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Popular Mechanics

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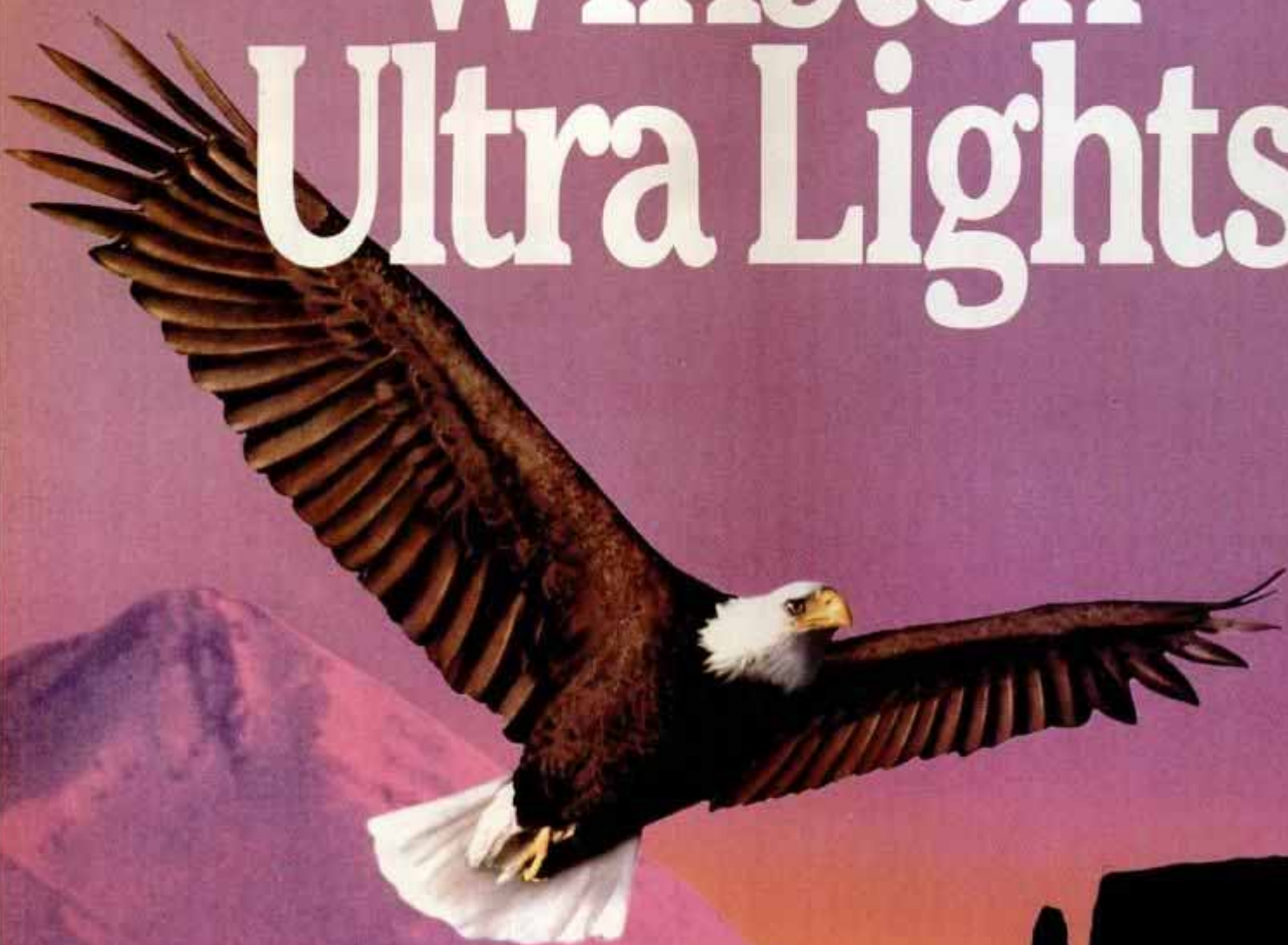
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—PM cover photo by
Brian R. Wolff



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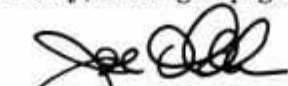
EDITOR'S NOTES

● I spent Memorial Day weekend in Indianapolis, and what a great weekend it was. You can't get any more Midwest than Indianapolis, and the folks there really roll out the hospitality for Indy 500 weekend. I love parades, and the Indy 500 Festival parade was the second best I've ever seen (the first being New York City's ticker-tape job for the Desert Storm troops on June 10). The 75th running of the race itself was great, too. Rick Mears made his move on Michael Andretti right in front of the grandstand we were in, and that was all she wrote for Andretti. But the highlight of the whole weekend was my ride in the Dodge Viper pace car. Dodge had arranged for Carroll Shelby, who drove the pace car during the race itself, to give rides in the Viper to members of the press. Being a bonafide, card-carrying member of the press, I was first on line.



A hot weekend in Indianapolis—parades, the Indy 500 and a hot lap around the Brickyard with Carroll Shelby. The V10-powered Dodge Viper R/T will be a '93 production car that will give new meaning to the word nostalgia.

Ol' Shel, legendary race car driver, builder of the Cobra sports cars and Shelby Mustangs of the '60s and, more recently, several high-performance offerings from Chrysler, is truly one of the famous names in the world of automobiles. In the past year, Shelby underwent a heart transplant that would incapacitate most men for a year or more. Yet, here he was behind the wheel of the pace car for the Indy 500 and enjoying every minute of it. He remembered me and greeted me by name, which did wonders for my ego, as I climbed into the Viper. I inquired about his health. He said he was okay. And we were gone. Shelby punched it and shifted up through the gears and into Turn One. Turn Two was a lefthand blur, and we were ripping down the back straight. The only thing I could hear above the roar of the wind was the V10's revs climb with a dull scream. Suddenly, I realized Shelby was talking to me. "Joe, look at this. Rock steady at 140!" he screamed over to me. I looked over. He then proceeded to take his hands completely off the steering wheel to demonstrate the Viper's stability. As the blood drained from my head, I wondered if I would live to tell this tale. But then, his little joke over, Shelby retook the wheel, punched the Viper through Turns Three and Four, and we were back on pit road, the next journalist eager to have the wits scared out of him by Carroll Shelby. The legend grows. . . . It seems almost impossible, but the Navy is packing 1990s technology into 1960s aircraft carriers and extending the life of these floating war machines well into the next century. Our cover story, starting on page 34, tells you all about it. Till next time.


Joe Oldham

Popular Mechanics

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Number 13 in a series:

Why cars like yours race on gasoline like ours.

As an enthusiast, you know how different race cars can be from street cars. But in the Escort World Challenge, sanctioned by the Sports Car Club of America (SCCA), the race cars *are* street cars. Except for racing safety gear, they're about the same as the Corvettes, Hondas, Eagle Talons, Mazdas, Mustangs, Oldsmobiles, Lotuses — and many other fine makes — that you may drive off your dealer's showroom.

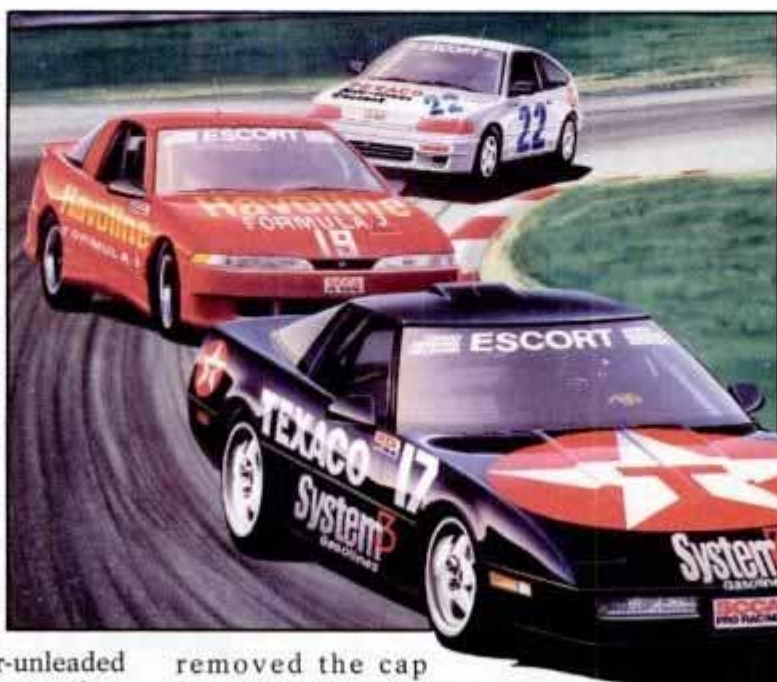
The official U.S. gasoline for the 1991 World Challenge series is also a street product. It's super-unleaded System³ Gasoline, just as you can buy in Texaco stations. And there's an interesting story in how well it works.

Racing on street gasoline.

Last year, teams in this series were allowed to run on special-purpose racing gasoline. When System³ was selected for the World Challenge this year, some competitors were concerned about tuning high-compression, high-performance engines to race on a street gasoline. This concern vanished at the first race. Here's what the racing teams looked for and found:

Density. Sometimes it's measured in terms of specific gravity and sometimes as pounds of fuel per gallon. Either way, the higher a gasoline's density, the better its mileage is likely to be. And World Challenge races are endurance events in which short pit stops are important. In fact, years ago some Formula One teams actually refrigerated gasoline to bring density up. We don't suggest you go that far. But we do suggest that you try Texaco System³ Gasoline. While we're making no special claims, its density met the track needs of the SCCA teams.

Vapor Pressure. If you've ever



removed the cap from a jug of gasoline sitting in the hot sun, you know what this is. Reid Vapor Pressure (RVP) that is too high can cause vaporlock and other evils. In racing, it can slow your refueling or mislead you into thinking your fuel cell is full when it isn't. Special-purpose racing gasolines have the advantage of extra-low vapor pressure if they're not blended for street use. Yet System³ performed well in the SCCA World Challenge.

Octane. The object of mystique and myth, octane is simply a rating system that measures a fuel's tendency to resist autoignition. Autoignition means knocking in an engine that doesn't have a knock sensor, or can lead to power loss in an engine that has one. Retarding spark reduces autoignition but robs engines of horsepower. Yet Mike DuPree, a key Corvette engine development expert, had this to say about the octane performance of System³: "We anticipated a much more significant power loss in changing from racing gasoline than we actually got. In fact, we were pleasantly surprised with Texaco System³."

Octane appetite control.

Now, we're not making any extrav-

agant octane claims about it. But it's true that System³ contains a patented technology to help control the appetite for higher octane a car may develop as it grows older, while providing the highest level of engine cleanliness. And System³ technology comes not just in super-unleaded, not just in plus, not just in regular — but in every octane grade.

Still think all gasolines are the same?

As an enthusiast, you may look to racing to learn something

about

your car's

performance. We do too. And we don't just look at gasoline performance. Texaco Anti-Freeze Coolant is also the official U.S. coolant for SCCA World Challenge races, where its main job is to keep the lid on high engine temperatures. Havoline Formula³ Motor Oil is an off-the-shelf product that performs in the Indy car engines of Mario, Michael, and Jeff Andretti — and the NASCAR engine of Davey Allison.

At Texaco, we're as enthusiastic about our product performance as you are about your car's performance. We race not only to prove our products, but with an eye toward improving them. You see, we don't want to be just another oil company. We want to be *your* oil company.



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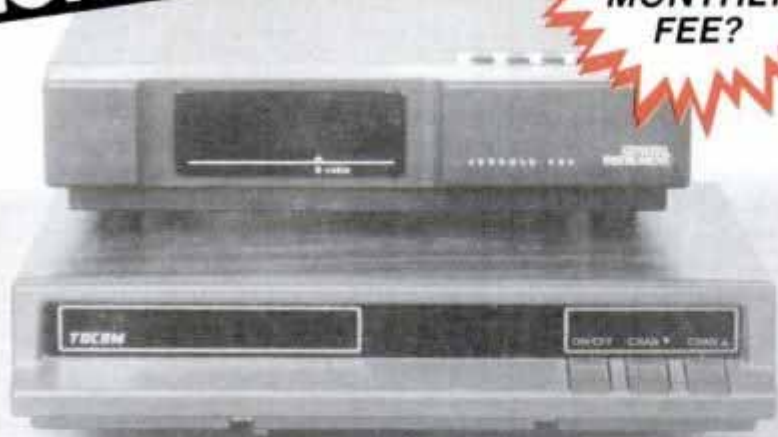


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Driver-side air bag	Standard	Standard
Drivetrain	Rear-wheel drive	Rear-wheel drive
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BUICK LESABRE



As a former owner of a 1985 Buick LeSabre and now a 1990, I had to respond to your Buick LeSabre Owners Report. True, Buick does make a beautiful car, and when you buy a new car you expect some kind of problem. But one would hope the dealer would have a service department with expert personnel to take care of the problems. If you don't get satisfaction from the dealer, you should be able to go to the manufacturer's customer service division. But it is worse than the dealer, and arbitration through the Better Business Bureau is a laugh.

You should poll people on the actions of the dealers and how problems were handled. It would serve to keep more dealers in line on their repair performance. And they wonder why everyone is switching to foreign cars. Are you listening GM?

SAL MANGIARACINA
N. MASSAPEQUA, NY

We do poll owners about their experiences with dealers. In the case of the Buick LeSabre, 82.7% of those responding said that their dealer performed repairs in a satisfactory

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

manner. And 88.8% of owners rated their dealer service as excellent or good. It's all in the chart. By the way, since about two-thirds of all cars purchased are domestics, you can hardly say that everyone is switching to foreign cars.
—Ed.

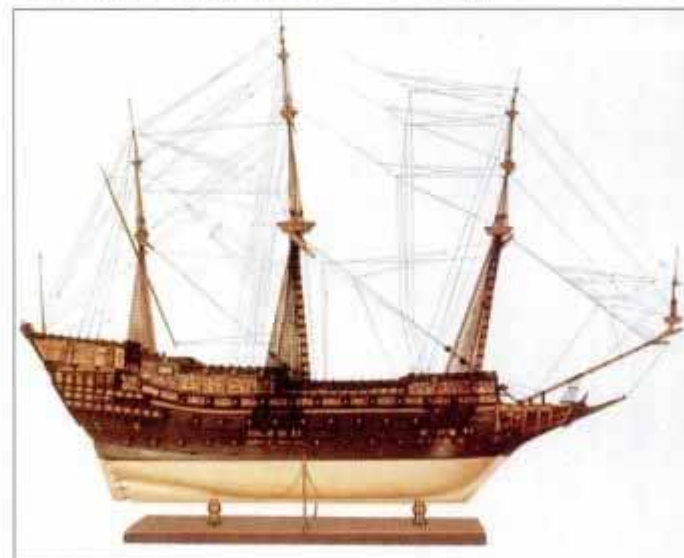
Made In The USA

I was amused by Donald Taylor's letter, in which he was so disgusted by the fact that some Ford automobiles are built outside the United States. Mr. Taylor, if you want to buy a vehicle that is built in the U.S., buy a Honda. The company has an assembly plant in Ohio. I wonder if the Dodge D-150 is built in the U.S. Maybe its assembly plant is in Kyoto or Osaka.

ED PARKS
AUSTIN, TX

Boatbuilding

After 50-plus years of building, I am enclosing a photo of your *Sovereign of the Seas*. The plans for this model were copyrighted in 1923 by POPULAR ME-



Reader R.H. Dunwoody spent 51 years crafting his ship.

CHANICS. This model ship was started in 1939 and completed in 1990. How's that for perseverance?

R.H. DUNWOODY
LARKSPUR, CO

Comparison Shopping

In my opinion, you manage the best magazine of its type in the business. Your Car Care and Home Improvement sections are outstanding, as is the rest of the magazine. I have been a subscriber to both *Popular Science* and *POPULAR MECHANICS* for many years, but I have decided to drop one at the next renewal. By chance, I happened to receive both magazines on the same day, and I decided to compare them, article by article. There is no doubt that you are head and shoulders above your competition.

Popular Science seems to have eliminated all reference to auto troubleshooting and has nothing to compare to your auto Owners Report. Your Car Care section is so good that I remove

it each month and file it in a notebook. I have found it to be a better reference, easier to comprehend and more accurate than many after-market shop manuals. I will definitely stay with PM and drop *Popular Science*.

SANFORD J. ZEMEL
LONGWOOD, FL

I wholeheartedly agree with your decision. —Ed.



Killing Machines

I don't get it. Your cover story "The Army's Newest Killer Chopper" advocates the killing of human beings. Just think about what you are doing. You display the new and advanced helicopter with an array of killing armaments. The background is filled with fire and smoke. And what is below? Humans being killed? At least that seems to be what you are trying to portray. The article itself embellishes this theme with a 2-barrel 20mm Gatling gun, Hellfire air-to-ground missiles and Stinger air-to-air missiles all designed to kill, kill, kill.

Come on, is this what we are in the world for?

It is a sad state of affairs that our legacy is such. Perhaps we really haven't

(Please turn to page 12)

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changed in the past 2000 years. Instead of developing thoughts and systems to take care of others, we design machines to kill. Do you think it may be possible to change the concept and strive to work toward a world with no killing machines?

JOHN A. TANGUAY
SHALIMAR, FL

Our cover doesn't "advocate" anything. It depicts what we report about inside the magazine—namely, the new technology that is incorporated into the Army's newest helicopter, just as we report this month on the rebuilding of aircraft carriers and next month on the new '92 cars.

Yes, one of the helicopter's jobs is to kill—if that's what it takes to defend this country. Hey, if the other guy has one, I want to have one too. —Ed.

Blackbird In Flight

As an avid fan of the SR-71 Blackbird, I found "The Blackbird Is Back" to be one of the best articles I've read on the subject.

You might be interested to know that the Blackbird's record flight from Los Angeles, California, to Washington, D.C., was 4 minutes faster than the time you printed.

The official time, verified by the National Aeronautic Association, in Arlington, Virginia, was 64 minutes, 20 seconds. Incidentally, on this same flight to the Smithsonian Institute on March 6, 1990, the Blackbird established a new aircraft transcontinental record. It covered the 2404-mile coast-to-coast distance in 67 minutes, 54 seconds.

These records, along with several other of its aviation world records, will help the Blackbird be remembered for its fantastic supersonic cruise capability and its more than 25 years of outstanding military service for our country.

ED YEILDING
ALEXANDRIA, VA

Jeeped

I could not believe my eyes when I saw "Beach Bandits." How could you compare the Jeep Wrangler with those four Japanese sardine cans? I have an '88 Wrangler (my fifth Jeep) with 60,000 miles—I've never changed the plugs—and it runs like a champ.

I disagree with you on how it drives in the city. I have off-road tires on my Jeep Wrangler, and it rides like a car. Let's start comparing apples and apples.

AL PURCELL
PHOENIX, AR

Too Big?

The introduction of superjumbo transport aircraft, in "Jetmakers Ready For A Growth Spurt," may relieve air route traffic and runway congestion, but will create horrendous airport terminal problems.

Not only will the runways, taxiways and parking areas need to be strengthened to support the greater weight of the aircraft, the terminal infrastructure changes that will accommodate 600 to 800 passengers may be too much to handle all at once. The ticketing and waiting areas at the gates must be expanded, along with

restroom and food facilities, customs and immigration areas, baggage facilities, parking areas and public transportation.

Most airports today can't even handle the load of two or more B747s arriving at the same time.

Carrying more passengers in one airplane will reduce the load on flight operations, but will greatly increase the problems on the ground. What will be the source of the funds that will be required to resolve these new problems?

MARTIN A. SNYDER
FREMONT, CA

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A Classic

I was thrilled to see Mark Smith's 1956 Ford pickup included in your "Gallery Of Great Cars" pictorial. Being an owner of a 1955 F-100 pickup myself, I believe the 1953-'56 Ford pickups are true classics.

The article did contain two mistakes, though. You mistakenly labeled the 1956 pickup as an F-150. The F-150 series did not appear on Ford pickups until 1975. The 1956 1/2-ton Ford pickup was labeled as F-100.

Also, you said Smith "brought the 292-cu.-in. V8 back to stock condition." In fact, the 292-cu.-in. V8 was

not introduced in Ford 1/2-ton pickups until 1958. The 1956 F-100 pickups came with 272-cu.-in. V8s.

ELMER D. PORTER
McDERMITT, NV

Standing By Saturn

In your Letters column there was a complaint about "Saturn Showdown." The writer complained that the article "could have been written by an advertising copywriter." That is absurd. I wonder, has the writer ever driven the Saturn to find out how it really is? I doubt it.

Pleasure.



Even shopping for a Moen Touch Control faucet is a pleasure, because you'll find so many affordable styles. In fact, the only difficult part of the process will be selecting the Touch Control faucet you like best. Who knows—you may have to buy more than one (we like to encourage that sort of thing). For information about Touch Control and the complete line of Moen faucets, see your local home improvement store, or call 1-800-347-6636.

MOEN

©1991 Moen Incorporated

Also, this car is not a carbon copy of what's already available in the General Motors' stable, as so complained. GM has more variety and personality in its cars than it ever has.

Can you tell the difference between a '51 Chevy and a '51 Pontiac at a glance? I know I can't, but I sure can tell the difference between the '91 Lumina and the '91 Grand Prix.

JASON STALNAKER
ELKTON, MD

Steel-Framed Homes

I was excited to read "Factory-Built Housing," which claimed to be a complete guide to manufactured housing. But I discovered to my dismay that you failed to include all of the information about manufactured housing to make the article fit its title.

I am particularly concerned with the exclusion of steel-framed homes. True, you did mention the use of galvanized-steel studding in the IBS panels, but the true steel-frame construction combines all of the best features of paneling, post-and-beam and log homes to produce the maximum flexibility, strength, DIY, durability, and wind, fire and earthquake safety.

H. WAYNE EARL
DENTON, TX

We didn't have room to cover every single aspect of the manufactured housing industry. Perhaps we'll have another chance in the future. —Ed.

British Cars

Car Clinic gave a very clear answer to why it is better to use a negative-ground electrical system, especially to aid spark-plug failure. But I do think your current science did not explain the old problem of hard-starting British cars.

On a cold, damp morning, there is no advantage to electron flow in either direction because both electrodes are cold. The problem is in the wire. Old Lucas systems used braided-steel wire with the strands spread out at the end over a tiny copper washer, held in place by a screw-down plastic cover. There is no real moisture seal, and with time, the flexing of the wire between the coil and distributor will cause some of the strands to break. A damp connection with only a few strands in contact will not send a spark very well. The polarity just will not matter.

Your explanation was fine, but old British engines can even bend the basic rules of electricity.

DAVID R. ROSSER
RICHBORO, PA

You're not a kid anymore.

It's been over ten years since you graduated from high school. It's probably hard to admit, but your body has changed. Fact of life. If you're still trying to get into the same old pair of tight fitting jeans, it's time you tried a pair of Lee Easy Riders. They're cut looser in the thighs and lower at the waist for a more comfortable fit. Nobody fits your body...or the way you live...better than Lee.

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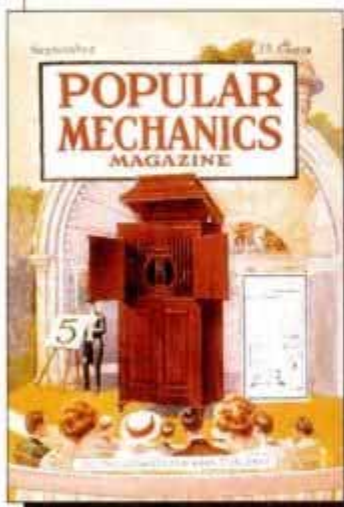
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TIME MACHINE

75 YEARS AGO: SEPTEMBER 1916



Blaster From The Past

Amplified music machines may seem a modern blessing, but even the old Victrolas could fill a city park with sound. In Tacoma, Washington, a gramophone mounted in an 8-ft.-tall sound cabinet provided twice-weekly concerts. An electric pump forced air through the record player's horn as the needle scratched away, generating tones said to be "almost indistinguishable from the human voice." The sounds could be heard 300 ft. away.



Silent Running

The world was still agog at the daring trans-Atlantic run of the German submarine freighter *Deutschland*.

Ducking a British blockade, the craft brought 750 tons of cargo into Baltimore Harbor. It was later fitted with torpedos and became U-155.

50 YEARS AGO: SEPTEMBER 1941



Geronimo!

Although D-Day hadn't even been planned yet, Britain was busy training paratroopers to go on the offensive. But in the middle of fighting for their sovereignty, the Brits couldn't spare precious aircraft for practice jumps. Fortunately, barrage balloons make excellent aerial platforms. Parachutists climbed into a basket slung below the balloon and were hoisted to the appropriate altitude. Then, one by one they leapt through the hole in the basket's bottom.



Built For Speed

Racers vied neck-and-neck for the land-speed record before one of them, John Cobb, finally cracked 400 mph and put it away in 1947. But plenty of other contenders built speed machines during this era of streamlining. Typical

was the *Golden Eagle*, a 26-ft. aluminum sprinter driven by Ted Ellis. The car could accommodate three different engines—two straight-8s at 200 and 350 hp each, and a 24-cylinder air-cooled monster of 1200 hp—to handle the run at the record.

25 YEARS AGO: SEPTEMBER 1966



Sidewinder

The Sidler was every urban motorist's dream. The device let a car nose into a parking space, then drive the rear wheels sideways. At the push of a button, two hydraulic rams lowered, to lift the rear wheels and deploy two fluted rollers that angled on to the ground and engaged the tires. Driving in Reverse moved the rollers to the right. Low gear shifted them to the left. The machine made a grand debut at a New York inventors' show. What-ever happened to it?

Jumbo Dreaming

The Boeing 747 was three years away, but already the air was filled with hype.

Some models would contain separate movie theaters and private suites, even play-rooms for children. **PM**



TECH UPDATE

News Of Tomorrow's Technology Today



PM ILLUSTRATION BY PAUL DIRANGE

Sweden's Smyge Is The Stealth Fighter Of The Seas

KARLSKRONA, SWEDEN—Last March, a revolutionary small attack craft slipped into the Baltic Sea. The experimental surface-effect vessel combines the agility and weapons flexibility of a state-of-the-art fighter aircraft. But its name tells the rest of the story: *Smyge*, Swedish for "stealthy."

Smyge's angular hull and low-profile bridge, built of Kevlar- and fiberglass-reinforced plastics, shrink its radar signature. Antennas and mast are hull-integrated. Weapons hide internally: To fire missiles, hatches retract and launch tubes rear out. Even the 40mm gun pops from a "stealth cupola."

Meanwhile, elastic materi-

al cushions the propulsion and surface-effect machinery to minimize noise, and quiet waterjets, not propellers, drive the vessel. Infrared-damping material lines exhaust outlets, while air intakes are concealed with radar-reflecting nets.

Belowdecks at *Smyge's* center of gravity is a moon-pool, from which sailors can lower hydrophones or mine-clearing robots.

Sweden's defense establishment will use *Smyge* as a test platform for weapons, communications systems and stealth materials.

Other navies may take

Editor: Abe Danc
Asst. Editor: Greg Pope
Contributors: Mike Fillon, Bob Scheier

note: Builder Karlskronavarvet plans to export a new line of small attack craft based on *Smyge*.

Sweden's *Smyge* combines low radar profile with quiet propulsion. Surface-effect ship's top speed is 40 knots.

Highlights This Month

- **Deep Sleuths**—Sonar and submarine robot team up to solve crime.
- **Leave The Driving To Us**—Remote-control vehicles for battlefield and mineshaft.
- **Killer-Diller Chiller**—Air conditioning the tunnel between England and France.
- **Invisible Mine**—New copper-reaping method won't scar landscape.
- **Radar Headlights**—Fords in your future will find their way through fog.
- **Patriot's Progeny**—Next-generation tactical missile busters from SDI.



Sleuthing ROVs Solve Crime

VIENNA, AUSTRIA—More than 14,000 ft. beneath the Arabian Sea lies the wreckage of the *Lucona*, a freighter that's the crux of a complex murder insurance-fraud mystery coming to trial in Austria.

Last winter, in an unprecedented tag-team operation, a towed-array sonar vehicle located the wreckage, and a remotely operated salvage robot photographed the evidence. It's the first time that

a salvage ROV and a sonar vehicle have worked together in such deep water.

Magellan 725, the salvage robot, is a new vehicle built by Eastport International to operate at record depths of 25,000 ft. Its partner was the *Ocean Explorer 6000*, which can dip to 20,000 ft. and packs sonar acute enough to spot a chair-size object 1½ miles away.

The sonar found the ship after a week of exploring a



Towed-array sonar (above left) teamed with deep-diving salvager (above) to photograph freighter (left) for a trial in Austria.

The evidence will serve in the trial of a Viennese restaurateur, suspected of being a KGB agent and accused of scuttling the *Lucona* in an insurance-fraud scheme.

450-sq.-mile area. Photographs taken by *Magellan 725* suggest that a hull explosion sank the vessel.

pected of being a KGB agent and accused of scuttling the *Lucona* in an insurance-fraud scheme.

Numbat To The Rescue

ST. LUCIA, AUSTRALIA—Where mine-rescue teams dare not tread, a remote-control vehicle named for a burrowing marsupial can scout ahead to locate missing or injured miners.

Developed by Australian government researchers, the amphibious 8-wheeler is

called Numbat. It travels on pairs of wheels mounted on rocker arms, allowing independent movement.

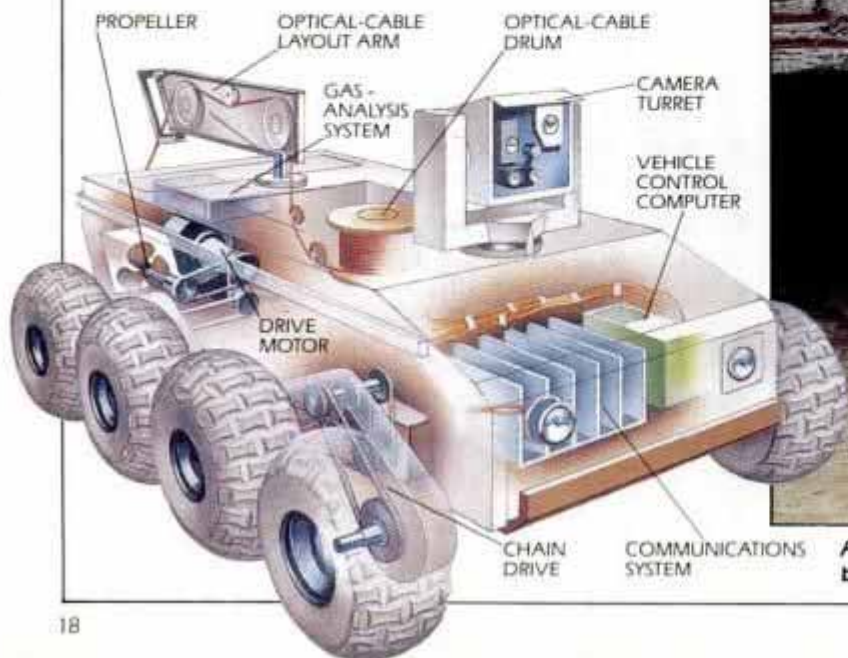
Numbat allows its surface-based controllers to navigate by looking through the vehicle's stereo video cameras. In murky locales, a radarlike phased-array ultrasound im-

aging system takes over. A third video camera provides closeups. Meanwhile, a gas-analysis system senses the composition of the mine's atmosphere.

To relay all this information to the surface, the vehicle uses a fiberoptic cable. A servo system pays out and

reels in the line from Numbat's rear. The reeling system responds automatically to changes in tension on the cable as Numbat advances or backs up.

Designed primarily as a surveillance tool, the vehicle could actually carry out injured miners in a pinch.



About 8 ft. long, Numbat is driven by twin electric motors, fed by a 48-volt battery. Range is about a mile and a half.

EASTPORT INTERNATIONAL PHOTOS

PHOTO ILLUSTRATION BY ADOLPHE BROTHMAN; CSIRO PHOTO

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Retailers may redeem coupon at face value plus B* handling and actual postage costs incurred if coupon is redeemed in strict accordance with The American Tobacco Company coupon terms, incorporated herein by reference. Copy available upon request. Cash value 1/20th of 1¢. Mail to: The American Tobacco Company, P.O. Box 880027, El Paso, TX 88588-0027.

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Signature (required) _____

By signing this I certify that I am 21 years of age, a smoker, and that I wish to receive news about future offers from Bull Durham. Offer expires 3/31/92.

Smart Space Hand

HOUSTON, TX—A robotic grasper that uses its own reflection to steer toward payloads is the heart of a new docking system that won its designer NASA's Inventor of the Year award.

The Targeting and Alignment Reflective Concept, or TRAC, uses three pieces of hardware: a TV camera in the Shuttle arm's end effector, a payload-mounted mirrored target and an operator's monitor. The target and the end effector are both marked with crosshairs. The operator uses the TV camera and monitor to view the target. As the end effector approaches the target, the operator sees its reflection in the

target's mirror. The astronaut then uses two joysticks to turn the end effector until the crosshairs on the target line up with the reflection of the end effector's crosshairs in the mirror. When the end effector and target are perfectly aligned, four magnetic plates on each surface lock together.

Much faster and easier than the current mechanical docking hardware, the TRAC system promises to take the tedium out of repetitive space chores. Astronauts ran the system through its paces on a recent mission aboard the Shuttle *Discovery*. Future refinements include replacing the crosshairs with mirrored corner cubes that line up with light-emitting diodes.



Johnson's Leo Munford and development team with TRAC test hardware.



- GRAPPLE FIXTURE
- ADAPTER
- RIGHT-ANGLE CAMERA
- EVA HANDLE
- MAGNETIC END EFFECTOR
- ALIGNMENT PIN
- AUXILIARY LIGHT
- CENTERLINE CAMERA
- MAGNET POLE
- MIRROR

PH ILLUSTRATION BY MAURO FERRO; NASA PHOTO

The Chunnel Chills Out

FOLKESTONE, ENGLAND—The tunnel system connecting England and France is nearly complete. One by one, the 600-ft.-long tunnel-boring machines have fallen silent. Their final mission: to dig their own graves. The huge mechanical moles are churning downward below the sides of the tunnels, where they'll be buried forever, entombed in concrete.

The next step will be to fit the two big tunnels with rail track—and, surprisingly, to air condition the entire 32-mile system. Engineers concluded three years ago that trains racing at 100 mph through the tight tunnels will whip air temperatures up to 130° F. Not only would such heat steam passengers, it could buckle the rails.



Channel tunnel's boring machines (top and bottom), more than 600 ft. long, are burying themselves. Monster compressor (right) is heart of cooling system. Engineers expect to have the job finished by mid-1993.



first passes through fan-driven cooling towers, then goes into eight centrifugal chillers, four at either end of the Chunnel. Driven by a compressor-motor combo the size of a VW Beetle, a Chunnel chiller consists of two 30-ft. cylinders lined with copper pipes through which refrigerant cycles. During the winter, the water will circulate through the cooling towers but bypass the chillers, saving electricity.

The solution: the world's most expensive air conditioner, a unique \$200-million system developed by York International. Chilled water will flow through 300 miles of 24-in. piping. It'll take 7 hours to circulate through the whole system.

Tunnel-warmed water

Having progressed quickly in the final stages of boring, engineers have regained confidence that the Chunnel will be ready for its scheduled June 1993 opening.



YORK INTERNATIONAL PHOTOS

LONDON PICTURES SERVICE PHOTO



Up until now, there was a flaw in power tape design that no one else could put their finger on. The lock button was in an awkward spot.

So we decided to use the human hand as our blueprint and design a power tape that was comfortable as well as functional. With the lock

button on top where your thumb says it should be. And a triple-riveted end hook and bumper system that's virtually indestructible.

With a design concept this intelligent, it's only a matter of time before other tapes follow Lufkin's rules.

Lufkin
CooperTools

This is the button that
started a revolution
in power tape design.





Surrogate Teleoperated Vehicle deploys day and night cameras, microphones, infrared sensor and laser designators on a 15-ft. scissor-lift mast.

Battle Robot Drives Itself

HAMPSTEAD, MD—The Army and Marines will soon test 14 unmanned vehicles in an effort to develop a remote-control reconnaissance platform.

Called the Surrogate Teleoperated Vehicle, or STV, the 6-wheeler is the product of Robotic Systems Technology. The STV operator can drive the vehicle anywhere, then pop out and send the robot ahead, using

a 6-mile fiberoptic cable for control and communication. Normally, a 25-hp diesel engine propels the vehicle, but a 3-hp electric motor can take over for stealth purposes.

STV's surveillance and target-acquisition sensors ride on a 15-ft. scissor-lift mast.

Evaluators will use the vehicle to define requirements for production models.



Early-Warning Car Radar

DEARBORN, MI—Researchers at Ford are developing an all-weather radar that would warn drivers of obstacles obscured by rain or fog.

A saucer-size antenna, operating at high-resolution millime-

ter wavelengths, would fit behind the grille. Processors convert the signals to a head-up display on the windshield.

Ford says the radar system could ship as an option on cars and trucks by the year 2000.

Radar bounces off road obstacles and cats'-eyes in lane markers to feed head-up display.

Freight Ferry To Freedom

WASHINGTON, D.C.—A key mission for the advanced rockets that NASA wants to build would be to ferry tons of supplies to Space Station *Freedom*. Aerospace companies are already sketching designs for cargo vehicles that would ride the big rockets into orbit, then steer themselves to berth at the Station.

For example, McDonnell Douglas proposes adapting its Delta Star SDI-test platform for the job. Engineers envision a payload module that's equipped with a kick-stage motor and docking thrusters to bring it to the Space Station. After the Station's robotic arm unloads the vehicle, the Shuttle would bring the empty shell to Earth for refurbishment. Lockheed, Martin Marietta, Rocketdyne, Boeing and Orbital Sciences are also working on proposals.

NASA is currently reviewing the proposals, trusting that the cargo



carrier's booster, basically a Shuttle fuel tank powered by modified Shuttle main engines, can fly by 1999.

Cargo vehicle uses kick motor to free itself from spent launcher, then thrusts toward Space Station. Booster is based on Shuttle.

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Shouldn't you find out more about ROTC? Call 1-800-USA-ROTC. Or contact your local University Professor of Military Science. It's your move.



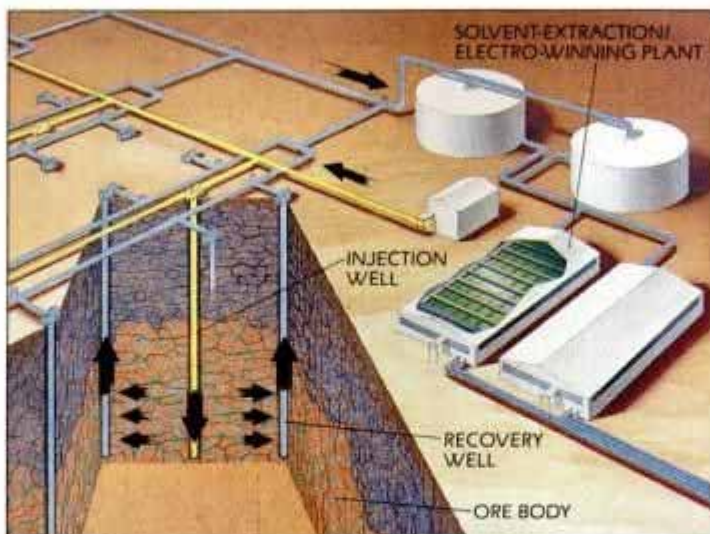
ARMY ROTC

THE SMARTEST COLLEGE
COURSE YOU CAN TAKE.

Mine Without The Pits

CASA GRANDE, AZ—The copper industry faces three challenges: extracting ore cheaply from small or low-grade deposits, boosting miner safety and minimizing environmental damage. Now, a technology called in-situ leach mining may solve all three problems, because it involves none of the capital costs and hazards of open-pit mining.

An in-situ mine consists of injection wells, which pump a dilute solution of sulfuric acid into the ground, and recov-



In-situ leach mine consists of well field, with injection and recovery wells in 5-spot patterns. Recovery plant plates out copper.

ery wells. The acid percolates through veins in the rock, which contain ore deposits of copper oxide.

The metal dissolves in the acid as copper sulfide, and the solution is then drawn to the surface via recovery wells. At a recovery plant, the copper gets plated onto cathodes in a process known as electro-winning. Ideally, the solution can then return to the well field with minimal treatment.

The Bureau of Mines and two mining companies plan to test the technology in Arizona, once they convince environmental officials the acid won't taint groundwater.

PM ILLUSTRATION BY ADOLPH E. BROTHMAN

Missile Versus Missile: SDI Scales Down To Guard Theater

HUNTSVILLE, AL—The Army's convinced that short-range theater ballistic missiles represent a threat that even upgraded Patriots can't counter alone. At Congress's behest, the Strategic Defense Initiative Office has stepped in. SDI is developing a 2-layered missile-defense system to protect American

forces and civilians abroad. The top tier of the protective umbrella would belong to THAAD, or theater high-altitude area defense, missiles. Like the Israeli Arrow missiles, these weapons would slam into their targets as far as 125 miles from the protected assets and as high as 95 miles above sea level. The al-

titude would theoretically allow any chemical agents to disperse harmlessly.

Ground-based, fire-control radar would track incoming missiles and assess impact, ordering a second shot if necessary. The missiles would probably use infrared seekers during the final run on their targets. The system must be transportable via C-130, according to SDI's baseline concept. Three contractors are contending for a single fast-track demonstration/validation contract, sped up so that a deploy-

able prototype system is ready in 1994.

Should missiles leak through the THAAD zone, ERINT, the extended-range interceptor, would go to work. The 15-ft. missiles would fly out of Patriot launchers adapted to hold 16 ERINTs. Nestled behind an ERINT's nose cone, 180 tiny rocket motors would fire to steer the missile at its target. Range is somewhere between the Patriot and the THAAD. LTV is developing the system, and will begin testing in 1992.



Two-tiered theater missile defense system starts with high-altitude THAAD interceptors (left). To pick off what THAAD misses, fire-and-forget ERINTs (right) blast from Patriot launchers.

MCDONNELL DOLUGLAS ILLUSTRATION

U.S. ARMY ILLUSTRATION

Quality is Job 1.SM

"When I see one of our freshly painted cars, I feel it's a piece of art."

Larry Dickinson, Paint Supervisor,
Ford Employee for 23 years.

Profile in Quality #27: Pride

The finish that Larry Dickinson's team puts on our cars is a true reflection of the quality we build into our cars.

Larry is one of over 366,000 Ford people worldwide who are committed to making quality Job 1.

Our goal is to build the highest quality cars and trucks in the world.



Ford Motor Company

FORD, MERCURY, LINCOLN, FORD TRUCKS

Buckle up — Together we can save lives.

Always insist on genuine Ford Motor Company collision repair parts.



GOODYEAR INVICTA GS. BASED ON A SIMPLE BUT PROVEN HYDRAULIC PRINCIPLE.



Wet or dry, this is all that touches the road: the contact patch.

No one likes to drive in the rain. Which is why Goodyear has devoted so many years, and many millions of miles, to the science of wet weather traction.

It's this unequalled knowledge that has led to Goodyear's development of the Invicta all-season family of

passenger car tires.

Invicta radials have already found favor with some of the toughest tire critics in the world: the engineers in charge of developing cars like the Lexus LS400 and the Buick Park Avenue Ultra.



The wet-weather technology that goes into Goodyear's 185+ mph Formula One rain tire also goes into the Invicta GS.

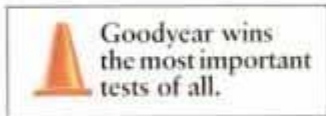


Chrysler Town & Country



Toyota Camry V6

You'll find Invicta radials on some of the best vehicles available in America. One of the reasons they were selected is their wet weather capability.



Goodyear wins the most important tests of all.

Invicta radials were chosen as original equipment for these cars after rigorous comparison with other makes of tires. For things like treadwear,

noise. And wet traction.

No one likes to drive in the rain. But you'll find it's when it rains that the Invicta GS really shines.



GOODYEAR

THE BEST TIRES IN THE WORLD HAVE GOODYEAR WRITTEN ALL OVER THEM.



NEW AGE EVs

EVs—electric vehicles—may help address environmental problems. But they pose problems of their own.

BY HERB SHULDINER

● “This is without a doubt many times greater in terms of technical change than anything that’s ever happened in the automotive industry,” says John R. Wallace, director of Ford’s electric vehicle program. “It’s like lifting up the hood ornament and sliding a new vehicle in underneath.”

Wallace was referring to the heroic engineering efforts now underway by auto companies to produce modern electric vehicles in time to meet a California-mandated deadline of 1998. That’s when any automaker with sales of more than 5000 cars annually in the Golden State must sell at least 2% of its fleet in zero-emissions vehicles.

The California laws will launch new generations of low-emissions and very-low-emissions cars that will probably burn methanol or compressed natural gas to meet the new restrictive limits on tailpipe emissions. But there are no alternate fuels other than hydrogen and electricity that can currently meet the most restrictive

zero-emissions part of the code. Hydrogen power for cars is still decades away, so automakers are focusing on electric vehicles to meet the California laws.

The revolutionary legislation is aimed primarily at improving Southern California’s air quality. But the benefits could improve the air that more than half of us breathe. Large numbers of EVs could also help slash oil imports. According to the Electric Power Research Institute (EPRI),

every EV represents a possible savings of 10 to 20 barrels of oil annually, and the Environmental Protection Agency is prepared to award Corporate Average Fuel Economy ratings of 120 miles per gallon to cars powered exclusively by electricity.

Cars and trucks devour about 63% of the 17 million barrels of oil the U.S. consumes daily, while less than 5% of our electricity is generated from oil.

At least 40,000 EVs are expected to roll onto California roads from 1998 on—and up to 200,000 more annually from the year 2003. And there could be many more EVs nationally as other states enact similar emissions requirements.

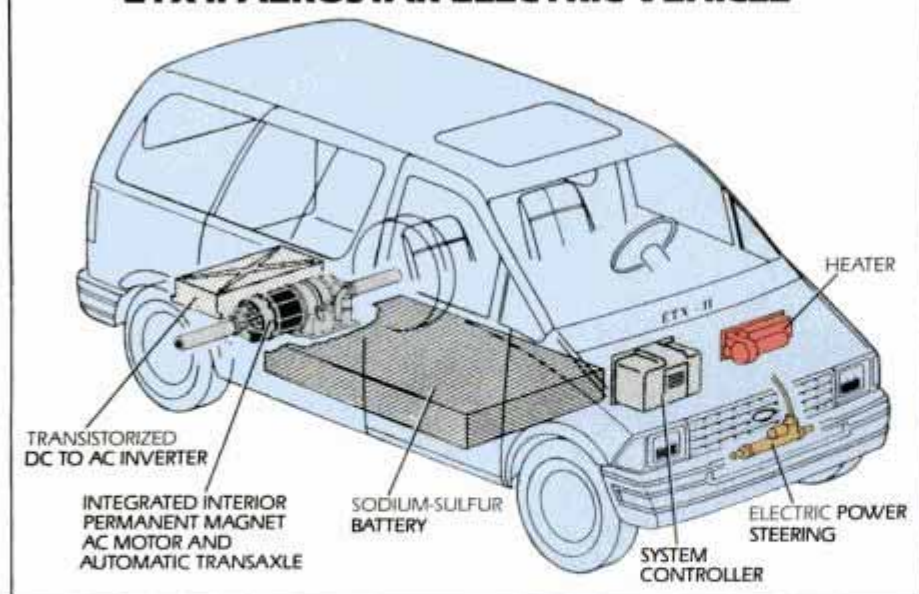
Where will the EVs come from and more importantly, where will EV builders get batteries with enough energy density to give the vehicles practical performance and range?

U.S. car builders say they won’t be able to market the kind of EVs Peugeot and Fiat now sell in Europe—conversions of



GM’s HX-3 concept car has a small gasoline engine, driving a large alternator to charge its battery pack. It can run in either hybrid gas-electric mode or as a pure electric when necessary.

ETX-II AEROSTAR ELECTRIC VEHICLE



Electric conversions of present-day vans require the least reengineering for production.

conventional cars and vans, with severely limited range and inadequate performance. Lead-acid batteries in these EVs provide up to 75 miles of 30-mph cruising. Stop-and-go city driving and higher speeds sharply diminish even that limited range. Even optional nickel-cadmium batteries don't extend range much.

"The battery is the key question," says Gary Purcell, of EPRI. But the investment needed to create an appropriate EV battery promises to be staggering, particularly for one company. That's why Chrysler, Ford and GM created the U.S. Advanced Battery Consortium (USABC) to jumpstart research and development of advanced EV batteries. USABC hopes to raise up to \$100 million annually for battery R&D with some help from EPRI, which is funded by 660 of the nation's electric utilities. The Department of Energy is also expected to contribute.

Worldwide programs

However, virtually all the world's leading car companies are expediting electric car programs without waiting for the ideal EV battery to be invented. In Japan, there are already a few electric vehicles in use on the highways, and most Japanese car companies are developing EVs because of government prodding.

Toyota converted one of its Town Ace vans to run on batteries last spring. Mitsubishi announced in May that it would build a new EV with a range of 125 miles. Nissan is hard at work on a new superfast charging system for batteries which will be included in an EV prototype it plans to exhibit at the Tokyo Motor Show this

fall. Isuzu recently built a battery-powered 2-ton truck for testing. And Daihatsu, like Fiat and Peugeot, is actually marketing small EVs for road use.

In Germany, Volkswagen has sold 60 Jetta EVs—at \$40,000 each—and has orders for 500 more. Mercedes is testing six NiCad-powered 190s. BMW has built 10 battery-powered 320s.

The EV projects of Detroit's Big Three are shifting into high gear, too. Though Chrysler won't do an all-new dedicated EV for 1998, according to Bob Davis, the company's manager of EV development, it will probably offer a battery-powered version of its minivan, called the TEVan. Chrysler is collaborating with EPRI on building the van, which is designed to run on 30 nickel-iron batteries, weighing 1800 pounds.

Submarine batteries

Nickel-iron batteries originated in Thomas Edison's day, but have never been mass produced. U.S. submarines formerly used nickel-iron batteries, and they are still used by the Soviet navy. The most significant drawback of nickel-iron batteries is that they produce hydrogen gas, which is potentially explosive if not well ventilated.

Chrysler's Davis says nickel-iron batteries have greater energy density and provide about 50% more cruising range than lead-acid cells. Also, the batteries are expected to last for the life of the vehicle—about 100,000 miles. The TEVan has a range of 118 miles, Davis claims. The vehicle also has a top speed of 65 mph and can accelerate from 0 to 50 mph in 14 seconds, according to Davis.

Ford focus

Ford is also focusing EV development on vans. Its latest EV is a converted Aerostar, called ETX-II and produced in collaboration with GE, which supplied the motors and power electronics. The ETX-II is powered by sodium-sulfur batteries that provide about three times the range of lead-acid batteries of the same weight. However, the drawback is that sodium-sulfur batteries must be maintained at extremely high temperatures (around 600° F) to create electricity.

Normal driving and charging activities will keep the batteries at that temperature. But you can't put sodium-sulfur batteries in a car you plan to park at the airport for a week. The batteries can be kept warm with an internal heater for only three days. Beyond that, the battery would cool down, the salts inside would harden, and the chemical reaction that pro-

Hybrids—EV Range-Extenders

● Hybrid electric vehicles use small gasoline or diesel engines that power generators to recharge battery packs while the car is cruising. Ford, GM, Volkswagen and other manufacturers are experimenting with the concept, which looks like an effective bridge between internal combustion and pure electric power—with one drawback: It doesn't quite satisfy the California zero-emissions regulation. The generator engines have minimal exhaust emissions.

GM's hybrid HX3 concept vehicle uses a 906cc sohc 3-cylinder gasoline engine to drive a large alternator that recharges 32 10-volt lead-acid batteries. The batteries power two 60-hp AC-induction electric motors that drive the front wheels. When the engine is shut down, the HX3 is actually a zero-emissions vehicle. When the batteries start to run low, the driver can switch

on the engine to start recharging the batteries. The system gives the HX3 a cruising range comparable to a conventional minivan. Another benefit of such a system is that the engine could be used to operate a conventional heating system. It could also serve as a stationary auxiliary generator for home use.

Ford plans to hybridize some of the electric Escort vans due for European testing next year, and it projects a range of 250 miles. VW is testing a Golf Diesel hybrid. For city driving, the car uses only its electric motor. Out of town, the car can be switched to use diesel power to drive the front wheels. The diesel is designed to kick in automatically when speeds exceed 31 miles per hour. VW plans extensive testing of 50 of these hybrids in Switzerland and Germany. —H.S.

duces electricity would stop.

Because of the high temperature, the active sodium-sulfur cell is housed in a double-walled vacuum chamber that's highly impact-resistant. Sulfur is extremely corrosive at high temperatures, so it's important to keep it contained in a crash. To test their crash resistance, Ford says, sodium-sulfur batteries have been dropped from buildings, shot with bullets and even roasted with flames. The sodium-sulfur batteries are expected to last three to four years in an EV.

In its next EV program, Ford will build 100 sodium-sulfur European Escort vans next year for field testing in the United States and Europe. The electric Escort will have a top speed of 70 mph and a range of 100 miles.

AC versus DC

Unlike Chrysler, which has decided to use bigger and more expensive DC motors in its EVs, Ford uses GE's small AC motors. AC motors are cheaper because they're currently made in a much larger quantity.

Then why did Chrysler choose a more expensive motor? The power electronics that mate with DC motors are substantially cheaper at this time, Chrysler's Davis points out. However, he admits that prices for these same components for AC motors are declining.

GM is also testing electric vans. Its GMC vans are being converted to battery power by Magna International's Vehma subsidiary. Magna International is Canada's largest supplier of components to the auto industry. Vehma plans to sell about 100 electric G-Vans with motors and lead-acid batteries supplied by Chloride EV Systems of Great Britain. The electric G-Van has a 2600-pound battery pack that gives the vehicle a cruising range of about 55 miles, according to Frank Fontana, of Consolidated Edison in New York City. ConEd has purchased five of these electric vans for long-term field testing.

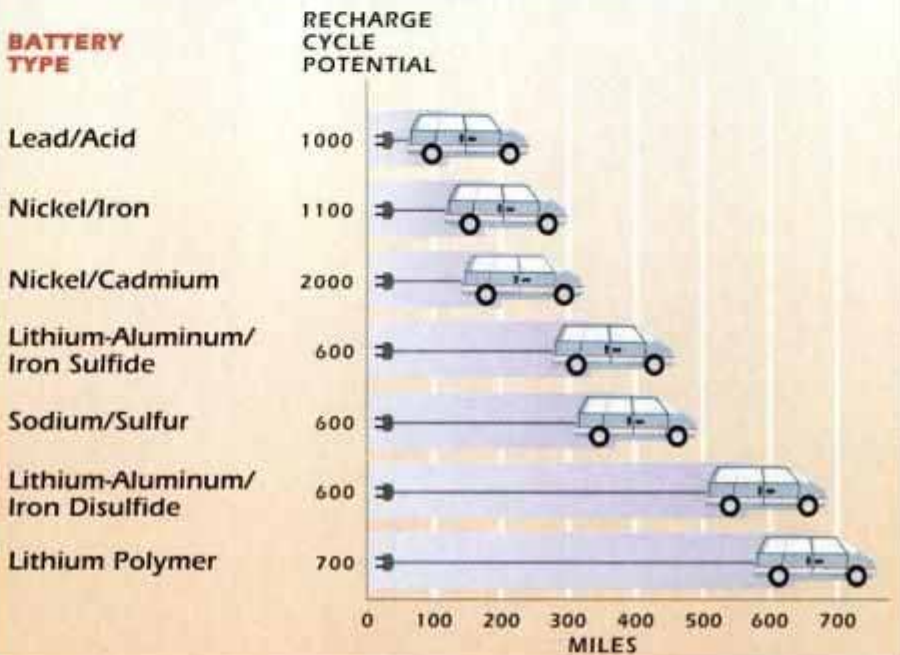
Fontana uses one of the G-Vans to commute about 33 miles to work. He says he makes it easily, but the vehicle must be recharged all day for his return trip.

I had an opportunity to take a short test drive in the battery-powered G-Van, along with PM Associate Automotive Editor Mike Allen. It was not the quiet experience we had expected. There is a peculiar windup noise as you accelerate and a wind-down noise under braking. The noises are caused by the



GM's Impact concept car uses conventional lead-acid battery technology.

BATTERY POWER AND RANGE



Newer, exotic battery types under development promise much-improved range.

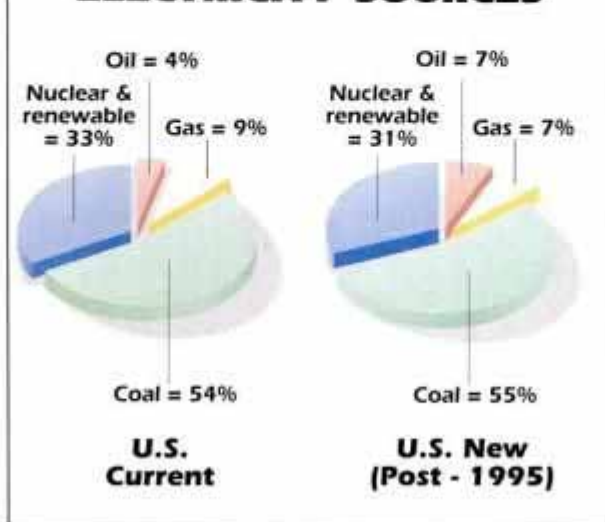
gears, according to Jim Chesney, a Vehma engineer, who says the company is working to eliminate the problem. But aside from the slow acceleration, driving the G-Van wasn't significantly different from driving a conventional vehicle.

Early last year, Roger Smith, then chairman of General Motors, unveiled a sleek prototype that he claimed was the first EV to perform as well as cars with internal combustion engines. The aerodynamic EV, with the unfortunate name of Impact, has a coefficient of drag of 0.19. No production car has yet achieved a Cd of less than 0.25. Impact's two 57-hp AC motors give it a top speed of 100 mph, but a governor limits its speed to 75 mph, GM says. The Impact can also accelerate from 0 to 60 mph in 8 seconds—faster than the sporty Mazda Miata—and cruise up to 125 miles on a single charge, according to General Motors.

What GM didn't say, however, is that in order to achieve the 125-mile cruising range, the Impact would have to deplete the entire charge in its 32 Delco lead-acid batteries. Even advanced deep-discharge lead-acid batteries, such as those used in electric forklifts or golf

(Please turn to page 102)

ELECTRICITY SOURCES



Electrical generation will continue to use little oil or gas.

AUTOMOBILES



PM's NiCad-powered Aries gets a quick recharge in the pits. Crew chief Lon Gillas and the author check batteries, stowed in engine compartment, back seat and trunk.



BATTERY CHARGERS

We go on-track in the first race for electric cars.

BY MIKE ALLEN, Associate Auto Editor; PM Photos by Ron Hussey

● The starter waves the green flag. As the pack of race cars accelerates across the start/finish line and into the first turn, the crowd roars to its feet.

Yes—the crowd noise is audible because this is the start of the first Solar and Electric 500. The entire field of 14 electric-powered cars makes about as much noise as a refrigerator.

The POPULAR MECHANICS entry was built and crewed by the guys from Pacific West Supply, a hazardous waste disposal firm from Oregon. Some of the hazardous waste they dispose of is nickel-cadmium batteries, used for standby power supplies and

aircraft starter motors. And for many of them, with a change of electrolyte, a recharge, they're like new.

Our unlikely looking race car, a 1981 Aries, carried enough NiCads to make a 120-volt, 220 amp-hour battery pack, worth about \$60,000 new. Motivation was supplied by a 30-hp General Electric DC motor bolted directly to a 4-speed transaxle, driving through the stock clutch. Weighing in at about 3900 pounds, the Aries rode on BF Goodrich Comp T/A tires.

Most of the competition were powered by lead-acid golf cart batteries, with barely enough battery ca-

capacity to make the 200-km (120-mile) race distance.

Certainly the most ambitious effort was the Honda CRX sitting on the pole. Sponsored by the Arizona Public Service Commission and built by battery-maker DEMI, it used experimental zinc-air batteries.

The PM effort made good practice times—more than 60 mph around the banked 1-mile oval at Phoenix. Only the Honda was faster. But a loose battery connection, followed by a partial battery meltdown, cost us a decent grid position. We qualified on the outside of the sixth row.

The DEMI Honda was scheduled to go the distance on its zinc-airs. We planned to run flat-out for 150 km and then stop for a battery charge.



This battery meltdown was caused by a loose connection. VW engine bay shows electric motor bolted to stock transaxle, a common electric-car conversion.

Photocell Flyers

● The other half of the weekend's activities was a 300-kilometer (180-mile) race for solar-powered vehicles, staged during the early afternoon hours on two consecutive days.

With the Sun at its zenith, the solar cars were at their best. Fastest qualifier was the Virginia Tech entry, but the race went to the super-high-tech Swatch Watch entry, imported from Europe specifically for this event.

Swathed in photocells, the ultralight solar racers use only small batteries for acceleration. Electric motors used to power them were rated at only 1 or 2 horsepower, and looked more suitable for electric clocks than a 20-ft. car. Riding on bicycle tires, the fastest managed to lap the track at speeds approaching 60 mph, enough to generate g-loading on the skinny little tires, which were never intended for such abuse. In fact, the MIT entry, while attempting a pass of the Swatch car late in the



Swatch Watch entry came from Europe to win solar-car race.

first day's laps, blew a tire in turn one, ending its chances for a win.

Days of Thunder it wasn't. It was eerie watching these cars circulating the track in near silence. With super-low-drag bodywork, there was no sound at all until they went past. Then all you could hear was the swishing of the tires on the pavement.

I saw at least one entry wearing a Michigan license plate. But the time when a solar-powered car is a viable vehicle for commuting is still a long way off.

—M.A.

It's possible to recharge a NiCad battery rapidly—just 5 or 6 minutes to about half charge, if you can get the current flowing. Pacific West brought enough extra NiCads to build a 240-volt battery pack in the pit. Putting this pack in parallel with the smaller pack in the car would do the job. We expected charging rates in excess of 2000 amps, so the cables were hefty.

Starting from the back of the pack, we were in first place by the end of the first lap, pulling gloriously away from the rest of the field—for 30 laps or so.

But it wasn't to last. Unbeknownst to the crew, a battery charger malfunction the evening before had left us with only a partial charge. We pitted with the NiCads on their last legs a good 60 laps early, while the Honda motored around to win.

As a racing experience, it was not, well, electrifying. But this is where the world is headed—and we're already working on next year's entry.

FM

“AT GM, WE’RE GETTING HIGH MARKS IN QUALITY FROM THE PEOPLE WE CARE ABOUT MOST.”

Our customers are the people we care about most.

So it’s very gratifying to learn that after thousands of miles of driving, 95% of our newest customers would recommend a Chevrolet, Pontiac, Oldsmobile, Buick, Cadillac or GMC



Truck to a friend.¹

Since satisfying our customers is GM’s very

definition of quality, we take this as a sure sign we’re delivering it.

QUALITY PAYS

We’ve learned over the years that the more quality we deliver to our customers, the more satisfied they become.

That’s borne out by the results of our national customer satisfaction study.

In the past six years, as we introduced more and more new cars and trucks redesigned and engineered for quality, our customer satisfaction

Electrical systems. Braking systems. Emission controls.

And we don’t ever plan to stop, because the heart of quality is

Today, 95% of our new owners would recommend a GM car or truck to a friend.

steadily increased.

Today, GM has 99 new redesigned and engineered models.

That’s more than 80% of our cars and 50% of our trucks. No wonder our customer satisfaction ratings are now the highest in our history.

And this year, we’ll bring out more new models than Ford, Chrysler and Toyota combined.

That’s not just new looks.

That’s new substance.

Quality from the inside out.

In engines. Transmissions.

continuous improvement.

ENGINES YOU CAN COUNT ON

Our 3800 V-6 engine balances power, emission control and fuel economy with technological advances such as counter-rotating balanced shafts, electronic engine controls and sequential-port fuel injection.

Result: No U.S. carmaker builds better six-cylinder engines than the 3800 V-6 offered in many popular Pontiac, Oldsmobile and Buick models.¹

The 4.9-liter V-8 engine in

Cadillac is unsurpassed in customer satisfaction compared with any European or domestic luxury nameplate.¹

CLEANER AIR

Today, it's not good enough to build strong performing engines that are reliable and dependable.

Today, they must also be *clean*.



EVERYONE AT GM IS WORKING TOGETHER TO PUT QUALITY ON THE ROAD

GM continues to work vigorously to minimize emissions in all of our vehicles.

So it's not surprising that GM has the lowest average emissions of all American carmakers.²

In fact, it takes twenty-five 1991 GM models to produce the same amount of emissions as it took *one* model to produce 21 years ago.

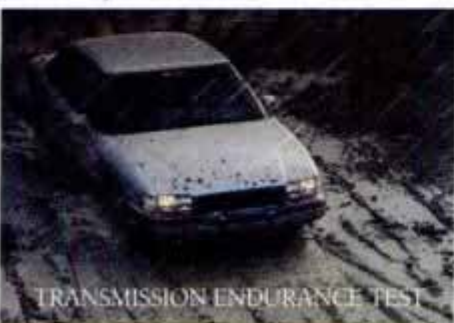
In air quality, it's clear, GM has come of age.

TRANSMISSIONS: TOUGH, SMART AND SMOOTH

If you have to think about your transmission, something's wrong.

With GM's automatic transmissions, there's little to think about. Millions of drivers have found them to be of better quality and more trouble-free than all domestics and many imports, such as Honda and Mazda.¹

And GM's state-of-the-art electronically controlled transmissions



TRANSMISSION ENDURANCE TEST

have proven to be just as smooth after 100,000 miles of grueling taxi-fleet testing as when they were new.

These electronic wizards monitor a dozen different car and atmospheric conditions to perform quick, smooth shifts with maximum efficiency and utmost reliability—whether you're driving up snow-packed peaks or

through heat-baked deserts.

A SURE START

The first sign of quality is a sure start. As thousands of tests have proved, our starting power is 99.9% sure every time you turn the key on your new GM car.

So it doesn't matter if you're in Maine or Mexico, in January or June, your new GM car or truck *will* start.

A SAFE STOP

We are the only U.S. carmaker to design, test and manufacture brakes.

We design and test brakes to high standards for lining wear and fade-resistance.

As a result, owners of 1991 GM cars report fewer problems with their brakes than owners of Ford, Chrysler, Nissan, Mazda or Volvo.¹

And GM offers more cars and trucks with anti-lock brakes as standard equipment than any other manufacturer in the world.

ALL PICKUPS: REAR ANTI-LOCK BRAKES

Today, GM offers an Anti-lock Braking System on all new pickups.

In panic stops, this patented GM system modulates the braking action to stop you faster and help prevent your pickup from skidding out of control—even when unloaded.

It's another reason why no American full-size pickup truck is more problem-free than full-size pickups from GMC Truck.

VALUE DOWN THE ROAD

Today, you're probably planning to keep your car or truck longer than you did in the past.

That makes long-term reliability and dependability more important to you than ever.

According to thousands of consumers, no U.S. carmaker has built more dependable cars over the past five years than GM.¹

In addition, the cars and trucks built by General Motors have kept more of their original value, on average, than cars and trucks made by any other U.S. maker.³

WE CARE ABOUT YOU

Today, there's a new commitment to quality in everything we do at GM. It's a genuine caring for you and a spirit of teamwork that pervades our



TRUCK DURABILITY TEST

company—from the people who design our cars and trucks to the people who build them.

We invite you to see for yourself at a Chevrolet,

Pontiac, Oldsmobile, Buick, Cadillac or GMC Truck dealer.



1. 1991 GM Customer Satisfaction Survey.
2. Based on Mobile Exhaust Emissions Standards for passenger vehicles.
3. Based on National Automotive Research Black Book for ten most recent available calendar years.

Chevrolet, Pontiac, Oldsmobile, Buick, Cadillac and GMC Truck are trademarks of the General Motors Corporation.



PUTTING QUALITY ON THE ROAD

Chevrolet Pontiac Oldsmobile
Buick Cadillac GMC Truck

COVER STORY

CARRIER

Making an obsolete carrier ready for 21st-century combat is one of the most complex rebuilding jobs in history.

BY DAVID P. COLLEY

● In dry-dock, the enormous scale of the USS *Constellation* suddenly snaps into focus. From the scaffold-encased pilothouse, the 4.1-acre, 2-in.-thick steel flight deck stretches 600 ft. toward the bow. Four hundred ft. aft, the white "ladder line" stripe on the lead-gray, skid-resistant surface reveals the length of the angled landing deck. Empty of aircraft and cluttered with workshops and the materials of a major overhaul, the flight deck still exudes latent power.

Twelve stories below, the keel is no less awe inspiring. Fascinating in its flat massiveness, it is a sight seen only

First carrier to receive a SLEP overhaul, the 35-year-old USS *Saratoga* now supports some of the most modern weapons systems afloat.

PM PHOTO BY BRIAN R. WOLFF

REBORN

once every seven years. Nearly as long as the 1072-ft. flight deck and more than 200 ft. wide, the keel sits some 7 ft. above a dry-dock floor at the Philadelphia Naval Shipyard (PNSY), bearing the weight of 60,000 tons and slowly compressing the rows of concrete and oak docking blocks that keep the *Constellation* upright. In the shadow of its own girth and the overhanging flight deck, the keel exists in permanent gloom, salmon pink in its first prime coat.

Launched in Brooklyn, New York, in 1961, and second of the 4-vessel *Kitty Hawk* class, the USS *Constella-*

tion, CV 64, is here to undergo what the Navy calls a "SLEP," or service life extension program.

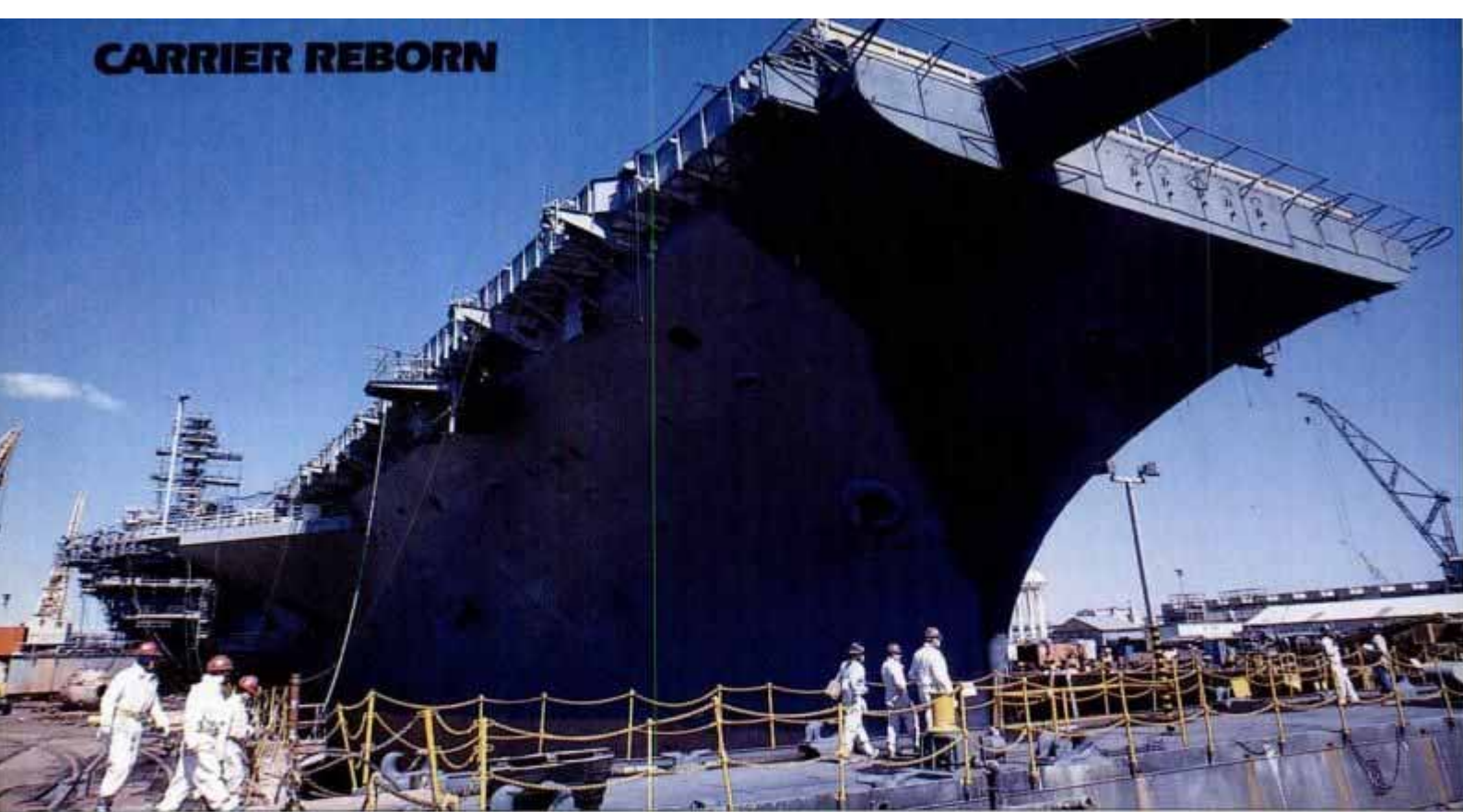
"Connie" was well past its prime in 1990 when it was nudged up the Delaware River to the shipyard some 3 miles from center-city Philadelphia. Big as it was at 88,000 tons (combat load) and 17 stories from keel to masthead, the ship had been battered by waves and eaten by corrosion. The equipment in its CIC system—Combat Information Center—was primitive and slow. After more than a quarter-century in the Pacific, including seven combat tours off Vietnam, its

catapults and arresting gear showed the scars of hundreds of thousands of launches and recoveries. Its propulsion system was anemic and inefficient, and its hull needed repairs. Its electrical system was unbalanced, with miles of once-functional electrical cable now leading nowhere.

SLEP or scrap

The Navy generally gives a carrier 30 years before scrapping or mothballing it. But the *Constellation* has been granted a reprieve. All the Navy's ships undergo periodic overhauls, but nothing as comprehensive as a SLEP;





in which the old ships are gutted and rebuilt from top to bottom.

The focus of the 3-year, \$725-million project—a fifth of the cost of a new carrier—covers repair of the hull and bulkheads, plus repair or replacement of piping systems, rotating machinery, the launch and recovery systems, the electrical distribution systems, weapons systems and electronics. When it's all over, the ship goes back to the fleet good for another 15 to 20 years, and almost as modern as the most recently commissioned carriers, such as the USS *Theodore Roosevelt* and the USS *Abraham Lincoln* (see "Show Of Force," page 49, March '90). In some cases, the equipment aboard the SLEP carriers is even closer to state of the art.

Constellation is the fifth carrier to be overhauled at PNSY, and a sixth, the USS *John F. Kennedy*, is tentatively scheduled to begin one in 1993, when the *Constellation* is completed. As a measure of the confidence the Navy places in its SLEP carriers, the USS *Independence*, rebuilt in the mid-1980s, was the first flattop to venture into the Persian Gulf before Operation Desert Storm.

Engineers involved in SLEP say that, next to developing vehicles for the space program, rebuilding an aircraft carrier is the most complex job in the world, and certainly the most intricate of shipbuilding tasks. Every

Uttering from the huge dry-dock at PNSY, the *Constellation* is the fifth carrier to be revitalized under the SLEP program.

compartment is a maze of wires, machinery, pipes and pumps that not only function to keep the ship afloat but allow it to fight a war. At sea, the *Constellation* is a small city with 5300 crew members. Just keeping the crew fed requires the ship's cooks to turn out 18,000 meals a day.

Constellation also is a floating elec-

tronic station. They began inspecting the ship during routine cruises. They poured over it to obtain data that was recorded and analyzed before rebuilding plans could move forward. At times, there were as many as 165 engineers aboard, talking with the crew, studying old plans and drafting new ones. By the time *Constellation* arrived at PNSY, the information was combined in an extensive workbook that spelled out every detail of the SLEP.

Almost before *Constellation* was dry, its hull was being visually scanned for areas of damage either from collision or corrosion. Workers test suspected areas with special hammers. Trained eyes and ears can determine whether a section of hull needs to be replaced or clad-welded. Connie's hull is dotted with splotches of past clad welds that show up like raised weaving on the smooth plates.

"The men doing the inspection have experience in the structural trades," says Bob Gorgone, a mechanical engineer and SLEP project director. "They take the hammer—designed something like a ball-peen hammer—and rap the hull. Sometimes it goes through. Sometimes the report is mushy, or the hammer leaves an impression in the corrosion."

Gorgone says that ultrasonic testing is also used to determine the thickness of hull plates. Technicians tap a probe around the suspect area and



Huge tools at PNSY's machine shop will refurbish the carrier's propeller shafts.

tronic station. It is an airport with 80 of the most sophisticated planes anywhere. And it is a powerplant with eight boilers that drive the ship, produce electricity and catapult 80,000-pound jets into the air at 170 miles an hour.

Damage report

Constellation's SLEP didn't begin at PNSY. Three years before, engi-



take readings from a monitor. Generally, a 25% reduction in hull thickness warrants repair. Hull plates vary in thickness, but average about three-quarters of an inch.

The hull is the ship's most prominent feature. But engineers are no less interested in ensuring that bilges, bulkheads and stiffeners are sound. For example, the steel decking beneath the boilers is removed and the bilge areas scanned for corrosion.

But the work goes far beyond replacement of damaged parts, extending into substantial new engineering on basic systems. One example is the system of list control tanks, which help maintain the carrier's balance. As planes fly on and off the deck, water is constantly moved among the tanks to keep the ship level. During a SLEP, weight is shifted and engineers must design so that the ship's balance is not disturbed.

Connie's cats

Reconstruction of the catapults may be the trickiest SLEP job. Subjected to tremendous forces, these powerful machines must be aligned to the finest tolerances, or they will self-destruct.

The newest feature of the rebuilt catapult systems are steam accumulators that replace the huge dry receivers, which had 4-in.-thick walls. One accumulator will do the work of three receivers, making available considerable workspace for other valuable functions just below the catapult areas. The accumulators will provide a constant flow of steam during each aircraft launch, whereas the receivers

Screws were removed to guard classified contours from prying eyes (above). Scarred bow (below) bears witness to years at sea.



gave only one blast that diminished as the plane reached the end of the catapult trough.

The added power will facilitate launching of heavier aircraft at higher speeds while reducing the wind-over-deck speed required during launch operations.

On our visit, Connie's cats were in various stages of repair. No. 4 waist catapult required extensive replacement of trough plates corroded by salt water, JP-5 jet fuel and AFFF fire-

fighting spray. It could have been worse, though. The bed on one of the USS *Forrestal's* catapults was so deteriorated that a workman's feet went through.

Once the catapults are rebuilt, engineers do a 3-dimensional laser realignment of the upper and lower support rails and the baseplate using shims as thin as $\frac{1}{5000}$ th of an inch. Realignment takes place at night when there are fewer vibrations and more constant temperatures.

To reign in the heavier aircraft launched by the upgraded cats, *Constellation's* old Mark 7, Mod 2 arresting engines have been replaced by the more powerful 50-ft., 43-ton Mark 7, Mod 3s—the same as those used on the Navy's newest carriers. Designed and built by the Navy's Air Engineering Center (NAEC) at Lakehurst, New Jersey, the arresting system is made up of four cables or "cross-deck pendants," that stretch across the angled flight deck to stop incoming aircraft. The cables, jettisoned into the sea after 100 recoveries, wind below the flight deck around a series of sheaves, or wheels, and attach to massive tubular hydraulic "engines."

While cable tension on the sheaves and new sheave dampers helps slow the aircraft, the main stopping force comes from the engine, which acts like a giant door closer. The engine's internal piston is slowed by the force of the surrounding hydraulic fluid. During landing operations, this hydraulic force is constantly adjusted to handle the different weights of incoming aircraft.

CARRIER REBORN



To line up the bolt holes on the big Mod 3s with those on the carrier deck, SLEP engineers used photogrammetry. In this process, high-precision cameras loaded with plate glass film shoot pictures of targets on the deck. The information is fed into a CAD system which correlates the bolt hole positions in three dimensions. When the new engines were lowered into place, the holes matched perfectly.

Even with the new engines, however, *Constellation's* angled deck was not long enough to safely accommodate the newer, heavier planes, so 8 ft. of flight deck will be added. Otherwise, F-14s that missed the initial three arresting cables and snared the last might drop over the side.

As a backup, the angled deck's two barricade stanchions were also rebuilt. These support a cross-deck net that will stop a plane that misses the cables.

The hunt for a blue hit

Possibly the most extensive job during the SLEP is reconditioning the ship's propulsion system. Forty-ft. x 40-ft. openings are cut through nearly every one of the *Constellation's* decks, from the hangar deck down to just above the keel. Then the four high-pressure (HP) and four low-pressure (LP) turbines, along with gears, generators and other major components, are lifted out. Many of the elements are sent to private contractors for reconditioning. Once returned, the parts are lowered into place and rebuilt for a "blue hit," or precision mesh. Connie's high-pressure turbines will be new, while the low-pressure turbines are being refurbished.

The eight boilers are rebuilt and rebricked. *Constellation's* four screws, each 21 ft. in diameter and weighing 22 tons, are removed and replaced by new ones, and sections of the four propeller shafts that need repair are re-

Island is clad in scaffolding (left), while removal of catapult receivers leaves new room belowdecks (right).

moved and refurbished.

The heart of any carrier in wartime is the CIC or Combat Information Center. When Connie arrived in Philadelphia, its CIC equipment was 1960s vintage, and its ability to locate, track and analyze sea and air threats was limited. The CIC has been stripped bare and will be re-equipped with the most sophisticated systems the Navy can provide.

As part of an upgraded Naval Tactical Data System (NTDS), the shipyard tears down much of the ship's electronics package and installs state-of-the-art equipment, including new radars, computers, and detection and jamming systems. To help cool all the hot, new equipment, more powerful

get new scopes, display terminals and digital converters to translate the analog waves from the radars and missile weapons systems. External communications systems also will be upgraded.

Most of the CIC's equipment is only as good as the radar that feeds data to it, so that too must be replaced. Carrier radar falls into three primary types: height finding, range and bearing; air search; and surface search. Connie's new radars will work faster, have greater range and operate more efficiently in all kinds of conditions.

Connecting all the electronics will be a rebalanced and partially new electrical system. More than 100 miles of armored electrical cable is being removed. Jacketed by a steel mesh to protect it in combat, the old wire weighs tons and removal will lighten Connie's load. The replacement cables are armored with a plasticlike material that produces little smoke in the event of a fire. The electrical distribution system will also be rebalanced so that Connie's switchboards carry more equal amperages. Gorgone notes that an old carrier is like an old house with some circuits carrying greater loads than others.

Constellation's SLEP complement of some 1800 officers and men are busy every day repairing and rebuilding the less-complex equipment such as pumps and valves and some simple electronics equipment. They also are responsible for reconditioning living quarters, painting and replacing furniture and fixtures.

Constellation is scheduled to be refloated in 1992 and will be ready for sea trials in 1993. Then it will set out to sea to determine if all systems are working properly. Normally, it takes several cruises to work out all the major kinks, but then the 64 will rejoin the fleet, ready to defend the United States until at least 2008. **PM**



Welder toils deep amid the tangled wires and pipes of the engine room.

air conditioners must be installed. New CIC computers, a quarter of the size of the old, will give the *Constellation* the ability to track hundreds of bogies at one time and analyze the threat potential at much faster speeds. Henry Heyser, director of PNSY's electronics systems division, says Connie's old tracking system was limited to analyzing about 20 bogies at one time. The CIC will also



THE ENFORCER

Glock's high-tech double-action, semiautomatic handgun has taken U.S. law enforcement by storm.

BY JOHN WOOLDRIDGE, Contributing Editor
PM Photos by Brian Kosoff

● The slide leaps forward to chamber the first round with a precise metallic snap. At the range officer's signal, you take aim and slip your finger inside the trigger guard. The Glock 17 is light and controllable in your hands, easy to point. White highlights on the front and rear sights line up quickly, and you squeeze off six quick rounds. Force of habit makes you think of the times you used to stop at this point and reload your old revolver. But now you continue to concentrate on the target and

fire 11 more rounds. After 17 shots, it's finally time to insert a fresh clip. The firepower is awesome.

The Glock 17 is a remarkable success story. With virtually no firearms experience, Gaston Glock, an Austrian mechanical engineer specializing in synthetic materials, produced the first working prototypes of the Glock 17 for the Austrian army, which was searching for a new 9mm sidearm that was lightweight, durable and equipped with a large-capacity magazine. In 1983, following rigorous testing and intense competition, the Glock 17 won the competition, and the Austrian army ordered 28,000 pistols. In 1984, after surpassing exist-

THE ENFORCER

ing NATO sidearms standards, the Norwegian army followed suit.

Before the decade was over and after a brief period of skepticism, Glock pistols became the issued or authorized sidearms for over 2700 U.S. federal, state and local law-enforcement agencies. Today, there are more than 300,000 in use nationwide. Achieving this kind of success was no accident. Nor was it easy.

Top gun

A few years ago, the Miami Police Department requested two Glock 17s to evaluate as potential duty weapons. With a primed casing in the firing chamber, a Glock 17 was hurled against steel and concrete walls, then repeatedly dropped 15 ft. to a cement walk, landing on all sides. Because of its revolutionary safeties, the firing pin never touched the primer.

Fully loaded with a live round in the chamber and 17 more in the clip, a Glock 17 was buried in beach sand, dug up and discharged 18 times. Fully loaded again, a Glock 17 was dropped into a bucket of seawater and left for 50 hours. It was retrieved, shaken dry and discharged 18 times.

According to the Miami Police Department, which subsequently purchased more than 1000 Glock 17s, the two test guns are still carried by instructors as duty weapons. Both have in excess of 50,000 rounds through



Cutaway shows first safety deactivated by touching trigger.

them without any breakdowns.

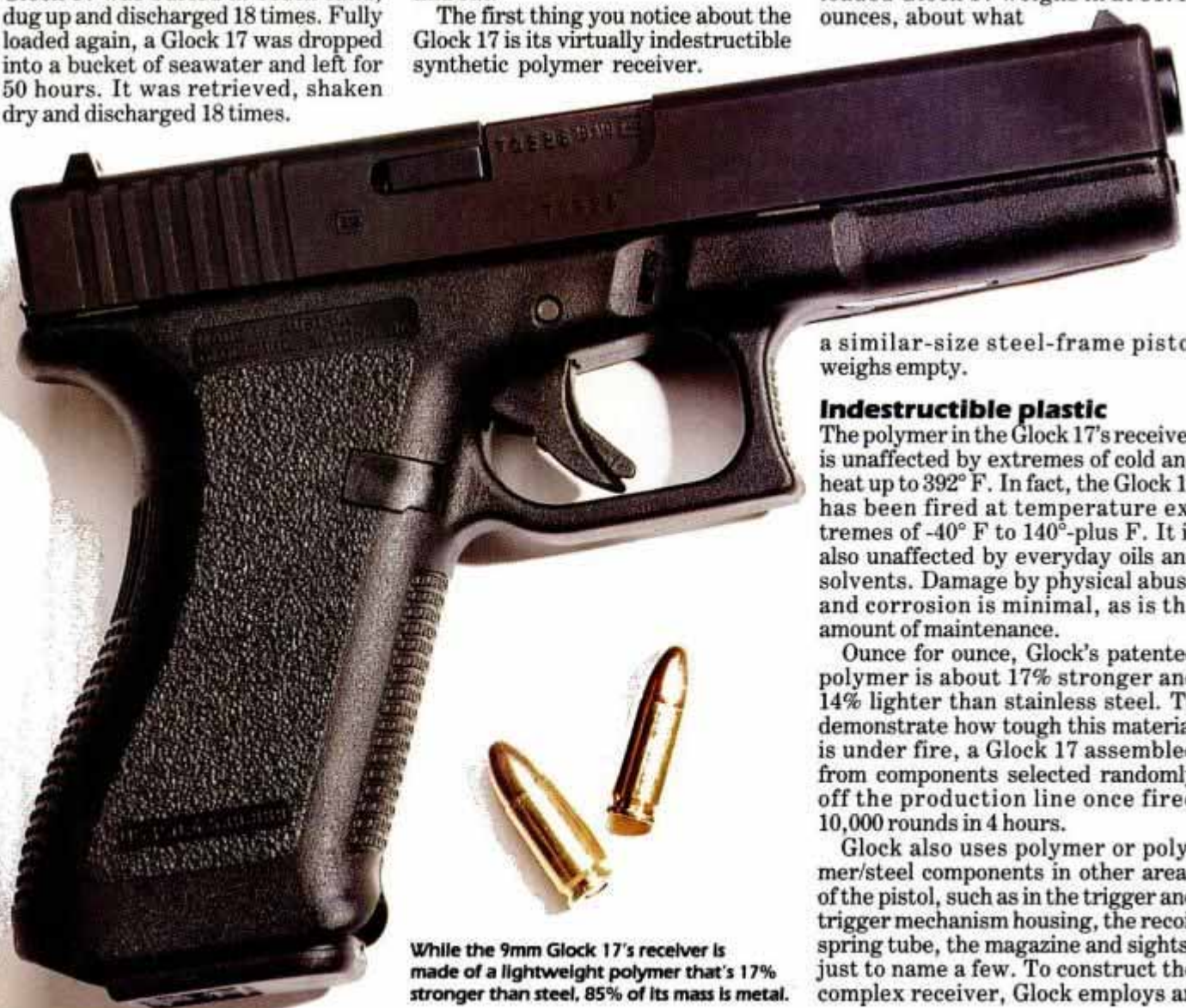
Aside from durability, what makes the Glock 17 the new top gun for law enforcement? We decided to go to a firing range in Smyrna, Georgia, to find out.

The first thing you notice about the Glock 17 is its virtually indestructible synthetic polymer receiver.

When it was first introduced in the U.S. in 1986, this component ignited a firestorm of controversy, which briefly hindered acceptance of the Glock as a viable law-enforcement pistol. The Glock 17 was described as an "all-plastic gun" that would "pass through metal detectors undetected," a claim that was proven untrue.

The Glock 17 isn't all high-tech plastic. In fact, 19 of its 24 ounces are metal, most of it in the massive steel slide. Overall, the Glock 17 is a hammerless, autoloading 9mm pistol that measures 7.21 in. long, 5.16 in. in height and 1.18 in. wide at the grips. These are roughly the same dimensions as the Colt M1911-A1 and most other standard-size pistols.

A double-column magazine accommodates 17 rounds that are stacked offset rather than in-line. There are *witness holes* on the back for a visual check of remaining rounds. A fully loaded Glock 17 weighs in at 31.41 ounces, about what



a similar-size steel-frame pistol weighs empty.

Indestructible plastic

The polymer in the Glock 17's receiver is unaffected by extremes of cold and heat up to 392° F. In fact, the Glock 17 has been fired at temperature extremes of -40° F to 140°-plus F. It is also unaffected by everyday oils and solvents. Damage by physical abuse and corrosion is minimal, as is the amount of maintenance.

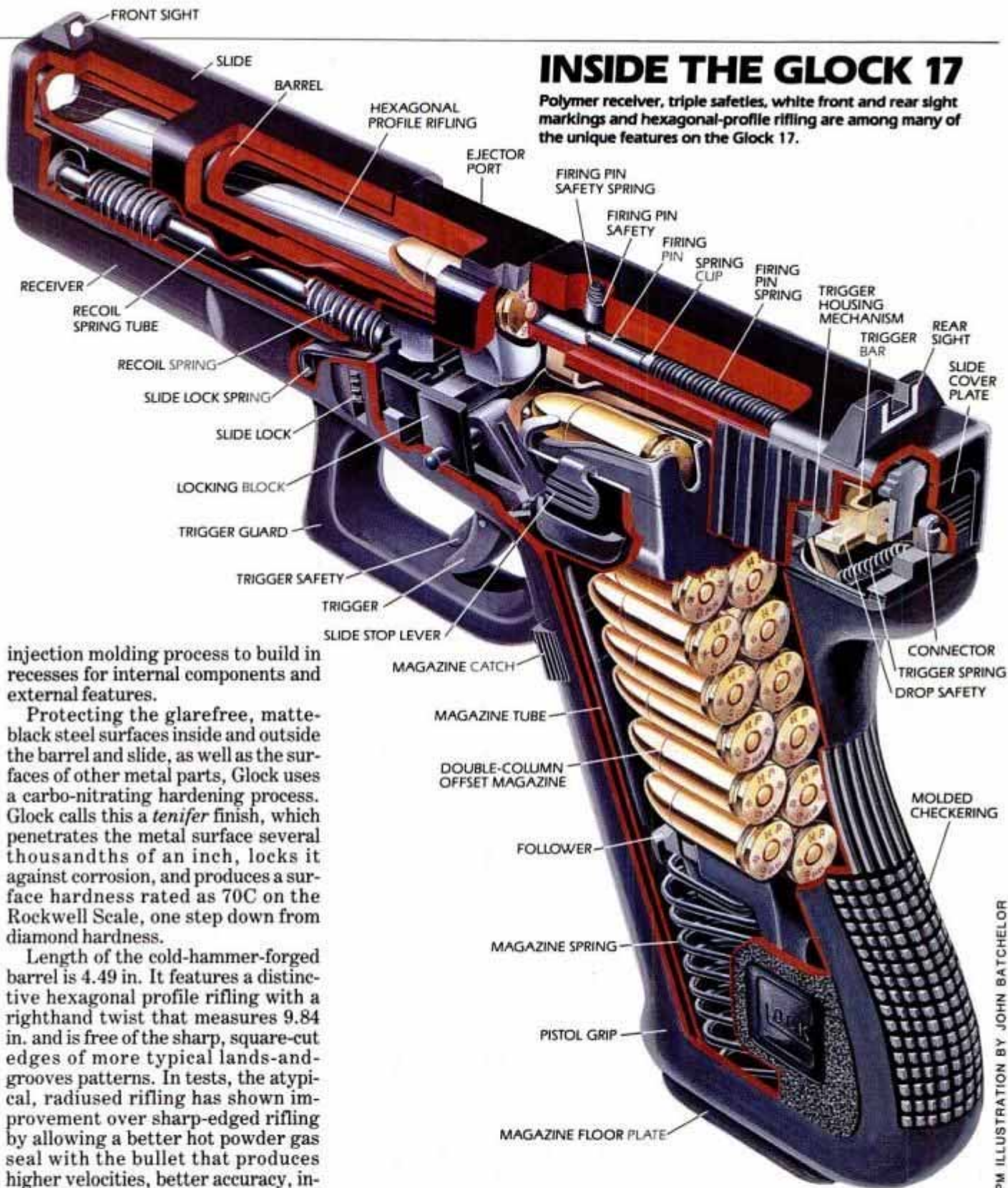
Once for ounce, Glock's patented polymer is about 17% stronger and 14% lighter than stainless steel. To demonstrate how tough this material is under fire, a Glock 17 assembled from components selected randomly off the production line once fired 10,000 rounds in 4 hours.

Glock also uses polymer or polymer/steel components in other areas of the pistol, such as in the trigger and trigger mechanism housing, the recoil spring tube, the magazine and sights, just to name a few. To construct the complex receiver, Glock employs an

While the 9mm Glock 17's receiver is made of a lightweight polymer that's 17% stronger than steel, 85% of its mass is metal.

INSIDE THE GLOCK 17

Polymer receiver, triple safeties, white front and rear sight markings and hexagonal-profile rifling are among many of the unique features on the Glock 17.



injection molding process to build in recesses for internal components and external features.

Protecting the glarefree, matte-black steel surfaces inside and outside the barrel and slide, as well as the surfaces of other metal parts, Glock uses a carbo-nitrating hardening process. Glock calls this a *tenifer* finish, which penetrates the metal surface several thousandths of an inch, locks it against corrosion, and produces a surface hardness rated as 70C on the Rockwell Scale, one step down from diamond hardness.

Length of the cold-hammer-forged barrel is 4.49 in. It features a distinctive hexagonal profile rifling with a righthand twist that measures 9.84 in. and is free of the sharp, square-cut edges of more typical lands-and-grooves patterns. In tests, the atypical, radiused rifling has shown improvement over sharp-edged rifling by allowing a better hot powder gas seal with the bullet that produces higher velocities, better accuracy, increased barrel life and less fouling and bullet deformation.

On the firing line

The first time you pick up a Glock pistol, you immediately notice the light weight and the comfortable grip, which easily accommodates the double-column magazine without feeling overly wide. The magazine catch is on the right side of the gun. Righthanded shooters must rotate the pistol grip slightly in their palm to release the magazine with the right thumb and

guide it out with their left hand. Left-handed shooters will actually find it a little easier, but in neither case can the magazine be accidentally released. A molded guard protects the slide stop lever from accidental engagement.

Experienced shooters will immediately notice the lack of an external thumb or grip safety, but this is hardly a drawback. Glock pistols are *double action only*, meaning that there is no way to fully cock the gun and then

engage a safety, a practice referred to by military and law-enforcement professionals as *cocked and locked*. However, it is possible to carry a Glock with a round in the chamber for combat or firefight readiness.

Glock pistols have a unique safety system to prevent accidental discharge. When the slide is retracted and released to chamber a round, the internal firing pin is moved rearward to a partially cocked position and the trigger is moved forward from its de-

PM ILLUSTRATION BY JOHN BATCHELOR

THE ENFORCER

cocked rearward position. Three safeties are engaged at this time: 1. the trigger safety, 2. the firing pin safety, and 3. the drop safety.

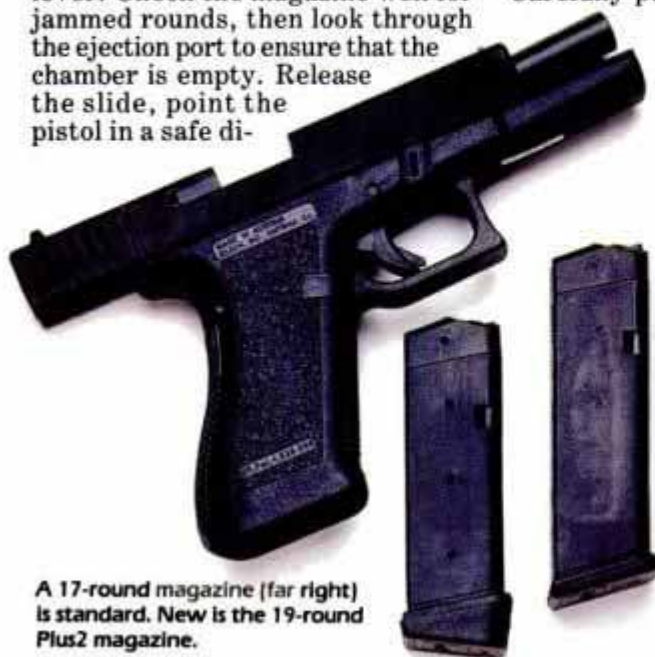
The trigger safety is a pivoted lever on the trigger's face that blocks rearward trigger movement. The firing pin safety is an overhead plunger that drops down to block firing pin movement. The drop safety is a cross-shaped portion of the trigger bar that prevents release of the spring-loaded firing pin without further rearward movement of the trigger.

Placing your finger squarely on the face of the trigger immediately negates the trigger safety. Then the initial pull on the trigger causes an upward extension of the trigger bar to lift the firing pin safety. Finally, the complete pull on the trigger causes the cross-shaped portion of the trigger bar to release the firing pin. Its wedge-shaped tip passes through a cut in the breech face to strike the primer and ignite the round.

Trigger pressure necessary to fire the first round is no different from that of firing subsequent rounds by nature of the always partially cocked firing pin/trigger mechanism, which improves first-shot accuracy. Depending on the trigger spring selected, a Glock 17 can have a 5-pound or an 8-pound trigger pull, the former being very crisp and responsive. Some law-enforcement agencies opt for heavier springs to minimize accidental discharge, should training be forgotten in a firefight.

Only 33 parts

Field stripping the Glock for normal cleaning is straightforward and simple. Remove the magazine, retract the slide and engage the slide stop lever. Check the magazine well for jammed rounds, then look through the ejection port to ensure that the chamber is empty. Release the slide, point the pistol in a safe di-



A 17-round magazine (far right) is standard. New is the 19-round Plus2 magazine.



Newer Glock models are, from the top down, the 10mm Glock 20, the standard-size .40-caliber Glock 22 and the compact 9mm Glock 19.

rection and pull the trigger. It will remain rearward.

Then, hold the pistol in either hand and pull the slide back approximately $\frac{1}{10}$ of an inch. Move it back too far, and you will partially cock the firing pin, which must be released by pulling the trigger, as described above. Using the thumb and index finger of your free hand, pull down on both sides of the slide lock. Push the slide forward, and it will separate from the receiver. Carefully push the tensioned recoil

spring and tube forward and raise it until free. Now, you can grip the barrel by its lugs and lift it free, chamber end first.

At this point, we should note that the Glock 17 has only 33 parts, roughly half the number found in other autoloading 9mm pistols. All of the components are manufactured on computerized machinery to strictly held tolerances that are so accurate that the parts from one Glock 17 are immediately interchangeable with those from any other Glock 17 pistol.

Because of its potential use in combat situations, the Glock 17 is warranted to fire a wide range of 9mm ammunition, from Federal's Hydra-Shok 147-grain subsonic round, to Winchester's 124-grain full-metal-jacket NATO round, to Remington's 88-grain jacketed hollow-point round, up to and including the powerful carbine rounds intended for military use.

While the first Glock models were chambered in 9mm for international military and police use, later ones are now available for use with the potent .40 S&W (Glock 22) that was recently developed by Smith & Wesson, the 10mm (Glock 20) and venerable .45 ACP (Glock 21). Two other pistols recently introduced are the compact-frame 9mm Glock 19 and .40 caliber Glock 23. Prices run about \$500 a copy.

Glock accuracy on the firing range is comparable to or better than most revolvers or semiautomatic pistols, but its true worth isn't revealed during target practice. It's revealed in the field, where the stakes are high and conditions are unpredictable. Here, the sidearm of choice is increasingly the Glock 17 or one of its newer brethren. If you're fortunate enough to get a chance to handle and fire one, you'll see why synthetic polymer Glock has taken U.S. law-enforcement agencies by storm. **FM**



HONDA ACCORD

America's best seller is better than ever.

● Did you ever dream that a Japanese car would outsell Fords and Chevys? Well, neither did Ford or Chevy. But the fact is the Honda Accord slipped past the Ford Escort in 1989 and has been America's best seller ever since.

But is the Accord really a Japanese car? Well, it is, and it isn't. Two-thirds of all Accords sold in America are imported from Marysville, Ohio, where Honda has set up a manufacturing operation. The rest come from Japan.

Not all the components that go into the Marysville Accords come from U.S. sources. On the other hand, Marysville did produce enough cars last year to ship Accords to Israel, Taiwan, Korea and even Japan—17,000 in all. So the issue of domesticity is muddy.

Accords have always sold well in this country. The first time we surveyed Accord owners, back in 1977, demand was so strong that we had to go to a private party to get a new car

BY MICHAEL LAMM, Contributing Editor
PM Photos by Ron Hussey



to photograph. The dealer didn't have one in stock, and he already had a long waiting list.

The Accord's marketing strategy was a little different back then. Honda offered basically one model, which was loaded with standard features. The idea was that the cost of all that equipment would be offset by volume and economies of scale.

Somewhere along the line, though, Honda changed its mind and now spreads the Accord over a wide range of models, prices and features, the way American automakers do. Now there are four models (DX, LX, EX and SE), each with progressively more standard equipment—and, of course, a commensurately higher price.

The fourth-generation Accord of 1990 and '91 is quite a bit different in other respects as well. It's still front-wheel drive, but it's bigger, more powerful, heavier—by almost 50%—and it uses slightly more fuel. Owners of the 1977 Accord posted 27.3/33.1 miles per gallon city/highway. The Accord owners in this survey group reported 25.7/32.4 mpg.

The Accord currently offers three body styles—sedan, hatchback and wagon. Honda also lists three horsepower ratings for its 2.2-liter 16-valve sohc all-aluminum Four: 125, 130 and

HONDA ACCORD



Honda Accord's analog instrumentation is straightforward and easy to read.

Seats drew some complaints for excessive firmness and lack of lumbar support.

Accord's 2.2-liter sohc 16-valve Four is smoothed by dual balance shafts.

140, depending on the model series.

In 1977, the Accord cost a whopping \$4145. Today's lineup starts at \$12,800 and goes up to \$20,020 for the SE sedan, replete with leather trim, 140 hp and ABS braking. (The new station wagon and Special Edition model weren't on the market when we mailed our questionnaires.)

What's the basic magic that keeps demand so high for the Accord? Owners cited Honda's reputation, or "track record," as a key factor for nearly half of all sales, with styling second at 28.3%. A number of women believed that the Accord was designed with women in mind, and well over half of the principal drivers in

our survey—58.3%—are female.

Workmanship was judged excellent by 75.9% and good by another 23.2%, leaving only 0.8% of the surveyed owners dissatisfied. Those are better scores overall than the marks scored by the '77 Accord, which was built in Japan. And there were many more complaints concerning mechani-

SUMMARY OF 1991 HONDA ACCORD OWNERS REPORTS*

Total miles driven:	2,107,206	Wagon	0.0**	Average	0.8	No	25.0
Average miles driven:	7862	Specific likes:		Poor	0.0	Dealer service opinion:	
Purchase price:		Styling	50.2%	Comfort opinion, front seats:		Excellent	44.7%
Average	\$15,288	Handling	42.8	Excellent	58.9%	Good	43.6
Range	\$11,600-\$19,800	Comfort/roominess	37.0	Good	23.2	Average	8.0
Why did you choose the Accord?		Power/performance	33.7	Average	4.7	Poor	3.7
Honda reputation	44.6%	Ride	32.9	Poor	1.1	Number of vehicles owned:	
Styling	28.3	Economy	32.9	Comfort opinion, rear seat:		This vehicle only	25.8%
Owned other Hondas	27.5	Specific dislikes:		Excellent	46.7%	Two vehicles	50.6
Performance	19.0	No complaints	12.7%	Good	45.1	Three vehicles	14.6
Price/value	16.7	Automatic shoulder belts	10.2	Average	4.7	Four or more	9.6
Model choice:		Firm seats/lumbar support	9.1	Poor	1.1	Principal driver:	
Accord LX	51.3%	Dealer service	6.1	Mechanical trouble?		Female	58.3%
Accord EX	38.9	Fuel economy	3.6	No	84.1%	Male	39.5
Accord DX	9.8	Decklid torsion rods	3.6	Yes	15.9	Equal	2.2
Accord SE	0.0**	Suggested changes:		What type of trouble?		Age distribution of owners:	
Avg. mpg, city/hwy:		No changes	18.5%	Air conditioner	27.9%	Under 29	24.0%
5-speed manual	25.7/32.4	Airbags	15.9	Electrical system	14.0	30-49 years	42.9
4-speed automatic	24.2/29.5	Offer ABS in all models	14.2	Transmission	14.0	50-plus	33.0
Transmission choice:		Softer seats/lumbar support	8.2	Jerky/hesitant shifts (auto)	11.6	Based on your experience, would you buy an Accord again?	
4-speed automatic	69.1%	Center front armrest	7.3	Did you repair it yourself?		Yes	74.3%
5-speed manual	30.9	Improve automatic belts	6.0	No	97.7%	Yes	74.3%
Body style choice:		Workmanship opinion:		Yes	2.3	Maybe	23.0
4-door	82.1%	Excellent	75.9%	Dealer repairs satisfactory?		No	2.6
2-door	17.9	Good	23.2	Yes	75.0%		

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

** Station wagon and Special Edition not available at time of survey.

cal problems back in '77—42.7% compared to 15.9% in this survey. Honda seems to have made great strides in reliability and quality control.

This is particularly interesting, because the 1977 Accord was regarded as one of the world's best-built automobiles, which places the '91 Accord that much higher on the same scale. It also means that in the long run the new Accord will be cheaper to drive, despite slightly higher fuel consumption, because it needs fewer repairs.

The '91 Accord's ride and handling got generally good reviews from our survey group, as did seating comfort, both front and rear. The owners liked the simple analog instruments, the visibility and the general feeling of safety inside the car.

Shoulder belt beefs

However, good as it is, the Accord did draw some complaints. Tops in this department was the motor-driven passive shoulder belts, which were criticized by drivers and passengers alike. A secondary problem had to do with the driver's sun visor. When it's against the side window, it snags the action of the automatic belt.

Some 16% of our respondents asked for airbags, available so far only in Accord wagons. Another 14.2% of our owners put ABS on their wish-lists. To get an Accord with ABS this year, you have to order the \$20,020 SE, and a lot of buyers didn't think that was fair.

Generalized complaints were mild. A few owners—9.1%—couldn't get comfortable in the driver's seat, criticizing it for being too firm and lacking lumbar support. Another 7.3% lobbied for a front center armrest (available as a dealer-installed option). Some wanted a bench front seat, and a few found the rake of the rear seat-back too far from vertical for comfort.

The torsion rods that hold the trunk lid open occasionally dropped the lid on unsuspecting heads. Air conditioners were defective in a few cars, and the automatic transmission jerked or hesitated in others.

Honda loyalty

Despite these scattered complaints, though, our Accord owners were generally very pleased with their cars. More than a quarter of our survey group had owned Hondas before, and 74.3% told us they'd gladly purchase an Accord if they had it to do over.

In a footnote on his questionnaire, a New Jersey engineer wrote, "I don't know why anyone would buy a more expensive car. Accords are great values and very luxurious." Most owners agree wholeheartedly. **PM**



Though conservative, the Honda Accord's styling ranked as the best-liked feature with the owners in the survey group. The LX sedan version dominates sales.

EDITORS REPORT

The Perils Of Committee

● When Ford launched the Taurus, the design was characterized as "customer driven," marketingese for determining exactly what the customer wants and then bolting it into the concept.

As a marketing position, this looks like solid ground, like taking a bold stance in favor of motherhood, lower taxes and the flag. But as an iron-clad design policy, there's a down side. Follow this ethic too far, and you can wind up with a serious case of the bland.

Ford navigated these shoals with rare skill and came up with a car that was bold and innovative. The Honda Accord, meanwhile, has been customer driven from bold and innovative to something much more mainstream. Refined, yes. Technically sophisticated, yes. Well-made, yes. Bold, no.

In our opinion, the Accord is a good example of what happens to a car when its designers strive to make it all things to all people. It may become better in every detail—this can be said for the Accord—but it loses character.

We offered this opinion in our long-term evaluation of the current Accord, and judging by the angry letters from droves of Accord owners, character isn't nearly as important as durability, reliability and a high level of civilization.

This is not to say the Accord is deficient in driving virtues. Driver sightlines are excellent, space utilization is exemplary and the control/instrument layout is first-rate. These are all traditional Honda design strengths, something that can also be said for the en-

gine. The Accord's 2.2-liter sohc 16-valve Four, with counterrotating balance shafts, is one of the best 4-bangers in the business.

On the other hand, a V6 engine is better, and there's a good one available elsewhere in this class. The Accord's Four gets noisy when pressed. And like some of the owners in our survey, we've experienced glitches with the 4-speed automatic.

We also wholeheartedly agree with owners who disliked the Accord's motorized shoulder belts.

On the road, the Accord is quiet, mannerly and comfortable. We find the seating to be good, and ride quality is better than good for a small car.

But we can't really go along with owners who regard the Accord as fun to drive. Even with front and rear anti-roll bars, the Accord retreats into stubborn understeer when it's pushed through corners. It's thoroughly predictable, and braking is very good (we agree that ABS should be available throughout the line, incidentally), but it's no sports sedan.

On the other hand, Honda isn't really after the sports sedan set with this car. This is family goods, and Honda has obviously struck a responsive chord. But will a customer-driven design philosophy continue to push the Accord toward anonymity? In our book, bland is bland, regardless of detail execution. It'll be interesting to see how long this approach can dominate the sales charts. —Tony Swan



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GIANT TV

We test the four biggest projection televisions.

● If you want to experience a football game smack in the middle of your living room, there's no better way to do it than with a projection television. The image is so large you can't help but feel like you're right out on the playing field. This feeling holds true not just for football but for any video image you put up on the screen. You're in the middle of the action, mostly because the on-screen image is nearly as big as you are.

Projection televisions are becoming big sellers, particularly with sports fans. For many, however, projection TVs are something they've only seen in a local bar.

Unlike direct-view televisions, which employ a single tube, rear-projection TVs use an array of red, green and blue lenses to create a video image. The lenses are aimed at an angle to reflect off a mirror at the rear of the set. The picture, a convergence of all three lens elements, is projected onto the rear of a translucent screen for viewing.

To find out just how good today's projection TVs are, PM found the four biggest projection TVs in existence. These four models are the offensive line of their class. They're all big, each measuring over 52 in. in screen size. Not only are they big, they're also heavy, weighing between 250 and 350 pounds. Think about confining these sets to the ground floor.

As in football, every big player isn't necessarily a great player. To find out how these projection TVs played, PM took them to the lab for a tryout, hoping to find something more than just a refrigerator. We did find a couple of stars and a couple that might make it

BY FRANK VIZARD, Electronics Editor
FRANK C. BARR, President,
Advanced Product Evaluation Laboratories
STEPHEN A. BOOTH, Contributing Editor

in some other league, but not PM's. On their own, each projection TV is impressive. It's only when you put them up against each other in a game situation that differences become apparent.

The roster

PM's tryout roster looks like this: a 60-in. model from Hitachi, a 70-in. model from Mitsubishi, a 61-in. unit from Philips and a 53-in. model from Sony.

While none are inexpensive, the Mitsubishi model is the most costly at \$6399. The other models range in list price from \$3400 to \$4400.

Projection TVs in this price range offer more than just big screens. With

the Hitachi 60SX1K, you get picture-in-picture for viewing another video source, Dolby Pro Logic surround sound and two remote controls. The 60SX1K also has a message timer

so you can leave an on-screen message for yourself or someone else at a programmed time.

Perhaps the most remarkable feature of the 60SX1K is its cabinet depth. While offering a screen size of 60 in., the Hitachi set measures only 28 in. deep. This compares favorably with smaller direct-view televisions. The other three models in PM's test all have greater cabinet depths.

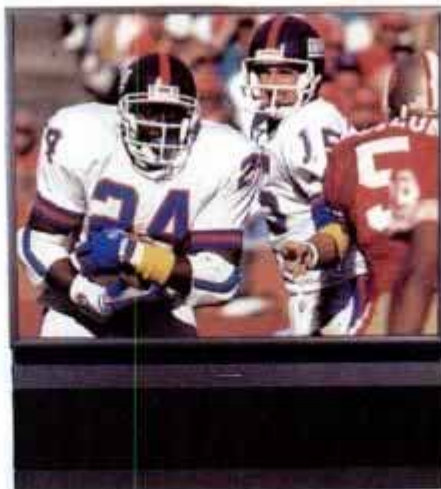
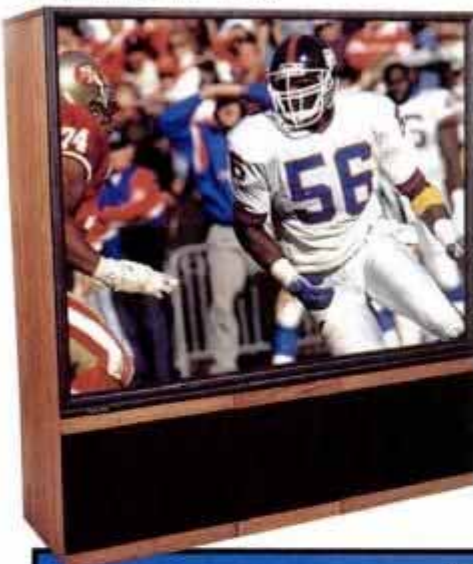
However, this is not to say that any of these projection televisions have trouble fitting through a standard-size doorway measuring 30 in. across. The Hitachi 60SX1K slides through a doorway as is, of course. For the others, delivery is not as difficult as it might seem.

The depth figure in PM's chart reflects the size of the projection TV fully operational. For both the Philips



RCA's universal remote can control the TV and other components, as well.

GIANT TV



PROJECTION TV SPECIFICATIONS

MANUFACTURER/ MODEL	SCREEN SIZE (in.)	LUMINANCE* (foot lamberts)	OFF-AXIS LUMINANCE (50°/70°)	HORIZONTAL RESOLUTION	FREQUENCY RESPONSE (MHz)	CONVERGENCE	AUDIO SIGNAL-TO-NOISE RATIO (dB)	EXT. SPKR. POWER (watts)	MTS SEPARATION, 1KHz (left-right channel, dB)	POWER (watts)	DIMENSIONS (h x w x d in.)	PRICE
Hitachi 60SX1K	60	146	63.3/7.6	880	11.0	0.20	76.1	4.5	23.2/23.8	250	62½ x 53½ x 28	\$4400
Mitsubishi VS-7004R	70	60.8	9.6/3.1	840	10.5	0.40	80.5	18.0	22.3/22.1	200	65 x 58½ x 38½	\$6399
Philips 61MP60	61	57.1	6.4/1.5	720	9.0	0.26	97.2	15.7	13.6/14.0	165	56½ x 51½ x 30½	\$3400
Sony KPR-53EX35	53	104	31.4/4.7	720	9.2	0.35	82.2	NA	18.0/18.5	190	54 x 45½ x 34½	\$3600

* 36.5% white window.

and Mitsubishi models, the rear mirrors slide down to reduce the overall depth to 28 and 27 in., respectively. This makes it easy to move either model through a doorway.

The same is true of the Sony KPR-53EX35. Sony delivers this model in two pieces. By removing the mirror assembly, the depth of the KPR-53EX35 is reduced to 26 in.

The Mitsubishi VS-7004R doesn't offer surround sound, but it does offer an 18-watts-per-channel amplifier for powering speakers. Other major features include picture-in-picture, two remotes and a variety of audio/video inputs and outputs. You can also plug a phone directly into the VS-7004R to make it easier to access pay-per-view telecasts.

The Philips 61MP60's major features include Dolby Pro Logic surround sound, picture-in-picture and a wealth of audio/video connections.

The most notable feature of the Sony KPR-53EX35 is the built-in Sound Retrieval System (SRS). This circuitry, designed by Hughes Electronics, creates a surround-sound effect without the need for additional rear speakers. Dolby Pro Logic, by contrast, requires separate rear speakers and often a center channel speaker and extra amplifier. Whether this approach measures up to Dolby Pro Logic is debatable, but it does have its space-saving merits.

Sony also includes audio/video inputs on the front panel so you can

quickly and easily connect a camcorder, for example. Picture-in-picture is also available.

The drills

Just as football players go through a series of running, passing and blocking maneuvers, PM put the four rear-projection televisions being tested through a series of drills. These drills, along with subjective viewing of a reference videodisc, determined the overall ranking.

The accompanying chart gives you an idea as to what types of tests were conducted. This chart compares key data and areas where there were significant differences. While additional tests were done to measure factors like overscan, black level retention, transient response and color quality, there were no significant differences among the four. In fact, all four performed admirably in these areas.

A white uniformity test, which measures the uniformity of white over the entire screen, did show that the Mitsubishi VS-7004R is rather dark in the corners of the screen. As a result, the middle of the screen appears to have a bow tie of light stretched across it.

The Mitsubishi model also exhibited a slight amount of overscan. This means that the video picture extends slightly beyond the borders of the viewing screen. Overscanning tends to make details at the center of the picture even larger.

The brightness of the screen is reflected in the luminance test. Luminance is measured in foot lamberts, with the higher number being better. Luminance for all four models was measured using a 36.5% white "window" at the center of a black screen. Measurements were taken at a distance of 1 meter. A score of 50 is acceptable. The Hitachi 60SX1K, which scored 146, is one of the brightest projection TVs ever measured by APEL.

One criticism of rear-projection TVs has been that off-axis viewing, or viewing from the sides, is poor. To see how well rear-projection TVs have improved in this area, APEL measured the luminance at 50° and 70° off-center. While the numbers show a steep decline, real life suggests the numbers are misleading. The eye doesn't perceive a big roll-off in picture quality at all. PM found off-axis viewing quite tolerable. There's definitely been a big improvement since the early days of projection TV.

Horizontal resolution measures the sharpness of the picture. Horizontal resolution is generally defined as the number of transitions from black to white that can be seen on a single horizontal scan line of a video picture. All four models can produce an image better than any broadcaster or video format can currently deliver.

Related to resolution is the frequency response figure. Video signals are amplified before they reach the

(Please turn to page 101)

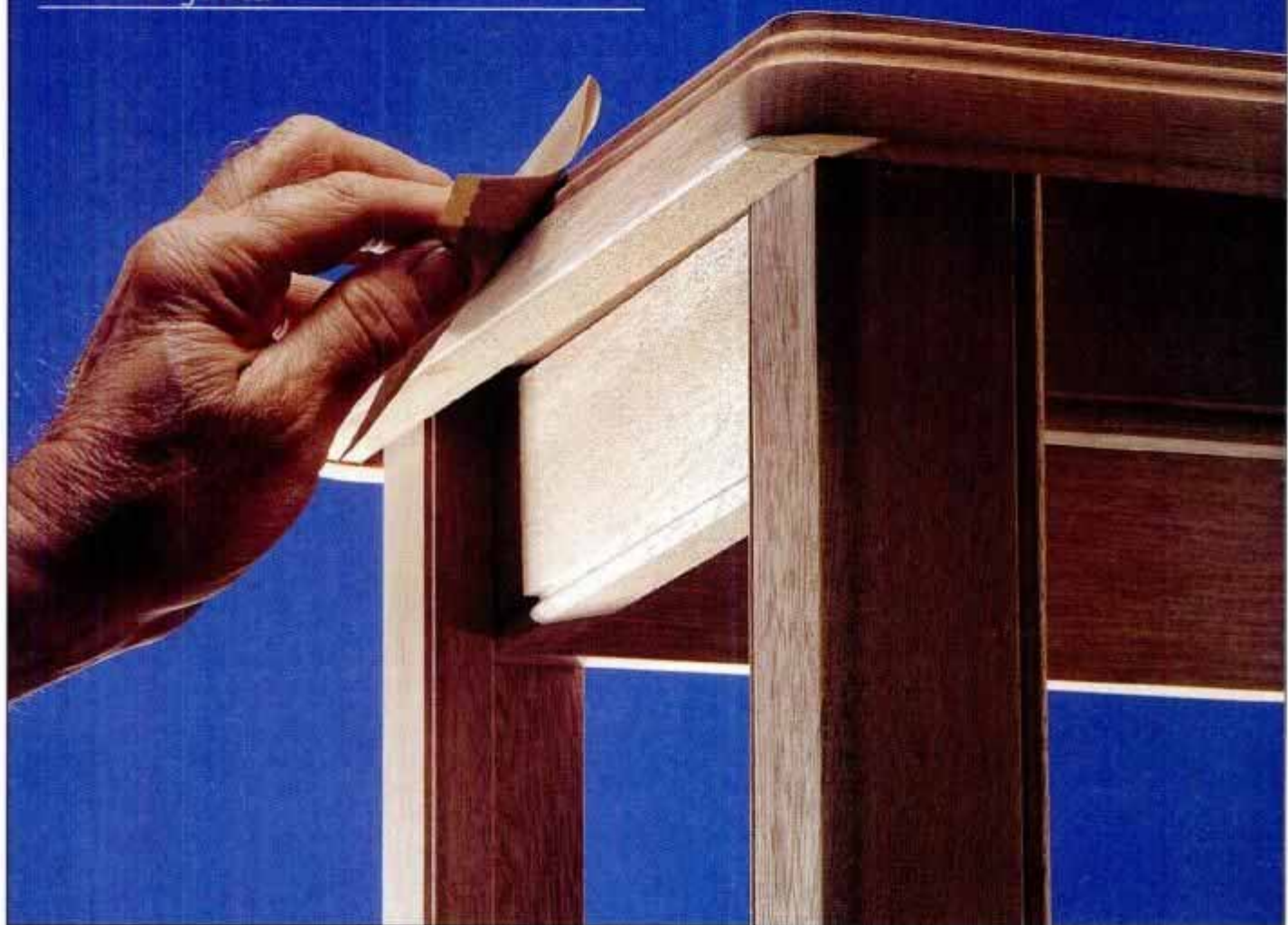
JOURNAL

SHOP TECHNIQUES

FINISH PREPARATION

The best wood finishes begin before the first coat is applied.

TEXT AND PHOTOS BY ROSARIO CAPOTOSTO,
Contributing Editor



● It doesn't matter how tight the joints are fit, how carefully the dovetails are laid out and executed, or how straight and square the assembly, the very first thing that everyone will look at is the finish. It stands to reason, therefore, that doing all you can to ensure that the finish is flawless will be well worth the effort. Your investment in time and energy will reap dividends for years to come.

However, knowing what finish to use and how to apply it is only half the battle. The first step in any finishing

process is to prepare the surface to accept the stain, varnish, paint or other coating product so that the wood—and your careful construction—is shown off to its best advantage. Never fall into the trap of thinking that a finish will hide imperfections. As a rule, stains and clear coatings accentuate every aspect of the surface—including planer marks, dust, scratches and other blemishes. Even a coat of paint will turn what seemed a smooth surface into a moonscape of bumps and irregularities.

Thankfully, the techniques to adequately prepare wood for finishing are relatively few and easily mastered. They include removing glue, tool marks and stains, repairing surface blemishes, and finish sanding and sealing. With some wood, grain filling is a prerequisite for creating a smooth finish. On other occasions, bleaching may be in order to lighten the wood or remove stains. Like all other aspects of woodworking, the key to successful finish preparation is patience and attention to detail.

Glue Cleanup

Because it's better to apply a little too much glue than not enough, some glue will always squeeze out around the joint. Some glue manufacturers recommend removing the excess with a cloth and warm water. Unless the surface is to receive an opaque finish such as paint or lacquer, this practice should be avoided. A diluted glue residue will remain on the wood and fill the pores of coarse-grained woods such as oak. The residue will interfere with the absorption of stains and remain apparent under clear coatings.

The best way to remove glue is to

first let it set until it begins to thicken. Then, run a sharp chisel along the joint to neatly peel off the glue bead (Photo 1). Glue that has completely dried is also removed with a sharp chisel followed by sanding.

In some situations, however, such as a tight corner or confined space, a dampened cloth may be the best way to remove the excess glue. In these cases, carefully remove most of the excess with a small stick or other pointed tool to reduce the amount of glue to be wiped up. Follow with the cloth and warm water, and let the surface dry. Then, hand sand.



1 Remove excess glue by carefully peeling it off the surface with a sharp chisel after the glue has partially set.

Tool Marks

Wood that has been surfaced on a planer has small parallel ripples that run from edge to edge across the board. The spacing of the ripples indicates the feed rate and rotational speed of the planer cutting head. If you use a jointer in your shop, one way to reduce planing marks is to slow the feed rate. Home workshop thickness planers generally have fixed feed rates.

It is possible to sand away planer marks with an orbital sander. However, the flexible pad of the sander may conform to the imperfections and simply follow their contour rather than remove them. The finish-sanded surface may look fine to a casual examination, but the ripples could very well show up when clear finish is applied.

A better method is to use a cabinet scraper. When it is properly sharpened, this tool will cut the tops of the ripples and leave a silky-smooth surface that requires very little followup



2 Use a sharp cabinet scraper to remove milling marks. A finely set, sharp hand plane will also work. Follow by sanding.

sanding (Photos 2 and 3).

Severe marks from coarsely planed stock can first be handled with a sharp, finely set hand plane. A plane has the advantage of leveling and flattening the stock without creating hollows. Any marks left from the hand planing operation are removed with the cabinet scraper.



3 Although not obvious during construction, milling marks will show up after finishing (below). Top half is scraped flat.

Of course, a belt sander will also remove planer marks. For most projects, however, this tool cuts too fast and will remove more stock than necessary. Unless you're very careful, you'll end up with a smooth surface that's no longer flat. Some belt sanders can be fitted with fence attachments for handling edge sanding.

Blemishes

Dents caused by sharp blows that compress the wood fibers can be eliminated by steaming. Place a moistened cloth over the spot, and apply heat and pressure with an iron (Photo 4). Repeat this procedure until the de-

pression is raised, and then sand.

Small holes and blemishes are patched with wood-filling compounds. These fillers come in various colors to match different woods such as ash, birch, maple, mahogany, oak and walnut (Photo 5). Although the

color may be a good match, the repair is rarely inconspicuous. And the contrast becomes more apparent under a stain or clear coating.

If a scrap of the same wood is handy, you can make a nearly invisible patch with a wood plug. Bore a



4 Use a damp cloth and hot iron to raise a dent. The steam causes compressed wood fibers to swell back to original size.



5 To repair small blemishes, use colored wood filler. Avoid over-spreading on coarse-grained woods such as oak.



6 Make an almost invisible patch with a plug cut from a scrap of the same wood. Bore out blemish, align plug, and glue.



7 Cover set nailheads with wood filler. Remove excess while leaving just enough filler to sand flush with wood surface.



8 Remove sticky, resinous pitch from knots by wiping the knot with a solvent such as turpentine or mineral spirits.



9 Seal knots with undiluted 3-pound-cut shellac. Apply two coats, sanding after each when dry with 220-grit paper.

shallow hole that completely removes the blemish, and then cut a plug to fit. Orient the plug so the grain runs parallel to the stock, and glue it in place. When the glue has dried, trim the plug flush with a chisel and sandpaper

(Photo 6). To cover finishing nails set below the surface, use ordinary wood filler, and sand (Photo 7).

Although knots may add visual interest, those that ooze pitch cause trouble when finishing. To solve the

problem, clean off the pitch with mineral spirits or turpentine (Photo 8) and then seal with shellac (Photo 9). Use white shellac if the final finish is clear. Orange shellac may be used under paint.

Sanding

Final sanding is one of the most important phases in preparing a wood surface for finishing. A top-quality finish demands a smooth-clean surface, and sanding is one of the easiest ways to achieve this. In addition, a complete sanding job creates a consistent surface quality on the entire piece

so the finish will appear uniform. Although some hand sanding is usually required, the bulk of the work is easily done with an orbital sander (Photo 10).

Because of the speed at which the pad of an orbital sander moves, you have some freedom when handling crossgrain construction. However, when hand sanding, always sand par-

allel to the grain direction. When the construction includes a crossgrain joint, such as in a frame around a panel, hand sand up to the joint line to avoid crossgrain sanding.

Work through progressively finer grades of sandpaper until you obtain a satin-smooth surface. If all tool marks and other blemishes have been re-



10 Use orbital sander to smooth all flat surfaces before finishing. Start with 100-grit, and work through grades to 220-grit.



11 Finishes don't hold up well over sharp corners. Always ease corners by lightly sanding them to a slight radius.



12 Carefully brush the work surface to remove stray abrasive grits when moving from coarser- to finer-grit sandpaper.



13 Clean and remove most of the excess sanding dust from the work with a vacuum cleaner and brush attachment.



14 After finish sanding and vacuuming, remove all remaining traces of fine wood dust with a naphtha-dampened cloth.



15 If water stain is used, first dampen the wood with a sponge to raise the grain. Let dry, sand lightly, and then stain.

moved, start with 100-grit paper. For painted or other opaque work, a final sanding with 180-grit paper will suffice. Work to be stained or clear finished requires a final sanding with paper no coarser than 220 grit. When using an orbital sander, it's especially important not to shift from a coarse paper to a fine paper and omit the intermediate grades. Otherwise, the orbital sander swirl marks from the coarse sandpaper will be nearly impossible to remove.

Finish coats don't hold up well over sharp corners. Therefore, it's important to ease sharp corners with light

hand sanding (Photo 11). When changing from a coarser- to a finer-grit paper, make sure to brush off the work surface to remove any coarse grits dislodged from the previous sanding step (Photo 12). Any strays that get under the finer paper will mar the surface.

If you're trying to sand out a minor imperfection, avoid sanding only the area of the blemish, or an obvious hollow will result. It's better to sand the whole surface, while spending slightly more time on the affected area.

Final sanding embeds the pores of the wood with a fine dust which must

be removed before finishing. A vacuum cleaner with a brush attachment will lift out most of the dust, but not all of it (Photo 13). To complete the cleaning, wipe the surface with a naphtha-moistened cloth (Photo 14).

Water-based stains have many advantages over the oil-based variety. However, they will raise the grain, which results in a fuzzy surface. If you intend to use a water-based stain, the problem can be avoided by pre-raising the grain prior to staining. Lightly sponge the surface with lukewarm water (Photo 15). Allow to dry, and then sand off the raised grain.

Plywood

Fir plywood, widely used for home workshop projects, has a characteristic wild grain that can cause finishing problems. The rotary-cut face veneer displays light, soft spring growth, separated by bands of dark, hard summer growth.

When sanding fir plywood, avoid using a small, padded sanding block, as this results in hollowing the soft areas. Instead, use a large, rigid block that bridges the soft areas and sands the surface uniformly (Photo 16).

Stain applied to raw fir plywood readily soaks into the soft areas while having little effect on the harder, denser wood. To even out the stain, first apply a sealer made up of the topcoat finish (varnish, polyurethane, etc.) diluted one to one with its solvent (Photo 17). Sand lightly with 220 sandpaper, and then stain.

If you're going to paint the plywood, first apply a coat of white-pigmented shellac primer/sealer. To seal the edges, precoat them with a solution of one part white or yellow glue to six parts water (Photo 18). Allow the solution to dry, sand lightly, and apply the sealer. Cover defects in plywood to be painted with patching compound (Photo 19), sand flush and seal with shellac.



16 Use a large, rigid sanding block on fir plywood. Block spans softer areas for a more uniform and flat surface.



17 If fir plywood is to be stained, first apply a coat of diluted topcoat finish to seal plywood and ensure uniform coloring.



18 Apply water-diluted glue to plywood edges to seal end grain and prevent over-absorption of stain or paint.



19 Use patching compound to repair defects in plywood that will be painted. Seal with shellac after compound dries.

Grain Filling

All hardwoods have pores that result from cutting across the grain structure of the wood. Pores appear most dramatically on the ends of the stock, but are also apparent along the surface due to the fact that the grain is never exactly parallel to the saw cut. In some woods, such as maple and birch, the pores are so small that they have little effect on finishing—a surface coating of varnish will lay flat and smooth. Other woods, such as oak, walnut and mahogany, have large pores. When a surface coating is ap-

plied, it seeps into the pores instead of creating a flat surface. To create a smooth, glasslike finish on these woods, the pores are first filled with paste wood filler to level the surface. Grain filling is not necessary on softwoods such as pine and fir.

Wood filler is available in a natural (buff) color that may be used as is, or tinted to match a stain or wood color. It usually comes in a pastelike form with the consistency of peanut butter, and must be thinned with a solvent before use. Some brands come ready to use. Always follow the manufactur-

er's directions supplied with the product for best results.

Apply the filler with a stiff brush and work it well into the pores (Photo 20). First brush with the grain, and then across the grain. Work only a small area of the surface at one time to prevent the excess filler from drying too quickly and becoming difficult to remove.

Allow the filler to set for about 30 minutes, or until it dulls over. Then, wipe across the grain with a coarse cloth to pack the filler into the pores while removing the excess (Photo 21).



20 Use a stiff brush to apply paste wood filler. Stroke first with the grain, and then across the grain to pack filler into pores.



21 When the paste wood filler has lost its wet look, remove the excess by wiping across the grain with a coarse burlap cloth.



22 After wiping across the grain with a coarse cloth, use a soft cloth to wipe lightly, parallel to the grain direction.

Follow by wiping gently with a soft cloth in the direction of the grain (Photo 22). Use a cloth over a pointed stick to remove excess filler from inside corners. Allow the filler to dry at least 24 hours, and then sand lightly to remove any residual filler from the surface. Next, apply a coat of sealer, and follow with a light sanding (Photo 23). If the work is to be stained, apply the stain first, then seal and follow with the filler. To match darker woods or stains, tint the paste wood filler with an appropriate Japan color (Photo 24). After grain filling, apply a compatible surface coating.



23 When the paste wood filler has thoroughly dried (about 24 hours), sand lightly, wipe clean, and apply a coat of sealer.



24 To alter natural, buff-colored paste wood filler to match the color of the wood or stain, mix Japan colors with filler.

Bleaching

Bleaching the wood surface lightens its color. You can use this technique to create a blonde effect or to remove local discolorations in the wood.

For aggressive bleaching, use a 2-solution commercial bleach, available at finishing supply dealers. Mix the solutions together in equal parts, or as directed (Photos 25 and 26). If a single application produces the desired result, the wood will only need a light sanding when dry. If two coats are applied, neutralize the residue by wiping the surface with diluted white vinegar, or as directed by the manufacturer (Photo 27).

To make a mild bleach that's well suited for spot bleaching and gentle overall bleaching, dissolve 1 ounce of oxalic acid crystals in 8 ounces of hot water. Apply the solution to the wood and allow it to remain until the surface is bleached (Photo 28). Then, rinse with water. To neutralize any remaining acid, wash the surface with a solution of 1 ounce of borax per 1 quart of water.

Always wear goggles and rubber gloves when handling bleach, and work in a well-ventilated area. Most commercial bleaches are flammable, so keep them away from an open flame and sparks. **PM**



25 Use 2-part bleaches to lighten the wood tone. Wear rubber gloves and goggles, and mix components as directed.



26 Apply the bleach solution with a synthetic sponge, and spread evenly over the surface. Bleaching action is immediate.



27 Neutralize the bleach residue with a solution of water and white vinegar, or as directed by the bleach manufacturer.



28 Localized stains and discolorations in the wood can be removed by spot bleaching with milder oxalic acid bleach.

TOOL TEST

**DELTA
ELECTRONIC
MEASURING
SYSTEM**

TEXT AND PHOTOS
BY THOMAS KLENCK,
Associate Home
Improvement Editor

● It might seem like woodworking would be the last place you'd need a computer chip and liquid-crystal digital display. However, if you're interested in precision, Delta's Electronic Measurement System (EMS) accessory may be for you.

We tested the EMS on a Delta Unisaw with the standard Jet-Lock rip fence. The basic system (No. 32-010) is designed to fit Delta saws equipped with their Unifence saw guide. To use it with the older Jet-Lock fence, we had to install the accessory mounting kit (No. 32-014). Other mounting kits are available for application with the Beismeyer T-Square fence and for mounting the unit on planers, wide belt sanders and drill presses. Delta claims the EMS can be mounted on virtually any wood- or metalworking machine.

The EMS unit is powered by two AA batteries and slides along the Mylar tape to measure relative distances. It features a high-resolution mode that measures in .001-in. increments. For table-saw work, Delta recommends the low-resolution mode of .005-in. increments. If you'd rather work in inches and fractions, your smallest increment is $\frac{1}{32}$ in. Metric display is also available.

In typical use, the EMS unit is set to zero with the fence just touching the blade. However, the unit can be set to zero, at any location for measuring relative fence movement. It can also be set to read from either the right or left side of the blade.

The Jet-Lock rip fence accessory is an L-shaped channel that's placed between the front fence guide bar and the tabletop. Unfortunately, the standard, tubular fence guide bar is designed to be aligned to the table through two spacers that seat in machined recesses in the table. When the spacers are replaced by the EMS channel, guide bar alignment is no



Mounted on a Unisaw with Jet-Lock fence, the Delta Electronic Measurement System accurately displays fence distance. Inset photo shows components for Unifence-equipped saw.



Capacitive tape is applied to L-channel, a Jet-Lock rip fence accessory. EMS unit reads distance based on position on tape.



L-shaped channel replaces spacers normally separating guide rail and table. Accessory is necessary for Jet-Lock fences.



Holes must be drilled in the Jet-Lock fence body for attaching the magnetic bracket that secures the EMS unit to the fence.



EMS unit slides on L-shaped channel to register fence distance. Unit will measure in .001-in., .005-in. or $\frac{1}{32}$ -in. increments.

longer assured. And with the channel in place, the bar-securing bolts are barely long enough to do their job.

Once installed, the EMS system performs as claimed and does provide consistent accuracy. However, after moving the fence, the unit takes a second or so to display the distance. And

if the shop is cold, the time lag seems more pronounced.

The Delta Electronic Measurement System costs about \$175, and the Jet-Lock fence accessory costs about \$38. For more information, write to Delta International Machinery Corp., Pittsburgh, PA 15238. **FM**



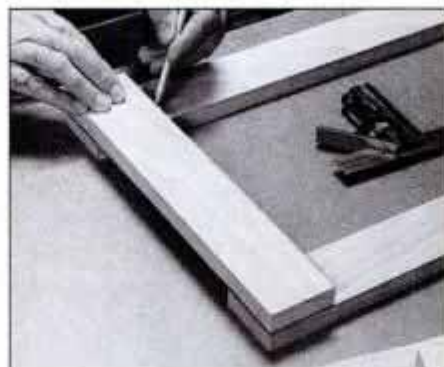
SHOP PROJECT

NEATNESS COUNTS

Keep your magazines in order with this simple but elegant rack.

BY ROSARIO CAPOTOSTO,
Contributing Editor

● Two or three evenings puttering around the workshop is all it takes to build this magazine rack, and it's a great way to relax. It also produces a means of keeping magazines off your



1 Rip and crosscut the frame members to size, then hold them in place to mark the guidelines for the half lap joints.



2 Use a tenoning jig to make the cheek cut in the frame members. Position the strip behind the workpiece to prevent tearout.

living room coffee table or the night stand in your bedroom. It consists of a pair of identical 3-piece frames that are joined together with a self-locking half lap.

Practically any wood can be used for this piece, but we chose yellow poplar. It works easily and when finished with a clear topcoat, it takes on a

cream color tinged with green. Poplar is widely available, and it is more reasonably priced than other cabinet-grade woods.

Begin by ripping and crosscutting the $\frac{1}{2}$ -in. stock for the pair of uprights and the crossmember for each 3-piece frame. Then mark the ends for the half laps (Photo 1).

Color photo: J.R. Rost
How-to photos: Rosario Capotosto
Technical art: Eugene Thompson
Photo stylist: Gabe Herrick

Each half lap is made with two cuts on the table saw. Use a tenoning jig to hold the workpiece vertically. If you don't have a commercial tenoning jig, make one as shown (Photos 2 and 3). A homemade tenoning jig consists of a saddlelike device that rides on the fence. The saddle's center equals the fence's thickness.

After you complete the end cuts, lower the blade and use the miter gauge to make the shoulder cuts that drop out the waste. Use a guide block clamped to the miter gauge fence when cutting the shoulders to ensure consistency from cut to cut (Photo 4).

Cut the angled-edge half laps next. Raise the saw blade so it projects a hair over half the width of the stock. Set the miter fence for an 18° miter, then make several passes to form the notch. Clamp a stopblock to the miter gauge fence, and butt the workpiece to it (Photo 5). It's easy to get confused when cutting an angled half lap joint. Refer to the drawing, and carefully mark out each notch before sawing it.

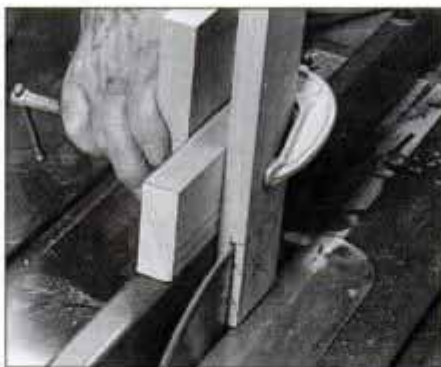
Before assembling the frames, check the fit of the edge notches (Photo 6). Avoid a snug fit to allow for a slight buildup of finish. Apply glue to the half laps, and drive two ½-in.-long brads to hold the pieces in alignment, then clamp the pieces together.

While the glue is drying, rip and crosscut the crossbraces. Cut them to size and shape, then use a doweling jig to bore a pair of holes for ¼-in. dowel pins in the top ends only (Photo 7). Insert a pair of dowel centers in the holes to transfer the hole centers to the frame crossmember. To do this, press the lower edge of the crossbrace against the frame edge, then slide the slat against the horizontal frame member to make the marks (Photo 8). Draw cross lines through the indents, and use the doweling jig to bore the holes.

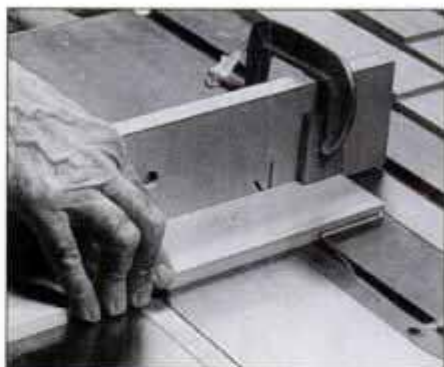
Push dowels into the end of the crossmembers using a little glue. Also apply a little glue at the bottom of the crossmember. Then push the dowels into the holes in the frame. Fasten it with 1¼-in.-long finish nails at the bottom (Photo 9).

Ease all the corners by sanding with a padded block, then smooth the surfaces with 120-, followed by 220-grit sandpaper. Wipe off sanding dust with a tack cloth, and apply three coats of Deft Satin Finish, per the label instructions.

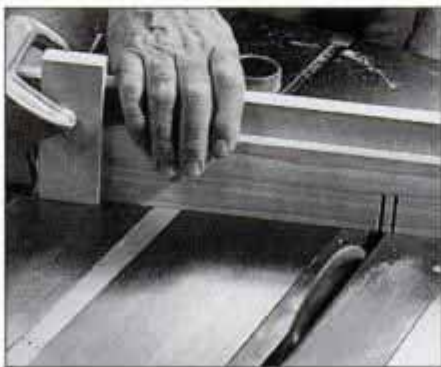
When finishing is completed, push the two sides of the frame together (Photo 10).



3 Shopmade tenon jig consists of a saddle that slides along the fence. Workpiece is clamped to it and moved over the blade.



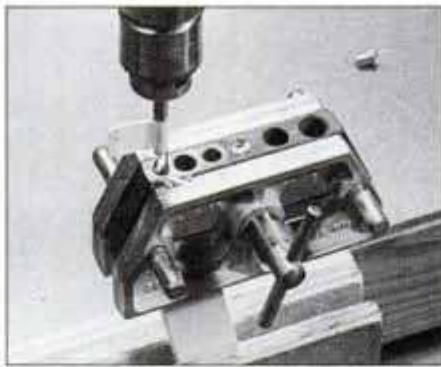
4 Use a miter gauge to make the shoulder cuts. Clamp a guide block to the fence to ensure identical repeat cuts.



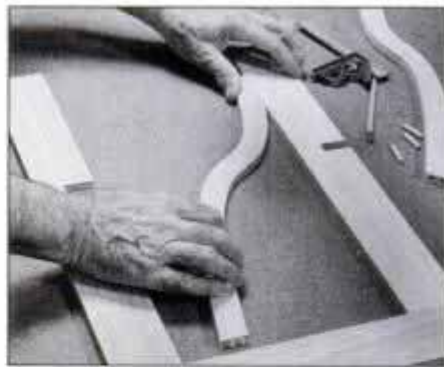
5 Tilt the miter gauge to 18° to make the half lap joints. Clamp a stopblock on the fence to make consistent cuts.



6 Check the half lap for proper fit. The joint should be slightly loose to allow for a couple of coats of finish on both sides.



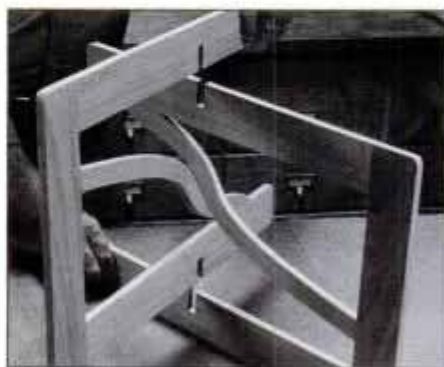
7 Use a doweling jig to bore holes in the slat's small end. Seat the jig so the holes will be perpendicular to the slat's face.



8 Use dowel centers to mark matching hole centers in the frame. Press firmly on slat's lower edge while sliding it forward.



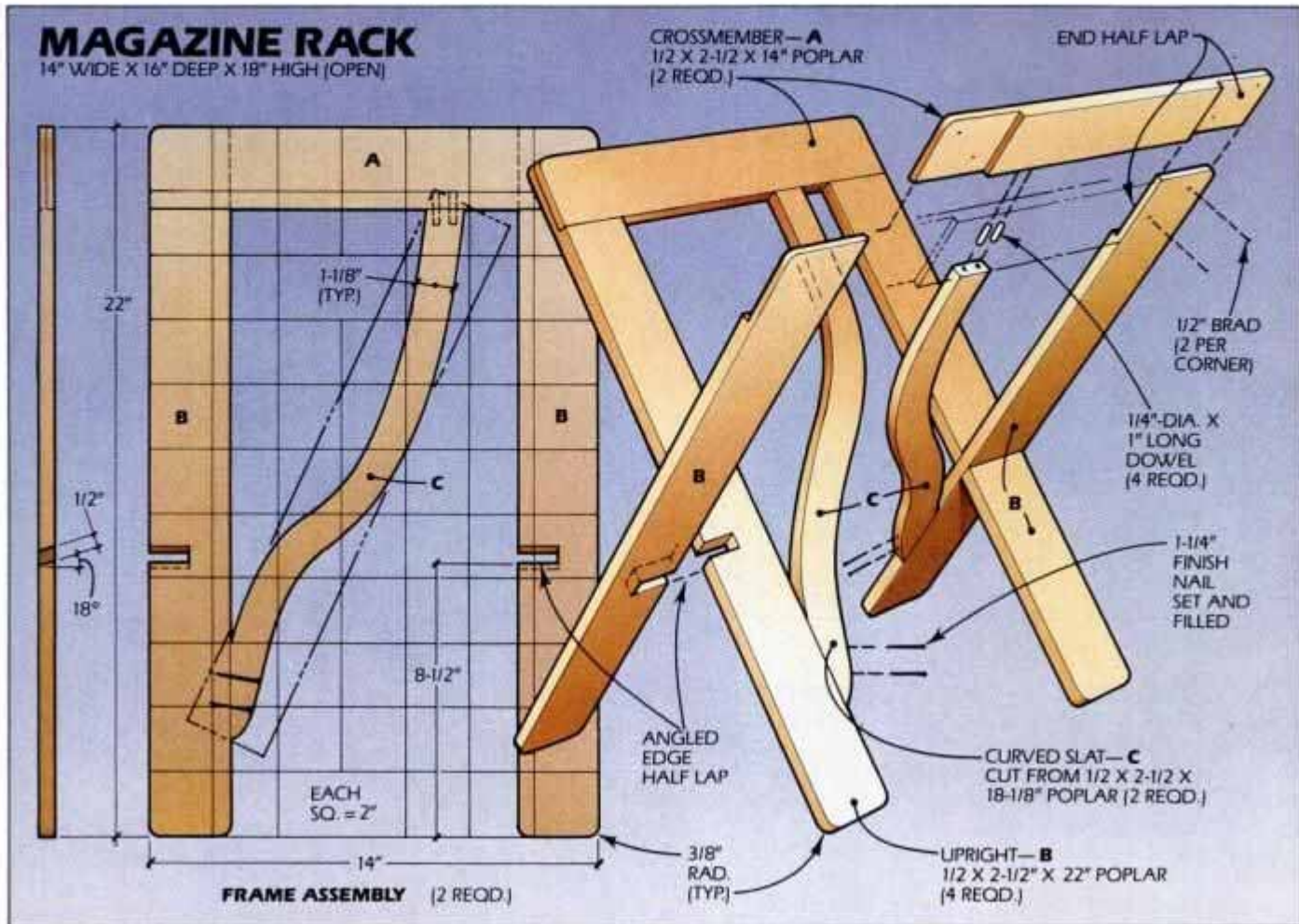
9 Secure slat with glue and two dowel pins at top and two nails at bottom. Drive nails after upper end is seated.



10 Push the two sections together without glue—the joint is self-locking. Apply finish to each section before assembly.

MAGAZINE RACK

14" WIDE X 16" DEEP X 18" HIGH (OPEN)



BOOK REVIEW

MOBILE HOME REPAIR

● There are approximately 9 million mobile homes throughout the United States, according to this book, and they comprise 5 to 10% of the country's single-family homes. Despite their large numbers, this is one of the few attempts (perhaps the only attempt) to provide comprehensive information on their repair and weatherization.

This thin book—110 pages of large type, photos and drawings—starts with the fundamentals of how mobile homes are built and positioned on a site, then progresses to discuss weatherization, repair, mechanical systems, ventilation and components such as doors and windows.

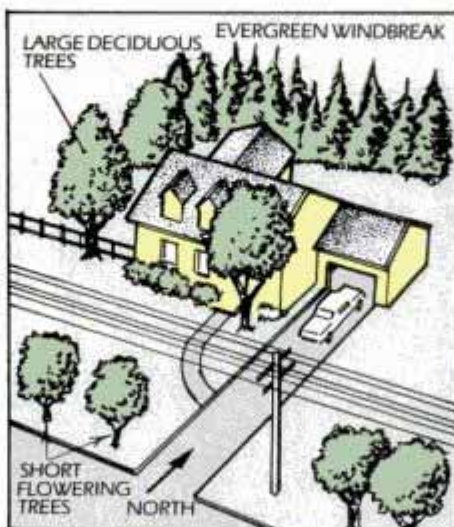
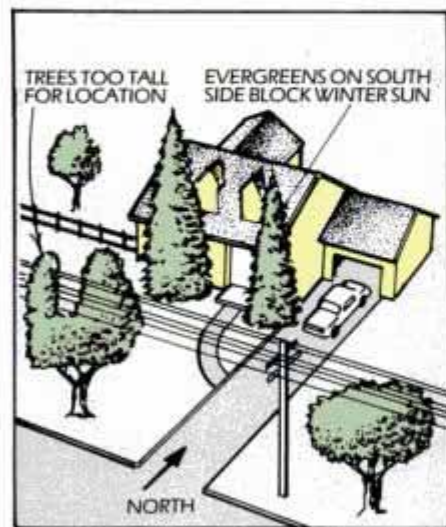
Not all the information in the book is relevant to do-it-yourselfers. For instance, there is ample information on how professional insulation contractors go about insulating such a home. While this isn't strictly useful, it does provide some insight into mobile home technology.

Whether you own a mobile home as your primary or vacation residence, or if you are thinking of buying one, this book is well worth its postpaid price of \$12.50. It is sponsored by the U.S. Department of Energy's Weatherization Assistance Program, which accounts, in part, for its low price. Write to Saturn Resource Management, 324 Fuller, Suite S-8, Helena, MT 59601. —Roy Berendsohn



HOMEOWNERS CLINIC

BY NORMAN BECKER, P.E., Contributing Editor



The National Arbor Day Foundation offers guidelines on tree planting and care.

Tree Planting

Cooler weather is an ideal time to plant trees. To ensure that you take full advantage of a tree's benefits—its shade, beauty and as a windbreak—follow tree-planting guidelines established by The National Arbor Day Foundation.

As shown in the illustration, above left, don't plant large trees under utility lines or large evergreens close to the house, especially on the house's south side where they block winter sunlight. Instead, follow the plan shown on the right by planting short flowering trees under utility lines and an evergreen windbreak on the north side to block cold winter winds.

Also, check with a nursery in your area for planting information specific to your region and to determine when to plant. Contact TNADF (address below) for a brochure on selecting the best tree to suit your needs.

The foundation is a nonprofit educational organization dedicated to tree planting and conservation. Its Bulletin No. 4, "The Right Tree For The Right Place," describes the environmental factors—moisture, temperature, light, soil, air pollution and pests—that determine the ability of a species of tree to thrive. It also describes other factors to consider before planting, including the tree's purpose (shade, aesthetics, windbreak, boundaries).

To obtain your free copy of this bulletin, send your name and address to The National Arbor Day Foundation, 100 Arbor Ave., Nebraska City, NE 68410.

Heat Pump Versus Furnace

My husband and I are getting ready to build our first home (1500 to 1900 sq. ft. with two stories). We are trying to decide on a heating/cooling system. Many people recommend a heat pump because it is energy efficient and pays for itself.

Others say a heat pump needs a backup system because it can't heat a home when the outside air falls below 32° F. Still others suggest a gas furnace. What are your thoughts on this confusing subject?

NORMA AND STEVE BARB
NEW MARKET, VA

Heat pumps are most effective in the Sun Belt. They lose their economic advantage in colder climates when the outside temperature drops near or below freezing because their auxiliary electric heaters kick in.

Considering the location of your home, if the decision is based on economics, I'd go with the heat pump.

Wet Attic

My 2-story house is 40 ft. wide on each side, and has three 12-in.-sq. vents on the roof's south side. There are four soffit vents on the house's north and south sides.

During the winter, frost collects on the attic side of the roof deck and on the rafters. The frost melts and drips on the insulation and seeps through the ceiling. What can I do to reduce the attic moisture in the winter?

JOHN WIDDER
CAROL STREAM, IL

Your problem is typical of an attic in the northern states that has excessive moisture buildup and inadequate ventilation. The unobstructed attic ventilation should be $1/300$ th of the attic floor area.

Based on your data, the vent openings are about 20% less than the recommended amount. If there are insect screens covering the vent openings, then the percentage is even more. An insect screen reduces the effective opening by about 40%.

To increase moisture reduction, the roof deck between the rafters should be "washed" with cool, dry air. This can be achieved with continuous ridge and soffit vents.

If these vents cannot be installed, then you must use additional roof and soffit vents. Frost tends to develop on the roof's north slope. There are no vents currently located there, so install the vents on the north side of the roof.

Also, moisture can migrate into the attic through wall cavities because water can collect in the basement or crawlspace after a rain. Keep those areas dry.

Black Spots On Ceiling

The cathedral ceiling in my 10-year-old house was okay until five years ago, when we noticed black spots appearing through the sand finish. I painted it and it looked good, but the black spots came back. No matter what I do, they come back. I have asked many carpenters what causes it, and none seem to know.

Can you help?

PAUL KRAWCZYK
NORTHAMPTON, MA

The black spots are probably mildew spores. Mildew is a fungus. Unless you kill it, it will come through a new layer of paint, especially a water-based paint.

Try washing the ceiling with a solution of bleach, detergent and water. After the ceiling dries, paint it with a mildew-resistant paint or use a fungicide additive in the paint to help protect it.

If the problem returns, it's probably related to ventilation or an improperly installed vapor barrier. **PM**

DO YOU HAVE A HOME-MAINTENANCE OR REPAIR PROBLEM?

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

**HOME
MAINTENANCE**

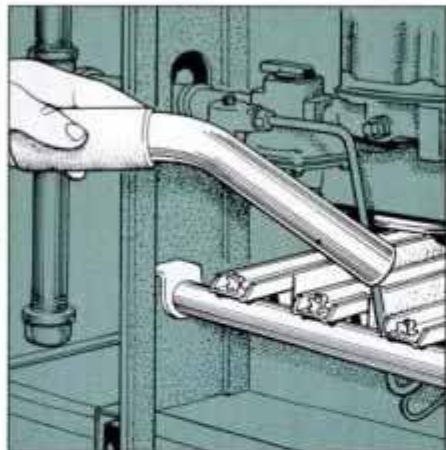
**GAS
FURNACE
TUNEUP**

BY MERLE HENKENIUS
PM Illustrations by
George Retseck

● You've probably seen the yearly ads offering a routine tuneup for your gas furnace. And if you're like most homeowners, you'd like to know first, whether the work is really necessary, and second, exactly what you'll get for your money. In most cases, the entire job consists of cleaning and lubricating the blower unit, and cleaning and adjusting the burner assembly.

Such simple maintenance is, however, well worth the typical \$40 to \$80 price tag. It's the best frontline defense in the battle against the twin threats to furnace life and efficiency—dust and rust. Simply put, a well-maintained furnace will operate more efficiently and last longer.

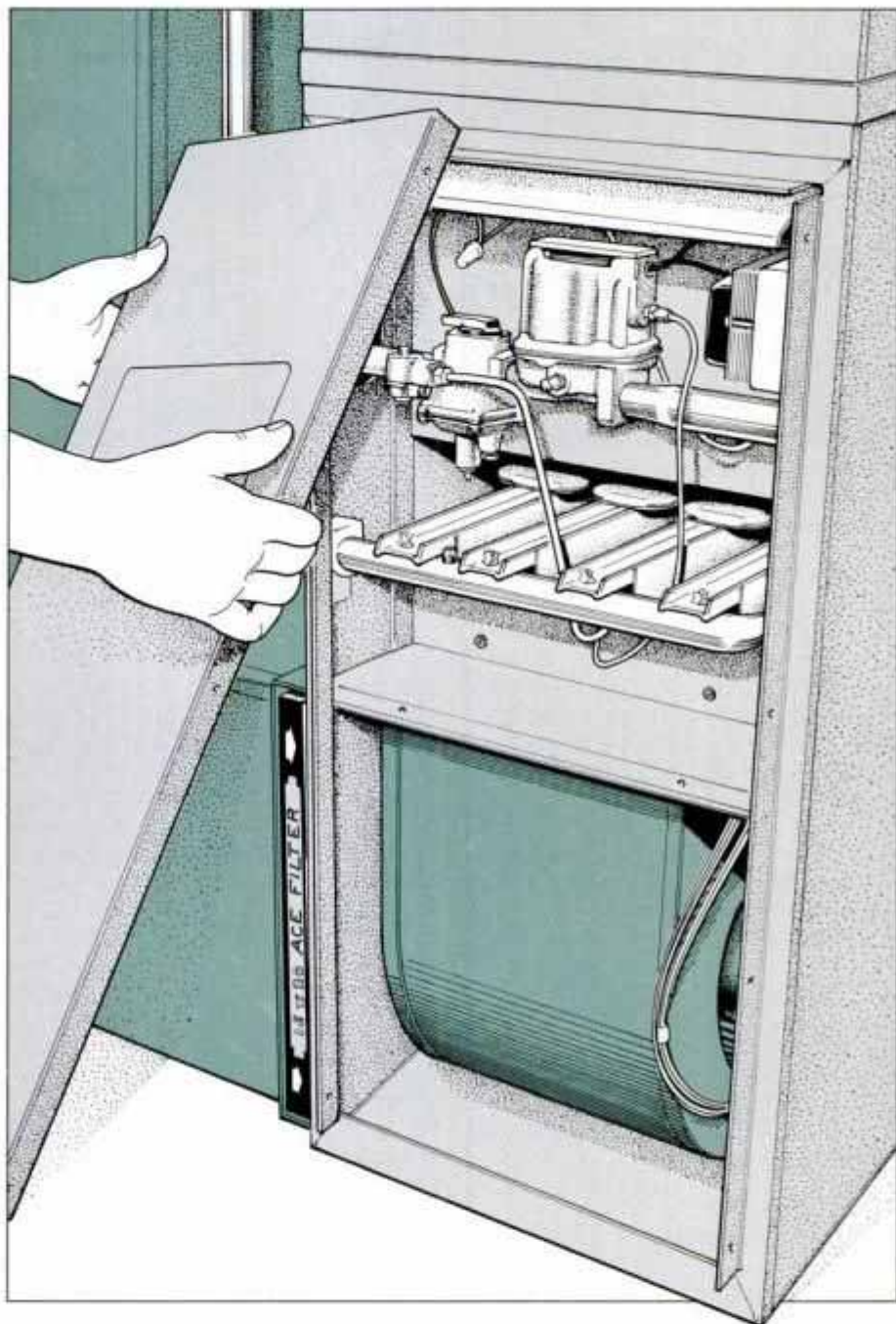
The value will be even greater if you handle the job yourself. The complete project takes less than an hour, and you'll save yourself the service



1 Begin by vacuuming the cabinet to remove dust and cobwebs that would soon foul a newly cleaned burner assembly.

charge, as well as scheduling hassles. As long as you stay clear of the control valve and limit switches, and put back everything as you found it, there's little chance for error.

The procedures that we're outlining are suitable for a typical older furnace that operates safely and predict-



ably. We'll limit the discussion to the simplest components within the furnace cabinet and leave the control valves, relays, thermostats and heat exchangers in the hands of the professionals. We'll also assume that you change furnace filters regularly.

What to look for

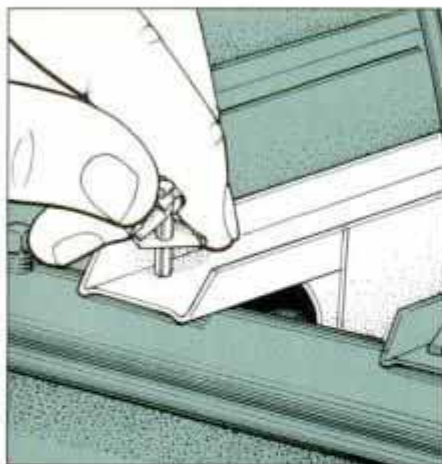
A dirty, improperly adjusted burner will display a variety of symptoms, all of which are visible during the heating cycle. To check out the system, all you'll need to do is pull up a chair, remove the furnace cabinet door to gain access to the burner assembly and watch the burners in operation.

A standard gas furnace will have two, three or four burners, each with

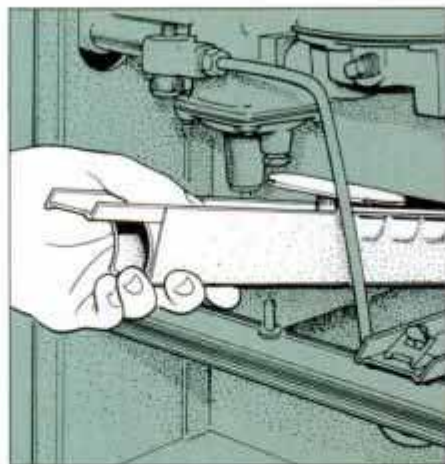
some sort of ignition crossover device. In order to troubleshoot the condition of the burner assembly, you'll need to study these components in both their startup and continuous-run stages.

Start the furnace by having someone turn up the thermostat while you observe the ignition. When the furnace starts, ignition should progress evenly from one burner to the next and without hesitation or a late flash. Then, observe the nature of the flames during normal operation. When working properly, each burner yields a continuous, steady blue flame.

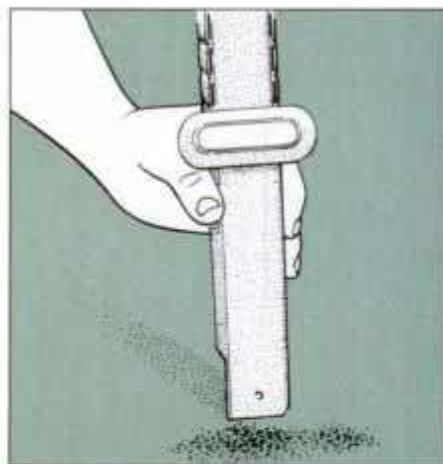
If you see a burner-to-burner ignition that displays a noticeable puff and small flash, then gas is not moving



2 To remove one of the burners for cleaning, slip off the small fastening clip that secures the burner to the gas feed piping.



3 Tip the burner up and slide it out where it can be worked on. Burners are often clogged on the inside with rust.



4 After the burner has been removed, tap the open end of the burner on the floor to clear the inside of loose rust.

through the crossover pieces that ignite each burner in sequence. In all likelihood, one of these crossover members is clogged with dirt or rust.

If you see a burner that doesn't ignite at all, or only puffs on and off sporadically, it's a good bet that the gas jet that feeds the burner is partially clogged with dirt or rust.

On the other hand, a burner that shows flame gaps along its length during normal operation suggests that some of the gas ports are clogged. If you see a burner whose flame lifts off its ports, you can bet that the air mixture on that burner is too rich. Conversely, a flame that burns orange and lazy (waving from side to side) means that there's too little air in the mix. Before attempting to regulate the air intake, the burner assembly should be cleaned.

Cleaning the burner assembly

To begin, shut off the electrical disconnect switch so that the furnace

can't come on while you're working on it. If your furnace doesn't have a dedicated disconnect switch, usually mounted on the side of the cabinet, turn the gas control from ON to PILOT. Then, vacuum the inside of the cabinet to remove all dust and cobwebs that could cause trouble later (Fig. 1).

Next, check the burner type and mounting mechanism. Most conventional burners fall into two general categories. One is the ribbon-type burner trough that we're showing in the illustrations. The other burner assembly is made of cast iron and has two rows of round ports at the top of each burner.

For the maintenance procedures that we're describing, the difference between these two designs is negligible. (If you find a third type consisting of several steel burner tubes welded together, you'll have to call a service technician. This type must be disconnected from the control valve and pulled out in one piece.)

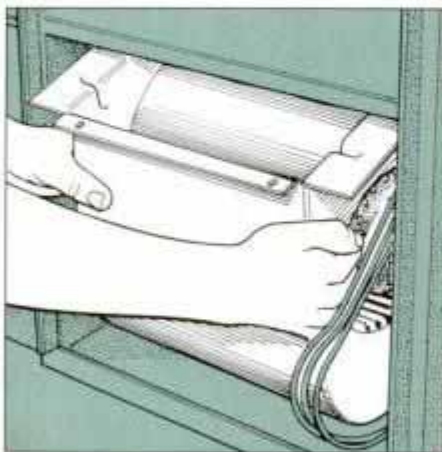
In most cases, each burner is at-

tached to a gas feed pipe and is served by a removable jet that delivers the right amount of gas to the burner. Each burner also has a provision for air-intake adjustment at its outer end. This allows you to adjust the air/gas mixture for most efficient burning.

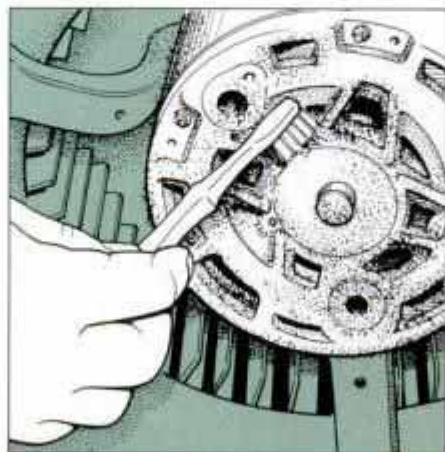
To take a burner out for cleaning, first remove the securing clip that holds the burner to the feed pipe (Fig. 2). Then, carefully lift up the burner and slide it out of its seat below the heat exchanger cell (Fig. 3). Once it's removed, turn it so that the open end faces down, and tap the burner repeatedly on the floor or some other hard surface to dislodge rust particles inside (Fig. 4).

If you've noticed gaps in the flames on that burner, poke a thin wire or small Allen wrench into each of the burner openings. Then, tap the burner on the floor again. Finally, clean the openings in the crossover member with a thin-bladed knife (Fig. 5), and vacuum the entire burner.

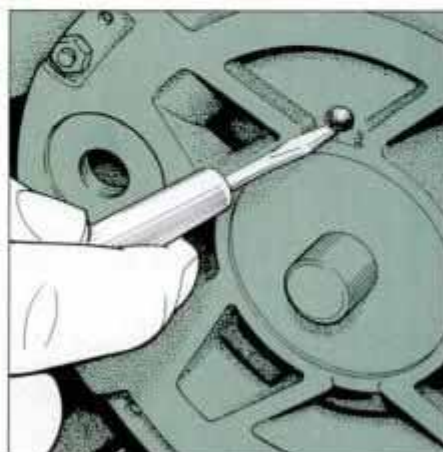
If one of the burners was not work-



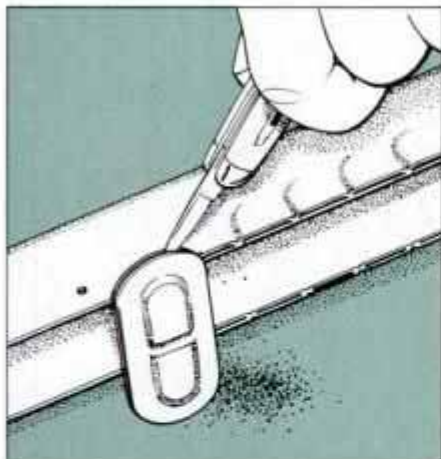
8 Most blower units are designed for easy service. To remove the unit, loosen the retaining screws and slide it out.



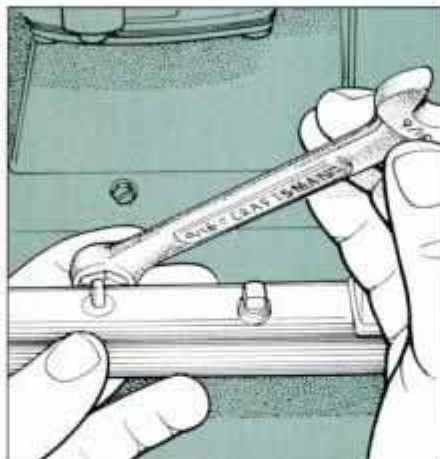
9 Use an old toothbrush to remove greasy dust accumulations from the motor housing and blower fan louvers.



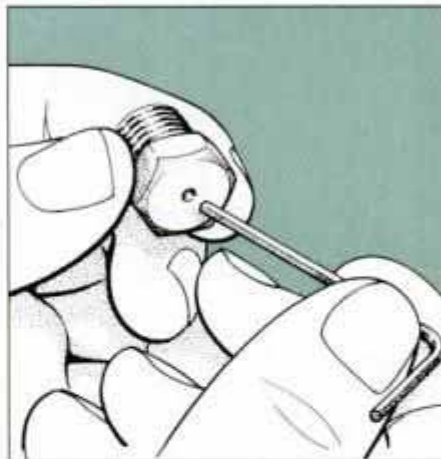
10 If the motor bearing oil ports are covered with rubber plugs, pry off the plugs with a small screwdriver or knife.



5 Slide a small knife or stiff wire through the crossover member to clear away rust particles and dirt that affect ignition.



6 Use a box-end wrench to remove a gas jet. Because the jet is brass, it loosens easily. Don't overtighten when reinstalling.



7 After removing a gas jet from the feed pipe, use a piece of wire or small Allen wrench to unclog the jet orifice.

ing, or flashed on only occasionally, you'll have to clean the gas jet serving that burner. It's usually best to back the entire jet from its threads in the feed pipe and clean it where you can see what you're doing (Fig. 6). Again, a thin wire or small Allen wrench works well in poking dirt or rust accumulation from the orifice (Fig. 7). When the jet is cleared, thread it back into its opening and tighten with a wrench until it feels snug. No joint compound is needed.

To replace the burner, simply slide it back in position and replace the clip that holds it to the feed pipe. Then, remove each subsequent burner, and repeat the process.

Servicing the blower

The blower assembly is comprised of a motor and a squirrel-cage-type fan that circulates air through the ductwork of the home heating system. Servicing a furnace blower is easier than you might think, partly because manufacturers have de-

signed them for easy access. Some blower housings are mounted on sliding tracks, while others tip down and out. At most, you'll need to undo a couple of hexhead screws and an electrical connection.

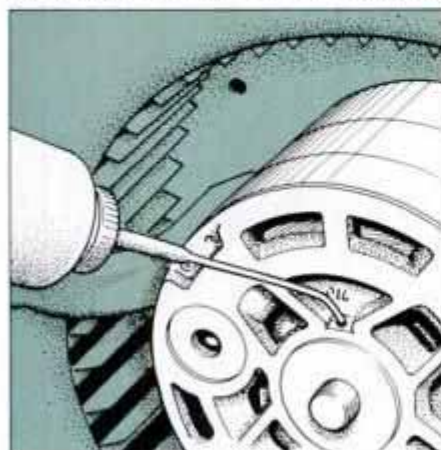
Begin by removing the blower compartment access panel. Remove the retaining screws, and pull the fan housing out into your workspace (Fig. 8). The unit's electrical connection will likely be in the form of a simple 2-prong plug. Unplug it to give yourself some room to maneuver.

Pulling the blower unit will reveal a good deal of greasy dust on the motor's bell housing and on the louvers of the fan. Both accumulations are potentially troublesome because they cause the motor to run hot and the fan to move less air. Brush the dust loose with an old toothbrush (Fig. 9), and then vacuum the entire assembly with a bristle attachment. It's also possible to remove the squirrel cage and hose it down with water, but this is seldom necessary.

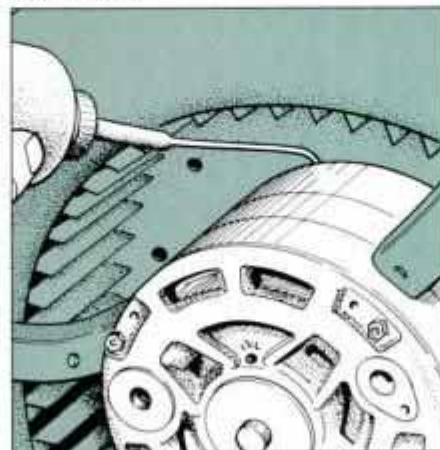
With the blower unit clean, check for oil ports on the motor housing that facilitate lubrication of the motor bearings. These are found at each end of the shaft, and are either flip-cap ports or holes covered with small rubber plugs. A third possibility is sealed bearings that are lubricated for life and require no maintenance. Check carefully to make sure that your motor has no provisions for lubrication before dismissing it as a sealed-bearing type.

If you find a rubber plug at each end, pry them out with a screwdriver (Fig. 10), and give each opening a squirt of turbine oil (Fig. 11). Turbine oil is more heat resistant than other light lubricants, and can be found at most appliance outlets. The turbine oil bottle has a long stem that allows you to reach the rear bearing without removing the motor (Fig. 12).

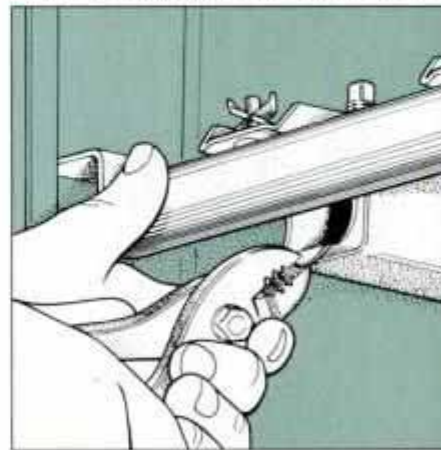
After lubricating, replace the rubber plugs and slide the blower unit back in place. If your unit has flip-cap oil ports, simply lift the caps to oil the



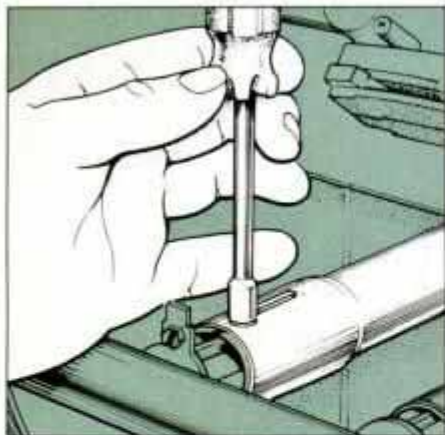
11 Use turbine oil to lubricate the motor bearings. Permanently lubricated motors have sealed bearings and no oil ports.



12 The long stem of the turbine oil bottle will allow you to reach rear shaft bearings without removing the motor.



13 To alter air/gas mix on burner with internal slide adjuster, pull or push the slide to increase or decrease opening.

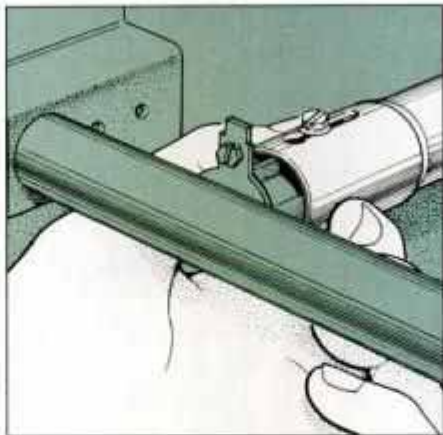


14 Adjust air/gas mixture on exterior-sleeve-type burner by first loosening set-screw that locks adjustment in place.

bearings. When you're done, plug in the electrical connection, slide the assembly back in place and reinstall the hexhead screws. Finally, replace the lower access panel and restore power to the furnace by turning on the electrical disconnect switch.

Adjusting the burners

Air adjustments for gas burners come in several designs, most of which are



15 With screw loosened, slide sleeve toward feed pipe to decrease air, or away to increase air. Then, tighten screw.

based on either sliding sleeves or rotating end caps. By sliding the sleeves in and out, or rotating the caps, you'll align their openings—to a greater or lesser degree—with openings on the burner (Figs. 13, 14, 15 and 16). In this way, the amount of air available to the burner is regulated.

To adjust the air/gas mixture, first turn up the thermostat so that the furnace starts. With the burners in oper-



16 Set rotating-cap air-adjustment mechanism by turning cap to increase or decrease size of air-intake opening.

ation, check for abnormal flames. If the flames burn blue but lift off the burner, reduce the amount of air intake until the flames settle down. If you see an orange, lazy flame, increase the amount of air intake. Continue to adjust each burner until you see a steady blue ribbon of flame above each. Then, replace the access panel, and settle down for a warm and comfortable winter. **FM**

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**HOME IMPROVEMENT
NEW PRODUCTS**

Improve the look and feel of your home.

BY ROY BERENDSOHN, Assistant Home Improvement Editor



Fresh Air

Trion says its Whole House Electronic Air Cleaner takes only minutes to install and is easy to maintain. The air cleaner is about 1 in. thick and replaces a standard furnace filter. First, it intercepts airborne particles with a pre-cleaner filter. Then, it imparts a positive electrical charge to dust particles and traps them in an ionizer-collector. Remaining particles are trapped by an after-filter. It costs about \$130 at home centers and hardware stores. For more information, contact Trion, Inc., 101 McNeill Rd., P.O. Box 760, Sanford, NC 27331.



Remote Location

To add flexibility to your low-voltage outdoor lighting, Malibu has introduced a remote ON/OFF switch, which costs about \$11. Formerly, the only way to separately control low-voltage outdoor lighting components was to walk back to the control box and turn off a branch circuit. Now, however, you wire the switch into a convenient location on the branch circuit, and a flip of the switch allows you to turn it on and off without walking back to the control box. The switch is sold at hardware stores and home centers. For more information, write Intermatic, Inc., Intermatic Plaza, Spring Grove, IL 60081.

Cap It Off

The stainless-steel Vacu-Stack chimney cap is designed to work with double- and triple-wall steel chimneys. Its manufacturer says it prevents wind-induced downdraft while circulating cooling air through the chimney's walls. The cap features a self-adjusting fastening mechanism. To attach the Vacu-Stack, simply squeeze its base and press down into the chimney's top. It's available in a range of sizes from 6 in. dia. (about \$87) to 10 in. dia. (\$145). For information, contact Improved Consumer Products, Inc., P.O. Box 1264, Towne St., Attleboro Falls, MA 02763.



**Contemporary
Can Opener**

This built-in can opener stays handy, yet out of the way, to keep the counter clear. It installs between the studs and comes with either a high-gloss white or black finish. Its magnet pops off its support for easy cleaning and for replacing the blade. It costs about \$100. Write Iron-A-Way, Inc., 220 W. Jackson, Morton, IL 61550.

A Storage Facility With Mobility

Rubbermaid's Pop-Up storage boxes not only store your tools and other household items, but are themselves easy to store—they collapse to a height of about 2½ in. When they're open, the plastic boxes measure 9½ in. high × 13½ in. wide × 18¾ in. long. A hand grip on each side makes them easy to carry. They come in a

variety of colors, and cost about \$11 at hardware stores and home centers.

For more information, write Rubbermaid, Inc., 1147 Akron Rd., Wooster, OH 44691.





Fan Out

Ventilation can be a do-it-yourself job with this clever device called the tube fan. It can vent moist air or cooking fumes, or increase airflow to make a room warmer or cooler. It simply mounts in any position on the house's framing, according to its manufacturer. Then, just wire the fan to a wall switch and run flexible duct to where

you want the fan to exhaust. Its fan blade spins on a sealed, permanently lubricated ball bearing. A 4-in.-dia. kit (about \$190) and a 6-in.-dia. kit (about \$200) are sold at hardware stores and home centers. The kits include the fan, mounting bracket and ceiling grille. For more information, contact Deflecto Corp., 7035 E. 86th St., Indianapolis, IN 46250.

Enlightening

If you're installing new lights, you may want to consider Sylvania's compact fluorescent bulb (about \$20 at hardware and department stores). It produces about the same amount of illumination as a 75-watt bulb, but has a life span equal to about 13 bulbs, according to the company. It also will save consumers about \$45 in electricity costs over its life, Sylvania estimates. For more information, write Sylvania Lighting Division, 100 Endicott St., Danvers, MA 01923.



Damage Control

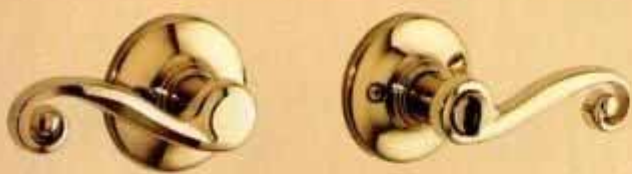
Abatron has two ways to save rotted wood, for jobs when it's better to repair wood than replace it. Liquid Wood is a consolidant that you pour and brush into rotted wood that's porous, but not ravaged. Wood Epox, is a nonshrinking adhesive paste applied with a putty knife to rebuild rot-ravaged timbers. Both are epoxy-based 2-component materials, a resin and a hardener, mixed in a 1-to-1 proportion. A 5-pint kit of Liquid Wood, Wood Epox and solvent is about \$55 (shipping extra). Both are sold through Abatron, 33 Center Dr., Gilberts, IL 60136.



Phone In

Phonex lets you place a phone at any power outlet because it uses the house's wiring to transmit phone communications. To ensure privacy, says the Heath Co., its signal never reaches beyond the nearest power transformer. Plug the base unit into a 110-volt outlet, then plug the extension into another outlet. You can plug a phone into the base unit or the extension, or keep a phone at both. It can be used with modems and answering machines. The Phonex (base and extension) costs \$130 (extra extensions cost \$60) through the Heath Home Automation Catalog, P.O. Box 8589, Benton Harbor, MI 49022.

tion into another outlet. You can plug a phone into the base unit or the extension, or keep a phone at both. It can be used with modems and answering machines. The Phonex (base and extension) costs \$130 (extra extensions cost \$60) through the Heath Home Automation Catalog, P.O. Box 8589, Benton Harbor, MI 49022.



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Fall Painting

Campbell Hausfeld says its new House Painter airless sprayer takes 5 minutes to set up and can spread oil or latex paint and stains. To simplify cleanup, it feeds paint right out of a 1- or 5-gallon can. Powered by a 1/2-hp high-pressure piston pump concealed by a removable cover, it comes with a 25-ft.-long hose, a built-in filter and a reversible anticlog spray tip. The company says the system is self-cleaning. It costs about \$300 at hardware stores and home centers. Write Campbell Hausfeld, 100 Production Dr., Harrison, OH 45030.



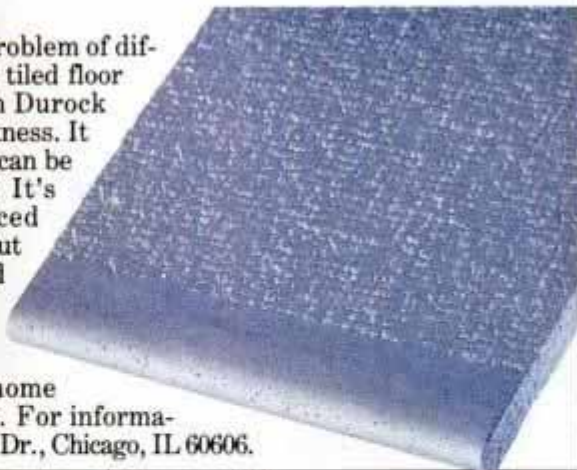
Like Magic

If you are replacing a kitchen cabinet, medicine cabinet, or constructing tool storage in your next remodeling project, consider a magnetic catch to keep out curious children. With the catch screwed behind the door, there is no exposed hardware to show how the door is opened. Press the magnetic key against the door to unlock the catch. Each magnetic catch costs about \$8, and the key is also \$8, from the Woodworkers' Store, 21801 Industrial Blvd., Rogers, MN 55374.

On The Threshold

USG addresses the vexing problem of different floor heights, where a tiled floor meets another surface, with Durock underlayment in a 5/16 in. thickness. It comes in 4-ft.-sq. sheets and can be used for tiled countertops. It's made of fiberglass-reinforced portland cement and can be cut with a utility knife. Spread mastic or latex mortar on the subfloor, then attach the Durock with nails or screws.

A sheet costs about \$20 at home centers and tile distributors. For information, write USG, 101 S. Wacker Dr., Chicago, IL 60606.



Two Of A Kind

Nevamar Fountainhead solid surfacing material can be matched with the door and drawer pulls on kitchen cabinets. The pulls in the FH (Fountainhead) Coordinates collection come in six colors. The installed cost of a 1/2-in.-thick Fountainhead countertop is about \$100 to \$140 per sq. ft. Matching pulls from FH Coordinates cost from \$3.50 to \$10 each. Both are sold through kitchen and bath dealers. Write Nevamar Corp., 8339 Telegraph Rd., Odenton, MD 21113.

Cover Up

Cover cracked plaster and dingy wallpaper with this textured material made from woodchips and recycled paper. Apply it with wallpaper paste, then you can paint it with interior latex paint. It comes in four textures, from fine to coarse. A roll costs about \$35, and most rooms can be covered for about \$100, says its manufacturer. It's sold at hardware stores and home centers. Write to Coverage, Inc., P.O. Box 8498, Warwick, RI 02888.



Beauty Treatment

Garages are generally ugly and dirty places, but you can turn them into storage areas, equal to the rest of your home with these cabinets. Designed specifically for garages, they are covered with melamine for neatness and easy cleaning. They come in a variety of sizes and configurations, such as double-wall units for storing

heavy objects and small overhead units for light storage. The system also includes drawers, workbenches and Peg-Board. Each assembly is custom made to the dimensions supplied to the manufacturer. They are shipped ready to assemble. A single-car garage outfitted as shown costs about \$2500. Contact Gourmet Garages by phone at (800) 233-2811. **PM**





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APPLIANCE CLINIC

BY STEVE TOTH,
Contributing Editor

Dishwasher Leaks

I have an insidious water leak in my model No. HDAH465-01BK, serial No. VM622407X Hotpoint dishwasher. Water drips from the bottom of the control panel at the top of the machine during the wash cycles. I removed the front panel and found water coming out of a plastic damper. What can you suggest?

ROBERT STEWART
PAINSEVILLE, OH

Sounds as if the vent damper is not seating properly. The vent opens during the dry cycle to let out steam. If it isn't working, water can leak out of some pretty unusual places.

First, disconnect the power to the dishwasher. Then remove the outer door panel and the control panel. The screws for both are located along the door's inside edge.

Next, remove the screws that hold the plastic vent housing to the inner door panel. Remove the entire housing and inspect the flat edges of the part that pulls against the inside surface of the door. Place a straightedge on the flat edge of the part, and look for a bow in the plastic housing. If it is bowed, replace it. Also check the damper door to be sure it's straight. Last, check the condition of the sealing gasket.

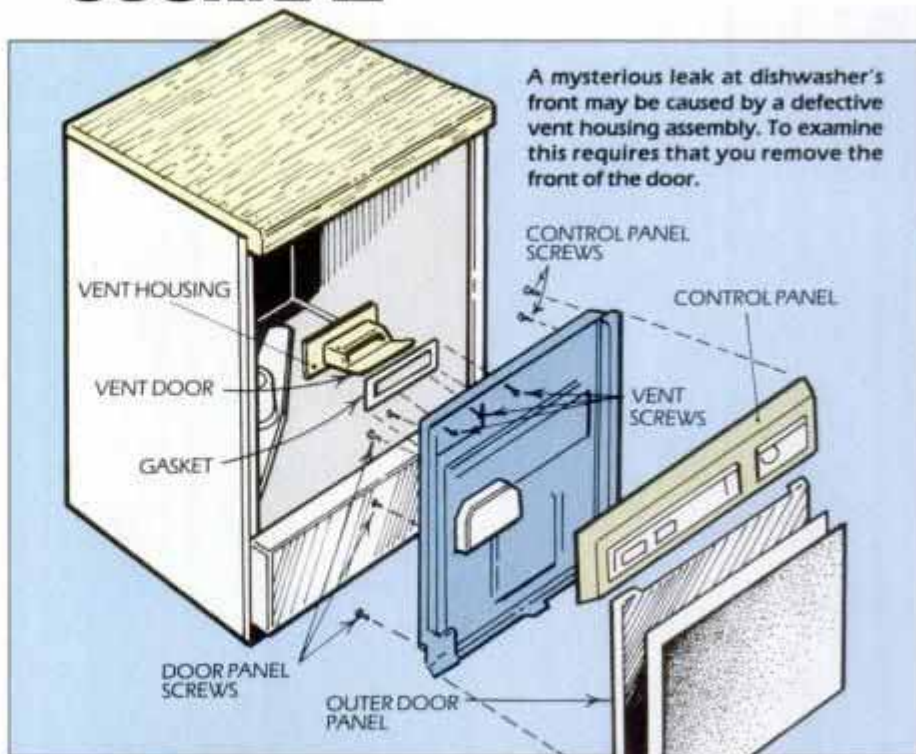
Each of these is available from GE parts distributors, or they can be ordered from the GE Hotpoint National Parts Center, (800) 822-7255. The vent housing (part No. WD24X5086) costs about \$13; the vent cover door (part No. WD24X5071) costs about \$14; and the door vent gasket (part No. WD8X5098) costs about \$4.

Icemaker Revisited

In the February issue, we reported that a replacement icemaker and parts were no longer available for Frigidaire's refrigerator-freezer, model No. FPCI-206T8. As it turns out, replacement parts for that refrigerator's IMK-8 icemaker are available. However, an entire replacement icemaker is no longer available.

Direct-Drive Driven

I have a Kenmore automatic washing machine, direct-drive, model No.



A mysterious leak at dishwasher's front may be caused by a defective vent housing assembly. To examine this requires that you remove the front of the door.

110.81362100, serial No. C33408516. There seems to be no repair information on a direct-drive Sears machine. Where can I find such information?

ALBERT MILLER
RIO RANCHO, NM

Stop by your local Sears repair parts center to order the "Do-It-Yourself Repair Manual For Kenmore Direct-Drive Washing Machines." Order it as a repair part from Division 26, Source 110, part No. Lit 4314044. It costs about \$8.

Digital Clock Quit

Our Dacor model F200 self-cleaning convertible range was installed in 1985. The clock started to make noise and within a few days quit working. I cannot find parts to fix the clock. Is Dacor out of business?

BARRY SCHIMMACK
FAIRBANKS, AK

Dacor is alive and well. Its address is: Distinctive Appliance Corp., 950 S. Raymond Ave., Pasadena, CA 91109-7202; (800) 772-7778.

A replacement clock for your range is available under part No. 82142. Your nearest authorized parts distributor is Appliance Service Station, 12546 N. Aurora Ave., Seattle, WA 98133; (800) 343-5950.

Can't Find Company

I have a Thermar Electric Tankless Water Heater 9KW super power pack that needs repair. I sent a letter to the company in Trumbull, Connecticut,

which came back stamped, "Moved, Not Forwardable." I'd like to know if the company is still in business and how I can get it repaired.

GILESTALLMAN
CHIPPEWA FALLS, WI

The Thermar Company has gone out of business, annulling the warranty in the process. However, Enviro Therm (5680 S. 300 West, Salt Lake City, UT 84107; (801) 262-8833) can repair your unit.

Pack up your heater along with a note stating your name, address and phone number, and enclose a check for \$30 to cover the service charge to diagnose your heater. Send the package to Thermar via United Parcel Service.

After the unit is tested, the company will call you or send you a letter with the cost of the repair. If you need repair parts for your heater, they can be purchased either from this company or from Myson, Inc., P.O. Box 7789, Fredricksburg, VA 22404; (703) 371-4331.

Either one of these companies can troubleshoot a problem if you're fixing the unit yourself. Or, they can help your plumber or electrician if they need information over the phone.

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

HOME IMPROVEMENT SEVEN HOME HINTS

BY GARY BRANSON
PM Illustrations by
George Retseck

1 Fixing Broken Veneer

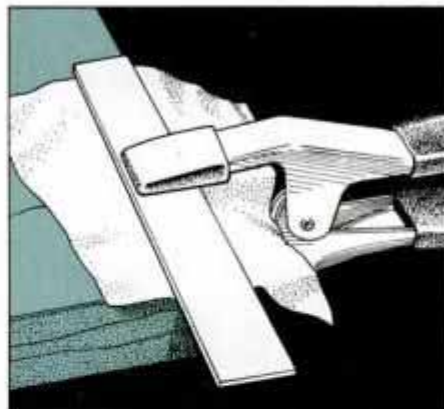
If you've ever had to trim the bottom of a hollow-core door so that it passes over a new floor or carpeting, you know how easy it is to damage the surface veneers while cutting. Of course, the best way to handle the job is to first score the cutline with a sharp utility knife, guided by a straight-edge. However, if the worst happens and you break away or loosen some of the surface veneer, you can repair the area by following a few simple steps.

To fix the splintered area, you'll need to first lift the broken wood away from the door with a putty knife, and then apply glue to resecure the veneer. Use a small tube of white carpenter's glue, or buy a glue injector with a needle applicator at a wall-covering store. The needle applicator will let you reach well under the veneer without damaging any delicate slivers of wood. After applying the glue, clamp the area until the glue dries. Use a strip of wood as a clamping pad to distribute the pressure evenly, and cover the veneer with a piece of scrap plastic sheeting to prevent the wood strip from becoming glued to the door.

When the glue has dried, remove



1A Use a putty knife to carefully lift any loose veneer around the damaged area. Apply white glue to reattach the veneer.



1B Lay plastic sheeting over the repair and use a wood strip to spread clamping pressure. Leave clamped until glue dries.



1C After removing clamp, use a putty knife to spread latex patching compound. Avoid spreading beyond damaged area.



1D Carefully apply a matching stain to the repaired area so it blends with the rest of the door. Then apply varnish to area.

the clamp and apply a coat of latex wood patcher. The latex patcher shrinks a bit when it dries so you may need to repeat this process once or twice to achieve a level surface. Avoid spreading the patcher beyond the repaired area. When the latex patcher is dry, sand with fine sandpaper. Use a sanding block to ensure that the surface stays flat. Check the job for smoothness by gently sliding your

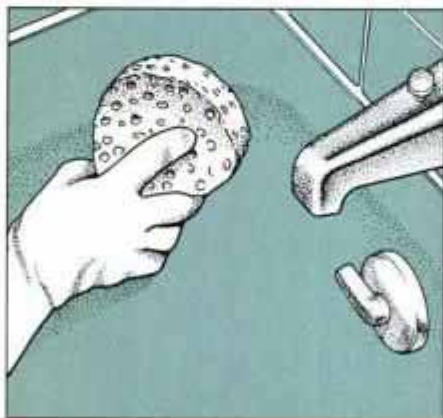
hand across the surface.

If the door was originally stained and varnished, buy a stain that matches the original color. If you have a scrap piece of the veneer, bring it to the store to help make an accurate color match. Apply the stain and wipe it with a soft cloth to blend it with the existing finish. After the stain has dried, apply a finish coat of varnish to the area.

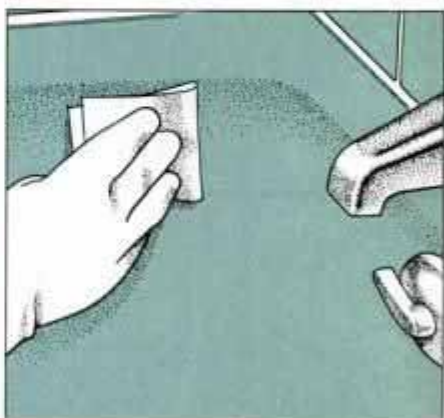
2 Bathtub Refinishing

Replacing a bathtub can be a messy and expensive job. That's one reason why more folks are turning to bathtub refinishing. Depending on the color of the tub and where you live, though, a professional epoxy resurfacing job could cost between \$200 and \$250. On the other hand, do-it-yourself refinishing kits cost about \$75. While these kits can be made to work, many people report a high failure rate. The problem lies in getting a good bond between the new epoxy coating and the old tub finish.

To get the best bond, you must get



2A Wash the tub thoroughly with a sponge or brush, using a strong solution of TSP. After several washings, rinse the tub.



2B After rinsing, roughen the surface by sanding with 80-grit wet/dry paper to remove the glaze from the porcelain.

the bathtub as clean as possible. The pros do the job by giving the tub a strong bath with industrial-strength acid. You can, however, get fairly good results by using a very strong solution of TSP (trisodium phosphate) available at paint dealers and home centers. Follow the directions for mixing an extra-strength solution, or as recommended for removing paint. Wear eye protection and rubber gloves when using this solution.

Clean the tub with the TSP solution and a scrub brush or sponge. Scrub the tub repeatedly—this is the most important step of the job. If you fail to get the surface clean, the epoxy will peel off. After washing the tub thor-

oughly, rinse it with clear water.

The next step is to wet-sand the surface with 80-grit wet/dry paper. Again, this must be a complete job—or the new finish may not adhere. The final step is to apply the epoxy. This comes in a resurfacing kit that contains the necessary tools—rollers and brushes—plus the epoxy finish and instructions.

Because professionals use heat to cure their epoxy finishes, they estimate that the new surface will last for up to seven years. With careful cleaning and sanding, a homeowner should get at least five years from a refinished tub before the process has to be repeated.



2C Mix the epoxy finish according to manufacturer's instructions. Use a brush and rollers supplied in the kit to apply epoxy.

3 Drying A Patch

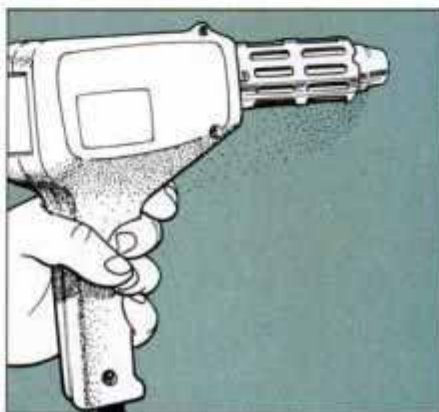
When decorating, waiting for plaster, drywall or patching compound to dry can be a frustration. Here are a few tips for speeding up the process.

First, choose your patching materials wisely. Compounds with a latex base will usually dry within a few hours at most. Patch plaster sets quickly, but takes longer to dry. If you use patch plaster to fill deep holes, you can use drywall compound for a smooth topcoat. Very small holes filled with Spackle will be dry enough for priming the same day.

For extensive repairs, use a quick-

set drywall compound such as Sta-Smooth or Durabond. These will set in as little as 45 minutes. Fast-setting compounds are harder to work with, however. Mix only small amounts at a time, and use a plastic pail for mixing. When the job is done, allow the waste to harden in the pail, and then flex the sides to break it loose. Keep your tools clean, and do not pour compound or wash water down your drains where it can set and harden in the pipes.

Finally, use warm water to hasten drying, or force dry the patch with a hair dryer or electric heat gun. With latex paint, you needn't wait until the patch is completely dry.



3A Using the hot air from an electric heat gun or hair dryer is one way to speed up drying time of wall patching compounds.

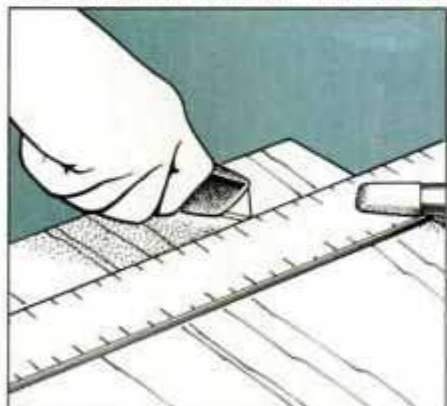
4 Shortening Hollow-Core Doors

If you ever try to shorten a hollow-core door, you may find yourself with a job you didn't bargain for. Because hollow-core doors have a hollow, honeycombed interior, cutting off more than 1 or 2 in. can completely remove the structural member at one end.

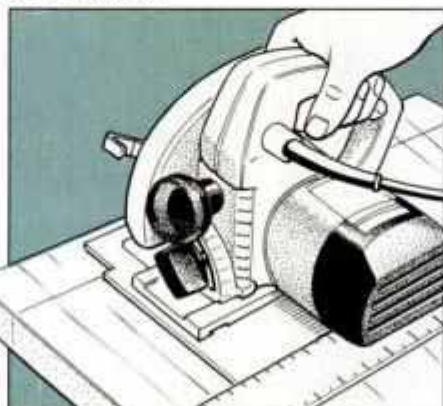
Not only does this leave the open core exposed, but the structural integrity of the door is affected.

To do the job, first mark the end to be cut. If you're trimming the door to suit a raised floor or new carpeting, this will always be the bottom. Then, remove the door by driving out the hinge pins with a screwdriver and hammer. Place the door flat on a pair of sawhorses.

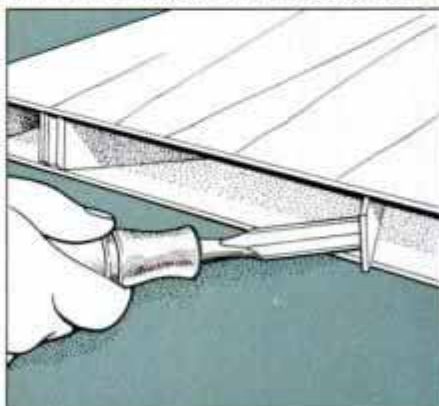
Use a straightedge to mark the cut-line on the door. Then, clamp the straightedge to the door and cut along the line with a sharp utility knife. Cut completely through the veneer to help prevent the veneer from splintering when you make the cut. Use a square to carry the line to the opposite face, and score the veneer on this side as well. Using a sharp blade in your circular saw, cut just to the outside of the



4A Clamp a straightedge to the door at the cutoff line. Then use a sharp utility knife to cut through the veneer.



4B Cut to the line with a sharp circular saw. Clamp a straightedge in place to accurately guide the saw along the scored line.



4C If you've cut into the door's hollow core, use a chisel to remove or push back the braces from inside the door cavity.

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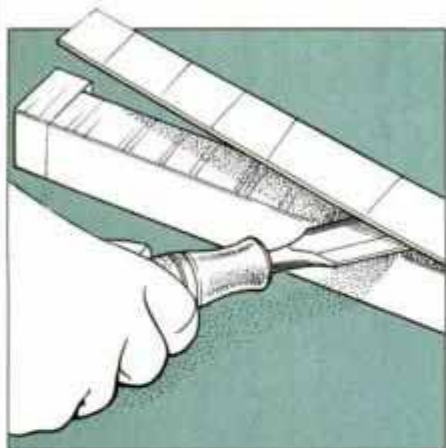


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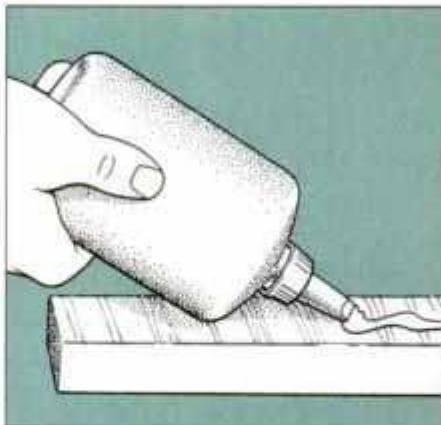




4D Use a sharp wood chisel to remove the veneer from both sides of the end-frame member. Scrape off all the old glue.

scored line. It's best to use a straight-edge to guide your saw precisely along the line, and adjust the blade so it just protrudes through the opposite face of the door.

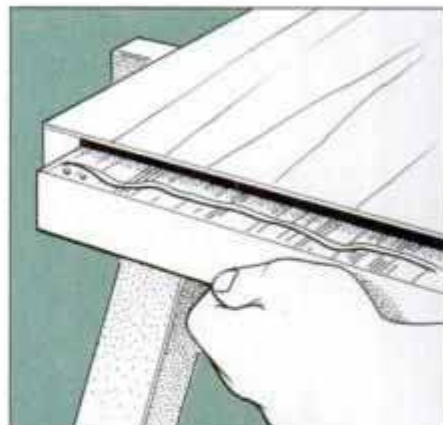
If you've cut into the hollow core of the door, you must replace the end frame member that you've cut away. First, reach into the open end of the door and push back or cut away the cardboard braces that you'll find.



4E After the veneer has been removed and the end-frame member is cut to length, apply carpenter's glue to both sides.

Then, use a sharp chisel to strip the veneer from the frame on the waste piece. Apply carpenter's glue to both sides of the frame. Gently pry apart the veneers on the door, and insert the frame into the hollow core.

Align the edge of the frame so it's flush with the veneer face edges. If you're customizing an existing door that's already painted or varnished, wipe away the excess glue with a



4F Insert the frame piece into the door cavity. Align it flush with door end, clamp until glue dries, and remove excess glue.

damp cloth. If it's an unfinished door, wait until the glue begins to set, and then peel it away with a sharp chisel. Clamp until the glue dries. Use at least three clamps with wooden strips placed between the clamps and the door to evenly distribute the pressure. After the glue has dried, remove the clamps and ease all sharp corners by light sanding with 120-grit sandpaper.

5 Hollow-Wall Hangers

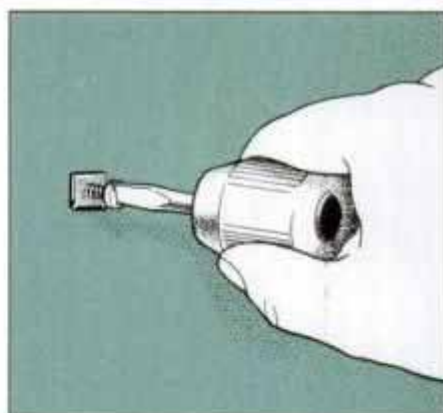
If you've ever tried to hang a rack or picture on a wall, you know there are only certain spots that hold a screw or nail—right over the studs that support the wall. Anywhere else requires a special fastener that grips the wallboard rather than the framing underneath. You'll find many types of hollow-wall fasteners at your hardware store. Most utilize a clamping mechanism that locks the unit to the wall and a screw for securing whatever it is you'd like to hang.

One type of fastener is called a Wall Grabber. Unlike some other designs, this fastener can be installed with only a hammer and screwdriver—no drill is required. And, if you ever decide to remove the fastener, you simply take out the screw, pull the base from the wall, and fill the remaining small hole with patching compound.

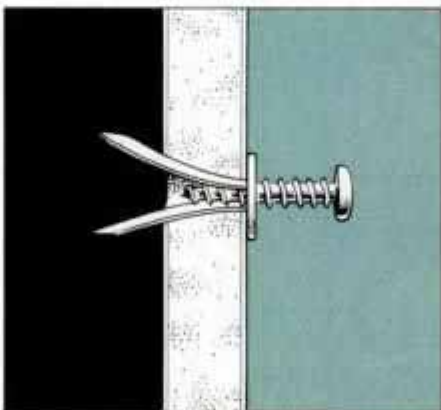
To install a Wall Grabber, first mark its location on the wall. Then, use a hammer to drive the pointed end of the base through the wallboard. Drive the base in until it's flush with the wallboard surface, insert the screw and tighten it. As the screw is driven, it spreads the two spring-steel legs of the fastener's base. The legs lock the fastener by tightly gripping against the back of the wallboard.



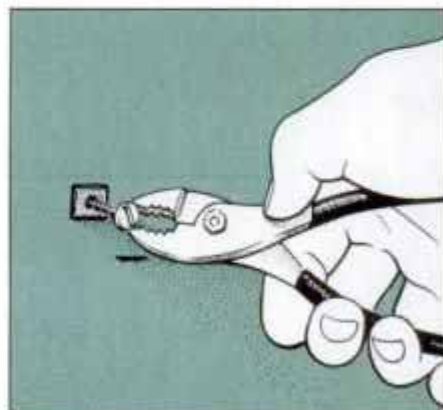
5A Place the pointed tip of the Wall Grabber against the wall. Then, drive the fastener in until it's flush with the surface.



5B Use a slot-head screwdriver to drive the fastener's screw into the base. Turn the screw clockwise until it's tight.



5C Section view of the unit shows how the two spring-steel legs of the unit spread out to grip the back of the wallboard.



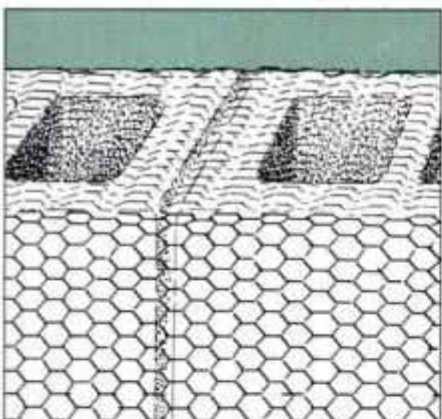
5D To remove the hanger, first back off the screw to close the steel legs. Then, use pliers to pull the hanger from the wall.

6 Concrete Retaining Wall Fix

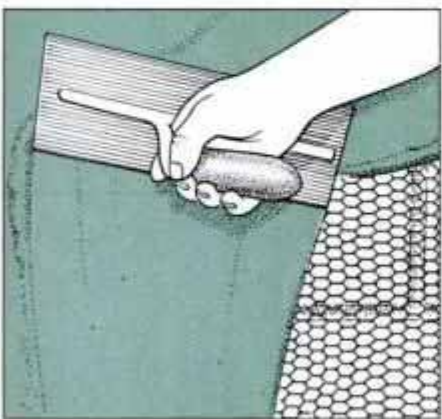
If you have a retaining wall made of concrete block, you can improve its appearance with a coat of stucco. If the block is new and clean, you can trowel on the stucco right away. Otherwise, apply a coat of concrete bond-er to the wall first. Your local concrete products dealer can recommend



6A If the concrete block wall is dirty or old, apply a coat of concrete bond-er before applying the stucco basecoat.



6B For damaged but straight concrete block walls, attach a layer of wire lath using concrete nails driven into bored holes.



6C Trowel base stucco coat over entire wall. Let basecoat set, then apply one or more finish coats of stucco mix.

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If the wall is badly cracked, but still standing straight, apply a layer of wire lath over the entire wall to tie the blocks together, and ensure that the stucco will adhere.

Secure the wire lath with concrete nails driven into holes bored with a masonry bit. Be sure to space the nails about 12 in. apart.

Mix a stucco basecoat of one part portland cement, one part mason's cement and two parts fine sand. Trowel this coat onto a thickness of about 1/2 in., or enough to cover the wire lath if you're using it. With the basecoat dry, trowel on a coat of stucco mix. After applying the first cover stucco coat, use a trowel or rubber float to create a textured-stucco pattern.

7 Maintaining Storm Doors

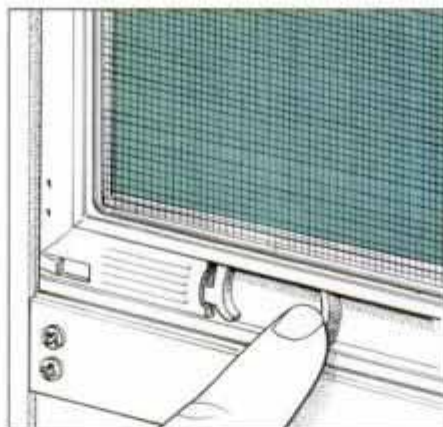
Maintenance on metal storm doors with their sliding windows and screens is often neglected—until things stop working properly. If you're having trouble opening and closing windows or screens, it's time to clean and lubricate the unit.

The first step is to check the sashes to be sure they're in the proper channels. If the retaining pegs at the sash top are in one channel, and the latch mechanism is in another channel, the window will bind if you try to slide it up. If it's not aligned, push in the latch buttons and withdraw the window

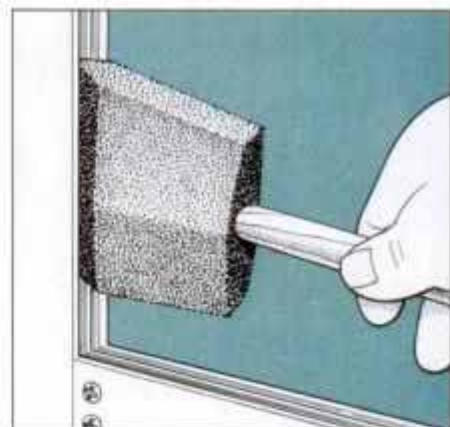
from the channel. Then, reinstall the window so it's aligned in one track.

To clean and lubricate the unit, remove the window and screen frames. Use a paintbrush or sponge paint applicator and mineral spirits to clean dirt and grit from the channels. Soak a clean cloth in mineral spirits and wipe the edge of the window and screen frames. Lubricate channels and sash edges with spray lubricant.

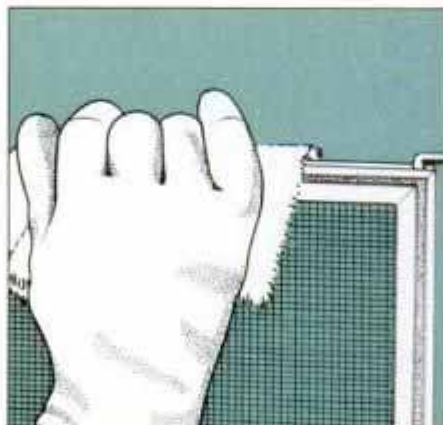
After you've cleaned all the channels, windows and screens, reinstall the components in the door frame. Make sure that the sashes are properly aligned and in the correct channels. Then, check that the windows and screens move freely. **PM**



7A To remove a sash, push the latch buttons on both sides of the frame inward. Pull out bottom and disengage top pegs.



7B To remove dirt in door frame, dip a brush or sponge paint applicator in mineral spirits, and clean the channels.



7C Wipe the frames of the windows and screens with a cloth soaked in mineral spirits to remove dirt and grime.



7D Lubricate the frames, latches and sash channels with a spray lubricant. Then, reinstall the sashes, and check operation.

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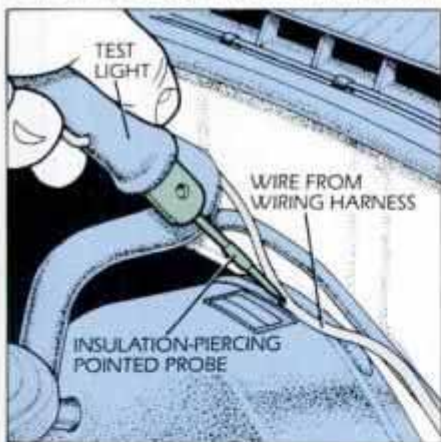
CAR CARE

MAINTENANCE BASICS

HOW TO USE A TEST LIGHT

BY DON CHAIKIN

- Although you can make a test light with wire and a bulb, you'll be better off buying one. When shopping, there are certain things to look for.
- Make sure you buy an automotive test light, not a household one. Automotive electrical systems are 12-volt, direct current (DC), while household electricity is 110/120-volt, alternating current (AC).
- One of the leads should be a long wire of at least 14-gauge thickness, with a heavy alligator clip at the end so you can easily reach the area where



Use the sharp probe to pierce the plastic insulation of the wires.

you need to work.

- The other lead should be a pointed metal probe that can cleanly pierce the insulation of wires you need to test and probe into wire connectors.

Test lights work on a simple idea: By connecting the light to both ground and to a power source, you complete an electrical circuit, and the bulb in the test light glows. If the bulb doesn't light up, there's a problem.

- Before attempting to trace any problems, always check that the light is working. Connect the light to your car's charged battery. If the light doesn't go on, change its bulb and/or check its leads.



If the electrical circuit is hot, then your connection tester's lamp will light up.

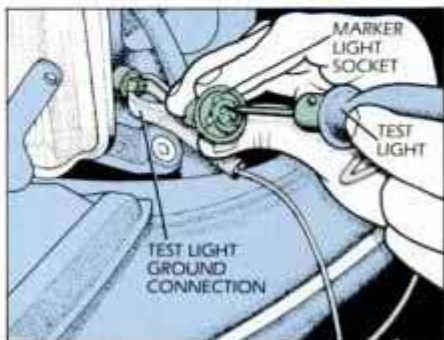
Whenever an electrical component stops working, first check its fuse. See your owner's manual for the location of the fuse panel, usually under the dash in a kick panel.

- Make sure the ignition and the switch for the suspect part are on.
- Connect the light to a good ground, such as a metal bolt or bracket.
- Probe both sides of the fuse with the test light. Modern, color-coded plastic spade fuses have small test holes.
- If only one side of the fuse illuminates the test light, the fuse is blown. If both sides light, the fuse is good.
- If the fuse is good, you can use the test light to see if the component itself is bad or if there's a bad connection or broken wire between the fuse and the component. Since at least one wire that goes to the component has to carry electricity to it, that wire will be "hot" when the switches are on.
- Ground the test light near the non-working light or accessory. With the test light's metal tip, probe the wire connector where it attaches to the

component. The light should go on in at least one connection. If not, there's a break in the circuit.

- Electric circuits need a ground connection to be complete. Use the test light to check these as well.

Connect the light to the component's ground wire or connection. Touch the light's probe to the battery's positive terminal, or another known "hot" source. If the light doesn't glow, the ground is bad. **FM**



Be sure the circuit you're testing is actually turned on at the switch.

HOW IT WORKS

RACK-AND-PINION STEERING

BY DON CHAIKIN

● While you may not think about it at all while you drive, each time you move your car's steering wheel, you set into motion a complex series of events. With each flick or twist of the wheel, considerable obstacles must be overcome just to get your car to change direction.

Given the weight of your car, its momentum and the tires' grip on the road, that's no small accomplishment. Turning the steering wheel also moves various gears, rods and links of the steering system to get those front wheels to react and to respond instantly.

Various steering systems have been used by vehicle makers since the beginning of automotive time, including worm and sector, worm and nut and the recirculating ball type still used on many larger cars and trucks.

The current system of choice is the rack and pinion. Since rack-and-pinion steering has relatively few parts compared to other systems, this system is lighter and more compact than others, both desirable traits for today's front-drive compact cars.

And that same simplicity of design results in direct action of the steering wheel on the front wheels, making the rack and pinion the choice of most sports cars. Unlike recirculating ball steering, rack-and-pinion steering has inherently low friction and very precise on-center feel.

The hip bone's connected to the...

At the other end of the steering shaft from the steering wheel inside the steering housing is a small gear called a pinion gear. Each movement of the steering wheel results in an equal simultaneous movement of the pinion. The pinion's teeth mesh with teeth cut in a bar, called a rack, inside a housing that they share. The housing runs from one side of your car to the other, between the front wheels.

The rack is basically a large gear that's been cut and flattened out, instead of being round like other gears. While the pinion and steering shaft are mounted so they can only rotate, the rack is free to slide back and forth in the housing. Each time you move the steering wheel, the pinion rotates

drive subcompact offers power-assisted rack-and-pinion steering.

The power to help steer comes from a hydraulic pump, driven by the engine, which pressurizes fluid inside the steering housing.

Seals around the rack, inside the housing, create chambers which separate the sides of the housing. The chambers are connected to the pump and each other by tubing.

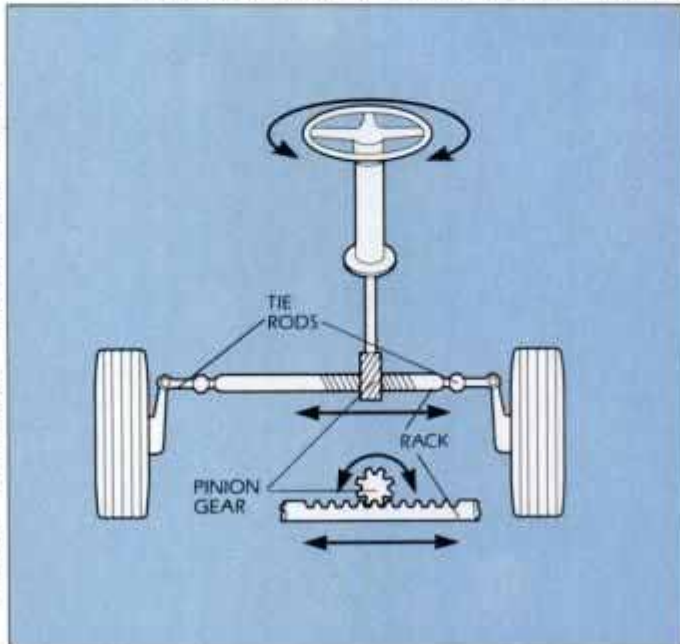
When you turn the steering wheel, the spool valve directs the fluid to one chamber or the other in the housing, to push on the rack, helping it move. The spool valve senses the amount of twist in the steering column—the more difficult to turn the wheel, the more hydraulic pressure it passes on to the rack.

As the steering effort eases, the spool valve closes enough to maintain the appropriate effort. A small torsion bar in the valve determines the amount of effort that's needed.

Some vehicles have systems that control the amount

of pressure, and therefore the level of power assist, based on the car's speed. That way, the steering can be "lighter" for maneuvers like parking, while still offering the good "feel" or feedback desirable for high-speed driving.

PM



Rack and pinion gears down steering motion by about 18 to 1.

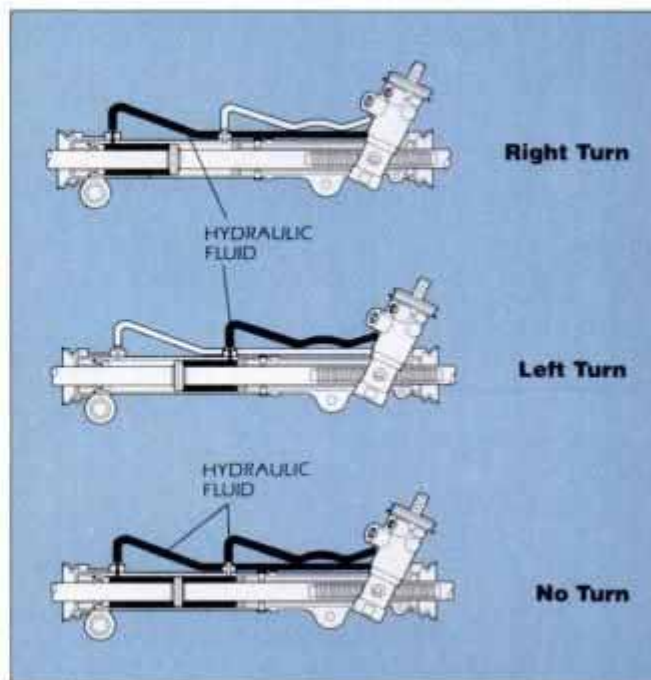
against the rack, forcing the rack back and forth.

The rack is connected to the front wheels by metal rods, called tie rods, which protrude from the ends of the housing. The ends of the tie rods are designed to allow the rods to move up and down with the front wheels as they hit bumps and potholes, without disturbing the steering rack.

So when you turn the steering wheel, the rack moves pulling one tie rod and pushing the other. The result is that the front wheels turn, steering the car.

Power please

While this simple and direct action from steering wheel to front wheels steers the car quickly, it requires a lot of muscle at the steering wheel. That's why even the most mundane front-



Hydraulic boost pressure is used to lower steering effort.

SATURDAY MECHANIC

HOW TO STORE YOUR CAR

BY DON CHAIKIN

● You've just received orders and you're going to be spending the next three years in South Korea. Or maybe this isn't a training exercise—it's what all your training has been about—you're going overseas with a couple hundred thousand of your closest friends to teach some Third World gangster that our military is second to none. Regardless of why you're shipping out and for how long, you just

know that your brand-new ZR-1 isn't going with you. You also know that you're definitely *not* going to leave the keys with your kid brother while you're gone.

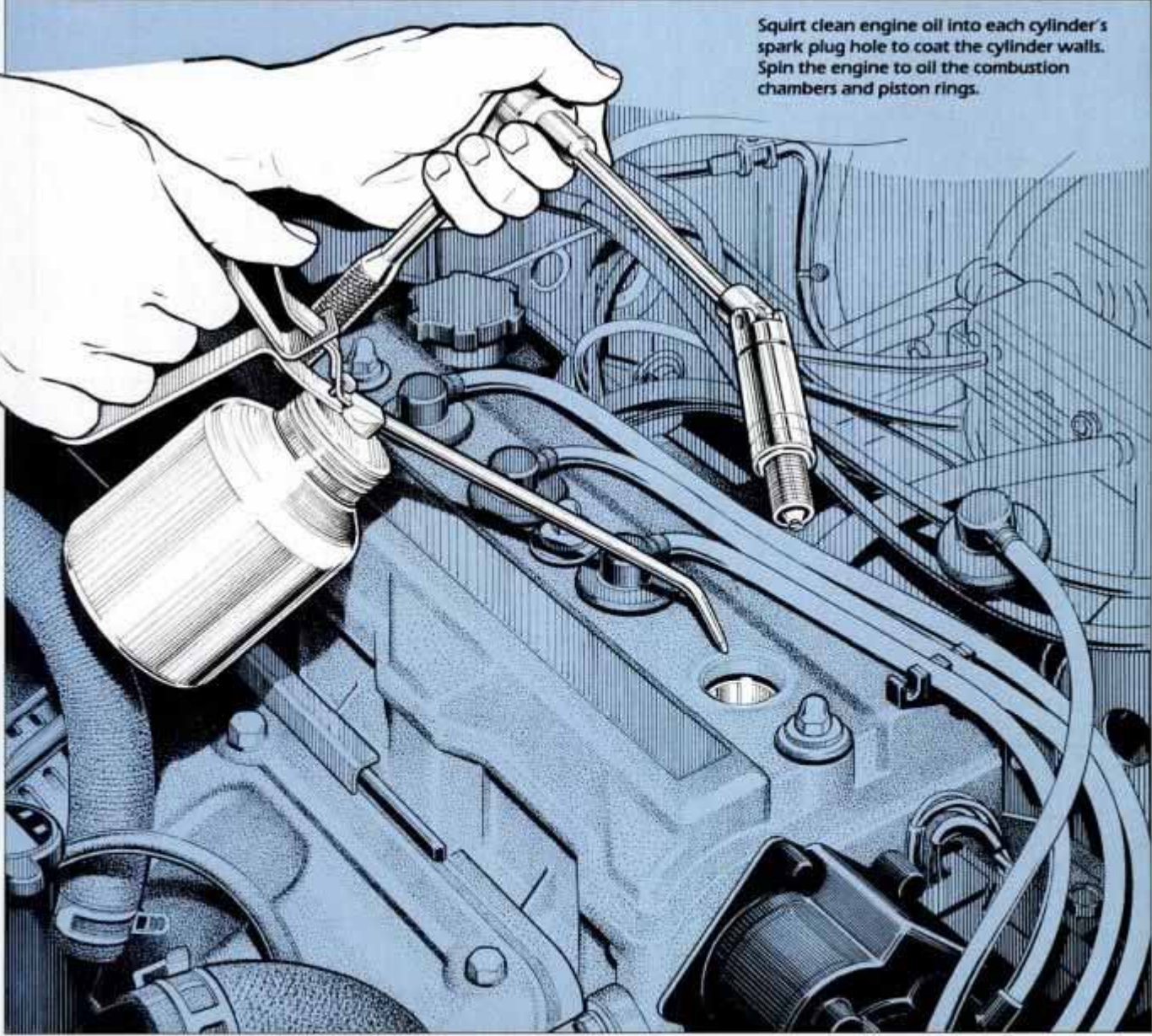
Whether you're going to put your new or like-new car, pickup truck or motorcycle in storage for a few months or a few years, you can help guarantee that it will be in the same primo condition when you take it out

of storage as it was when you put it in.

You'll also have a minimum of grief getting it back on the road.

Drive it before you park it

While you can easily coat various external surfaces to seal them from the ravages of moisture and exposure, short of totally disassembling your car, you can't quite as simply protect internal surfaces. But there are criti-



Squirt clean engine oil into each cylinder's spark plug hole to coat the cylinder walls. Spin the engine to oil the combustion chambers and piston rings.

CAR CARE

cal unseen areas that must be protected from corrosion, rust and the formation of varnishes and gums. Drive far enough and long enough to thoroughly warm up all of the vehicle's vital fluids—engine oil, transmission fluid, gear oil and engine coolant. Then, drive home and drain everything. Draining all the fluids while they're hot removes any corrosive moisture and sludge with them.

Naturally, replace the engine oil filter. Replace the fuel filter as well. Then refill with fresh lubricant.

Next, flush and refill the cooling system. Either drain the old coolant from the radiator and engine block or use a reverse-flush kit, with a special flushing Tee installed in a heater hose.

Once the cooling system is completely free of old coolant and rusty water, refill the system with a fresh 50/50 mix of antifreeze coolant and water. Check the protection-level chart on the coolant container.

Remember, a mix that's purely antifreeze is not as potent as one that has some water in it, due to the chemical reactions of the ingredients. Also, the anticorrosion additives in the coolant rely on the presence of a certain amount of water to do the job, so don't go any stronger than 70% coolant and 30% water.

With fresh coolant in the engine and new lube in the engine, transmission and drive axle, go for another drive. Again, the purpose is to fully lubricate all internal moving parts and seals. This time, drive to a filling station that you've known and trusted for years to have pure fuel in clean tanks. But before filling your car, pour a fuel-stabilizing additive into the fuel tank.

Fuel stabilizers are designed to prevent stored gasoline from breaking down, forming varnishes and gums inside the fuel system. If your auto parts store doesn't stock a fuel stabilizer, try an outdoor power equipment dealer, where it's sold for lawn and yard equipment. Add as much stabilizer as needed for your vehicle's fuel tank. Then fill the tank with fuel, and drive just enough to mix the stabilizer and pump it into the carburetor or fuel injectors.

While totally draining gas from the tank and running the engine until the carburetor, fuel pump, filter and lines are empty also prevents the buildup of varnish, it leaves room inside the fuel system for condensation to build. The condensation causes corrosion. A full tank leaves no room for condensa-

tion or corrosion in the fuel system.

Now you can drive home to finish the storage procedures.



Add fuel-stabilizer additive to prevent varnishes inside the fuel system.

Batten down the engine

Further protect the inside of your car's engine by putting a coat of oil on surfaces that normally aren't heavily lubricated.

Once the engine is cold, remove the spark plug from each cylinder. Then squirt several shots of clean engine oil into all the cylinders through the spark plug holes. Apply antiseize compound to the spark plugs' threads, and reinstall the old plugs in the cylinder head. Disconnect the ignition, leaving off all the plug leads and the leads to the distributor or control module. (If you have an electronic ignition, you should check the service manual for the appropriate way to disable the ignition. Simply pulling the high-tension leads may cause spark box failure.)

Turn the ignition key to spin the engine several times. This ensures that

the oil in the cylinders not only covers the cylinder walls for the entire piston stroke, it forces the oil up into the combustion chamber and onto the valves, to help protect those surfaces.

Coat each ignition system connection system with dielectric grease as you reinstall all the wires. Also, disconnect the battery leads and coat all the terminals, including the exposed terminals on the starter, with petroleum jelly. Remove the battery from its tray and attach it to a trickle charger, away from the car.

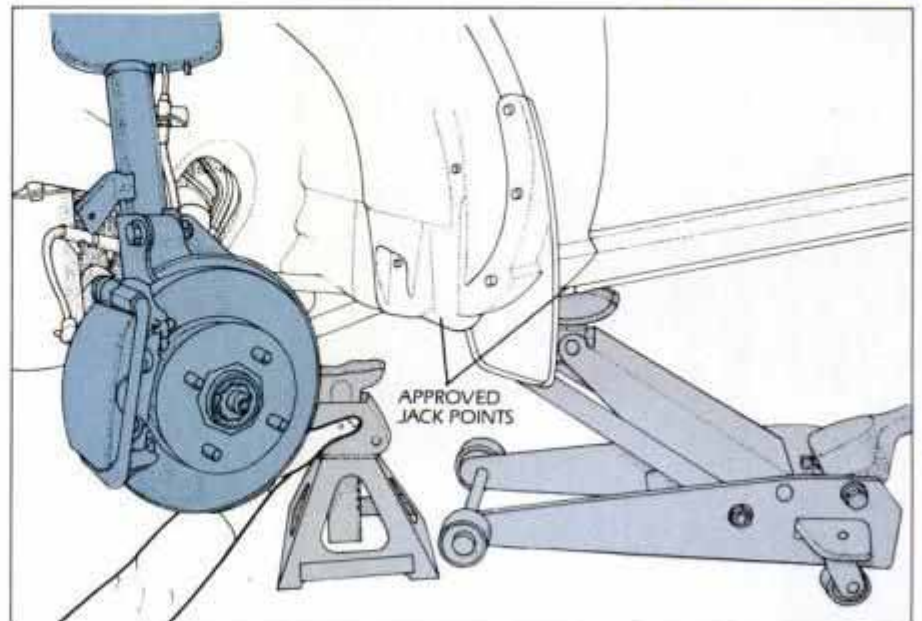
Besides protecting all electrical connections with petroleum jelly or silicone to seal out moisture, apply silicone spray to all accessible hoses—fuel lines, coolant hoses, vacuum hoses—to help prevent them from drying out.

To help prevent rust and corrosion to unpainted metal parts—such as the throttle linkage, exhaust manifold, clamps and brackets, coat them with petroleum jelly, silicone or penetrating oil.

Lastly, to discourage mice and other small creatures from taking up winter quarters in your engine compartment, roll fist-size packets of camphor balls in cheesecloth. Place the camphor packets around the engine compartment, tucking some in corners near the firewall and against the felt or foam sound-deadening material on the hood's underside.

Tape a plastic bag over the air-cleaner intake and exhaust pipe exit to prevent mice and squirrels from nesting or storing seeds inside.

(Please turn to page 84)



Place the car on safety stands for the duration of the storage.

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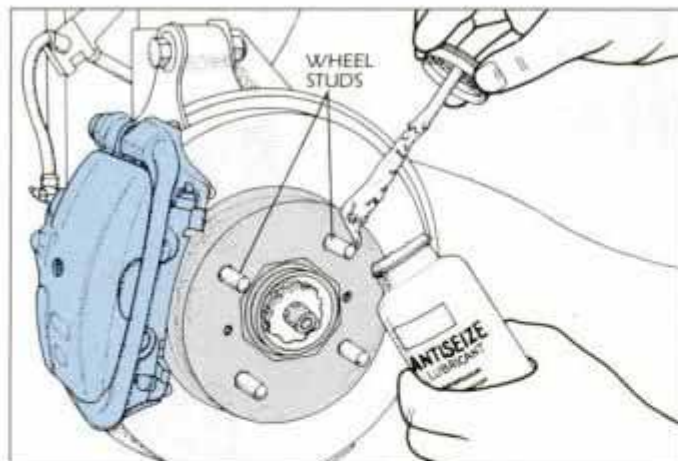
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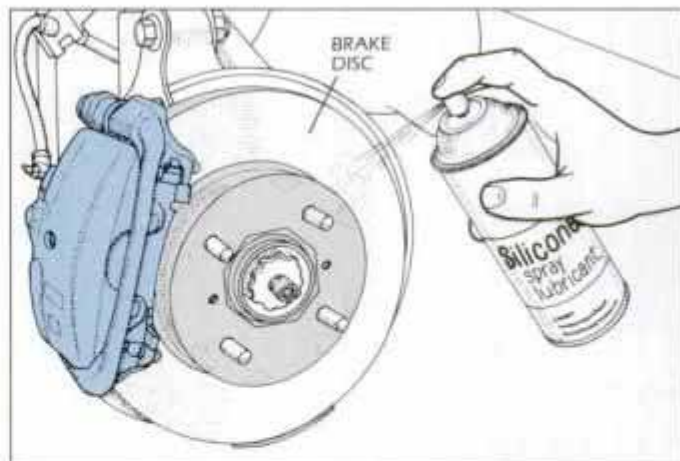
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CAR CARE



Coat the wheel studs' metal threads with antiseize compound.



Coat rotors and calipers and other exposed metal parts with silicone.

Underside up

To prevent the tires from developing a flat side while resting in the same spot for so long and to ease the load on the springs, shock absorbers and the rest of the suspension, your car or truck should be stored sitting on safety stands.

Make sure your stands are large enough to securely hold your rig off the ground. Each stand should have a broad base and large enough cradle, as well as being rated to hold at least one fourth of the vehicle weight. Jack up your car or truck so that when it's resting on the safety stands, the bottom edges of the tires all clear the ground by an inch or so. You don't need the vehicle towering above the ground. It should be just high enough for the tires to rotate freely. If you're storing the car on an unpaved surface, use lengths of wood long enough to prevent the stands from sinking into the surface as the seasons progress.

Place each safety stand carefully. Support your vehicle under frame rails or other structural members, not under axles or suspension components. If you place the stands under an axle, the weight of the vehicle will still compress the springs and shock absorbers. With the safety stands under the vehicle's frame, the wheels, springs, shocks and suspension components all hang free, holding only their own weight.

With your rig up in the air, remove all four wheels and tires, and lay them aside for now. Slide underneath and inspect the entire underbody. Remove any clumps of wet or dry leaves, grass, caked-on mud or anything that could trap moisture,

helping in the formation of rust.

Look for any bare metal areas and seal them. If appropriate, prime and paint them, otherwise coat the surfaces with silicone, penetrating oil or another water barrier to prevent rust and corrosion. Key areas to protect include steel suspension components, brake drums, wheel spindles and bearing covers, as well as disc brake calipers and rotors. Also protect exposed shift linkages and non-stainless-steel exhaust pieces.

While you're underneath, coat all rubber surfaces with silicone spray to keep them from drying out. This includes suspension bushings, fuel lines, the lower radiator hose, brake lines and constant-velocity joint and steering rack boots.

Lastly, check for grease fittings on suspension and steering components as well as at the driveshaft universal and slip joints. If there are any fittings, grease them with the recommended lubricant. And then hang some more camphor and cheesecloth packets around the undercarriage to

help discourage nesting.

Now, before putting the wheels and tires back on, clean the inner and outer sidewalls of the tire, and apply silicone to both. Also, clean both sides of all the wheels. Put a coat of wax on the cleaned wheels, but don't buff it off. Apply antiseize compound to the threads of the wheel-mounting studs, and reinstall the wheels and snug up the lugnuts, torquing them to specifications. Then coat the nuts' outer surfaces with wax. Make sure the tires are all inflated to the correct cold-inflation pressure to help them keep their shape, and cap the valve stems. Then reinstall any wheel covers.

Double check that the car is high enough off the ground so that the wheels are all hanging freely to prevent flat spotting the tires.

A clean body

Next, thoroughly clean the car, inside and out. In fact, detail the car as though you were about to be taking it to a car show. With one important difference—don't make it shine.

Thoroughly and carefully wash the car. Remove the license plate brackets and luggage racks that can trap dirt and moisture, and clean the areas they normally cover.

Store these pieces in the trunk, along with the radio antenna mast, if it is not the type that fully retracts, and the windshield wiper arm assemblies. By removing the wiper arms, you relieve the pressure on their hold-down springs. But be sure to coat the exposed wiper shafts with petroleum jelly to protect them from corrosion after you've finished washing the car.

(Please turn to page 86)



Clean all interior plastic, vinyl or leather surfaces with the appropriate product. Shampoo the carpets and cloth seats.

Now! Cash in on emergency shortages of qualified people in 4 fast-growing fields. FREE OPPORTUNITY KITS tell you how...

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a Pro Key Machine at no extra cost! The work's easy, the money's good and the demand is skyrocketing.

Never before have opportunities been so great for qualified locksmiths. With crime zooming, the lock and key business has multiplied a thousandfold. This Foley-Belsaw course gives you everything you need to start your own locksmith business — including

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CAR CARE

Take extra time to be sure to totally remove any stains. Bird droppings, tree sap, dead bugs and globs of road tar and other substances can etch the car's finish if given months—or years—to work at it. Use a chemical solvent, like bug and tar remover, to completely clean all stubborn spots. Then, wash and rinse the car again to remove any residue of the solvent. Dry the car, using chamois or old terry-cloth towels. Then inspect the finish carefully.

Check for any chips, nicks or scratches in the paint. Any damage down to bare metal will surely rust—possibly through—given enough time in storage. Treat any bare spots with a rust stabilizer, then prime the area and, after the primer dries, touch up the damage with the correct color body paint.

Next, apply a moderate coat of wax. However, unlike what you normally do, cover the entire car at once and then simply let the wax dry to a haze. You won't buff off the wax until you take the car out of storage.

Similarly treat all chrome surfaces of your car—wire wheels, grilles, headlight bezels—with a quality chrome polish. Also treat plastic and vinyl surfaces with an appropriate polish. Protect weatherstripping around the windshield and backlight, as well as all the doors and the trunk, with silicone.

Go inside

Next, do a thorough cleanup of the car's interior. Wash and vacuum all upholstery, carpets and floor mats. Clean and polish the dashboard, door panels, armrests, pedals, shift lever, window crank and door levers. After cleaning, coat all noncloth surfaces with the appropriate polish. Spray the clean upholstery and carpeting with a cloth protector.

Be totally sure there's no water trapped anywhere inside the car. Otherwise, it will not only be a source of rust and corrosion, the moisture will encourage mildew to develop. Make certain all vent holes, such as the bottom of the doors and under the cowl, are clear to allow moisture to escape. As an added antimildew measure, spray some household disinfectant into all the heater/defroster/air conditioning vents, as well as into the fins of the heater core and air conditioning evaporator.

Before sealing up the interior, place a couple of open boxes of baking powder around the passenger compartment. Place one box under the front

seats, one in the rear and one under the dash to absorb odors. Then close all the windows, and close the doors.

If your car is a convertible, close the top and install any zippered-in



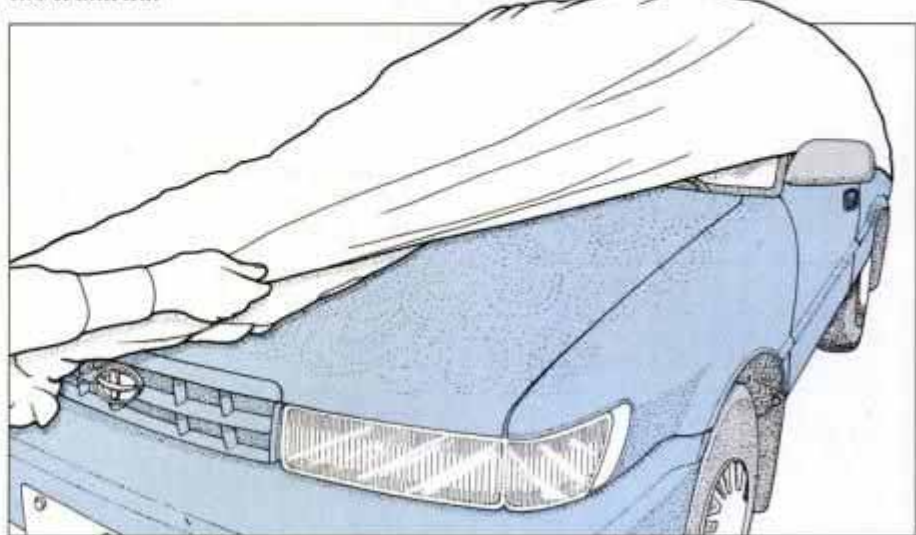
Place a moderate coat of wax on the car's finish, but don't buff it off.

windows or side curtains. Besides helping to seal the interior, this installation will help prevent the convertible top and the car's side curtains from cracking at the folds.

Next, clean the trunk or cargo area of station wagons and hatchbacks. Again, be very careful that there are no pockets of water or moisture anywhere. Clean and dry the rain channel around the trunk or hatchback opening. Remove the spare tire and jack from their storage well, and be sure that area is dry.

Before reinstalling the spare, inflate it to its proper pressure. But to keep the spare from getting misshaped in storage, lay it flat on the floor of the trunk or cargo area, out of its mounting bracket.

Place an open box of baking powder in the trunk to absorb moisture and odors. Be sure that the weatherstripping is coated with silicone, and close the trunk lid.



Seal the entire car with a cover to keep out dirt, dust and moisture.

Cover it up

Whether you store your car inside, as is preferable in a heated, humidity-controlled garage, or in an unheated barn, chicken coop, carport or out in the yard, put a quality cover over the car. A cover not only keeps dirt and dust off the car, it shields the car from the Sun's ultraviolet rays, the ozone and other airborne pollutants. Logically, the more of the car you can cover, the better.

It's critical then that your cover is the correct size for your car or truck. While you can have a cover custom tailored to fit your rig, you can also buy a more-or-less universal one off the shelf. Custom-made covers not only protect all of your car, they fit snugly, leaving less room for moisture or critters to get underneath. A well-fitted cover also stands a better chance of staying in place if the car is outdoors and subject to wind and weather. If you buy a ready-made cover, make sure that it's the correct size for your car. The cover has to slip over and under your car's front and rear bumpers and under the rocker panels on both sides of the rig.

Regardless of which type of cover you select, make sure it's made of a soft material that won't scratch the car. In addition, the cover should be lintfree and tightly woven to prevent dirt and dust from passing through. Yet, it should allow air to pass through so moisture won't settle under the cover.

Before putting the wraps on your car, be sure that you've properly sealed it, and that the radio antenna is either lubricated with penetrating oil and fully retracted or removed and in the trunk with the wiper arms. **PM**

CAR CARE

NEW PRODUCTS IMPROVE YOUR CAR



Neither Rain, Nor Snow...

Used to be that the fat, low-profile tires that kept your really hot car stuck to the road also kept that car off the road in the snow and slop—in more ways than one. Now, with high-performance, all-season tires, like the BF Goodrich Comp T/A HR4 and VR4, you don't have to stay home when it rains. Sized to fit anything from a Corvette or a Porsche to more mundane machinery, the tires share a unique tread pattern that sheds water, grips in the snow and is quiet in the dry. And the VR4 is rated up to 149 mph. The tires also share better tread-life ratings than any other speed-rated tires. Suggested prices start at about \$125 and climb along with speed range and size.



Stop, Thief!

An ignition cutout is a proven theft deterrent. So is a loud alarm. Radio Shack has combined the two with the Mobile Alert Remote Control Auto Alarm. When the alarm is tripped, a loud—104 dB—siren sounds and the ignition system is disabled, preventing the car from being started. There's a remote switch, so you can

arm or disarm the unit from up to 20 ft. away, as well as a panic button, valet switch and a choice of 2000 secret codes. The alarm is set off when either the motion or vibration detectors sense trouble. The control unit can be hidden, but a dash-mounted LED serves as a visible warning. Available in all Radio Shack stores, the alarm sells for \$89.95.

Take It All Off

You can get that old Bee Gees sticker or any other decal or bumper sticker off your car without solvents or a heat gun. Special Scotch-Brite abrasive discs from 3M attach to an electric drill via 3M's Roloc adapter. The combination of the speed of the wheel and texture of the Scotch-Brite dissolve the sticker's adhesive backing, turning it into a powder that wipes off. It costs about \$35 for a package of 50. From 3M, P.O. Box 33600, St. Paul, MN 55133-3600; (800) 362-3456.



Wet 'N' Wild

You might as well let the water you use to wet down your car help scrub and suds it, too. The Soft Brush from Swirlon does just that. The Soft Brush actually has two brushes in it, both of soft, nonscratching bristles. The inner brush is spun by the water as it flows out the unit's head. By setting a rotary control valve, car wash solution can be dispensed into the water stream from a cup in the unit's handle. Moving the valve can stop the soap flow or the water flow altogether. Thanks to an adjustable brush-head angle and a 24-in. extension handle, you can reach all parts of your car or truck.

The price of the brush is \$19.99. From Swirlon Industries, Inc., 5101 Commerce Dr., Baldwin Park, CA 91706; (818) 337-5087.

FM

Cap It Off

One good way to make sure you don't leave your gas cap at the filling station is not to take the cap off in the first place. The Rapid-Fill fuel cap has a spring-loaded center section that lets you pour gasoline or fuel-additives through it, while the cap is in place. The center section opens enough for a fuel-pump nozzle—or the neck of a bottle of fuel additive—to slip in. The caps are available in two types to fit all major domestic and imported cars with vented, pressurized fuel systems. The Rapid-Fill caps cost \$24.95 each. From Capmasters, Lake Forest, Illinois; (800) 457-9006.



CAR CLINIC

BY MIKE ALLEN,
Associate Automotive Editor

Legacy

In 1985, I bought a used 1980 V8 Pontiac with about 40,000 miles on it. Apparently, the previous owner had never performed any maintenance on it whatsoever. I removed the rocker covers and oil pan and scraped off as much sludge as I could, and have been changing the oil regularly since. I also flushed the radiator, which drained rusty brown coolant. Since then, I've flushed and filled the cooling system with fresh coolant every two years.

Last week, one of the freeze plugs started to leak, so I replaced it. The bottom third of the plug was corroded through, and the corroded area was covered with a familiar-looking rusty brown sludge.

Why didn't the anticorrosion additives in the fresh coolant prevent the sludge from building up and the plug from corroding? JOHN SHERMAN
OSSINING, NY

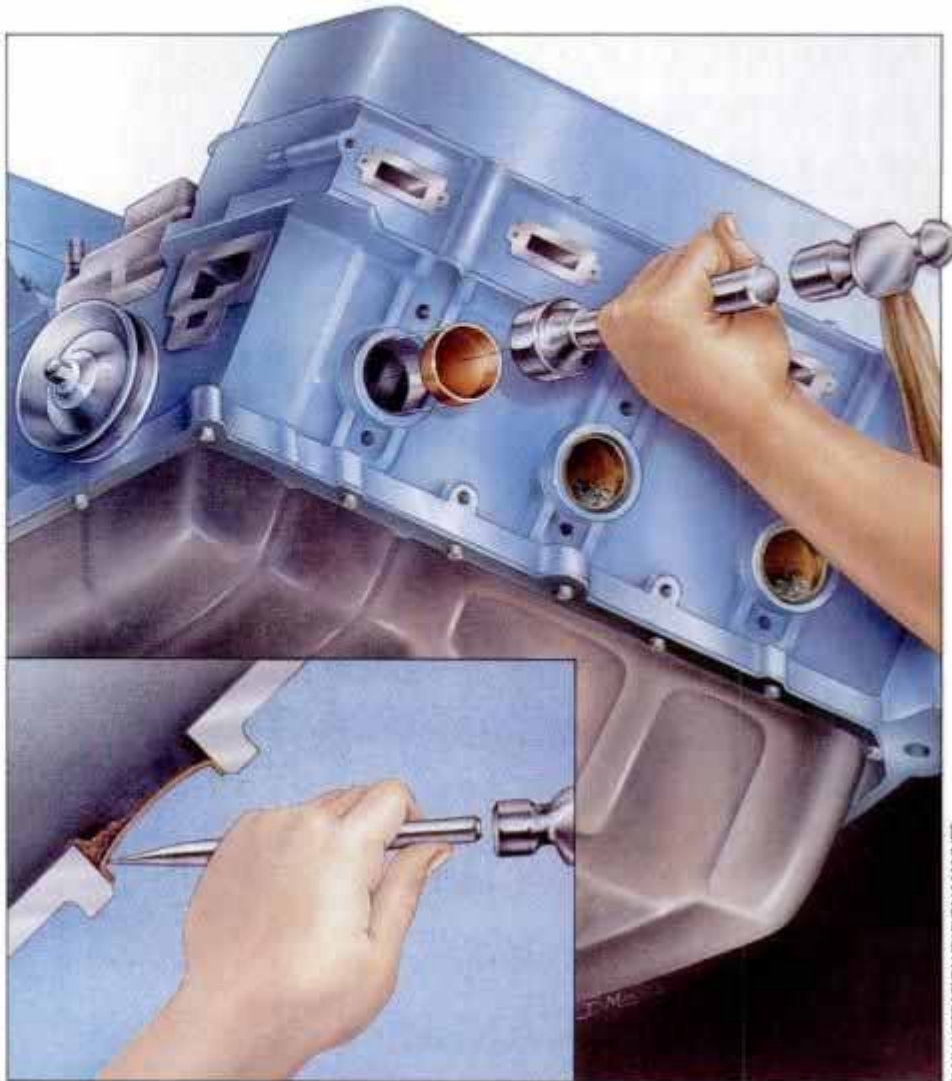
Normally, fresh coolant's additive package will prevent sludging—but I bet the sludge on your core plug was left over from 1985. (It's more correct to call it a core plug than a freeze plug. The hole the plug fills is there to let out the casting sand used at the foundry, not to prevent block damage in the case of accidental freezing.)

Ordinary power flushing, which is usually sufficient for normal maintenance of cooling systems, won't remove really bad sludge—you need to use a chelating-type flushing chemical, the kind intended to be left in the engine for several hours.

According to several chemists and engineers I talked with at Zerex, the rusty sludge must have prevented the additives in the fresh coolant you've been adding from ever reaching the steel core plug's surface.

Dollars to doughnuts the rest of the core plugs are corroded too. Someday, when it's convenient, I'd use a chelating flush and then replace the rest of the core plugs before they start seeping too.

Use a chisel to drive the old plugs sideways, and then pull them out with pliers. There's a special tool (see main illustration) for installing the plugs, but you can use a wooden dowel or a socket to drive them in. Use some nonhardening sealer and drive the plug in far enough to center it in the block.



PM ILLUSTRATION BY DON MANNES

Ten-To-One Odds

As I was driving home from work, a car cut me off on the freeway. I noticed the ABS badge on his trunk and got to wondering if I shouldn't revise my one-for-ten rule on following cars—one car length for every 10 mph.

The more I thought about it, the more I wondered how can a brake that pulsates on and off stop a car better on dry pavement than an identical car that locks 'em up? I realize the advantages of ABS on slippery surfaces—but what happens on a sunny day? Should we revise the one-for-ten rule?

FRED HARTWAY
WESTLAND, MI

Fred, I think you have an erroneous idea of how ABS really works.

First off, tires don't generate their maximum deceleration when they are completely locked up. Because of the hysteretic characteristics of the rubber, the best braking comes when there is only a small percentage of "slip." Slip can be thought of as the difference between the relative speed of the tire's contact patch and the speed of the pavement. A smoothly rolling

tire would have zero slip, while a locked tire would have 100% slip, at least until the car stopped. Best braking, depending on the tire and the characteristics of the pavement, is probably between 5% and 10% slip.

Racing car drivers can maintain that slip by modulating the brake pedal just short of the lockup point. When I fifth-wheel test cars here at PM, I do the same. And invariably, if I use a little too much pedal and lock even one wheel, the braking distances are longer. ABS systems don't simply pulse the brakes rapidly. The ABS computer actually reads the wheel's angular velocity and can predict when it's about to lock up.

The computer then opens and closes valves rapidly to maintain the appropriate slip percentage. Consequently, the braking distances are as good as the most skillful driver can achieve, and are a few feet better than just simply standing on the pedal.

And of course, because the wheel never stops rotating, the car still will respond to steering inputs, giving you a fighting chance of driving around that 4-year-old on his tricycle.

CAR CARE

A Fitting End

The oil light switch in my 1976 Buick is defective. I tried to replace it, but none of my socket wrenches fit it. Is there a special socket to remove oil light switches? **HERMAN R. FORD**
BROOKLYN, NY

There sure is Herman—any auto parts store, Sears and even some better-stocked mass merchandisers should have the special socket intended for the bizarre shape of most oil warning light switches.

This switch uses a tapered pipe thread. Use Teflon tape or a sparing amount of pipe thread compound, and be careful not to introduce any foreign substances directly into your engine's oil gallery. Clean the surface in the vicinity of the switch before you remove the old one.

One Trick Pony

I have a 1966 Mustang with the original 6-cylinder motor, and 171,000 miles. I partially rebuilt the motor at about 90,000, and it runs fine most of the time. But when the engine is hot and I drive at 35 to 40 mph, it dies. It's fine after it cools off, so I'm assuming

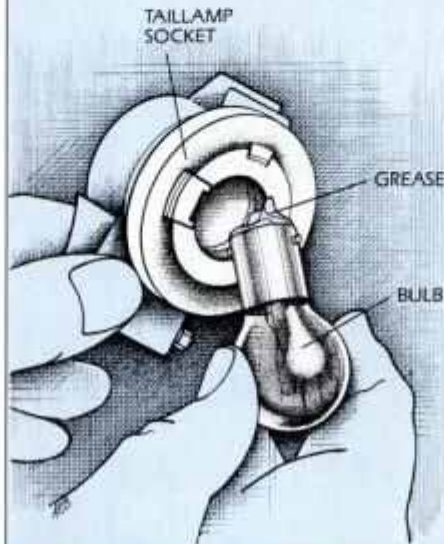
(Please turn to page 90)

Shedding A Little Light

● I just recently had occasion to change the taillight bulb on my much-abused 1974 Ford pickup for the first time in its life.

Fun it was not. The hardware that held the socket together was rusty, and the bulb had corroded itself to the socket, shattering in my hand as I tried to remove it (necessitating removal of glass from my thumb with pliers).

By the time I got the remains of the bulb's base out of the socket, the socket was history, and I wound up making a trip to the Ford dealer to order another complete reflector assembly. Grrrrr...



You can be sure that when I install the new assembly and bulb, I'll coat the base of the bulb with silicone or white grease to keep moisture from corroding things so badly.

Wheel-bearing grease will work, too. *Don't* use antiseize compound though—the metal-bearing compound will short the electrical connections.

I have always used silicone grease on trailer connections and battery posts, too.

But be careful about doping up any underhood connections for the fuel injection. Some of them must be assembled dry, and others require a particular type of lube.

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CAR CARE

it's vapor lock. I replaced the metal line between the mechanical pump and carb with insulated rubber, which helped a little. Any ideas?

PAUL DEGROOT
HOUSTON, TX

Gasoline nowadays has a higher vapor pressure than it did in '66—and older cars sometimes have a problem with vapor lock because of this.

Insulating the fuel line was a head start—but the vapor lock is more likely to be on the suction side of the pump, between the tank and pump. Try insulating that.

Some cars use a bypass fitting built into the carb or in the line right near the car. This T-shaped gadget fits into the hose and bypasses a small amount of fuel back into the tank to keep cool fuel flowing even when the engine is using little gas—like during your low-speed driving. You'll have to add a return line to the tank for this, though.

Also, you might try insulating the

float bowl. As a last resort, try replacing the mechanical pump with an electric pump mounted as near to the tank as possible.

Stronger Than Dirt

I have a 1985 Plymouth Reliant with the 2.2-liter engine. Every six months, I have to take it to the mechanic for cleaning and adjustment of the carburetor because of a rough idling problem. The auto mechanic says this is because the carb has such fine tolerances and requires cleaning very regularly.

Is this true of Plymouth carburetors, or am I getting gypped?

DONALD DREHER
LONG PRAIRIE, MN

Plymouth cars, and Chrysler Corp. vehicles in general, have carburetors made to tolerance standards that are much the same as they are in the rest of the auto industry. There is nothing special about your carburetor.

However, because your engine is small, the metering jets and passages are small too and are more sensitive to dirt and gum formation.

My suggestion is to be sure the air cleaner and all the connections between it and the carb are tight. Look for missing gaskets, cracked hoses and anything else that would leak uncleaned air into the carb.

Replace the fuel filter annually, and add a can of carb cleaner to the tank every three to four months.

If the rough idle returns again, you might try using a can of spray carb cleaner to clean the carb. Remove the air cleaner pipe from the carb, and follow the directions on the can.

It's Only A Paper Moon

My mom delivers 200-some newspapers every day in her Ford Aerostar, 44,000 miles worth since 1988. The ATF is supposed to be changed at 40,000, but she says, "I never changed it in my old car, and I never had any problems." Please help me convince her.

CHRIS COPLER
DETROIT, MI

I recommend replacing the ATF at no longer than the manufacturer's recommended interval, which in this case is 40,000 miles. There's no need to be compulsive about it—within a few months or so on either end is no biggie. Are you there, Mom? Listen to your son.

FM

DO YOU HAVE A CAR PROBLEM?

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

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ECO-TOURISM ARRIVES

BY JOE SKORUPA, Boating/Outdoors Editor



● This is the year of the close-to-home vacation. It's also the year of *eco-tourism*, a travel industry term referring to destinations that focus on low-impact adventure in the great outdoors. Combining these two trends, I thought I'd spotlight a couple of close-to-home, eco-tourism opportunities that have recently come of age.

The first comes from our friends in Washington, D.C.—the federal government. The second comes from Kampgrounds of America (KOA), an organization that's been involved with eco-tourism since it started in 1962.

Green marketing

So, what the heck is eco-tourism? It's rafting down the Colorado River. It's wildlife watching in the Florida Everglades. It's fly-fishing in Montana. It's bicycle touring in Vermont. It's horseback riding in Wyoming. It's Jeep touring in New Mexico. It's scuba diving in Key Largo. And add it all up, it's the fastest growing segment in the U.S. travel industry.

Adventure travel's slice of the travel market currently adds up to more than \$30 billion. Eco-tourism's portion of this slice is growing at a phenomenal rate and has already emerged as adventure travel's domi-

nant force. While most people think of eco-tourism in terms of African safaris and expeditions to the Amazon rain forest, the federal government and KOA recently realized that domestic eco-tourism sites are also part of the trend.

According to a survey that was recently published by the U.S. Fish and Wildlife Service, 134.7 million Americans visited 661 million acres of federal public land last year with a specific eco-tourism intent—observing wildlife. These nonconsumptive visitors—a bureaucratic term that is used to differentiate bird watchers and photographers from hunters and fishermen—spent more than \$14 billion to enjoy their experiences.

This awareness, backed up by statistics, has had a dramatic effect. The Bureau of Land Management (BLM) and the U.S. Forest Service, longtime rivals primarily charged with managing land resources for business interests (lumbering, mining, ranching and so forth), are now channeling much of their energies into multi-agency recreational programs.

Watchable wildlife

The first major multiagency eco-tourism effort is a program called Watchable Wildlife. By the year 2000, the BLM, the Forest Service and the De-

fenders of Wildlife hope to establish 5000 Watchable Wildlife sites on public and private land. The sites will be marked alongside roads, so that families can drive to them. State-by-state guidebooks will be prepared and sold for \$5.95 apiece. By next year, 14 guides will be available. For further information about guides in your area, write Defenders of Wildlife, 1244 19th St. N.W., Washington, D.C. 20036; or call (202) 659-9510.

Two other federal programs that are ideal for driving vacations are the U.S. Forest Service's Scenic Byways and the BLM Back Country Byways. Designated routes in these programs cover secondary and unpaved roads through some of the most spectacular scenery in the country. Some require high-clearance, 4-wheel-drive vehicles, such as the one used by the serious off-roader shown in the photo, but many do not. Maps are clearly marked and graded for difficulty.

For more information on these programs or Watchable Wildlife, write the USDA Forest Service, Recreation, 201 14th St. S.W., Washington, D.C. 20093; or BLM Public Affairs, 1849 C St. N.W., Washington, D.C. 20240. You can call the Forest Service at (202) 447-7756, and the BLM at (202) 343-5717.

Recently, KOA moved more strongly into eco-tourism by expanding its network of camping facilities in the United States and Canada with Tent Villages and Kamping Kabins. Tent Villages provide a covered cooking and eating area, running water, lockable storage and a private tent site. Kamping Kabins are rustic structures with beds and mattresses for four. KOA has more than 600 locations, and many are ideally situated for eco-tourism vacations. For a copy of the KOA Road Atlas and Camping Guide, write KOA Directory, P.O. Box 30162, Billings, MT 59107; or call (406) 248-7444.

Naturally, PM urges that all mechanized adventurers follow the principles of Tread Lightly and observe the highest standards of outdoor etiquette, especially when interacting with wildlife. But this is the age of eco-tourism. Outdoors ethics is standard procedure.

PM

PM HOTLINES

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LEARNING FROM DISASTER

BY ABE DANE, Science/Technology Editor



● The pattern is familiar. A disaster grabs the headlines for a month or two, scientists gear up to determine how to prevent it from happening again, and before they can come out with any results, the issue has dropped out of sight.

So I thought I'd follow up on some of the research that was undertaken after the *Exxon Valdez* spilled 11 million gallons of North Slope Crude into Alaska's Prince William Sound two-and-a-half years ago. As is often the case, the catastrophe presented a unique opportunity to learn. The pristine waters of the sound became a grand-scale laboratory for trying out cleanup technologies and for investigating the effects of oil on sensitive ecosystems.

What with the deliberate pace of science, many questions remain unresolved. But on at least a couple of key questions, the initial returns are worth reporting. Overall, the news coming from Prince William Sound is encouraging, at least considering the severity of the spill. "Most of the sound right now is normal," says Joseph Talbott, *Exxon Valdez* project manager for the National Oceanic and Atmospheric Administration (NOAA), which just finished surveying about 600 segments of the shoreline around the sound. "You'll be able to find evidence five or 10 years from now, but you'd have to know what

you were looking for. The average person could go kayaking, and they would never know."

This remarkable comeback is more a tribute to natural resilience than to anything humans did. "I'd like to say that it's because of the cleanup, but in reality a lot of it's due to natural mechanical washing," Talbott says. "It's a very high-energy environment. You have a good tide range that flushes twice a day. It's like running it through a cement mixer."

Oil and hot water

As it turns out, much of the work done during the massive, multibillion-dollar cleanup may actually have been worse than useless. Hosing down the beaches with hot water—a treatment used on about 400 miles of the sound—appears to have been a particularly bad idea. It made the beaches look better. But a study issued this spring by NOAA indicates that overall it did far more harm than good. Many shellfish, crustaceans, plants and microorganisms that would have survived the spill were wiped out by the high-temperature spray.

The study sampled 22 sites around the sound, including oil-fouled beaches that had received a hot-water wash and, for the sake of comparison, others that had been left untreated. To serve as controls, six beaches that had

escaped pollution altogether were considered as well.

Mollusc massacre

The results were pretty near conclusive. By the summer of 1990, populations of the dominant species of plants and animals on the oiled but untreated beaches were approaching those on beaches that had never been oiled at all. On the beaches treated with hot water, however, long stretches had been virtually sterilized. In the band between high and low tide levels, thermal shock killed nearly everything the hot water touched. Worse, the treatment washed contaminated sediments down into the lower reaches of the beach, where it may harm sensitive algae, clams and grasses for years to come.

Why such a destructive treatment was used is a vexing question. According to Talbott, much of it had to do with politics. "With a spill like this, there's a real hue and cry to get them out washing rocks," he says. But as NOAA chief scientist Sylvia Earle points out, "Sometimes the best, and ironically the most difficult, thing to do in the face of an ecological disaster is to do nothing." **PM**



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NEW CARS



PM PHOTO BY MIKE ALLEN

Here's One Firebird That Can Really Fly

● Next time you pull up behind a red Firebird at a traffic light, check to see if it's wearing a discreet Firehawk logo on the rear bumper. Aside from the steamroller tires, that logo will be the only clue that you're following a very special limited-edition car—until the light changes, and it disappears.

Developed by Ed Hamburger of SLP Engineering in Toms River, New Jersey, the Firehawk is available through your neighborhood Pontiac dealer.

Starting with 5.7-liter (350-cu.-in.) cast-iron V8 blocks, 4-bolt main bearings and SLP-modified aluminum heads, Firehawk motors are assembled by GM in Flint, Michigan, on the same line as regular production 5.7s. SLP also provides a steel billet hydraulic roller cam, as well as its own downdraft TPI intake manifold.

The manifold draws induction air from twin air cleaners, located behind the headlights, and through twin 52mm throttle butterflies. Once assembled, the engines are shipped to SLP. They're rated at 350 hp, 390 ft.-lb. of torque, and they're efficient enough to escape the gas-guzzler tax.

GM also ships complete Firebird Formulas—red, of course—equipped with 5.0-liter V8s and automatic

transmissions, to SLP, where the drivetrain is replaced. Mated to the 5.7 is a ZF 6-speed transmission—the same one used in L-98 Corvettes. Next comes a 3-in. aluminum drive shaft coupled to a Dana 44 rear axle with a 3.54:1 ring and pinion ratio.

SLP also recalibrates the suspension with new shocks; larger front and rear antiroll bars; lower, stiffer springs; and stiffer lower control arm bushings. The Firestone Firehawk 275/40 Z-rated SZs are mounted on 17 × 9½-in. one-piece rims.

We had a chance to spend a day with a brace of Firehawks on Road Atlanta's road course. The performance numbers are impressive—0 to 60 in 4.9 seconds and the quarter-mile in 13.2 at a rousing 107 mph. Named for the Firestone-backed IMSA street



Huge 4-piston Brembo brakes are optional.



SLP-engineered and GM-built, this modified 350 V8 makes 350 emissions-legal horsepower, 390 ft.-lb. of torque.

stock racing series, the Firehawk has all the straightahead urgency of a good L98 'Vette, but without the too-many-cups-of-coffee nervousness at speed. There's plenty of torque at any rpm, enough acceleration to make your insurance agent lose sleep, and handling to back it all up.

The price is \$39,995, plus shipping from Toms River. Your Pontiac dealer may have to wait a little to get one for you. But it's covered by GM's normal warranty.

And if you want to go racing, there's a \$10,000 option that includes a set of Brembo brakes—virtually identical to those used on the Ferrari F40—a Recaro racing seat and racing harness, a full roll cage, and an aluminum hood.

Better hurry, though. Initial plans called for a total run of just 250 Firehawks, and they're certain to be collector's items.

—Mike Allen

PM PHOTO BY MIKE ALLEN

Lexus ES Update

Among its other qualities, the new Lexus ES300 epitomizes the taming of the modern front-wheel-drive automobile. It handles as well as most rear-drive cars, it's devoid of torque-steer, its mild understeer is more or less industry standard, and it's almost as quiet as its big brother, the LS400.

Like the ES250 it replaces, the ES300 shares the Toyota Camry platform and drivetrain, which in this application is the same setup that Toyota will introduce as an all-new model in September.

New looks

While all but identical mechanically, the two cars look entirely different. The ES300's sheetmetal says Lexus all the way. It's nearer in size and shape to the LS400. The wheelbase has stretched 5 in., and there's 3 in. more shoulder room, plus an extra inch of legroom, front and rear. It's a visibly bigger package.

The ES300 again uses Toyota's transverse V6, which has been expanded by 500cc to 3.0 liters. Other upgrades of this dohc 24-valve engine include port modifications for better breathing, fine-mist fuel-injector nozzles and variable-flow intake runners to boost low-end torque.

The 3.0-liter V6 delivers nearly as much torque at 2000 rpm as it does at its 4400-rpm peak. Horsepower is up 20%, to 185 at 5200 rpm, yet fuel economy is the same as the ES250—19 mpg city/25 mpg highway, with the 5-speed manual transmission.

The ES300 uses a hydraulically driven cooling fan with thermo-electronic sensing, introduced recently on the Lexus SC400 sports coupe. The fan drive shares fluid with the power-steering system, but has a separate pump that's back to back with the power-steering pump, and drives off the same shaft. The fan's advantages include less noise and a more controlled engine temperature range.

Available transaxles for the ES300 are the 5-speed manual and an optional electronically controlled 4-speed automatic that is all but seamless in operation.

The Lexus chassis isolates the powertrain on hydraulic engine mounts plus a rectangular front subframe. There's an additional I-shaped subframe for the rear suspension, all consistent with current Toyota chassis design.

There are struts at all four corners, and the rear struts have dual links with fluid-filled support bushings to reduce ride harshness. There are also

(Please turn to page 98)

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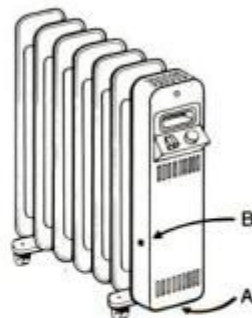
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This replacement program is being undertaken in cooperation with the United States Consumer Product Safety Commission. The Commission believes that electrical failures in some control panels could cause house fires. The manufacturer does not believe that any safety hazard exists.

The involved units have production numbers found on the underside of the metal box that holds the controls beginning "80..." through "88..." (See A) A small number of heaters were sold under the Sears and Welbilt brand names. These heaters bear the code number "816F" next to the U.L. label on the side of the metal control box. (See B)

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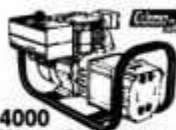
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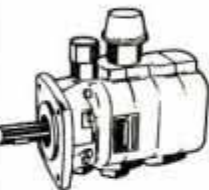
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NEW CARS (Continued from page 97)



Lexus ES300 shares Toyota Camry floor pan and improved 185-hp 3.0-liter dohc 24-valve aluminum V6. New car is 5 in. longer than ES250, with better leg and shoulder room.



antiroll bars fore and aft.

Based on initial impressions, the ES300's road manners are equal to anything in the small sport sedan class, including BMW and Mercedes. The speed-sensitive rack-and-pinion steering is crisp and precise, and nothing ruffles the suspension.

Handling gets a major assist from wide, sticky Goodyear V-rated Eagle GA 15-in. tires. The torquey (195 ft.-lb. at 4400 rpm) V6 never bogs or lugs, and the 5-speed snicks as though the transaxle were directly under the shifter.

The 4-wheel disc brakes, with ABS, perform very well, even with hard use, and the multiadjustable seats should provide solid comfort for just about anyone.

No quirks

All in all, it's a pleasantly quiet car that's completely free of quirks—an extremely able machine in every way.

Fit and finish are what you'd expect of Lexus and Toyota. Every convenience and luxury comes standard in the ES300, including a superb 8-speaker, 6-amplifier 180-watt sound system. Among the few available options are leather upholstery, a CD player, heated seats and a moonroof.

Performance, according to Lexus, includes 0-to-60 mph in 8 seconds, the quarter-mile in 16.2 seconds and a top speed of 135 mph. We don't doubt these claims. Pricing wasn't available at preview time, but it's expected to start at \$25,000. —Michael Lamm

Volvo's Pollution Solution

● Volvo is field-testing a new electrically heated startup catalyst system (EHC) that may be the answer to the next round of tighter emissions regulations.

Currently undergoing extended evaluation by the Southern California Air Quality Management District (SCAQMD), the system is designed to sharply reduce the emissions that occur in cars before the catalytic converters warm up. In particular, California's 1994 regs call for a 60% reduction of NOX (oxides of nitrogen) and a 31% reduction in hydrocarbons.

The EHC is installed upstream of the conventional 3-way converter. An extra battery, mounted in the car's trunk, heats the EHC for about 20 seconds on starting, or whenever the temperature in the

EHC drops below its 700° F operating temp. The small EHC heats up quickly to treat exhaust gases, much quicker than the 2-minute warmup common to most contemporary catalytic systems.



Other related hardware extras include a bigger alternator, to keep both batteries charged, and an air-injection pump that adds oxygen to the exhaust gases before they get to the catalytic converters.

Volvo's SCAQMD fleet consists of five

flex-fuel 940 sedans running primarily on 85% methanol and 15% unleaded gasoline. And just how effective is that? According to Henry Morgan, an SCAQMD official, "These cars may be the cleanest liquid-fueled vehicles ever tested." —Herb Shuldiner

ELECTRONICS

RECORDABLE MINI-CD

BY FRANK VIZARD, Electronics Editor



● Just when you thought the music world was settling down to two digital formats—the compact disc and the soon-to-be-revealed Digital Compact Cassette (DCC), along comes Sony with a different idea.

Sometime next autumn, Sony plans to produce a 2½-in. magneto-optical Mini-Disc (MD) that will hold 74 minutes of digital audio. This equals the capacity of the larger CD already being sold in stores. MD is housed in a protective caddy similar to a computer diskette.

To make the product more interesting, you'll also be able to record onto an MD as you can do with a tape. Pre-recorded software can't be overwritten, however.

The problem is that the MD is not compatible with current CD hardware. You can only play MD discs on MD machines.

Why introduce MD just when it seemed we were entering an age of format stability? The CD version of the ubiquitous Walkman tape player doesn't stand up to portable use that well. If you're jogging, for example, the vibrations you cause are likely to make a personal CD player skip or shut down. For these types of pursuits, nothing compares to the ruggedness of a personal tape player.

With the exception of MD, perhaps. Music from the MD is first routed

through a 1MB memory chip capable of storing 3 seconds of sound. If an MD player is jostled enough to cause mistracking, music pours out of memory for 3 seconds. This is enough time for the laser to find its place again.

Sony is betting MD will go running into sales history with the Walkman. Competition in the portable arena is likely to come from DCC tape machines. Once again, people will not only have to decide what music they want to hear but how they want to hear it.

Meanwhile, digital audio tape

(DAT) is being relegated to a small, high-end portion of the market catering to sound professionals.

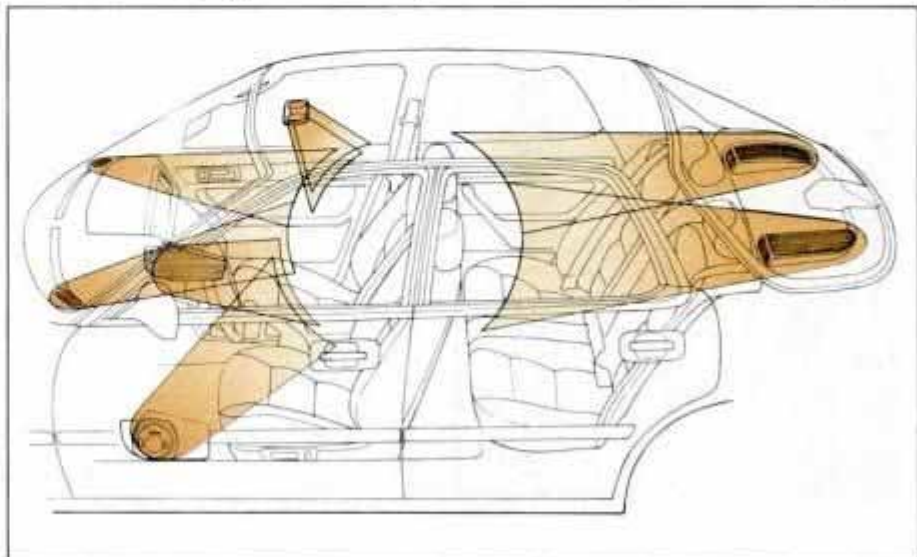
Vigorous Sound

Digital Sound Processing (DSP) circuitry can make a car or room interior sound like a different venue entirely. While DSP has been available in aftermarket components for some time, the 1992 Acura Vigor is the first car with a factory-built DSP system.

At the touch of a button, you'll think you're listening to music in an outdoor arena, concert hall, small club, church or recording studio. There's also a DEN setting that produces an acoustic environment similar to an average living room.

The speaker placement in the Vigor is just as interesting. On the rear deck are two 6 × 9-in. full-range speakers. In each door there's a 6½-in. woofer, and two 1½-in. tweeters are located in the dashboard. More interestingly, a pair of 2-in. midrange speakers are installed in the roof liner to either side of the overhead light. The overhead speakers and the dashboard tweeters combine to create a better sense of staging.

DSP is an enjoyable technology with certain types of music, but it can also become tiresome after awhile. The music, fortunately, never did thanks to the well-conceived sound distribution pattern in the Vigor. **FM**



Acura Vigor passengers can hear sound from eight directions.

DETROIT SPY REPORT

BY JIM DUNNE, Detroit Editor

Bolt-On Blazer

● There's a lot of current S-10 Blazer in this prototype (right), but the front-end clip shows which way GM's design staff is headed with its popular midsize sport/utility vehicles. Due for the 1993 model year, GMC's S-15 Jimmy and Chevy's S-10 Blazer will look stronger, more muscular and more rounded.

Yes, it does look a lot like competing entries from Toyota and Nissan, but since Toyota and Nissan are recognized as design leaders in this field, this isn't necessarily bad.

The prototype shown here is disguised to hide the sloping hoodline that will be part of the restyling. Like many manufacturers, GM uses new front-end clips mounted on current models to test their effect on cooling systems.

According to GM insiders, there'll be more muscle to go with the brawnier look. The 4.3-liter V6 that powers GM's midsize sport/utility vehicles and pickup trucks will be uprated for '93, to keep pace with Ford and Jeep.

Masked Ranger

Ford's disguise for its midsize pickup isn't quite as elaborate as Chevy's, but it's just as effective. Even so, this early '93 prototype gives some clues about the next-generation Ranger pickup.

Grillwork is similar to Ford's new full-size van lineup, and the door openings wrap into the roof, eliminating drip rails. The rear of the cab pro-



trudes slightly over the cargo bed, and the rear window has been moved back an inch or so for more room.

Saturn Quality

Saturn has drawn some criticism for its slow production startup, but it's hard to criticize the company's commitment to quality.

One example of this is a production scheme that allows virtually any worker to shut down the assembly line when he or she spots a problem, a Japanese technique that's been adopted at the new Spring Hill, Tennessee, facility.

An even better example is Saturn's recent difficulty with a bad batch of antifreeze supplied by an outside vendor to the factory. The antifreeze was so corrosive that it began producing water pump failures almost immediately.

Instead of trying to fix the cars, which might have left some owners with problems further down the road, Saturn took the unprecedented step of offering owners of affected vehicles a new car or a complete refund.

While this approach to customer satisfac-

tion is costly, it proves that Saturn management is determined to give owners what they bargain for—an American small car that's the equal of its imported competitors.

T-Bird Facelift

Ford plans only minor revisions for the 1993 Thunderbird SC. Small, round air holes in the front bumper will replace the current rectangular cutouts.

What lies behind the air passages may be a surprise, though. Insiders say that Ford's dohc 32-valve high-performance version of its 4.6-liter modular V8 may replace the current supercharged 3.8-liter V6.



Surprises may lurk behind T-Bird SC facelift.

The high-output version of the 4.6 V8 engine is scheduled to make its debut in the Lincoln Mark VIII, also due as a '93 model.

PM



Redesigned body of '93 Ranger should provide roomier cab.

GIANT TV (Continued from page 48)

screen. The better the response of the video amplifier, the better the picture will be. One megahertz generally equals 80 lines of resolution.

The convergence figure indicates how well the red, green and blue beams converge to create the picture on the screen. The convergence for any projection TV must be readjusted periodically because drifting does occur. The convergence is user adjustable with the aid of a crosshair test pattern built into the projection TV.

The audio signal-to-noise ratio is a measure of how good the sound system is in each model. The more distortion-free an audio system is the higher the S/N number will be. All four models perform very well in this regard.

Less impressive was how well these models receive stereo (MTS) broadcasting signals. While the Hitachi unit scored the best, even these numbers are well below what's theoretically possible. In fairness, most video manufacturers fall well short of what is possible as far as MTS is concerned.

"The Turk" arrives

In football camp, an assistant coach nicknamed "The Turk" knocks on your door in the middle of the night to let you know you haven't made the team. After analyzing the numbers and after viewing each projection TV with the same source material simultaneously, PM's coaching staff thinks only two models make the final roster, those being the Hitachi and Sony models.

While the Philips projection TV tested well and yielded good numbers, the 61MP60 bottomed out in the subjective viewing process. To put it simply, the other three pictures looked better. The Philips unit was a prototype, so actual production runs may yield an improved version.

The Mitsubishi VS-7004R is impressive due to its size. Yet, bigger isn't always better. In addition to the dark corners and a bit of overscan, the VS-7004R PM tested also had a small amount of geometric distortion—a bowing or pincushion effect—at the edges of the picture. The lack of features like surround sound and the hefty price tag are also negatives.

Choosing between the Sony and Hitachi models is tough. The picture quality of the Sony KPR-53EX35 is comparable to a direct-view television. It's as good a picture as we've seen anywhere. The depth of field, in particular, is remarkable.

The Hitachi 60SX1K is PM's top choice, however. The picture quality is right up there with the Sony model.

(Please turn to page 103)

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carts, cannot take continual deep discharging without being seriously degraded, admits Donald L. Runkle, GM's vice president of advanced engineering. Optimum life for lead-acid batteries can only be achieved if discharges below the 50% level are infrequent, Runkle says.

Runkle is heading up GM's project to design a production version of the Impact, expected to be on the market soon, perhaps in two or three years. Unlike Chrysler and Ford, GM is designing an all-new chassis from the ground up.

Fun to drive

Runkle promises "to make this a real car, so that it's fun to drive." He won't reveal specifics, but hints that the vehicle will be highly aerodynamic and give good performance—although not necessarily matching the Impact's top speed and acceleration marks. Still, Runkle promises the new EV will not be a compromised vehicle despite its conventional lead-acid batteries—a statement that leaves some experts skeptical.

Runkle refuses to say how big the production EV will be or how many passengers it will carry. But the lightweight plastic body should help compensate for the huge battery pack the vehicle must use to obtain a decent range. The heavy battery load will also diminish passenger and cargo loads for the vehicle.

GM President Lloyd Reuss says the company will probably sell the EV through selected dealers in more than one division. Runkle says it will be a premium-priced model "because it's more costly to build than a car with an internal combustion engine."

Another factor that promises to make EVs expensive is battery pack replacement. Owners face a replacement cost of anywhere from \$3000 to \$5000. Projecting a battery pack life cycle of two to four years, this represents a big hidden cost for the prospective buyer. Some manufacturers are discussing battery leasing plans to offset this problem, while others are considering schemes that will factor the battery replacement cost into monthly payments.

GM's investment in the EV project, however, will be far below startups like the Saturn. Runkle says GM's investment in the EV will be "in the hundreds of millions." The Saturn project cost about \$2.5 billion.

The EV will be built in the Craft Centre in Lansing, Michigan, former home of the Buick Reatta. The facility had a production capacity of 60 Reattas per day, running one shift. Informed speculation has it that GM will

probably offer an EV similar to the Impact and also a small gasoline/battery hybrid minivan at about the same time.

Plentiful problems

Before the Big Three launch their production EVs, huge marketing, engineering and safety problems must be resolved. The foremost of these is convincing buyers that a car with a "fuel" capacity of 1 to 3 gallons will be adequate for their needs. Then producers have to persuade buyers that the new technology works and that it won't cause driving or service problems. And then there's safety—will the EV be as safe as a conventional automobile?

"We're going to make the EV's driving characteristics as transparent as possible," says Robert A. Kiessel, manager of product planning for Ford's EV program. GM's Runkle says, "You shouldn't have to buy this car because it's electric, but because it's a neat car."

Engineers are still trying to perfect the powertrains of EVs. Gear noise is a problem. Accelerator feel is also being worked on. All EVs have drive-by-wire characteristics that may take getting used to. More efficient brake regeneration systems are also in the works. This allows the energy created in braking to be channeled to the batteries and stored there. It's a small range-extender, but in EVs, every bit of energy is important.

Restricted range

The range of EVs probably will never compare to what cars with internal combustion engines can provide, regardless of how good a battery will eventually be developed. Two conventional lead-acid batteries contain only as much energy as a shot glass of gasoline.

But in all performance areas other than range, the car companies are determined to make no compromises in their EVs. Kiessel says Ford has the same corporate acceptance standards for EVs as it does for its other vehicles. That includes safety and climate controls for the vehicle.

The vision of a half-ton of batteries cascading across a freeway during an EV accident is frightening. Ford is taking the same steps to protect the EV battery pack as those it uses to protect gas tanks and bolt down big engines in conventional cars.

Climate control

Climate control management is far more difficult in EVs than conventional cars. Heating and defrosting of conventional cars is accomplished

with waste heat from the engine, via the cooling system. But heating in EVs requires about 20% of the amount of current it takes to propel the vehicle down the road, cutting sharply into the vehicle's driving range. So EV engineers are trying to develop more efficient heating and defrosting systems, to cut down on power consumption.

Engineers are also proposing some innovative uses of insulation to keep vehicle interiors from getting as cold. Ford's John Wallace also says it's possible the passenger compartments of vans will be separated from the cargo area by a bulkhead—only the passenger cockpit would be heated.

Air conditioning soaks up even more electricity than heating. EPRI is assisting the auto companies in the development of heat pumps that work more efficiently than today's air conditioning units. Manufacturers are also considering better venting systems—or even solar-powered exhaust systems—to keep vehicle interiors from getting too hot in direct sunlight. These solutions could also help cut down on drawing current from the battery.

Political backing

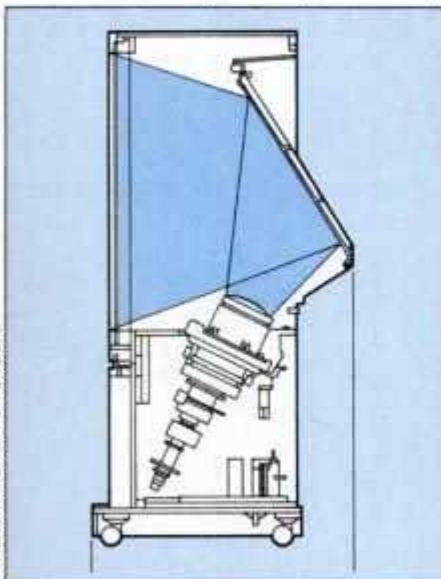
Politicians who favor EVs as a way to help cut down on air pollution are attempting to assist the car companies with research money. Congressman George Brown of California and Senator Jay Rockefeller of West Virginia have introduced National Electric Vehicle Acts in their respective houses of Congress. The bills would provide about \$50 million for EV research. Other political leaders are talking about enacting legislation and regulation that might help entice buyers: special parking areas, dedicated freeway lanes, lower registration fees and sales taxes—even special recharging stations to enhance EV practicality.

Consumer confidence

But there can be no laws or inducements that would compel consumers to buy EVs if there is no confidence in obtaining enough performance and cruising range to make them useful.

One engineer who is acutely conscious of this is Jim Hall, a member of the original Impact team who is now at work on ultrasecret future GM projects. Hall says the problems ahead are still so formidable that engineers working on EV development could either throw up their hands and say, "Oh my God," or roll up their sleeves and say, "Oh boy!" The enthusiastic Hall says, "For us, it's oh boy!" **FM**

In the lab, the Hitachi 60SX1K PM tested, also a prototype, had the best scores in just about every category. The relatively small size of the cabinet—note the 28 in. depth—makes this projection TV a space saver. And all the features you'd expect from a



PM ILLUSTRATION BY RON CARBONI

In rear-projection TVs, the image bounces off a mirror onto a screen.

high-end television are included.

What does the future hold for really large projection television? In the near term, Mitsubishi is adding a new 70-in. model to its lineup later this year. The VS-7017R is expected to be much like the VS-7004R, but with a better on-screen programming methodology.

Also, Toshiba intends to market a 55-in. model, the TR5580A. List price is \$4000. Features include picture-in-picture and Digital Sound Processing circuitry that mimics the acoustic interior of four venues. Pioneer is also scheduled to debut a 55-in. model, the SD-P5553, listing for \$4500.

In the long term, our bet is that 70 in. represents the practical limit for rear-projection television. Front LCD projection TVs are able to project larger viewing areas onto walls or large screens much easier.

Currently, the largest picture tube made is 35 in., and the price is comparable to larger-sized projection televisions. As rear-projection TVs become easier to manufacture, and provided the picture quality is good, don't be surprised if you see projection TV competing head-on with or superseding direct-view models.

Right now, if you want a larger screen size than what direct-view can offer, rear-projection TVs are the way to go. If you shop around, the bigger screen size won't cost you anything as far as picture quality is concerned.

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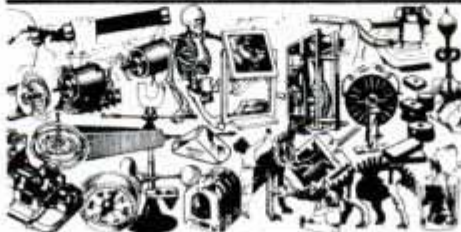
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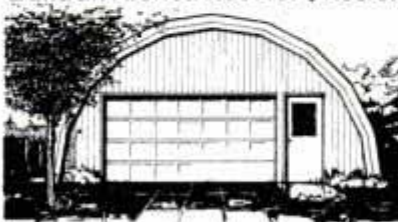
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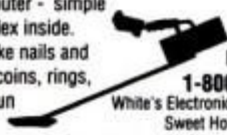
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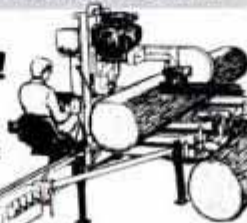
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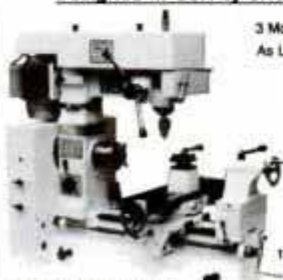


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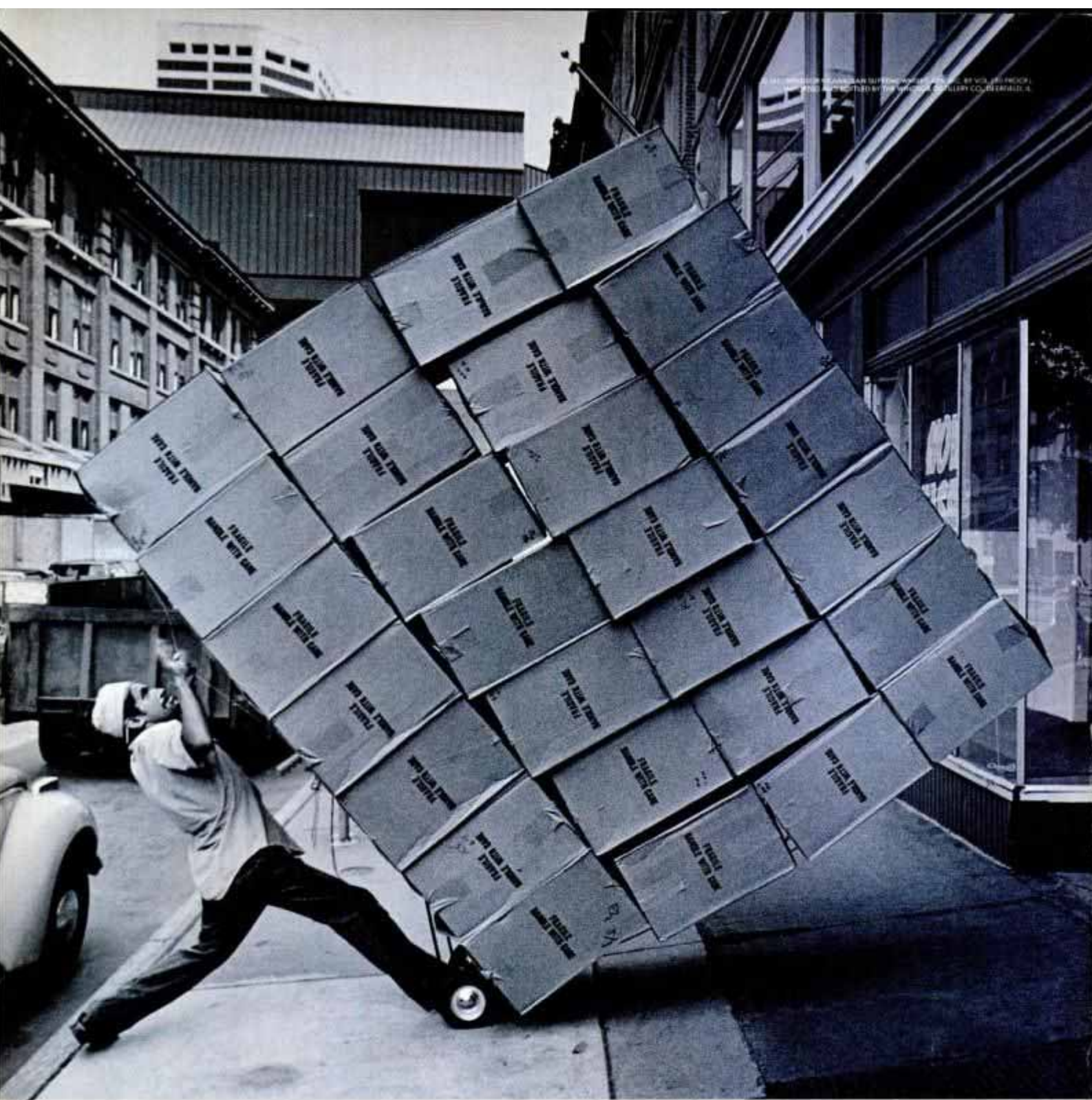
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