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# Popular Mechanics

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# X

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# Popular Mechanics®

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AND



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PRESENT

# THE NATIONAL AUTO QUIZ

1. The car shown here is the:



A) Hyundai HCD-II. B) Ford Ghia Focus. C) GM UltraLite. D) Pontiac ProtoSport 4.

2. The most expensive 1994 production car is made by:

A) Rolls-Royce. B) Bugatti. C) Aston Martin. D) Lamborghini.

3. What is the recommended drain interval for synthetic motor oil?

A) Every 3,000 miles. B) Every 10,000 miles. C) Every 25,000 miles. D) The same interval as recommended in your owner's manual for conventional oil.

4. The first race at the Indianapolis Motor Speedway in its inaugural year (1909) was won by what make automobile?

A) Marmon. B) Stutz. C) Buick. D) Ford.

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Send us your auto-related questions. If we use one of them in a future quiz, we'll send you a free car care video. In case of duplicate questions, the one with the earliest postmark will win.

Send your entries to:  
National Auto Quiz  
POPULAR MECHANICS  
224 W. 57th St.  
New York, NY 10019

5. The purpose of steel struts cast into an aluminum piston is to:

A) Provide increased strength. B) Provide increased weight at the piston crown for added stability. C) Provide increased heat transfer from the piston head to the piston pin. D) Control thermal expansion.

6. What was the average price for a new car in 1940?

A) \$750. B) \$1,400. C) \$2,000 D) \$3,000

7. What company manufactured the first mass produced V8 engine?

A) Cadillac. B) Chevrolet. C) Ford. D) Hupmobile.

8. Engine overheating can be caused by which of the following conditions:

A) Low engine oil level. B) incorrect ignition timing. C) Broken fan belt. D) All of the above.

9. America's first "official" auto race took place in Chicago, on Thanksgiving Day, 1895. J. Frank Duryea was declared the winner. What was his average speed?

A) 5.05 MPH. B) 23.62 MPH. C) 34.11 MPH. D) 48.01 MPH.

10. What car was introduced at the 1964 World's Fair in New York?

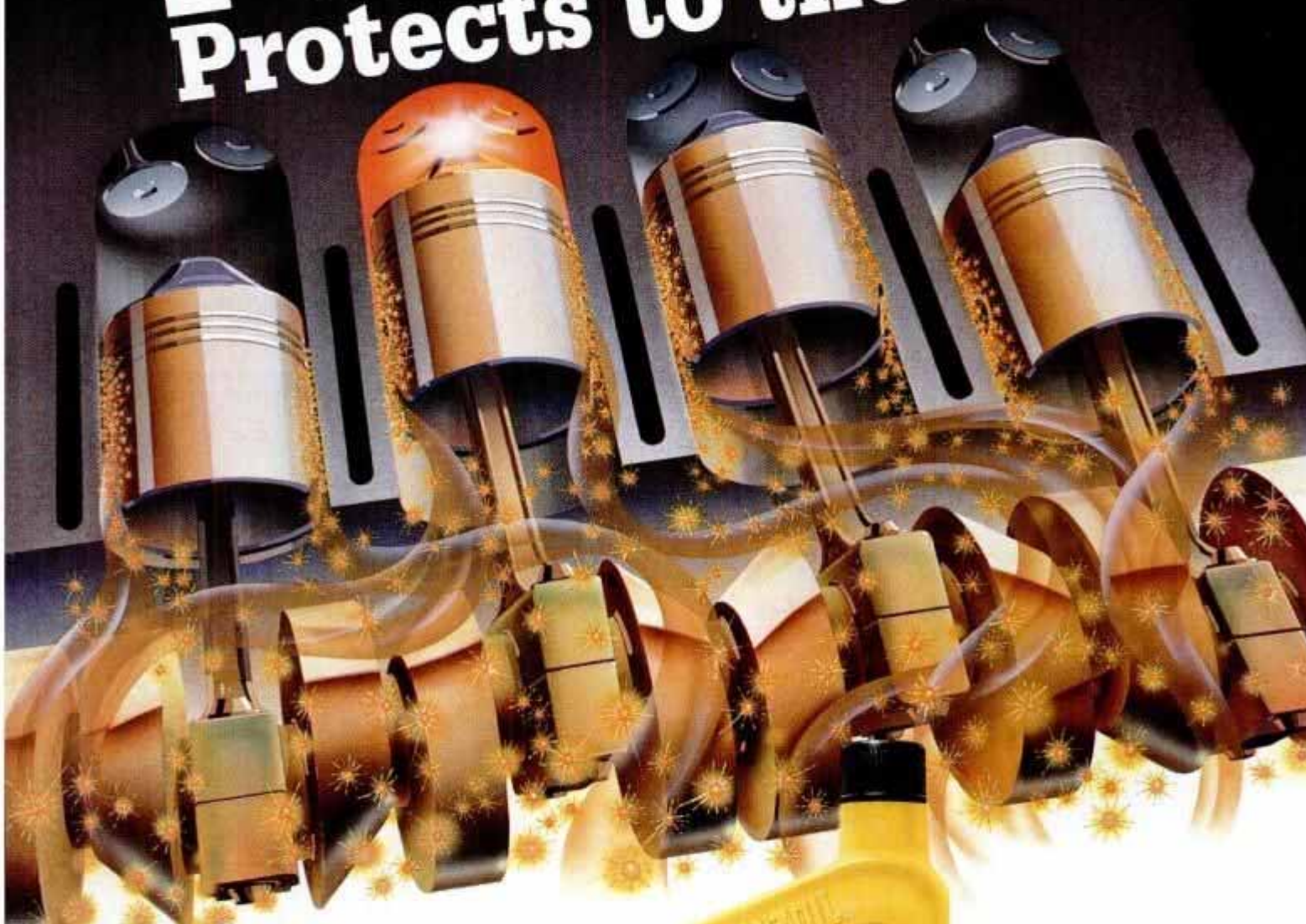
A) Buick Skylark. B) Ford Mustang. C) Pontiac GTO. D) Chrysler Turbine.

ANSWERS  
1. C 2. B (The EB 110 costs about \$1million) 3. D 4. C (The first Indy 500, won by a Marmon Wasp, wasn't run until 1911) 5. D 6. A 7. A (1915) 8. D 9. A 10. B.



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# EDITOR'S NOTES

● That's a U.S. Navy attack sub poking its head up through the polar ice in the photo to the right. And standing on the ice is our own Abe Dane, Science/Technology Editor. The scene is somewhere north of the Arctic Circle (actual location classified), and the sub has just transported Dane via a secret under-ice passageway to Ice Station X, a classified, super-secret base where our armed forces train for arctic warfare. If all this sounds fantastic, like something from a Hollywood movie, hey, what can I tell you? It's all real and it all exists, as you'll see from Dane's incredible article beginning on page 30. . . . **The article is the last piece you'll see in these pages from Abe Dane, at least for a while.** He recently accepted one of only eight Knight Science Journalism Fellowships at the Massachusetts Institute of

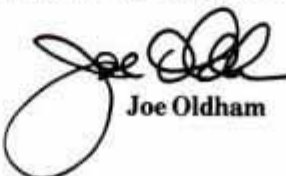


Abe Dane and a U.S. Navy attack sub north of the Arctic Circle.



Joe Skorupa (right) with the Camel Trophy winners in Borneo.

Technology. So rather than writing great articles for POPULAR MECHANICS, Dane will spend the next nine months talking to MIT scientists and engineers, attending classes at Harvard University and pursuing independent research in the labs and libraries of MIT, one of the world's great academic institutions. The objective of the program is to develop the talents of journalists who have shown unusual potential in explaining science and technology to the general public. We think Abe has a great head start along those lines. . . . **If you think Abe Dane has traveled to exotic places in journalistic pursuit of a story, how about Boating/Outdoors Editor Joe Skorupa?** He recently traveled to Borneo to hook up with the American team in this year's Camel Trophy rally—perhaps the toughest off-road competitive event in the world. I don't want to give away the whole story, which begins on page 40, but I will tell you that the Americans won. Way to go, guys! . . . **Every time I vow never to do another project car, someone comes up with a great idea for one and hooks me.** This time, we're turning a good Buick Roadmaster Estate Wagon into a great wagon that hauls—and hauls. We're calling it Project Workahaulic. Our basic premise is to add more power and better handling to make towing an effortless proposition. If we also make everyday trips more enjoyable too, so much the better. We start this month, on page 27, and we'll follow up when the project is complete. . . . **This year, our annual Woodworking Guide is devoted entirely to making your completed furniture project look even more beautiful through professional-quality finishing.** This is the final step in any project—the one that separates a utilitarian piece of furniture from a dazzling showpiece that you're proud to display. Here's all you need to know to dazzle 'em every time. Till next time.

  
Joe Oldham

# Popular Mechanics

Editor-In-Chief Joe Oldham

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## Editorial Offices

224 West 57 St.,  
New York, NY 10019  
(212) 649-2000

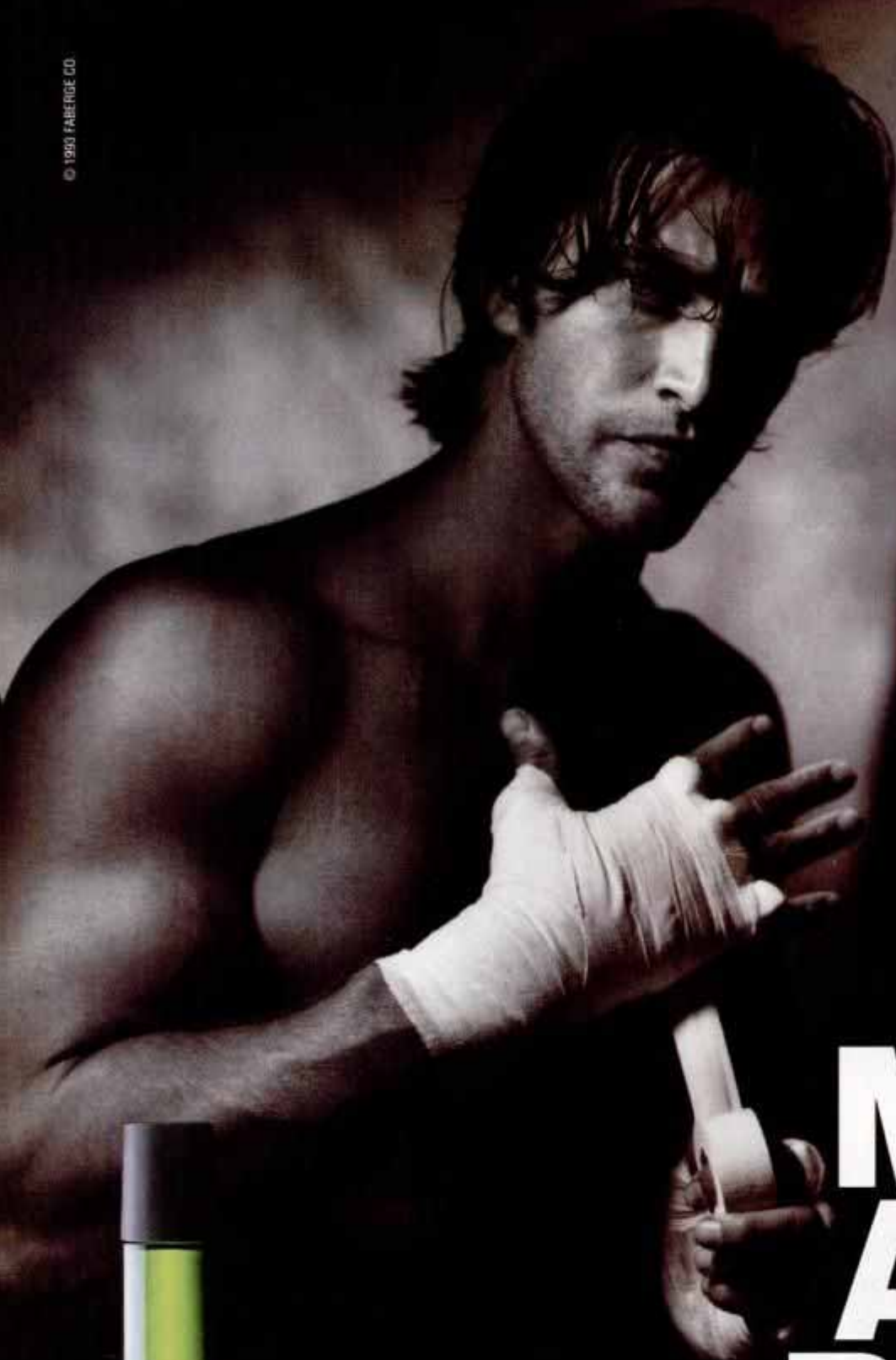
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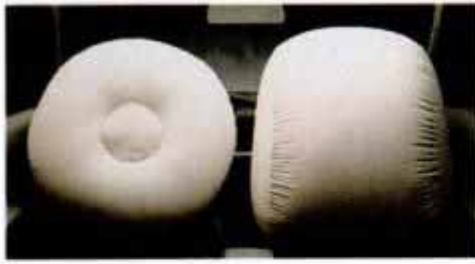
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# MEN ARE BACK

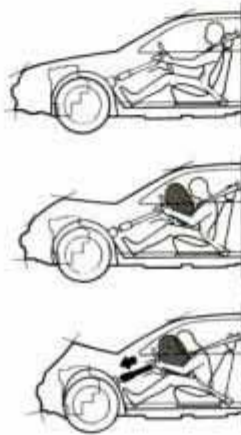


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*Statistics indicate the airbag effectively helps to save lives. That's why every 1994 Nissan Altima\* is equipped with two. Standard.*

*The steering column, like the ones found on the Mercedes, BMW and Lexus, is designed to absorb maximum impact energy.*



*Steel side-door guard beams, utilizing a pipe-style design, increase intrusion resistance. In other words, there's a better chance the cabin will stay a cabin.*

*Not all anti-lock braking systems are created equal. Some rely on two sensors. Some, three. The optional ABS on the Altima\* has four, one for each wheel.*



**It's a \$14,000 car in a showroom,**

*Unlike any other sedan in its class, the Altima features Super Toe Control™ to help you avoid accidents. As cornering forces increase, rear wheels turn in proportion, resulting in remarkable maneuverability.*



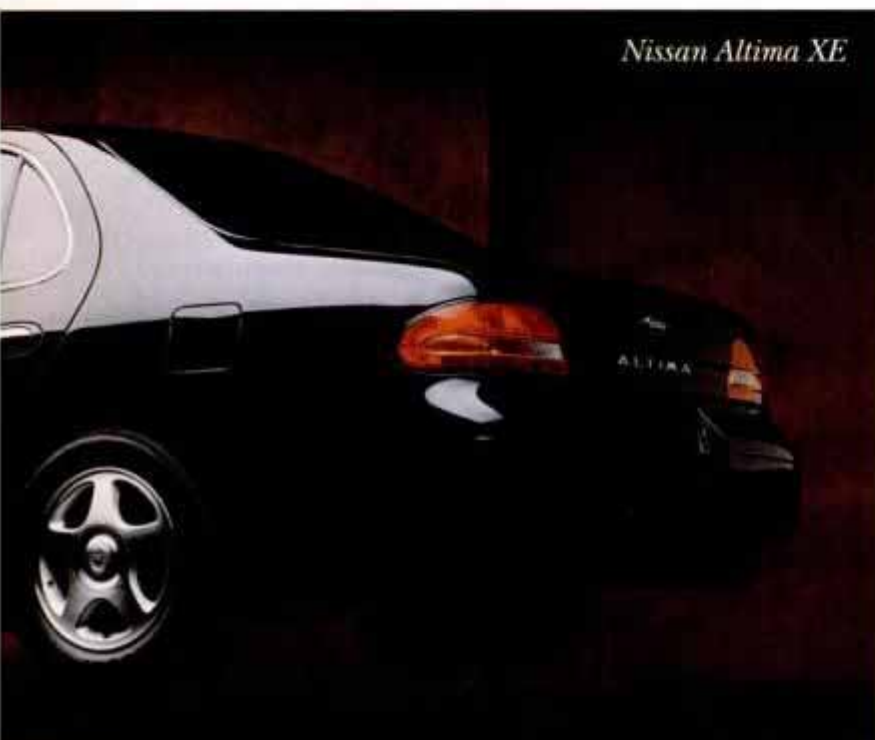
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*Passenger protection is provided by our Intelligent Body Assembly System and its 51 robots responsible for the DURASTEEL® unibody construction.*



*New three-point active seat belts with adjustable shoulder belt anchors provide greater comfort and convenience without sacrificing safety.*



*Nissan Altima XE*



*We conducted the equivalent of close to 15,183 man years of crash testing on the Cray® XMP/12 computer to determine the structural design of the energy-absorbing crumple zones.*

**but a \$45,000 car in an accident.**

*Besides having many of the same luxury features, the \$14,000\* Nissan Altima and the typical \$45,000 sedan share many of the same safety features. Of course, the Altima doesn't have a fancy hood ornament. But what kind of protection do you suppose is offered by a hood ornament? For more information, call 1-800-NISSAN-3 ext 459.*



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# LETTERS

## America's Best Seller



What a relief to read articles such as "Owners Report: Ford Taurus." Quality issues such as fit and finish and reliability finally have been addressed. After waiting 20 years for American automakers to get it right, I now plan to respond positively with my pocketbook when I purchase my next automobile. American cars are back, Japan. Get used to it.

JOSEPH M. FERRANT  
SAN JOSE, CA

### Un-American?

The letters regarding PM's "anti-American bias" were extremely unfair. I am a PM subscriber primarily because it's one of the most neutral magazines I have ever read. Keep up the good work.

RICHARD 126  
READER BULLETIN BOARD

### Build A Better Bill

In September's Letters column, you agreed with Ed Gonfindini's assertion that readers should fight against the Clunker Bill. Let's not just fight this possibly useful legislation, let's think of how to reshape it and make it better. If we craft a good bill and

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

take clunkers off the road, we will have:

- More, not fewer, recycled parts for true restorations.
- Lower parts prices and a growing restoration industry.
- Less air pollution in urban centers where older cars now dominate.
- Better sales of U.S. autos, which means more jobs.
- Protection of lower-income persons by a state tax on registrations of pre-1974 non-restored light vehicles, plowing this money into mass transit.

I hope your readers will weigh in on the Clunker Bill, but in a fashion to get the real junk off the road. This could lessen pollution, create jobs and better serve lower- and fixed-income persons than the way things are now. BION D. HOWARD  
UPPER MARLBORO, MD

### More Great Trains

I enjoyed the article "Great Trains, Great Rides," but you should have included the Great Smoky Mountains Railway. It runs through North Carolina from Dillsboro to Bryson City and from Bryson City to Murphy.

ROBERT V. SUGGS  
GREENSBORO, NC

*For more information, write Great Smoky Mountains Railway, P.O. Box 397, Dillsboro, NC 28725.*

I appreciate your recent effort in telling the story of America's railroad revival, but you failed to mention the nation's historic steam railroad museum and an excursion known as Steamtown National Historic Site, located in Scranton, Pennsylvania. Although the site is still under construction and will not officially open until the spring of 1995, the

railyard, roundhouse areas and excursion runs are open to the general public on a year-round basis.

ROBERT J. DAVIS  
DUNMORE, PA

*For more information, write Superintendent, Steamtown National Historic Site, 150 S. Washington Ave., Scranton, PA 18503; (717) 961-2033.*

You excluded the Skunk Train that operates between Fort Bragg, California, on State Route 1, to Willits, on Highway 101. It's a beautiful 40-mile train ride through redwood groves going from an elevation of 80 ft. to 1365 ft.

DALE F. DOWIS  
HUNTINGTON BEACH, CA

*For more information, write Skunk Train, P.O. Box 907A, Fort Bragg, CA 95437; (707) 964-6371.*

You missed two very important railroads—the East Broad Top Railroad in Orbisonia, Pennsylvania, and the Cumbres & Toltec Scenic Railroad in Chama, New Mexico, and Antonito, Colorado. The East Broad Top is the only narrow-gauge railroad in the Eastern United States still operating at its original site. The Cumbres & Toltec is America's longest and highest narrow-gauge steam railroad. It operates on 64 miles of track and is one of the most scenic railroads in operation.

JIM CASSATT JR.  
HUMMELSTOWN, PA

*For more information, write either the Antonito Depot, P.O. Box 668, Antonito, CO 81120; (719) 376-5483, or the Chama Depot, P.O. Box 789, Chama, NM 87520; (505) 756-2151. PM*

## Reader Project Of The Month



I wanted to build an outside toy for my son to play on. While looking at other plans, I recalled a toy sailboat that was in my grandpa's copy of PM (August 1963). The backyard sloop was easy to make and I used pressure-treated lumber so it will last a long time. Since C.J. is only 2 years old, I'm waiting to put up the rope ladders. This, however, has not stopped him from enjoying the boat.

MICHAEL L. GRAVOIS  
BIRMINGHAM, AL

# John's losing his hair. His mission: get it back.

ASAP!

But how?

Weaving?

No.

Transplant?

Not for him.

A hairpiece?

Never, never.

What John really wants is his *own* hair back.

And now he's learned for male pattern baldness,

**Only Rogaine has been proven to regrow hair.**

**Rogaine**  
TOPICAL SOLUTION minoxidil 2%

*Rogaine*<sup>®</sup> Topical Solution (minoxidil 2%) works in part by prolonging the growth of hair, which grows in cycles. With more hairs growing longer and thicker at the same time, you may see improved scalp coverage.

Dermatologists conducted 12-month clinical tests. After 4 months, 26% of patients using *Rogaine* reported moderate to dense hair regrowth, compared with 11% of those using a placebo (a similar solution without minoxidil—the active ingredient in *Rogaine*). After 1 year, 48% of the men who continued using *Rogaine* in the study rated their regrowth as moderate to dense. Thirty-six percent reported minimal regrowth. The rest (16%) had no regrowth.

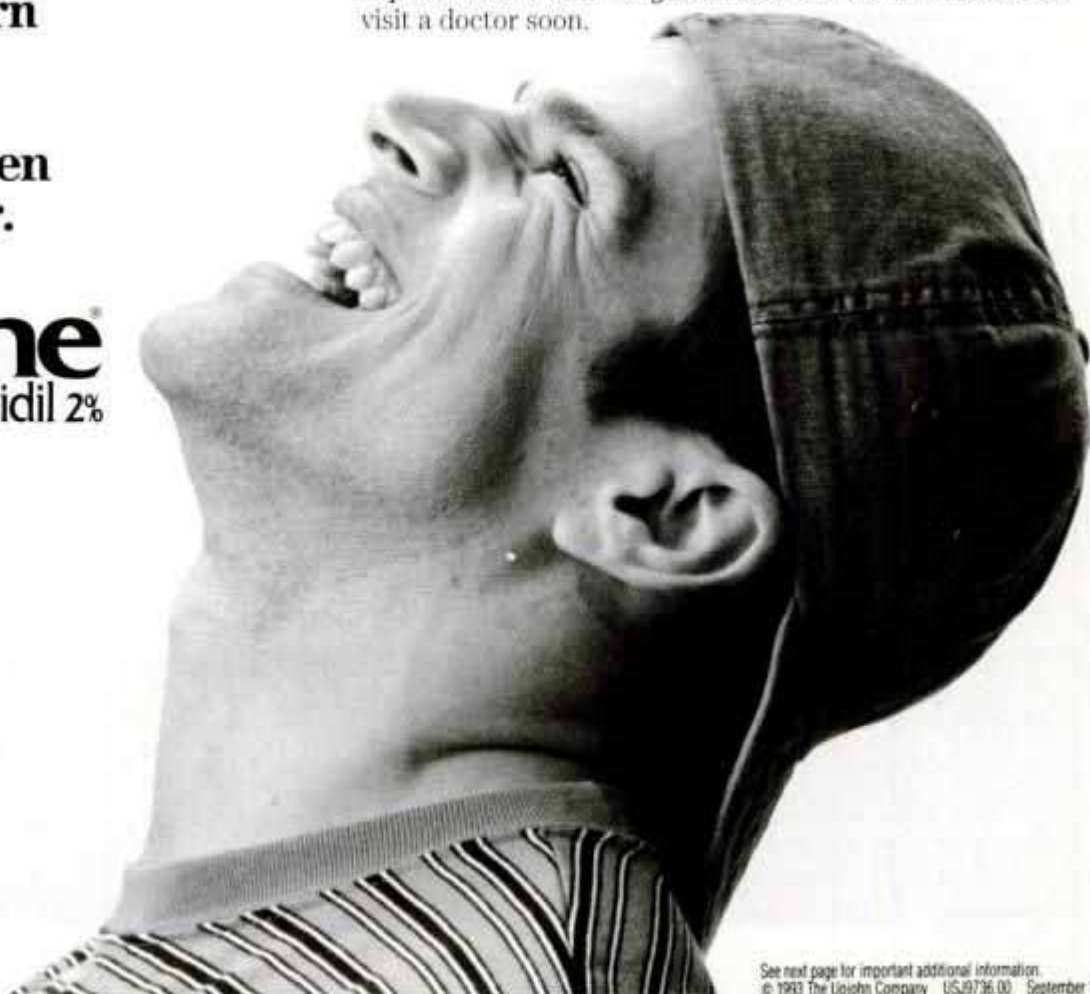
Side effects were minimal: 7% of those who used *Rogaine* had itching of the scalp. *Rogaine* should only be applied to a normal, healthy scalp (not sunburned or irritated).

Studies indicate that *at least 4 months of twice-daily treatment with Rogaine* are usually necessary before there is evidence of regrowth. So why not make it part of your normal routine when you wake up and go to bed, like brushing your teeth.

As you'd expect, if you are older, balding longer, or have a larger area of baldness, you may do less well.

*Rogaine* is a treatment, not a cure. So further progress is only possible by using it continuously. Some anecdotal reports indicate that if you stop using it, you will probably shed the newly regrown hair within a few months.

Why wait? Find out whether *Rogaine* is for you. Call **1-800-333-9199**. Today. We'll send you an informational brochure explaining all about the product and how to use it. And because *Rogaine* requires a prescription, we'll include a list of nearby *dermatologists or other doctors experienced in treating hair loss* and a \$10 incentive to visit a doctor soon.



See next page for important additional information.  
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**Rogaine**<sup>®</sup>  
TOPICAL SOLUTION  
minoxidil 2%

## The only product ever proven to regrow hair for male pattern baldness.

### What is ROGAINE?

ROGAINE Topical Solution is a prescription medicine for use on the scalp that is used to treat a type of hair loss in men and women known as androgenetic alopecia: hair loss of the scalp vertex (top or crown of the head) in men and diffuse hair loss or thinning of the front and top of the scalp in women. ROGAINE is a topical form of minoxidil, for use on the scalp.

### How effective is ROGAINE?

**In men:** Clinical studies with ROGAINE of over 2,300 men with male pattern baldness involving the top (vertex) of the head were conducted by physicians in 27 US medical centers. Based on patient evaluations of regrowth at the end of 4 months, 26% of the patients using ROGAINE had moderate to dense hair regrowth compared with 11% who used a placebo treatment (no active ingredient). No regrowth was reported by 41% of those using ROGAINE and 60% of those using a placebo. By the end of 1 year, 48% of those who continued to use ROGAINE rated their hair growth as moderate or better.

**In women:** Clinical studies with ROGAINE were conducted by physicians in 11 US medical centers involving 256 women with hair loss. Based on patient evaluations of regrowth after 32 weeks (8 months), 19% of the women using ROGAINE had at least moderate regrowth compared with 7% of those using a placebo. No regrowth was reported by 41% of the group using ROGAINE and 60% of the group using placebo.

### How soon can I expect results from using ROGAINE?

Studies show that the response time to ROGAINE may differ greatly from one person to another. Some people using ROGAINE may see results faster than others; others may respond with a slower rate of hair regrowth. You should not expect visible regrowth in less than 4 months.

### How long do I need to use ROGAINE?

ROGAINE is a hair-loss treatment, not a cure. If you have new hair growth, you will need to continue using ROGAINE to keep or increase hair regrowth. If you do not begin to show new hair growth with ROGAINE after a reasonable period of time (at least 4 months), your doctor may advise you to discontinue using ROGAINE.

### What happens if I stop using ROGAINE? Will I keep the new hair?

Probably not. People have reported that new hair growth was shed after they stopped using ROGAINE.

### How much ROGAINE should I use?

You should apply a 1-mL dose of ROGAINE twice a day to your clean dry scalp, once in the morning and once at night before bedtime. Wash your hands after use if your fingers are used to apply ROGAINE. ROGAINE must remain on the scalp for at least 4 hours to ensure penetration into the scalp. Do not wash your hair for at least 4 hours after applying it. If you wash your hair before applying ROGAINE, be sure your scalp and hair are dry when you apply it. Please refer to the instructions for use in the package.

### What if I miss a dose or forget to use ROGAINE?

Do not try to make up for missed applications of ROGAINE. You should restart your twice-daily doses and return to your usual schedule.

### What are the most common side effects reported in clinical studies with ROGAINE?

Itching and other skin irritations of the treated scalp area were the most common side effects directly linked to ROGAINE in clinical studies. About 7 of every 100 people who used ROGAINE (7%) had these complaints.

Other side effects, including light-headedness, dizziness, and headaches, were reported both by people using ROGAINE and by those using the placebo solution with no minoxidil. You should ask your doctor to discuss side effects of ROGAINE with you.

People who are extra sensitive or allergic to minoxidil, propylene glycol, or ethanol should not use ROGAINE.

ROGAINE Topical Solution contains alcohol, which could cause burning or irritation of the eyes or sensitive skin areas. If ROGAINE accidentally gets into these areas, rinse the area with large amounts of cool tap water. Contact your doctor if the irritation does not go away. If the spray applicator is used, avoid inhaling the spray.

### What are some of the side effects people have reported?

ROGAINE was used by 3,857 patients (347 females) in placebo-controlled clinical trials. Except for dermatologic events (involving the skin), no individual reaction or reactions grouped by body systems appeared to be more common in the minoxidil-treated patients than in placebo-treated patients.

**Dermatologic:** irritant or allergic contact dermatitis—7.36%; **Respiratory:** bronchitis, upper respiratory infection, sinusitis—7.16%; **Gastrointestinal:** diarrhea, nausea, vomiting—4.33%; **Neurologic:** headache, dizziness, faintness, light-headedness—3.42%; **Musculoskeletal:** fractures, back pain, tendonitis—2.59%; **Cardiovascular:** edema, chest pain, blood pressure increases/decreases, palpitations, pulse rate increases/decreases—1.53%; **Allergic:** nonspecific allergic reactions, hives, allergic rhinitis, facial swelling, and sensitivity—1.27%; **Metabolic-Nutritional:** edema, weight gain—1.24%; **Special Senses:** conjunctivitis, ear infections, vertigo—1.17%; **Genital Tract:** prostaticitis, epididymitis, vaginitis, vulvitis, vaginal discharge/itching—0.91%; **Urinary Tract:** urinary tract infections, renal calculi, urethritis—0.93%; **Endocrine:** 0.47%; **Psychiatric:** anxiety, depression, fatigue—0.36%; **Hematologic:** lymphadenopathy, thrombocytopenia—0.31%.

ROGAINE use has been monitored for up to 5 years, and there has been no change in incidence or severity of reported adverse reactions. Additional adverse events have been reported since marketing ROGAINE and include eczema; hypertrichosis (excessive hair growth); local erythema (redness); pruritus (itching); dry skin/scalp flaking; sexual dysfunction; visual disturbances, including decreased visual acuity (clarity); increase in hair loss; and alopecia (hair loss).

### What are the possible side effects that could affect the heart and circulation when using ROGAINE?

Serious side effects have not been linked to ROGAINE in clinical studies. However, it is possible that they could occur if more than the recommended dose of ROGAINE was applied, because the active ingredient in ROGAINE is the same as that in minoxidil tablets. These effects appear to be dose related; that is, more effects are seen with higher doses.

Because very small amounts of minoxidil reach the blood when the recommended dose of ROGAINE is applied to the scalp, you should know about certain effects that may occur when the tablet form of minoxidil is used to treat high blood pressure. Minoxidil tablets lower blood pressure by relaxing the arteries, an effect called vasodilation. Vasodilation leads to fluid retention and faster heart rate. The following effects have occurred in some patients taking minoxidil tablets for high blood pressure:

**Increased heart rate:** some patients have reported that their resting heart rate increased by more than 20 beats per minute.

**Salt and water retention:** weight gain of more than 5 pounds in a short period of time or swelling of the face, hands, ankles, or stomach area.

**Problems breathing:** especially when lying down; a result of a buildup of body fluids or fluid around the heart.

**Worsening or new attack of angina pectoris:** brief, sudden chest pain.

When you apply ROGAINE to normal skin, very little minoxidil is absorbed. You probably will not have the possible effects caused by minoxidil tablets when you use ROGAINE. If, however, you experience any of the possible side effects listed above, stop using ROGAINE and consult your doctor. Any such effects would be most likely if ROGAINE was used on damaged or inflamed skin or in greater than recommended amounts.

In animal studies, minoxidil, in much larger amounts than would be absorbed from topical use (on skin) in people, has caused important heart-structure damage. This kind of damage has not been seen in humans given minoxidil tablets for high blood pressure at effective doses.

### What factors may increase the risk of serious side effects with ROGAINE?

People with a known or suspected heart condition or a tendency for heart failure would be at particular risk if increased heart rate or fluid retention were to occur. People with these kinds of heart problems should discuss the possible risks of treatment with their doctor if they choose to use ROGAINE.

ROGAINE should be used only on the balding scalp. Using ROGAINE on other parts of the body may increase minoxidil absorption, which may increase the chances of having side effects. You should not use ROGAINE if your scalp is irritated or sunburned, and you should not use it if you are using other skin treatments on your scalp.

### Can people with high blood pressure use ROGAINE?

Most people with high blood pressure, including those taking high blood pressure medicine, can use ROGAINE but should be monitored closely by their doctor. Patients taking a blood pressure medicine called guanethidine should not use ROGAINE.

### Should any precautions be followed?

People who use ROGAINE should see their doctor 1 month after starting ROGAINE and at least every 6 months thereafter. Stop using ROGAINE if any of the following occur: salt and water retention, problems breathing, faster heart rate, or chest pains.

Do not use ROGAINE if you are using other drugs applied to the scalp such as corticosteroids, retinoids, petrolatum, or agents that might increase absorption through the skin. ROGAINE is for use on the scalp only. Each 1 mL of solution contains 20 mg minoxidil, and accidental ingestion could cause unwanted effects.

### Are there special precautions for women?

Pregnant women and nursing mothers should not use ROGAINE. Also, its effects on women during labor and delivery are not known. Efficacy in postmenopausal women has not been studied. Studies show the use of ROGAINE will not affect menstrual cycle length, amount of flow, or duration of the menstrual period. Discontinue using ROGAINE and consult your doctor as soon as possible if your menstrual period does not occur at the expected time.

### Can ROGAINE be used by children?

No, the safety and effectiveness of ROGAINE has not been tested in people under age 18.

**Caution:** Federal law prohibits dispensing without a prescription. You must see a doctor to receive a prescription.

**Upjohn**

DERMATOLOGY  
DIVISION

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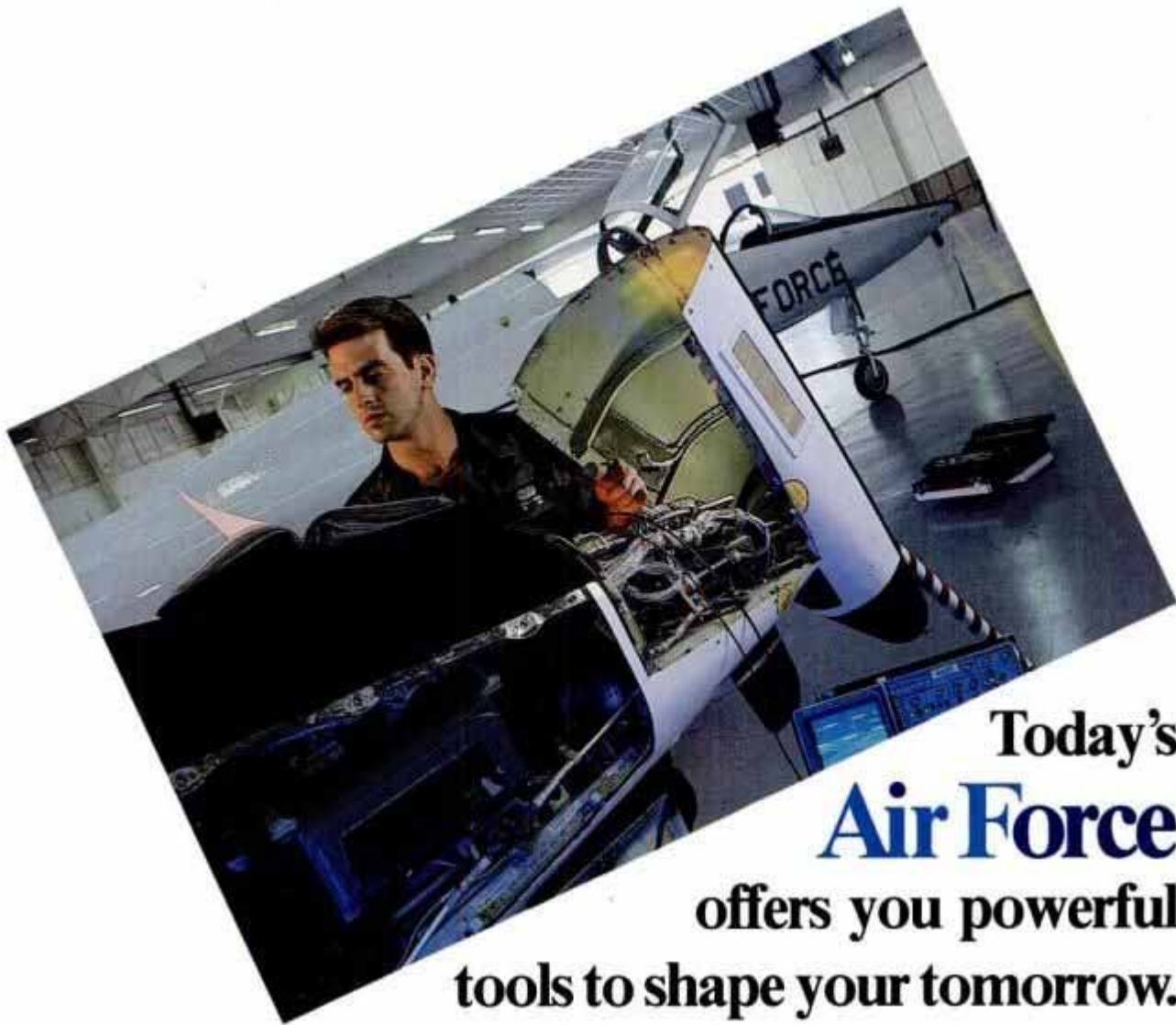
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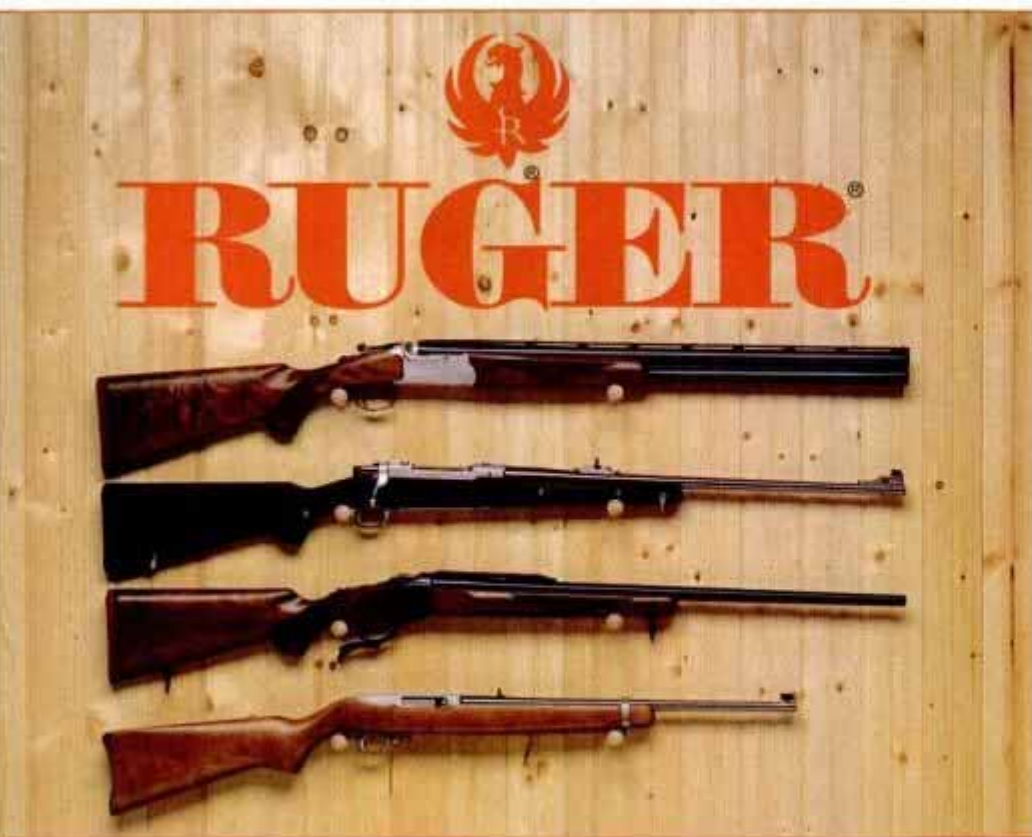
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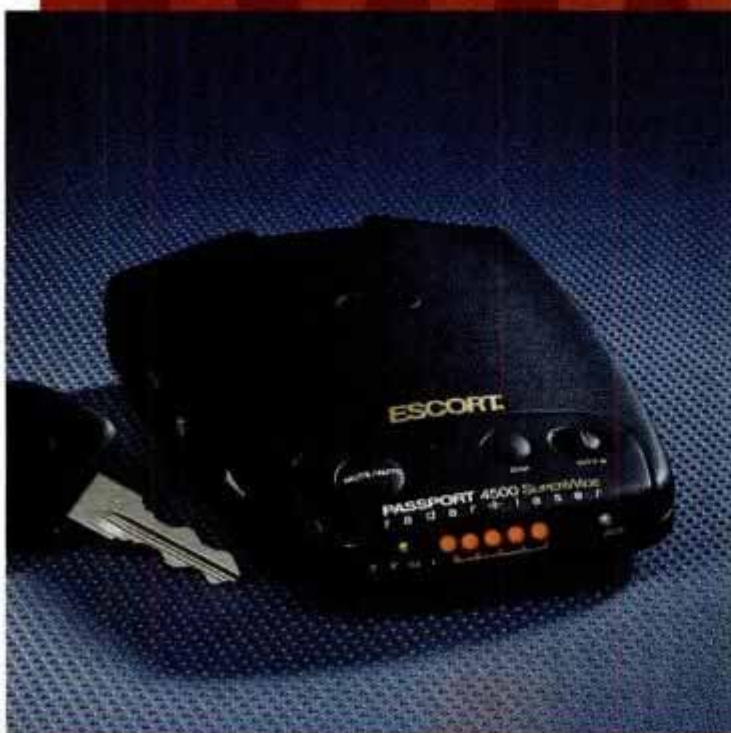
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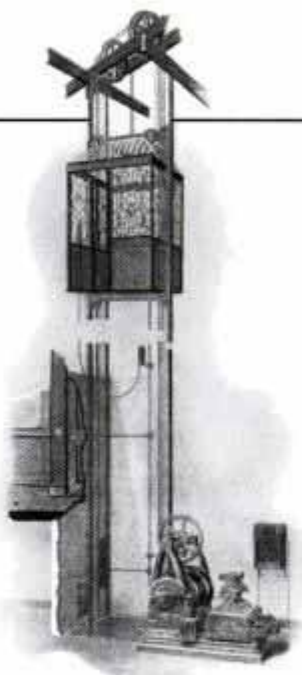
# TIME MACHINE

## 90 YEARS AGO: NOVEMBER 1903



**Schnellbahn**  
Europe was abuzz with the exploits of the German engineers who used 13,000 volts to boost two railcars to 130 mph. The setting: a 14½-mile stretch of rail near Berlin. Work crews had rebuilt the line after previous experiments mangled the tracks. Then the headlong ride began, and 14 passengers watched the scenery melt into a blur. "Where were we going?" asked our writer. "Were we on rails or in the air? We could not answer."

**Going Up**  
Meanwhile, pushbuttons were threatening to push the elevator operator out of business. Otis was introducing electric automatic elevators in which the rider became "his own elevator boy." Conceived for the new residential high-rises, the "boyless" elevator was quickly taking over in hospitals, hotels and office buildings. The elevator boy survived, however, until electric-eye floor leveling and elevator-fleet switchboards took over.



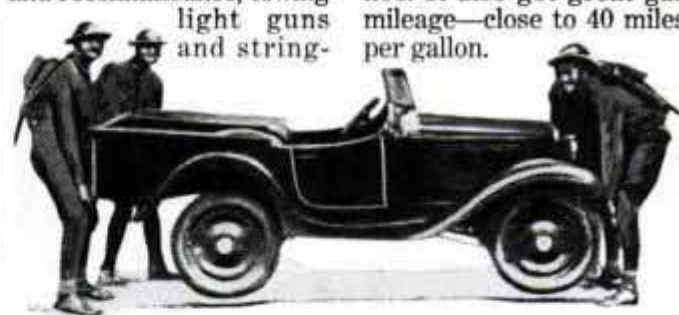
## 60 YEARS AGO: NOVEMBER 1933



**Water Ferrari**  
The Italians were piling up world speed records with amphibious aircraft and oceanliners. Now they were turning their attention to racing boats. The results were nothing like the typical speedboats of the '30s. Riding on twin pontoons, the sleek bullet-nose racers featured overhead aircraft engines that drove air propellers. In their way, they presaged the jet-driven thunderboats that command today's water speed records.

**Motor Scouter**  
Well before the advent of the Jeep, the U.S. Army was experimenting with a midget truck weighing less than a half-ton. The low-slung pickup was designed for quick raids, scouting and reconnaissance, towing light guns and string-

ing communication wires—in short, the vehicle was to be a jack of all trades. The truck was designed for cross-country travel. But if terrain turned too tough, its 4-man crew could portage it around like a canoe. It also got great gas mileage—close to 40 miles per gallon.



## 30 YEARS AGO: NOVEMBER 1963



**Utah Thunder**  
The black stripe along the Bonneville salt flats had lured many a daredevil to a fiery end. All had been trying to break John Cobb's land speed record of 396 mph. Craig Breedlove brought his *Spirit Of America* to the desert with the same purpose, and he told PM readers how he succeeded. Keys to his triumph were its 3-wheeled crouch and tail fin, a last-minute addition that kept the car's nose on the straight and narrow.

**Buck Rogers In The 20th Century**  
The Air Force was preparing for the day when space flight meant real flight, with pilots in control of their rocketships, perhaps even dueling with each other. To give aviators a taste of the future, engineers outfitted three fighter jets with the accoutrements of space travel—AR-2 rocket engines on the tails and reaction-jet nozzles in the wingtips and noses. The planes were to be flown at 25-mile altitudes, where

pilots would practice space steering. Apropos of the mission were the jets selected—they were F-104 Starfighters. **PM**



# TECH UPDATE

News Of Tomorrow's Technology Today



PM ILLUSTRATION BY PAUL DIMARIE

## Shredding Robots Clean Up A Witches' Brew

OAK RIDGE, TN—Kerr Hollow is a setting straight from a B-grade horror movie. For decades, the Department of Energy filled this flooded quarry with radioactive clutter—including drums of liquid sodium and potassium, used as coolant in nuclear reactors. Not only is the liquid radiation-tainted, it's also spectacularly explosive.

Enter two intrepid robots. So far they've plucked out 17,000 objects, surviving a couple of blasts with little worse than singed paint jobs.

The machines aren't bringing the volatile material to the surface. That's just asking for trouble. Instead, they are feeding the drums into a

25-ton shredding machine at the quarry's bottom.

The shredder minces the drums into chips that tumble into a collection basket. The processing allows the liquid metal to burn up in water without detonating in bulk.

One of the robots is a modified Perry submersible vehicle, outfitted with an arm that can pick through debris, close the shredder's containment doors and bring the basket to the surface. The other is a barge equipped with a jointed arm and a grapple.

The project, engineered by Sonsub Environmental

Editor: Abe Dane  
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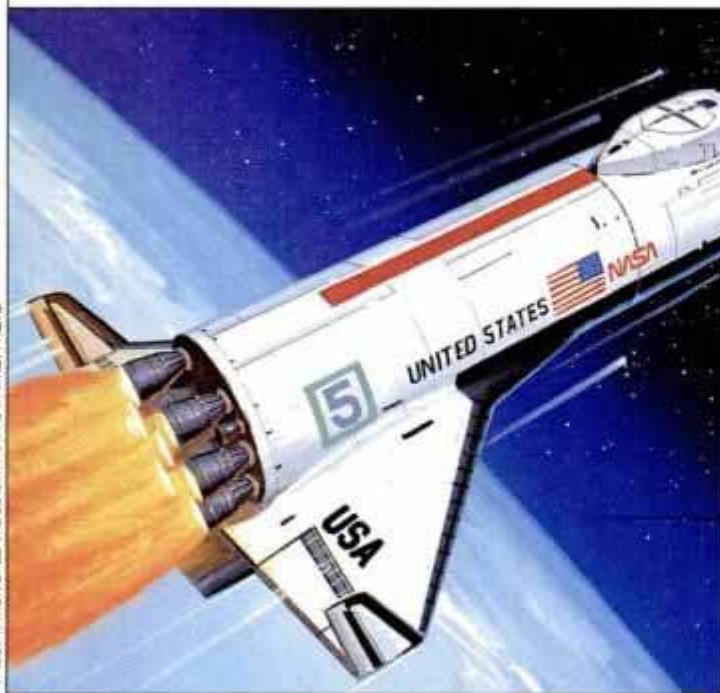
Services, will serve as a model for other Energy Department cleanup efforts.

Submersible robot and grapple-handled surface barge feed and empty waste shredder.

## Highlights This Month

- **Regular Or Super?**—Singular Russian rocket burns multiple fuels.
- **Bus Stop 2000**—Aerospace expertise turns to mass transit.
- **Saw Mole**—Latest tunnel-boring machine carves out arched passages.
- **Razzle-Dazzle Nozzles**—Thrust-vectoring F-16 starts flying.
- **Going With The Glow**—Satellite to test nuclear electric propulsion.
- **Weather Eyes**—New atmospheric satellites will fill in the blanks.

## One Rocket, Two Fuels



Advanced Manned Launch System could be made up to 38% lighter by using dual-fuel RD-701 rocket engines (right).

WEST PALM BEACH, FL—Which makes a better rocket fuel, hydrogen or kerosene?

Pound for pound, hydrogen delivers a greater kick, but takes up more room. While not as energetic, kerosene—much denser than hydrogen—can occupy

smaller, lighter fuel tanks.

Each has its advantages. So why not burn both? The Russians, who are masters of kerosene rocketry, are developing a rocket engine that can do just that. NPO Energomash is working on the concept, with support from Pratt & Whitney.

Known as the RD-701, the engine derives from the RD-170, which boosts Russia's Zenit and Energiya launch vehicles. The RD-701 would burn a mixture of kerosene and liquid hydrogen as it blasts off, thus unloading the heavier fuel as it escapes gravity. Once at high altitude, the engine would switch to pure hydrogen.

NASA's Langley Research Center recently studied the application of the RD-701 to its Advanced Manned Launch System, its proposed Shuttle follow-on.



## Recombinant Weaponry

ORLANDO, FL—Watch a new trend emerge in Pentagon weapons procurement. Instead of spending billions for brand-new systems, engineers will splice together the best features of existing weapons.

Case in point: the experimental Roadrunner Multi-Weapon Defense System, developed by the Army's Tank-Automotive and Missile Commands.

The Roadrunner starts with a stretch version of an M113A2 armored personnel carrier chassis. Grafted to the front is the 3-man crew cab from the Army's Multi-

**The Frankenstein of weapons, Roadrunner combines body parts from four different systems.**



ple-Launch Rocket System (MLRS).

On its back ride two veteran missile systems. One is the ground-to-air Chaparral, but minus the gunner's transparent dome. Instead, the gunner sits in the MLRS cab, protected by its ballistic armor. Meanwhile, from the same firing platform shoot ground-to-ground variants of Hellfire missiles.



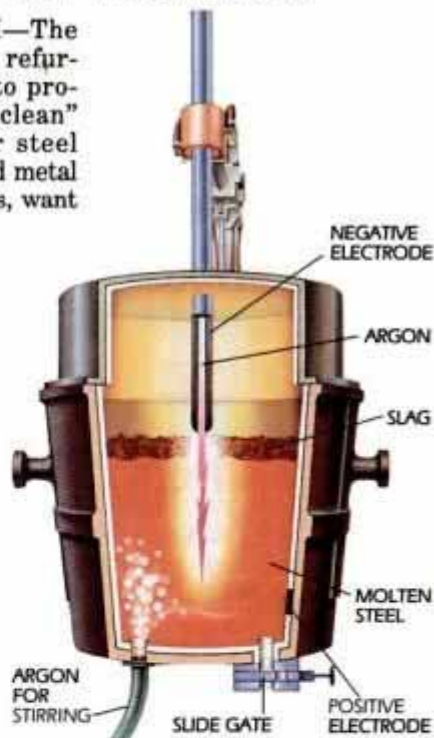
## Clean Steel For Foundries

MILWAUKEE, WI—The big steel mills have refurbished themselves to produce high-quality "clean" steel. Now smaller steel foundries, which mold metal into finished products, want to do the same.

There's a hitch, however. Clean steel requires extra-long refining, in which the steel must be kept red-hot. Steel mills do this in huge heated vessels called ladles. But foundries work with small ladles, which don't hold the heat so well.

Now a promising solution, developed with help from the Electric Power Research Institute, is up and running at Maynard Steel Casting. It's an 8-ton arc-plasma refining ladle.

In operation, the ladle's electrode spits a plasma arc into the molten steel, stabilizing the steel's high temperature. The arc also superheats the surface slag to encourage the refining reac-



Plasma ladle keeps foundry's steel molten while refining takes place.

tions. Meanwhile, argon gas bubbles in to stir the entire bath of molten metal.

The system lets Maynard buy commercial-grade steel but produce castings of various high-quality alloys.

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Boom-mounted cutting wheel buzz-saws out the perimeter of an arched roadway tunnel.

swinging a boom-mounted cutting wheel in a broad arc. Around the edge of the wheel, steel discs and ceramic cutters chew into the rock. The arch tunnel that is created can measure 39 ft. wide x 27 ft. high.

The Miner works faster than hydraulic wedges and other rock-breaking equipment. It's also safer than dynamite for use in densely populated environs. That's why the Japanese firm Taisei Corp. has purchased the Miner.

## Swinging Tunnel Cutter

KENT, WA—The latest tunnel-boring machine slashes through granite the way an explorer machetes through the jungle.

The Ranging Mobile Min-

er, designed and built by the Robbins Co., is the construction-industry derivative of a device developed for subterranean coal mining.

The 380-ton juggernaut is

the first tunnel-boring machine developed to make arched roadway tunnels. By contrast, a conventional borer simply drills headlong into the rock, leaving a cylindrical burrow in its wake.

The Miner operates by

## Chopper Spotter

HAIFA, ISRAEL—Dodging radar with terrain-hugging "nap of the earth" approaches, attacking helicopters can pop into view without warning. But a passive acoustic tracking system developed by Israel's Rafael could detect and track these marauders as far away as 7 miles, before they start launching their missiles.

Called Helispot Mark 2, the device consists of 16



microphones mounted on a folding cruciform array. The mikes pull in sounds from a

360° search sector and process them for bearing and identification.

Cruciform microphone array spots approaching helicopters before they're too close.

The system has many advantages. It's immune to radar-jamming or antiradar missiles. It doesn't need a line of sight to its targets. And it can operate during severe signal-to-noise conditions in the chaos of battle.

Helispot is designed for combat vehicles such as armored personnel carriers. But it can also operate in a fixed position to protect command centers.

## Waiting For The Stealth Bus

LOS ANGELES, CA—No, it's not invisible to radar, or even riders. But it is an Advanced Technology Transit Bus, and it comes off the same drawing boards that blueprinted the B-2 stealth bomber.

The Los Angeles Metro-

politan Transportation Authority tapped Northrop Corp. to design a bus for the 21st century. At 9 tons, the vehicle must weigh a third less than a current bus. And it must roll for 25 years with only half the normal upkeep. What's more, L.A.

will require 30% of its fleet to be zero-emissions vehicles by 2000.

To meet these goals, Northrop and its automotive collaborators plan extensive use of composite construction and a hybrid internal-combustion/electric powertrain. Right now, engineers are looking at gas-turbine,

rotary and Stirling-cycle engines because they fit in smaller engine bays. But ultimately fuel cells and flywheels will play a role.

If more funds become available, the MTA will construct a prototype.

Designs feature aerospace composites, disabled accessibility and extensive electronics.





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## Superjokers Take Flight

EDWARDS AFB, CA—Flight testing has begun for axisymmetric thrust-vectoring engine nozzles (see Tech Update, page 18, Jul. '92) that promise to heighten agility and reduce drag.

Nozzles built by General Electric are now aboard the F-16 VISTA in a test program called Multi-Axes Thrust-Vectoring, or MATV. The modified fighter will rear up at high angles of attack and slow to dangerously low airspeeds, conditions in which the F-16 normally can't maneuver well. But the nozzles can direct thrust in

any direction and should support better handling.

Meanwhile, out of mothballs comes the F-15 STOL/MTD, the short-takeoff demonstrator that flew between 1985 and 1991. NASA and the Air Force will jointly test the jet in a program called Advanced Control

Technology for Integrated Vehicles, or ACTIVE.

F-16 VISTA is already vectoring while retrofitted F-15 STOL/MTD (below) files next year.

Test flights, to begin next fall, will demonstrate how well the vectoring nozzles can trim the aircraft during cruising and maneuvering. The technique could shave away drag, boost cruise speeds, lengthen range—even make control surfaces unnecessary. The aircraft is currently flying with standard F-15 nozzles to provide comparative data.



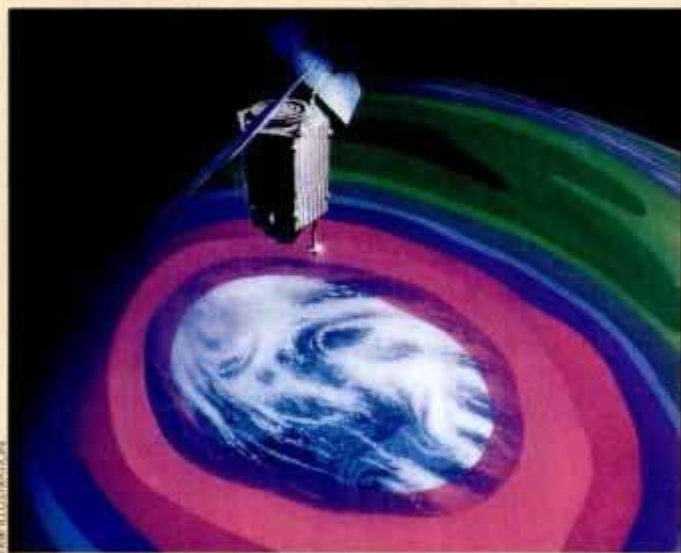
## Who's Watching Our Atmosphere?

GREENBELT, MD—Right now, the state of the atmosphere is a little foggy in the minds of scientists. Two instruments that map the ozone layer have failed. And American meteorologists have been making do with a single weather satellite in geosynchronous orbit, "borrowing" a less powerful European spacecraft to TOMS-EP Earth Probe, a TRW Eagle lightweight satellite, will renew ozone mapping.

cover the East Coast. Fortunately, new eyes should be in the sky by next summer.

Last May, the veteran Nimbus-7's Total Ozone Mapping Spectrometer (TOMS) finally conked out after more than 14 years of service. Two weeks later, a similar instrument aboard Russia's Meteor-3 keeled over. Instruments on other spacecraft have been filling in, but don't offer the same precision.

GOES-Next goes up next April. New weather satellite will bring unprecedented crispness to radar cloud images, thanks to high-resolution radiometer.



A new TOMS is scheduled for launch in July on a TRW-built Earth Probe satellite, to fly into orbit on a Pegasus winged booster.

Meanwhile, the National Oceanic and Atmospheric Administration hopes that the next Geosynchronous Operational Environmental Satellite, or GOES, will

make up for the cost overruns and delays that have plagued its development.

GOES-Next promises a lot. It won't spin, but rather will lock into one position to stare down at Earth full-time. If all goes as planned, you'll see the difference during next summer's weather forecasts.



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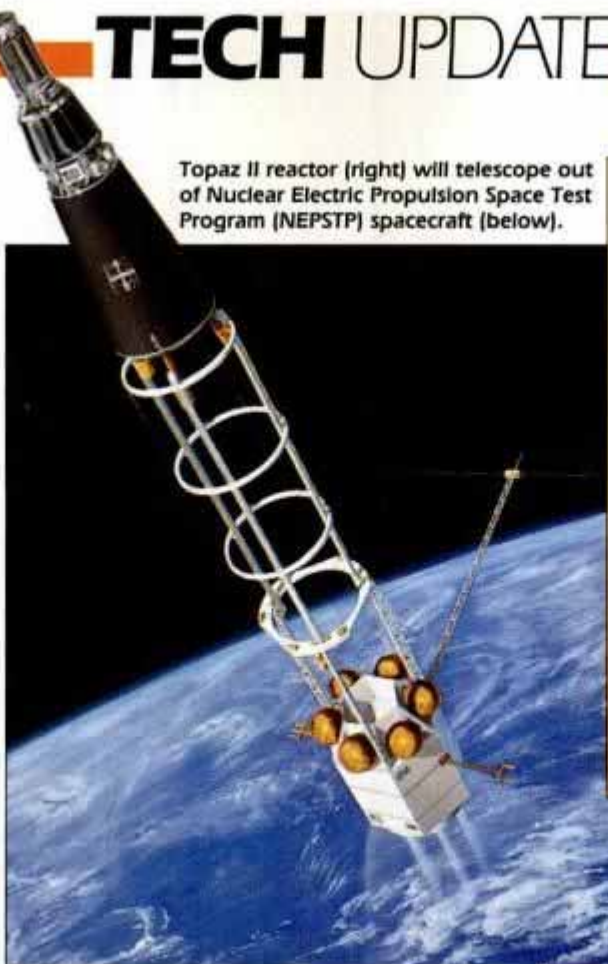
## New Plans For Space Nukes

LOS ALAMOS, NM—U.S. defense officials want to put a Russian nuclear reactor in space.

The thought may conjure up memories of Cosmos 954, the nuclear-powered Soviet satellite that spilled radioactive debris over Canada in 1978. But Russia has far more experience with space nuclear power than we do, and its latest reactor design assures much better safety.

So the Ballistic Missile Defense Organization has bought a pair of Topaz II reactors from Russia and is drawing up plans for a spacecraft testbed.

The 6-kilowatt reactor draws power from 37 thermionic fuel elements. In each element, uranium fuel generates heat to boil a flow of electrons off an emitter, somewhat like a TV picture tube. Surrounding the reactor core are swiveling control and



Topaz II reactor (right) will telescope out of Nuclear Electric Propulsion Space Test Program (NEPSTP) spacecraft (below).



Labels in diagram: THERMIONIC FUEL ELEMENT, BORON-CARBIDE NEUTRON POISON, BERYLLIUM REFLECTOR INSERT, COOLANT RETURN LINE, ELECTRO-MAGNETIC PUMP, SAFETY DRUM, CONTROL DRUM, COOLANT LINE, RADIATION SHIELD, ELECTRICAL LEADS, REACTOR CONTROL, RADIATOR.

safety drums, which turn reaction-quelling boron-carbide to face into the hot core.

For safety reasons, the fuel elements won't be allowed to "go critical" until

the spacecraft reaches a high orbit of more than 3200 miles. Ultimately, it will spiral up to geosynchronous orbit.

Using ion thrusters, the spacecraft will test nuclear electric propulsion, which promises tremendous fuel efficiency.

## Digital Modelmaking

WHITE OAK, MD—Some recent wind-tunnel experiments at the Naval Surface Warfare Center illustrate

Douglas engineers in California used a computerized fluid-dynamics program to predict the ideal airflow around a Mach-14 waverider, a conceptual hypersonic aircraft design (see Tech Update, page 20, June '93).

The fluid-dynamics data was then shunted into a computer-assisted design, or CAD, program, which rendered a representation of the aircraft.

The CAD data then went directly over the phone lines to a numerically controlled machine tool at the wind-tunnel facility, which carved a model automatically. At no

point were blueprints ever drawn up.

As if to complete the circuit, the purpose of the tunnel tests was to verify the soundness of modifications to the original fluid-dynamics program.



Wind-tunnel tests computer-conceived model to verify fluid-dynamics program.

just how abstract the aircraft design process is becoming. The model tested was generated entirely by computer.

First, a team of McDonnell

## Off-Road Mini-Trucks


HOUSTON, TX—Call them the sport/utilities of the trucking world. They can sash through swamps and stampede through sand, carrying 5000-pound payloads.

SS-300s are now rolling off a Stewart & Stevenson assembly line, via license from ESARCO Ltd. While the 8-wheel-drive pygmy can mimic the sure-footedness of a tracked vehicle, it can switch to 4-wheel drive to keep up with highway traffic. Meanwhile, front- and rear-axle steering provide a nifty turning radius under 14½ ft.

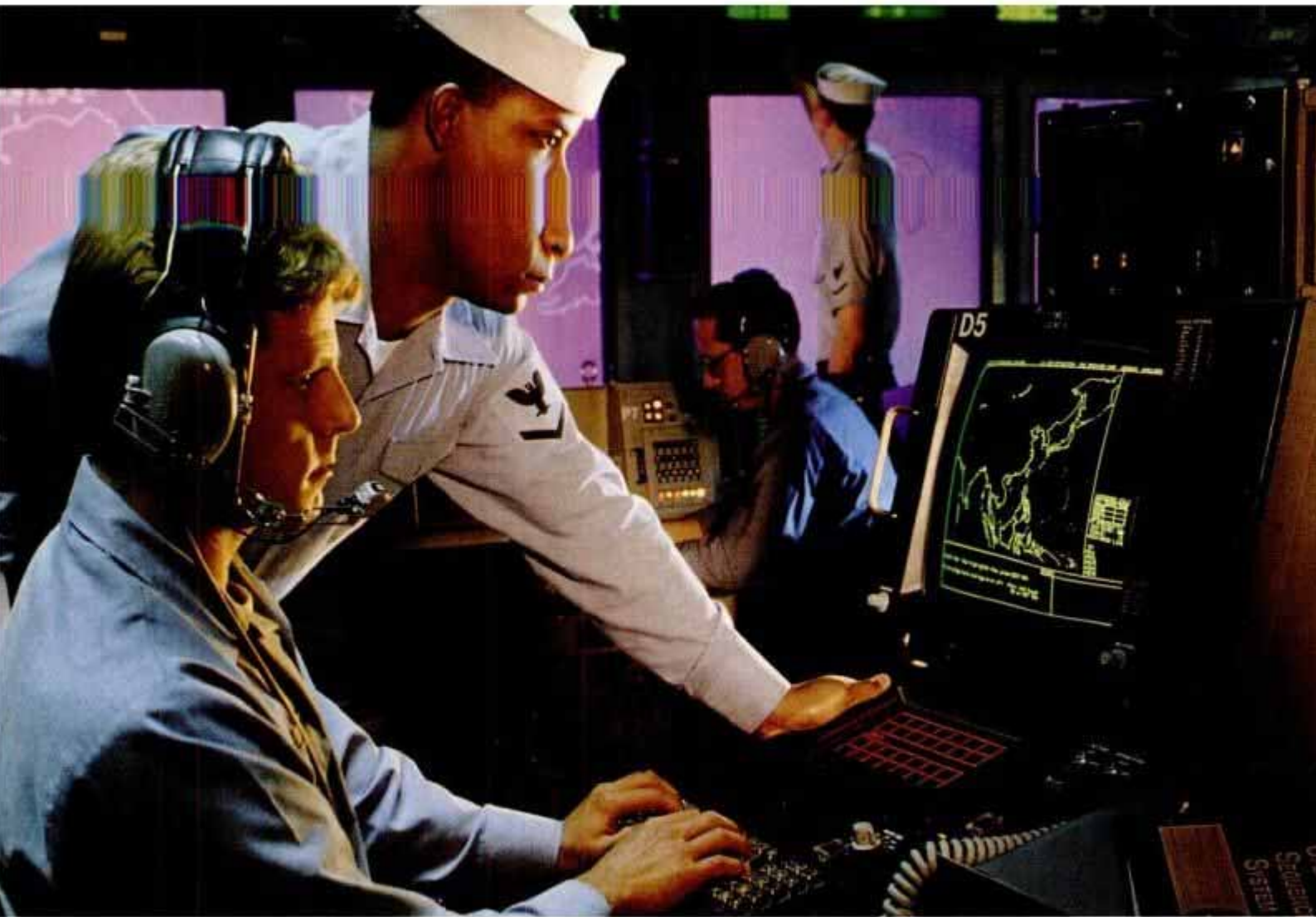


Mini-trucks combine all-wheel-drive traction with highway capability.

A British Army major designed the truck after the Falklands War pointed up the need for an all-terrain hauler. Stewart & Stevenson has beefed up the suspension system with heavy-duty shock absorbers and coil springs. A tilting cab, mounted over the 6-cylinder turbodiesel engine, is another American touch.

A smaller version, the 6-wheel-drive SS-200, is now under development. 





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## TECHNOLOGY

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HAVE YOU DRIVEN  
A FORD LATELY?

# Why We Race



# WORKHAULIC

Turning a roly-poly Buick Roadmaster Estate Wagon into our vision of the ultimate long-distance road hauler.

TEXT AND PHOTOS BY CLIFF GROMER

● What ever happened to the great American station wagon? You know, those cavernous slab-sided beasts that packed big, cheap-gas-guzzling V8s. Mammoth rolling boxes that performed yeoman duty as the family moving van, vacation bus and Little League team hauler. You could pack half your house into one of those wagons, then slap a tow hitch and trailer on the back and haul the other half.

Seems the traditional station wagon got lost someplace in the shuffle of minivans and the current crop of soft-style front-drive V6 interpretations of what a '90s wagon should be. Of course, these wagons perform well for what they are, but they're not cut out for the heavy-duty work that the old rear-drive V8 brutes were made to handle, especially when it comes to towing.

Nowadays, folks who need to pull a decent-size boat, a quartet of snowmobiles, a couple of large touring motorcycles or the like, look to something in a pickup

truck or sport/utility to do the job. But trucks lack the ride comfort and luxury of a car. Of course, there are rear-drive V8 cars still made that do a credible job towing, notably variants built on the GM B-platform, which include the Chevy Caprice, Buick Roadmaster and Cadillac Fleetwood. As a matter of fact, in our July '93 issue we ran a story on towing a 7000-pound boat and trailer 2000 miles in just such a Fleetwood. The Caddy was comfy and did a good job towing, but it lacked the wagon's convenience of being able to heave and then retrieve massive amounts of stuff from its interior.

Even so, as good as the wagon versions of the Caprice and Roadmaster are, they, like most cars, are a compromise. In an effort to please a wide variety of buyers, the showroom editions tend to favor an easy-to-take ride—at the expense of handling. Our taste, on the other hand, leans more to the performance side of

**ROADMASTER**  
ESTATE WAGON

## WORKHAULIC



the curve—more of a sport wagon, if you will.

Sport wagons are nothing new, of course. Chevrolet built the first version in the '50s with its Nomad. But this was more of a sport appearance package than a hauler with real sport soul. Other wagons that have scored closer to the mark include the Volvo 1800ES, essentially an 1800 sport coupe saddled with a wagon's back end and not much utilitarian value, the Pontiac 6000SE and a series of Ford Taurus wagons—all front-drivers lacking serious horsepower and hauling ability—and prototypes and concept cars put together by various manufacturers and/or magazine staffs.

All of which brings us to the project at hand—our interpretation of the ultimate long-distance hauler—a hauler (as in carrying loads) that also

hauls (as in hauling tail) and handles. We want to build a wagon that offers the best of all worlds for the man who wants to get himself—and his toys—there quickly, and in style.

The starting point for our ultimate wagon project is a '93 Buick Roadmaster, which we borrowed from Buick. The car came loaded with standard equipment, including a 180-horsepower (300 ft.-lb. of torque) 5.7-liter V8, auto climate control, power everything, dual airbags and alloy wheels. Our only significant option was the trailer-towing package, which gave us a 3.23:1 rear-axle ratio, heavy-duty engine cooling, engine oil cooler, heavy-duty suspension and automatic level control. To establish baseline performance levels—both hitched and unhitched to our trailer—we ran the Roadmaster through our stand-

ard battery of road and track tests.

Right off the bat, we have to say that, while the Roadmaster wagon has strong appeal in some circles, in stock form it's not really our idea of an appealing driver's car. Even with the heavy-duty suspension, the springing is overly soft and underdamped considering our intended use as a hauler. The stock 5.7-liter V8 drivetrain is well done, delivering decent acceleration (0 to 60 mph in 9.4 seconds and quarter-mile readings of 16.84 seconds at 79.66 mph), good driveability and fuel economy in excess of 20 mpg on the freeway.

The wagon is memorable not for what it does, but for what it doesn't do—there are no quirks, no nasty surprises. On our 700-ft. slalom course, the Buick clocked 50.6 mph—not what you'd call torrid, but considering the







car's long wheelbase and relatively soft ride, not particularly slow either. The ponderous but predictable pachyderm fared better here than some other cars in the incredible bulk class that we've tested in recent times.

Running the Roadmaster on its door handles through the skidpad course, we managed to generate .65 g of lateral acceleration—one of the lowest numbers we've ever recorded. The combination of smallish tires with a high tread-wear rating and, of course, a suspension built for comfort rather than speed are to blame.

The limiting factor here is understeer. After you turn in so much steering input, you can turn in another whole lock and nothing else happens except that the front tires make more noise. This gives the driver what we call "predictable" handling. Cook it too hard through a turn and you always know that you're going to plow off the road front-end first.

Performance with our race-car-laden trailer (towing weight: 5500 pounds, tongue weight: 700 pounds) cut our quarter-mile time to 24.5 seconds at 49.8 mph, and we ran out of dragstrip before we could hustle the car up to 60 mph.

Towing on the road was another story. Without the help of equalizer bars, we soon discovered that the trailer tended to spend more time in the lane next to us than rolling along behind us. The soft, underdamped rear suspension was mostly to blame,



Basically a pleasant package, Buick's Roadmaster Estate Wagon has the power, with its 180-horsepower (300 ft.-lb. of torque) 5.7-liter V8, to haul heavy loads and still deliver decent fuel economy. Handling is a different story, as the stock suspension system is not up to the task. Comfy interior comes with power controls to do everything but serve you lunch.



requiring greatly reduced speeds and greatly increased levels of attention. Equalizer bars would have helped some, but the generous side-to-side bushing compliance gets the rear suspension moving horizontally in relation to the chassis of the car in lane-changing maneuvers and induces an ever-increasing sway if you don't stay on top of things. Here, the body-on-frame construction works well to isolate vibration, but that isolation can work as a flexible joint when you're trying to tow something. It's like trying to drive a car with a hinge in the middle.

The good news is that all of these negatives are eminently fixable, mostly via Buick's own parts shelves. Which means that building on the Roadmaster's already good qualities to come up with the ultimate hauler is a practical proposition. Watch for the conclusion of Project Workaholic in an upcoming issue. **PM**



# ICE STATION

PM ventures onto and under the Arctic ice, where the Navy is at last taking the wraps off years of secret, Cold War research.

BY ABE DANE, Science/Technology Editor; PM Photos by Brian R. Wolff

● A halting voice comes to us through a hole in the Arctic ice. "Marvin, this is Eagle. Long count, please." Daniel Steele, stamping his mukluks on the dry snow, replies, counting slowly into the underwater telephone. Below, the 292-ft.-long nuclear attack sub *Puffer* is coasting silently among the jagged ice keels, listening to the measured cadence of his speech and homing in.

We are at Surfacing Site Papa Mike, an X scratched at a thin spot in the pack ice that overspreads the top of the world like an eggshell. The landscape is still and nearly featureless, undisturbed except by the occasional wandering polar bear. Nothing in the nature of the place hints at what is about to happen.

"Marvin, this is Eagle. Apple minus two zero. Over." Echoing up from the frigid depths, the submariner's voice reaches us with a strange metallic edge. They're now directly beneath us, 80 ft. down and rising vertically at 30 ft. per minute.

Our small party of scientists, Navy and support personnel is scattered over the site. Dark specks against the endless white, they lumber about in their parkas, hauling equipment, checking instruments and looking on expectantly.

Then, a jab from below causes one point on the ice

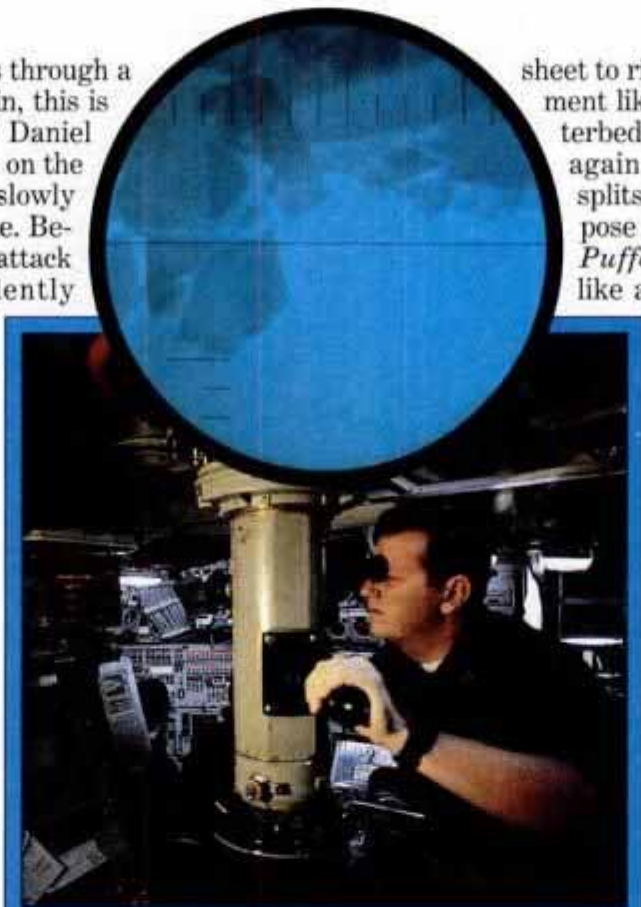
sheet to rise, fall and undulate for a moment like the surface of a shaken waterbed. There is a pause and it rises again, this time more powerfully, splits at the top and crumbles to expose the glistening black sail of the *Puffer*, heaving out of the ocean like a tremendous medieval jousting helm. "Eagle, this is Marvin. Incredible show, incredible show," exults Steele, as freezing water cascades down the sides of the sail and the sub's hull settles firmly against the underside of the buckled ice.

Our ride's here.

## Research rendezvous

Of course, the reasons for the *Puffer's* dramatic entrance go beyond picking up a POPULAR MECHANICS editor and photographer. The spot where it broke through was instrumented to record exactly how the ice slab, several feet thick, would react to the jolt from below. The data will join an archive of Arctic knowhow that has been building since World War II, yielding steady improvements in the design of submarines and in the tactics that guide their use.

Through the long, grim years of the Cold War, parties such as our own regularly ventured up here to learn the ways of the world's most unforgiving battlefield. Of necessity, most of this work was carried out in



Officer of the deck peers up at ice through *Puffer's* No. 2 scope. New tech should make under-ice navigation simpler.

# ICE STATION X

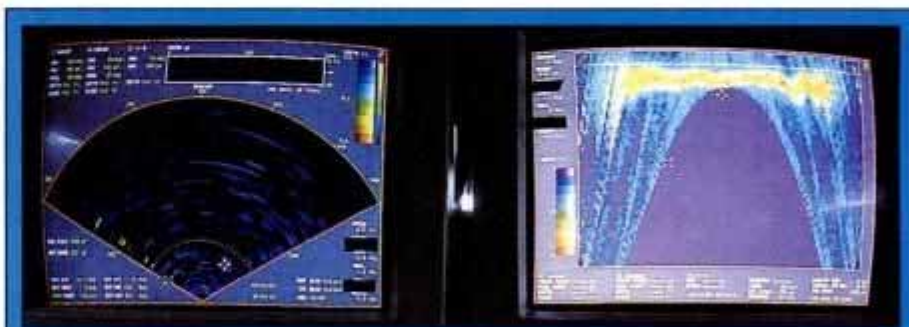


Polar bear lookout is posted by the *San Juan*. First of the new 688 I subs, it improves on the previous *Los Angeles* class with under-ice capabilities and better silencing.



secret. But now the small community of Arctic-hardened researchers cultivated during those years is opening up. **POPULAR MECHANICS** was among the first invited to share their understanding of this bitter and beautiful place, to see some of the most complex and formidable forces arrayed in our defense, and to learn about ways that abilities born out of military need might one day be put to peaceful use.

Research headquarters and prime repository for America's knowledge of under-ice operations is the Navy's Arctic Submarine Lab in San Diego, California. This facility was founded by Dr. Waldo Lyon, who as a young physicist helped guide the submarine *Nautilus* on the first-ever transit beneath the ice cap in 1958. The lab maintains a 120-ft. x 30-ft. modeling basin where Arctic sea ice can be created and studied, and its small staff of highly specialized personnel advises submarine crews on the fine points of Arctic seamanship and develops technologies to make them more effective. It is from here that the



Space is tight in an attack sub, so electronics for the experimental EXUS sonar had to be mounted on skids in the torpedo room. EXUS readouts (above) show color-coded maps of the ice canopy's underside. With the currently fielded ice-avoidance sonars, planesmen (left) have to keep the sub exactly level or keels may escape the scan of the narrow, forward-looking beam.

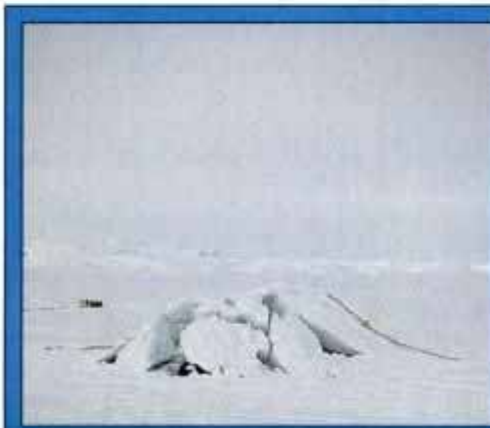
Navy's regular research expeditions onto and under the pack ice have been directed.

The operation we visited is called ICEX and involves two nuclear subs working in collaboration with a temporary camp on the surface. The camp, known as APLIS (Applied Physics Laboratory Ice Station), is set up and managed for the Navy by the University of Washington's Applied Physics Laboratory, a government-supported center for sonar research. It consists this year of a small

clump of insulated plywood huts flown up piece by piece aboard a Twin Otter turboprop in mid-March. We set down aboard this same robust little bush plane a few weeks later, bumping to a stop at the end of the refrozen ice lead that serves as the camp's airstrip and lifeline to the outside world.

## Springtime in the Arctic

APLIS feels more like a high-IQ lumber camp than a military installation. The graduate engineers and





Visits to the surface are rare, so the *San Juan's* crew enjoys a chance to take on fresh supplies from the camp's Twin Otter. Jet Ranger (right) deploys field parties and equipment.

Ph.D. scientists walking among the huts have the look of grizzled Arctic veterans, unshaven and apparently oblivious to the cold. Clearly, survival is complicated enough here without spit and polish.

Simplicity is the watchword, and a spirit of good-humored endurance pervades the place. A handwritten sign outside the camp's single make-shift bathing apparatus reads: "This shower is dedicated to all former Arctic heroes, real or imagined. You may not get clean, but you will get cleaner. Passed inspection 3/93, Arctic Code 117.6: 'If it works, it's done.'"

Yet sophisticated work is going on here. Capt. Bruce Scott, the camp's commanding officer of the Arctic Submarine Lab, shows us into the Command and Control Center, a plywood hut distinguished from the others by an assortment of aeries sprouting from the roof. Inside, sonar pings reverberate weirdly over a speaker, and a handful of men monitor equipment. One wall is lined with radio gear used to keep in touch with the home base, field parties and the camp's Jet Ranger helicopter. By the door is a rack holding rifles and shotguns. As a precaution against polar bears, no one leaves the camp alone, and no group goes out without a gun and a radio.

The most important equipment in this hootch, though, is that associated with the submarine tracking range. Used to keep a precise fix on the two subs working with APLIS, the sys-

tem's main components are hydrophones arrayed at four locations 500 yards from camp, a computer and an atomic clock. Similar clocks in the submarines trigger sonar pings on a predetermined schedule, so that by timing the sound's passage through the water, APLIS can pinpoint the subs within a few yards.

Designed by experienced Arctic hands from the Applied Physics Laboratory, the range is quick to set up and tear down—a good example of the technical approach demanded by this environment. "If it has a lot of bells and whistles on it, it's probably stupid to bring up here, especially when somebody's life depends on it," says Capt. Scott.

Beyond ensuring that the two submarines stay safely apart, the tracking range provides a rock-steady frame of reference for the research that provides much of the justification for this year's trip north. In addition to their role as giant battering rams for the ice mechanics research, each sub is testing new sonar equipment aimed at enhanced under-ice capabilities.

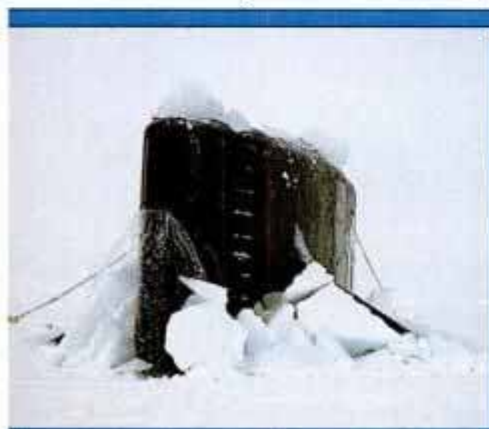
The *San Juan*, a member of America's newest attack-sub class, is trying out a computer-integrated suite of sensors called the AN/BSY-1, developed to improve target tracking and identification capabilities vital in the hunter/killer role. Meanwhile, the *Puffer*, although a ship of the earlier Sturgeon class, wields the even more radical EXUS system, which harnesses a compact super-



computer to produce high-resolution sonar images of the ice canopy's underside.

Before we set out to meet the *Puffer*, Cmdr. Carl Wales, the camp's Officer in Charge, takes us to the chow hut for a talk with a few of the scientists. Judy Baylis of the Naval Surface Warfare Center at Carderock, Maryland, supervises the ice mechanics work. "We're looking at how the ice reacts to loadings from underneath," she says, trying to keep it simple for me.

The tests use an elegant and highly accurate apparatus devised by Dr. Devinder Sodhi of the Army Corps of Engineers Cold Regions Research and Engineering Lab. Two flexible plastic tubes filled with antifreeze solution are laid across one another in an X, and one end of each is raised off the ice by a tower of precisely known height. When a sub strikes within this grid, gauges tapped into the tubes at regular intervals track changes in the solution's pressure as the ice rises and falls. Comparing the pressure along the tubes with that



*Puffer's* emergence at Surfacing Site Papa Mike (named in honor of PM's visit) demonstrates the "slam dunk" approach to icebreaking, in which 4700 tons of sub strike the canopy at 30 ft. per minute. It's dramatic, but ice mechanics studies found the gentler "pick and blow" approach to be just as effective. Ramming noise-emitting targets on the surface of the ice is not a mission attack submariners normally train for, but ICEX crews soon get the hang of it. One of the antifreeze-filled tubes used in that work can be seen draped over the *Puffer's* sail here, a testament to the sub's accuracy.

# ICE STATION X



Life at APLIS centers around chow hut (far left) and Command and Control Center (left).

atop the towers yields a reading of ice deflection accurate to within about 1mm.

Our briefing complete, we leave the warmth of the chow hut and chopper out to the surfacing site where we'll see the system in action. *Puffer* plays its hole-punch role beautifully, arriving to whoops of approval from the ice mechanics team. Steady practice has refined the crew's aim, and despite tricky currents below, the sub has emerged neatly centered within the X. A harvest of high-quality data should result.

## Aboard the *Puffer*

After the crew sends a few teetering ice blocks crashing from the top of the sail and hoists photographer Brian Wolff's gear aboard, we're invited to make the climb up the sail's slick rungs. From the bridge, we descend through a dim, steel-lined trunk and drop into an utterly different world. From the wide-open wastes of the Arctic, we've entered the scene of a precisely ordered, close-quarters choreography of men and unimaginably complex machine. The trunk opens out into the control room, the nerve center of the sub. Preparations are now under way for us to dive.

Periscopes, snorkel and radio masts are retracted into their protective recesses, and the positions of valves and vents throughout the ship have been double checked. From a small raised platform by the periscopes, the officer of the deck reports: "Captain, the ship is ready to submerge. Two-thousand fathoms under the keel. No exceptions." Cmdr. Rick Wright replies, "Vertical submerge the ship," and with that, a cascade of orders begins bouncing from station to station around the control room.

"Vertical dive, vertical dive" blares the PA system, followed by two

blasts of the diving alarm. The diving officer calls for the after main ballast tanks to be opened. At the ballast control panel, the chief of the watch repeats the order, opens the vents, and calls back that they indicate open. The tanks, which jacket the vessel's pressure hull, flood and we begin to settle stern first. With the prop safely clear of the ice, the forward tanks flood and we slide gently downward.

Water washes over the upward-looking video camera atop the sail,



Ice holes are melted (top) or drilled with an auger to gain access to seawater.

and on the monitor we can see the hole we left in the canopy receding. Ice chunks frozen to our hull begin to wash loose and float upward through the shaft of light. "Looks like the underside of a scotch on the rocks," says Wright.

It is an extraordinary sight, but right now the crew is preoccupied. Getting clear of the keels that jut beneath the ice is a ticklish maneuver, imposing strict limits on their control of the sub and leaving an un-

comfortably thin margin for error.

Hovering straight down with engines disengaged, our movements are determined entirely by shifting water into and out of the buoyancy control and trim tanks. The diving planes, which could normally be turned to pull us out of a runaway dive, are useless without forward speed. What's more, the row of last-resort "chicken switches" that tap the sub's high-pressure air banks for an emergency blow of the main ballast would only send us crashing into the ice above.

As we approach our ordered depth of 180 ft., the main propulsion clutch has been engaged. The fair water planes on the sides of the sail are shifted down from the vertical position used for cutting through ice, and locked into the range of motion where they can be controlled with the planesman's yoke. We're ready to motor off.

## Ice eyes

Since the *Nautilus*'s first Arctic transit 35 years ago, techniques for avoiding under-ice obstacles have been refined, but the basic principles are remarkably unchanged. A conical beam of sonar pings, narrow at the source and widening as it projects forward, is emitted to feel out the way ahead like a blind man's cane. Pings bouncing back tell operators the range to oncoming keels, and the question of whether they hang deep enough to threaten the sub is settled by knowing how near they are at the point when the beam is too narrow to pick them up.

It's a simple and reliable approach, but new technologies offer the potential to do the job a lot better. The EXUS sonar, now in its first under-ice trial, has been temporarily shoe-horned into *Puffer* to explore the possibilities.

The heart of the system lies in a hefty box of electronics secured to a skid in the torpedo room. Linking 130 separate processing units in a parallel architecture, the computer breaks down problems and attacks

(Please turn to page 132)

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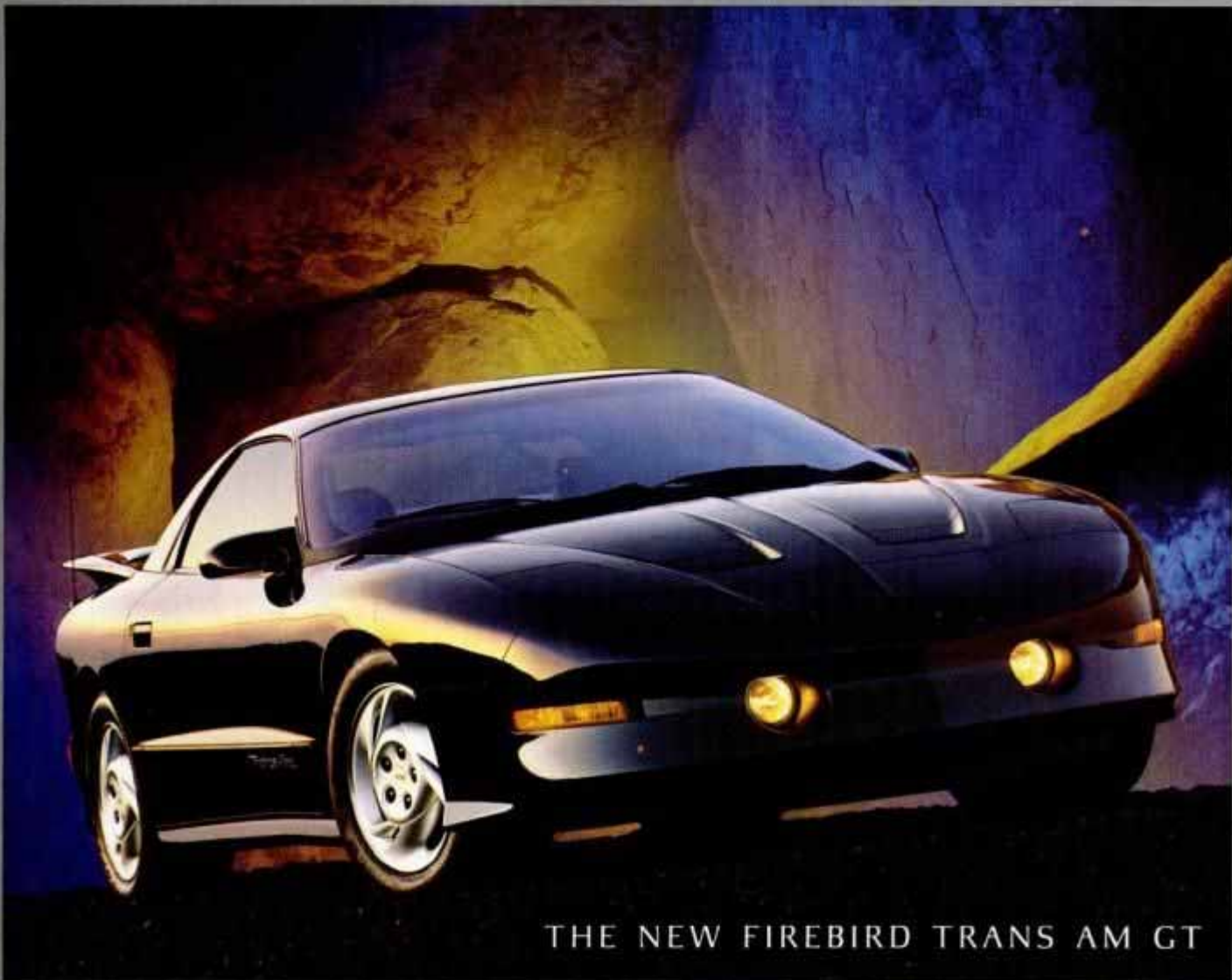
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# NEW VIEW

Improved optics give binoculars a sharper focus and a brighter image—even at night.

BY FRANK VIZARD

● I'm standing alone in the dark hours at the edge of what memory tells me is a clearing in the woods. Beyond the clearing is a small lake. I can hear the water lapping softly against the shore, but I can see nothing.

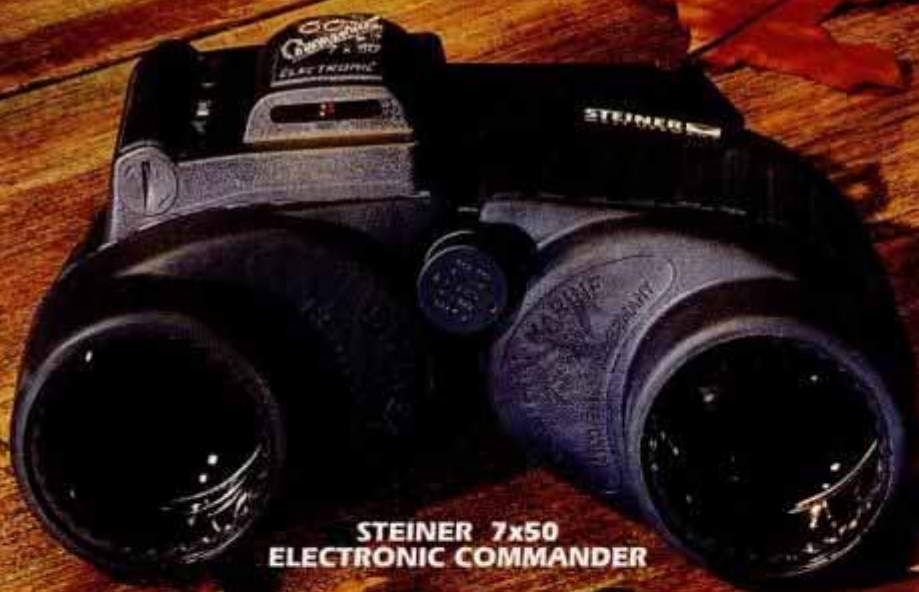
A light, of course, would illuminate the scene but the cast of characters that may be playing in the night will flee the stage as soon as it is turned on. The deer that may be standing at water's edge or the hare that may be chewing a blade of grass will promptly disappear—gone perhaps before I know they are even there.



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MPN 30K  
NIGHT VISION



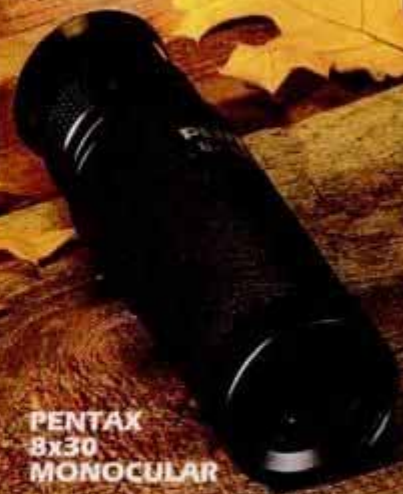
PENTAX  
16x24 UCF III



STEINER 7x50  
ELECTRONIC COMMANDER



OLYMPUS  
8x22 RC



PENTAX  
8x30  
MONOCULAR

## NEW VIEW

If there is anything out there, I don't want to scare it away. I reach into a fanny pack on my hip for a pair of bulky, black binoculars. Even in the dark, they feel strange—two tubular lenses melded to a third cylinder. Two steel cables also connect the cylinder to the lenses.

The binoculars are Russian. They certainly don't feel American. There is

## POWER



**7X**



**10X**



**12X**



**16X**

Magnification power is illustrated by the pictures above. Relative brightness level is shown on the opposite page.

PHOTO BY WENDY NEVUS



The top picture is a night scene seen with the eye. Night-vision binoculars produce the greenish view at left. A monocular spotter is also available (below).

not much thought given to a sleek, stylish design here—these binoculars are strictly functional in looks. Despite their bulk, they are surprisingly light, just under 3 pounds. I'm no longer in the Adirondack Mountains. I suddenly feel like I'm in a Siberian forest, maybe with a red star on my shirt collar. It's a hard feeling to shake.

There's a power switch on the cylinder. The ON/OFF markings, I had noticed earlier, are in both Russian and English. I turn on the power, supplied by two AA batteries, and hear a faint hum. An emerald glow fills each eyepiece. I raise the binoculars to my eyes, conscious that I'm about to see the unseen—for these are night-vision binoculars. I'm also a little uneasy. Without these binoculars, I would never know if there is a bear 50 ft. away. Now I'll know.

The night-vision landscape is a green one. Theoretically, it could be any color, but green provides the most contrast. I can see clearly across the field, discerning the solitary tree standing some yards before the lake shore. The lake is black, but its beginnings are clearly visible. There are no animals around. I'm filled with a mixture of disappointment and relief. To see a deer is one thing. To see a bear would be another thing entirely. I turn my head, eyes glued to the eyepieces. The trail back to the main road is easy to see.

Some minutes later, I'm standing under a tree on the dark side of Mirror Lake across from the town of Lake Placid. Now I really feel like a renegade Soviet commando. With the naked eye, all I can see of the town is



a collection of lights. But when I look through the night-vision binoculars, I see a world of eerie green activity. Cars going up hills, plumes of bright green shooting from the head- and taillights. People are visible, strolling down by the canoe landing. The experience is oddly voyeuristic. I can see the town with all its activity, but no one can see me.

What I'm actually watching, though, is television. With standard binoculars, the bigger the objective or larger lens, the more light will be captured for a brighter image. Night-vision binoculars work much differently. The model MPN 30K I'm using, imported by Moonlight Products of San



Bushnell's autofocus binoculars let you focus on an object instantly at the touch of a button.

## BRIGHTNESS

PHOTO BY LEONARDO LEE BUI III



24



35



42



50



80

Diego, has at its heart a light intensifier made up of a photocathode, a microchannel plate and a phosphor screen.

The photocathode is a semitransparent negatively charged electrode. When light hits the photocathode, electrons are emitted and collected by the microchannel plate. The plate is actually a silicate glass wafer made up of thousands of hollow glass fibers fused into a single bundle. The plate accelerates the collected electrons, which are then displayed as the amplified image on a phosphor screen that operates much like a television. When you look through the binoculars, what you are seeing is the image displayed on the phosphor screen.

In the case of the MPN 30K, ambient light is being amplified up to 30,000 times with a visual magnification of 2.5. More sophisticated night-vision gear, employing fiberoptic technology and special lens coatings, is used by the U.S. military, but the cost is many times the suggested list price of \$849 for the MPN 30K. In terms of night-vision equipment, the Moonlight line represents a price breakthrough for average consumers. At the low end from a price standpoint is the MPN 1500, a monocular or single lens scope with a pistol grip, listed at \$449 and rated to amplify light 1500 times. Needless to say, exposing the lens of these binoculars to bright light could be very damaging to the lens.

Also working well at night are binoculars like Steiner's 7x50 Electronic Commander. Designed for boating, binoculars like this with an objective lens brightness rating of 50 (the first number indicates magnification) work well for star gazing, making the Milky Way look like a beach of stars.

The principal feature of the Electronic Commander (\$1999) is its ability to provide an accurate bearing for boaters. An electronic sensor measures the magnetic field of the Earth, and this data is analyzed by a microprocessor. The bearing is then displayed internally on an LED screen. Leica's 7x42 Geovid model (\$6000) takes a similar tack, combining an

infrared sensor with an electronic compass to measure both distance and direction.

Steiner, in fact, is among those leading the way in application-specific binoculars. For example, one new Steiner model is a 9x40 binocular (\$899) made for hunting. A CAT (color-adjusted transmission) lens coating works to improve visibility in low light and block glare in bright sunlight or hazy conditions. Steiner's 8x30 Firebird model (\$449) goes even further, applying a red coating to the objective lens so what you

wind up with is a big pair of sunglasses. Bushnell's Mini model (\$110) also works like sunglasses to block ultraviolet light.

Big binoculars with large ob-

jective lenses and large exit pupil diameter in the ocular or smaller lens capture a lot of light and provide expansive fields of view—typically between 300 and 500 ft. at 1000 yards. On the other hand, they're often too big or unwieldy to carry on hiking or camping trips.

Compact binoculars that fit easily into a pocket are the more mobile alternative. Despite their diminutive size, many pack a lot of power. Especially pleasing is the new Pentax 16x24 UCF III model (\$215), a compact that offers one of the highest magnification powers available in a rugged one-piece design. Another eyepleaser in a more traditional design is the white Olympus 8x22 RC (\$205)—a tiny model that features a remarkable and clear field of view of 372 ft. at 1000 yards.

Small with a difference is the Bushnell 10x25 autofocus binocular

(\$280). Like a camera, this binocular instantly focuses on an object at the touch of a button. In theory, the autofocus feature should be most advantageous when tracking a moving object, a task simply accomplished by holding down the red autofocus button. In practice, the focusing system proved to be a bit jumpy and didn't provide a smooth tracking movement.

Another small alternative is a new breed of mini monoculars. These are reminiscent of the old spyglasses used by



Steiner's hunting binoculars are designed for the sport. Another application-specific model is the Electronic Commander, which features a module (inset) for taking bearings.

pirates, except that they don't extend. A good example of the breed is the Pentax 8x30 model (\$216) that is only 5 in. in length. It also comes with an attachment that converts the monocular into a microscope for real close-up work.

To see what the naked eye cannot has always been a fond desire. A good pair of binoculars is a move in that direction.

FM

# WILD MEN IN BORNEO

The U.S. Camel Trophy team conquers jungles, raging rivers, mud, snakes and leeches to win the 4-wheeler's olympics. And we go along for the ride.

● Backbreaking work, no sleep, miserable conditions. This could be the unofficial motto of the Camel Trophy, the Olympics of 4-wheeling, except for one thing: It's pure understatement. It doesn't begin to convey the grueling experience of the 1000-mile expedition across Sabah, Borneo, which followed a route over little-used jungle tracks, washouts and raging rivers. Nor does it convey the 16 exhausting days of coping with mud, dust, snakes, leeches, insects, heat, humidity and sleep deprivation.

And, as if these conditions weren't challenging enough, the 16 international teams that comprised the 1993 Camel Trophy convoy pushed their skills

BY JOE SKORUPA, Boating/Outdoors Editor  
PM Photos by Peter MacGillivray



It takes manpower to keep the jungle convoy rolling.

and stamina to the limit by performing mandatory tasks such as swimming across rivers, building bridges out of fallen trees, making field repairs on disabled vehicles and orienteering through the heart of the jungle.

From my eyewitness perspective, the Camel Trophy makes the Hawaiian Ironman Triathlon seem like a stroll in the park. What kind of people do this kind of thing? Well, people like Tim Hensley, a mechanic from Portland, Oregon, and Mike Hussey, a geologist from Middlebury, Vermont. Not only did they volunteer for the Camel Trophy, they beat out hundreds of applicants enthusiastically vying for the privilege.



When the road disappeared, the convoy used an inflatable raft equipped with outboard motors to ford rivers.

For their efforts, Tim and Mike were sent to Borneo, a Malaysian island in Southeast Asia, where they proved their mettle by becoming the first U.S. team to win top honors—the coveted Camel Trophy itself.

I first met Tim and Mike at a jungle camp on the muddy Pedas River, which used to run fast and clear until upstream clear-cutting turned it chocolate brown. I had just traveled halfway around the world by way of jet, bus and train. Tim and Mike had just traveled halfway around Sabah, the northern province of Borneo, by way of Land Rover Discovery—the official vehicle of the Camel Trophy. Despite Tim's

and Mike's ordeal, they looked better than I felt.

While my adventures couldn't compare with theirs, mine included 10 hours of sleep in three days, 26 hours on airplanes, a change of 13 time zones, a train derailment, rain every day and several nights in a small tent under a critter-filled jungle canopy.

Still, this was nothing compared to what participating Camel Trophy journalists endured. Each team is required to carry two media representatives. For the United States, it was



## WILD MEN IN BORNEO



A rotten log almost sends the French team into a washout, but teamwork, important in the Camel Trophy, pulls them through.



Peter MacGillivray and John Phillips. I met them during the last few days of the expedition, and they actually looked worse than I felt.



Riding through the jungle for 16 days in the back seat of a crowded, dirty, un-air-conditioned Land Rover Discovery takes its toll. Like Tim and Mike, the participating journalists also had to beat out a pack of volunteers for the privilege of receiving a megadose of what is fondly called the Camel Trophy experience. And like Tim and Mike, Peter and John were pushed to their limits, and

they looked it, too.

By now you're probably wondering: What exactly is the Camel Trophy? Well, it's this:

- A European company that makes adventure clothes, but doesn't sell them in the United States.

- A motorized, cross-country event sponsored by the above clothing company, which lends its name and lack of American recognition.

- A wilderness expedition that's more of a convoy with tasks than a rally.

- A one-design, point-scoring competition that not only rewards skill

and stamina, but also compatibility, cooperation and overall helpfulness.

- And finally, a male-bonding, ego-satisfying 4wd olympics.

The winning teams for 1993 were France for Special Tasks (second year in a row), the Canary Islands for Team Spirit and the United States for the overall Camel Trophy, which is determined by combining the points tallied in the first two categories. Although this is the first time that the U.S. team has won top honors, last year's team won the Team Spirit award.

As you can see by the nationalities of the winners, the Camel Trophy is an international event. Other com-

## Land Rover Discovery Tdi

- King of the jungle at this year's Camel Trophy was the Land Rover Discovery Tdi—a safari-tough 4x4 that's built in Solihull, England, for the world market. While it's not yet available in the United States, Land Rover is making plans to introduce it here for the 1995 model year.

I had a chance to drive an expedition vehicle at the jungle camp, but conditions weren't suitable to give the intercooled turbocharged diesel much of a workout. In the limited gear range I was able to test, the inline 4-cylinder 111-hp engine produced plenty of low-rpm torque for clawing through rough terrain. And as might be expected of a Land Rover, the suspension was adept at coping with sharp off-camber articulation. The front features a live axle with hydraulic dampers and coil springs. The rear has a live axle with A-frames, hydraulic dampers, coil springs and helper springs.

What makes the Camel Trophy's Discovery especially interesting is the bundle of expedition features that come with the Tdi spec level. These include a bull bar with driving lamps, heavy-duty winch,

front and rear towing hitches, brush guard wires that run from the bull bar to the roof rack, rear door-mounted ladder to roof rack, full roll cage, trip meter and quite a few others. On the roof rack, which is fitted with four spotlights, participants



were able to stow sand tracks, a spare wheel, four carrying cases, ropes, jacks, tools and much more.

Sport/ute fans will appreciate the jungle-

taming features of the compact, 5-door, full-time 4wd, affordable (less than \$30,000) Discovery when it appears in the U.S. with a gas V8, in 1994. —J.S.



The Land Rover Discovery absorbs abuse with aplomb—mud (above) and a night's worth of winching (right).



petitors were from Austria, Belgium, Germany, Greece, Holland, Italy, Japan, Malaysia, Poland, Russia, Spain, Switzerland and Turkey.

The first Camel Trophy was staged by a group of German adventurers 14 years ago, and has since evolved into the foremost 4-wheel-drive competition in the world. During the first year, the bushwackers used three Jeeps to navigate through the Brazilian jungle. During the second event, the convoy switched to vehicles supplied by Land Rover, a practice that continues to this day. During the third, in 1982, teams from three other nations joined the trek and the international character of the event was born.

Over the years, the Camel Trophy has been staged in some of the wildest locations on the planet, including Southeast Asia, Africa, Siberia and South America. Harsh climate and unmaintained roads are the only requirements.

Despite the assault-and-conquer mystique of the Camel Trophy, the truth is that it makes a genuine effort to be politically correct, at least as much as possible. It always runs on existing roads, leaves tangible improvements behind and cleans up after itself.

This year, in a special nod to environmental responsibility, the convoy organized a special task that involved building a research facility in the wilds of the Maliau Basin, which is known as the Lost World. The 2-story structure was built in less than 24 hours and will be used by scientists to study one of the oldest and least explored ecosystems in the world.

While the U.S. team came through the jungle unscathed, others weren't

so lucky. Half a dozen vehicles lost clutches and dinged body parts. Two vehicles were rolled. One competitor knocked himself out during an orienteering task. One came down with fevers, chills and hallucinations from dengue fever. And, perhaps unluckiest of all, a participating journalist got hurt by falling off the roof of his vehicle on the way to the hotel after the event officially had ended.

However, all vehicles and participants made it to the final destination, in Kota Kinabalu, in fine shape. All,

that is, except for the competitor with dengue fever, who had tears in his eyes when the helicopter took him to the hospital.

He's probably over the illness by now, but it's doubtful he's over the disappointment of missing the memorable "You Made It" ceremony, which was celebrated by the convoy on a beach on the South China Sea.

The rules of the Camel Trophy state that it's a one-time-only event, strictly for enthusiasts. Drivers who have ever held a professional racing license are prohibited. In addition, there's no pay or prize money (only expenses). The reward is basically in the doing, the opportunity to make international friendships, bragging rights to last a lifetime and the memories.

Ah, and what enduring memories. Interestingly, there were 14 support vehicles for the 1993 Camel Trophy expedition, and most were manned by former competitors who return year after year. In a strange way, the Camel Trophy has become a bonding experience so powerful that many veterans are making it a lifetime commitment.

Next year's Camel Trophy will start in Brazil and go through Paraguay and Argentina on its way to Chile. The route will include Ignacio Falls, Patagonia, the Andes and the Atacama Desert. Backbreaking work, no sleep, miserable conditions. I wonder if there's still time for me to reserve a back seat. **FM**



The winners of the 1993 Camel Trophy are Mike Hussey (left) and Tim Hensley, the first Americans to capture top honors.

For further information, contact: Camel Trophy, U.S. Coordinator, Dept. 4WOR, P.O. Box 587, Snowmass, CO 81654.

# WHOMPER



•4.0 LITER V-6 ENGINE\* •PUSHBUTTON FOUR-WHEEL DRIVE •P265 ALL-TERRAIN TIRES\*

\*Some features shown are optional. \*\* Ask dealer for details regarding the limited warranty.



# ROOM.



RANGER 4X4 SUPERCAB



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## COMPARISON TEST



**POLARIS INDY XLT SPECIAL**

● From Maine to Montana, winter weekends echo with the shrill howl of high-performance snowmobile racing. Like race fans everywhere, snowmobilers not only cheer their favorite racers but also the stock-class sleds they ride. Many fans, in fact, ride the same sleds they root for at the track when they get back home.

We thought it was time to look at these speedsters, and focused on the popular 580-cc class. While they aren't the most powerful snowmobiles available—muscle sleds go up to 900 cc—they offer a unique combination of flat-out speed and agile handling, a potent blend that makes them perennial best sellers.

For the best riding in the country, we went to West Yellowstone, Montana, to wring out four 1994 models: Arctic Cat ZR 580, Polaris Indy XLT Special, Ski-Doo Formula Z and Yamaha Vmax 600. Test results

were very close among the four models, but each machine displayed a distinct personality.

### **Arctic Cat ZR 580**

The most race-oriented sled of the group is the Arctic Cat ZR 580. While not the lightest, fastest or most powerful sled in the group, the ZR felt the quickest on the trail, thanks to a low center of gravity that keeps the ZR poised and upright in high-speed turns.

The ZR's advanced suspension also contributes to stability. A double A-arm is used in the front with coil springs and gas-charged shocks. In the rear, there's also a pair of gas shocks. Interestingly, the ride is somewhat stiff at low speeds, but comfortable at top end.

Motivation is supplied by a 90-hp 580-cc Suzuki twin-cylinder engine. The engine's low mounting sys-

# WHITE HOT

Sports-car speed and agility converge in the best-selling 580-cc class of snowmobile. We go to Yellowstone to test the four best.

BY CHARLES PLUEDDEMAN; PM Photos by Rich Cox

tem leaves no room for an electric starter as an option, but the engine turns over easily with the standard recoil starter.

A few of the ZR's race-ready features may be a mixed blessing for casual riders. The steel skis are narrow for excellent turning, but they tend to hunt around on rutted trails. The large hydraulic brake is powerful, but it's difficult to modulate.

Overall, the ZR is designed to be fast over rough terrain, adjustable and easy to service. Aggressive riders will appreciate its breeding.

## **Polaris Indy XLT Special**

The XLT stands for Xtra Light Triple, a reference to the sled's 3-cylinder 579-cc engine and svelte 468-pound weight, which enables it to enjoy a 10-pound to

23-pound advantage over the other models.

Despite the 95-horse engine's 3-cylinder design, the Fuji-built powerplant weighs no more than twins of equal displacement. Polaris trimmed additional weight by forming chassis components from aluminum.

The XLT uses a proven front suspension: a pair of transverse links attached to the chassis with a trailing arm, coil spring and gas shock on each side. A torsion bar between the skis enhances stability. The rear suspension features a pair of gas shocks.

Riding ergonomics on the XLT are excellent. The seat's contour keeps the rider firmly in place on rough trails, and offers lots of foot- and legroom. Heated handgrips and throttle are standard, but the switches are located in an awkward spot on the cowl.

The XLT gives a smooth, controlled ride that will

## WHITE HOT



YAMAHA VMAX 600



over moguls. Plus, the sled required a lot of body lean and muscle to stay upright in high-speed turns.

Aggressive riders, of course, won't mind putting in extra effort, especially when they're leading the pack.

### Yamaha Vmax 600

The Vmax 600 is a member of a family of midrange sport models based on the Vmax-4 muscle sled. The unit we tested is the most performance-ori-

satisfy your need for speed. As a bonus, you don't have to drive fast to appreciate its performance.

### Ski-Doo Formula Z

The Ski-Doo Formula Z is a new and faster model based on the slimmed-down Formula 2000 chassis, which weighs 40 pounds less than last year's steel-and-aluminum design.

The heart of the Formula Z is the 581-cc Rotax engine, which uses proprietary rotary-valve induction to achieve a whopping 110 hp. Its front suspension is similar to the Polaris setup. The rear features three coil springs with gas shocks.

Outstanding features on the Formula Z include the most comfortable seat of the group, plenty of legroom with great toe-hooks, the most attractive graphics and body design and composite skis that glide better and weigh less than steel skis.

After hours of riding, the test team found the handlebars to be a long reach for the driver and angled in a way that reduced leverage in turns. And while the throttle is progressive, it's not linear, so we often got more power out of turns than we wanted.

The Formula Z led the pack in top-end speed, and the Rotax motor was the most responsive of the group. Unfortunately, the suspension soaked up small bumps but bottomed out

### TEST PARAMETERS

Trail-riding was done on the hundreds of miles of groomed trails around West Yellowstone, which is at an elevation of about 6700 ft. Observed top-end speed was measured with a radar gun and conducted by a solo PM test rider on an old airstrip. Estimated speed refers to speed at sea level.



### MODEL

### ARCTIC CAT ZR 580

|                                     |   |
|-------------------------------------|---|
| Length/Width/Weight/Fuel Capacity   | 111.0"/45.0"/483 lb./9.0 gal.                     |
| Engine/Displacement/Horsepower      | Suzuki 2-cylinder/580 cc/90 hp                    |
| Seat Height/Engine Height/Clearance | 22.5"/19.75"/5.0"                                 |
| Suspension Travel, Front/Rear       | 6.0"/8.5"   |
| Top-End Speed, Observed/Estimated   | 81 mph/95-100 mph                                 |
| Handling                            | Stiff, race-bred suspension smooths out at speed  |
| Cornering                           | Low center of gravity rewards aggression in turns |
| Ergonomics                          | Easy-to-grip throttle, excellent riding position  |
| Special Features                    | Advanced suspension, racing hydraulic brakes      |
| Price                               | \$5999  |
| Address                             | P.O. Box 810<br>Thief River Falls, MN 56701       |

All sleds come with easy-to-use pull starters—typical of lightweight racing sleds. All have optional electric starters, except the Arctic Cat ZR 580. All are equipped with cleated rubber drive tracks that measure 15 × 121 in. All have 40-in. ski stances—the distance between the centerlines of the steering skis. All have 2-stroke oil-injected engines. All hp ratings are estimates—the snowmobile industry doesn't provide this figure.



Front suspension features a double A-arm with coil spring and gas shocks.



**ARCTIC CAT ZR 580**

**SKI-DOO FORMULA Z**

ented model, which is equipped with a twin-cylinder 98-hp Yamaha engine that displaces 598 cc.

The Vmax ran neck-and-neck with the Polaris and Arctic Cat, and it offers plenty of smooth power, but without an abundance of snap or full-throatedness.

The model's TSS front suspension places a sliding strut over each ski, with a spring and shock-absorber cartridge inside a tube that looks and

functions like a motorcycle fork. The rear suspension has a pair of gas shocks with adjustable coil springs.

The Vmax glides on lightweight steel skis that have plastic skins on the running surface. The seat is well contoured and deep set, and this helps lower the sled's center of gravity. On the down side, our knees were a bit cramped.

While the TSS front suspension was smooth, the track suspension

was a little stiff. It's worth noting that we tested a model with a prototype suspension, and Yamaha claims the ride will improve when production begins.

Even in pre-production form, the Yamaha displayed excellent fit-and-finish, and its suggested retail price (\$5649) is the lowest of the group. If Yamaha can improve the rear suspension, the Vmax 600 will be the best value in this class. **FM**



**POLARIS INDY XLT SPECIAL**



**SKI-DOO FORMULA Z**



**YAMAHA VMAX 600**

|  |   |   |
|--|---|---|
| 106.0"/45.0"/468 lb./10.7 gal.                   | 110.0"/46.0"/478 lb./11.1 gal.                    | 110.6"/45.5"/491 lb./10.0 gal.                      |
| Fuji 3-cylinder/579 cc/95 hp                     | Rotax 2-cylinder/581 cc/110 hp                    | Yamaha 2-cylinder/598 cc/98 hp                      |
| 23.75"/21.5"/6.25"                               | 25.0"/20.5"/6.25"                                 | 22.0"/22.5"/6.5"                                    |
| 8.0"/8.0"  | 6.5"/7.5"   | 7.2"/8.5"   |
| 80.5 mph/95-100 mph                              | 84.5 mph/100-105 mph                              | 81.5 mph/95-100 mph                                 |
| Smooth at all speeds, never bottoms out          | Engine more advanced than the suspension          | Prototype suspension was fairly stiff at all speeds |
| Predictable in all situations, no misbehavior    | Requires some muscle to get through hard turns    | Low center of gravity makes pinning turns easy      |
| Lots of foot- and legroom, convenient throttle   | Superb except for long-reach throttle/handlebars  | Low seat cramped knees, otherwise superb            |
| Heated grips and throttle, integrated seat cover | Composite skis, easy-to-adjust springs and shocks | Low-friction plastic ski skins, sculpted body       |
| \$5899   | \$6199  | \$5649  |
| 1225 Hwy. 169 N.,<br>Minneapolis, MN 55441       | 7575 Packer Dr.,<br>Wausau, WI 54402              | 6555 Katella Ave.,<br>Cypress, CA 90630             |



Lightweight 3-cylinder block is fitted with three 34mm Mikuni carbs.



Dash panel has instruments with large numerals that are easy to read at speed.



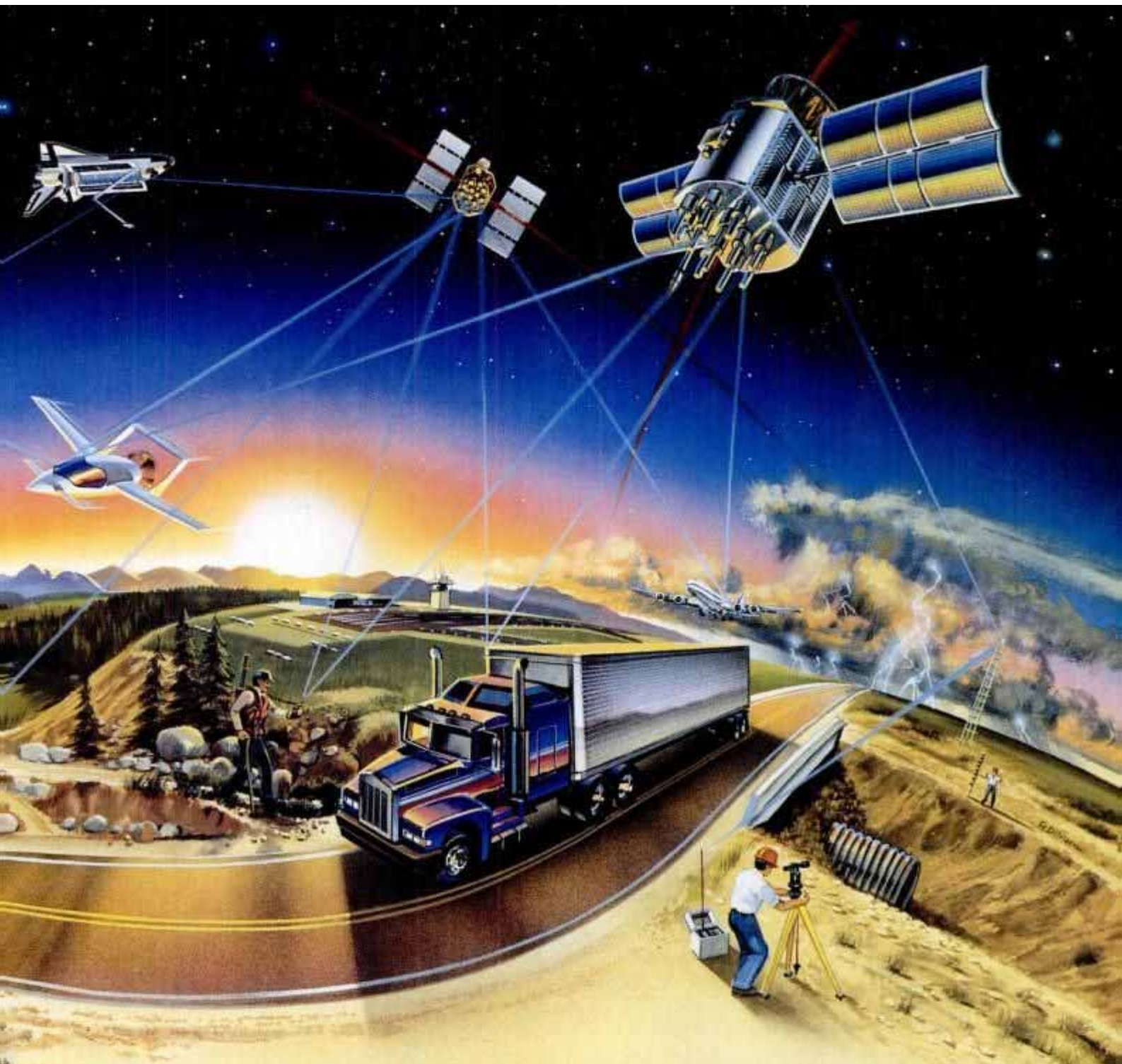
Side engine cover drops down for easy access to clutch and drivebelt.



# YOU ARE HERE

Built for war, the Global Positioning System has become a surprise peace dividend for thousands of enterprising users.

BY PHILIP CHIEN; PM Illustration by Paul DiMare



● Forty years ago, who would have thought you could use a phone line to mail a letter, play a game or pay off a loan? And 20 years ago, would you have guessed that a \$10-billion fleet of military satellites, developed at the height of the Cold War, would help you rediscover a fabulous fishing hole?

Yet it can. Well over 100,000 Global Positioning System receivers are in civilian hands. "The potential for GPS is to be as ubiquitous as the telephone and as pervasive as the personal computer," says Michael Swiek, executive secretary of the U.S. GPS Industry Council. "Each time you turn around, you see a new application you never thought of before."

The system's original purpose was far from peaceful: It was developed to tell moving aircraft, warships and missiles exactly where they were with re-

spect to their targets. Last June, the 24th satellite rocketed into orbit, completing the constellation. Says GPS system program director Air Force Col. Larry Graviss, "When you walk outside, you will have at least four satellites available to give you velocity, altitude and location anywhere in the world."

### Name the time and place

In a nutshell, GPS is an exercise in triangulation. Each satellite keeps track of two things: exactly where it is (thanks to radar tracking) and exactly what time it is (thanks to four on-board atomic clocks). The satellite continuously emits signals that convey this information.

Your receiver also carries a clock and notes the time that it intercepts a signal. By comparing this time with the time broadcast by the satellite, the

GPS has found a place in countless applications, from left to right: New military uses, such as precision-strike weapons guidance, remain the system's top priority. But boaters have been quick to pick up on the technology for navigation. Meanwhile, several companies have developed in-car navigation systems, with GPS signals translated into moving maps. Private pilots also rely on GPS for navigation, pioneering the method well before recent Space Shuttle experiments along the same lines. On the ground, backpackers (and hiker rescue teams) have embraced the technology. Long-haul trucking companies track loads with GPS. Surveyors mark off land parcels with extra-precise differential GPS, while airports are now phasing in this technique to land planes during foul weather.

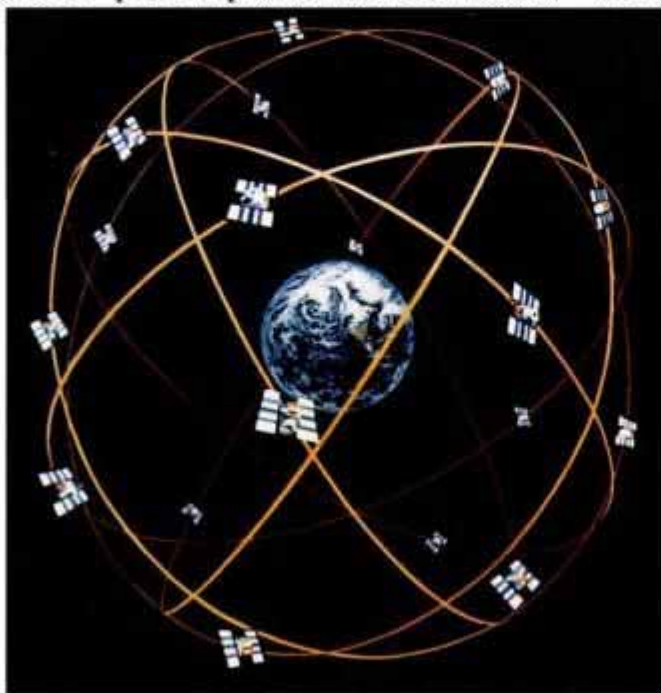
## YOU ARE HERE

receiver calculates its distance from the satellite. Then by triangulating from three other satellites, the receiver gets a fix on its own longitude, latitude and altitude.

The satellites broadcast several varieties of signal, however. American and allied military forces carry receivers that can descramble the encrypted P-Code signal, which pinpoints locations to within 50 ft. The rest of us can pick up the civilian C/A signal, which provides accuracy to roughly 80 ft. Fearing that hostile forces could use C/A signals to guide missiles, however, the Pentagon has purposely muddied that signal with pseudo-random noise. This so-called Selective Availability mode degrades C/A accuracy to about 300 ft.

Ironically, one arm of the U.S. military—the Coast Guard—has embraced a trick that overcomes Selective Availability. Local-area differential GPS, or DGPS, works on the principle that all the receivers in a given vicinity will be off by the same amount. In DGPS, a stationary GPS receiver, its geographic location known precisely, picks up the satellite broadcasts and calculates the error. This reference station then broadcasts a correction

over another frequency. The result is an accuracy of 10 to 15 ft.—better than the military P-Code. The Coast Guard has set up prototype reference stations around the coastline and plans to provide DGPS services to



GPS satellites ring the globe in six orbital planes.

U.S. harbors by the year 1996.

In addition, the Federal Aviation Administration has begun installing DGPS at airports, aiming to replace the radio beacons that usher in planes during instrument-guided approaches.

More controversial is a plan by Inmarsat, which provides maritime satellite-navigation services. Starting in 1995, a new generation of Inmarsat satellites will shower wide areas with signals carrying DGPS corrections. This would create a worldwide civil navigation aid. The Pentagon has already objected, suggesting, among other things, that terrorists could spoof the signals to crash airliners.

Meanwhile, researchers keep whittling away at the built-in inaccuracies. Stanford University, for example, has experimented with kinematic GPS. This technique takes advantage of the Doppler effect—a shift in the GPS carrier frequency that appears to a moving vehicle as it passes a signal transmitter. The system is complex, requiring both a ground-based reference receiver and so-called “pseudolites,” which retransmit GPS signals from fixed locations. But it can resolve an aircraft’s altitude to within 1 ft.—well inside the demands of stringent runway-approach rules.

This and other techniques will only fuel the explosion in civilian applications, which appear more ingenious every day. As Świek says, “The imagination is the only limit.” **PM**

## Ten Scenes From The GPS Revolution

After the 1989 earthquake, the city of San Francisco commissioned a survey of the Golden Gate Bridge and its vicinity. Field teams calibrated survey points down to the centimeter, using differential GPS. After the next quake, the points will be re-surveyed—to see how far the Earth moves.

Dashboard navigation systems are popping up everywhere. One, from DeLorme Mapping, turns GPS data into a “trail of bread crumbs” on a moving map. All you need is a receiver and a portable computer with a CD-ROM drive, which houses a nationwide map database.

Mongolia’s Gobi Desert harbors unique dinosaur fossils that have attracted paleontologists from the American Museum of Natural History. Not only do the researchers mark the location of finds with GPS, they also rely on GPS to find their way in and out of the forbidding wasteland.

In Brazil’s Pantanal floodplain area, biologists are using Magellan handheld GPS receivers to lay out a wildlife survey grid. Meanwhile, aboard low-flying aircraft, other biologists use GPS to log in the location of crocodiles tagged with paint splashes on their backs.



Zilca Campos uses handheld GPS to map habitat of Brazilian crocodiles.

While GPS still isn’t standard equipment on the Shuttle, it is on NASA’s TOPEX/Poseidon satellite, which measures sea surface heights. No other satellite is tracked so precisely. GPS readings combine with laser and radar tracking to pinpoint the orbiting bird to within 4 in.

The California Department of Transportation, East Bay District, has embarked on an experimental program with GPS-equipped tow trucks. Each truck’s receiver transmits its location back to headquarters. When a call comes in, the dispatcher radios the nearest available truck.

The Billfish Foundation is sponsoring a tag-and-release program. Hooked fish get tagged with their locations, as provided by GPS. Sportfishermen are then asked to report where they catch tagged fish. So far, one globe-trotting marlin was released off North Carolina and showed up in Angola.

GPS found the lost city of Ubar, the fabled center of frankincense in ancient times. Archeologists spotted the likely site in Oman from Earth-observation satellite images. They then used GPS to home in. Using Magellan GPS receivers, diggers register the location of relics unearthed.

The days of flagmen guiding cropdusters along their runlines are long gone. Instead, a Trimble Navigation product combines GPS with a display of lights on the aircraft’s glare shield. The system keeps the pilot on track and points out spray activation and cut-off points for surgical strikes against pests.

Ships and aircraft can tap GPS signals to gauge pitch, roll and yaw. A system conceived by Trimble combines one receiver with an array of antennas. Since the GPS signals hit each antenna at slightly different times, the receiver can calculate phase differences and determine attitude.



# MERCURY VILLAGER, NISSAN QUEST



Alternatives to the gold standard.

● The greatest compliment you can pay a minivan is to say it drives like a car. And carlike is what a lot of the owners we surveyed said about their Mercury Villagers and Nissan Quests.

There aren't many differences between the two. The Quest sports a version of the Maxima grille, while the Villager has Mercury's familiar lightbar. Both vans have their own unique taillamps, body moldings, wheel covers and optional alloy wheels. Other than that, they're the same.

While both vans come in two trim levels—Villager GS and LS, Quest XE and GXE—there are some distinctions in equipment. All Villagers come standard with 4-wheel antilock brakes, but ABS is a \$700 option in the Quest. All Quests have air conditioning, but it's an option in the basic Villager GS. The Quest GXE comes with an auxiliary rear air-conditioning system, but in the Villager it's built into several different option packages.

All Quests come with tilt steering wheels and AM/FM/

BY MICHAEL LAMM, Contributing Editor  
PM Photos by Rich Cox



cassette stereo systems, but in the Villager they're standard only in the LS. A rear-window defogger is standard in all Quests, but it costs extra in all Villagers. The base Quest XE lists for \$17,395, the Villager GS for \$16,790.

Nissan handled most of the design and engineering work in the development of the Villager/Quest, while Ford took on manufacturing issues and final assembly. Assembly takes place in Ford's former van plant near Avon Lake, Ohio.

Nissan supplies the V6 engine, the automatic transaxle and most of the major body stampings from its plant in Smyrna, Tennessee. The 151-hp V6 and electronically controlled 4-speed transmission—the only powerteam available—derive from the Nissan Maxima, as do most of the steering and front-suspension components. However, enough parts come from Nissan's U.S. plant and from Ford and other domestic suppliers that the Villager/Quest qualifies as a domestic vehicle.

# VILLAGER/QUEST



Some owners wanted stronger panel lighting.

Seating got high marks, controls drew pans.

Smooth V6 engine pleased most owners.

It's clear that the Villager/Quest's marketing target is Chrysler's gold-standard minivans—the Plymouth Voyager, Dodge Caravan and Chrysler Town & Country. Dimensionally, the Villager/Quest stretches

nearly a foot longer than the standard MoPar minivan (Grand versions of the Caravan and Voyager stretch to 190.5 in.), and the rear seat is 4 in. wider. But other interior dimensions are almost identical. Total cargo vol-

umes, with the second-row seats removed, are also virtually identical for all the standard vans.

Our survey showed that owners particularly like the way the Villager/Quest handles. Fully 77% judged

## SUMMARY OF VILLAGER/QUEST OWNERS REPORTS\*

|   |                   |                                      |       |                                      |       |   |       |
|---|-------------------|--------------------------------------|-------|--------------------------------------|-------|---|-------|
| <b>Total miles driven</b>                     | 2,362,572         | Good                                 | 22.0  | Average                              | 6.4   | Yes   | 79.4% |
| <b>Average miles driven</b>                   | 7225              | Average                              | 1.0   | Poor                                 | 0.6   | No  | 20.6  |
| <b>Purchase price:</b>                        |                   | <b>Braking:</b>                      |       | <b>Specific likes:</b>               |       | <b>Mercury dealer service opinion:</b>  |       |
| Average                                       | \$20,406          | Excellent                            | 62.2% | Handling                             | 53.1% | Excellent   | 56.1% |
| Range   | \$16,000-\$28,000 | Good                                 | 34.0  | Styling                              | 41.5  | Good  | 35.0  |
| <b>Why did you choose the Villager/Quest?</b> |                   | Average                              | 3.8   | Ride quality                         | 38.9  | Average   | 7.2   |
| Styling                                       | 46.0%             | Poor                                 | 0.0   | Comfort                              | 35.7  | Poor  | 1.7   |
| Handling                                      | 20.9              | <b>Overall performance:</b>          |       | Versatile seating                    | 22.5  | <b>Nissan dealer service opinion:</b>   |       |
| Roominess                                     | 16.6              | Excellent                            | 68.7% | Engine power                         | 18.6  | Excellent   | 48.5% |
| Versatile seating/cargo                       | 14.7              | Good                                 | 30.2  | <b>Specific dislikes:</b>            |       | Good  | 36.6  |
| Price/value                                   | 10.1              | Average                              | 0.7   | No complaints                        | 12.6% | Average   | 12.7  |
| Standard equipment                            | 8.9               | Poor                                 | 0.3   | Vague parking dimensions             | 11.5  | Poor  | 2.2   |
| Ride quality                                  | 8.9               | <b>Control layout:</b>               |       | Fuel economy lower than expected     | 8.6   | <b>Mercury dealer sales policy:</b>   |       |
| <b>Avg. mpg, city/hwy:</b>                    | 18.6/23.5         | Excellent                            | 44.5% | Noises and rattles                   | 7.8   | Excellent   | 57.0% |
| <b>Model choices (Mercury):</b>               |                   | Good                                 | 43.8  | No airbags                           | 7.8   | Good  | 35.2  |
| Villager GS                                   | 62.3%             | Average                              | 11.0  | <b>Suggested changes:</b>            |       | Average   | 7.3   |
| Villager LS                                   | 37.7              | Poor                                 | 0.7   | Airbags                              | 26.2% | Poor  | 0.5   |
| <b>Model choices (Nissan):</b>                |                   | <b>Instrumentation:</b>              |       | Improve shoulder-harness comfort     | 10.7  | <b>Nissan dealer sales policy:</b>  |       |
| Quest XE                                      | 63.2%             | Excellent                            | 51.4% | Center-seat cup holders              | 8.7   | Excellent   | 45.7% |
| Quest GXE                                     | 36.8              | Good                                 | 42.8  | Improve center console               | 6.7   | Good  | 37.9  |
| <b>Seating choices:</b>                       |                   | Average                              | 4.1   | More cargo space with seats in place | 6.3   | Average   | 15.1  |
| 7-passenger                                   | 98.5%             | Poor                                 | 1.7   | Improve instrument illumination      | 5.6   | Poor  | 1.4   |
| 5-passenger                                   | 1.5               | <b>Driver sightlines:</b>            |       | <b>Mechanical trouble?</b>           |       | <b>Number of vehicles owned:</b>  |       |
| <b>Options/Accessories:</b>                   |                   | Excellent                            | 50.9% | No                                   | 66.3% | This vehicle only   | 16.3% |
| Antilock brakes                               | 79.2%             | Good                                 | 37.8  | Yes                                  | 33.7  | Two vehicles  | 50.9  |
| Handling package                              | 47.5              | Average                              | 8.6   | <b>What type of trouble?</b>         |       | Three vehicles  | 20.2  |
| Center-row captain's chairs                   | 32.6              | Poor                                 | 2.7   | Rear wiper won't shut off            | 22.1% | Four or more  | 10.2  |
| Keyless entry                                 | 29.2              | <b>Workmanship opinion:</b>          |       | Electrical problems                  | 15.0  | <b>Principal driver:</b>  |       |
| Digital instruments                           | 21.6              | Excellent                            | 65.3% | Brakes                               | 11.5  | Female  | 66.0% |
| Towing/performance package                    | 20.1              | Good                                 | 33.1  | Heater fan                           | 8.0   | Male  | 28.3  |
| Sunroof                                       | 15.5              | Average                              | 1.2   | Air conditioner                      | 7.1   | Equal   | 5.7   |
| Leather upholstery                            | 13.4              | Poor                                 | 0.3   | Fuel system                          | 6.2   | <b>Age distribution of owners:</b>  |       |
| <b>Engine power:</b>                          |                   | <b>Comfort opinion, front seats:</b> |       | Heater                               | 6.2   | 29 and under  | 5.9%  |
| Excellent                                     | 51.5%             | Excellent                            | 73.5% | <b>Repair it yourself?</b>           |       | 30-49   | 66.0  |
| Good  | 43.3              | Good                                 | 24.4  | No                                   | 98.2% | 50-plus   | 28.1  |
| Average                                       | 4.8               | Average                              | 2.1   | Yes                                  | 1.8   | <b>Based on your experience, would the Villager or Quest be your choice if you had it to do over again?</b> |       |
| Poor  | 0.3               | Poor                                 | 0.0   | Dealer repairs satisfactory?         |       | Yes   | 71.6% |
| <b>Handling:</b>                              |                   | <b>Comfort opinion, rear seats:</b>  |       | No                                   | 98.2% | Maybe   | 24.2  |
| Excellent                                     | 77.0%             | Excellent                            | 41.0% | Yes                                  | 1.8   | No  | 4.2   |
|   |                   | Good                                 | 52.0  |                                      |       |   |       |

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

handling excellent, and another 22% scored it good. Owners also like the V/Q's style and ride quality, along with overall comfort.

There was a lot of praise for the V/Q's versatility in seating and cargo arrangements. Nissan claims up to 24 different seat configurations. The second-row seats, available as a single bench seat or separate captain-style buckets, have quick-release mounts and lift out easily. The third-row bench can then slide forward on tracks, and can be folded and refolded right up against the front seat backs. You can also remove the third bench with hand tools. This leaves an uncluttered interior of 126.4 cu. ft. Additionally, all second- and third-row seat backs fold flat so they can serve as tables.

What V/Q owners didn't like were the mouse-motor shoulder harnesses and manual lap belts. This is a common complaint that's disappearing as airbags replace automatic belts in passive systems. However, the V/Q vans in our survey weren't equipped with airbags—a driver's airbag will be standard with '94 models—and 26.2% of our owners expressed unhappiness with this omission. A number of them also criticized the lack of a child safety seat option.

Another peeve had to do with parking. The V/Q's sloping hood provides no reference points, and some owners confessed to parking by ear.

The ergonomic gripes we tallied mostly had to do with stereo and ventilation controls. These are clustered on a console pod between the driver and passenger, and the buttons are so small and so numerous that they provoked a number of complaints.

Back on the plus side of the ledger, more than two-thirds of our respondents reported no mechanical difficulties of any kind. Of the 33.7% who did have problems, dealers made first-time repairs in roughly 80% of all cases. Since service constituted one of the main reasons for choosing between Mercury and Nissan, it's interesting to note that Villager owners were more pleased with dealer sales and service policies than were Quest owners.

Minivans tend to be transitional vehicles—people move into and out of them as their needs change. They're handiest, obviously, for growing families. So it's quite a compliment that 71.6% of our respondents said they'd buy a Villager or Quest next time around. Only 4.2% gave a definite thumbs down. This means that the majority of these minivan owners think that the Mercury Villager and/or Nissan Quest is their kind of car. **PM**



Slick styling seduced more Villager and Quest buyers than any other trait. However, owners listed carlike handling as the best-liked feature. Ride quality also ranked high.

#### EDITORS REPORT

## The V/Q Alternative

● It's amazing that something as successful as the Chrysler minivan has taken so long to provoke a direct challenge. Although there are some 18 minivan nameplates on the market, these two—the Villager and the Quest—are the first that square up head to head with the original Chrysler concept: sedan driveability, small-van volume.

A week of touring the Los Angeles area in the Villager shown here—plus a year of living with a Villager long-term test vehicle in Detroit—leaves us with no doubt concerning the driveability issue. These minivans are mannerly and predictable, with very good steering feel and excellent ride quality. They're also exceptionally quiet. It's hard to remember that you're hauling around all that cargo volume.

But the most telling testimonial concerning the Villager/Quest driveability quotient comes from the people doing the day-to-day driving. Based on our survey, almost two-thirds of these people are women. And in our experience, women have a much more demanding definition of "carlike" than men. Minivans riding on compact pickup chassis need not apply.

Recognizing that blazing 0-to-60 performance isn't an important consideration in minivan purchase decisions, we'd call this van's powertrain good. Nissan's V6 is wonderfully smooth, and the 4-speed transaxle is almost transparent in its operation—

upshifts in particular are difficult to discern in ordinary driving. And even though some of our owners weren't pleased with their fuel economy, we regard this van's mpg as competitive. Our own travels around L.A. netted just over 18 mpg.

About the only time we wished for more muscle was in passing situations on 2-lane highways. With almost 2 tons of minivan to tow, passing exposure times feel a little lengthy. We also think the tow rating—3500 pounds—is optimistic. If towing in that weight range is likely to be a regular part of your van's workload, we recommend one of the rear-drive minivans and more power.

There are a couple of areas where the Villager/Quest gives something away to the Chrysler minivans. It has only one powertrain offering—albeit a good one—versus a varied Chrysler lineup that includes the option of all-wheel drive. The V/Q comes in just one size, in contrast to the stretched Grand versions of the Dodge Caravan and Plymouth Voyager. And Chrysler's airbags and optional integrated child seats have been strong selling points.

However, Villager/Quest gets a big edge in seating/cargo flexibility, and its styling is competitive. Stir a standard driver's airbag into the mix ('94 model year), and you've got a strong alternative to the industry's perennial minivan sales leaders. It's always nice to have choices. —Tony Swan



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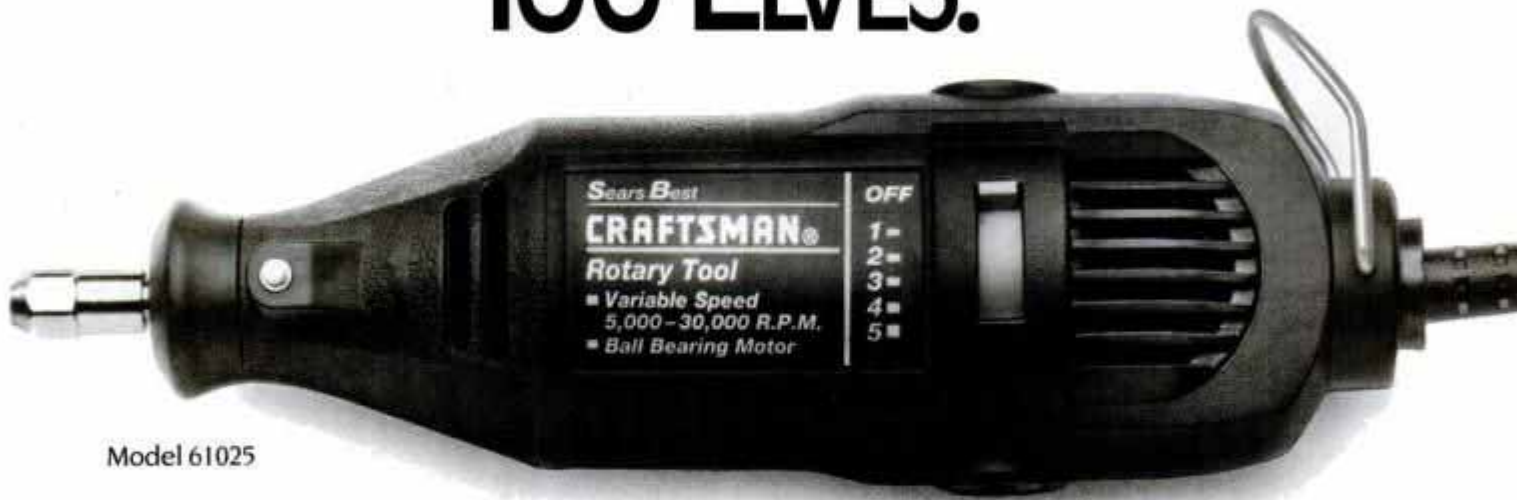
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# Furniture Refinishing

All that's old is new again.

BY THOMAS KLENCK, Associate  
Home Improvement Editor

**R**efinish. When you think about it, the word itself poses an interesting problem. After all, once something is finished, aren't you through with it? Well, when it comes to furniture, time travel is a well-documented reality. Not only can you go back and refinish something that's already done, you can give a piece of furniture a character and personality never imagined by the original craftsman. You can recreate an authentic look or transform a traditional piece to match a contemporary setting. You can free the hidden beauty of the wood trapped beneath a half-dozen coats of paint, or you can rejuvenate a piece that's on its last legs. In fact, that's really what refinishing is all about—rejuvenation—to give new life to the furniture of the past.

If you ask any experienced woodworker, you'll find out that furniture finishing—applying those thin protective and reflective layers to the surface of wood—often takes as much as one-half the time it took to complete the joinery and assembly. And, it's not simply because finishes take time to apply and to dry, it's because finishes are vitally important to the appearance of the piece—important enough to demand a substantial investment in time and energy.

The job of the refinisher is to redo this last, crucial step in furniture making. However, that's not all it entails. Often, years of use take their toll in the form of loose joints and broken or worn parts. Here, the refinisher becomes the repairer, so the base for the new finish is restored as close as possible to the original condition. Also, many pieces utilize hardware such as hinges, drawer pulls and latches. If

one or more of these components are lost or broken, it's the refinisher's job to make it right with hardware appropriate to the style of the piece.

In this Woodworking Guide, we'll take you through the basic steps necessary to rejuvenate your prize from the past. However, because finishes—both old and new—and the problems and techniques associated with them can vary tremendously, we've divided our coverage into three case studies. Each case study is a real-

world example of a typical finishing project that you might encounter.

The first deals with one of the most common flea-market finds—a painted cupboard, featuring beaded tongue-and-groove back panels, frame-and-panel doors and traditional molding details. We'll explain how to get it down to bare wood and then bring it back to life with a traditional-looking delicate amber stain and a modern clear gel wipe-on finish.

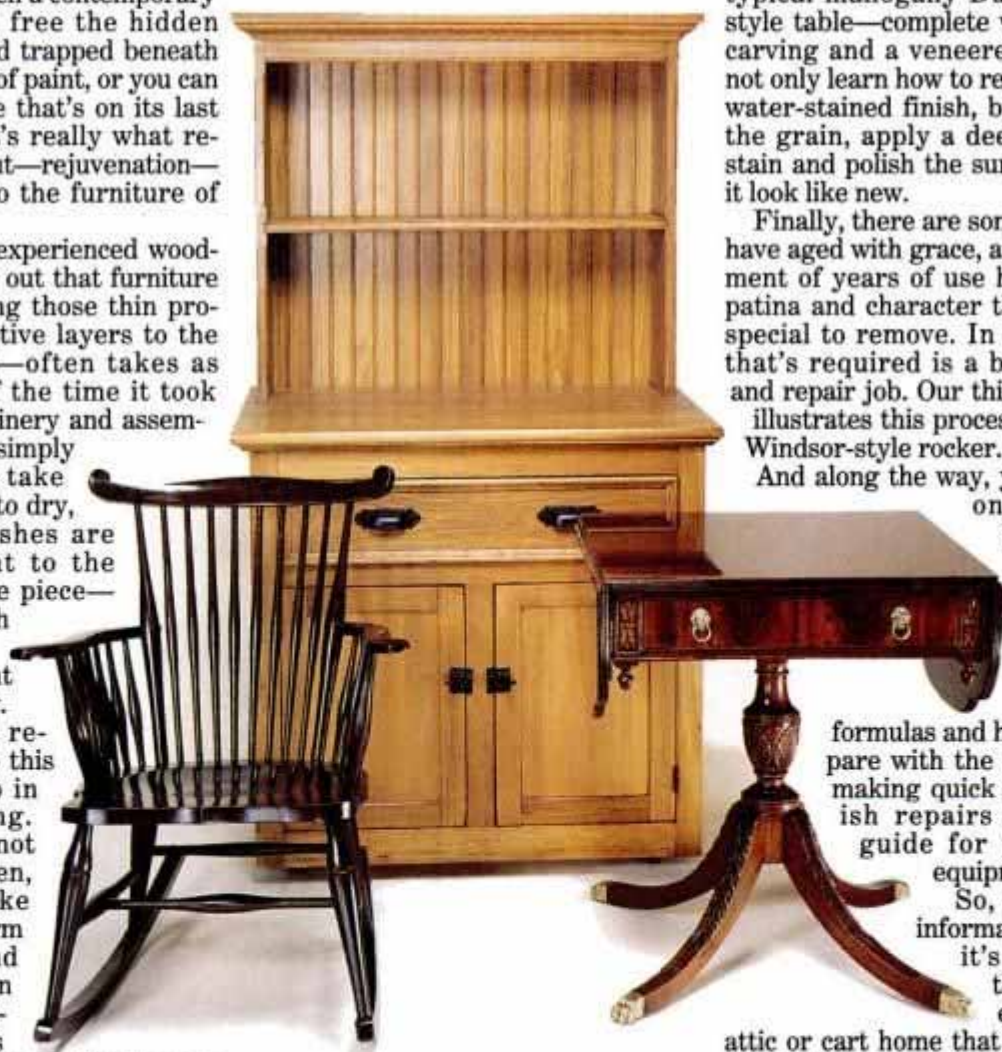
Our second case study deals with a typical mahogany Duncan Phyfe-style table—complete with intricate carving and a veneered top. You'll not only learn how to remove that old water-stained finish, but how to fill the grain, apply a deep mahogany stain and polish the surface to make it look like new.

Finally, there are some pieces that have aged with grace, and the investment of years of use has created a patina and character that's just too special to remove. In this case, all that's required is a basic cleanup and repair job. Our third case study illustrates this process on a classic Windsor-style rocker.

And along the way, you'll get tips on refinishing supplies and tools, the lowdown on those new environmentally friendly formulas and how they compare with the old, hints for making quick and easy finish repairs and even a guide for using spray equipment.

So, with all this information on hand, it's time to pull that old dresser out of the

attic or cart home that Hoosier cupboard that's going cheap. Time travel is a reality—at least where furniture finishes are concerned. And, there's no time like the present to start your journey. **PM**



A country cupboard, Windsor-style rocker and Duncan Phyfe table form the centerpiece for our guide to refinishing. Shown here after restoration, they illustrate a complete range of refinishing techniques.

WOODWORKING  
GUIDE

# Refinisher's Toolkit

The right tools and supplies make refinishing easy.

BY THOMAS KLENCK, Associate  
Home Improvement Editor  
PM Photos by Rosario Capotosto

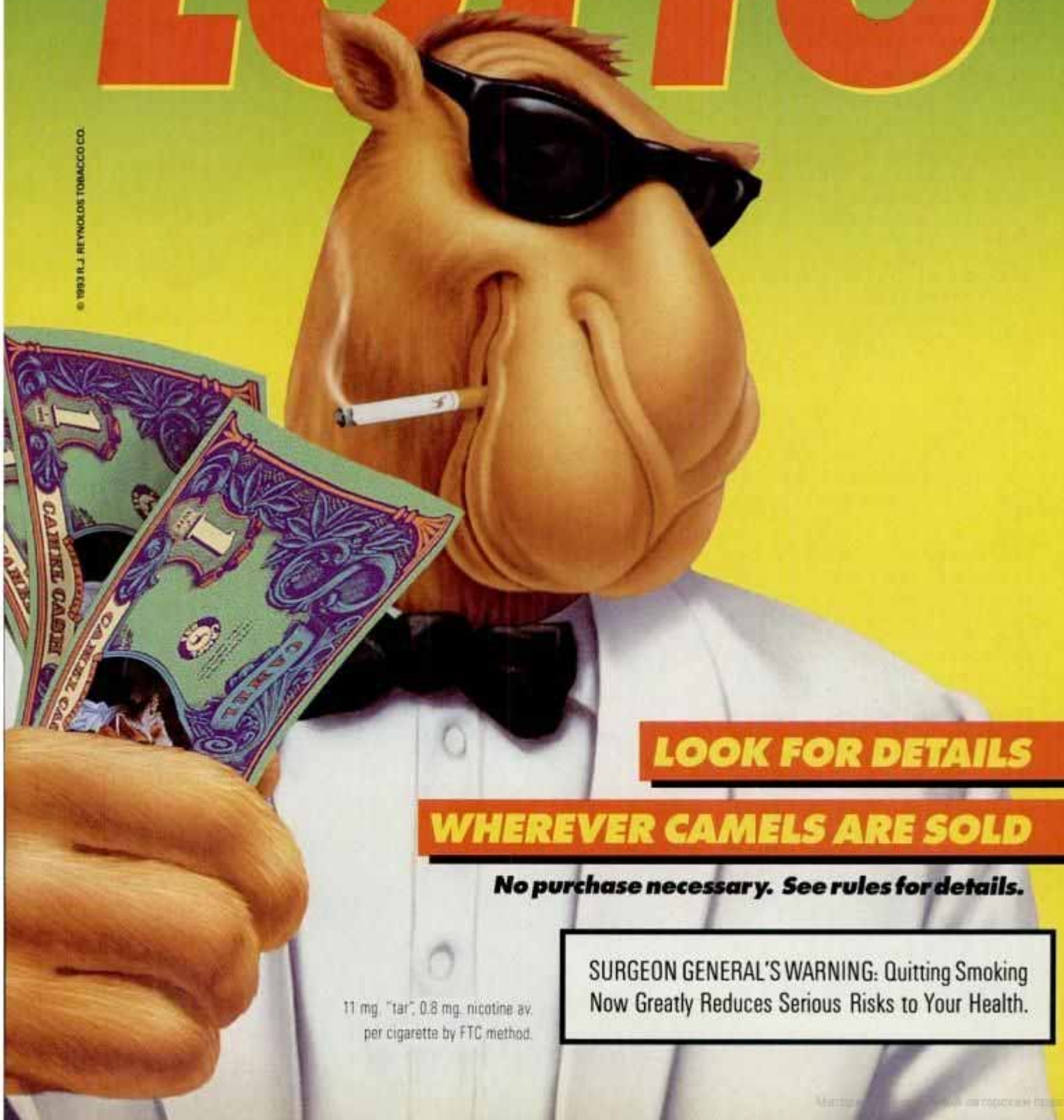
One of the beauties of refinishing is that the tools are so simple. Although it's possible to spend hundreds of dollars on elaborate spray equipment and a workspace to do the job right, for the most part, applying or removing a finish can be a fairly low-tech operation. Except for a small sander and a good light to work by, you won't have to plug in anything, and the only horsepower rating involved is what you can accomplish with your own two hands.

The really interesting thing about refinishing tools is that many of them are unlike any other tools in the workshop. Instead of being mechanical, they're chemical. And although they're relatively inexpensive and easy to use, these chemical tools are the result of some very high-tech research and develop-



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## WOODWORKING GUIDE

ment. In fact, the strippers and solvents used to prepare for a new finish are the real power tools of the refinishing world.

Like any other collection of tools, the list of things you need to meet every contingency can get a little out of hand. At the same time, what you need for one specific project might only require a few minutes in the hardware store and a \$10 or \$20 investment. Our basic refinisher's toolkit includes most of the things you need to complete a variety of refinishing jobs, and it is designed to serve as a guide for getting started.

### Finish Removal Tools

**Strippers**—Most refinishing jobs start with a chemical stripper. And up until a few years ago, that meant a product that might be as hazardous to you as to the finish it dissolves. These days we have another option—water-base strippers that are less caustic and more environmentally friendly. If you run across a finish that standard strippers won't touch, you've probably stumbled onto an old milk-base coating. The solution here is to use a lye-base stripper, such as Behlen's P.D.E. Strippers commonly range in price from \$6 to \$8 per quart.

**Solvents**—This chemical tool both thins finishes before application, and cleans tools and surfaces throughout the refinishing process. After stripping, you'll also use a solvent to clean away the stripper and the dissolved paint. The universal solvent for handling oil-base finishes is mineral spirits (about \$1.50 per quart). If you're using shellac, keep an alcohol shellac solvent on hand for cleanup and thinning, and lacquer thinner is appropriate for some strippers. Always check the manufacturer's recommendations for the appropriate solvent.

**Scraping and abrading tools**—After your stripper has softened the finish, it's time to scrape it away. A putty knife (\$2 to \$8) is a good tool for this, and special plastic knife-type scrapers are less likely to mar the wood. A paint scraper will also come in handy if it's kept sharp and used with care. For tight inside corners and moldings, contoured scrapers called shavehooks (about \$12 to \$24) do a good job.

For carved wood or intricate moldings, it's best to opt for a stiff plastic-bristle brush, available at hardware stores for about \$3. Another useful tool for cleaning up and smoothing is a brass-bristle brush. These small



# WOODWORKING GUIDE



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**PLASTIC-BRISTLE  
BRUSHES**



**BRASS-BRISTLE  
BRUSH**



**SANDING BLOCK**



**ABRASIVE PADS**

## WOODWORKING GUIDE

brushes, often called oven-cleaning brushes, cost about \$2.

Steel wool has long been a favorite for cleaning and smoothing. This abrasive tool comes in a range of grades and costs about \$1.50 for a package of eight pads. It is less than ideal when used with water-base products because embedded particles will rust. One solution is a synthetic variation such as 3M's Synthetic Steel Wool. These abrasive pads also come in a range of coarseness grades and can be washed out and reused (about \$3 for a package of six pads).

**Sanding tools**—Sandpaper types differ in grit material and the size of the grit, or grade. Flint paper is the cheapest, but wears quickly. A better choice is garnet paper—a red-colored paper that holds up longer (about 50 cents per sheet). Aluminum-oxide paper will stand up better than garnet paper and is the choice for power sanders. Aluminum-oxide paper is also available as wet/dry paper for wet-sanding finishes between coats. Emery paper comes in extremely fine grades for producing the smoothest possible surface.

For flat surfaces, you need a sanding block (\$2 to \$9) to hold the sandpaper. And, where there's a lot of sanding to be done, a small orbital sander (about \$35 to \$100) will speed up the work. (Be sure that each successively finer grade removes the sanding marks left by the previous sanding.) Ornately turned legs pose a sanding problem that sandpaper doesn't handle well. Here, sanding cord is often the solution. This abrasive cord can be wrapped around turnings for cleaning out tight details. Sanding cord costs about \$10.

**Cloths**—Hardware stores sell cheesecloth (about 60 cents) for wiping on stains, oils and other refinishing products, although soft, lint-free

rag also work. If you're planning to use a grain filler in the finishing process, have burlap rags on hand to wipe away the excess filler.

Another important type of rag is called a tack cloth (about 65 cents). This tool is a cloth that's impregnated with a resin that holds dust. Use a tack cloth after sanding and just before finishing to clean surfaces. In addition to an assortment of rags, have a dropcloth on hand to protect both your work surface and the floor. Ordinary polyethylene film will work, or special dropcloths are available for about \$1.50.

**Safety equipment**—Rubber gloves (about \$2 to \$4) are a must for stripping. They not only protect your hands, but they make cleaning up quicker and more agreeable. Eye protection is also a requirement—choose goggles that completely protect your eyes from the sides, bottom and top, as well as from the front. A typical plastic variety costs about \$5.

When sanding, a dust mask provides protection against the larger airborne particles. For better protection from both dust and toxic fumes, choose a respirator (about \$35 to \$50). These masks use filters for the dust and cartridges to absorb vapors. Different cartridges handle different vapors, so be sure to get the right cartridge for your job.

**Finish applicators**—The simplest tool for applying oil finishes and many stains is a soft, lint-free cloth. Varnishes are usually applied with a brush. In general, use a natural-bristle brush for the traditional oil-base varnishes and synthetic brushes for water-base finishes. Natural brushes range from about \$5 to \$35, and synthetic brushes range from about \$1.50 to \$10. Another tool that works well with polyurethane varnishes and other modern formulations is a foam

applicator. These lay down a smooth uniform coating, and their low cost (35 cents to 75 cents) makes them a good disposable option.

**Fillers and sealers**—To fill the pores and create a smooth surface on woods such as oak, mahogany and walnut, use a paste wood filler before finishing. Paste wood fillers are applied to the surface, and then wiped to leave filler in the pores. They cost about \$12 for a 1-quart can. Another prefinish component is a sanding sealer. This is applied to the wood to reduce finish absorption and provide a good base for the next coat. For controlling stain absorption and blotchiness associated with woods such as pine and fir, apply Minwax Wood Conditioner before staining.

Keep a can of wood filler on hand for filling nail holes or other small defects. Used sparingly and colored with a refinisher's felt marking pen, filled nail holes can be made nearly invisible.

### Finishing Products

**Stains**—Stains come in two basic types: pigment stains and aniline stains, often called dyes. Pigment stains are what you generally find at your local hardware store or home center (about \$4.50 per pint). These are made up of a pigment that's suspended in a solvent base. They're applied with a rag or brush, and then wiped to leave a colored film on the surface. Many professional woodworkers prefer to work with aniline dyes. These penetrate the surface of the wood and produce a more uniform coloration. In addition to these two types, stains are also available in an easy-to-apply gel form or in combination with a polyurethane finish.

**Finishes**—When it comes to the actual surface coating, you can choose an oil finish, varnish, shellac or lacquer. Oil finishes (\$7 to \$12 per quart) are penetrating finishes that generally produce a thin, low-luster protective coating. Along with penetrating oil products (actually thin varnishes), one popular option is tung oil.

Varnishes include traditional oil-base formulas, polyurethane and new water-base variations. Where durability is a concern, opt for polyurethane (about \$9 per quart). However, if you intend to rub out a quality furniture finish to a high, smooth gloss, choose a traditional rubbing varnish. Paste wax (about \$6) is useful for adding the final glow. It can be used on bare wood, but permits water stains to form on the surface. **PM**



# HOW TO FIND YOUR WAY THROUGH THE WOODS.

In woodworking, every project is an adventure. You explore the wood, studying its grain, searching for something hidden within.

Your goal is to emerge, weeks later, with a proud souvenir. A planter. A Shaker chair. Or perhaps a rustic chest of drawers.

Ironically, the ease of any woodland journey depends largely on a decision you make *before* embarking: your choice of tools.

To this end, a move in the right direction is Skil Woodshop Tools.™

Skil Woodshop Tools are a full line of woodworking tools designed to make any project a pleasure.



10" benchtop tablesaw. Its powerful 13.0 amp motor and exclusive Accu-Lign™ self-aligning, quick-set rip fence makes short work of sizing raw stock.

Whatever your plans call for next, the HD 1875 plunge router is sure to be part of them. Its 2¼ hp motor can carve signs, cut joints and trim decorative edges with power to spare.

For accurate, repetitive drilling, the 3380 benchtop drill press is precisely what you need. The depth measurement and sturdy, adjustable table guarantee consistency from first hole to last.

When it's time for

Every step of the way.

Enter the woods with a confident first cut on the 3400

assembly, try the innovative HD 1605 plate joiner.

Simply cut matching slots, pop in a wooden biscuit, glue

and you have yourself a quick, durable joint.



Once it's all together, give your project a once over with the HD 7576

palm grip sander. The 7576 performs an exacting 1/16" orbit 13,000 times a minute for a fast finish.

Next time you explore the woods, bring along the perfect traveling companions—Skil Woodshop Tools. You'll find those shown here and other Woodshop tools in

stores everywhere. Just look for this label.

It's a sure sign you're on the road to woodworking success.



# SKIL





**CASE 1 STUDY**

# Refinishing A Painted Cupboard

A modern finish gives new life to an old piece.

TEXT AND PHOTOS BY ROSARIO CAPOTOSTO,  
Contributing Editor

**S**tyles change, needs change—people change. That's the answer. The question? Well, it's the one most folks ask when they stumble on a nicely proportioned and detailed cupboard and wonder: "Why ever did they cover that beautiful piece with paint?"

We found our cupboard in a local antique shop. And, like everything else on display, this cupboard had charm. From the beaded back panels to the stately molding details, this example of country furniture had all the elements for a challenging refinishing project.

The first job was to remove the old paint. In doing so, we discovered that the work went beyond a simple strip and finish. A few corners were badly worn, and although we might have left them alone, we opted for careful repair. Also, several discolored areas demanded careful touchup to create a uniform base for our finish.

One of the fascinations with stripping painted furniture is discovering the wood that the builder used. Although most pieces of this type are pine, our cupboard was made of fir. After stripping, we applied a stain to impart a mellow antique look, and completed the job with a satin wipe-on finish.



**BEFORE**

Although this old country cupboard boasts sensitive detailing, the green paint needs to go and repairs need to be made.



**AFTER**

After stripping, repairing and refinishing, our cupboard features a warm amber glow and a durable satin clear finish.

## WOODWORKING GUIDE

### Preparation

To prepare for stripping a cabinet, first remove all hardware (Photo 1). Although you don't have to take the entire piece apart, it's best to remove the components that are easy to take off before stripping.

If you already know the type of finish on the piece, choose a stripper

that's appropriate (see "Strippers And Finishes," page 73). If you're not sure, make spot tests with several stripper types (Photo 2). If none of the usual strippers work, the finish is probably a milk-base paint, in which case you need a lye stripper.

After making several spot tests, we opted for 3M's Safest Stripper—

a water-cleanup formula that's non-flammable and doesn't give off harmful fumes. These considerations are important when you're working indoors. Before applying the stripper, lightly sand the surface with 150-grit paper, scuffing the surface to help the stripper penetrate the finish (Photo 3).



**1** Begin the job by removing all hardware, doors and drawers. Check the condition of the hardware screw pilot holes.



**2** If you're unsure of the old finish, spot test with several strippers to determine the best. We used a water-base stripper.



**3** Lightly sand the old finish with 150-grit paper before stripping. The scuffed surface makes the stripper more effective.

### Stripping

After the hardware, doors and drawers are removed and the old finish is scuff sanded, pour the stripper into a can and use a large, soft-bristle brush to apply a thick coating (Photo 4).

Each stripper formula will have specific instructions for application, so be sure to check the instructions on the container. Also, be sure to follow all safety precautions. When using the stripper, avoid overbrushing the thick semi-paste coating. This is important because the stripper skins over to contain the solvents in the layer that dissolve the paint. Back-and-forth brushing breaks down this crust, allowing the solvents to escape.

Next, allow the stripper to dissolve the finish. Don't rush the job, but check occasionally to see if the paint is sufficiently softened for removal. When the old finish is ready to come off, use a plastic scraper to remove it (Photo 5). Where the plastic scraper can't reach, use abrasive pads moistened with stripper to remove the remaining traces of paint. If the paint coating was very thick and some paint remains, you may have to repeat the stripping process.

When using a water-base stripper, avoid using steel wool, as small particles can remain on the surface and will rust. A better choice is a synthetic abrasive pad made with plastic fibers. Use the pads in conjunction with a shavehook or profiled scraper to remove the softened paint in the moldings and crevices (Photo 6).

The beaded tongue-and-groove paneling in the back of our cupboard was particularly difficult to strip completely. Use a combination of abrasive pads and small profiled scrapers to get the job done (Photo 7).

After all the surfaces have been

scraped, rinse away the stripper residue with clean pads and fresh water. The combination of water-base stripper and water cleanup will raise the grain of the wood. After the wood is thoroughly dry, lightly sand all surfaces.



**4** Apply the stripper with a soft brush. Avoid overbrushing water-base stripper. Let stand until paint is soft.



**5** Use a scraper to remove the softened paint. Although gloves aren't required for a water-base stripper, they're a good idea.



**6** Where a large flat scraper can't reach, use a synthetic abrasive pad. Avoid steel wool with water-base products.



**7** Clean small beading on tongue-and-groove back panels with stripper-dampened abrasive pad and small scrapers.

## WOODWORKING GUIDE

### Repair

Once the paint has been removed, you may find numerous dents, gouges, cracks, scratches and wear areas that were concealed by the paint. While you might choose to leave these imperfections to impart an antique or country character to the piece, most can be easily repaired before refinishing.

Our cabinet had torn-out areas at the bottoms of the side panels and some deep wear areas. While replacing missing wood with a patch cut from new stock rarely makes a good match, you can find closely matched stock by cutting small portions from

a hidden component of the piece. We cut ample material for our repairs from the top surface of the top panel (Photo 8). If you can't find an area from which to cut repair stock, select new wood carefully for both color and grain pattern.

To repair a worn area, first make straight cuts around the section with a sharp utility knife (Photo 9). Then, use these cuts as guides and remove the waste with a chisel (Photo 10). Once the worn area has been cut away and the surfaces of the notch are smooth and flat, cut a patch so the grain direction matches the surrounding wood as closely as possible.

Cut the patch slightly oversize to allow for flush trimming and sanding after it's secured.

Repair torn sections in the same way. After trimming the edges of the area and leveling the bottom to make a firm base for the patch, cut an appropriate patch and glue it in place. Use masking tape to hold it until the glue dries (Photo 11).

Dents and shallow scratches can also be repaired. For dents, press a hot clothes iron over a damp cloth placed on the dent. The steam produced will swell the compressed wood of the dent and raise the wood to the original level. For shallow scratches, lightly sand with fine paper. Avoid excessive sanding in one small area—it's better to sand the surrounding area as well to keep the surface as flat as possible.

Repair gouges, cracks and nail holes with wood filler. Apply the wood filler with a small putty knife, and sand it flush when it's completely dry (Photo 12). Although most fillers are available in a range of colors, you may find it hard to exactly match the wood you're filling. We had better luck with Behlen's Scratch Remover Markers, applied over the filled areas (Photo 13). These markers are available in 12 wood colors.

To remove dark stains caused by a reaction between the iron in the nails and the wood, spot bleach the areas with oxalic acid. Oxalic acid is available in powder form at paint and hardware stores. Make a solution by dissolving 1½ ounces of the powder in 1 pint of water. Always add the acid to the water, never the other way around.

Then apply the bleach solution to the stain with a small brush (Photo 14). If the stain persists, try a more concentrated solution. When the wood dries, rinse away the residue with water.



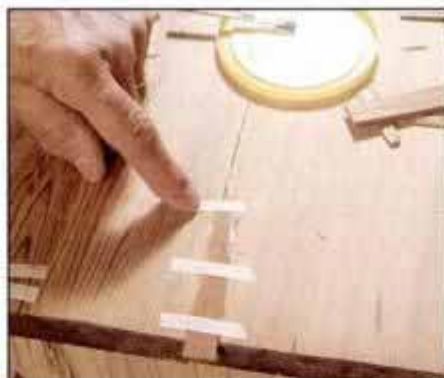
**8** Fixing splintered and worn wood means finding matching stock. Use small pieces cut from a hidden area like the cabinet top.



**9** To repair this worn area on the case side, first use a sharp utility knife to define a uniform area to be cut away.



**10** Use a sharp chisel to remove the worn section. Pare the sides of the notch smooth and flat so the patch seats well.



**11** Cut each patch slightly oversize to fit the trimmed area. Glue and hold in place with masking tape until dry. Then trim flush.



**12** Fill nail holes and small cracks with wood filler. Apply the filler with a small putty knife and sand it flush when dry.



**13** If wood filler color doesn't correspond to wood, use a wood-colored marker to tone filled areas so they match.



**14** Where iron in nails have discolored wood, bleach the area with oxalic acid. Wash off residue when bleach has dried.

## WOODWORKING GUIDE

### Sanding

After the repairs are done, sand with 120-grit paper and move to 220-grit paper in preparation for finishing. To smooth broad areas quickly, use an orbital sander (Photo 15). When you're done power sanding, lightly sand by hand with the grain to remove any swirl marks left by the sander. Moldings, narrow edges and other details must be hand sanded. Use a sanding block on small flat surfaces to avoid rounding over the corners. Fold over sandpaper to reach inside beaded details and the inside corners of moldings (Photo 16).



**15** Use an orbital sander to speed smoothing of broad areas. Finish by hand sanding with the grain to remove any swirl marks.



**16** Hand sand tight crevices with folded sandpaper. Use a sanding block on narrow flat surfaces to avoid rounding corners.

### Hardware

We intended to replace the porcelain doorknobs with catches that match our original black iron bin pulls. Because suitable catches were only available in brass, we painted ours with black spray paint for metal (Photo 17). We then gave the original bin pulls a fresh coat of paint, as well. Before finishing, it's a good idea to check that either new or original hardware can be secured properly. To fix worn hinge screwholes, use a doweling jig to bore oversize holes. Then glue dowels in place, and bore new screw pilot holes (Photo 18).



**17** To match brass hardware with the original black iron bin pulls, spray with black paint formulated for metal.



**18** Use dowels to plug worn screw pilot holes. A doweling jig will yield the most accurate holes for dowels.

### Finishing

We decided to finish the piece in keeping with our idea of how our country cupboard might look today if it had never been painted—deep amber in color with a satin texture. The amber color simulates the look of wood that has darkened over the years, and the medium-gloss finish reflects just enough light to accent the moldings and details.

To do the job, we chose an easy-to-apply gel stain and a gel clearcoat. However, staining softwoods often results in a blotchy appearance due to variations in the absorbency of dif-

ferent areas of the wood surface. To solve the problem, first apply a coat of wood conditioner (we used Minwax's product) to ensure even staining. Apply the conditioner with a brush and wipe it off with a cloth after about 10 minutes (Photo 19). Then, let the surface dry completely.

To tone the wood to our desired color, we used a gel stain. This is a mixture of pigment and dye stains that blends easily with each stroke, leaving no lap marks. Simply wipe on the stain with a soft, lint-free cloth, and allow it to dry (Photo 20). If the application looks a little light, re-

apply the stain after about 4 hours to intensify the color. If it looks too dark, wipe the wood with a cloth dampened in mineral spirits.

After the stain is dry, apply two coats of gel clear finish. Use a cloth for the main application (Photo 21). However, in tight crevices such as the beaded tongue-and-groove back panels, switch to a brush for adequate coverage, and wipe away the excess with a cloth. In addition to being easy to apply, an advantage of a wipe-on gel finish is that dust, brush marks, runs and sags are never a problem. **PM**



**19** Apply wood conditioner before staining to prevent blotchy, uneven coloration. Wipe off excess after 10 minutes.



**20** Use a cloth to apply gel stain. If the application is too light, apply a second coat. If too dark, wipe with mineral spirits.



**21** Apply two coats of gel clear finish with a cloth. Wipe-on finishes eliminate dust problems and visible brush strokes.

# The Power of Partnership

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FIND OUT HOW YOU CAN LOWER ENERGY COSTS, INCREASE COMFORT, AND HELP THE ENVIRONMENT.

PLUS, 8 QUICK TIPS TO MAKE *YOUR* HOME MORE ENERGY EFFICIENT.



More Comfort for Less Cost



Comfort with Efficiency



Making It Easier to Buy a House

## Electricity

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TAKING YOU INTO THE FUTURE

BROUGHT TO YOU  
BY AMERICA'S  
ELECTRIC UTILITIES

# You Can Do Something For The Environment Every Time You Turn On The Right Light.

At first glance, that statement seems to go against everything you've been taught. The less you use, the



you're saving money.

The potential is enormous. Technologies are improving all the time, so we'll continue

better off we all are. But advances in electric technologies are changing all that.

and emissions that are being released into the air.

to find new ways to conserve electricity without sacrificing com-

Today, we're actually able to get more out of each



Lighting is a good example of how far electricity's efficiency has already come. Today's compact fluorescent lights are 75% more efficient and can last up to ten times longer than incandescents. This new technology means we're conserving fuel, reducing pollution and

fort or convenience. To find out more, give the residential representative at your electric utility a call. It could do a lot for the address you call home. The street, the state and the planet.

*Replacing an incandescent with one of today's compact fluorescent lights reduces energy consumption by 75%.*

*Today's compact fluorescent lights can last up to ten times longer than incandescents.*

kilowatt hour. Use less energy and get more power in return, while reducing costs

 **ELECTRICITY**  
*Taking you into the future.*

More Comfort for Less Cost

The electric utility can become a financial partner to customers who replace inefficient systems with high-efficiency heat pumps.

**F**ew of us think much about electricity, other than to be concerned about our bill and wonder what we can do to cut it down. That's precisely why America's Electric Utilities have provided the following information — to help you save on your energy costs without sacrificing one degree of comfort, and to help the environment, too.

Yes, the environment. We're all realizing just how important it is to our daily lives. And though how we use electricity may not come to mind as readily as concerns about solid waste, or air and water pollution, the wise use of electricity is one of the keys to keeping the environment clean.

It may surprise you to know that your electric utility wants you to spend less, not more, for electricity. They have created programs that lower your monthly bill while lessening the environmental impact of the electricity we use. In fact, your electric utility is really your partner helping you control costs, preserve the environment, and increase the comfort of everyday living.

**The partnership that pays**

This partnership starts in your home. To make it even more comfortable and to run more efficiently at less cost, your electric utility can show you practical ways to use electricity wisely and save money. The programs they offer come in all shapes and sizes. Summertime programs — with names like Kilowatchers, Summer Savers, or Powerplus — reward customers who voluntarily let their electric utility cycle their central air-conditioners on and off, by remote control,



"EVER GET UP ON A COLD MORNING, TURN UP THE HEAT, AND THEN WAIT FOR THE HOUSE TO GET WARM? I DON'T HAVE TO DO THAT ANYMORE."  
Annette Kazes

Maybe you don't think about air-conditioning when you're trying to save money on your heating bill. But heat pumps also serve as air-conditioners, and Annette Kazes, of Seattle, Wash., thought a lot about keeping cool.

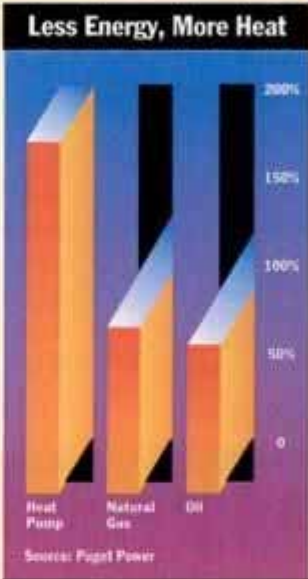
Annette lives in a mobile home with a flat roof that doesn't provide much insulation against the sun's heat. Nor does it keep heat in during the winter. That used to mean higher bills.

But Annette's home qualified for Puget Power's Comfort Plus program, which helps customers convert to more-efficient heat pumps by paying part of the installation costs. Ordinarily, says Puget Power's Mike Spradlin, a customer would have to upgrade both insulation and windows before qualifying for

the installation grant. But with mobile homes, a heat pump is the only feasible energy improvement.

The dollar amount of the grant is based on the projected saving in electrical usage that is the natural by-product of a heat pump. Once heat pumps are installed, customers pay normal electric rates. Even so, Annette's bill was reduced by \$20 per month based on Puget Power's rates.

And what about those cold winter mornings? Annette doesn't think about that now, because every heat pump in the Comfort Plus program comes with a thermostat that automatically turns down the heat at night and turns it up again before dawn. Annette's house is comfortable, but she doesn't waste energy to make it that way.



Because heat pumps don't create heat, but rather extract it from either the air or ground, they are more efficient than systems that burn fuel to create heat. Compared to the efficient fossil-fuel furnaces, heat pumps are 100% more efficient.

JERRY DAVIS

Comfort with Efficiency

**Forming a partnership to save electricity, a utility company and its customers postpone building a new generating plant until the 21st century.**

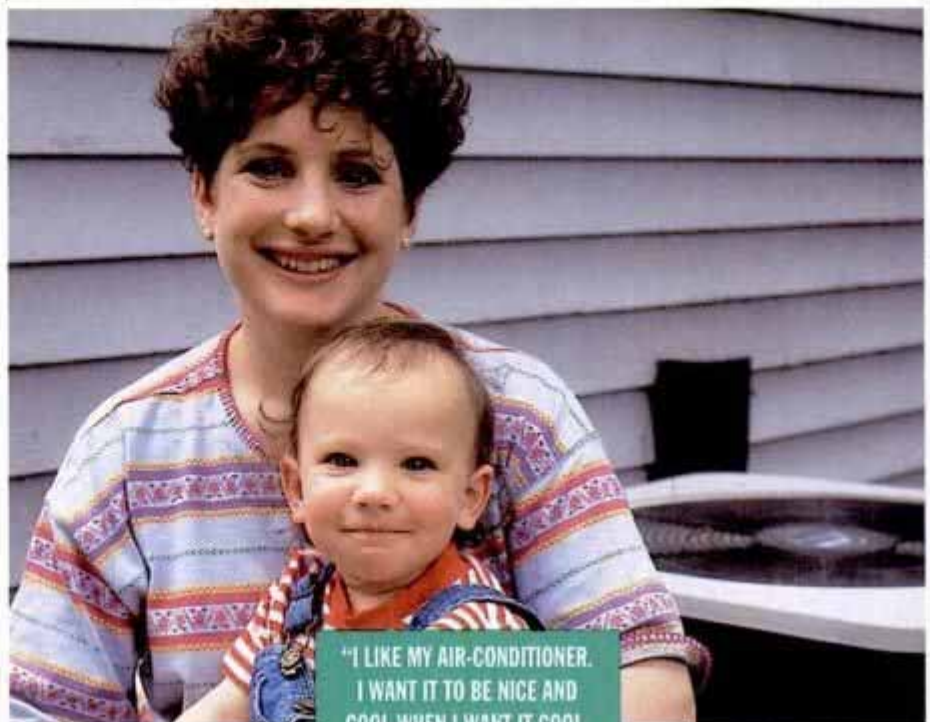
for a few minutes an hour on the hottest days. The initial reward is financial, as much as \$9 credited to the bill every summer month. But the reward down the road is bigger: The reduced demand for electric power resulting from these programs can mean deferring the need for additional generating plants. In effect, customers who participate in these programs are actually partners with their electric utility in helping manage the resources that generate electricity.

**Save money with better windows and insulation**

A poorly insulated, drafty house is not only expensive to heat and cool, it's uncomfortable to live in. To solve this problem, many electric utilities offer programs to help you add insulation or replace inefficient windows with energy-saving thermal panes. They'll evaluate your heating and cooling systems to make sure they're working their best. Incentives vary from financial assistance to a cash rebate when the job is done. Sometimes the reward includes lower electric rates. But these improvements almost always mean lower electric bills and more comfort.

**Watch for a new super-efficient refrigerator**

Electric utilities are also active partners with equipment and appliance makers in a quest for products that are more energy efficient. A dramatic result of this partnership is the Super-Efficient Refrigerator Program (SERP). Started in 1989 by 24 utility companies, SERP challenged American appliance makers to develop a refrigerator that not only exceeded the already high efficiency standards

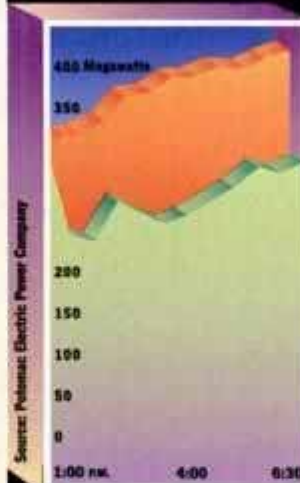


"I LIKE MY AIR-CONDITIONER. I WANT IT TO BE NICE AND COOL WHEN I WANT IT COOL. I DON'T KNOW IF MINE WAS CYCLED ON AND OFF OR NOT, BUT I WAS TOTALLY COMFORTABLE."  
Jane DeSantis

At 1 P.M. on a July afternoon it's 91 degrees on the way to a high of 100. Air-conditioners in Washington, D.C., and the Maryland suburbs are working overtime. So is Potomac Electric Power Company (PEPCO). Hot days like this push the demand for electricity close to maximum capacity. But PEPCO has another resource, the Kilowatchers Club, and at 1:30, the company sends a radio signal to 104,000 modified central air-conditioners and heat pumps belonging to the club members in its service area.

This signal triggers a pre-programmed switch that cycles the units — 17 minutes on, 13 minutes off — until 5 P.M., reducing electric consumption by about the generating capacity of a new plant.

**Kilowatchers at Work**



The red line shows what the demand for electricity would have been had there been no way to temporarily reduce usage. The green line shows what actually happened when the radio-controlled air-conditioners began to cycle on and off. The difference between the two lines is the amount of electricity generated by an average power plant.

The cost to customers who volunteer for the club? Nothing. In fact, PEPCO credits each one's electric bill with \$7-\$9 every month from June through October.

PEPCO's Jack Stevenson says that while saving was the big motivator when the program started in 1987, "today, customers responding to our surveys say they like the program because it helps defer power-plant building, which helps the environment."

Technology played a part, too. The idea that the same technology used to communicate with submarines could put money into your pocket was intriguing.

Do people notice any difference in comfort? Again, no. The on-off cycles affect only the compressor. The fan continues to move cool air through the house.

JOHN DRIEMEN





# THE INSIDE STORY.

**WILLIS CARRIER WAS THE FIRST INSIDE GUY.**

Following a hunch he had about the relationship between humidity and coolness, Willis Carrier had a groundbreaking idea. In 1902, he put his idea to practical use. He invented air conditioning. Suddenly, being inside was comfortable year-round.



**SINCE 1902, WE'VE BEEN MAKING IT BETTER INSIDE.**

What began with Willis Carrier's brainstorm and hard work has been

carried on by Carrier people all across the country. Residential air conditioning and heating has become a comfortable way of life, and Carrier dealers have become the "Inside Guys" people count on. Innovations such as energy saving heating and

cooling equipment, humidifiers, air cleaners and electronic comfort controls have reinforced Carrier's name as #1 in comfort from coast to coast.

**THE BRAND INSIDE AMERICA.**

Carrier is the brand that homeowners know best. Since 1902, American consumers have relied on Carrier products for efficiency and comfort. And that confidence is why more Americans choose Carrier heating and cooling products.



**We're The Inside Guys.**

that went into effect in 1993, but also eliminated chlorofluorocarbons (CFCs). In early 1994, Whirlpool Corporation, the winner of the challenge, will introduce a 22-cubic-foot refrigerator that is projected to be 100% more efficient than similarly sized models that were for sale in 1990.

**CFC-free air-conditioning is right around the corner**

Work is being done by the Carrier Corporation and other companies to incorporate CFC-free technologies into whole-house air-conditioning systems, making them as environmentally friendly and super-efficient as the SERP refrigerator. A new development for cooling products is the programmable motor from General Electric. It allows compressors and fans to run more efficiently at lower speeds, thus reducing electrical consumption without any impact on comfort.

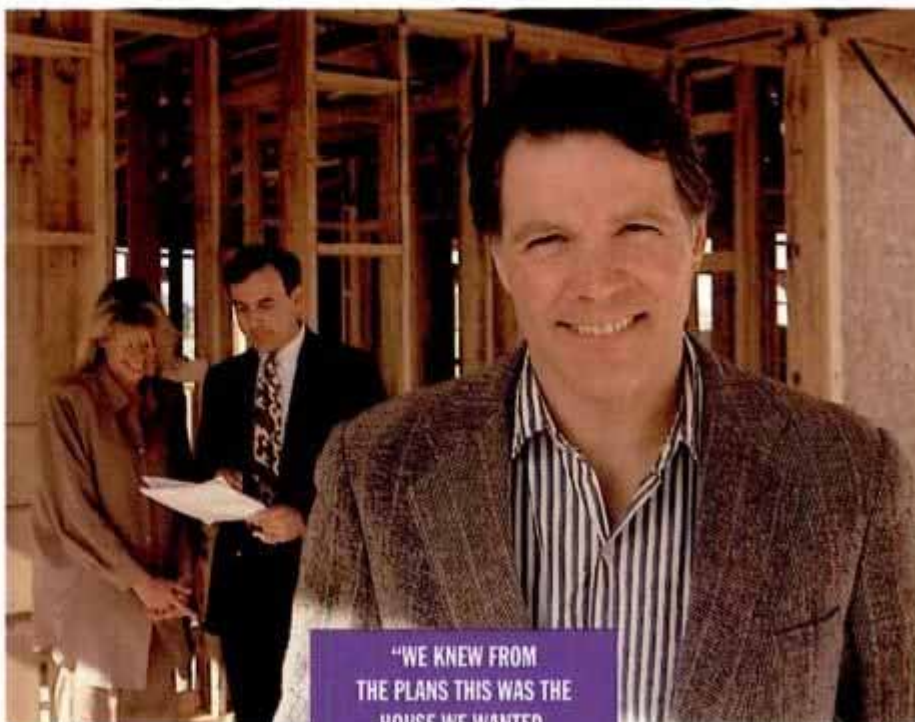
**Buy a light bulb that lasts 15 years**

In lighting, the E-Lamp developed jointly by American Electric Power, in Columbus, Oh., and Intersource Technologies, of Sunnyvale, Calif., is both more efficient and lasts longer — 15 years — than today's light bulbs. Along with compact fluorescent tubes, they're changing the way we light our homes.

This is just a sampling of what your electric utility has to offer. As your partner, they are ready to help you cut energy costs, improve the comfort of your house, and conserve the environment. Whether they are an active or a silent partner depends on you. Give them a call today.

**Making It Easier to Buy a House**

**A three-way partnership among electric utilities, builders, and bankers not only helps new home buyers get more for their money, it also makes that house more energy efficient.**



NANCY HILL

**"WE KNEW FROM THE PLANS THIS WAS THE HOUSE WE WANTED. BUT WE DIDN'T EARN ENOUGH TO PAY FOR IT WITH A STANDARD MORTGAGE."**  
Bob Johnson

**Qualifying for a mortgage is something most new home buyers think about a lot. But in Phoenix, Ariz., a few builders are doing something to make it easier to get that mortgage. They're building better homes.**

**In this case, better means more energy efficient. These houses incorporate a list of energy-saving features specified by Arizona Public Service and other electric utilities in the area: Framing is done with two-by-sixes instead of two-by-fours so more insulation can go into the walls. The windows are double-paned and have a reflective coating to keep out 60% of the sun's heat. The houses are also equipped with high-efficiency heat pumps.**

**Most important, a house with these features helps the buyer qualify for an energy-efficient mortgage. "If buyers can show that they will be paying less for electricity because of these energy-saving features, we can take the saved money and add it to the value of the mortgage," says Butch Brown, of U.S. Bancorp, in Phoenix. "The credits for the saved energy allow us to up the debt-to-income ratio from 29 to 31 percent. For a family with a gross monthly household income of \$3,000, this means they can increase their house payment by \$60. And that means they can borrow more money — at current rates, about \$8,200 more."**

**Buy More House**

|                                | Conventional FHA Mortgage | Energy Efficient Mortgage |
|--------------------------------|---------------------------|---------------------------|
| Monthly Income                 | \$3,000                   | \$3,000                   |
| Interest Rate                  | 9%                        | 9%                        |
| Maximum Monthly Payment        | \$870                     | \$930                     |
| Applicable % of Monthly Income | 29%                       | 31%                       |
| Loan Amount                    | \$97,000                  | \$105,200                 |

Source: Arizona Public Service

Energy-efficient mortgages offered by some banks allow you to count the money you will save on your electric bill toward qualification for a larger mortgage on a new energy-efficient house. With this mortgage you can apply 2% more of your income toward your house payment and your total debt-to-income ratio can go from 29% to 31%. Using the example above, that means that you can qualify for \$8,200 additional financing.

# ANY MICROWAVE CAN COOK. THIS ONE DOES DISHES.

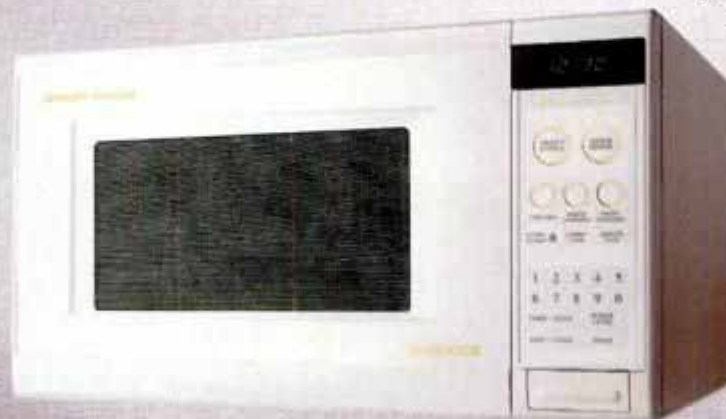


Leave it to Sharp to create microwave ovens so intelligent, they go beyond simple cooking and reheating. Smart & Easy™ microwaves are dedicated to the proposition that all dishes are not created equal.

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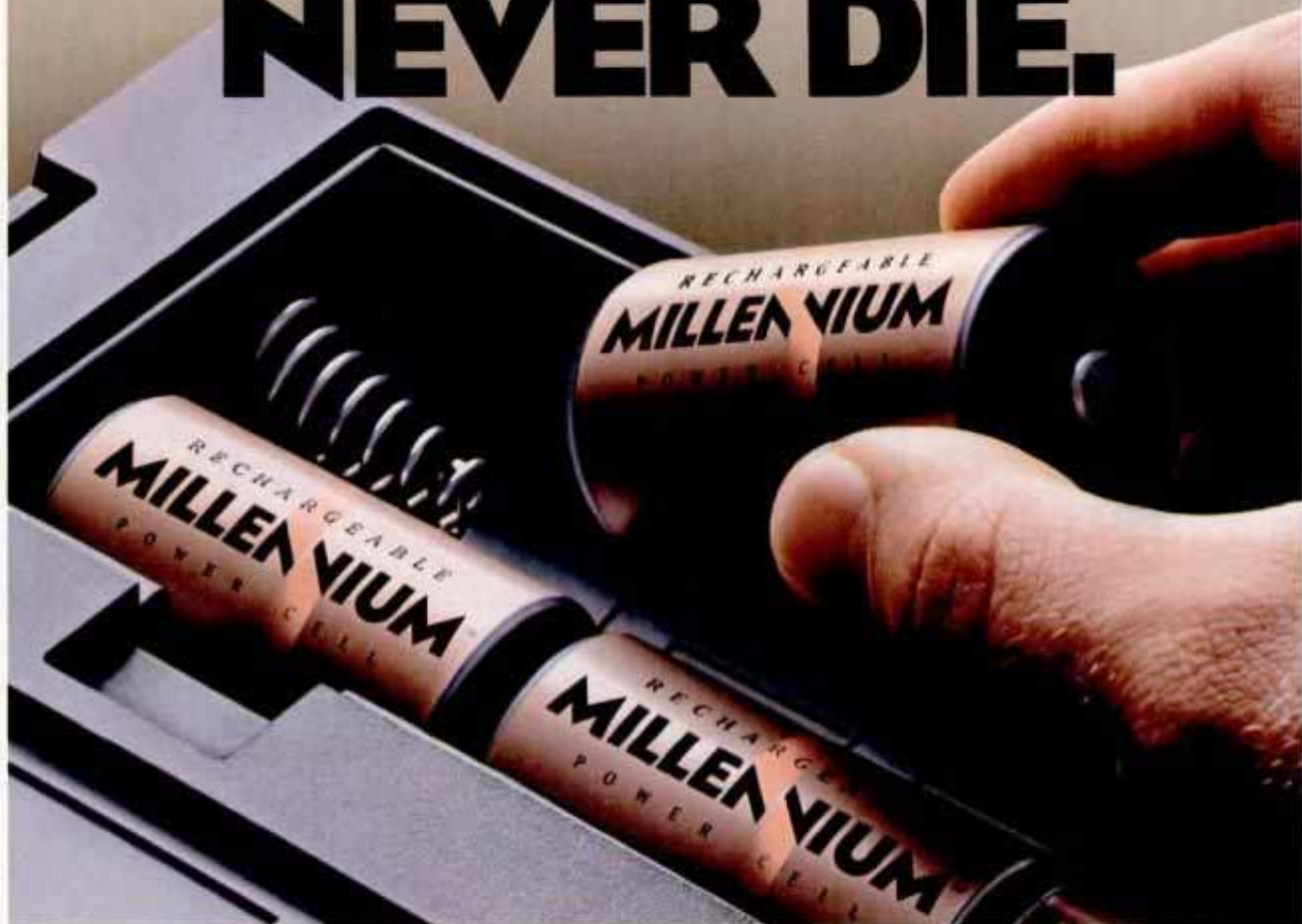


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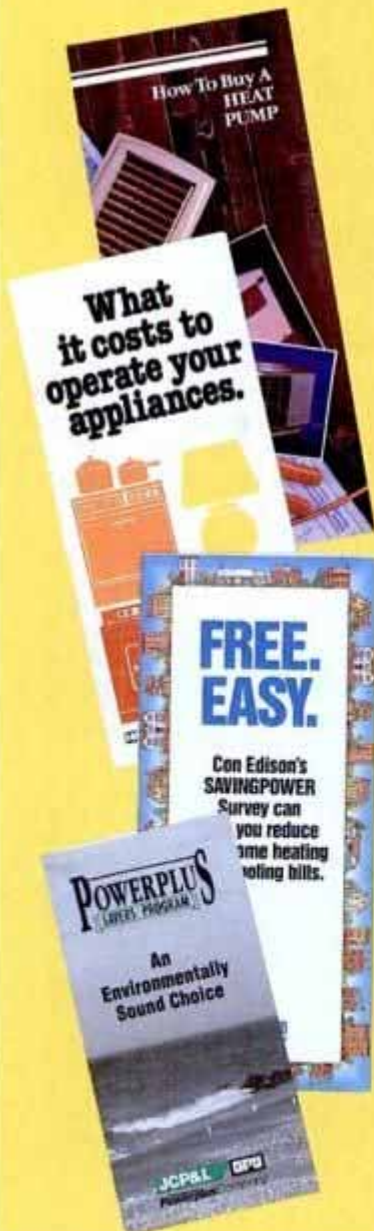
\* See official warranty for details of terms and conditions. For the Millennium retailer nearest you, call 1-800-CAN-POWER. © 1993 Millennium Power System.

## Bringing the Savings Home

Resources and ideas you can use now!

# H

ow does your house stack up? Are you paying more than you need to for energy? Do you want better temperature control in both summer and winter? And what about the environment — do you want to see your efforts really count for something? It's easy to bring cost savings, comfort, and energy efficiency to your home with just a little education.



First, test your energy IQ with this short quiz. Mark each statement true or false. Then turn the page for the correct answers and take a short tour through a typical house with some easy built-in energy-saving ideas.

T F

- ■ 1. Adding weather stripping to windows and caulking cracks in the wall are all you have to do to keep heat from escaping.
- ■ 2. A big deciduous tree on the south side of your house can reduce what you pay for heat in the winter and air-conditioning in the summer.
- ■ 3. It's now possible to buy fluorescent tubes that last for 10,000 hours of use and cost 57% less to operate than a regular incandescent light bulb.
- ■ 4. In the winter, the ground in your backyard is either too cold (or too frozen!) to be a heat source for your house.
- ■ 5. The only way to get fresh air into the house is to open a window.
- ■ 6. Putting a "jacket" on your water heater holds in the heat, saving energy and money.
- ■ 7. Thermostats allow only a single temperature setting at a time. Once you set it there, that's where the temperature stays.
- ■ 8. When it comes to insulation, thickness is the only thing that counts. The more you have, the warmer you'll be in the winter and the cooler you'll be in the summer.



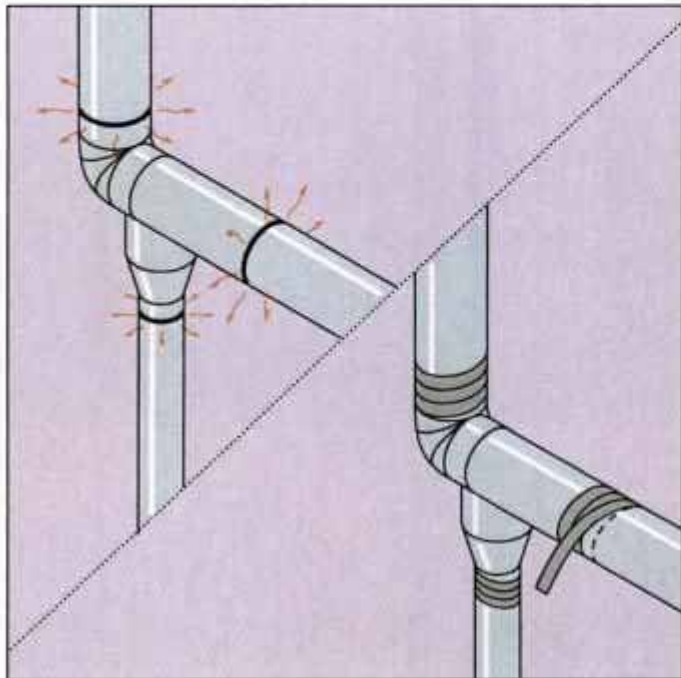
**Good Cents, Smart Saver, Power Miser, Powerplus.** These are some of the proven programs that save energy and money. To find out what you can do in your home, call the customer service representative at your local electric utility...and start partnering now!

### Question 1

**False**

Sealing cracks around doors and windows keeps heat inside the rooms. But a lot of heat is lost through leaky duct work before it ever gets to where it's needed.

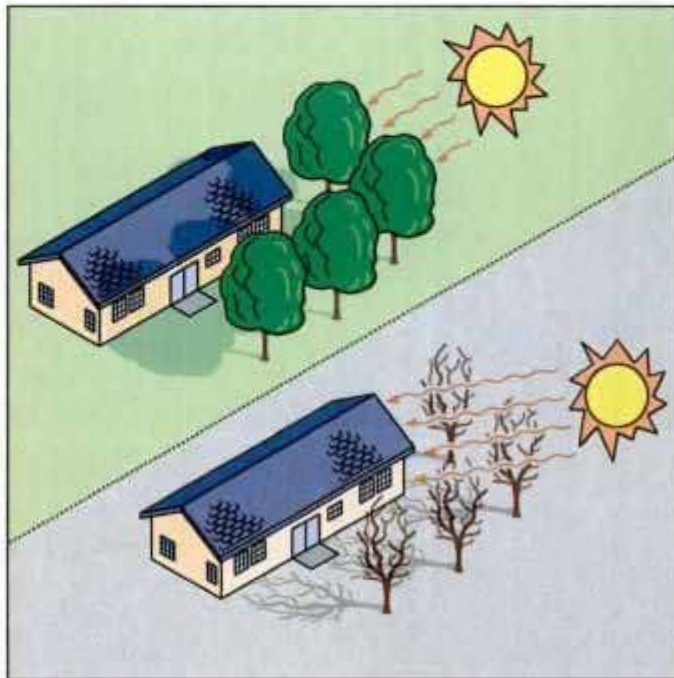
To save that heat, insulate the ducts and seal the joints along the duct work.



### Question 2

**True**

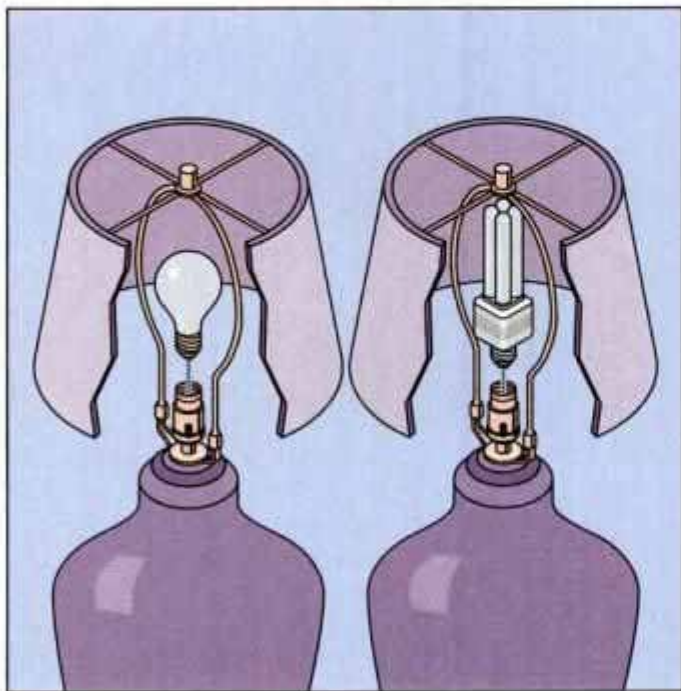
In summer, a leafy tree shades your house from the sun's heat. In winter, when the leaves are gone and the sun is lower on the horizon, the sun's rays can get through the trees and provide a little extra "solar heat."



### Question 3

**True**

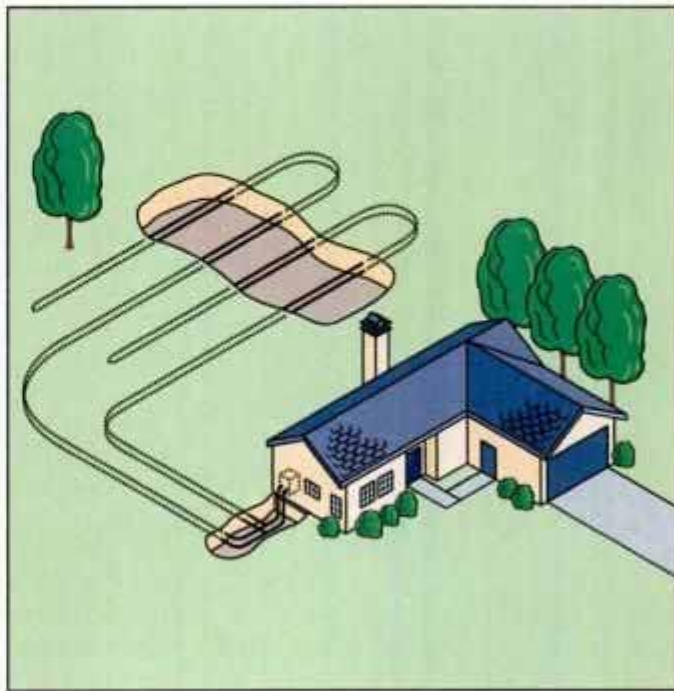
A 13-watt compact fluorescent tube puts out the same amount of light as a 60-watt bulb, but lasts 12 times longer. If you're paying 8 cents per kilowatt-hour for power, you save \$46 over the tube's 10,000-hour life.



### Question 4

**False**

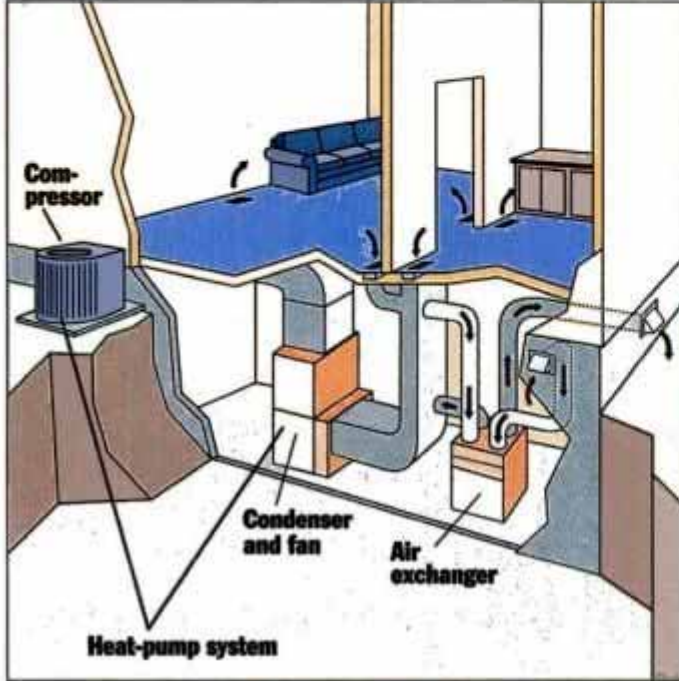
The earth below the frost line — about 4 feet deep — has a constant temperature of 55 degrees, more than enough to provide a heat source for a geothermal heat pump. Pipes buried in the ground extract the heat and bring it to your house.



### Question 5

**False**

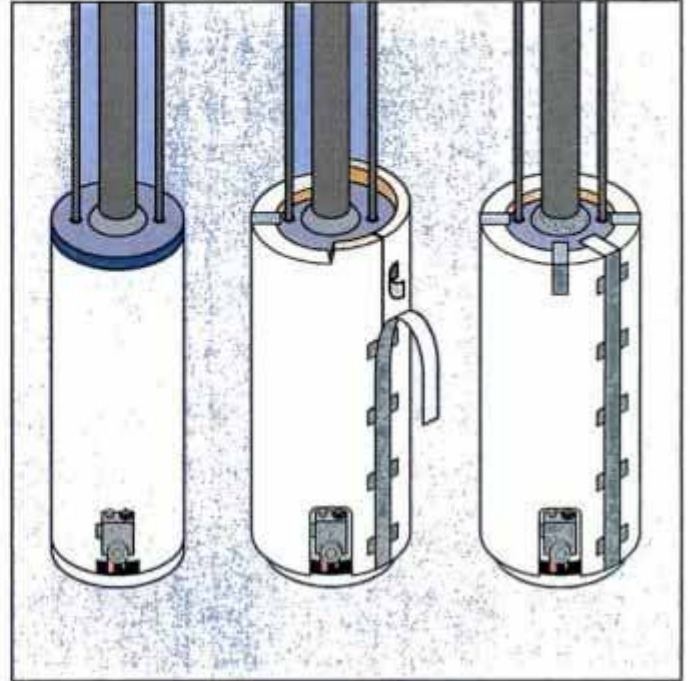
In a well-insulated and sealed house, fresh air is important. From exhaust fans to air-exchangers, many systems can provide fresh air indoors. Ask your utility representative what's right for your home.



### Question 6

**True**

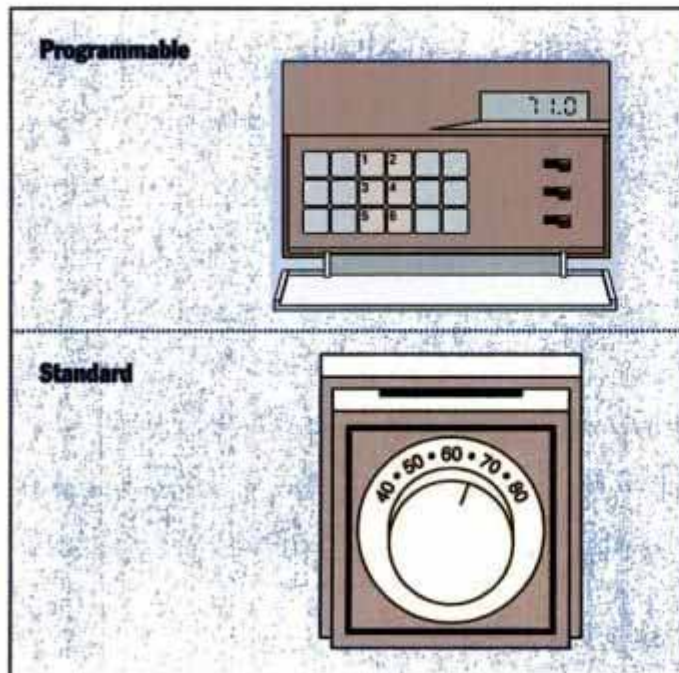
Installing an insulation jacket around your water heater keeps the water inside hotter longer, so it reheats less often. This helps you save money on your electric bill and gives your family greater comfort.



### Question 7

**False**

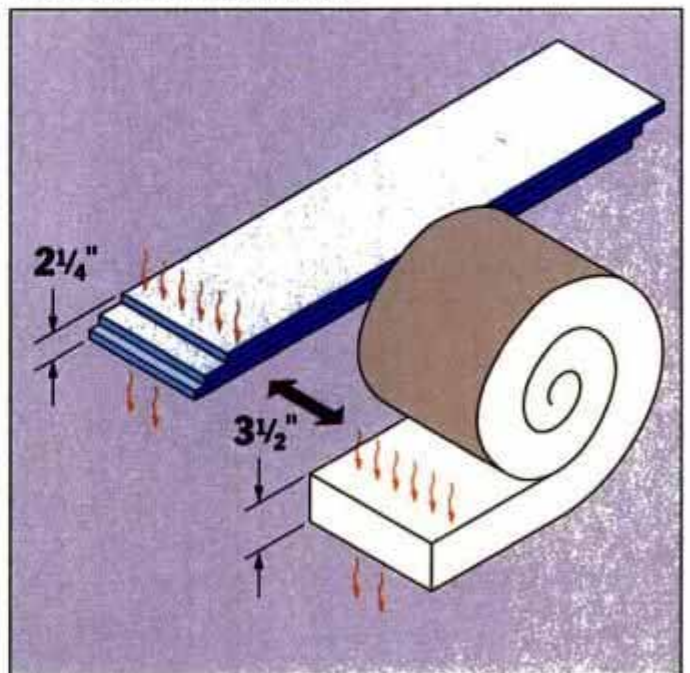
Programmable thermostats let you change temperature settings at different times of the day and night, automatically. And you can program those settings up to seven days in advance.



### Question 8

**True**

Generally, with insulation, the thicker it is the better. But some materials insulate better than others. For example, 2 1/4 inches of rigid polystyrene provide the same amount of insulation as 3 1/2 inches of fiberglass batt. Ask your electric utility representative about the best ways to insulate the different areas of your house.



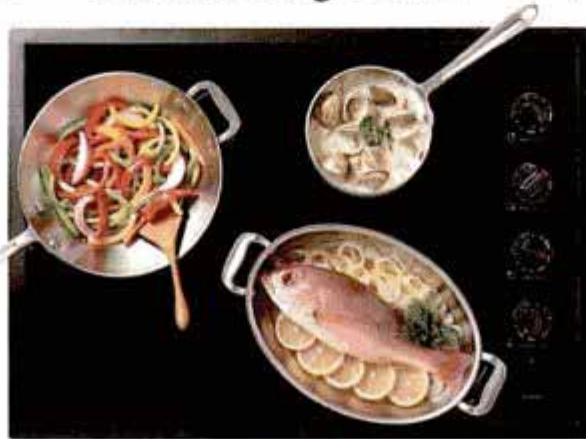
# Chances Are, You're Already Powering Your Home For Less And Don't Even Know It.

Every time you cook a meal in a microwave oven, heat something on an induction cooktop or heat and cool your home with one of today's high efficiency heat pumps, you're using energy more wisely.

You're using less energy and getting more in return.

That's due largely to the advances in electric technology. Advances that are allowing you to get more out of each kilowatt hour. Since these advances mean less fuel is being burned,

it also means less pollutants are being released



*Induction cooktops eliminate waste by heating the food in the cookware, not the air around it.*

into the air. That not only saves money, it also helps the earth.

New high efficiency heat pumps are a good example of how electric technology has improved. Today's models heat and cool three to four times more efficiently than



*High efficiency heat pumps heat and cool three to four times more efficiently than fossil fuels.*

fossil fuels. They not

only operate more effectively, they also conserve fuel.

A smart move for you, a good one for the environment. And considering all the advances in technology, one that will only con-

tinue to improve.

To find out more, give the residential representative at your electric utility a call. After all, making better use of electricity not only saves you money, it also helps the environment.



*Automated controls allow appliances to run on cost saving cycles.*

 **ELECTRICITY**  
Taking you into the future.



**WOODWORKING  
GUIDE**

# Strippers And Finishes

New finishing products are safer than ever—  
but the old ones are still around.

BY MERLE HENKENIUS  
PM Photo by Rosario Capotosto

**I**f you've strolled down the paints and finishes aisle of your local hardware store lately, you've no doubt noticed a bigger selection, with a growing number of products sporting green and yellow labels. If these new products seem to be screaming, "Federal regulation!," you're right, but not as right as you might think.

While the EPA is laying down the law on many of the effective but hazardous finishing products we've relied on for years, in many cases these old products are still available—right alongside the new low-solvent, low-toxicity water-base substitutes. The fact that the new products are selling well has less to do with government regulations and more to do with the marketing value inherent in a safer, environmentally friendly product.

However, the picture isn't consistent from coast to coast. Because federal guidelines leave it up to the states to regulate finishing products, some states may offer a wider selection than others, and it may be possible to cross a state line to buy a more potent product. And even that's not always necessary, as many laws don't apply to quantities less than a gallon.

Finishing products are being regulated on two fronts: VOCs (volatile organic compounds)—substances suspected of reducing the Earth's ozone layer—and direct-exposure hazards. While it's hard

## WOODWORKING GUIDE

to say just where things are headed, the VOC issue is the one most likely to result in regulated limits nationwide within the next few years.

The direct-exposure issues are more likely to result in comparative-risk statements and warning labels, mostly because safety precautions can reduce risk. In other words, intensive consumer education can be expected regarding relative hazards and acceptable safeguards.

While it's not possible to attribute a definitive risk rating to every product, keep in mind that the latex or water-base alternatives are generally safer and less volatile.

### Strippers

Chemical strippers contain solvents that are aggressive enough to break down the protective surface films formed by paints, oils, varnishes, lacquers, polyurethanes, epoxy coatings and polyesters.

They're available in several consistencies to suit the application. If the piece you are stripping has detailed carvings and can be held horizontally, then a liquid stripper will do a better job reaching into the crevices. If you're working with vertical surfaces or overhead woodwork, then a semi-paste or paste does a better job.

Strippers also differ in terms of flammability. About 40 years ago, Klean-Strip offered the industry's first nonflammable stripper, which made stripping indoors a good deal safer. Today, nearly every manufacturer offers both flammable and nonflammable products. As a general rule, flammables are less potent than nonflammables.

The workhorse ingredient in the most popular strippers is methylene chloride. This aggressive solvent is quick and thorough, often requiring only one application. It's also effective on the widest range of finishes.

Methylene chloride strippers are available in several strengths. The weakest and least expensive is diluted with acetone and toluene (flammables). This type may require several applications on the newer finishes or on multiple coatings.

The most popular type is a mid-strength formulation, which is usually a blend of methylene chloride and methanol. This nonflammable stripper works well on most finishes with the exception of the newer solvent-resistant epoxies and polyesters.

The strongest formulations contain acids (oxalic) or alkalis (ammonia). Those with acid additives are

pretty much limited to commercial use, while the alkali blends are often sold as marine strippers because they work on epoxies, polyesters and baked-on finishes. Alkali-fortified strippers should not be used on hardwoods that won't be painted, however, as they tend to darken the wood.

Methylene chloride evaporates fairly quickly—and when it evaporates, the stripper stops working. One solution is to add paraffin wax to the formula. When applied, the wax separates from the solvents and forms a seal over them, retarding evaporation. Some of the wax is invariably left behind, so a final rinse with denatured alcohol or lacquer thinner is a good idea. Other sources suggest covering the applied stripper with fabric or plastic. The Peel-Away company provides a laminated fabric cover with some of its strippers. When you lift up the fabric, the dissolved coating comes up with it.

While methylene chloride is effective, it's a suspected carcinogen and may trigger heart failure in those with existing heart conditions. While the debate is far from over, manufacturers opted years ago to develop alternative strippers.

One of the departures is a blend of acetone, toluene and methanol (ATM). The ATM class of strippers

works reasonably well on a variety of finishes, and is still relatively fast-acting. In fact, it shares many of the characteristics of methylene chloride strippers, including volatility, but is thought to be less toxic.

It too is available in liquid and semi-paste consistencies. Lacking a wax evaporation retardant, however, liquids are less effective on paints, varnishes and polyurethanes. The semi-paste ATM strippers work best in these cases. Liquids do work well on lacquers and shellacs, however. The primary advantage of the ATM class is lower cost. Its primary disadvantage is flammability.

While the ATM class is inexpensive, its next rival is not. Strippers containing N-methyl pyrrolidone (NMP) are roughly twice as expensive and would not have found a niche in the market if not for a more health-conscious consumer. NMP strippers evaporate very slowly, have a low flammability rating and are less toxic. In most respects, they work well (if a little slower) on traditional finishes. They are not as effective on the newer synthetic finishes.

Like the NMP class of stripper, the newer dibasic-esters (DBE) class does away with both methylene chloride and flammable solvents. These water-base strippers are safer than

### Typical Finish Strippers

|                        | <b>METHYLENE CHLORIDE</b>   | <b>ATM (acetone, toluene, methanol)</b>  | <b>NMP (N-methyl pyrrolidone)</b>   | <b>DBE (dibasic-ester)</b>  |
|------------------------|---|--|---|---|
| <b>BEST FOR</b>        | All finishes except some epoxies, polyesters, milk-base paint               | Varnish, lacquer, shellac, latex paints, some oil-base paints  | Most paints and varnishes   | Lacquer, varnish, shellac, some latex paints  |
| <b>CLEANUP</b>         | Water, lacquer thinner, mineral spirits                                     | Lacquer thinner, mineral spirits   | Water   | Water   |
| <b>PROS</b>            | Available in liquid and semi-paste, fast-acting, medium price, nonflammable | Available in liquid and semi-paste, fast-acting, inexpensive   | Available in gel, medium fast-acting  | Safe to use with little ventilation, nonflammable, protective clothing not required, semi-paste |
| <b>CONS</b>            | Suspected carcinogen, heart and lung hazard                                 | Flammable, hazardous to user and offspring, may be absorbed through skin                                   | Not effective on epoxies, relatively expensive, suspected reproductive hazard | Not effective on epoxies and polyesters, relatively expensive, slow-acting                      |
| <b>SAFETY MEASURES</b> | Good ventilation, eye protection and solvent-resistant gloves*              | Good ventilation, avoid sparking devices (switches, tools) keep skin protected, use respirator and goggles | Good ventilation, use goggles and respirator, wear long sleeves and gloves    | No long-term data on DBEs. Use goggles, gloves may be necessary but not required                |

Chart includes commonly available strippers that handle modern finishes. Milk-base paint requires lye stripper. \*Respirator cartridges do not filter methylene chloride.



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■ Ask any man who ever owned one...he'll tell you it's the best jacket he ever had. For millions of G.I.'s, the official issue U.S. Army Field Jacket was the most prized piece of gear from Army days. Earning its stripes from World War II to Desert Storm, it always came home with the troops. Now, *The Genuine Leather U.S. Army Field Jacket* combines the rugged good looks and comfort of the jacket that veterans treasure with the richness of supple genuine leather! Available exclusively from Willabee & Ward.

### Authentic Details.

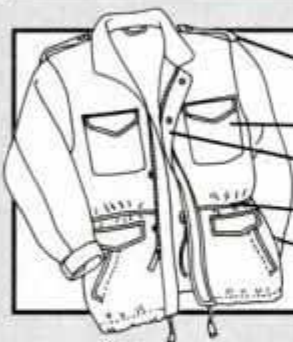
#### Practical Hip-Length Cut.

All the great features that made the original so popular are here. For starters, there's the famous fit and cut. It's comfortable and it covers you to the hip. The regulation shoulder epaulets, roomy snap-close pockets, zipper and snap-front closures, adjustable cuffs, and drawstrings at the waist and hip. What's more, we've updated the classic design by adding convenient side-entry pockets, two zippered inside breast pockets, and a comfortable satin-blend lining. The result is a great-looking jacket that's perfect with jeans, yet the luxurious genuine leather makes it dressy enough for a night on the town.



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For each jacket, charge 6 installments of \$34.75\* to my credit card  VISA  MasterCard  Discover  Am. Ex.

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\*Any applicable sales tax will be billed with shipment. Higher shipping/handling outside U.S.

## WOODWORKING GUIDE

methylene chloride and the ATMs and cheaper than NMPs—but at a cost. Although lab tests indicate shorter stripping times, some pros complain of slow and erratic performance. Some finishes will strip away in less than an hour, but multiple coatings and the tougher finishes may need to be left overnight and given additional coats.

As DBEs are water-base strippers, many complaints are often water related. When water is left in contact with wood for a prolonged period, it can warp the thinner solid-wood components and delaminate veneers. It will also raise the grain, which then requires sanding. And as water is slow to evaporate from wood, you may need to wait a week to apply a finish.

One type of finish that all modern strippers have a problem with is milk-base paint—a relatively common coating on old furniture. The traditional solution to this problem is lye. The problem with straight lye is that it's enormously dangerous (caustic) to use. A drop on your skin will cause serious burns, while a drop in your eye could cause blindness. Moreover, lye reacts with tannic acids in some hardwoods and causes staining. While today's lye-base strippers are safer than mixing your own, caution still must be maintained.

When checking out the price tag on strippers, keep in mind that the

key is projected coverage. While some strippers will cover 125 sq. ft. or more per gallon, a few specialty strippers will cover as little as 16 sq. ft. Read the labels carefully for both content and capacity.

### Finishes

When most of us think of finishing, we think of varnish. And at one time, the term varnish was used for any coating applied as a liquid that dried to a hard, solid film. Today, varnish is still a catchall term, but it is usually confined to finishes that contain oil and natural or synthetic resins, or, lately, latex and hardeners like polyurethane. The new, user-friendly water-base latex varnishes go on white and dry clear, in contrast to the yellowing tendencies of older formulations.

While polyurethane resins are found in just about everything these days, they also deserve a category of their own. These plastic coatings are hard and resistant to scratches, abrasions, heat and moisture, and almost nothing sticks to them.

Unfortunately, polyurethane has trouble holding its grip on raw wood, and spot repairs are difficult because an old coat won't accept a new coat. Polyurethane is so good at repelling things that it even repels additional coats of polyurethane once it has cured. Still, for high-traffic surfaces, such as tabletops and floors, it's hard to beat its durability.

Oil finishes come next on the list of popular coatings. Originally, furniture was finished with linseed oil. But linseed oil never really dries hard. For that reason, most woodworkers prefer tung oil, Danish oils or other so-called penetrating oils. Several coats of tung oil, which usually comes thinned and fortified with drying agents, provide a low-luster satin finish that remains flexible and resists moisture and impact. Because tung oil dulls fairly quickly and is not terribly resistant to scratches, it's not the best finish for dining tables and other high-use surfaces.

Penetrating oils may contain tung oil or linseed oil, but they go beyond these oils by incorporating resins that harden in the wood. As such, these finishes are actually thin varnishes. They offer the subtle appearance of an oil finish, but are generally harder and more resistant to scuffs, abrasions and scratches.

Shellac is an old-world standby that has found new favor, though it's far from perfect. Although available in dry form, most woodworkers today buy shellac premixed with alcohol. It has a limited shelf life and does not cure well on damp days. It brushes on easily and dries with great speed. Shellac forms a poor barrier for standing liquids and can be redissolved with alcohol. While not tougher than polyurethane, it does provide a hard finish that often clings

## Typical Surface Coatings

|                            | POLY-URETHANE VARNISH                                | SYNTHETIC, NATURAL RESIN VARNISH               | WATER-BORNE LATEX VARNISH                        | PENETRATING OIL (THIN VARNISH)                    | TUNG OIL  | SHELLAC  | LACQUER   | WAX  |
|----------------------------|--|--|--|---|---|--|---|--|
| <b>SOLVENT</b>             | Mineral spirits                                      | Mineral spirits                                | Water  | Mineral spirits                                   | Mineral spirits   | Alcohol  | Lacquer thinner   | Mineral spirits                                    |
| <b>TYPICAL APPLICATOR*</b> | Brush  | Brush  | Brush  | Cloth   | Cloth   | Brush  | Spray   | Cloth  |
| <b>BEST FOR</b>            | High wear areas, floors, worktables, kitchens, baths | Medium wear areas, furniture                   | High and medium wear areas, furniture            | Medium to low wear areas, furniture               | Medium to low wear areas, furniture                                       | High wear areas, furniture                     | High wear areas, furniture  | Low wear areas, adding luster                      |
| <b>FINISH QUALITY</b>      | Gloss, satin, matte                                  | Gloss, satin, matte                            | Gloss, satin, matte                              | Satin, matte                                      | Satin, matte  | Gloss  | Gloss   | Gloss, satin                                       |
| <b>DRYING TIME</b>         | 8 to 10 hours  | 8 to 10 hours                                  | 2 hours  | 8 to 10 hours                                     | 24 hours  | 10 to 20 min.                                  | 20 min.   | 10 min.  |
| <b>PROS</b>                | Good moisture, wear and scratch resistance           | Good adherence to wood and previous coats      | Non-yellowing, easy cleanup, dries fast, no odor | Easy to apply and repair, thin natural appearance | Easy to apply and repair, thin natural appearance                         | Quick application, easy to repair and touch up | Easy to repair, easy application for experienced sprayer          | Easy to apply                                      |
| <b>CONS</b>                | Ambers over time, thick consistency                  | Ambers over time, not as tough as polyurethane | Low resistance to liquids                        | Slightly less durable than polyurethane           | Less durable than urethane, needs periodic application to maintain luster | Poor water resistance, dissolved by alcohol    | Spray application although brushing lacquer is available, brittle | Poor water resistance, needs periodic applications |

Chart shows the most common finishes available for furniture. VOC regulations currently affect formulation and availability of traditional mineral-spirit solvent finishes. \*Application methods may vary depending on technique and requirements.

to wood better than synthetic resins.

Lacquer is probably the most popular finishing product with professionals because it yields a durable protective coating that dries fast. Lacquer is usually applied with a spray gun, and it's highly flammable. This means that you need a controlled environment with explosion-proof ventilation and switches. Brushing lacquers are available to get you around the spray equipment problem, but they're still volatile. New, water-base substitutes are available for spray application.

With wax polishes in spray cans these days, it's hard to remember that wax was originally a finish and not a finish dressing. The wax we're referring to here is paste wax, which consists of a blend of bee's wax and carnauba wax. While paste wax can be applied over raw wood, its poor resistance to water makes a preliminary finish a requirement. Periodic touchup coats are necessary to maintain luster. Some pros recommend removing the wax with turpentine every few years, and reapplying it.

## Stains

By far, the most popular stains are comprised of a pigment suspended in an alkyd (solvent) or latex base. You apply this type with a brush, roller or cloth, and then wipe the excess until the coverage is uniform. If these products have a down side, it's that they're messy. They can also leave lap marks if they are not applied properly.

To simplify application, manufacturers have developed wipe-on gel stains. These products are made with a low-volatility base and thickeners. Because the pigment suspended in the gel is absorbed more slowly, you have more control.

Though not technically stains, aniline dyes are another coloring option, especially if you're partial to primary colors and pronounced grain. Comprised of coal-tar derivatives that dissolve in water or alcohol, these dyes penetrate deeper into the wood, yet do less to soften the grain than pigmented stains. Aniline dyes are the usual choice of professionals.

Finally, a number of manufacturers offer one-step stain and finishes by blending synthetic resin hardeners, such as polyurethane, with thick wiping gels. The primary disadvantage of these products is that gels make finishing more time-consuming, and are therefore better suited to small projects.

PM

# The new Delta 12" band saw. Proof that you can never have too much of a good thing.



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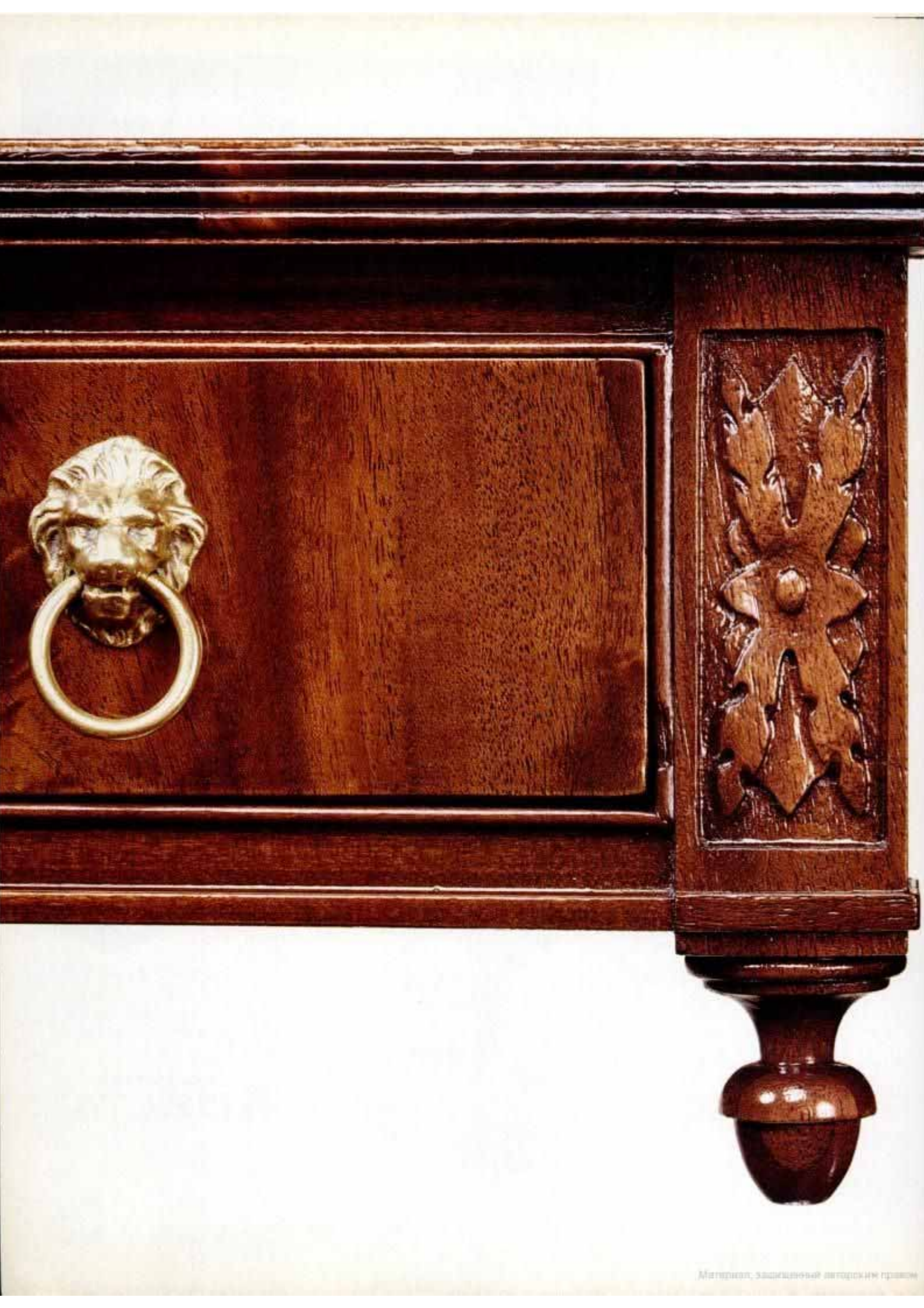
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**CASE 2 STUDY**

# Restoring A Veneered Table

Getting back to the original finish means starting from scratch.

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TEXT AND PHOTOS BY ROSARIO CAPOTOSTO,  
Contributing Editor

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**W**hen you're dealing with a few coats of old paint, it's not difficult to start stripping. After all, once down to bare wood, things can only get better. However, some pieces require a slightly different strategy. More sophisticated pieces were often made out of particularly attractive woods, finished clear and perhaps stained to highlight the grain and color. And, because these pieces were valued for their natural look, they're still likely to have the finish they had when they left the maker's shop. In this case, you have the opportunity to recreate a finish that matches the original.

This small mahogany drop-leaf table is a prime example. It features intricate carving and reeding and has a veneered top. It also has an assortment of water stains, and the finish has literally worn away on some areas of the top and legs.

Of course, the first step is stripping. Then, to reproduce an authentic-looking finish and bring out the beauty of the mahogany veneer, you want to use the coloring agent many pros use—aniline dye. And, the large pores of mahogany necessitate a grain filler to smooth the surface before anything goes on. Lastly, you want to sand between each coat of varnish to achieve the flattest surface possible in preparation for the final rubbing.



Showing signs of age and abuse, this table is an ideal candidate for a new finish that recreates the original luster and color.



After stripping, refinishing and polishing, our table is ready to grace the decades ahead with timeless elegance from the past.

## WOODWORKING GUIDE

### Preparation

Begin by disassembling the piece, removing all hardware and any components that are screwed together (Photo 1). Check that all the hardware is in good condition. If some components need to be replaced, order them before refinishing the table in case screw pilot holes need to be moved or plugged.

After removing drawer or door pulls, plug the holes with paper so the stripper, stain and finish won't drip through (Photo 2). Inspect the surface for broken veneer or other problems, and make repairs.

### Stripping

The first job is to decide on the best type of stripper. For veneered furniture, it's best to stay away from water-base strippers because the water used in cleanup can lift the veneer. And, when intricate carving is involved and there's a heavy buildup of finish in the crevices, you want a fast-acting, strong formula. Finally, if you're doing the job indoors, go for a product that's nonflammable.

Based on these requirements, we chose a methylene chloride stripper. Keep in mind that methylene chloride is toxic. And a conventional respirator won't help, although expensive ventilated respirator systems exist. So simple, good ventilation is a necessity. You also need neoprene gloves, and wear goggles for the entire stripping operation.

Begin by spreading newspaper or a dropcloth under the work, and pour a small amount of stripper into a wide-mouth can. Use an inexpensive bristle brush to lay on a heavy coat, working one section at a time (Photo 3). Load the brush fully after each stroke, and be sure to avoid brushing back and forth. Allow the finish adequate time to work, and wait until the old finish bubbles and lifts off.

Use a plastic scraper to remove the loosened finish from flat surfaces (Photo 4). When it comes to removing the sludge from crevices, a variety of tools come in handy. For small areas, use a small brush or old toothbrush (Photo 5). For larger carved areas, use a plastic scrub brush (Photo 6). Fine turnings are best handled with a piece of coarse twine (Photo 7), and abrasive pads work well on molded areas. After removing as much old finish as you can, wash away the residue with lacquer thinner or denatured alcohol. These materials are flammable, so work on small areas to minimize vapor buildup (Photo 8).



**1** First, disassemble the piece and remove all hardware and metal components. Separate pieces are easier to strip and finish.



**2** Use paper to plug holes left after removing hardware. This prevents stripper and finish products from dripping through holes.



**3** Use a brush to apply stripper. Non-water-base stripper is best for veneered work where water may delaminate veneer.



**4** After the finish has softened, remove the old finish on flat surfaces with a plastic scraper or a wide putty knife.



**5** At small carvings and details, use an old toothbrush or small plastic-bristle brush to remove the stripper and finish.



**6** On larger carved areas, remove the stripper waste with a large plastic-bristle brush. Be sure to reach all crevices.



**7** For detailed turnings, use coarse twine to remove the waste. Wrap twine around the turning, and pull back and forth.



**8** After the stripper has been removed, rinse away residue with recommended solvent. Don't use water on veneered work.



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## WOODWORKING GUIDE

### Staining And Sealing

Before applying the stain, use fine sandpaper to smooth the wood. Don't use a power sander on veneer—the veneer may be only  $\frac{1}{40}$  in. thick, and it doesn't take much to accidentally sand through to the substrate underneath. Use a soft-bristle brass brush to smooth out coarse spots in the carvings, and an extra-fine abrasive pad to smooth the curved surfaces and moldings.

When the work is sanded, clean and dry, it's time to apply the stain. To recreate the rich, deep-red mahogany color of the original finish

and enhance the grain, we used Behlen's Solar Lux NGR Medium Red Mahogany aniline stain. Unlike typical water-base aniline formulas that raise the grain creating a fuzzy surface, this product is non-grain raising (NGR). However, it is a fast-drying stain intended for spray application, and doing the job by hand easily causes ruinous lap marks. To solve the problem, use a special Behlen's retarder to extend drying time. Mix the retarder and stain 1-part retarder to 10-parts stain.

Apply the stain mixture to the flat surfaces with a soft cloth, and wipe

parallel to the grain direction (Photo 9). Use a small brush to stain the irregular surfaces (Photo 10), and follow with a rag to blot up any accumulation in the carving crevices.

Allow the stain to dry thoroughly, and then apply a 1-pound-cut shellac wash coat to facilitate wiping on the grain filler—the next step in the finishing operation. To make the 1-pound-cut shellac sealer, mix 3 parts of 3-pound-cut shellac to 4-parts alcohol. Use a soft cloth to apply a uniform coat of the thinned shellac sealer to the entire stained surface (Photo 11).



**9** To color wood with aniline dye, first mix with retarder to eliminate lap marks. Apply with a soft cloth in grain direction.



**10** Use a small brush to reach crevices when staining detailed carvings and moldings. Blot up any excess with a cloth.



**11** After the staining is done, apply a thin coat of shellac to act as a sealer and form a good base for the paste wood filler.

### Grain Filling

Like oak and walnut, mahogany has large open pores that remain apparent if the raw wood is simply varnished. To obtain a smooth, flat surface for the final finish, the open pores must be filled after staining.

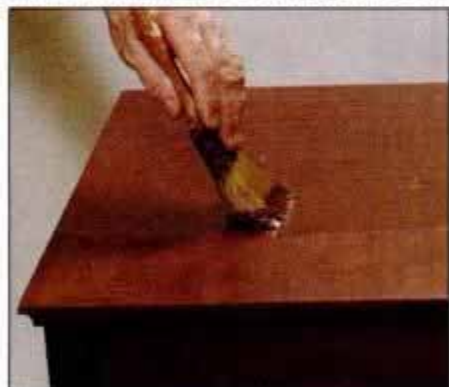
To do the job, you need a paste wood-grain filler. Paste wood fillers (not to be confused with wood fillers used to plug nail holes and cracks) come in a variety of stain colors and either in a heavy paste, which must be thinned before use, or a ready-to-use formulation. To match the color

of our stain, we used a medium-red mahogany wood filler that required no mixing. When you buy paste wood filler, be sure to check its compatibility with topcoats and choose your final finish accordingly.

Apply the filler with a stiff brush, working small areas at a time. First, brush it on with the grain, and then across the grain to fill the pores (Photo 12). When the filler loses its wet look, wipe across the grain with a coarse cloth, such as burlap or a deep-pile towel (Photo 13). The object is to remove the excess so that

the filler remains packed only in the pores. Then, gently wipe with the grain using a soft, clean cloth. Use a plastic-bristle brush to remove most of the excess filler from the carved areas (Photo 14).

After the filler is thoroughly dried, use fine sandpaper to remove any filler that remains on the flat surfaces. Use a gentle touch and be careful to avoid sanding through the stain. Then, use an abrasive pad to clean up the dry residue on the curved areas, and clean up the carving details with a soft brass-bristle brush.



**12** Apply appropriate color paste wood-grain filler with a brush. Work first with the grain, and then across to fill pores.



**13** After the wet look of the filler is gone, wipe away the excess with a burlap cloth. This leaves filler packed in pores.



**14** To remove the excess paste wood filler from crevices in carved details, use a stiff plastic-bristle brush.

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## WOODWORKING GUIDE

### Varnishing

We finished our table with four coats of rubbing varnish. Rubbing varnishes are designed for a fine abrasive polish after the last coat. If you intend to rub out the last coat, make sure that your varnish is suitable for this technique.

Thin the first coat of varnish with an equal part of mineral spirits to serve as a sealer. After this coat has dried overnight, lightly dry-sand with 320-grit wet/dry silicon-carbide paper.

Next, prepare a can to hold the varnish with a strike wire—a piece of wire stretched across the open end of the can. You'll use the strike wire to gently wipe the excess varnish from the brush after each dip.

Pour some varnish into the can and dip about one-half the bristle length into the varnish. Then, gently strike off the excess on the wire. Flow the varnish onto the surface slowly to avoid bubbling. Work across the grain first, then with the grain to smooth the coat (Photo 15). Next, wipe the brush over the strike wire to remove the excess. Then, brush lightly with the grain, allowing only the tips of the bristles to touch the surface to level out lap marks, runs and sags (Photo 16).

On the carved areas, first spread the varnish over the surface. Then dab in the brush tips to reach the crevices. Pass the brush over the strike wire, dab again and gently lift out the brush to soak up any puddles.

After the second coat is dry, use a



**15** Fill half the bristle length with varnish and wipe excess on wire affixed to can. Flow on across grain, and then with grain.



**16** Then, remove all excess varnish from brush and gently wipe the wet coat with the bristle tips in the direction of the grain.



**17** After the first two coats, dry-sand with 320-grit paper. Use a rubber sanding block to maintain a flat uniform surface.



**18** After the third coat, wet-sand with 400-grit paper and water. Move to 600-grit paper to wet-sand the final fourth coat.

firm rubber sanding block and 320-grit paper to dry-sand the surface and level high spots (Photo 17). Then apply a third coat of varnish. When it's dry, wet-sand with 400-grit

wet/dry paper moistened with water. Dip the paper frequently and rub with care—especially at the corners. After the final fourth coat, wet-sand with 600-grit paper (Photo 18).

### Finishing The Finish

Two final procedures impart a pleasing gloss without the harsh glare of raw varnish. The first step is to rub the finish with rottenstone. This is a fine abrasive powder available in hardware stores and furniture finish dealers.

Sprinkle water and rottenstone

powder on the surface, and then rub gently but thoroughly using a felt pad or a wood block surfaced with short-nap carpeting (Photo 19). Use a brush on the carved areas (Photo 20). Periodically, wipe off the slurry to check your progress. When you're satisfied with the uniformity and level of the gloss, thoroughly clean

the surface with a damp cloth.

When the finish is clean and dry, apply a coat of paste wax according to the directions on the can. Apply a thin layer with a clean cloth or cheese-cloth, and then allow the wax to dry for about 15 minutes. After the wax is thoroughly dry, use a clean cloth to buff the surface (Photo 21). **PM**



**19** Begin the final rubbing with rottenstone and water. Use a soft cloth to smooth the surface, checking progress frequently.



**20** Use a small plastic-bristle brush to apply rottenstone to carved details. Then, clean the entire piece and let dry.



**21** Finally, apply a thin coat of paste wax. Let the wax dry thoroughly. Then buff with a soft cloth to achieve desired luster.

# Spraying Finishes

The fastest way to a professional finish.

TEXT AND PHOTOS BY ROSARIO CAPOTOSTO,  
Contributing Editor



**A**fter hours of stripping, sanding and repairing, all that remains is to choose your finishing product, right? Well, perhaps, if you're locked into the two basic application methods: cloth and brush. However, there is another way to go. A way that the pros embrace with almost unanimous support, and that more and more home refinishers are turning to—spray finishing.

The reasons are compelling. First of all, spraying is fast—less of a concern if you're finishing a coffee table, but a big deal if you're taking on a dining room suite. The second advantage of spraying is the quality of the finish. With a little practice, you can lay down coats of remarkable uniformity. Brush and lap marks are a thing of the past and, if it's a fast-drying finish, dust is less of a problem.

On the down side, traditional high-pressure spray finishing is wasteful—a large percentage of the finish never reaches your work at all. And, the usual finishes are highly flammable, making an expensive spray booth equipped with explosion-proof electrical components and

## WOODWORKING GUIDE

impressive ventilation a necessity.

Fortunately, two modern developments have changed the picture. High volume, low pressure (HVLP) spray equipment reduces the over-

spray waste problem, and new water-base finishes eliminate the need for a dedicated spray booth with special wiring and ventilation.

Whichever system you choose, the

application techniques are the same. In all cases, be sure to work in a well-ventilated area, wear a respirator and adhere to manufacturer's precautions and instructions.

### Adjusting The Gun

There are two adjustments on the spray gun: one that controls the spray pattern and another that controls the material flow. To adjust the spray pattern, turn the ears on the spray cap to form either a round or a fan shape (Photo 1). Use the round pattern—ears set diagonally—for spraying small areas. For large areas, set the ears either vertically or horizontally for a fan-shaped pattern. Use the vertical position for making horizontal passes, and the horizontal position for making vertical passes.

To adjust the material flow, turn the knob at the rear of the handle (Photo 2). Each job and finish necessitates minor adjustments to material flow. For example, if you change the size of the spray pattern by moving



**1** Adjust cap diagonally for a round spray pattern. Vertical and horizontal spray-cap positions produce elongated fan patterns.



**2** Control the amount being sprayed by adjusting knob at the back of handle to suit spray pattern and distance from work.

closer or farther away from the work, you have to adjust the flow accordingly. Generally, the working distance should be around 8 in., but may

be between 1 in. and 12 in. depending on the job at hand. The best way to learn how to adjust the flow is experimentation with your equipment.

### Preparing The Finish

Your spray equipment is designed to work best when handling a fluid in a specific viscosity range. Therefore, the first thing to do is to check your finish for proper viscosity, and thin it if necessary. Both the spray gun manufacturer and finish manufacturer offer directions for achieving the right viscosity for spraying and using the appropriate solvent for thinning. Be sure to check the spray gun manual and the instructions for your finish.

Most spray guns come with a viscosity cup to measure the consistency of the material to be sprayed. To use the cup, pour the finish into it and measure the time it takes for the finish to empty through the small hole in the bottom of the cup (Photo 3). Then, compare this time with the rec-



**3** To determine proper finish consistency, measure the time it takes material to flow through viscosity cup. Thin if necessary.

ommended time stated in the manufacturer's timing chart.

After checking the viscosity and thinning if necessary, pour the mix-



**4** After checking viscosity, pour finish in spray gun cup through a strainer. This removes lumps that may clog the spray gun.

ture through a strainer into the spray cup of the gun (Photo 4). The strainer removes any lumps that may clog the gun.

### Spray Technique

Like most other techniques, skill with a spray gun comes with practice. While it's easy to make a few mistakes in the beginning, it's equally as easy to learn to apply the uniform thin coats necessary for a good finish.

Begin practicing on cardboard or sheets of newspaper. Use opaque paint for your practice sessions because it's easier to see the results. Experiment to get the feel of triggering the gun to start and stop the paint flow. Practice making uniform strokes and experiment with the paint-flow adjustment knob.

Hold the gun about 8 in. from the



**5** Always move spray gun parallel to the worksurface. Practice moving gun in a straight line to uniformly cover flat surfaces.



**6** For even coverage, overlap each pass about 50%. Start each pass so pattern is centered on bottom edge of the last pass.

## WOODWORKING GUIDE

surface, pull the trigger and observe the spray pattern as you move the gun parallel to the surface. If the pattern is weak and dusty, the gun is moving too fast, too little paint is

flowing, or both. If the paint piles up causing runs or sags, you're either moving the gun too slow or too much paint is flowing.

Next, work on operating the trig-

ger and maintaining a proper stroke. Set up a 4-ft.-wide test panel, and adjust the air cap for a vertical fan pattern. Practice moving the gun in a straight, horizontal line across the

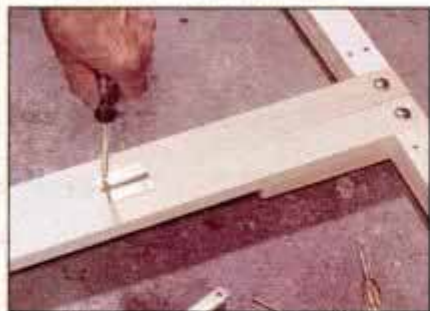
### Knockdown Spray Booth



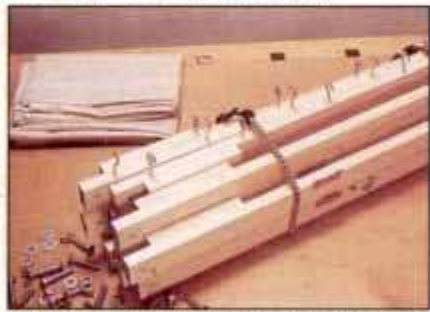
This spray booth helps confine overspray in small shops. It's designed for HVLP systems and nonflammable finishes.



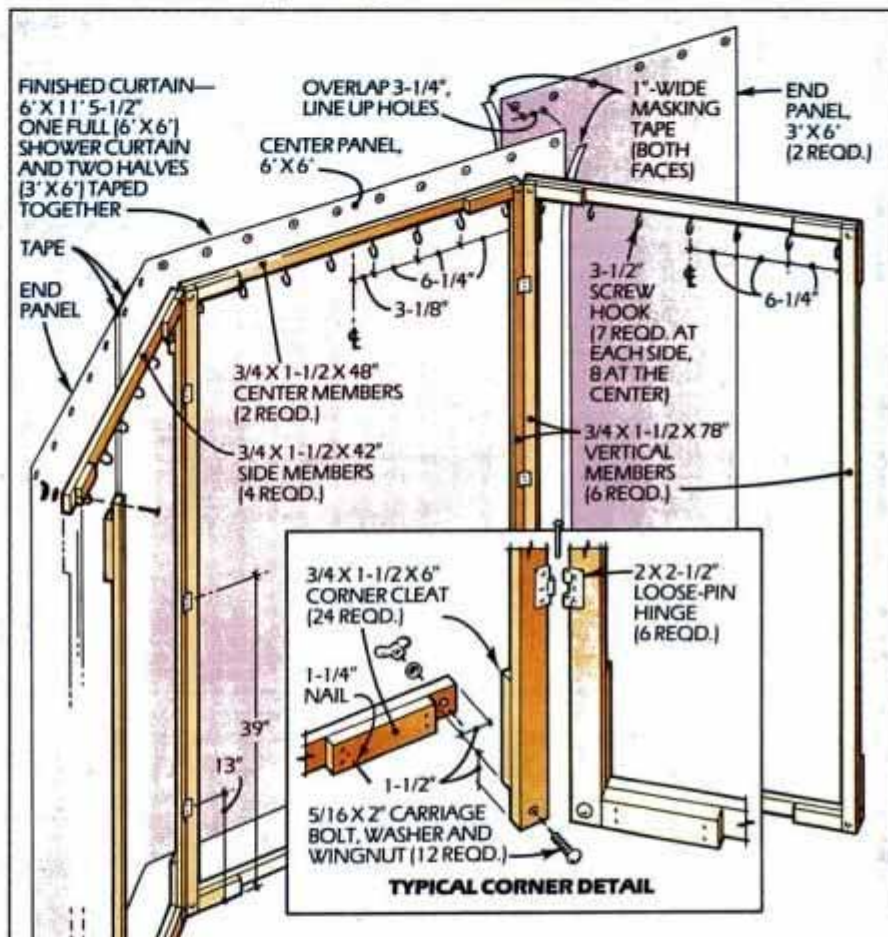
After cutting 1 x 2 stock to length, secure cleats to the ends of each long member. Set cleats back 1 1/2 in. from ends.



Assemble frames with carriage bolts and wingnuts. Then attach frames with loose-pin hinges for easy disassembly.



With the shower curtain removed and the frames disassembled, the spray booth can be packed away for easy storage.



● Because high volume, low pressure (HVLP) sprayers have minimal overspray and water-base finishes are safer and nonflammable, you may be tempted to spray your project right in your workshop—a dangerous and hazardous undertaking if

you were using traditional high-pressure spraying and flammable finishes.

However, you will have some overspray to contend with and one solution to the problem is to build this 3-sided, knockdown spray booth. Made of 1 x 2 pine stock, a couple of shower curtains and easy-to-find hardware, this booth will keep the overspray away from the rest of the shop and then fold up quickly for easy storage.

To build the unit, first cut 1 x 2 pine to length to make the six vertical, two center and four side members as shown in the drawing. Then cut the 24 1/2" x 6-in. cleats. Secure a cleat to each end of the

vertical, center and side members with nails and glue, so that each cleat is set back 1 1/2 in. as shown.

Next, bolt the components together with carriage bolts and wingnuts to make three separate frames. Drill pilot holes and attach the screwhooks to the top member of each frame at the specified centers. Then, link the frames together with loose-pin hinges.

Cut one of the shower curtains in half, and tape each piece to an edge of the uncut curtain with a 3/4-in. overlap. Make sure the curtain holes line up. Finally, hang the curtain on the frames. To disassemble, simply remove and fold up the curtain, and separate the frame members by removing the carriage bolts.

Remember: All spraying has some degree of overspray and no finish is truly safe for human consumption. Always provide adequate ventilation and wear a respirator. This spray booth is not designed for high-pressure spray equipment or flammable finishes such as standard lacquer.

—R.C.

## WOODWORKING GUIDE

### Choosing Spray Tools

● If you decide to set up for spray finishing, you have a few choices to make—not only in terms of the system you buy, but in terms of price and flexibility.

We recommend an HVLP system because of its minimal overspray qualities. One system that's well suited to home-shop use is the Wagner FineCoat System (left, about \$180) that we used for this story. This kit comes complete with gun, viscosity cup and turbine. Because HVLP systems use large volumes of air at low pressure, standard air compressors are unsuitable.



Standard high-pressure spraying does have a few pluses, however. First of all, the air compressor you use to drive the gun is useful for other jobs as well—like pumping tires and running pneumatic equipment.

Keep in mind that air compressors are rated by the amount of air they move at a specific pressure. When choosing one, make sure it handles the range of tools you use.

Compressors without tanks run continuously to maintain airflow. For spray painting, team up this type with a bleeder-type spray gun that allows the airstream to continue even when the trigger is released. With tank compressors, such as the Sears model No. 15292 (bottom right, about \$300), you can use a non-bleeder gun.

In terms of guns, you'll find a wide range available in bleeder, nonbleeder, pressure feed and siphon feed. Choose pressure feed for thicker finishes that need to be moved faster, and siphon feed for extra-fine work. Many guns can be converted from one type to the other. Although you can pay more than \$150 for a professional model, small-shop models such as the Campbell Hausfeld model No. DH4200 (upper right) are available in the \$30 to \$50 range.

—Thomas Klenck



7 To achieve a uniform spraying rate, start and end each pass outside the work area. Press trigger only over the work area.



8 Spray corners from an angle so adjacent faces are covered simultaneously. Set the spray gun air cap for a round spray pattern.

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panel and parallel to it. Be sure to move your entire arm from the shoulder to avoid a natural tendency to move the gun in an arc (Photo 5). A parallel stroke will deposit a uniform coating across the board.

For uniform coverage of a flat surface, move the gun at a constant speed and overlap each stroke by about 50%. Aim the center of each stroke at the bottom edge of the preceding stroke (Photo 6).

In order to avoid excess paint at the edges of the object, start the stroke outside the area and press the trigger as soon as the stroke reaches the area. Then, release the trigger at the end of the area, but continue moving the gun a short distance beyond (Photo 7).

When spraying corners, avoid spraying each adjacent face separately. Instead, spray diagonally into or at the corner so that both adjacent faces are covered simultaneously (Photo 8). After the corners have been painted, fill in the faces with a fan-shaped spray pattern (Photo 9).

It's always better to orient the work so that the gun is held relatively level. However, in some cases, such as finishing a tabletop, you'll have to tilt the gun down. When





**9** After the corners are finished, spray the surfaces with a fan pattern. Set the cap vertically for horizontal application.



**10** When spraying horizontal surfaces, start at the edge nearest you and work toward the far edge to control overspray.



**11** Use a round spray pattern with a vertical motion for turned legs. Do all edges and corners first. Then spray broad areas.

painting the top of a horizontal surface, start spraying at the edge nearest you and work toward the back so that the overspray doesn't settle on a wet area (Photo 10). This is especially important when spraying fast-drying finishes.

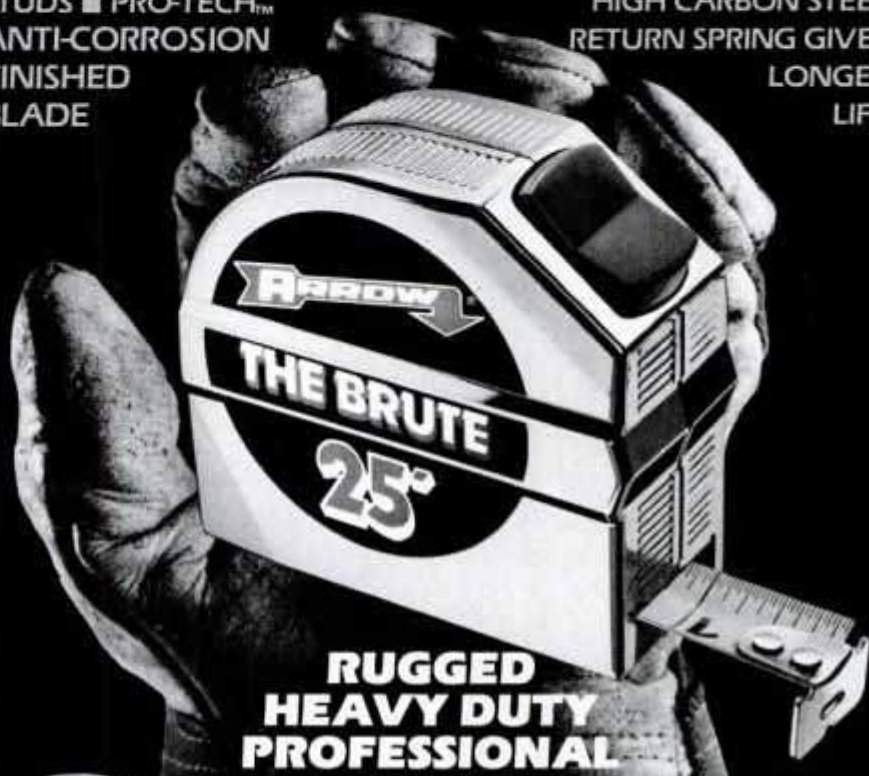
Remember to adapt the spray pattern to suit the object and spray motion. Use a round spray pattern for corners, and also for turned furniture legs (Photo 11). When spraying pieces with many edges, do the edges first with a small round pattern, followed by vertical or horizontal fan patterns as required. **PM**

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**CASE 3 STUDY**

# Cleaning Up An Old Chair

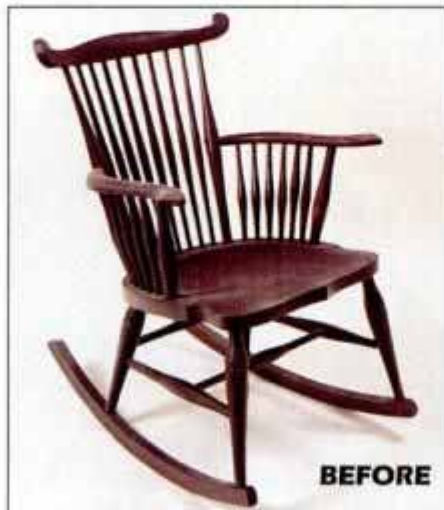
When the old finish still looks pretty good,  
don't remove it, just clean it up.

TEXT AND PHOTOS BY ROSARIO CAPOTOSTO,  
Contributing Editor

**T**here's one important fact you have to face about refinishing an old piece. When the job is done, you no longer own an original chunk of history, you own a hybrid—a piece with materials and design from the past, combined with a high-tech finish of the present. And while refinishing may be the only solution for many examples, there are times when the original finish is best left in place.

Take this Windsor-style chair as an example. When we found it in an antique shop, it stood out—not only because of its sensitive design, but because the original finish enhanced the chair's character. Areas of wear on the armrests and back had lightened the dark stain, producing gentle transitions in tone that no refinishing job could duplicate. However, our find did need some help—the finish was dull and dirty, and some of the spindles had come loose. Our strategy, therefore, was to first restore the chair's structural integrity and then rejuvenate the finish cosmetically.

There are no hard-and-fast rules for deciding when to refinish or when to simply clean up the old finish. However, bear in mind that an old piece of furniture is more than just a design in wood, it's a complete example of the techniques and styles of the past. More than that, it tells a story. And, sometimes, that story is just too interesting to rewrite.



**BEFORE**

Wear areas and changes in color gave this old rocking chair a character that was too good to lose by refinishing it.



**AFTER**

Three-step rejuvenation process of cleaning, buffing and finishing retains original look while adding new life.

## WOODWORKING GUIDE

### Structural repairs

It's not uncommon for the joints in old furniture to have loosened. And, of all furniture types, chairs are the most prone to this problem. Chairs handle a greater load than other pieces—and the load is dynamic. Combine this with the natural tendency for spindles to loosen due to expansion and contraction caused by seasonal changes in humidity, and you're almost guaranteed to have a few repairs to make before concentrating on the finish.

Begin by determining which joints are sound and which need attention. We used a Quick-Grip Spreader tool to spring apart the loose joints. This tool is similar to a Quick-Grip Clamp, except that it works in reverse—it spreads apart parts for disassembly.

If possible, leave intact joints alone. However, if you must take apart a good joint, inject a little vinegar to soften the glue. Then, use a rubber mallet or dead-blow mallet to tap the joints loose. Always protect the work with a cloth pad to prevent marring.

With the loose joints apart, scrape away the old glue with a chisel and file (Photo 1). This is important because the new glue won't adhere to the old. Be careful not to remove any wood because the fit won't be as good



**1** After spreading apart the loose joints, prepare for gluing by using a chisel and file to clean off all the old glue.

and the joint will fail when stresses are applied. Then, apply white or yellow carpenter's glue and reassemble the joints.

Don't try to ensure against future joint failure by using epoxy. While this adhesive will work, the joint will be impossible to disassemble if repairs are necessary on other components of the chair at a future date. If the reassembly time will be longer than a few minutes, use hide glue to increase the time before the glue sets.

After applying the glue and reinstalling the spindles, clamp the components together until the glue has dried. Ordinary clamps are of little value for gripping the irregular con-



**2** Apply glue to the joints and reassemble. Use a shopmade tourniquet clamp or band clamp to hold components together.

figuration of this splayed-leg chair. You can use band clamps for the job, or try the tourniquet clamp that we used (Photo 2).

Wind a flat cloth band or strong ribbon around the spindles to be clamped. Then, place a stick through the ribbon windings. Rotate the stick to twist the ribbon and draw the spindles together tightly. You can also use rope in place of the cloth band or ribbon. However, rope may mar the spindles, so be sure to pad them with cloth first.

After the clamps are in place, use a damp cloth to wipe away any excess glue. Be sure to remove all of the glue from the original finish.

### Finish Repair

● If your original finish has a few defects that you just can't live with, a complete refinishing isn't your only alternative. Often, small problems can be made right with a few simple techniques. The materials you need are available through woodworking catalogs and finish supply outlets.

Although blistered and chipped pieces of veneer aren't finish problems, you should take care of them

before finishing. To fix blistered veneer, apply heat with an iron. Place kraft paper between the iron and the work, and use medium heat. The heat softens the glue and gentle pressure holds the veneer in place.

If the veneer is chipped, select a sample of the same species, and test stain it to match the finish color. Then, use a knife to trim the chipped area and cut the patch veneer to fit. After gluing it in place and trimming, apply a finish to blend with the original. Ve-

ner sample kits are available through mail-order catalogs and are a good source for patching veneers.

Before attempting any finish repair, try to determine the type of finish on the wood. To test for shellac, use a small brush to dab denatured alcohol on an inconspicuous spot. If the finish dissolves, it's shellac. To test for lacquer, repeat the process with lacquer thinner. If the lacquer thinner doesn't dissolve the finish, but just crinkles and lifts it, chances are you're dealing



Use a clothes iron with kraft paper underneath to flatten blistered veneer. Keep the iron on medium heat.



Repair chipped veneer with a patch veneer of the same species. Cut patch to fit trimmed area and stain to match.



Restore alligatored lacquer by wiping with a lacquer-thinner dampened cloth. Small artist's brush handles fine scratches.

## WOODWORKING GUIDE

### Restoration

There are several products available for rejuvenating an old finish. First, you need a cleaner such as Formby's Furniture Cleaner to remove dirt, grease and wax buildup, or you can simply use mineral spirits. Check for minor surface imperfections, or a dull appearance. If these are a problem, use a paste polishing compound. Then, apply a paste wax or wipe-on polish to restore the desired luster.

We opted to give our chair a complete treatment with Formby's Furniture Face Lift. This kit includes Cleansing Liquid, Buffing Cream, Face Lift Finish and three applicator pads. The kit is designed for use only on finishes that are sound and not worn through. Before starting with any product, test for compatibility on an inconspicuous area to be sure the finish won't dissolve.

Begin by thoroughly wetting an applicator pad with the cleansing liquid. Then, rub the surface in a circular motion to remove wax and grime (Photo 3). Apply a liberal coat of buffing cream and buff gently for a few minutes to remove light finish scratches (Photos 4 and 5). Finally, use a finishing pad to apply the Face Lift Finish. Wipe on a thin, even coat, and reapply after about 4 hours for extra protection (Photo 6). **PM**



**3** Use a furniture cleaner to remove all dirt, grime and old wax. Apply the cleaner with a soft pad in circular motions.



**4** To remove minor surface scratches and blemishes, use a polishing compound. Rub each area for several minutes.



**5** To clean up the chair spindles, wrap the cloth or applicator pad around them and polish along their length.



**6** Apply Face Lift Finish with the felt-faced applicator pad. Wipe on the finish in thin, even coats.

with a standard varnish. If the lacquer thinner has no effect, you're probably dealing with polyurethane.

Scratches are common finish defects. If they're shallow and haven't penetrated the wood—and the finish is shellac or lacquer—you can blend the finish over the scratch. Using alcohol or lacquer thinner, depending on whether the finish is shellac or lacquer respectively, apply a small amount with an artist's brush to the scratch. Repeat, if necessary, until



Small scratches and holes can also be filled with a wax pencil. These are available in a range of wood colors.

the finish dissolves and flows together to subdue the scratch.

Alligatorated lacquer finishes are characterized by a network of fine surface cracks caused by the expansion and contraction of the wood under a brittle surface coating. To remedy the problem, dampen a soft cloth with lacquer thinner and rub it over the surface. You can repeat the process, but don't overdo it or apply too much pressure to avoid cutting through the finish.



Use the burn-in method with a shellac stick to fill deep scratches, dents and gouges. Practice first on scrap stock.

Another way to handle small scratches is to use a wax pencil designed for finish touchups. These are available in a range of wood-tone colors and also can handle small holes.

Scratches, dents and gouges can be repaired with a shellac stick of the appropriate color. Called burn-in, the process uses a special knife called a burn-in knife to apply the shellac stick material to the surface defect.

Use a soot-free alcohol lamp to heat the burn-in knife (a grapefruit knife also works). Then, apply the stick to the hot blade held over the blemish, allowing the melted material to drip onto it. Before the patch hardens, use the clean face of the hot knife to compress the material. This process is tricky, so be sure to practice it before working on good furniture. The knife temperature must be just right—if it's too hot, it can damage the surrounding finish.

Use a special liquid abrasive with a felt pad to level the patch without damaging the surrounding finish. Then, apply a burn-in sealer to the area and apply a finish to blend in with the surrounding surface. —R.C.

# Best New Finishing Products

BY ROY BERENDSOHN, Assistant Home Improvement Editor



## Crossover Tools

These tools cross over nicely from re-finishing projects to painting. They are: a 1/4-in.-wide chisel putty knife and the 5-in-1 painter's tool from Hyde Tools. The latter functions as a scraper and a putty knife, and it has an extra point for removing softened paint from crevices. A circular cutout removes paint from its rollers. Finally, like the putty knife, it's stiff

enough to chisel hardened putty out of a window sash. Both tools have a high-carbon steel blade set in a laminated wood handle. Each lamination is resin impregnated, and the entire handle is heat cured and set with brass-plated grommets and rivets. The tools cost about \$9 at hardware stores, paint stores and home centers. Write Hyde Tools, 54 Eastford Rd., Southbridge, MA 01550.

## The Secret's Out

P.D.E. paint remover has been around for years, but not too many people other than professional wood finishers know about it. It's a very powerful lye-base formula that's capable of stripping heavy layers of oil, latex, casein and milk paint, which is notoriously difficult to remove. The manufacturer says it will remove up to eight layers of finish at a time. Unlike most strippers,



which are liquids or gels, it is crystallized. You dissolve the crystals in water to use it, and according to the manufacturer, the creamy liquid it then becomes does not give off toxic fumes. A 1-pound can of the remover costs about \$9 through woodworking catalogs or through the company. For more information, write H. Behlen & Bro., 4715 State Hwy. 30, Amsterdam, NY 12010.

## Multipurpose

The ProForm Scrape-N-Cut is really three tools in one. As shown here, it's a straight-blade scraper that can be used to remove paint that has been softened by a stripper. Loosen the lock-down screw, insert a utility razor blade so it sits in an angled groove, tighten the screw and the tool becomes a utility knife. You can also mount a hook-type scraper blade in the tool for scraping paint that has



## Use It Again

This stripper is not only reusable, its manufacturer says, but it works on any varnish, lacquer, shellac or paint, and it won't loosen veneer or glue joints. Also, it's self-neutralizing—meaning that the stripped piece does not need to be cleaned with water afterward. The non-methylene chloride formulation comes in a semi-paste consistency for removing heavy finishes (1 gallon, about \$30) and a liquid for removing lighter finishes or for penetrating crevices and carved surfaces (1 gallon, about \$25). The two strippers can be used together. The liquid can serve as a final wash after using the semi-paste. That way the paint is removed from all crevices. Take-It Off is sold by mail-order through Constantine, 2050 Eastchester Rd., Bronx, NY 10461.



not been softened by a stripper. The crank-neck tool is heavily constructed out of zinc-plated steel and has a foam-like cushioned grip. It comes with a utility razor blade, and costs about \$9 at paint and hardware stores and home centers. (Extra blades cost from \$1.40 to \$2.50, depending on blade type and quantity.) For more information, write Sunbelt Tool & Die Inc., 2058 Sigman Rd., Conyers, GA 30207.

## WOODWORKING GUIDE



### New Paint For An Old Look

This paint gives you a new durable finish on woodwork or metal while mimicking an antique look. Called Cracklin' Finish, it's available in six Colonial shades that include rust, gray, green and cream. The spray paint comes as a 2-part kit. Spray on the basecoat, and then spray on the topcoat. It's sold at paint and hardware stores and costs about \$13. For more information, write Plasti-Kote Co. Inc., 1000 Lake Rd., P.O. Box 708, Medina, OH 44258.

### Clean Hands

Permatex Parr Hand Cleaner is designed especially for removing paint, stain, varnish and polyurethane. It uses fine pumice as an abrasive and dibasic ester as the primary solvent. The manufacturer says this is a safer alternative to petroleum-base solvents, and it is gentler to your skin. The hand cleaner also has Vitamin E, aloe, lanolin and jojoba oil to leave skin moist and protected.



Prices range from about \$4 for a 7.5-ounce squeeze bottle to about \$22 for a 60-ounce pump bottle. The cleaner is sold in auto parts stores. For more information, write Loctite, 705 N. Mountain Rd., Newington, CT 06111; or call (800) 828-2524.

### Triple Play

This unusual-looking tool is a variation on the standard can opener, but it has other features that are handy to wood finishers, too. Push its tip under the paint can lid to pry it up (below left). Place its claw under the rim and lever it down to press the lid back on the can without denting the

rim (below right). Finally, place another claw under the rim and lever its hook into the can rim to puncture holes in the rim. This allows excess finish to drain from the rim into the can, and this ensures the can may be neatly re-sealed. It costs about \$2 at home centers. Write Bloch, P.O. Box 296, Worcester, MA 01603.



### Brush Up

This professional-quality brush is made with ox hair, considered by many painters and wood finishers to be the finest brush material because it is so soft and imparts such a smooth surface to the finish. The brush has an alderwood handle and a round-edge stainless-steel ferrule.

It's called the Ox-O Thin, and it comes in widths from 1 in. to 3 in. in ½-in. increments. It costs from about \$13 for the 1-in.-wide model to \$26 for the 3-in. model. The Ox-O Thin is sold at professional paint dealers. For more information, write Purdy Corp., P.O. Box 83097, Portland, OR 97283.



### Good Things In Small Packages

If you don't happen to have spare finishing supplies hanging around, small projects can be a nuisance, but this kit makes these projects a little easier. It consists of a handy plastic package, two plastic handles and 10 foam pads (five pads each in 1-in.-wide and 2-in.-wide sizes). If you like, you can pour the finish into the recyclable package to apply it, rather than dip the pad in the can. The kit costs about \$5 at hardware stores and home centers. For more information, write EZ Painter, 4051 S. Iowa Ave., Milwaukee, WI 53207.



## WOODWORKING GUIDE



### Terrific Trio

If you are a stickler for historical accuracy, this oil-base paint is for you. It's supposed to be the identical shade commonly used on Windsor chairs in the 1700s. Its formula was developed by analyzing the green paint that had been preserved in the crevices of antique Windsor chairs. A quart of the paint costs about \$15, plus shipping.

Wunderfil is a dual-purpose filler. Use it right out of the container to cover nail holes and cracks, or thin it with water to a creamy consistency and use it as a grain filler on furniture. An 8-ounce can costs about \$5, and a quart costs about \$13, plus shipping.

These three wood-finishing products let you make the switch completely from petroleum-base finishes to water-base ones. The EF line (for environmentally friendly) includes water-base stains and two types of finish: clear and high-performance. Use the clear finish on furniture that



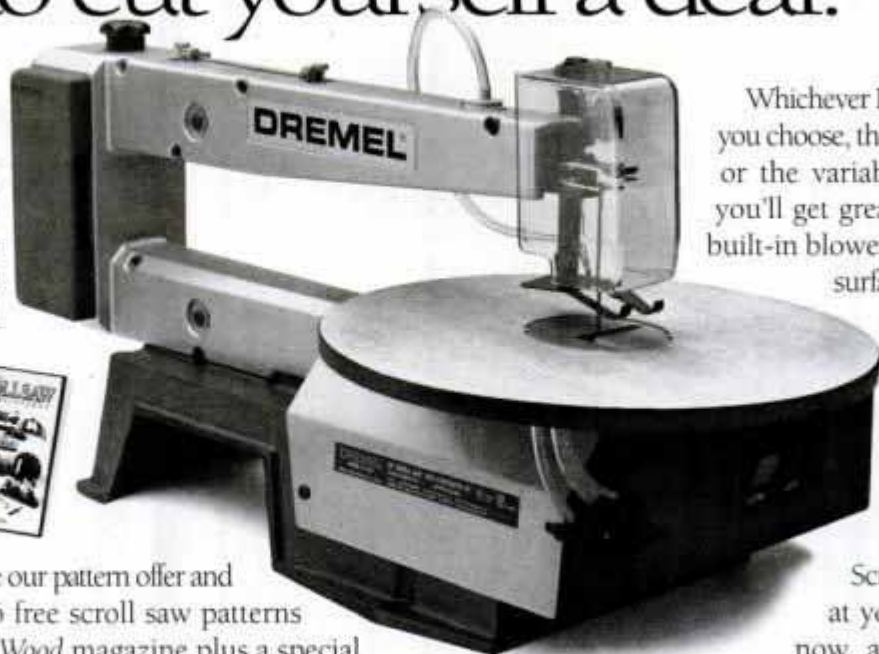
sees regular wear and tear, and high-performance on floors, furniture and trim. Both types of finish are available in gloss and satin. A quart of stain costs about \$10, a quart of high-performance gloss \$20, and a quart of clear satin \$14, plus shipping. For more information, write the Woodworkers' Store, 21801 Industrial Blvd., Rogers, MN 55374.

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## DREMEL®



## WOODWORKING GUIDE



### Move Over Sandpaper

Sandpaper is considered the standard workshop abrasive, but plastic abrasive pads, such as these, have a place in a refinisher's toolkit because they work in places where sandpaper doesn't. Made of webbed nylon, the pads have an abrasive bonded to them. They come in three types: a Paint & Varnish Stripping Pad that's meant to be used with chemical strippers, a Metal Finishing Pad that's used to remove rust and a Between Coats Finishing Pad that's used to remove dust and imperfections in coats of clear finish before you apply the last coat. The pads cost about \$3 each at paint stores, hardware stores and home centers. For more information, write Norton Co., P.O. Box 15008, Worcester, MA 01615. **PM**

### A Specialist

Klean-Strip formulated its varnish remover strictly to handle furniture and trim that is not painted. It has no methylene chloride, and its thinner consistency lets it penetrate corners and carved surfaces. While it's powerful enough to work on just about any clear finish, including shellac and lacquer, its manufacturer says it's gentle enough not to remove the patina on antiques. It can also be used on metal surfaces. It's sold in quart and gallon sizes (about \$5 and \$14) at hardware stores, paint stores and home centers. For more information, write W.M. Barr & Co., Klean-Strip Division, P.O. Box 1879, Memphis, TN 38101.



### Easy Going

The beauty of Bartley gel finishes is that they are easy to apply and have a low odor. And, because they are gels, they won't run on vertical surfaces. Starting with a sanded surface, you rub on the gel stain with a rag or paper towel. The stain dries tack-free in minutes, and can be reapplied to achieve a darker hue in 6 hours. Next, apply one or several coats of rub-on varnish in the same manner, allowing 6 hours

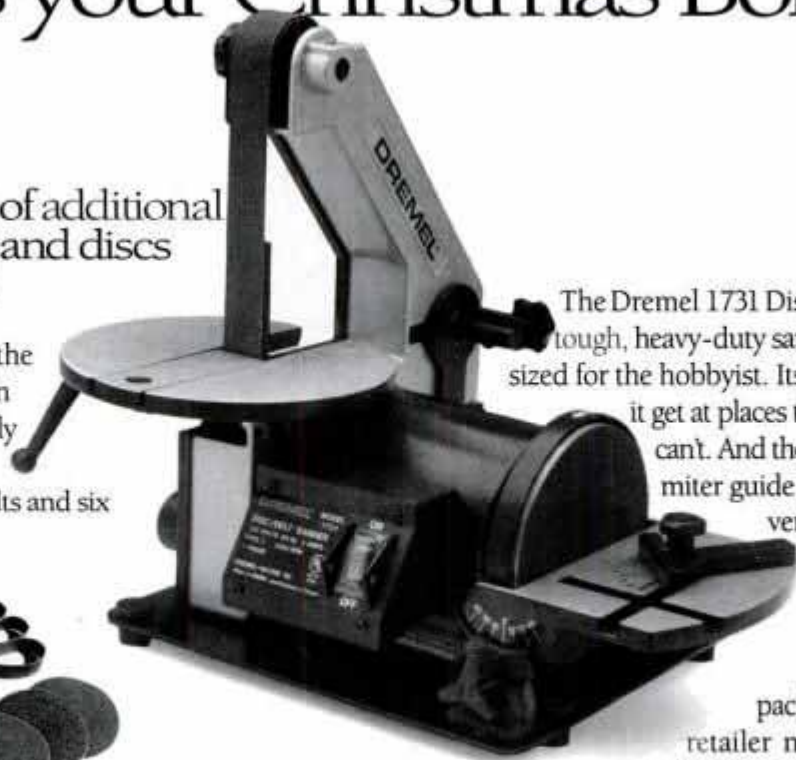


between coats. You don't have to sand between coats or rub them out with steel wool. According to the company, the resulting finish can be waxed or left as it is, and is durable enough to withstand washing with a gentle soap and water. A pint of gel stain or varnish costs about \$9 and a quart, about \$15. They are sold at hardware stores and through woodworking supply catalogs. Write The Bartley Collection Ltd., 29060 Airpark Dr., Easton, MD 21601.

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# CAR CARE

## CAR CLINIC

BY MIKE ALLEN,  
Associate Automotive Editor

### Chiseler

I tried to replace the wheel bearings on my Mustang after one of them failed. But I couldn't get the outer pieces of the inner and outer bearings off. So I put it back together with part of the new bearing, leaving the old pieces in place. Will this work?

KEN GRESHAM  
TUCUMCARO, TX

*Go back to the auto parts store immediately and get all new bearings and seals. Wheel bearings always need to be replaced as a unit, and mixing and matching rollers with odd races is bad, bad, bad. Especially when some of the parts are used. Those bearings will fail fairly soon.*

*To remove the outer race from the brake drum or disc, start (after you remove the thing, of course) by cleaning the grease from the bearing cavity. A parts-washing solvent and a brush are good, but a roll of paper towels is good enough for the disassembly.*

*Once you've got out most of the goo, feel around for one of several small reliefs in the bore where the bearing race sits. These reliefs are cast into the disc or drum to allow you to use a punch to tap out the bearing race. Tap lightly. The race will move only a millimeter or two before it cocks sideways and jams. So alternate your tapping from side to side or in a circle.*

*The inner-bearing race still left on the spindle can be a tough nut to crack. If the wheel bearing was heavily worn, the race may have been spinning slightly on the spindle's surface, rather than the rollers spinning on the race. This movement of the race on the spindle wears grooves on the spindle, and the race will refuse to move. Worse yet, if the bearing was really bad, the metal of the spindle may have galled and seized the race to the spindle.*

*Use a cold chisel—not a wood chisel—and a ball-peen hammer,*



*and wear safety glasses. Put the point of the cold chisel into the hairline gap at the inside of the race and tap lightly.*

*No go? Tap harder. Remember that the bearing race is hardened and the spindle is ductile. Ductile is engineerspeak for soft—or at least not as hard as the bearing race. Minor imperfections in the spindle can be cleaned up with a fine file and crocus cloth. Just remember that the spindle is holding up your car, and you should assess any damage accordingly.*

*Smacking the spindle harder than you really think you should and still no go? Well, I mentioned*

*the bearing shell is hard—which also means that it's pretty brittle. Turn your cold chisel 90°, and maybe the shell will crack. Maybe not.*

*As a matter of last resort, a sharp hand with a cutting torch should be able to keep the spindle cool while the flame cuts the old bearing shell off of the spindle. I'd reserve this tactic for emergencies and vehicles for which spindles are not obtainable by mere mortals.*

### Computer, Open The Databanks

Our car club has opened a sort of library—we've all pooled our shop manuals and technical books. We've

## CAR CARE

got more than 100 linear ft. of books, and we figure we've only covered a few of the cars we're interested in. Do you know who we might call in Detroit to get more?

JOHN COLTRESDEO  
MINNEAPOLIS, MN

*You should see my office—I gave up on trying to keep an exhaustive collection of shop manuals years ago.*

*I don't have any place to send you*

*in Detroit. You might go around to your local car dealers and see what you can scrounge, though.*

*Around here, I used to keep an ALLDATA System Three. This is a CD-ROM-based database of service manuals, wiring diagrams and vacuum-hose charts, Technical Service Bulletins, parts lists and flat-rate manuals. It was great. But eventually the ALLDATA people wanted their expensive machine back. And*

*you thought we journalists got everything for free? A repair shop could justify buying this machine within a few months easily, however.*

*While a dedicated CD-ROM machine might be a little out of the ballpark for your car club, ALLDATA has now made it possible to search its database over the phone. You need a PC with a 9600-baud modem, a mouse and their software. You also need a printer if you want any hard copy of the data, obviously. Cost is \$39.95, and that includes the use of the database for enough time to do a pretty exhaustive search for one car's problems. Additional searches are about 40 cents per minute, including long-distance charges.*

*I've been using this software, called ALLDATA-Link, for about three months now to compile Service Tips for this column. It's very complete and easy to use. Highly recommended. Contact: ALLDATA at (800) 829-8729, ext. 3052. Tell them Car Clinic sent you.*



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### Cool Misinformation

I read an article in another car magazine about a replacement for Freon R-12 called OZ-12. It supposedly has already been approved by the EPA.

LOREN HARMS  
RED BUD, IL

### SERVICE TIPS

- If you smell raw gasoline inside your 1989-1993 Ford Taurus or Mercury Sable when the outside temperatures are in the 90s, it's probably caused by a fuel-filter vent located below the back seat. There's a kit to relocate the vent tube elsewhere.

- If you have a 1990-'92 Brougham or Fleetwood equipped with a 4L60 Hydra-Matic transmission, you may have noticed a buzzing noise at idle, especially when idling in REVERSE. Replacing the pressure regulator valve with new P/N 8684048 will improve oil-pressure stability at lower rpm and eliminate the noise.

- If you're removing the head on any 1985 or later Geo Sprint, Metro or Tracker, be sure not to reuse the old head bolts. While in service, they may have elongated, which is normal for some vehicles with aluminum heads. There are two different-length bolts. Bet this applies to the Suzuki versions of these vehicles as well.

## CAR CARE

OZ-12 has not and is never likely to be approved by the EPA as a CFC-free replacement for R-12. It can, according to the manufacturer, be mixed with R-12, which is exactly the problem the EPA has with it. It will contaminate federally required R-12 recycling machinery if the vehicle is ever serviced again, making it illegal to mix the two.

There is, as of this writing, no proper substitute for increasingly scarce R-12, which will no longer be produced anywhere after Jan. 1, 1995. Retrofits to vehicles to use environmentally benign R-134a will cost somewhere between \$200 and \$500—once the retrofit kits start hitting the market in a year or two.

There could be a couple of long hot summers coming up folks, at least until somebody comes up with an acceptable drop-in replacement for R-12. **PM**

### DO YOU HAVE A CAR PROBLEM?

Just ask Mike about it. Mail your question to Car Clinic, Popular Mechanics, 224 West 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.

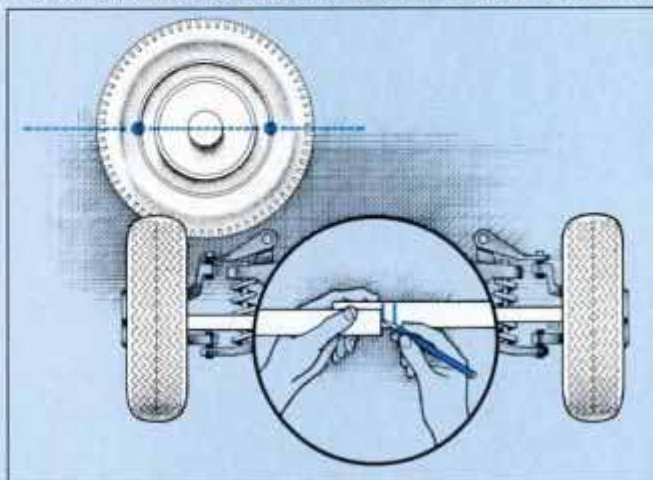
### Straight And Narrow

● Invariably, weekend projects are finished late Sunday night, with just enough time to clean up and stagger off to bed. Meaning, we're stuck driving to the office Monday without the benefit of a trip to the alignment shop.

Well, a few miles of driving in heavy traffic with an inch of toe-out will make you vow to give up auto repair. Scary stuff, wandering all over the road like that.

Not to worry. Take a couple of tomato stakes or other thin wood sticks, crawl under the car with a helper and put the sticks between the edges of the rims

at the very front of the tires. Mark the sticks. Then move them to the rear of the rims. Mark them again. The distance between the marks is the toe-in—or the toe-out. Makes no difference. Adjust the tie rods so the marks line up and you've got zero toe-in, which is good enough for a day or two.



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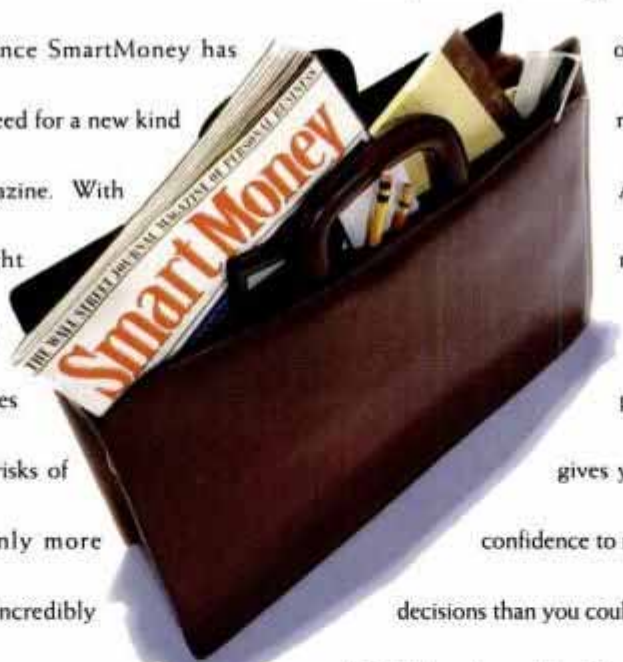
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## SATURDAY MECHANIC

# REPLACING FRONT-WHEEL-DRIVE WHEEL BEARINGS

BY JOHN DECKER

● It starts as a faint whirring noise that grows to a whine as you go around turns. After a few weeks, the noise gets louder—more of a rumbling sound—and it's easy to tell that it's coming from the right front wheel, especially when you turn left. After another few days, it's obvious that your front suspension is filled with angry little pieces of metal trying as hard as they can to part company with your car.

A bad front-wheel bearing, you

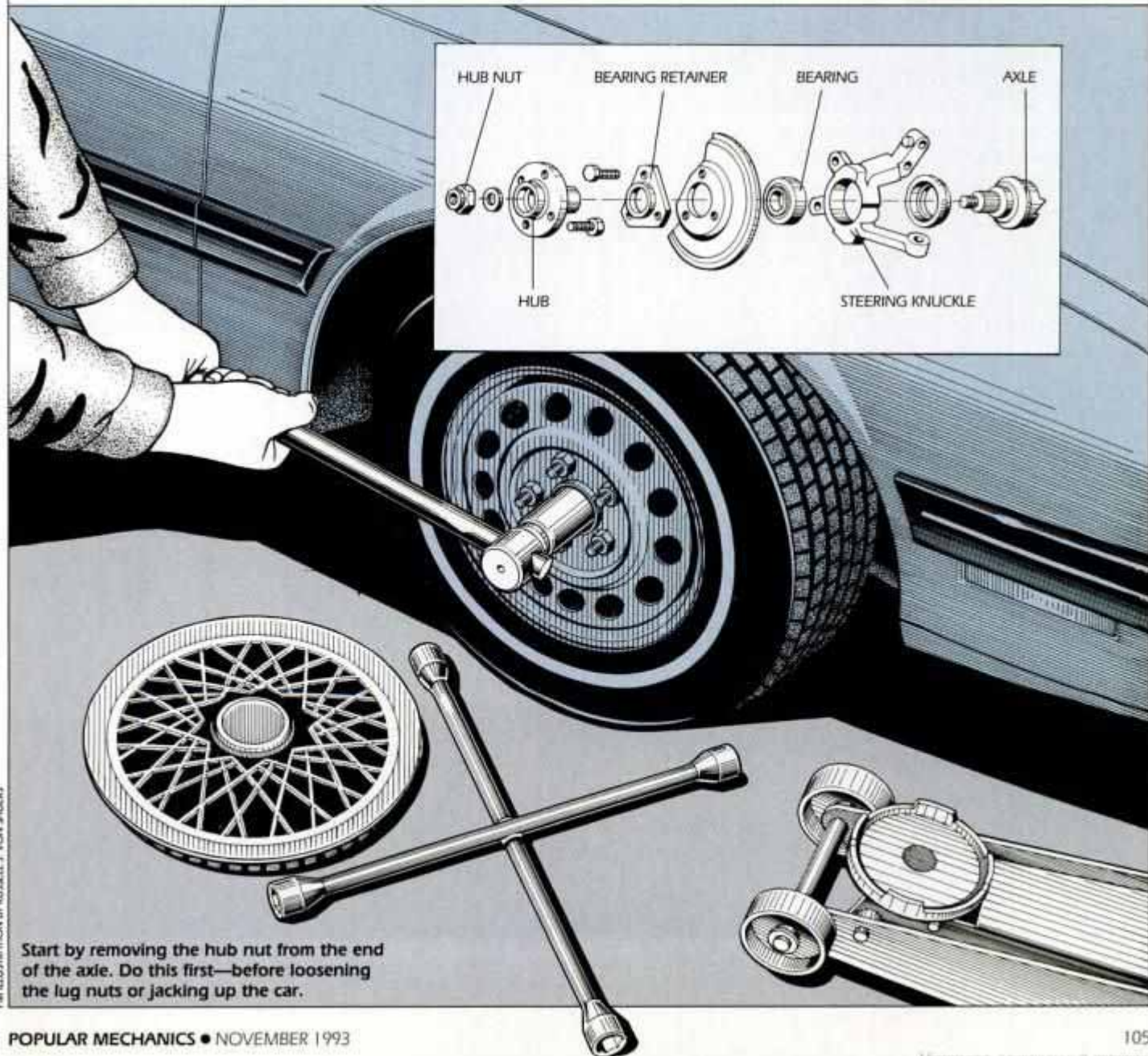
say? It's an easy diagnosis. And replacing one is an easy Saturday morning job—at least it was when you had a rear-drive car. But now you have a front-driver, and you're wondering if you should tackle something that is admittedly a little more complicated.

Actually, the job is possible—even easy to do in your driveway—on many front-wheel-drive cars. You might have to rent a tool or two. And on some cars, a bearing press will come in handy. Local machine shops

and parts stores have presses and will be happy to press your bearing out and back in for a few dollars while you wait, especially if you buy the replacement bearing from them.

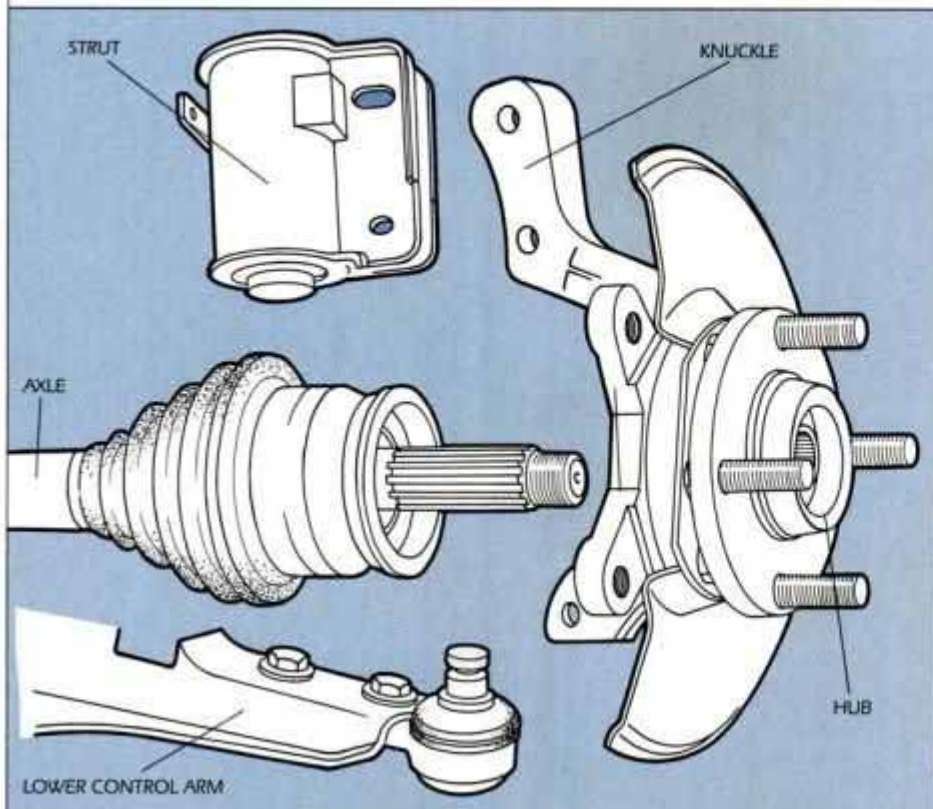
### What's up front

One of the main advantages of front-wheel drive is that the engine and transmission sit directly over the front wheels. The extra weight provides additional traction, especially on wet or icy roads.



Start by removing the hub nut from the end of the axle. Do this first—before loosening the lug nuts or jacking up the car.

PH ILLUSTRATION BY RUSSELL J. VON SALTERS



Some vehicles require you to remove the knuckle and hub as an assembly by unbolting it from the suspension. Mark the position of the strut bolts for reassembly.

But all that extra weight puts a hefty load on the front wheel bearings. And the added load doesn't stop there. The front wheels also do all of the accelerating, most of the braking and all of the turning.

And you won't find a small stationary spindle on a front-driver, either. Because the drive axles power the front wheels, the axle-shaft travels through the bearings to the hub.

Like rear-drive cars, each front wheel has an inner and outer wheel bearing. Working together, these two bearings handle axial (up-and-down) as well as the radial (side-to-side) loads created when turning.

But unlike rear-drivers, the two bearings on most front-drive cars are housed in a one-piece unit which you can't take apart. And many are permanently sealed and lubed for life.

The good news is, the typical front-wheel-drive bearing is designed to last about 200,000 miles, according to Randy Sturm, a spokesman for BCA/Federal Mogul.

But don't put away your floorjack just yet. Sturm also says that getting wheel bearings to last for two trips around the odometer only happens when the car is driven at normal speeds and normal loads. "Double the speed, and you cut the life of the bearing in half," he explains. "Double the load, and you cut the life by 90%."

Also, fwd bearings are vulnerable to shock loads. One good shot against a curb, one hard enough to bend a rim, and within a week or two you'll hear the funeral dirge of the dying

bearing. So be careful during bad weather. If you must hit a curb or pothole, at least straighten the wheel and release the brakes just before impact to lessen the load on the bearings and suspension.

## Basics

Typically, there are two kinds of front-drive wheel bearings. Ford, and most Japanese cars use opposed tapered roller bearings. Even though they're in a one-piece sealed unit, they're remarkably similar to the opposed tapered wheel bearings that you find in the front hubs of rwd cars.

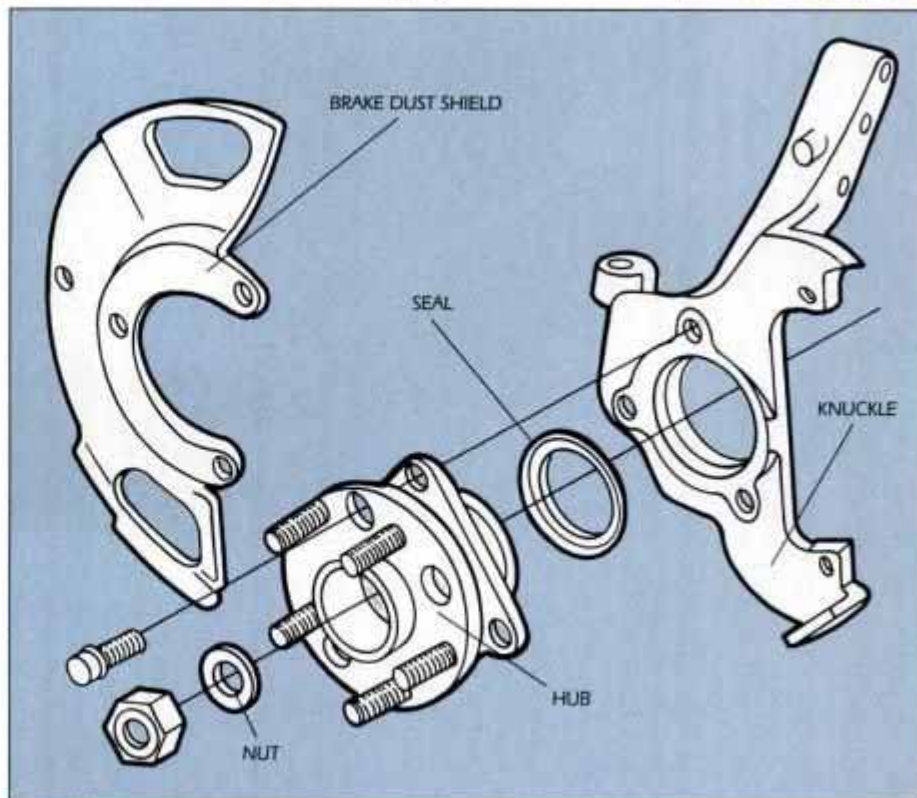
GM, Chrysler and most European carmakers use what is called a double-row, angular-contact bearing. It's basically two rows of ball bearings that run next to each other. The difference from typical ball bearings is that the inner and outer races in each row are offset to handle the radial loads encountered during turns.

The advantage of this type of bearing is that it has less rolling resistance, and therefore offers a slight increase in fuel economy. But it's still a tradeoff: The tapered rollers can handle a little more load.

## Tooling up

Before you change the wheel bearings in a front-drive car, you need to

*(Please turn to page 109)*



Other vehicles allow you to unbolt the hub/bearing assembly without unbolting the strut from the knuckle and changing the alignment settings.



## The big easy

How hard or easy it is to change a front-drive wheel bearing depends on how the bearing is installed. If it's pressed into the spindle, bearing installation and removal can be hard because the steering knuckle often has to be removed to do the pressing—something that normally makes a wheel alignment necessary.

GM cars (and many Chryslers) have the easiest front-drive wheel bearings to change by far. The hub assembly, which contains the bearing, simply bolts onto the knuckle. This makes it easy to unbolt and pull off with a hub puller. It also makes removal of the knuckle—and wheel alignment—unnecessary. To replace the bearing, you simply buy a new hub assembly and bolt it into place.

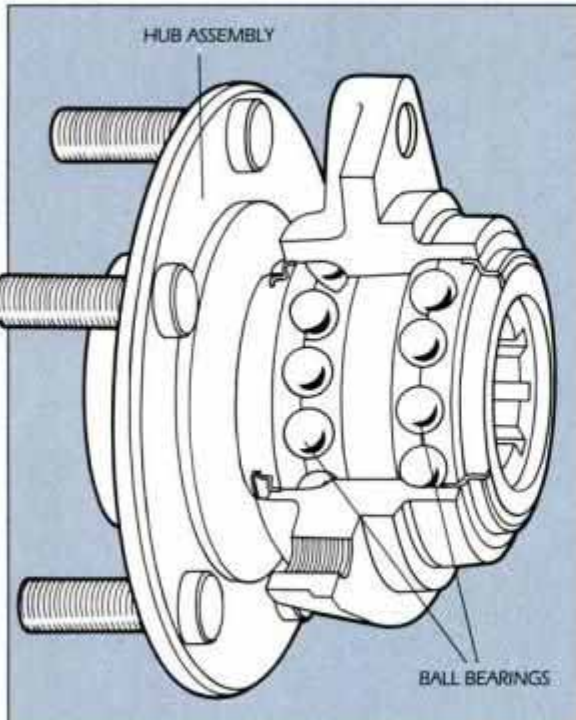
You can tell if a Chrysler has the easy-to-change hub assembly by looking at the hub once the brake disc has been removed. The hub retainer is held by bolts that travel through the back side of the knuckle. This means that when you look at the retainer, all you see are the threaded ends of the bolts. If you see bolt heads there, you're looking at the other type.

To change the front bearing, begin by loosening the hub nut using the 3/4-in. breaker bar mentioned earlier. Then loosen the wheel lug nuts before jacking up the car and placing it on stands. After removing the front wheel, unbolt the brake caliper. But don't let it hang by the hose. Get it out of the way by hanging it on the suspension spring with a wire coat hanger or rope.

On GM cars, the bolts that hold the hub assembly to the knuckle are immediately behind the hub. Remove these bolts. If you plan to reinstall the original hub assembly, mark one of the holes on the hub and the corresponding holes in the knuckle so you'll be sure the hub assembly is mounted in its original position. Then mount a hub puller to the wheel studs and pull the hub assembly from the knuckle.

On Chryslers, because the hub-nut bolts are on the back side of the knuckle, the knuckle must be removed from the axle shaft to access them. To do this, separate the lower-control-arm ball joint as well as the steering tie rod. Then tie the axle to the frame with string or wire for support, and remove the knuckle from the axle.

Once the hub is out, you'll notice that there is a second seal mounted inside the knuckle. It should be removed, and a new one should be installed. Many bearing makers and suppliers, such as BCA/Federal Mogul and NAPA, supply this seal along with the new hub assembly.



Most fwd bearings are double-row angular-contact style, and are prelubed at the factory and sealed for life. Others use tapered rollers, and may not be sealed.

buy or rent a couple of special tools. First, you need a 3/4-in. breaker bar to loosen the hub nut on the end of the axle shaft.

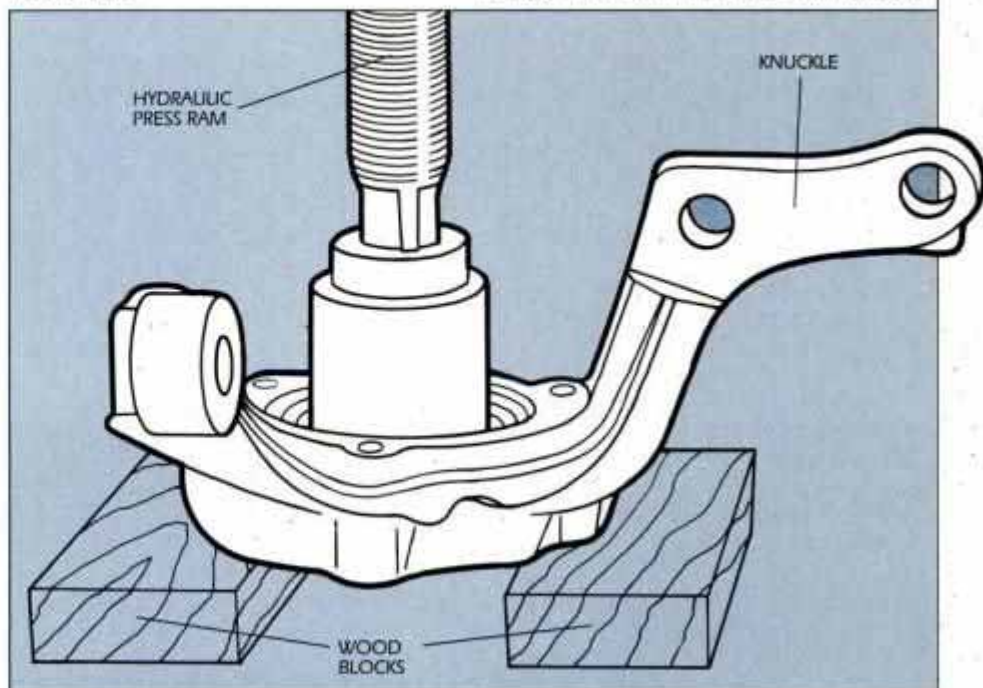
The torque specifications for these nuts vary, but they are typically tightened from 185 ft.-lb. to 225 ft.-lb. Use a 1/2-in. bar to loosen one, and you'll end up with a bent bar and the nut still won't have budged. If you must use a 1/2-in. bar, at least use one with a warranty so you can return it for a new one later.

And once you have the new bearing installed, your final act—save for putting on the hubcap—will be to tighten a new hub nut in place. You need a 250 ft.-lb. torque wrench to do this.

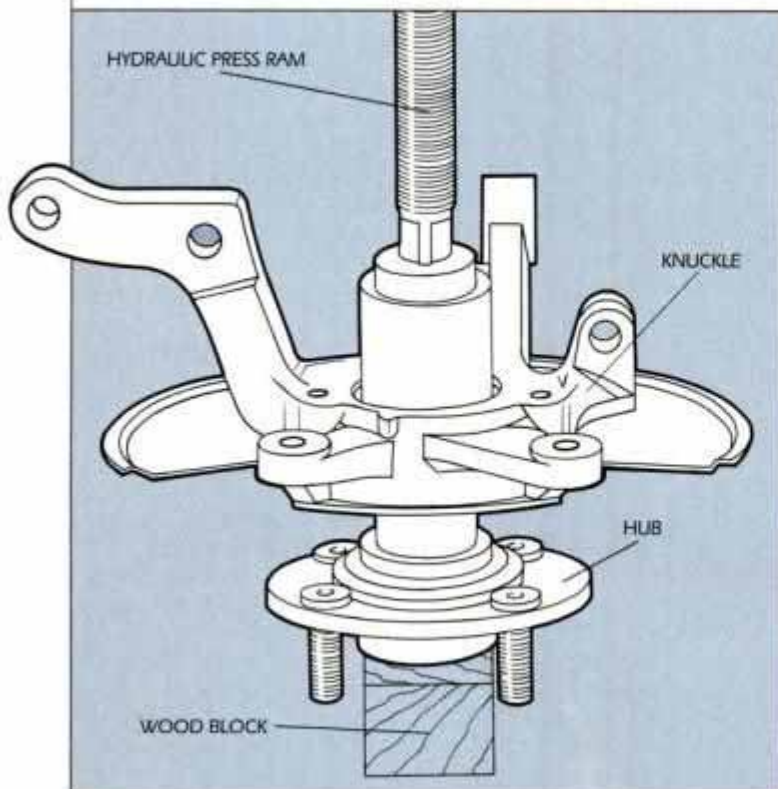
Don't even think of using an impact gun to tighten or loosen the hub nut. Banging off the nut trashes the CV joints in the axle. And banging on one wrecks the new bearing you just installed.

In many cases, you also need a hub puller to pull the hub out of the spindle.

And while you might be tempted, don't try to guess the proper hub-nut torque by using a breaker bar to get the nut "real tight." According to BCA/Federal Mogul, the largest cause of front-wheel-drive bearing failure is improper hub-nut torque—especially if the nut is too loose. A loose nut allows the bearing to bang back and forth in the knuckle.



Any machine shop can use a hydraulic press to remove the old bearing from the knuckle. Wood blocks support the knuckle and provide room for the bearing to drop.



Similarly, press the new bearing into the knuckle with a press. Clean and deburr the bore carefully first.

They also supply a new hub nut.

Before installing the new hub assembly, make sure the steering knuckle is in good shape and that the surface where it mates with the hub assembly is clean and dry. If necessary, polish off any corrosion with crocus cloth.

After the hub assembly is in place, torque its mounting bolts to the proper specification and loosely install the new hub nut supplied with the hub assembly. On Chryslers, reinstall the knuckle. Then, after installing the brake disc and caliper, install the wheel and lower the car to the ground before tightening the hub nut to the proper torque.

Whatever you do, don't move the car before the hub nut is torqued. Moving the car with a loose hub nut will damage the wheel bearings because it allows the axle to bang back and forth inside the bearing.

### A little harder

Ford, many Chryslers and most Japanese cars have front-drive wheel bearings that are pressed into the steering knuckle. This means that you have to remove the knuckle from the car, so that a machine shop or auto parts store can press out the old bearing and press a new one in place.

While the car is still on the ground, loosen the hub nut and lug nuts. On Chryslers, you must remove the

cotter pin first.

Next, raise the car and put it on stands before removing the wheel. Then remove the caliper and brake disc, making sure to hang the caliper with a piece of wire.

With the brake parts out of the way, separate the lower ball joint and the steering tie rod from the knuckle.

There are usually two pinch bolts holding the MacPherson strut to the top of the knuckle. The top bolt fits into a slotted hole. This allows for camber adjustment when doing wheel

alignment. It's important to carefully scribe around the two eccentric washers that clamp the knuckle to the strut. This way, when you reinstall the knuckle, you can turn these washers to the same location and the camber alignment will be close.

After you remove the two bolts holding the knuckle to the strut, the knuckle will come off the car. But don't remove it until you've supported the axle by hanging it from the chassis with wire. Letting the axle hang unsupported can damage the CV joints.

Once the knuckle is off, it's a good idea to check the rubber boots surrounding the CV joints. If you find one that is cracked or broken, now is the time to change it.

### Pressing problem

When you take your steering knuckle to the machine shop or auto parts store, it will press out the old bearing and hub and press a new bearing in place. If the hub is scored or damaged, or the wheel studs are in bad shape, replace the hub.

### Installing the knuckle

Once the shop is done with the pressing, install the knuckle by sliding it onto the axle. Then, mount the knuckle to the MacPherson strut with the two pinch bolts. Before tightening, rotate the top bolt until

the eccentric washers line up with the scribe marks you made earlier.

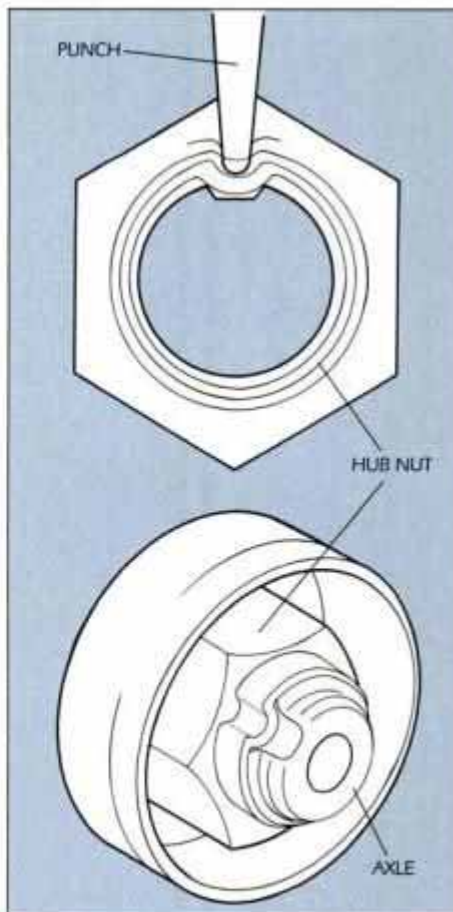
Next, reinstall the lower control-arm ball joint, replacing the ball-joint pinch bolt with a new one if the manufacturer calls for it. In any case, it's important to torque this bolt to the proper specification.

After installing the tie rod onto the knuckle using the proper torque spec, loosely attach the new hub nut and any required washers. Remove the wire you used to hang the axle, and then reinstall the brake disc and caliper before reinstalling the wheel.

With the car lowered to the ground, torque the hub nut to the proper specification as well as the lug nuts, and you can take the car in for a wheel alignment.

And for those of you who grow nostalgic for the ritual of cleaning, lubing and adjusting the front bearings on rear-wheel-drive cars, be of good cheer.

All you have to do is move to the back of your front-drive car. There, you'll find stationary spindles, two tapered wheel bearings and the grease seals you're used to. And they need periodic service just like the front bearings on a rear-drive car. **FM**



Finally, torque the hub nut and stake or cotter pin it to keep it secure.

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**B** FIRST MEANS



**DRIVE A BETTER CAR**

## MAINTENANCE BASICS

# TRANSMISSION INSPECTION

BY DON CHAIKIN,  
Contributing Editor

• While your engine might be at the top of its game, your transmission may not be taking full advantage of the engine's output. If you neglect the transmission, you are not fully maintaining your vehicle's drivetrain.

Begin by checking the level and the quality of the lubricant in the transmission.

• Most automatic transmissions have a dipstick so you can check the fluid level. This check may be done with the engine running and idling, or the engine off—check your owner's manual.

• Some manual gearboxes for front-wheel-drive cars have dipsticks. On some, the dipstick may be the speedometer cable. Check your owner's manual.

• Manual gearboxes on rear-wheel-drive vehicles do not have dipsticks. Check the oil level from underneath. Remove an inspection plug on the side of the gearbox housing—the oil level should be up to the bottom of the plug's hole.

Top up the transmission, if necessary, using the lubricant specified by the carmaker.

• Some manual gearboxes may require a specific grade of oil or possibly automatic transmission fluid.

• There are different types of automatic transmission fluids—only use the type specified in your owner's manual.

• Do not overfill any gearbox—automatic or manual. If you overfill a manual gearbox, you can increase internal drag and create leaks.

In addition to checking the level of the transmission's lubricant, check its quality.

• Most carmakers recommend draining and refilling the gearbox lubricant periodically.

• Automatic transmissions also have an internal filter to keep crud from getting into the sophisticated transmission valve body. This filter must be cleaned or replaced periodically. This requires draining the fluid first and possibly removing the transmission oil pan.

Next, check the exterior of the gearbox.



Check the operation of the various shift linkages of your automatic or manual transmission. Lubricate the pivots with a water-resistant, light lubricant.

• Raise the car and put it on safety stands or ramps.

• Look for leaks at the seals and gaskets. A leaking seal must be replaced. You may be able to cure a leaking gasket by tightening the bolts.

• Be sure that any vacuum tubes are connected and not cracked or torn.

Also inspect all the linkages that control the transmission's operation.

• Check shift linkages to see that they are clean and not sticking. Have a helper move the shift lever through all quadrants as you check the linkage movements.

• On automatic transmissions with a

mechanical, throttle-operated kick-down, have your helper tromp the accelerator pedal (engine off) while you check the operation of the kickdown linkage.

• On manual transmissions, have your helper step on the clutch pedal. Check the clutch linkage operation to see that it moves smoothly.

• Use an aerosol cleaner to remove corrosion and built-up grease and grime from the joints of the linkage. Use a brush if needed.

• Lubricate the linkage joints with a light oil or water-resistant white grease.

PM

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PM635i



## HOW IT WORKS

# ALTERNATOR

BY DON CHAIKIN,  
Contributing Editor

● Each time you turn the ignition key, you take it for granted that your car or truck's battery will have the moxie to spin the starter motor with enough verve to start the engine. It is the responsibility of the alternator to ensure that the battery is fully charged and ready to go.

### Generator with a difference

The alternator under your hood is an engine-driven electric generator that produces alternating current (AC).

An alternator produces current using the same basic principle used by all electric generators—by passing a loop of wire through a magnetic field.

In an alternator, unlike in a typical direct current (DC) generator, the magnetic field moves while the wire loop is stationary.

Current from the battery flows through the alternator's brushes where it is picked up by slip rings on the end of the rotor's shaft. This current flows through the wire windings in the center of the rotor, which then magnetizes the soft metal rotor.

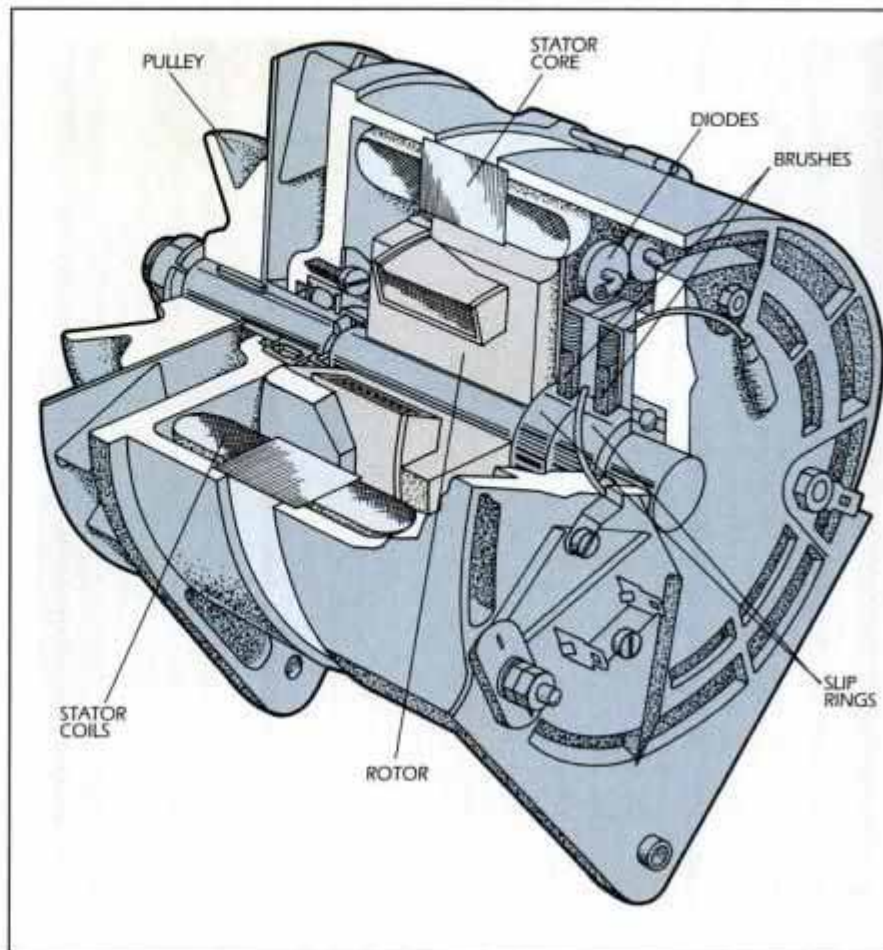
The rotor consists of two halves, with interlocking, triangular-shaped fingers. These fingers are the magnetic poles. All the fingers on one half of the rotor are north poles, those on the other half are south poles. The rotor is spun by an engine-driven belt.

Surrounding the rotor are wire coils wound around a soft, layered iron core in the alternator's housing. These coils and an iron ring make up the alternator's stator. As the magnetized rotor spins inside this stator, electricity is generated inside its windings.

### Rectifying the alternating condition

The alternator's rotor spins continually in the same direction. However, since the rotor's interlocking halves are opposite magnetic poles, the magnetic field created by the spinning rotor is constantly being reversed. This constant reversal is what defines alternating current.

In order for your car's elec-



An alternator is simply a mechanically driven electric generator, which produces alternating current in its stator. This current passes through the diodes to become direct current to charge the battery and run electrical accessories.

trical system to use the electricity generated by the alternator, it must be converted to direct current before it even leaves the alternator.

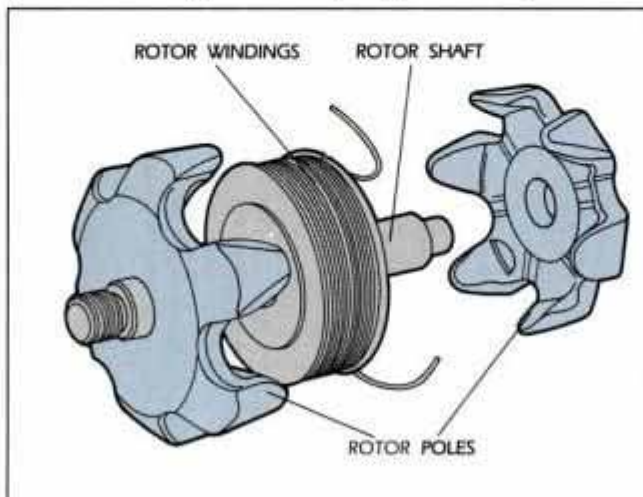
This task is performed by rectifiers, or diodes. These small (dime-size) devices are silicon semiconductors. They act as one-way valves, allowing electricity to pass through

them in only one direction. As the constantly reversing electric current leaves the stator, it passes through the diodes, which convert the AC to direct current.

### Regulating the flow

The faster any generator turns, the more electricity it produces. Since alternators are lighter than old-fashioned DC generators, they are geared to spin faster, producing more electricity at slower speeds. To prevent the alternator from producing too much current at higher speeds, its output must be controlled. If the alternator generates too much current, it overcharges the battery and causes other electrical system damage.

An alternator's output is controlled on the input side. A regulator governs how much voltage goes to the rotating electromagnet, controlling the strength of the magnetic field and therefore the amount of electricity generated. **PM**

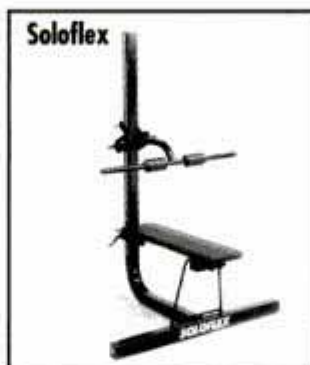


The triangular-shaped fingers of the rotor halves are the magnetic poles. The alternating of north and south poles causes the generated electric current to alternate.

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| <b>2</b> Easy to use  | <input checked="" type="checkbox"/> YES No assembly/disassembly required between exercises.  | <input checked="" type="checkbox"/> NO Requires assembly/disassembly between exercises.   | <input checked="" type="checkbox"/> NO Requires assembly/disassembly between exercises.   |
| <b>3</b> Leg Extension Unit included                            | <input checked="" type="checkbox"/> YES Permits both leg extensions and lying leg curls.   | <input checked="" type="checkbox"/> NO Costs \$200 extra.   | <input checked="" type="checkbox"/> YES, <b>BUT...</b> Leg unit included doesn't permit lying leg curls.  |
| <b>4</b> Butterfly Unit included                                | <input checked="" type="checkbox"/> YES No extra cost.   | <input checked="" type="checkbox"/> NO Costs \$200 extra.   | <input checked="" type="checkbox"/> YES, <b>BUT...</b> You must assemble before each use, and disassemble to use bench press.                               |
| <b>5</b> Strength conditioning for all five major muscle groups | <input checked="" type="checkbox"/> YES <b>HEALTHMAX</b> strengthens all five: arms, legs, abdominals, back and pectorals.             | <input checked="" type="checkbox"/> YES, <b>BUT...</b> You must purchase \$400 in extra accessories to do comparable exercises for legs and pecs. | <input checked="" type="checkbox"/> YES, <b>BUT...</b> Why would you pay \$700 more than <b>HEALTHMAX</b> ?   |
| <b>6</b> Comfortable bench                                      | <input checked="" type="checkbox"/> YES Padded bench is a full 47" long, 12" wide, and a comfortable 20" high.                         | <input checked="" type="checkbox"/> NO Padded bench is only 40" long, making some lying down exercises awkward.                                   | <input checked="" type="checkbox"/> NO Padded 40" bench is short, narrow (only 9" wide), and too high (24") off the ground.                                 |
| <b>7</b> Hydraulic cylinder resistance system                   | <input checked="" type="checkbox"/> YES Adjusts to your personal resistance level with a simple twist of a dial.                       | <input checked="" type="checkbox"/> NO Uses rubber bands which must be changed to vary resistance level.  | <input checked="" type="checkbox"/> NO Uses complicated cord/pulley/mechanical resistance system.   |
| <b>8</b> Full refund of return freight if unit returned         | <input checked="" type="checkbox"/> YES If not satisfied, we will refund your cost, shipping/handling charges, and all return freight! | <input checked="" type="checkbox"/> NO You pay over \$85 to return. It must go by truck to Oregon!  | <input checked="" type="checkbox"/> NO You pay about \$65 to return by UPS.   |
| <b>9</b> Payable in installments                                | <input checked="" type="checkbox"/> YES 9 easy installments of just \$36.56!<br>(\$49.00 S/H added to first installment.)              | <input checked="" type="checkbox"/> YES, <b>BUT...</b> You pay \$39 per month for the next 2 YEARS!   | <input checked="" type="checkbox"/> YES, <b>BUT...</b> At 4 payments of \$250, each installment is almost as much as the total cost of a <b>HEALTHMAX</b> ! |



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## NEW PRODUCTS

### IMPROVE YOUR CAR

#### Locking Shifter

If a thief breaks into your car and starts the engine, he still won't be able to drive it away if he is unable to shift the automatic transmission out of PARK. That's the theory behind the new S/S Shifter Loc from Hurst Performance. The unit is essentially a pistol-grip shifter handle with a key-lock cylinder, which replaces the stock button-actuated handle on floor-mounted shifters. Currently, S/S Shifter Loc fits most GM floor-mounted automatic transmission shifters with a 1/2-in.-dia. stick. After you have moved the shift lever to PARK, lock it in place with the key. Price is \$49.50, from Hurst Performance, 8700 Brookpark Rd., Cleveland, OH 44129; (216) 398-8300.



#### Pickup Truck Tent

Anyone who owns a pickup knows sleeping is a bit better in the cargo bed if it's covered. Enter the Sportz Truck Tent. It is a nylon dome tent designed specifically to fit in the cargo box of a pickup truck. Available in five different sizes for most trucks, the Sportz Truck Tent is similar to other dome tents. The tent has a screened door and windows for ventilation, a polyurethane floor and a fitted rain fly. The rolled tent fits into a small sack. Price is \$169.95 for full-size trucks, \$159.95 for compacts, both plus shipping. From Napier Enterprises, 2315 Whirlpool St., Suite 161, Niagara Falls, NY 14305; (800) 567-2434.

#### Seven-Spoke Alloy Wheel

Aftermarket wheels continue to be one of the most popular and effective ways to personalize your car. To help you, Ronal International has introduced a new 3-piece 7-spoke wheel, called the ACT SX. The ACT SX has a silver-painted, all-aluminum center section mated to cold-rolled polished aluminum halves. The wheel is protected with a clearcoat finish. The ACT SX is available in 16-in. through 18-in. sizes. Price is about \$550 per wheel, depending on size. From Ronal International, 15692 Computer Ln., Huntington Beach, CA 92649; (714) 891-4853.



#### Radar/Laser Detector

More and more speed-conscious drivers are turning to laser detectors to complement their radar detectors. For their convenience, Cincinnati Microwave has introduced a combination radar and laser detector, the Escort 4500. The pocket-size unit detects X-, K- and Ka-band radar frequencies as well as laser. The unit is claimed to discriminate between lights from other sources and laser, plus it filters "false" radar alarms. The \$229 Escort 4500 is available from Cincinnati Microwave Inc., 5200 Fields-Ertel Rd., Cincinnati, OH 45249; (800) 433-3487.



#### High-Performance Shocks

Saleen Performance, the Mustang tuners, has a new line of shock absorbers and struts matched to the suspension settings of Saleen's springs. The shocks are of a low-pressure gas design and have been specifically designed for cars with lowered suspensions. The struts feature high-performance urethane upper bushings. For even more handling and ride control, Saleen offers custom valving for road racing, autocrossing and drag racing applications. Prices are \$59 for each front shock, \$119 for each strut. From Saleen Performance Parts, 3080 E. 29th St., Long Beach, CA 90806; (310) 595-5964. **PM**





# STRETCH DRIVE

BY JEREMY SHAW



● With a dozen memorable events completed and four races left to run as we went to press, the 1993 IndyCar season had resolved itself into a 2-team battle, between Newman-Haas Racing and Penske Racing. Team PM/Dick Simon Racing, however, had earned the distinction of being the only other team capable of mounting a consistent challenge.

The Lola/Fords of Nigel Mansell and Mario Andretti and the Penske-Chevrolts of Paul Tracy and Emerson Fittipaldi had established themselves as this season's haves, winning 11 of the first 12 races. But Team PM drivers Raul Boesel, Scott Brayton and Jimmy Vasser herded their Lola/Fords to consistently respectable finishes, with Boesel, in particular, poised for a breakthrough into the victory circle.

It is clear that Mansell added an extra dimension to the championship. The level of competition was higher than ever before and international exposure increased enormously.

The well-financed Newman-Haas and Penske teams held another significant advantage over their rivals in that they received preferential support from their respective engine suppliers—Ford (via Cosworth Engineering) and Chevrolet.

Sure, the Ford-Cosworth XB and Chevrolet Indy V8/C engines were available to other teams, but when horsepower-enhancing improvements came along they went to the franchise teams first.

Most recently, the Ford engine benefited from new camshafts and a

revised injection system that's worth, according to knowledgeable estimates, an extra 35 horsepower at peak rpm. The difference was especially noticeable on the high banks of Michigan International Speedway, where the Newman-Haas Lolas were consistently 5 mph faster than cars propelled by the older edition of the Ford-Cosworth XB.

Top speed didn't matter quite as much on the smaller 1-mile New Hampshire International Speedway oval, however, and Boesel showed once again that he could make his Duracell/Mobil 1/Sadia Lola run with the best, qualifying just six-thousandths of a second behind



Raul Boesel emerged as the top challenger to 1993's deep-pocket IndyCar teams.

Mansell in the fight for the pole.

Boesel battled on even terms with Mansell and the two Penske cars for 120 laps before a brush with the wall took him out.

"There were a lot of cars in front of me and suddenly my car lost downforce, I think from all the turbulence," Boesel explained. It was the first race this season in which he failed to score points.

Though they were farther back on the starting grid, Boesel's Team PM colleagues Scott Brayton and Jimmy

Vasser fared better in New Hampshire. Brayton ran a consistent pace to claim sixth place in his Amway/Northwest Airlines Lola/Ford-Cosworth, while Vasser overcame clutch problems to finish ninth in his Kodalux/STP entry.

"It was a really exciting race and I'm really pleased," commented Brayton. "That's the best racing I've had this year."

When the IndyCar contenders moved on to Road America in Wisconsin two weeks later, Team PM was looking forward to having the updated Ford-Cosworth XB engines, but at the last minute they failed to materialize.

Boesel nevertheless qualified an impressive fourth, more than a full second faster than the next Lola/Ford, and also ahead of Fittipaldi. Unfortunately, his chances for that first IndyCar victory were dealt

a severe blow during an early full-course caution period, thanks to garbled radio communication with the pits.

As a result, Boesel stopped early and out of sync with the rest of the pack. While this helped him run as high as second at one point, subsequent stops put him back to midpack and he did extremely well to fight his way back to fourth by the end of the race.

Brayton drove another steady race to finish seventh and move up two places in the PPG Cup point standings to 13th.

Boesel, for his part, seemed to be very likely to carry Team PM colors into the top-five in the final points standings.

PM

## AUTOMOBILES

# DETROIT SPY REPORT

BY JIM DUNNE, Detroit Editor



### Riviera, 1995

Buick will offer this 2-door personal luxury model as a replacement for the Riviera. Look for its debut in showrooms next spring, though Buick will display the car at shows early in 1994. Built on the same chassis as the Oldsmobile Aurora (but with two doors), Riviera will have a 3.8-liter V6 as its standard engine and an optional supercharged 3.8-liter V6 engine in the 250-horsepower range. Note the family resemblance to the Park Avenue's front-end styling. This is a fairly large coupe, with an overall length of about 205 in. and a wheelbase of 113.8 in. Price? Probably about \$30,000.

### Another Sport/Ute

Kia, a Korean company best known here for building the Festiva subcompact for Ford, will market this tidy little sport/utility vehicle starting with the 1994 model. This is the 2-door version of the Sportage. Compare it to the Suzuki Samurai in overall dimensions. Wheelbase is 93 in., and overall length is 128.5 in. Two 2.0-liter engines will be offered: a 95-hp single-overhead-cam Four and a 135-horsepower dohc Four. A larger 4-door Sportage has already been announced. Both models are 4-wheel-drive equipped.

### Rotogate

Mercedes has a machine tool that can clamp and weld four different body styles on one assembly line. Called "Rotogate," the single machine will weld 2-door, 4-door, wagon and convertible bodies automatically.

For auto folks, the advantages are

sets of fixtures and welding guns. As a new body enters the line between the wheels, they rotate so that the correct tools are lined up with the body. Then the body parts are fixed and welded. As the next body moves into the Rotogate area, the wheels automatically rotate to the correct welding position.

### Opel U.S.A.

In 1996—for the first time—Opel will offer a built-in-the-U.S.A. vehicle. GM plans to build an Opel version of its compact van here in the United States, and sell the vehicle in Europe. The van is the new design for Chevrolet Lumina, Pontiac Trans Sport and Oldsmobile Silhouette. Unlike the current plastic-panel vans, the new vehicle will have an all-steel body. A passenger-car power pack—front wheel drive, 4-speed automatic transmission, V6 engine—will be standard. However, Opel may also offer a 4-cylinder engine for European buyers. A major innovation will be an optional sliding door for the driver's side.



Korean automaker Kia brings the Sportage 4x4 sport/utility to our shores in '94.

enormous. Rotogate eliminates the need for four separate body lines, with their own special fixtures and welding systems.

The machine consists of two large wheels set at the sides of the welding line. Attached to the wheels are four

### Chevy Simplifies


Chevrolet will simplify its small-car lineup during 1995 and 1996. The names Corsica and Beretta will be dropped. The Cavalier will offer a 4-door version of the popular Z24 model. The Geo Storm, formerly supplied by Isuzu, will be discontinued

*(Please turn to page 122)*

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1995 Grand Marquis gets new grille and sheetmetal.

lights, too. While major dimensions and drivetrain will be similar to those of the current Marquis, look for new sheetmetal styling on every exterior panel except the roof. (On this model, only the grille and bumper are new. Mercury uses this setup for early testing of engine cooling.)

for one year, and then the name will reappear as a new model for the 1996 model year. Replacing the Corsica and Beretta will be a new 4-door built on GM's N body, the same one now used by the Pontiac Grand Am, Buick Skylark and Oldsmobile Achieva. At the same time, Chevy will offer a steel-body replacement for the Lumina van (see "Opel U.S.A."). This model will offer a driver's-side sliding door option.

### New Face For Marquis

Mercury will put this new grille (shown above) on its full-size Grand Marquis sedan as part of 1995's major restyling program. In addition to the Lincoln resemblance up front, the car will have Lincoln-like tail-

### Sleeker Continental

Lincoln will have this 1995 Continental (shown below) ready for production next spring. Sheetmetal styling changes are car-wide. They make the body appear longer, wider and heav-



Continental gets longer, lower, wider look, as well as 4.6-liter modular sohc V8 engine.

ier. A big change takes place under the hood, too, where the Lincoln Town Car's 4.6-liter V8 engine is nestled. Continental will drop the 3.8-liter V6 engine from its lineup—all the better to compete with Cadillac's overhauled De Ville lineup and to undercut some of the more expensive V6-powered imports.

### Chrysler's JA

Chrysler started its current product revolution with LH as its big car code name. Next came PL, the code for Neon. Now the code is JA, for the compact sedans Chrysler is planning to introduce next year as replacements for Spirit and Acclaim. JA will look much like the LH models, featuring by-now familiar "cab forward" styling, with wheels set out to the far

corners of the chassis, and will offer both 4-cylinder and V6 engines. Rear suspension systems will be new, too. JA will have independent rear suspension—a first for Chrysler in its compact-car designs.

### Pricey Wheels

Chrysler released some surprising details about steering wheel costs. If you order a steering wheel with a plain painted rim, Chrysler's cost is one dollar. Put a leather cover on that wheel, and Chrysler's cost goes up to \$22 to \$25. Then, if you want a foam pad under the leather wrap, Chrysler has to shell out \$23.75 to \$25.75. It's items like these that separate luxury cars from plain Janes. You need a huge advantage in your invention if you want the auto companies to buy. Take a minor change in steering wheels. Wheels are safety devices that need expensive testing to gain acceptance. Chrysler engineers point out that tests must be made for airbag deployment, color, horn life, horn position, gauge visibility and material life before they are okayed for production. Crash tests for airbag safety are expensive and take time. So the auto engineer tends to keep the designs that are proven, not considering new devices unless they promise a breakthrough. **PM**

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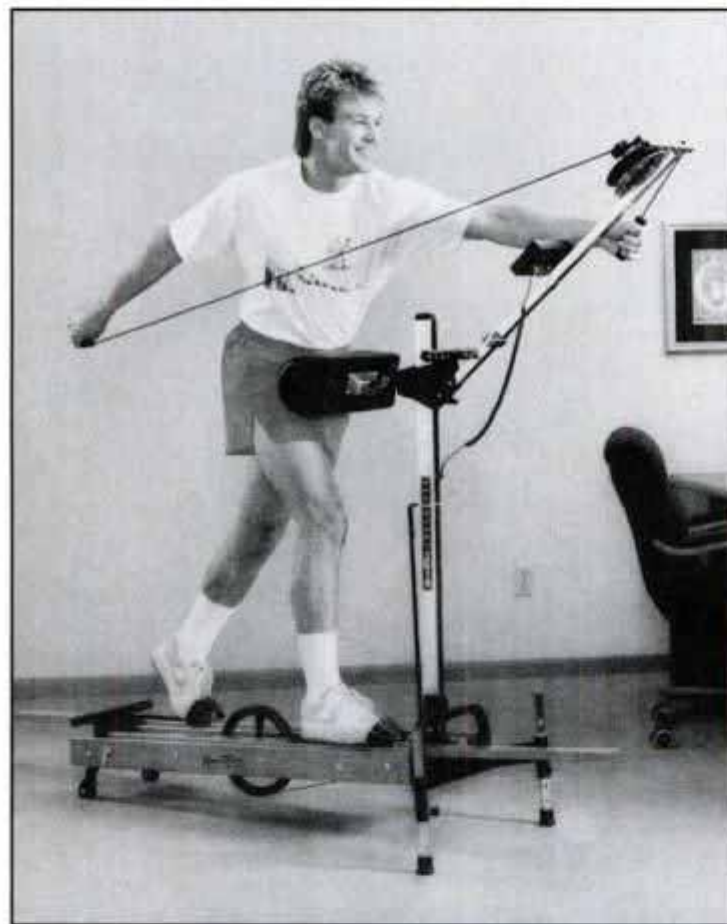
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# FREEWAY TO MARS

BY GREGORY T. POPE



• You won't hear much public talk from NASA these days about manned missions to Mars, particularly after last summer's *Mars Observer* fiasco. But that doesn't mean there aren't people at the space agency quietly planning man's first steps on the Red Planet.

The storyboards of that visit have changed radically since 1989, when then-President Bush asked NASA to reach anew to the Moon and Mars. Gone is the \$300-billion architecture of NASA's initial response to his directive. That plan, the so-called 90-Day Study, featured a monstrous 700-ton vehicle, assembled and fueled in low Earth orbit. Dubbed "Battlestar Galactica" by its detractors, the leviathan would have dwarfed space station *Freedom*.

Instead, a leaner script has taken over. You blast off from Earth and go straight to Mars. You explore. Then you rocket home. No assembly required.

Key to this simplicity is traveling without excess baggage. There's no need to lug your return-journey's rocket fuel along with you. Instead, you can manufacture it on Mars.

The most zealous advocate of the new approach is Robert Zubrin, senior engineer at Martin Marietta

Aeronautics. "This is a manned Mars mission reduced to Apollo times two," he argues. "You don't need giant interplanetary spaceships from the realm of science fiction. This is something you could actually conceive of us doing."

Back in 1990, Zubrin first broached the idea under a proposal

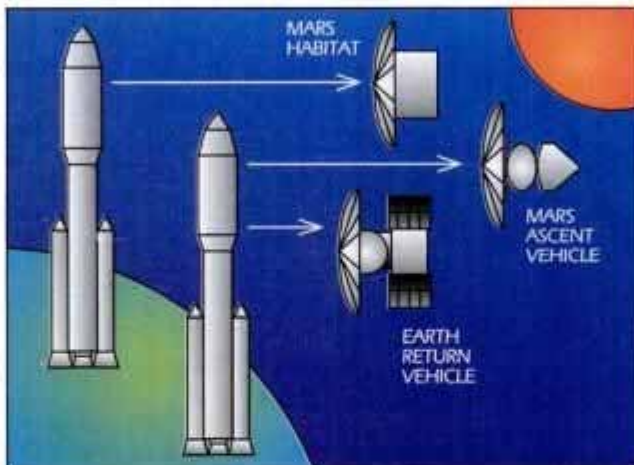
chemical-processing plant.

This last item, powered by the nuclear plant, goes to work as soon as the payload lands. Inside, two chemical processes begin to bubble. One causes the hydrogen brought from Earth to react with carbon dioxide from the Martian atmosphere. The output: methane and water. The second reaction, familiar electrolysis, splits the water into hydrogen and oxygen.

Pumps compress and store the oxygen and methane. Meanwhile, the hydrogen is cycled back into the first reaction. Eventually, the plant creates methane/oxygen rocket fuel with 18 times the mass of the hydrogen brought from Earth.

Scene two: A pair of heavy-lift launch vehicles leave Earth two years after the initial blastoff. One carries a duplicate of the first payload: reactors and a return vehicle. The other carries four crew members in a surface habitat, equipped with three years of provisions and a ground rover.

Both payloads touch down near the original Mars landing site, where a fueled-up Earth return vehicle is now standing by. The pioneers explore for a good year and a half, then ride home in a return vehicle—either



Mars Direct (top) lands nonstop return vehicle. In Semi-Direct (above), ascent vehicle docks with an orbiting return vehicle.

he called Mars Direct. That mission would follow a 2-part scenario.

Scene one: A heavy-lift rocket hurls a single unmanned 40-ton payload toward Mars. The package contains an unfueled Earth return vehicle, a 50-kilowatt nuclear reactor, a few tons of liquid hydrogen and the pivotal technology—an automated

the original craft or the one that came with them as a backup.

And that's Mars Direct. Obviously, the mission's success hinges on the chemical reactor and its in-situ propellant production. But Zubrin confidently characterizes the processes as "19th-century chemical engineering." Indeed, engineers at Old Dominion University and the University of Arizona have built laboratory-scale reactors that show the technique to be feasible.

Mars Direct piqued interest at NASA's Johnson Space Center. Mission designers there, however, raised qualms about the architecture. Zubrin and the Johnson group have subsequently restructured the scenario into a mission known as Mars Semi-Direct.

The big difference: Instead of sending the Earth return vehicle straight to the Martian surface, Semi-Direct lands a smaller Mars ascent vehicle. Meanwhile, a fully fueled Earth return vehicle swings into orbit around the planet. When it's time to bid adieu to Mars, the ascent vehicle lifts off and docks with the return vehicle.

The advantages? The return vehicle can be made roomier for Mars-weary explorers. And because only a third as much propellant need be manufactured—just enough to lift the ascent vehicle into Mars orbit—power requirements are less daunting. Even if in-situ propellant production fails as a technology, the ascent vehicle is small enough that it could be flown to Mars fully fueled, at the cost of another heavy-lift launcher.

Two disadvantages loom, however. One, the explorers can't inspect their Earth return vehicle—"kick its tires," as Zubrin puts it. And two, if the orbital docking maneuver doesn't come off, everyone is stranded.

Still, the Johnson group likes Semi-Direct enough that it has become the basis for the current design reference mission study. Says Johnson's Mike Duke, "We need some kind of demonstration that will convince people that it's a conceivable way to go."

One possibility is an unmanned sample-return mission, in which a robotic spacecraft journeys directly to Mars, manufactures its return fuel and then flies back to Earth, clutching a 60-pound chunk of Martian geology. At the University of Washington, aerospace engineering professor Adam Bruckner and a cadre of students recently fleshed out this idea and presented it to NASA, meeting enthusiasm. The sample-return vehicle would not only bring a piece of Mars to mankind—it would foreshadow a mission that brings mankind to Mars. **PM**



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## OUTDOORS

# SALMON AT THE BRINK

BY JOE SKORUPA, Boating/Outdoors Editor



PHOTO BY DOUG WOODHURST LIGHT

● Baseball great Ted Williams is a man of many talents, not the least of which is charm. Did I say charm? I know this runs counter to the familiar image of this Hall of Famer as a hot-headed slugger, but a couple of years ago I spent three days in Florida fishing with Ted, and came away impressed with his intelligence, wit, energy, curiosity, depth of knowledge on a variety of subjects and, yes, easygoing manner.

Well, to be perfectly honest, Ted does have a habit of testing strangers early in a conversation by pinning them down to gauge the level of BS being tossed about. But, when you pass the test, he resumes his natural manner, which I can only describe as charming.

Whenever I think of Ted Williams, two things leap to mind: The first is that I'm an idiot for not getting my picture taken with him, and the second is how amazingly pro-conservation he is. We probably spent more time talking about the degradation of fishing stocks, especially those of Atlantic salmon, than about any other subject. In retrospect, I guess it's not so surprising. The plight of salmon on both coasts is extraordinarily bleak.

In 1805, when Lewis and Clark received a gift of Pacific salmon from a tribe of Nez Percé Indians along the Snake River in what is now Idaho, biologists estimate that 16-million

adult salmon and steelhead returned each year to the Columbia River Basin to spawn. In the mid-1980s, the number was 2.5 million (including ocean catch), and 75% of those were hatchery-raised fish. In 1991, only 1-million salmon and steelhead entered the mouth of the Columbia River.

The West's fabulous migratory spectacle, which dazzled not only Lewis and Clark but also pioneers traveling on the Oregon Trail, has been reduced to a shadow of its former glory. On the East Coast, where Ted Williams once fought a 30-pound salmon in a feeder stream using light fly gear, it was virtually wiped out.

This is a tale of two coasts, where parallel stories unfold along a different timetable but share a common ending—the battle against extinction.

On the West Coast, where there are still fish to count, salmon and seagoing trout are at dangerously low levels. Of the 55 stocks evaluated by the Oregon Department of Fish & Wildlife, 41 were classified as depressed, two populations were classified as of special concern and six stocks were ominously listed as of unknown status.

In Northern California, where the chinook salmon run was extir-

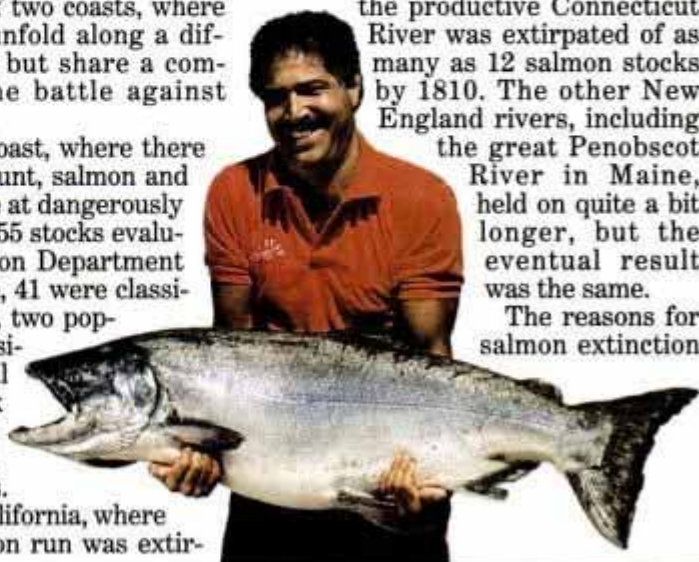
pated on the San Joaquin River in 1948 by the Bureau of Reclamation, 35 existing stocks of chinook and coho salmon are faced with extinction. Estimates indicate that there are fewer than 5000 wild coho salmon now spawning in all of California.

In the Puget Sound area of Washington, 41 salmon stocks are classified as being at risk of extinction or of warranting special concern.

In Idaho, where Lewis and Clark first witnessed the massive runs, four individual sockeye salmon and 76 wild chinook made it in 1991.

On the East Coast, where pressure on fish populations began long ago, the productive Connecticut River was extirpated of as many as 12 salmon stocks by 1810. The other New England rivers, including the great Penobscot River in Maine, held on quite a bit longer, but the eventual result was the same.

The reasons for salmon extinction





aren't hard to understand. They include: pollutants entering rivers from agricultural runoff, acid rain, over-siltation caused by development on erodible slopes (this includes grazing, logging and mining) and over-fishing by drift netters at river mouths and ocean feeding grounds.

Despite this long list of threats, the major culprit is dams. They are not only formidable obstacles to migrating fish, but are sources for a host of other problems, such as: the creation of warm, slow-moving reservoirs that impede the downstream migration of juveniles, the setting of water levels too low to sustain fish and the installation of deadly hydroelectric turbine blades.

Most people have seen the network of Rube Goldberg-style chutes and ladders that some dams install to help salmon migrate upstream, but few realize that the real danger for the fish is in returning downstream. The young smolts not only have to swim twice as hard through the series of slackwater lakes that now make up a modern river, fight off predators that pick them off in the slow current and avoid swimming into diversionary irrigation canals, but when they approach a hydroelectric dam, they also have to confront a high-speed turbine.

Most fish interpret the increased waterflow near a turbine to be a place of strong current and are sucked into the spinning blades. The series of 19 hydroelectric dams on the Snake and Columbia Rivers causes a mortality rate of between 91% and 99% of the smolt migration, depending on the species. By contrast, only between 1% and 7% is lost to commercial fishing.

So that's the grim picture of salmon in the United States. What can be done? On the East Coast, the plan is to restore the runs by using non-native species. So far, the effort has paid off in limited dividends in the Penobscot and a few other rivers in Maine. Two big events that threatened the restoration plan were overcome in the mid-1970s and the late '80s by international treaties. These occurred when Danish drift netters first found the Atlantic salmon's previously unknown feeding grounds near Greenland, and then Newfoundland drift netters began intercepting salmon just outside their native rivers. In both cases, Atlantic salmon stocks collapsed across national boundaries, and the situations required international cooperation.

On the West Coast, many of the traditional salmon rivers may be beyond the possibility of restoration,

such as California's San Joaquin and Idaho's Snake. The problem in these and several other major rivers is the existence of dams without passable routes for the fish. Right now the effort on these rivers centers on catching adult fish and transporting them around the dams. Clearly, this is an unworkable solution, and the results have been poor.

While it's impossible to undo the damage caused by dams on some rivers—the Columbia River with its Grand Coulee and Bonneville Dams comes to mind—there may be a way to fully restore many others, such

as the Kennebec in Maine and the Rogue in Oregon. On these rivers, dams exist that are obsolete, marginal or abandoned. An effort should be made to identify such dams and remove them. Then, with a sound restoration plan in place, salmon can resume their annual migratory spectacle.

Recently, the federal government agreed to remove works built in Southern Florida by the Army Corps of Engineers that were slowly strangling the Everglades. Removal of destructive dams on prime rivers should be next on the agenda. **PM**

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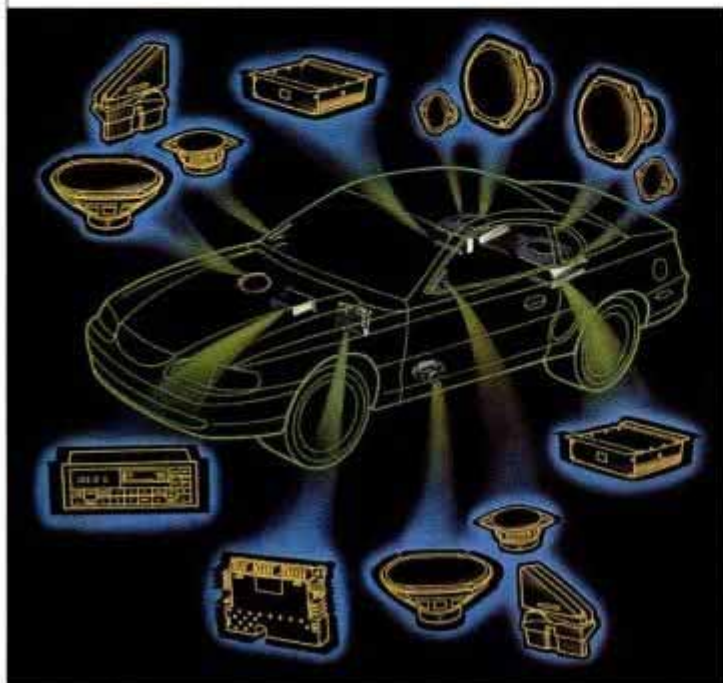
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# ROAD MUSIC

BY FRANK VIZARD, Electronics Editor



Ford's new Mustang features a great-sounding audio system (components seen in the diagram at left). The key element, particularly effective in the convertible version, is the sail speaker in the doors.

● A muscle car used to be defined solely by how much horsepower was under the hood. And while a powerful engine is still a big attraction, for many people an audio system with a lot of muscle is becoming nearly as important to the driving experience.

The importance of sound is evident in a number of new cars just hitting the road. The sonic muscle on display is impressive. By and large, these types of audio systems were once only available through aftermarket car stereo shops. Now they are factory installed.

In driving three of the newest cars

around, some interesting comparisons were drawn. The cars involved were the new Ford Mustang, the Lexus GS 300 and the Dodge Intrepid. Two of the car audio systems were superb, the third less so.

All of these cars are outfitted with a long list of gear familiar to most car audio enthusiasts: compact-disc players or changers, subwoofers for deep bass response and high-powered amplifiers, to name some key components. As a side note, Ford offers a Mini-Disc player as a dealer option.

The key difference, though, is in how each audio system treats the

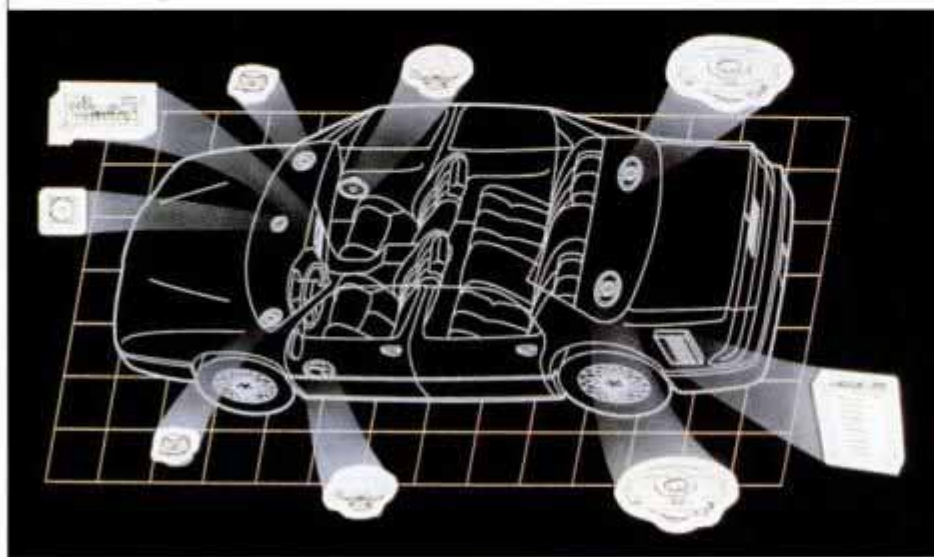
placement of the front tweeters. These tweeters are very important in terms of creating a realistic musical experience. In essence, these speakers are responsible for creating the sound stage.

In both the Ford Mustang's Mach 460 system and in the Nakamichi system of the Lexus GS 300, the critical front tweeters are installed in small enclosures in the "sail" area of the front doors. The sail area is the triangular-shaped area near where the outside mirrors are attached.

By placing tweeters in the sail area, the high frequencies, which are also the most directional, are aimed almost directly at the listener's ears. Musically, the effect is tremendous. The advantages of this tweeter placement are used to the greatest effect in the Mustang convertible.

Generally speaking, tunes played with the top down tend to disappear in the wind or become just a lot of noise. In the Mustang convertible, though, the audio system sounds wonderful even in the open air. The 230 watts of amplifier power, capable of 460-watt peaks, help a great deal, of course.

Similarly, the Nakamichi sound system in the Lexus GS 300 packs a



The Dodge Intrepid, lab tested for noise and vibration, adds a center channel speaker.

lot of power—225 watts. The fact that the Lexus sound system is superb should come as no surprise. When the Lexus LS 400 debuted in 1990, the Nakamichi sound system installed in the car made it the premier mobile listening room around.

In the GS 300, the most noticeable change is the inclusion of ported 4 $\frac{1}{4}$ -in. speakers in the doors. The port appears as a small, separate hole near the actual speakers. By porting the door speakers, bass response is improved. The risk is that ported speakers can sometimes sound boomy, but in this instance, there is no such problem.

Points should also be awarded to Lexus for the large easy-to-use buttons of the in-dash electronics. At the same time, this is one area where the system lets down a bit—FM reception isn't as good as it should be in a system of this caliber.

By contrast, Chrysler's sonic efforts in the Dodge Intrepid weren't as satisfying. In this car, the front tweeters are mounted in the top of the dashboard toward each corner and face upward toward the windshield. Mounted between the corner speakers is a center-channel speaker, which is supposed to firmly anchor the sound stage in front of you.

Unfortunately, when the high frequencies bounce off the windshield glass, they have a tendency to scatter, creating a harsh and unmusical experience. This problem is compounded by speakers that seem unable to handle the 120 watts produced by the trunk-mounted amplifier. Even at moderately high volume levels, these speakers quickly broke up, producing lots of distortion.

Clearly, when it comes to sound systems, some carmakers have their ears better tuned than others.

### Lighter Speakers

With an eye toward the increasing demand for fuel efficiency in cars, speaker manufacturers are developing a new breed of very lightweight car speakers.

Kenwood, for example, has a new design that reduces speaker weight by 80%. Three-fourths of a speaker's weight is attributable to the magnet circuit, comprised of the magnet, yoke and plate. Another 15% comes from the frame.

By contrast, the new Kenwood design uses a compact repulsion magnetic circuit featuring a neodymium magnet inside the voice coil. Very little steel is used, the yoke is eliminated and the frame is lighter in weight.

Pioneer, meanwhile, is using an injection-molded polypropylene com-

posite called Rigilite for its speaker cones. The material is actually a network of microscopic glass balloons filled with air. The resulting speakers are 12% lighter and are actually more rigid than traditional paper speaker cones.

### In-Dash Phone

Cellular phones in cars are nearly as common as radios these days. So it was probably only a matter of time before a car phone was installed in the radio dashboard hole.

Honda is taking this evolutionary step in its 1994 Accord, Prelude and

Acura Integra models, offering the in-dash phone as a dealer-installed option. Actually, the in-dash phone is installed in a hole just above the radio.

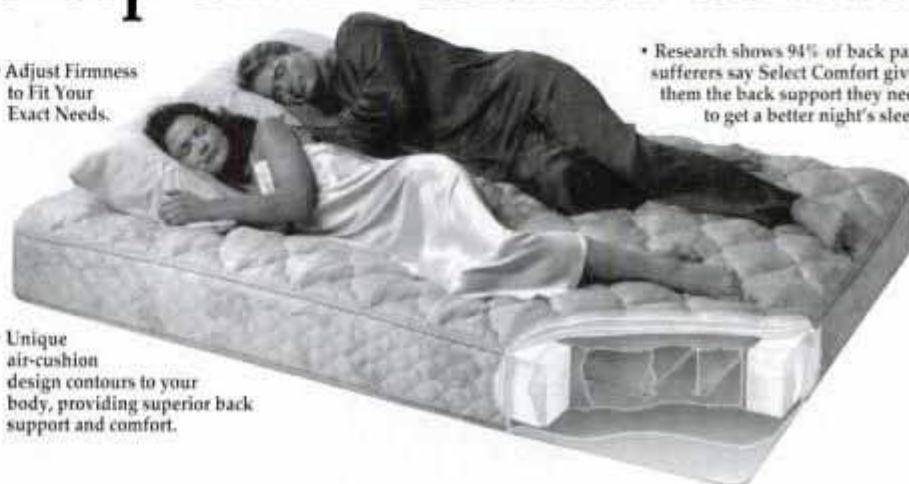
Obviously, the Honda approach is designed to save space. Conversations are heard through the car's audio system speakers. A microphone mounted in the center of the dashboard console picks up the voices of the vehicle's occupants. There's also a small handset available for private conversations.

With this approach, you dial phone numbers the same way you dial in radio stations. **FM**

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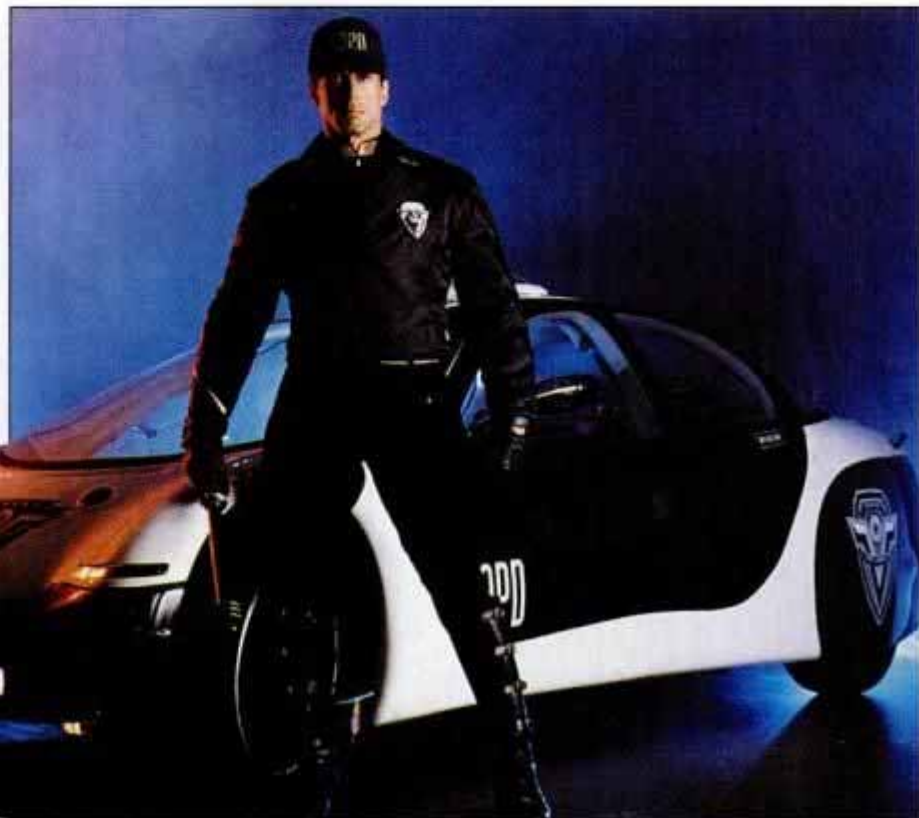
# CARS AS STARS

BY CLIFF GROMER

● Los Angeles, 2032. A city at peace with itself. Crime has been virtually eliminated. Graffiti is a relic of the distant past. The few bad guys that crop up from time to time are frozen in "cryogenic pucks" and stored—the way you store hamburger patties in the freezer—while their brains are subjected to "rehabilitation waves." This is the way the world is in the new Sylvester Stallone/Wesley Snipes thriller, "Demolition Man."

One of the big challenges of any sci-fi film is to make the future look and feel real. That challenge was met in "Demolition Man," by using the latest existing West Coast architecture, and cutting a deal with General Motors to feature 16 of its advanced designs and one '95 production model—not simply as static displays, but making up the normal traffic flow on the streets of Los Angeles.

The star cars credit roll reads like this: **Chevrolet California Camaro**—a near-future 2+2 sports car designed from the California perspective. **Chevrolet Venture**—a utility 4-door family sedan with the performance of a sport coupe. **Chevrolet Corvette Sting Ray III**—a 2-seat sports car that points the way to future Corvettes. **Buick Park Avenue Essence**—a near-term exercise in full-size luxury sedan design and engineering. **Buick Wildcat**—a mid-engine sports car featuring total integration of design, structure, electronics, powertrain, driver and passenger. **Cadillac Aurora**—a test bed designed to examine ideas for an international high-performance luxury sedan. **Cadillac Solitaire**—a highly aerodynamic 4-passenger luxury coupe. **Cadillac Voyage**—a 4-passenger test platform for aerodynamic design, performance and handling. **Pontiac Banshee**—a futuristic performance coupe exploring design and engineering directions for future Firebirds. **Pontiac ProtoSport4**—a feasible 4-door 4-seat ultrahigh-performance sports car. **Pontiac**



**Sunfire**—an affordable 4-seat sport coupe using near-future technology and design concepts. **Oldsmobile Aurora**—a 1995 production 4-door performance luxury sedan, on sale in the spring of 1994. **Oldsmobile Silhouette III**—a 4-seat sport coupe designed to explore the benefits of low-drag shapes. **GM HX-3**—an experimental hybrid-engine vehicle on a passenger-van platform, testing alternative power concepts. **GM Lean Machine**—a motorcycle-based 3-wheel 200-mph commuter car. **GM UltraLite**—an engineering vehicle that tests ultimate fuel economy and packaging techniques in a 4-passenger sedan.

The whole idea behind using GM concept cars in the first place started when producer Joel Silver saw a photo of the GM UltraLite concept vehicle on the cover of the April 1992 issue of POPULAR MECHANICS. Our cover story, "Ultracar," detailed how this vehicle, operational in every respect, would carry four passengers and achieve an unheard-of real-world fuel economy of 100 miles per gallon.

The "Demolition Man" script actually had circulated Hollywood for a

number of years, but it was thought that producing the number and quality of vehicles required for the desired realistic effect was too costly. (The cars make up the film's most important and expensive props.) The vehicles were a real stumbling block—until the GM connection was made.

GM, of course, doesn't fling open its garage doors for just anyone who wants to play with \$69-million worth of its prize hardware. GM first had to be satisfied that its interests were being protected through adequate insurance and legal arrangements. The automaker realized the benefits of turning its cars into celluloid stars. Here, it could roll out an essentially mothballed concept-vehicle fleet, so millions of movie fans could see GM as a positive, forward-thinking company. And this doesn't even include the additional exposure—and cash—value of the inevitable movie side-promotion spinoffs.

Silver saw the UltraLite as a perfect police cruiser, because with all the bad guys on ice, policework had evolved into pretty light-duty stuff. The problem was that the studio needed 12 of these little fuel squeez-



ers, and GM had only one. Not to worry. Warner Bros. lined up noted specialty-car builder Bob Graham to clone the necessary number of UltraLites.

While the body of the original UltraLite was made from expensive carbon fiber, the clones would be dressed in more mundane fiberglass. One of GM's concerns was that the design integrity of the UltraLite be maintained in the copies. Graham had set up operations at a secret skunkworks in Burbank, across the street from the Department of Water and Power. By a sheer stroke of good luck, the man who originally designed the UltraLite, Steve Small, had recently been appointed to GM's Advanced Concept Center, in nearby Newbury Park. A deal was worked out where Small worked his day job from 7:30 am to 4:30 pm, and then went to work on the Warner Bros. clock starting at 6 pm.

UltraLite clones were built up from chromemoly steel tubing, with a central truss-type spine frame. Other deviations from the original UltraLite included torsion-bar suspension, front and rear, versus an independent double-wishbone setup, comput-

er-controlled front and rear on the GM version. Also, the 111-hp 3-cylinder 2-stroke engine in the show car was deferred to a "classified," and presumably more pedestrian, powerplant in the clones. Hughes Aircraft Co., a Los Angeles-based GM subsidiary, came up with the futuristic displays used to spice up the cockpit. The total clone bill to Warner Bros. came to a cool \$2 million, or about a few days anticipated gross receipts when the film opens in early October.

At that time, moviegoers will be treated to the heavy-duty action they've come to expect from Stallone films. Snipes plays a psychopathic, supercreek type named Simon Phoenix. Stallone, cast in his usual misunderstood-and-abused-good-guy-who-gets-even-in-the-end role, plays Snipes' adversary in the form of Los Angeles Police Department Sgt. John Spartan. Not one for following orders from his superiors to the letter, Spartan gets the handle Demolition Man for his habit of demolishing everything in sight—sort of like turning a bank into a parking lot—all in the line of duty, of course.

The story unfolds in 1996 during

L.A. Riot III. Phoenix takes 30 hostages from a municipal bus. Disregarding orders, Spartan jumps 300 ft. from a helicopter into Phoenix's fortified stronghold to capture the criminal. But Phoenix has time to activate his doomsday plan, blowing up his compound along with all the hostages. He then blames Spartan for the carnage. The bottom line is that both characters get the cold shoulder in California's CryoPrison.

Phoenix, who for some reason hasn't had his brain pelted with rehab waves, gets thawed out for a parole hearing, overpowers his guards and escapes. The 2032 police force is no match for this arch villain. Who is going to save L.A.? Guess who gets to go for a spin on the defrost cycle inside the prison microwave? Neat stuff, eh?

If you're a classic-car fan, "Demolition Man" even has something for you. In contrast to all this futuristic rolling stock is another GM star car—a solitary "Jurassic Park" throwback to the muscle-car era in the form of a 1970 Olds 4-4-2. Seems the Stallone character had been in the deep freeze for so long, it's the only car he knew how to drive.

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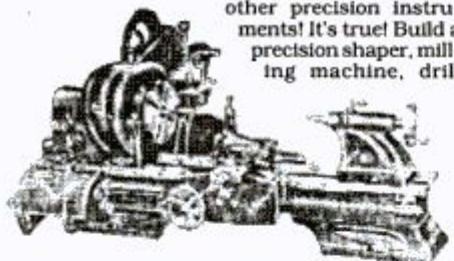
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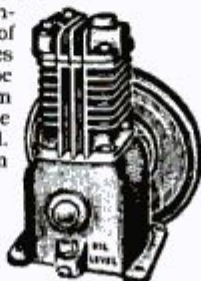
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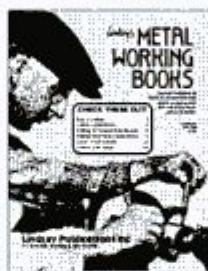
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### ICE STATION X

(Continued from page 34)

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For his part, Dr. John Huckabay, who helped develop EXUS at the University of Texas at Austin, is extremely pleased to see a system he's been working on for years functioning as intended. "If you're doing your job at the cutting edge, about 50% of what you do won't work," he says. "The proof was when we got up here and turned it on."

### Polar promise

Sonar researchers are not the only ones who'd love the chance to try their ideas in this setting. Nearly five times the expanse of the Mediterranean, and believed to play a vital role in global climate, the Arctic Ocean represents one of our last and most important scientific frontiers. But few organizations around the globe have the resources to operate here, and those that do, have historically done so in secret.

The fact that we were invited to view this year's ICEX is one of the first signs that this is changing. More concrete is the fact that this past August, a group of civilian scientists for the first time set sail aboard a U.S. nuclear submarine on a journey devoted to peaceful exploration of the Arctic. As this is written, the *USS Pargo*, a Sturgeon-class sub like the *Puffer*, is under the ice with a non-military complement of five. They will study the ocean's almost totally uncharted floor, track the movements of the ice pack and look into threats to the Arctic environment.

It's too soon to know whether the formidable fighting capabilities designed into these subs will suit them to the cost-effective pursuit of science. But the extraordinary investment of talent and energy—not to mention money—involved should be incentive enough to find out. **FM**



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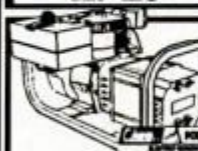
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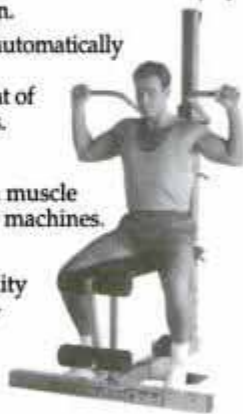
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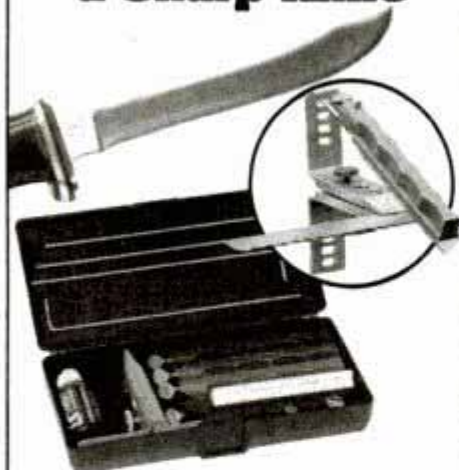
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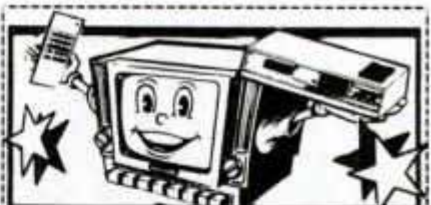
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