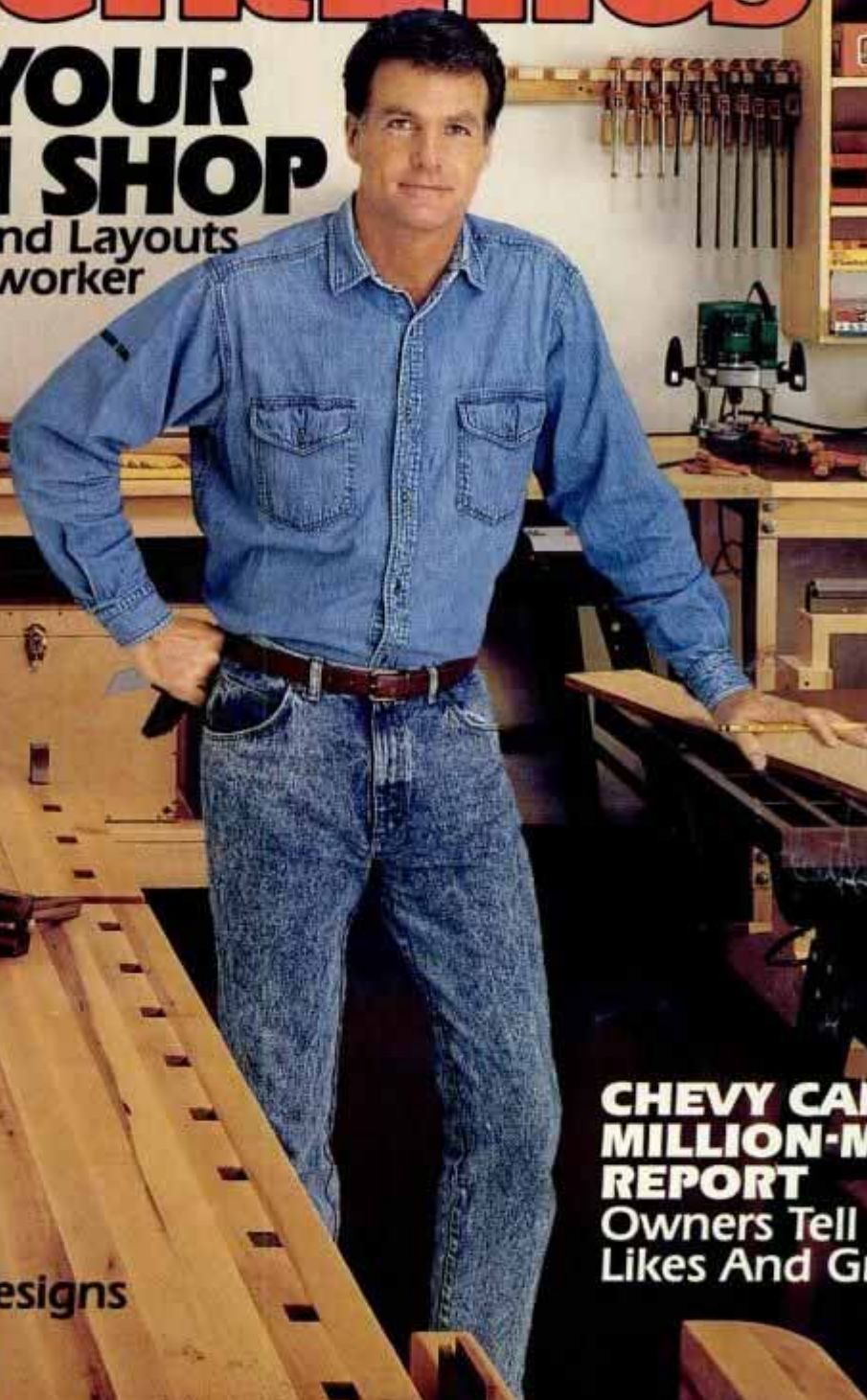


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Popular Mechanics

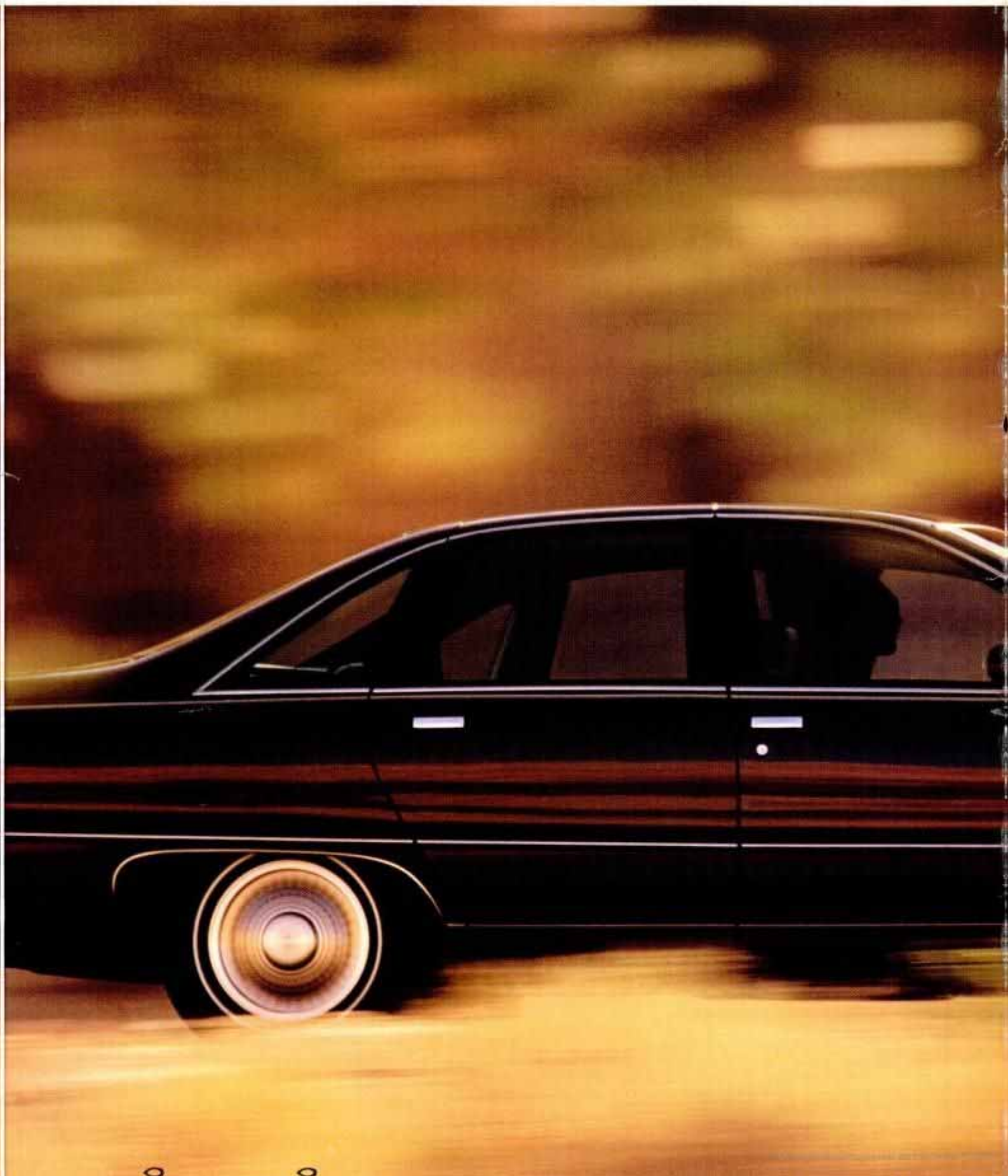
BUILD YOUR DREAM SHOP

Projects, Ideas And Layouts For Every Woodworker



**CHEVY CAPRICE
MILLION-MILE
REPORT**
Owners Tell Us Their
Likes And Gripes

- Super Shop Designs
- Tool Selection
- Workbenches
- Shop Storage
- Accessories
- And Much More



RELAX. CAPRICE IS ONE LUXURY YOU CAN AFFORD.

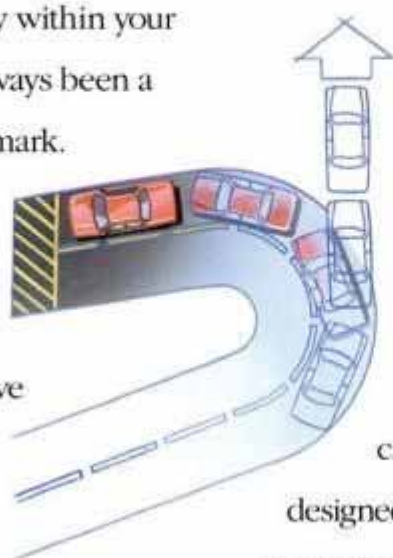
Putting luxury within your means has always been a Caprice trademark.

And Caprice retains the traditional values that have made it

America's best-selling

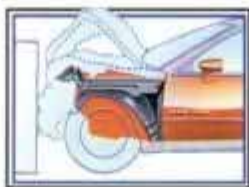
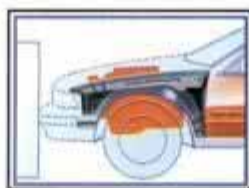
full-size car. Six-passenger comfort. Rear drive. Available leather seating areas. Ample V8 power. ♦ But clearly the new Chevrolet Caprice has come a long way. It's roomy, quiet, smooth, comfortable and aerodynamic.

Its corrosion protection is unsurpassed. It has luxuries you would expect to find on many higher-priced cars. And its long list



of standard safety features includes 4-wheel anti-lock brakes (ABS), driver's-side air bag and a "safety cage" which is

designed to help protect the passenger compartment in the event of a collision. ♦ That



wealth of solid value and forward thinking helped make the

Caprice Classic LTZ *Motor Trend's* 1991 Car of the Year.

But obviously, by any standard, it's a lot of car. And one well within your means.



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Chevrolets: surprising touches,
thoughtful designs, conveniences
you'll appreciate every day. Like car
doors that lock automatically. Or
standard anti-lock brakes (ABS) on
more models than anyone. The
PASS-Key® Security System. Cup
holders. Trunk cargo nets.
Scotchgard™ Fabric Protector on
seats and doors. You get the idea.
It's very simple and very Chevy:
We give you more than you'd expect.
No wonder Chevrolets are the cars
more people depend on.



THE HEARTBEAT
OF AMERICA IS
WINNING.™



CAPRICE CLASSIC

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This One



SHQK-CW7-LTK3

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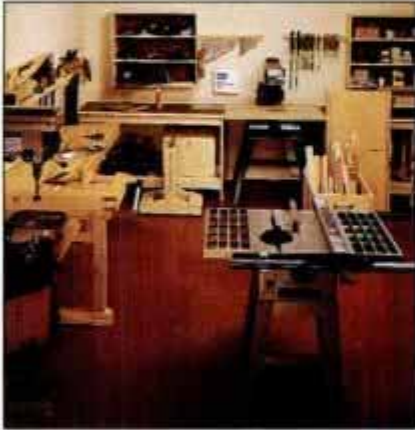
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Popular Mechanics®

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NO. 11



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—PM cover photo by
John Griebisch



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EDITOR'S NOTES

● **Building your own workshop** just the way you've always wanted it may be one of the most indulgent things you ever do in this lifetime, but the rationalization for it is so perfect. It goes like this: Sure, building my own shop is time consuming and will cost a few bucks. But once I have it, I'll be able to handle all those projects around the house that I've been putting off, like refinishing the dresser in the bedroom and repairing that dining-room chair. Meanwhile, you have this great shop set up just the way you've always dreamed it. That's the whole idea behind Dream Shop—this year's Woodworking Guide that takes you through the concept, design and building of the perfect shop, whatever your woodworking skill level. Home Improvement Editor Steve Willson, Associate Home Improvement Editor Tom Klenck and Contributor Neal Barrett help you be self-indulgent beginning on page 57.



Sjoberg briefs Automotive Editor Swan.

... Just about every automotive editor in the universe has had a ride in the super-hot Dodge Viper R/T 10 sports car by now. Even me (see Editor's Notes, page 4, Sept. '91). But how many people outside of Chrysler Corp. engineers and executives have *driven* the car? I'll answer that for you. Hardly any. But recently, Automotive Editor Tony Swan had the opportunity, and he made the most of it. Besides the time Swan spent pinned to the back of the Viper's bucket seat, he also received a technical briefing from Roy Sjoberg, the captain of Team Viper, the group of engineers and product planners within Chrysler bringing this car to market next year. Go for a ride with Swan beginning on page 54. ... There are slam dunks, and then there are *slam dunks*. Patrick Ewing of the Knicks putting it through up to his elbows is a slam dunk. Darryl Dawkins, formerly of the New Jersey Nets, breaking the backboard glass is a *slam dunk*. But the king is Michael Jordan of the Chicago Bulls. "Air" Jordan has hundreds of different ways of going up and putting it through. Brooklyn College Professor of physics Peter Broncazio has made a study of Jordan, Dawkins, et al., to come up with some scientific reasons why these guys are capable of performing acts that seem impossible for mere mortals. Professor Broncazio tells you how the magic happens on page 42. Till next time.



Darryl Dawkins leverages shot.


Joe Oldham

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Everything you want in tomorrow's passenger van is easy to find.

Just look at today's New Club Wagon from Ford.

The new shape is bold, aerodynamic. And, it's been protected with a hard new chip-resistant primer.

The spacious new interior holds everything from a new instrument panel to available Ford JBL audio systems. "Out Front" engine placement means more room up front. An available high-capacity climate-control system circulates far more air.

Club Wagon's Twin-I-Beam suspension provides a smoother ride, while its body-on-frame construction enhances

Club Wagon in mind: Tomorrow.



The new more ergonomic instrument panel makes everything easier to see and reach.



Full-size comfort for every passenger.

This new optional console may prove indispensable.

Finally, the 1992 Club Wagon is backed by Ford's new warranty—a 36-month/36,000-mile Bumper-to-Bumper

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Today's best-selling full-size van really is filled with news.

Tomorrow is looking very good.



The only full-size van with a driver air bag.*

trailer-towing capability. This van's maneuverability is better than ever.

Every tomorrow

should be safe. So, Regular Club Wagons now have a driver air bag to supplement safety belts. And, all outer seats have new 3-point safety belts.

Rear anti-lock brakes are standard.

*Air bag effectiveness depends on wearing your safety belt, so always buckle up.
**Ask your dealer for a copy of this limited warranty.
*Best-Built claim based on an average of consumer-reported problems in a series of surveys of all '81-'91 models designed and built in North America. Sales by Division.



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

LETTERS

Gun Shy



I have never seen a gun article in PM like "The Enforcer." And if I ever do again, it will be too soon. To give this much attention to a handgun is outrageous. Do you read the papers? With the entire country plagued by drive-by shootings, accidental discharges and murders for no reason, the need for handgun control is overwhelmingly obvious. You might include a paragraph and a photo to point out the neat mechanical stuff about the weapon, but don't try to give readers the impression that they have to have one to be the total mechanical know-it-all. If I wanted a gun magazine, I would have subscribed to one.

If I see another article like this again in my favorite car/home/appliance/woodworking magazine, I'm outta here.

DAVID AVERY JR.
STAMFORD, CT

Thank you for the excellent presentation of the Glock 17 pistol. I think that future guns will use caseless ammunition that is electrically ignited. Electric power and electronics will make sophisticated safety systems practical. We need some-

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

thing chemically safer than lead for bullets and a limited-range slug, which would go only so far through the air before turning to liquid or powder. In the future, guns may be designed to satisfy antigun politicians rather than hunters and shooters.

Perhaps the automatic principle in which power to reload and fire the weapon comes from the explosion of the cartridge will give way to motor-driven repeaters. I hope not. I suspect gun control will become as dead as sword control because guns will become obsolete as weapons.

WINFIELD MASSIE
SPRING, TX

Congratulations. Your article covered this innovative state-of-the-art, semi-automatic pistol far more in depth for the lay reader than Glock's advertising literature and how-to articles in handgun magazines. How about one on the new military Beretta 92-S?

DANIEL D. MOYNIHAN
HICKSVILLE, NY

All Aboard

As a small child, our now 10-year-old son, Brandon, was absolutely fascinated with trains. So rather than build a tree house of some kind, my husband decided to design and build a caboose house. It is 6 x 16-ft. overall, made of treated-wood platforms, insulated walls finished with light-birch paneling, a galvanized tin roof and double-hinged plexiglass windows. We want to share our unique project with any readers who are interested in the blueprints (\$45).

ROGER AND TOOTIE HOOD
525 GLENWOOD TRAIL
SOUTHERN PINES, NC 28387



In Accord

You seem mystified by the enormous popularity of the Honda Accord. Perhaps it is because you and I are car enthusiasts. This car is not for us. We are willing to pay a higher price and higher insurance premiums because we look at driving as entertainment.

My wife clarified this for me by picking the Accord as her favorite car. She looks at driving as a waste of time. But she wants something that looks nice, is comfortable and, above all, is dependable. She makes too much sense sometimes. A good argument is always ruined by someone with logic.

ERICH ROESCHKE
ALBUQUERQUE, NM

You are 100% out-to-lunch in calling the Honda Accord bland. As a former product and graphic designer, I consider the Accord classy and tasteful. Indeed, the smooth rounded lines and

integrated look are very much the wave of the future. You need eyeglasses or development of taste. The Accord will remain sleek and pleasing to the eye long after its garish contemporaries have begun to look idiotically dated and gimmicky. If you ask a few designers, whose jobs depend on good taste, they'll agree with me a lot more than your cretinous reviewers.

JOEL ANDERS
VENICE, CA

You never understand that the average American car buyer is not going to purchase an exotic sports car. Your comments in the Honda Accord Owners Report show a narrow-minded outlook. Automobile buyers are interested in quality, reliability, predictability, price, value, economy and comfort. Being the fastest 0 to 60 mph is not as important as the ability to

(Please turn to page 12)



The caboose house Brandon Hood's father designed and built.

Why cars like yours race on gasoline like ours.

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

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

Racing on street gasoline.

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

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

Vapor Pressure. If you've ever



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

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

Octane appetite control.

Now, we're not making any extrav-

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

Still think all gasolines are the same?

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

about

your car's

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

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



TEXACO SYSTEM³ AND
HAVOLINE FORMULA³

T E C H N O L O G Y I N M O T I O N

enter traffic flow safely. How fast the car can negotiate a negative-banked descending curve is less important than how easy it is to park. And the instrument type is not as important as the layout. In other words, will the car serve as Mom's taxi without leaving her on the side of the road? I considered these things when I bought an '87 Honda CRX-HF and an '87 Chrysler LeBaron. Our next car will be an Accord, even if you can't understand why they sell so well.

NED H. GAUDETTE
SANFORD, NC

Home-Run Pointers

I have always played a variety of sports, but it is my enthusiasm for softball that makes the winter seem so long. Before my league started, a friend gave me "The Mechanics Of A Home Run," by Lou Piniella, and now things have changed.

I switched my stance from an even-weight distribution to a front-knee cock to get the weight back. What a difference. I now deliver a more powerful upward diagonal. The nature of my hitting has changed from line drives to hits that are high and deep. So far, I have two home runs, as opposed to last year when I had none all season. The perception of my importance to the team has changed not only in the eyes of my teammates, but in mine as well. Thanks, Lou, for the expertise.

MARK WAGNER
MOUNT KISCO, NY

Fighting Back

I was amazed at the letter you received about "The Army's Newest Killer Chopper." I'm glad we have it and they don't.

Yes, Mr. Tanguay, war is hell and can be best summed up by the famous orders of Gen. George S. Patton: "To so use the means at hand to inflict the maximum amount of wounds, death

and destruction on the enemy in the minimum time."

I think this quote says it all for what our great military and their machines are expected to do.

JACK MALONE
UVALDE, TX

If Tanguay wants a world with no killing machines, then I suggest he take his case to Saddam Hussein. Maybe after Saddam finishes chopping off his hands and feet and skinning him alive, he will then take the time to hear what Tanguay has to say.

WALLINGTON SIMPSON
POMONA, NY

it is because propane is not competitive in the carburetion market yet. Distributors were not always less expensive than dealers or stations, and I found truck stops to be the most over-priced facilities.

MANGHAM DAVID LEHR
COLUMBIA, MO

I agree with you about propane. If engines are set up correctly, there is a very small horsepower difference between LPG and gasoline. In 1978, I bought an Oldsmobile 403-cu.-in. custom station wagon and had it set up to run on propane, as well as gasoline. It now has 207,000 miles on the speed-

ometer, and the only repair on the engine has been a timing chain replacement. I don't understand the government and automobile companies that have gone to the expense of controlling pollution and emissions with little success, when the use of propane is such a simple and obvious solution.

PENNY JONES
LAS CRUCES, NM

A Welcome Reception

"World Radio," was an excellent article on short-wave radio. I want to thank you for the publicity you have given to this hobby. Most manufacturers give little information in their manuals, and, once hooked

on listening, radio hobbyists do not know where to go for more information. The American Shortwave Listener's Club (ASWLC) is mainly for listeners west of the Mississippi, while the Association of DX Reporter (ADXR) covers the East. Write to ADXR, 7008 Plymouth Rd., Baltimore, MD 21208, or ASWLC, 16182 Ballad Ln., Huntington Beach, CA 92649.

STEWART MACKENZIE
HUNTINGTON BEACH, CA

Back To Sea

I enjoyed "Carrier Reborn." The SLEP modernization program is an

P.B. DON'T MEAN:



POLYNESIAN BOBSLED

Fill It With Propane

Your positive report on the use of propane as an alternate fuel in "Propane-Powered Buick" is most welcomed. My Itasca RV is a dual-fuel gasoline-LP unit, and I use propane whenever conditions permit, for it is clean and easier on the environment. At first I was frightened by the explosive reputation of propane, but now I consider it to be safer than gasoline. My propane tank is much more durable than my gasoline one and less likely to rupture in a collision. The negative feature of using propane, however, is the pricing. On a recent trip, I found the prices to be very inconsistent. I guess

excellent program, which saves taxpayers billions and provides the Navy with modern carriers for the fleet. However, its future is in question. The easing of tensions between the Soviet Union and the United States has caused the Navy to scale back plans from 15 to 12 carrier battle groups.

Meanwhile, the nuclear carrier building program continues with the completion of the USS *George Washington* due next year and with plans to complete the USS *John C. Stennis* and USS *United States* in the late '90s. This creates a situation of more aircraft carriers than required. The SLEP modernization of the carriers

USS *America* and USS *John F. Kennedy* may be canceled, while carriers that have already been modernized, such as the USS *Saratoga* that was pictured in your article, may be prematurely deactivated without serving 15 years after the SLEP modernization. I hope Congress and the Navy make maximum use of existing ships when considering the budget for future building and modernization plans.

I suggest that no new carriers be funded during the 1990s, and the *America* and *John F. Kennedy* be placed in mothballs to be modernized at a later date. This would allow the Navy to reduce the number of carrier battle groups while making use of modernized carriers.

BRUCE D. WHITCOMB
COLLINSVILLE, IL

I greatly enjoyed your aircraft carrier SLEP article, but there are a couple of points that need clarification.

First, barrier nets are only installed during emergencies when an approaching aircraft is unable to deploy its arresting hook. It is not used to catch airplanes that miss the last wire. An airplane "boltering" this way simply becomes airborne and

goes around for another try.

Second, the USS *Constellation* has been handling heavy jets like the F-14 for years, even before SLEP. I suspect the *Constellation* had an extra 8 ft. of runway installed to make arrested landings on the fourth wire a little less brutal—being the last wire, it would have less distance available to stop the landing jet—not because the F-14 would go over the side.

RON M. ARYEL
PHILADELPHIA, PA

Domesticity

The letter from Ed Parks did not amuse me. Sure, many Japanese cars

and a great many of the parts bought in the U.S. are sold by Japanese-owned suppliers.

Few Americans are employed since robotics are used, which are also made in Japan. Buy American before you lose your job.

WALTER H. WIDMER
UPPER SADDLE RIVER, NJ

My family has owned a 1970 Dodge Polara, retired with 246,000 miles, and a 1978 Pontiac LeMans, traded in at 212,000, and currently owns a 1986 Pontiac 6000, which is still running flawlessly at 79,000 miles. And by far, the best of the lot is our luxurious 1989 Olds Cutlass Ciera. My friends who

own small foreign cars are amazed by its quality and ride. Lucky once or twice? Possibly. Four times in a row, however, is more than good luck. I will continue to shop for the best car for my family, be it foreign or domestic. So far it has always been American, and as far as I can see, it will continue to be so.

TERRY MANKUS
CHICAGO, IL

Showing Off

When we went to war in the Persian Gulf, I have to admit I was worried that we wouldn't come out on top. Many people question whether it was all worth it. And

some say that we didn't really win, considering the fact that Saddam Hussein is still in power. But I believe we showed the world that the United States is a strong force to be reckoned with.


And the videotape your magazine produced emphasizes that fact even more. Thanks for clearing up my doubts.

FREDRICK GORMAN
OLATHE, KS

To buy a copy of the POPULAR MECHANICS video, America's New War Machines, call toll-free (800) 888-4078. Or visit your nearest Kmart or Wal-Mart store.

PM

P.B. DOES MEAN:



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LOTS OF REAL PEANUT BUTTER

are made in the United States, but he and others should understand that all of the manufacturing profits go back to Japan. This is also true with "domestic" parts suppliers. Even though we require transplant vehicles to use 75% domestic parts, most come from the 240 Japanese-controlled suppliers in the U.S.

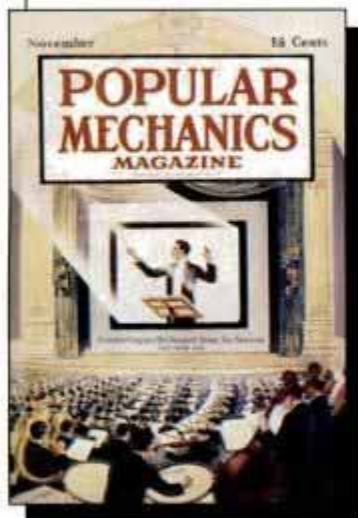
Better buy from the Big Three to save your future.

PHIL PAULEY
SAN JOSE, CA

Ed Parks needs an education. Honda is not made in the United States. All major parts are constructed in Japan,

TIME MACHINE

75 YEARS AGO: NOVEMBER 1916



Movie Maestro

One motion-picture application that flared briefly in Chicago involved replacing an orchestra conductor with a baton-waving silver-screen image. Not only would the technique capture for posterity the antics of the world's greatest conductors, but the larger-than-life images would spur musicians to peak performances. What's more, proponents said, the highly visible maestro could allow promoters to muster enormous orchestras with hundreds of instruments.

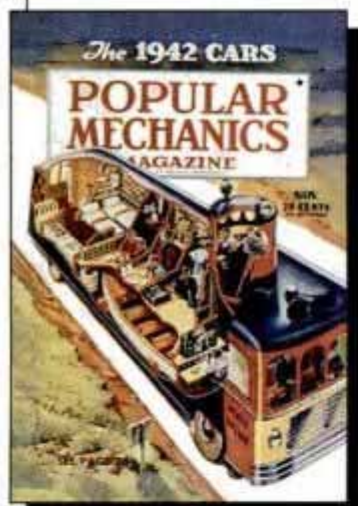


Enter The Tank

They didn't break the bloody stalemate on the Western Front, but they did change the face of war forever. Several dozen British tanks,

bearing little resemblance to our artist's concept, rolled into no man's land that fall, breaching the trenches and barbed wire that had bogged down mobility.

50 YEARS AGO: NOVEMBER 1941



Bust Bus

The state of Illinois was building the ultimate police vehicle—an armed mobile crime lab. Inside, gear included X-ray equipment, a complete chemistry set, a ballistics lab, a fingerprinting apparatus, a lie detector and plenty of crowbars, cutting torches and the like for getting into crime scenes. For more active police work, the vehicle housed a speedboat and a hydraulically lifted machine-gun turret which could rear through the roof if bad guys besieged the bus.

Economy Drive

Car buyers faced the prospect of gasoline rationing, so fuel economy took on unprecedented importance. Stingiest among the new 1942 offerings was the diminutive Crosley, which could cover almost 50 miles on a gallon. To sell its bigger sedans, Detroit touted the new automatic transmissions, dual carburetors and smaller rear-axle gear ratios as fuel-saving meas-

ures. Tugging at shoppers' patriotism, carmakers broadcast with pride how little aluminum, chromium and other defense-related metals their products contained.



25 YEARS AGO: NOVEMBER 1966



Jungle Birds

While GIs and guerrillas stalked each other through Vietnam's undergrowth, the air above was filled with the widest variety of warplanes ever mobilized. F-4 Phantoms shared the skies with prop-driven A-1 Skyraider dive bombers and C-47 gunships. But perhaps the gutsiest missions were flown by what the Viet Cong called "little old ladies"—the unarmed Cessna O-1 Bird Dogs that cruised the treetops seeking targets for their supersonic brethren.

Turbo Charger

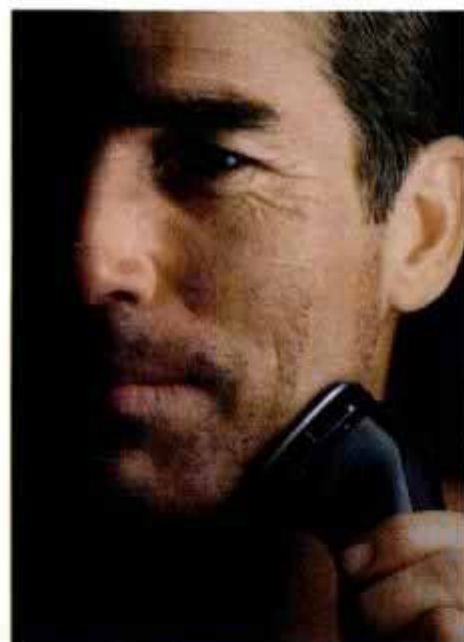
Could the railroads gain ground on passenger jets by investing in turbine powerplants? It took new, compact helicopter turbines to make the idea attractive. Canadian National Railroads ordered five turbotrains, which featured body-tilting technology.



TO FULLY APPRECIATE NORELCO'S INCREDIBLY CLOSE, COMFORTABLE SHAVE, YOU HAVE TO LOOK BENEATH THE SURFACE.

It's amazing, but true.

Norelco® can actually shave *below* skin level. And equally amazing, Norelco can shave you without the blades even touching your skin.



This feat is accomplished with a patented technology unique in all of shaving. The "Lift and Cut"™ system.

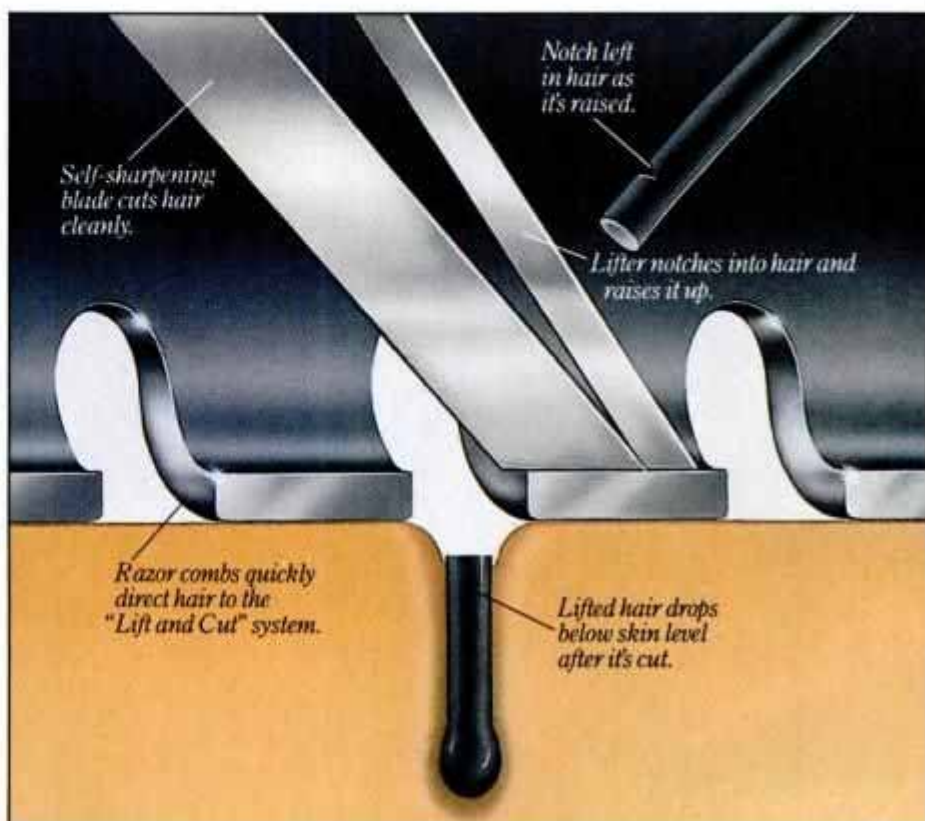
Here, a precision



Hair enters the chamber.

Lifter raises the hair.

Blade cuts hair which then drops below skin level.



Self-sharpening blade cuts hair cleanly.

Notch left in hair as it's raised.

Lifter notches into hair and raises it up.

Razor combs quickly direct hair to the "Lift and Cut" system.

Lifted hair drops below skin level after it's cut.

mechanism has been engineered by positioning a lifter in front of the blade. When the lifter notches into a hair, it lifts it up. As the blade cuts it, the hair shaft can actually drop back *below* the skin.

The result is an incredibly close shave. And because you can shave without the blades even touching your face, it's incredibly comfortable.

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PZ-10

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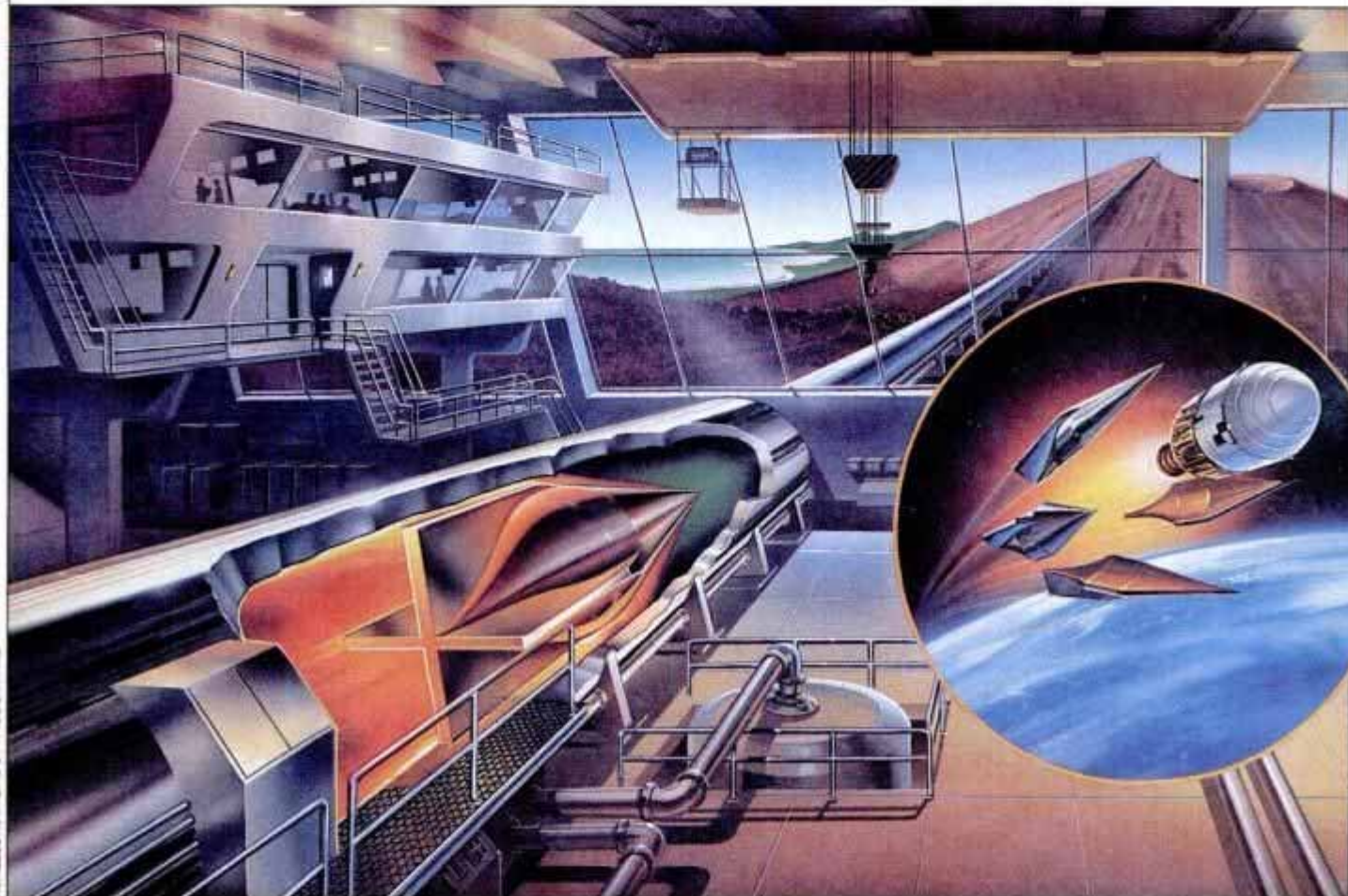
- **Intelligent Power Zoom Lens** for increased creative control
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TECH UPDATE

News Of Tomorrow's Technology Today



PM ILLUSTRATIONS BY PAUL DIMARE

Hypersonic Scramjet Cannon Aims For Orbit

MOORPARK, CA—Streaking through the stratosphere at Mach 10, the National Aero-Space Plane will rely on scramjet engines to burn fuel in air that's moving at supersonic speeds. Engineers now want to harness the same principle in a giant cannon that could jolt payloads into orbit cheaply.

The future launch system would feature a Scramaccelerator—the most ambitious in a family of devices known as ramaccelerators.

Ramaccelerators all work on the same premise: A tube several miles long contains a mix of fuel and oxidizer. At one end stands an injector, such as a gas gun, which fires a projectile into the tube at

roughly 1000 miles per hour.

As the projectile races through the tube, the fuel-oxidizer mixture slips between its sides and the inner face of the tube. Shock waves touch off supersonic combustion of this mixture. Expanding combustion gases push against the projectile's afterbody, boosting it to speeds greater than Mach 15. At the tube's end, the projectile pops through a diaphragm and shoots into space.

Research began at the University of Washington, but is now worldwide. A Scramaccelerator prototype

Editor: Abe Danc
Assistant Editor: Greg Pope
Contributors: Philip Chien, Mike Fillori,
Oliver Fultz

is currently undergoing tests with 5-ounce projectiles at NASA contractor Advanced Projects Research, Inc.

Heat-shield-enshrouded space payload gains hypersonic momentum as gases ignite behind it in Scramaccelerator.

Highlights This Month

- **World's Smartest Bat**—Winged submunition hunts down moving tanks.
- **Eye On The Storm**—Camera scopes out tornadoes from space.
- **Being There**—Virtual-reality games for chemists and arcade jocks.
- **Air Rockets**—Future missiles convert to ramjets.
- **Mine Reader**—Airborne infrared scanner spots buried explosives.
- **Ship Of Tools**—Navy's newest floating oceanographic laboratory.

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 17. Luxury steering wheel.
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 19. Cloth & vinyl reclining seats.
 20. Bodyside molding.
 21. Aero-style halogen headlamps.
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 24. Full interior carpeting.
 25. Child-restraint tether anchors.
 26. Bodyside paint stripes.
 27. Fuel cap tether.
 28. Front & rear anti-sway bars.
 29. Dashboard cubby bin & lockable glove box.
 30. Single key locks with valet key.
 31. Bumper rub strips.
 32. Flash-to-pass.
 33. Maintenance-free battery.
 34. Day/night rearview mirror.
 35. Compact spare tire.
 36. Side window demisters.
 37. Counterbalanced-shaft engine.
 38. Trip odometer.
-
- Total \$12,129****

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Dodge Spirit and Plymouth Acclaim start out with an impressive list of standards – including a driver's airbag and a warranty choice no other manufacturer offers. And even when you load them with options, they're still terrific values.

To make sure you get a Spirit or Acclaim with all the equipment you see here...at the right price*...simply ask your dealer to show you vehicles with Preferred Package 22D.

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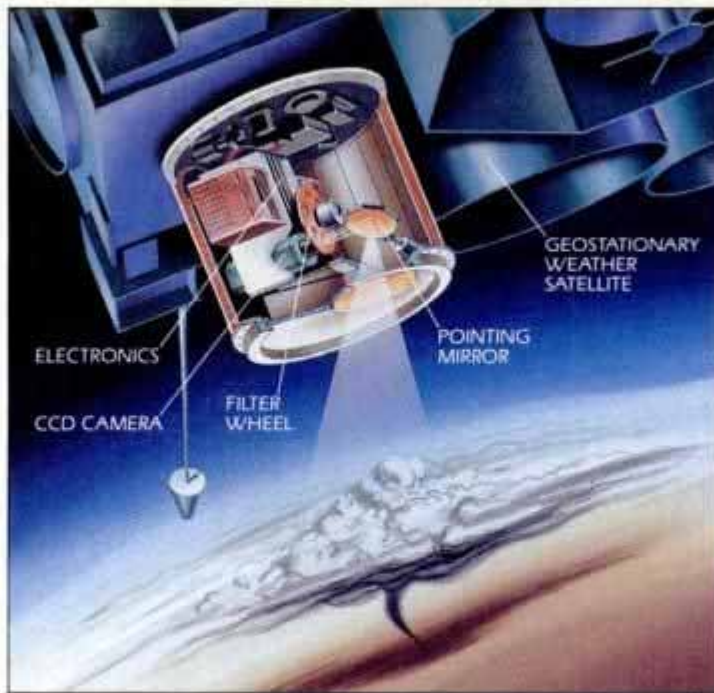
Dodge Spirit

Plymouth Acclaim

Tornado Detector

ENCINITAS, CA—A simple device mounted on a geostationary weather satellite could give authorities as much as 25 minutes to notify population centers that a tornado is likely to form.

Called a cloud-top radiometer, the instrument takes advantage of the fact that just before the onset of a severe storm the tops of clouds rise rapidly. A small electronic camera peers through one of six different spectral filters that allow it to monitor discrete depths of the atmosphere, a technique called "sounding." A stepper motor drives a wheel that positions each spectral filter in front



of the camera lens.

Meanwhile, a pointing mirror, adjusted by ground controllers, shifts the camera's focus to trouble spots. Data shunted to Earth details cloud events in $1 \text{ km} \times 1 \text{ km}$ ground footprints. The device can distinguish between cloud motions that signal the formation of a tornado or a severe hailstorm, say its developers.

About the size of an office wastebasket, the sensor weighs less than 25 pounds and uses less than 50 watts of power. Space Instruments, Inc., developed the device under a NASA small-business grant.

Cloud-top radiometer can detect telltale cloud movement before tornadoes begin.



Virtuality arcade game has display visor that tracks head motion.

Virtual Vertical Takeoff

LEICESTER, ENGLAND—Virtual-reality (VR) technology continues to nudge arcade games closer to true flight simulation. The latest manifestation—billed as the first pure VR arcade game—is Virtuality, a system that was developed by a small British company called W Industries.

The player "flies" a Harrier-type vertical-takeoff jet (an intergalactic space-cruiser version is also available). A wraparound visor fitted

with two color liquid-crystal displays provides stereoscopic vision.

Magnetic sensors monitor head movements and shift the display scene accordingly. Four speakers in the visor provide quadraphonic sound. Players can compete or team up, using visor-mounted microphones to communicate.

The Japanese were the first to try Virtuality outside the United Kingdom. U.S. distribution is expected by the end of this year.

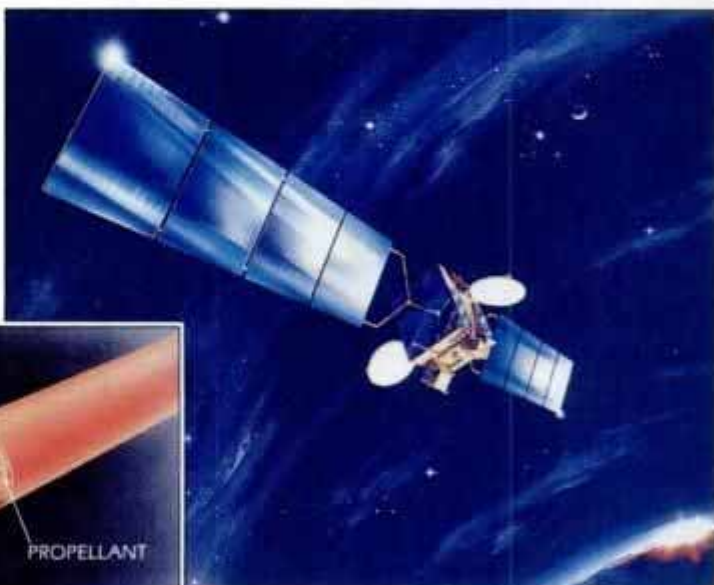
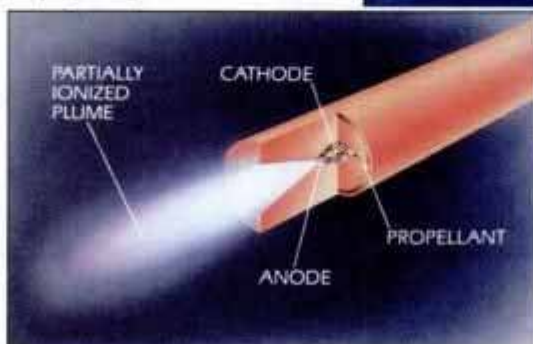
Electric Thrust

REDMOND, WA—When AT&T's Telstar 4 communications satellite goes up in 1992, it will use an electric arcjet thruster to help hold itself locked in geosynchronous orbit. The small station-keeping thruster will embody the first space-based demonstration of the new technology.

In an arcjet, a direct-current electric arc leaps between a cathode and an anode to heat the decomposition products of hydrazine propellant. The arc begins at a small bottleneck and fans out across the thruster nozzle, which acts as part of the anode. Propellant gases

passing through the arc quickly heat up and expand against the nozzle, providing a specific impulse higher than that attained by conventional rocket thrusters.

NASA and the Strategic Defense Initiative Office are funding research to develop high-powered arcjets fueled by hydrogen.



Arcjet (left) will provide station-keeping on Telstar 4, to be launched next year.



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We Put A Lot Of Energy Into Our Batteries.

At Rayovac, we devote our energy and resources toward continually improving all our batteries. That's why Rayovac batteries are chosen for some of life's most demanding situations.

For instance, our batteries received the prestigious honor of being chosen to power a computerized back-up system on the Space Shuttle's main engine.

And, because Rayovac batteries have proven such reliable performers in extreme temperatures, they were used in backpack radios in Operation Desert Storm.

Our ability to condense power into a small yet powerful form has made us the number one manufacturer of hearing aid batteries in the world.

Given the facts, a Rayovac battery that performs this well under extreme conditions will give you optimum performance at home. In fact, all of our energy goes into making sure of it.

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When Performance Really Counts.



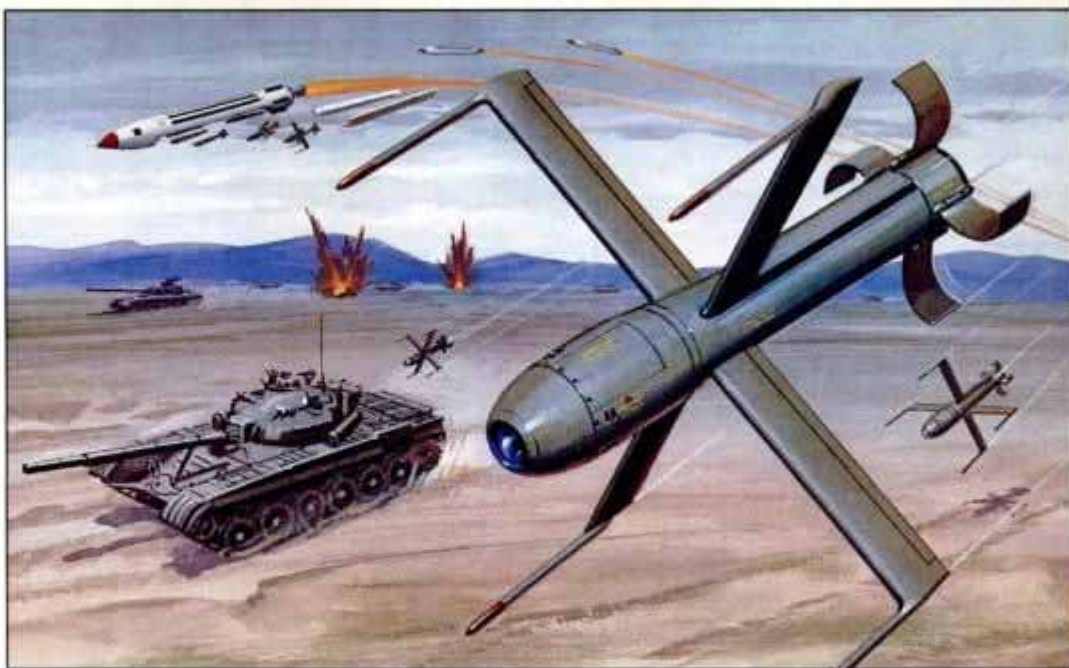
Tank Spanker

LOS ANGELES, CA—Soon enemy tanks will no longer be able simply to pick up and scoot away from Army rocket attacks. A new submunition developed by Northrop and subcontractor Raytheon will hunt down armored vehicles on the move deep behind enemy lines.

The 44-pound Brilliant Anti-Tank weapon, or BAT, will drop from rockets or the still-classified stealth cruise missile known as the Tri-Service Standoff Attack Missile.

As the BAT descends, four wings, tipped with acoustic sensors, will unfold, along with four curved tail fins. A nose-mounted infrared sensor will also contribute to the tank hunt.

Roughly a yard long and 5 in. in diameter, the unpowered weapon is tipped with a



shaped-charge warhead.

The BAT program, managed by Redstone Arsenal, has now entered the engi-

neering and manufacturing development phase. Production should begin in the late 1990s.

BAT submunition uses acoustic and infrared sensors to zero in on moving tanks.



Radar Gets Sunburned

ALBUQUERQUE, NM—The scorching temperatures of hypersonic atmospheric travel can addle radar in the nose of a missile or spacecraft. To quantify heat-induced radar error, researchers are turning to apparatus originally built to help develop solar power.

The National Solar Thermal Test Facility at Sandia National Laboratories features 220 Sun-tracking mirrors that can train up to 250 watts on a square centimeter and bake targets to temperatures of more than 900° F.

Field of Sun-tracking mirrors replicates aerodynamic heating of missile's radar.

A team from Johns Hopkins University sponsored by the Army and Navy, has been using the facility to heat-test a missile radome. Knowing how homing errors relate to temperature, engineers can introduce corrective circuitry into the missile guidance system.

Sandia personnel also have run tests, mimicking atmospheric reentry, on a radar antenna designed for the National Aero-Space Plane.

Molecular Docking Arm

CHAPEL HILL, NC—Chemists can explore their atomic world and feel the forces that rule molecular behavior, thanks to a virtual-reality system built at the University of North Carolina.

The heart of the apparatus is a ceiling-mounted robotic arm, salvaged from a radioactive-waste handling system. The user wears 3D glasses and watches a big screen while grasping the arm's pistol-grip end effector. Wielding the arm like a joystick, a chemist can swing one computer-generated image of a molecule around another.

The aim is to "dock" the molecules, but it isn't easy: Attractive and repulsive forces between atoms in the two molecules show up as

force feedback, which causes the arm to jerk forward or resist the user's motion. Only when the molecules are properly aligned will they lock into unison.

Chemists can use this videogame approach to design pharmaceuticals and test their interaction with molecules in the human body.

Robotic arm shifts computer images of molecules and duplicates atomic forces.





**GOODYEAR HAS NOW
MOVED PERFORMANCE TIRES
INTO WARP DRIVE.**

INTRODUCING THE OF ULTRA-PERFOR



These days, it seems that almost everyone claims to have the ultimate performance tire.

It's usually a top-of-the-price-range tire.

And it comes with the inference that it is the best tire ever made for every performance car.

In much simpler times, when performance car designers and engineers took a much less varied approach, this claim was improbable.

Today, it's simply laughable.

Today, performance cars are simply too varied.

In engine size, type, power and placement.

In drive systems: front-drive, rear-drive, or both.

There may be seats for two, four, or five.

Chassis and suspension systems may vary from "Computer Controlled" to Formula One-derived.

Some may be true exotics, only driven on fine days. While others are designed to be driven daily, year-round.

It is for all of these reasons that Goodyear is introducing a family of ultra-performance radials.

Working closely with many of the world's leading car designers and chassis engineers has led Goodyear to this new performance-specific approach.

And each member of the new Eagle GS family has met with instant approval.

E A G L E G S - A

The Eagle GS-A was designed in conjunction with Ferrari, for use on the very limited-edition Ferrari F40.

EAGLE GS FAMILY MANANCE RADIALS.



The Asymmetric design allows more tread contact on the outer shoulders, maximizing dry lateral acceleration.

INITIAL SIZE AVAILABILITY: 235/45ZR17; 335/35ZR17.

E A G L E G S - D

The Eagle GS-D is a unidirectional radial, designed for year-round performance in the wet and dry.

The unidirectional design gives superior hydroplaning resistance and excellent wet handling.

The Eagle GS-D is original equipment on the Lotus Elan; Lexus SC400; Toyota Supra Turbo; and the 1992 Porsche Carrera 2 and 4.

INITIAL SIZE AVAILABILITY: 205/45ZR16; 205/55ZR16; 225/50ZR16; 225/55R16 93V.

E A G L E G S - C

The Eagle GS-C is both asymmetric and unidirectional. This gives you very progressive handling characteristics on both wet and dry surfaces.

There is exceptional traction.

The ride quality is excellent.

Tread noise is low.

There is superior resistance to hydroplaning, both straight-line and in corners.

The Eagle GS-C has been chosen as the exclusive tire for all new 1992 Corvettes, including the ZR-1.

INITIAL SIZE AVAILABILITY: 205/50ZR15; 205/55ZR16; P225/50ZR15; 225/50ZR16; P245/50ZR16; 245/45ZR16; P255/50ZR16; P275/40ZR17; P315/35ZR17.

WHAT THE COMPETITION NOW HAS TO AIM FOR.



The "contact patch" of the Eagle GS-A.



The "contact patch" of the Eagle GS-C.



The "contact patch" of the Eagle GS-D.

Trying to fly with the Eagles can be exhausting work. Just ask any of our competitors.

They've never really managed to catch up to the Eagle "Gatorback," our first unidirectional performance tire.

Now we've gone the competition three better. So you can imagine just how nervous they must feel reading this.

You've read of the immediate acceptance of the new Eagle GS family by some of the best-known and most desirable name plates in the world:

Ferrari. Corvette. Lotus. Lexus. Porsche. Toyota.

Now here are some quotes from four-time Indy 500 winner Rick Mears.

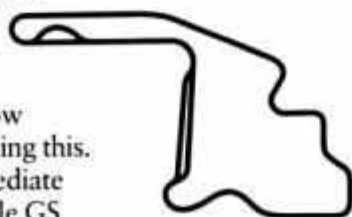
He drove a 1992 Corvette ZR-1 on Goodyear Eagle GS-C radials at Mid-Ohio race track.

(Rick owns a ZR-1, on Eagle "Gatorbacks," and is very familiar with Mid-Ohio.)

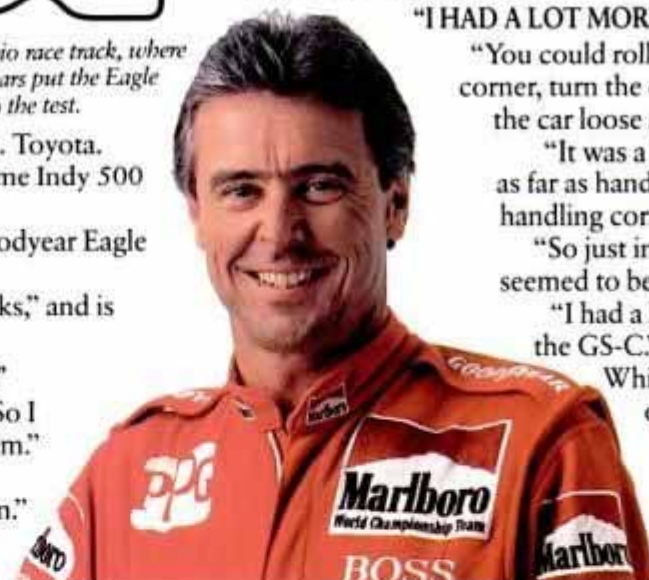
"I COULDN'T BELIEVE THE DIFFERENCE."

"The original Gatorback is a great tire. So I couldn't believe the difference between them."

"There is really no comparison. The GS-C is just a gain in almost every direction."



Mid-Ohio race track, where Rick Mears put the Eagle GS-C to the test.



Rick Mears, four-time Indy 500 winner and owner of the first-ever production Corvette ZR-1.

"The first thing I noticed was the ride. The GS-C seemed to soak up harshness quite a bit more. It absorbed the sharp edges of the pavement much better."

"The other big thing you notice is the response the tire has, the forgiveness."

"Grip was also noticed. Under power, off the corners."

"I noticed we had a lot more forward bite."

"It wasn't just the grip. The construction of the tire would help turn the car even more as I wound more into the steering."

"The GS-C was more consistent from lap to lap, much more drivable."

"I HAD A LOT MORE FUN."

"You could roll the car into the corner, turn the car in, and not shake the car loose as much."

"It was a lot more progressive as far as handling the car and handling corrections."

"So just in all aspects, the tire seemed to be much, much better."

"I had a lot more fun driving the GS-C."

Which, all in all, is the one thing we're sure we're never going to hear from our competition.



The Lexus SC 400



The Toyota Supra Turbo

Both of these performance cars come with Eagle GS ultra-performance radials.

GOODYEAR

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

Dream Boat For Science

MOSS POINT, MI—The latest marine machine for U.S. oceanographers is a state-of-the-art 274-ft., 3250-ton vessel christened the M/V *Thomas G. Thompson*.

Built by Halter Marine Shipyard, the *Thompson* features a dynamic positioning system that locks the ship within a 300-ft. radius and a Krupp Altas multibeam sonar system that can probe down to 30,000 ft.

The ship's main deck and lab floors have 2-ft.-sq. grids of sockets that accommodate hardware for temporary walls and fixtures. This enables quick rearrangement



for new missions, addressing a frequent complaint of oceanographers.

The University of Washington operates the ship under the Navy's aegis.

Thomas G. Thompson features modular lab space surrounded by working decks.

TRINITY MARINE GROUP PHOTO

Spud Light

COLUMBUS, OH—The latest targets for laser beams aren't compact discs or missiles—they're groceries. Battelle Columbus, the contract research laboratory, has come up with a fast, efficient way of cleaning away the skin from vegetables: continuous-wave carbon-dioxide lasers.

The technique isn't designed for household kitchens but for large commercial food processors such as the H.J. Heinz Company, which holds the patent. A conveyor belt moves the produce under a spinning mirrored wheel which



is peppered by three lasers. The beams, reflecting off the wheel, sweep back and forth across the vegetables, vaporizing the skin.

Because carbon-dioxide laser beams are absorbed by water, they burn off the dry skin but are quenched when they hit the moist flesh of the vegetable.

The lasers could replace the messy, time-consuming technique currently used—a pressure-cooker method that literally blows the skin off, wasting 15% of the product. Battelle is evaluating the process on different foods.

Laser beam vaporizes potato skin but leaves underlying meat undamaged.

BATTELLE PHOTO

Heavy-Duty Particle Beam

ARGONNE, IL—Under the auspices of the Strategic Defense Command, Argonne National Laboratories will soon run a particle accelerator

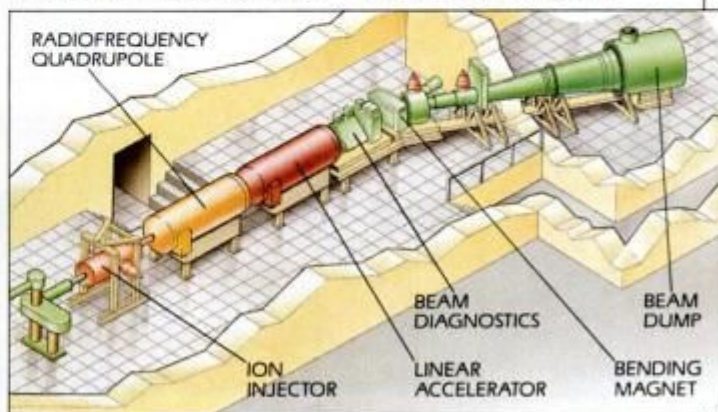
that will unleash a fierce barrage of heavy ions.

Under construction by Grumman Corp., the Continuous Wave Deuterium Dem-

onstrator (CWDD) will combine an unprecedented high average current with the punch of a negatively charged deuterium ion. While other accelerators can move heavier ions, none can move enough of them to match the CWDD's multiple-

milliamp current.

When complete, the machine will have applications ranging from producing neutrons or short-lived medical radioisotopes in abundance to serving as a model for a possible future space-based particle-beam weapon.



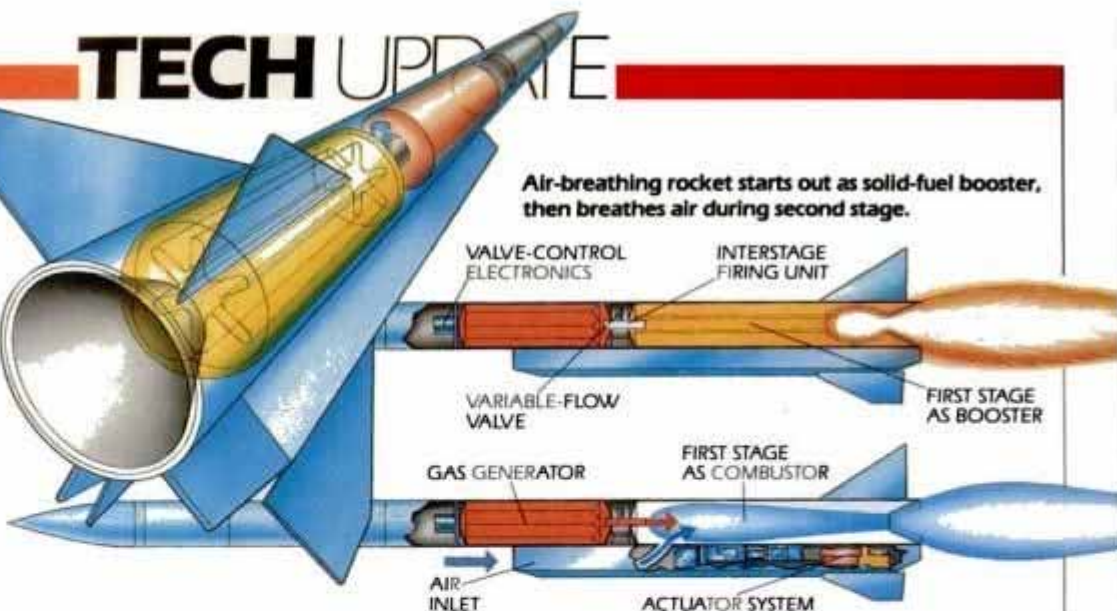
CWDD will have highest average current yet achieved for heavy ions. Ion injector (left) is already complete.

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

Rockets Breathe Air

McGREGOR, TX—In order to squeeze as much range out of its missiles as possible, the Air Force is sponsoring research into a 2-stage rocket engine that converts into a jet after the first stage has exhausted its fuel.

The air-breathing rocket, under development by Hercules Aerospace, functions as a conventional solid-fuel booster while the first stage is burning. Once the first-stage propellant is spent, however, the second stage, a gas generator, begins releasing



Air-breathing rocket starts out as solid-fuel booster, then breathes air during second stage.

fuel into the empty chamber through a variable-flow valve. Meanwhile, twin air scoops, which also act as

rudders, channel air into the booster chamber, which now acts as a combustor.

Because the second stage

uses oxygen from air instead of carrying oxidizer, the rocket can hold more fuel and cover more ground.

Sky Sweeper

LIVERMORE, CA—A helicopter may seem an unlikely vantage point to comb the landscape for buried mines, but physicists at Lawrence Livermore National Laboratories have developed technology that will allow them to do just that.

The key is a dual-band infrared sensor that captures soil-temperature variations. Because buried objects warm up and cool off at different rates than the surrounding soil, the device can single out topsoil that radiates an anomalous temperature signature. The nitrogen-cooled instrument can detect tempera-



ture variations as small as a third of a degree Fahrenheit.

The scanner generates color-coded maps of the terrain that the helicopter has covered. Using a pattern-recognition algorithm, a computer can then distinguish buried objects by their shapes.

The technique, developed under funding from the Defense Advanced Research Projects Agency (DARPA), is a refinement of a methodology used to locate buried archeological artifacts. Future efforts will focus on integrating the infrared scanner with other remote-sensing gear.

Dual-band infrared scanner peers out of helicopter seeking buried land mines.

High-Flying Ozone Watcher

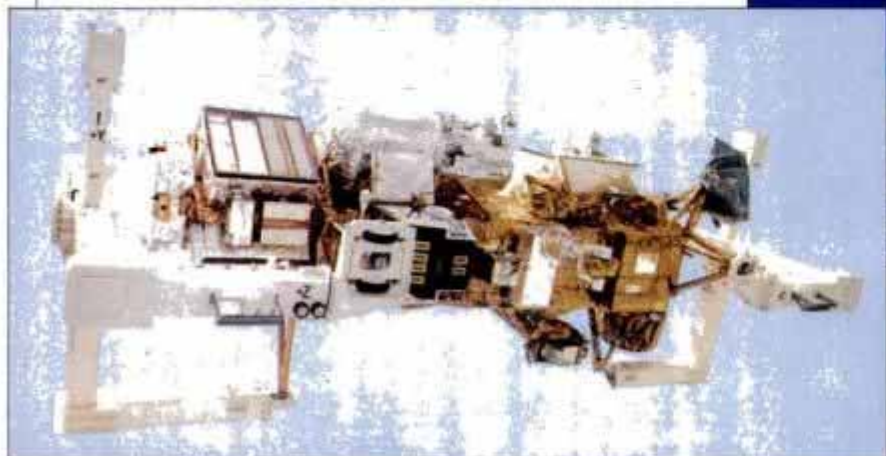
KENNEDY SPACE CENTER, FL—Although NASA has recently launched spacecraft to study the atmospheres of other planets, the agency hasn't lofted one to probe our own atmosphere since 1984. But for the next three years, the Upper Atmosphere Research Satellite

(UARS) will train a battery of sensors on the gases that swirl between 6 and 60 miles above Earth's surface.

While UARS can't see the ozone-layer holes that open over polar regions, it will track industrial chlorofluorocarbons and their effects on ozone. The key instrument

for this task is a spectrometer cooled to -436° F with a 150-pound block of frozen

neon. Other sensors will clock high-altitude wind speeds, measure ultraviolet



UARS, a 15,000-pound satellite, will orbit 375 miles up, looking down at Earth's atmosphere.

rays from the Sun and examine charged particles.

At press time, the probe was slated for an October deployment from the Space Shuttle *Discovery*.

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THE WRAP

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STREET SMARTS

Roads and cars that think together may be the key to a freewheeling future.

BY DAVID W. FREEMAN; PM Illustration by John Berkey

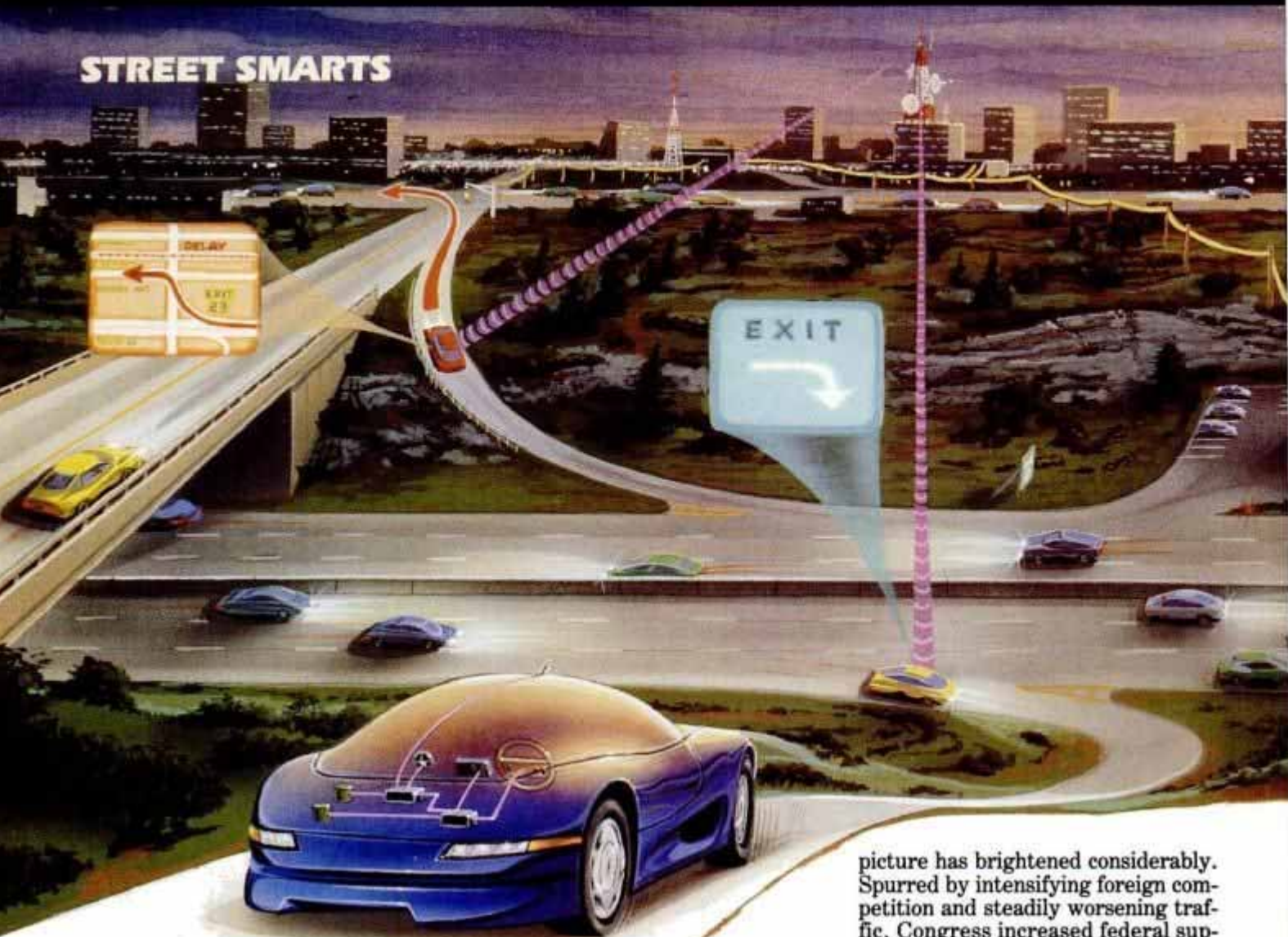
● Long celebrated as a symbol of personal freedom and of a carefree, exuberant lifestyle, the automobile is losing its appeal for many Americans. The reason is simple: traffic.

Between 1950 and 1986, the U.S. population increased by about 60%, yet during

the same period the number of automobiles grew by almost 257%. Once a problem only in big cities, traffic is now causing headaches across the nation. In fact, so fierce is congestion nowadays that on urban interstates designed for speed, nearly two-thirds of rush-hour traffic



STREET SMARTS



pokes along at less than 35 miles per hour. Frustration has grown to the point that many Americans now consider traffic a bigger threat to the country than unemployment, overpopulation or crime.

Ironically—but not happily—the same speed limits that once seemed needlessly restrictive are now hopelessly optimistic. These days, drivers are happy just to get out of Second gear.

Various proposals have been offered for easing our national gridlock. Environmentalists recommend driving less and relying instead on walking, riding a bike or using mass transit. Lay more pavement, urges the construction lobby. To date, however, neither of these approaches has demonstrated much promise.

Despite their frustration, Americans seem reluctant to be pried from their cars, and undeveloped land has become so precious that burying it under additional highways verges on the criminal.

Dumb cars/dumb highways

A growing number of transportation experts see a solution simply in making better use of highways already in

place. Doing so is impossible now, these experts maintain, not because drivers or urban planners are dumb, but because cars and highways are. This argument is not without merit. Digital engine controls, antilock brakes, digital dashboards and other examples of high-tech automotive hardware notwithstanding, a first-generation personal computer boasts more brainpower than many cars now on the road. Likewise, highways have changed little since 1956, when President Eisenhower ushered in the modern era of transportation by signing the Federal Interstate Highway Act.

Making vehicles and highways intelligent is by no means a new idea. General Motors and Ford first popularized "modern highways" at the 1939 New York World's Fair, and government officials and industry executives have been proposing variations on the theme ever since. Countless studies were done, countless papers written, and one experimental technology gave way to another. Still, implementation proved elusive. And research and development came to a virtual standstill in the 1970s, when federal funding all but disappeared.

Over the past year, however, the

picture has brightened considerably. Spurred by intensifying foreign competition and steadily worsening traffic, Congress increased federal support from \$2.3 to \$20 million between fiscal years '90 and '91. The appropriation for '92 will almost certainly surpass \$150 million. Decades of hand-wringing is at last giving way to action, bringing forth a family of technologies known collectively as Intelligent Vehicle/Highway Systems (IVHS).

First-generation IVHS will be limited primarily to traffic-control systems that monitor conditions on the roads in a particular city and to driver information systems that keep drivers informed of changing traffic patterns. Later, IVHS will provide for automatic spacing of vehicles on the highway and then collision avoidance. Ultimately, highway travel will be automated from entrance ramp to exit ramp. A motorist will simply push the appropriate button on an electronic console inside the car to indicate the desired destination. The computer will then determine the fastest route to, say, the office, taking into account information about current traffic. The motorist still must drive the car in the current manner as long as he remains on surface streets. Once he is safely on an interstate or similar throughway, the car takes over.

Following a brief diagnostic check of on-board systems (including



whether there's enough gasoline in the tank to complete the trip), the driver can remove his hands from the steering wheel and his feet from the pedals. As the car speeds along, he can sit back and read, type a memo on a laptop computer—even indulge in a catnap. The car automatically locates and joins a platoon of vehicles headed in the same direction. When it is time to exit the highway, the car beeps to alert the driver that he is soon to take control. To ensure that he is ready for the transition, he must enter a numerical code into a dashboard keypad. Experts predict that full vehicle control will bring the average speed during a commute from 30 to 40 miles per hour up to 75 miles per hour.

First steps

Weaving together the first threads of these future networks are a number of pilot projects now under way around the world. Three separate vehicle-navigation systems have been extensively tested in Tokyo, and such systems are now under evaluation in Berlin, London and elsewhere.

The largest single program is PROMETHEUS, a 7-year, \$875-million effort undertaken by a consortium of European government agencies and automakers. PROMETHEUS stands for Programme for European Traffic with Highest Efficiency and Unprecedented Safety and aims not only to heighten efficiency on European roads, where the average speed has

fallen to a mere 9 miles per hour, but also to halve the annual toll of fatalities, currently at 55,000.

Central to PROMETHEUS is a network of road sensors capable of communicating via radio with passing vehicles. Motorists punch in their initial location and destination upon sliding behind the wheel. Sensors along the route pick up this information and route it to a central station, where computers rebroadcast signals to the car. These signals, showing up as directional arrows on the dashboard, indicate the best route to take.

With the resurgence of funding in the United States, several efforts are now gearing up to compete with PROMETHEUS, both in scale and in sophistication. The first fully operational IVHS route in this country is a "smart corridor" along a 13-mile stretch of Los Angeles's Santa Monica Freeway, among the busiest sections of freeway in the country. This \$1.7-million project, undertaken by GM, the federal Department of Transportation and the California Department of Transportation, seeks to determine the effectiveness of on-board navigation systems. A secondary goal is to determine whether interacting with the system is detrimental to safety.

Each of the 25 Pathfinder cars is equipped with \$10,000 of equipment—a 4-in. computer monitor on the dashboard, a compass on the rear deck, wheel-motion sensors, and, in the trunk, a radio transceiver and an optical disk containing maps of high-

In an IVHS network of the near future, cars radio location and speed data to a central station, where it is combined with police reports and sensor signals to form an overall traffic picture. This is radioed back to the cars and then overlaid on digital map data to determine the best route.

ways and surface roads throughout the corridor. Before starting a trip, a Pathfinder driver keys in his original location and his desired destination. The appropriate map is automatically displayed on the screen, and the car's position appears as a tiny blip. This blip remains stationary as the car moves, but the map moves to stay current with the car's location. Electronic gear in the trunk monitors heading changes and wheel rotation to fix the car's current position on the map. Although simple, Pathfinder's dead-reckoning, map-matching technology is quite accurate, and any mistakes can easily be corrected by punching a few buttons on the monitor. The maps can be viewed on a variety of scales, permitting fast, efficient navigation even on unfamiliar roads.

Periodically, the vehicle reports its position, speed and heading to the CalTrans Traffic Control Center. There, information on traffic flow is obtained from a variety of sources, including updates from other Pathfinder vehicles, police accident reports, data from loop sensors buried in the roadways and real-time video from cameras placed along the corridor. Once each minute, this information is relayed back to the Pathfinder vehicle, where it is displayed graphically, textually or, if the driver so desires,

STREET SMARTS

with simulated voice. If the system works as intended, the driver will use this information to bypass heavy congestion by selecting an alternate route. Pathfinder will last one year.

A more ambitious project, dubbed TravTek, gets under way along Interstate 4 in Orlando, Florida, sometime in 1992. Like Pathfinder, this \$8-million, 3-year effort will involve GM cars with on-board videoscreens, a microcomputer and radio gear. But more vehicles will be used (100 versus 25), and instead of merely being informed about traffic snarls, motorists will be shown the best route to a particular destination. Moreover, participants in the program will have instant access to community calendars, emergency services and information on restaurants and hotels—sort of a rudimentary Yellow Pages.

America's largest IVHS effort was launched this summer in the northwestern suburbs of Chicago. Scheduled to begin operation throughout a 200-sq.-mile area in early 1993, the \$35- to \$40-million project will involve up to 5000 cars. Each will be equipped with a global positioning satellite receiver, which provides more consistently accurate location information

than the dead-reckoning systems used elsewhere. The Motorola-designed in-car electronics package will also include an optical-disk map database, dead-reckoning gear and a user interface with a color videoscreen and synthesized voice outputs. A dynamic information transceiver would maintain radio contact with a traffic information center, allowing the car's computer to constantly update the best route to its destination.

Transportation experts are generally sanguine about the prospects of these early IVHS efforts. But even if the technology proves feasible, these experiments may fail psychologically—no one knows whether motorists are willing to be advised by a computer screen. A report of congestion ahead may not be sufficient impetus for a driver to forsake the main road for unfamiliar—and potentially dangerous—side roads.

Farther on up the road

Pathfinder, TravTek and Advance are examples of motorist information services, the least spectacular among three different applications of IVHS technology. The other two types of IVHS applications are vision enhance-

ment and advanced vehicle controls.

At first, vision enhancement will use radar, sonar or even laser beams to spot unseen obstacles at the sides and rear of the vehicle. Drivers will be warned via symbols projected onto the windshield or rearview mirror, on a dashboard videoscreen or with simulated speech over loudspeakers. Similar systems using infrared beams will extend a driver's vision at nighttime, or in heavy fog or precipitation. Next: computer vision. Instead of peering through the windshield, drivers will watch computer-generated "virtual" representations of the road on videoscreens. Eventually, computer vision will supplant human vision altogether, much as it has in certain forms of manufacturing. With virtually no input from the driver, the computer will spot obstacles and other potential dangers, and then steer around them safely.

The first systems to actually relieve the driver of some measure of control over his car will probably be adaptive cruise-control systems. Now under development at the University of California and elsewhere, these use radar or possibly pattern-recognition technology to monitor the position of other vehicles on the road. If the car ahead changes speed, the system reacts by audibly warning the driver of an incipient collision, or by automatically applying the brakes or accelerator.

Eventually, adaptive cruise control will enable an entire platoon or "road train" of cars to move together in a single, unbroken and orderly procession. In one scenario, cars entering the highway would hook up with cars headed in the same direction and travel along with minimal input from the driver. Platoons of vehicles at 100-ft. intervals traveling at 80 miles per hour could conceivably increase the carrying capacity of a highway by sevenfold, according to recent studies.

There's no doubt that smart cars and highways are on the way. Without them, America's love affair with the automobile will soon be transformed from a cliché into a misnomer. All that remains to be seen is when the technology will begin to appear, how effective it will be and who will profit from it. On that last point, the news may be bad unless the U.S. transportation community continues toward a more streamlined approach to IVHS research and development. "More than half the cars on California highways are foreign built," points out Robert Parsons, an industry consultant and former DOT official. "If American industry doesn't act soon on IVHS, we might find ourselves driving on foreign streets." **PM**



TravTek system now being built into 100 Oldsmobile Troféos uses the car's stock color CRT for map readouts. Steering wheel buttons allow driver inputs while in motion.



PM PHOTOS BY G PHOTO



CHEVROLET CAPRICE

Brand-new shape, same old virtues.

BY MICHAEL LAMM, Contributing Editor; PM Photos by Roy Attaway

● Change comes slowly in Chevy's full-size Caprice line. The last major redesign occurred in 1977, when the cars were significantly reduced in size. So when a new edition of this all-American standard finally came along for 1991, we immediately started getting in touch with the new owners, to see how this dramatic styling departure would rate.

And we emerged with the feeling that Chevrolet's product planners have struck a well-conceived balance between new and tried-and-true.

Fundamentally, the Caprice blends old with new. Although it's 2 in. longer and 2 in. wider, it still uses the same chassis, with body-on-frame construction and rear-wheel drive. It also carries over Chevy's solidly established small-block V8, in this case the 170-hp 5.0-liter with throttle-body fuel injection. The only available transmission is the L60 4-speed over-



drive automatic with lockup torque converter. Air conditioning and most power-assisted equipment remain standard.

On the new side of the ledger, the redesigned Caprice also offers anti-lock brakes, a driver's airbag and 3-point shoulder harnesses—front and rear—as standard equipment. The restyled body improves the Caprice's aerodynamic efficiency by 27%, going from a barnlike Cd of 0.42 to 0.33.

The new Caprice affords driver and

passengers a better view of what's going on, with 50% more glass area. The base wheels and tires are wider, and power-steering assist has been recalibrated to improve road feel.

More glass and more sheetmetal add up to more weight—at 3900 pounds, the new Caprice is about 300 pounds heavier than the old. That's a lot of weight, but it was interesting to learn that many of the Caprice owners

in our survey viewed it as a plus in the old road-hugging sense.

The new Caprice comes in only two body styles—sedan and station wagon. The 2-door is history. The wagon, with seating for up to eight, is similar in form to the Buick Roadmaster and Oldsmobile Custom Cruiser. All three of these full-size wagons share mechanical components and even some sheetmetal.

Our questionnaires revealed some interesting information about the

CHEVROLET CAPRICE



new Caprice owners. For example, nearly half of them are 65 or older. That's not the audience Chevrolet had in mind for the new body style. The product planners were hoping to attract a yuppie crowd.

We also learned which features the owners valued most, and found that they're not the ones we've come to expect from younger owners. The new car's styling, though positively received, wasn't the big persuader it is with so many cars. What Caprice owners value is just what they've always valued: a big, roomy, traditional American car with storage to rival a warehouse, a feeling of safety and the sense of cruising down the highway in a Barcalounger—a car that's worth its asking price and holds its resale value. The Caprice delivers on all counts.

Asked whether they'd buy the same make and model again, 72.1% of our owners said yes, a very solid response. And most of the would-buy-again group told us they *wouldn't* be interested in any of Chevy's smaller



Wheel-mounted airbag became standard equipment in Caprice redesign.

sedans, like the Corsica or even the Lumina. We are talking Caprice faithful here. We might even be on to a new kind of cult car.

This is not a group to be seduced by sports-car handling. Nevertheless, 65% of the owners in our survey ordered either the F41 or FE2 suspension option. The F41 handling package adds a very modest \$49 to the bottom line. The FE2 is part of the towing package. Both come with meatier tires, stiffer shocks and heftier antiroll bars.



Chevy's 5.0-liter pushrod V8 inspired confidence of Caprice owners in survey.

We conclude from this that Caprice traditionalists do put some stock in a car's ability to respond. Overall, the Caprice's handling ranked fourth on the list of owners' specific likes.

The Caprice's fuel economy left most owners smiling. EPA ratings for this car are 17 mpg city/26 highway, but our respondents beat the city number by 10% at 18.6 mpg. On the highway, though, the real-world Caprice came in 0.7 mpg less than the EPA projection.

Not surprisingly, roominess and

SUMMARY OF 1991 CHEVROLET CAPRICE OWNERS REPORTS*

Total miles driven:	2,107,966	Styling	40.8	Average	5.3	Dealer repairs satisfactory?	
Average miles driven:	6274	Overall comfort	35.9	Poor	0.6	Yes	77.0%
Purchase price:		Handling	31.4	Comfort opinion, front seats:		No	23.0
Average	\$18,359	Roominess	20.7	Excellent	65.6%	Dealer service opinion:	
Range	\$13,965-\$22,529	Economy	15.9	Good	30.9	Excellent	42.7%
Avg. mpg, city/hwy:	18.6/25.3	Specific dislikes:		Average	2.6	Good	43.1
Why did you choose the Caprice?		No complaints	17.3%	Poor	0.9	Average	9.3
Styling	43.4%	Squeaks and rattles	6.6	Comfort opinion, rear seats:		Poor	4.9
Owned other Chevrolets	34.7	Boring instrument panel	5.9	Excellent	59.5%	Number of vehicles owned:	
Size	15.9	Paint quality	5.9	Good	38.6	This vehicle only	33.4%
Rear-wheel drive	12.2	Doors too heavy, bulky	5.1	Average	1.6	Two vehicles	42.4
Chevrolet V8	9.4	Fuel economy	5.1	Poor	0.3	Three vehicles	14.0
Price/value	9.4	Quality of materials	5.1	Mechanical trouble?		Four or more	10.3
Model choice:		Suggested changes:		No	66.9%	Principal driver:	
Caprice Classic	78.5%	No changes	31.7%	Yes	33.1	Male	45.4%
Standard Caprice	21.5**	Revise instrument panel	3.8	What type of trouble?		Equal	31.6
Major options:		More manageable doors	3.8	Electrical problems	22.8%	Female	23.0
Power door locks	98.5%	Improve horn buttons	3.8	Transmission	14.0	Age distribution of owners:	
Preferred package No. 1	82.7	Reduce dashtop glare	3.8	Engine oil leaks	12.3	Under 29	0.6%
Preferred package No. 2	77.1	Reduce windshield glare	3.8	Wheel alignment	9.6	30-49 years	14.5
Premium sound system	72.4	Eliminate squeaks, rattles	3.5	Brake squeal	8.8	50-plus	84.9
Handling suspension	65.0	Improve fuel economy	3.5	Balky power door locks	7.0	Based on your experience, would you buy a Caprice again?	
Limited slip	51.9	Improve overall quality	3.5	Shift-point adjustment	7.0	Yes	72.1%
Leather upholstery	28.6	Workmanship opinion:		Did you repair it yourself?		Maybe	19.4
Specific likes:		Excellent	49.9%	No	96.5%	No	8.5
Ride	48.5%	Good	44.2	Yes	3.5		

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

** Station wagon and LTZ models not available at time of survey.

ride quality got excellent reviews from virtually all our owners, as did interior comfort. Those wide seats make this car a favorite for family vacations, and the 23-gallon fuel tank (22 gallons in the wagon) provided good driving range between fillups. The owners in our survey also gave us positive comments on the Caprice's towing performance.

Of course, even America's classic can skip a heartbeat now and again. For example, while most owners acknowledged that dealers treated them right, many felt they had to go back to the shop for repairs too often. Fully a third of our sample group reported mechanical problems, compared with only 20% for the 1991 Buick LeSabre (see Owners Report, page 39, June '91).

Quick fixes

The Caprice's most common headaches were electrical, and required only one trip to the dealer to fix in 77% of all cases reported. Like the buy-again index, that's a good mark, and surveyed owners gave overall dealer service a combined good or excellent rating of 85.8%.

Early-production Caprices had problems with water leaks due to ill-fitting door and trunk seals. Window moldings, too, would sometimes ride down in their channels and allow water to seep through into the cabin.

Several owners complained that trunk space was smaller than in previous Caprices. That's because the spare tire, which bolts to the center of the trunk floor, took up valuable space.

A handful noted that the fabric seats, Scotchgarded at the factory, felt sticky if the driver or passenger was wearing shorts. Another minority complaint had to do with the front doors, which seemed heavy and unwieldy on sloping driveways or hillsides to some owners. Wheel covers, held on by plastic clips, were easy to knock off against curbs. And a number of drivers offered wry congratulations to Chevy for its success in hiding the two small horn buttons.

Warm feelings

But those criticisms paled beside the warm feelings most Caprice owners expressed for their vehicles. Size and weight notwithstanding, they seemed to regard this car as a design that's totally up to date in technology, safety and styling.

And perhaps even more important, they seemed united in their conviction that the Chevy Caprice beats all of its competitors in terms of roominess, comfort, reliability, durability and dollar value.



Radical styling and past Chevy experience help to sell the new Caprice.

EDITORS REPORT

Our Kind Of Caprice

● Although we've accumulated lots of Caprice seat time, thanks largely to our recently completed long-term evaluation (page 32, June '91), this Owners Report gave us a chance to spend some time with the Caprice LTZ. When we returned it, we were convinced that this is the Caprice we'd most like to own.

The heart of the LTZ option is a suspension package designed to make this big sedan a little more responsive in terms of handling. Specific elements are stiffer shock valving, higher spring rates, a rear antiroll bar and a heavier-than-stock front antiroll bar. Tires are 235/70V-15 Eagle GT+4s, compared to the standard Caprice's 215/75-15s, and there are bigger drum brakes, with cooling fins, at the rear, 11.0 in. versus 9.5.

Chevy has quickened up the LTZ's steering, reducing the number of turns lock to lock from 3.16 to 3.06, and the level of power assist has been reduced, improving feel.

What all this adds up to is a Caprice that's much more responsive, with more roll stiffness and consequent reduction in weight transfer.

It's also a little quicker than the rest of the Caprice lineup. Chevy has achieved this without doing anything under the hood—the LTZ's 5.0-liter V8 is rated the same as the standard Caprice. However, the LTZ rolls out with a 3.23:1 rear axle ratio, considerably lower than the stock 2.56:1 and peppier than even the 3.08:1 that goes with the towing package.

While this adds a few rpm to the LTZ's engine speeds in highway

cruising, it has no effect on fuel economy, and it knocks a few tenths off the LTZ's 0-to-60-mph performance. The standard Caprice manages this run in about 10.5 seconds, while the LTZ gets the job done in the high 9-second range. That's not exactly neck-snapping, but it's not bad for a 2-ton sedan.

Elsewhere, the LTZ has the same virtues that our Caprice owners love so well—lots of space inside, living-room comfort, solid construction and world-class reliability. Solidity is a quality that has long set this car apart from most family sedans. Our long-term Caprice absorbed all sorts of New York City punishment with never a squeak or rattle, and other encounters with the new model, including the LTZ, suggest that Chevy has done well in carrying this most important trait forward to the new generation.

As for reliability, there's something to be said for an engine with almost four decades of development behind it. Chevy's evergreen small-block V8 may not have quartets of valves or duets of overhead camshafts, but it's quiet, smooth, torquey and unbreakable. About the only criticism we can level is excessive intake noise at wide-open throttle.

As we said, the LTZ is our kind of Caprice. But with or without the LTZ option, it's easy to understand why owners love this big Chevy. It combines the best qualities of another age in American motoring with a wholly contemporary standard of durability. How many of today's cars do the same? —Tony Swan

How do you improve on a symbol for quality? You make

The New LeSabre

Buick LeSabre has earned an enviable reputation for quality. Of course, that didn't stop the people at Buick from striving to make LeSabre even better.

Safer

The new LeSabre offers the safety of anti-lock brakes (ABS), as

well as a standard driver-side air bag supplemental restraint.

Roomier

LeSabre's 6-passenger seating now gives you even greater front headroom and rear legroom.



And the spacious trunk is easily accessible, thanks to the new low liftover design.

Quieter

LeSabre's aerodynamic new exterior is one designed to please both your eyes and



the car that became a legend in America? it better.

ears. Wind noise is reduced to a whisper, while special acoustical insulation all but banishes road noise from the interior.

More Powerful

The LeSabre's 3800 V6 engine now offers even more horsepower. Yet it gets an EPA estimate of 18 miles per gallon city/28 highway.

To learn more about the

qualities that make the new Buick LeSabre even better, please call 1-800-531-1115.

Or better yet, we invite you to



see your Buick dealer and enjoy a test drive today.

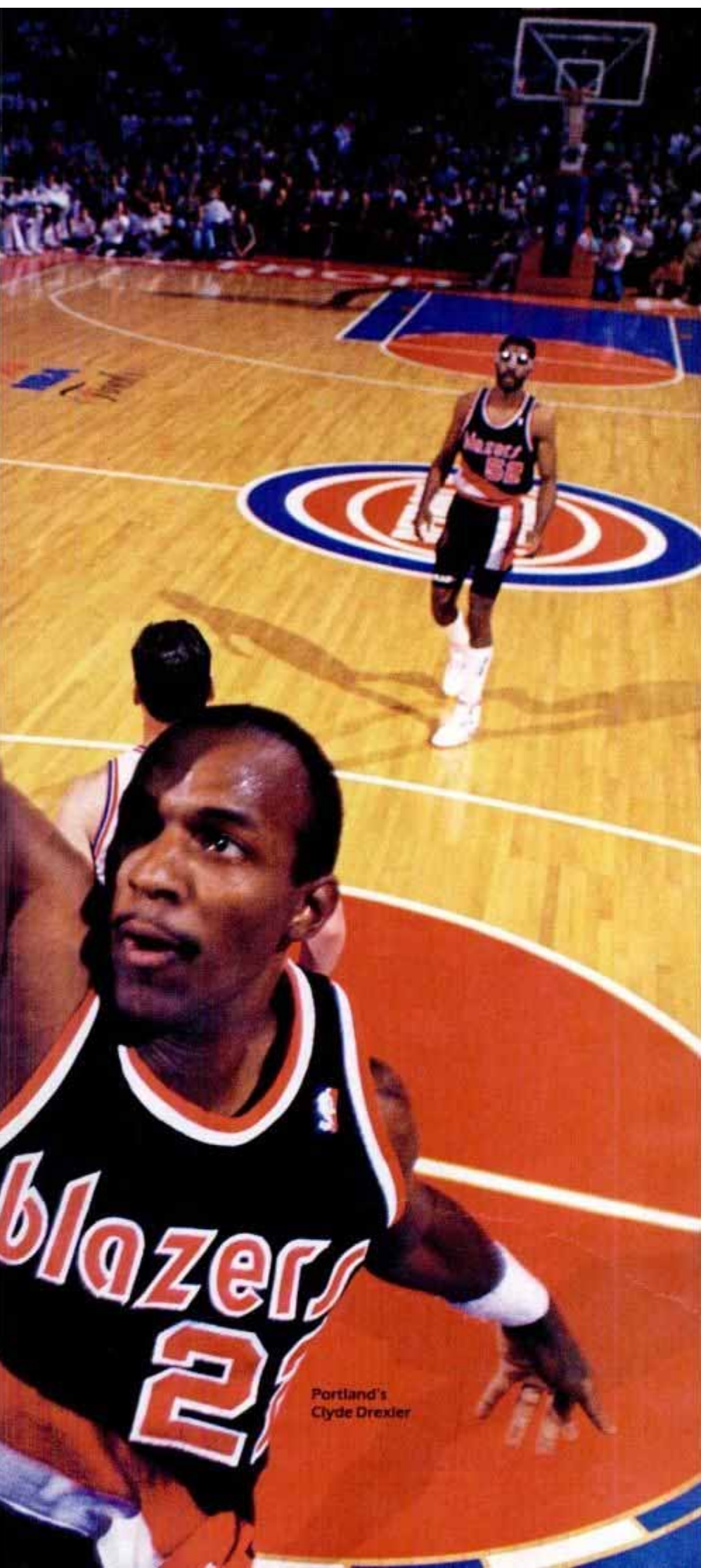


BUICK

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In America.



THE MECHANICS OF A
**SLAM
DUNK**



Portland's
Clyde Drexler

Come fly with us, say
the NBA's best players.
Here's how.

BY PETER BRANCAZIO

● The slam dunk invariably brings a basketball crowd roaring to its feet and, more often than not, the player making the shot will follow it with a pumped fist or some other display of self-congratulation. But just how important is the slam dunk as an offensive weapon? Is it great basketball or just showmanship? How much skill is required to be a successful dunker?

The scientific study of any phenomenon normally begins with the description and classification of its forms. In this case, careful observation reveals that slam dunks actually fall into a relatively simple set of categories. The basic slam dunk begins with the shooter getting the ball on a pass or rebound within 3 ft. of the basket, requiring, at most, one step to get to the hoop. The ball may be delivered one- or 2-handed with varying degrees of force, ranging from a gentle dropped-in dunk to a resounding 2-handed overhead slam.

The next level of dunkmanship is the alley-oop. In this play, the player catches a pass in midair above the rim and jams it home. Requiring unspoken communication between passer and receiver, an accurately thrown pass and a well-timed leap and reception by the jammer, a perfectly executed alley-oop is a thing of beauty.

The take-it-to-the-hoop or flying slam dunk represents an even higher level of skill. Here, the player must move horizontally as well as vertically, and the shot must be taken off the dribble. (In a game, the player is generally allowed to take two steps between his last dribble and the takeoff for the shot.) This move calls for good acceleration and quick, instinctive body movements in addition to great leaping ability.

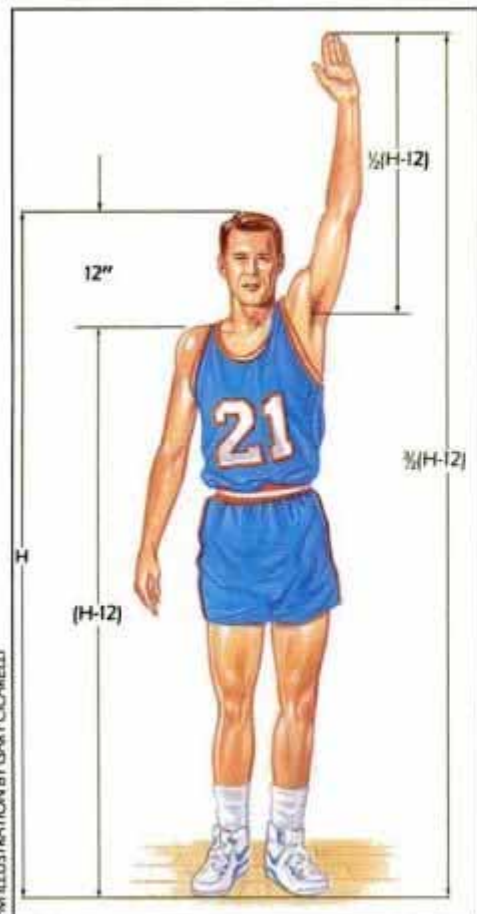
The last and most spectacular variety is the freestyle slam dunk. Here, the player is not required to dribble the ball or face a defender, so his performance is limited only by physical skill and imagination. A player can show off moves that he rarely gets to use in a game because they are too bizarre, too difficult or just plain illegal. The best freestyle slam dunks involve an amazing array of windmills, double-pumps, 360s, tomahawks and the sometimes unnameable.

The slam dunk was unknown in the early days of professional basketball.

Peter Brancazio is a professor of physics at Brooklyn College and is the author of the book Sports Science.

MANNY MILLAN/SPORTS ILLUSTRATED PHOTO

THE MECHANICS OF A SLAM DUNK



FM ILLUSTRATION BY GARY CICARELLI

BODY HEIGHT (H)	STANDING REACH (R)	VERTICAL JUMP (V)
5'6"	6'9"	45"
6'0"	7'6"	36"
6'6"	8'3"	27"
7'0"	9'0"	18"
7'6"	9'9"	9"

Many of the players of the 1940s and '50s were quite capable of dunking the ball, but to do so was to invite retaliation, either by having your legs taken out from under you on the way down, or by getting whacked later on with an elbow or forearm when the referee wasn't looking. In those prehistoric days, a slam dunk was considered an insult that had to be answered.

The entrance of Wilt Chamberlain into the NBA in 1959 represented a key evolutionary turning point. At 7 ft. 2 in., Wilt could dunk the ball easily, and it soon became his calling card. With his great physical strength and remarkable agility for a man of his size, Chamberlain was virtually unstoppable. Even the best defenders could only hope to deny him position under the hoop once in a while.

The slam dunk's rising popularity was due to the founding of a rival professional league, the American Basketball Association, in 1967. In an effort to attract fans, the new league emphasized a more wide-open, offensively minded game. The great star of the ABA was Julius Erving, who is to slam dunking what Mozart is to classical music. With his huge hands, Erving could hold a basketball as if it were a grapefruit. Whether in the open court on a fast break, or in the half court against one or more defenders, the Doctor's graceful, soaring moves to the hoop redefined the standards of the slam dunk. Erving's signature move was his tomahawk dunk in which he brandished the ball overhead—arm fully extended—as he approached the hoop. With the

merger of the two leagues in 1976, Dr. J was able to bring his game to a nationwide audience. His success and popularity inspired others to develop their own slam-dunk repertoire.

Today, nearly every NBA player can slam dunk, and the move has become almost commonplace. Virtually every team has at least one great flying dunker. The Portland Trailblazers have Clyde "The Glide" Drexler. The Utah Jazz have the "Mailman," Karl Malone. The Boston Celtics have Dee Brown, last year's winner of the NBA's Slam Dunk contest. The list of great dunkers is a long one. However, it is generally agreed that to this day, only two players—Michael Jordan of the Chicago Bulls and Dominique Wilkins of the Atlanta Hawks—have surpassed Erving in terms of the spectacular, mind-bending move.

Physical requirements

What are the physical attributes needed to be able to dunk a basketball? The obvious requirement is, of course, that you have to be able to get the basketball over the edge of a 10-ft.-high rim. This, in turn, calls for a combination of body height and jumping ability. It is also extremely helpful to be able to palm—grip securely with one hand—the ball. While it is not impossible to dunk the ball if you can't palm it, the variety and creativity of your dunks will be limited.

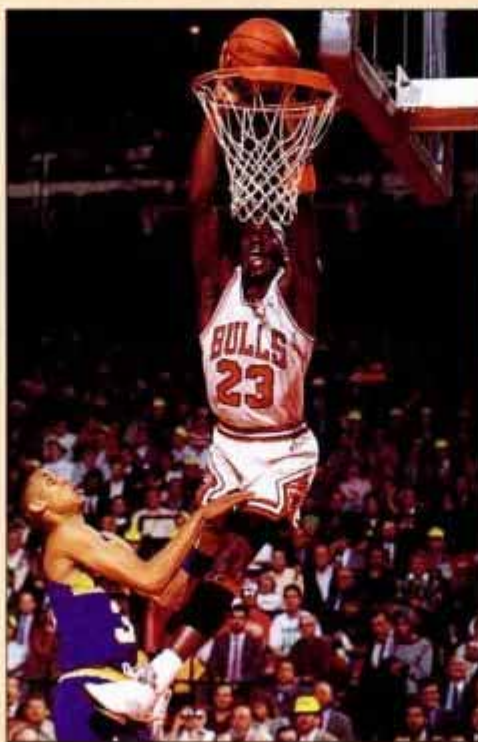
As a minimum requirement, you have to get your wrist to rim level in order to dunk the ball. This means that the sum of your standing reach and vertical leap must be 10 ft. 6 in. or

High Flyer

● Michael Jordan of the Chicago Bulls is acknowledged as today's premier slam dunker, as well as perhaps the National Basketball Association's best player. As such, Jordan has an arsenal of dunks at his command. Yet, they basically fall within four classifications. As seen in the accompanying photographs of Jordan (from left to right), there is the basic slam dunk from a standing position, the alley-oop dunk off a pass, the flying slam dunk after spinning through defenders and the freestyle slam dunk.

The freestyle dunk is the most instinctive and creative of moves to the basket. Jordan himself notes that he doesn't know what he's going to do until after his feet have left the ground. Good elevation and the ability to shoot while on the way down contribute to Jordan's seeming ability to defy the laws of gravity.

While freestyle dunking is perhaps the most visually exciting, the powerful, flying slam dunk is perhaps the most devastating since it signals a serious breakdown in the opposition's defense.



SPORTSCHROME PHOTO; FOCUS ON SPORTS PHOTO

more. Your standing reach is essentially the distance from the floor to the tips of your fingers when you are reaching upward from a standing position. Using some basic observations about human anatomy, we can devise an approximate formula that relates vertical reach to body height. The length of the average person's arm is about half the distance from his shoulder to the floor. If we take a person's body height in inches (H), subtract the distance from the top of the head to the shoulder (about 12 in., on average), and then add back half of this distance (about one arm's length), we arrive at the formula: $R = 3(H-12)/2$, where R is the individual's standing reach in inches. The chart on page 44 shows what the calculated vertical reach should be for different body heights. As we can see, a 7-footer's vertical reach should take him to within 1 ft. of the rim.

The difference between your vertical reach and 10 ft. 6 in.—the minimum height that must be attained for a successful dunk—must be made up by jumping. The third column in the chart shows the vertical leap in inches required for a player of a given body height to dunk the ball. For example, a 6-footer with a standing vertical reach of 7 ft. 6 in. must have a vertical leap of at least 36 in. to get into dunking range. All of the numbers in the chart are approximate. Actual values will vary according to body type.

What constitutes a good vertical leap? The average playground basketball player has a vertical leap in the 18- to 24-in. range. Anything in

the 24- to 36-in. range is considered to be unusual, and any vertical leap over 36 in. is exceptional. The best vertical leap ever recorded for a basketball player is 48 in., set by Darrell Griffith of the Utah Jazz in 1976. In the history of the NBA, probably only a handful of players have had vertical leaps exceeding 42 in. Most of the great acrobatic dunkers, like Jordan and Wilkins, are in the 36- to 40-in. range.

If you would like to know what your own vertical leap is, you can measure it fairly easily. Just stand facing a wall, extend your arm upward and make a mark with a pencil or piece of chalk. This is your vertical reach. Now jump vertically as high as you can, making a second mark on the wall. The difference between the two marks is your vertical leap.

Given the size and athletic ability of any hoopster good enough to make it to the NBA, or even for that matter to any top-ranked Division I college team, we should not be overly impressed by anyone 6 ft. 6 in. or more being able to dunk. All they need is fairly ordinary leaping ability. It's far more impressive to see someone dunk a ball when they're 6 ft. to 6 ft. 3 in. having a leap of 30 to 33 in.

Given this criterion, perhaps the most amazing dunker in professional basketball is not Wilkins or Jordan, but none other than Spud Webb, also of the Hawks. Listed at 5 ft. 7 in., Webb has a vertical leap in the 42- to 45-in. range. Or consider David Thompson, who played for the Denver Nuggets in the late '70s and '80s. Standing 6 ft. 4 in., with a vertical

leap of 42 in., Thompson was capable of lifting a basketball a foot and a half above the rim.

Hang time

To players and fans alike, the great slam dunkers appear to be airborne for seconds at a time and seem to hang in the air almost at will. In truth, their flight times are surprisingly short. According to the laws of physics, an athlete's hang time depends entirely on his upward speed at the moment of takeoff and cannot be extended once he is airborne.

In fact, hang time and vertical leap are mathematically related. The formula relating the vertical leap V (measured in inches) to the hang time T (measured in seconds) is $V = 48^2 T$. According to this equation, a vertical leap of 48 in. translates to a hang time of exactly 1 second. A 36-in. vertical leap corresponds to a hang time of 0.87 second. As unbelievable as it may seem, the great high flyers of the NBA perform their greatest moves in the space of $\frac{8}{10}$ to $\frac{9}{10}$ of a second. No small part of Jordan's greatness is the fact that he seems to cover enormous horizontal distances in the air. He accentuates this illusion by releasing his shots on the way down, rather than at the peak of his trajectory.

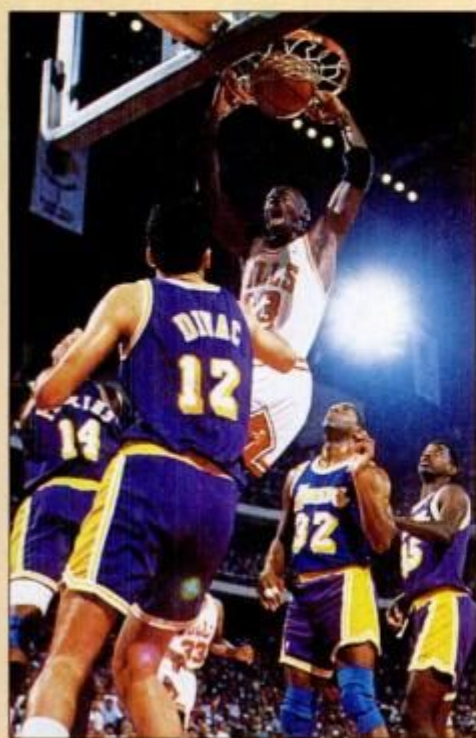
Clearly, it's not a big deal for almost any NBA player to dunk a basketball. So why are fans so excited by the sight of 7-footers like Patrick Ewing of the New York Knicks or David Robinson of the San Antonio Spurs jamming one down? And why do the players get so turned on by what for them is really not a difficult accomplishment?

It's easy to understand why the fans are so impressed. After all, the act of dunking a basketball is far beyond the capability of the average spectator, who is as likely to dunk a ball as he is to set foot on the Moon.

As for the players, they are all large, well-built individuals, capable of acts of great physical strength. Yet, shooting a basketball almost always requires a soft touch, calling for a carefully modulated and rather gentle application of force rather than an explosion of brute strength.

Slam dunking a basketball is perhaps the only opportunity a player ever gets to really unload in a game. To be able to break through the confines of a tight pressure defense, to get close enough to the basket with the ball in your hands, and to go up and over a tough defender and throw the ball down through the hoop with as much force as you please just plain feels good. When a great player unloads, it can be both intimidating and inspiring.

PM



AUTOMOBILES

LONG-TERM TEST CARS

Shaking down an all-new fleet.





BUICK PARK AVENUE ULTRA

PHOTO BY BOY ATTAWAY

● Since our last report (see page 32, June '91), we've had an almost total turnover in our long-term test fleet. Our Ford Escort GT and Toyota Previa minivan are the only holdovers, and this report will be the Escort's final chapter.

Meanwhile, we have five newcomers: a Dodge Dakota V8, Suzuki Swift GT, Chevy C2500 pickup, Buick Park Avenue Ultra and an Oldsmobile Cutlass Supreme with GM's new 205-hp Twin Dual Cam V6.

Dodge Dakota Sport V8

What you're looking at here—a V8 engine in a compact pickup—is a neat idea, and we're surprised neither Ford nor GM have followed suit.

While the 318-cu.-in. V8 doesn't offer much more grunt than the V6 engines powering its rivals—165 hp at 4000 rpm, 250 ft.-lb. of torque at 2400—there's enough to give this nifty mid-size hauler good punch off the line and plenty of low end for 4-wheel driving in the dirt.

There's also enough muscle for hefty towing assignments—the V8-powered Dakota carries a maximum tow rating of 6700 pounds. However, the fancy Sport package includes a nice-looking rear bumper that has to be removed if you want to mount a Class III hitch.

Accordingly, our Dakota has been relegated to local hauling chores, a couple trips into the New Jersey Pine Barrens and lots of just lookin' good around the New York suburbs. It's performed well through the 3976 miles we've accu-



OLDSMOBILE CUTLASS SUPREME

mulated so far, although as we went to press, a minor oil leak showed up. Fuel economy has averaged out at 19.2 mpg. —Tony Swan

Buick Park Avenue Ultra

Ordinarily, we pick up our long-term test cars at the manufacturer's headquarters, but we took possession of our Park Avenue Ultra at Ray Lathem Buick in Detroit. This gave Buick a chance to showcase its 20-minute delivery routine, with the salesperson taking us through every working part of the car.

This rundown on all the little features helps owners extract the most from their new car. Ordinarily, you would have to read the owner's manual to get most of this information.

The Lathem salesman told us he'd call back the next day and also the following week, to see how the car was performing.

He made good on both promises.

Aside from *two* nail-flattened tires, the only problem we've had through the first 4785 miles was a broken fastener that allowed the car's fuel lines to dangle below the passenger-side rocker panel.

Beyond that, we've enjoyed the Ultra's excellent road manners and superb comfort. We occasionally find ourselves wishing for a little more power from the 3800 V6 engine. Buick has cured this for '92 by offering a supercharged version.

But we're impressed with the car's economy—close to 23 miles per gallon



FORD ESCORT GT

PHOTO BY RON HUSSEY

LONG-TERM TEST CARS



PM PHOTO BY ROY ATTAWAY

SUZUKI SWIFT GT

cam Mazda-supplied engine is probably much closer to its peak horsepower rating of 125.

Fuel economy has also improved as the engine has loosened up, and our average for the entire year-long test is 31.7 mpg. We think that's pretty impressive for a car that sees a fair amount of spirited driving.

The Escort invites this kind of driving. We've found that it performs on a par with its small sport coupe rivals, cars like the Chevy Cavalier Z24, for example, or the Toyota Corolla GT-S.

About the only two persistent complaints in the logbook concern the seats, which become uncomfortable

overall. And the Park Avenue Ultra is quiet.

—Jim Dunne

Oldsmobile Cutlass Supreme

Our Olds has been languishing in the driveway the past few days, thanks to an a/c system that packed up on one of the hottest days (of course) in a hot New York summer.

Aside from that, the only problem we've had with our Cutlass Supreme in 6730 miles is a small piece of door trim that's vanished.

Balanced against that very minor irritation is the performance of the 3.4-liter Twin Dual Cam V6 engine. Not only is there plenty of peak horsepower, there's also impressive low-end torque for a multivalve, and the electronically controlled transaxle makes the most of it—you always seem to be in the right gear.

The Delco-Moraine ABS VI anti-lock-brake system, GM's new low-cost setup, continues to astonish us with its performance. You need this system on whatever car you drive.

Economy has varied from 16 mpg in NYC traffic to over 25 on the open road. We're sure the car is capable of better, but the engine keeps us de-



PM PHOTO BY ROY ATTAWAY

TOYOTA PREVIA LE

prioritizing mpg in favor of get up and go. The 3.4 has more than its share of this commodity.

—Mike Allen

Ford Escort GT

With 15,697 miles on the clock, our Escort GT is headed for home. And in some ways, it's a better car than when we picked it up. Most of these ways have to do with performance. The shifting has lost any hint of notchiness, and the 1.6-liter 16-valve twin-

after about 3 hours, and the clutch engagement, which isn't as smooth as we'd like. But on balance, the Escort looks like a good value in a small GT—good handling, good power, good ride, good looks and excellent durability.

—Rick Titus

Suzuki Swift GT

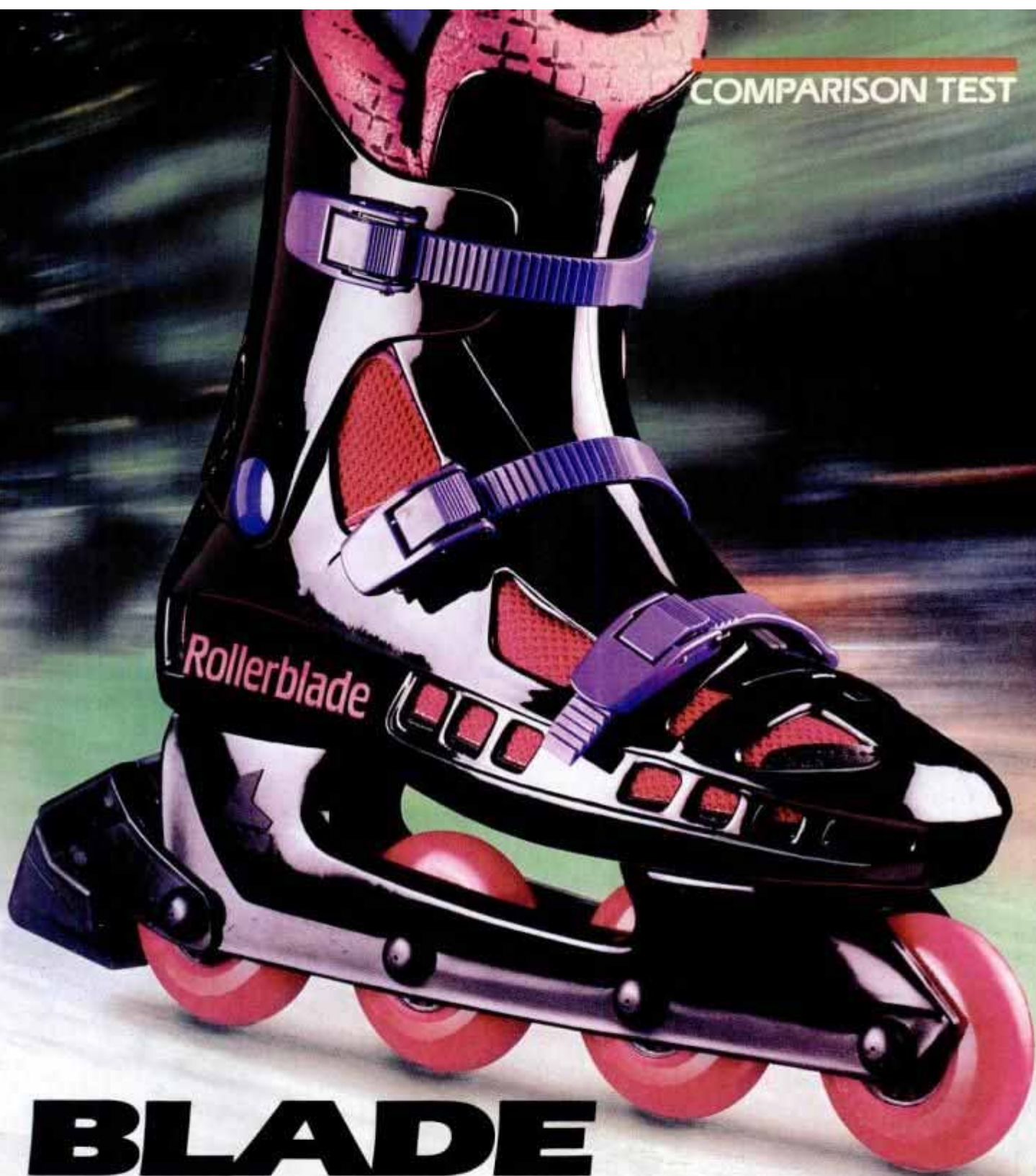
There are herds of competent little commuter cars around these days

(Please turn to page 135)



CHEVROLET C2500 SILVERADO

PM PHOTO BY GEOFF HEWITT



BLADE RUNNERS

Good times and fitness roll into the '90s on in-line skates. We test five models from \$100 to \$350.

BY WAYNE FASSETT; PM Photos by Brian Kosoff

● Supercool image to the contrary, the hottest sport of the '90s, in-line skating, is definitely *not* the latest export from ultra-hip California. Nor is it a recent trend from slick-and-quick New York. In-line skates have been

around since the early 1980s and originated in the Midwest. They were developed as a way for hockey players and cross-country skiers to extend training into the off-season.

For several years, a small number

of gung-ho winter athletes had in-lines all to themselves. But, eventually, the rest of the world caught on. In 1984, only about 20,000 pairs of in-lines were in use. Today, about a million pairs glide over U.S. pavement.

BLADE RUNNERS

We decided it was time to find out what in-lining was all about and, in the process, test five hot models from the top manufacturers. For a month and a half, the PM test team bladed over roads, sidewalks and bike paths in skate-to-skate comparison runs. While no hard data could be produced, we discovered that differences in design and performance were evident. We established rankable categories and added up the results.

Bauer XT/7

As soon as you slip on the XT/7, it's clear that Bauer, a leading name in ice skates, knows boots. While others in the industry move toward ski-boot fasteners, the XT/7 features both conventional laces and a ratchet buckle. This system offers the best of both worlds for comfort and support. The laces do the tightening, while the buckle firms up the ankle.

The XT/7 was also strong in durability and rolling ease. The high score in durability comes from the ultra-sturdy glass-reinforced nylon composite used in the shell. Another strong point for the XT/7 is weight. It's the lightest in the test.

Bauer's hard-rubber brake stop takes longer to grip than other skates, but this was the only nit we could find to pick, and the stop can be easily replaced. Overall, in the rapidly evolving field of in-line skates, the XT/7 is currently at the head of the class.

Inside The Switch It Interchangeable Skate



TEST PARAMETERS

A PM test team analyzed each pair of in-lines for a 6-week period. Testers stressed the skates by logging miles and hours on a variety of surfaces: asphalt, concrete, pavement, sidewalks and bike trails. All skates were stock and unmodified. The durometer is the standard for measurement of hardness in rubber, composites and plastics. The lower the durometer number, the harder the measurement. In general, the harder the wheels, the faster the skates. Bold numbers appearing at the beginning of each line indicate rank. Wheelbase is the measurement of the distance between the front and rear axles.



MAKE/MODEL	1. BAUER XT/7	2. ROLLERBLADE AEROBLADE
Overall Height/Heel Height/Weight	12.75 in./7.25 in./6.38 lb.	13.5 in./9.25 in./6.51 lb.
Wheelbase/Wheel Diameter/Wheel Hardness	11.0 in./72mm/82A durom.	11.0 in./76mm/ 78A durom.
Comfort	1. Heel is snug, toes don't slip	2. (tied) Arches felt pinched despite adjustment
Support	1. Excellent in ankle and overall	2. (tied) Firm in foot, less in ankle
Style	1. (tied) Sleek, clean look	1. (tied) Integrated boot/liner, look of the future
Durability	1. (tied) Exceptionally strong shell	1. (tied) Tough, lightweight wheel frames
Rolling Ease	1. (tied) Great gliding, ultralight	1. (tied) Speedy and shock absorbent
Braking	2. (tied) Good location but hard-rubber slips	1. Rubber stop ideally placed, grips well
Special Features	Buckle and lace system provides best fit	Innovative vented shell, aluminum axles
Price As Tested	\$300	\$330
Address	Canstar Sports USA, 50 Jonergin Dr., Swanton, VT 05488; (800) 362-3146	Rollerblade, 5101 Shady Oak Rd., Minnetonka, MN 55343; (800) 232-7655

Rollerblade Aeroblade

The latest *roll* model, the Aeroblade, from the company synonymous with in-line skating oozes with new technology: vented shells for breathability, integrated outer and inner boot layers, and roller frames made of glass-reinforced nylon.

The vented copolymer shell adds welcome breathability, reduces weight and enables the boot to better wrap around the foot for a snug fit.

Aeroblade also gets high marks for durability, braking and especially rolling ease. From the aluminum axles to the fast Kryptonics 908 wheels, this in-line is built for speed.

The only problem was in the area of comfort. After skating a couple of miles, one tester developed serious blisters, especially near both arches.

Despite this problem, it still finished a close second and, with tweaking, should ensure Rollerblade's continued market dominance.

Ultra-Wheels Gretzky Wings

First Team Sports decided to make a run at Rollerblade by hiring hockey superstar Wayne Gretzky and developing a new skate. The result is the Gretzky Wings model, which has smoothness and speed in common with the Great One.

The skate's most interesting component is its 10.5-in. wheelbase, the shortest in the test, which improves

control and handling. Outstanding speed and rolling ease are derived from high-precision bearings and large wheels.

Comfort, however, turned out to be a mixed bag. Out of the box, the memory-foam liner molds well to the foot. Out on the pavement, the liner and boot don't mesh as expected. They felt imperfectly matched, and the laces couldn't pull the stiff molded-isomer shell tight enough. The all-buckle version of this model probably makes for a better fit.

SwitchIt 1141

Innovative Sport Systems (ISS) started in 1988, and it carved out a unique niche by developing a single-screw process that enables the user to remove the wheelbase from one skate and switch it to the other. As an added bonus, the wheels on the 1141 can be replaced with ice-skate blades.

Another SwitchIt innovation is that the brake stop can be changed without tools, and two are standard. While two is better than the one on other models, we found the small round pads have less stopping power than the commonly used large square ones. They wear faster, too.

Adequate marks were notched by the 1141 in comfort and support, but there was noticeable slip in the toes and ankles. The large 76mm wheels were reassuringly smooth and slide-resistant, but were the test's slowest.

ISS has made impressive contributions in a few short years. As it grows, more good things should follow.

Roller Derby TK4000

One of the granddaddies of conventional roller skates, Roller Derby, recently introduced the TK4000, which incorporates the features of a top-of-the-line skate at an entry-level price.

It held its own in comfort, durability and support. However, it didn't score as high in rolling ease, which was plagued by axle wobble, and in construction, where inexpensive materials and workmanship showed.

Perhaps the biggest problem was braking. The stop is located so high off the ground that it forces the skater to crouch and lean far back to effectively slow down. Control and handling were a bit off, too, because of the TK4000's long wheelbase.

The TK4000 is aimed at the entry market, and novices should love it. Serious skaters will quickly move on.

The PM testers found in-lines to perform more like ice skates than conventional roller skates. When you hit water, there's virtually no control. Also, braking is awkward and slow.

Padding for the knees, hands, wrists and elbows is mandatory. Several memorable wipeouts occurred during preparation for this story with only scuffed equipment to show for it. Besides, the pads look just as cool and colorful as the skates. **PM**



3. ULTRA-WHEELS GRETZKY WINGS

13.5 in./9 in./6.6 lb.

10.5 in./72.5mm/78 durom.

3. Fit was awkward

3. Boot and liner don't mesh well

2. Good colors, but 14 logos detract

2. (tied) Screws showed rusting, otherwise fine

2. Good speed, smooth ride

2. (tied) Easy to apply the skids

Memory-foam liner, one-piece molded shell

\$249

First Team Sports, 2274 Woodale Dr., Moundsview, MN 55112; (800) 458-2250

4. SWITCHIT 1141

13 in./8.5 in./6.8 lb.

11.5 in./76mm/80A durom.

2. (tied) Good, except for some foot slippage

2. (tied) Better in ankles than toes

3. (tied) Colored buckles are only effect

2. (tied) Only brake wear was noticeable

3. Slow and steady, but very stable

3. Small brake stop has less stopping surface

One-bolt wheel-frame assembly, ice blade option

\$250

Innovative Sport Systems, 6507 Cecilia Cir., Minneapolis, MN 55439; (612) 941-1916

5. ROLLER DERBY TK4000

14.5 in./9.25 in./7.32 lb.

11.5 in./75mm/88A durom.

2. (tied) Good overall, but sole needs padding

2. (tied) Thick liner is effective

3. (tied) Slightest of design touches

2. (tied) Fine except for loosening of axles

4. Slow and wobbled when coasting

4. Brake stop mounted too high

High, supportive liner, long wheelbase

\$130

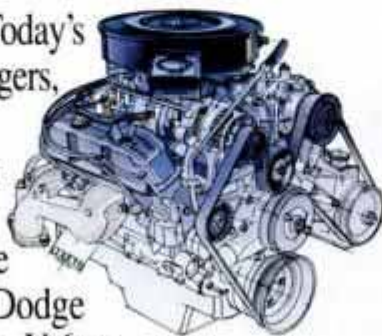
Roller Derby Skates, 311 W. Edwards St., Litchfield, IL 62056; (217) 324-3961

A Simple

Overall, today's Dodge trucks, gas and horsepower than Ford,

It's the simple truth. Today's Dodge pickups, Ramchargers, Ram Vans and Ram Wagons are a force to be reckoned with.

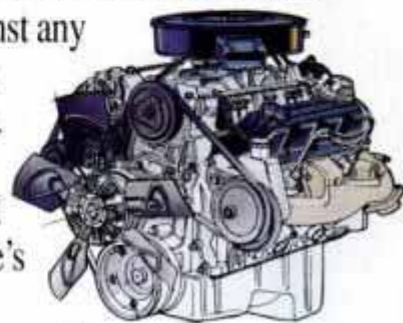
Because now they're available with the new Dodge Magnum Series Engines. V-6 or V-8 gasoline-powered engines with new sequential multipoint fuel injection for more power and torque. Or the mighty Cummins Turbo Diesel with new charge-air cooling. And what these engines do



3.9L Magnum V-6

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Put the mid-size Dakota with an available Magnum V-6 up against any compact pickup from Ford, Chevy or Japan. With its 2,550 lbs of available payload and 180 horsepower, there's just no contest.



Or choose a Dakota with a 5.2L Magnum V-8 and you've got a mid-size with 6,900 lbs of available towing capacity and 230 horse-

Dodge Dakota Club Cab V-8

Dodge Dakota Sport V-6



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*Total scores of combined model segment comparisons. Competitive claims based on '91 data ('92 competitive data incomplete at time of printing).

**4x2 model comparisons. †See limited warranties, restrictions & details at dealer. Excludes normal maintenance, adjustments & wear items.

770
336

Promise:

diesel, can deliver more payload, towing Chevy or any import.* Period.

power. That's more than standard half-ton Ford or Chevy pickups.**

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5.9L Magnum Cummins Turbo Diesel

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Advantage: Dodge



Dodge Ram Club Cab Cummins Diesel





BEAUTIFUL BRUTE

We drive Chrysler's 400-hp V10 Viper sports car.

BY TONY SWAN, Automotive Editor

● Torque. Torrrrrrque. Good ol' gut-wrenching, eyeball-flattening, Yankee Doodle torque. Steam-engine torque. Torque piped in from those thrilling big-inch days of yesteryear.

Torque has traditionally distinguished American performance cars from the rest of the world. And it certainly sets the Viper R/T 10 apart from its contemporaries. The big (488-cu.-in.) aluminum V10 doesn't generate quite as much torque as the old 427 Cobra, but 450 ft.-lb. is more than you can get from any other production sports car today. Ferrari's fabled F40 is rated at 425 ft.-lb., the Lamborghini Diablo makes 428, and the ZR-1

produces a comparatively tepid 370.

Tramp on the Viper's throttle and the seatback exerts an urgent and exhilarating pressure across the shoulder blades, the kind of pressure you associate with a car capable of hustling from 0 to 60 mph in about 4 seconds. Keep your foot down and it'll keep hustling, up to a top end of about 180 mph. (We saw only 130 in our brief session, held under the anxious eyes of Chrysler engineers who wanted the car back in one piece.)

But earth-mover torque is just one of two traits that make this new super roadster such a blast. The other is handling that seems as good as any of

its pricey rivals. The Viper turns in like an attack helicopter, sticks like sun-softened bubble gum and changes direction like a vintage Walter Payton, without a trace of body roll.

The source of this race-car response is a chassis that looks as though it began life as a railroad trestle. The Viper development team claims it'll be far stiffer than a Corvette. Suspension is massive double A-arms, fore and aft, and the brakes are huge 4-piston Brembo discs at all four corners—no ABS. A Borg-Warner 6-speed transmission sends power to the rear wheels, via a Dana limited-slip differential. The 17-in. alloy wheels, de-



signed to optimize brake cooling, are from Kelsey-Hayes, and the fat Z-rated tires—275/40 front, 335/35 rear—are Michelin.

Like the chassis, the pushrod V10 engine is simple and massive. The design was derived from Chrysler's 5.9-liter V8, with help from Lamborghini in developing the aluminum castings. The crankshaft is forged steel, the cast-iron cylinder liners are free-standing and the pistons are forged aluminum. Contemporary touches are limited to roller lifters, distributorless ignition, throttle-body injection and magnesium valve covers.

Chrysler chose to develop the body-

V10 engine (above left) will eventually see service in Dodge trucks. Viper's instrument panel (above) reinforces retrocar theme, while massive tube-frame chassis (above right) provides race-car level of handling.

work with a resin transfer molding (RTM) process, rather than the sheet-molded compound used by Corvette, to save development time. The Nippondenso instrumentation is consistent with the overall theme of potent simplicity, and the seats are what you might expect of a car intended for endurance racing—highly supportive and surprisingly comfortable.

We look forward to the next encounter.

PM

Specifications

Price	\$50,000 (est.)
Vehicle type	Front-engine, rear-drive
Body style	2-seat roadster
Engine	90° OHV V10
Bore	4.0 in. (101.6mm)
Stroke	3.88 in. (98.6mm)
Displacement	488 cu. in. (7997 cc)
Horsepower	400 @ 5000 rpm
Torque	450 ft.-lb. @ 3500 rpm
Transmission	6-speed manual
Wheelbase	96.0 in.
Length	175.0 in.
Width	75.0 in.
Height	45.0 in.
Curb weight	3200 lb.
Tires, f/r	275/40ZR-17, 335/35ZR-17

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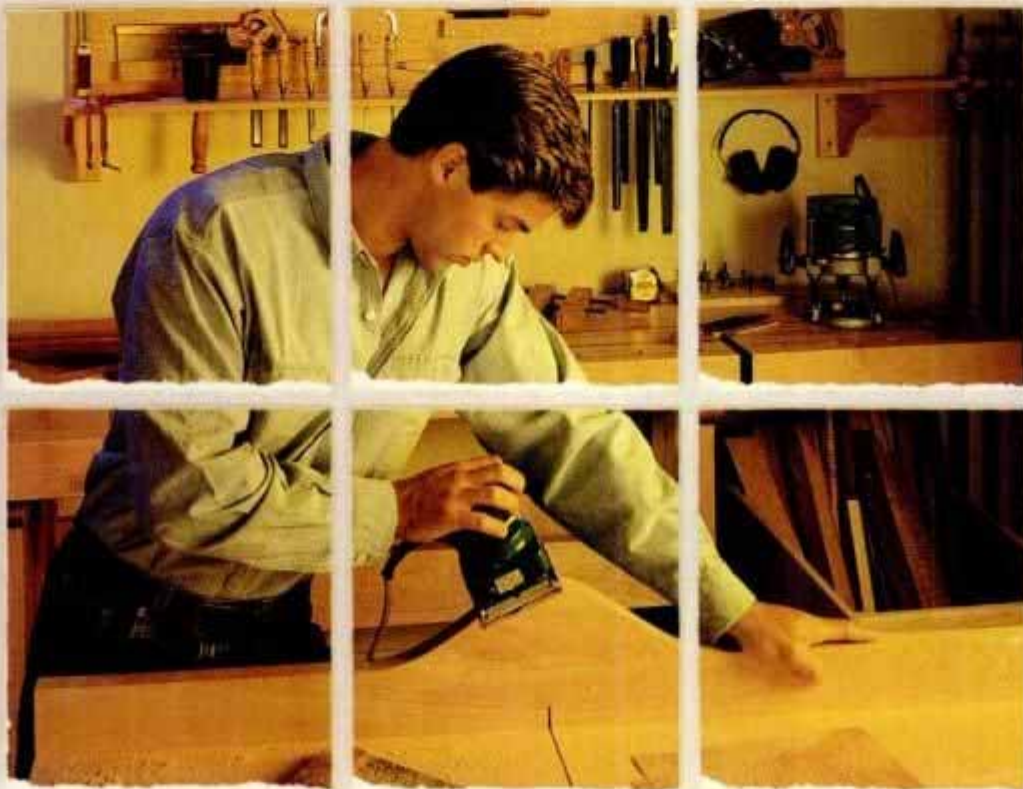
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SPECIAL SECTION

DREAM SHOP



FOR WOODWORKERS OF ALL LEVELS

- **Three Super Shop Concepts**
- **Shop Layout And Tool Selection**

Plus: Projects To Make Your Shop More Than Just A Collection Of Tools

**Workbenches • Shop Storage • Sawhorses
Shop Accessories • And Much More**

PM PHOTO BY JOHN GRIEBSCH



WOODWORKING GUIDE

BASIC SHOP

A simple, portable and practical workshop to start with—and grow with.

BY NEAL BARRETT

Color photos: John Griebisch
Black-and-white photos: Neal Barrett
Technical art: Eugene Thompson

● For most of us, the word workshop conjures up images of expensive machinery; shelves full of exotic stains, oils and varnishes; racks and drawers full of razor-sharp tools, jigs, squares and gauges; and most of all, a massive workbench upon which all manner of joints and assemblies are cut and fitted. And, if you leaf through the pages of any woodworking supply catalog, you may get the impression that all real workshops are nothing less than complete to the last nailset and marking gauge.

The fact is, workshops, like woodworkers themselves, are constantly evolving. There's always some new piece of equipment that will make the



next project easier and more successful. Is there one ideal shop—one collection of tools arranged in a basement or garage so as to efficiently take on any conceivable woodworking task? Maybe. It's more likely, though, that the successful workshop reflects the needs, experience, space and budget of the woodworker who uses it.

On the following pages, we're offering three distinct woodworking shops, their equipment and layout. And, each shop features a host of exciting projects that you can build to make your shop as special as the work that comes from it.

We've designed the shops so that each builds upon the previous one rather than replaces it. However, any one stage might also be an end in itself if it meets your particular requirements. Or, you may find that a combination of elements from two—or all three—is just right for your needs.

Starting At Square One

Our first shop may not look much like a workshop at all. It needs no walls to hang tools on, takes up little space and can be set up just about anywhere that work is going on. In fact, calling it a shop may be stretching the definition of the word. Its basic components, however, are the same as the most expensively equipped shop. It features surfaces for supporting and holding the work; tools for layout, cutting, trimming and assembly; and storage for the tools.

The collection of equipment and tools is suited to a wide range of work. You'll find it equally useful for building a backyard deck or a set of simple shelves. And when you're done, you'll only need 7 sq. ft. in the basement or garage to pack away everything.

Where a typical shop has a workbench with a vise, and an assembly/layout table, we've included two carefully designed sawhorses (see pages 62 and 64) and a Black & Decker Workmate. The Workmate allows you to clamp and hold stock, and the sawhorses—along with a few boards or a piece of plywood—make a worktable of substantial capacity.

Of course, it's not enough to simply own a few tools. You need to have some place to put them so they don't get lost, stay sharp and are out of the way of little hands. Our toolbox is designed to accommodate a basic selection of tools and then some (see page 60). If you decide not to build one yourself, check out the store-bought toolboxes on page 62 to see if one suits your tool collection.



Expanded and ready to take on woodworking chores from house framing to cabinet construction, this basic, portable workshop (above) packs neatly away until the next project comes along (left). Designed to utilize a basic set of hand and power tools (see page 60), the ensemble also includes a Black & Decker Workmate, two stable, yet lightweight, sawhorses and an ample toolbox. And, you can make the horses and toolbox yourself (see pages 60 through 64).

Choosing Tools

Ask a carpenter what tools are essential, and there's a good chance you'll be told you need a hammer, saw and square. Beyond that, you'll undoubtedly enter a discussion to determine exactly what kind of carpentry you're talking about.

Our kit includes these three tools, plus some extras that will help in a range of around-the-house projects. And, the whole collection fits neatly in the toolbox described below.

Here's our choice for a basic kit: 7¼-in. circular saw, sabre saw, 15-in. toolbox saw, hacksaw, a set of four chisels, a plane, sharpening stone, try square with level, bevel gauge, tape measure, Surform tool, pry bar, combination screwdriver, four fast-action clamps, utility knife, doweling jig, locking pliers, adjustable wrench, nailset, ⅜-in. variable-speed/reversible drill and orbital sander. For accessories, we're including a range of twist drill bits, spade bits for larger holes, an assortment of screwdriving bits for the ⅜-in. drill and a spare carbide-tipped circular-saw blade.



This handsome and durable toolbox is designed to hold all of the tools shown. It features two lift-out trays and a generous storage compartment for power and hand tools.

Building The Toolbox

The toolbox is made with ½-in.-thick Baltic Birch plywood, ¼-in. birch plywood and pine. Baltic Birch plywood is better than ordinary plywood because the uniform veneers and lack of voids offer better screw-holding characteristics. And, the edge grain looks good, too. If your lumber dealer doesn't stock Baltic Birch, contact Allied International, Box 56, Charlestown, MA 02129.

First, plan the cuts so the grain will run horizontally on the sides, front and back of both the box and the lid. Cut the parts to exact size with a circular saw guided by a straightedge. Use a rip guide to make the narrow lid cuts (Photo 1).

Next, mark screw locations on the

pieces and bore and countersink the pilot holes (Photo 2). Because the stock is thin, make sure that the holes are positioned accurately so the screws will be centered in the adjoining edge.

Cut the circular-saw blade storage partition (F) and the cleats (G). Secure the cleats to the side with brads and glue, and attach the partition in the same way. Before making the circular-saw stand (parts H, I and J), check the dimensions of your particular saw to make sure that it will fit. Apply glue to the bottoms of the saw stand supports (I and J), clamp them in place to the box bottom (E) and secure with screws. Then attach the platform (Photo 3).

Fasten the right box side to the bot-

tom with screws and glue. Then, join the left side to the back. Cut and assemble the two partitions L and K, and glue the assembly in place to the back and left side. This compartment holds a bevel gauge. Complete the box by fastening the left side and back to the right side and bottom. Then, add the front panel. Assemble the lid by first joining the sides and top, and then adding the front and back pieces.

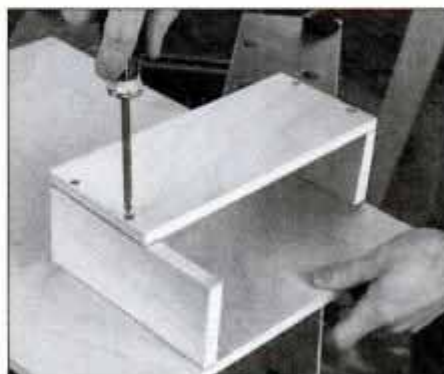
Cut the hacksaw hangers (M) with a handsaw and Surform tool or file, and install with screws and glue. Then, secure the ledges (N, O and P) that hold the tool trays. Construct the retainers for the handsaw, Surform and combination square as shown. Then shape the saw handle turnbutton, and cut and bore the block that holds the



1 Cut plywood to size with a circular saw. Use a straightedge guide for wide pieces and a rip guide for the narrow stock.



2 After laying out box screw locations so they're centered ¼ in. from edge, bore and countersink screw pilot holes.

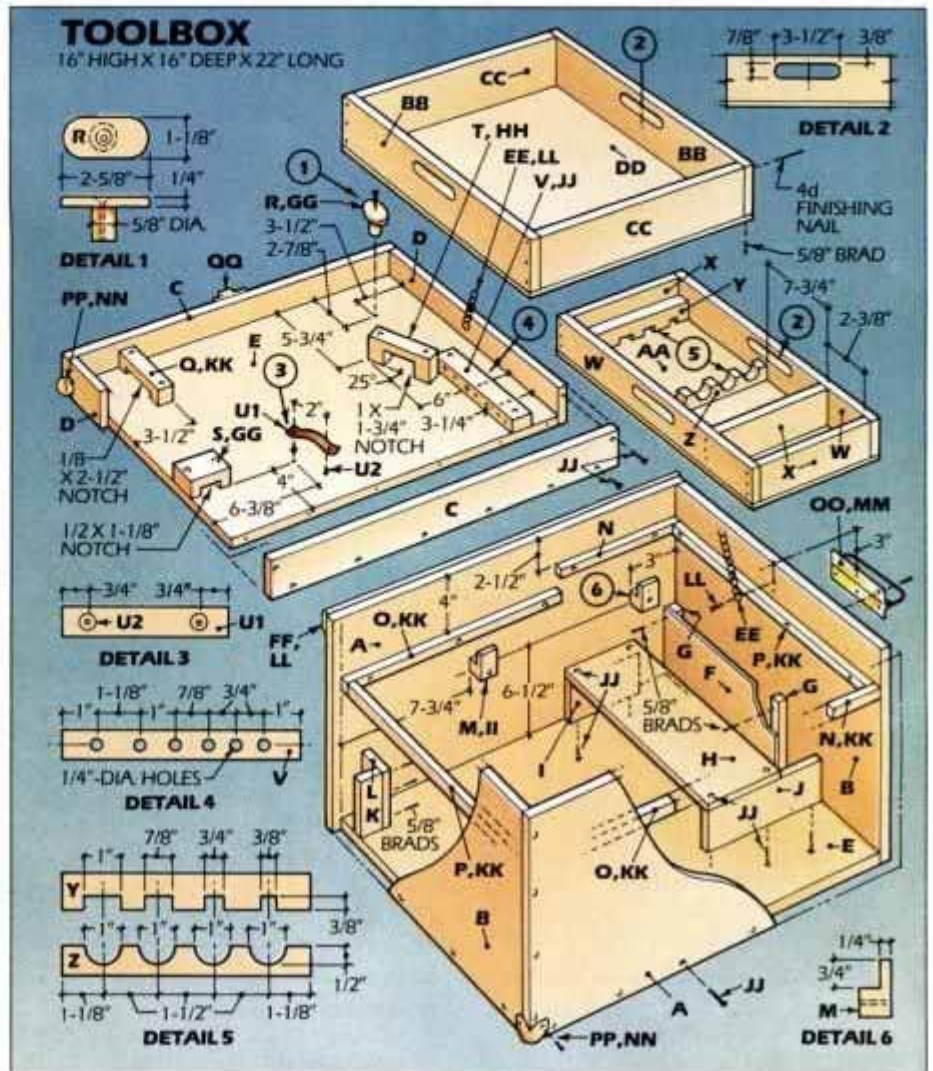


3 Assemble circular-saw stand to box bottom with screws and glue. Space under stand is used to store clamps.

MATERIALS LIST—TOOLBOX

Key	No.	Size and description (use)
A	2	1/2 x 14 x 22" plywood* (front/back)
B	2	1/2 x 14 x 15" plywood* (side)
C	2	1/2 x 2 x 22" plywood* (lid front/back)
D	2	1/2 x 2 x 15" plywood* (lid side)
E	2	1/2 x 15 x 21" plywood* (top/bottom)
F	1	1/4 x 5 x 8 1/2" plywood (blade partition)
G	2	1/2 x 1/2 x 5" pine (cleat)
H	1	1/2 x 4 1/2 x 11" plywood* (saw platform)
I	1	1/2 x 3 x 4 1/2" plywood* (support)
J	1	1/2 x 3 x 7 1/4" plywood* (support)
K	1	1/2 x 1 1/4 x 3 1/2" pine (partition)
L	1	1/2 x 1 1/2 x 3 3/4" pine (partition)
M	2	3/8 x 1 1/2 x 1 1/2" pine (hacksaw hanger)
N	2	1/2 x 1/2 x 8" pine (tray ledge)
O	2	1/2 x 1/2 x 13" pine (tray ledge)
P	2	1/2 x 1/2 x 14" pine (tray ledge)
Q	1	3/4 x 3/4 x 3 3/4" pine (handsaw blade retainer)
R	1	1 1/4 x 1 1/4 x 2 3/4" pine (handsaw handle turnbutton)
S	1	1 1/4 x 1 1/2 x 2 1/2" pine (combination square retainer)
T	1	3/4 x 1 1/2 x 3 1/2" pine (Surform retainer)
U1	1	3/4 x 3 3/4" leather (Surform strap)
U2	2	snaps
V	1	3/4 x 1 1/4 x 6 1/2" pine (bit block)
W	2	1/2 x 2 x 14 3/4" plywood* (side)
X	3	1/2 x 2 x 6 1/4" plywood* (end/divider)
Y	1	3/4 x 1 x 6 3/4" pine (chisel blade guard)
Z	1	3/4 x 3/4 x 6 3/4" pine (chisel rack)
AA	1	1/4 x 7 1/4 x 14 1/4" plywood (bottom)
BB	2	1/2 x 3 1/2 x 14 1/4" plywood* (side)
CC	2	1/2 x 3 1/2 x 12" plywood* (end)
DD	1	1/4 x 13 x 14 1/4" plywood (bottom)
EE	1	12"-long, 3/8" brass chain
FF	1	22" brass piano hinge
GG	3	1 1/2" No. 8 fh screw
HH	2	1 3/4" No. 8 fh screw
II	2	1 1/4" No. 8 fh screw
JJ	73	1" No. 6 fh screw
KK	18	3/4" No. 6 fh screw
LL	14	1/2" No. 4 fh brass screw
MM	12	1/2" No. 7 fh brass screw
NN	24	3/8" No. 4 rh screw
OO	2	handle, Brainerd stock No. 1257PB
PP	8	corner, Brainerd stock No. 476PB
QQ	1	drawbolt, Brainerd stock No. 0867PB

Misc: glue; 4d finishing nails; 3/8" brads; polyurethane varnish.
* Baltic Birch plywood.



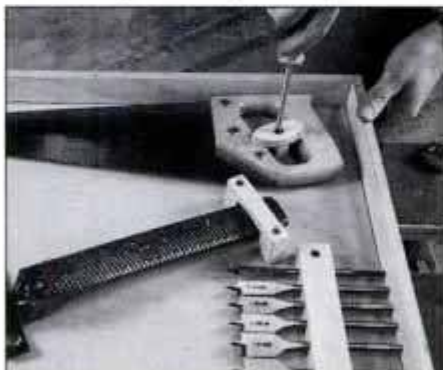
spade bits. Double-check your specific equipment to make sure that the dimensions shown will work (Photo 4). The leather for the Surform strap and the snaps are available at arts-and-crafts supply stores. The top snap halves are riveted (riveting tool available with the snaps) to the leather and the bottom halves are screwed to the toolbox top.

Cut the piano hinge to length with a

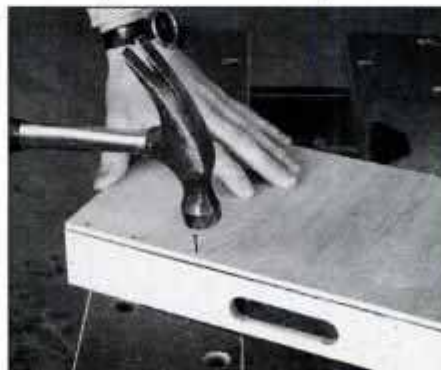
hacksaw. Use the hinge to mark the screw locations, bore pilot holes, and attach the hinge to the lid and box. Then, attach the 3/8-in. brass chain to the box and lid sides to act as a lid restraint. Cut out the parts for the two trays as shown in the drawing. To make the hand cutouts, first bore 3/8-in.-dia. holes, and complete the cutouts with the sabre saw. Assemble both trays with 4d finishing nails and

glue as shown (Photo 5).

Make the chisel rack (Z) by first boring a row of four 1-in. holes on wide stock, spaced as shown in Detail 5. Then, rip the piece along the row centerline. Cut the notches for the blade guard (Y) with a handsaw and chisel, and glue both pieces to the tray (Photo 6). Finish with three coats of polyurethane varnish, and install the brass box corners, handles and latch.



4 Use your actual tools to locate retainers in the toolbox lid. Turnbutton rotates to hold or release handsaw handle.



5 After making tray sides, secure bottoms with 3/8-in. brads and glue. Use 4d finishing nails and glue to join sides and ends.



6 Shape chisel rack components to suit your chisel sizes. Test fit the chisels before gluing components to tray bottom.

Sawhorses

Even the most elementary repair or woodworking project requires a surface on which to work. And while you might use the kitchen table or a few dining room chairs, these options will definitely not increase your popularity with the rest of the family. The simplest solution to the problem is to build a pair of sawhorses. Found in virtually every workshop and on every job site, the classic sawhorse is the universally accepted tool for getting the project off the ground—where you can work on it.

While sawhorses can be built from construction lumber or plywood, and kits are available to make the assembly easier, the design shown here has several distinct advantages over the common, garden-variety horse. First, its splayed legs offer excellent stability and strength without the need for standard leg braces. This means that the units can be stacked and set over objects on the floor or ground. The 5/4 pine that we used makes for a lightweight, easily portable sawhorse. Best of all, this design features a broad, flat top board that turns each horse into a small portable bench. Our sawhorses are assembled with glue and nails. If they will be used primarily indoors, use ordinary



carpenter's glue. Otherwise, choose a waterproof glue.

Begin construction by cutting leg blanks from 5/4 x 4 stock. Cut the legs 1 or 2 in. longer than the finished leg dimension. Use a bevel gauge and protractor to mark the compound angle cuts at the top and bottom of each

leg. Then, mark the taper on the outside of each leg (Photo 1). Note that for each bench, two legs are the mirror images of the other two, so take care when laying out the cuts. Clamp each leg in the Workmate or to a table, and cut the taper with a sabre saw (Photo 2). Be sure to stay on the waste

Store-Bought Toolboxes

● There was a time when every artisan crafted a toolbox that was custom designed for a specialized toolkit. Today, you can choose to build your own, or select from dozens of models available in just about every shape and size.

You'll find everything from small tackle-box models to huge, roll-around toolchests for your woodworking shop. There are even specialized tool storage units designed to fit

in the back of your pickup truck.

In keeping with the scale of our basic shop, there are several models that fit the bill. The Plano 701 Power-Toolbox (lower left) is made of impact-resistant plastic and weighs a scant 7 pounds. It features a removable tool tray for small tools and hardware. The tray has its own handle so it can be used separately. The 21-in.-long, 12 3/4-in.-high model 701 costs about \$32. Write to Plano Molding Co., 431 E. South St., Plano, IL 60545.

The latest toolbox from Sears is its 4816-cu.-in. SST (Sit, Stand and Tote). Designed to do more than just hold tools, the 17-in.-high SST (upper right) also functions as a seat and step stool. The unit features a 2 1/4-in.-deep small-parts tray that nestles inside a 4-in.-capacity tool tray (shown stacked together in photo). With the trays in place, there's enough depth in the bottom section to hold a circular saw. To carry the toolbox, you have the option of two side handles, a top handle or a shoulder strap. The box lid even has a V-groove to hold dowels or pipe for cutting. The Sears SST costs about \$46 at Sears stores or through the Sears catalog. Contact Sears, Roebuck and Co., Sears Tower, Chicago, IL 60684.

Rubbermaid's model 7716 (lower right) is the largest in its line of six new Roughneck toolboxes. It measures 10 3/4 x 11 x 24 in., and features two removable stacking tool trays. The compartmentalized trays have unique stacking handles—when



the trays are together, the separate handles mate to form a single handle. This 1940-cu.-in. model also has an inch scale and a metric conversion table molded into the tray and box lid. The Rubbermaid model 7716 costs about \$33. Contact Rubbermaid, Inc., 1147 Akron Rd., Wooster, OH 44691.



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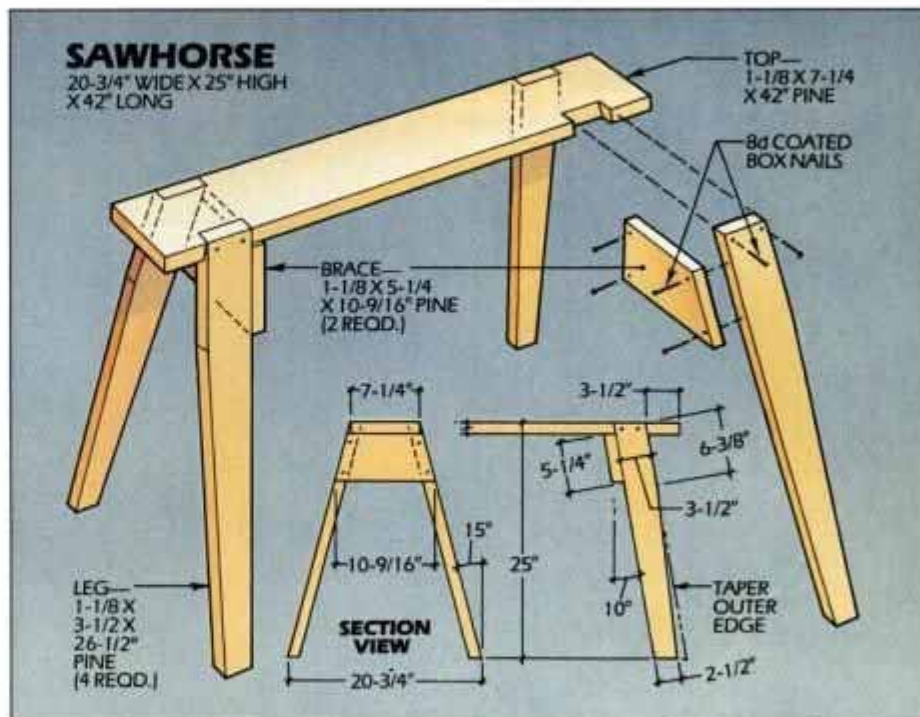
side of the line. Then, use a sharp hand plane to remove the saw marks and trim the taper to the line.

With the tapers cut and the compound angles at the tops and bottoms clearly marked, use a handsaw to make the compound angle cuts (Photo 3). Saw just on the waste side of the line. Then, clamp each piece to a worksurface and trim to the lines with a hand plane. Always plane toward an acute angle of the compound cut so that the plane follows the grain direction and tearout is reduced.

Cut the benchtops to length from $5/4 \times 8$ stock. Use your bevel gauge, protractor, square and straightedge to lay out the notches for the legs. To cut a notch, clamp the stock on edge and use a handsaw to make the stopped cuts at each end. Note that these cuts are compound angles, so extra care is required. Check frequently to make sure the saw cuts stay just to the waste side of the line.

Use a sharp chisel and mallet or hammer to remove waste from the notches. Then, finish by carefully paring down by hand to the line (Photo 4). Test fit each leg. If a leg is too tight, trim the leg with a hand plane.

Cut blanks for the leg braces from $5/4 \times 6$ stock. Mark the angled ends on each piece, and cut with a sabre saw.



Mark guidelines for the beveled top and bottom edges of each brace, and trim to the lines with a plane.

Begin assembly by first applying glue to a leg notch in the top, and then attach the leg with two 8d coated box nails (Photo 5). After all the legs have been fastened in this way, turn the

bench on end, and apply glue to the inside surfaces of the legs for securing the braces. Attach each brace with two 8d coated box nails driven into each leg (Photo 6). Allow the glue to dry for at least 4 hours. Then, sand with 120-grit sandpaper and soften all sharp corners and edges. **PM**



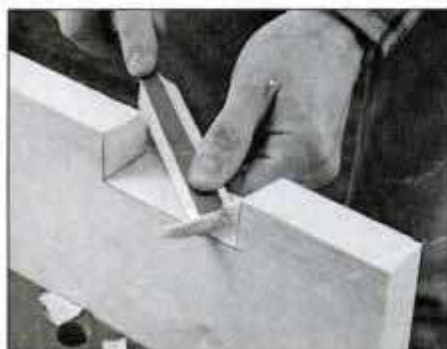
1 After cutting $5/4 \times 4$ stock slightly over-size, mark leg tapers with a straightedge and lay out compound angle end cuts.



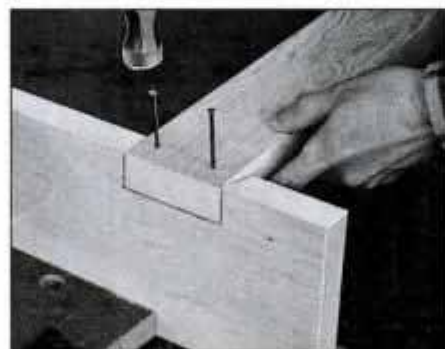
2 Clamp stock to worksurface and cut tapers with a sabre saw. Cut to the waste side of the line, and trim with a plane.



3 Use a handsaw to cut the compound angles on the leg ends. Follow angle layout lines, and trim smooth with plane.



4 After handsawing end cuts on notches, use a sharp chisel to remove waste. Finish by carefully paring down to the lines.



5 Apply glue to top board notch, and fit in leg. Check that top is flush, and secure with two 8d coated box nails per leg.



6 Use glue and nails to secure braces to inside edges of legs. Top and bottom brace edges are beveled with hand plane.

Kinder? Gentler? No Way.



Buckle up, America!

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WOODWORKING GUIDE

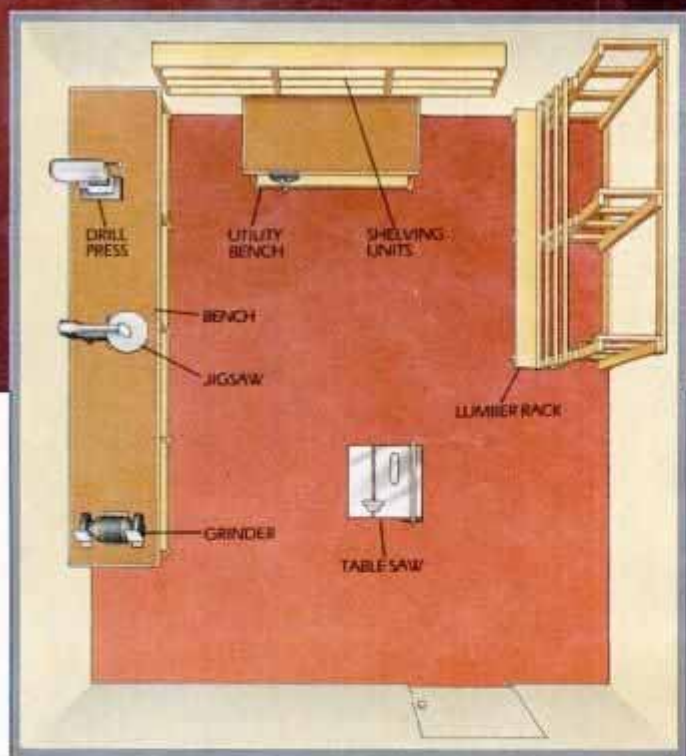
INTERMEDIATE SHOP

Workbenches, storage and stationary tools signal the move into a dedicated workspace.

BY NEAL BARRETT

Color photos: John Griebisch
Black-and-white photos: Neal Barrett
Technical art: Eugene Thompson

● If you've worked with portable equipment for long, you've probably found that you store your tools in the same place each time you're done. And, if the space is more than a small closet, you also may have found that more and more of your work actually takes place right there—whether it



You'll be surprised at the amount of work you can handle in this shop. Benchtop stationary tools provide greater accuracy and control than portable counterparts. Benches and storage units keep the shop organized and efficient.

be a corner of the basement, the back of the garage or a spare room in your house.

Once this happens, and your tools and projects take root in their own dedicated area, you have the beginnings of a full-fledged workshop. It's a place not only to cut and assemble the practical and fanciful, but an inner

sanctum where you can leave the world behind and concentrate on the important issues.

Our concept for this stage in workshop evolution introduces benchtop stationary machinery. The table saw is central. Many manufacturers offer benchtop models ranging from about \$200 to \$600. Although they are port-

able, they're also an excellent and economical way to enter the world of stationary tools. A radial-arm saw is an alternative to a table saw. It's better at crosscutting, but far less convenient for ripping. And, in its usual place against the wall, you may lose productive bench space. Instead, consider adding a power miterbox for benchtop crosscutting chores.

For cutting curves, we're including a benchtop 16-in. jigsaw. You could also substitute a small band saw, which would increase your cutting capacity but sacrifice the ability to cut completely enclosed holes. A benchtop drill press will produce the uniform holes required for accurate joinery, and a versatile bench grinder will sharpen and prepare your cutting edges for honing.

In terms of portable power tools, there's one that no modern woodworker should do without—the plate joiner. And, if you don't yet own a router, it's time to pick up one, along with a selection of bits. A standard, nonplunge router is fine for most work. You'll also want to round off your portable power-tool collection with a belt sander.

One of the most important tools is also one you can make yourself—a workbench. Our utility bench (see page 68) features simple but strong construction, and uses easily available lumber and hardware. A longer, narrower bench that runs along one wall of our shop handles the benchtop tools. The one we show is built the same way as our workbench.

To hold your growing tool collection and all the miscellaneous boxes, bottles and cans that seem to multiply in all workshops, we've designed shelving units (see page 71). And finally, there's a sturdy and sensible lumber rack that's designed to handle plywood as well as solid lumber.

The layout for this equipment is simple and, of course, will vary with the exact nature of your space. However, this shop would easily fit in one end of a basement. It will also fit in a garage with room left over for things like garden tools, a lawnmower and bicycles. Because the only central tool is the table saw, you can easily make room for other activities. If you're planning a garage or outbuilding shop, keep in mind that electrical outlets not dedicated to a specific machine should be GFCI (ground fault circuit interrupter) equipped. All workshops should have a first-aid kit and a fire extinguisher on hand for emergencies.

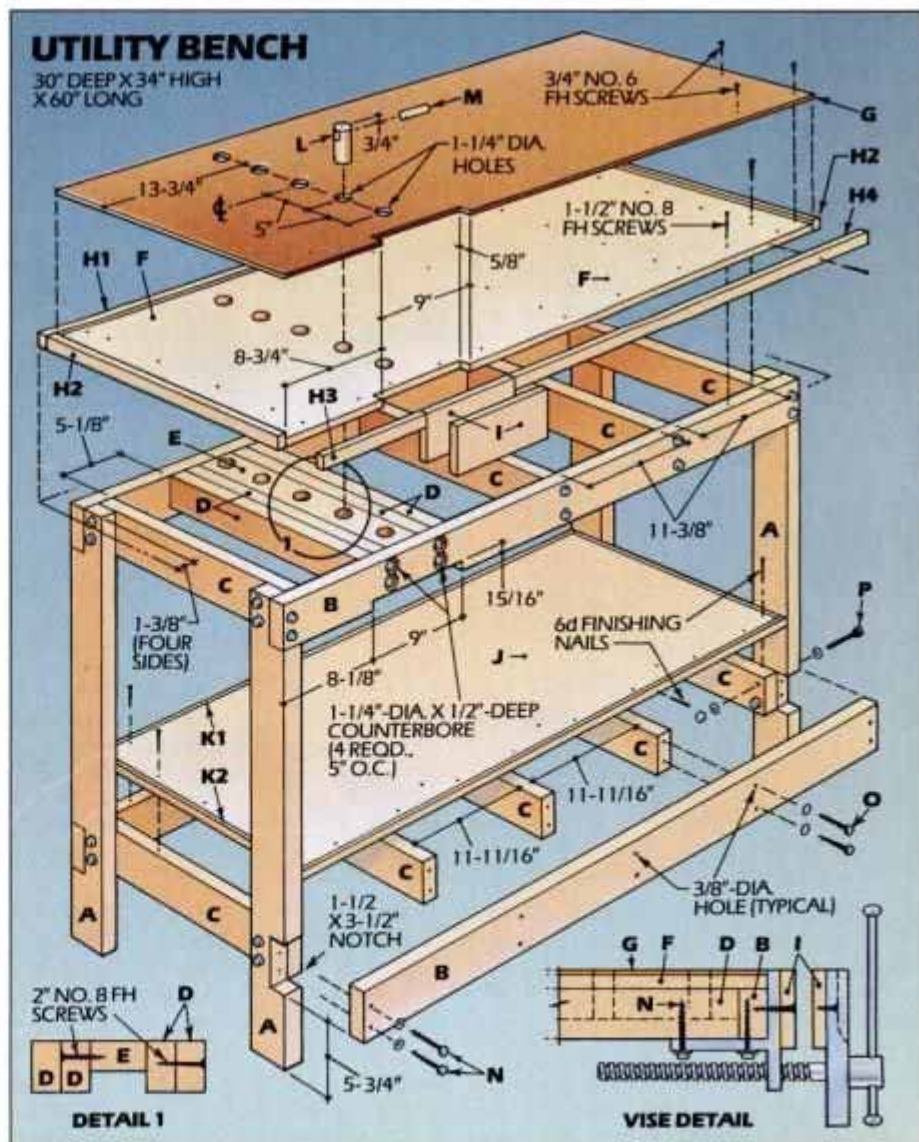
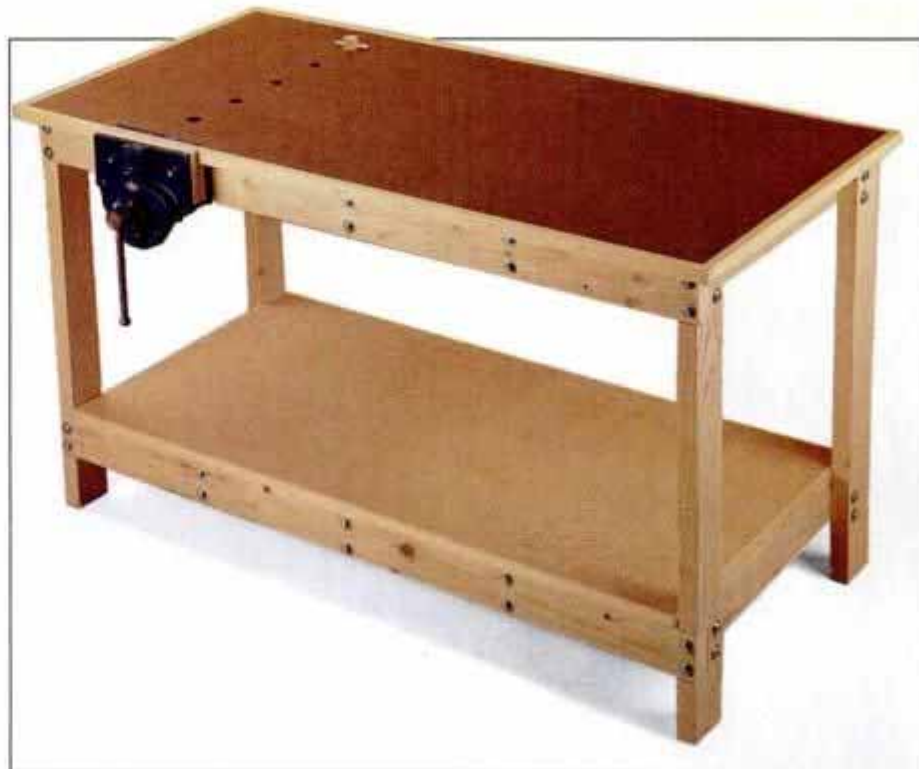
Utility Bench

If the move from portable power tools to benchtop machinery is the next step on your woodworking agenda, then there's one thing you'll need before any work begins—a stable workbench. Our design not only fills the bill for benchtop tools, its ample work surface makes an ideal layout and utility table. It features a simple and stout 2 × 4 frame that supports a heavy-duty vise (we chose a Record model 52½ D, available from many mail-order tool houses) and a large storage shelf below. We've also included an easy-to-make bench dog system. The bench's simple bolt-and-lagscrew construction makes it adaptable to a range of needs such as the long machine bench shown in the photo on page 66.

Begin construction by cutting 2 × 4 lumber to length for the legs, rails and cross supports. Then, lay out the notches in the legs that house the top and bottom rails. Use a table saw to make a series of cuts that remove most of the waste from the notches (Photo 1), and finish the notches with a sharp chisel. Cut the vise notch in the top front rail in the same way.

Lay out and bore all the ⅜-in.-dia. holes in the long rails. Then, counterbore the holes above the vise notch in the front top rail so the bolt heads will sit below the surface. After boring ¼-in. pilot holes in the legs, attach the long rails to the legs with ⅜-in.-dia. × 3-in.-long lagscrews.

Clamp the end cross supports to the front and back assemblies, and bore holes for the ⅜-in.-dia. × 3½-in.-long bolts (Photo 2). Assemble the frame using washers under the bolt heads and nuts. Join the remaining cross supports to the rails with lagscrews. Clamp or tack-nail the supports in



MATERIALS LIST—UTILITY BENCH

Key	No.	Size and description (use)
A	4	1½ x 3½ x 33" spruce (leg)
B	4	1½ x 3½ x 57½" spruce (rail)
C	9	1½ x 3½ x 24½" spruce (tie)
D	4	1½ x 2⅞ x 24¼" spruce (vise support)
E	1	1½ x 3 x 24¼" spruce (vise support)
F	1	¼ x 28½ x 58½" plywood (top)
G	1	¼ x 28½ x 58½" hardboard (surface)
H1	1	¼ x 1 x 60" pine (edge band)
H2	2	¼ x 1 x 28½" pine (edge band)
H3	1	¼ x 1 x 9½" pine (edge band)
H4	1	¼ x 1 x 41½" pine (edge band)
I	2	¼ x 4 x 9" pine (jaw pad)
J	1	¼ x 26½ x 53½" plywood (shelf)
K1	2	¾ x ¾ x 54¼" pine (edge band)
K2	1	¾ x ¾ x 26½" pine (edge band)
L	1	1½"-dia. x 3¼" dowel (dog)
M	1	⅜"-dia. x 2" dowel (dog pin)
N	20	⅜ x 3" lagscrew and washer
O	28	⅜ x 3½" lagscrew and washer
P	16	⅜ x 3½" carriage bolt, washer and nut

Misc: 6d finishing nails; 2" No. 8 fh screws; 1½" No. 8 fh screws; ¼" No. 6 fh screws; Record 52½ D woodworking vise; polyurethane varnish.

place when boring the pilot holes (Photo 3), and use washers under the lagscrew heads.

Next, rip and crosscut the vise support rails to exact size. This assembly not only secures the vise, but reinforces the bench dog holes in the top. Use glue and screws to join the parts as shown in Detail 1 in the drawing (Photo 4). Then, attach the assembly to the bench frame with lagscrews (Photo 5).

Cut the plywood shelf to size with a circular saw guided by a straightedge clamped to the stock (Photo 6). Rip $\frac{3}{8}$ × $\frac{1}{4}$ -in. pine edge banding, and secure to the shelf edges with 6d finishing nails and glue.

The worktable top is made of a ply-

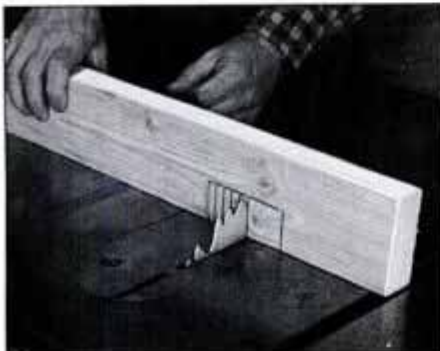
wood base that's covered with $\frac{1}{4}$ -in. hardboard. The hardboard provides a smooth, splinterfree surface that can be replaced when necessary. Cut the plywood and hardboard to exact size. Note the top overhangs the frame except where the vise mounts. Use a sabre saw to make a notch in both pieces for the vise.

Attach the plywood top with $1\frac{1}{2}$ -in. No. 8 fh screws, countersunk so the heads are flush with the surface (Photo 7). Then, attach the hardboard with $\frac{3}{4}$ -in. No. 6 fh screws. Countersink these screws slightly below the surface so their heads won't mar your work. Rip $\frac{3}{4}$ × 1-in. edge banding, and apply with finishing nails and glue (Photo 8).

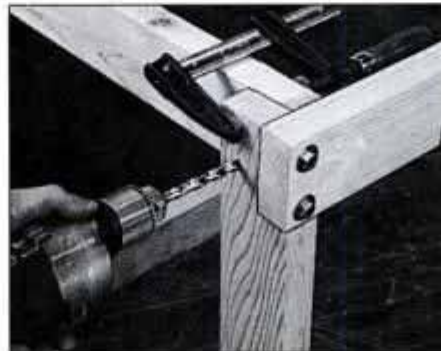
To attach the vise, lay the table on its back legs, and position the vise on the front rail. Bore $\frac{1}{4}$ -in. pilot holes, and attach the vise with $\frac{3}{8}$ -in. lagscrews and washers (Photo 9). Then, lay out the bench dog hole positions on the top, and bore the holes with a Forstner bit.

To make the bench dog, cut a $1\frac{1}{4}$ -in.-dia. dowel to $3\frac{1}{4}$ in. long, and bore a $\frac{5}{16}$ -in. hole through it about $\frac{1}{2}$ in. from one end. Glue a piece of $\frac{5}{16}$ -in. dowel in the hole to act as a stop. Finally, cut two wooden vise-jaw liners and secure to the vise through the threaded holes in the jaw faces.

To finish the bench, we used three coats of polyurethane varnish, applied according to the directions.



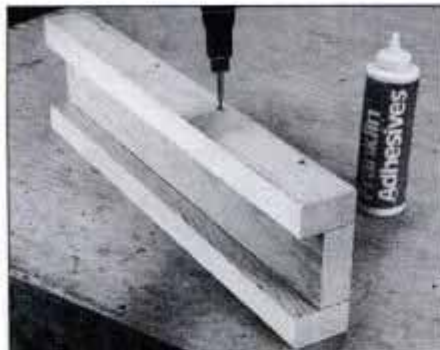
1 Lay out notches, and use a table or circular saw to make a series of cuts to remove most of waste. Finish notch with a chisel.



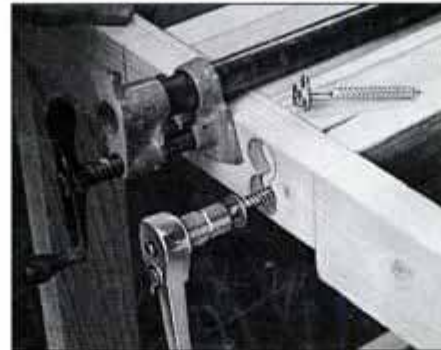
2 After assembling front and rear rails to legs with lagscrews, clamp to side rails and bore holes for $\frac{3}{8}$ -in. bolts.



3 Temporarily clamp or nail shelf and top cross supports to frame. Then, bore pilot holes, and secure with lagscrews.



4 Cut vise support parts to exact size, and assemble with screws and glue. Vise support also reinforces bench dog holes.



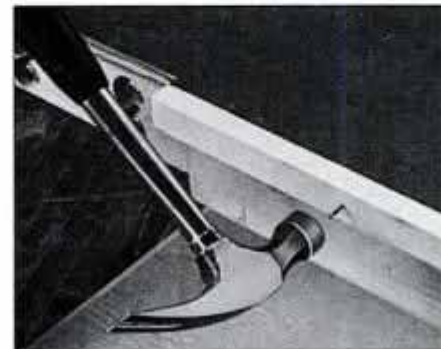
5 Use lagscrews to attach vise support assembly to front and rear top rails. Note counterbored holes in front rail.



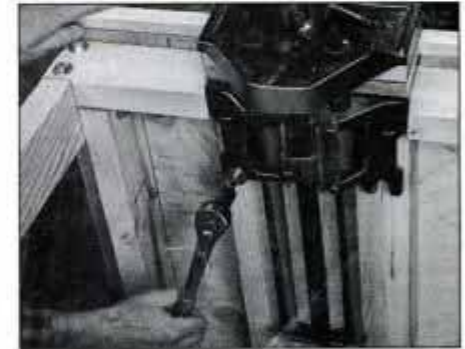
6 Cut plywood for benchtop and shelf to exact size with a circular saw guided by a straightedge clamped to stock.



7 Attach top to frame with flathead screws. Countersink screws flush with surface. Note notch in top for vise.



8 After attaching hardboard with screws countersunk slightly below the surface, secure edge banding with nails and glue.



9 With bench on its back legs, position vise and attach with four $\frac{3}{8}$ -in.-dia. × 3-in.-long lagscrews and washers.

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Modular Shelves

If all you needed for a woodworking shop was a few power tools and a pile of wood, life would be simple indeed. For better or worse, woodworkers are notorious for collecting boxes of hardware, tool accessories, jigs, finishes, stains and a multitude of little things that might be just too important to throw away. It's no wonder, therefore, that one of the most important considerations for any well-equipped woodshop is storage.

The shelf unit shown here is simple and inexpensive to build. It features adjustable shelves and can be easily mounted on your shop wall. The modular nature of the design means you can attach several units together to form a larger storage area. Best of all, you can use this modular design as a basis for household shelving units and cabinets.

Begin by cutting 1 × 10 pine to length for the case sides, top and bottom. To crosscut long stock easily on a table saw, first rough cut the pieces slightly oversize with a portable circular saw or handsaw, then finish the cuts square and to exact length on the table saw. Clamp the sidepieces to your worktable to rout a $\frac{3}{8}$ -in.-deep ×



$\frac{3}{8}$ -in.-wide rabbet in each end. Use a $\frac{3}{4}$ -in. straight bit and router edge guide to make the cuts (Photo 1).

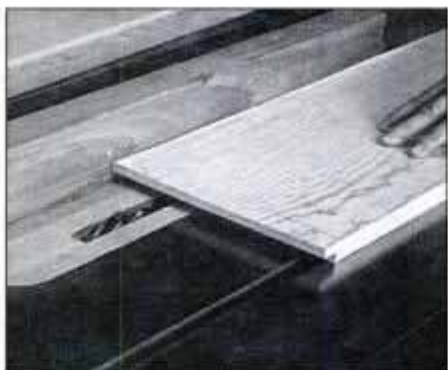
Install a dado blade in the table saw, and cut the $\frac{3}{16}$ -in.-deep × $\frac{5}{8}$ -in.-wide grooves for the shelf tracks, also called standards (Photo 2). Note that the space between the front case edge

and the forward track is different than that between the rear edge and the rear track. This allows for equal spacing once the case back is in place.

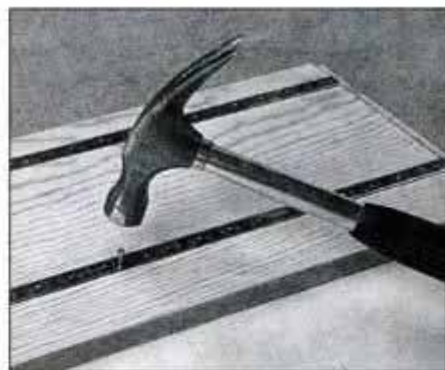
Most tracks have numbers along their faces to facilitate positioning the shelf clips. To mark the tracks for cutting, first align the lower-number end



1 Clamp the case sides to a worktable, and use a router, edge guide and straight bit to cut the rabbets for the corner joints.



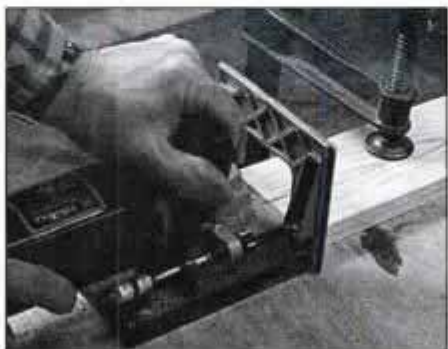
2 Install a dado blade in the table saw, and cut the $\frac{3}{16}$ × $\frac{5}{8}$ -in. grooves in the case sides that house the metal shelf tracks.



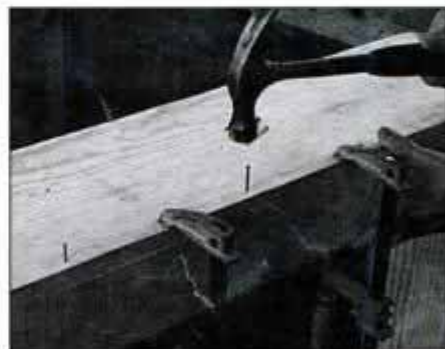
3 After positioning the tracks so the slots are aligned, and then cutting to length, attach to sides with provided nails.



4 Join the case sides to the top and bottom pieces with glue and 6d finishing nails. Check for square, and let the glue dry.



5 Use a plate joiner to cut slots for joining the back frame pieces. Clamp stock firmly. Doweling jig and dowels can also be used.



6 Attach back frame to case so frame is flush with rear edges. Secure with glue and nails. Then, hang case and install back.

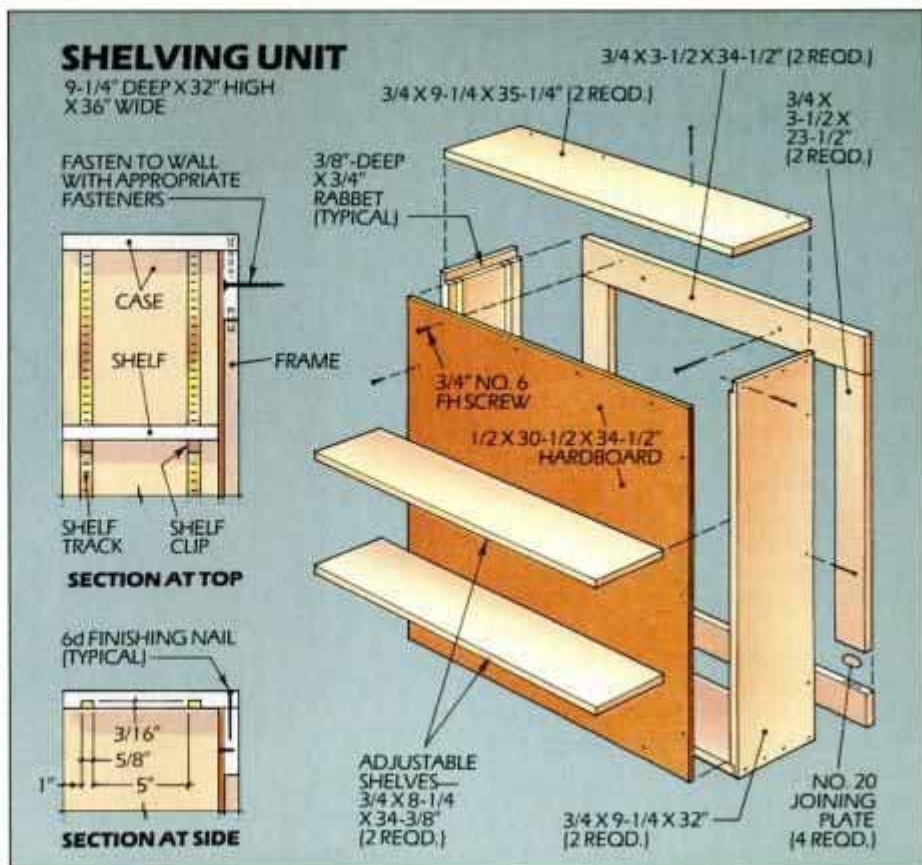
of each track with the top edge of the bottom rabbet on the case sides. Then, mark the finished length on the edge of the top rabbet. Pay extra attention to aligning the track slots on all four tracks within a case so the shelves will lie flat and level. Cut the tracks with a hacksaw, and use the provided nails to attach the tracks to the sides (Photo 3).

Use glue and 6d finishing nails to fasten the sides to the top and bottom (Photo 4). Then, check that the unit is square by measuring the diagonals, and allow the glue to dry.

Cut the 1 x 4 back frame pieces to size. We used a plate joiner to assemble the frames, but a doweling jig could also be used. After marking the plate locations, clamp the stock to the worktable, and cut the slots (Photo 5). Apply glue to the slots, install the plates, and assemble the frames. Clamp until the glue sets.

Test fit each frame to a case, and trim the frame if necessary. Secure the frames with glue and 6d finishing nails driven through the sides, top and bottom (Photo 6).

Sand all surfaces with 120-grit sandpaper, and finish with polyurethane varnish. When the finish is dry, hang the units by screwing through



the frames into wall studs, furring strips or masonry anchors, depending on your wall construction. Cut and in-

stall the hardboard backs, and secure with 3/4-in. brads. Cut the shelves to length from 1 x 10 pine stock.

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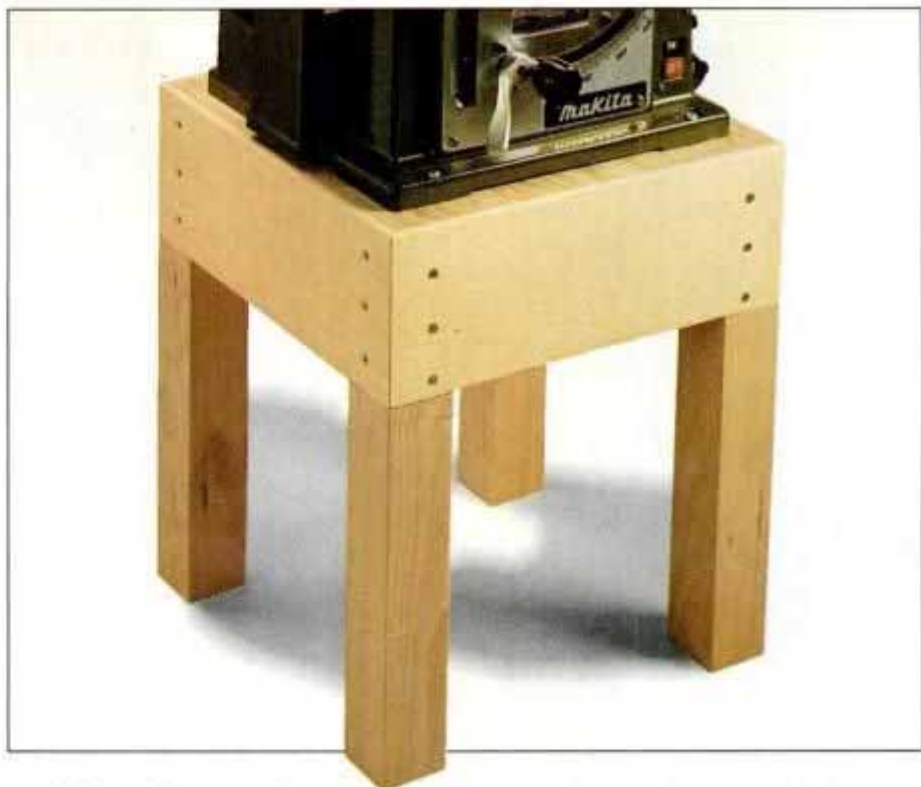
Bench Saw Stand

Benchtop tools are a great way to equip a small shop. And, all you need is a bench to put them on—until you move up to a table saw, that is.

A table saw naturally demands access to all sides so that you can handle a wide range of stock sizes. The best solution for small bench models is a dedicated stand. Our version features 4 × 4 legs, a pine apron and a plywood top. Although we designed it specifically for the Makita 2708W saw, you can easily modify the plans to suit models from other manufacturers.

Begin by cutting the 4 × 4s square and to exact length with a handsaw. Then, lay out the notches for the apron. Use a router and 3/4-in. straight bit to remove most of the notch waste. A straight stop clamped across the leg guides the router across the bottom of the notch. To support the router as the cut is nearly completed, leave a strip about 1 in. wide (Photo 1). Then, remove this with a handsaw or chisel.

Cut the apron pieces oversize in length from 1 × 8 pine. Then, use a router, edge guide and 3/4-in. straight bit to cut the rabbet on the upper apron edge. Mark the exact length of the pieces, and use a circular saw to cut the mitered ends. Clamp a



straight guide squarely across the stock to guide the cuts (Photo 2).

Next, lay out the screw hole locations on the aprons, and bore and countersink the holes. Place two legs and an apron squarely in position on

the worktable, bore pilot holes into the legs, and attach with screws (Photo 3). After completing the opposite side, apply glue to the mitered joints, attach the remaining aprons and

(Please turn to page 76)

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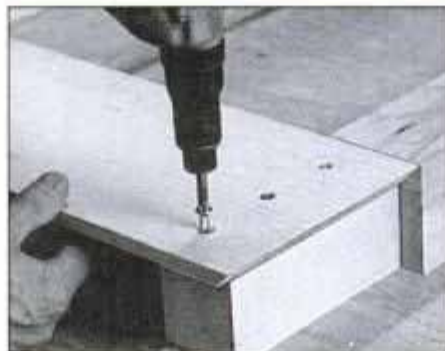
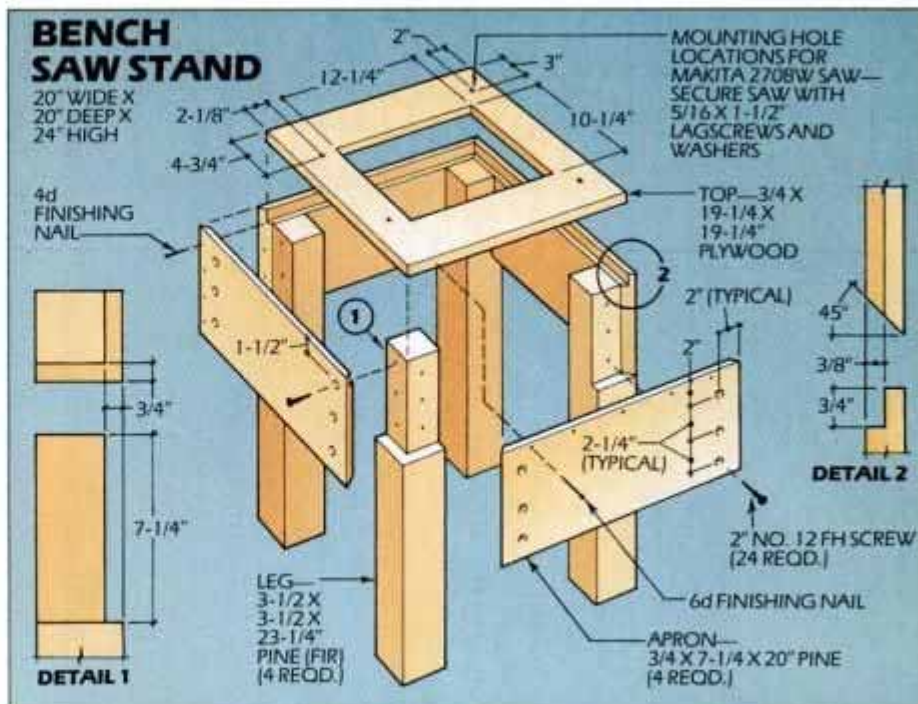
Cut fir plywood to size for the top, and install with 6d finishing nails. Mark the cutout for the sawdust hole. Bore 1/2-in. holes at each corner, and finish the cut with a sabre saw (Photo 4). Finish the stand by marking and boring the holes for the lagscrews that hold the saw. Then, attach saw.



1 Use a router to remove the waste in leg notch. Leave a strip of wood for support that's removed with handsaw or chisel.



2 Cut the mitered apron ends to length with a circular saw set to 45°. Straightedge clamped to stock guides cut.



3 Assemble the aprons to the legs with 2-in. No. 12 fh screws and glue. Stagger screws on adjacent pieces at corners.



4 After installing plywood top with 6d finishing nails, bore 1/2-in. holes at cutout corners, and finish cutout with sabre saw.

Buying Tools

● It's been said before and it's still true: Buy the best tools you can afford. They not only last longer and give more satisfaction, you'll probably save money in the long run. However, you needn't buy the biggest tools on the market. A 3/8-in. VSR drill, for example, is fine for typical hole boring. But a standard plunge router should handle 1/2-in. shank bits if you plan to use it for joinery.

When comparing motors, keep in mind that the horsepower ratings of induction motors (fixed-speed motors usually found on machinery) can be misleading. Consumer- and semiprofessional-level motors are rated at the maximum horsepower that's generated just before the motor stalls under a heavy load. Industrial-grade tools are more often rated by continuous-running horsepower. A closer comparison can be made by comparing the amperage requirements.

It's a good idea to look over the professional models, even if they're out of your price range. Knowing their features, materials and construction will help you better

evaluate a less-expensive tool. If possible, always check out the tools in person. But these days, mail-order suppliers can be the most economical and convenient route to go, especially if you know exactly what you want—and what you'll get. Following are some of the leading mail-order sources and woodworking tool manufacturers.

Some major catalog suppliers:







- Constantine, 2050 Eastchester Rd., Bronx, NY 10461
- Garrett Wade, 161 Avenue of the Americas, New York, NY 10013
- Woodcraft, 210 Wood County Industrial Park, Box 1686, Parkersburg, WV 26102
- Woodworker's Supply of New Mexico, 5604 Alameda Pl. NE, Albuquerque, NM 87113
- Trendlines, 375 Beacham St., Chelsea, MA 02150
- Sears, Roebuck and Co., Sears Tower, Chicago, IL 60684
- Tools On Sale, 216 W. Seventh St., St. Paul, MN 55102

Some major tool manufacturers:

- AEG, Three Shaw's Cove, New London,

CT 06320

- Black & Decker, 10 N. Park Dr., Hunt Valley, MD 21030
- Bosch, 100 Bosch Blvd., New Bern, NC 28562
- Delta, 246 Alpha Dr., Pittsburgh, PA 15238
- Freud, 218 Feld Ave., High Point, NC 27264
- Hitachi, 4487-E Park Dr., Norcross, GA 30093
- Makita, 14930 Northam St., La Mirada, CA 90638
- Milwaukee, 13135 W. Lisbon Rd., Brookfield, WI 53005
- Porter-Cable, Box 2468, Jackson, TN 38302
- Powermatic, Morrison Rd., McMinnville, TN 37110
- Ryobi, 1424 Pearman Dairy Rd., Anderson, SC 29625
- SCMI Corp., 5933-A Peachtree Industrial Blvd., Norcross, GA 30092
- Stanley Tools, New Britain, CT 06050
- Skil, 4300 W. Peterson Ave., Chicago, IL 60646

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LENNOX
Air Conditioning • Heating



HOME AUTOMATION: THE FUTURE AT YOUR FINGERTIPS

By the year 2001, some form of home automation will be as common as a second car. Many people will buy automated homes or install an automated control system as part of a remodeling project because they see how it can improve home security. Others will be attracted by the system's bells and whistles—features that let you preprogram home entertainment on a room-by-room basis. But the real

benefit of home automation is its potential to save energy.

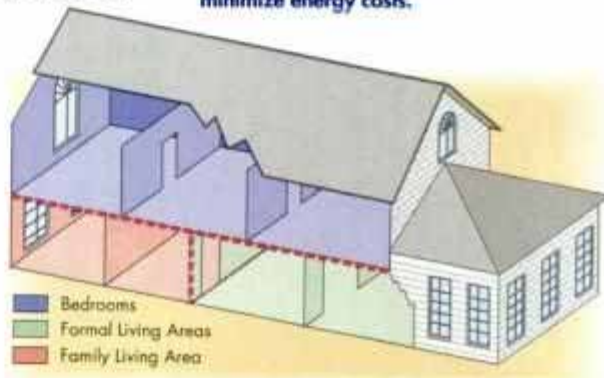
You could, for example, cut energy costs as much as 50 percent by programming your home-automation computer to anticipate heating and cooling needs, then coordinate those needs with the most favorable time-of-day electric rates and use that information to operate a high-efficiency heat pump that supplies several individually regulated temperature zones throughout your home.

The technology to make this happen already exists and has been shown to work in demonstration projects like the Electric SMART HOUSE in Atlanta, where an entire menu of futuristic control features are literally at your fingertips by means of a touch-control screen. This screen not only provides video monitoring of entrance doors and controls lighting and audio programming, it also serves as a visual thermostat that lets you set temperatures for each heating and cooling zone. When used in this mode, the screen also gives you a readout of the current condition in every room of your house.

While this touch screen looks like it walked off the set of *Star Trek*, the computer power that makes it work is no more complex than the PC you're already using at home or work. In fact, you can buy electronic interface devices that allow your PC to control certain appliances and some parts of your home's lighting system. And more is on the way. The Electronic Industries Association, which represents the manufacturers of consumer electronics products, is working to establish industry standards that will allow every electronic product to "communicate" with every other electronic product. This is the same process of standardization the video people went through when they decided that the VHS cassette was going to be their industry's playback format.

A few years from now, when this standard has been adopted, you will be able to join together an unlimited number of electronic products and control devices to create a home-automation system that meets your needs. Of course, control and programing features may not be on a par with what the SMART HOUSE offers, but they're a solid indication that the future of home automation has begun.

Zone heating puts the warmth where you need it. Add an electronic thermostat to maximize comfort and minimize energy costs.



The Electric SMART HOUSE in Atlanta demonstrates an entire menu of futuristic control features that are literally at your fingertips by means of a touch-control screen.

YEAR
1995

TOUCH-SCREEN
COMPUTERS GIVE YOU
FINGERTIP CONTROL OF
YOUR AUTOMATED
HOUSE, ALLOWING YOU
TO CHECK THE SECURITY
OF ENTRANCE DOORS,
PROGRAM MUSIC ROOM
BY ROOM, AND SET
TEMPERATURES TO VARY
DURING THE DAY.

YEAR
1996

NEW BUILDING
TECHNOLOGIES
REDUCE THE COST OF
CONSTRUCTION AND
INCREASE OVERALL
ENERGY EFFICIENCY TO
A POINT WHERE THEY
USE ONE-THIRD THE
ENERGY REQUIRED
IN 1990.

Y E A R
1997

**SUPEREFFICIENT
ELECTRIC HEAT PUMPS
PROVIDE HEAT IN THE
WINTER AND COOLING
IN THE SUMMER TO
REDUCE OUR
DEPENDENCY ON
FOSSIL FUELS.**

LOW-COST HEATING AND COOLING YOU CAN LIVE WITH

Until about 25 years ago, if you wanted a warm house, you burned something. Fuel was converted into heat by means of fire. Heat pumps don't work that way, and because they don't, by the year 2001 we will have rethought the way in which we heat and cool our homes.

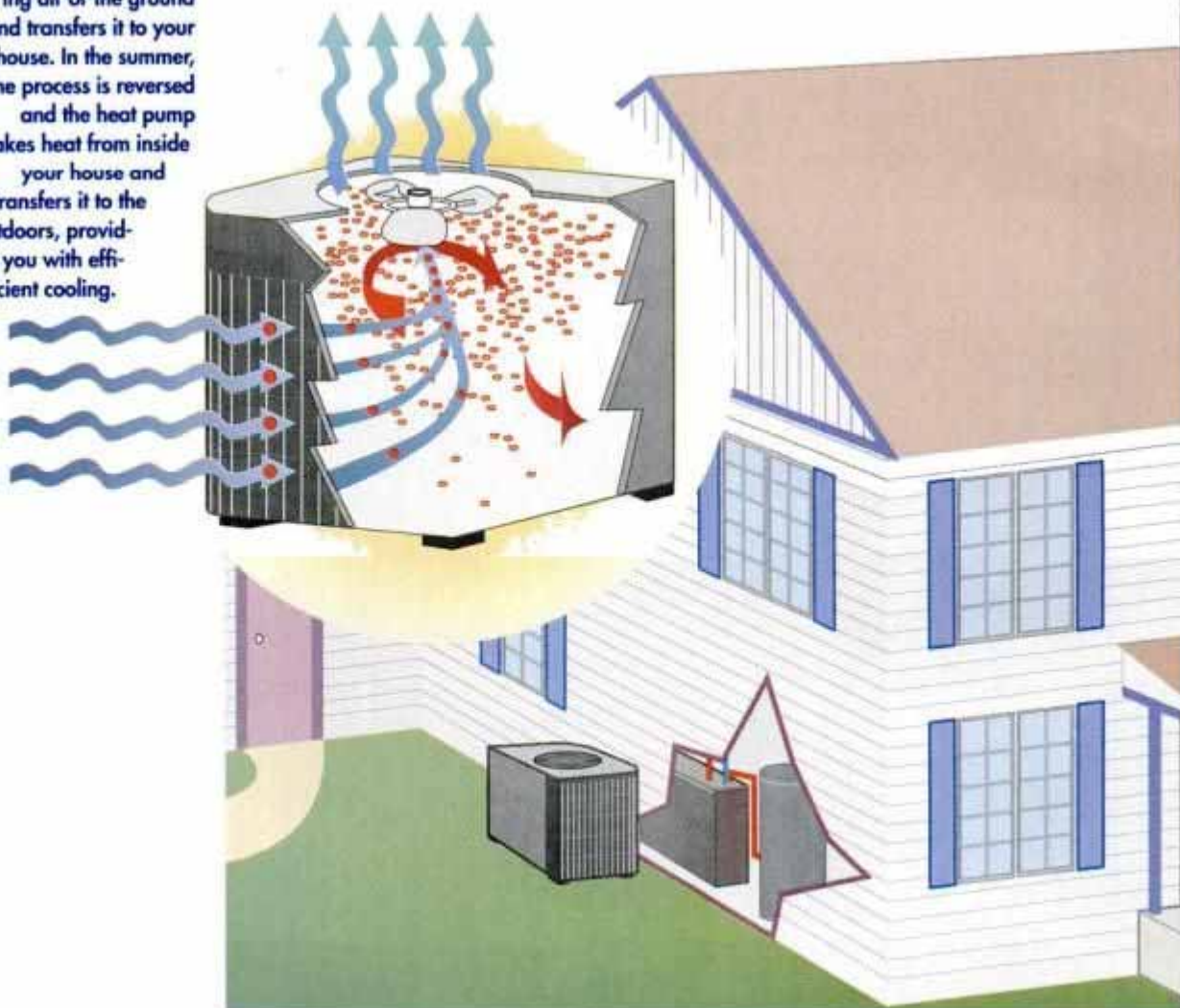
An electrically operated heat pump doesn't burn anything. Instead, it takes heat from the surrounding air or the ground and transfers it to your house. In the summer, the process is reversed and the heat pump takes heat from inside your house and transfers it to the outdoors, providing you with efficient cooling.

Think of a heat pump as a large refrigerator. This isn't as far-fetched as it sounds, because the refrigerator in your kitchen—which actually is a heat pump—doesn't create cold, it removes heat from the food compartment. That heat has to go somewhere. Stand near your refrigerator when the compressor is running and you can feel the warm air blowing through the grill near the floor. Heat pumps generate the same warm air, and that's what heats your house.

As efficient as older-model heat pumps were, several technological breakthroughs make today's heat pumps the most efficient heating-and-cooling systems for your house. The most important of these breakthroughs is the use of new variable-speed motors to control how much warm air is distributed. Derek Maris, director of advanced technology for Carrier, thinks a better way to explain this new technology is to call it variable-capacity heating and cooling, because what actually changes is the amount of warm air that the system puts out.

Older heat pumps and all forced-air furnaces, no matter what fuel they use, have only two operating modes: on and off. To keep your house at a constant temperature, these systems cycle on and off regularly. However, on/off cycles can cause a temperature swing of up to four degrees from the set point on

A heat pump takes heat from the surrounding air or the ground and transfers it to your house. In the summer, the process is reversed and the heat pump takes heat from inside your house and transfers it to the outdoors, providing you with efficient cooling.



Y E A R
1998

**NEW FEDERAL ENERGY
STANDARDS REQUIRE
ALL ELECTRICAL
APPLIANCES TO
OPERATE 60 PERCENT
MORE EFFICIENTLY
THAN THEY DID
IN 1990.**

your thermostat.

Variable-speed technology allows the compressor and blower motors to operate in sync with each other: Their speeds continually adjust in perfect harmony to meet the heating-load requirements. An immediate benefit is that your house temperature never varies more than one degree from your thermostat setting!

Variable-speed heat pumps seldom run at maximum speed, and when running at lower operating speeds they use less electricity and thus save money. They also make less noise when they operate—up to eight times less than older models that run at constant speeds—about the same as a refrigerator.

Another development that promises improved efficiency is a change in compressor design that cuts the number of moving parts down to two. The new scroll compressors, as they're called, increase a heat pump's heating or cooling capacity without increasing its physical size. This reduction in moving parts means even greater reliability for a product already known for its ability to provide years of trouble-free operation.

Heat pumps can even be used to supply your domestic hot water. In summer, heat taken from the house during the cooling cycle is diverted to heat the water—an absolutely free by-product of normal operation. Producing hot water in the wintertime is a bit more complex because the heat taken from the surrounding air has to be shared between the house and the system that heats the water. There is a small price tag for getting wintertime hot water this way, but it still costs far less than heating water by more conventional means.

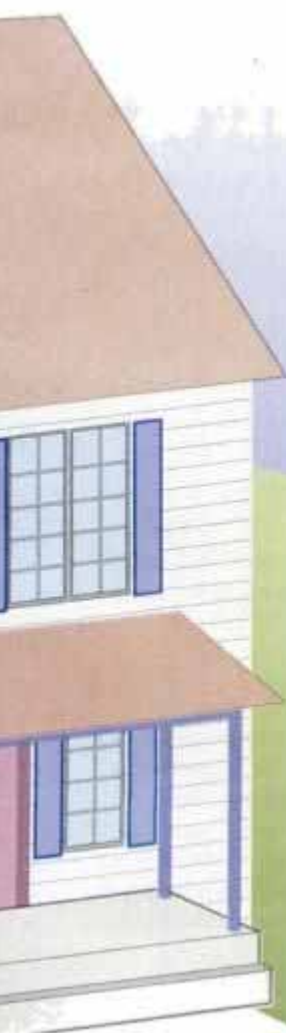
Air-source heat pumps have been around for a quarter of a century, though they have been used mostly in parts of the country where winter temperatures are moderate—usually no lower than 30 degrees. Even at that temperature, there is more than enough heat in the air to make the heat pump keep you warm and cozy inside. As we approach the year 2001 and the new variable-speed technology becomes more commonplace, air-source heat pumps will become viable options for more northerly parts of the country.

The New Language of Efficiency

Older heating systems measured efficiency as a percentage of the fuel converted into heat. A typical fossil-fuel furnace, for example, might have an efficiency rating of 74 percent—meaning that 74 percent of its heat goes into your house while the rest goes up the chimney. A high-efficiency furnace improves efficiency to around 92 percent.

Heat pumps don't convert fuel into heat, they simply extract it from one place and move it to another, so their efficiency is expressed in terms of a Heating Season Performance Factor or HSPF. It is determined by taking the total amount of heat delivered during a heating season (measured in British Thermal Units, or BTUs) and dividing it by the number of watt-hours needed to run the system. The higher the resulting number, the more efficient the heat pump.

Today's heat pumps have HSPFs approaching 10, which means they output ten times more BTUs than they use in watt-hours. By the year 2001, that figure should increase to 14. To put these numbers in perspective, a heat pump with an HSPF of 10 is almost three times more efficient than a furnace rated at 92 percent. Or, in terms of your checkbook (where it really matters), a heat pump can cut your annual operating costs.



GRAPHIC CHART AND MAP CO.

Y E A R
1999

A NEW COMMUNICATIONS STANDARD LETS ELECTRONIC PRODUCTS "TALK" TO EACH OTHER, SO YOU CAN PROGRAM YOUR PC TO REGULATE YOUR THERMOSTAT ACCORDING TO REPORTS FROM THE NATIONAL WEATHER SERVICE. THE COST OF THIS LINKUP IS LESS THAN \$10.

Y E A R
2000

ENERGY AND POLLUTION STANDARDS, ADOPTED BY CALIFORNIA IN THE EARLY 1990s, ARE NOW THE LAW OF THE LAND. THE NEW LAWS AFFECT EVERYTHING FROM HOW WE DRIVE OUR CARS, TO WHEN WE WATER OUR LAWNS, TO HOW WE PAINT OUR HOUSES.

YEAR
2001

ELECTRONIC CONTROLS
AND A TELEPHONE-
COUPLED INTERFACE
MAKE IT POSSIBLE FOR
YOU TO CALL YOUR
APPLIANCES FROM
ANYWHERE—AND
THEY WILL LISTEN
TO YOU.

**THE
ELECTRIC
KITCHEN OF
THE FUTURE**

Imagine your dishwasher loaded up and ready to go. You hit the start button. But instead of moving into the wash cycle, the dishwasher contacts your local utility company, finds out what time the best electric rates go into effect, and waits until that time to do the dishes. Or how about this: You put the roast in the oven when you leave for work, not knowing when you're coming home. No problem. Later on, you pick up the phone, tell your oven you'll be back at 7:30. Dinner is done when you arrive.

What will make this possible are microprocessor controls—which are already part of many electric appliances. Think of them as small computer keyboards that let you create cooking and clean-up programs to meet your needs of the moment. The real beauty of these microprocessor controls is that an interface device allows them to be activated by telephone touch-tones. You can already buy simple versions of this: inexpensive plug-in units that let you turn on a light or start your coffee maker with a phone call.

But if you think that the kitchen of the future will be a place where a computer and a little abracadabra turns a piece of freeze-dried T-bone into a romantic dinner for two you'll have to wait another hundred years. Next century's kitchen will look pretty much like the one we're used to, with advanced versions of our basic electric appliances.

We're already seeing major changes in cooktop technology. The traditional coil elements are being replaced with quick-response halogen elements housed under easy-to-clean ceramic glass. Not only do these electric elements provide instant heat, their electronic controls let you make an infinite number of small adjustments to fine-tune temperatures. No more cooking within the constraints of high, medium, and low.

The electronic keypad controls of today's cooktops give you infinitely variable, quick-response heat settings.

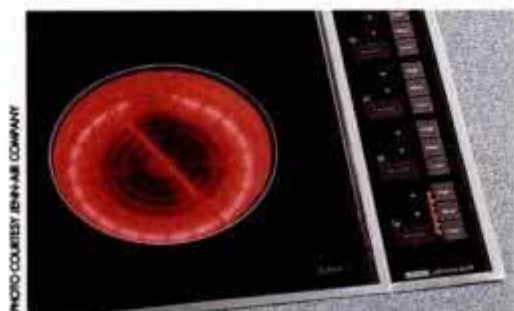


PHOTO COURTESY ZENYAH COMPANY

Refrigerators, too, are going to change drastically. They may not look any different, but federally mandated energy standards, set to go into effect in January 1993, will require them to be 30 percent more energy efficient. That's a big reduction in electric use, according to Doug Ringer, director of product planning for Maytag. He thinks there will be a lot of small improvements rather than one big leap in technology. So expect to see better compressor efficiency, more insulation, changes in how door liners are made, and more responsive controls. But don't plan on living with these improvements for very long, because a new—and as yet unwritten—set of efficiency standards for refrigerators is due in 1998. And these are likely to set the energy requirement that we will have to live with in the year 2001 and beyond.

Perhaps the biggest change in the kitchen of the future will be how we use the microwave. A whole generation of post-baby boomers is coming into the market—people who have been using microwaves since early childhood and don't know how to cook any other way. Tomorrow's microwaves will cook faster, have rotisserie and broiler elements for better browning, and provide more controllable power settings for preparing sauces, egg dishes, and seafood, making microwaves even more versatile.

YEAR
2002

A COOKING TECHNIQUE
CALLED *SOUS VIDE*
(FRENCH FOR "UNDER
VACUUM") LETS YOU
HEAT PREPACKAGED,
CHEF-PREPARED
GOURMET FOODS IN A
MICROWAVE. THE PRO-
CESS IS AS EASY AS
MAKING A SANDWICH.

Gourmet-quality meals are ready in a snap using a cooking technology called *sous vide*. These vacuum-packed, reheatable foods are fresh-tasting, nutritious, and delicious. A few supermarkets already offer these products: By the year 2001, they will be as commonplace as canned soup.



PHOTO COURTESY VIE DE FRANCE CORP. MUSEAN, VA

Gates Energy Products

WILL BE RETURNED TO CUSTOMER'S ADDRESS UNLESS OTHERWISE INDICATED ON RETURN TO DIRECTOR



Millennium Rechargeable Power Cells are covered by our Lifetime Replacement Guarantee.

AND YOU THOUGHT FRUITCAKE LASTED A LONG TIME.

This holiday season, give the Millennium Rechargeable Power System. These long lasting products are the perfect gift for the person who has everything (except, of course, long lasting rechargeable products). So give Millennium rechargeables this year. That way, no one will ever accuse you of giving the same old, stale gift. Call 1-800-CAN-POWR for a retailer near you.

MAIL-IN REBATE
SAVE UP TO \$15.00

BUY A 1-HOUR MILLENNIUM RAPIDCHARGER (MODEL #CH4A.ACD) AND FOUR AA MILLENNIUM POWER CELLS AND RECEIVE A FREE BACK-UP SET OF FOUR AA'S BY MAIL.

Name _____
Address _____

Store where purchased _____

To receive your free AA Power Cells, buy a 1-hour Millennium RapidCharger and 4 AA Power Cells, then send completed coupon, UPC code from the RapidCharger Package and original receipt to: Millennium 1-Hour Back-up Offer, P.O. Box 4201, Meriden, CT 06450. Coupon must be received by 3/31/02. Limit one coupon redemption per household. Maximum value \$15.00. Only original certificate accepted. Void where prohibited by law. Not valid with any other offer. Allow 6 to 8 weeks for delivery.



MAIL-IN REBATE
SAVE UP TO \$10.00

\$5.00 MAIL-IN COUPON ON ANY MILLENNIUM CAMCORDER POWER PACK REPLACEMENT BATTERY.

Name _____
Address _____

Store where purchased _____ Total Retailer \$1 \$10

of packs purchased _____



To receive your rebate, send UPC code from the Camcorder package and original receipt to: Millennium Power Packs Rebate, P.O. Box 4056, Meriden, CT 06450. Coupon must be received by 3/31/02. Limit two Camcorder Packs per household. Maximum value \$10.00. Only original certificate accepted. Void where prohibited by law. Not valid with any other offer. Allow 6 to 8 weeks for delivery.

MAIL-IN REBATE
SAVE UP TO \$6.00

\$2.00 MAIL-IN COUPON ON ANY TWO-PACK OF MILLENNIUM POWER CELLS. (NOT VALID WITH 2-AA RAPIDCHARGER OFFER.)

Name _____
Address _____

Store where purchased _____ Total Retailer \$2 \$4 \$6

of packs purchased _____



To receive your rebate, send completed coupon, UPC code from the Power Cell Package and original receipt to: Millennium 2-Pack Rebate, P.O. Box 4201, Meriden, CT 06450. Coupon must be received by 3/31/02. Limit 3 two-pack rebates per household. Maximum value \$6.00. Only original certificate accepted. Void where prohibited by law. Not valid with any other offer. Allow 6 to 8 weeks for delivery.

*Lifetime Replacement Guarantee on AA, AAA, C, D and 9-Volt. Fully year replacement warranty on Camcorder Power Packs and RapidChargers. See official website for details of terms and conditions. The Millennium Rechargeable Power System from Gates Energy Products. © Millennium. ® RapidCharger © 1999 Gates Energy Products.

**YEAR
2003**

COMPACT FLUORESCENTS HAVE REPLACED THE OLD INCANDESCENT BULBS. THEY COST SO LITTLE TO OPERATE THAT MANY ELECTRIC UTILITY COMPANIES GIVE THEM AWAY TO ENCOURAGE ENERGY SAVINGS.

LIGHT UP YOUR LIFE FOR LESS

The light switch is everyone's instant access to electricity. Flick it on and you light up your life. But by the year 2001, the type of light your switch controls will be very different from what we're used to today: Long-lasting, energy-efficient compact fluorescents will replace the incandescent bulbs you grew up with.

This new generation of fluorescent lighting is a far cry from the long, bulky tubes of the past. The new compacts come with screw-bases that fit any light socket in your house. And because they are close to the same size as the incandescent bulbs they replace, you can use them in table lamps without changing the shade. New ballasts—the devices needed to turn on any fluorescent—give an almost instant on and off, so no more "fluorescent flicker."

It's been known for decades that fluorescents use less energy than incandescent bulbs, and the savings are even greater with the new compacts. For example, a 13-watt compact produces the same amount of light as a 75-watt incandescent, yet uses one-fourth the power. And when it comes to life expectancy, there's no comparison at all. The compact fluorescents will provide 10,000 hours of light, against a typical incandescent bulb that lasts only 750 hours.

Substituting fluorescent or compact fluorescents for incandescent bulbs will drastically reduce the amount of electricity used for lighting. This chart shows some examples of what those savings can be.

ROOM	INCANDESCENT WATTS REQUIRED	NUMBER OF BULBS	NUMBER OF REPLACEMENT FLUORESCENTS	DOLLARS SAVED
Bath	100 watts general 180 watts above mirror	one 100-watt seven-eight 25-watt	two 20-watt tubes three 20-watt tubes	\$60 \$90
Bedroom	100-200 watts general 50-150 watts reading	two 60-watt one 50-150-watt three-way	two 9-watt compacts two 9-watt compacts	\$51 \$57
Dining	150 watts	two 75-watt	two 13-watt compacts	\$114
Halls	75-100 watts	one 75-watt	one 13-watt compact	\$57
Kitchen	200 watts	four 60-watt	four 9-watt compacts	\$102
Laundry	150 watts	two 75-watt	two 15-watt compacts	\$114
Living	200-300 watts	four-six 60-watt	four-six 9-watt compacts	\$102- \$150



Savings based on 10¢ per KWH, calculated at a tube life of 10,000 hours

**YEAR
2005**

AN ELECTRIC CAR IN YOUR DRIVEWAY CUTS THE COST OF AROUND-TOWN TRAVEL TO ALMOST NOTHING, BUT STILL GIVES YOU THE BEHIND-THE-WHEEL PERFORMANCE OF A GASOLINE-POWERED SECOND CAR.



Standard base fits all regular light bulb sockets.

It's a typical Sylvania invention: a bulb that gives better light, and more of it, on less energy, for a lot longer than ordinary bulbs.

Lasts up to 3 times as long as ordinary bulbs.

Gives a whiter, more natural light, to bring out the true colors and textures of your home.

The Sylvania Halogen is part of a full line of Sylvania lighting products for the home. We promise you: try just one and you'll flip.

Stays brighter over more of its lifetime.

Burns up to 10% brighter on the same amount of energy as ordinary bulbs.

Get up to \$2 back.

Get a cash refund of \$1 for purchasing one bulb, \$2 for two bulbs, by sending this completed form to Sylvania, along with: One proof-of-purchase seal from Halogen package for \$1 refund; two proof-of-purchase seals for \$2 refund; your cash register receipt (with Halogen purchase circled). Mail to: Sylvania Halogen Refund Offer, P.O. Box 1515, Young America, MN 55551-1515. Allow 8-10 weeks for delivery. Claims must be postmarked by 12/31/91.

NAME _____

ADDRESS _____ APT. _____

CITY _____ STATE _____ ZIP _____

Sylvania Halogen. The bulb that's standing the lighting industry on its head.

SYLVANIA **GTE**
LIGHT. MADE RIGHT.

YEAR
2015

YOU BUY YOUR HOUSE FROM YOUR BUILDER'S CATALOG, CHOOSING LIVING AND SERVICE MODULES THAT MEET YOUR LIFESTYLE NEEDS. WHEN THOSE NEEDS CHANGE, YOU SIMPLY TRADE ONE MODULE FOR ANOTHER.

THE PARTNERSHIP THAT PAYS

For most of us, the mental picture we have of our electric utility company is no larger than the envelope that contains the bill. Sure, we may pay some attention to the conservation tips the company sends, or the free energy

audit services. But for the most part, we see our supplier of electricity as some anonymous corporate force that we take for granted—just as we take for granted that when we flick a switch the lights will always go on.

It may come as a surprise that your electric utility company wants you to pay less for energy rather than more. In fact, the people at your utility are developing demonstration centers, with trained staff, to show you how to economize. Already up and running is Southern California Edison's Customer Technology Application Center, or CTAC, which opened last year. It's likely to become a model for similar centers around the country.

"CTAC is the most comprehensive showcase of customer-based electric technologies in California. It exemplifies the electric utility industry's commitment to quality customer service, energy efficiency, and concern for the environment," says Project Manager Ruby Irigoyen. CTAC's 1,000-square-foot *House of the Future* demonstrates high-efficiency heat pumps, electronic meters, home-automation systems, water-conservation options, an electric van, and other advances in efficient technology for home life. In the Lighting Design Center, visitors can see over 150 lamps (including the new compact fluorescents), experiment with different color lighting schemes, and learn about innovative and energy-efficient lighting for merchandise displays and show windows.

CTAC also works with product manufacturers to, as Irigoyen puts it, "see if we can provide an electric technology solution to an emissions problem or an improvement in product quality and productivity."

Utility companies in all localities also sponsor programs to increase the energy efficiency of your house. Sometimes these programs have substantial economic incentives. PSI Energy's Smart Saver program, for example, offers a 30-percent reduction in electric rates to homeowners who install qualifying energy-saving features. In Arizona, there are financial incentives for builders who install heat pumps and double-pane windows. Delaware rewards sealed-duct systems and efficient water heaters. What these programs mean to you is that if you're in the market for a new house and want to buy one whose energy-saving features meet next century's standards, you can do so without paying extra for them. Your electric utility company has picked up the tab for you.

Your utility encourages you to ask about the many consumer and builder programs it offers to help you live more efficiently. The people who work for your utility are really your partners. They want to see the dollar you spend for electricity go farther. When it does, not only will there be more electricity to go around, but the benefits of our energy-saving efforts on the environment will be there for all of us to enjoy.



Call your local utility company to find out what programs are available in your area.

YEAR
2010

A WHOLE NEW CLASS OF REFRIGERANTS THAT DO NOT HARM THE OZONE LAYER HAVE COMPLETELY REPLACED THE FREON-BASED SUBSTANCES THAT WERE ONCE USED IN REFRIGERATORS AND AIR CONDITIONERS DURING THE 20TH CENTURY.

The practical electric car is no longer just a futuristic dream. Introduced in 1990, the GM Impact has a range of 120 miles per charge and travels at highway speeds. Ford is also developing an electric car and expects to go into large-scale production in the mid-to-late 1990s.



PHOTO COURTESY GENERAL MOTORS ELECTRIC VEHICLE

©1991 Edison Electric Institute. All rights reserved.



If there's one thing every great cook hates, it's something burning. Especially money. Which is why so many cooks choose Tappan for their new kitchens. With Tappan, you can afford high performance and high design. Because nobody builds in features and value like we do. Create the perfect look with a modular electric

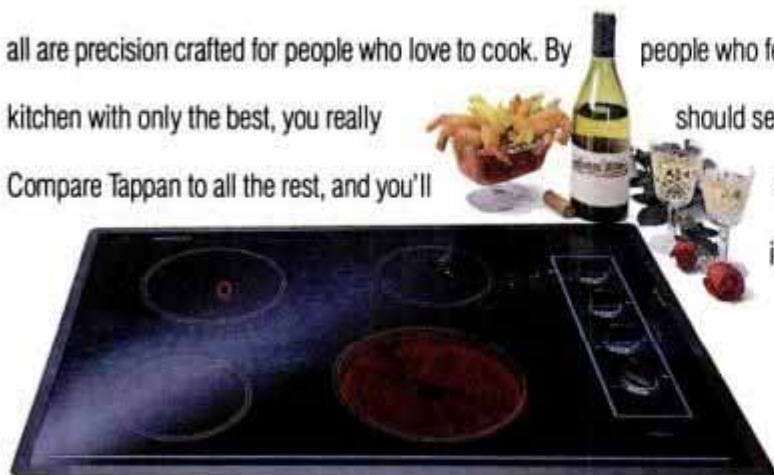


After cooking to perfection, our White-on-White wall oven cleans itself automatically.

downdraft cooktop for indoor grilling at its best. Next, consider the sophistication of a Ceran™ electric cooktop. Or the precision and easy cleanup of solid disc electric burners. Then add your choice of one of the finest lines of electric built-in ovens you can buy. No matter which Tappan built-ins you choose,

Something You'll Never Burn With A Tappan.

all are precision crafted for people who love to cook. By people who feel the same. So if you're thinking about upgrading your kitchen with only the best, you really should see Tappan. Unless, of course, you have money to burn. Compare Tappan to all the rest, and you'll see why nobody builds in as much as we do. For free information, call toll-free 1-800-537-5530.



The smooth surface of our black glass Ceran™ electric cooktop cleans with a wipe.

TAPPAN
Precision Cooking Machines™

YOU CAN SAVE A LOT OF ENERGY IF YOU KNOW WHAT TO LOOK FOR IN A HOUSE.



You know just what you want in a house - how many bedrooms, the type of yard, maybe even the color of the shutters. But have you given much thought to what the energy source should be? When you shop for a home, remember the advantages of high-efficiency electric applications. A high-efficiency electric home uses less energy for staying warm and keeping cool. Electricity also gives you plenty of design flexibility, so you can choose from a wide range of energy-efficient appliances.

And if you're building your new home, remember that building electrically can cost less. Because you don't need extra piping for gas or oil. You should also know that advances in technology are making electric applications more efficient. This helps conserve our energy resources, which contributes to a cleaner environment, now and in the future. If you'd like to know more about energy saving programs in your area, contact your electric utility. We can promise you it won't be a waste of energy.

 **ELECTRICITY**
Taking you into the future.

Lumber Rack

Once your shop is set up, it's time to figure out where to put the actual center of attention—the wood. Our lumber rack holds solid and plywood stock, and is built with construction lumber and plywood.

Begin by cutting all 2 × 4 parts to exact length and boring 3/8-in. holes in the cross supports for lagscrewing to the uprights. Lay out the cross-support positions as a group to ensure alignment (Photo 1). Clamp the cross supports to the uprights, and bore the pilot holes for the lagscrews (Photo 2). Then, assemble the three upright sections with 3/8-in.-dia. × 3-in.-long lagscrews and washers.

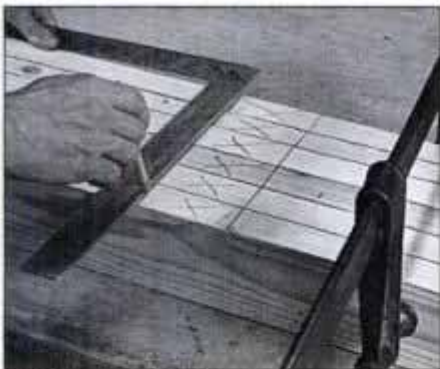
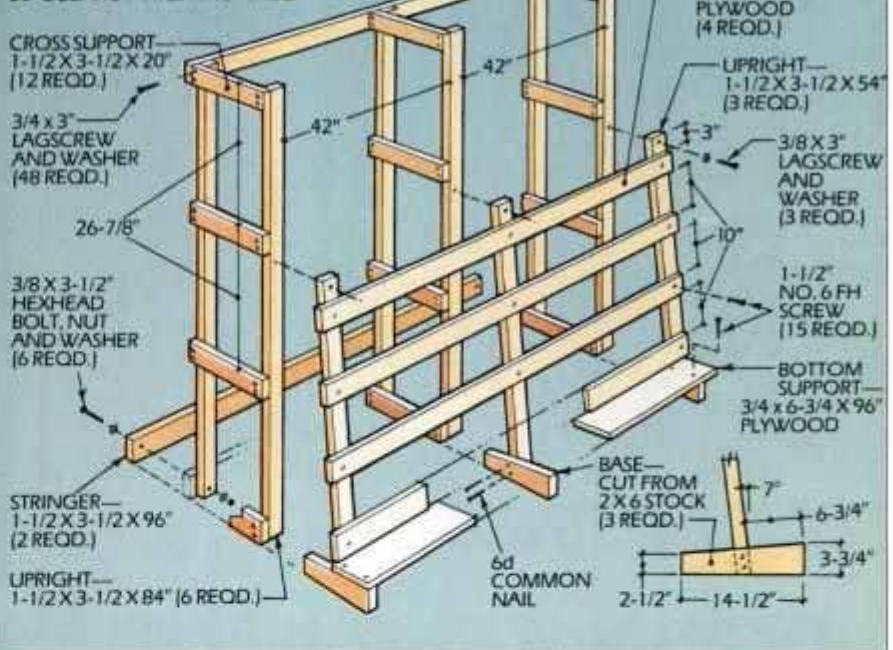
Lay the three sections on the floor, and clamp the back stringers in place. Bore holes for the 3/8-in.-dia. × 3 1/2-in.-long bolts, and attach the stringers (Photo 3). Cut the bases for the plywood rack from 2 × 6 stock, and join the bases to the short uprights with 16d common nails. Then, bore a 3/8-in. hole at the top of each upright.

Position each of the three plywood rack sections against a main upright, and attach with lagscrews and washers. Rip 3/4-in.-thick plywood strips for the plywood rack base and back supports, and screw them in place (Photo 4).

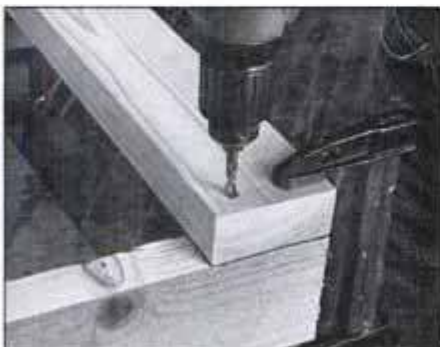


LUMBER RACK

36" DEEP X 84" HIGH X 96" WIDE



1 After cutting all 2 × 4 pieces to length, clamp the six uprights together and mark the cross-support locations.



2 Clamp the cross supports to the uprights, and bore lagscrew pilot holes in the uprights. Then, assemble upright sections.



3 Use 3/8-in.-dia. × 3 1/2-in.-long hexhead bolts, washers and nuts to attach rear stringers to upright sections.



4 After bolting plywood rack uprights to main sections, attach rack base and back support strips with 1 1/2-in. No. 8 screws.



WOODWORKING GUIDE

ADVANCED SHOP

A fully equipped workshop isn't the end—it's just the beginning.

BY NEAL BARRETT

Color photos: John Griebisch
Black-and-white photos: Neal Barrett
Technical art: Eugene Thompson

● In a sense, a woodshop is one massive tool that, instead of picking up, you enter and control from inside—a total environment that you and the wood move through as your project evolves through each stage of construction. Like all good tools, you expect your shop to perform—to meet the high standards that you set for yourself and that your finished work demands. Each component, like the internal parts of a machine, must not only be up to its job, but also must be effectively placed so that work progresses safely and efficiently.

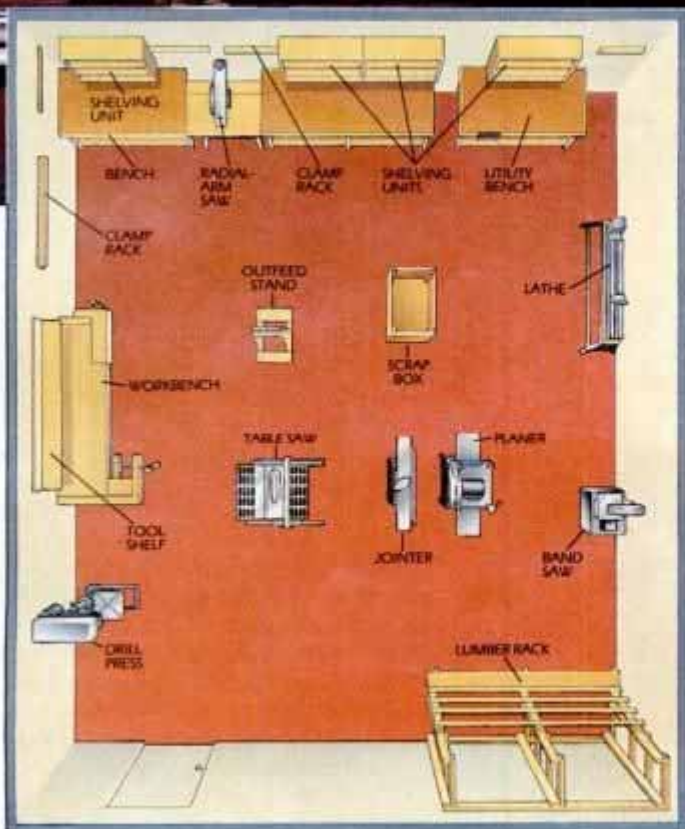
Our final shop is designed and equipped for woodworkers who expect their workshop to function as ef-



ficiently as the individual tools that make it up. We've upgraded our benchtop stationary machinery to full-size professional floor models. While you'll still find a use for the jig-saw, a band saw now handles the bulk of your curve cutting. In addition to a 10-in. table saw and floor-model drill press, we're moving up to some new machinery that will expand your woodworking horizon. A jointer will true edges and flatten surfaces, and, in combination with a thickness planer, it will transform rough lumber into flat dimensioned stock.

Of course, no home workshop would be complete without a lathe. With this tool, you can make spindles, bowls and other circular forms as accurately as your table saw makes straight and square cuts.

You'll also notice a radial-arm saw positioned between two benches. Not only do the benches extend the saw table, but they provide extra workspace with storage underneath. The benches are constructed in the same way as the utility bench in the previous shop (see page 68). Other im-



Here's a shop with the equipment to take care of just about any project you're likely to tackle—from rough lumber through final sanding. Its layout is designed to maximize space and provide easy access to tools.

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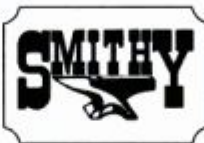
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WOODWORKING GUIDE

Improvements on our previous shop include a heavy-duty plunge router, random-orbit sander, a wider assortment of hand tools and a complete collection of the tools you'll never have enough of—clamps. Keep all types on hand, ranging from small spring clamps through quick-action clamps in various sizes to long pipe clamps for large assemblies.

Our projects for this shop range from a simple and practical scrap box to a classic European woodworking bench. This solid maple workbench features a shoulder vise, tail vise and bench dogs for holding your work. We also show you how to build a basic tool shelf for your hand tools, an outfeed stand to help you handle long stock and a sliding table for making square, accurate cuts on your table saw.

Layout

While machine placement will be largely determined by your own space and the equipment you use, there are

Outfeed Stand

If you've ever ripped a long board and found yourself finishing the last few inches of the cut while trying to support several feet of lumber on the opposite side of the saw, you know how necessary an outfeed stand is. In addition to making the job safer, adequate stock support also improves accuracy because the work is less likely to shift.

Our compact design is adjustable in height and utilizes a 12-in.-long roller for smooth operation. (Outfeed stand rollers are available through many woodworking catalogs. See listing on page 76.) Of course, the stand's use isn't confined to the table saw. You'll also find it handy when using the jointer, planer and band saw.

We used 5/4 and 1-in. pine for this project. Our 5/4 stock measured 1³/₁₆ in. thick. Because the actual thickness can vary depending on the supplier, be sure to check your stock and adjust the dimensions accordingly.

Begin construction by cutting the pieces for the side channels to exact size. Mark the ends of the slots that the threaded rod will pass through. Then, use a router and edge guide with 1/2-in.-dia. straight bit to rout the slots. It's best to rout the slots in several passes, increasing the depth of cut after each pass. Drill pilot holes in the four short channel pieces as shown, and attach these to the slotted pieces with screws and glue (Photo 1).

Lay out the angled cuts on the inner base pieces, and use a band saw or

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(For Leigh Jigs)

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- #404 1/2" 8° \$12.00

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a few general rules to follow. Except for the table saw, all of the machines shown have a blind side that can be close to or against a wall, column or other machine. Placing your band saw, for example, against a supporting post in your shop can make the area around the post more useful.

Because the jointer is used in concert with the planer when thicknessing stock and the table saw when ripping boards to width, we placed it in between these two tools. It's also a good idea to orient each machine so that shavings and scrap are concentrated in a common area. Although we haven't included a dust-collection system in our shop, arranging your machines in this manner facilitates setting up dust-collection ductwork. An area outside of this machine space near the workbench can be reserved for assembly.

Ideally, machines should be oriented with the long axis of your shop so you can handle the longest stock pos-

sible. In very confined spaces, it's often useful to align the tools on a diagonal to maximize the space available. Another option for those tight on space is to make your stationary machinery mobile so you can easily move the tool out of the way when it's not needed. Special wheeled bases for many machines are available through woodworking supply catalogs (see listing of catalogs on page 76).

Make sure you have adequate power and wiring. Heavy-duty tools can often be wired for either 110 or 220 volts. The latter is preferable because the amperage draw is halved, and the wire size, therefore, can be reduced. Each machine should have its own circuit.

And, don't skimp on lighting. Fluorescent fixtures are the most economical way to go. However, gooseneck-type incandescent fixtures placed by workbenches, the band saw, lathe and drill press will do wonders when it comes to illuminating the subject.



sable saw to cut them to shape. Then, attach each inner base section to a side channel with screws and glue (Photo 2). Finish the stand sides by cutting the angled outer base sections and attaching these to the stand sides with screws and glue (Photo 3).

Cut the pieces for the roller support assembly. Use a dado blade in the table saw for the rabbet on the top edge of the sides. Then, bore the 1/2-in.-dia. hole in each roller support sidepiece

for the threaded rod, and bore the screwholes for fastening the sides to the top crosspiece.

Note that the bottom rail is made from two pieces, each with a groove in its edge. When assembled with epoxy, the grooves house the threaded rod and lock it in place. Cut the rail pieces to size, and use a dado blade in the table saw to cut the tenons on the ends. Then, readjust the dado blade,



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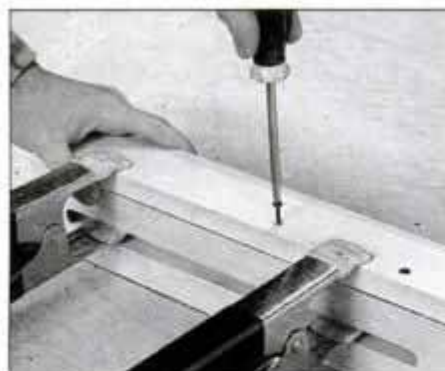
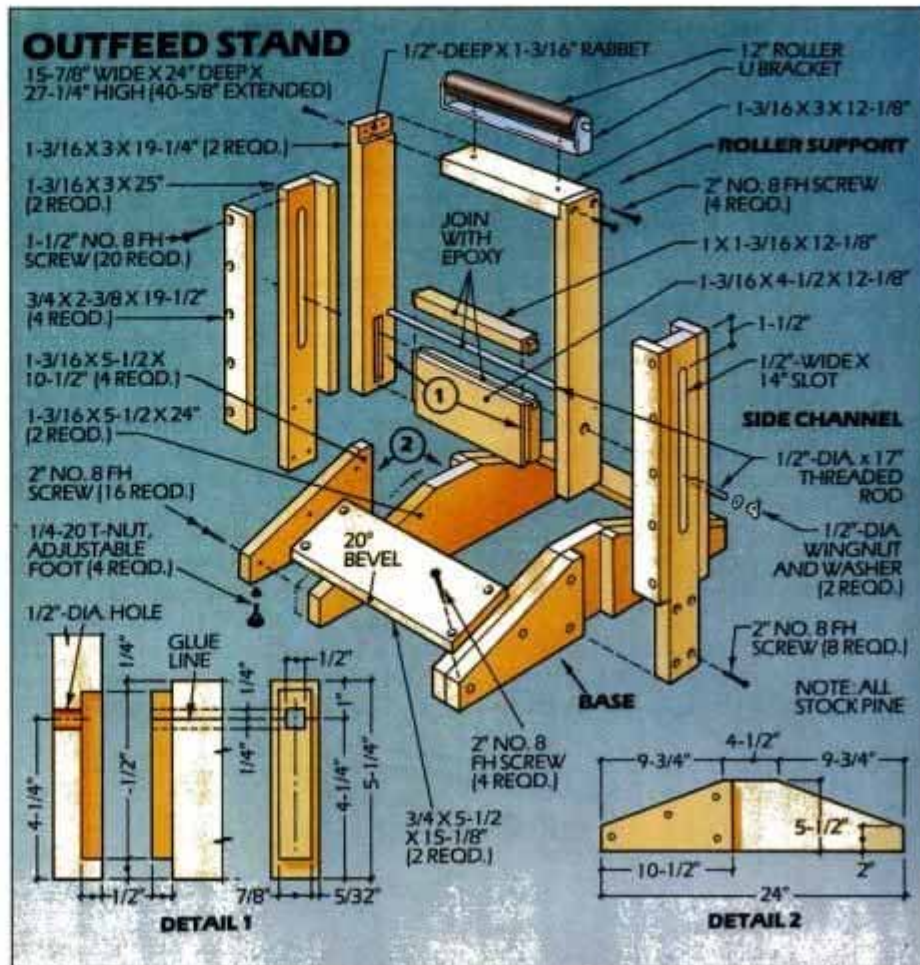
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and cut the 1/4-in.-deep × 1/2-in.-wide grooves (Photo 4). Cut the threaded rod to length, and spread epoxy in both grooves and along the mating edges. Position the threaded rod in a groove, assemble the rail, and clamp until the epoxy sets. Lay out the mortises in the roller support sidepieces. Use a 7/8-in. Forstner bit to remove most of the waste, and finish with a sharp chisel (Photo 5).

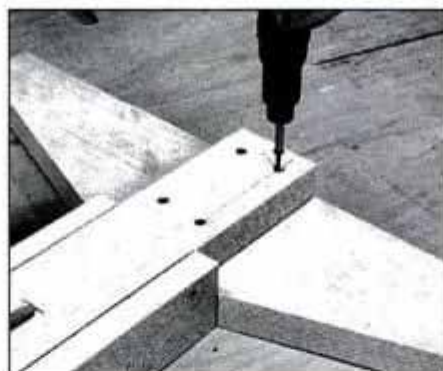
Assemble the roller support top piece and rail to the sides with screws and glue (Photo 6). Cut the two base crosspieces to size, and bevel the lower edge of each on the table saw as shown. Bore screwholes for attaching the crosspieces to the stand sides.

To complete the outfeed stand, first position the roller support assembly between the two side channels with the threaded rod extending through the slots. Then, screw the base crosspieces to the stand sides. Place washers and wingnuts on the ends of the threaded rod. Attach the U bracket to the top rail with screws, and slip the roller in place.

Sand all surfaces and ease sharp corners. We mounted adjustable feet on the base to handle uneven floors. Bore 5/16-in. holes in the base, drive in 1/4-in.-20 T-nuts, and thread the feet into the T-nuts as shown.



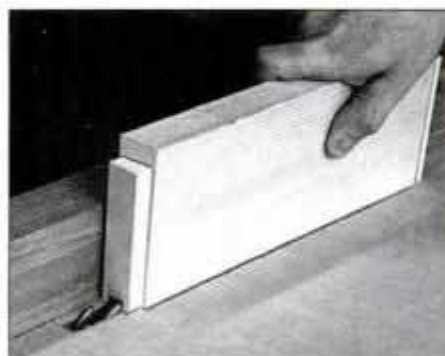
1 After routing adjustment slot in both channel sidepieces, assemble channels with 1 1/2-in. No. 8 fh screws and glue.



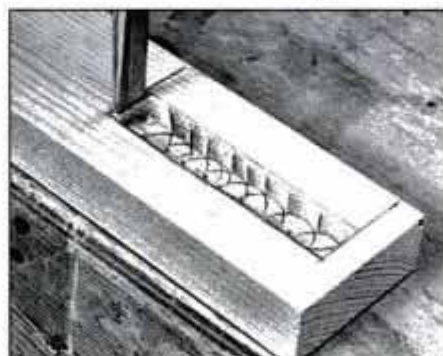
2 Cut angled inner base pieces on band saw or sabre saw, and secure to channels with 2-in. No. 8 fh screws and glue.



3 Secure angled outer base sections with screws and glue. Outer sections lock channel in place and strengthen base.



4 After cutting tenons on lower rail ends, use dado blade to cut threaded-rod groove on both top and bottom rail halves.



5 Bore overlapping holes in roller support sidepieces to begin shallow mortise. Finish cutting mortise with sharp chisel.



6 Join the roller support sides to the rails. Threaded rod extends through slot for locking stand height.

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Both doors open smoothly, as do the hood and trunk. The front wheels turn with the steering wheel.

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Sliding Table

One common task in a woodshop is cutting wide panels square. Our sliding table features a long stable fence that supports stock for accurate crosscutting. This design prohibits the use of the standard blade guard. Therefore, take special care when using this jig, and be sure to observe all standard safety precautions.

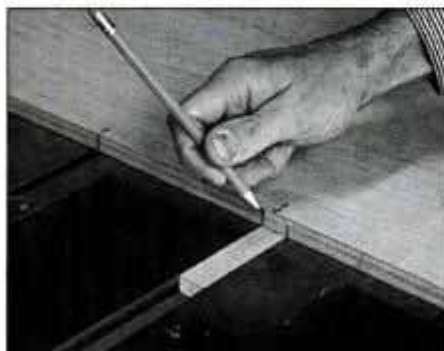
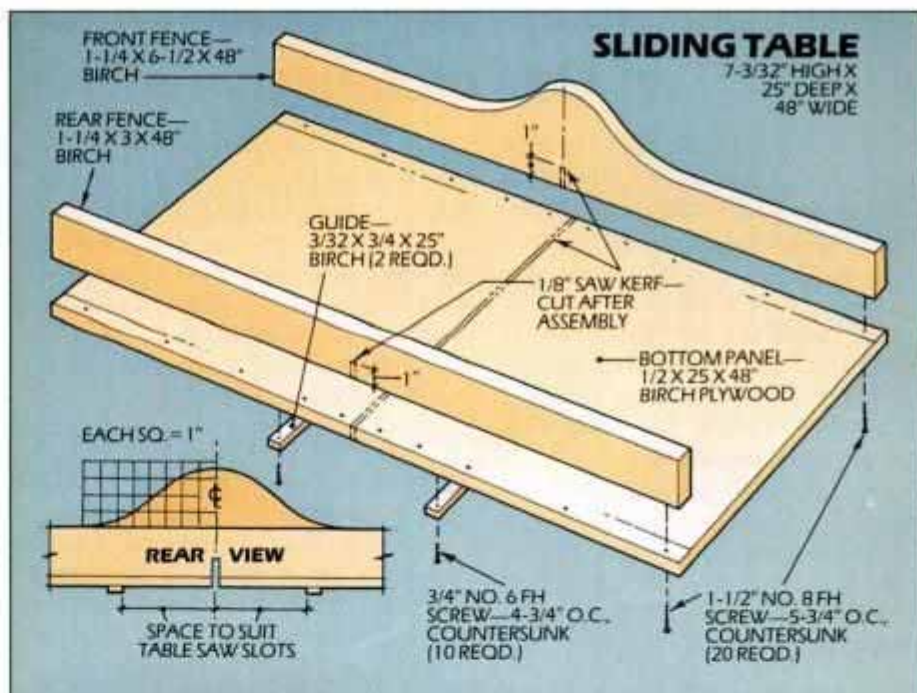
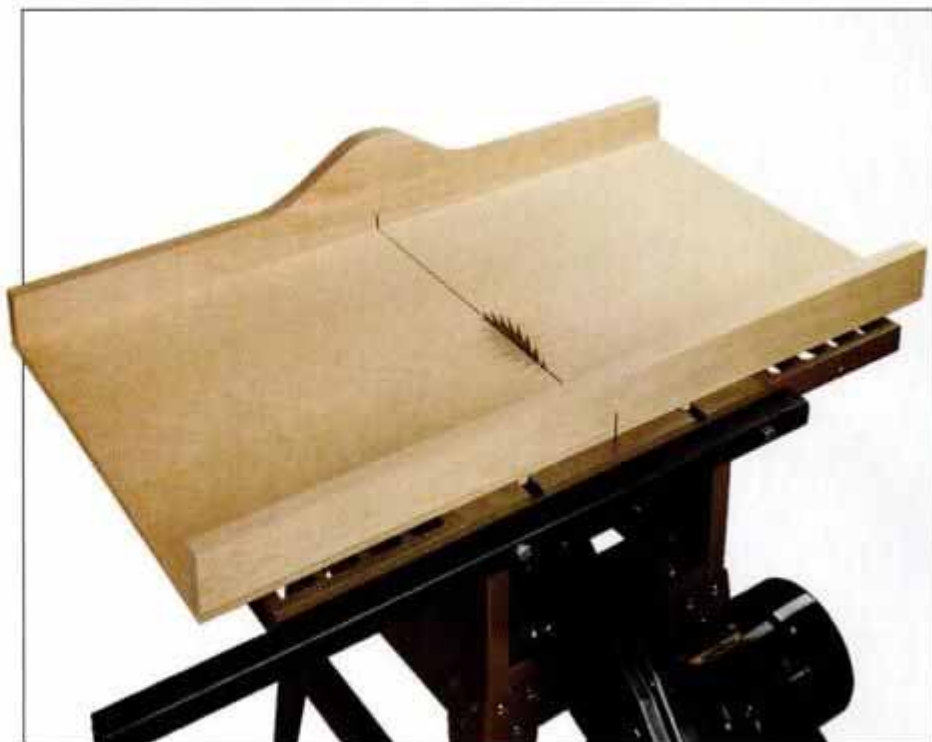
Start construction by cutting guide strips to fit the slots on your saw—most slots are $\frac{3}{4}$ in. wide. The strips should fit snugly, but slide easily. Trim the strips flush with the table saw top, but don't cut them to length. Then, cut the plywood bottom panel.

Place the guide strips in the table saw slots, and lay the bottom panel over them so it's parallel to the table edge. Mark the location of each strip on the edges of the panel (Photo 1). Also mark the blade position. Remove the panel, and extend these lines across the panel bottom.

Screw the guide strips to the panel, and trim the ends flush (Photo 2). Cut the back fence to size, and screw it to the panel. Be sure to keep screws away from the blade (Photo 3). Then, cut a blank for the front fence, lay out the curve, and cut to the line.

Bore one screw hole in the right front corner of the bottom panel, and attach the front fence at this point only. Clamp the opposite end of the fence flush with the panel edge. Then, with the blade completely lowered, place the sliding table in position. Turn on the saw and raise the blade until it protrudes $\frac{1}{2}$ in. Push the sliding table forward to cut the blade slot in the base and front fence.

Make a test cut with a 10- to 12-in.-wide piece of plywood, and check the cut with a square. If necessary, loosen the clamp and adjust the fence. When the cut is square, screw the fence to the panel. Apply a light coat of wax to the guide strips.



1 With guide strips in the table saw slots, lay the bottom panel on the saw and mark the guide strip locations on both edges.



2 Align the guide strips and attach to the bottom of the panel with $\frac{3}{4}$ -in. No. 6 fh screws. Countersink the screw pilot holes.



3 Clamp rear fence to bottom panel so it's flush with edge, and attach with screws. Keep screws away from blade line.



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Tool Shelf

In addition to keeping your hand tools sharp and ready for work, you'll need a place to put them—a place where each tool is immediately accessible, yet safely stored and out of the way. Our tool shelf has adequate space for a good selection of tools. Plus, it has racks for holding handsaws, slots for chisels, files and Surform tools, and space for a marking gauge, mallet and squares. If you're storing different tools, simply modify the plans to suit your collection.

First, cut 1 × 8 stock to length for the shelf and 1 × 10 stock for the back. Use a dado blade mounted in the table saw to cut the rabbet along the bottom edge of the backboard. Then, cut small pine blocks to use as blanks for the turnbuttons that secure the saw handles. Draw the outline of each turnbutton on the blank, and use a dovetail saw to cut the rough shape. Refine the shape with a rasp, followed

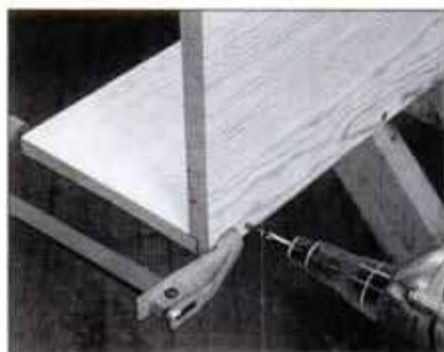
(Please turn to page 100)



1 Make handsaw blocks from 5/4 pine, and cut rabbet with dado blade. Lay out saws on backboard, and install blocks.



2 Use a router with 3/8-in.-dia. straight bit and edge guide to cut elongated holes for holding chisels, files and rasps.



3 Temporarily clamp shelf to backboard, and bore screw pilot holes. Countersink holes, and assemble with screws and glue.

Safety Considerations

● Unfortunately, it's not all that rare to meet a group of woodworkers and shake hands with one who's inadvertently customized the length of a finger.

Woodworking is a potentially hazardous activity—with hand or power tools. Manufacturers take care to ensure that their tools are as safe as practically possible and utilize up-to-date equipment such as blade guards and anti-kickback devices.



In conjunction with shopmade push sticks and a healthy dose of common sense, woodworking can be a safe experience.

However, personal safety goes far beyond keeping your fingers away from the blade. Flying bits of wood, airborne contaminants and the continuous noise demand special equipment.

If you've ever neglected eye protection—just once—and found yourself in the doctor's office with a scratched cornea or worse, you don't need to be told how vulnerable your eyes are. The simplest approach is to wear safety goggles every time you operate a tool. Have several pairs on hand, placed conveniently around the shop. Alternatively, you can use a full face shield or folding safety glasses that slip into your pocket.

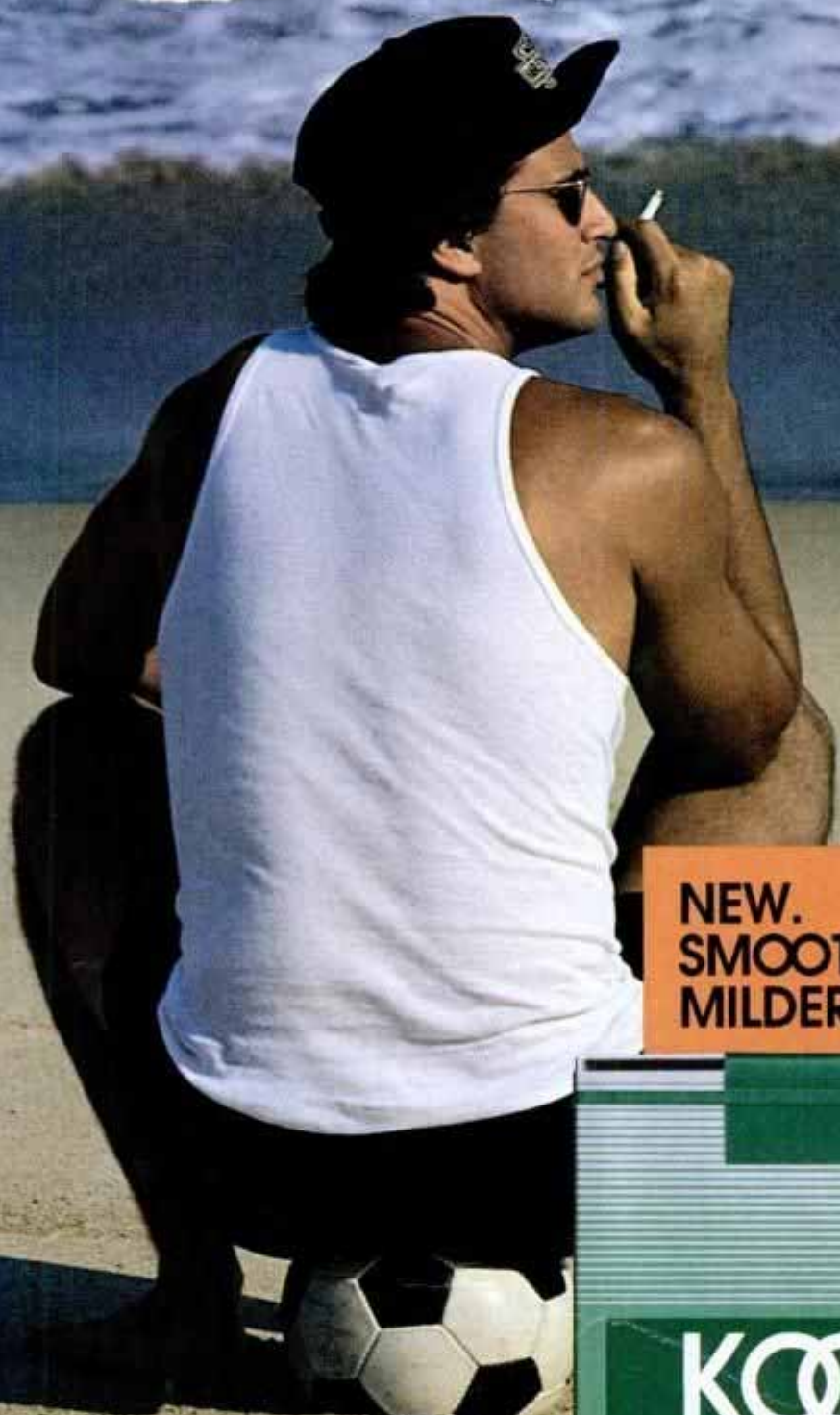
Because noise isn't as immediately crippling as an eye injury or a bandaged hand, woodworkers and manufacturers tend to take the problem lightly. However, the continual scream of routers, circular saws and other power tools can, over time, permanently affect your hearing. If you'd like to hear

all that you're capable of, be sure to use ear protectors or plugs. Airborne contamination is another long-term hazard that you can do something about. Simple masks that cover the nose and mouth are fairly effective at filtering out dust particles, and are useful even if you have a dust-collection system. To protect yourself against organic vapors from solvents and finishes, use a respirator. You'll have to install the right filter for your job, and most suppliers offer guidelines to help out. To be sure, contact the manufacturer and request a hazard data sheet for the product you're using. Then, send this information to the filter manufacturer to determine the best filter.



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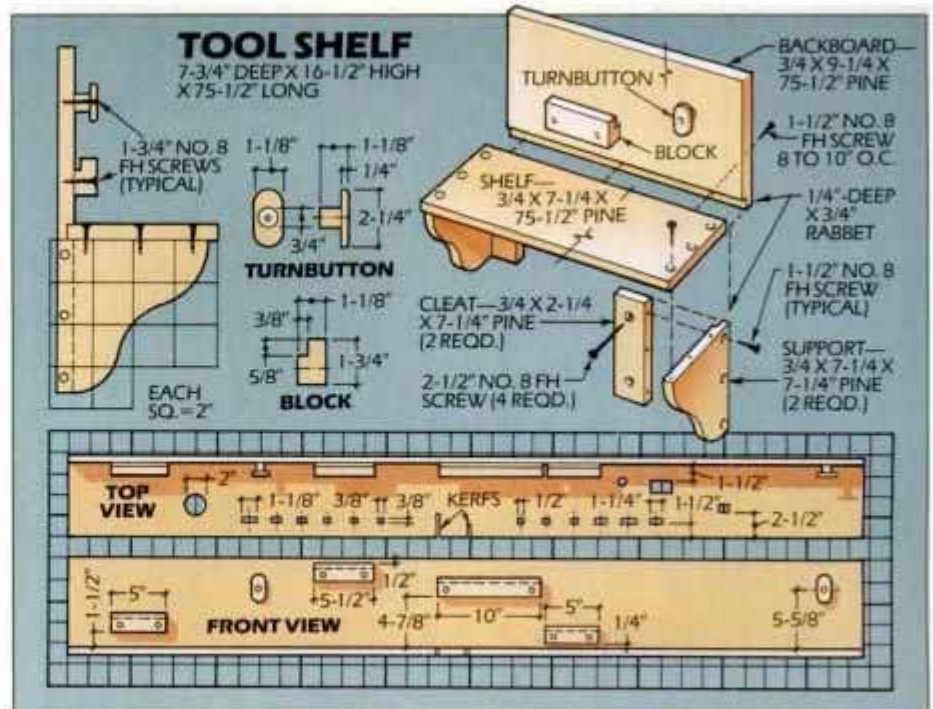
by smoothing with a file and sandpaper. Bore and countersink a screw-hole in the center of each turnbutton for securing it to the shelf back.

Next, cut a length of 5/4 stock to 1 3/4 in. wide for the blocks that hold the handsaw blades and the coping and dovetail saws. Make this piece long enough to produce all the blocks you'll need. Cut a rabbet along the length of the stock using a dado blade and table saw. Then, cut into the shorter lengths required for each saw.

Lay the backboard on your worktable, and place the tools in position. Mount the blocks and turnbuttons to the backboard with 1 3/4-in. No. 8 fh screws (Photo 1). Lay out the position of each tool that will be held on the shelf. In our design, the flat Surform tool and marking gauge require rectangular holes. To form these, bore through the shelf inside the layout lines for the holes. Then, use a sharp chisel to trim the holes to the finished shape.

We bored a 2-in. hole through the shelf to hold the handle of a round carver's mallet. Use a Forstner bit mounted in the drill press for this job. Bore a 3/4-in. hole to handle the round Surform tool.

Next, use your table saw to cut slots in the shelf edge to hold a try



square and combination square. Use a router with edge guide and 3/4-in.-dia. straight bit to cut the elongated holes for storing chisels and files (Photo 2).

Clamp the shelf and backboard together, and bore countersunk screw pilot holes along the back edge (Photo 3). Attach the shelf and backboard with glue and 1 1/2-in. No. 8 fh screws.

Lay out the support brackets on 1 x 8 stock, and cut the rabbet along the back edges with a dado blade. Cut the bracket curves on the band saw, and smooth the edges with a file. Then, cut the mounting cleats to size and secure to the brackets with 1 1/2-in. No. 8 fh screws. Finally, screw the brackets to the shelf and sand.

The Shopsmith Alternative

● If you're tight on space—or you have full-size machinery tastes that you're trying to satisfy on a bench-tool budget, it might pay to take a good look at the Shopsmith Mark V. It's one tool—and one price tag—that sets you up with a table saw, drill press, horizontal boring machine, disc sander and lathe.

Shopsmith machines first gained popularity in the '50s as the do-it-yourself, home-workshop movement established itself across the country. After a 7-year respite in production, the versatile Mark V appeared on the woodworking scene in 1973.

In addition to the five functions of the basic Mark V, Shopsmith offers a full range of attachments, such as an 11-in. band saw, jigsaw, 4-in. jointer, 6-in. belt sander and narrow-belt sander. All of the above tools mount right on the Mark V, and are powered by its variable-speed drive unit. You can also get a 12-in. power-feed, thickness planer attachment.

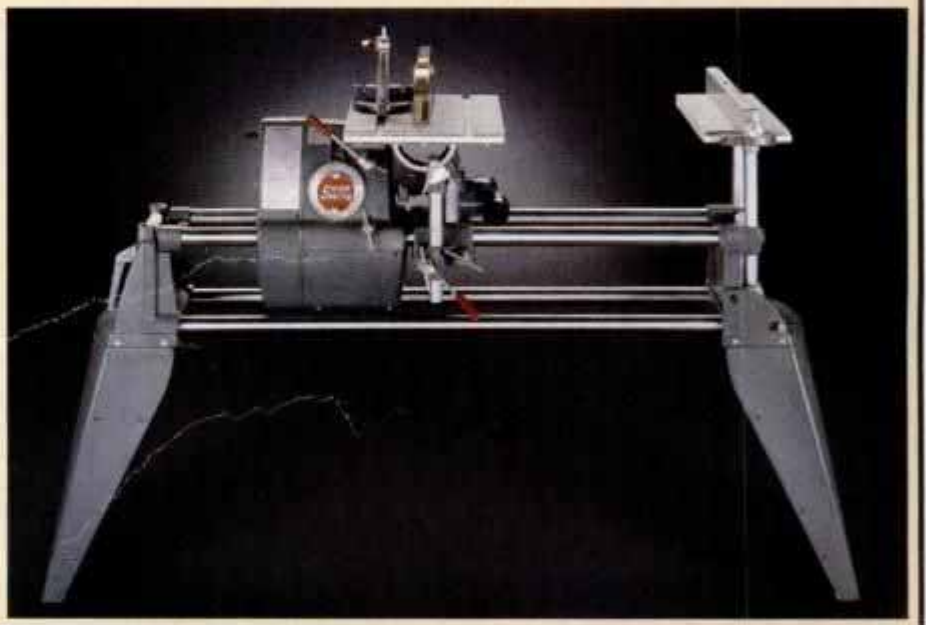
Like many combination tools, the Shopsmith system may force you to rethink how you go about building projects—especially if you're accustomed to individual machines. It does take a little time to shift from

one operation to another, and it therefore pays to group similar operations together. If you don't, you may spend more time switching attachments than building. However, organizing your construction schedule is not a bad skill to develop—no matter how you set up your shop.

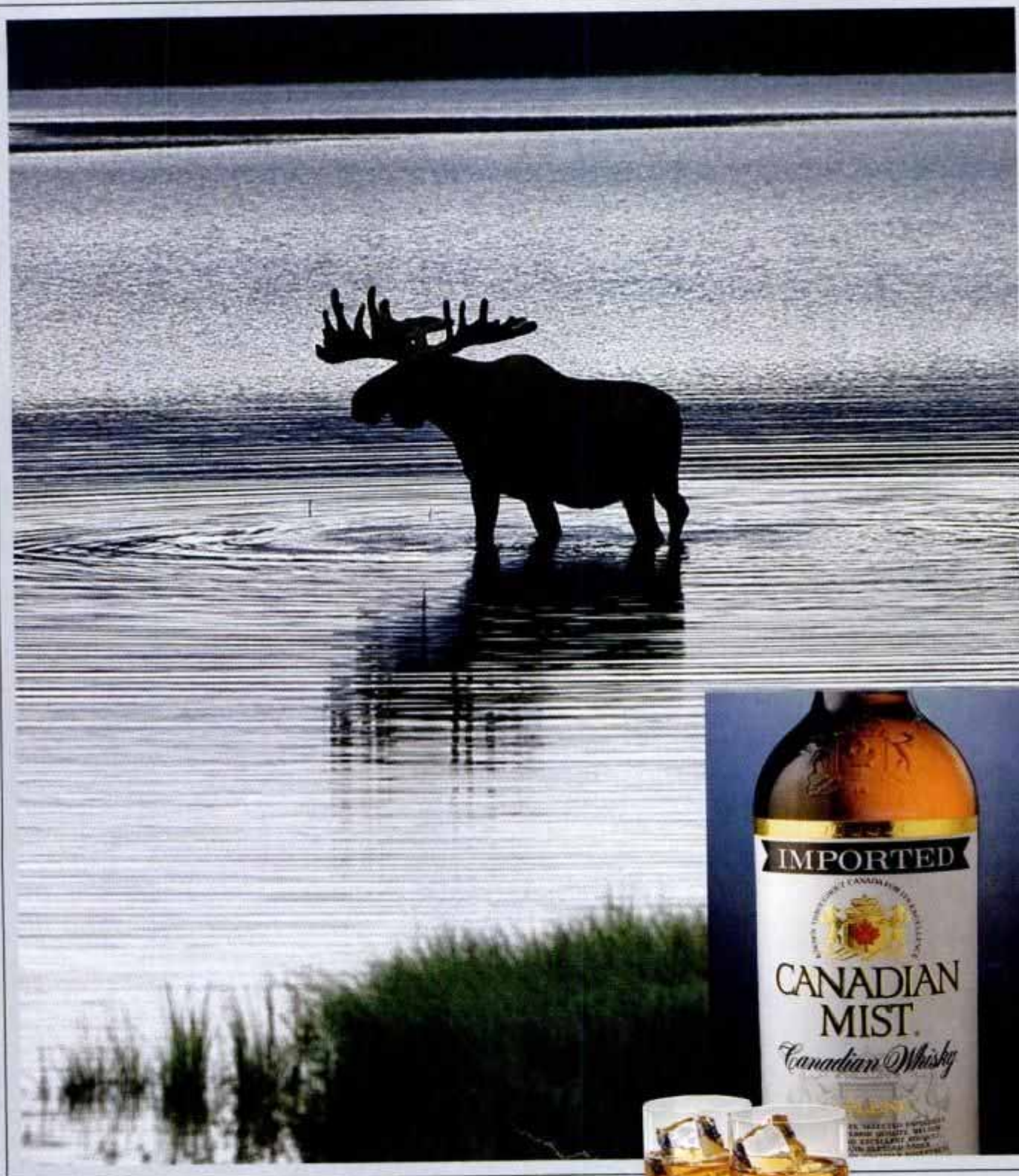
The basic Shopsmith Mark V Model 500 costs about \$1600. The Mark V Model 510

(shown below) has extra features such as wider tables and extension tables, a dust-collection provision and a 2-position lathe rest. It costs about \$1900.

Shopsmith also offers a catalog filled with additional attachments, individual machines, tools and woodworking supplies. Contact Shopsmith, Inc., 3931 Image Dr., Dayton, OH 45414.



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MELLOW

Scrap Box

No matter what kind of projects you're interested in building, there's one thing you'll produce that every other woodworker across the country is making as well—scrap wood.

We've designed our scrap cart with the home workshop in mind. It's adequately sized to take care of offcuts and waste, and is mounted on casters so you can wheel it over to the machine or bench you're working at. Construction is simple and sturdy, featuring economical fir plywood, 2 × 2 construction lumber and pine. The handles and casters are generally available at hardware and building supply dealers.

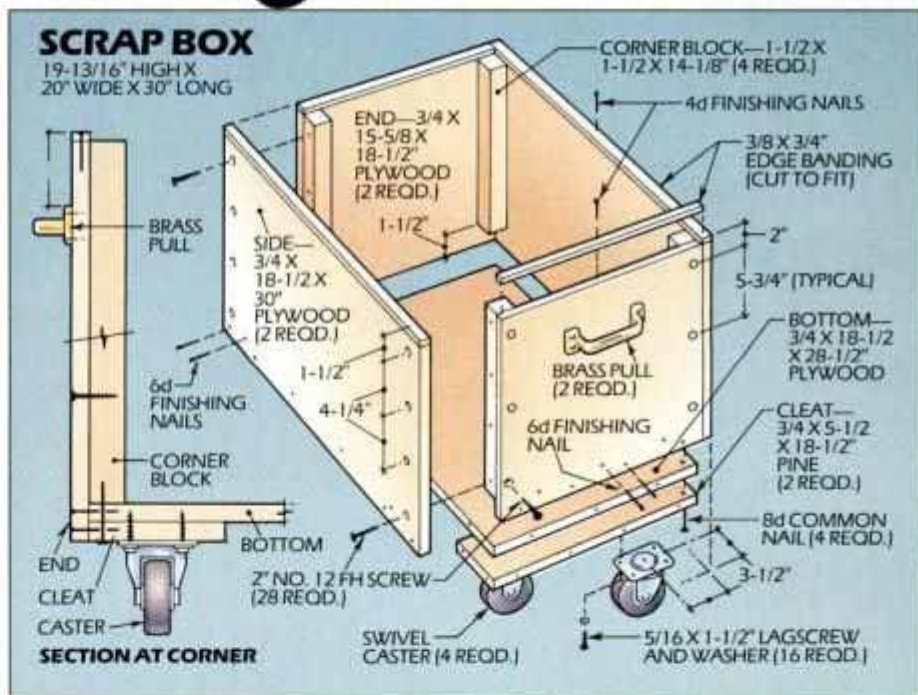
The first step is to cut all the plywood parts exactly to size with a table saw or portable circular saw. Cut the 2 × 2 corner blocks to length, and attach them to the ends with screws and glue. Then, apply glue to the corner blocks, and attach the two long side panels with screws as shown (Photo 1).

Next, turn the box upside down and drop the bottom panel in place so it rests on the corner blocks. Note that the bottom is recessed $\frac{3}{4}$ in. Nail through the box sides into the bottom to fasten it in place.

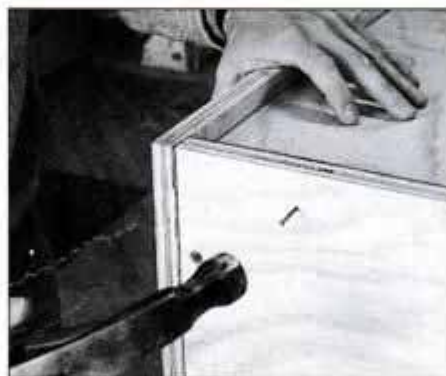
Cut the 1 × 6 cleats to length, and position across the ends of the bottom panel. Use 8d common nails driven through the cleats and into the corner blocks (Photo 2). Then, nail through the sides and ends into the cleats.

Cut edge banding from $\frac{3}{4}$ -in. pine, and attach to the top box edges with 4d finishing nails and glue. Use a caster as a template to mark the caster mounting-hole positions. Bore pilot holes, and mount the casters with $\frac{5}{16}$ -in.-dia. × 1½-in.-long lagscrews and washers (Photo 3).

Finally, mark the locations of the brass pulls, bore pilot holes, and secure the pulls with screws. **PM**



1 Attach end panels to 2 × 2 corner blocks with screws and glue. Then, secure the long sidepieces in the same way.



2 Use 6d finishing nails driven through the sides to secure bottom. Drive 8d common nails through bottom in corner blocks.



3 Attach swivel casters to 1 × 6 cleats secured to bottom panel. Use $\frac{5}{16}$ -in.-dia. × 1½-in.-long lagscrews and washers.

Workbench

Whether you work with hand tools alone, or favor a modern, fully equipped woodworking shop, this workbench is sure to be one of your most-appreciated pieces of equipment—especially when you build it yourself. Based on traditional designs, it has all the time-honored features of a classic cabinetmaker's bench.

Our bench is equipped with two vises. The front shoulder vise is designed to allow long work to be held vertically at any position. The vise screw and supporting hardware do not pass under the jaws as with other types of vises. The end vise is called a tail vise. Here, the work can either be held between the vise body and the bench, or the vise can be used with bench dogs for holding stock on the benchtop. We used standard vise hardware for this bench. Although this hardware comes complete except for the handles, we modified the installations to provide a more reliable and durable finished product. The optional guide bar and linear bearing shown with the shoulder vise improves clamping jaw alignment. We had a local machine shop make the guide bar and supply the bearing.

The bench is made from maple because this wood is hard, long wearing and heavy. Whatever wood you use, keep in mind that weight is important in providing the stability required for sawing, planing and chopping mortises. Also, make sure that your wood has been dried adequately—ideally to match the humidity environment of your workshop.

The joinery we employed is straightforward and simple, requiring standard power tools and machinery. The result is a solid, strong and enduring workbench that's not only practical, but is likely to be a continuing inspiration for years to come.

Benchtop

Begin construction by jointing and ripping the 12 1 $\frac{1}{4}$ -in.-thick benchtop laminations and two outer tail vise laminations to width and crosscutting slightly longer than the finished length. Test the grain direction of each piece by taking a light cut with a plane. By constructing the top with a uniform grain direction, planing the finished assembly is easier. Set aside the wider strips, and mark joining plate locations on the remaining strips. Cut the slots, being careful to hold both the joiner and the stock flat on the worksurface to ensure good



lamination alignment (Photo 1). Although we used a plate joiner, you could use ordinary splines or dowels.

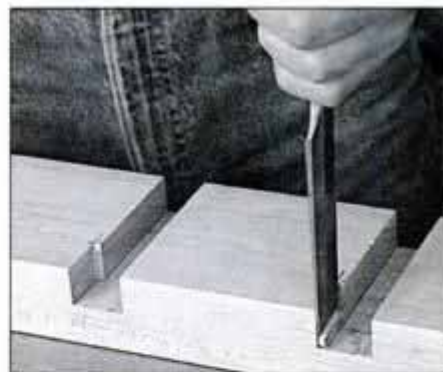
Apply glue to three or four of the 2 $\frac{1}{4}$ -in.-wide laminations with a short-nap roller, insert the joining plates and clamp. Join the remaining 2 $\frac{1}{4}$ -in.

pieces in the same way and when the glue has set, glue and clamp the benchtop halves together. Then, crosscut the top to length. Cut the rear 4-in.-wide piece to length and glue it to the benchtop edge.

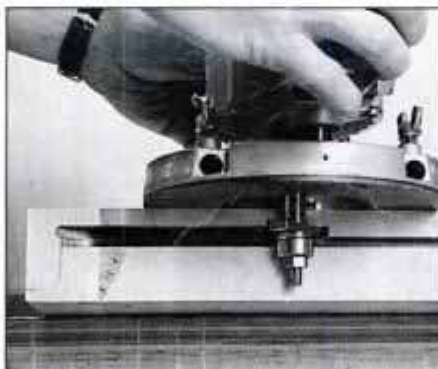
Cut the four bench front pieces and



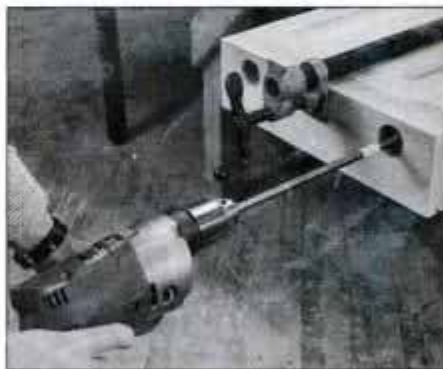
1 Rest plate joiner and stock on a flat surface to ensure accurate slots. Dowels or splines could also be used to join top pieces.



2 After cutting bench dog slots with a dado blade, use a chisel to square the recess that holds the bench dog head.



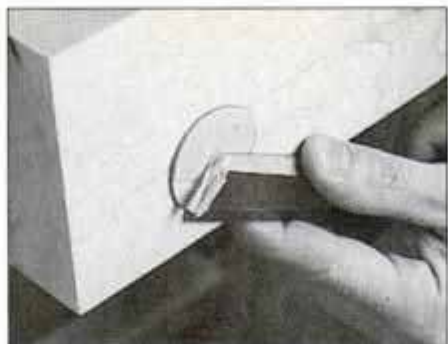
3 Rout the 1/2-in.-wide x 1/2-in.-deep spline grooves for the endcaps with a 1/4-in. slotting cutter. Two passes are required.



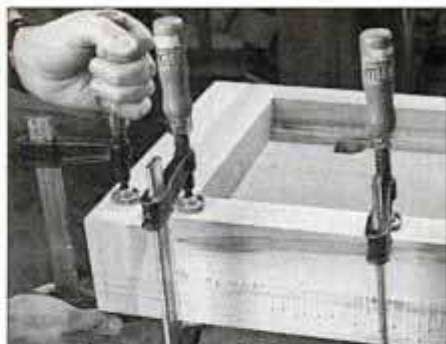
4 After counterboring 3/8-in.-dia. bolt holes in the endcap, clamp endcap in place and extend bolt holes into benchtop.



5 Use a chisel to square a washer and nut seat in 1½-in.-dia. × 1¼-in.-deep holes bored to intersect endcap bolt holes.



6 After bolting endcap in place, make plugs with plug cutter. Glue plugs in counterbores, and trim flush with a sharp chisel.



7 Cut the tail vise backer plate to exact shape, and glue to bench and endcap. Backer block holds tail vise guide plate.



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two tail vise outer pieces to length. Lay out the bench dog slots on the benchtop and tail vise parts as shown in the drawing. Note that the slots in the vise are angled in the opposite direction to those in the benchtop. Use a dado blade and radial-arm saw to cut the slots. To house the bench dog heads, make a short stopped cut with the dado blade, and square the cut with a chisel (Photo 2).

Cut joining plate slots in the four bench front and two tail vise laminations, assemble these pieces and set aside. Avoid glue squeeze-out in the dog holes. If necessary, scrape away the glue after it thickens slightly.

Make the benchtop endcaps by gluing up thinner stock and planing to finished dimensions. Set aside the long endcap, and install the short one first. Use a ¼-in. slotting cutter in the router to cut the ½-in.-wide spline grooves in the endcap and bench end. Two passes are required (Photo 3). Cut the spline from ½-in.-thick Baltic Birch plywood, and round the edges to match the grooves.

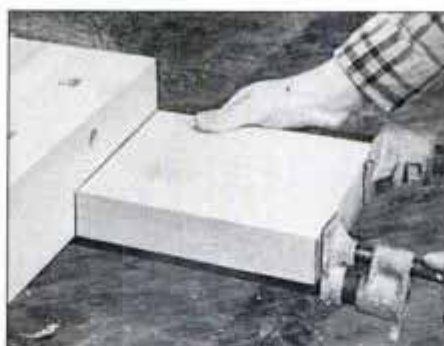
Use a drill press to bore the ⅜-in.-dia. bolt holes and 1½-in.-dia. × ¾-in.-deep counterbores in the endcap. Clamp the endcap in place and use a long ⅜-in. bit to extend the holes into the benchtop (Photo 4). Turn over the top and mark the mortise locations for the captive nuts. Use a Forstner or multispur bit to bore the 1⅜-in.-dia. × 1¼-in.-deep holes, and then use a chisel to cut the flat seat for the washer and nut (Photo 5).

Bolt the short endcap in place, but do not use glue, to allow for seasonal movement of the top. Cut two 1½-in.-dia. plugs with a plug cutter in the drill press, and plug the counterbores to cover the bolt heads. Then, trim the plugs flush with a chisel (Photo 6).

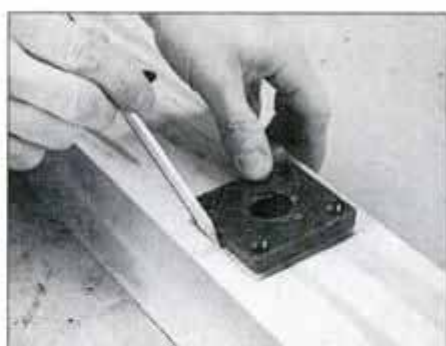
Make the tail vise plate backer block (N) using a band saw to cut the notch that allows the block to fit under the endcap. Glue in place (Photo 7). After the glue has set, turn the benchtop on edge and clamp to your work-



8 Turn benchtop on edge and rout a $\frac{1}{8}$ -in.-wide \times $\frac{5}{16}$ -in.-deep clearance groove for the tail vise upper guide plate.



9 Use a $\frac{1}{2}$ -in.-thick spline to join the shoulder vise filler block to the benchtop. Align with end of bench and clamp until dry.



10 After boring holes to accept shoulder vise screw housing, trace mounting flange outline and rout away recess.

table. Use a router with an edge guide and a $\frac{1}{8}$ -in.-dia. straight bit to cut the $\frac{5}{16}$ -in.-deep groove in the edge of the benchtop (see Detail 6 and Tail Vise Cross Section on drawing). This groove provides clearance for the tail vise upper guide plate (Photo 8).

Cut and plane the shoulder vise arm to size and mark the location of the vise guide bar (Z) hole on both the arm and the benchtop front lamination. Clamp the two pieces together, and use a drill press to bore a $\frac{1}{4}$ -in. hole through both. Separate the pieces and again use the drill press to bore $\frac{3}{4}$ -in. guide bar housing holes, centered on the $\frac{1}{4}$ -in. holes, in each piece as shown. Then, turn both pieces over and bore the $1\frac{1}{4}$ -in. bolt access holes for fastening the guide bar in place.

Assemble the front benchtop lamination to the top using glue and joining plates. Use a plane to flatten the surface. Work diagonally across the top and check for winding (twist) by sighting across two straight sticks laid across the top. Use a straight-edge along and across the top to check for straightness. Finish plane along the length of the top with the grain.

Shoulder Vise

Cut the shoulder vise filler block (O) and use the router to cut the spline grooves in the bench front and block edges as shown in the drawing (Detail 1). Cut a spline from $\frac{1}{2}$ -in. Baltic Birch and glue the block to the bench front, carefully aligning the edge with the end of the bench (Photo 9).

Lay out the position of the vise screw in the shoulder vise arm, and clamp the arm to the drill press table for boring a $1\frac{1}{4}$ -in. hole from the inside face. Then, without removing the arm, install a $1\frac{3}{4}$ -in.-dia. Forstner or multispur bit in the drill press and counterbore a $2\frac{9}{16}$ -in.-deep hole. Slip the vise screw housing into the hole, and mark the outline of the mounting flange (Photo 10). Use a $\frac{1}{4}$ -in.-dia. straight bit to rout away most of the waste, and finish with a sharp chisel

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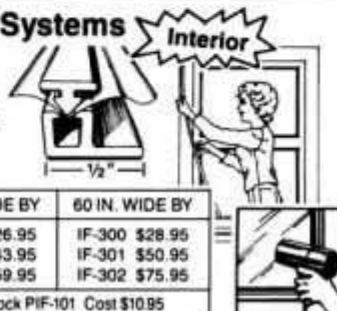
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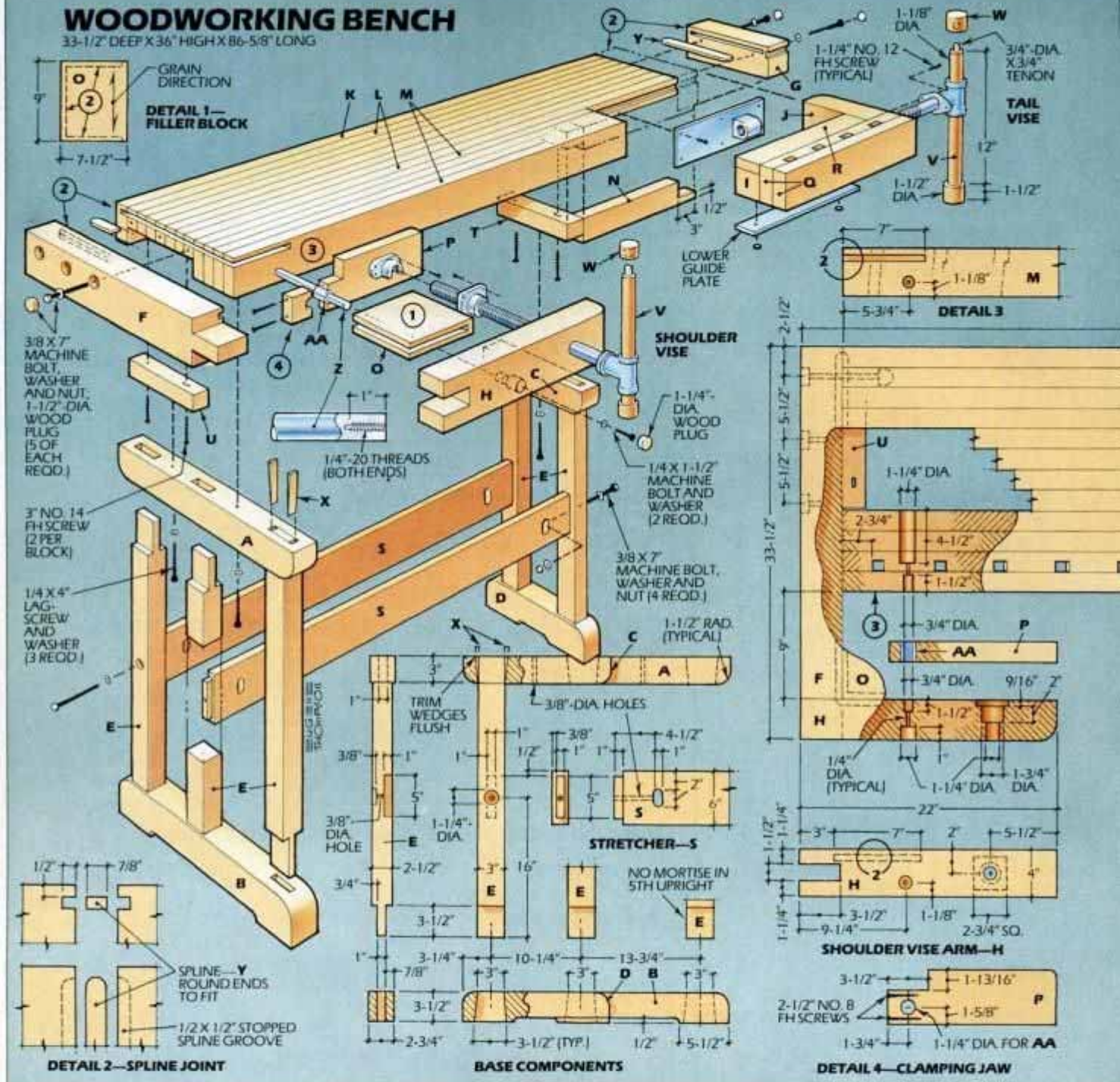
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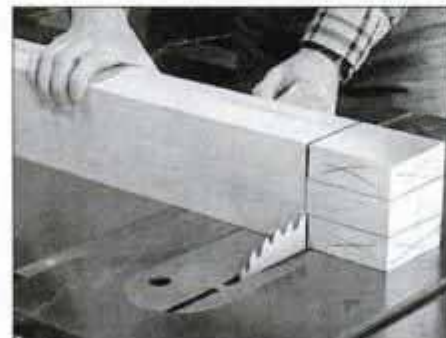
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WOODWORKING BENCH

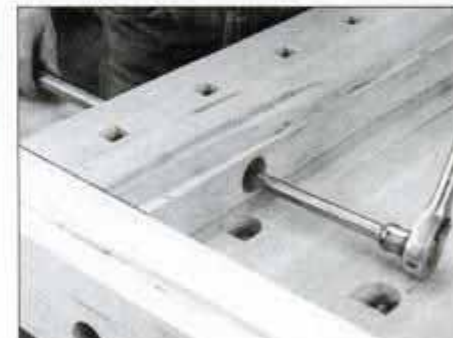
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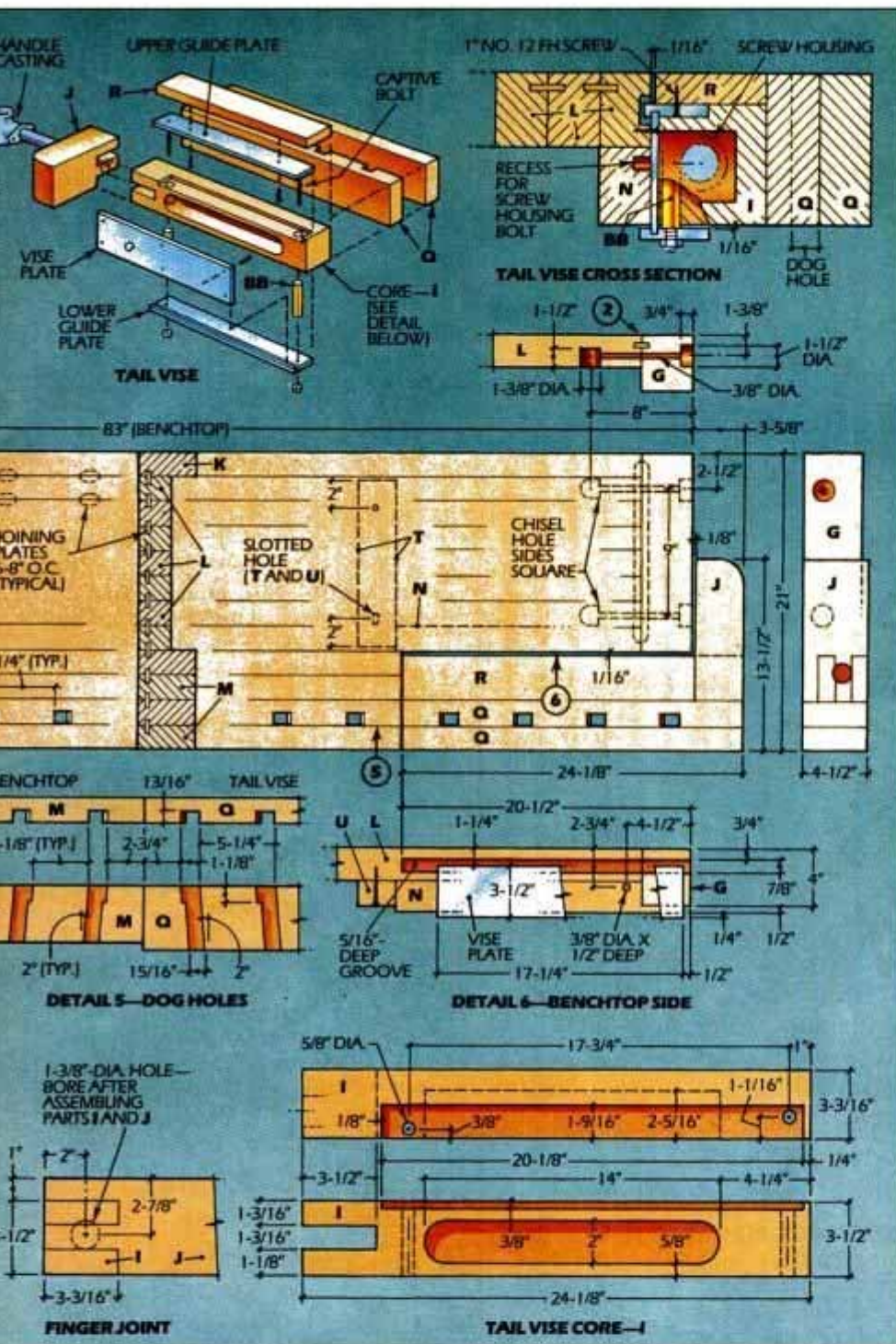
11 Band saw the finger joint slot for the shoulder arm joint. Then, make a series of cuts, and remove waste with chisel.



12 Use the table saw and miter gauge to cut the arm tenon. Finish the tenon cheek cuts on the band saw, and test fit joint.



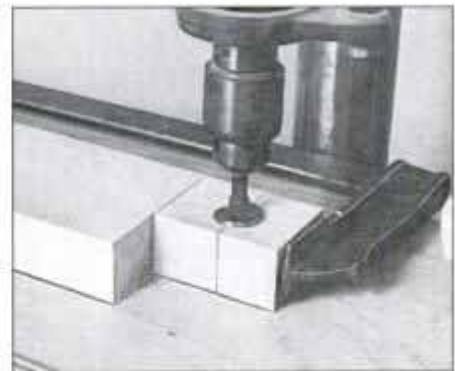
13 After boring holes for shoulder vise guide bar, glue front bench laminations in place and install guide bar.



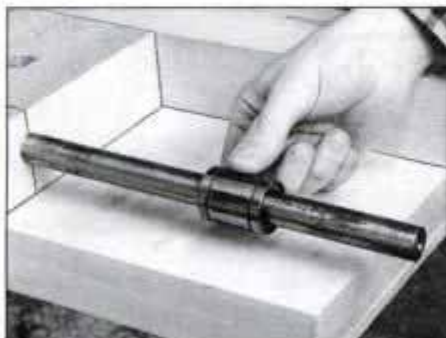
MATERIALS LIST—WORKBENCH

Key	No.	Size and description (use)
A	1	2 3/4 x 3 x 30 1/2" maple (top crossmember)
B	1	2 3/4 x 3 1/2 x 30 1/2" maple (foot)
C	1	2 3/4 x 3 x 16 3/4" maple (top crossmember)
D	1	2 3/4 x 3 1/2 x 16 3/4" maple (foot)
E	5	2 1/2 x 3 x 32" maple (upright)
F	1	3 1/2 x 4 x 33 1/2" maple (endcap)
G	1	3 1/2 x 4 x 14" maple (endcap)
H	1	3 1/2 x 4 x 22" maple (shoulder vise arm)
I	1	3 7/16 x 3 1/2 x 24 1/4" maple (tail vise core)
J	1	3 1/2 x 4 1/2 x 10" maple (tail vise)
K	1	1 3/4 x 4 x 76" maple (top lamination)
L	7	1 3/4 x 2 1/4 x 76" maple (top lamination)
M	4	1 3/4 x 4 x 59" maple (top lamination)
N	1	1 3/4 x 2 1/4 x 20 1/2" maple (backer block)
O	1	1 3/4 x 7 1/2 x 9" maple (filler block)
P	1	1 3/4 x 4 1/2 x 14 3/4" maple (clamping jaw)
Q	2	1 3/4 x 4 1/2 x 24 1/4" maple (tail vise lamination)
R	1	1 x 3 7/16 x 20 9/16" maple (cap block)
S	2	1 3/4 x 6 x 56" maple (stretcher)
T	1	1 3/4 x 2 3/4 x 12" maple (cleat)
U	1	1 3/4 x 2 x 12" maple (cleat)
V	2	1 1/2"-dia. x 13 1/2" maple (handle)
W	2	1 1/2"-dia. x 1 1/2" maple (knob)
X	20	3/8 x 1 x 4" maple (wedge)
Y		1/2 x 3/8" Baltic Birch plywood, approx. 6 ft. reqd., cut to fit (spline)
Z	1	3/4"-dia. x 12" cold-rolled steel bar (guide)
AA	1	3/4" L.D. x 1 1/4" O.D. LBB-12 (linear bearing)
BB	2	1/2" L.D. x 3 7/16" copper tubing (spacer)

Misc: 5 1 1/2"-dia. maple plugs (endcaps); 1 1 1/4"-dia. maple plug (shoulder vise); 9 3/8 x 7" machine bolts, washers and nuts (top and base); 2 1/4 x 1 1/2" machine bolts, washers and nuts (guide bar); 3 3/8 x 4" lag-screws and washers (base); 4 3" No. 14 screws (cleats); 22 1/2" No. 8 fh screws (shoulder vise clamping jaw); 2 1" No. 12 fh screws (tail vise); 6 1 1/4" No. 12 screws (tail vise); glue; short-nap roller; sandpaper; joining plates; shoulder vise hardware (No. 70G02.03) and tail vise hardware (No. 70G04.02) available from Garrett Wade, 161 Avenue of the Americas, New York, NY 10013; bench dogs (No. 16A71) available from Woodcraft, 210 Wood County Industrial Park, P.O. Box 1686, Parkersburg, WV 26102.



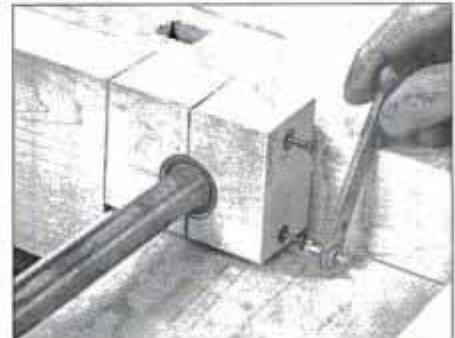
16 Clamp together main clamping jaw body and endpiece. Bore hole through joint line to house the linear bearing.



14 Slide linear bearing onto shoulder vise guide bar. Guide bar and bearing help keep clamping jaw aligned during use.



15 Glue and clamp shoulder vise arm to benchtop assembly. Then, secure guide bar end to arm with bolt and washer.



17 With vise screw attached to clamping jaw, use offset screwdriver to screw clamping jaw endpiece on linear bearing.

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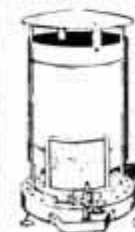
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WOODWORKING GUIDE

so the housing flange is flush with the surface.

Next, lay out the large finger joint that joins the long endcap and the shoulder vise arm. Use a band saw to make the outlining cuts for the joint, followed by a series of parallel cuts to remove most of the waste. Finish with a sharp chisel (Photo 11). Test fit the joint and adjust it too tight by light paring with a chisel. Use the table saw to make the shoulder cuts for the tenon (Photo 12), and band saw the cheek cuts to remove the waste. Temporarily join the components, and shape the 1 1/2-in. radius at the corner with a band saw followed by sanding.

Use the slotting cutter to rout the spline grooves in both the endcap and vise support arm. Bore the bolt holes and mortises for the nuts that secure the endcap in the same manner as described for the short endcap. Install the long endcap using glue only in the joint between the cap and the shoulder vise filler block. Clamp until the glue sets.

Install the 3/4-in.-dia. guide bar (Z) into the bench front and secure it with a 1/4-in. bolt and washer (Photo 13). Slide the linear bearing (AA) onto the bar (Photo 14). Dry assemble the shoulder vise arm to the bench to make sure all parts mate properly. Then, apply glue to the finger joint and install the arm. Clamp the joint tight and install the bolt in the opposite end of the guide bar (Photo 15).

Note that the linear bearing is held captive in the clamping jaw (see Detail 4). After shaping the stock as shown, make a cut that divides the short extension of the jaw into two pieces. Then, clamp the pieces back together, and bore the 1 1/4-in.-dia. hole on the joint line (Photo 16). Drill and countersink pilot holes for 2 1/2 in. No. 8 fh screws through the end of the jaw to hold the halves together. Position the jaw in the bench, and attach the vise hardware to its face. Install the screws and jaw end block to lock the bearing in place (Photo 17).

Tail Vise

The structure of the tail vise is the hardest part of the bench to visualize. Spend time studying the plans so that you fully comprehend the design before starting. Note that the wooden core of the vise is sandwiched between an upper and lower guide plate. These plates travel along a third plate that's fixed to the side of the bench (see Tail Vise Cross Section detail).

Begin by cutting the vise core (I) to size and laying out the shallow top

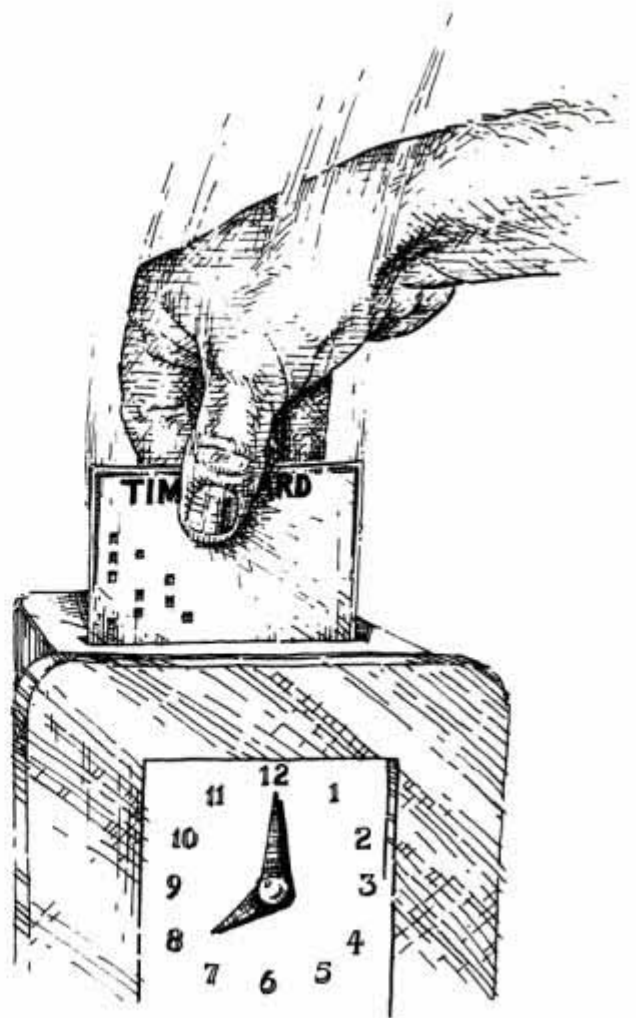
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mortise for the upper guide plate and the deep side mortise that accommodates the vise screw housing (Photo 18). Use a router with 1/2-in.-dia. straight bit to remove waste from the guide plate mortise. Then, use a sharp chisel to complete the job. Position the guide plate in the mortise and mark the bolt hole locations.

The vise core acts as a spacer between the upper and lower guide plates. To make the assembly dimensionally stable with seasonal changes in humidity, we added copper tubing spacers (BB). These spacers control the distance between the upper and lower guide plates. Note that there is 1/16-in. clearance between the lower plate and the vise core to allow for slight wood expansion. At the bolt hole centers, bore 3/8-in. holes for the spacers. Cut the copper tubing with a tubing cutter, and test fit the spacers in the holes (Photo 19).

Bore a series of 2-in.-dia. holes to remove most of the waste in the screw housing mortise (Photo 20). Clean up the sides with a sharp chisel—the mortise ends can be left round. Lay out the finger joint on the vise core and the tail vise end piece (J). Then, use a band saw and chisel to cut the joint (Photo 21). Test the joint for fit, and assemble. Construct a jig to hold the assembly upright and square on

the drill press table, and bore a 1 3/8-in.-dia. hole into the tail vise that extends through to the screw housing mortise (Photo 22).

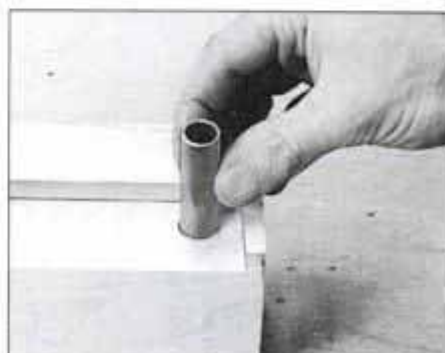
Mark the location of the side vise plate on the bench, and bore a 3/8-in.-dia. x 1/2-in.-deep recess for the screw housing bolt that holds the housing to the plate. Before mounting the plate, check its fit in the upper and lower guide plates. Because we found the fit between the side plate edges and the grooves in the upper and lower plates to be excessively loose, we used cyanoacrylate glue to attach a piece of .025 shim stock to the back of the plate. The plate is then lightly filed to a proper fit. Clamp the side guide plate to the bench edge and carefully

adjust its position so it is precisely parallel to the benchtop surface (Photo 23). Then, drill pilot holes and mount the plate with 1 1/4-in. No. 12 fh screws.

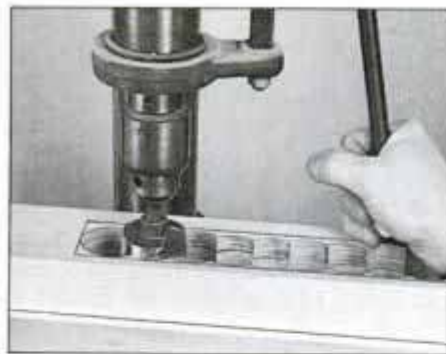
Install the copper tubing spacers, and clamp the upper and lower guide plates to the core. Insert the vise screw, and check that the vise operates smoothly and moves parallel to the benchtop (Photo 24). If there are any problems, make any necessary adjustments to the copper spacers, guide plates and wooden parts. When the assembly operates well, remove the guide plates and glue on the front dog hole lamination (Q). Cut the vise cap block (R), and attach the top guide plate to it with 1-in. No. 12 fh screws. Be sure to install the carriage bolts to



18 After laying out mortises on vise core, rout upper guide plate mortise and hold bar in place to mark bolt hole locations.



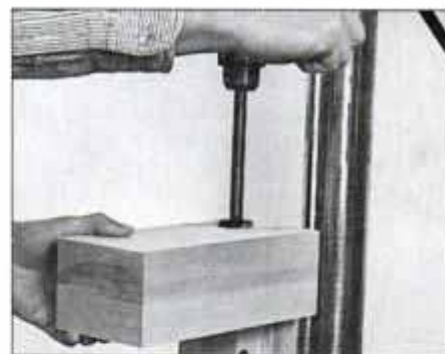
19 Fit copper tubing spacers at bolt hole locations. Spacers help to ensure and maintain accurate guide plate spacing.



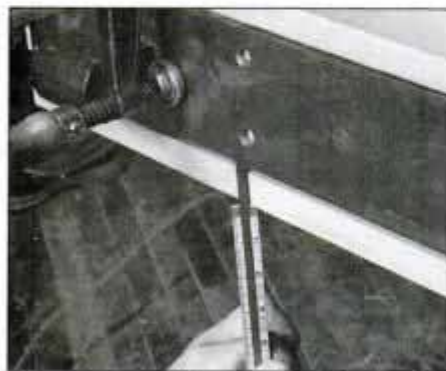
20 Shape most of screw housing mortise with drill press and 2-in.-dia. bit. Trim sides flat with chisel—ends are left round.



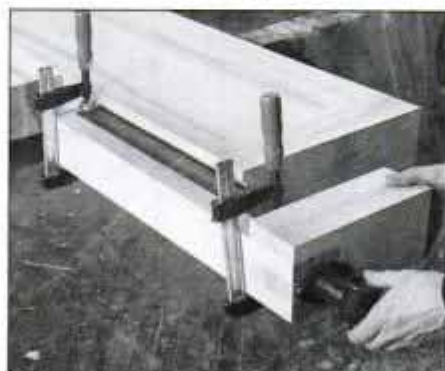
21 Lay out finger joint on tail vise arm pieces. Cut to joint lines on band saw and remove waste with sharp chisel.



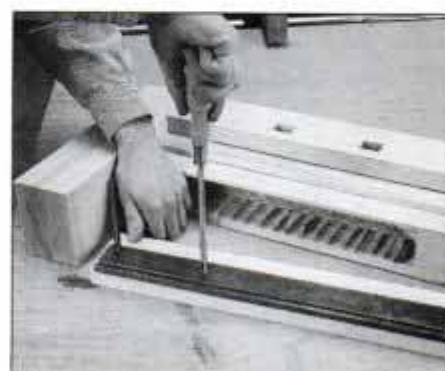
22 Mount assembled tail vise arm squarely on drill press table. Then, bore hole that extends into screw housing mortise.



23 Clamp tail vise side guide plate to benchtop edge and align exactly parallel to benchtop surface. Then, install screws.



24 Test vise operation by clamping upper and lower guide bars in place. Adjust spacers, guide bars, or trim wood if necessary.



25 Screw upper guide bar to tail vise cap. Note that bolts are installed first and held captive by cap. Glue cap to core.

the plate first since they're held captive by the cap block (Photo 25).

To install the vise, first engage the upper vise guide plate on the bench side plate. From underneath, insert the copper-tubing spacers, and secure the lower guide plate with the

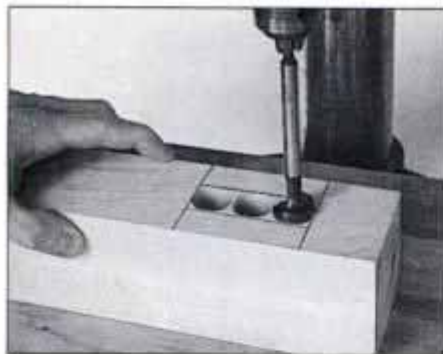
carriage bolt nuts. Finally, thread in the vise screw, and screw its collar to the end of the tail vise. If necessary, plane the vise surface flush with the benchtop. Remove the vise, band saw the 1½-in. radius on the corner, and sand smooth.

Base

Laminate the components for the two leg assemblies (A, B, C, D and E) from thinner stock. After jointing and planing to finished dimensions, cut the pieces to length and lay out the tapered mortises on the top and bottom members of the leg assemblies. Use a drill press to remove most of the mortise waste (Photo 26).

Then, finish the mortises and cut the angled sides with a sharp chisel. Use a dado blade in the table saw to cut the tenons on the ends of the base uprights. Then, use a miter gauge on the table saw to cut a series of small wedges about 4 in. long and tapering from ⅜ in. to 0 in. wide.

Lay out the blind mortises in the uprights that house the stretcher (S) ends. After cutting them with a drill press and chisel, bore a ⅜-in.-dia. hole through the center of each mortise. Then, countersink a 1¼-in.-dia. × ⅜-in.-deep hole for the bolt heads. Use a band saw to cut a 1½-in. radius on the crossmember ends as shown, and cut



26 Lay out the tapered mortises in the leg assemblies, and remove most of the mortise waste on the drill press.



27 Apply glue, and drive wedges in tapered mortises to help lock tenons in place. Trim wedges and tenon ends flush.

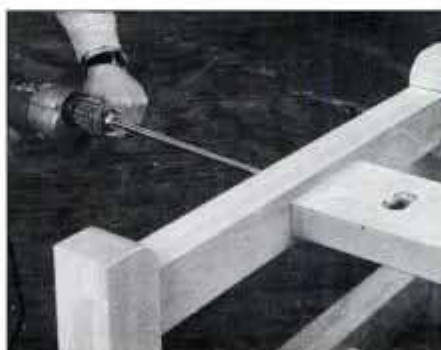
the ½-in.-deep recesses to form the bench feet.

Beginning with the smaller leg assembly, apply glue to all the mortises and tenons, and assemble the pieces. Apply glue to the wedges and drive in place alongside the tenons (Photo 27). Repeat the procedure for the other leg assembly. When the glue is dry, cut protruding tenons and wedges flush.

Cut the stretchers to length, and cut the tenons with a dado blade. Mark the location of the captive nut and washer, and bore two adjacent 1-in. holes to begin the opening. Clean up the holes with a chisel. Assemble the stretchers to the leg assemblies without glue, and use a long ⅜-in. bit to bore through the stretcher ends and intersect the nut and washer holes (Photo 28). Then, install the bolts, washers and nuts.

Install the two cleats (T, U) with screws noting that one screw hole on each block is elongated to allow seasonal expansion and contraction of the top. Then, bore holes in the base and cleats for attaching the top to the base with ⅜-in.-dia. × 4-in.-long lagscrews and washers.

Remove the shoulder vise clamping jaw, vise hardware and tail vise from the top. After thoroughly sanding, mask the shoulder vise guide bar and apply three or four coats of boiled linseed oil or Watco Danish Oil. Be sure to finish the bottom of the benchtop. To complete the bench, make the vise handles on the lathe. Turn a fixed knob on one end of each. At the other end, turn a tenon for securing a loose knob after installation. **PM**



28 Use a long ⅜-in. bit to bore bolt holes that intersect the nut and washer holes in the stretchers. Then, install bolts.

Clamp. Release. Clamp. Release.



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CAR CARE

MAINTENANCE BASICS

REPLACE YOUR SPARK PLUGS

BY DON CHAIKIN

● While your owner's manual gives the carmaker's recommendation for spark-plug replacement intervals, play it safe by changing plugs at least once a year. The task is relatively inexpensive, since new spark plugs cost a few dollars, and installation is relatively simple.

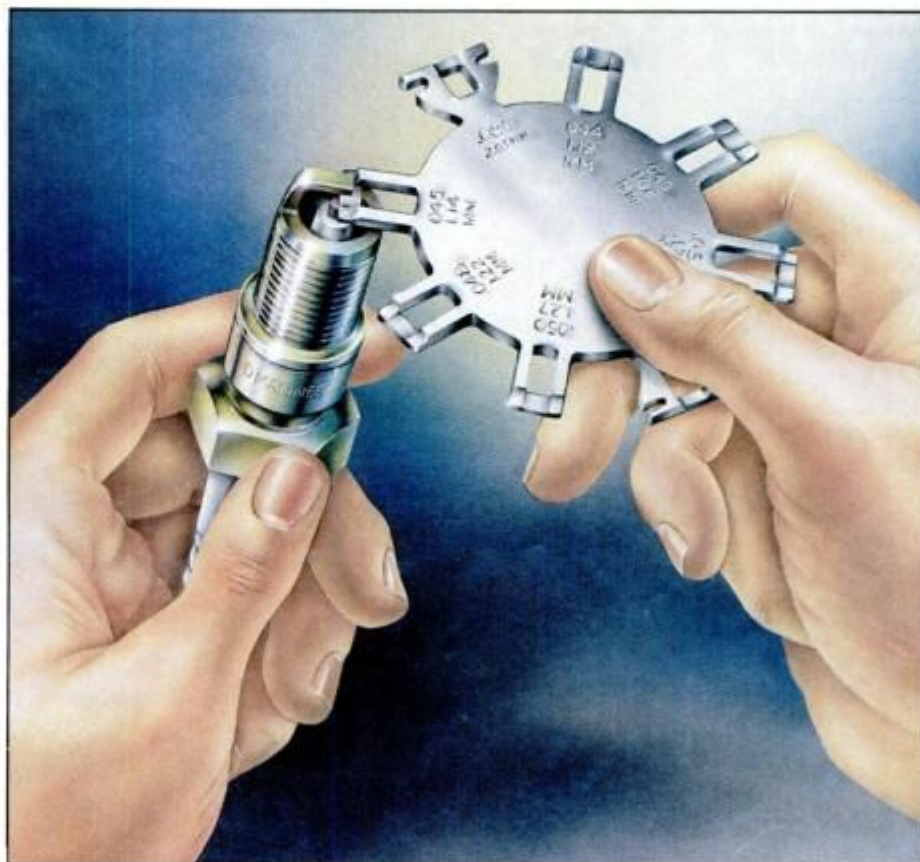
To do the job right, you'll need a ratchet, a spark-plug socket sized for your plugs and a few extensions to allow you to reach all the plugs. You'll need a special spark gap tool to measure and adjust the gap between the plug's electrodes. You also might need a spark-plug boot puller, silicone spray and some antiseize thread compound. Naturally, you'll need the right number of new plugs. Check your owner's manual for the specified spark plug.

● Some plugs have long threaded portions, others short. Plugs also are made in several different diameters.

● Some plugs require a metal ring gasket to seal the plug against the engine, others do not.

The wrong plug can damage your engine. Don't experiment with plugs that look close.

Work on a cool engine, and change one spark plug at a time, starting at



one end and working in order. To begin, disconnect the spark plug's wire from the plug.

● Do not pull the wire—you can break it internally. Twist and tug on the heavy boot that covers the plug.

● Use a special spark-plug wire pulling tool or a looped piece of wire for boots you can't grasp. Next, remove the plug. You may have to rap the ratchet handle with the heel of your hand if the plug is in tight.

● Before removing the plug totally, blow air through a hose to remove dirt and debris from around the base of the plug.

After extracting the old plug, inspect it. Its electrodes should be golden brown. Heavy black or blistered white deposits indicate a problem. If there are no problems, prepare to install the new plug.

● Check the electrode gap. The tune-up decal under the hood lists the correct gap. Adjust the gap as necessary by gently bending the hooked side electrode as needed.

● Put a dab of antiseize compound on the plug's threads to help the plug come out easily next time.

● If the replacement plugs have gaskets, be sure there's one on the new plug. Also be sure the old gasket came

off along with the old plug.

● Thread the new plug in by hand to avoid crossing the threads. Use a piece of hose slipped over the top of the plug, or use the spark-plug socket without the ratchet handle.

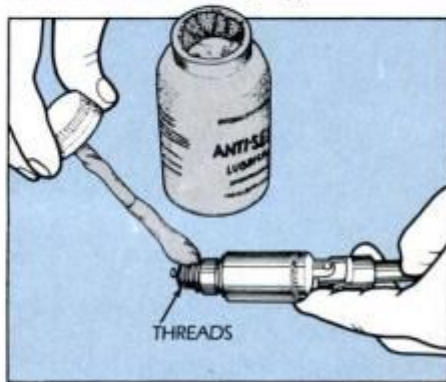
● Snug the spark plug down with the ratchet, but don't overtighten it, or you may damage the plug.

● Before reattaching the spark plug's wire, spray some silicone into the boot. This makes it easier to remove the wire next time.

● Place the boot over the tip of the plug and push it home, making sure that the metal connector inside the boot connects to the plug. **PM**



You may need to use a special tool to remove stubborn spark-plug connector boots.



Use antiseize compound on the threads of new plugs to facilitate their removal.

PM ILLUSTRATION BY DON MANNING

PM ILLUSTRATIONS BY RON CARBON

HOW IT WORKS

VISCOUS COUPLINGS

BY DON CHAIKIN

● Drive around a gentle curve after rolling through a puddle, and you'll see that each of your car's wheels follows its own arc. Since each wheel travels a different distance, then each travels at its own speed through that arc.

Though small, this difference in speed among wheels is sufficient to damage a drivetrain—unless some provision is made for slippage. In 2-wheel-drive cars, the differential compensates for the difference by allowing wheels on the same axle to spin at different rates.

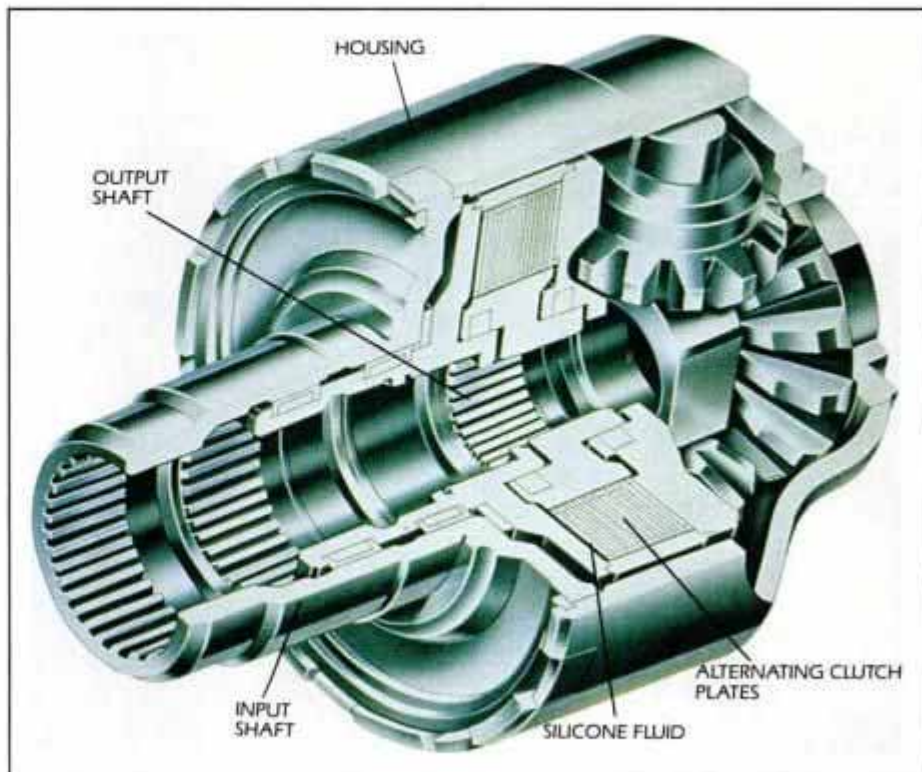
For 4-wheel-drive vehicles, which are normally operated in 4wd off-road or on wet or slippery surfaces, the low coefficient of friction between tire and the driving surface allows the front and rear wheels to slip as needed to preserve the drivetrain.

But the challenge is different for a full-time all-wheel-drive vehicle. Increasingly common in passenger cars, all-wheel-drive systems are designed to send power to all four wheels, even on dry pavement. Without some means of compensating for wheel-speed variation in cornering, an all-wheel-drive system would fail in short order. Thus, all-wheel-drive vehicles are equipped with some sort of differential device between their front and rear axles.

Differentially speaking

The typical differential, as used to drive the inside and outside wheels on the same axle, is a ring-and-spider gear. In front-engine/rear-drive vehicles, the differential is integral with the final drive pinion gears in the axle. This type of differential is too large and heavy to be practical for most all-wheel-drive applications.

Instead, to split power between front and rear axles, most makers of all-wheel drives, from Chrysler's minivans to Mitsubishi's 3000GT, utilize a compact device called a viscous coupling. In fact, viscous couplings are



Alternating clutch plates are separated by a thin layer of silicone fluid.

finding their way into standard differentials to split power between the wheels on the same axle.

Some vehicles simply use the viscous coupling to carry power to the other end of the vehicle, but there's an upper limit to the amount of power transmittable this way. Others use a planetary-gear differential, with a viscous coupling as a slip-limiter. This also permits engineering a preset torque split fore and aft, by using the appropriate-size sun and planet gears in the planetary gearset.

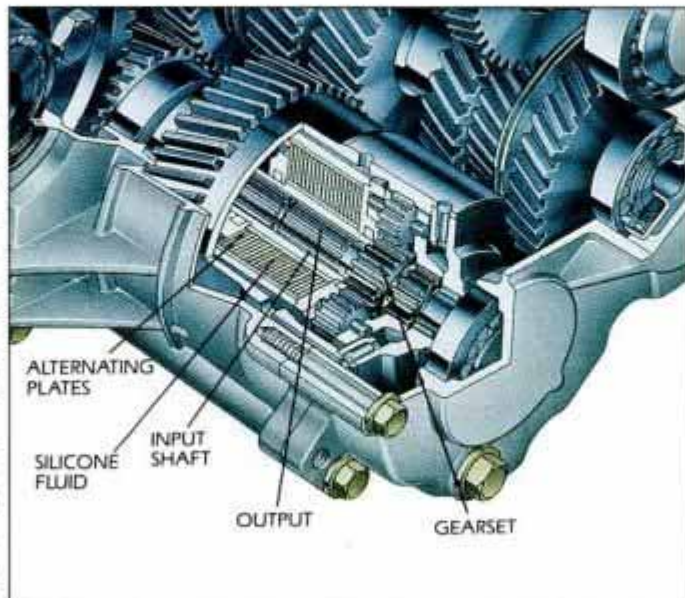
Silicone slush

Mounted inside the outer shaft, over the inner shaft, is a series of thin plates, much like the clutch plates in an automatic transmission. These plates are splined, half of them driven by the outer housing, half driving the inner shaft. The plates are separated by thin spacer rings only a few thousandths of an inch thick. The unit is about 80% full of a heavy, oillike silicone fluid. The remaining volume is taken by air bubbles in the fluid.

When the vehicle is moving in a straight line on a dry road, the wheels rotate at the same speed, so the two shafts and their plates all rotate together. However, when wheels move at different speeds, in cornering, for example, the plates spin at different rates, preventing binding.

As the plates are forced to spin at different speeds, they churn the silicone, which produces heat buildup. As the fluid heats, its pressure rises, compressing the bubbles and allowing the alternating plates to slide closer together. The thin layer of silicone transfers torque from the unloaded plates to the plates driving the loaded wheels. As speeds equalize, the fluid cools, and the plates separate.

PM



Some automotive manufacturers bury the viscous coupling inside the vehicle's transmission or transfer case.

SATURDAY MECHANIC

FIXING YOUR HEATING/ AIR-CONDITIONING SYSTEM

BY DON CHAIKIN

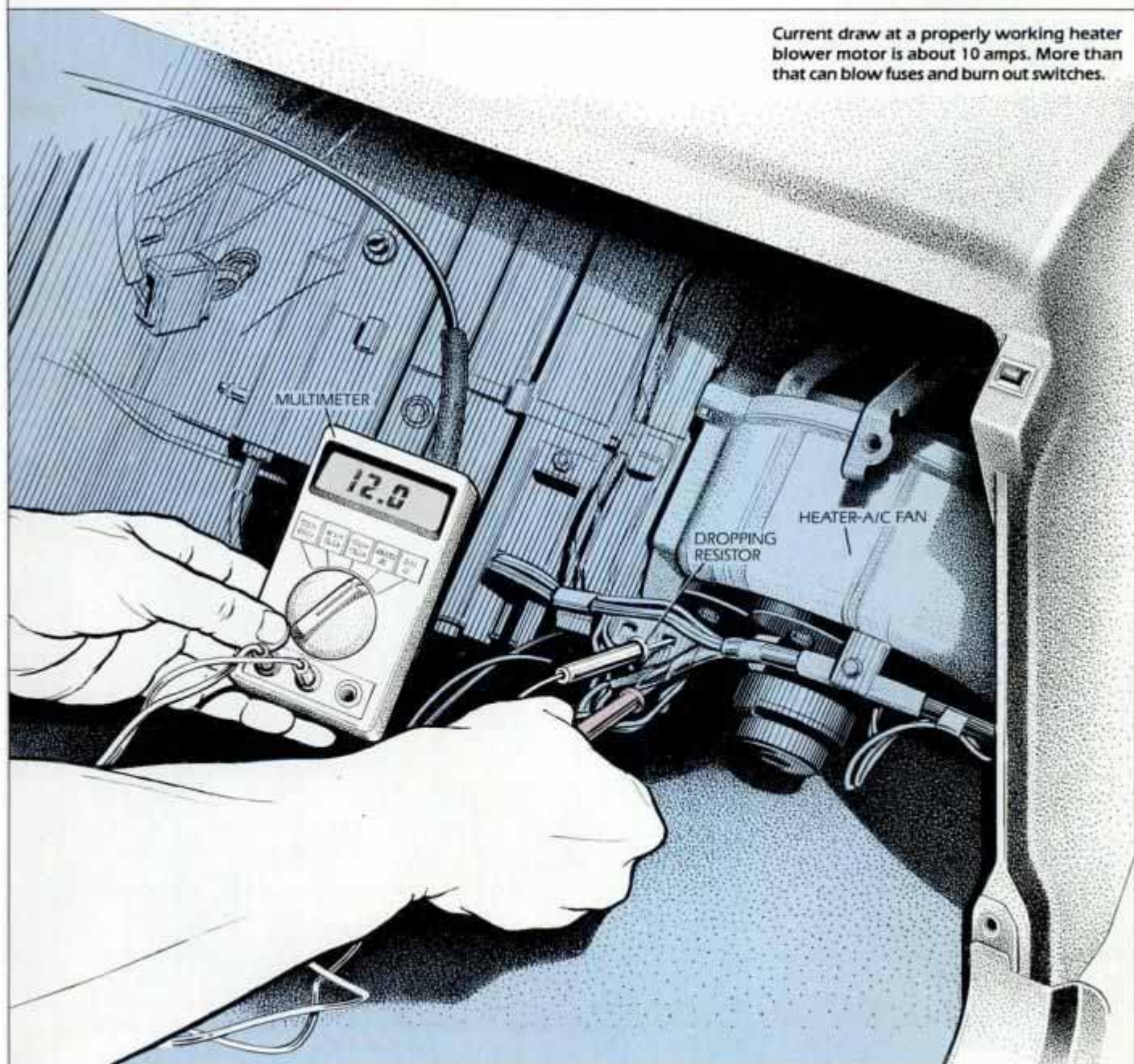
● It's a long drive home from Grandmother's house—a long drive indeed, in the dead of a frosty winter night with your car's heater producing only a trickle of tepid air. Soon your toes and fingers are numbing, interfering

with proper operation of your car's controls.

Beyond comfort, your car's ventilation system is important to good driving and safety, almost as much as the brakes and steering. We tend not to

think about the heater or a/c until they don't work—usually during the worst of weather conditions. Fortunately, regardless of your vehicle's age, make or model, care and repair of its heater/defroster/air-conditioning

Current draw at a properly working heater blower motor is about 10 amps. More than that can blow fuses and burn out switches.

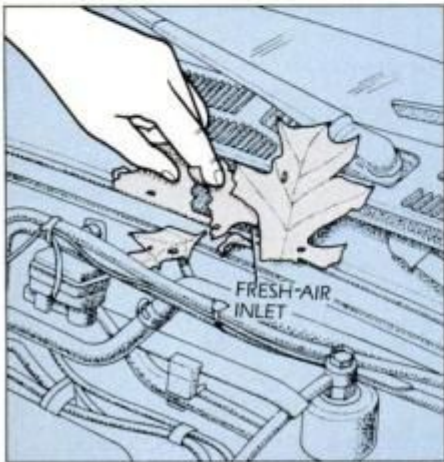


system is well within the scope of the competent Saturday mechanic.

Forced flow

Air enters the car through the fresh-air intake in the cowl, under the bottom edge of the windshield, through ductwork and dash-mounted outlets and exits through vents in the C-pillars, at the base of the backlite, or both.

Therefore, the first step in guaranteeing proper ventilation is making certain that the air intake is clear. With the hood open, reach into the ventilation intake and remove leaves,



Clean out leaves, twigs and other debris from the fresh-air intake.

twigs and other debris. You may have to remove a grille cover or open the chamber by moving the vent control to FRESH. Clear the drain holes in the bottom of the plenum, and flush the chamber with water from a hose.

Air doors

Small flapper-type blend-air doors located in the ductwork beneath the dash direct the airflow to the outlets you want. These doors typically are opened and closed via cables or vacuum diaphragms.

On cars with vacuum-operated systems, you should hear a slight hiss along with the sound of the doors opening and closing as you move the airflow selector switch. On cars with cable-operated doors, you should feel the resistance of the doors moving and hear a reassuring clunk as you move the selector. Besides directing the air between the various dash-mounted outlet vents, these doors also direct the flow of air around or through the heater core after the air passes the a/c evaporator. Cars with a RECIRC/FRESH switch utilize another door to allow air from the fresh-air intake into the system.

First, check that all the ductwork is connected. From underneath the dash, feel the backs of all the vents. Gaining access to the ducts may require removing the glove compartment and some trim panels. Either a solid, molded-plastic duct or a flexible, reinforced duct hose should be attached. Follow the duct back to the main heater outlet compartment, and be sure that end is also connected. Check that there are no tears in any of the ducts. Reconnect any loose ducts and patch any tears with duct tape.

If all the ductwork is intact but air is not getting to where it should, inspect the dashboard airflow selector switch. If there's no access to the rear of the switch from underneath the dash, you may have to remove the radio and some trim panels.

On vacuum-operated systems, make certain the selector lever bellcrank is properly attached to the vacuum switch and that all the vacuum hoses are connected to the vacuum switch or to a separate connector attached to the switch itself. Start the engine to determine which vacuum hose goes to the vacuum source.

If none of the hoses shows vacuum, check for a leak. Vacuum for the control panel is supplied by the engine, quite possibly by way of a vacuum reservoir mounted in the engine compartment. Trace the source hose back to the engine compartment—the other hoses will run to the vacuum diaphragms mounted near the blend-air doors. Check that the hose is properly connected and that it has no cracks, kinks or holes. If the hose is good, disconnect it at the source, and supply

vacuum to it with a manual vacuum pump. If the hoses and the vacuum switch are good, the system will hold the vacuum, and the selector switch should move the doors. If so, inspect the vacuum reservoir for a leak and check that the vacuum port on the engine is clear. Check the hose connection between the vacuum port and the reservoir.

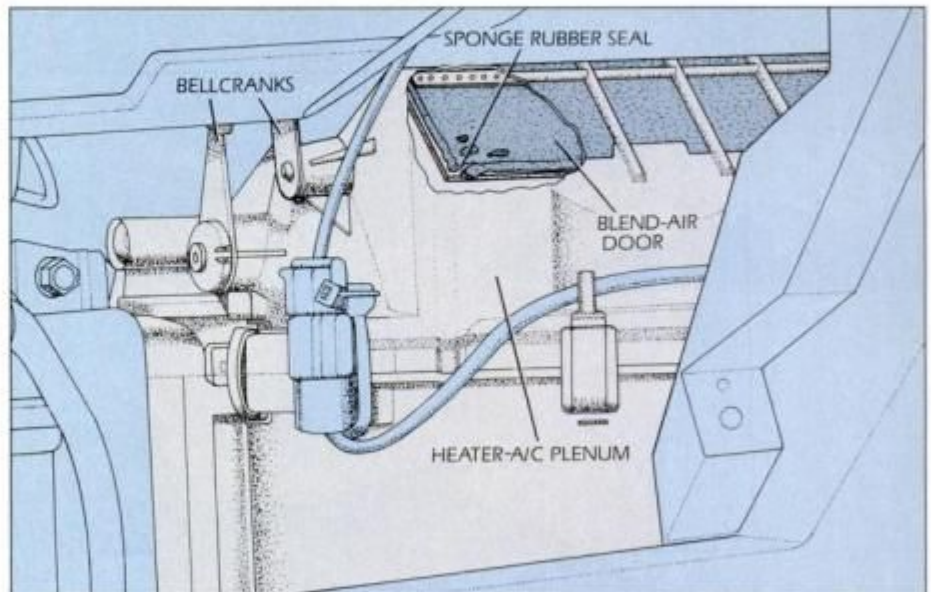
Replace any damaged hoses. Repair small holes or cracks with vinyl tape, or splice in a section of new hose.

If vacuum is getting to the switch or connector, but not to the individual diaphragms, apply vacuum to the individual diaphragms. Disconnect each hose in turn at the switch and connect it to a manual vacuum pump. Apply between 5 and 10 psi of vacuum. If the rod or link on the diaphragm does not move, check the diaphragm's hose for leaks. If the hose is bad, replace it. If the hose is good, attach the manual pump directly to the diaphragm and reapply the vacuum. If the diaphragm still does not move, or if the diaphragm cannot hold the vacuum reading, replace the diaphragm.

If the diaphragm link pulls on the door, but the door doesn't move, or barely moves, disconnect the diaphragm's link from the door and check that the door itself is free. A judicious application of penetrating oil may do the trick. Also inspect the door's seal. Glue down any tears or spots where it could be catching on the ductwork.

If each vacuum diaphragm works properly and none of the hoses is leaking, but the doors do not open or close as they should, replace the switch.

(Please turn to page 118)



Check carefully under the dashboard for misadjusted cables, loose bellcranks, binding blend-air doors or torn foam-rubber seals in the heater housing.

Buck Smith hasn't changed his overalls since he was fifteen.



Actor Portrayal

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CAR CARE

To check the operation of a cable-operated selector switch, first ascertain that the cable (or cables) is properly connected to the back of the selector lever. If not, reattach the cable and cinch it down, either by tightening its loop on the lever or by snug-ging down any retaining clips or clamps.

Next, check the other end of the cable. Again, if it is disconnected, reattach it. Next, be sure that the cable is properly clamped along its run from the selector to the door lever and that the cable is not binding en route.

If the cable and both levers are operating properly, check the adjustment of the cable. Disconnect the cable from the door-operating lever, and push the selector all the way to the end position. Slowly move the door-operating lever through all its detents, listening carefully to hear the doors open and close as you go. With the door-operating lever moved to its extreme position, reattach the cable. If the cable end does not match the door-operating lever position, loosen the cable's mounting clamp or cinch nut and then adjust the cable as necessary.

Reattach the cable, and move the selector lever back to the other extreme. Remove the cable from the door-operating lever, and ascertain that the door is also at the end of its travel. If the door lever can still move, adjust its linkage to meet the cable end. Perform this adjustment for each cable and its flapper door on systems with more than one cable. As with vacuum-operated doors, be sure that the doors are all free and are not

binding on their hinges and that their seals are not torn or sticking.

Blow hard

If the blower does not work with the ignition and heating system turned on, check its fuse. If the fuse is blown, replace it. If the fuse is good, or if the new fuse blows, there is a problem in the fan's motor, switch or the wiring between them.

To determine if the blower motor itself is the problem, connect a jumper wire directly to it from the battery. First, disconnect the blower motor from the wiring harness. If the wiring connector to the motor has two wires, one is hot and the other is ground. To test the motor, connect a jumper wire from a good ground to one terminal of the motor's connector and another directly from the battery's positive terminal to the other. Connect the wires only briefly—the motor should run, spinning the fan. If not, the motor is defective.

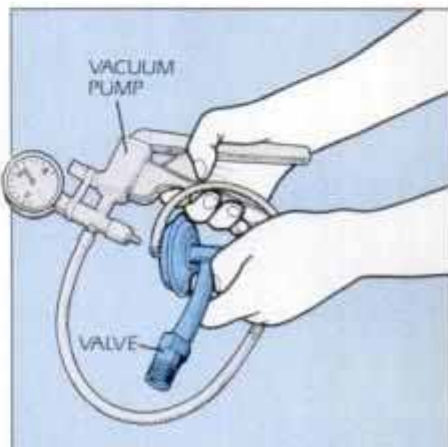
Before reconnecting the wiring to a good motor, inspect the wiring and its connectors, and clean corrosion from the connector's terminals. If the motor, its fuse and wiring are all good, but the fan still does not blow air, the problem is in the fan switch or its resistor. Since the resistor regulates current flow depending on switch setting, a fan that blows full tilt all the time, regardless of switch setting, probably indicates a bad resistor.

Depending on your car's system, current for the motor either flows from the fuse box to the control panel, then to the motor and then the fan switch and the resistor, or from the

panel to the fan switch and the resistor and then to the blower. Check your wiring diagram to see exactly how your car's system is configured.

Check the fan switch to see that all the wires are connected and that the switch itself is not charred or obviously broken. Also check the resistor, typically mounted near the switch, to see that its coils are not burned out. If everything looks good, test the switch.

Depending on your car's system, you can test the switch without removing it: Use a test light to determine which wire carries current to the



Verify a vacuum-operated heater control valve by applying 10 pounds of vacuum.

switch, with the ignition and the heater on. Then, jump across from the hot wire to each of the other terminals on the switch. If the fan runs at each connection, the switch is defective. Replace it. If the fan doesn't run with the switch bypassed, the resistor is bad.

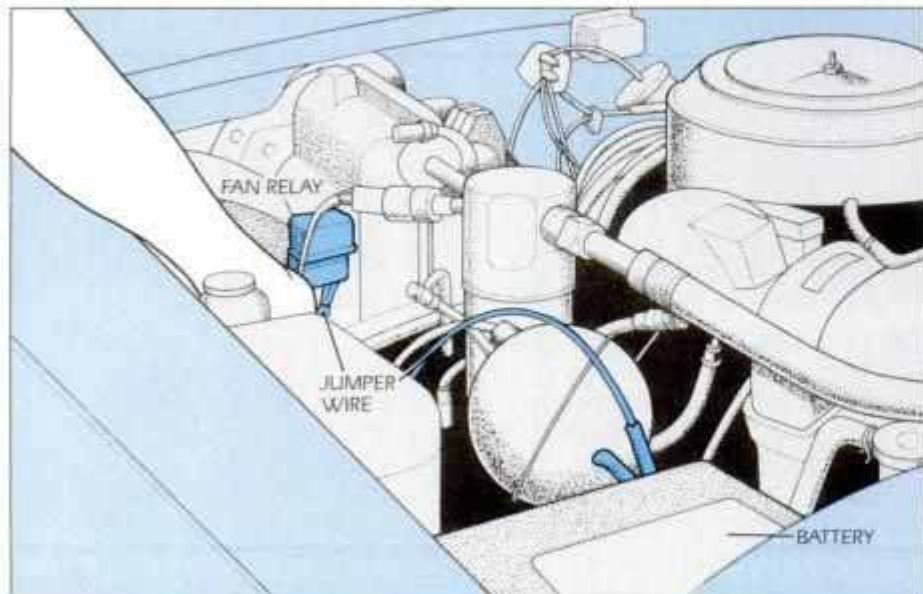
Some systems also incorporate a special high blower-speed fuse and/or a relay in addition to the fuse in the fuse panel. If the blower runs only on low speed, check the fuse and relay.

Hot and cold

Lastly, the incoming air must be heated or cooled the way you want it. When the heater switch is at max, and the engine is fully warmed up, the air coming from the outlets should be well over 100° F, as much as 120° F or more. And cars with air conditioning should be able to produce air that's cooled to a temperature that's at least 20° F cooler than the outside air. Place a thermometer in an outlet vent, run the heater at full heat and the a/c at full cold to check temperatures.

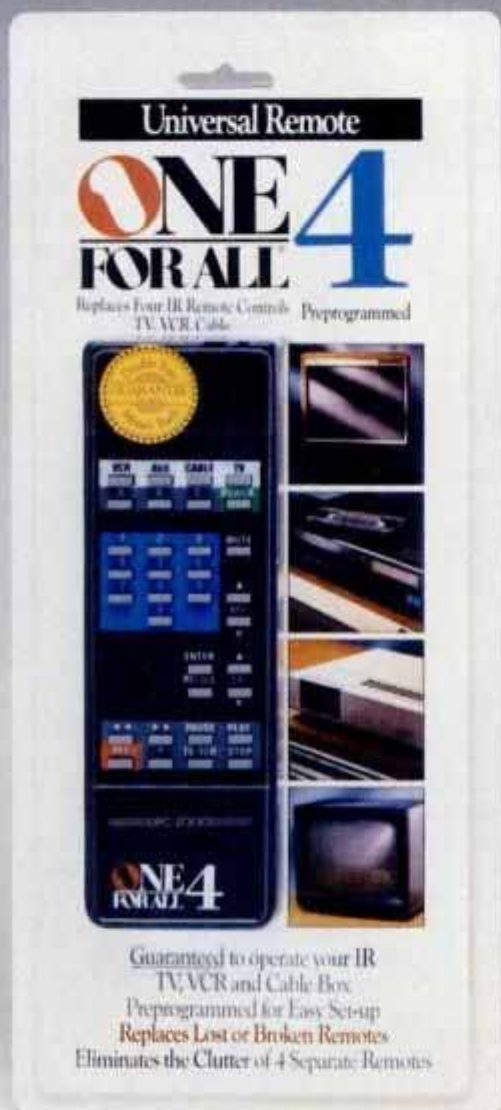
If the heated air is cool, first inspect the engine's cooling system. The heat for the heater is supplied by engine

(Please turn to page 120)



Run a 12-volt jumper wire directly to the blower motor or relay from the battery to check if the motor is in good running order.

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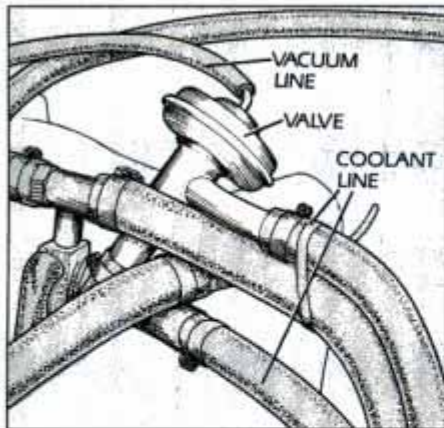
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The heater control valve is located in the engine compartment, in the heater inlet hose.

coolant circulating through the heater core, itself a small version of the engine's cooling radiator. Therefore, the engine must reach proper operating temperature. If the engine is running cool, check that the thermostat is not opening too early and the radiator's electric cooling fan is not switching on at too low a temperature or, on cars so equipped, that the clutch in a clutch-type fan has not locked up.

With engine coolant temperature correct for your car—typically about 200° F—but the heater still blowing cold, check the heater control valve, if your car has one. Most cars have a valve in the heater inlet hose, which runs from the heater core nipple at the firewall to the engine. The valve may be mounted at the heater core.

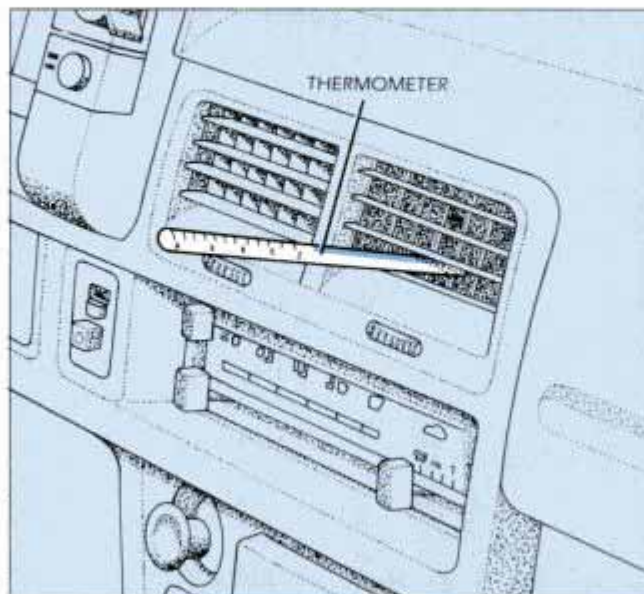
To check that the valve is working, move the dash-mounted temperature selector to its coolest setting. With the engine running at operating temperature, feel the hose on both sides of the control valve, if accessible. The engine side should be hot, the heater side cool. Next, move the selector to maximum heat, and feel the hose. Both sides should now feel hot. If not, the valve or its switch is defective.

Heater control valves are actuated either by a cable or vacuum. Check the dash-mounted heater switch in the same manner you checked the airflow selector switch. To check a vacuum-controlled heater valve, with the engine running, apply vacuum from a manual vacuum pump directly to the valve. If the two sides of the heater hose are now equally hot, the valve is good. Make sure it is getting vacuum. If there is no temperature change, the valve is bad.

If the heater control valve is operating properly, but there's no heat, make sure that there is ample coolant flow through the heater core. With the engine cool and the temperature selector to full heat, briefly disconnect the heater outlet hose at the fire wall. With the engine running, there should be a steady flow of coolant from the heater. If there is just a trickle, the heater is blocked. You can attempt to backflush the heater core, but keep water pressure less than 20 psi or you may damage the core. Otherwise, replace the heater core.

Cars without a heater control valve, such as those with automatic climate-control systems, regulate air temperature by directing cooled air from the air-conditioning evaporator past the heater core. If the air blows cold when it should be warm or warm when it should be cold, the doors directing the air past the heater core are not operating properly. Check them in the same manner that you checked the other airflow doors. With full heat, all air should go through the chamber with the heater core. With full a/c, none should.

Tepid air or a defroster that does not remove humidity, regardless of temperature setting, indicates a problem with the air-conditioning system. Automotive air-conditioning systems have come under greater scrutiny since the relationship of the refrigerant R-12, known as Freon, with the depletion of the Earth's ozone layer has become a major concern. Accordingly, repair of a/c systems should be left to a properly equipped pro. However, you can still

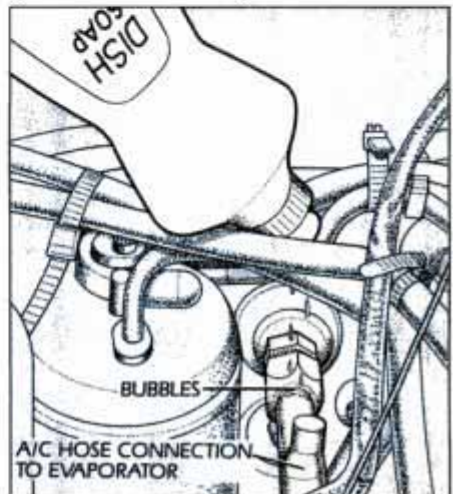


Hold a thermometer in the outlet vent to measure both heater and air conditioning performance.

make some checks of your car's a/c.

First, make sure that the compressor clutch engages when the air conditioner is switched on—either via its own switch as with many imports or via the setting of the heater switch—and that the engine is fully warmed and running. If you do not hear the click of the compressor switch or you can see that the clutch has not engaged, check the system's fuse, relays and wiring. If the clutch engages, be sure that the drivebelt is not slipping.

If the compressor runs, but performance is weak, make sure there is good airflow through the condenser.



Soap dripped over a/c fittings will bubble if the system has a leak at that fitting.

The condenser is mounted against the engine's radiator. Use a soft brush, soap and water to clear bugs and debris from the condenser fins.

Next, check all the tubing fittings for leaks. With the engine and the air conditioner running, cover the fittings with light oil or soapy water. A trickle or stream of bubbles indicates a leak. However, because overtightening the fitting can distort the sealing O-ring, leave the snugging of the fitting to a professional. You'll have to take the car to him anyway to have him recharge the system.

If your car's a/c system has a sight glass in the accumulator, check the glass while the engine is running with the air conditioner on. If you see bubbles in the refrigerant, the system's pressure is low and should be recharged. Again, recharging an automotive air-conditioning system should be done by the properly equipped pro who will capture all the old refrigerant and recycle it. **PM**

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CAR CLINIC

BY MIKE ALLEN,
Associate Automotive Editor

Low-Static Chip Replacement

I bought one of those aftermarket chips to install in the engine computer of my Camaro. It was supposed to give me more horsepower and better mileage, but after reading the installation instructions and what they said about static electricity, I elected to have it installed by a local mechanic. This cost me \$50. Well, the chip made no perceptible difference in power, and mileage is actually down, not up.

So, I'd like to reinstall the original chip. But I'm reluctant to drop another \$50 to do so.

Is this really that tough?

FRED MUELLER
OSHKOSH, WI

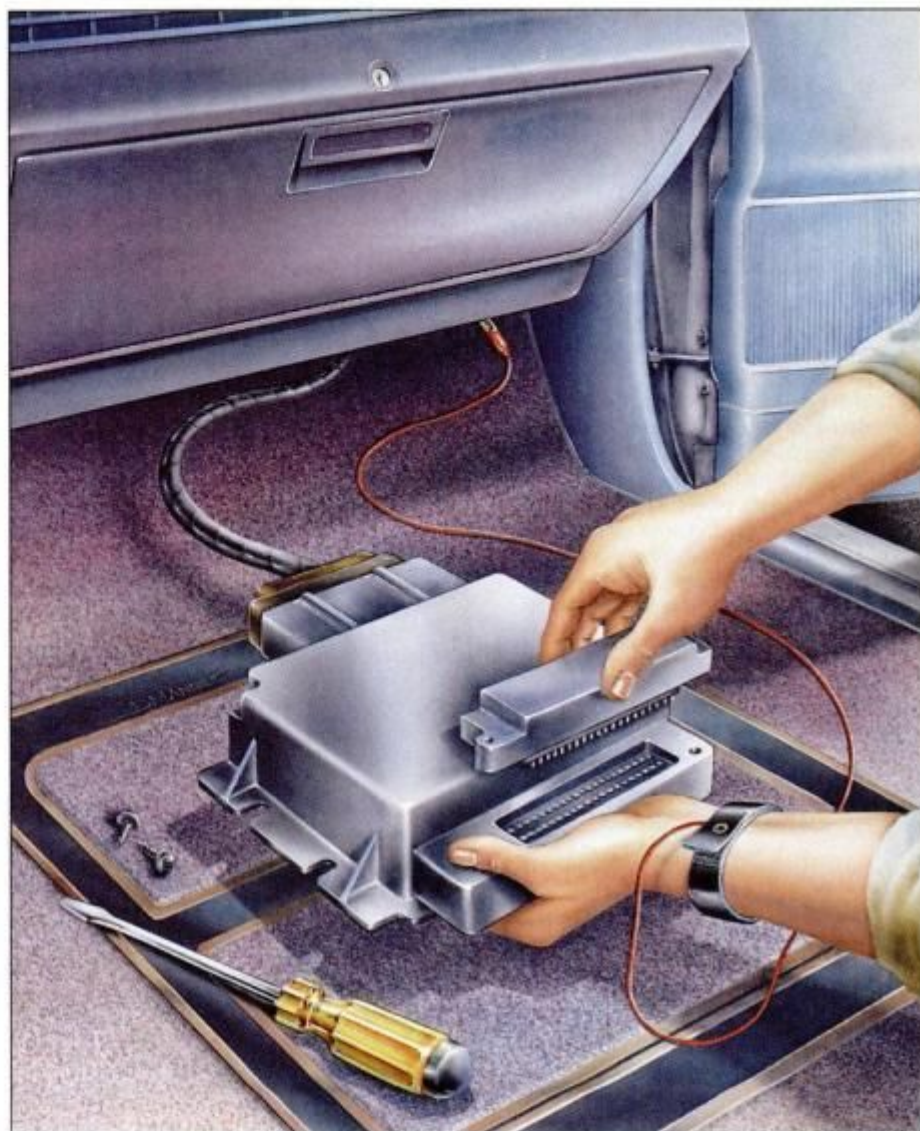
It's pretty easy, Fred, so save the money and reinstall the chip yourself.

Start by getting out the engine management computer. On some cars it's buried under the dash, but it's pretty easy to get to on your Camaro. Don't remove the wiring harness to the computer—generally, there's enough slack to work on it without disconnecting it. Disconnect the battery ground terminal, just to be sure you don't get interrupted.

Remove the cover over the EPROM chip you're accessing. Now you need to ground yourself carefully, by touching either the door jamb light-switch housing or the ignition lock. Static electricity generated by sliding across the nylon seats can easily reach 50,000 volts, more than enough to blast your chip into the bit bucket. Both of these points have bare, grounded metal, and touching them will discharge any static.

Another way is to get an inexpensive conductive armband from Radio Shack or any electronics supply house. The wire-lead ground will continuously drain static from your electrifying corpus. Otherwise, simply touch a ground periodically, especially if you slide your backside over the seats while you're struggling with the computer.

Now you can pry the chip from its socket, carefully. If it's stubborn, there are inexpensive chip-pulling tools to be had at the same place where you found the armband. Check to see that the pins on the chip you're about to install are straight, and



PM ILLUSTRATION BY DON IMANINES

ground yourself again. Carefully insert the chip, making sure all the pins are entering their respective sockets. If they're not, pull it back up, straighten the pins and try again. Tap down the chip until it's seated.

Retrobelts

I have a nice 1974 Chevy pickup. It has a lap belt, but never had a shoulder harness installed by the factory. I drive a lot on the military base where I live, and the MPs are forever stopping me because they can't see any shoulder harness through the window. (The military requires that seatbelts be worn on base.)

Can I just go get some seatbelts out of another truck from a junkyard? The mounting point for the top of the harness seems to be there on the pillar.

TOM 1904

(FROM THE PM BULLETIN BOARD)

Do not just go to a junkyard and get belts from any old truck. Older belts may have weakened nylon webbing,

either from age or from being stretched in an accident—which may be how they got to the junkyard in the first place.

One option is to get an older set and have them rewedded at a trim shop with new nylon, reusing all of the hardware and buckles. Or maybe there's a parachute rigger on the base you could persuade to do this.

You may want to install an inertia-reel belt system, instead of manually adjustable belts. Be sure to mount the inertia-reel mechanism properly. The pendulum inside may or may not care whether it's mounted straight along the vehicle's axis—but if it does, and you've mounted it, say, 90° out, it may not latch at all in an accident. Be sure to wear your new harness off base, too.

Risky Business

If I disconnect the speedo pick-up connector from the transmission, will this cause the computer to malfunction? Will this cause incorrect fuel/air mix-

CAR CARE

ture? What other long-term effects might result from such a simple, warranty- and mileage-saving alteration? My SERVICE ENGINE SOON light comes on after driving with the speedo disconnected.

TOM FOX
DALLAS, TX

The engine management computer requires information as to vehicle speed to stay in closed-loop mode. In this mode, the O₂ sensor constantly checks for richness/leanness in the engine, and the computer will adjust the amount of fuel delivered accordingly. Same for spark control—the amount of ignition advance depends on many engine parameters and is set continuously by the computer.

When one of the sensors—like the speed sensor—is out of whack, the computer stays in open-loop mode. In this mode, normally used while the engine is warming up, the computer simply uses preset amounts of fuel and advance. Mileage, power, drivability and emissions are all much poorer in this mode. Don't do it.

Cold Blooded

I have a 1984 Crown Vic wagon. I've blown a bunch of ignition modules, all after about 5000 miles. I suspected overheating, so I replaced the 195° thermostat with a 160° one.

ROBERT ESPANGA
INVERNESS, FL

Robert, read my answer to Tom Fox immediately above this letter, if you haven't already. I'll wait.

Back? Okay. One of the sensors your computer uses is the coolant temp. Your vehicle is probably getting warm enough to get into closed-loop—there's a time limit in the software on how long the engine has to warm up properly. If your CHECK ENGINE light is off, you're not triggering it. I'd expect that a 160° stat would do so—so you're getting away with it.

This engine was engineered and calibrated for higher temps, and tinkering is likely to reduce engine life through excess sludging.

I agree that heat is killing the ignition module. Be sure the ignition module is installed with the right amount of heat-sink grease between the module and its mounting pad. Look for any other problem that might cause abnormally high underhood (as opposed to coolant) temps, such as missing fan shrouding or airdam, or accumulated mud or leaves.

(Please turn to page 126)



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Hello, Dolly

● I was about to reinstall the oil pan on a friend's pickup last weekend, after changing the rear main seal for the second time. The conclusion I had come to was that the main seal hadn't really been leaking—it was really the pan gasket dribbling all over whenever the engine was running.

Sure enough, inspection of the pan showed that someone else had come to the same conclusion—and had tried to fix it by torquing the pan bolts big time. This left big indentations around the bolt holes, preventing the cork gasket from sealing properly.

The fix was simpler than a new pan. I just lightly tapped out the dents with a body hammer and a metal finishing dolly. You could use a ball-peen hammer and anything that would back up the metal pan, even a piece of hardwood.

Take a close look at that leaky rocker arm cover, too.



PM ILLUSTRATION BY ADOLPH E. BROTHMAN

Hole-In-One

I was replacing the PCV valve on my '76 Malibu, and the rubber grommet in the valve cover was so hard that it cracked and fell in the hole. I got a new grommet, but will this affect or harm anything in the engine?

JIMMY WHITELIGHTNING
NO ADDRESS GIVEN

Well, regardless of how hard the rubber grommet was, it's not nearly hard enough to damage any of the reciprocating parts in the valvetrain.

But it has the potential to block oil return passages between the head and block, or perhaps even plug the oil inlet screen if it breaks down into chunks small enough to drop down that far.

If that were my car, I'd pull the valve cover (a simple hour's task—get a new gasket before you start) and retrieve the thing.

It may have broken up into smaller pieces. You should try to jigsaw-puzzle back together what you can find in the rocker gallery.

If much of it is unaccounted for, I'd think real hard about dropping the pan and cleaning there, too. **PM**

DO YOU HAVE A CAR PROBLEM?

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

SERVICE TIPS

- 1988-'89 Chevrolet C/K trucks with a rattle in the rear suspension may be suffering from nothing more serious than loose shock-absorber nuts. TSB 89-104-3D says to tighten the retaining nuts to a revised specification of 95-110 Nm.
- If your '89 Eldorado or Seville has a squeak or scraping noise when you depress the brake pedal, have the dealer look at the centering of the brake-pedal pushrod in the master cylinder. Correcting this condition involves adding a shim P/N 3250709 to the two lower mounting studs of the hydraulic booster mounting adapter. The shim goes between the front of the noise barrier and the brake booster mounting bracket gasket. T-89-64
- If the fuel delivery to the engine of your '89 Firebird is nonexistent or poor—even if the pump is running—the in-tank fuel pump may have become uncoupled from the fuel tube portion of the pump/fuel level assembly. TSB 89-6-33
- If you're concerned about the difference in the tire-spring clearance between the right- and leftside suspension of your 240SX, TSB TS89-056 explains that an 8mm difference is perfectly normal, and that no corrective action is necessary—or wise.



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DETROIT SPY REPORT

BY JIM DUNNE, Detroit Editor



Mazda's MX-6 Makeover

● If it's true that styling still sells cars, these spy shots seem to indicate that Mazda should do quite well with its redesigned MX-6 sport coupe.

With its softer contours and much lower hoodline, the next-generation MX-6 looks to be right in step with current Mazda design trends.

However, the makeover goes well beneath the skin. According to sources in Japan, the new sheetmetal rides on an all-new platform, with major suspension improvements.

There's also a new engine. Mazda will replace the current 12-valve 2.2-liter turbo Four in GT models with a 2.5-liter 24-valve V6. Developed from the MX-3's tiny 1.8-liter V6, the 2.5-liter version is expected to produce about 160 hp.

Powder Painting

Chrysler is using a new powder paint for the rocker panels of its Imperial/New Yorker/Dodge Dynasty car lines—the first exterior application for this type of paint in the industry.

Powder paint has a tough surface that resists stone damage, and Chrysler claims that its process produces a finish that's smoother than other anti-chip coatings.

The process entails heating the powder paint with lamps to melt it to the consistency of a traditional wet paint. Once dry, the powder-painted surface is finished with final coats of color and clear paints.

LH Update

Chrysler is looking beyond the introduction of the still-to-be-named Dodge and Eagle LH cars, due next fall, with plans for a luxury version.

Destined to wear Chrysler badges, this car will be bigger than the Dodge/Eagle version by about 4½ in. in overall length. Most of the stretch will be devoted to rear-seat legroom.



Wagon version of Saturn sedan is due for 1993.

Styling differences will show up in the front, where Chrysler's trademark waterfall grille will be featured. At the rear, the C-pillar will be more vertical, creating a more upright backlite and more formal appearance.

Chrysler promises to have something hotter in the engine bay—a 3.5-liter sohc 24-valve V6. The development team is targeting 215 hp and 245 ft.-lb. of torque for this offspring of Chrysler's 3.3-liter V6.

Saturn Wagon

This concept sketch, developed from insider reports and various spy photos of development mules, shows the production-ready shape of the Saturn station wagon due out next year as a 1993 model.

The wagon will employ sedan sheetmetal almost as far aft as the rear wheelwells. Powertrain offerings will be the same as the sedan series. A convertible model, based on the Saturn coupe, has been shelved for the future. **PM**

BOATING

CRUISE CRAFT

BY JOHN WOOLDRIDGE, Contributing Editor



● It's no secret to PM readers that shredding chop and carving glass in a sporty personal watercraft (PWC) is one of our favorite outdoor activities. But this doesn't mean we endorse the behavior of jet-powered no-brainers who run endless figure 8s about 50 ft. from the launch ramp or thrillseekers who play chicken with passing powerboats.

For a different perspective, last spring we joined a high-spirited group of PWC riders for a cruise on the Intracoastal Waterway (ICW) out of Corpus Christi, Texas. And several months later, we used a pair of PWCs to explore the islands and bays of 32-mile-long Lake George, New York.

Yamaha Waverunner IIIs and Waverunner VXR's were the vehicles of choice in both cases. These multi-passenger machines have the shape, size and muscle for PWC cruising.

Explore the shore

Cruising is the newest wave for PWC riders, and it's shaping up to be a big one. The timing couldn't be better. While we were in Lake George this summer, new PWC restrictions were put in place. Restrictive regulations are pending or in force on numerous

bodies of water across the country. And the reasons are obvious. No-brainers do doughnuts all day right off shore. They jump wakes within a handshake of running boats, and, even worse, they follow no known rules for safety and courtesy.

Behavior like this, naturally, tends to create ill will even among the most easy-going users of the waterways—which is why we support the move toward PWC touring. And the newest generation of mod-V-bottomed tandem-riding PWCs are well suited for this purpose. They're comfortable enough to damp a full day's worth of wave pounding, yet remain highly maneuverable and responsive. New models have enlarged gas tanks to help extend touring ranges and expanded storage compartments to enable riders to carry a modicum of gear. Beefier engines ensure high-performance punch for tandem riding and adequate reserve power when necessary. Importantly, none of the Waverunner III's or Waverunner VXR's freewheeling agility and penchant for power has been compromised to improve cruisability.

To be sure, novice riders who love hotdogging to a fault are living out the

dream they see in ads and brochures—vigorous, hard-bodied young men and women who jump waves for radical air and slam into spray-filled spin-outs. These scenes are aimed exclusively at young, action-oriented individualists.

Yet, most major players in the PWC industry claim to be seeking new markets: young families, college graduates, couples and other potentially responsible users. To attract this crowd, why not portray the joys of PWC cruising? And while we're asking rhetorical questions, why are most PWCs muffled so poorly? Is a snarling engine a necessary part of the macho image?

The PWC industry should take a cue from the itinerary of our recent group ride in Texas. After launching from Pita Island, just southeast of Corpus Christi, we ran 22 miles north to Port Aransas, which guards a natural break in the coastal barrier islands. We checked our charts and plotted a course along the ICW, staying close to the channel to avoid underwater obstructions. We gave wide berth to passing vessels of all sizes, including head boats that transport crews to offshore fishing fleets and gi-

ant commercial tugs. Most importantly, we operated our craft in a safe, predictable fashion—the same as any other boat on the ICW.

After lunch and a refueling stop, we headed out Aransas Pass for a little wave jumping and exploring of desert islands. By then it was time to go, and we made a late-afternoon dash home. Total cruising distance was more than 50 miles.

Tour duty

I split my touring time equally between the Waverunner III and the VXR. Both are comfortable cruising machines in completely different ways. The Waverunner III (\$5560) is a large 3-person craft that weighs in at 454.1 pounds and has a 10.6 gallon fuel tank. The VXR (\$5099) is Yamaha's 2-person high-performance sports sedan. It tips the scales at 378.4 pounds and carries 7.9 gallons of gas.

For vibrant colors, eye-catching graphics and contemporary design, the sporty VXR is a surefire winner. It's among the fastest production PWCs on the market. For those times when you're far from shore, there's no hotdog maneuver you can't do with the sprightly VXR.

An additional 3.5 in. of width and 6.6 in. of length give the Waverunner III a bit more stability than the VXR. A higher profile allows for a drier ride and extra storage. The added weight and bulk seemed to give the Waverunner III an edge in overall comfort, particularly after a long day of pounding the chop.

Both models are powered by 50-hp, 633-cc Yamaha engines equipped with oil injection, and both are capable of 38-mph top speeds with one rider aboard. Actually, the VXR can hit a few miles per hour more than that.

Like swimming, two PWCs are safer than one for cruising. Here are some other tips. Equipment needed for cruising includes: a 50-ft. length of nylon line to use for towing, a small anchor, watertight first-aid and survival kits, waterproof charts and compass, a waterproof flashlight and a plastic whistle.

In addition, it's imperative that you plan your trip well. Don't try to cover too much water in a day. Call ahead to make sure that gas is available. Take enough fluids to avoid dehydration. Use plenty of sunscreen.

Above all, respect the rules of the road, and the rights of others to enjoy the water. The way we act on the water affects the way all PWCs are perceived. We can be ambassadors or no-brainers, and frankly, ambassadors are better. **PM**

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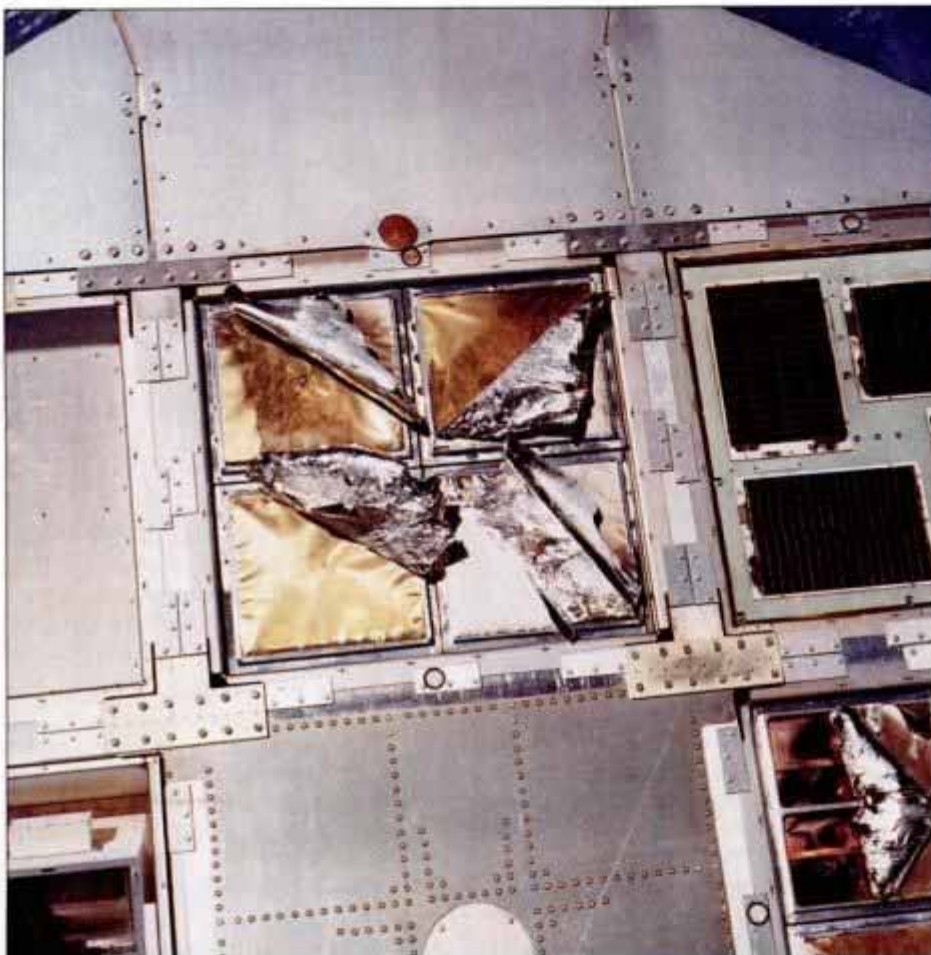
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SCIENCE

THE RAVAGES OF SPACE

BY ABE DANE, Science/Technology Editor



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● Throughout the latter half of the 1980s, an aluminum spacecraft the size of a school bus braved shotgun-like blasts of hurtling debris, bursts of radiation, extremes of temperature and constant bombardment with atomic oxygen. Known as the Long Duration Exposure Facility (see [Tech Update, page 21, April '90](#)), its mission was simply to stay in orbit, exposing the patchwork of 86 experimental panels that covered its multifaceted surface to the environment 250 miles above our heads. Scientists would note the condition of these samples on their return to Earth and decide which were best suited to future space construction jobs.

LDEF's stay was supposed to last one year. But crisis on the ground brought a change in plans. In the near paralysis that followed the *Challenger* disaster, NASA's priorities shifted and LDEF was stranded in space,

still gathering data and waiting for a ride home.

It was six years before the Shuttle *Columbia* snatched the now-dilapidated spacecraft from its decaying orbit. During that time, the satellite traveled 741 million nautical miles, and strange things began happening to its load of samples, some expected, others still unexplained.

On its return to Earth, LDEF was sealed in a clean room, photographed and examined. Then it was dismantled and its components dispatched for further scrutiny to the experimenters who designed them. Now, after 19 months of study by an international team of hundreds of scientists, the results of LDEF's unintended odyssey are beginning to come clear.

Lessons of LDEF

To tap the latest thinking on space structures, our correspondent Philip Chien attended the first conference of

LDEF's silvered Teflon thermal blankets were ruptured (left), probably by thermal cycling. Other damage included meteoroid penetrations of a fiberoptic cable (top) and of another thermal blanket (middle), which was then discolored by atomic oxygen. Atomic oxygen ate through Kapton disc (above).

LDEF scientists and engineers, held in Kissimmee, Florida, earlier this year. There were 122 papers presented, constituting a trove of data many compared to that resulting from the *Apollo* Moon rocks.

Even on the basis of preliminary data, those at the conference expressed confidence that long-lasting space structures can be built from present-day materials.

However, few of the 10,000 samples aboard LDEF came through the ordeal unscathed, and some fared worse than expected, pointing up the importance of choosing just the right material for the job at hand.

(Please turn to page 132)



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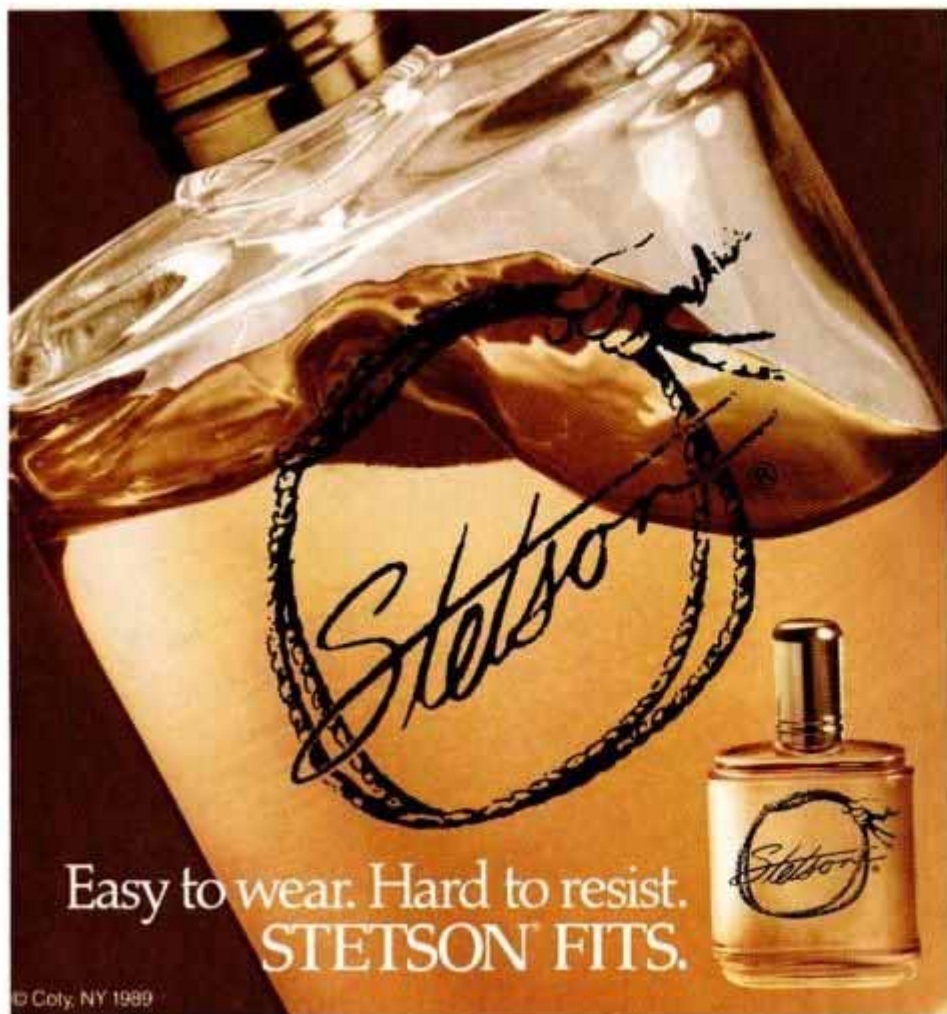
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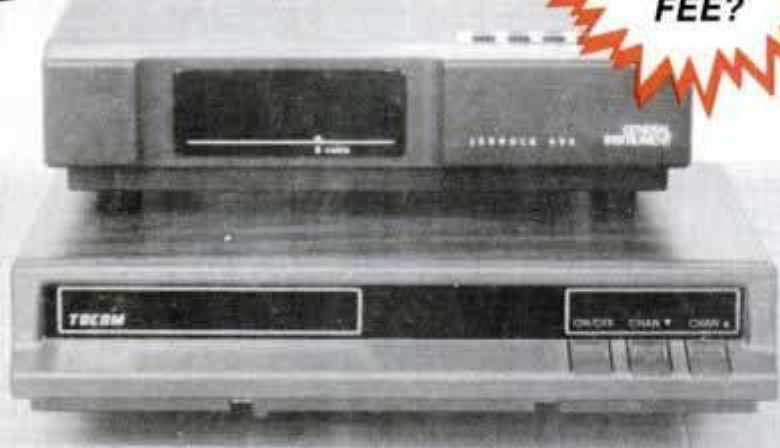
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SCIENCE (Continued from page 130)

One immediate concern was the condition of the silver Teflon blankets used to cover many of the experiments. Meteoroid hits had left the originally mirrorlike material discolored and milky. This was particularly troubling at the time because the soon-to-be launched Hubble Space Telescope relied heavily on the insulating properties of these blankets. Fortunately, a crash analysis determined that the damage was mostly cosmetic. While the silver backing had delaminated from the Teflon, it retained its heat-reflecting properties.

Overall, meteoroid and debris impacts provided some of the most interesting and important data. Traveling at speeds greater than 20,000 mph, a 3mm particle packs the destructive energy of a hefty bowling ball going 60 mph—easily enough to destroy an unshielded spacecraft. Investigators cataloged evidence of 34,336 impacts on LDEF. While the count was no higher than expected, scientists were surprised to find that a large proportion of the impacts had occurred during a few relatively short bursts. Data from Interplanetary Dust Experiment, an array of 459 detectors that recorded impacts for a period of one year, showed that fully one-quarter of them had come from six distinct clouds of particles. By retracing the orbits, scientists have already determined that at least one of these was produced by the same Shuttle mission that launched LDEF. Investigators continue to try to match up rocket launches and particle impacts to find the origins of the other clouds.

A subtler, but equally destructive, aspect of the orbital environment is a substance known as atomic oxygen, which makes up the uppermost reaches of the atmosphere. Split into single atoms, rather than the dual-atom molecules found at lower altitudes, atomic oxygen is extremely reactive, and bonds to almost anything it touches.

As LDEF's orbit decayed from its original 257-mile height to a perilously low 185 miles, atomic oxygen began eroding the spacecraft's leading edge at an ever-increasing rate. In one experiment, the top five layers in a stack of thin Kapton discs were completely eaten away.

Although LDEF returned to Earth looking somewhat the worse for the wear, the overall findings of the mission were that the low-Earth orbit environment to be inhabited by Space Station *Freedom* is a relatively benign one. And if the Station can survive its current political troubles and make it into space, it should have little trouble staying there.

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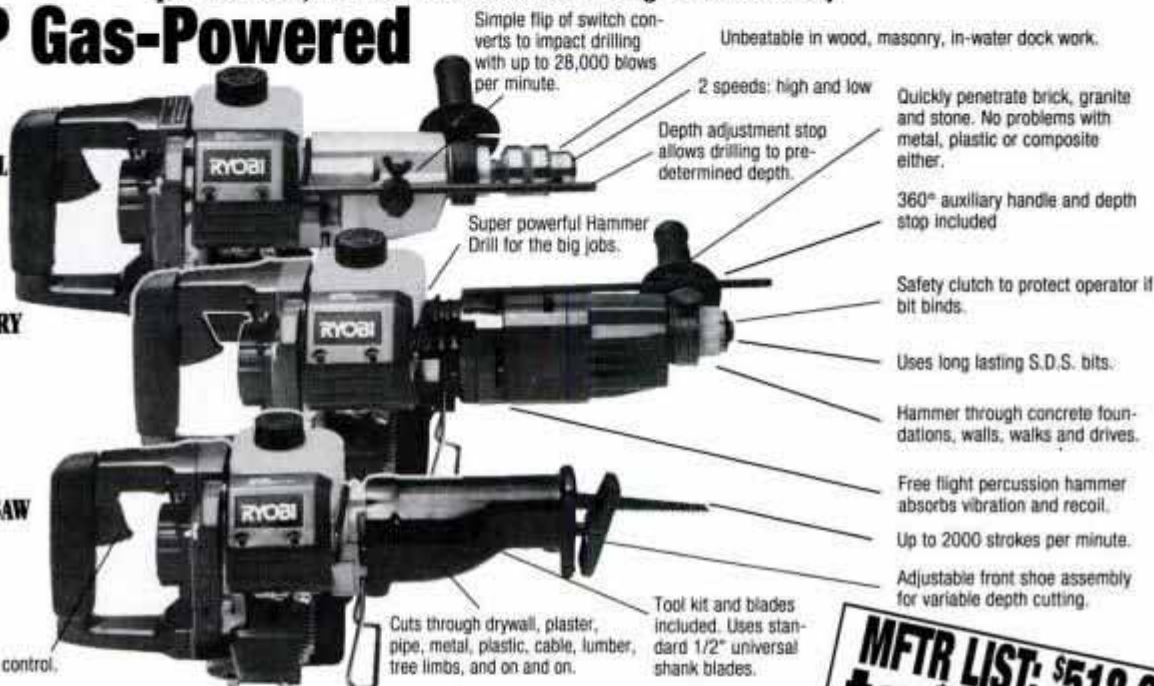
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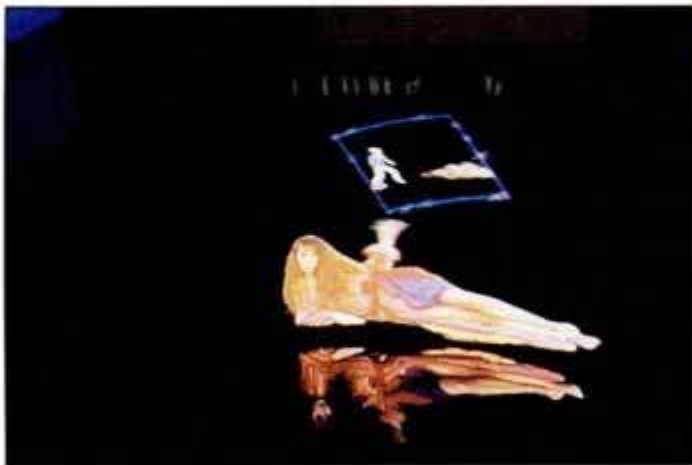
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ARCADE MAGIC

BY FRANK VIZARD, Electronics Editor



● When you pop your money into an arcade videogame, you're not expecting to see a movie. But that's essentially what you get with a new game now making its way into arcades around the country. Not only are you a player of the game, but you're also the writer/director since it's your decisions that determine the outcome of the game.

For the first time, real actors and actresses are being cast in an arcade videogame. Called *Time Traveler*, the new hologramlike game promises to boot the old cartoony heroes out the arcade door. *Time Traveler* is made by Sega, the Japanese game manufacturer, but relies on a number of U.S.-developed technologies for its operation. What you wind up seeing on the game screen are actors and actresses operating in what appears to be a three-dimensional setting.

The game is not a true hologram, however. Holograms are viewable from every angle and appear to move in space just like real people. The *Time Traveler* game requires a darkened stage and is viewable from only a 240° angle. Nevertheless, as an onlooker moves, the Lilliputian-size figures on stage appear to change perspective and follow the viewer. Like a hologram, however, you can reach out and put your hand through the image appearing on the stage.

The *Time Traveler* game, which can be basically described as a micro-theater, combines optical, television

and laserdisc technology. Patents for this use of the technology are held by With Design In Mind of Chatsworth, California. Two other Californian companies helped in the development of the software. The Allen Design Group, under President Rick Dyer, gets credit for inventing this particular game. Dyer invented the first-ever laserdisc arcade game, *Dragon's Lair*, in 1982. Special effects were done by Imagitrek.

Inside the *Time Traveler* is a television monitor. The images on the screen, supplied by the laserdisc player, are reflected by a concave mirror onto a horizontal plane or stage above the mirror. Controlling the action is a Logic Control circuit board. This board receives input from the game

player and, in response, commands the laserdisc machine to produce the proper sequence of images.

Time Traveler uses 40 actors and actresses. Our hero is Marshall Gram, played by actor and stuntman Steve Wilbur (this may be the answer to a trivia question someday). The story follows the familiar save-the-princess plot. Gram visits several periods in history and the future during his heroic quest.

Gameplay is generated randomly so the gaming experience can vary tremendously. If a game ends prematurely, players can cheat death by purchasing time reversal cubes. These cubes allow you to reverse your steps and try again.

Time Traveler definitely changes the nature of arcade play, and there may be future implications as well. Videogames got their start in the arcade, so a variation of this technology may appear in the home sometime in the future. At the current price of \$6000, *Time Traveler* is perhaps a little expensive for most homeowners. The game is a little big too—measuring just over 4 ft. in height and weighing 370 pounds.

In the meantime, more real-actor games will be appearing in arcades across the country. You can also expect to see these machines in use as directories in malls.

This technology will also allow more actors and actresses to get away from waiting on tables. Someday you'll be reading about an actor's career and learn that his professional life started inside a videogame. **FM**



The *Time Traveler* arcade videogame (right) uses real actors (above) instead of animation.

—but how many would you be willing to take to a weekend autocross? That's the Swift GT for you: A nimble little pocket rocket that sorts out rush-hour traffic like a coyote turned loose in a herd of sheep. With a Swift GT, driving in Manhattan is closely akin to motorsports, and once you get where you're going, this tidy little package (just over 12 ft. long) loves leftover parking.

You can buy the 70-hp garden variety Swift at your Chevy dealer, where they call it a Geo Metro. But only Suzuki offers the GT version, with stiffer suspension, a little more in the way of tire contact patch and a lot more horsepower. With dual overhead cams, 16 valves and a 10:1 compression ratio, the 1.3-liter Four makes an impressive 100 hp at 6500 rpm. Hitched to an 1850-pound car and a close-ratio 5-speed gearbox, this results in gratifying quickness.

There's also good fuel economy. In our first 3549 miles with the Swift, almost all in Manhattan, we recorded a respectable 32.3 mpg average.

On the minus side, the logbook shows complaints about high steering effort and suspension tuning that's too stiff to deal with New York's potholes and pavement ripples. But for the everyday autocrossers among us, those are daily tradeoffs we look forward to making. —Tony Swan

Chevrolet C2500 Silverado

The pickup truck is an all-American invention designed to be an all-around beast of burden. And though the beast is getting fairly civilized, it still hasn't forgotten its basic function—particularly a beast like this one.

Chevy's C/K full-size pickup series entails a broad range of engines, axles, cabs, bed lengths and load ratings—enough to cover just about any need. Our need was pretty specific. We wanted something capable of towing our Olds Quad 442 race car, so we checked off the 454-cu.-in. box on the order sheet. And what we're here to report, brother truckers, is that this is one serious hauler. Even with 2700 pounds of race car riding about 1800 pounds of U-Haul trailer and some 600 pounds of tools, tires and spares in the cargo box, our big Chevy pulls itself over hills and dales almost as though it was empty. About the only place where the difference shows up is in fuel economy. Empty, it's about 15 mpg. With the load described above, the mpg slips to about 10.

Aside from small mpg numbers—the inevitable price of big-time torque—about the only other negative we associate with this truck is its

seating. There's simply not enough adjustability for real comfort, although the extended cab does allow for decent legroom.

A word about the trailer. Faced with a hefty cash outlay for a car transporter last spring, we looked into the alternative of renting one on an as-needed basis instead. This led to U-Haul lending us a transporter for evaluation—that's it, hooked to the back of the truck.

We've been almost as impressed with this trailer as with the truck. It's exceptionally smooth on the road, even empty, thanks in part to dual axles. It has its own hydraulic braking system, which saves wear and tear on the tow vehicle. Built-in ramps, an onboard winch and an ingenious built-in tie-down system make it wonderfully easy to load, and it's also very well lit.

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Toyota Previa LE

Our Toyota Previa has accumulated mileage—almost 10,000 so far—at a faster rate than normal for our long-

term testers. That's because it's my vehicle of choice for spending weekends as far away from Manhattan as I can get.

One of the Previa's major enticements is its killer in-dash CD/cassette/FM stereo system. It's head and shoulders better than any sound system we've seen in a vehicle in the under-\$25,000 price range.

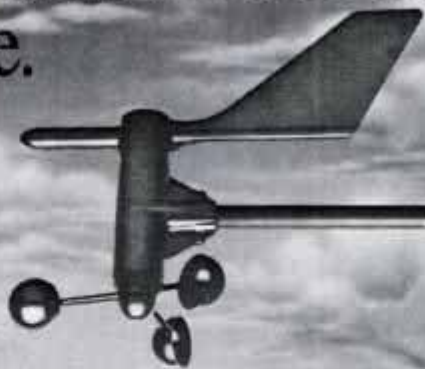
The Previa is a good people-hauler, though the people who sit in the rear-most seats mustn't mind crawling over the middle seats to get there.

As a cargo-hauler, it's not up to some of its competitors. The seat-backs can be folded a couple different ways, but the resulting cargo space isn't as useful as the space that opens up when you remove the seats from one of the GM-10 vans.

We've been seeing fuel economy of just over 17 mpg around town and over 20 mpg on the highway—not particularly impressive. We attribute this performance in part to the all-wheel-drive machinery.

The power window on the driver's side is becoming increasingly sluggish, and the switch for the tailgate courtesy light won't click off without a vigorous slam, something we learned when the battery went flat in an airport parking lot. —Mike Allen

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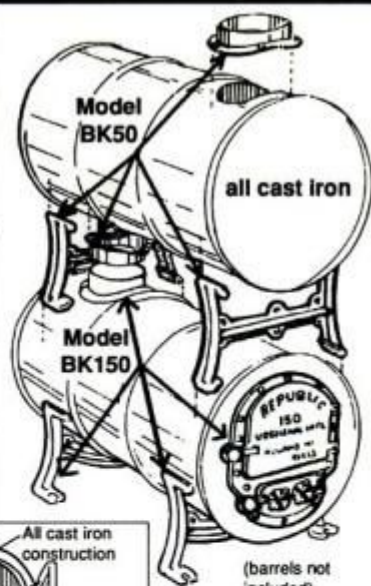
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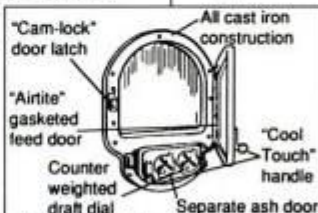
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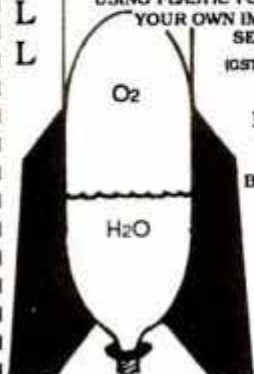
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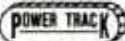
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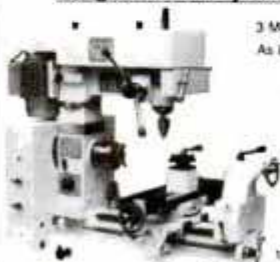


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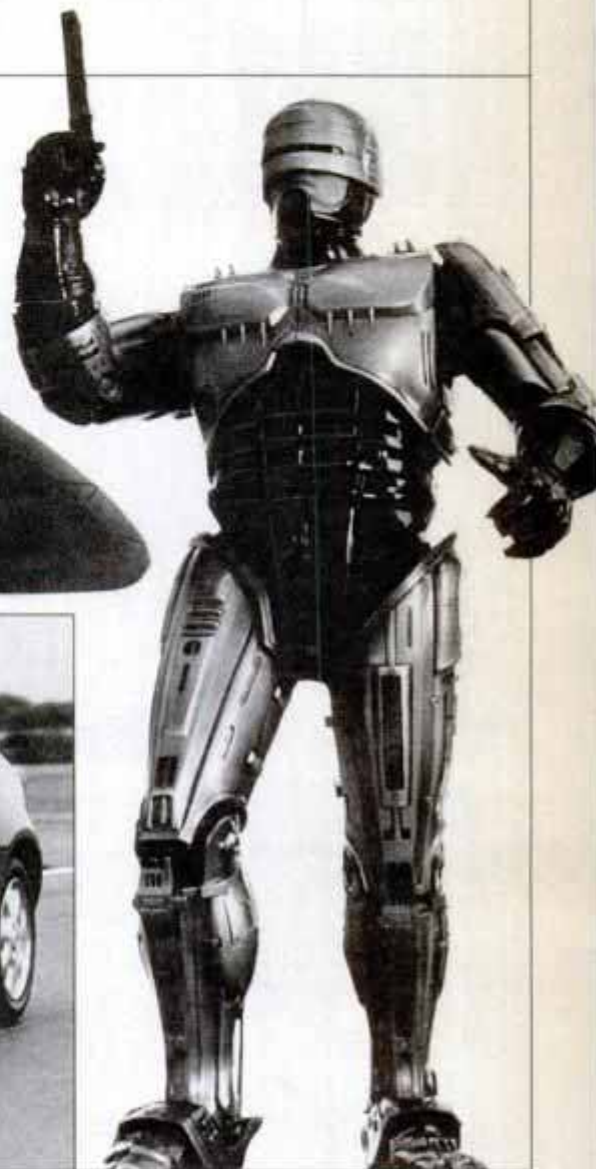
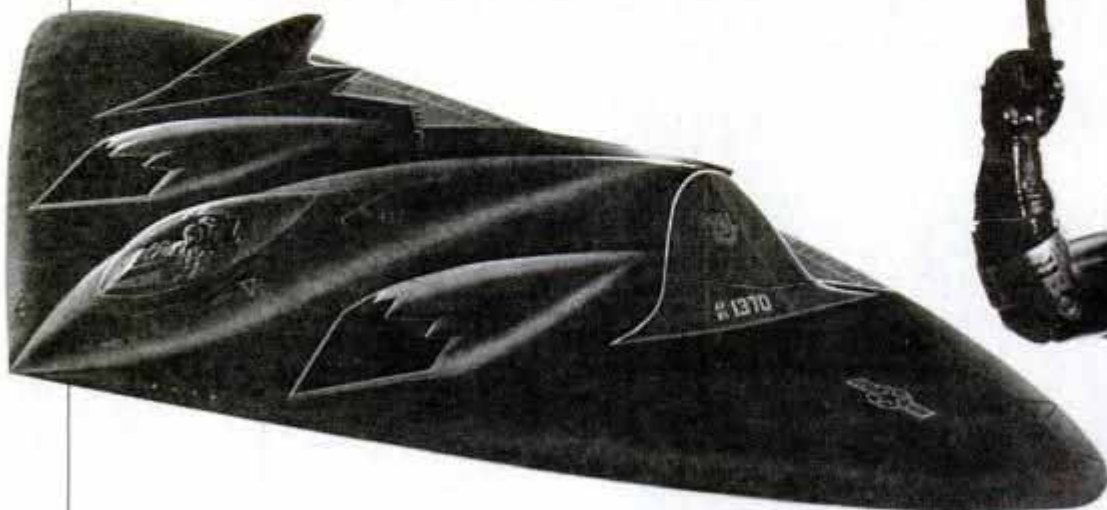
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1" CHERRY VENEER
GRAIN ORIENTATION AS SHOWN

SEE DETAIL A-A

FLOOR SURFACE

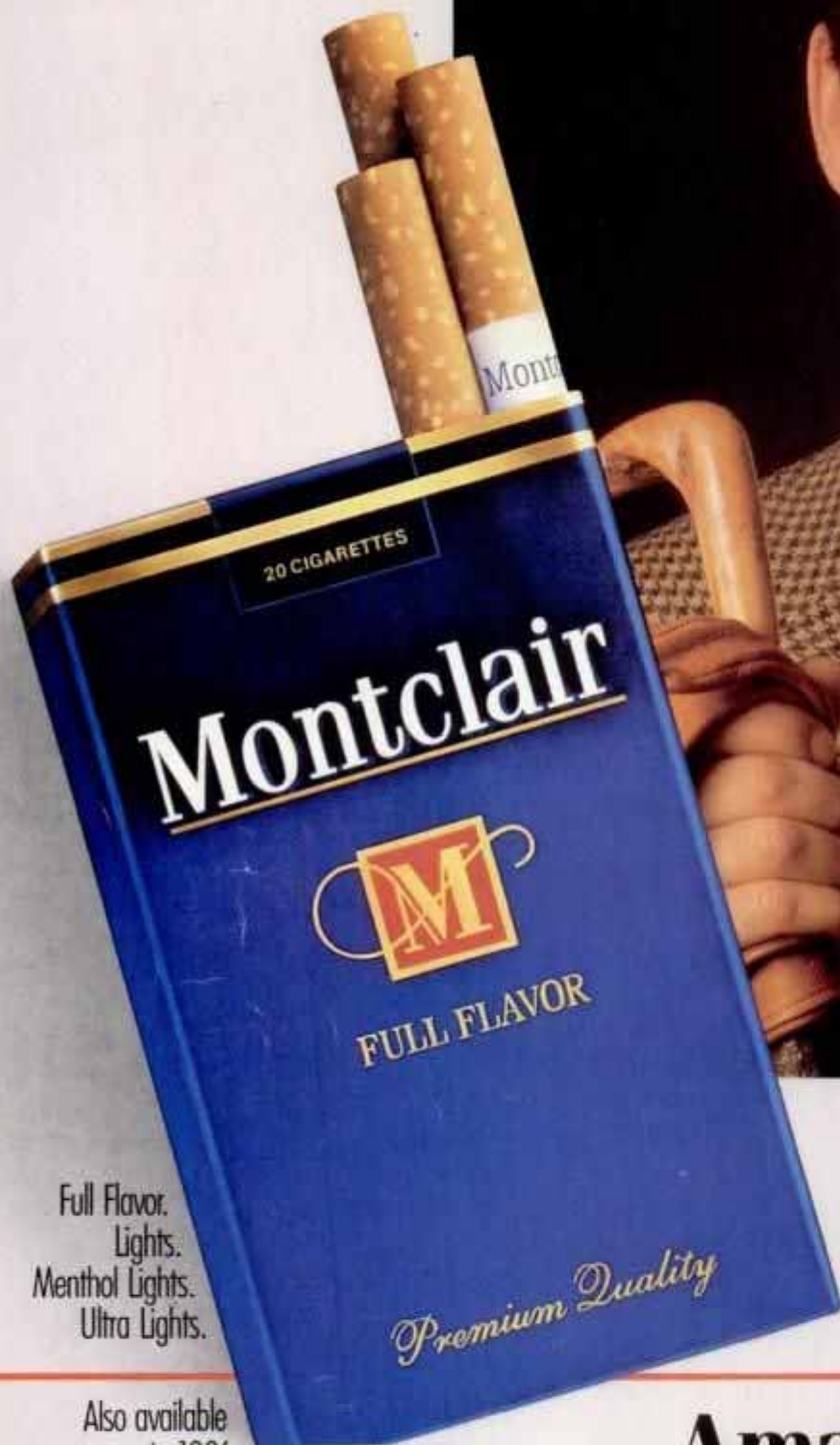


Canadian Club

A PREMIUM WHISKY, UNRIVALED IN QUALITY AND SMOOTHNESS SINCE 1858.

40% Alc./Vol. Blended Canadian Whisky. Imported in Bottle by Heam Walker and Sons, Inc. Farmington Hills, MI © 1991

Материал, использованный в рекламе, является собственностью Heam Walker and Sons, Inc.



Full Flavor.
Lights.
Menthol Lights.
Ultra Lights.

Also available
in 100's

**Surprising
taste.**

Amazing low price.

NOT FOR QUALITY

SURGEON GENERAL'S WARNING: Smoking By Pregnant Women May Result in Fetal Injury, Premature Birth, And Low Birth Weight.

Ultra Lights 100's: 6 mg. "tar", 0.6 mg. nicotine; Lights & Menthol Lights, Kings and 100's: 12 mg. "tar", 1.0 mg. nicotine; Full Flavor Kings and 100's: 16 mg. "tar", 1.3 mg. nicotine av. per cigarette by FTC method.