in the allotted time. It could be that a lint buildup has clogged the filter, or that the drive belt is loose. Also, the drain hose may be clogged or kinked, or the hose from the pump to the filter may be clogged.

Remove the hoses and pour water down them to check for clogs. Flush out lint by holding the hose under a faucet. Prevent water from squirting out at the faucet end by wrapping a damp rag around the faucet and the hose's end. Pick lint out of the filter openings.

Check the drive belt by spanning two pulleys with a straightedge. Press on the belt and check that its deflection does not exceed $\frac{1}{2}$ in. from the straightedge. If deflection is more than $\frac{1}{2}$ in., the belt's too loose and you'll need to tighten it by adjusting the motor's position. For a complete description of this, and other service procedures, purchase a Sears Kenmore belt-drive washer service manual from your local Sears store or service center.



Check tension on drive belt. Also check for clogged or kinked drain hose and clogged hose from pump to filter.

Musical Hot Water

Our natural gas-fired A.O. Smith water heater, No. KGA40860, hums during the heating cycle. It is glass lined and has a 40-gallon capacity. The hum, which appears to come from the control box, does not appear to affect its ability to heat water. What causes the hum, and what can be done to remedy it?

E.A. MICHELSON
SYLVANIA, OH

I contacted A.O. Smith, and they tell me that it may be due to high or low gas pressure at the gas control. This causes the internal diaphragm on the control to vibrate, creating the sound.

Also, if the control is attached to a flexible gas connector, the gas flowing over the connector's ribs may be causing the sound. Have a licensed plumber replace a flexible connector with a rigid one.

There are many other possibilities. The manufacturer suggests having your local gas utility company check the house's gas pressure. If these measures are not successful, contact the plumber who installed the heater or A.O. Smith.

Gas Fridge Parts

We have an old Servel gas refrigerator (11 cu. ft. with a freezer on top) that was bought new in 1947 and is still running strong. It is being used as a backup to the big side-to-side in the kitchen. We would like to replace the door seals and to convert it from natural gas to L.P. gas. Can you

direct us to a supplier for parts and information?

C.N. YUEN
SOUTH PASADENA, CA

Contact Kerns Refrigeration, 3929 La Mesa Ave., Central Valley, CA 96019; (916) 275-6382. They have complete data on all Servel models from 1933 on, including kerosene-fired models. They service and sell parts for all makes of absorption refrigerators and freezers.

To make the conversion, Kerns will need the refrigerator's model number, cooling unit number or BTU input rate. If you can't find these numbers, send them a photo of the refrigerator with the door open and include dimensions of its box. They also need to know the altitude at which the refrigerator is operating.

The cost of the conversion parts, which include an orifice sized to your model refrigerator and a turbulator for L.P. gas, is \$14 plus shipping.

The company strongly recommends you purchase a copy of its gas refrigerator repair manual (\$6) for Servel and Whirlpool refrigerators, 1933 to 1957. The manual will assist you in installing parts, making flame adjustments, as well as cleaning the flue systems.

The company can also supply you with a universal door gasket material that fits all Servel/Whirlpool doors from 1947 on. It costs about \$1 per ft., instructions included. **PM**

Service Tip

Dishwashers that are used in areas with hard water can develop a white, yellow or brown film on the inside of the tub. To remove this film, first empty the dishwasher and set the timer for one wash cycle. Start the dishwasher through the cycle. When you hear that the water has stopped entering the tub, unlatch the door and pour in $\frac{1}{4}$ - to $\frac{1}{2}$ -cup of citric acid crystals (available at your local drugstore). Read the precautions on the package before using the crystals.

Close and latch the door, and let the machine go through the cycle. Depending on the buildup, it may take a few treatments but eventually the inside will look like new again.

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.

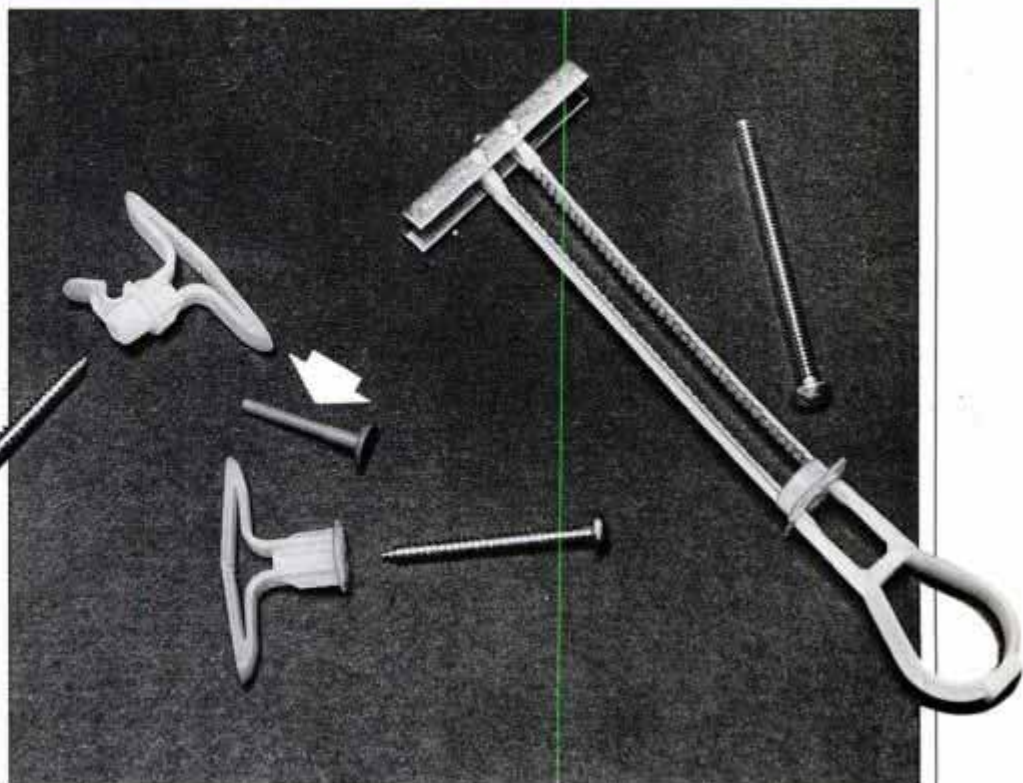
FASTENING TECHNIQUES

HOLLOW- WALL ANCHORS

TEXT AND PHOTOS
BY ROSARIO CAPOTOSTO,
Contributing Editor

WHEN IT'S necessary to attach or hang something from a standard house wall, the best method is to drive a screw or nail directly into a framing member behind the wall surface. But as we all know, this isn't always feasible. More often than not, you'll have to select a fastener that was specifically designed for gripping in the hollow spaces between studs and joists. Plastic anchors, Molly screws and toggle bolts can all accomplish these tasks very well. When you add to these three fasteners the venerable lead anchor—for joining materials to masonry surfaces—you've covered just about all the fastening bases. You've also got a lot of different anchors.

The Toggler anchoring system can cut down on your hardware clutter, because these clever devices were designed with versatility in mind. The basic Toggler is the screw anchor which can work in both solid-wall and hollow-wall applications. It consists of a polypropylene anchor and a small plastic setting key. All you do is drill a hole in your wall and slide the anchor in place. For solid walls, the anchor is just wedged into the hole, like a normal plastic anchor. If the wall is hollow, you simply slide the key setting



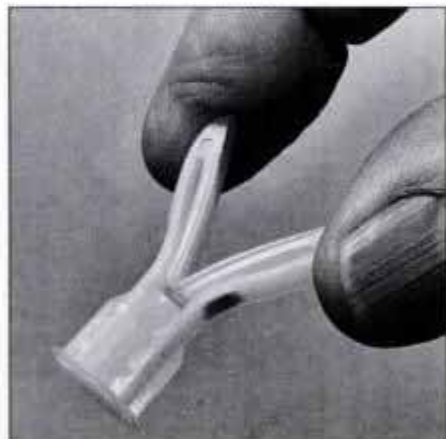
Toggler anchor system offers three options: simple picture hook with screw (left), wall anchor with screw (middle) and toggle-type anchor with bolt (right). Plastic setting key (arrow) is used to snap open wings on picture hook and wall anchor.

pin into the anchor and push. This action forces the wings on the anchor to pop out and bear against the inside surface of the wall. Once you remove the setting pin, all you do to attach something is drive a self-tapping machine screw through the object and into the anchor.

The basic anchors come in different sizes, depending on the thickness of the wall material. The smallest one works in panels—like those found on hollow-core doors—that are $\frac{1}{8}$ to $\frac{1}{4}$ in. thick. The next size handles material that is $\frac{3}{8}$ to $\frac{1}{2}$ in. thick, and the largest is designed for surfaces that are $\frac{5}{8}$ to $\frac{3}{4}$ in. thick. These dimensions

indicate the thicknesses that allow the anchor to fully expand on the backside of the surface covering. Of course, in solid-wall applications they'll all work. Each anchor will hold at least 40 pounds of weight and is designed to accept screws ranging from sizes No. 6 to No. 14.

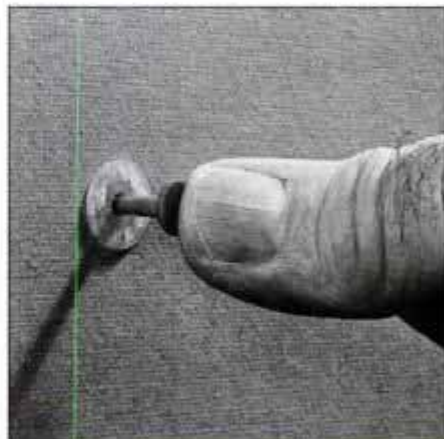
The basic anchor is complemented with other models used for specific purposes: a picture hook (Fig. 7), an anchor for mounting perforated hardboard with the correct spacing from the wall, and ones designed for mounting wire rack storage systems, adjustable metal shelf standards and all sorts of electric cables.



1 To install anchor, first bore hole in wall then squeeze anchor wings together.



2 Insert folded anchor into hole and press until flush with surrounding surface.



3 For hollow walls, press setting key into anchor to pop out wings on inside of wall.

If you have to support heavier loads—up to 150 pounds per anchor when installed in concrete block—the Toggler toggle bolt fills the bill in ways that a standard toggle bolt can't. This version is installed in the wall independent of any bolt. Because the support wing on the inside of the wall is secured by the fixture, instead of the bolt, the bolt that holds the object

can be removed and replaced at any time without the wing falling down inside the wall.

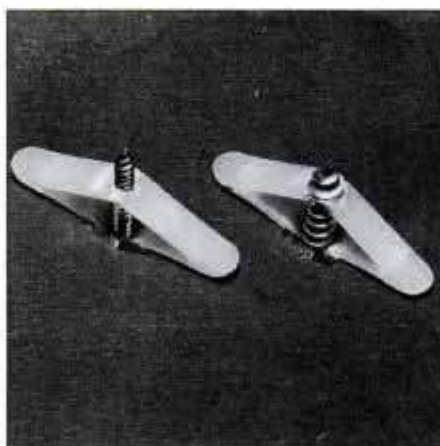
Another virtue of these toggle bolts is that they require a smaller wall hole. Most ¼-in. toggle bolts require a ¾-in. hole but the Togglers need only a ½-in. hole. And, the anchor is designed with a flange around its plastic cap that covers the edges of the hole

and leaves a presentable finished appearance when exposed.

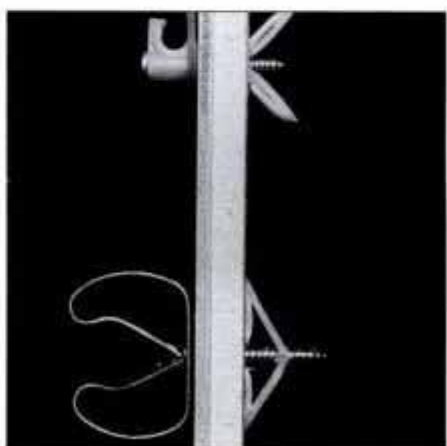
The Togglers are available at hardware stores and home centers, and are usually sold in packages of eight for about \$1.70. For more information, contact: Toggler Anchor System, Div. of Mechanical Plastics Corp., P.O. Box 328 Castleton St., Pleasantville, NY 10570. **PM**



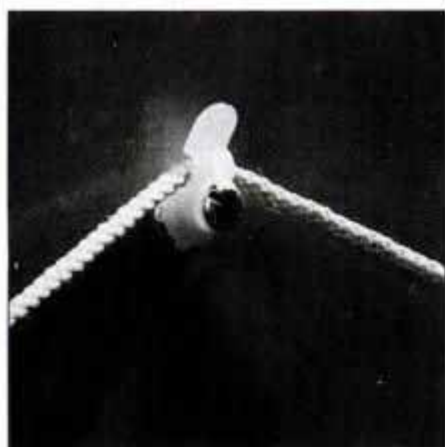
4 Attach desired hardware to wall anchor using self-tapping machine screw.



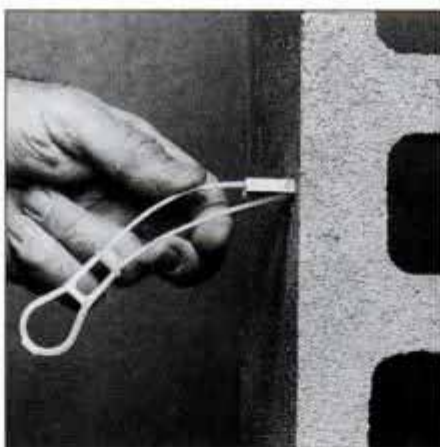
5 Anchor (back side view) can hold screws from size No. 6 (left) to No. 14 (right).



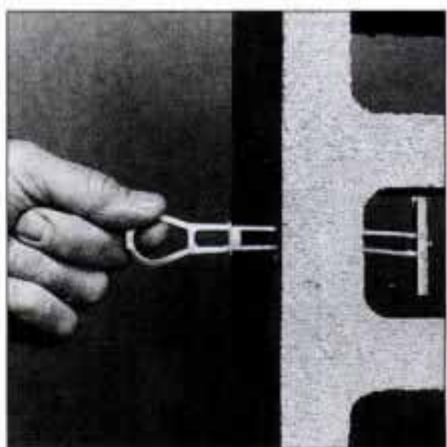
6 Fully spread anchor (bottom) grips best, but also holds well partially spread (top).



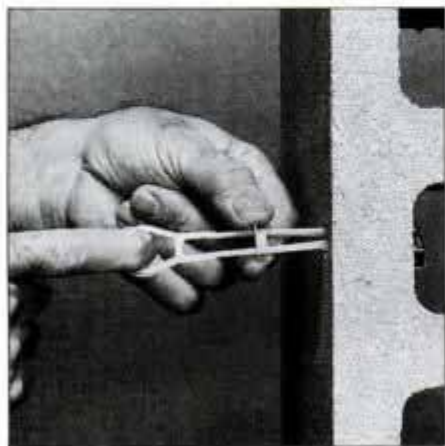
7 Picture hook is great for hanging frames and supporting small cable wires.



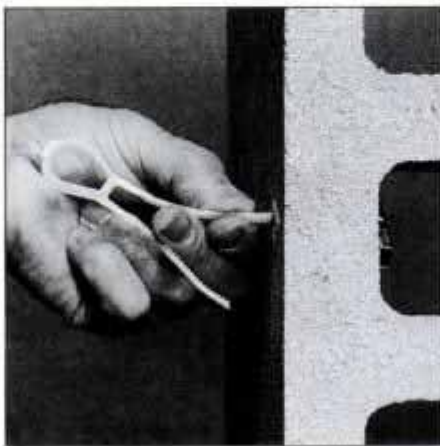
8 To install toggle-type anchor, fold wing against strap and push into prebored hole.



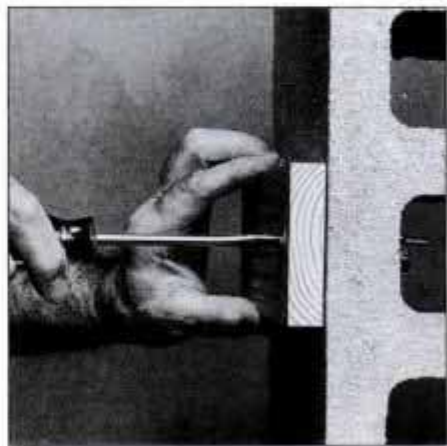
9 Once through hole, pull out until wing hits inside surface of wall.



10 Secure anchor by pushing cap into hole until flush with surrounding surface.



11 Once cap is firmly seated, bend straps from side to side until they break off.



12 Attach object to wall using bolt of proper length. Bolt threads into wing.

RACING 1990

AMERICA AT SPEED

SEASON PREVIEW

- CART ● NASCAR
- IMSA ● SCCA

PLUS

- TOP FUEL DRAGSTER TECH
- GRASS ROOTS RACING
- WORLD OF OUTLAWS

PM PHOTO BY RON HUSSEY



CHASING EMMO

Can Fittipaldi make it two in a row?

BY DAVID PHILLIPS

THE 1990 Indycar season shapes up as one of the most competitive and technologically diverse in the history of Championship Auto Racing Teams (CART). At the same time, CART—which has sanctioned the PPG Indycar World Series since its inception in 1979—faces challenges crucial to the long-term future of Indycar racing. Stir these two elements vigorously, and it seems certain that 1990 will be anything but dull.

On the hardware front, it figures to be another good year for the Chevrolet Indy V8, although a much stronger challenge is expected this year from Porsche, with Cosworth, Judd and Buick also hoping to improve.

Never short on power, the Mario Illien/Paul Morgan-designed Chevy shed its early reputation for fragility and was absolutely bulletproof last season. With further refinements and more efficient engine management—and teamed with Roger Penske and Newman-Haas Racing as well as the



Adversaries in '89, Rick Mears (left) and Indycar champion Emerson Fittipaldi will be Penske teammates during '90 season.

new Galles/Kraco partnership—look for Chevy-powered cars to dominate again in 1990.

The addition of 1989 Indycar champion Emerson Fittipaldi—and Marlboro sponsorship money—to its already impressive lineup of Rick Mears and Danny Sullivan, makes Penske Racing the team to beat. Unlike last season, when Penske sold three of his Nigel Bennett-designed PC-18s to Patrick Racing, Bennett's PC-19 will be Penske only.

Logistics and team chemistry will be key to the recently merged Galles and Kraco teams. Rick Galles and Maury Kraines each ran multiple car teams in the past with minimal success. However, the lure of a Chevy engine for Kraines and the financial wherewithal for Galles to build his own chassis, plus the close friendship of drivers Bobby Rahal and Al Unser Jr., proved irresistible. With the Alan Mertens-designed chassis not due until late in the year, Rahal and Little Al will run Lola chassis.

An equally formidable driver pairing—Mario and Michael Andretti—will again carry the K mart/Havoline standard at Newman-Haas Racing. Michael proved to be every bit the force he was expected to be in 1989—his first season with Chevy power—and only an overdose of the legendary Andretti bad luck cost him a serious shot at the title.

Patrick Racing is the big question mark for 1990. Although Pat Patrick's organization won five races, including the Indy 500, plus the 1989 CART title, the team ended the season with its



driver (Fittipaldi) and major sponsor (Marlboro) ready to sign with Penske.

As a result, Patrick has effected a partnership with Alfa Romeo, with the popular Roberto Guerrero, Alfa's driver in '89, part of the bargain, as well as the prospect of a new March chassis. Since its debut at Detroit, the Alfa engine has been reliable, though more power is needed for it to be truly competitive.

With just one car, Porsche has been playing a rather unlikely David to Chevrolet's Goliath, and proved last year that it meant business. Thanks to a splendid March 89P chassis and a new motor—wider powerband and better throttle response—Porsche went from pest to rival and scored a win at Mid-Ohio.

Quaker State/Porsche team manager Derrick Walker promises the March 90P will be "quite a bit different." Although still limited to a 1-car effort (a second entry is planned for Indy), Porsche too will look to increasingly sophisticated electronics to coax more power and better low-end response from its V8.

It took a couple of lean years to get perennial front-running Cosworth to respond to the Chevy juggernaut. With two teams using its new short-stroke DFS engines, Cosworth got its first win since late 1987, scored by Bobby Rahal in a downpour at the Meadowlands.

Just how Cosworth can massage a design that dates to 1967 is open to debate. The DFS still lacks the throttle

response and torque required for road and street circuit racing.

The outlook for John Judd's engine is murky. After scoring a rather fortunate win at Pocono in 1988, Judd and U.S. partner Truesports Racing made the Honda-based V8 available to a 3-team developmental partnership last year—Truesports, Raynor and Shierson—but performance was spotty. Yes, Truesports rookie Scott Pruett finished second at Detroit and was in the top 10 almost all season, but the Judd was distinctly underpowered on the faster circuits.

With an interim developmental motor on tap for 1990, Truesports boss Steve Horne seems confident the Judd will be a match for the other powerplants. Certainly Pruett, with a full season under his belt, will be a factor.

Last, but not least (at least at Indy) is Buick's stock block V6. Given an extra 10 in. of turbo boost by USAC at Indianapolis, the Buick remains a viable alternative at the Brickyard, and a number of teams expect to run Indy-only Buick programs. Elsewhere, though, the Buick is severely handicapped by CART's across-the-board boost rule.

The off-track intrigue regarding new rules for 1990-'94—rules designed to reduce cornering speeds and enhance driver protection—was still in progress at press time. Since the new regs would essentially render '89 and older cars obsolete, a compromise was eventually reached that grand-

Teo Fabi's Porsche-powered March figures as the dark horse of the 1990 campaign.

1990 CART PPG INDYCAR SCHEDULE*

April 8	Phoenix, Arizona
April 22	Long Beach, California
May 27	Indianapolis 500, Indiana
June 3	Milwaukee, Wisconsin
June 17	Detroit, Michigan
June 24	Portland, Oregon
July 8	Cleveland, Ohio
July 15	Meadowlands, New Jersey
July 22	Toronto, Ontario
August 5	Irish Hills, Michigan
August 26	Denver, Colorado
September 2	Vancouver, British Columbia
September 16	Lexington, Ohio
September 23	Elkhart Lake, Wisconsin
October 7	Nazareth, Pennsylvania
October 21	Monterey, California

*As of October 4, 1989

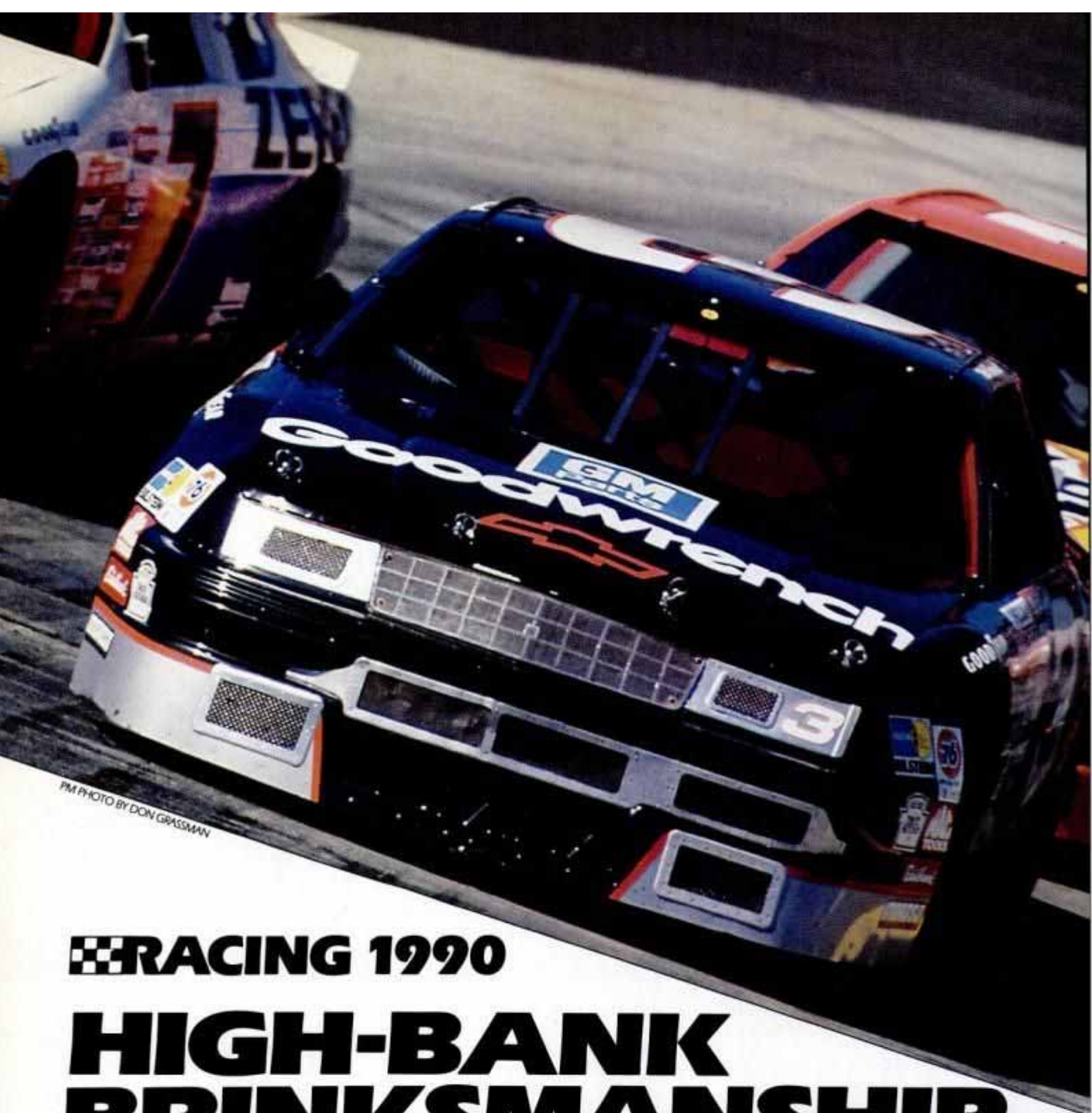
fathered older cars into the series through 1992. The U.S. Auto Club, however, left its rules for the 1990 Indianapolis 500 virtually unchanged.

The '90 spec Indycars are expected to be at a significant disadvantage versus their predecessors. There is expected to be significantly less aerodynamic downforce to work with, owing to the mandated smaller sidepods and the repositioning of the rear wing. Because the driver's feet must now be behind the centerline of the front wheels, the '90 cockpits will also be more centrally located. This, in turn, will require a repositioning of the fuel cell, resulting in unfavorable weight distribution. The net result, should USAC stick to its position, is that most teams will either keep their '89 cars specifically for Indy, or run hybrid '89/90 cars there.

Just who is going to emerge as the champion is, as usual, anybody's guess. Most forecasters rated Fittipaldi a dark horse at the start of 1989. But if you like dark horses, keep an eye on Teo Fabi. Porsche made huge strides in 1989, while March again proved itself capable of producing a state-of-the-art chassis. If the March 90P is as capable as its predecessor, then Fabi could very well win the title he so narrowly missed in 1983. **PM**



Rick Mears scored three victories for Team Penske to finish second in the '89 standings.



PM PHOTO BY DON GRASSMAN

❑ RACING 1990

HIGH-BANK BRINKSMANSHIP

NASCAR may or may not be the greatest show on earth, but it sure don't get no closer than this.

BY AL PEARCE

IT ALL GOES back to Bob Latford and a summer afternoon he spent at the Boot Hill Saloon in Daytona Beach.

Latford was serving as public relations director at the Atlanta International Raceway when NASCAR executives Bill France, Lin Kuchler and Bill Gazaway commissioned him to find a better way to determine their

annual champion. Privately, they feared that a steady-but-unspectacular driver (dare they say undeserving?) might someday steal their most significant title. They feared that a midpack runner might simply ride around in enough races to outpoint the big-name stars who ran hard and risked crashing or blowing up.

Do something about that, they told Latford. Help us keep a midpack stroker from backing into our cham-

Dale Earnhardt's black Chevy Lumina was a dominant force through much of the '89 NASCAR Winston Cup season.

pionship and making us look silly.

So in the summer of '74 Latford sat down with two racing buddies and some beer at the old Boot Hill. They talked about their sport, toyed with some numbers, drank some beer, toyed with more numbers, drank more beer and talked more about racing. Several hours later, Latford had NASCAR's new points system all figured out on cocktail napkins.

His formula encouraged drivers to

start every race, run hard, lead laps and stay on the track as long as they could—even if their cars were beat and battered and hopelessly behind. Drivers who led the most laps got extra points. Drivers who led even one lap got extra points.

Unlike some of the previous systems, Latford's scheme proposed that every race be weighted equally. Winning the Martinsville 500, for example, would pay exactly the same championship points as winning the Daytona 500.

The new plan almost guaranteed that the series champion would be the driver whose equipment and crew performed best, week in and week out, over the long haul.

Better yet, it ensured that the championship wouldn't be decided until late in the season, perhaps (here you could almost imagine France, Kuchler and Gazaway breaking into wide grins) at the last race.

Who will win the \$1-million prize this year? Smart money will be on the slick Chevy Lumina of Dale Earnhardt and Darrell Waltrip, as well as Rusty Wallace's Pontiac Grand Prix. Each of them had an outstanding '89 season and each returns to a well-financed, well-equipped team backed by an excellent crew.

Waltrip, now 43 and mellowed after years of being NASCAR's bad boy, was a contender last year until an uncharacteristic late season swoon in his Rick Hendrick, Tide-sponsored Chevy. He'll recall the season with bittersweet emotions. He finally won the Daytona 500 after 17 years of try-



PM PHOTO BY DON HUNTER

the points lead with either a win or a second-place finish on that bright fall afternoon. Instead, he fell even farther behind.

Another crash the following weekend at Rockingham, North Carolina, all but ended his '89 title hopes.

Wallace, for his part, was an even stronger contender in '89 than in '88, when he lost the title to Bill Elliott despite a late-season charge. His '89 campaign, while clearly successful, was also noteworthy for a well-publicized feud with car owner Raymond Beadle. Both filed lawsuits in a nasty contract dispute that left Wallace's status with the team in question.

But contending for the championship made everything better, and the Kodiak-backed team rallied strongly in the final weeks of the season. They're together again for 1990.

Given somewhat longer odds of winning this year's Winston Cup are Martin, driving the Jack Roush Thunderbird, Rudd, Ken Schrader, Geoff Bodine, Harry Gant, Davey Allison, Terry Labonte and Elliott. Rudd, Bodine and Labonte are proven winners,

Rusty Wallace's Pontiac Grand Prix came on strong in the closing of the campaign.

strong qualifier last year, and 1989's rookie of the year, 39-year-old Dick Trickle, a veteran short-track specialist who had several top-10 finishes.

NASCAR's drivers and crews won't see many new sights this year. Their tour will run exactly the same tracks. In fact, except for a minor change or two, this year's schedule is almost identical to '89.

In case you're wondering, this year's 10-month, 29-date, 16-track, 13-state grind adds up to 11,801 miles of racing. That's a lot of time on the road. It's a good bet Latford didn't consult wives or girlfriends when he came up with his idea.

PM



PM PHOTOS BY DON GRASSMAN

PM PHOTO BY CINDY KARAM

Rusty Wallace (left) was strong down the stretch. Defending champ Bill Elliott (middle) never recovered from Daytona crash. Dale Earnhardt (right) faded in the final weeks.

ing, but lost the Winston All-Star race three months later to Wallace on a controversial late-race bump.

Earnhardt (some call him Down-and-Dirty Dale), a 3-time champion, may have blown his fourth title shot at North Wilkesboro, North Carolina, in mid-October when he tangled with Ricky Rudd's Quaker State Buick while leading in the final seconds of a 400-lap race. Earnhardt and the Mr. Goodwrench Chevy would have taken

but will need time to grow accustomed to their new teams. And while Schrader, Gant, Allison and Elliott all won races last year, they didn't display enough consistency to challenge Wallace and Earnhardt.

Martin seems to be the strongest contender in this group, on the impressive strength of the Roush organization.

A couple other drivers to watch in 1990 are Alan Kulwicki, a consistently

1990 NASCAR Winston Cup Schedule*

February 18	Daytona Beach, Florida
February 25	Richmond, Virginia
March 4	Rockingham, North Carolina
March 18	Atlanta, Georgia
April 1	Darlington, South Carolina
April 8	Bristol, Tennessee
April 22	North Wilkesboro, North Carolina
April 29	Martinsville, West Virginia
May 6	Talladega, Alabama
May 27	Charlotte, North Carolina
June 3	Dover, Delaware
June 10	Sears Point, California
June 17	Pocono, Pennsylvania
June 24	Irish Hills, Michigan
July 7	Daytona Beach, Florida
July 22	Pocono, Pennsylvania
July 29	Talladega, Alabama
August 12	Watkins Glen, New York
August 19	Irish Hills, Michigan
August 25	Bristol, Tennessee
September 2	Darlington, South Carolina
September 9	Richmond, Virginia
September 16	Dover, Delaware
September 23	Martinsville, Virginia
September 30	North Wilkesboro, North Carolina
October 7	Charlotte, North Carolina
October 21	Rockingham, North Carolina
November 5	Phoenix, Arizona
November 19	Atlanta, Georgia

*As of October 4, 1989



PM PHOTO BY BILL STAHL

RACING 1990

DON'T LOOK BACK

Road racing's defending champs—IMSA, SCCA, Formula One—face an especially lean and hungry flock of challengers.

BY MAC DeMERE



PM PHOTO BY HAL CROCKER

Dorsey Schroeder commemorated Mustang's 25 years by dominating the '89 Trans-Am.

BASEBALL legend Satchel Page may never have come within throwing distance of a race car. But his famous admonishment—"Don't look back, something might be gaining on you"—is apt advice for the 1989 champions of the major U.S. road-racing series. For 1990, the challengers appear to have excellent shots at dethroning the champions in the GTP and GTO divisions of the International Motor Sports Association (IMSA) Camel GT series and, to a lesser extent, in the Sports Car Club of America (SCCA) Trans-Am Championship.

Though the all-conquering Electromotive Nissan team has won two consecutive GTP team championships and 20 of its last 26 races going into the season finale at Del Mar, California, it faces rapidly maturing opposi-



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DON'T LOOK BACK

tion from Jaguar and Toyota, as well as from perennial contender Porsche in the long races.

In GTO, Jack Roush's factory Mercury Cougars opened up an early advantage and held on to take the 1989 driver's and manufacturer's titles. However, by the end of the season it was clear the factory-backed Audis had become the team to beat. Also, look for renewed GTO efforts from Mazda and Nissan, as well as, believe it or not, a new program from Ferrari.

The 1989 Trans-Am campaign was nearly a Roush Racing benefit, as Roush Mustangs won more than half of the races. But for 1990, teams from Oldsmobile, Pontiac, and possibly even Cadillac and Chrysler's Eagle division, seem ready to challenge.

IMSA GTP

Don Devendorf's crew at Electromotive Engineering know that the energy and investment required to stay on top often equals or exceeds the effort needed to just get there. That's why 2-time IMSA champion Geoff Brabham and '89 runner-up Chip Robinson will be driving all-new Trevor Harris-designed, Electromotive-built Nissan GTP ZX-Turbos in 1990.

"Our advantage is how the whole team works together," said Wes Moss, vice president of Electromotive. "The new cars will have similarities with the '89 cars, but will feature aerodynamic changes and enhancements which will translate into a total performance improvement."

Although cast once again as supporting players, the Castrol Jaguars showed dramatic improvement in 1989 by winning three races. The Indiana-based arm of Tom Walkinshaw Racing is already embarked on an extensive winter testing program, together with an R & D program for TWR's European Group C.

"If you just stand still you won't keep even, much less get ahead," said Jaguar team manager Tony Dowe. "Race teams seem to go in 3-year cycles. When you're starting from scratch, it takes two years just to be



Jack Roush's Cougars won the '89 IMSA GTO title, but by season's end Audi's 4wd was king.

competitive. The dividends come in the third year."

For power, Jaguar will rely on the V6 turbo it introduced successfully at the end of last season, though the team may run at least one V12 at Daytona's 24-hour event. Jaguar's drivers will be Americans Price Cobb and Davy Jones, joined in the long races by John Nielsen and Jan Lammers.

Dan Gurney's All-American Racers will campaign two Toyota-powered Eagles in the '90 GTP series. Despite running one car originally built in Japan for Group C as well as its own Eagle HF-89 Toyota, AAR scored several top-five finishes in 1990. It's likely Willy T. Ribbs, Juan Manuel Fangio II, Drake Olson and Rocky Moran will return as drivers.

Although Porsche 962Cs often make up a large portion of the GTP fields and the Jim Busby/Miller Beer Porsche 962s scored two wins in 1990, the cars are at a severe disadvantage under IMSA rules. The wide flat-Six engine with its water-cooled heads restricts the size of the 962's ground-effects tunnels and thus limits downforce compared to other GTPs.

Still, Porsche has done extensive development and is building several new 962Cs which will likely be run by

Busby, Rob Dyson (for driver James Weaver), Bruce Leven's Bayside Racing, Tom Milner and others. It's possible one of these teams may elect to buy last year's Electromotive Nissans to campaign in the series—if Electromotive elects to sell.

The Camel Lights class for smaller displacement GTP machines was a modern family affair in 1989. Roommates Scott Schubot and Linda Ludemann also shared the driver's seat of a Spice Buick. They took seven wins and the championship for Schubot.

Look for Schubot to return to the class along with runner-up Charles Morgan, Tom Hessert and a new Honda-powered entry for veteran Parker Johnstone.

IMSA GTO

The key in IMSA's GTO (GT over 3.0 liters) series is all-wheel drive. Though the Roush Cougars won the 1989 driver's and manufacturer's championship quite handily, by the end of the season it was clear that four powered wheels are better than two.

Unlike most factory-supported racing teams, Audi's IMSA program is run right out of its Michigan offices. For 1990, Audi will campaign a pair of Audi 90 Quattros, using the chassis that dominated the second half of the '89 season. Though no contracts had been signed at press time, Hurley Haywood and Hans Stuck are good bets to return behind the wheel.

Roush Racing team manager Lee White was unsure if the team, including drivers Halsmer and Wally Dallenbach Jr., would even return to GTO. "We're concerned with our ability to compete with the tire advantage enjoyed by all-wheel drive," said White. "But I'm optimistic we'll be back."

Strong opposition will also come from Clayton Cunningham's 300ZX



Tom Walkinshaw's Jaguars are expected to lead challengers for Nissan's IMSA GTP title.

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DON'T LOOK BACK

Turbos and a pair of new 4-rotor Mazda RX7s for Jim Downing and, possibly, Elliott Forbes-Robinson.

After a reconnaissance program in the final two races of 1989, it appeared that Ferrari of France might enter an F40LM in the 1990 GTO series. Originally designed for the stillborn GTC class of the World Sports Prototype Championship, the production-based F40 will be at a handicap to the purpose-built tube-frame opposition.

In GTU, look for veteran Roger Mandeville to challenge '89 champion Bob Leitzinger's Nissan 240SX with a Mazda MX-6.

Trans-Am

Roush Racing Mustangs won half of the 1989 Trans-Am races, and unheralded driver Dorsey Schroeder took the driver's championship. However, Roush's advantage may not have been as large as it seemed. Schroeder only won one of the first five races. At that point, Roush's tremendous depth and bench strength allowed the team to take control of the series.

Schroeder will defend his crown, joined in Roush Mustangs by Lyn St. James and Robert Lappalainen.

Leading the Stop-Roush effort will be Irv Hoerr, who won three early



Alain Prost will wear Ferrari livery in '90 World Driver's Championship campaign.

races in an Olds Cutlass and Paul Gentilozzi in either an Olds or, possibly, a Cadillac-bodied entry. Others who are considering a Trans-Am program include former champion Tom Gloy, ex-IMSA GTU champ Jack Baldwin and Tommy and Bobby Archer.

Chevrolet has finished second in the Trans-Am manufacturer's championship the past four years. In 1989, the factory-backed C&C Chevy Ber-

ettas, driven by Tommy Kendall and Max Jones, were always in the hunt but couldn't quite match the pace set by the Mustangs and Hoerr's Oldsmobile. Darin Brassfield scored one win in an independent Corvette and Greg Pickett, driving the Morrison Development Corvette campaigned by Corvette platform engineer John Heinricy in SCCA club races, won the Detroit Grand Prix.

Whichever team Chevrolet elects to back in 1990, you can bet the bowtie guys won't be satisfied with another runner-up spot.

After Audi steamrolled the series in 1988, SCCA moved to limit all-wheel drive and turbocharging in '89. For 1990, both will be outlawed.

Formula One

The World Driver's Championship was an open question right to the end of the season in 1989, but it was a familiar question: Which Honda driver would claim the championship, defending champ Ayrton Senna or all-time-win leader Alain Prost.

The question was resolved—spectacularly—in the Japanese Grand Prix when Prost and Senna tangled on track, ending Senna's repeat title hopes.

Although Honda/McLaren can be regarded as the team to beat again, real opposition is expected this season from Ferrari, which pairs newcomer Prost and Nigel Mansel against Senna and Gerhard Berger.

SCCA Supercars

After five years of living in the shadow of the successful Firestone Firehawk series, SCCA's Escort Endurance series for showroom stock cars will get a shake-up for 1990.

In an effort to make the series more attractive to TV, SCCA will include high-end sports cars like the Corvette, Porsche 944 Turbo, the new Nissan 300ZX Turbo, the new Dodge Stealth/Mitsubishi 3000 GT and even Honda's yet-to-be-introduced Acura NS-X. Exotic labels like Ferrari and Lotus will be welcome.

SCCA will meld its old A- and B-support classes into one group, making the 1990 races a 2-class show. The club's pro-racing officials plan to address performance distinctions between the old A and B cars with a handicap system. Races will be much shorter—three of 1-hour duration, three of 3 hours, plus the traditional Mosport 24-hour race—and SCCA plans to link at least five of the races with Trans-Am events.

Besides being a sharp departure from past Escort Endurance formats, the new Supercar series also marks the end of the Corvette Challenge. **FM**

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The 1957 Chevrolet Bel Air

Chevrolet



Model shown smaller than 8 1/2" actual length.

A Meticulously Engineered Die-cast Metal Replica of One of America's Greatest Cars.

It was the last of the classic Chevrolets...the most desirable American car of the 1950's...the 1957 Chevrolet Bel Air.

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Send no money now. Simply return the Reservation Application. The price of \$88.50 is payable in three monthly installments of \$29.50 each. If you wish, you may charge your installments to MasterCard, VISA or American Express.

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🏁 RACING 1990

FOR MEN ONLY

Sprint cars—racing's answer to a rhinoceros stampede.

BY NORMAN S. MAYERSOHN, *Contributing Editor*

ALL TOO OFTEN, the blind pursuit of technology in motorsports does little to improve the show

that spectators pay to witness. Active suspensions, on-board telemetry, ground-effect aerodynamics, carbon-fiber composites—there's no question

that technological advances can give a winning edge to the well-heeled team. But the American racing heritage lies elsewhere, rooted in the elemental thunder, dust and smoke of a Saturday night bullring brawl.

Welcome to the world of sprint cars. Where the machines are equal-

ized by conditions so that it's raw, undistilled moxie that wins races.

This doesn't necessarily mean that sprinters are down at the agricultural end of the techno scale. It's just a level of technology that has little use for subtlety.

Basic specifications are your first clue to the highly favorable thrills-per-lap ratio: a 410-cu.-in. V8, pumping out 800-plus horsepower on methanol, shoehorned into a short-wheelbase chassis weighing 1400 pounds ready to race.

The small-block Chevy clones that dominate this sport are a highly specialized, thoroughly modified genus. Aftermarket alloy blocks and cylinder heads are crowned by constant-flow fuel-injection setups. Exotic, dry sump lubrication systems assure reliable oil delivery in the high-G corners—important, since cornering occupies about 75 percent of a sprint car driver's time.

Mechanical sophistication ends with the powerplants. Beyond the engines, the rest of the setup is classifiable as primordial. No starter motor, no battery, no clutch, not even a multispeed transmission. Juice is supplied by a magneto, and the gearbox is a simple, robust in-out setup designed to take punishment.

Braking isn't much of a priority, either. Most sprinters use no more than two disc brakes, both mounted on the lefthand side.

The hardware reflects the direct, take-no-prisoners nature of the combat. Finishing positions aren't determined by late braking into tight corners or precisely timed gearshifts. All that counts is who's willing to stand on the gas the longest and muscle through the lefthand turns with the least wasted motion.

To any fan reared on open-wheeled pavement racing, the sprint car is certainly one alien machine. It is impossibly upright, with the driver's head at a bystander's chest level, rather than somewhere below his kneecaps. The tires actually have tread patterns, with passenger car proportions on the front wheels and gummy steamrollers in the rear.

More unsettling is the fact that the



Even on short tracks, frontrunners like Sammy Swindell can hit 130-mph plus.

rears differ visibly from left to right—the sizes are staggered by as much as 10 in. of circumference to set up for the left-turn courses.

This trait dictates the driving style, too. At the end of the brief straightaway, backing off the throttle pitches the car sideways and the pilot chooses his line according to location of the racing groove and, of course, traffic.

If this doesn't sound like the Rick Mears school of precision control—you've got the idea.

What really throws the newcomer off, though, is that giant wing, with the dimensions of a dining-room table. Not only have these aluminum superstructures driven home the concept of aerodynamic downforce to the dirt oval racers, they've also become the distinctive signature of the breed. Most cars include a driver-controlled hydraulic system to jockey the wing front and back as a way to adjust traction during the race.

Even the vertical sideboards have a job, keeping the car from getting too sideways in the lefthanders that connect the straights.

Aside from the cosmetics, the cars are remarkably similar. The typical frontrunner buys his tube-frame chassis from Tennessee-based Gambler Competition—about \$15,000 (without wing)—then bolts in a \$25,000 engine, produced by several small manufacturers (Gaerte, in

Rochester, Indiana, and Shaver Specialties, in Torrance, California, are two top shops). Bodywork is available from several long-established sources, and some of the wingmakers actually travel to the various tracks.

Torsion bars and adjustable racing shock absorbers control wheel movement. A quick-change differential allows the final drive gearing to adapt to track conditions with a few minutes of wrench work. Power-assist steering is one of the few concessions to modern convenience tolerated in otherwise bare-knuckle sprint car ranks.

Like any other motorsport, sprint car racing has its own set of national heroes. Many of these come from the ranks of the World of Outlaws tour, putting on over 100 shows in 25 states during its February-to-November season. Doug Wolfgang, Bobby Davis and Keith Kaufman all have followings among the Outlaw fans.

The rival United Sprint Association runs a shorter schedule, but delivers top stars (and former World-of-Outlaws champs) like Steve Kinser and Sammy Swindell.

For both circuits, the venues are hardpacked dirt ovals ranging from one-quarter to a full mile around, some situated on state fairgrounds, others just a patch of level clay at the edge of some small town.

As you might expect, there's nothing fancy about this kind of show—leave your Calvin Kleins on the hanger and your Guccis in the closet. Pick an upper-row seat and you'll be able to see every inch of every lap—a 16-second, 130-mph trip on the half-mile course. Venture down a bit lower in the stands and you'll be baptized with a sprinkling of Turn-One soil.

In either place, the combination of methanol fumes and earthshaking power may just alter your notions of what is and isn't real racing. Because this is about as real as it gets. **PM**



Jeff Swindell sets up for a turn.



Kenny Jacobs at Williams Grove, Pa.



Introducing the new ESCORT

New technology makes this radar detector perform unlike any other in the world

In 1978 we introduced the original ESCORT. Its superheterodyne technology changed the science of radar detection forever.

At the time, *Car and Driver* said, "If you can imagine the Turbo Porsche of radar detectors, this is it...it's a brilliantly conceived device. In no test did any of the other detectors even come close." But that was just the beginning.

Our strategy

Since then, we've continuously advanced the science of radar warning by encouraging our engineers to spend their time on only one thing: improving performance. Because of this program, ESCORT and PASSPORT have unequalled reputations for performance, winning test after test.

But we've never stopped striving for another quantum leap, a revolution in technology that could redefine radar detection again. And now we've done it. The key is a new technology: DSP.

Incredible technology

DSP is Digital Signal Processing, a technology virtually unheard of in personal electronics, but used in many exotic electronic devices.

DSP is used by NASA to create detailed space photos from blurry images. It's used by military radar to distinguish enemy aircraft from friendly aircraft. It's used to deliver sharp images of internal body tissue from medical scanners. And now we're using DSP to find radar signals too weak to be detected by conventional technology.

The heart of ESCORT's DSP circuitry is this custom 20 MHz 24 bit parallel HCMOS processor, capable of 10.25 million instructions per second.

How it works

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

Breakthrough performance

The new ESCORT's DSP circuitry was developed using everything we've learned about advanced radar detection. The end result is incredible.

The new ESCORT's advanced signal processing provides an incredible increase in sensitivity on both bands. Quite simply, this means that the new ESCORT picks up radar signals much further away than was ever before possible.

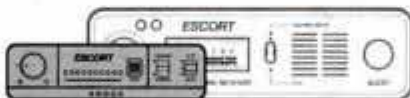
In fact, not since we introduced the first ESCORT has there been a performance improvement like this. But there's more.

Complete warning system

The new ESCORT keeps you fully informed with a variable audible warning with adjustable volume, and different tones for X and K bands. And both a Mute and a new Auto-Mute function.

For visual warning, there's an alert lamp and ten-segment signal strength meter, both dimmed to suit ambient lighting. There's also a Dark mode for more discrete operation.

ESCORT is housed in a heat treated aluminum housing, finished in low-glare black, and is incredibly compact, only 1 1/8" high and 3 1/4" wide. And everything you need is included.



The new ESCORT is only a fraction of the size of the original.

Everything included

The new ESCORT comes complete with visor clip and adjustable windshield mount, and power cords to suit any installation (both a coiled and a straight cord that plug into your lighter, and a cord for direct wiring into your car's electrical system, if you prefer).

There's also a leather carrying case, and a comprehensive owner's handbook. ESCORT also incorporates our revolutionary Digital Key security system (see sidebar for the full story).

Satisfaction guaranteed

We only sell ESCORT direct from our factory to you, and we guarantee your satisfaction. To order, just call us toll-free. After you receive ESCORT, if you're not completely satisfied within 30 days, just return it. We'll refund all of your money and your return shipping costs, no questions asked. There are no hidden charges.

The new ESCORT outperforms any other radar detector in the world. But don't take our word for it. Order today and see for yourself.

Bad news for thieves:

A new security system in new ESCORT and SOLO makes them of little use to anyone but the rightful owner. Here's how it works:

The system is fully automatic, and easy to use. Included with your new radar detector is a tiny electronic "Digital Key"™ to put on your key ring (see the main photo above and the cutaway at right).

About every two months, your detector's circuitry will prompt you to insert your Digital Key into a small jack on your detector, and turn your detector on. After confirming that you used the right Key, your detector will reset its lock and will be ready for two more months of use. That's all there is to it.

May we help you? ESCORT and SOLO bring totally new technologies to radar warning. But there's one thing we didn't change: Our system of selling direct from our factory to you.

Just call us toll-free. One of our radar experts will be glad to answer your questions or take your order. And remember, our 30 day trial lets you try new ESCORT or SOLO at no risk. Call today.

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Ohio residents add
\$17.70 sales tax

Prices slightly
higher in Canada

ESCORT
RADAR WARNING RECEIVER



Introducing self-powered SOLO

A new kind of radar detector— No power cord

If you're a business traveler, always switching between cars and using rentals in distant cities, you need the most convenient radar detector possible. But radar detectors have always been less than ideal for traveling. Until now.

First things first

After years of development, we're introducing self-powered SOLO. It has the same long-range warning as our test-winning PASSPORT, and it's even smaller (only 1/4" high and 2 1/4" wide). But incredible performance isn't the breakthrough.

However, for someone who doesn't have the right key (and there are thousands of different Digital Keys), the radar detector simply won't work. And there's little economic incentive for a thief to steal your radar detector if he can't sell it. And if a stolen ESCORT or SOLO is ever returned to us for service, we'll immediately contact you (if you have reported the theft to us).

Although nothing is totally "theft-proof," our new Digital Key security system will help keep your new ESCORT or SOLO yours.

Actual size cutaway of Digital Key

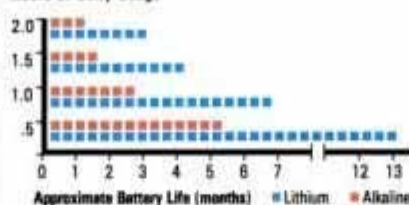


Revolutionary convenience

SOLO is the first self-powered superheterodyne radar detector. You just mount it on your visor or windshield and turn it on. It's that simple.

SOLO doesn't need a power cord, recharger, or add-on battery pack. Its remarkable design operates about 200 hours on a single 9 Volt lithium battery (or 80 hours on a standard alkaline). For most drivers, that's several months of use.

Hours of Daily Usage



For most drivers, a single battery will last several months.

Total performance

Unlike most battery powered devices, SOLO maintains full performance over its full battery life. And when you finally need to replace the battery, SOLO tells you five hours in advance so you have plenty of time to plan ahead.

Needless to say, there was only one way to make self-powered SOLO a reality. Starting with a clean sheet of paper, our engineers have designed the most efficient superheterodyne radar detector in the world. SOLO uses only 2% of the power of a conventional radar detector.

Incredible technology

The advances that made SOLO possible would fill this page, but here's a brief outline: A varactor-tuned GaAs FET microwave oscillator, four custom CMOS integrated circuits, seven circuit boards, and hundreds of SMD components controlled by a CMOS microprocessor and powered by a digital power supply. All contained in a thin wall magnesium housing for incredible strength and lightness (just 5 1/2 ounces complete with battery).

Standard equipment

SOLO has all of the advanced features we pioneered with ESCORT and PASSPORT. Variable rate audio warning, with adjustable volume and different tones for X and K bands. An alert lamp and ten-segment LED signal strength meter, both automatically dimmed to suit ambient lighting. And a Dark mode for even more discrete operation.

In addition, SOLO has both a Mute switch and a new Auto-Mute function that automatically reduces the audio to a lower level after the initial alert. There's even a special battery-saver circuit that turns SOLO off if you forget to.

And our new Digital Key security system means your SOLO will be of little use to anyone but you (see sidebar for the full story).



Instead of a conventional meter, SOLO uses ten Hewlett Packard AlGaAs LEDs bonded directly to a tiny circuit board.

The complete package

SOLO comes complete with everything you need. An articulated visor clip that opens wide for padded visors, but folds flat for convenient handling. A windshield mount that easily adjusts for different windshield angles. A leather pouch for everyday use, and a travel case for taking SOLO with you on trips. And of course, we include two batteries, both a lithium and an alkaline, to get you started.

Factory direct

We only sell SOLO direct from our factory to you. Just call us toll-free to order, or for more information. And we guarantee your satisfaction. If you're not completely satisfied in 30 days, just return SOLO for a full refund. SOLO is also backed by our one year limited warranty.

Some people will see SOLO as a convenience breakthrough. But also consider the performance advantage of having a radar detector you'll use every time you get in your car.

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SOLO
RADAR-RECEIVER

RACING 1990

CHEAP THRILLS

Four grass-roots rides—low investment, low maintenance, high on fun.

BY RICH TAYLOR, Contributing Editor



IF YOU'RE like us, racing is something you've always wanted to try, but thought you simply couldn't afford.

Wrong. Although you'll probably never see them on ESPN, there are lots of hobby-level racing opportunities, from drag racing to local oval tracks to road racing. Four of the more popular—and economical—approaches are detailed here.

Enduro Karts

Question: What do Emerson Fittipaldi, Scott Pruett, Lake Speed and dozens of other professional racing drivers have in common?

Answer: They all got their start racing go-karts. Not go-karts the way you think of them—little putt-putts for the backyard—but bonafide 120-mph racing cars that compete at places like Elkhart Lake, Willow Springs, Daytona and Mid-Ohio. And believe it or not, quick-handling, quick-stopping karts hold outright lap records at some of the twistier tracks.

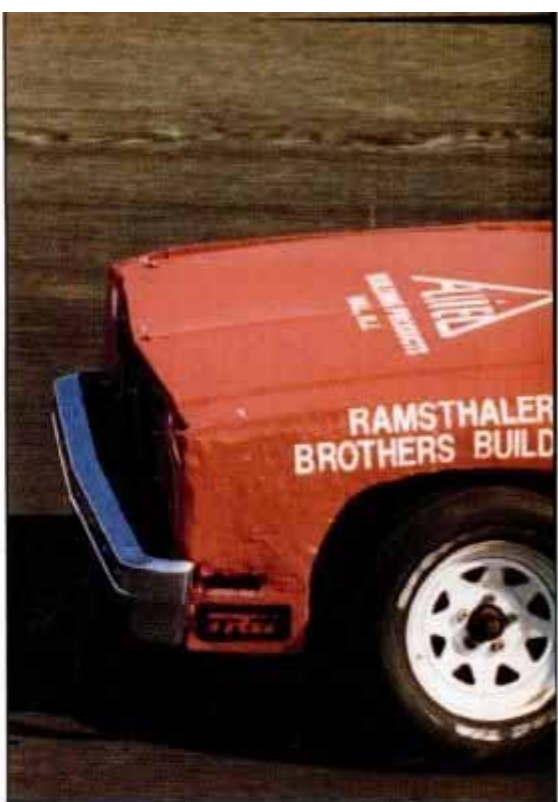
Lay-down road-racing karts are called Enduro karts, to differentiate them from upright Sprint karts that race on dirt ovals. The most popular Enduro karts use 100-cc Yamaha 2-cycle, 1-cylinder engines driving centrifugal clutches.

The frame is steel tubing. There are disc brakes and miniature racing slicks on alloy wheels. Top speed: about 100 mph. About \$1500 will get you on the track, and you can transport your racing car in the back of a pickup or station wagon.

The same basic kart can be used to race in five or six different classes. You can add a second engine to create an even faster machine, or bodywork that moves your racer into yet another classification.

The fastest karts are now B/stock and B/limited machines with twin 100-cc engines built by Parilla or BCR. With fiberglass nose cones, side panels and rear bodywork, you can hit over 120 mph.

For more information, contact:



Kart racing (left) offers plenty of speed and close racing for not much money. The primary operating costs for Bomber Stocks (above) are the body shop fees.

World Kart Association, 5906 Mayfair Rd., North Canton, OH 44720. Telephone (216) 499-0454.

Bracket Racing

Most racers start out drag racing on Main Street in Mom's Buick. Bracket racing lets you wear a helmet and race Mom's Buick at the track, for a \$3 entry fee. There are even cash prizes. All of which explains why bracket racing is the most popular form of motorsports in the world.

You show up at your local dragstrip almost any Wednesday or Friday night and pay your three bucks. There will be hundreds of other racers there. You can race anything. You don't even need a rollbar unless your car can do the quarter in less than 11 seconds.

You have to declare how quickly your car will get through the quarter-mile, and that's written on your window in white shoe polish. Obviously, your first few times at the strip will be spent just figuring out how fast you can go. Then, after a smoky-burnout to warm up the tires, you're lined up next to another competitor and the Christmas tree lights blink down... yellow, yellow, yellow, green!

Bracket racing rewards consistency and quick reactions. The whole idea is to beat the car in the next lane without breaking out of the time you declared you'd run. Most low-buck racers use ponycars with a mild V8.

And that's what it takes. Remove

Bracket racing can be the cheapest way to go racing in America.



PHOTO BY LESLIE LOVETT



the slicks to drive home and you can use the car to commute to work in the morning. There is no cheaper way to go racing.

For more information, contact: National Hot Rod Association, Box 5555, Glendora, CA 91747. Telephone (818) 914-4761. International Hot Rod Association, Box 3029, Bristol, TN 37625. Telephone (615) 764-1164.

Bomber Stocks

There are literally hundreds of small oval tracks all around the country, quarter-mile and half-mile bullrings where you can race once or twice a week, all season.

The least expensive way to start out in oval-track racing is Street Stock, or, as they're more affectionately known, Bomber Stocks. Whether you buy a car or build your own, plan on spending about \$3000.

The most popular Street Stocks are old musclecars like Chevy Chevelles, Plymouth Dusters or Chevy Camaros, but you can run just about anything. At most tracks, you'll be required to equip your car with a 6-point rollage, a racing fuel cell, a 5-point racing seatbelt and a racing seat.

Typical Street Stock rules allow only small block V8s with a stock 4-bbl. carburetor and stock manifolds. Wheels are usually reinforced steel, maximum 6-in. width. You are allowed to run stiffer springs and shock absorbers, but tires must be DOT street legal. Nerf bars along the sides and reinforced bumpers are legal, as well as advisable.

The biggest expense in a season of racing will be bodywork.

Typically there will be two or three qualifying races at the beginning of the evening, then a consolation final.

All those runs provide qualifiers for the final. New racers often spend half a season before they even get into a final, but they still get plenty of racing.

At most tracks, the winner will take home \$200 or so, with smaller amounts to the guys behind him. But no matter where you finish, you'll be learning about racing in traffic, and how to set up the car.

For more information, contact your local oval track. Rules vary, and there is no national sanctioning body.

proved constructors, engines have equal horsepower—sealed to prevent tampering—and the street tires are identical.

It works. At a typical Spec Racer event, the first 20 cars might all qualify within the same second. The racing is close and spirited, and no matter where you may be in the pack you'll always find someone else to race with.

So far, there are about 500 Spec Racer machines around the country. Used or new, they're worth about



Spec Racers

The most popular of the 23 Sports Car Club of America amateur road-racing classes is the Spec Racer class, formerly known as Sports Renault. A Spec Racer is a small, single-seat, pure racing car of the type generally known as sports/racers. The frame is a tube-steel birdcage with built-in rollbar and the bodywork is four big pieces of molded fiberglass.

Most of the running gear is Renault Alliance, with the transverse engine/gearbox mounted behind the seat and driving the rear wheels.

The whole idea of Spec Racer is to get the cars as evenly matched as possible, leaving the outcome to the skill of the pilots. The class is administered by SCCA, the cars are built by ap-

With no change from season to season, SCCA Spec Racers are good for years of fun.

\$10,000, ready to race. You can buy one, race it for years, and sell it for just about what you paid. Not many race cars fit this description.

The SCCA even runs a drivers' school aimed specifically at Spec Racers, where you can learn the basics of road racing and decide whether Spec Racer is for you. They provide everything, including the car.

For more information, contact: Sports Car Club of America, 9033 E. Easter Place, Englewood, CO 80112. Telephone (303) 694-7222. SCCA Enterprises Spec Racer National Racing School, 14570 E. Fremont, Englewood, CO 80112. Telephone (303) 693-2111.

PM

TOP FUEL TECHNOLOGY

Inside racing's 4000-horsepower, nitromethane-burning techno showcase.

BY PAUL STENQUIST

LIKE HEAVY artillery aimed at the heavens, eight exhaust pipes spit fire and raw nitromethane fuel. The ground shakes in tempo with an explosive, syncopated idle.

Tiny front wheels—a scant 13 in. dia.—inch carefully into the staging lights. The mammoth 17-in.-wide rear slicks, hot and sticky after being spun and smoked across the asphalt staging area, follow some 20 ft. behind. In this trembling 1900-pound rocket a fire-suit-clad driver sits some 9 in. above the ground, peering over a tiny windscreen.

The starting lights go yellow, then green. Huge fuel-injector doors, protruding directly behind the driver's head, flop open and the starting line is suddenly consumed with an ear-splitting fury unequalled anywhere else in the world of motorsports.

Swallowing thousands of cubic ft. of air per minute, and pumping 2 gallons of nitromethane per second, the 500-

cu.-in. powerplant hammers more than 4000 hp into a multistage centrifugal clutch. The fat rear tires claw at the concrete launch pad, struggling for bite, coping with the transfer of 4G-accelerative might.

The 100-mph mark comes in about a second. It takes only 2 seconds more for 200 mph. And less than 5 seconds after the accelerator pedal went to the metal, this needle-nosed missile trips the clocks at the quarter-mile mark, registering a speed of more than 290 mph before the driver pops the drag chute.

The power of an AA-fuel dragster is brutal. But the technology that makes it all happen is intricate, highly refined and constantly expanding.

The powerplant is a derivative of the famous late-model hemi engine built by Chrysler in the '60s. But over the years, the drag-racing fuel motor has been so refined and altered from its original configuration that it bears little resemblance to its ancestor. About the only thing that's the same is the spacing of the bore centers.

Today's engine combines an aluminum-alloy water-cooled block with solid aluminum cylinder heads. Combustion chambers are semi-hemispherical with two sparkplugs and two huge valves per cylinder. The sides of the chamber are drawn in from the true hemi configuration of the old Chrysler to help contain the charge and prevent cooling at the periphery. Fuel-injector nozzles are mounted in the cylinder heads just behind the valves and in the throttle body unit. The throttle body or injector hat sits above a huge Roots-type supercharger.

Down in the crankcase you'll find a spin-forged steel crankshaft of 4½-in. stroke. The pistons are 4³/₁₆ in. dia. and are pinned to the end of forged aluminum connecting rods. The aluminum connecting rods absorb some of the tremendous combustion hammering, but only last for a dozen quarter-mile runs. Steel rods are stronger, but would immediately destroy the crankshaft.

All eight pistons are changed after each quarter-mile pass by a crew that has been trained to completely disassemble and reassemble the engine in less than 40 minutes. When necessary, the cylinder sleeves and bearings are renewed as well—all in less time than it takes most of us to change our oil and filter.

This is all neat stuff, but the most intricate and amazing mysteries of a top fuel dragster are the control systems that alter variables as the car hurtles down the strip, and the computer system that records data for post-race analysis.

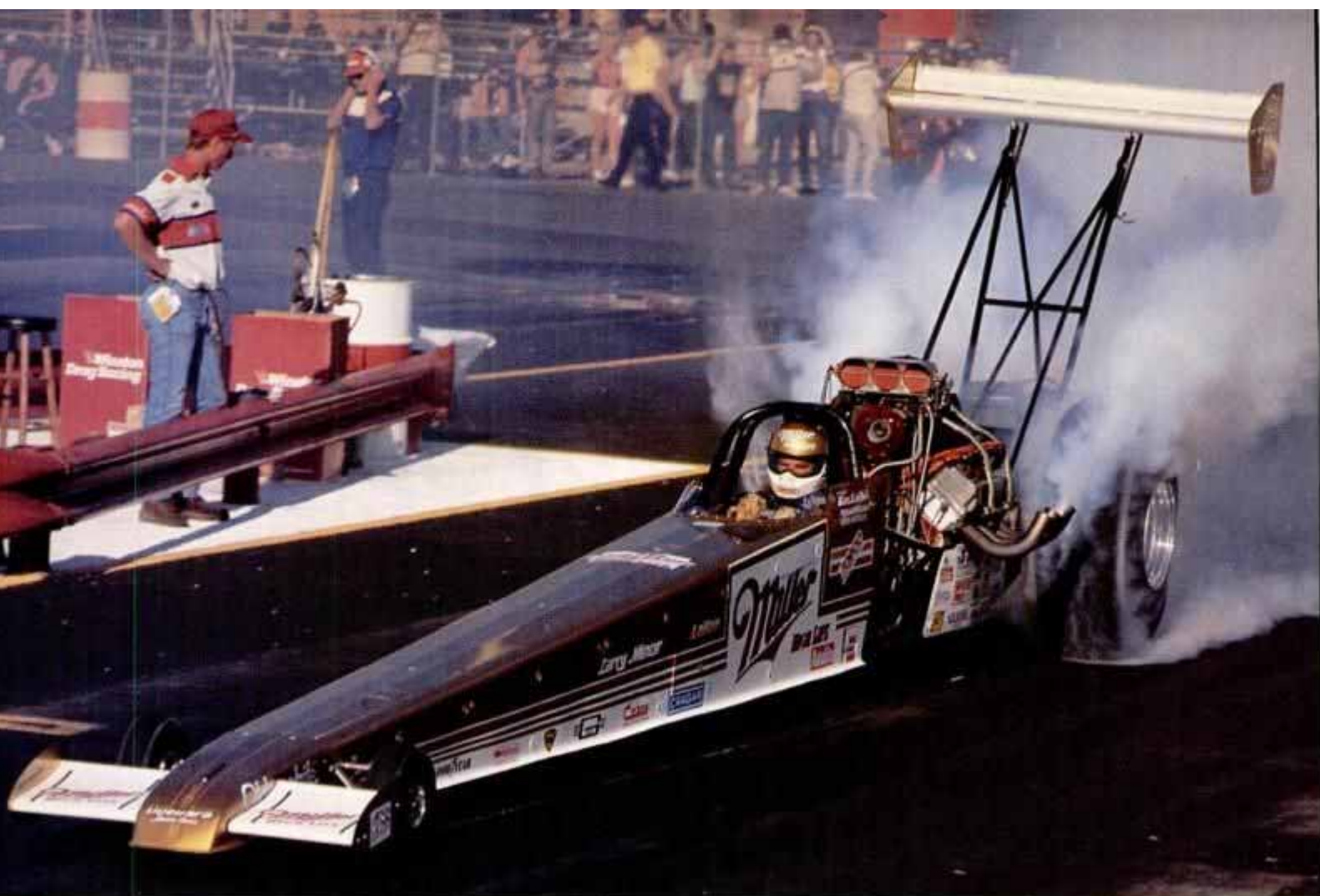
During those 4-plus seconds it takes a top fuel dragster to travel a quarter-mile, a battery of electronic timers controls approximately 15 events that help optimize acceleration. (Direct computer control of events is not allowed under current drag racing rules.)

These events may include as many as eight different clutch-engagement stages. Each stage reduces the amount of clutch slippage allowed and applies more of the engine's tremen-



PHOTOS BY LESLIE LOVETT

Massive output of AA-fuel dragster powerplants require beefy multiplate clutches (left). High-output ignition systems (above right) and Roots-type supercharger (bottom right) help extract maximum power from 500-cu.-in. V8s.



dous output to the rear wheels.

The clutch is a centrifugal unit with multiple sintered iron discs and steel floaters between the discs. The stages are controlled by gradual application of centrifugal force to the clutch disc pack. When the car leaves the starting line, engine rotation causes the clutch fingers to move to the stage one location. The accelerator pedal activates various timers as it moves floorward. When the first clutch timer reaches its deployment point, it switches a solenoid that activates an air-pressure device, which deploys stage two. This process is repeated as each clutch stage is engaged.

Meanwhile, other timers alter the fuel mixture to maximize engine power as the car moves down the track. A typical program might plot a 6-point fuel curve that tailors requirements in respect to load and rpm.

Okay, but how does a top fuel crew chief determine the adjustment of these and a multitude of other variables? That's where the computer recording system comes into play. While the car is sprinting toward the finish line, a microprocessor gathers data from a variety of input sensors. Individual sensors note temperature at each of eight exhaust pipes, engine speed, driveshaft speed, manifold pressure, fuel pressure at the throttle body and at the intake ports and a variety of "event switches" that record

the timing of clutch-engagement stages and fuel mix changes.

After each quarter-mile pass, while the crew is tearing down the engine, the crew chief connects a printer to the on-board computer and generates graphs of all the variables plotted against time.

There is a multitude of judgments he can make by comparing the various numbers. One example: By comparing sparkplug condition with the temperature readouts of the cylinders, he can locate lean or rich cylinders. If the mixture problem isn't the result of compression loss, he can juggle fuel-injector nozzle sizes to compensate.

Another example: A comparison of driveshaft speed versus engine speed quantifies clutch slippage. Considering clutch slippage in respect to clutch-stage deployment times can help him determine if clutch-stage adjustment is necessary. But it's not that simple. Other factors, such as the amount of centrifugal weight on the clutch and the power output of the engine, affect clutch slippage as well. Finding the right balance of variables involves much more than matching numbers on the computer printout.

Are there any limits on top fuel performance? Some 30 years ago, an automotive journalist suggested that it was impossible to exceed 150 mph in a quarter-mile. On October 7, 1989, at Ennis, Texas, Gary Ormsby recorded

With 4000 hp on tap, AA-fuel dragsters are capable of covering a quarter-mile in less than 5 seconds.

the fastest and quickest pass ever made in a top fuel car to date: 4.91-second elapsed time at 293.73 mph. Minutes later, Michael Brotherton clocked 294.88 mph.

But there's a bad piston in the bunch. Drag racing's principal sanctioning body, NHRA, is concerned about the insurance and safety implications of increasing speeds and has decided to impose a mandated rear-axle gear ratio for next season. All cars will be required to run a 3.20:1 or lower (numerically higher) rear-axle ratio. Most now use a ratio in the neighborhood of 2.70:1.

Will the new axle ratio slow down the cars? Probably not, say the experts. But it will tax the engines more as they wind tighter. It will also require extensive reworking of drivetrain combinations, an exercise that almost always results in broken parts, blown engines, crashes and fires.

Imposing limits on drag racing's supposedly unlimited class hasn't worked to anyone's advantage in the past, and it probably won't work now.

Nevertheless, the show will go on. The ground will shake. Hands will fly to cover ears. And top fuel drivers will disappear off the edge of the world: one, two, three, four . . . just like that.

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SOLVING HESITATION PROBLEMS

BY PAUL STENQUIST; PM Illustrations by Fred Wolff

DOES YOUR CAR procrastinate? When you jab the throttle floorward does your engine draw an empty breath, sag, think about it for a moment, and then finally respond? If so, you have a hesitation problem, or—in mechanic's jargon—tip-in stumble.

Besides the annoyance factor, engine hesitation can be extremely dangerous in severe cases. When you mash the pedal to cross a busy inter-

section, you want your car to move *right now*. Fortunately, the condition is fairly easy to diagnose and repair.

If the hesitation is present only when the engine is cold, it's caused by a defect in the choke, EFE or heated intake air systems. We'll limit the discussion to warm-engine hesitation.

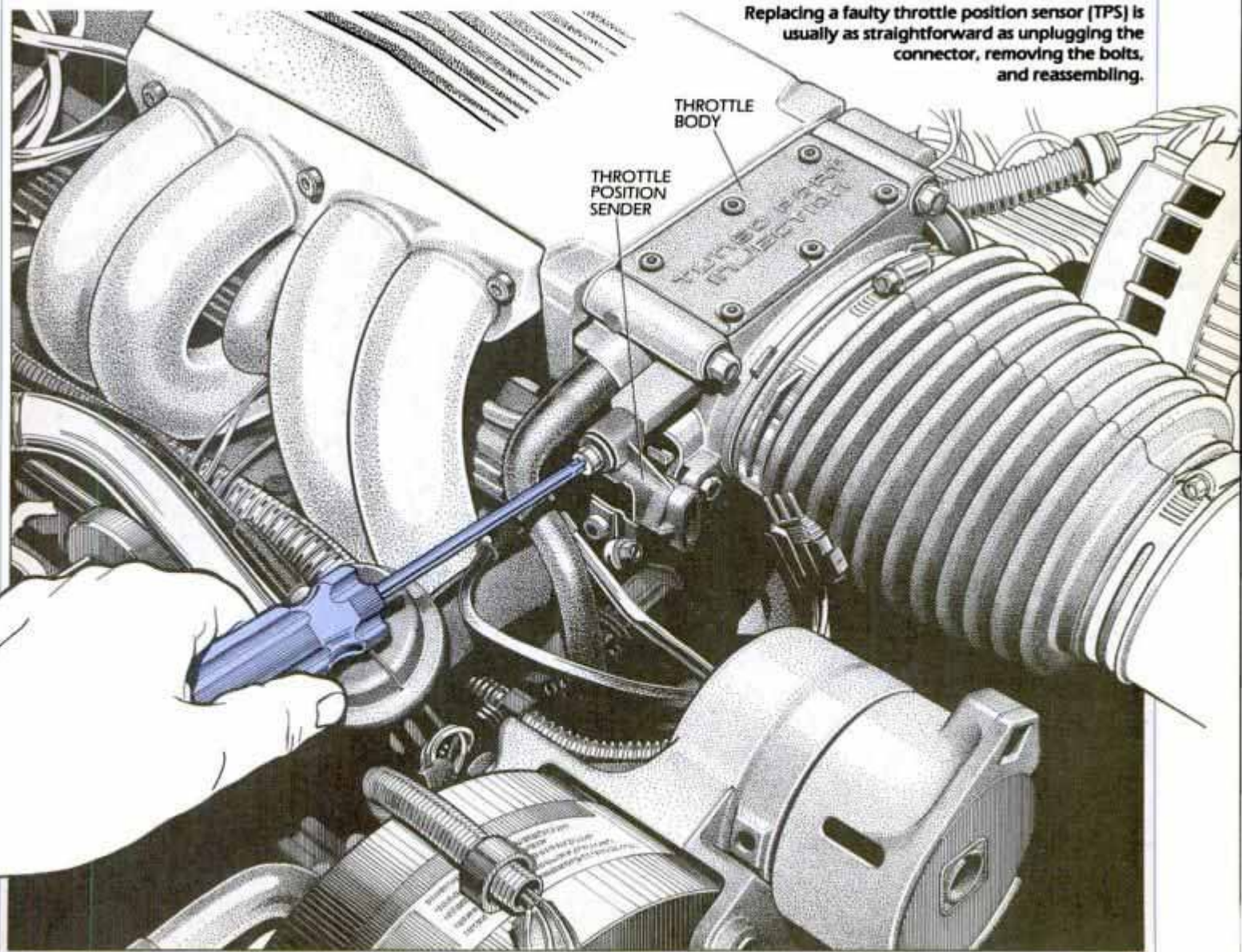
Plan of attack

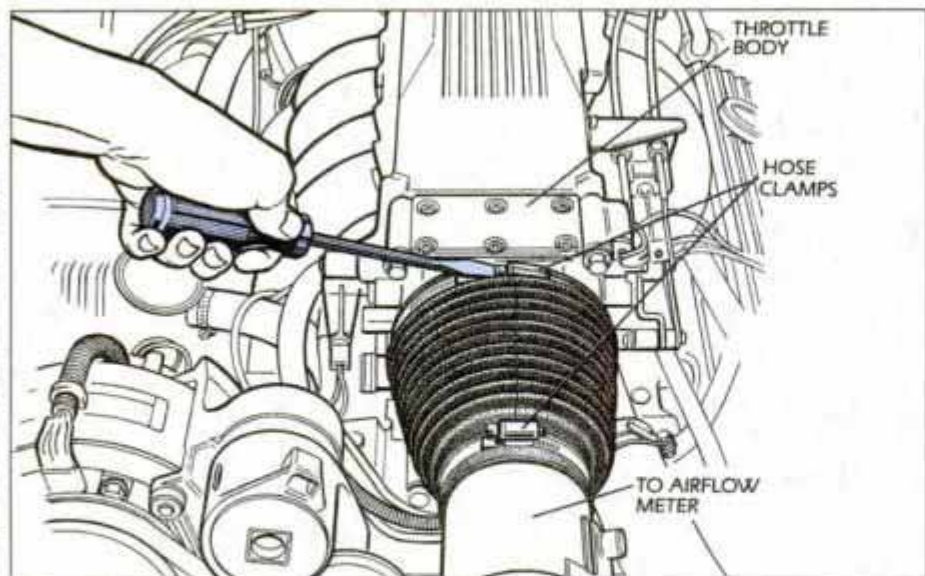
On late-model cars with computer control systems—that includes most

cars built since 1981—check for trouble codes in the computer system before you move on to other kinds of diagnostic work. You'll find instructions in the fuel injection, carburetor or driveability and emissions chapters of your service manual. If you do find that a trouble code has set, perform the indicated troubleshooting routine that corresponds to that code.

If the problem has not been diagnosed by the engine computer, move

Replacing a faulty throttle position sensor (TPS) is usually as straightforward as unplugging the connector, removing the bolts, and reassembling.





1 Check ducting between airflow meter and throttle unit of a port-injected engine.

on to the checks that follow. Of course on cars without a computer system, you'll begin with the visual checks described below. Notice that the routine differs in some places, depending on whether your engine is fuel injected or carbureted.

Basic visual checks

Because a vacuum leak can cause the fuel mixture to be excessively lean, it is a prime cause of hesitation. In some cases—but not all—a vacuum leak may also cause a rough idle.

Begin your visual check by examining all vacuum hoses for splits, kinks and improper connections. (You can determine where each hose should be connected by studying the vacuum diagram on the Vehicle Emissions Control Information label.)

A cracked or split hose is some-

times difficult to detect by sight alone. But if a hose is split or cracked, it will also cause rough running at idle. So vacuum leaks can sometimes be located by squeezing off each vacuum hose with hose-crimping pliers (available at auto parts stores) or a similar device. Simply close off the hose as near as possible to the vacuum port that it connects to. If a rough idle clears up, you've located a leak.

Once you're sure that all the vacuum hoses are okay, check for air leaks at the base of the carburetor or throttle body. First, make sure the bolts or nuts are reasonably tight. Don't make them as tight as you can get them—as you could break one. If access room allows it, use a torque wrench and tighten them to spec. If you can't reach the fasteners with a torque wrench, use a box wrench or open-end wrench that

is about 8 or 9 in. long, and tighten with moderate pressure.

If the bolts seem to be tight enough, spray some carb cleaner around the base of the carb or throttle body with the engine idling. If the idle smooths out somewhat or its speed changes even momentarily, there's a leak, and you'll have to replace the gasket. Remember that engines with electronic idle-speed control will automatically correct the idle, so the change resulting from the carb cleaner blocking the vacuum leak will be less pronounced than on an older engine with mechanical idle-speed adjustment. Carb cleaner is highly flammable, which is why it works. Don't spray it near the distributor or alternator, or you could lose your eyebrows.

On all cars, check for air leaks at the intake manifold gasket. You can use the carb-cleaner spray. On fuel-injected cars with airflow sensors, check carefully for air leaks at all intake locations between the sensor and the engine.

Make sure you carefully examine any ducting between the airflow meter and throttle. If the ducting is attached with screw clamps, make sure they're secure, but not so tight that they dig into the ducting (Fig. 1). Check intake manifold bolts and those that join the ram tubes to the intake manifold for tightness (Fig. 2).

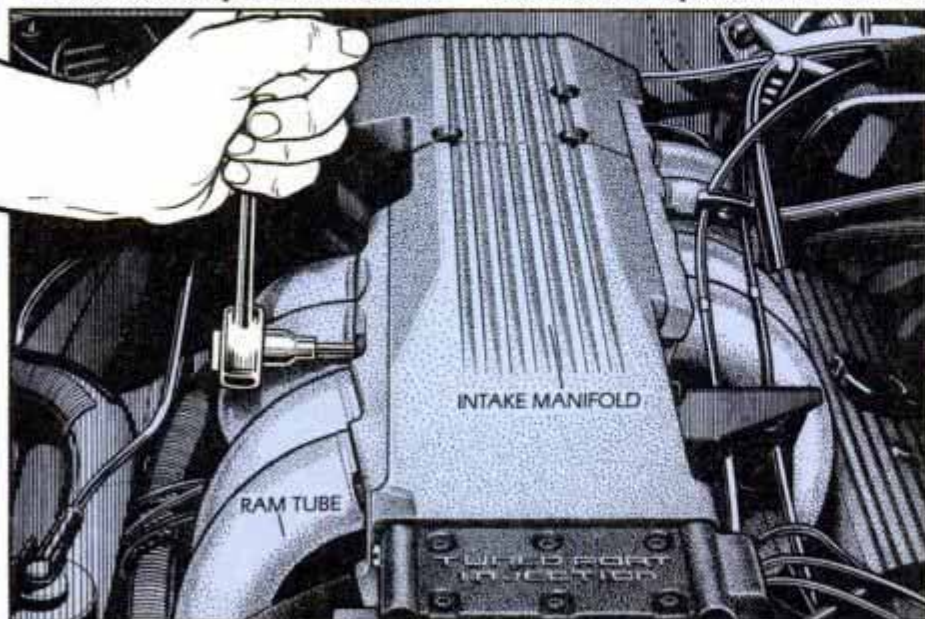
Check the oil filler cap for proper sealing. On some cars with closed PCV systems, or with limited-intake PCV systems, a loose or leaky oil filler cap can cause hesitation.

Make sure your EGR valve isn't passing exhaust gas at idle. This can cause leaning of the mixture and hesitation. If you're in doubt, check by temporarily replacing the EGR gasket with a solid piece of cardboard. If this cures the hesitation problem, your EGR valve is dirty or defective. Don't leave the cardboard in place—spark knock problems will result.

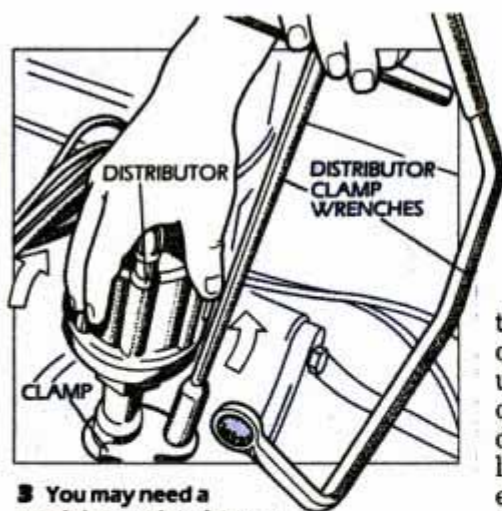
Ignition timing

There are other factors that can cause a lean mixture, but many are common either to carbureted or fuel-injected engines only, so we'll deal with those later. For now, let's consider another likely cause of tip-in stumble—incorrect ignition timing. If ignition spark is not advanced enough to burn the initial charge, you'll get a hesitation that is virtually identical to one caused by a lean mixture.

You'll need a good timing light, of course. And you'll also need a tachometer to adjust idle speed. You can find



2 A vacuum leak between the airflow meter and intake valve can cause hesitation.



3 You may need a special wrench to loosen the distributor clamp bolt and adjust timing.

the correct timing and idle specification for your car on the Vehicle Emissions Control Information label found in the engine compartment. The label will also provide some instructions in regard to any vacuum hoses that have to be disconnected when you check the timing. On fuel-injected cars with idle-speed control motors or idle air valves, consult your manual for instructions on idle-speed adjustment.

Timing is adjusted by loosening the distributor clamp and rotating the distributor one way or the other (Fig. 3). For example, if the distributor rotation is clockwise, rotate counterclockwise to increase advance.

Next, check the ignition wires for cracking, hardness and proper connections at both distributor and sparkplugs. Ignition problems are usually more common to rough running than hesitation symptoms, and it's a long shot here, but a hesitation that is accompanied by rough running can be caused by an ignition problem.

Check the sparkplugs to make sure they're not fouled. (If they are, the fouling may only indicate that your hesitation is not really hesitation, but rather rich-mixture "blubbering.")

Check all low-voltage wiring for proper connections, paying particular attention to wires going to fuel injectors. Look for corroded terminals or cut wires. Again, a low-voltage electrical problem will usually cause rough running in addition to hesitation.

Carbureted engines

Hesitation problems are probably more common to carbureted engines than to fuel-injected engines. This is true because carburetors depend on a rather failure-prone device—the accelerator pump—to enrich the mixture when you first mash the throttle. In many cases, a bad accelerator

pump will also cause difficult starting when the engine is cold.

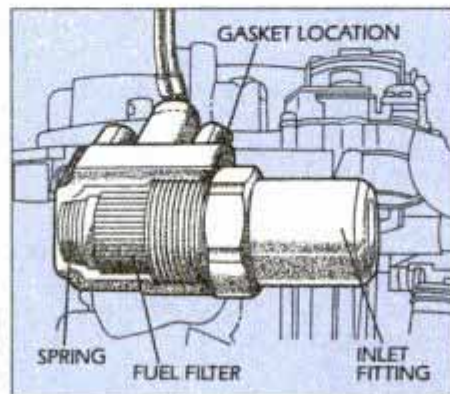
The accelerator pump is located within the carb, and it's difficult to determine whether or not it works by just looking at it. Your best bet is to see if the pump produces any results.

Here comes the fun part. To see if the pump delivers any fuel when you open the throttle, you'll have to climb up on top of your engine—or at least on top of the fender—so you can peer down into the carburetor with a flashlight while you open the throttle. The engine should be cool and turned off, of course. When climbing around the engine compartment, take care that you don't crush any wire connectors or other delicate components.

Aim the flashlight down the carb primary barrels. On 4-barrel carbs, or staged 2-barrel carbs, the primaries are the smaller barrels. Inside you should see one or two little nozzles that point down toward the center of the barrel. These are the accelerator pump nozzles. Now, while holding the flashlight so that you can see the nozzles, open the throttle briskly to the full-open position. The accelerator pump nozzle(s) should deliver a substantial stream of fuel to the carb barrel. If nothing happens, or just a few drops dribble out, either the accelerator pump is bad, or something is limiting the accelerator pump's fuel supply.

Before you dig into the carb, check the fuel filter and fuel pump. If the pump can't fill the carb's fuel bowl completely, the accelerator pump may not be able to draw a full charge.

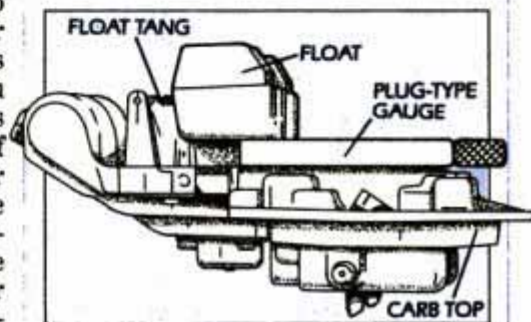
The fuel filter is either in the fuel line or behind the carburetor inlet nut (Fig. 4). If you haven't replaced it in the last few thousand miles, do so now. Don't change the filter on a hot engine. Let it cool down first. And use rags to catch any spilled gasoline.



4 Typical GM carb fuel filter shows spring and location of potentially leaky gasket.

To check the pump, you'll need a fuel-pump pressure gauge. Install the gauge by disconnecting the fuel line at the carb. The gauge kit should come with adapters for connecting the gauge to a neoprene line or to a threaded steel line. Run the engine at idle. The gauge should show between 4- and 7-psi fuel pressure. If it does, check pump volume by holding the disconnected fuel line in a graduated container while a helper runs the engine. Record how long it takes the pump to deliver a pint of fuel.

A typical fuel pump on a carbureted engine should produce a pint of fuel in 30 seconds. Some V8 engines require a pint every 20 seconds. You can find a spec for your engine in the manufacturer's service manual. The fuel



5 Most carb kits use cardboard plug gauges to check the float adjustment.

should be relatively free of air bubbles. If it's not, there may be a pinhole in the fuel line between the tank and pump. If either fuel pressure or volume is below spec, the fuel pump should be replaced.

If both the fuel pump and filter have been eliminated as potential problems, you'll have to dig into the carb or replace it with a rebuilt. Rebuilds are expensive, however, and there's no reason why you can't rebuild your own carb. And since rebuilding kits are relatively inexpensive, there's little point in disassembling your carb without installing a rebuild kit. What's more, the kit comes with a new accelerator pump which is probably what you need. Aside from a bad pump, other likely sources of the problem are incorrect float adjustment or a clogged passage.

The kit will come with at least cursory instructions. You'll also find instructions in your service manual. Take extra care in adjusting float height. You can use the plug gauge that comes with the kit (Fig. 5), or a steel rule (Fig. 6).

There are two relatively common types of accelerator pumps, and your carb is likely to have one or the other.

One is a diaphragm, the other a plunger. The diaphragm is attached to the outside of the carb (Fig. 7), the plunger-type is within the carb and hangs from linkage on the bottom of the carb air horn or top cover (Fig. 8).

Some recent carbureted engines with computer control are also fitted with a throttle-position sensor (TPS) like that described in the fuel-injection section below. Because this device helps the carburetor deliver the extra fuel needed for acceleration, it can be a cause of hesitation. If your engine is equipped with a TPS, your service manual will include adjustment and replacement instructions in the carburetor chapter.

Fuel-Injected engines

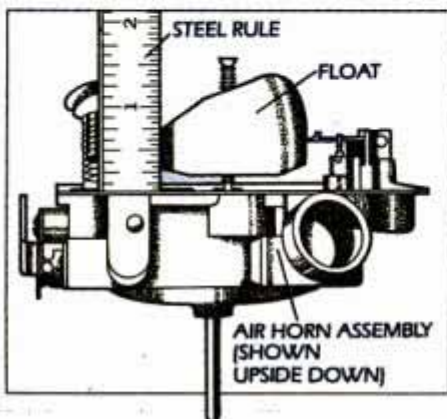
On a fuel-injected engine the throttle-position sensor or TPS bears primary responsibility for telling the computer that you've just opened the throttle, and that it ought to hurry up and increase the fuel supply. The TPS is a potentiometer that is connected to the throttle shaft of a fuel-injected engine's throttle body or throttle. Wires connect the TPS to the engine's fuel-injection computer.

As the throttle valve is opened, the amount of current passing through the TPS to the computer increases. Thus the computer can tell when you hammer the throttle home, and it will provide more fuel. If the TPS fails, or its wiring is defective, it won't tell the computer what's going on and the engine will hesitate. In many cases, this condition will set a trouble code and turn on the CHECK ENGINE light. On most GM cars, a defective TPS will set code 21 or 22.

But a TPS that just binds or sticks may cause hesitation without setting a code, so make sure you check that this device is operating correctly.

Some early fuel-injected import cars with Bosch electronic fuel injection

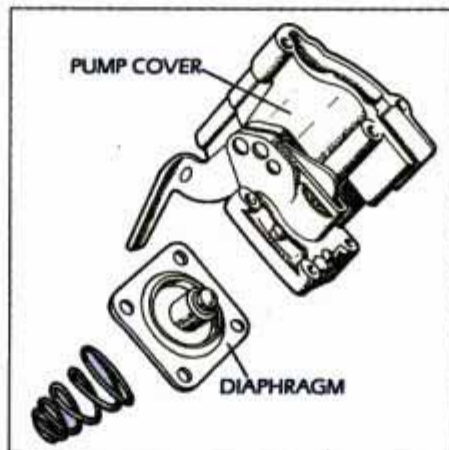
6 You can also use a steel rule to check float height on most carbs.



tion have a TPS, but don't set trouble codes. On these cars you can usually tell whether or not the TPS is working by checking output voltage with the throttle opened and closed. You'll find instructions in your service manual, but in general, the voltage should increase as the throttle is opened.

Installing a new TPS is usually quite easy, but varies from car to car. On a GM car with port fuel injection, disconnect the battery's negative cable. (Never work on any electronic control system without disconnecting the battery's negative cable.) Disconnect the TPS electrical connector and remove the TPS Torx screws, along with the lockwashers and retainer (See lead illustration).

To install the new unit, hold the throttle valve in the normal closed idle position, and install the TPS. Reinstall the retainers, screws and lockwashers using a thread-locking compound. Then reattach the electrical connector and adjust, following



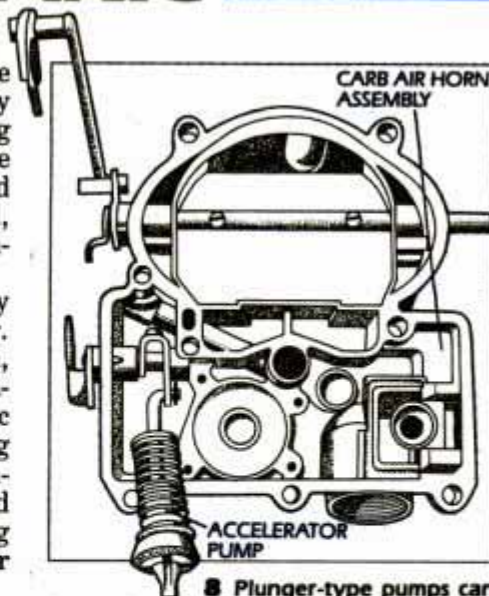
7 Accelerator pump from a Chevette carb is typical of the diaphragm type.

the instructions in your shop manual.

If you're satisfied that the TPS is not the source of the problem, check fuel pressure. We've described this procedure a number of times in recent months, but we'll run through it once more. Checking fuel-injection system pressure has become an integral part of troubleshooting almost any kind of engine-performance problem.

To check fuel pressure, you'll need a fuel-injection pressure gauge. GM, Ford and Chrysler engines with port injection have a fuel-pressure gauge attachment point, so you simply connect the gauge to this port. (For Chryslers with TBI, see below.)

In most cases, the gauge point is a Schrader valve, like the kind you'll find on a tire. On TBI cars, the fuel-pressure gauge point may be right on the throttle body. On many port-in-



8 Plunger-type pumps can be serviced after the air horn is removed.

jected cars, it's on the fuel rail. On 2.5-liter, GM 4-cylinder engines, you'll find the gauge point between the fuel filter and throttle body. On 1.8- and 2-liter Fours with TBI, the gauge point is under the car near the fuel filter.

On Chrysler products, you have to relieve pressure before checking. Do this by loosening the gas cap and removing the wiring harness connector from one fuel injector. Then ground one injector terminal with a jumper and connect another jumper between the second terminal and the positive post of your battery. Leave the wires in place for 10 seconds. To attach the pressure gauge to a Chrysler TBI system, remove the fuel-intake hose from the throttle body and attach the pressure gauge between the filter hose and throttle body.

On those Chryslers, start the engine and take a pressure reading. TBI systems should produce 34 to 38 pounds, port-injection systems are 52 to 55 pounds.

With Ford and GM products, you'll have to supply electricity to run the pump. You should not attempt to check fuel pressure with the engine running. On a GM car, just connect a jumper between the positive battery cable and terminal G of the ALCL connector under the dash. On Fords, disconnect the electrical connector to the fuel pump, which is located just forward of the fuel tank. Then connect a 12-volt jumper to the connector to run the pump.

Compare your pressure reading to the specification in your service manual. Most Ford and GM fuel-injection systems of the high-pressure variety should produce between 35 and 45 psi. GM TBI units are low pressure and will pump up about 9-psi fuel pressure.

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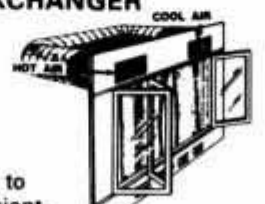
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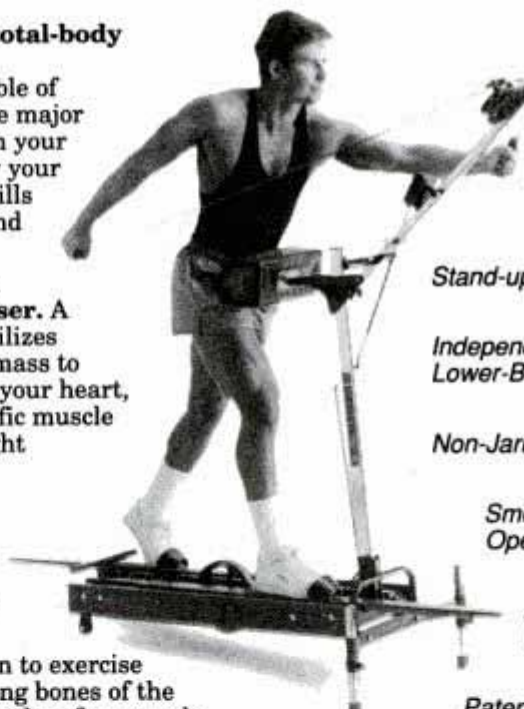
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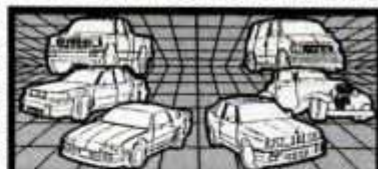
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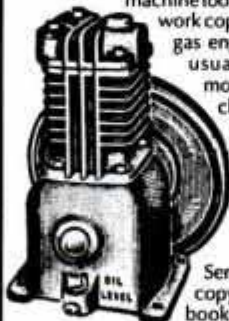
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