

Popular Mechanics

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OF AMERICA

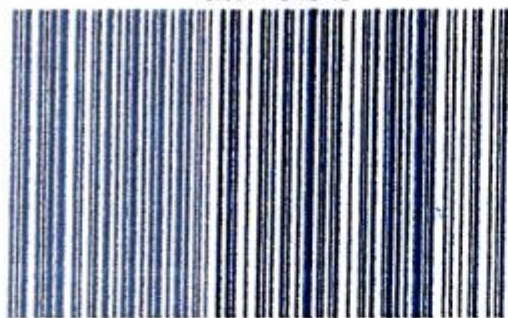


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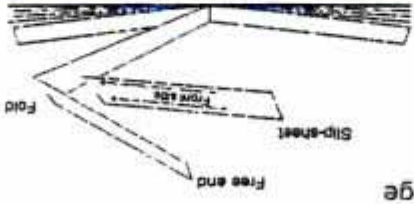
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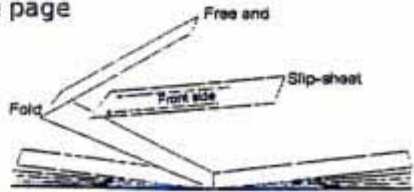
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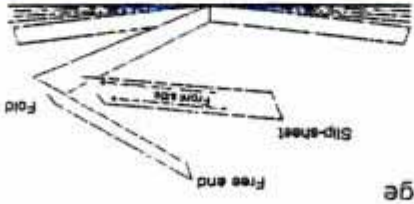


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Foldout slip-sheet



THE ADVANCED FULL-SIZE CHEVY

You figure if life were fair we'd all be good-lookin' and smart. And all trucks would be equal. But you know it doesn't work out that way. One truck's gotta be better than the other. And that's the one you want. The one you need to get the job done.

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The fuel-injected Vortec is built on advanced principles that make it a lean-burning, high-compression V6 with 15 more standard horsepower in the half-ton than Ford's old-design in-line six.



For heavier duty hauling there are fuel-injected 305 and 350 V8s and, in one-ton trucks, the mighty 454 V8. And unlike Ford, Chevy offers big 6.2L diesel power in all models.

Chevy hauls more than Ford. And gives you more ways to haul.

Chevy's got a bigger standard half-ton payload than Ford. Plus Chevy's rigid steel frame is bigger and heavier than Ford's in the half-ton truck. And that

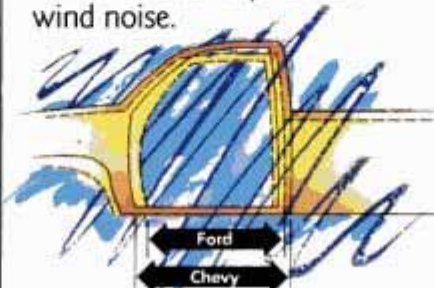
MORE STANDARD HALF-TON POWER AND PAYLOAD, MORE CAB ROOM, MORE TWO-SIDED GALVANIZED STEEL THAN FORD'S OLD-FASHIONED PICKUP.



helps maintain body integrity. In addition, Chevy has two-tier loading Ford doesn't offer. The tailgate is easily removable too, for extra long, bulky loads.

More room, more glass area. Some day all trucks will be this comfortable.

There's more leg room, more shoulder room and more total cab room than Ford. And there are other major comforts Chevy has that Ford lacks. Like more glass area and the flush-mounted windows that help reduce wind noise.

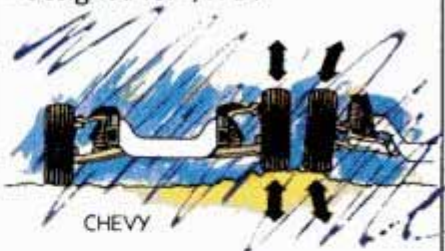


Chevy has more two-sided galvanized steel than Ford.

Every outside panel except the roof is two-sided galvanized steel. More than Ford. In some critical areas, there are as many as seven layers of corrosion protection. Including a high-gloss clear-coat finish that Ford doesn't offer.

Advanced double A-arm independent front suspension.

Ford's old twin I-beam front suspension makes the tires travel in an arc. Chevy's advanced double A-arm suspension keeps the tires square to the road. Chevy also offers an independent front suspension specially designed for 4WD.



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*Based on Manufacturer's Suggested Retail Prices for option packages versus options purchased separately. Comparisons based on data available at time of publishing.

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BUYING
A FORD
TURN THE PAGE.
YOU'RE ABOUT TO
HAVE A SERIOUS
CHANGE OF
Heart**



This One



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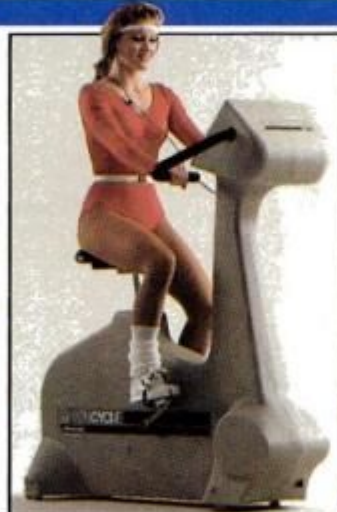
Metropolitan Life
AND AFFILIATED COMPANIES



72 COVER STORY

The gyroplane has had to carry its share of criticism in recent years. But now, its image is changing.

—PM photo by
Budd Davisson



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EDITOR'S NOTES

EVEN IN THE FIRST issue of POPULAR MECHANICS, there was a home and shop section. Back in the early days, it was called the "Shop Notes" section and it contained all kinds of projects to build, information on new tools, tool techniques that could be used in one's home shop, and home-improvement information. Today our home and shop pages are still the most numerous in POPULAR MECHANICS and still contain projects to build, information on new tools, tool techniques that can help you build a project easier and with more professional results, and home-improvement ideas that can be applied to just about everyone's living quarters. Doesn't seem like things have changed much in 86 years, does it? One thing that definitely hasn't changed is that our home and shop pages are part of the very fabric of POPULAR MECHANICS each month. And that will always be. These days, our home and shop department is headed up by Steve Willson, Home & Shop Editor. He's ably assisted by Shop & Tools Editor Joe Truini, Associate Home & Shop Editor Tom Klenck, and Editorial Secretary Lynne Abbate. The fruits of their considerable labor this month is a special 48-page "Woodworking Guide" (page 77) that can show you, step by step, how to build one of the most beautiful—and practical—bedroom suites we've ever seen. This furniture can solve your storage problem once and for all—and who doesn't

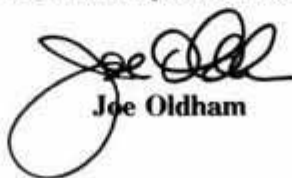


Truini, Willson, Klenck, Abbate.

have a bedroom storage problem? The Guide also tells you all about wood, shows you some great finishes for your furniture projects, and even includes a wall poster that will surely help you select the best type of wood for your next project. If this poster isn't hanging on thousands of shop walls by next month, I'll eat my typewriter. . . . Speaking of eating, that's one thing I do too much of. So it was with special interest that I read Contributing Editor Rich Taylor's report on the latest computerized fitness machines (page 62). The new fitness machines can definitely help you take control of your own overall fitness program and make the exercise seem, well, if not fun, at least more tolerable. . . . Next time you see Wesley Walker, wide receiver for the New York Jets, going long for a bomb from Ken O'Brien, you'll know that there's a lot more going on than meets the eye—if you've read our article, "The Mechanics Of The Bomb," on page 66 of this issue. Aerodynamics, lift, drag, trajectory and other factors are just as important as Walker's speed and O'Brien's accuracy. It's conceivable that a quarterback could be a better passer if he knew these scientific facts. The NFL will never be the same. . . . Aerodynamics are just as important to the new breed of gyrocopters as they are to footballs. The newer models have full fairings, as you can see from our cover, and are sleeker, faster and still inexpensive enough to provide the thrill of flight to a whole bunch of people (page 72). There is still a question of safety with any gyrocopter, and there's a risk in flying one. But what a view! . . . You get a different sort of view through the windshield of a Ford Mustang police car, while it's hammering hard around a racetrack at over 100 mph for 24 hours straight. Why? To prove a point. A myth has surrounded cop cars since the first police department pressed a 4-wheeler into pursuit service. Police cars are faster. They're tougher, they're meaner than your average run-of-the-mill automobile. Is the myth true? I'd been hearing it for 45 years. We decided to find out.

Check page 57 for the results of our research.

'Til next time.



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LETTERS

Navy Of The Future

YOUR article "Battlecruiser 2000" (page 56, July '88) was fascinating and well written. I'm sure it sparked the interest of a variety of readers. Your interest in defense and in our future capability to assure maritime commerce is commendable.

FRANK CARLUCCI
THE SECRETARY
OF DEFENSE
WASHINGTON, D.C.

I found the article about Adm. Metcalf to be very thought-provoking. He has promoted a variety of innovative programs, including the battlecruiser. We are pursuing many of these and other possibilities that will shape the Navy of the 21st century.

WILLIAM L. BALL III
THE SECRETARY
OF THE NAVY
WASHINGTON, D.C.

I applaud your achievements in informing the American people of new ideas in technology. And I enjoyed your cover story and poster, "The American Fighting Cruiser, 1797-1988."

J.W. NYQUIST
VICE ADM., U.S. NAVY
WASHINGTON, D.C.

Old Bikes Never Die

As the president of the Arizona Antique and Classic Motorcycle Enthusiasts (AACME), I enjoyed your old-bikes story, "ReCycles," (page 64, Aug. '88). I hope it encourages anyone who is contemplating buying a vintage motorcycle to do his homework. There are many excellent books and magazines dealing with older motorcycles, and many enthusiasts' clubs as well. The problem with most American and British bikes is that so



Future battlecruiser was featured on PM's July cover.

many parts will fit even though they don't belong, because different models were developed slowly with minor changes from one year to the next. The thing to avoid is buying a bike that isn't the one that it pretends to be.

JOHN EBERT
PHOENIX, AZ

Properly Steamed

I'm the owner of a general renting firm and can assure your readers that the most common type of wallpaper steamer is powered by electricity, not propane. Full of water it weighs less than 30 pounds and doesn't have to be strapped to your back! Bob Vila should also be aware that these steamers come with a perforator that punctures the paper as you roll it up and down the wall. This is much easier than the utility knife method that Vila suggests in his "Removing Wallpaper" story ("Old House Restoration," page 20, Aug. '88).

RICHARD E. HAMLIN
PRESIDENT
RENTAL CONCEPT
MACON, GA

Bob Vila replies: True, the modern, electric-type wallpa-

per steamers (where available) are certainly very safe and probably a faster alternative than the garden-sprayer method of stripping I recommended. However, up here in New England we often find there's no other choice than the propane tank when it comes to steaming wallpaper for stripping.

Precise To A Fault

Your article "How To Replace A Water Heater" (page 107, July '88) was well done and very informative. The only thing left out was the suggestion to strap the water heater to a wall or other suitable support so it doesn't "walk away" during an earthquake. I made two semicircular supports of plywood and a 2x4 and bolted them to the wall studs. Then I used 1/2-in.-wide steel straps to secure the tank at the top and bottom.

RICHARD MUELLER
GRANADA HILLS, CA

Really A Classic

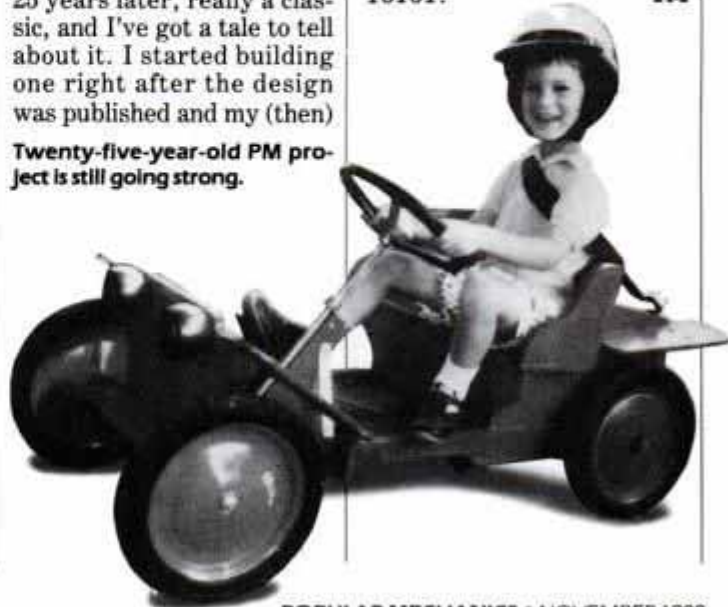
Your little electric car ("Sidewalk Classic," Part 1, page 146, Nov. '63 and Part 2, page 128, Dec. '63) is now, 25 years later, really a classic, and I've got a tale to tell about it. I started building one right after the design was published and my (then)

Twenty-five-year-old PM project is still going strong.

2 1/2-year-old son first drove it on Memorial Day 1964. It has been used regularly over the years by children of friends and neighbors and is now being put to the test by my grandsons (grandson No. 2 is in the photo below). I've replaced belts, wheels and batteries due to normal use but haven't had to make any structural repairs. My grandson is wearing a helmet and safety belt because of the souped-up powertrain that provides enough power for travel on grass and speeds up to 15 mph on hard pavement. Five to 8 miles on a single battery charge around our 1/4-mile track is its range. Thanks for providing this father/grandfather a quarter-century of enjoyment.

E. JOHN FORSYTH
DANVILLE, KY

PM readers build things to last! We're glad this project has brought so much pleasure for so many years. The plans for the Sidewalk Classic in its original form with convertible top are still available: Send \$6.95 for Plan PL-1227 to POPULAR MECHANICS, Box 1014, Radio City Station, New York, NY 10101. **PM**



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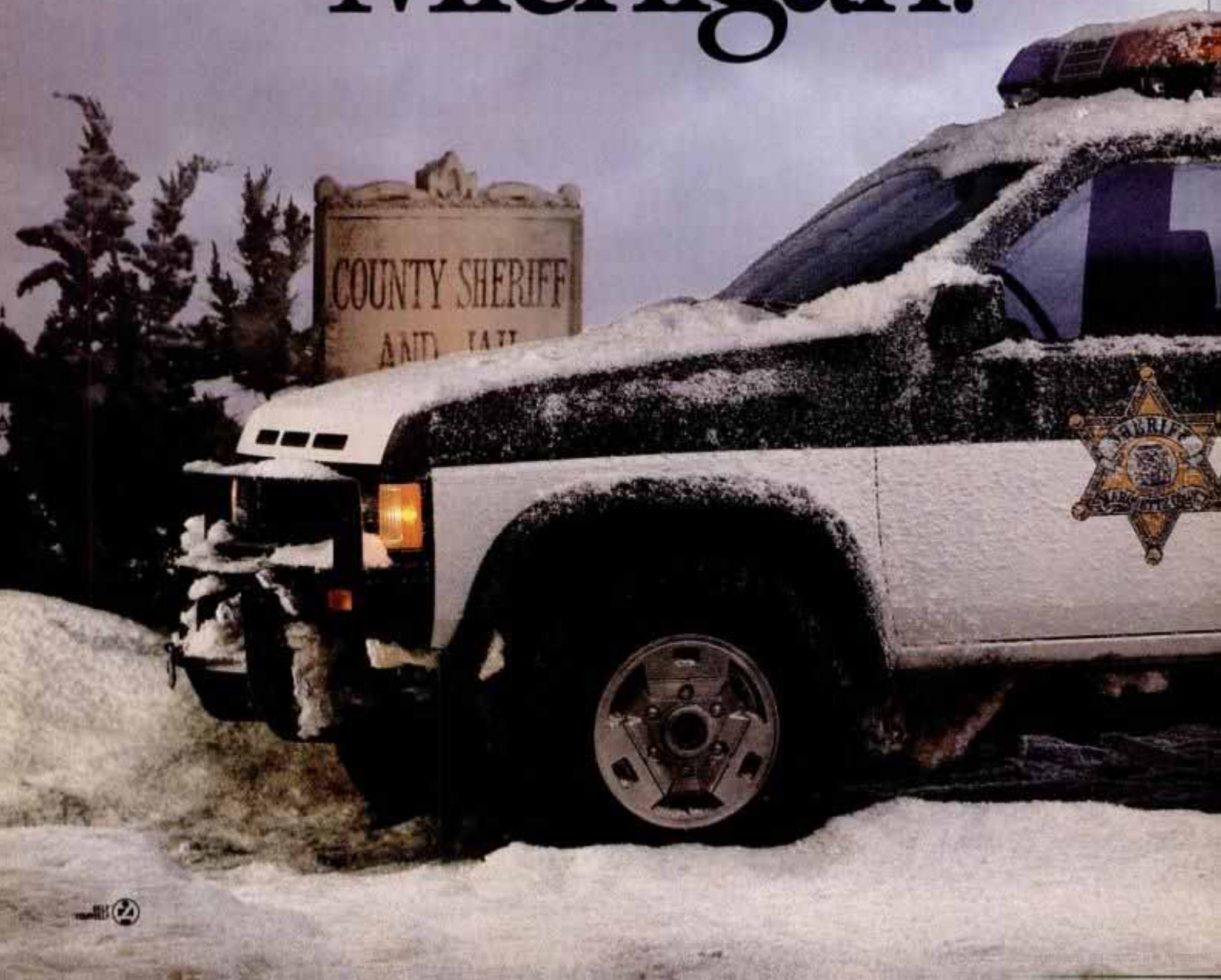
Big A has halogen sealed beams, plastic halogens and halogen capsules built so tough they're backed by a lifetime warranty. If they should ever fail, Big A will replace them free for as long as you own your car or truck.*

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It's easy to get into trouble around Marquette County.

You could get stuck exploring one of the deep, underground caves. Take your snowmobile out on a frozen lake—and find out it's not quite frozen enough. Or just go for a walk. With a million acres of dense forests and marshes, getting lost is so simple anyone can do it.

So you can understand why the Sheriff's Search and Rescue Team wanted a tough vehicle. And, as you'd expect, it didn't take them long to find what they were looking for.

A Nissan® Hardbody™ 4x4.

Straight off the showroom floor, they had a towing capacity of 3,500 pounds. Massive 31x10.5R15 tires. Triple underbody skid plates. And 145 horses of V6 power.

So about all the Sheriff's Department needed was a couple of emergency lights, a heavy-duty winch, an insulated shell, and some radio equipment to make their Hardbody ready to take them where people shouldn't go in the first place.

And more importantly, bring them back.

That's not a job to take lightly. After all, if the Search and Rescue Team gets stuck, who's going to come and rescue them?



Built for the Human Race.

TIME MACHINE

75 YEARS AGO: NOVEMBER 1913



Gun Running

As global tensions sharpened, the Great Powers were coming to grips with the concept of amphibious assault. On our November 1913 cover, crewmen unloaded field guns via a cable strung from battleship deck to a tripod derrick on shore. Two sailors usually rode shotgun on the trolley, to stabilize the load and prevent sudden spills. The technique would help European and American navies to deliver the devastating howitzers of World War I.

Wet-Look Wheels

We've always kept an eye out for imaginative car designs, and 75 years ago we spotted this streamlined silhouette. Inspired by motorboat modeling, the car's seatbacks were flush with the gunwales, and a small deck filled the space behind the front seats. Other nautical

touches included wave-like fenders and rows of brass fastenings in the mahogany side panels. Note, too, the absence of the doors and the running boards. French auto-design legend Jean-Henri Labourdette built "Le Skiff" on a Panhard chassis.



50 YEARS AGO: NOVEMBER 1938

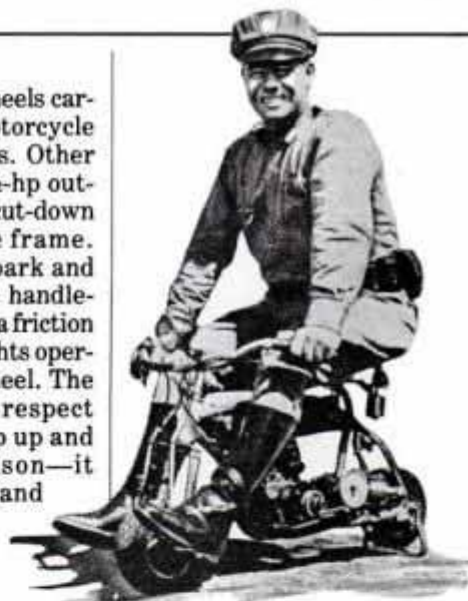


Deadly Porpoise

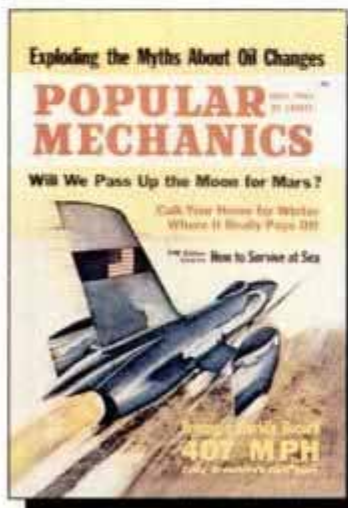
Our cover 50 years ago showed a British *Porpoise*-class submarine firing a torpedo. The purpose of the *Porpoise*, however, was minelaying. The mines were enclosed in a long casing at the top of the pressure hull. During operations, a conveyor chain shuttled mines to the stern, where they rolled down chutes and through trapdoors. Six of these craft were built before World War II, but only one survived, rendered quickly obsolete by new tube-launched mines.

MicroCHiPs

Two airplane tail wheels carried this midget motorcycle around Los Angeles. Other parts included a 2½-hp outboard motor and a cut-down reinforced bicycle frame. Throttle, brake, spark and cutout switch were handlebar-mounted, while a friction generator for the lights operated off the rear wheel. The microbike earned respect during a round trip up and down Mount Wilson—it scooted at 40 mph and got 150 miles to the gallon.



25 YEARS AGO: NOVEMBER 1963



Spirit Of Speed

Only weeks after his *Spirit of America* had shattered a 16-year-old land/speed record, Craig Breedlove gave PM readers the inside story. He'd begun assembling the *Spirit of America* in his backyard, before bringing in Goodyear and Shell as co-sponsors. The vehicle, a wingless fighter plane powered by a GE jet engine, raced on three wheels. Challengers topped his 407.45 mph record, but a year later Breedlove would rebuild the engine and break 526 mph.

Maybe Mars

As the moon race got underway 25 years ago, stories began to swirl that a flight around Mars might be easier than a lunar landing. We outlined an early-'60s scenario for a Mars shot, featuring Saturn-lifted fuel tanks that crews would attach to a Mars craft in orbit. But biology stood in the way: NASA didn't have the know-how to keep men in space for 14 months. And the Apollo program swallowed funding. Unknowns included physical effects of weightlessness and

radiation, and technology for long-term life support—problems that remain as we ponder Mars today. **PM**





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TECH UPDATE

Insect Tech: Putting The Bug On Killer Bees



OAK RIDGE, TN—Some time next year, killer bees will begin crossing the border into Texas and Arizona. Engineers at Oak Ridge National Laboratory are developing apparatus to help monitor and contain the bees' invasion.

The northward expansion began after African queen bees escaped from a Brazilian laboratory. Their descendants—known as Africanized or "killer" bees—look like familiar honeybees of the European strain but are too aggressive to domesticate.

A detector invented at Oak Ridge will help beekeepers distinguish the two strains without triggering the Africanized bees' trademark behavior—relentless stinging. Africanized bees beat their wings at 270 Hz, a slightly higher frequency than their European cousins. Using noise-analysis circuitry developed for nuclear-reactor inspections, the detector can pick out the buzz of a few Africanized bees among a hive of Europeans.

Meanwhile, scores of Africanized bees may soon be captured alive in Mexico to have tiny infrared-locator transmitters glued to their backs. Powerful miniaturized solar arrays, combined with sensitive infrared detectors, give the transmitters a 1-mile range.

Although a line of sight is required to pick up the signal, the transmitters will work in treeless flatlands in Mexico and Texas. There researchers will study the mating habit of Africanized bees, seeking clues to stop their proliferation.

Editor: Tim Cole
Assistant Editor: Gregory T. Pope
Contributor: Mike Fillon



Microchip on killer bee's thorax (above) will help scientists track invasion, while detector (below) will identify bees by buzz. Map (left) shows potential spread of killer bees based on cold-weather survival.



TRITIUM-FILLED
GLASS TUBEPARABOLIC
REFLECTORPHOSPHORUS
COATINGREFLECTIVE
TAPE

Parabolic reflectors
cast light over
a wider area.

Radioluminescent Lighting

OAK RIDGE, TN—Oak Ridge National Laboratory has developed remote-air-strip lights that require no external power source.

Inside glass tubes, tritium—a radioactive form of

hydrogen—decays, releasing electrons. The electrons crash into a light-triggering phosphor coating.

The Air Force plans to use the lights in rapid-deployment situations.

Airport 2000: Radial Design, Supersonic Traffic

DENVER, CO—The nation's first new airport in 15 years will serve this mountain metropolis, replacing the aging Stapleton International. And amid the local political turmoil surrounding plans for the new airport, a radical new airport design has emerged that purports to alleviate the airport traffic congestion.

Inventor Jim Starry says his radial airport, consisting of a huge dome, would also

save fuel and curb pollution. Planes would accelerate by rolling down a 2-percent gradient before engine throttles are advanced, saving fuel. The same gradient would decelerate landing planes, saving fuel-eating thrust reversal. Built over a parking garage, the dome would centralize ticketing and save passengers long baggage-laden walks. Intermediate floors would house a convention



Leashed Satellites

HOUSTON, TX—In the 1990s, NASA plans to release two tethered satellites from the Space Shuttle. The first will float skyward on a taut 13-mile cord, generating electricity as the tether cuts through the ionosphere. The second will deploy Earthward on a 65-mile cord.



Tethered satellite's tail booms will house scientific instruments.



Boeing's planned 5000-mi.-range supersonic, and smaller Concorde.

center, restaurants and shops. Heat from the parking garage would melt snow on the runways, while under-

ground lights would also delineate runways on the surface. Though the design won't fly under today's FAA regulations, it could influence airport construction in the 21st century.

Meanwhile, in a study commissioned by NASA, Boeing and McDonnell Douglas conclude that the projected boom in trans-Pacific travel justifies building a new supersonic passenger airliner, separate from an X-30 National Aerospace Plane effort. Such a plane would carry three times the payload of the Concorde and cruise between Mach 2 and 3, knocking 7 hours off today's Los Angeles-Tokyo flight time. According to Boeing, a fleet of supersonics will be needed by the beginning of the century to carry an estimated 315,000 daily long-range travelers.



Subsurface highways would feed parking lot, hotels and convention center under Starry's radial airport.

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When I first saw the data from our government's most prestigious laboratory charting their tests of TUFOIL, I almost fell off my chair.

I know TUFOIL is a superior product. After all, I've been working on the problems of dispersing Teflon® or Fluon® in oil since the early 1970's and getting patents all over the world. But here was confirmation from on high! My reaction was, "Wow! TUFOIL's slipperier than Teflon!"

Their test data showed a steel on steel 4-ball surface friction of .029 with remarkably low wear. I rushed to my library, grabbed a lubricant handbook to see if my memory was correct. Sure enough! Teflon was listed at .04.

TUFOIL is not just a little slipperier than Teflon. It's a lot slipperier than Teflon. There was the handbook data right in front of me!

People ask, "Why don't the auto and oil companies recommend TUFOIL?" It's simple. The big oil companies' profit comes from gasoline, not lubricants. The auto companies' comes from car sales. Just think. Some of our test cars are pushing 200,000 miles. If Detroit recommended TUFOIL, they might cut their sales in half... not likely! Some of our customers' cars are well over 200,000 miles, with their engines purring like kittens.

So it's up to you to decide for yourself, just as tens of thousands of our customers already have!

People like you send us letters raving about improved starting, smoother operation, spectacular acceleration, gas savings and much longer trouble-free engine life.

TUFOIL has been written up in prestigious scientific journals, newspapers such as the Wall Street Journal, Boston Globe, New York Times and Christian Science Monitor and tested in Universities and laboratories all over the world. The results are overwhelming! As far as we can see, TUFOIL has the lowest

friction and wear of any known lubricant. TUFOIL is making history!

For the last few years, we've been running full page award-winning ads in NASA Tech Briefs. In them, we call TUFOIL, "The Transistor of Lubrication." Our competitors are way back in the vacuum tube era with products primitive by comparison. No other lubricant even comes close.

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TUFOIL means big savings for you, your car and your machines! So rush your order now and get these marvelous benefits:

- Increases acceleration
- Boosts gas mileage
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- Makes engines run better, last longer

Here's what some of our customers say.

This customer wrote a beautiful 4-page letter raving about gas savings, easy starts. He went on...

"My acceleration was also noticeably increased and where my normal engine running temperature had been with the needle halfway between HOT and COLD, it is now only one third of the way in between."

... R. W., Yarmouth Port, Ma.

This customer got fantastic fuel savings...

"The use of TUFOIL in my autos has been so successful that I purchased a gallon of TUFOIL and now use it in my 3 lawnmowers, garden tiller and shredder."

... D. W., Seattle, Wa.

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Just add one 8-oz. container of TUFOIL to your standard crankcase. (It'll treat 4 to 5 quarts of engine oil.) If you want to super treat your engine, add two bottles! You will see the results in less than 1,000 miles. Once your engine is broken in on TUFOIL, add 4 ounces (½ bottle) with each oil change to keep new performance levels. Use TUFOIL repeatedly over the life of your engine to help keep it purring like new!

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See NASA Tech Briefs for technical details, 1986, 1987 and 1988.

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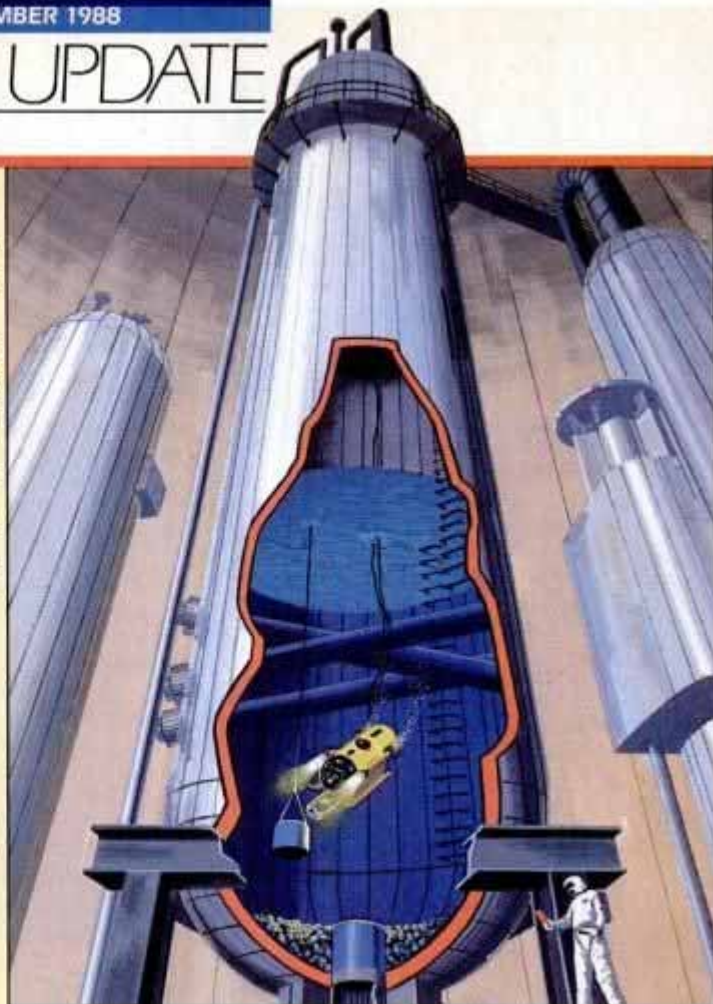
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Robots Hit The Road

NEW YORK, NY—Though robotic wheeled vehicles are still in their infancy, they've developed enough for researchers to test concepts and map out future applications.

Oak Ridge National Laboratories recently gave the Army a roboticized 8-wheeled Chikusui utility vehicle, which will serve as a test platform for planned man-machine interactions. Built for the Soldier-Robot Interface Project (SRIP), the vehicle will roll at the end of a 400-yard fiberoptic cable.

From a remote-control station, teleoperators will propel and steer the SRIP vehicle, monitor surroundings from two vehicle-mounted video cameras, and control a manipulator with a 300-pound lifting capacity. The Army will initially use the vehicle to disarm unexploded artillery shells, but is eyeing future applica-



TV camera inside acrylic bubblefront guides cleanup operation.

Sub Nuke Plant Cleaner

HARRISBURG, PA—A miniature remote-control submersible is the latest robotic vehicle to help decontaminate the Three Mile Island nuclear plant.

The 3-ft. sub is a standard oceanographic vehicle modified for use inside the plant's

cooling-system pressurizer. Radioactive core debris from the reactor vessel had accumulated in the pressurizer's bottom during the 1979 accident. The sub is operated via a cable from another building. Similar subs may be used for other inspections.

Ecology In Space

KENNEDY SPACE CENTER, FL—NASA researchers here are working toward a Controlled Ecological Life Support System (CELSS) for long-duration space flights and, eventually, colonization.

So far, experiments have centered on a hydroponic plant-growth chamber. Tubes in growth trays anchor roots and provide a nutrient solution through porous membranes. So far, Irish potatoes, sweet potatoes and soybeans have been grown successfully. Water vapor given off by plants can be either returned to the nutrient solution or converted

to drinking water. Engineering studies are focusing on environmental control.



Chamber also supports microgravity plant-growth tests.



Army's robot utility cart laden with own electronics boxes.

tions in refueling and nuclear decontamination. Planned upgrades include a tetherless data link and stereo vision.

On the civilian side, researchers at Carnegie Mellon University are giving vehicles total autonomy. They have outfitted a Chevy van with some innovative self-navigation gear, in a project called NavLab—short for Navigation Laboratory.

One essential piece of hardware is a laser rangefinder that scans the road ahead of the van, providing distance information at thousands of points at once.

The result is a low-resolution 3-dimensional image. A cab-mounted TV camera provides additional visual information.

An experimental parallel-processing computer handles the intensive number-crunching that turns these images into useful data. The van uses the data to follow a preprogrammed path. In addition, researchers are testing software that will let the van blaze its own trails without maps. Key tasks will be recognizing and avoiding obstacles. The overall system will guide underwater and Mars-surface explorers.



NavLab Chevy drives itself at up to 2.7 mph.

***THE TOUGH NEW
SPIRIT OF DODGE.***





NEW DODGE CUMMINS

It's been said that there's strength in numbers. That being the case, Dodge has added some impressive numbers to an already formidable lineup. Consider the arrival of our new Dodge Cummins Turbo Diesel. A state-of-the-art 5.9L turbocharged diesel workhorse. Created to not only deliver outstanding fuel efficiency,

but also the fastest acceleration, most towing, strongest altitude performance and longest powertrain warranty of any diesel pickup. The new Dodge Cummins Turbo. Simply put, it's the hardest working diesel pickup in America. And a powerful statement on The Tough New Spirit of Dodge.*

*Acceleration/alt. perf. claims based on USAC tests of D250 vs. comparably equipped '88 Chevy 3500 & Ford F250 models (w/optional auto. trans. & a.c.) under equal loads. Competitive claims based on '88 data ('89 competitive data incomplete at time of printing).



TURBO DIESEL PICKUP.





NEW ANTI-LOCK BRAKING

Performance also comes from within. And our full-size Dodge Ram pickups continue to possess a definite inner strength. Witness new electronic fuel injection on our big available 360 V-8. The result? More raw horsepower. More sheer torque. And more out and out

guts. Not to mention the improved stopping power of all-new anti-lock rear brakes, standard on every full-size pickup we build. Electronically fuel-injected V-8 power. And new anti-lock rear brakes. Two more strong examples of The Tough New Spirit of Dodge.



AND 360 EFI V-8 POWER.





NEW DUAL REAR-WHEEL

Some jobs demand the toughest type of performance. Meet our answer to that challenge. The new D350 Dual Rear Wheel Ram Pickup. With four rear wheels, it does more than just deliver the goods. It improves stability and gives you the kind of increased towing control

that makes heavy trailer duty a breeze. The new Dual Rear Wheel D350. A powerful performer for those with serious towing needs. When you need heavy-duty performance for the long haul, you've got it coming and going. Courtesy of The Tough New Spirit of Dodge.



DODGE RAM PICKUP.





THE TOUGH NEW SPIRIT OF DODGE

THE PERFORMANCE DIVISION OF CHRYSLER MOTORS

BUCKLE UP FOR SAFETY.



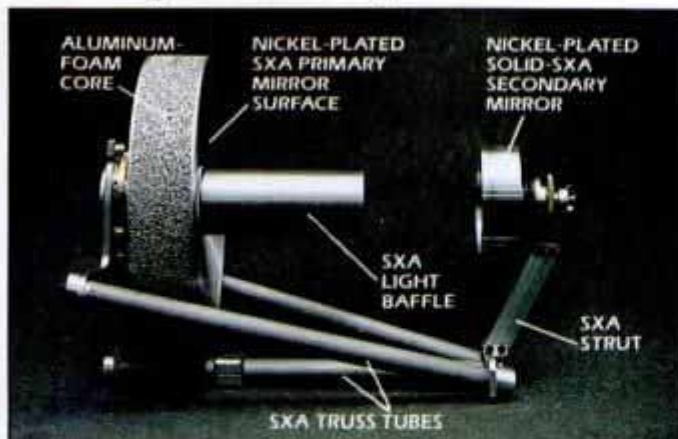
7/70

With all that's new, there's one thing that remains unchanged. Our commitment to be the best. That's why every U.S. built Dodge truck comes equipped with the longest powertrain warranty in the business. 7 years or 70,000 miles. And as if that weren't

enough, our new Cummins Turbo Diesel carries a 7 year or 100,000 mile engine warranty. See these limited warranties, their restrictions and the entire lineup of tough Dodge trucks at your Dodge dealer. And experience The Tough New Spirit of Dodge.

TECH UPDATE

Ultralight Telescope



Metal-foam core and SXA construction allow weight reduction.

TUCSON, AZ—Using two lightweight materials, University of Arizona engineers have pared down a 12-in. reflector telescope from 50 to 10 pounds. Contributing to the breakthrough is an aluminum-foam primary mirror that weighs only 4½ pounds.

A comparable glass mirror would weigh 20 pounds. SXA, a new aluminum-silicon carbide composite used for other parts, also helped shave pounds off the telescope. In the future, they hope to use foamed SXA in the cores of primary mirrors.



Computer anatomy hardware.

Cadaver On Videodisc

PALO ALTO, CA—Anatomy students may soon be using the Electric Cadaver, a new computer-based learning tool developed at Stanford University. The system started with 1600 standard-

reference dissection slides and anatomical line drawings, which were digitized and transferred onto videodisc. Associated software allows a user to view parts of the body at different angles.

Wiring The World With Superconductors

NEW YORK, NY—Engineers are trying to harness the promise of new high-temperature superconductors. One practical application: electrical wire that carries current without resistance.

At Georgia Tech, researchers are working with chemical vapor deposition to coat thin fibers with superconducting material. The process involves piping several ele-

ments in gaseous form into a furnace. Once inside, they react chemically and deposit a solid layer on an object.

The Tech group has had success creating shatterproof ceramics with this technique. Since the new superconductors are ceramics, the group is hoping to both reduce the materials' brittleness and boost their current capacity by depositing rela-

tively thick layers on to thin nonconducting fibers. Another focus will be forging junctions between superconducting wires and normal electric and electronic hardware.

Meanwhile, applied physicists at Stanford University are using a method called laser-heated pedestal growth. This technique allows formation of single-crystal fibers, which have very pure superconducting properties.

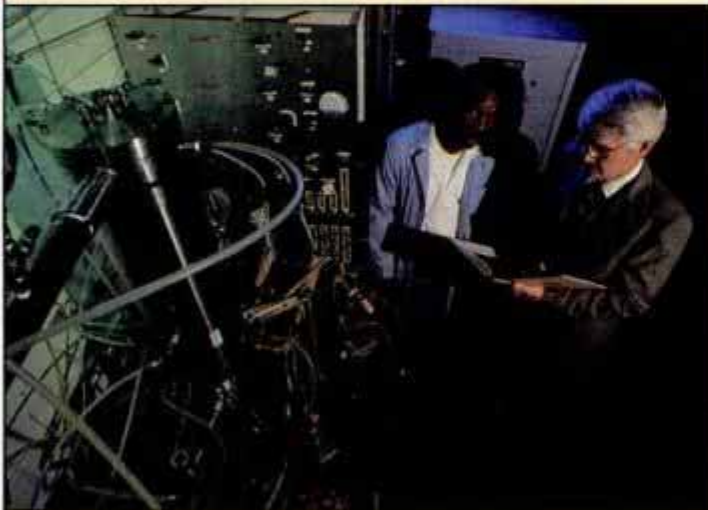
First a rod of the superconducting material is formed. Laser beams melt the top of the rod, and a "seed" of the material is pushed into the heated area.

When the seed is slowly pulled away, a crystal fiber is drawn out like a string of Turkish taffy.

The Stanford scientists have used the process to study superconducting crystals. But the fibers grown show signs of being able to handle high currents, a property that will help transform superconductors from lab curiosities into useful tools.



Inside pedestal-growth chamber (above) curved reflector focuses laser beam on all sides of hot spot. Process (below) involves pulling fiber away while feeding more source material into molten zone.



Chemical vapor deposition takes place in steel-jacketed furnace.

Prop Plane To Break Sound Barrier



Mach Buster I features tail-pusher prop and high stubby wings to maximize lift-to-drag ratio.

SAN RAMON, CA—This supersonic needle-nose is designed to shatter speed records at a projected top velocity of 950 mph. No prop plane has ever topped Mach 1. Built for the Reno and other unlimited-class races, the aircraft will draw power from a super-charged automotive V8 that burns methanol. A 4-blade propfan will push the plane. NASA and fighter-jet engineers contributed to the design. Future versions will use turbine and jet engines.

Special Report: SDI Research Finds Civilian Spinoffs

WASHINGTON, DC—The Pentagon has pumped billions of dollars into research on high-powered beam weapons under the Strategic Defense Initiative (SDI).

Moreover, the medical community wants to take advantage of the FEL's tunability, searching for the best wavelengths for specific laser-tissue effects. One focus

is photodynamic therapy, in which a laser selectively destroys cancerous cells that have absorbed light-sensitive chemicals. The FEL will aid development of a variety of such chemicals that react to different wavelengths. Researchers are exploring a similar process to cleanse viruses from blood.

Civilian applications may also fit the accelerators that deliver high-speed electrons into FELs. At Lawrence Livermore National Laboratories, researchers have conceived commercial uses for the compact, superefficient linear induction accelerator.

One possibility is a food-irradiation process that doesn't rely on radioactive material. Instead, accelerators would slam electrons into metal plates, directly triggering X-rays. Such a system could run off a 750-kilowatt diesel generator.

In another setting, the accelerator could shower electrons through powerplant emissions. The electrons would add an electric charge to the gases that contribute to acid rain, allowing electrostatic cleaners to filter them out of emissions.

Meanwhile, researchers also envision commercial uses for a different kind of SDI accelerator—one ironically invented in the Soviet Union. Known as a radio-frequency quadrupole accelerator, the device is small enough to sit on a tabletop. That has made



Low-power versions of free-electron laser (above) would cut clean without charring of carbon dioxide lasers (left).

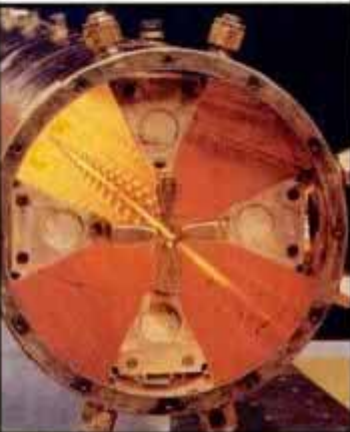
Whether or not such exotic artillery ever comes to be, the funding has nurtured technology with numerous nonmilitary applications.

Medical researchers, for example, have been showing great interest in scaled-down versions of the free-electron laser (FEL).

The FEL uses an array of magnets to warp the path of a near-speed-of-light beam of electrons. Its output: short high-energy laser pulses, which permit cleaner surgery without the charring associated with other lasers.

is photodynamic therapy, in which a laser selectively destroys cancerous cells that have absorbed light-sensitive chemicals. The FEL will aid development of a variety of such chemicals that react to different wavelengths. Researchers are exploring a similar process to cleanse viruses from blood.

Civilian applications may also fit the accelerators that deliver high-speed electrons into FELs. At Lawrence Livermore National Laboratories, researchers have conceived commercial uses for the com-



Radiofrequency quadrupole focuses particle beam.

it a focus of interest for powering space-based particle-beam weapons. In civilian settings, such particle beams could deliver cancer therapy, produce radioisotopes for medical diagnostic scanning, probe metal aircraft components during quality-control inspection, and detect explosives at airports.

Portable food irradiator in trailer-mounted operation.



LIVERMORE PHOTO

LOS ALAMOS PHOTO

PM ILLUSTRATION BY ADOLPH BROTHMAN

Marlboro Lights



The spirit of Marlboro in a low tar cigarette.

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SURGEON GENERAL'S WARNING: Cigarette
Smoke Contains Carbon Monoxide.

10 mg "tar," 0.7 mg nicotine av. per cigarette, FTC Report Feb '85

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M E R C U R Y

WHERE COMFORT AND CONTROL ARE ONE.

FREEWHEELING

BY TONY SWAN

"Tucker: The Man And His Dream"

ALTHOUGH the auto industry has produced its share of colorful personalities, few have had the kind of life story that packs movie theaters. If you made up a list of autodom's bigger-than-life characters, then winnowed it down on a basis of drama quotient, it's fair to say the list would be no more than a few names long.

And if you were Francis Ford Coppola or George Lucas, the name at the top of your short list would be Preston Thomas Tucker.

America was hungry for new cars in the revitalized economy of the late '40s, and the car Preston Tucker proposed was new and then some. The projected engine, worked up from a design by Tucker's friend Harry Miller, of Indianapolis fame, was an aluminum 589-cu.-in. opposed Six, featuring hydraulic overhead valves, hard-chromed cylinder bores, a cast-magnesium sump, hemispherical combustion chambers and fuel injection. Horsepower was modest at 150, but torque was massive—450 lb.-ft.

The prototype drivetrain was just as novel. Electing to mount the engine at the rear, Tucker and chief engineer Ben Parson planned to get power to the rear wheels via a pair of variable-pitch torque converters.

Other mechanical points of interest included 4-wheel disc brakes with full friction surfaces (as distinct from the spot calipers used today), fully independent Torsilastic suspension using torsion bars with rubber damping and a safety glass windshield that popped out on impact.

The shape that surrounded the Tucker's intriguing engineering still looks good today. Before America had

even been introduced to the annual new-model litany—"longer, lower, wider"—this Alex Tremulis design, which went from concept sketch to running prototype in just 100 days, set striking standards for all three. The



Jeff Bridges brings Preston Tucker to life on the silver screen.

Tucker stood only 60 in. high, and looked lower still, thanks to an overall width of 79 in. Overall length was 219 in., and the wheelbase was 130.

To make his low-slung design user-friendly, Tremulis extended the doors into the roofline, beating Detroit to the punch by some 15 years. Frontal area was plentiful, but the shape had excellent aerodynamics—Tremulis calculated a C_d of about 0.30.

There was enormous interior volume—enough for "six Chicago Bears fullbacks," according to Tucker—and a number of interesting safety touches like dashboard padding and reinforced crash wells for driver and passenger to drop into when collision seemed imminent.

The car's center-mounted third headlight, which tracked with the steering, may not have been accurately classifiable as safety equipment, but it did seem well calculated to add inter-

est. And from the car's first showing, in 1947, there was plenty of that.

The manufacturing realities of an undercapitalized firm dictated a number of mechanical changes in the actual production car. The Miller/Parson engine proved to have more problems than benefits, so Tucker substituted a 334-cu.-in. Franklin flat Six originally designed for use in helicopters, adding water-jacketing and one of the industry's first pressurized cooling systems in the process. The twin torque converters gave way to more conventional transmissions, one of them borrowed from the old 810/812 Cord, and the disc brakes were replaced by conventional drums.

Nevertheless, the Tucker was an impressive performer for its day. With the Franklin engine punching out 166 hp and 372 lb.-ft. of torque, the 4260-pound car could hit 60 mph in about 10 seconds, and

had a top speed of about 125. A pair of Tuckers spent 10 days at Indianapolis in July of 1947, putting in about 8 hours per day at speeds over 100 mph, and another Tucker set a production-car record at Bonneville with a 2-way average of 131.64 mph.

Pilot production got underway in Tucker's vast Chicago factory, a war surplus facility formerly devoted to aircraft, in 1949, but serious problems loomed. Although Tucker had thousands of orders from an enormous dealer body, whose members had paid cash for their franchises, he was cash-poor and under severe scrutiny by the Securities and Exchange Commission. On March 3 of 1949, the Tucker works was shut down, although a few employees hand-built 12 more cars, bringing the total production to 51.

In October of that same year, Tucker and his chief lieutenants went into Federal Court in Chicago to face a 31-count indictment for mail fraud and violation of various SEC regulations. They were acquitted on all counts, but their company was dead.

Francis Ford Coppola's portrayal of all these events

(Please turn to page 33)

How to build clothes that last 100 years.



For 100 years, we've been building clothes that last. That's because Carhartt brown duck garments,

for example, are made with only the finest 100% cotton duck fabrics available.

And unlike other companies, we triple-stitch the main seams for more strength than the material itself.

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No one told us we had to build Carhartt clothes this tough. But we know that if we didn't, they wouldn't last as long.



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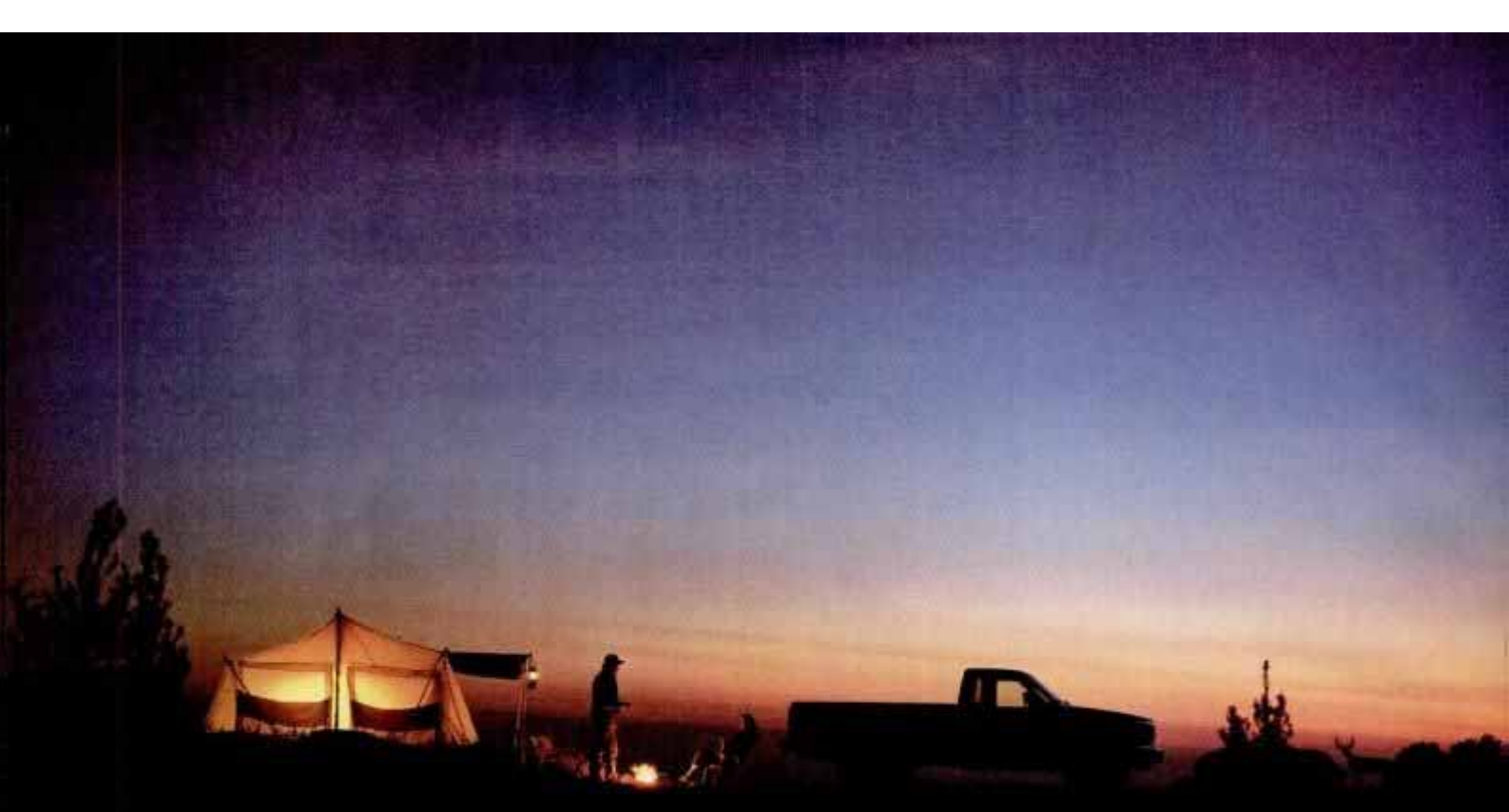
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It came with power steering, power brakes and a rear-wheel anti-lock brake system (operates only in two-wheel drive). Optional Rally Wheels, four-wheel drive, air conditioning and an electronic stereo radio with cassette made it a personal truck.

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FREEWHEELING

(Continued from page 30)

would have us believe that Tucker was a victim of collusion between the automotive establishment and government influence-peddlers. The suggestion is that Tucker's car was so revolutionary that the Big Three banded together to squash the fledgling company before it could fly.

The truth is more mundane. Tucker's company suffered from the worst of all corporate afflictions—inadequate financing—a disease that few new businesses ever survive. But Coppola and leading man Jeff Bridges do capture the essential quality that endeared Preston Tucker to post-war America: Tucker dreamed in technicolor, and on a big screen at that.

And for that matter, Tucker is a more sympathetic character than some of the would-be carmakers who've come along since. Imagine this same movie with John DeLorean cast as the hero.

Bondomobile

At first glance it seems a little startling to see a distinguished hotshoe like Bob Bondurant with a rig like the one pictured here. But when you think about it, who has more right to a set of training wheels than America's best-known trainer of high-performance drivers?

And they are, in fact, training wheels, but not in the beginner bicycle sense. Each of the outriggers contains a hydraulic hoist, controlled by the instruc-



Outrigger-equipped Skid Car has become a fixture in the Bondurant driving school.

tor from inside the car. The idea is to hoist one or more corners of the car, thus altering the coefficient of friction between one or more of the tires and the road surface which, come to think of it, is a pretty good recipe for a skid.

That's the plan, of course. The Skid Car's magic outriggers allow instructors to give students a grounding in skid response without a big, nasty oil-covered skidpad. The Skid Car duplicates the loss of adhesion that goes with ice, snow and slush.

While this may be overkill for training new drivers in your household, Bondurant does have plans to market the Skid

Car rig. If you've always wanted to be first on your block with a new toy, this gadget's a guaranteed winner.

Sympathy For The Devil

As you might expect, people in the business of directing traffic and writing parking tickets aren't exactly respected by their fellow citizens. What you might not expect is just how disrespectful we can become.

A case in point is New York City's Traffic Control force, an unarmed police auxiliary group whose basic function is to keep Manhattan out of the throes of gridlock. When you stop to consider that Manhattan swallows some 1.7 million vehicles every day, it becomes plain that this assignment ranks right up there in the realm of heroic, although it's hard to think of someone who's screaming at you to "move it! move it! move it!" as a hero.

Nicknamed the Brownies, for their brown uniforms and patrol cars, these are the people who, among other activities, take over intersections during rush hour and cause cars to be towed away with dismal regularity.

Since a New York City tow job costs \$200—that's cash only, mister—this sort of thing tends to make the Brownies a little unpopular.

How unpopular? Of the current 2400-

member force, almost half report that they've been physically assaulted at one time or another or have at least experienced verbal abuse. There were 538 Brownie assaults recorded in Manhattan in 1987, more than 1986, and 1988 is running well ahead of that.

The pay for this hazardous profession averages about \$18,000 per year, which is about enough to keep you fed in Manhattan—provided you're on a 1500-calorie diet and eat every other day. And housing is another matter altogether.

Most Brownies dream of the day they'll be elevated to a job less dangerous—like manning a toll booth. **PM**

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* Retained value percentage based upon the MSRP of three-year-old comparably equipped vehicles produced during the years 1982-85, compared against the average wholesale auction price of vehicles as reported in the January 1985-1988 issues of the National Automotive Research Black Book. Deloitte Haskins & Sells, independent certified public accountants, have compiled the resale value percentages.



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OLD HOUSE RESTORATION

BY BOB VILA

The Art Of Stenciling

STENCILING is a relatively easy and economical way to decorate a home—old or new. Whether you desire an authentic period look or a contemporary look, the possible combinations of design and color give you plenty of options from which to choose.

Although it's common today for custom stencilers to unify a room using patterns from draperies and furniture, old-house owners—striving to re-create the past—will want to use stencils common to the period of their home. No matter what era you're trying to re-create, from Early American to post-Victorian, you should consider stenciling as a part of your historical decorating plans. But before you begin, it's helpful to have some historical knowledge of the way stenciling has been used in this country.

Stenciling in America

In early American times, stenciling was generally done by itinerants who traveled the countryside practicing their art. These early hand-cut stencils were usually only two colors, and the designs were not very complex or precisely measured.

During this period, many stencil designs were based on the feel of the new nation. Stencils patterned with eagles, bells and swags abounded and the colors tended to be bright and vivid. It wasn't unusual to find nearly every inch of wall space in an Early American home covered with these simple patterns.

Stenciled floors were also popular because carpeting and rugs were still too expen-

Contributing Editor Bob Vila is host of public television's "This Old House."



In colonial times it was not uncommon for people to stencil nearly every square inch of a wall surface, using various patterns.

sive. Sometimes a border was used to edge around the floor, then the center section was patterned throughout to simulate the look of a rug. Other times, an all-over pattern was stenciled with no definable borders.

During the Victorian era, stenciling became much more sophisticated and was a decoration available—for the most part—only to the elite groups who could afford it. With the advent of machine-cut stencils, designs became much more precise and geometric with rigid lines or very flowing and intricate patterns. Much more formal than the earlier stencils, only the most talented professionals could work with these fancy designs.

In Victorian homes, stenciling was usually used high up around ceilings, coves and friezes. Patterns were much larger, based simply on the

high-ceilinged architectural structure of this period. It wasn't uncommon to see Victorian stencils 10 to 14 in. high.

Like everything else, the color pallet, too, changed to reflect the times. *Muddy or dirty* colors, like oxblood reds, drab olive greens and lots of blacks and browns, abounded. (Of course, only a real purist would want to decorate with these colors. Many times, a period design is stenciled in an old home using colors popular today.)

Although stenciling continued through the mid-19th century, it waned because of the Industrial Revolution and the abundance of rugs and wallpaper that followed. No longer a major decorating movement, stenciling nevertheless did not disappear but continued adapting to change through the Art Nouveau and Craftsman periods.

Finding patterns

Many of the stencils you'll find commercially are designed with the feel of colonial and country homes. Fortunately for old-house restorers, reproductions of stencils found in historical homes are also available. Adele Bishop (P.O. Box 3349, Kinston, NC 28502) and Decorative Arts Studio (RR #1, Box 136, Route 30, Dorset, VT 05251) are two companies I know that carry authentic stencil designs.

There are also some excellent books available to help the old-house restorer. If you're an Early American enthusiast, *Early American Stencils On Walls And Furniture* by Janet Waring (Dover Publications, Inc., New York, NY; \$9.95) is a wonderful reference tool. Dover also publishes a series of inexpensive *Cut & Use* stencil books, containing authentic stencil designs from several historical periods.

In those rare instances when nothing you find seems appropriate, you can always make your own stencils. Sometimes patterned after old wallpaper or perhaps a design found carved in wood trim, homemade stencils are truly a unique way to decorate your rooms.

It takes a little practice to create a workable stencil, so it isn't something I'd recommend to beginners. But for those who have some experience working with commercial stencils, it shouldn't be too difficult. I've found the best material to use for this is a polyester film called Mylar. In its briefest form, creating your own stencil involves tracing the design on to the Mylar with a permanent marking pen, then cutting out the design with a razor-blade-type knife.

(Please turn to page 36)

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(Continued from page 34)

Tips for success

Surprisingly, stenciling is a very easy technique to learn. Sharing some tips I've learned through the years will help you get started.

As far as materials go, you must use a stencil brush if you expect expert results. Choose a natural-bristled brush rather than a synthetic one—the bristles on the latter are too stiff. Although you can use water-based paints, most experts use oil-based Japan paints. The main advantage Japan paints have is

that they dry instantly, which eliminates the smudging that can result from moving a stencil over an area of still-wet paint. Also, the color quality of these oil-based paints is simply wonderful. By nature, they provide the ability to shade and make the paint look old—something you just can't do with most acrylics.

Part of the magic of stenciling is that there really is nothing you can do that can't be fixed. Think of the wall as a giant blackboard. If you make a mistake, you just have to touch up the spot with a

bit of wall paint and start over.

One of the hardest techniques to learn is how much paint to put on the brush. Very little is required for each stencil. Never dip the brush directly from the paint to the wall—you'll have far too much paint on the surface. Instead, towel out all excess paint, then touch just the tip of the brush to the wall.

Coupled with the importance of the amount of paint you put on the brush is the fact that the paint must also be kept at the right consistency throughout the project. The best way to do this is to pour a teaspoon or two of paint into a saucer. Then add a few drops of paint thinner or mineral spirits periodically to ensure it stays loose and smooth.

You'll be surprised how little paint you'll use. For example, a 2-ounce can of Japan color easily will be enough to stencil a green vine completely around the frieze in a 10 x 12-ft. room!

What about surface preparation? Al-

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Floor stencils, painted onto a light-colored background, were used in place of rugs.

though you don't need freshly painted walls as a base to stencil, the paint job should be relatively new—say within six months or so. Other than that, you don't have to do any special surface prep. It's not necessary to seal the stencils either, although some folks do protect this decorative work with a coat of polyurethane or latex-based finish.

Stenciled floors, however, are another story. The wood must be sanded first to remove all traces of wax, polyurethane, dirt and grime. Next, you can stain or paint the floor, then stencil. Finally, follow the stenciling with a minimum of three coats of polyurethane. (If the floor is in a high-traffic area, like a kitchen, add a few extra coats.)

If it's done correctly, a stenciled floor will last a long, long time. And, aside from periodic damp mopping, it's maintenance free. Of course, you'll have to keep an eye on the polyurethane. When it begins to wear, recoat the floor. **FM**

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Материал подготовлен редакцией журнала "Оружие"

BY TIM COLE

Simulating Planets In The Laboratory

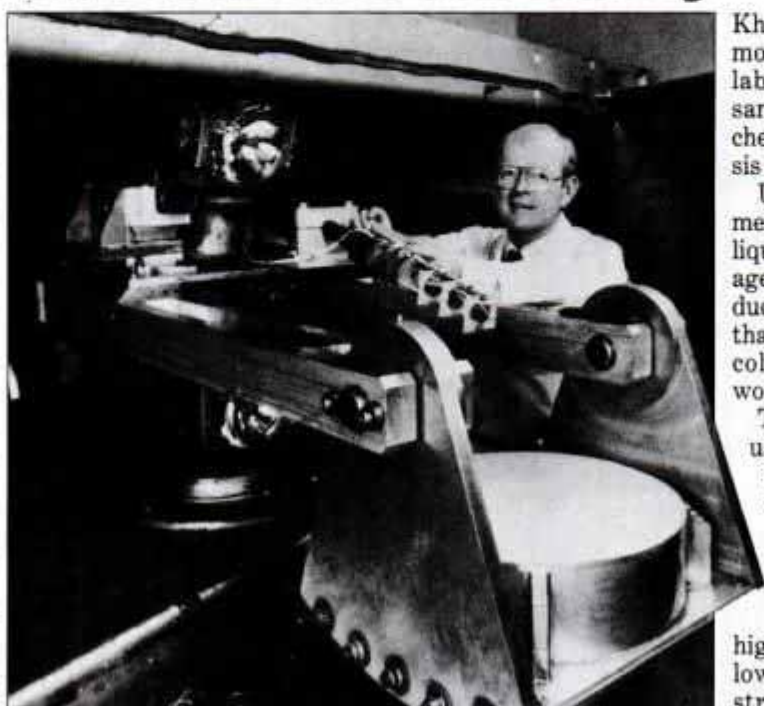
UP UNTIL now, our knowledge of the solar system was limited largely to visual observation from Earth and from remotely controlled spacecraft like *Voyager 2*. But now, scientists are re-creating planetary environments in the laboratory that give new insight into the dynamics of other worlds.

Dr. Robert Schmidt of the Boeing Aerospace Co. has developed a technique for duplicating the cratering that characterizes the solar system's inner, or terrestrial planets, and the moons of the outer planets. Under a 3-year, \$200,000 NASA study, Schmidt is using a powerful centrifuge that can generate up to 600 Gs to form craters in soil combinations or a Permaplast modeling clay. The scaled-down craters simulate craters as large as a mile in diameter.

"Much of the information we have about the planets comes from observing their surfaces," says Schmidt. "All of the planets have been continually bombarded throughout their histories, and craters are the fingerprints left by these impacts."

The size of a crater is proportional to the energy that it took to create it. Inferences can be made as to the kinds of bodies that swirled through the solar system just after the planets coalesced from an aggregate of asteroids and dust.

A 30-hp electric motor powers the Boeing centrifuge, which is housed in a protective shield. Samples are placed on the machine's "swinging basket," held in place by the building G force. A gun powered by a hybrid powder/gas charge sends a polyethylene projectile into the sample. The formation of the crater is recorded by a



Boeing Aerospace Co.'s Robert Schmidt and his cratering machine.

pair of Nikon F2 cameras.

The Boeing centrifuge also permits parallel studies of the cratering effects of high explosives.

"The real advantage of the device," Schmidt says, "is in helping us develop scaling laws. We can very nearly duplicate an actual hypervelocity impact. And then we can

study parametric variations by changing the G field or lithostatic pressure."

Like the Boeing investigation, a recent Cornell study attempts to duplicate planetary conditions in a controlled environment. Cornell University's redoubtable Carl Sagan and his associates Reid Thompson and Bishun



Carl Sagan (center) and the Cornell team with their Uranus simulator.

Khare have created the atmosphere of Uranus in the laboratory, concocting the same carbon-based organic chemistry that forms the basis of all known biology.

Using a complex arrangement of glass tubes, dry ice, liquid nitrogen and high-voltage coils, the team has reproduced the chemical interplay that forms the content—and color—of this frigid outer world.

The planetary simulator uses a series of tubes to feed simple gases thought to occur in otherworldly atmospheres—methane, hydrogen, helium—into a glass receptacle surrounded by a high-voltage coil of wire. At low pressures similar to the stratospheres of outer planets, the gas molecules are rearranged by a plasma of electrons similar to those in Uranian auroras.

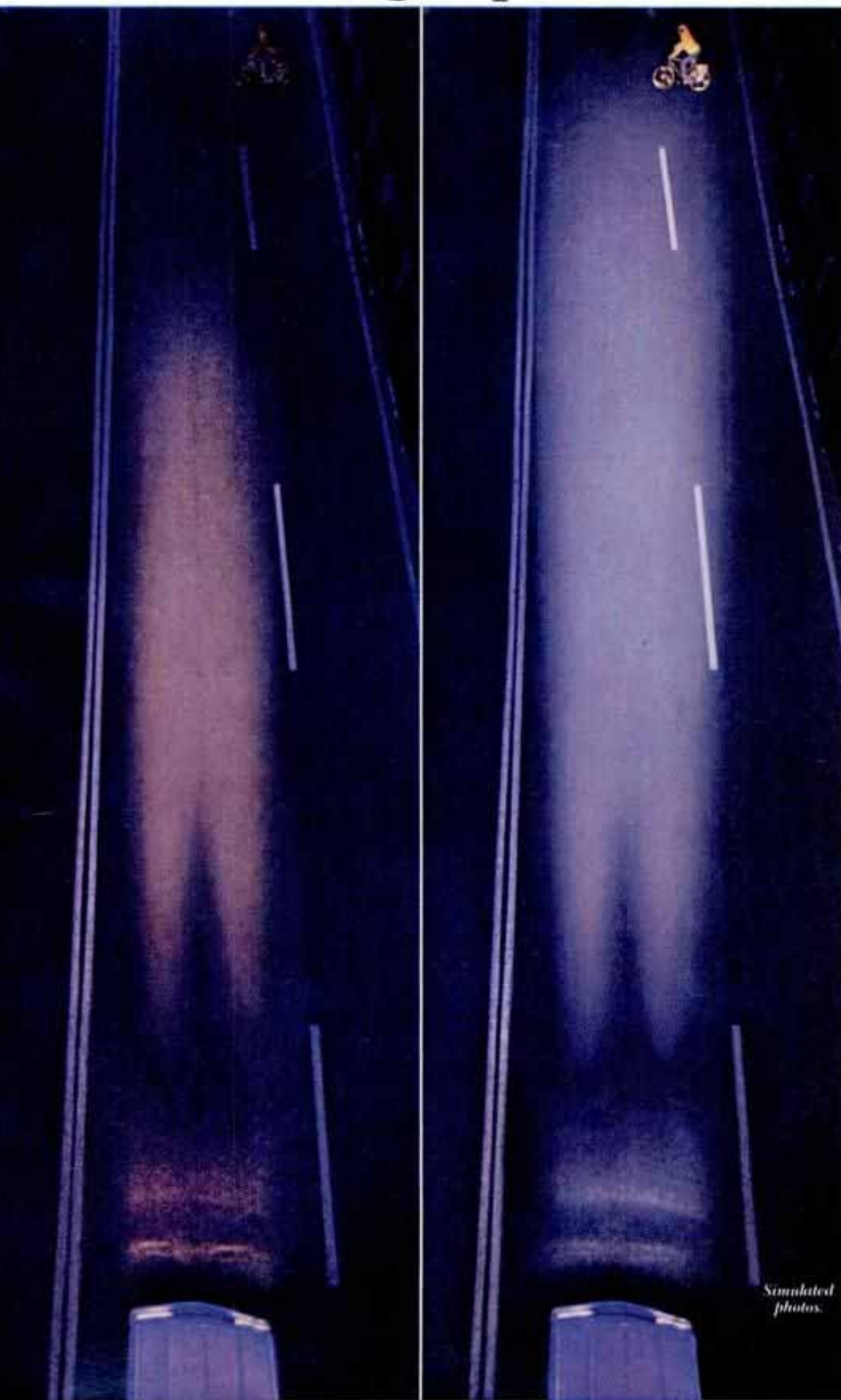
After this electron bombardment, the working gases commingle in unique ways, synthesizing dozens of organic compounds—substances that may be the font of life on other planets. The compounds are then condensed and removed for analysis using gas chromatography/mass spectrometry techniques.

In an interesting parallel, exposure of these base gases to plasma electrons produces compounds that closely match the reddish hues or "optical constants," of Uranus's atmospheric aerosols as set by *Voyager 2*.

Planetary simulations are expected to become a more important field as a new generation of interplanetary spacecraft like *Cassini* and *Magellan* are prepared for liftoff, and the venerable *Voyager 2* approaches Neptune for an August 1989 flyby.

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IMPORTS

BY BILL HARTFORD

Peugeot 405 Makes A Dramatic Entrance



Peugeot 405 S has alloy wheels and excellent complement of standard equipment.

WAITING for Peugeot, a drama enacted at PM's Broadway offices, had us on the edge of our seat for months. Before the curtain went up on the introduction of the new, front-wheel-drive 405 sedan in the United States, and before our long-awaited test drive, the Pininfarina design had already stolen the spotlight in Europe.

Soon after the French 4-door's bow on the Continent last autumn, it ran away with several honors, ultimately taking the European "Car of the Year" award. Then, this July, as the first U.S. models were making their way here, the 405 Turbo 16 rally car became king of the hill as two of them blasted to the top of Pikes Peak. They finished 1-2, the first 405 setting a new record time of 10 minutes, 47.22 seconds for the 12.42-mile "Race to the Clouds."

With Peugeot at center stage, we were more than ready to get behind the wheel of a 405.

When we did, it was the 3-spoke, leather-wrapped wheel of the top-of-the-line Mi 16, the car with the highest excitement and comfort level among the three models in the series.

The 405 Mi 16 (\$20,700) is a striking automobile, espe-

cially in the black paint and gray leather interior of our test car.

Recognized by the rear spoiler on the trunk lid, the Mi 16 has the 16-valve, dohc, 150-hp version of Peugeot's



Ergonomic perfection: relationship of dash, controls, driver's seat.

1.9-liter Four. Standard on the Mi are fabulous butt-gripping leather sport seats, Alpine stereo, halogen fogs and the equipment that's listed below for the S model. Only Mi option, available soon, will be ABS brakes.

The 405 S (\$17,700) is the best buy of the three models. Its 1.9 doesn't have 16 valves (the sohc is rated at 110 hp), but it shares with the Mi such goodies as power moonroof, dual power heated side mirrors, cruise control, power windows, power antenna and electrically heated front seats.

The 405 DL (\$14,500) is a very civilized base model,

\$6200 less than the Mi and \$3200 less than the S, but still sharing with them the same Bosch Motronic system for fuel injection and electronic ignition, super suspension setup, 4-wheel discs, a/c,

there's more growl than purring from the engine behind the lion badge: Mechanical noise from the 16-valve lets you know you're in a sporting sedan—as does the suspension, independent all around, which bestows superb ride and fun handling.

It's easy to perceive the quality built into the 405 models, and just as easy to realize that a certain exclusivity will be built in, too: We will get only 1200 a month.

Geo Storm

Geo. Great name for a line of world cars—GM's imports from Japan and those it manufactures jointly with Toyota. In '89, we'll have the Geo Prizm (formerly Nova), Geo Metro (formerly Sprint), Geo Spectrum (formerly Chevy Spectrum) and Geo Tracker (a second-generation Samurai). In 1990, the Geo Storm, seen here, will replace the Spectrum. **PM**



With 1.5-liter, 16-valve, twin-cam Four, '90 Storm hatchback will fly.

ELECTRONICS

BY STEPHEN A. BOOTH

Shake, Rattle 'N' Roll

EVERYONE'S probably got a list of inventions which have contributed to human progress or, at least, improved the quality of life. A typical roster might include the radio, telephone, hot and cold running water, and high-speed dental drills. Video cassette recorders and camcorders don't quite belong in the same category as pasteurization or the wheel, but they do add a measure of convenience and joy to life.

One recent refinement in the camcorder department merits attention, because it eliminates one objectionable side-effect of otherwise enjoyable homemade movies. This refinement is the electronic image stabilization (EIS) system reported in last month's "Home Video" column (page 50).

Camera shake has afflicted home movies ever since Kodak bestowed its 16mm Model-A Cine camera on an unsuspecting public in the 1920s. Jittering, rolling images are almost a sure bet in amateur movies because the camera's base is a most unstable one—a walking, talking, breathing human being. Unlike professional moviemakers, amateurs rarely use tripods or rolling dollies to track the action flat. Lugging such gear would defeat the purpose of lightweight, portable camcorders. It would also inhibit the spontaneity that compact, self-powered electronics affords.

Once again, electronics has come up with a remedy. Image stabilization systems costing tens of thousands of dollars have existed in the professional realm for some years, but now EIS can be found in top-of-the-line camcorders in the \$2000 range. An explanation of how the compensation works, and a

diagram of the smart lens systems, comes from Panasonic, which manufactures the camcorders under its own brand name and others.

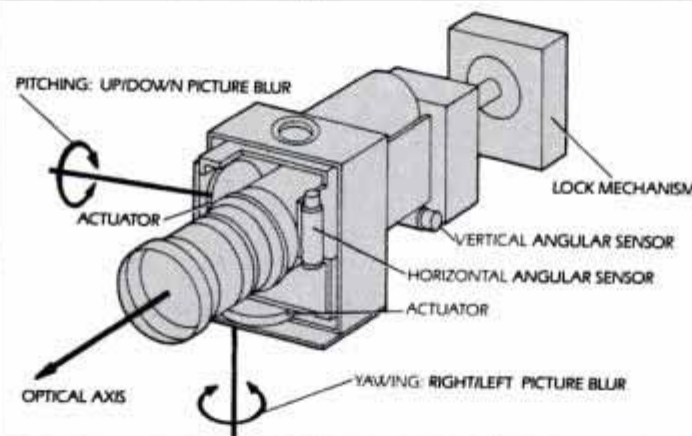
According to the company, its EIS system can detect and compensate for about 80 percent of excess, undesirable camera motion. It operates in both the horizontal plane, side to side, and the vertical plane, up and down.

The image-taking lens itself is gimbal-mounted with-

nal. This signal, once amplified, is transmitted to a servo control system. With virtually instant response, actuators in the servo system apply the appropriate amount of movement to the lens to counteract the direction and force of the camcorder's movement.

As beneficial as EIS might be, there are instances where it might prevent creativity—such as when the videographer wants to sweep

How Camcorder Image Stabilization Works



EIS system sensors detect motion and direct actuators to compensate.

in the camera body, much the way a compass or a stove is mounted in a pleasure boat to keep it level. But whereas these items are installed with a passive mounting system, the EIS apparatus is active and electronic.

Motion is first detected by a device called the angular rate sensor. One is sensitive to horizontal motion, called yawing, and the other to pitching, or vertical movement. Excessive yawing would cause sideways, left/right picture blur. Pitching would mar your movies in the up/down direction.

When the sensors detect any disturbance in their respective planes of sensitivity, a piezo crystal in the sensor emits an electrical sig-

nal. This signal, once amplified, is transmitted to a servo control system. With virtually instant response, actuators in the servo system apply the appropriate amount of movement to the lens to counteract the direction and force of the camcorder's movement. This is as it should be in a high-priced camcorder that is likely to appeal to creative videographers. Most likely, though, the vast majority of home moviemakers will leave the EIS system on constant vigil.

What's good for videography is also good for still photography. Electronic Image Stabilization is coming for film cameras.

Canon has shown advance prototypes of its system, for point-and-shoot cameras as well as more sophisticated SLRs.

Kiddy Computer

Children love to play grown-ups—but this charade quickly loses its charm when your kid borrows your computer for a toy. Although it's now fashionable for children to have everything the folks have, from designer clothes to cameras, the most indulgent parent might draw the line at buying Junior a PC—even bargain-basement clones run about \$800.

One way around the horns of this dilemma is to introduce Junior to JC, The Junior Computer—a \$70 educational toy from San Jose, California-based Integ.

This child's computer is a laptop look-alike, with pop-up screen and built-in carrying handle, 76 alphanumeric keys, cursor controller and more. Built-in educational programming includes games to improve reading, arithmetic, artistic, musical and problem-solving skills. Optional plug-in cartridges (\$20 each) enable the young user to store and save his efforts, or, go on to more advanced tasks.

JC runs on four C batteries and, just like a real laptop computer, it will turn itself off to conserve power if left unattended for more than 5 minutes.

FM

Junior Computer educates kids and looks like the real thing.



CAR CLINIC

BY MORT SCHULTZ

"Weight" And See

IS IT TRUE that the weight of a lot of keys on a key ring can damage an ignition lock? Someone told me I should keep the ignition key on a separate key ring, but there's no statement to this effect in my 1985 Oldsmobile owner's manual.

ERIC SWENSON
OMAHA, NE

One of the series of tests given to ignition locks at the Lock and Key Division of Briggs & Stratton, the principal supplier of ignition locks to GM, is called the pull test. It involves hanging weights from locks that simulate a full load of keys on key holders. These tests confirm that keeping keys on a key ring that includes the ignition key will not damage an ignition lock. Has anyone out there had a

different experience? If so, let's hear from you.

Bright Eyes

I have a 1983 Jaguar XJ12 and wish to replace the standard headlights with halogens. Will this cause any problem with the electrical wiring?

W.R. M'NICHOL
PARAMUS, NJ

No. But if you're not careful, it could cause a problem with the state of New Jersey. It depends on what kind of halogen headlamps you want to install.

If you have in mind a European-style 2-part headlamp consisting of a separate reflector and halogen or quartz-iodine bulb, my advice is don't do it. There's a law on the books—an old law to be sure, but a law nonethe-

less—that prohibits European-style 2-part headlamps in the United States because of the possibility that the reflective material will deteriorate.

When you take your car through the annual inspection required by New Jersey, one of the more stringent state inspections in the country, you'll flunk. To pass, you'll have to install sealed beams. Which brings us to this—you can buy halogen sealed-beam headlamps for your car which are approved by the Department of Transportation (DOT).

These units bear the letters DOT. They are available at places like K mart and Sears, as well as from autoparts and supply dealers. They're not as bright as the Euro-spec lamps, by DOT regulation, but they're at least a little better than the conventional

tungsten sealed beams.

Incidentally, a lot of newer cars are using halogen lamps with polycarbonate lenses, and if you have one of those, you're stuck with replacing them with original-equipment style lamps.

Court Of Last Resort

You are my last resort, before I sell my 1981 Cutlass Supreme with a 260-cu.-in. engine that's been driven only 19,000 miles. A strong odor of gasoline in the garage after I park the car for the night has been driving me nuts. A mechanic at the local garage did a tuneup and swears there are no leaks. I've taken the car to the local Oldsmobile dealer who says there's nothing wrong.

What gives?

JOE GRUM
NORTON, OH

Tire Mix & Match Chart

Snow tires should be applied to the drive axle (whether front or rear) or on all four wheel positions, as desired. Where two snow tires are used, check compatibility with other tires on vehicle as recommended in the chart below.

		FRONT TIRES (READ DOWN FOR REAR TIRE RECOMMENDATION)												
		BIAS on front					BELTED BIAS on front			RADIAL ON FRONT				
Constructor		Numeric & 80 Series	78/75 Series	70 Series	85/50 Series	Numeric & 80 Series	78/75 Series	70 Series	80/50 Series	Numeric & 80 Series	78/75 Series	70 Series	85/50 Series	
Series (Profile)														
REAR TIRES (READ ACROSS FOR FRONT TIRE RECOMMENDATION)	BIAS on rear	Numeric & 80 Series	OK		NO	NO				NO	NO	NO	NO	
		78/75 Series		OK		NO				NO	NO	NO	NO	
		70 Series			OK	NO				NO	NO	NO	NO	
		80/50 Series				OK				NO	NO	NO	NO	
	BELTED BIAS on rear	Numeric & 80 Series				NO	NO	OK			NO	NO	NO	NO
		78/75 Series					NO		OK		NO	NO	NO	NO
		70 Series				NO				OK	NO	NO	NO	NO
		80/50 Series								OK	NO	NO	NO	NO
	RADIAL on rear	Numeric & 80 Series	NO	NO	NO	NO	NO	NO	NO	NO	OK	NO	NO	NO
		78/75 Series	NO	NO	NO	NO	NO	NO	NO	NO		OK	NO	NO
		70 Series	NO	NO	NO	NO	NO	NO	NO	NO			OK	NO
		85/50 Series	NO	NO	NO	NO	NO	NO	NO	NO				OK



Charting A Safe Course

Contrary to what you may have read or heard, the Rubber Manufacturers Assn.'s Tire Industry Safety Council and the National Highway Traffic Safety Agency do not recommend mixing radial and nonradial tires. When you're in the market for new tires, this mix-and-match chart will help you select the tires recommended by these agencies for use with the tires you're keeping in service.

Note that in the chart OK is the preferred application, NO is not recommended, and the cross-hatch boxes indicate acceptable.

It's hard to believe that after almost two decades since its inception, there are still professionals who apparently seem to overlook the evaporative emissions control system as a major cause of gasoline odor. Let's assume there are no leaks, that you aren't overfilling the gas tank and bringing the odor on yourself, and that the fuel cap and filler neck are in good condition so fuel vapors aren't escaping from these points. What else could be causing the odor? Just one or more of these parts of the EVAP system:

- A clogged filter in the base of the vapor storage (charcoal) canister.
- A clogged canister, a cracked canister or a canister having loose fittings. In either case, replace the canister.
- A canister control valve (often referred to as the purge valve) that isn't working.
- A purge hose that's loose.

(Please turn to page 50)

“Mopar offers a full line of accessories for your Dodge truck or Jeep. Things like sport bars, grille and brush guards, fog lights, running boards and bedliners...things that fit right, look good, and perform great. If you're like me, and think truck accessories are actually necessities, see the Mopar line at your Dodge Truck or Jeep dealer. For your free copy of the 1988 Mopar Accessories brochure, call 1-800-521-3186.”



Don Garlits

3-time NHRA World Champion



ACCESSORIES

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Our headquarters

CAR CLINIC (Continued from page 48)

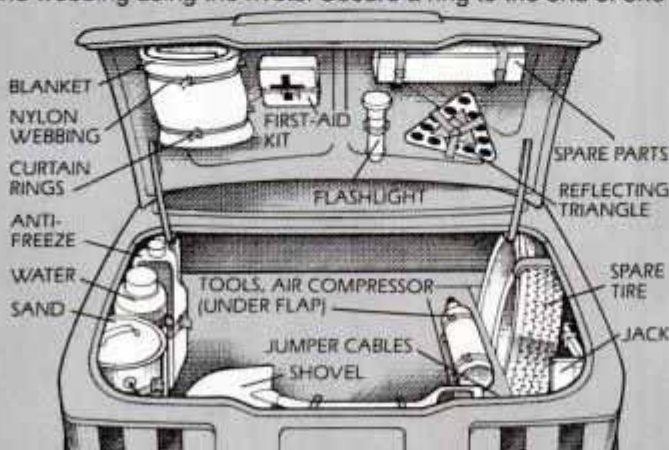
Order In The Trunk

Making up your mind to carry emergency equipment in the trunk of the car, especially during the coming winter, makes good sense. But when it comes to storing that equipment—well, that's when some decide to chuck the idea rather than having items roll around.

Now, though, you can store items neatly by using this idea offered by the Bostick Division of Emhart Corp., the maker of POP rivets. You'll need a POP Rivetool, a box of 1/4-in.-long POP rivets, rivet backup plates, curtain rings (or stronger steel rings available at hardware stores) and 2-in.-wide nylon webbing straps of the kind used for lawn chairs. The quantity depends on how much of the equipment shown in the illustration you make part of your emergency tool kit and how you adapt this tip to your specific trunk layout.

Drill 1/8-in. holes in the reinforcement bars which crisscross the lid and sides of the trunk to attach the webbing using the rivets. Secure a ring to the end of one

strap to serve as a buckle to hold the end of the other strap. One important cautionary note: Be sure to exercise extra care when you drill holes near the gas-filler assembly and over the gas tank for the rivets. Also, take care not to puncture any hoses or wires, either.



kinked or plugged. This hose extends from the carburetor to the canister control valve.

■ A loose or plugged fuel-vapor pipe, between the canister and fuel tank.

■ A loose, plugged or kinked thermal-vacuum switch-to-canister hose.

Mistaken Identity?

We own a 1983 Buick Century with the 3-liter engine. Recently, when we had it at the local dealership to repair a problem, we were told that the head gaskets needed to be replaced. The car's been driven only 38,000 miles. The service manager claims this is a common occurrence with the '82-'84 GM 3-liter engine, and that his department had repaired 200 of these engines in the past three years at \$600 per car.

Is there any truth to this? If so, isn't the company responsible?

MONTE & LORI SAILOES
NO ADDRESS GIVEN

I've had no complaints about GM 3-liter engine head-gasket failure, but perhaps readers of "Car Clinic" who have experienced this trouble just haven't written. There have been company-issued modifications in the form of technical service bulletins (TSBs) relating to original intake manifold gasket and oil pan gasket

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failure with the 3-liter engine. These have to be replaced with gaskets of a different design that have enhanced sealing ability. There was also a problem with the head gaskets of the 4.1-liter engine. I suggest you and the service manager get together and discuss this again. It might be in your best interest to get a second opinion.

Cover Story

In Service Tips of "Car Clinic" last Feb. (page 27) you mentioned that the noise coming from the rear of a 1987 Escort or Lynx might be cured by having shock absorber insulators (part No. E8FZ-18A179-A) installed as described in TSB 87-19-5. I had that done, but the noise didn't abate, so I took my case to the Consumer Protection Agency which, in turn, took it to the Department of Motor Vehicles in Glen Burnie, Maryland. I thought you'd be interested in the results.

According to the inspector who was given the case, "The writer has verified the noise about which Mrs. Cover complains. This noise is apparently present in Escorts and has been verified in three other Escorts. The noise is caused by the strut coming in contact with the rear inner fender panel when going over bumps on full rebound. There is only 8-

mm clearance in this area by design."

In other words, Mort, as another part of the report states, "The noise . . . is a normal condition in Escorts," and I'm stuck with it.

LINDA M. COVER
CUMBERLAND, MD

High-Priced Idea

I have a 1986 Cadillac Cimarron with the optional 2.8-liter V6 engine and 4-speed transmission. Can I replace this 4-speed unit with a 5-speed? If so, which one? I have asked local Cadillac and Chevy dealers. They don't know.

LEE RHONEY
HICKORY, NC

Yes, you can. In fact, the standard transmission used in the Cimarron equipped with the 2.8-liter optional engine used to be the 4-speed unit. Beginning with model-year 1987, the transmission became a 5-speed—specifically, the Muncie-Getrag MG282. But do you have any idea how much it will cost? About \$2000, not including labor.

PM

DO YOU HAVE A CAR PROBLEM?

Just ask Mort about it. Send your question to Car Clinic, Popular Mechanics, 224 West 57th St., New York, NY 10019. While letters cannot be answered individually, problems that are of general interest will be discussed in the column.

SERVICE TIPS

■ General Motors becomes the first automaker with an additive to protect the exhaust valve seats of pre-1971 passenger cars designed to run on leaded gas when leaded gas isn't available. The product is called GM Anti-Valve Recession Additive (part No. 12345492). One container per 20 gallons of unleaded gas will provide valve protection equivalent to using gas having a concentration of 0.1 gram of lead per gallon. Can you use this product in non-GM engines designed to run on leaded gas? Sure!

■ Do you have a 1987 or 1988 Chrysler Motors front-wheel-drive car built here in the United States? Does it have an automatic transaxle that seems to take forever (actually, 5 seconds or a little longer) to engage when shifted into Drive or Reverse and/or gives a jolt when engagement takes place? If so, get the car back to your dealer and have procedures outlined under TSB 21-03-88 applied.

■ Were you one of the first in line to buy a 1989 Probe? If yours was built before 6/30/88, you can save yourself some future grief by having your dealer carry out the provisions of Ford TSB 88-12-10. It calls for lubricating the center bores of the cast-aluminum wheels with disc brake caliper lubricant (part No. D7AZ-19590-A), preventing a buildup of galvanic corrosion that can weld the wheels to the hubs, preventing removal.

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WINNERS RIDE SAFELY. Remember, ATVs can be hazardous to operate. For your safety, always wear a helmet, eye protection, and protective clothing, and never ride on paved surfaces or public roads. Never carry passengers, and never engage in stunt driving. Avoid excessive speeds, and be particularly careful on difficult terrain. And keep in mind that riding doesn't mix with drugs or alcohol. The FourTrax[®] 70 is recommended for riders 12 years and older. All other FourTrax are recommended for riders 16 years and older. Additionally, the FourTrax[®] 250R and FourTrax[®] 250X are recommended for highly experienced riders. Honda recommends that all ATV riders take a training course. For safety or training information, call the SVIA at 800-447-4700.



OUTDOORS

BY JOE SKORUPA

A Taste Of Rocky Road



Jeep Cup competitors climb an 11,000-ft. summit during an off-road rally through the Colorado Rockies.

IT WAS A BRIGHT, crisp Colorado morning. We were on the outskirts of Denver in a parking lot filled with rally drivers and vehicles—about 50-percent Jeeps and the rest Broncos, Blazers, Suburbans, pickup trucks and other rugged, go-anywhere machines. In a few minutes rally officials would send us off on a twisting, off-road route up into the spectacular Rocky Mountain summits of the Arapahoe National Forest. For 42 2-man driving teams, the day was going to be 4x4 heaven.

I pulled into the inspection station in a spanking new 1988 Jeep Wrangler. Officials of the Sports Car Club of America and the United Four-Wheel-Drive Assn. were looking for irregularities. Entrants for off-road rallies, such as this Jeep Cup regional event, sometimes try to bend the rules.

Riding beside me was Larry Junker, general manager for Emich Jeep/Eagle, in Lakewood, Colorado.

Junker's the man who lent me the upscale, khaki-colored Sahara model Jeep.

As Junker hopped out of the Jeep he said to the officials, "This vehicle better pass inspection, it comes right off the showroom floor." He had nothing to worry about.

Hot electronics

In addition to making sure basic safety equipment was in working order—lights, tires, horn and so on—the inspectors looked for odometers that read hundredths of a mile, professional rally driver's trip computers, and programmable laptop computers. All are illegal. My Jeep was clean.

Jeep Cup off-road rallies, which total five regional events in the United States and five in Canada that culminate in an overall championship, limit competitors to standard automotive instruments, stopwatch and non-programmable calculators. I stunned my inspector by saying I had neither stopwatch

nor calculator. "Flying by the seat of your pants?"

Not exactly, I told him, I brought a copilot who could do upper-level math in her head—my wife. Aside from precise navigation and high-speed number crunching, I wouldn't place undue pressure on her.

In rallying, top-end speed is unimportant. The object is to travel an unannounced route at a median speed. Arriving early at a surprise checkpoint incurs the same penalty as arriving late, one point per second.

At the start of the rally each team is given a road book, which has clues describing observable landmarks and hieroglyphic-style symbols, called tulips, which point out the correct way to go. Mileage and average speed between landmarks is also provided, so it's a simple formula to figure out the time it should take between points. Nothing to it.

Keeping your cool

"Once you get rattled, everything deteriorates rapidly," said Bob Lathrop, of Hagerman, New Mexico. Lathrop and his wife are veterans of three Jeep Cup rallies and other regional events. He rates himself "better than the bozos, but behind the pros."

By deteriorate, Lathrop means you get off course, tempers flare and you begin to compound your mistakes. To avoid this situation, Lathrop prints out a spread sheet showing the time it takes to go any distance up to 25 miles at any speed up to 55 mph. This is allowed by the rules and eliminates the need to do calculations on the fly.

I told Lathrop of my personal method of eliminating mid-course calculations. "First rally?" he said. I replied it was. He smiled and wished me luck.

(Please turn to page 132)



Strategy breaks are provided at each of five surprise checkpoints.

INSIDE DETROIT

BY JIM DUNNE

Chrysler Imperial For 1990

IN JUST a few more months, a stretched version of Chrysler's New Yorker sedan will make its appearance as the new Imperial. The Fifth Avenue will also be introduced in time for an early 1990-model debut, and will replace the current rear-drive Fifth Avenue.

The wheelbase of the new cars will be 5 in. longer than the New Yorker/Dynasty, and will be 8 in. longer overall. The first production models will use Mitsubishi's 3.0-liter V6 engine and Chrysler's 4-speed automatic overdrive transmission, the same powertrain currently offered in the New Yorker. A year later Chrysler will install its own U.S. 3.3-liter V6.

While the Imperial shown here looks much like the New Yorker, the C-post is quite different. An opera window is fitted to the rear door, and the door is in the area where extra length shows up most. Taillights are horizontal in shape, stretching across the trunk to each fender.

Roadmaster Return

Buick's venerable Roadmaster nameplate is set to reappear in 1993 when a completely new luxury car will be introduced. Details of the new model are sketchy now, but it will be a rear-wheel-drive 4-door sedan similar to the Cadillac Brougham. The car will adopt the chassis being developed for the 1991 Chevrolet Caprice. So you can look for independent rear suspension, antilock brakes and perhaps even a V8.

Caprice Prototype

Chevy plans to build 34 full prototypes of the 1991 Chev-

Chrysler will revive the Imperial nameplate to appear on a stretched New Yorker.



rolet Caprice. The number far exceeds any built for a similar new-car development, and shows how extensive the changes will be in the new model.

Exterior styling will be thoroughly revamped. The aero look and highly curved glass surfaces will produce a car completely different in appearance from the current Caprice. Independent rear suspension and a number of electronic systems for brakes, engine, transmission and wheel traction will be available on the Chevy big-car line for the first time. But Chevy does not want to let the Caprice's styling out of the bag until the car is introduced to the public. That means the bodies of the prototypes will be heavily disguised and testing routes will be kept hidden from prying eyes.

Calais Crash

If you've never had a closeup view of a 33-mph side-angle impact, here's what it looks like. Tests like this are routine at any of the automakers' research labs. They prove the soundness of the car's structure and document the likelihood and severity of injury to passengers.

A couple of interesting facts: The brand-new Calais shown here, like all other crash cars, is routinely rele-

gated to the crusher after the test measurements are taken. That means tires, wheels, lights, batteries, engines, transmissions, radios and so on, are simply thrown away, not recycled for use in other cars.

"We have to include all the parts of a standard car in the tests," explains GM's road safety chief Richard "Doc" Whitworth. "We have to see how each part works to protect the passengers." Why throw away seemingly good parts? GM does not want to be sued by the inevitable purchaser who might claim an accident-causing failure of a part was caused by a previous crash test.

GM reports that it costs

about \$20,000 to conduct a crash of this type. About 200 crash tests are run each year at GM alone.

Car companies are occasionally able to save money by using the same car for more than one crash. This Calais, for example, might also be used to measure rear-end collision damage in a separate test. Take a close look at the ram on the front of the vehicle on the left. It's a new throwaway device shaped to simulate the front end of a car. GM is proposing the device as a standard ram to replace a real car in crash tests. Its use would produce crash results that are uniform because the same type ram can be used by all automakers. **PM**



Crash-testing programs yield plenty of data and even more waste.



HOT PURSUIT

THERE'S A scene in the "Blues Brothers" movie that illustrates how this story began. Dan Akroyd (Elwood) is explaining to John Belushi (Jake) why he swapped the band's Cadillac for a seedy-looking ex-cop car. Addressing Jake in the deliberate style one uses with children and half-wits, Elwood says, "It's got cop tires, cop shocks and a cop motor."

In other words, even if the car looks like a destruction derby also-ran, cop components automatically guarantee that it's gotta be a bullet.

Think about this for a second. If you're like us, you've accepted this notion as an ancient and immutable truth of automotive life, dating almost to the dawn of cars in police work. However hot your ride might be, the cops had something hotter.

This perception was not without foundation. The concept of the police interceptor special dawned in the '30s, but reached its zenith during the

When the chase goes on for 24 hours, only the strong survive.

BY TONY SWAN, Automotive Editor
PM Photos by Humphrey Sutton,
Geoffrey Hewitt and Ron Hussey



PM Team at Nelson Ledges (l to r): Editor Swan, Art Director Canniff; Editors Frank, Allen, Taylor; Crew Stefan Frank, Nigri, Handlemeyer Jr., Blosser, Handlemeyer Sr.; Chief Mechanic Tison, Henderson, Crew chief Sprafka.

heyday of big-inch V8 engines in the '50s and '60s. All the major manufacturers offered special police packages that included plenty of extra muscle, and some departments specified powertrains that tiptoed along the edge of race-ready.

Legendary police units evolved during this era. The Signal Hill Mercurys, near Long Beach, California. The LAPD 421-cu.-in. Pontiacs. The dreaded Pennsylvania Turnpike Chryslers, booted along by 300 series hemis.

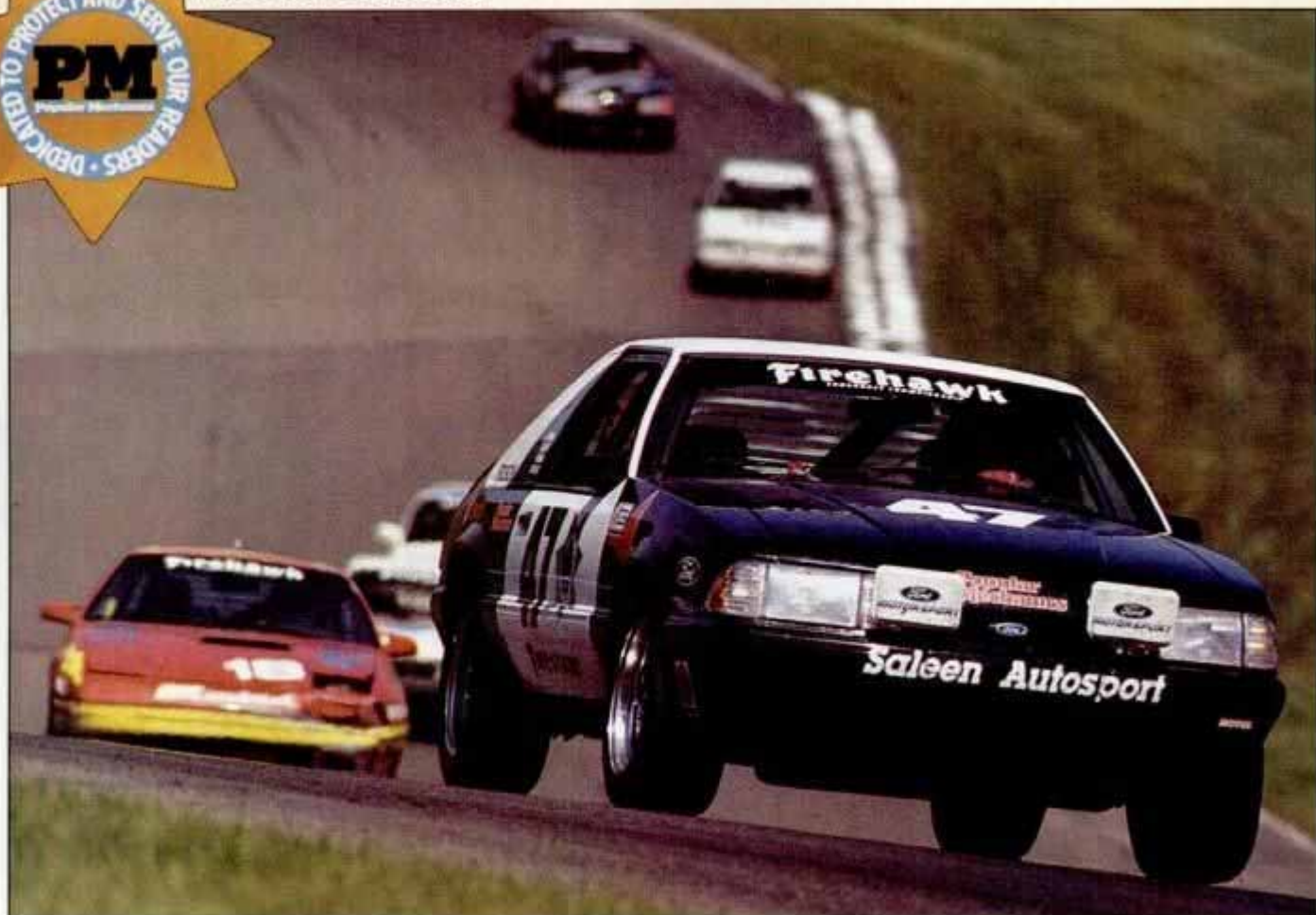
But the question that intrigued us was whether the police interceptor special continues to be the tire-smokin' bad boy of days gone by—or has it become a car that's very much like its civilian counterparts.

We leaned toward the latter, and to test our theory we devised one of the toughest road tests ever attempted.

We began by targeting the hottest police car in wide use today. Employed as a high-speed pursuit unit by a number of state highway patrol organizations, the Ford 5.0-liter Mustang is as good a performance buy at the fleet sales level as it is for the average enthusiast. Its power-to-weight ratio (in cop trim) of 13.5 lbs./hp gives it an edge over all but a handful of cars when it



HOT PURSUIT



comes to the thrills of the chase.

Naturally, we wanted to see what a combat-ready police Mustang could do, so we obtained the loan of a cop-spec car in California for basic performance testing (see sidebar). The results were what we expected—0-to-60 in 7.1 seconds, with a quarter-mile time of 15.48 seconds at 94.32.

Those numbers aren't the worst we've seen for a 5.0-liter HO Mustang, but they aren't the best, either. In fact, our own homemade police special was somewhat quicker: 6.8 seconds 0-to-60, 15.1 seconds at 95.62 mph for the quarter. But we're getting ahead of ourselves here.

While West Coast Editor Len Frank was busy logging performance data on the cop-spec Mustang, we decided to escalate the entire exercise by creating a Mustang that would be the performance equal of any police edition in the country and the endurance champ of them all.

In short, we decided to create a Mustang capable of running flat-out, around the clock, under the most demanding conditions.

And it was this decision that led us to take on a pair of 24-hour showroom stock races, one at Watkins Glen, in upstate New York, the second at Nelson Ledges, Ohio, where endurance racing of this kind got its start.

The 135-mph straightaway speeds at Watkins Glen necessitated repeated brake-pad replacement, which PM's pit crew ultimately managed to complete in sub-2-minute pit stops.



The Saleen connection

We called our friends at Ford, who generously donated an '88 LX hatchback Mustang. Then we sat down and took a realistic look at the race dates bearing down on us—at that point, little more than a month away—and realized we needed help. Even in showroom stock racing, where the only major modifications to the car are safety related—roll cages, fire systems and so on—there's an enormous amount of preparation.

After drawing up a list of everything that would need to be optimized to make a decent showing at the Glen, we decided to call the most successful Mustang racers we knew. And to anyone who's been following the Sports Car Club of America Escort Endur-



ance series recently, that can only mean Steve Saleen and the Saleen Autosport organization.

Based in Anaheim, California, Saleen is emerging as Ford's new Carroll Shelby. His Saleen Mustang street cars, available through selected Ford dealers, bring out the latent grand touring machine that lurks within every 5.0-liter Mustang. And his showroom stock racers reinforce the technical credibility of the organization. Led by the driving skills of Rick Titus and Saleen himself, the Saleen Mustangs raced to GT-class honors in the 1987 Escort series.

Clearly, we could be in no better hands. And even though his group has its hands full campaigning vehicles in two professional series—the SCCA



Nelson's high temps, short straights, poor track conditions, unpredictable traffic and second-place Camaro kept PM drivers and pit crew busy through the race.



Escort Endurance races and the Coors Racetruck Challenge—Saleen adopted us and agreed to get the car ready for its 2-race campaign. The execution of this project was left to Howard Comstock, who runs the new Saleen shops in Livonia, Michigan.

We gratefully left the car in Howard's capable hands and turned our energies to logistics and personnel. The preparations for a 24-hour race resemble nothing so closely as buildup for a small invasion.

First there's equipment to be gathered. Besides basic hand tools, we needed radios, air wrenches, floor jacks, nitrogen bottles, a compressor, a generator, an overhead fuel rig, assorted lights for night pit work, lumber, a wagon for hauling local small

freight, fire extinguishers, special tools for brake changes, engine oil, brake fluid, spare wheels, tires, windshields, brake rotors and brake pads. Especially brake pads.

On the human side of the ledger there's the problem of assembling enough crew to get you through the night, and assembling sufficient food and drink to keep everyone happy.

Stock around the clock

We expected Watkins Glen to be the tougher of the two races, which proved to be the case. This was due in some measure to our state of readiness—on the morning of race day Federal Express was still stopping by at intervals, bringing us more stuff to bolt onto the car, and crew members

were still learning each other's first names—but it was due even more to the quality of the field.

This event was part of the 13-race Firestone Firehawk series, sanctioned by the International Motor Sports Assn. (IMSA). Now in its fourth season, the Firehawk series is basically identical in concept to the rival SCCA series—optimized stock cars running in three classes—but with two major distinctions. First, the series allows unmuffled exhausts, lending a more authentic racing sound. Second, all Firehawk competitors must use Firestone Firehawk tires, which the manufacturer supplies at a friendly price.

When this series was launched in 1985, it was presumed that the restriction to a single make of tire would limit sponsorship potential and thus give the edge in growth to the SCCA. However, just the opposite seems to have occurred. Stimulated by better exposure—Firehawk races are more often teamed with real crowd-producing events and have also had an edge in TV coverage—the IMSA series regularly draws fields that are twice the size of Escort races.

Winning a Firehawk race of any duration requires exceptional driving and pit work. Without putting too fine a point on it, we didn't expect our de-

HOT PURSUIT



Endurance racers learn to sleep wherever they can. Even a concrete floor feels pretty soft by about 4 a.m., but Allen and von Sauers managed the luxury of chairs.

but to end in victory. Our focus was more in the area of getting through unscathed and still running.

To this end, Saleen Autosport's contribution was invaluable. We got the car off our transporter, noted that we had more negative camber on the left front than on the right, looked at a couple of sparkplugs, changed the oil, scratched our heads a little—and ran it exactly as delivered.

We could have done much worse. Comstock and crew had given us a

race car that was easy to drive and reasonably fast. Although there were a couple other Mustangs in the field that were faster—along with a herd of Camaros, a couple of Porsches and a very good Nissan 300ZX Turbo—we were by no means slowest. By the wee small hours of Sunday, the PM cop car was nibbling at the edges of the Top 10 in the Grand Sports class, until a cracked brake rotor cost us about 30 minutes.

At the end of the race, the Mustang

was running just as fast as at the start, and when the checkered flag was displayed we found ourselves 24th overall and 14th in our class, which included 37 cars in all. We were credited with 511 laps of the beautiful 3.77-mile Watkins Glen circuit—a little over 1926 miles—and used 22 Firehawk tires in the process.

We also learned something that could be of value to anyone campaigning a real police Mustang in a real police chase. If the pursuer finds himself

This Mustang Chases Porsches For A Living

AND CATCHES THEM, too. It's hard to say how many Porsches the California Highway Patrol (CHP) actually chases with its Mustangs, but at Watkins Glen, five of the six (944S) Porsches entered finished behind the PM Mustang.

There are surprisingly few differences between the CopStang and its civilian LX brother. Remember that

police cars are in constant motion—the CHP retire theirs after about 80,000 miles and usually in two years or less. The PM Project car is the heavier hatchback, about 200 pounds heavier, slightly less rigid, a little cleaner aerodynamically than the coupe usually used by police.

The Special Service Package (read, "police") adds: an air deflector in front of the radiator, relocated decklid release

(solenoid switch), Kevlar drivebelts and HD tensioner, reinforced front floor pan (under seat area), aircraft-type hose clamps, underhood and trunk lights, single-key door-lock system, heater hose inlet restrictor, HD front bucket seats, 140-mph calibrated speedometer, police special transistorized voltage regulator and 15X7 alloy wheels painted black.

An engine oil cooler, external automatic transmission cooler, air conditioning, cruise control and various power accessories are options.

The car is very easy to drive at its limit, at least until the unshaved tires start to overheat and chunk. The Mustang is basically a strong understeerer, though power oversteer can be used to balance the car. Throttle response is wonderful, pedal placement good, shift linkage excellent.

On rough surfaces, the rear wheels have trouble maintaining traction. Ride is surprisingly hard—subjectively harder than the racing car, which nevertheless behaves better in the transient response department. Seats are low, better than expected but not as good as the optional Recaros and not nearly as good as our race car's superb Flofit racing seat.—Len Frank



Editor Frank explains merits of Mustang cop cars after impromptu high-speed run.



Contributing Editor Mayersohn (above) uses radio to relay information to PM car. Swan (right) collects trophy for the all-editor team's endurance race win at Nelson Ledges.



in a pursuit that requires repeated hard braking—chasing the bad guys along a mountain road, for example—he can fully expect his brakes to simply go away within 15 minutes and probably less. Watkins Glen is a demanding circuit, and even though all four drivers—Contributing Editor Rich Taylor, Assistant Auto Editor Mike Allen, West Coast Editor Frank and the author—tried to minimize brake use, we found ourselves going through front pads at an appalling rate, 10 sets in all.

This is by far the weakest point of an otherwise durable car.

Nelson Ledges revisited

If regular readers experience a little *déjà vu* in connection with this obscure Ohio place name, it's because we've taken you there before. In 1982, a POPULAR MECHANICS-sponsored Porsche 944 won this event, which meant we could do no less. Which meant the pressure was on.

This was the ninth annual renewal of the Longest Day of Nelson, and it's ironic that the spiritual progenitor of an entire class of racing has become something of an outlaw race. Although the event continues to be sanctioned by the SCCA, it's not on the Escort Endurance calendar, thanks to a problem-plagued race in 1985.

On the other hand, thanks to the tireless efforts of perennial chairperson Anne McHugh, the Longest Day is beginning to fatten up its starting fields once again—25 cars this year—and the competition for the overall win was comparable to what the PM team faced last time.

Perhaps the most intriguing entry was a prototype from Consulier Industries, a new concern headquartered in Florida. Looking like a miniature IMSA GTP racer, with a proposed price of \$41,000, the mid-engined Consulier wore plastic body

panels over a tube frame chassis and a Shelby/Chrysler 2.2-liter intercooled turbo powertrain.

With abundant power, low curb weight (about 2200 pounds) and race-car handling, the little Consulier captured pole position with a quickest lap of 1:20.55 (80.6 mph) around the fast 2.0-mile circuit.

Next fastest was a well-prepared IROC-Z Camaro (Dave Weitzenhof, Mac DeMere, Roger Marble, Brian Goodwin, John Gimbel), qualifying at 1:21.77, with our cop car one-hundredth of a second behind. Since we'd

field to finish 14th overall, while the Camaro had difficulties with fuel pickup and a leaky rear-differential seal. Despite ambient temperatures in the 105° area, the Mustang ran cool and fast, building a 1-lap lead by the end of the first hour.

By the seventh hour we had a 7-lap advantage, but just when it was beginning to look like a laughter we managed to inject an element of drama. A rogue thunderstorm blasted the track with lightning bolts and dumped an astonishing volume of water. Our Mustang, with your humble narrator at the helm, still running on shaved tires, encountered a freshly formed pool of the wet stuff in Nelson's notorious carousel. The Mustang suddenly seemed to remember some aquatic ancestry and slithered off the course like a demented eel, stopping with its front wheels on a tire wall.

Though the car was undamaged, extraction consumed six laps, and fixing the consequences of extraction—the winch cable destroyed our tailpipe mounts—took a couple more. But by the end of that same driving stint we were back on top, a lead we were able to again extend to seven laps and then nurse to the end.

Despite a lengthy caution period following the thunderstorm, we covered 923 laps—1846 miles, averaging 76.9 mph—the second best total distance in Longest Day history. We consumed only four sets of brake pads this time around, although Nelson's abrasive surface used up 24 of the Generals.

So what did we prove? Well, for one thing we'd be willing to match our cop car against a real one anytime. Although Chevy may offer a Caprice police package with a 454-cu.-in. truck V8 at its heart, for the time being cop cars just ain't what they used to be.

Now, if only they didn't have those radios . . .

Acknowledgements

We wish to extend our gratitude to the following firms for their contribution to the PM racing cop car.

- Ford Motor, Mustang LX project car.
- Saleen Autosport, race-car prep.
- General Tire, tires and tech support for Nelson Ledges 24-hour.
- Kenwood Corp., uhf handheld radios.
- Setcom, helmet radio prep.
- Walker Engineering, performance exhaust system.
- Peter Farrell Racing, refueling rig.
- Monroe Auto Equipment, Formula GP shock absorbers.
- Motorcraft, filters and sparkplugs.
- Auburn Gear, limited-slip differential.
- Top Line, Comp 82 racing seat.
- Motul, high-temp brake fluid.

qualified using the exact driving discipline we intended to use in the race—extreme conservatism with the brakes—we knew we were in the hunt. We also felt that our tires for this race—245/50VR-16 General XP2000V radials—would give us an additional edge, since they had the endearing quality of providing uniform adhesion right down to the cords.

And this is exactly the way it played out. The Consulier, with virtually zero racing development time, encountered problem after problem and soldiered backward through the



MUSCLE MACHINES

Working up a sweat with the latest in fitness technology.

BY RICH TAYLOR, *Contributing Editor*

STAYING in shape takes on a whole new dimension with the latest in computerized fitness machines. Instead of the usual haphazard regime of bending and stretching exercises half-remembered from high school, boot camp and Jane Fonda videos, these fancy exercisers can be used to analyze your fitness needs, then programmed to put you through a workout custom-designed to get you in tune. In addition, bright computer graphics lighten the drudgery with videogame displays that make exercising both interesting and fun.

The acknowledged state-of-the-art is the Cybex 340, a \$45,000 2-seater used by professional sports teams such as the New York Giants to keep their players at peak performance. It's compact enough to fit a home spa/workout room, though obviously a bit pricey for most families. Heart of the 340 is an IBM PC-compatible computer with floppy disk, 30-megabyte hard disk and 60-megabyte streamer tape for backup institutional use. A Mitsubishi color graphics monitor handles visual displays—a color dot-matrix printer lets you keep a hard copy for future reference.

The 340 comes preprogrammed with 18 different tests for shoulders, elbows, wrists, hips, knees and ankles. You can measure flexion and extension angles, torque versus speed, work fatigue for all muscle groups, and then develop an exercise program that will strengthen muscles isokinetically for maximum development without damage.

Both measurement and exercise are performed by pitting your strength against a dynamometer mounted beneath the twin bucket seats. Even the seats are of an advanced design, with tilt and fore-aft adjustability, ergonomically correct lumbar support and 3-point seatbelts to hold you in position during rigorous workouts.

If the Cybex 340 seems like overkill to you, less expen-

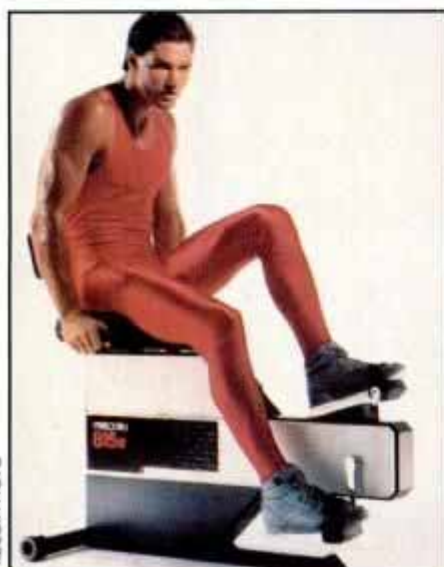
Computer-controlled Cybex 340 measures and exercises 18 different muscle groups. It can also be programmed for a personal workout.

PHOTO BY MANNY GONZALES

MUSCLE MACHINES



UNIVERSAL PHOTO



PRECOR PHOTO



EAGLE PHOTO

Universal Aerobicycle (top) has five preprogrammed exercise modes, LED display and clip-on pulse-rate monitor. Precor 815e (center) features semirecumbent seating position for greater efficiency and digital readout with calorie ergometer. Eagle Upper Body Exerciser (above) strengthens arms, shoulders and chest with hand-cranked pedals; eye-level instruments monitor work rate.

Precor 718e simulates mountain-climbing motion with adjustable steps.

sive, less elaborate home exercisers still offer high-tech ergonomics and computer controls. Most are compact enough to fit in your bedroom, basement or den and can easily become a part of your daily exercise routine.

Our favorite is the Liferower, a stylish sliding-seat rowing machine. You face a 13-in. CRT, on which color graphics depict your own rowing scull and a pace boat. Inside the box is a cable drum dynamometer, adjustable for resistance.

At the starting gun, you start rowing to the splash of your oars in the water, the shouts of your coach, and the cheers of the crowd lining the course. The race is graphically depicted on the screen, until you cross the finish line. On-screen graphics keep track of your strokes-per-minute, distance traveled, race time remaining and calories burned-per-hour. It's as much fun as any videogame, plus you're forced to race through your workout—motivated to beat that pace boat. The psychology is simple, but it keeps you exercising.

Universal Gym Equipment's Aerobicycle brings similar electronic monitoring to the stationary bicycle. A digital display at the handlebars includes a timer, work-load level adjuster, pedal speedometer, odometer, pulse-rate monitor and calories burned-per-hour meter. You can choose from five preprogrammed exercises, including a steady uphill climb, rolling hills, a target pulse-rate, constant rpm and a standardized YMCA fitness test adjusted for age and sex.

A more compact exercycle is the Precor 815e, which consists of a padded seat on a frame, with adjustable pedals mounted to give you a recumbent seating position that's said to be more efficient than the traditional upright bicycle. An electronic LED panel mounted between the pedals measures time, distance, rpm and calories burned-per-hour. Of course, pedal effort is adjustable.

The matching Precor 718e Fitness

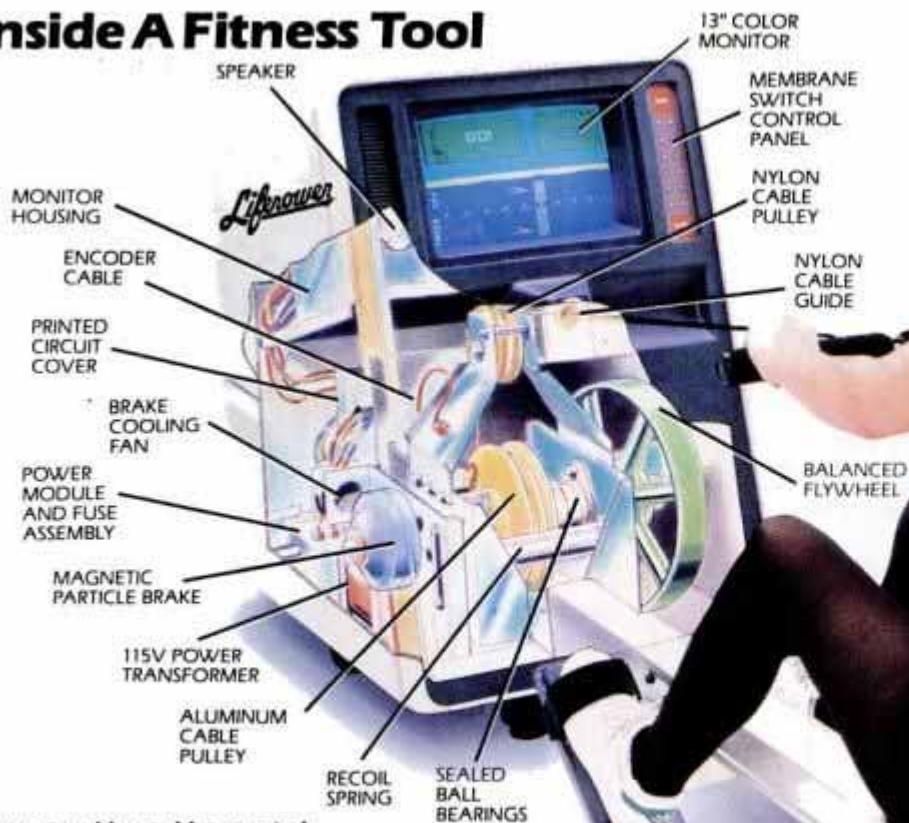


PRECOR PHOTO

Climber duplicates a mountain-climbing motion with adjustable resistance on alternating step pads. The computerized digital instrument panel between the hand-grips measures distance, time and steps-per-minute. Like the Precor 815e, this simple exerciser is nominally priced, particularly compared to some of the higher-tech competition. And most athletes can relate to the benefits of running stairs.

Many fitness experts consider cross-country skiing to be the best total-body aerobic exercise there is. You can't work on specific muscle

Inside A Fitness Tool

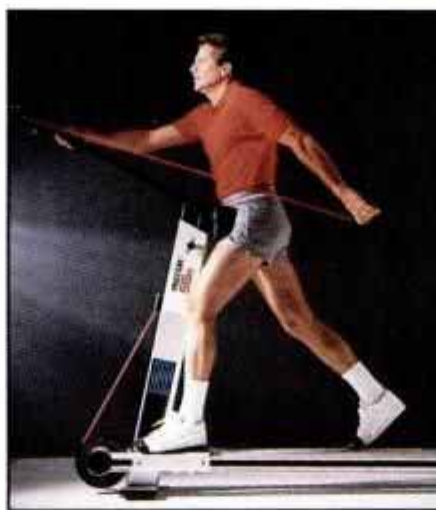


Liferower combines cable-operated flywheel with color graphics computer to make rowing more like a videogame than hard work.

groups as you can with more single-purpose machines, but for an all-round workout, cross-country skiing—simulated or for real—does the job better than almost anything else. NordicTrack pioneered the cross-country exercises. Now there's a computerized version of the traditional cross-country device, the Precor 515e. This has the usual sliding tracks for your feet and pull-cables for your hands, but with the addition of an adjustable flywheel to change resistance and a computerized control panel. Digital instruments measure distance, time and pace, helping you keep track of the amount of exercise you're getting.

For building upper body strength, we like the Eagle Upper Body Exerciser. The UBE is a vertical stationary bicycle designed to be pedaled by hand, while you sit in an adjustable bucket seat. A digital gauge at eye level shames you into working at maximum effort, which of course is adjustable depending on whether you're built like Hulk Hogan or Dr. Ruth.

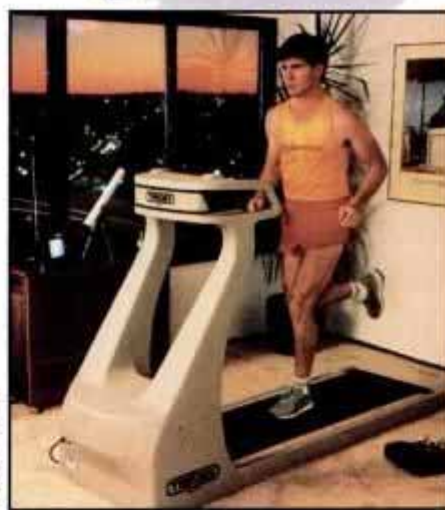
Universal Gym Equipment also makes the Tredex, a computerized treadmill that matches the Aerobicycle. The running belt can be adjusted for speed from 1 to 10 mph, and the digital display keeps track of time, distance and your pace in either miles or kilometers. Place your hand near the top of the control console, and you'll break a photocell beam that



Precor 515e is an anodized aluminum cross-country skiing machine with adjustable flywheel and digital dashboard.

stops the running surface in case of emergency. Tredex is a clear advantage for people with limited time and opportunity to run outdoors.

Having a computer screen on your fitness machine won't make your muscles any bigger or your heart pump more. But the computer can make it more fun to exercise, so you'll have an incentive to exercise more often. The digital readout will give you more information, so you can measure your progress and create the exercise program you need. The latest round of high-tech fitness machines have all been designed for maximum exercise



Computerized Tredex treadmill has polyethylene housing, 1- to 10-mph variable-speed rubber running surface, digital control.

efficiency without strain or injury. And that makes them the most attractive thing to happen to fitness since, well . . . Jane Fonda. **PM**

Fitness Machine Sources

- Cybex, 2100 Smithtown Ave., Ronkonkoma, NY 11779, (516) 585-9000
- Eagle, P.O. Box 9003, Ronkonkoma, NY 11779, (516) 585-9000
- Life Fitness, 9601 Jeronimo Rd., Irvine, CA 92718, (800) 634-8637
- Precor, from The Sharper Image, 650 Davis St., San Francisco, CA 94111, (800) 344-4444
- Universal Gym Equipment, P.O. Box 1270, Cedar Rapids, IA 52406, (800) 553-7901
- NordicTrack, 141 Jonathan Blvd. N., Chaska, MN 55318, (800) 328-5888

The Mechanics Of THE BOMB

It's football's most exciting play. But also an intricate combination of spin-stabilized ballistics and aerodynamic lift.

BY JOHN BAKKE
PM Illustration by Ed Valigursky



FOOTBALL MAY BE a game of inches, but a long pass, "the bomb," takes them by the thousand, breaking the sport's ground-attack pattern in a single long-distance gambit. It's football's slam dunk, its home run. Nothing else can accomplish so much so quickly, or with so much excitement.

Part of the play's drama is its all-or-nothing style, but those who know best insist the bomb is more craft than crapshoot. Indeed, its success relies on timing and coordination from the players, as well as the smooth and accurate lofting of a ball not particularly suited to easy flight.

Field-level logistics

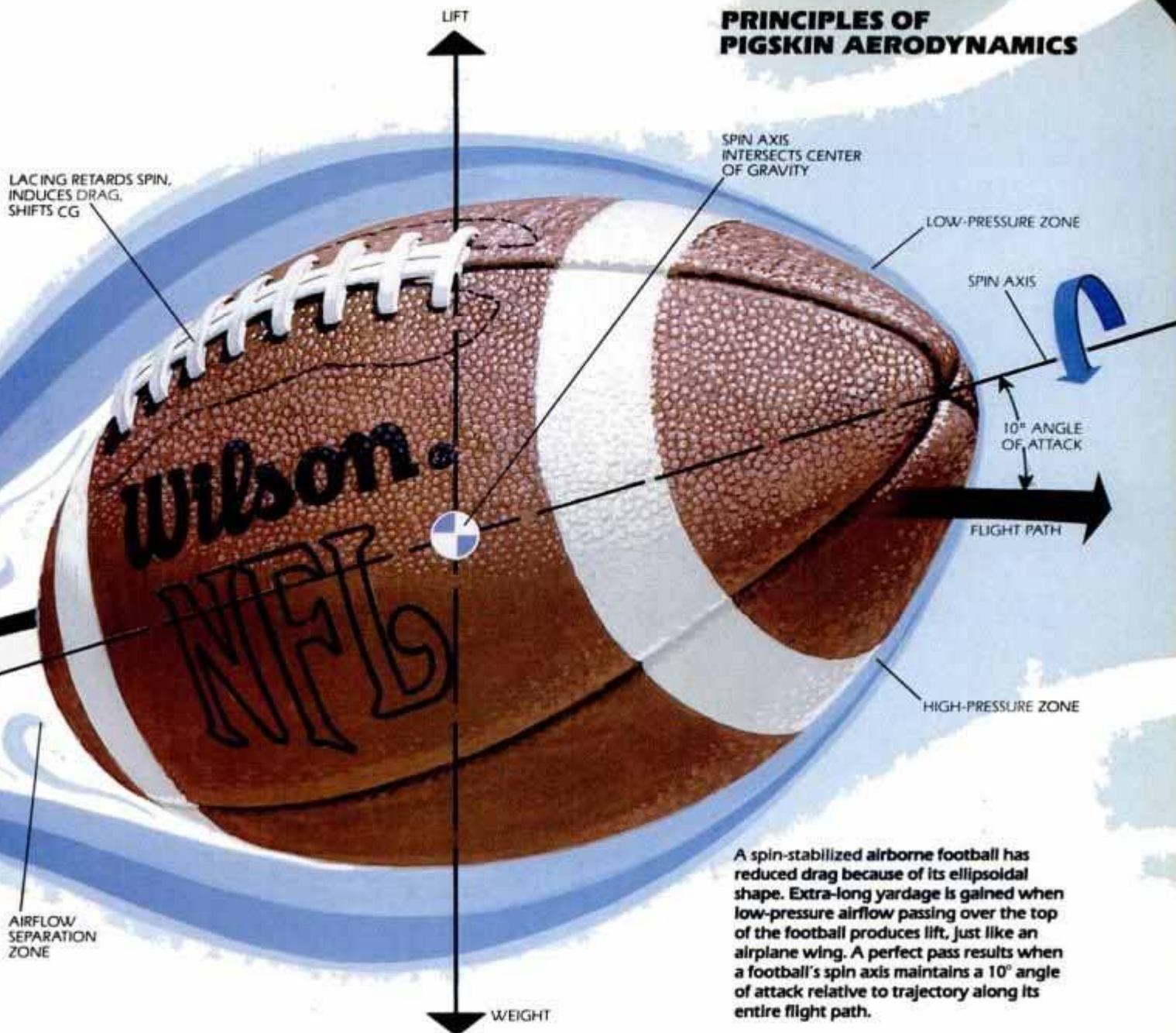
For the football strategist, precise timing is the key.

"It's far more important than arm strength," says Don Shula, coach of the National Football League's Miami Dolphins.

The play's development can actually be faster than passing plays covering less distance. With the need for quickness, the quarterback customarily drops back only five steps, instead of the usual seven. In that time—just 3 to 4 seconds—the receiver has moved downfield 10 or 15 yards and is just coming alongside the player defending him.

The play is at its crucial moment in two regards.

PRINCIPLES OF PIGSKIN AERODYNAMICS



A spin-stabilized airborne football has reduced drag because of its ellipsoidal shape. Extra-long yardage is gained when low-pressure airflow passing over the top of the football produces lift, just like an airplane wing. A perfect pass results when a football's spin axis maintains a 10° angle of attack relative to trajectory along its entire flight path.

First, the receiver must have gotten in position to move past his defender and stay ahead of him the rest of the way. If he hasn't, the critical timing is destroyed. If he has, the rest of the play is an all-out sprint for another 30 or 35 yards where, if all goes well, the ball will be waiting for him.

Second, the pass itself must be launched to near perfection, possibly with defenders closing in. The quarterback must throw to a spot some 50 yards away, where the intended recipient will not be for another 4 or 5 seconds. The margin of error may only be 1 yard in either direction.

Quarterback Dan Marino is one reason why Shula's Dolphins led the NFL last year with an average of nearly 260 passing yards per game. As much as anyone, he appreciates

the coordination that's involved.

"Like any passing pattern, timing is essential," says Marino, who holds the NFL record for most touchdown passes in a season: 48 in 1984.

As delicate a feat as it seems on the field, throwing an accurate bomb is even more remarkable when considered in a mechanical context. Spin, angle of attack, trajectory and velocity all combine to bring a football into the hands of its intended receiver.

Pigskin ballistics

The most significant consideration in a football's flight is also the most obvious—its shape. A football can present many different profiles to the air it sails through, varying considerably the forces governing its flight.

"Aerodynamically, a football is a very unstable object," says Professor Pasquale Sforza, head of the Aero-

space Engineering Department at Polytechnic University of New York. "Baseballs and other spheres are very simple by comparison."

The fundamental effect of its oblong shape is a lack of stability and the resulting need for spin, which creates a steadying gyroscopic effect.

To throw a good spiral, regardless of desired distance, the quarterback must spin the ball around an axis that runs lengthwise through the center of the ball. If the spin axis is off, the pass will assume a drag-inducing wobble.

Assuming perfect spin, a football's angle of attack can still vary—that is, the position of its nose in relation to the trajectory, which is the same as the path traveled by the ball's center of gravity.

If the ball is at a positive angle of attack, with the nose above the direction of flight, air forcing its way over

THE MECHANICS OF THE BOMB

and under the ball will give it some lift, much like an airplane wing.

Dragging rights

When air passes over any object, there is always some drag. For a football, the coefficient of drag can vary. From studies of a rotating projectile in axial flow (spinning the same way a football does) one might conclude that the drag coefficient would decrease with the speed of the spiral. Unfortunately for the quarterback, though, the spin would likely have to be well over 1000 revolutions per minute, whereas the typical good pass is only in the range of about 600 rpm.

Velocity is a different story. The faster the ball travels, the lower the coefficient of drag. Curiously, for a sphere there is one range where the drag coefficient drops considerably with only a slight increase in velocity, so throwing just a touch harder will mean far less deceleration due to drag. For a football, there is no data to support a similar effect. But aerody-

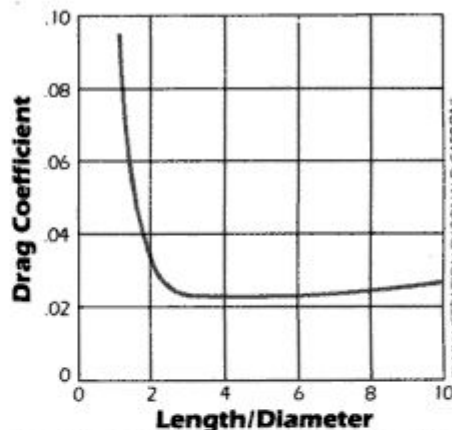
namacists think it might occur in the range of 40 to 45 mph.

The skill factor

Here too, the gyroscopic phenomenon brought about by the spin comes into play. Beyond basic stabilization, it acts to maintain and self-correct the ball's orientation. Consider a rising pass, its nose pointed upward and its spin axis aligned ideally with the trajectory. As it ascends, reaches its apex and starts to descend, the nose slowly continues to tip forward and ultimately points downward because—in the same way that a gyroscope resists disruption, or a top returns to its upright position when slightly disturbed—the football's spin acts to keep the spin axis and trajectory aligned, maintaining maximum lift and minimal aerodynamic drag.

Not all passes gracefully turn over in this way, though. The ones that don't tend to be launched at high-trajectory angles and with overly positive angles of attack. The gyroscopic effect keeps the spin axis in a constant angle of inclination and on descent the ball will assume an even greater angle of attack. With a far greater lift and torque than in an ideal orientation, the result is precession, or a wob-

FOOTBALL PHYSICS



Drag decreases with longer projectiles—like bullets and spinning footballs.

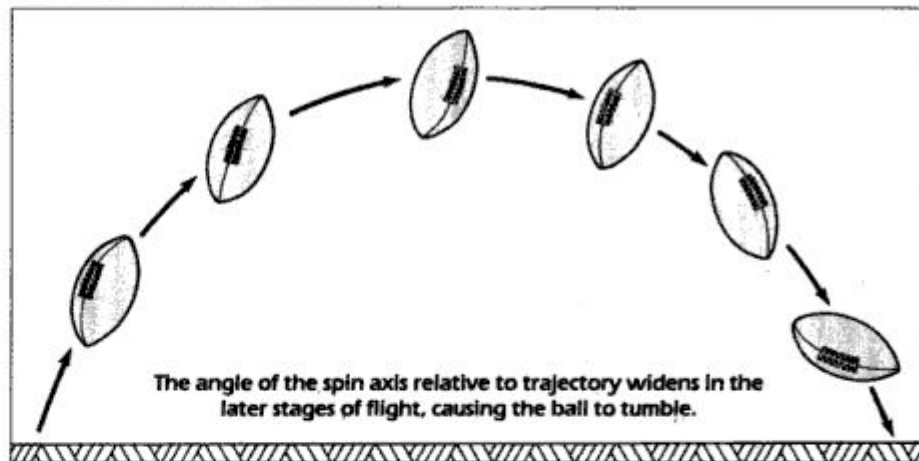
bling, of the football's spin axis.

Nonetheless, a great quarterback might very well instinctively use factors such as angle of attack to control the ball's flight.

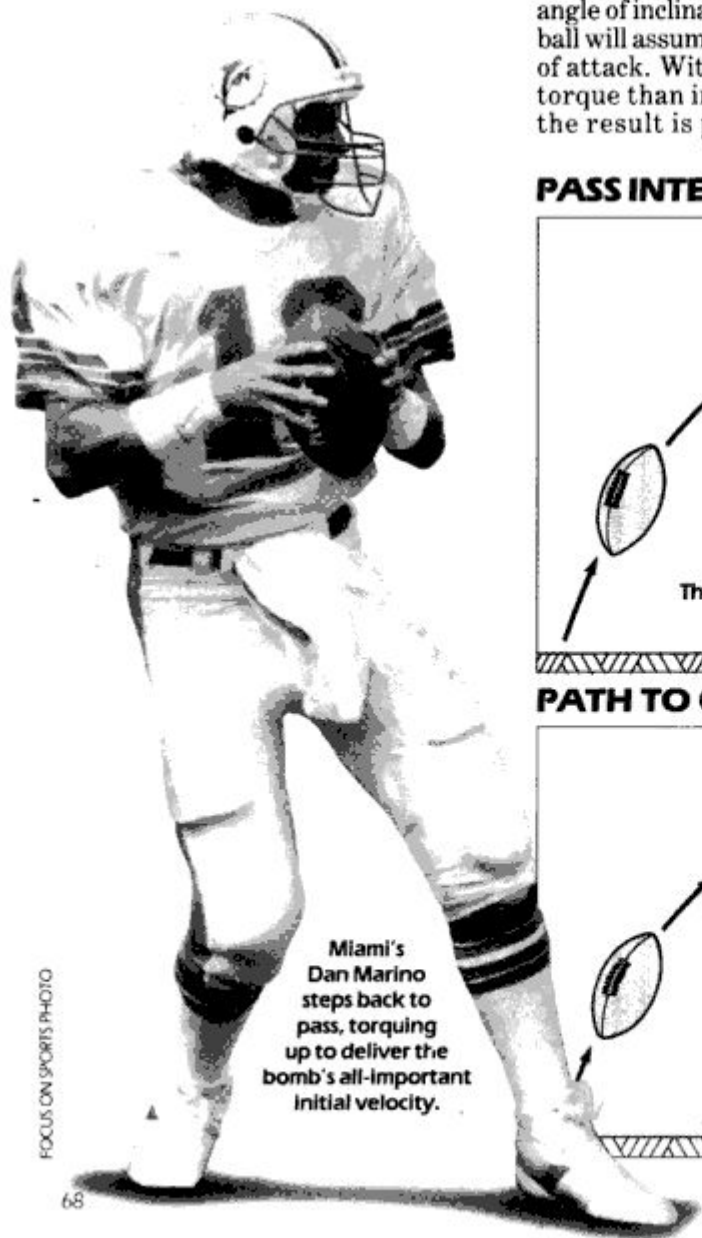
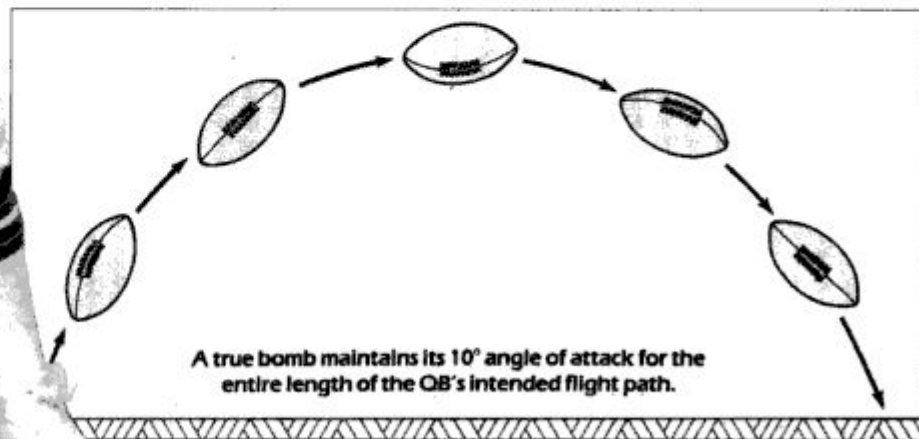
"These are things we might measure after a quarterback has developed his particular technique through trial and error," says Sforza. "For a great quarterback, minor adjustments in headwinds or tailwinds or crosswinds, or getting a little extra hang time by using a slightly greater posi-

(Please turn to page 128)

PASS INTERFERENCE



PATH TO COMPLETION



Miami's Dan Marino steps back to pass, torquing up to deliver the bomb's all-important initial velocity.

FOCUS ON SPORTS PHOTO

STEREO EQUIPMENT

MUSIC FOR ONE

New stereo headphones use infrared light to eliminate that umbilical cord to the hi-fi.

BY FRANK VIZARD, Contributing Editor
PM Photos by Alan Zenreich

NOT TOO LONG AGO, headphone listeners were confined to the home, tethered to their stereo systems by a length of wire. A pillow or a pair of hands was mandatory equipment, propped behind the head to alleviate the weight of the 'phones—especially during long listening sessions. Today's headphone listener is more likely to be jogging than sitting. With the arrival of Walkman-type portables, music appreciation became a movable feast, and lightweight headsets



MUSIC FOR ONE



Sennheiser's SI/HDI 234 infrared transmitter and headphone system (\$570) handled CDs the best in our ears-on evaluations.



Koss JCK/200 infrared combo (\$160) matched the Sennheiser in all but CD reproduction quality, but offers best value.



Nady's IRH-210 transmitter/headphone package (\$120) worked fine for TV and stereo FM radio.

alleviated the pain in the neck. But even if you're listening to your home stereo system, your freedom of movement needn't be restricted by the headphone's leash. The latest models bring you the melody on a beam of infrared light.

The recent development of infrared, cordless headphones is clearly revolutionary (see sidebar, "Dancing On A Lightbeam"). Less obvious is the revolution occurring in all headphones, including traditional wired models. As many joggers already have noticed, headphones are smaller and lighter than ever. More importantly, today's headphones sound better than ever, despite their newfound sveltness.

The improvement in dynamic headphones is made possible by the use of more advanced materials. The most significant change has been the switch to samarium cobalt magnets from the ferrite-and-ceramic magnets used previously. Samarium cobalt—a rare-earth compound—provides a higher magnetic-field strength than ferro-ceramic magnets of the same weight. This means designers can use a smaller, lighter magnet to achieve the same—or better—results.

Additionally, samarium cobalt magnets are more energy-efficient. Headphones using samarium cobalt magnets require less current to drive—a real benefit for battery-

operated products such as personal stereos. The small amount of electrical current used by a headphone travels through a voice coil made from copper wire that is thinner than a human hair. The current magnetizes the voice coil, which is alternately drawn toward and repelled by the magnet. This piston-like motion excites a diaphragm to produce sound.

The motion of the voice coil takes place in an extremely narrow slot called the air gap. The smaller the air gap, the greater the efficiency of the headphones. Used in conjunction with a samarium cobalt magnet, a headphone with a narrow air gap is capable of producing very high sound-pressure levels. The samarium cobalt magnet is usually surrounded by a yoke of soft iron particles that help conduct the magnetic flow. The voice coil generally floats between the magnet and the yoke.

The other critical element in a headphone is the diaphragm—a disc of strong but pliant material, such as Mylar, that performs the same role as the driver cone in a loudspeaker.

The motion imparted by the voice coil is manipulated across the diaphragm to produce a wide range of frequencies, from the lowest bass to the highest treble notes. A variety of dampening filters and variously shaped acoustical cavities help the relatively small diaphragm to produce this range of sounds. The domed shape of the diaphragm prevents it from breaking up when reproducing high frequencies. Meanwhile, the diaphragm must be softly suspended within the headphone—able to move freely so it can reproduce the large amplitudes demanded by low bass frequencies.

Dynamic headphones fall into two design types, either open or closed systems. Open-system headphones, those that do not totally surround and enclose the ear, are by necessity designed to maximize the diaphragm's ability to reproduce low frequencies. This is because bass notes are the most likely to slip out of open, lightweight headphones.

Open headphones benefit from their intimate contact with the ear cavity. The closer a headphone is to your ear, the greater is the perception of loudness.

A closed-system headphone is probably best for critical listening, if only because of its ability to shut out external noise. This is accomplished by the padded collar that surrounds and envelops the ear. From a manufacturing standpoint, closed headphones are easier to make because there isn't the same need to maximize the diaphragm's low-frequency capability. Bass notes don't escape through the padded surrounds of a closed headphone.

The trade-off from a user's standpoint is weight, because closed models generally weigh more than open ones. For sustained headphone listening, an open headphone might be more comfortable.

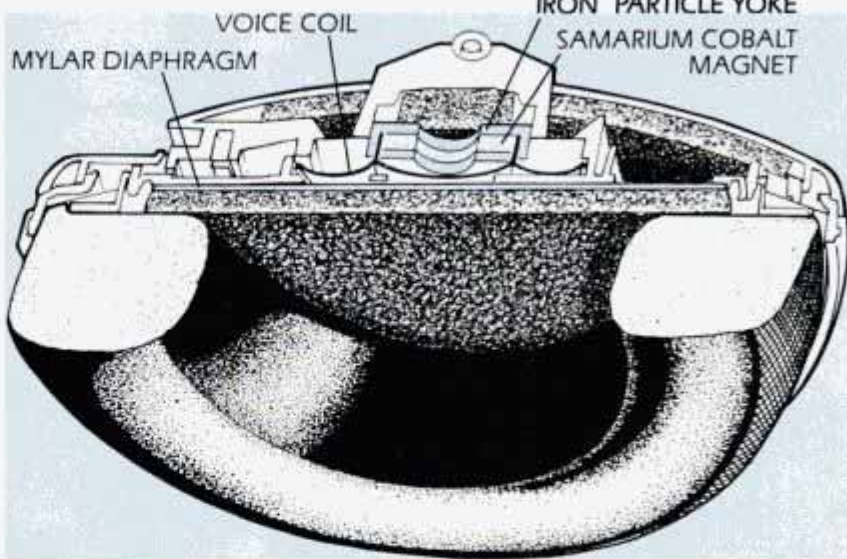
If your listening environment is quiet to begin with, an open headphone using samarium cobalt magnets probably will offer as much satisfaction as a closed model.

Most dynamic models sell for well under \$100 with rare exceptions exceeding \$200. With about 30 major manufacturers supplying multiple models, there are more than enough headphones from which to choose. The wide variety of choice is an advantage to potential buyers, because headphone listening is a subjective experience. Unlike other audio components, there are no concrete specifications that provide a technical basis for comparison.

Once you've found the headphone that suits your ears, you'll find that headphone listening has a character all its own. While loudspeakers seem to disseminate sound from a definite point in the room, music heard through headphones seems to emanate from a point just above your head, enveloping you to some extent. This effect occurs because the music is not being affected by the absorptive or reflective sonic characteristics of your listening room.

Lastly, of course, headphones can create a private space anywhere, indoors or out. You can plug a headphone into portable or home equipment, creating a private listening environment where you live—and a quiet environment for those with whom you live. If the headphone is cordless, you've got mobility, too. **PM**

ANATOMY OF A HEADPHONE



To reproduce high-fidelity music, good materials and construction (as shown here) are critical.

PH ILLUSTRATION BY GEORGE RETSECK

Dancing On A Lightbeam: Cordless Headphones

TWIST AND TURN, dance around the room, do handstands and somersaults—there's no wire to rein you in. The freedom of movement afforded by cordless headphones will make them welcome in many homes. Now, you can have musical accompaniment while you vacuum the rug or repair the vacuum, without fear of entanglement.

Cordless 'phones have been around for some years in Europe and Japan, but these models work on radio frequencies, which our Federal Communications Commission frowns upon for residential use. Accordingly, the current crop of cordless models transmits the music using infrared (IR) light as a carrier. Although different manufacturers might add a proprietary twist to the technology, in general, IR headphones work like this. The 2-part package includes a transmitter and a headset fitted with a receiver. The IR transmitter, powered by AC, plugs into any sound source (hi-fi system, TV, portable stereo) equipped with a headphone jack. The left and right stereo channels are converted into two discrete carrier frequencies, compressed, multiplexed and transmitted as an IR light wave. At the headphone end, a built-in photo-receptor snatches the beam, the multiplexed signal is converted back to left and right channels, decompressed and routed to the appropriate ear as electrical signals. A 9-volt battery stowed in the headset powers all the decoding circuitry and amplifies the musical signal.

Like the illumination from a bare lightbulb, the IR signal spreads throughout the listening room, even bouncing off reflective surfaces. Like all light too, IR diffuses over distance, can't turn corners or penetrate through walls. Generally, though, you can expect a strong, clear signal as far as 35 ft. from the transmitter. We say generally because, although IR is immune to electrical interference, bright sunlight or even a blazing fireplace contain enough IR to cause a snap-crackle-and-pop in your ears. In this instance, you can adjust the volume with the controls built into the 'phones while you scramble to draw the blinds or bank the flames.

Infrared cordless headphones offer a level of convenience that's obvious. Their marginally extra weight, owing to the battery and receiver circuitry, is easy enough to bear given the already light weight of the 'phones themselves. The innovation seemed too good to be true, so we began to wonder about the level of performance they could offer.

Accordingly, we picked three representative models for an ears-on test: the Sennheiser SI/HDI 234 (\$570), the Koss Kordless JCK/200 (\$160), and the Nady IRH-210 (\$120). We also tried some nonstereo wireless models in the \$50 to \$70 range, sold under a variety of names through mail-order and retail outlets. Our evaluations determined that:

- Though quite good, the sonic quality of wireless 'phones falls a bit short of their wired brethren in the same price range.
- In IR technology, you get what you pay for.

For the record, we conducted our evaluations with four sound sources: digital audio compact disc; commercially duplicated, analog Dolby-B cassettes; stereo FM radio and monaural TV broadcasts. In general, all of the 'phones handled the less-demanding TV adequately. The under-\$70 mono models are not designed to do much more, despite their inclusion of a pseudo-stereo switch. We'll leave it at that.

Not surprisingly, the \$570 Sennheiser system managed all the tougher hurdles with aplomb. CD sound was simply excellent. The company's proprietary HiDyn circuitry lived up to its billing as being able to improve the signal-to-noise ratio of wireless infrared transmission. This is critical for CD listening, as digital material has virtually no background noise. Any noise from the IR transmission will detract from the music.

At \$160, the Koss JCK/200 matched the Sennheiser system in every category but CD listening. The digital material still sounded quite good through the Koss gear—but background noise from the transmission was audible. At its price, though, the JCK/200 offers the best value in our group.

Nady's IRH-210 was quite good on FM, fair with cassettes, but not quite up to the task of delivering CD sound with the clearness it merits. We also found the Nady system to have less range than the others, and to be more prone to interference. Like the Sennheiser and Koss 'phones, the Nady is a closed system, so external noise was not a factor.

Although the models we evaluated contain their receiving apparatus, decoding circuitry and power supply in the headset, other IR cordless 'phones outboard this cargo. The electronics is packaged in a small module that clips onto a belt or pocket, enabling you to plug in the headset of your choice. This means you're back to the umbilical cord—but only between your ears and the portable module. And, you can use lighter open-system 'phones.—F.V.

GOOD GYRATIONS

After years of questionable safety, new designs and an emphasis on training have created a renaissance in gyroplane flight.

BY BUDD DAVISSON

WHAT A VIEW! El Mirage Dry Lake spread out as far as the eye could see. The machine I was astraddle was invisible except for the control stick in my hand and a few scant pieces of aluminum sticking up between my feet. I was stranded in the air like a genie without a carpet.

The surrealism of the entire adventure was so complete that I had forgotten I was a confirmed acrophobic and should have been scared to death. I also forgot I was flying a machine I had vowed never to fly—a gyroplane.

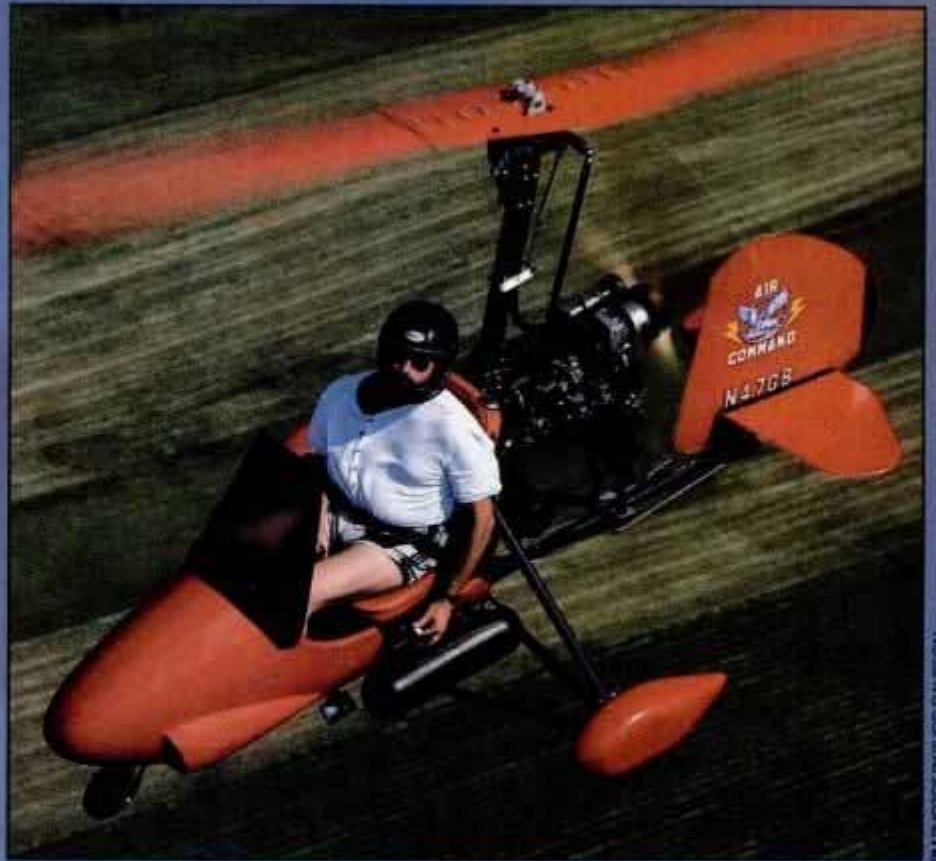
But never is a long time, and blasting along with the desert beneath my feet, I could see I had made the right choice. Acrophobia and common sense be damned. This was really fun—a sensation that conflicted sharply with all my expectations.

The gyroplane has had to carry its share of criticism in recent years, the result of a safety record that, at one time, generated accident and fatality statistics that would have given Evel Knievel's insurance agent heartburn. But, the gyro's image is changing, and that's what put me on this 3-dimensional rotoscooter, grinning like a loon as lake dust caked my front teeth.

The new wave

I had come to El Mirage to investigate both the notoriety—and the lure—of the gyroplane. In the past five years, the gyroplane has seen amazing strides in public acceptance, most of it due to a growing recognition that proper training is vital to





PHOTOS BY BILLO DAVISSON

Jim McCutchen and Kurt Shaw's Wind Ryder (left) represents the dramatically changing face of gyroplane flight. Pilot is entirely enclosed in the monocoque composite fuselage powered by a Rotax 532 65-hp water-cooled engine. Air Command (above) uses a composite fairing to dampen wind blast.

GOOD GYRATIONS

gyroplane safety and enjoyment.

Also, while the gyroplane's stark, bare-bones design has always been intended to fly low and slow, we're now seeing more sophisticated, more streamlined spinoffs. Air Command, based in Liberty, Missouri, offers pilot pods for its single-place machines (priced around \$6000), full bolt-on fairings that dampen wind blast.

Air Command, as well as Ken Brock and other gyromakers, also offer a full 2-place powered gyro in their product line (roughly \$7000) that's crucial to the new emphasis on training.

Jim McCutchen and Kurt Shaw's Wind Ryder, made in Broomfield, Colorado, has given the basic gyroplane a real James Bond look by replacing the traditional aluminum lawn chair-type frame with a full monocoque, fiberglass composite fuselage. The sleek design and high-tech engineering give the \$13,500 Wind Ryder a sea-level cruising speed approaching 100 mph, and a standard maximum altitude of 10,000 ft.

The usual powerplant—as I found on the Brock KB series that I piloted at El Mirage—is the McCullough drone engine, a 4-cylinder, 90-hp 2-stroke. Volkswagen conversions are also used, but a serious weight penalty must be paid, and weight is clearly the gyroplane's worst enemy. Increasingly, the 65-hp liquid-cooled Rotax 2-stroke is gaining favor.



Gyro junkie Ken Brock flying high over El Mirage Dry Lake.

PHOTO BY BLISS DAVISSON

Up, up and away

While this gyroplane renaissance can be found in certain enthusiastic pockets nationwide, the soul of these machines may be located at El Mirage, where Ken Brock preaches the new religion of gyroplane instruction.

In the past, the simplicity of the machine and its ability to use relatively short fields, made it fair game for adventuresome individuals who actually believed some of the early "fly it from your backyard without a license" advertising.

It is amazing how otherwise sensible people would climb into a machine that is, like all flying machines, designed specifically to take them high enough to kill them.

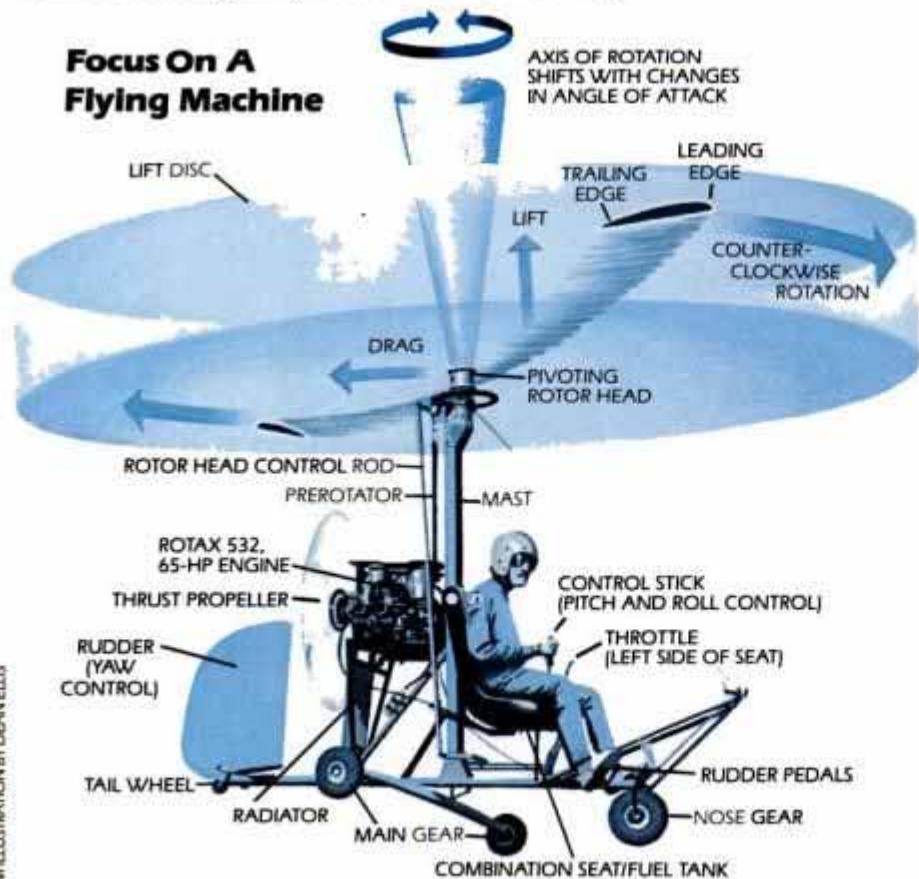
All of that has begun to change. The Popular Rotocraft Assn., which acts as rotordom's collective conscious, insists that training is essential to the continued existence of the breed. Ken Brock, a gyroplane pioneer and a major gyroplane manufacturer, clearly agrees. Dennis Feters of Air Command, a new arrival to the gyroplane field, bases his sales pitch on the same thing: "Safety comes through training." Still, while the training that Brock and Feters offer is important, it's not officially sanctioned by the FAA. The only firm that offers FAA-recognized gyroplane training is Farrington Aircraft Corp. in Paducah, Kentucky.

Legally, if a gyroplane weighs more than 254 pounds, and most do, it must be licensed by the FAA and carry an "N" number. All a pilot needs to fly it is a student pilot's license endorsed for solo in that particular machine by a certified flight instructor. That automatically says the pilot-to-be must get a physical from an FAA medical examiner (usually a local doctor) and undergo sufficient training to solo.

If an individual is already a licensed pilot, he theoretically can fly the experimental gyroplane with only a verbal check out. That could be a serious mistake, though, as I found out in the dry heat of El Mirage. Although experienced in a reasonable variety of air-

A propeller pushes the gyroplane forward, causing the unpowered rotor blades to rotate and produce aerodynamic lift. The pilot changes the angle of the rotor blades to control the aircraft's direction.

Focus On A Flying Machine



PM ILLUSTRATION BY DEAN ELLIS

planes, the gyroplane had a few surprises in store for me, and I was glad to be getting dual training from an expert like Ken Brock.

Fly by disc

The aerodynamics of the gyroplane fall somewhere between those of a regular airplane and a tumbleweed. The helicopter is a very, very distant cousin. Two things differentiate a gyroplane from a helicopter: First, the pilot has no direct control over the rotor blades other than changing the angle of the blades and thereby the angle of the "lift disc" that the rotating blades form in the air; and, second, the rotors have no power driving them. The gyro depends entirely on the forward thrust generated by the pusher propeller to keep the rotors turning, thus generating lift.

The rotor actually is nothing more than a long, high-aspect ratio wing, pivoted in the middle. As it spins, it generates lift. As its disc is tilted one way or the other, that lift pulls the machine in the desired direction.

But the gyro does have two characteristics that are unique. And that's where proper training comes in.

Because the pilot is suspended from the middle of what is essentially a bent bow (the rotor), it is entirely possible to overcontrol pitch and get a Pilot Induced Oscillation, or PIO. A PIO will send a pilot bouncing up and down in the middle of the disc. If he lets go of the stick at that point, the gyro will almost immediately damp out the oscillation, but most beginning gyro pilots aren't smart enough to let the machine sort itself out. Instead, they try to fight the oscillation and are almost always 180° out of phase.

The second characteristic unique to gyroplanes is the truly prodigious drag the aircraft can create with only a few degrees change in angle of attack. On takeoff, for instance, the trick is to keep the machine balanced on its main gear, keeping the nose wheel barely clear of the runway. At that attitude the machine will levitate on its own. However, increase the angle just a few degrees more and the lift vector is angled backward, producing a sizable increase in drag. If kept in this nose-up, high-drag attitude, the engine won't be able to overcome the drag and the gyro will most likely stay on the ground—as you run out of runway.

The incredible drag buildup is the most startling aspect of the gyro and Ken Brock has built his training program around recognizing proper attitude, thereby directly controlling the lift/drag relationship. He spent a lot of

time hammering that relationship home to me.

Desert dry run

Brock's training ground is a private airport on the edge of El Mirage about 25 miles east of Palmdale, California. The runway is for normal airplanes while the lake is his own gyro training ground. For instruction he uses a 2-place, engineless gyro tethered to a Ford stationwagon that has obviously seen thousands of passes up and down the lake. The Ford produces the forward motion that eventually lifts the glider off the lake bed, giving the neophyte his first taste of gyro flight with Ken Brock strapped next to him.

The advantages of the towed glider concept work well with the seemingly limitless surface

Air Command's 2-place machine has become a vital tool in gyroplane safety.

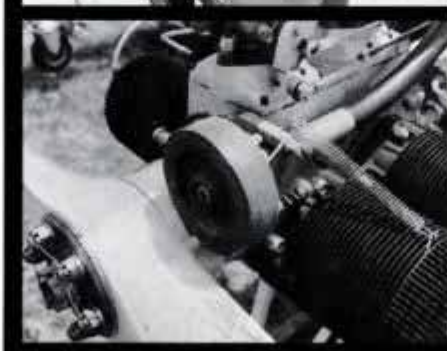


PHOTO BY BUDD DAVISON

GYRO COMPONENTS IN DETAIL



Counterclockwise from top: A simplified instrument panel gives operator compass heading, air speed, altitude and fuel remaining. Pilot seats often double as fuel tanks. Twin 6-gallon tanks extend range for cross-country travel. Rotor blade prerotorator engages rotorhead gear. Power comes from flexible cable turned by contact wheel on crankcase extension. Roll cage adds safety and weight.



PHOTOS BY TIM COLE

GOOD GYRATIONS

of the lake bed. In the course of a single 6-mile-long pass, we made as many as a dozen takeoffs and landings, with Brock demonstrating or requesting certain maneuvers.

The first challenge was feeling the proper rpm for the rotors. It is entirely possible to get too much forward speed for the amount of rotation, which overloads them and causes them to flap. If that happens, you have to kill the power and return to square one. That is one reason the "prerotator" option is so popular on homebuilt gyroplane kits. A simple rotating cable powered off a crankcase extension, which is clutched to a

problem with new gyro pilots, so he has a favorite exercise for neophytes. He yelled at me to keep it right behind the station wagon and hold altitude. Then he suddenly lunged out one side of the machine, hanging his body as far out as possible. Naturally, the gyro tried to follow, and only a healthy dose of side stick kept us vaguely in the middle. Then he just as suddenly came back into the center, forcing me to correct in the other direction. This went on for several 6-mile passes while I tried to take off and land, with Ken literally leaping all over the fragile gyroplane, causing it to heave and buck.

and pilot felt much more at home and strict attention was paid to keeping the nose attitude down to let the speed build. If the nose is kept a little too high, the airplane will fly on the engine, but if it quits, the forward speed will diminish, and pilot and machine will very quickly arrive at ground zero. If the attitude is right and the speed is up, the engine can quit and the pilot only has to lower the nose to land normally.

Bring it home

The best way to describe landing a gyroplane is to visualize a large hawk landing on a fence post. The nose is kept down until reasonably close to the ground, and then brought up gradually, trying to time the drag buildup to the rate of closure with the ground. After only a few landings, it became second nature to come swooping down, like the aforementioned hawk, sticking the landing gear to the ground at the bottom of a gentle arc like a pair of talons. Made with power-off, that kind of arrival took up maybe 50 ft. and I've seen Brock do it in a wind and have no forward motion at all on touchdown.

In experimenting with the gyro's ability to create drag, I taught myself a valuable lesson. Flying within a few feet of the ground with approximately $\frac{3}{4}$ throttle, I began gently bringing the nose up while maintaining altitude. At a certain angle, a very flat one, I could feel the craft decelerate and more angle was needed to maintain altitude, which continued to increase drag.

In far less time than it takes to read about it, the gyro had literally dragged itself out of the air and landed on the lake bed while the engine was still screaming away.

Keeping the nose down is the most important lesson a new gyro pilot can learn. He has to treat the control stick like the spoiler control on a glider, since bringing it back quickly creates more drag than lift.

What did we learn about gyroplanes in the course of our adventures?

Among other things, it dashed a lot of preconceived notions. In the first place, it flies just like a real airplane, so long as the aircraft's drag is taken into consideration.

Most important, I found the gyroplane to be safe if flown within its limitations, and to know those limitations, instruction in a 2-place machine is *crucial*. Self discovery is fun, but not when your ankles are the only thing separating the aircraft from the ground. **PM**



A towed unpowered machine gives beginning pilots first clues in gyro dynamics.

drive mechanism on the rotorhead. This imparts enough rpm to the rotor before the gyroplane starts moving to shorten takeoff runs dramatically, alleviating the problem of matching machine speed to rotor speed.

Flying free

The first liftoff is a gas. And also a relief, since it gets the glider up out of the dust cloud created by the training wagon. I was amazed to find that the machine flew like a real airplane. In fact, although its response is a little faster, I could have been flying a naked Aeronca Champ. Or flying a Champ naked, since that is the best description of being 30 ft. high with no visible means of support.

Brock says overcontrol is often a

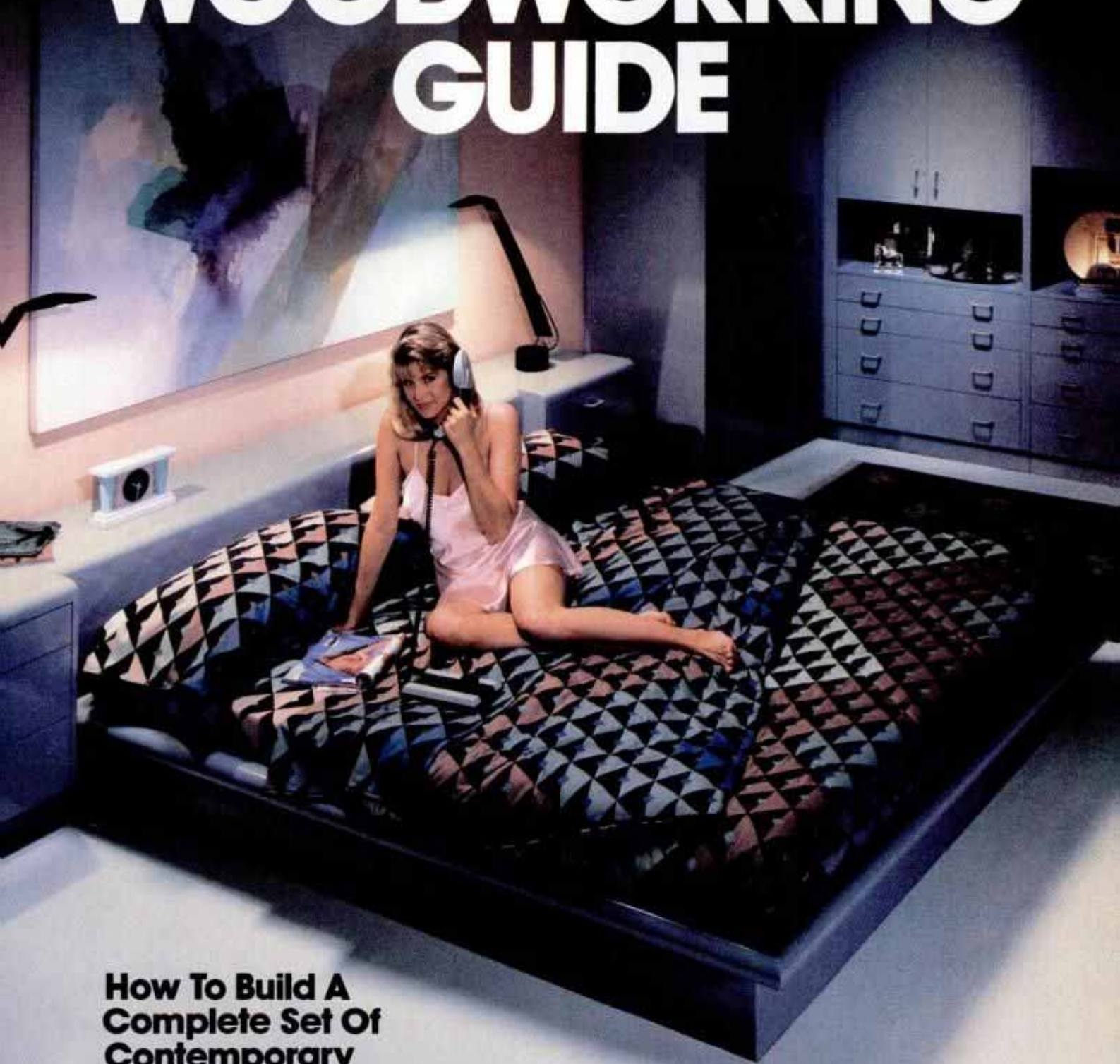
Show time

Later, Brock rolled out his well-known black air show machine and checked me out on the controls. In a minute or two, I realized he wanted me to solo his pride and joy. He didn't look worried. But I did.

He jumped into the Brock Gyro-Ford and drove alongside me, signaling with his hands—more power, less attitude, and so on. It was easy to look over and do his bidding. We ran up and down the lake, with me balancing the black gyro on its main gear, getting a feel for the proper attitude.

That first solo liftoff gave me none of the apprehension I had expected. In fact, after bouncing across the lake bed for miles, it was an absolute joy. Once off the ground, both machine

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FANTASTIC FINISHES

From the ordinary to the extraordinary,
the secrets lie in the finishing.

BY ROSARIO CAPOTOSTO, Contributing Editor

IT'S BEEN said that beauty is only skin deep. If there's any truth to that adage when it comes to woodworking, it suggests that the final, skin-deep finish is of undeniable importance. We've decided to put that theory to the test. Not satisfied, however, with simply offering one way to finish wood, we're offering a host of techniques and products each with its own personality.

As a vehicle to display each finish, we chose identical, garden-variety unfinished chests—the kind available at unfinished-furniture stores everywhere. The material is knotty pine and the design is basic.

As for our finishes, they run the

Clockwise from bottom left: marbled top with 1-step stain and finish on bottom; quartersawn oak graining; decorative stenciling on painted cabinet; lustrous brushed lacquer natural finish.

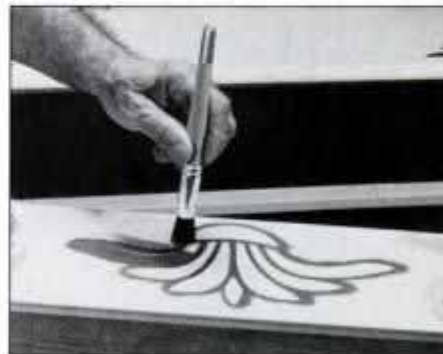
Color photo: J.R. Rost
Black-and-white photos: Rosario Capotosto



1 Mylar film is taped over drawing and cut with a razor-sharp knife to make stencil. Errors can be taped with transparent tape.



2 Stenciling requires a smooth, flat background. Latex satin-finish enamel is applied over the primer. Avoid glossy paints.



3 Up and down dabbing strokes are used to apply paint through cutouts. Make sure to remove any excess paint from brush.

gamut from stenciled ornamentation on a painted background, graining and marbleizing—ways to actually make the pine look like a totally different material, oil-based stain for that rich traditional look and a crystal-clear gloss lacquer finish.

Whether you're a dyed-in-the-wool workshop enthusiast or are simply trying to make the most of a ready-made piece of unfinished furniture, we think you'll find that these techniques open a world of possibilities.

Preparation

Before applying any finish, first sand with 100-grit sandpaper, then 150 grit and finish with no coarser than 220-grit paper. Inspect the piece for loose joints and exposed nails, screws or staples. Reglue joints where necessary and fill all holes. Apply a coat of sealer to all the interior surfaces to prevent moisture absorption.

If the piece will receive an opaque

finish, seal all knots on exposed surfaces with shellac. This prevents the resins in the knots from bleeding through the final finish. Then, apply a primer such as BIN or Enamelac to the entire surface to provide a good base for painting.

Stenciling

The materials for stenciling are available at art-supply stores. You'll need a stencil brush, paint and a material from which to cut the stencils. Stencil brushes come in various sizes.

For our project, a No. 12 (3/4-in.-dia.) stencil brush was ideal. Any fast-drying paint can be used. We chose an acrylic paint because it has good covering characteristics and cleans up with water.

While precut stencils are available, we designed and cut our own. Create the designs on full-size drawings of the parts to be stenciled. If you're opting for symmetrical shapes as we did,

it's easier to make an accurate drawing if you draw only one half of the shape on tracing paper and then flip it over to produce the other half.

Polyester film such as 3-mil Mylar is an ideal stencil material. The type with one frosted side allows you to draw directly on the stencil with pencil. To cut the stencil, simply tape your drawing to a cutting board and tape the film over it. Trace the outline with a razor-sharp knife (Fig. 1).

After preparing the surface as described, paint the entire piece with latex satin-finish enamel in the color of your choice. We used Benjamin Moore Aquaglo Fawn No. 333-53 (Fig. 2).

To avoid any seeping of the stenciling paint under the stencil, spray the back of the stencil with a light coat of artist's spray adhesive. Then, align the stencil and lay it in place.

We used Country Colors Acrylic Green Olive No. 2442 for the stenciling paint. It's available in 2-ounce squeeze bottles. Place some stenciling paint in a shallow container and dip the bristles of the brush straight down into the paint so only $\frac{1}{16}$ in. of the bristles are covered. Remove any excess paint and dab the brush straight up and down through the stencil openings (Fig. 3).

To get a solid coat of paint as we did,

make several applications over each segment before the paint dries. Then, lift the stencil and move it to the next location.

Never allow the acrylic paint to dry on the brush—keep it in water during waiting periods and dry it before use. We covered the finished job with two coats of Deft semigloss Wood Finish.

Marbleizing

Marbleizing is known as a *faux* (rhymes with low) finish from the French word meaning false. To a great extent, the success of the illusion depends on marbleizing only those parts that might really be made of marble such as the top slab of our chest of drawers.

Begin by masking off those areas not to be marbleized—use newspaper and masking tape. Then, seal and prime the top followed by a coat of black, semigloss enamel (Fig. 4). When this coat is dry, apply a coat of 3-pound cut shellac.

Next, prepare the glaze. The glaze is a coating that can be manipulated and added to while still wet to produce the desired effect. Prepare one cup of clear glaze by mixing 6-tablespoons semigloss clear alkyd varnish, 6-tablespoons boiled linseed oil, 10-tablespoons mineral spirits and then 2-tablespoons of Japan drier. The

marble veining is done with white, raw sienna and burnt sienna artist's oil paints. Squeeze a small bead of each color into separate small dishes and pour about 1-teaspoon clear glaze over each color. The main veining color is made by mixing equal amounts of white and raw sienna and adding the glaze.

Apply a coat of clear glaze to the top. Lightly dip a 2-in. brush into the white paint and then into the glaze. Pass the brush very lightly on the glazed chest top in semicircular strokes. Try to deposit small amounts of paint in a haphazard manner. Then, dab at these traces of white with a soft cloth moistened with clear glaze to produce a faint cloudy effect against the black background (Fig. 6). If the glaze begins to dry, then add more.

Begin the veining by holding a No. 2 artist's brush between the thumb and the index finger and dip it into the main veining color. Holding the brush in this way helps in creating irregular, natural looking patterns. Starting at an edge, draw the brush across the surface in a rambling path. Vary the pressure on the brush occasionally to obtain lines of different thickness and density. Every so often, press down the brush and twist to diffuse the color and sharpness of the vein (Fig. 7).

During the course of the veining,



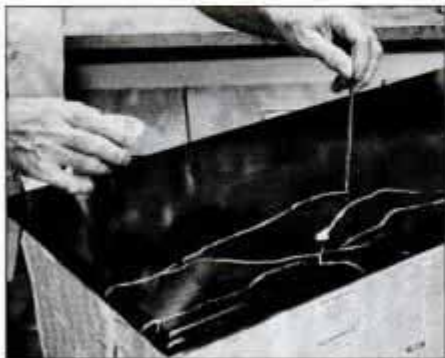
4 After priming the top for marbleizing, apply a coat of alkyd semigloss black paint. Masking protects the rest of the chest.



5 After painting the top black, apply a coat of shellac to produce a smooth surface. Then, apply a coat of clear glaze.



6 Add traces of white with a 2-in. brush to the glazed surface. Use a cloth wetted with clear glaze to soften white areas.



7 Artist's brush dipped into main veining color and moved in an irregular path makes veins. A loose grip helps the effect.



8 When the marbleizing is done, apply four coats of gloss varnish. If dissatisfied, wipe off the glaze and start again.



9 Wood-Sheen stain and finish can be applied with a soft cloth or foam pad. We applied two coats for desired luster.

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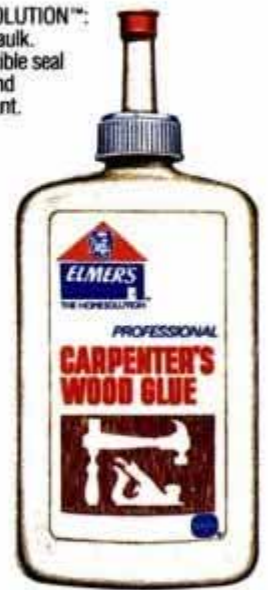
Problem: How to attach Formica® to a countertop.
THE HOME SOLUTION™: Elmer's Contact Cement. Forms a strong bond.



Problem: How to replace caulking around your tub and tile.
THE HOME SOLUTION™: Elmer's Tub Caulk. Provides a flexible seal that's water and mildew resistant.



Problem: How to protect your hands from paint, oil and grease.
THE HOME SOLUTION™: Elmer's Invisible Glove™ Protective Hand Cream. Just apply before any dirty job.



Problem: How to glue the arm back on the armchair.
THE HOME SOLUTION™: Elmer's Carpenter's Wood Glue. Penetrates wood deeply for a strong bond.

occasionally dip smaller brushes into either the white or burnt sienna and make a light pass through an existing vein. If the completed veining doesn't look quite right, simply wet a cloth with mineral spirits, wipe the top clean, and start again. When you're satisfied, let the top dry for 48 hours and apply four coats of clear gloss varnish (Fig. 8).

Oil-base stain

To accent the marbled top and provide a rich traditional look, we decided a warm stain with a soft luster would be appropriate. We used Minwax Wood-Sheen to achieve both goals in one simple operation. Wood-

Sheen is available in six colors plus natural. To get the exact color we wanted, we mixed one part Colonial Walnut with six parts Mandarin Maple. Because pine is difficult to stain evenly, apply a coat of Minwax Wood Conditioner first. Then, apply two coats of Wood-Sheen with a cloth or foam pad (Fig. 9).

Graining

The second of our faux finishes is a graining technique that virtually transforms the appearance of the ordinary pine into the look of expensive quartersawn oak. Like marbleizing, graining utilizes a base coat and glaze coat. We used Red Devil Acrylic La-

tex Antiquing Graining Base Coat M and Oil-Base Glaze Coat No. 202 Oak. You'll also need a 2-in. brush, No. 2 artist's brush, and two hair combs—one with coarse teeth and the other medium. Make sure that the teeth lie on a straight line. Use sandpaper and sanding block to dress the comb teeth flat.

Prepare and prime the chest as described in the stenciling section above, then apply the graining base coat (Fig. 10). After this is dry, mask off half of the top panel. This allows working each half of the top separately creating the look of two book-matched oak boards. We divided the sides into three boards each.



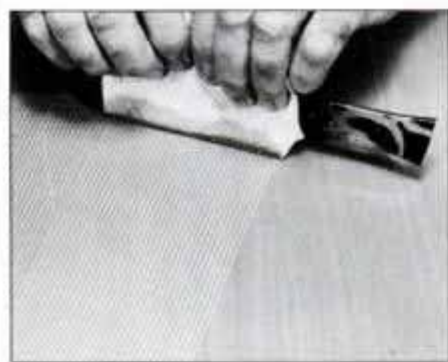
10 Begin the graining by applying a colored base coat over the primer. Base coat is a quick-drying satin latex paint.



11 To create the look of two book-matched solid oak boards, mask half of the top before applying glaze coat.



12 A coarse-tooth comb wrapped in a soft cloth is best for making grain lines. Make sure teeth points are in a straight line.



13 Pull the cloth over the glaze in a slightly diagonal direction. After each pass, wrap the comb with a clean piece of cloth.



14 The medium-tooth comb is used without the cloth. Pull it across main grain lines at about 10° or parallel to top edge.



15 The rays are painted with an artist's brush and diluted glaze. Brush is held loosely to allow it to waver slightly.



16 After each section is dry, remove adjacent masking and mask off finished areas. This creates the look of individual boards.



17 For a lustrous high-gloss natural finish, use three coats of brushing lacquer. Sand between coats with 220-grit sandpaper.



18 After final coat has dried, rub down cabinet with polishing compound. This softens the harsh gloss of the lacquer.

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WOODWORKING GUIDE

Apply the glaze evenly, but don't be too concerned about brush marks (Fig. 11). Wrap a soft cloth around the coarse comb and pull it in continuous strokes along the top at a slight angle to the masked centerline. Start each pass with a clean cloth. Then, use the medium comb without the cloth to create lines about 10° to the original lines (Figs. 13 and 14).

To make the characteristic ray pattern of quartersawn oak, first mix 1 teaspoon of mineral spirits to 1 ounce of glaze. Dip the artist's brush in the glaze and make irregularly curved strokes in a general crossgrain direction. Release the pressure at the end so the ray becomes lighter and narrower. Avoid making each ray exactly the same. But, at the same time, try to create a fairly uniform overall pattern. Then, make light rays beyond the main rays (Fig. 15).

While the first half of the top is drying, you can begin the side boards. Vary the grain pattern between each section to emphasize the look of three boards. Wait until each section has dried before masking off that section to work on an adjacent area (Fig. 16). The bookmatched top is achieved by creating a mirror reflection of the finished side.

When the graining is completed and dry, apply two coats of satin polyurethane varnish.

Lacquer

While our other finishes all change the wood's appearance, applying a simple high-gloss clear finish remains an excellent way to highlight the natural beauty of the wood.

Today, most lacquer finishes are applied with spray equipment and are known for their durability and luster. However, Fabulon's High-Gloss Brushing Lacquer is a simple-to-use finish that only requires a light sanding with 220-grit paper between coats. We used three coats, rubbing down the last coat with Armor Rub polishing compound for a smooth, high-luster finish (Fig. 18). **FM**

Source List

- Armor Products, P.O. Box 445, East Northport, NY 11731 (Armor Rub)
- Benjamin Moore & Co., 51 Chestnut Ridge Rd., Montvale, NJ 07645
- Deft, Inc., 17451 Von Karman Ave., Irvine, CA 92714
- Fabulon Products, P.O. Box 1506, Buffalo, NY 14240
- Illinois Bronze Paint Co., 300 E. Main St., Lake Zurich, IL 60047 (Country Colors)
- Minwax Company, Inc., 102 Chestnut Ridge Plaza, Montvale, NJ 07645
- Red Devil Paints & Chemicals, 30 West St., Mount Vernon, NY 10550
- Wm. Zinsser & Co., 39 Belmont Dr., Somerset, NJ 08873 (BIN)

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CUT AND DRIED

Working with wood is a joint venture between you and the material. Learn to get along.

BY THOMAS KLENCK, Associate Home and Shop Editor
PM Illustrations by Dyck Fledderus



IN A WORLD WHERE the most commonplace operations are often computer controlled, where lasers routinely handle delicate surgical operations and the once approachable automobile is quickly achieving the sophistication and repairability of an orbiting weather satellite, it's somewhat paradoxical that wood is still *the* universally accepted building material.

The reasons are both practical and passionate. Historically, it was the only easily available material that combined an impressive strength-to-weight ratio with ease of shaping and joining. And, its good looks did not go unrecognized. The warmth and richness of its infinitely variable colors and grain patterns make each board a finished work of art—even before construction begins. Today, wood continues

to serve our practical requirements while having achieved an almost symbolic status that reflects good taste and a sense of tradition.

The nature of wood

Wood is natural. Unlike a synthetic material whose properties can be tailored to suit a purpose, we take wood as it comes. It isn't designed to be made into houses, furniture and decks. It's best suited to being part of a living tree. Some of the properties that make wood work so well in the tree can, and do, cause real problems for the woodworker.

The cellular structure of wood contributes to its ability to shrink and expand with changes in the humidity of its environment. To make matters worse, wood is naturally round in cross section. It grows in a

series of concentric rings. When it dries, it shrinks to a greater degree concentrically (around the tree) than it does radially (from the center out).

Getting flat from round

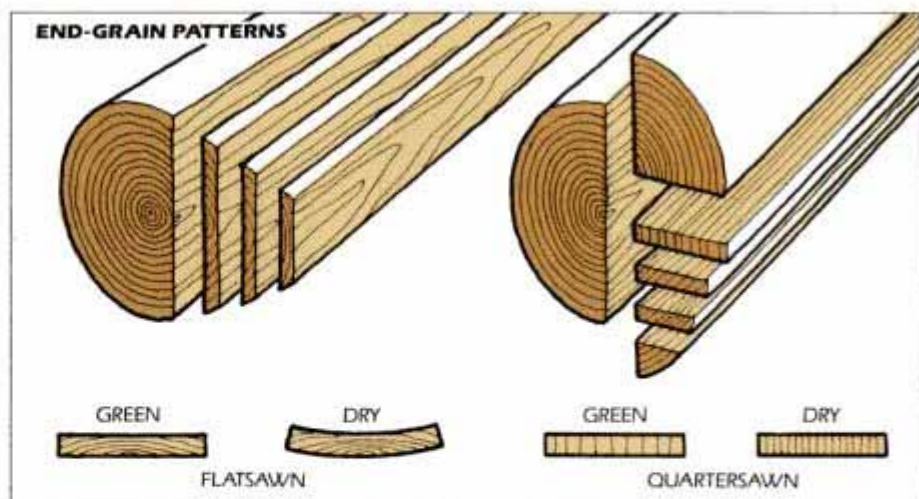
Flatsawn lumber—boards sawn in parallel layers across the width of the log—show a pattern of growth rings running in arcs across the width of the board as shown in the photo on the preceding page. A flatsawn board will cup as its moisture content varies due to the different rates of shrinkage parallel to and across the growth rings.

Quartersawing produces an end-grain pattern called vertical grain where the growth rings run from face to face across the thickness of the board (Fig. 1). In this case, the wood will not cup as its moisture content changes, but simply shrink or expand more uniformly. Because quartersawing produces less usable lumber per log, boards cut this way are more expensive than flatsawn boards.

While quartersawn lumber in certain species is available from larger furniture grade wood dealers, most lumber is flatsawn. It's not unusual, however, to find wide common-pine boards that have been sawn right through the center of the log. Effectively, a 1x12 sawn this way will produce two roughly 5-in.-wide vertical-grained boards. Avoid using the center, or pith, of the tree. This wood will move and check more rapidly than the surrounding wood.

On the move

You can expect common flatsawn wood to cup as sure as the seasons



1 Flatsawing (left) produces the most usable lumber from the log. Boards will cup away from the log center as they dry. Quartersawing (right) produces a vertical-grain pattern on the board ends. While the boards will still shrink, cupping is reduced.

change. Knowing how the wood will cup can help you to produce more successful projects. For example: When gluing together several narrow boards to create a wide panel, reversing the direction of the growth-ring arcs will even out the cupping effect. Drawer fronts should have the heartwood (inside of the log) facing out. If the wood dries, the joints at the top and bottom will be forced tightly together (Fig. 6).

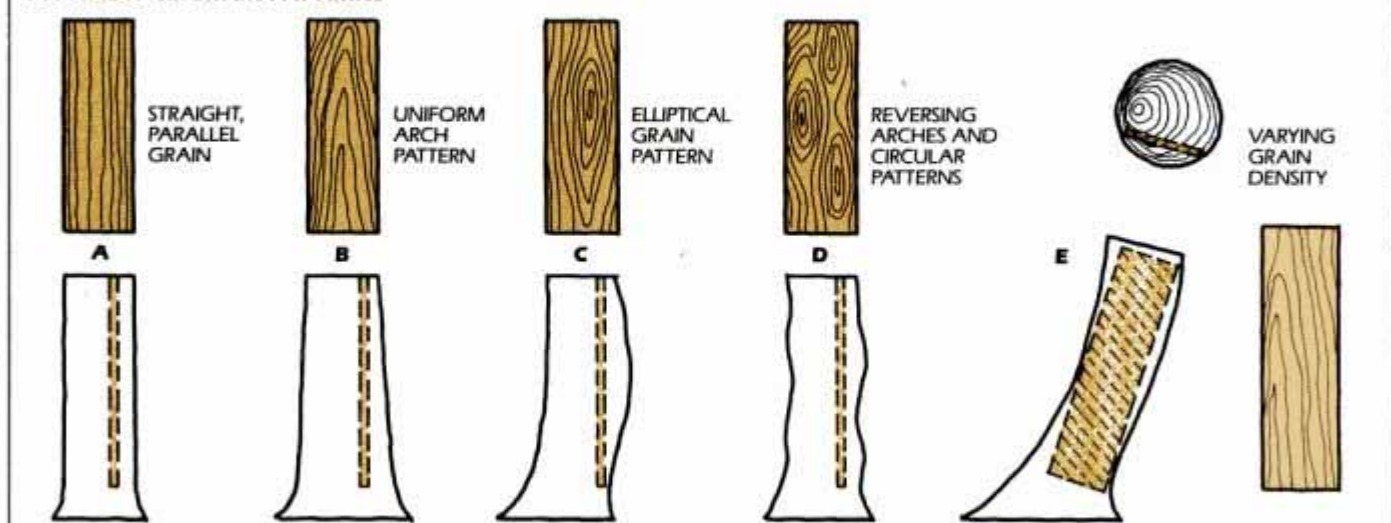
In addition to cupping, stresses imparted as the tree grew—or varying grain densities—can cause the wood to deform either while it's drying or when you're cutting it. Checking the uniformity of the grain on the edges and faces can provide clues as to whether a board is likely to deform.

Uniform straight, parallel lines

mean that the board is likely to react uniformly to drying and cutting. Long uniform arches on the board's face are also a good sign, but if there are many circular patterns, quickly changing arches or rapid changes from dense to less-dense wood, you may be in for trouble. Not only are these boards more likely to deform, but they're more difficult to work as well (Fig. 2).

The absence of knots has long been one of the basic standards for grading wood. The first thing to realize about boards without knots, is that they didn't come from a tree without branches. The clear log was, however, long enough to produce useful length boards. The key word is useful. Boards containing knots can be used to make knot-free furniture. You just have to work a little harder when de-

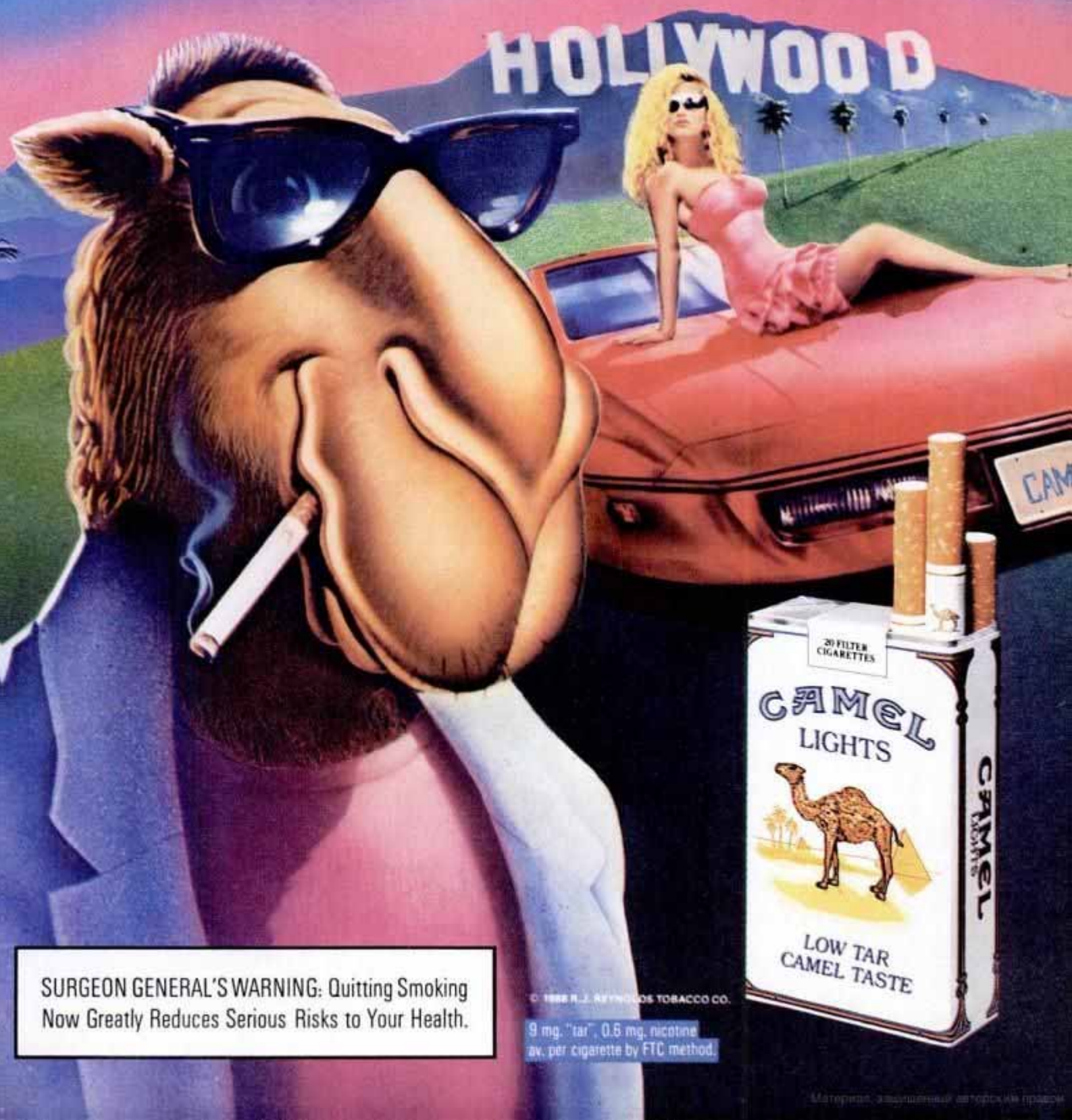
TYPICAL FACE-GRAIN PATTERNS



2 Face-grain figure offers clues to the shape of the tree and may signal excessive deformation as the board dries or when it's cut. (A) Straight-grain board suggests uniform drying and machining but has less interesting grain figure. (B) Typical arch pattern reflects ta-

pering trunk. (C) Bend in the tree produces elliptical rings on board. (D) Many rings and reversing arches indicate an irregular trunk. (E) Trees that grew at an angle may have denser grain on one side and contain stresses which lead to warping.

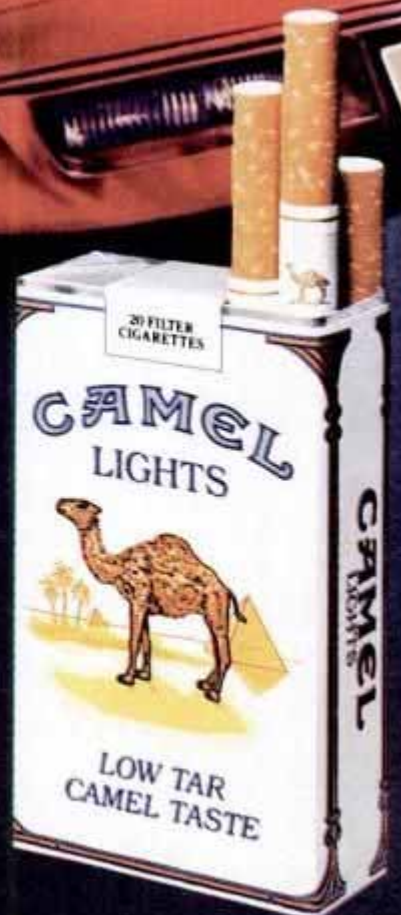
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termining how each board should be cut. Where knots are impossible to avoid, make sure they're not on the edge and try to use them as a design element of the finished object.

Getting it dry

There are two ways to bring lumber to a moisture content that will ensure that it won't move or distort significantly after the project is completed. The simplest is to let it dry naturally in the air. Boards are typically stacked with evenly spaced sticks placed in between the layers for air circulation. The time it takes depends on the moisture content of the wood and the relative humidity of the air. And, the final drying must take place in an environment that has the same humidity as the project's final location. Don't be tempted to speed up the process by bringing green wood directly into your house. The wood will dry too quickly, causing cracks and checks.

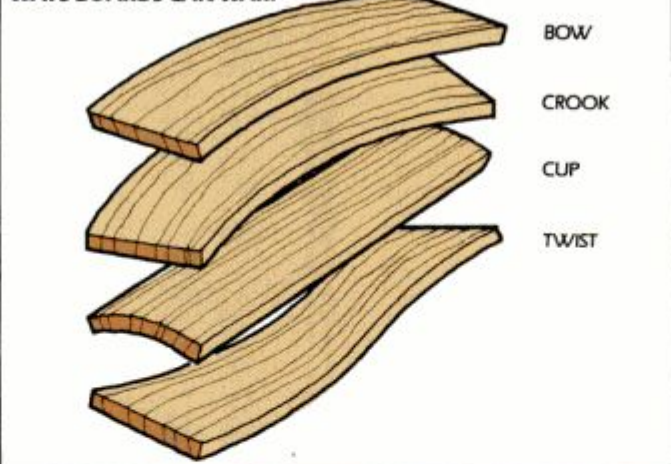
Kiln-dried wood has been subjected to an accelerated drying process. Unfortunately, if kiln drying is done too quickly, it can cause problems. Case-hardening occurs when the outside of the board dries first and becomes rigid. When the inside dries, it stretches as it conforms to the rigid outer shell (Fig. 4).

This internal stress becomes apparent when the board is ripped—the saw kerf will immediately close behind the cutting edge and bind on the blade. It also means that removing any stock from only one face will cause the board to warp as the stress is relieved. In extreme cases, casehardening can cause internal cracks called honeycombing.

No matter what wood you buy, how dry the dealer says it is—and regardless of how much you pay for it, the wood will move (shrink, expand, cup, crook, bow or twist) if it hasn't been dried to the same moisture level as it will eventually attain. Even after your wood has been dried adequately, it will continue to move with seasonal changes in humidity.

The easiest way to determine the moisture content of your wood is to check it with a moisture meter. The most common type works on the principle that water conducts electricity and dry wood is an insulator. The meter measures the resistance of the wood to electric flow and translates

WAYS BOARDS CAN WARP



3 As well as expanding or contracting across the grain, boards can change in shape or warp as moisture content varies. A bow is seen along the edge of a board. Crooked boards may lie flat, but their faces are curved. Cupping and twisting appear on end.

the data into a moisture-content percentage. Although these meters typically cost \$100 and up, considering the usual outlay for a woodworking shop,

it's a small price to pay.

And, don't forget that the finish you apply will affect the rate that the wood will absorb or release moisture. Because finishes act as moisture barriers, applying a finish to only one side of a board means that each face will react to humidity changes at different rates. The safest rule is to apply the same number of coats of the chosen finish on all surfaces of each piece in the project. This rule also applies to veneering. Covering one side only is a sure formula for disappointment. When using decorative plastic laminates, special backing laminates are

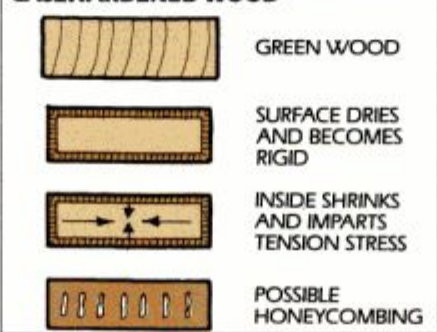
available for application on the hidden side of the stock.

Manufactured wood

Traditional construction techniques have evolved to tolerate woods' natural peculiarities. Frame and panel construction, for example, allows the panel to expand or contract freely within a frame. In a sense, a frame and panel assembly is a manufactured wood product that can be relied upon to be stable. Several panels can be joined with little concern for the effects of wood movement.

The lumber industry has taken this idea of assembling wood components to produce a stable product several steps further. And, in the process, given the designers a virtual field day in freeing furniture designs from past

CASEHARDENED WOOD



4 Kiln drying can produce casehardened wood. In extreme cases, internal cracks known as honeycombing can develop.

SAWING BOARDS WITH INTERNAL STRESSES



5 Cutting or planing boards with stresses can change the shape of the wood. It's wise to leave enough stock so the board can be rejointed after ripping. When planing, remove stock from each face equally. Binding (left) is typical of casehardened wood.

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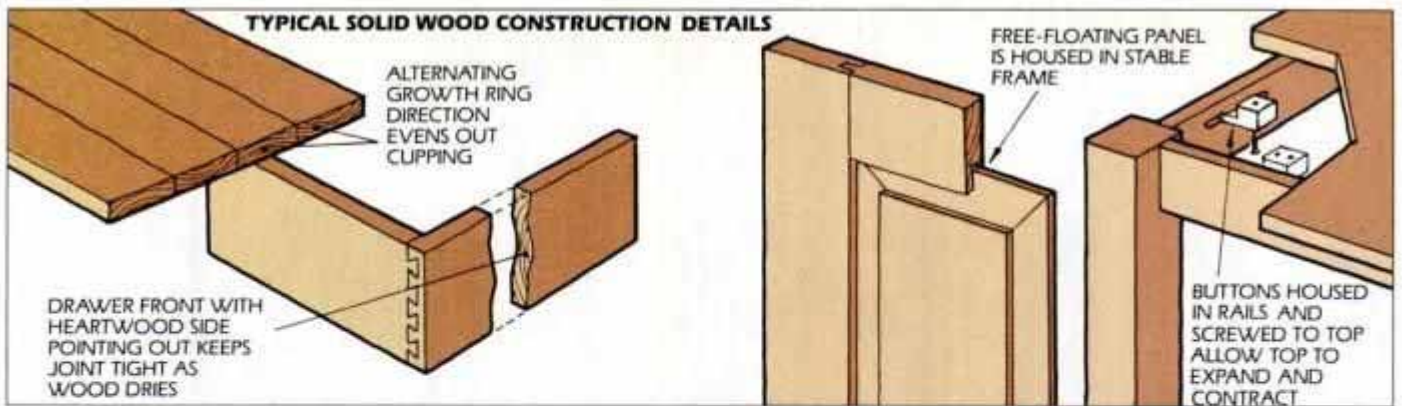
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6 Examples above illustrate traditional ways of dealing with woods' tendency to deform. In other cases, dimensional changes can be used to the woodworker's advantage. Spindle chairs often

use dry rungs that are mortised into green legs—mortises then shrink tightly around rungs. Wooden boat hulls become water-tight as planks absorb moisture and swell.

constraints. The most common example is plywood.

Veneers, or thin layers, of wood are glued together with the grain direction of adjacent layers oriented at right angles. This constrains swelling and shrinking. The veneers are produced by either rotary or flat slicing. Plywood with flat-sliced face veneers displays the same grain figure of solid wood and is the choice where a solid wood look is desired.

What to do with the edges remains one of the real problems of plywood construction. They can be taped with a thin veneer of similar wood, covered with thicker trim that's glued and clamped in place, or even mitered at all corners. More expensive veneer-core plywoods—because of the quality of the interior veneers, offer you the option of simply sanding and finishing the raw edge. Of course, any pretensions to solid wood are lost with this honesty-to-materials approach. For a good compromise between the stiffness of solid wood and the convenience and stability of plywood, solid-

core plywood is available. This material has two top veneers at right angles to each other on each face. The core is made up of solid wood.

Perhaps the best use of plywood is in combination with solid wood frames. This updated frame and panel construction makes the best use of both materials.

Further from the tree

Particleboard—a composition of wood particles and glue compressed into panels—is available with veneer surfaces or in its *natural* state. Fiberboard makes use of finer wood particles or fibers that are compressed under heat and pressure. Medium Density Fiberboard (MDF) provides a consistent density throughout the thickness of the panel. This makes for easily machined and painted edges. It is the obvious choice for the uncluttered broad surfaces of contemporary painted furniture such as the impressive bedroom suite (page 100) that we show you how to build.

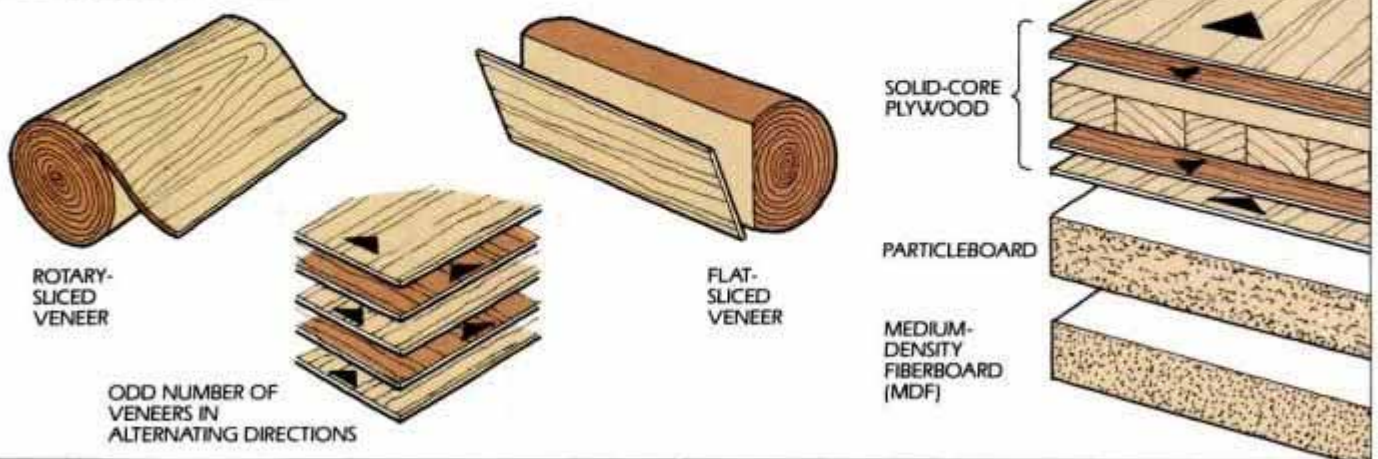
In solving some problems, manu-

factured panels create others. The glue that holds the panel together is notoriously hard on cutting edges. Unless you enjoy frequent sharpenings, the use of carbide-tipped blades is a necessity. Also, common hardwood veneer plywoods may have voids—small internal areas where a layer is missing. Hoping to miss these voids when cutting plywood is like playing Russian roulette.

While a panel's typical 4 × 8-ft. size may be an advantage where large components are necessary, there is a problem with storage. All panels are best stored by laying them flat on the floor. If you must stack them upright, make sure that they are as vertical as possible to avoid warping.

Keep in mind that when you buy plywood, particleboard, fiberboard—or even solid lumber—you're buying a product that has been manufactured. Whether you work with solid wood that's been cut and dried, or high-tech MDF panels, knowing your material is the best way of ensuring a successfully completed project. **PM**

MANUFACTURED PANELS



7 Manufactured panels offer increased stock size, uniform thickness and greater stability. Rotary-sliced veneer is typical of softwood veneer plywoods. Hardwood veneer plywood usually has a

flat-sliced surface veneer that looks like solid wood. Solid-core plywood is also available and stable. Flat particleboard and medium-density fiberboard come with or without surface veneers.

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SUITE DREAMS

A king-size platform bed with headboard and night tables.

BY NEAL BARRETT

A QUICK LOOK AT any of today's popular home-design magazines—or home sections in local newspapers, for that matter—will reveal a change that's taking place in the contemporary American home. These days, more and more emphasis is being placed on the master bedroom. Some have space for a king-size bed, some easy chairs or a couch, a desk, a television and stereo equipment, plus one or two large walk-in closets and a spacious, comfortable bathroom attached.

The idea of such *master suites*, as the real estate folks call them, is appealing. Instead of using a bedroom primarily for sleeping, this design theory contends that by making the room bigger with more accommodations, the space is much more versatile. Such rooms can then function as a kind of refuge—a decompression chamber if you will—that is very attractive to many parents, especially if both work outside the home. Unfortunately, this option exists only for new-home buyers. Those who live in older homes must undertake either a complicated remodeling project or simply live with the arrangement that they have.

In the hopes of helping out owners of older homes, we designed and built the bedroom furniture shown here. Included are a king-size platform bed with headboard, two night tables, three modular wall units and a free-standing wardrobe.

While this furniture may not make your bedroom any larger, it will certainly yield a great deal more storage space. The wardrobe will augment your existing closet volume and the wall units have plenty of room for clothes as well as a television, stereo equipment and a dry bar if you want to alter the layouts to suit your specific needs.

While the number and size of these projects may



seem daunting, special attention was devoted to making them as easy to build as possible.

All eight pieces are made of inexpensive medium-density fiberboard (MDF) and the finish is easily available enamel paint. Of course, any single piece can be constructed and used alone, or in combination with some of the others. But once you get started, the joinery techniques for all the pieces are so similar, you may find that building the whole ensemble isn't much more time-consuming than building just a couple of the individual units.

Following are directions for building the bed, headboard and night tables. The wall units and wardrobe are described in later stories.



Platform bed is constructed in five individual pieces that can be separated for moving ease.

Night tables and headboard

Begin construction by cutting the night table and headboard sides to size. Cut sufficient $\frac{3}{4}$ " poplar stock for the edge banding as indicated in the plans.

The $\frac{1}{4}$ -in. rad. on the front edge of the case tops is cut with a $\frac{1}{4}$ -in. rounding-over bit with a ball-bearing pilot. Since the overall diameter of the bit is rather large, a heavy-duty router is strongly recommended for this work. In addition, it may be necessary to replace the plate on the router base with a thicker plate for

Color photos: J.R. Rost
 Black-and-white photos: Neal Barrett
 Technical art: Eugene Thompson
 Styling: Gabe Henick

Apply glue to the spline grooves, splines and the mating edges of the top and the edge banding, then clamp together. When the glue has thoroughly dried, use the 1/4-in. rounding-over bit to shape the front edge of each night table top only. Do not shape the headboard top at this time.

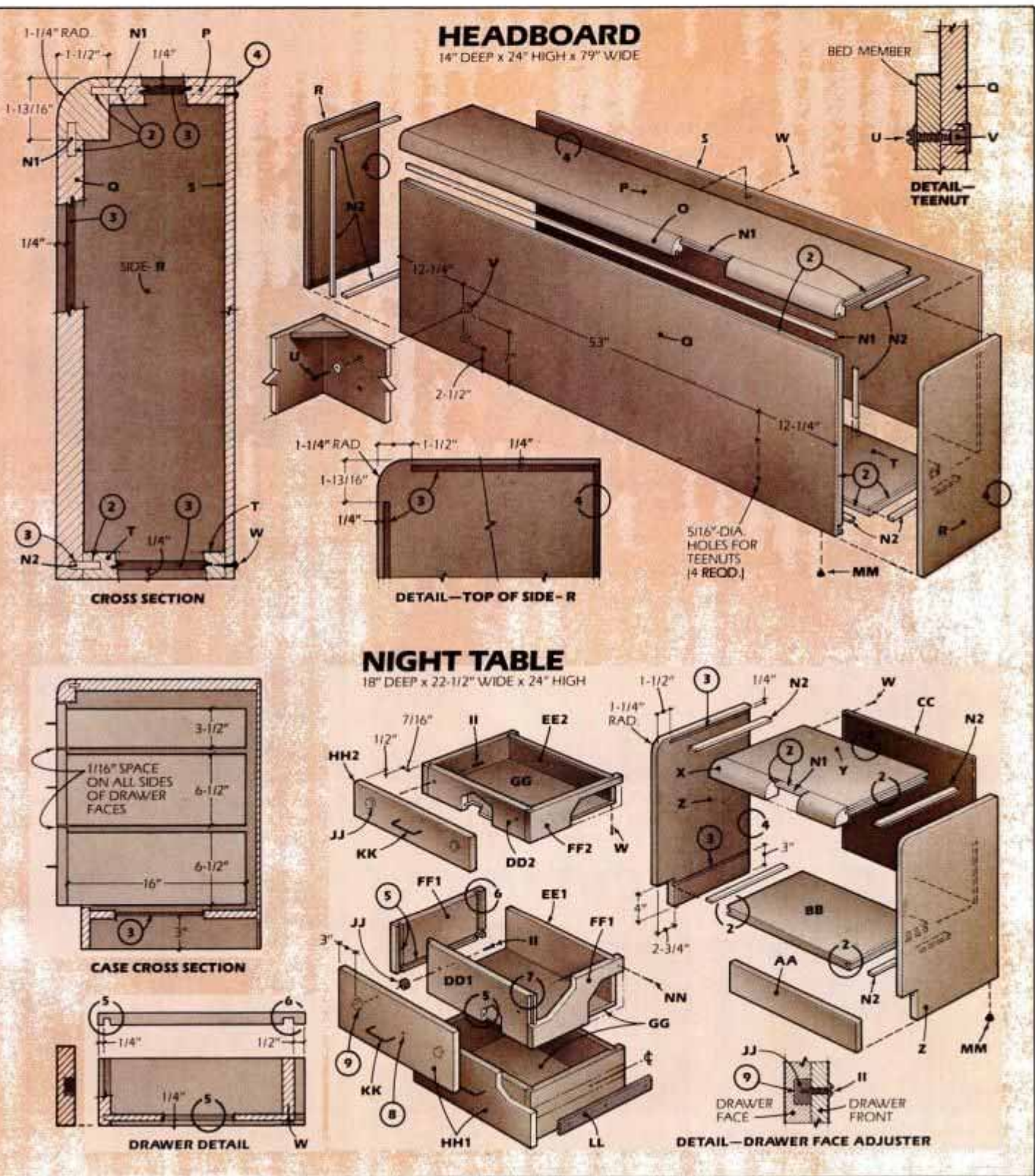
Using the table saw, rip and cross-cut the case tops, bottoms and head-

board front to finished size. Then, using the slotting cutter, rout all the spline grooves in the night table tops and in the top, bottom and front panels of the headboard. Note that the grooves in all top panels are stopped 1/2 in. short of the front edge.

Next, using a router with a 1/2-in. or 3/4-in. straight bit and edge guide, cut the rabbets for case backs in all top

and side panels. Note that the rabbet is stopped 1/4 in. below the top of the case sides.

Use a 1/4-in. straight bit and edge guide in the router to cut the groove in all the sides for the top spline joint. Use the same setup to cut the groove in the bottom edge of the headboard edge banding. Also cut the grooves in the headboard sides for the front and



bottom spline joints. Again, note that these grooves must be stopped at various points. Refer to the plans for specific dimensions.

Next, remove the edge guide from the router. Then, use a straightedge clamped on the workpiece to guide the router in cutting the spline grooves for the night bottoms in the sides. These grooves will be hidden in the front of the case by the toeboard. At this point, lay out the notches for the toe space and use either a jigsaw or band saw to cut out the waste. Cut the toeboards to finished size.

Now, cut the splines for case assembly to the required size. Note that two different size splines are used in these projects: 1-in. splines for joining

the edge banding to the tops of all three pieces and to the front panel of the headboard, and $\frac{7}{8}$ -in. splines for the rest of the joinery. Once all the splines are cut, glue and clamp the headboard top to the front panel.

To assemble the night tables, apply glue to the spline grooves and splines, position the case bottom and top between the sides, and clamp until the glue has set. Be sure to check that the case is square. After the glue has set, glue and clamp the toeboard in place.

Now, rout the $\frac{1}{4}$ -in. rad. on the top front corner of the headboard edge banding. Then glue and clamp the bottom to the front using the proper spline. Let this assembly dry. Then apply glue, insert the proper splines

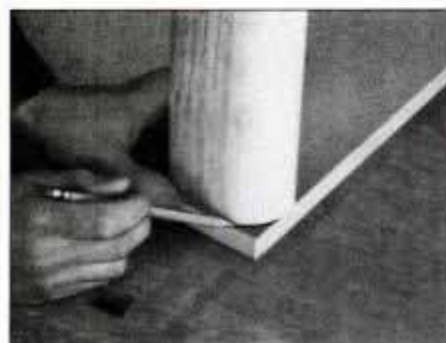
and clamp the headboard sides to the front-and-top assembly. Use long bar clamps to hold the sides tight.

Bore $\frac{5}{16}$ -in.-dia. holes in the headboard front as indicated in the drawing, then install $\frac{1}{4} \times 20$ teenuts—from the inside of the headboard—into these holes. These nuts will fasten the headboard to the bed during final assembly.

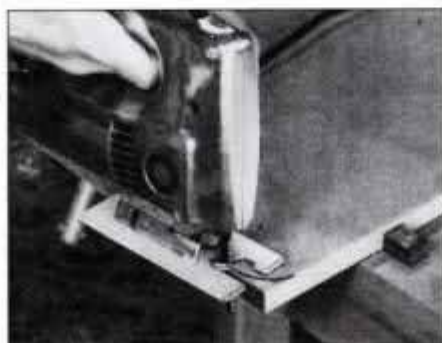
Cut the headboard back from $\frac{1}{4}$ -in.-thick hardboard and install it with $\frac{5}{8}$ -in. No. 5 rh screws. Cut the night table backs at this time but do not install until after the finishing process.

Platform bed

Rip and crosscut the base sides and crossmembers to finished dimension.



1 To make template for all case-top corners, begin by cutting proper radius on scrap poplar then trace onto piece of MDF.



2 Using a jigsaw, cut template to shape keeping blade on waste side of line. Then refine the profile by sanding it smooth.



3 Align case side over template and clamp both to bench. Rout side flush to template using $\frac{1}{4}$ -in. straight bit and pilot guide.



4 Cut poplar edge banding to size, then clamp securely to bench. Cut spline groove in edge using slotting cutter and router.



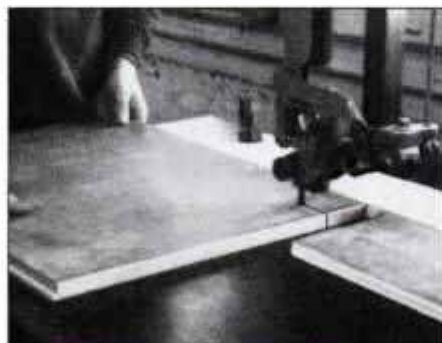
5 Glue and clamp poplar to case top and let dry. Then shape poplar edge by routing with $\frac{1}{4}$ -in.-rad. rounding-over bit.



6 Rout spline groove on both ends of case top using a slotting cutter. Stop grooves $1\frac{1}{2}$ in. behind front of edge banding.



7 Rout rabbet—for case back—in case top and sides of both night tables. Use a straight bit and edge guide for accuracy.



8 Use band saw or jigsaw to cut notch in case sides for toe space. Stopblock clamped to table makes duplicate cuts easier.



9 Rout spline dado in case sides using $\frac{1}{4}$ -in. straight bit and router edge guide. Stop dado $1\frac{1}{2}$ in. behind front edge.

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SAWS



SANDS

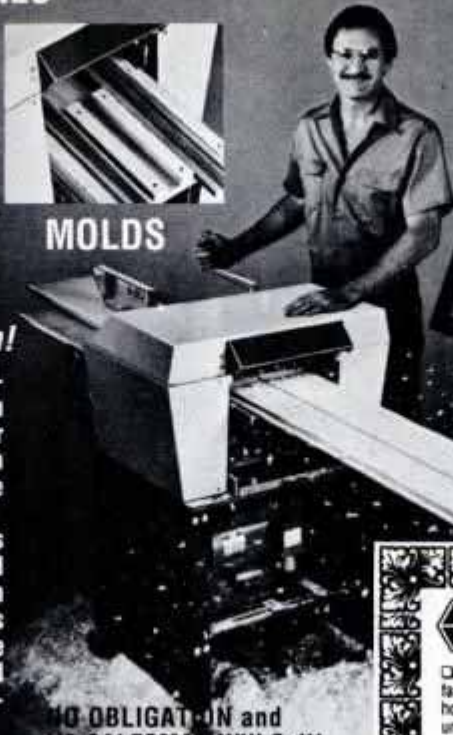


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Using a $\frac{3}{4}$ -in. straight bit and edge guide, rout the rabbets at the ends of the long base sides. Remove the edge guide and use a straightedge to guide the router when cutting the dados for the center crossmembers. Apply glue to dados, rabbets and cross-member ends, and assemble the base halves, clamping the joints until the glue sets. Be sure to check each base half for square.

Cut the MDF corner gussets for the base to size. Then install the gussets in the corners of the base frames as shown in the plan. Use hot glue for installation, and keep the gussets flush with the top edge of the base. These gussets serve to keep the base square and can also be used to screw down

the bed platform if you should desire to do so. However, we found the weight of the platform was sufficient to keep it from shifting.

Next, clamp the base halves together and bore $\frac{5}{16}$ -in.-dia. holes through the adjoining sides for connecting screws shown in the drawing. Also bore $\frac{1}{4}$ -in.-dia. holes in the headboard end of the base for attaching the base to the headboard. During final installation, machine screws will thread into the teenuts that were installed earlier in the headboard.

Cut the stock for the platform to finished size and cut the poplar stock for edge support and edge banding to dimension. With the platform halves upside down, apply the edge supports

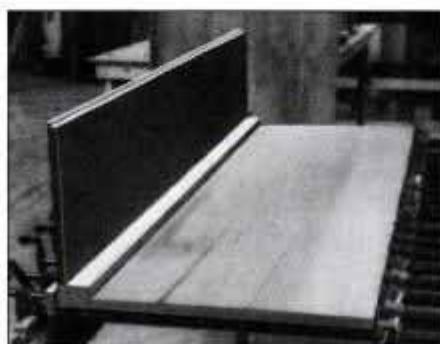
flush with the edges as shown in the plan. When the glue is dry, apply the mitered edge banding, using bar clamps to hold the joint tight.

With the platforms still upside down, use the $\frac{1}{4}$ -in. rounding-over bit to rout the profile on the bottom edge of the platforms. Turn the platforms over and rout the top edge to form a bullnose profile.

Mark the positions for the tight-joint fasteners along the joining edges of platform halves. Bore and rout the recesses for the fasteners, following the dimensions given in the drawing. Then use a $\frac{3}{4}$ -in. slotting cutter and router to cut a spline groove in the mating edges of the platform halves. When assembling the platform, use a



10 Glue and clamp poplar edge banding to front of headboard top. Let dry, then rout rabbet in back edge of top for case back.



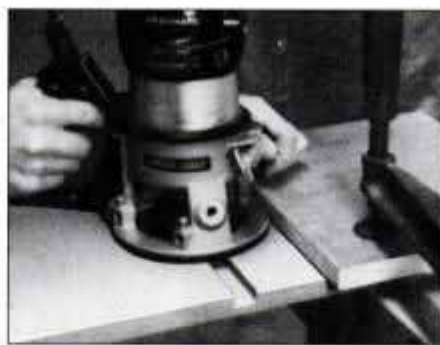
11 Rout spline grooves in top of front panel and bottom of edge banding. Apply glue, insert spline and clamp to top panel assembly.



12 Rout radius on top corner of headboard edge banding with $\frac{1}{4}$ -in.-rad. rounding-over bit. When done, sand profile smooth.



13 Cut long base sides for bed to size, then cut rabbets at the ends using a $\frac{3}{4}$ -in. straight bit and router edge guide.



14 Lay out positions of crossmembers in bed base sides. Clamp straightedge guide in place and rout each dado $\frac{3}{8}$ in. deep.



15 Assemble both bases and glue corner blocks in place. Clamp bases together and bore clearance holes for connecting screws.



16 Temporarily install connecting screws to secure both bases. Check for flush alignment along top edges, then remove screws.



17 Attach edge banding and support strips to platforms, then rout radius on bottom edge first. Turn over and rout top edge.



18 Use tight-joint fasteners and unglued spline to join both halves of bed platform. This joint is easily disassembled for moving.

dry (no glue) $\frac{1}{4} \times 1$ -in. spline to align the platform surfaces. This system allows for precise assembly and easy disassembly for moving.

Drawers

Cut the drawer stock to size for all drawer parts. We used $\frac{1}{2}$ -in.-thick Baltic Birch plywood for these parts, but any $\frac{1}{2}$ -in.-thick wood stock will work as well. Use the dado blades in the table saw to cut the dados in drawer sides for the fronts and backs. Then plow a groove in drawer sides and fronts for the drawer bottom, and cut the rabbets on the ends of the drawer fronts. Cut the drawer bottoms to size from $\frac{1}{4}$ -in.-thick birch plywood and complete the stock preparation by sanding all surfaces with 120- followed by 220-grit sandpaper.

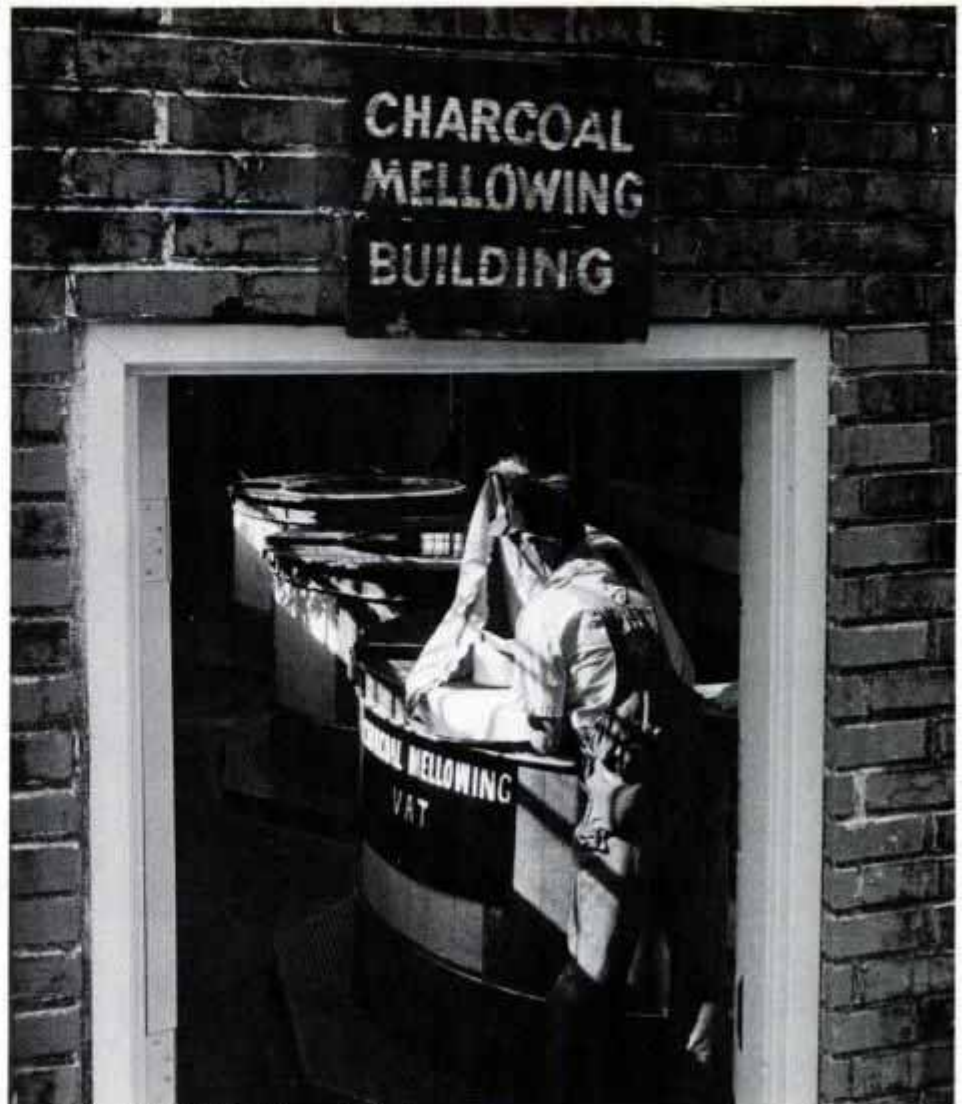
Assemble the drawer boxes using glue and brads. Check each for square by comparing opposite diagonal measurements. Then, slide the bottoms into their grooves and fasten in place by screwing into the bottom edge of the back.

Next, cut the drawer faces to size and temporarily clamp in position on the drawers. Bore pilot holes through the back of the drawer fronts into the faces to mark the position of the drawer front adjusters. (These adjusters are knock-in fittings that provide a simple method of aligning the drawer faces in the cabinet.) Then bore a 20-mm \times $\frac{1}{2}$ -in.-deep hole for each adjuster in the back of the drawer face using the pilot holes as a guide. Press the adjusters into these holes and attach the drawer faces to the drawer fronts using the machine screws indicated in the materials list. When adjustment is required, merely loosen the screws, move the drawer face, and retighten.

When satisfied with the fit, number each drawer box and face so you can identify them later. Then remove the faces, bore and countersink pilot holes for the drawer pulls and set the parts aside for finishing. Next, mount the drawer slides according to the manufacturer's instructions and make sure all drawers operate properly. Remove the slides before painting.

(For details on how to apply the finish, please see the directions in the Wardrobe story, page 120.)

After the finish has been applied and cured, install the backs on the night tables, attach the pulls to drawer faces, and attach the faces to drawer boxes. Reinstall drawer slides and drawers, then adjust the drawer faces. Complete the job by driving steel furniture glides into the bottom corners of the night tables, headboard and platform bed. **PM**



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A PLACE FOR EVERYTHING

Three modular wall units for all your storage needs.

BY NEAL BARRETT

IT SEEMS THAT storage space is always at a premium. No matter how many times we vow to keep the attic, basement or garage under control, the ever-growing volume of possessions seems to undermine the best intentions. Nowhere is this situation more frustrating than in a bedroom closet. That old jacket that defined something special years ago, those broken-down work boots that served for so long, and the countless other objects that we don't use much but still can't part with, all seem to come to rest there.

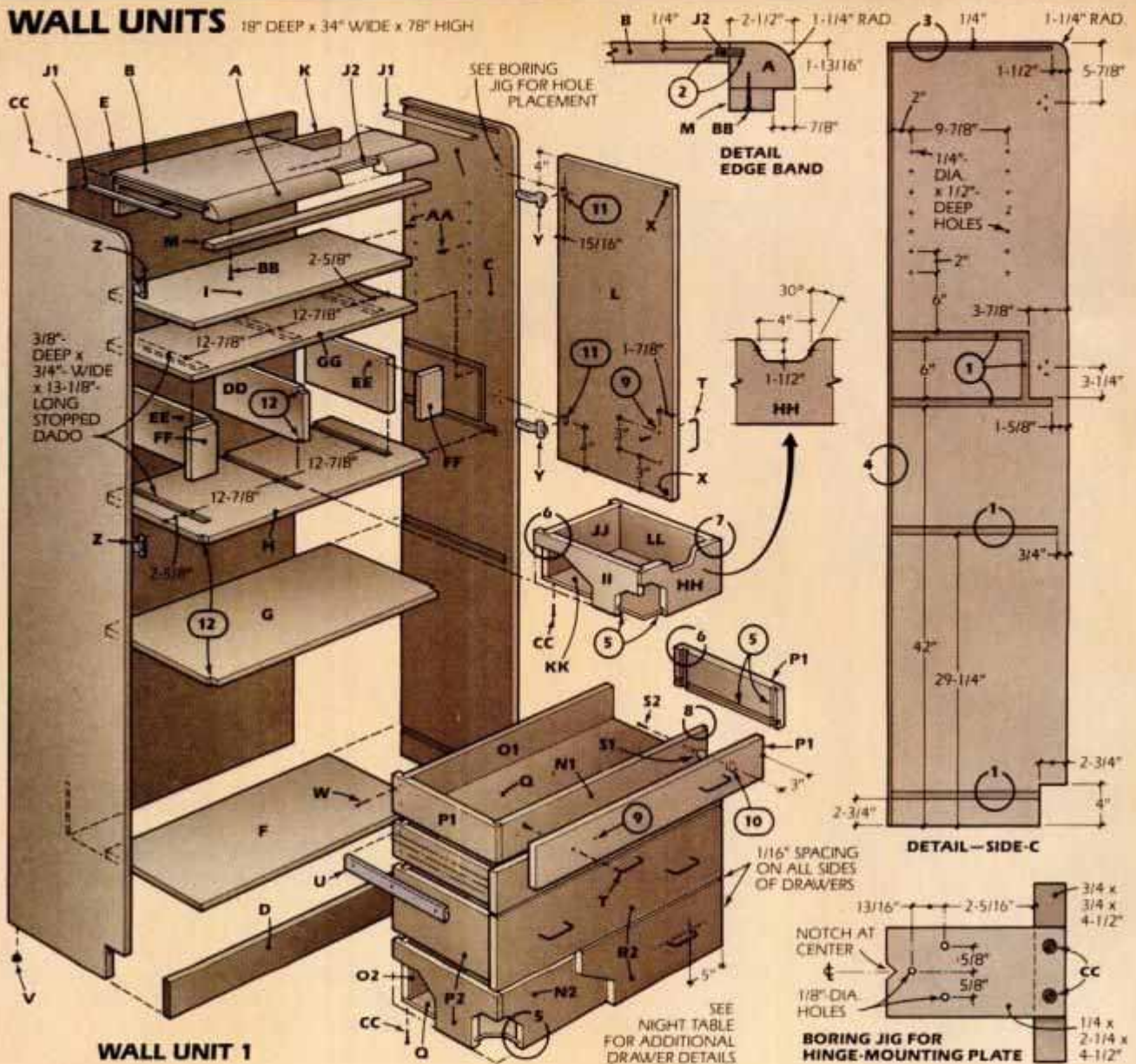
Remodeling to gain more storage space is always an option. But achieving the goal with furniture is usually more economical, especially if you build it yourself. We hope the wall units shown here can help solve some of your storage problems.

Color photos: J.R. Rost
Black-and-white photos: Neal Barrett
Technical art: Eugene Thompson
Styling: Gabe Herrick



These storage units are all based on the same module, so they can be arranged and customized to suit individual needs.

WALL UNITS 18" DEEP x 34" WIDE x 78" HIGH

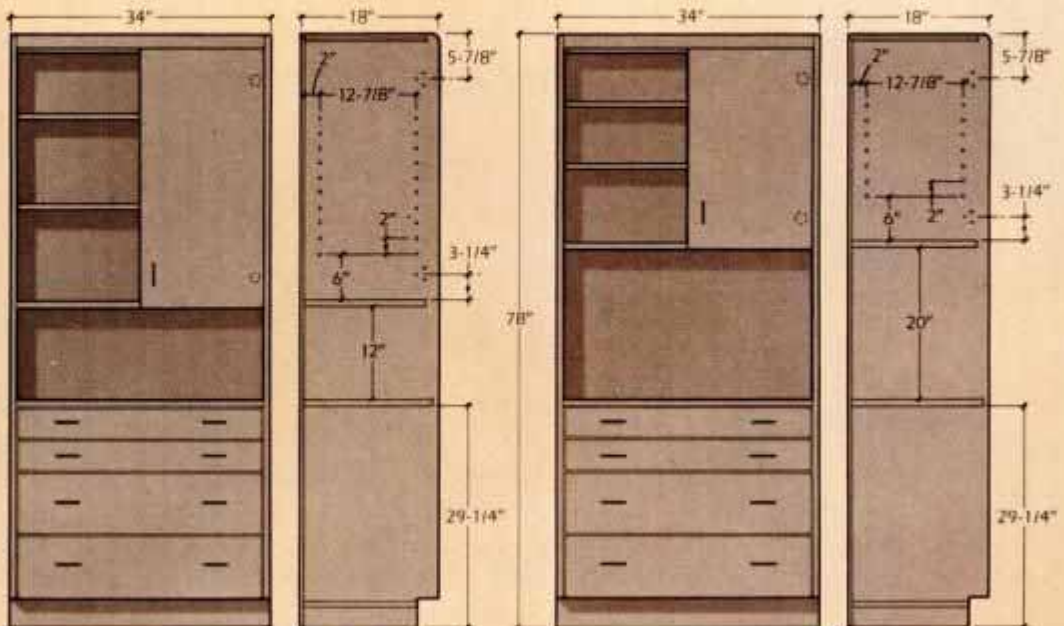


WALL UNIT 1

NOTES:

- 1— 3/8"-DEEP x 3/4" DADO/GROOVE
- 2— 1/4 x 1/2"-DEEP GROOVE
- 3— 1/4 x 3/8"-DEEP GROOVE
- 4— 1/4 x 1/2"-DEEP RABBET
- 5— 1/4 x 1/4"-DEEP DADO/GROOVE
- 6— 1/4"-DEEP x 1/2" DADO
- 7— 1/2 x 1/2"-DEEP RABBET
- 8— 1/4 x 1/4"-DEEP RABBET
- 9— 5/32"-DIA. HOLE THROUGH
- 10— 20MM-DIA. x 1/2"-DEEP HOLE
- 11— 35MM-DIA. x 1/2"-DEEP HOLE
- 12— 3/8"-DEEP x 3/4" NOTCH

ALL THREE UNITS ARE SIMILAR EXCEPT FOR THE SIZE OF THE DOORS AND UPPER SHELVES, AND THE CUBBY-DRAWER ASSEMBLY IN UNIT 1.



WALL UNIT 2

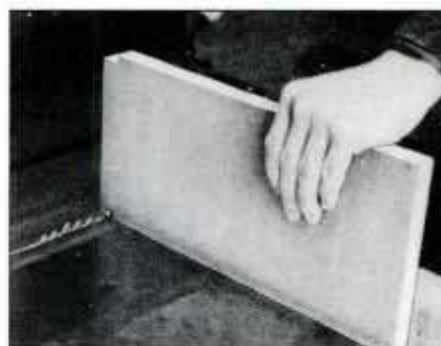
WALL UNIT 3



1 Cut side panels to size, then lay out and rout shelf dadoes in sides using $\frac{3}{4}$ -in. straight bit and straightedge guide.



2 On case No. 1, lay out and rout additional dadoes to house the cubby drawer assembly. Use a straightedge to guide the router.



3 Cut fixed shelves, bottoms and partitions (where required) to size. Then cut notches in front corners to size shown on drawing.

Designed to be versatile and easy to build, these three pieces are all based on the same module. Each case has the same overall dimensions and requires the same construction techniques. The differences lie in the sizes of the display areas and the presence or absence of small cubby drawers in the upper section of each unit. By rearranging the details presented in each case, you can customize the cabinets to suit your individual needs. In the directions and materials list that follow, we explain how to build unit No. 1. The others are constructed the same way except for the cubby drawers and their support framework.

Construction details

Cut the case top and edge banding slightly oversized, then rout the spline groove on the front edge of the top using a $\frac{1}{4}$ -in. slotting cutter. Cut a matching groove in the edge banding, also using the slotting cutter. Then cut stock for the splines from $\frac{1}{4}$ -in.-thick plywood or hardboard. Be sure that the spline stock is thick enough to yield a snug fit.

Next, apply glue to spline groove, spline and mating edges, and clamp the edge banding to the case top. When the glue has set, use the $\frac{1}{4}$ -in.-rad. rounding-over bit to rout the profile on the edge banding. Use the table saw to rip and crosscut each top to finished dimension.

Next, cut the case sides to size, and using the corner template from the platform-bed project, rout the corner profile on each side. Use a $\frac{1}{2}$ -in. straight bit with a pilot bearing. Then lay out the notch for the toe space in each side and use a jigsaw or band saw to make the cutout.

Using the router with $\frac{1}{2}$ -in. or $\frac{3}{4}$ -in. straight bit and an edge guide, cut the rabbet for the case back on each case side.

Be sure to stop the rabbet $\frac{1}{4}$ in. shy of the top edge and use a sharp chisel to square the end of the cut. Use the same router setup to cut the rabbet on the back edge of case top.

Now cut and attach the wall cleat to the back edge of the case top using glue and clamps. When this assembly is dry, cut stock for the upper case

doorstop, and screw it to the underside of the edge banding.

Using the drawing as a guide, lay out the dadoes on each case side. Note that all the dadoes, except those for the case bottom, are stopped short of the case front. Cut these dadoes using a router with a $\frac{3}{4}$ -in. straight bit and a straightedge guide. When all the dadoes are cut, use a sharp chisel to square the ends of the stopped dadoes. Finish routing the sides by cutting the spline grooves for the side-to-top joint. Use a $\frac{1}{4}$ -in. straight bit and a straightedge guide. Note that these grooves are stopped $1\frac{1}{2}$ in. short of the case front.

Cut the shelves and cubby drawer assembly parts to size. Then using a table saw, band saw or jigsaw, cut the required notches in the front corners of the shelves and partition.

Finally, lay out and rout the dadoes in the shelves for the cubby drawer assembly.

Assembly

Glue and clamp the cubby drawer assembly together and set it aside to

Key	No.	Size and description (use)
A	1	$1\frac{13}{16}$ x $2\frac{1}{2}$ x $32\frac{1}{2}$ " poplar (edge band)
B	1	$\frac{3}{4}$ x $15\frac{1}{2}$ x $32\frac{1}{2}$ " MDF (top)
C	2	$\frac{3}{4}$ x 18 x 78 " MDF (side)
D	1	$\frac{3}{4}$ x 4 x 41 " MDF (toeboard)
E	1	$\frac{1}{4}$ x $33\frac{1}{2}$ x $77\frac{1}{2}$ " hardboard (back)
F	1	$\frac{3}{4}$ x 15 x $33\frac{1}{2}$ " MDF (bottom)
G	1	$\frac{3}{4}$ x $17\frac{1}{4}$ x $33\frac{1}{4}$ " MDF (divider shelf)
H	1	$\frac{3}{4}$ x $16\frac{1}{4}$ x $33\frac{1}{4}$ " MDF (fixed shelf)
I	2	$\frac{3}{4}$ x $13\frac{1}{2}$ x $32\frac{1}{2}$ " MDF (adjustable shelf for Unit 1 only; for Units 2 and 3 the shelves measure $\frac{3}{4}$ x $16\frac{1}{4}$ x $32\frac{1}{2}$ " MDF.)
J1	2	$\frac{1}{4}$ x $\frac{3}{4}$ x 15 " hardboard (spline)
J2	1	$\frac{1}{4}$ x 1 x $32\frac{1}{2}$ " hardboard (spline)
K	1	$\frac{3}{4}$ x 4 x $32\frac{1}{2}$ " poplar (cleat)
L	2	$\frac{3}{4}$ x $16\frac{1}{2}$ x $34\frac{1}{2}$ " MDF (doors for Units 1 and 3; for Unit 2 the doors measure $\frac{3}{4}$ x $16\frac{1}{2}$ x $25\frac{1}{2}$ " MDF.)
M	1	$\frac{3}{4}$ x $1\frac{1}{2}$ x $32\frac{1}{2}$ " MDF (doorstop)
N1	2	$\frac{1}{2}$ x 4 x 31 " Baltic Birch plywood (drawer front)
N2	2	$\frac{1}{2}$ x $7\frac{1}{2}$ x 31 " Baltic Birch plywood (drawer front)
O1	2	$\frac{1}{2}$ x $3\frac{1}{2}$ x 31 " Baltic Birch plywood (drawer back)
O2	2	$\frac{1}{2}$ x 7 x 31 " Baltic Birch plywood (drawer back)
P1	4	$\frac{1}{2}$ x 4 x 16 " Baltic Birch plywood (drawer side)

MATERIALS LIST — WALL UNITS†

P2	4	$\frac{1}{2}$ x $7\frac{1}{2}$ x 16 " Baltic Birch plywood (drawer side)
Q	4	$\frac{1}{4}$ x $15\frac{1}{4}$ x 31 " birch plywood (drawer bottom)
R1	2	$\frac{3}{4}$ x $4\frac{1}{2}$ x $32\frac{1}{2}$ " MDF (drawer face)
R2	2	$\frac{3}{4}$ x 8 x $32\frac{1}{2}$ " MDF (drawer face)
S1*	8	drawer front adjuster No. D3994
S2	8	8-32 x $\frac{3}{4}$ " rh machine screw
T**	8	3" gray nylon wire pull No. HC160
U*	4 pr.	Accuride 16" full-extension drawer slides No. D7509
V*	4	$\frac{3}{8}$ "-dia. steel furniture glide No. C1722
W		$\frac{1}{2}$ " brads, as reqd.
X*	4	self-sticking plastic door cushions No. D9678
Y*	2	96" self-closing hinge No. D9615 (right door, Unit 1 only)
Z*	2	176" self-closing hinge No. D9633, with inset plate No. D9638 (left door on Unit 1 and both doors on Units 2 and 3)
AA*	8	adjustable shelf pin No. D9154
BB	3	$1\frac{1}{4}$ " No. 8 fh screw
CC		$\frac{3}{8}$ " No. 5 rh screws, as reqd.
DD	1	$\frac{3}{4}$ x $6\frac{1}{4}$ x $13\frac{1}{4}$ " MDF (center partition Unit 1 only)
EE	2	$\frac{3}{4}$ x $6\frac{1}{4}$ x $13\frac{1}{4}$ " MDF (side partition Unit 1 only)
FF	2	$\frac{3}{4}$ x $3\frac{1}{2}$ x 6 " MDF (partition cap Unit 1 only)

GG	1	$\frac{3}{4}$ x $13\frac{1}{4}$ x $33\frac{1}{4}$ " MDF (upper fixed shelf Unit 1 only)
HH	2	$\frac{3}{4}$ x $5\frac{1}{2}$ x $12\frac{1}{2}$ " MDF (cubby drawer front Unit 1 only)
II	4	$\frac{1}{2}$ x $5\frac{1}{2}$ x $13\frac{1}{4}$ " Baltic Birch plywood (cubby drawer side Unit 1 only)
JJ	2	$\frac{1}{2}$ x $5\frac{1}{2}$ x $12\frac{1}{2}$ " Baltic Birch plywood (cubby drawer back Unit 1 only)
KK	2	$\frac{1}{4}$ x $12\frac{1}{2}$ x $13\frac{1}{4}$ " birch plywood (cubby drawer bottom Unit 1 only)

Misc.: glue, 120-, 220- and 320-grit sandpaper, polyurethane, mineral spirits, wax, paint (De-Vo-Ko Interior Enamel Undercoat primer and Bar-Ox Flagstone No. 1M51D Gloss Enamel, manufactured by Devco & Reynolds Co., Box 7600, Louisville, KY 40207).

† The abbreviation MDF that appears in this list stands for medium-density fiberboard.

* Available from The Woodworkers' Store, 21801 Industrial Blvd., Rogers, MN 55374; send \$1 for catalog. (Parts numbers shown are stock numbers for The Woodworkers' Store.)

** Manufactured by Forms & Surfaces, Box 5215, Santa Barbara, CA 93108. (Available through hardware supply outlets.)

dry. Then cut all the splines to proper length. To assemble the case, begin by laying one side on the bench with the inside surface facing up. Apply the glue to all dadoes and spline grooves, shelf ends and splines. Insert the shelves and top assembly into the side. Then apply glue to dadoes in the opposite side and place it over the existing assembly. Clamp the entire case together, using cauls under the clamp jaws to evenly distribute the pressure. Check the case for square by comparing opposite diagonal measurements, and readjust the clamps if necessary.

Cut the toeboards for the toe spaces to size, then glue and clamp in place. Next, cut the case back to size from

1/4-in.-thick hardboard. Set the back aside. It will be installed after the finishing process is complete.

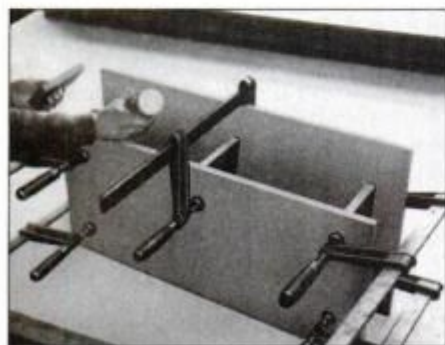
Then, lay out the position of the adjustable-shelf holes inside each case. By making a template from a piece of scrap plywood or MDF, you can simplify this process. Simply bore a series of 1/4-in.-dia. holes 2 in. on center, along the length of the template. Clamp the template in the proper position, then bore the pin holes right through the template into the side. Cut the adjustable shelves to size and set aside for finishing.

Doors

Cut stock to size for the cabinet doors, then, using a 35-mm bit, bore the

hinge holes in the doors. (These bits are available from mail-order hardware and tool suppliers.) It's a good idea to clamp a fence to the drill press table, so you can easily locate the holes a uniform distance from the door edges. When the holes are bored, mount the hinges using the specified screws. We used self-closing hinges on the doors to eliminate the need for door catches. We also specified 95° hinges on the right door of unit No. 1 to prevent the door from swinging into the wardrobe. If you aren't building the wardrobe, or placing it adjacent to the wall units, use wider swinging 176° hinges throughout.

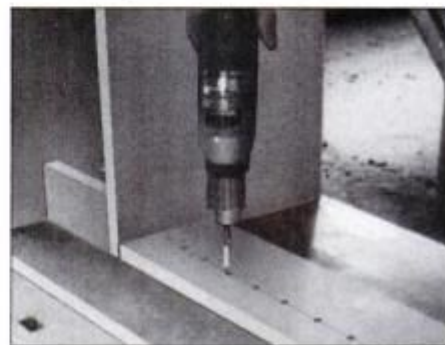
Using the drawing as a guide, fabricate a template for boring the mount-



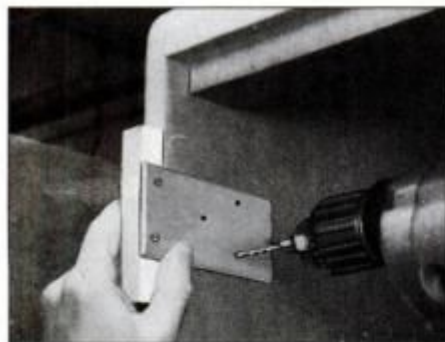
4 Preassemble cubby drawer unit for case No. 1 using glue and clamps. Check for square and readjust clamps if necessary.



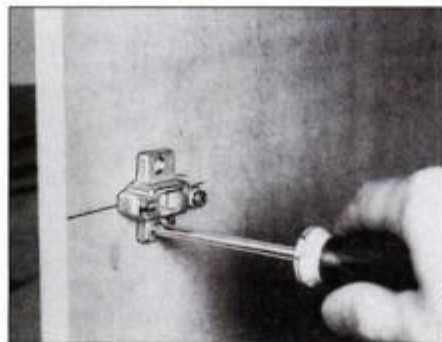
5 Glue and clamp wall cleat and edge banding to top panel. Rout profile on edge banding and attach doorstop to bottom edge.



6 Glue and clamp case parts together. Then bore adjustable-shelf pin holes in sides. Use prebored pattern jig for accuracy.



7 Construct jig—as shown on drawing—for boring door-hinge pilot holes. Properly position jig on case sides and bore holes.



8 Temporarily attach hinge-mounting plates to case sides. They will be removed later to make the finishing process easier.



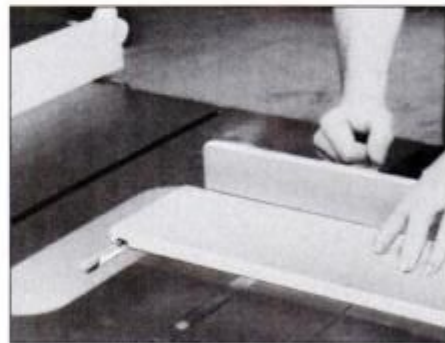
9 Carefully locate hinge positions on back of doors, then bore hinge-mounting hole. Push hinge into hole and attach with screws.



10 Hang cabinet doors by sliding hinge into mounting plate on case side. Tighten hinge screws, then close door and check fit.



11 To obtain proper fit, turn adjusting screws as required. Screws can move door in and out, up and down, and side to side.



12 Cut drawer parts to size, then using dado blades in table saw, cut dadoes in sides to receive drawer fronts and backs.

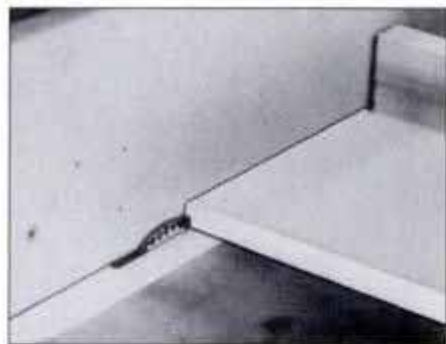
ing plate holes and the case sides. Align this template as shown on the drawing, then bore the holes and mount the plates. Keep in mind that we used Blum hinges for this project. While there are many other suppliers of European-style hardware, we find that these hinges are easy to install, easy to adjust and they hold up well over time. If you choose other hinges, the hinge locations may be different.

Hang the doors on the cases by sliding the hinges onto the plates and tightening the mounting screws. Adjust the doors, then lay out and bore clearance holes for the door pulls.

Drawers

Cut the parts for the cubby drawers to size. Then use the template, shown in the drawing, to trace the finger-pull cutouts on the drawer fronts. Make the cutouts with a jigsaw, then sand the edge smooth.

Use the dado blades on the table saw to make the required dado and rabbet cuts in drawer parts, then cut drawer bottoms to size. Assemble the drawers with glue and brads and check for square. Slide the drawer bottoms in place and fasten with screws to the bottom edge of the drawer back. Sand the drawers thoroughly. Keep in mind that these two drawers will be finished entirely with

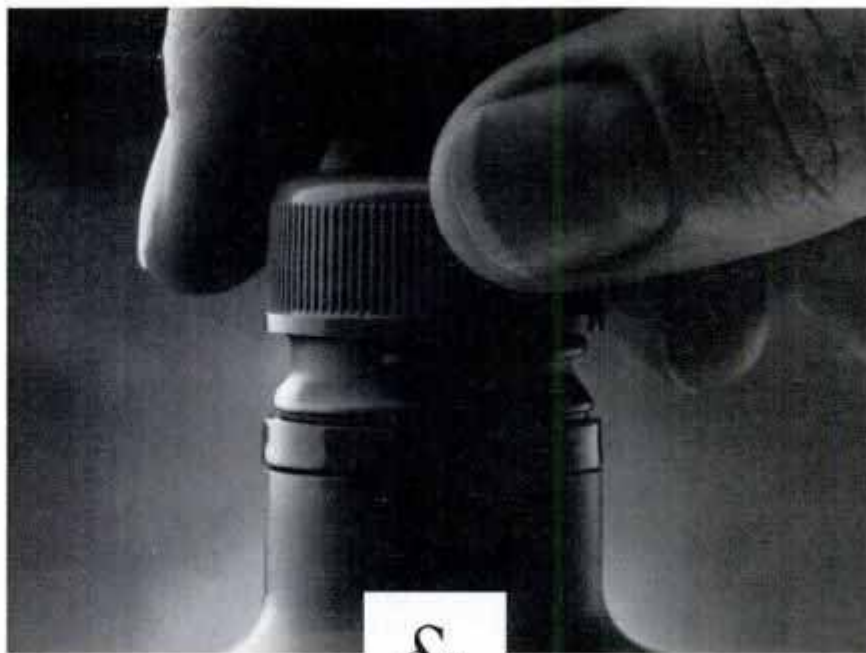


13 Cut rabbets in ends of drawer fronts using 1/4-in.-wide dado blade in table saw. Be sure to keep board tight to fence.

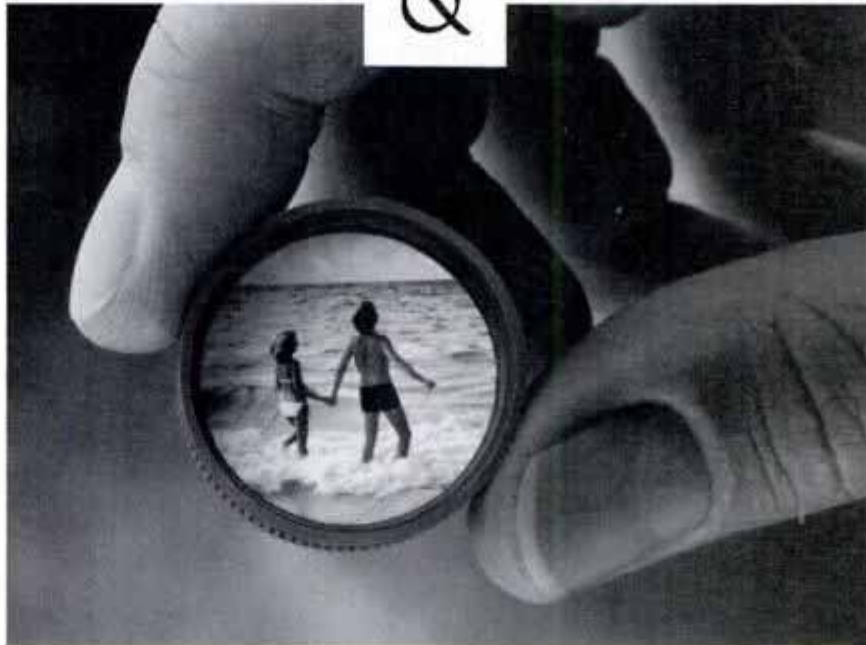


14 Readjust table saw fence and cut 1/4-in. groove in drawer sides, fronts and backs to receive drawer bottom panel.

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the enamel paint. The other drawers receive a natural finish. Only the drawer faces will be painted.

Next, cut the parts for the bottom case drawers from 1/2-in.-thick Baltic Birch plywood. Use dado blades in a table saw to cut the groove for the drawer bottom in the drawer sides and fronts. Then, readjust the saw to cut the dados for drawer fronts and backs in the sides, and to cut the rabbets on the ends of the drawer fronts. Cut the drawer bottoms to size from a sheet of 1/4-in.-thick birch plywood.

Assemble the drawers using glue and brads. Fasten the bottoms to drawer backs using screws. Mount the drawer slides in place following the manufacturer's instructions.

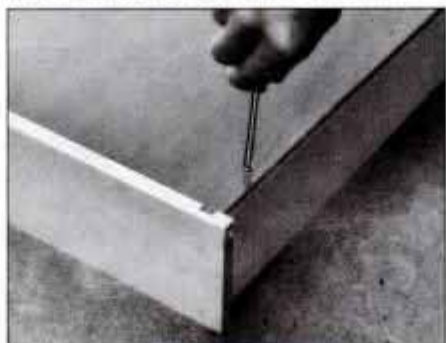
Next, cut the drawer faces to size. Clamp each drawer face to its respective drawer box. Then bore pilot holes through the drawer front into the face to mark the position of the drawer front adjusters. Remove the face and number it for easy reassembly later. Bore the holes for the drawer front adjuster in the back of the drawer face then tap the adjusters into place. Lay out and bore the holes for the drawer pulls, being sure to countersink these holes on the back side of the drawer face so the screw heads won't project above the surface. Attach the pulls, then reattach the drawer faces and in-

stall the drawers in the case. Adjust the slides, if necessary, for smooth operation, then adjust the drawer faces to yield uniform spacing around each.

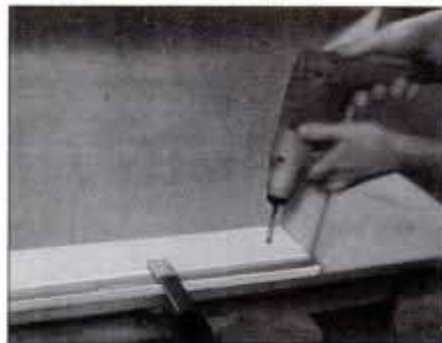
Remove all doors, drawers and hardware, then separate the drawer faces from drawers. If the cases are to be used in a side-by-side configuration, temporarily clamp the cases together and bore 5/16-in. holes for the connecting screws. While the exact location of these holes is not important, it's best if they are placed within the upper and lower cabinet enclosures so they won't be visible when the doors and drawers are closed.

The lower drawers on these units are finished with a clear polyurethane varnish. Thin the first coat 25 percent with mineral spirits, let dry overnight and sand lightly—with 220-grit paper—before applying a second coat full strength. If desired, a third coat can also be applied after overnight drying and light sanding. For directions on how to apply the enamel finish to the rest of the unit, see page 120 of the wardrobe story.

When the finish has dried, reattach the drawer faces and install the case back. Remount all hardware, hang the doors and slide the drawers in place. Make any final adjustments for proper door and drawer alignment and the cases are complete. **PM**



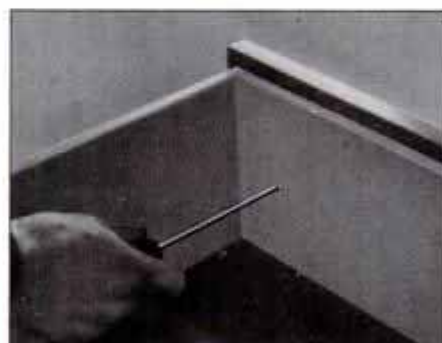
15 Cut bottom panels to size, then assemble drawer parts with glue and brads. Slide bottoms into place and attach with screws.



16 Cut drawer faces to size and clamp to drawer fronts. Bore pilot holes through front into face to locate drawer adjusters.



17 Remove face and bore adjuster holes in back sides. Tap adjusters into place, then attach face to front using adjuster screws.



18 Mount drawer slides on drawer and case, install drawer and check fit. Loosen screws to adjust drawer face and retighten.



TOOLS FOR SALE

New tools and accessories for today's woodworkers.

Home Plate Joiner

ONCE FOUND only in professional cabinetmaking shops, plate joiners are now becoming popular in home workshops. Plate joiners, also known as biscuit joiners, provide a quick, easy way to assemble many basic wood joints. Specifically: butt, edge-to-edge and miter joints. Use a plate joiner to join solid wood, plywood and particleboard.

Porter-Cable offers the first American-made plate joiner (model No.



Bottomside-view of plate joiner shows carbide-tipped blade and adjustable fence. Knurled knob at left controls depth of cut.

555). Unlike other plate joiners, the Porter-Cable unit has a vertically mounted motor and a rear handle with a trigger switch. Also, the No. 555 is belt-driven, not gear-driven, so that it's quieter than other joiners. A 2-position, adjustable fence allows you to assemble square (90°) and miter (45°) joints.

A 5-amp motor drives a 4-in.-dia., 6-tooth, carbide-tipped blade at 8000 rpm. Push the tool into the mating workpiece edges to cut semicircular slots that accept a football-shaped spline, called a biscuit. The biscuits

WOODWORKING GUIDE

are made of compressed beech and come in three sizes: No. 0 ($\frac{3}{8} \times 1\frac{1}{4}$ in.); No. 10 ($\frac{3}{4} \times 2\frac{1}{8}$ in.); No. 20 ($1 \times 2\frac{3}{8}$ in.).

When the biscuits are glued in place, they swell and lock tight in the slots. A bag of 1000 biscuits cost about \$30. Be sure to store biscuits in a dry, sealed container to prevent them from absorbing moisture and swelling

prematurely. The Porter-Cable plate joiner costs about \$270 at hardware stores and through mail-order tool firms.

For more information, contact Porter-Cable, Box 2468, Jackson, TN 38302.

Use joiner to cut semicircular slots in mating edges of workpieces. Then, glue biscuits in slots and glue two mating parts together.



Speedy Sander

I F YOU THINK that all belt sanders are alike, then check out the new Ryobi electronic belt sander (model No. BE-321). The 3 x 21-in. sander has several unique features designed to increase sanding efficiency and overall performance.

First, a variable-speed control knob allows you to select the appropriate belt speed for the material being sanded. The knob has six settings that range from 755 sfpm to 1148 sfpm

(surface feet per minute). The tool's slim, in-line design permits flush sanding and it maneuvers easily in tight spots. The unit has a sawdust vacuum system and comes complete with a dust collection bag. Other features include a 5.4-amp motor, belt-release lever for quick belt changes, belt-tracking adjustment knob, and a total weight under 8 pounds.

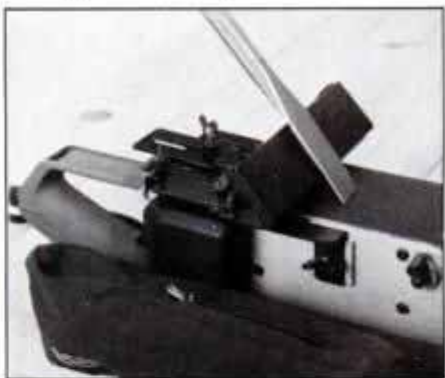
Ryobi offers three useful accessories that are worth mentioning. A snap-on sanding plate lets you preselect the amount of stock the sander will remove. This is especially handy

when sanding thin veneers. A pair of specially designed C-clamps are offered for securing the sander upside down to a workbench for use as a stationary tool. Finally, an adjustable bevel plate is available for use as a sharpening/grinding jig.

The sander costs about \$244. For details, contact Ryobi, 1433 Hamilton Pkwy., Itasca, IL 60143.



Flat-top design allows sander to be inverted for use as a stationary bench sander. The two C-clamps are sold as optional accessories.



Adjustable bevel plate bolts to sander. Use it to grind and sharpen chisels and knives. Also, to sand bevels on small wood parts.



Variable-speed, electronic belt sander is shown with sanding plate installed. The plate controls the amount of stock the sander will remove to prevent sanding too deep.

Spin-To-See Storage System

H ERE'S A CLEVER, new small-parts storage idea. Called Stor-Master, it consists of a wall-mounted, rotating octagonal drum that holds 32 clear, unbreakable containers. To find a desired item, simply rotate the drum and then, with a twist of the wrist, remove the container. The major advantages of this system is that it

takes up very little space and there are no lids to lose—the containers screw right into the drum. The drum, held by a steel bracket, can be installed horizontally or vertically.

Stor-Master costs \$28.95 postpaid from U-Neek Products, Box 8246, Cherry Hill, NJ 08002. Or, call toll-free (800) 228-6335. New Jersey residents, include 6-percent sales tax.

Rotating drum holds 32 clear storage jars. Drum is 11 in. long and can be mounted on wall or under a workbench or cabinet.



Sawdust Sentinel

DEALING WITH SAWDUST is a necessary, if not enjoyable, part of woodworking. And while collecting sawdust may never be fun, Shopsmith's new DC3300 dust-collection system can make it easier. The high-powered system uses a ½-hp motor to create an airflow of 330 cfm—three times the capacity of standard shop vacuums.

Inside the collector, heavier dust particles and wood chips fall down into a clear, 30-gallon, disposable plastic bag while superfine particles and wood dust are trapped in the upper polyester/felt filter hood.

The vacuum can be used with a hose and wand for floor cleaning or it can be attached directly to three different woodworking machines at the same time. Run the vacuum without any hoses or hookups and it acts as a continuous shop air cleaner. The DC3300 system costs \$449 and comes com-



Large wood chips and debris fall into a clear plastic bag. Upper filter hood traps superfine wood dust. Unit weighs about 75 pounds.

plete with two 8-ft. hoses, two 20-in. extension wands, two attachments, two inlet-plug assemblies, a reducer and six clear collection bags. For details, contact Shopsmith, 3931 Image Dr., Dayton, OH 45414.

Power Station

IT SEEMS THAT a workshop never has enough storage space or electrical outlets. Well, now you can gain both with the Power Shelf from Vermont American, Box 340, Lincolnton, NC 28093.

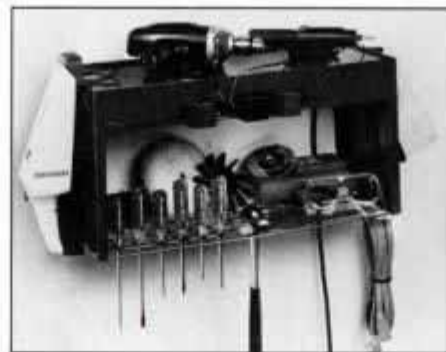
The wall-hung unit provides two shelves for storing portable power tools and hand tools, and six electrical outlets.

The Power Shelf is especially handy for recharging cordless power tools, flashlights and vacuums.

The 10 × 12-in.-high × 24-in.-long metal unit also features a large hook for hanging extension cords and a circuit breaker with reset button to pre-

vent the possibility of overloads.

The UL-approved Power Shelf costs about \$40 at hardware stores and home centers.



Wall-hung shelf provides a place to park and plug in power tools. The electrical outlet strip will accommodate up to six tools.

Six Shooter

NOW HERE'S A terrific idea: a portable drill attachment that lets you bore screwholes and then drive the screws *without* fussing with a chuck key to change bits.

Dial-A-Drill consists of a rotating

cylinder that houses four drill bits— $\frac{3}{32}$ -, $\frac{1}{8}$ -, $\frac{3}{16}$ -, $\frac{1}{4}$ -in.-dia.—and two screwdriver bits—slotted and No. 2 Phillips.

To use, simply chuck the attachment in an electric drill, push the cylinder forward and rotate it to align the desired bit with the exit port. Then, pull back on the cylinder to expose the bit and you're ready to go. Dial-A-Drill costs \$21.95 postpaid from Tekna-Tool, Box 216, 450 East 1000 N., North Salt Lake, UT 84054.



Drill accessory houses four drill bits and two screwdriver bits.

Copy-Cat Woodturning



Lathe duplicator turns exact replicas quickly, easily. Here it's shown following a flat template as the cutter slides on the worktable.

SHOPSMITH recently introduced a lathe duplicator that's designed for use with its Mark V (models 500 and 510), Mark II and Mark VII woodworking machines. The easy-to-use duplicator allows even novice woodturners to turn exact duplicates of an original turning or template.

The duplicator (\$349) features a unique free-floating cutter assembly that slides on a flat worktable. This allows you to work the cutter freehand. A small, nylon wheel, that is aligned with the carbide cutter, follows the shape of the original turning or template to produce an exact replica. Contact Shopsmith, 3931 Image Dr., Dayton, OH 45414.

Power To Go

PANASONIC, new to the power-tool industry, recently introduced a cordless drill/screwdriver that has several convenient features. The $\frac{3}{8}$ -in., reversible, variable-speed drill (model No. EY-571B) has two speeds. Low speed operates up to 350 rpm, high speed from 150 to 1000 rpm. A 5-stage clutch lets you choose the correct torque for driving screws. An electric brake stops the chuck immediately after releasing the trigger.

The drill also features a keyless chuck—no chuck key to fuss with or lose. Simply hand tighten the chuck to secure the bit.

Powered by a 1-hour-rechargeable, 9.6-volt, nickel cadmium battery, it comes with a plug-in charger for about \$240. Contact Panasonic, Power Tool Dept., 425 E. Algonquin Rd., Arlington Heights, IL 60005. **PM**





EVERYTHING IN ITS PLACE

A separate wardrobe for
increasing your closet space.

BY NEAL BARRETT

WHILE THIS wardrobe was designed as a companion piece to the wall units described in the previous story, it can also stand on its own as a source of additional storage space in almost any contemporary environment. By increasing the cabinet depth, we created enough space for hanging clothes which should relieve some pressure on your crowded bedroom closets. We also incorporated a combination of open shelves and cubby drawers for keeping smaller items organized. If you would prefer to have more room for hanging clothes, or fewer drawers and more open shelves, simply study the plans to understand the basic building techniques, then change the dimensions to suit your individual needs.

Construction details

Begin by cutting the panel for the case top slightly oversized in both length and width, and cut the $\frac{5}{4}$ poplar edge banding to length. Use a $\frac{1}{4}$ -in. slotting cutter and router to cut the spline grooves in the mating edges of the top panel and the edge banding. Cut stock for the spline from $\frac{1}{4}$ -in.-thick hardboard or plywood. Then, apply glue to the spline, groove and mating edges, and clamp all parts together. After the glue has dried,



This wardrobe can stand alone or be joined to the wall units by means of a simple filler strip.

use a $1\frac{1}{4}$ -in. rounding-over bit to rout the top corner of the edge banding.

Next, rip and crosscut the case top and sides to finished dimension. Then, use the radius template made for the platform bed to guide the router in shaping the upper corners of case sides. Clamp the sides over the template with the edges flush and use $\frac{1}{2}$ -in. straight bit to trace the template. Lay out the toe-space notch and use a jigsaw or band saw to make the cut-outs.

Dadoes and rabbets

Use the router with $\frac{1}{4}$ -in. straight bit and edge guide to cut the grooves in the case sides for joining them to the top. Note that these grooves are stopped $1\frac{1}{2}$ in. short of the front edge of the sides. Then, using a $\frac{1}{4}$ -in. slotting cutter, cut the matching spline grooves in edges of the case top.

Using a $\frac{1}{2}$ - or $\frac{3}{4}$ -in. straight bit and edge guide, rout the rabbets in the case top and sides to receive the case back. Note that the rabbet in case sides is stopped $\frac{1}{4}$ in. shy of the top edge. Use a sharp chisel to square the

ends of these stopped cuts. Next, lay out the dadoes for case bottom and top shelf in the sides, and use a $\frac{3}{4}$ -in. straight bit to rout the dadoes. Be sure to use a straightedge to guide the cut. Again use a sharp chisel to square the ends of stopped dadoes.

Cut the bottom and top shelf to size, then lay out and cut the notches at the front corners of both pieces. Then, lay out the dadoes in the bottom and

Color photo: J.R. Rost
Black-and-white photos: Neal Barrett
Technical art: Eugene Thompson
Styling: Gabe Herrick

top shelf for the false side and center partition. Rout these stopped dados using a 3/4-in. straight bit. Cut the partition, false side and facing strip to size, then glue and clamp the strip to the false side.

After the glue dries, lay out the dados in the partition and false side, and, using a straightedge guide, rout the dados. Square all stopped dado ends with a sharp chisel.

Assembly

Next, cut the short shelves to size and again, using either a band saw or jigsaw, cut notches in front corners. Then glue and clamp together the false side, partition and shelves. Use a clamp over each shelf joint to make sure that all joints are brought tight. Then check for square.

Continue assembly by gluing and clamping the bottom and top shelf to the false side and partition. Use cauls across the joints to evenly distribute the clamping pressure. Finally, glue and clamp the case sides to the existing assembly. When glue dries, cut and install the toeboard at the bottom of the case. Then, cut the case back to size but do not attach it yet. Also, locate and temporarily install the closet pole sockets as shown in the drawing. Then cut and install the closet pole.

Next, cut the doors to finished size, and using a 35-mm bit, bore hinge-

mounting holes on back side of doors. Then, temporarily mount the hinges on the doors. By using three self-closing and two free-swinging hinges on each door, you won't need door catches. Also keep in mind that if you want to position this wardrobe next to the wall units—like we did—you must install 95° hinges on the door that swings against the wall units. These hinges will prevent the wardrobe door from hitting the wall units.

Next, lay out the center location of hinge-mounting plates on case sides. Use the template shown in the wall units drawing to bore these holes. Attach the mounting plates, then hang the doors on the cabinet, and check for proper fit. Adjust the doors, using the screws on the hinges and mounting plates, for uniform margins on all edges. Bore the holes for door pulls at this time.

Drawers

Cut the drawer fronts to size. Then lay out the finger-pull cutout on a piece of scrap MDF and use a jigsaw to make the cut. Sand the profile smooth, then use this template to trace the cutout onto each of the drawer fronts. Cut each and sand smooth.

Next, cut the drawer sides, backs and bottoms to size. Use dado blades in a table saw to cut the rabbets on the

ends of the drawer fronts and to cut the dados in sides for the drawer backs. Then cut the grooves for drawer bottoms in fronts and sides, and sand all drawer surfaces smooth. Assemble the drawers with glue and brads, as shown.

To prepare for finishing, remove the drawers, doors and all hardware from the case. Sand all surfaces with 120- followed by 220-grit sandpaper. Dust off thoroughly and wipe clean with a tack cloth.

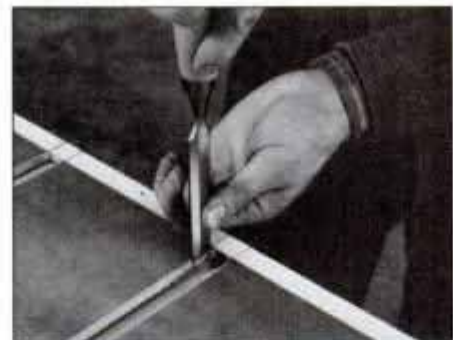
Finishing

In choosing a finish for these pieces, we had to balance our desire for a high-gloss look with the relative toxicity of many gloss finishes. While the toughest and glossiest finishes are either epoxies or polyurethane enamels, these materials yield fumes which are best left to an industrial, not a home environment. We did, however, find a gloss enamel that is safe for home use. It is Devco Paint's Bar-Ox Alkyd Quick Dry Gloss Enamel. This is a full-gloss enamel that dries so rapidly that we found dust contamination—a problem with gloss finishes—was no problem at all.

This finish can be applied by either brush or spray. The best results will come from spray application. A unit such as the Wagner Power Painter will yield excellent results. But in our



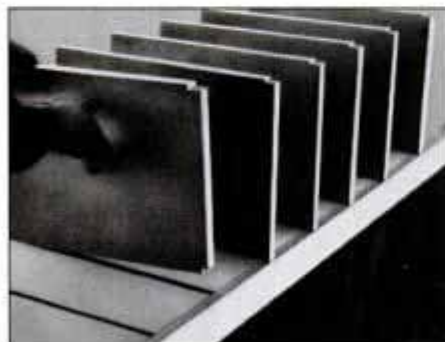
1 Cut case partitions to size, then lay out shelf locations on both. Use router and straightedge guide to cut shelf dados.



2 Using a sharp chisel, carefully square ends of all stopped shelf dados. Then cut the case bottom and top shelf to size.



3 Again using a router and straightedge guide, cut dados in case bottom and top shelf to house the case partitions.



4 Cut shelves to size and notch corners. Then begin assembly by gluing shelves into dados cut in both interior partitions.



5 Quickly clamp assembly together before glue starts to dry. Be sure to check for square and readjust clamps if necessary.



6 Glue and clamp top shelf and case bottom to partition assembly. Use cauls under clamp jaws to distribute clamping pressure.

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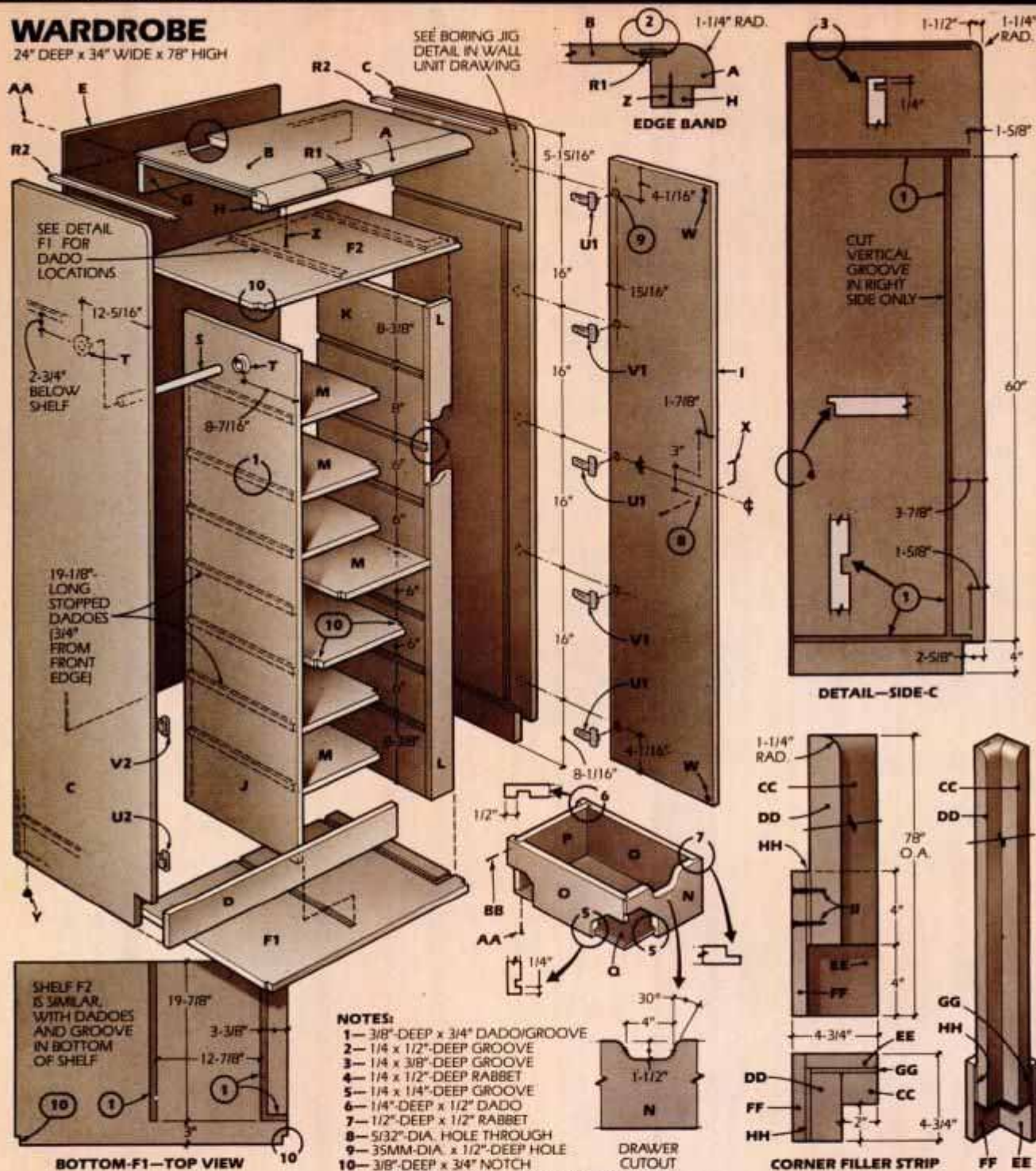
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Key	No.	Size and description (use)
A	1	1 1/2" x 2 1/2" x 32 1/2" poplar (edge band)
B	1	3/4" x 21 1/2" x 32 1/2" MDF (top)
C	2	3/4" x 24" x 78" MDF (side)
D	1	3/4" x 4" x 34" MDF (toeboard)
E	1	3/4" x 33 1/2" x 77 1/2" hardboard (back)
F1	1	3/4" x 22 1/4" x 33 1/4" MDF (bottom)
F2	1	3/4" x 22 1/4" x 33 1/4" MDF (top shelf)
G	1	3/4" x 4" x 32 1/2" MDF (cleat)
H	1	3/4" x 1 1/2" x 32 1/2" MDF (doorstop)
I	2	3/4" x 16 1/2" x 72 1/2" MDF (door)
J	1	3/4" x 19 1/2" x 60" MDF (center partition)
K	1	3/4" x 19 1/2" x 60" MDF (right partition)
L	1	3/4" x 3 1/2" x 60" MDF (facing)
M	7	3/4" x 13 1/2" x 19 1/2" MDF (shelf)
N	5	3/4" x 5 1/2" x 12 1/2" MDF (drawer front)
O	10	1/2" x 5 1/2" x 19 1/2" Baltic Birch plywood (drawer side)
P	5	1/2" x 5 1/2" x 12 1/2" Baltic Birch plywood (drawer back)
Q	5	1/4" x 12 1/2" x 18 1/2" birch plywood (drawer bottom)

R1	1	1/2" x 1" x 31 1/2" hardboard (splines)
R2	2	3/4" x 3/8" x 22 1/2" hardboard (splines)
S	1	1 1/2"-dia. x 15 1/2" fir closet pole
T	1 pr.	1 1/2"-dia. closet pole sockets
U1*	3	176" self-closing hinge No. D9633, with inset plate No. D9638 (right door only)
U2*	3	95" self-closing hinge No. D9615 (left door only)
V1*	2	176" free swing hinge No. D9631, with inset plate No. D9638 (right door only)
V2*	2	95" free swing hinge No. D9612 (left door only)
W*	4	self-sticking plastic door cushions No. D9678
X**	2	3" gray nylon wire pull No. HC160
Y*	4	3/8"-dia. steel furniture glide No. C1722
Z	3	1 1/2" No. 8 fl screw
AA		3/8" No. 5 rh screws, as reqd.
BB		3/4" brads, as reqd.
CC	1	1 1/2" x 2" x 74" poplar (post)
DD	1	1 1/2" x 3 1/4" x 74" poplar (post)
EE	1	3/4" x 4" x 8" MDF (toeboard)

FF 1 3/4" x 4 1/2" x 8" MDF (toeboard)
 GG 1 1/2" x 3 1/4" x 4" hardboard (spacer)
 HH 1 1/2" x 4" x 4" hardboard (spacer)
 II 4 1 1/2" No. 8 fl screw

Misc.: glue, 120-, 220- and 320-grit sandpaper, mineral spirits, wax, paint (De-Vo-Ko Interior Enamel Undercoat primer and Bar-Ox Flagstone No. 1M51D Gloss Enamel, manufactured by Devco & Reynolds Co., Box 7600, Louisville, KY 40207.

† The abbreviation MDF that appears in this list stands for medium-density fiberboard.

* Available from The Woodworkers' Store, 21801 Industrial Blvd., Rogers, MN 55374; send \$1 for catalog. (Parts numbers shown are stock numbers for The Woodworkers' Store.)

** Manufactured by Forms & Surfaces, Box 5215, Santa Barbara, CA 93108. (Available through hardware supply outlets.)

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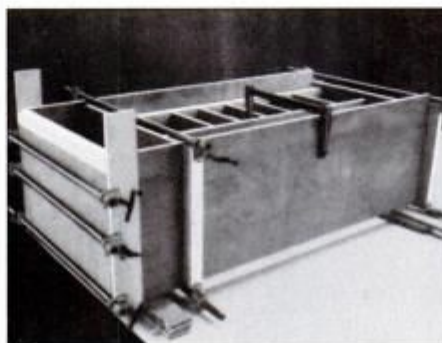
WOODWORKING GUIDE

case, a conventional spray system was available. It is extremely important when applying this, or any, solvent-based finish, that a proper respirator be worn and a fan used to exhaust fumes to the outside.

Begin the finishing process by priming all surfaces with the enamel undercoat. One coat of primer is sufficient on the flat surfaces, while two coats are necessary on the panel edges. Sand lightly with 320-grit open-coat sandpaper between coats and dust off thoroughly. After priming, examine all surfaces by shining a bright light across each. This technique will aid in spotting any scratches or irregularities that will need further work before top-coating.

For application of the top coat, thin the enamel with up to 1/2 pint of mineral spirits per gallon of paint. Always coat the interior surfaces of cases first, followed by the exterior surfaces: edges first, then flat surfaces. When spraying, keep the gun approximately 8 in. from the work, with your arm moving in a line parallel to the work surface.

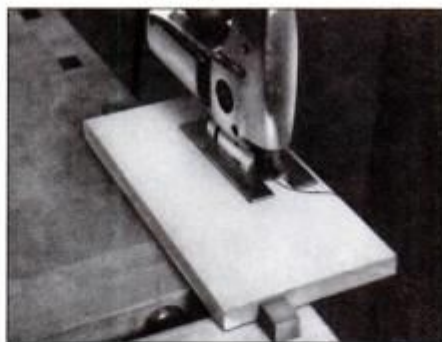
Let the first coat dry thoroughly—at least 12 hours at 70° F, longer if the temperature is lower. Scuff lightly with 320-grit paper, and wipe with a tack cloth. Apply the second coat as you did the first and let it dry thoroughly. Finally, examine the finish carefully to see if there are areas that might require a third coat.



7 Join case sides to existing assembly using glue and clamps. Again, use cauls to evenly distribute clamping pressure.



8 Cut drawer fronts to size, then make template for finger-pull cutout on scrap board. Trace template onto each drawer front.



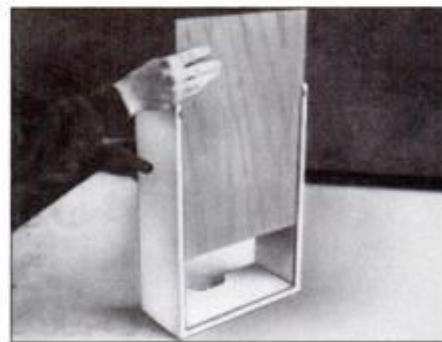
9 Use a jigsaw or band saw to make the finger-pull cutouts. Sand edge smooth with drum sander to remove saw marks.



10 Cut rabbets on drawer fronts and dados in sides using dado blades. Stopblock clamped to miter gauge speeds cuts.



11 Assemble drawer with glue and brads. Set and fill brad heads, then check for square before setting drawers aside to dry.



12 Once glue is dry, slide bottom into place and attach to bottom edge of drawer back with screws. Be sure to bore pilot holes.

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We'll help you every step of the way and show you how to be your own boss in less than 30 days. Now, don't get us wrong. This is not the "lazy man's way to riches."

It's a proven system that requires some hard work and dedication on your part. It also requires start-up capital of about \$2,000.

If you've got a few hours a week to invest in your financial future, chimney sweeping may be for you.

MILLIONS OF DIRTY CHIMNEYS NEED TO BE CLEANED

As you know, chimneys need to be cleaned and maintained on a regular basis to prevent the dangerous build-up and combustion of creosote. even the smallest accumulation of soot can be a threat to your home safety, and there are millions of dirty chimneys out there just waiting for disaster to occur.

If you've ever witnessed a chimney fire, you've seen the volcano-like eruption with flaming balls of creosote spewing out the top of a chimney with the force of a jet engine. And you've heard that unmistakable roar that sounds like a locomotive chugging into your living room.

If you haven't seen such a fireworks show yourself, ask your local firefighter for a description. It's a nasty sight, and he'll tell you all about the thousands of chimney fires each year causing millions of dollars of destruction, thousands of injuries, and hundreds of deaths each year.



Home heating is a leading cause of residential fires, and chimney sweeps are urgently needed now.

YOU CAN DO SOMETHING ABOUT THIS NOW

There's really only one way to prevent these disasters from happening, and that's to clean a chimney before it catches fire. This is where you enter the picture...as a professional chimney sweep with the August West System.

The Mother Earth News call it "The Height of Technology," and we must admit there's nothing else like it in the world. But simply stated, the August West System provides you with what you need to be your own boss in a chimney cleaning business of your own.



Diane and John Goodman of Montana enjoy the special rewards of working together in their own chimney sweeping business. "I don't know of any other business with such low overhead, fabulous money and great hours—Thank you August West!" said Diane.

Included in the system is a high-powered, high-volume dust collection unit which utilizes state-of-the-art filter technology. We call this machine the SootSweeper®, and it allows you to efficiently clean a chimney in record time and guarantee cleanliness to your customers. That means no worries about white carpets. It also means a dollar per hour ratio that just can't be beat.

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\$55.00 AN HOUR ARITHMETIC

Once a sweep, instead of thinking in dollars, you'll be thinking in chimneys. Now, let's look at the arithmetic.

If you were to put in a full day's work and charge \$55.00 per flue to clean a chimney WHICH CAN USUALLY BE DONE IN UNDER AN HOUR, your totals for the day would like something like this:

MOONLIGHTER'S WEEKLY EARNINGS

3 chimneys × \$55/ea. = \$ 165 Monday
3 chimneys × \$55/ea. = \$ 165 Tuesday
3 chimneys × \$55/ea. = \$ 165 Wednesday
10 chimneys × \$55/ea. = \$ 550 Sat./Sun.

Weekly Total: = \$1045

NO STRINGS ATTACHED

We're not going to tell you how many chimneys you should clean or how much you should charge. We're not selling you a franchise, and we don't take a percentage of your earnings.

August West does provide you with what you need to start making money immediately. That includes equipment, training, newsletters, workshops, advertising and promotion ideas, and even a tophat. MasterCard and VISA accepted so you can pay in small monthly installments if you wish.

NOW HEAR IT FROM THE SWEEPS

We know this all sounds too good to be true, so why don't you hear it from the sweeps themselves. All you have to do is fill out the coupon or call our 800 number, and we'll rush you out a recording that we made from telephone conversations with sweeps around the country. Sweeps like:

Diane and John Goodman of Montana who said: "Earn \$1,000 a week, right??? RIGHT!!! From day one we saw sweeping with the August West System as a fast way to reach our goal to build a house in the mountains. Our hard work has paid off, and the house is now completed."

We at August West heard that the Goodman's house is spectacular and called Diane for a picture of it. Well, she said business was so good that she'd send it as soon as she had a moment to breathe. Not bad for a former insurance agent and nurse who traded their ties and titles for tophat and tails.

When Chimney sweep **Tom Anderson of Irmo, South Carolina** isn't out brushing flues, chances are you'll find him behind a news desk brushing up on the weather forecast he's about to deliver on WIS-TV in Columbia, South Carolina. "In my first year as a sweep, I earned just five hundred dollars less than my yearly radio income...the second year saw a 55% increase in income over the first year." Not bad for a part-timer!

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It really is possible to write your own ticket to success and happiness as a chimney sweep using the revolutionary August West System. It's a great way of life...spare time or full time. And judging from the lifestyles and bank accounts we've heard about and seen, chimney sweeping really is a great way to make a living.

FREE INFORMATION KIT TELLS MORE

So, call or write today to find out more about the growing field of chimney sweeping. You'll receive information that will convince you that it will be the best \$2,000 investment you'll ever make.

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or write:

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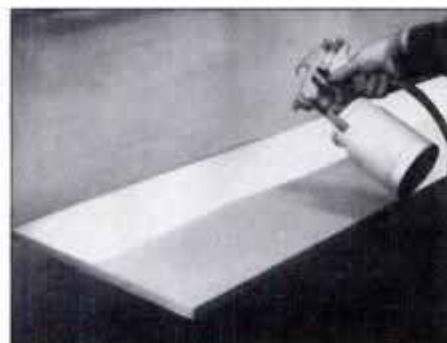
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This finish will dry to the touch in 12 hours. But, you should allow it to cure for at least a week before putting the pieces into service. After a week, install the case back, drawers, door and closet pole. Apply a small amount of wax to shelves where drawers will slide to ease the action and protect the painted surfaces from scratching.

To stabilize this wardrobe, it's a good idea to screw it to a wall. To do this, simply locate the wall studs, transfer these locations to the wall cleat in the back of the case, bore clearance holes and drive the screws into place.

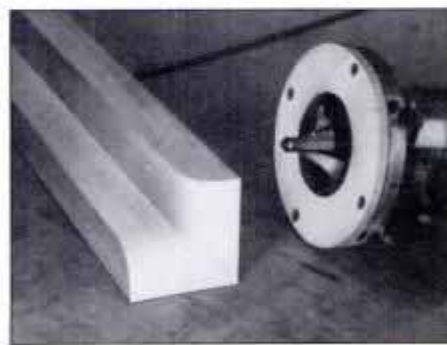
If you want to attach the wardrobe to the wall units, build the filler strip shown in the drawing. **PM**



13 When spraying enamel, hold gun about 8 in. away from work. Keep gun moving and overlap previous spray about 50 percent.



14 Once finish is completely dry, apply light coat of wax to drawer shelves to prevent scratching and ease drawer movement.



15 If wardrobe is to be joined to wall units, build filler post out of poplar boards. Rout same radius on top edge of assembly.

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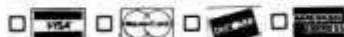
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THE MECHANICS OF THE BOMB

(Continued from page 68)

tive angle of attack, are second nature, a subconscious talent."

Getting a grip

Considering the precision that a good pass requires, the football seems almost designed to resist throwing.

To control spin and orientation, the hand needs to be close to the center of gravity, that is, near the ball's middle. However, to generate sufficient velocity the hand's force needs to come from behind, in other words, as far back as possible.

The resulting grip represents a compromise. A QB will hold the ball as far back as he can while still far enough forward to maintain control.

Throwing a football well is a talent in itself, since the hand needs to create several forces on a somewhat cumbersome object. Beyond finding the right balance of direction and velocity, the quarterback must control spin and orientation. Little wonder that the experts rate the bomb high on a list of quarterbacking duties.

"The bomb is one of the most delicate passes a quarterback has to throw," says Sid Gilman, a coaching veteran of 27 collegiate and 25 professional seasons. "You've got to throw it not just with distance but also trajectory. It's got to be laid up there and timed perfectly."

Gilman has worked for five NFL teams, and was head coach of the San Diego Chargers for 12 years. Many consider him the pioneer of the passing game in the NFL, which inducted him into its Hall of Fame in 1983.

"What you're doing, if you have a productive deep passing game, is stretching the field vertically," says Gilman, who sees the long ball as both a tactical and psychological weapon. "And I mean a productive game. Defenders start to worry about getting beat deep."

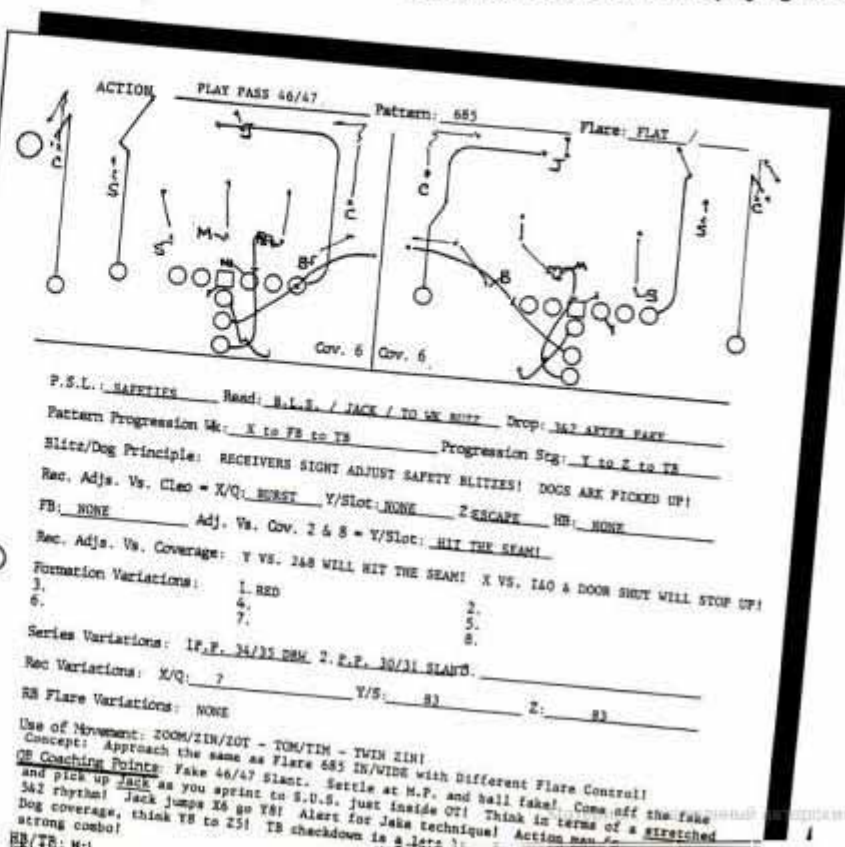
Both Gilman and Shula are careful to distinguish between the true bomb and plays that rely on a little bit of luck. For instance, the long, desperate play known as the "Hail Mary" can be mistaken for a bomb because it goes so far, but as a pass it is basically just a heave.

"The bomb is tougher to complete but the rewards are greater. A quick in or quick out is easier to execute but it gains under 10 yards. You use it to keep your drive going. You hit the bomb and it's 50 or 60 yards and a touchdown," says Shula. His quarterback agrees.

"I think any quarterback gets a feeling of excitement when the long bomb is completed," says Marino.

The beauty of football is its coordinated action and the long pass is an impressive expression of just that—two players, widely separated, connecting their efforts with the high flight of a pass rising from finesse to drop . . . just like a bomb. **PM**

A play from the Sid Gilman playbook: The "685" sends the left wide receiver on a "6," or in pattern; the right wide receiver runs a "5" or comeback; a back runs the flare. But the primary receiver (right scenario) is the tight end going for the bomb. The quarterback makes a snap decision based on defensive saturation of the playing field.



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Roll Top Desk—Nostalgia buffs will especially appreciate the always popular roll top desk for both home and office: it's an antique cherished by many. Make one yourself in fine cherry and take pride in this charming heirloom. You build it as two separate units, a base and a roll top. (PA-1736—\$5.95)



Pop-Top Desk—A great tilting-top desk for youngsters ages 3 to 10. Adjusts safely to any angle and contains two roomy drawers for art supplies, games and papers. A swing-out tray provides easy access to small items. Plans tell you how to make the chair, too. (PA-1010—\$5.95)



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OUTDOORS

(Continued from page 53)

At the starting line, the teams are sent off a minute apart. Ten minutes before each team's scheduled start, officials hand out the road book. Then it's off into the unknown.

The 93.4-mile route took us from Lakewood through scenic Clear Creek Canyon to the 100-year-old mining town of Central City. From here we left paved roads and shifted into 4wd.

The lumber road climbed steadily, at first, then turned ugly. Vehicles bottomed out and wheels were spinning in the air. At one point the vertical slope seemingly forced us to defy gravity.

Rocky Mountain high

After the first series of climbs, we reached an elevation of 11,000 ft. and were treated to a panoramic view of the snowcapped peaks of Rocky Mountain National Park. This was followed by a steep descent past St. Mary's Glacier, a short section back on paved roads, and a 20-minute stop for lunch in Idaho Springs, another old mining town. Distance: 52.5 miles. Time: 3 hours.

After lunch we climbed back up into the mountains on a civilized dirt road, where 4-wheel drive wasn't necessary. We wound back down near Red Rocks Park and cut over to Golden, past the huge brewery for Coors Beer. From here the route was paved highways.

Despite not having the full complement of allowable electronics, or having any instruments at all, we were 9 seconds off the median time after the first control and 8 seconds off after the second. Our 17-second total put us in 6th place at this point.

It didn't hold. As soon as we hit the rough stuff, I pulled out my camera and started acting like a reporter. I got some terrific shots. We were a few minutes off after the third control, more after the fourth and so on. We finished well off the pace.

The winners were Dave Jameson and Karl Broberg, both of Tucson, Arizona, who had only 57 seconds of error over 5½ hours of driving. This was the team's second straight year to win the event. The top three teams earned expense-paid trips to Toronto, Canada, to compete in the Jeep Cup Championship.

Bob Lathrop and his wife did much better than the "bozos." They finished a respectable 5th and felt good about their performance. "We're getting better," Lathrop said, "although there are still some things we can improve."

I felt the same way. For next year's rally I'm going to get rid of my camera. I'm going to bring an expensive stopwatch, an ultrahigh-tech calculator, and a spread sheet like Lathrop's.

And I'll probably finish last.

PM

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One of the country's most respected research institutes reported applying a powerful ultrasonic cleaning process to a Slick 50 treated engine and were surprised at its permanence. "We actually expected the Petrolon Slick 50 TFE Resin coating to also be removed, but later found it was still there."

TUV, a German testing laboratory with credentials every bit as prestigious as our Underwriters Laboratories, tested Slick 50 in 1986. They found substantial increases in both gas mileage and horsepower. Their tests showed that these gains were due to a reduction in friction.

The Federal Aviation Administration has fully accepted a similar product for aircraft—Slick 50 Aircraft Piston Engine Treatment (F.A.R. #33.49). This FAA endurance test-simulated 1400 hours of engine use.

The power technology laboratory at a leading southwestern university stated, "Slick 50 does increase horsepower and decrease fuel consumption in tests done at the university."

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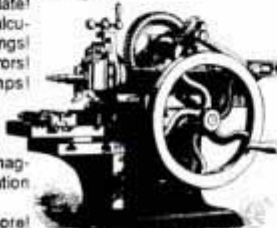
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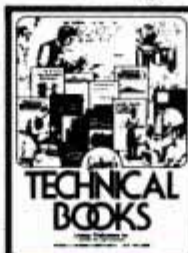
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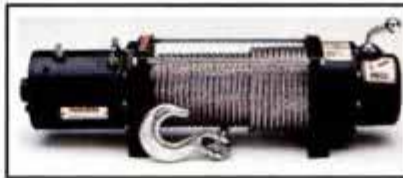
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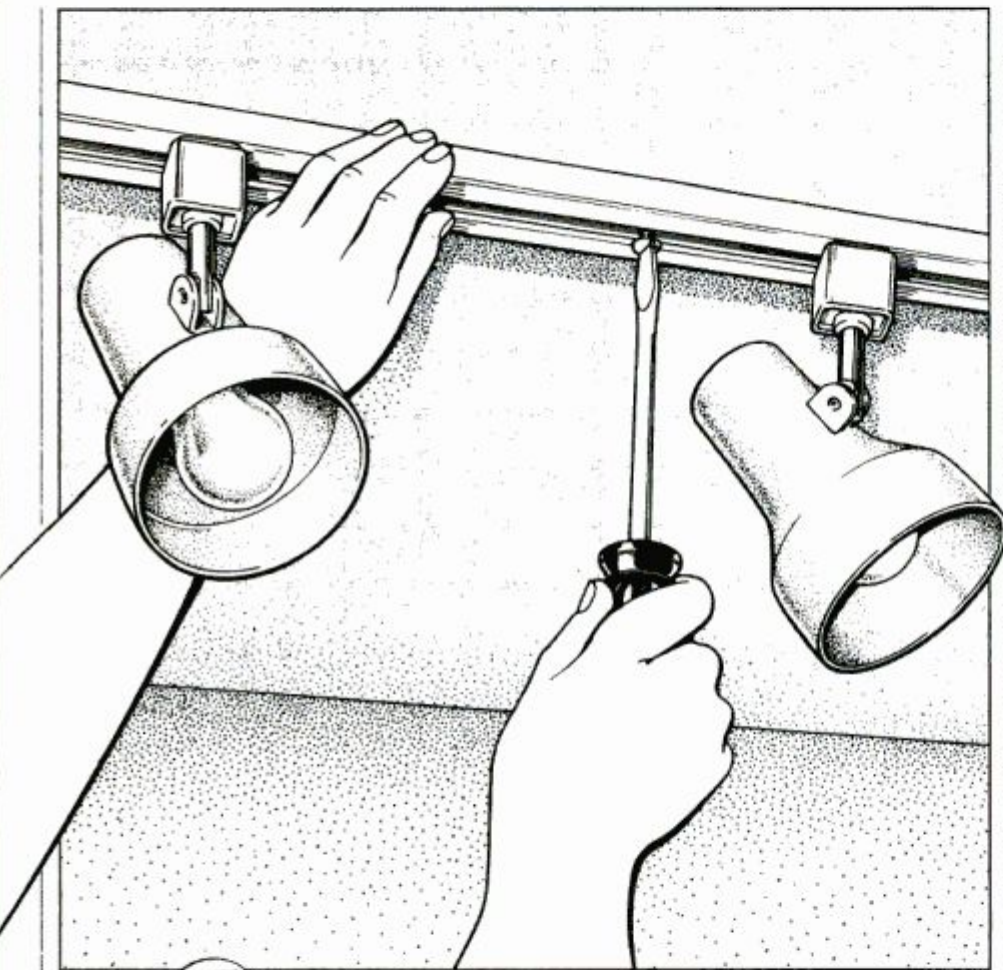
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How To Install TRACK LIGHTING

BY MERLE HENKENIUS; PM Illustrations by George Retseck

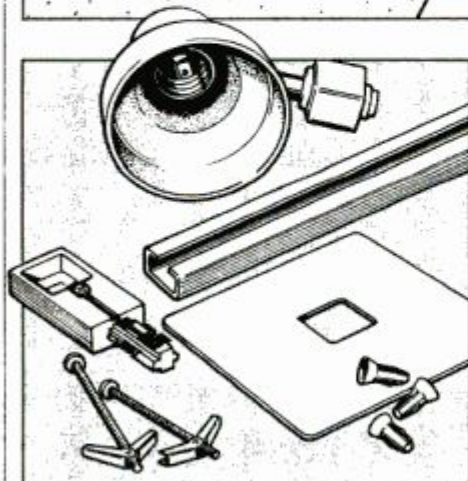


WHEN it comes to creating dramatic indoor lighting with a modest investment, track lighting excels. It can be used to highlight a wall hanging, isolate a piece of sculpture, or simply brighten a darkened hallway. The effects are as varied as equipment options.

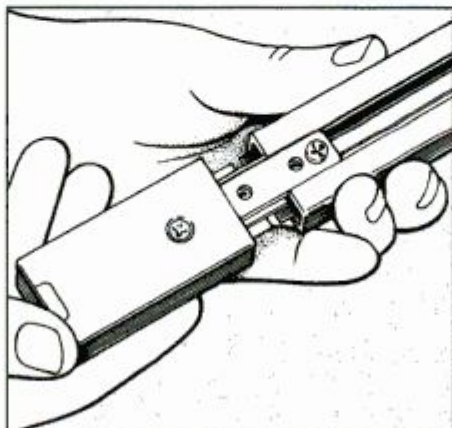
You'll find track lighting comes in many different styles, and because most units are modular, you'll be able to mix and match components to suit specific needs. While good lighting design does require skill and imagination, installation is pretty basic, especially if you are simply replacing an existing switched light fixture, as we did for this story. All you need are some common household tools.

Layout

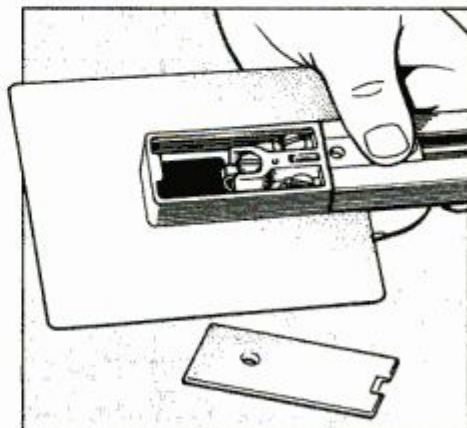
Because you'll be dealing with an existing light fixture, your options will be limited to the location of those fixtures. For the best appearance, keep the track parallel to the house wall closest to the fixture. Do keep in mind, however, that you can install track lighting wherever you want it. But if no wiring is in place, you will have to fish new wiring through your walls and ceiling, which is a fairly complicated task better left to a licensed electrician.



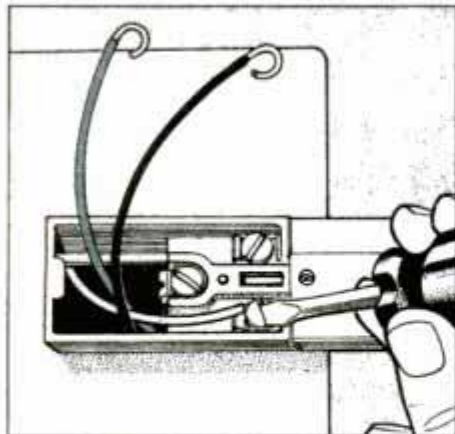
1 Lighting kit includes lamps, track, hot cap, covering plate and usually some toggle bolts. You supply the wire nuts.



2 Begin assembly by sliding the hot cap into one end of the track. Then tighten the fastening screw securely against the track.



3 Remove the back panel from the hot cap and install the kit's covering plate. This plate will conceal any standard ceiling box.



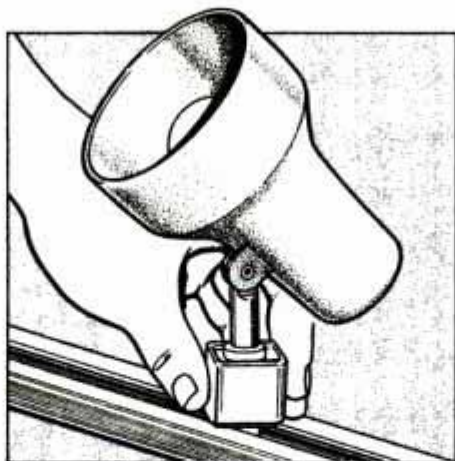
4 Attach pigtails to the hot cap as follows: white wire to silver screw, black to gold, and green to center grounding screw.

Assembly

Begin by sliding the hot cap that comes with your kit into one end of the track (Fig. 2). Attach it by tightening the fastener screw. Then screw the oversized covering plate onto the backside of the hot cap (Fig. 3). This plate is designed to cover the entire perimeter of a standard ceiling box.

Once the covering plate is in place, remove the top panel of the hot cap. This will reveal the binding screws that secure your electrical connections. Either cut 8-in.-long insulated pigtails from scrap wire or buy pre-made pigtails from a hardware store. You'll need one white, one black and one green wire. Make sure the gauge of the wire you use matches the wire in your ceiling box *and* fulfills the manufacturer's requirements stipulated in the product literature.

Attach the white pigtail to the silver-colored screw, the black to the gold-colored screw, and the green to the center binding screw (Fig. 4). Each end should wrap around the screw in a clockwise fashion. Make



5 Slide the lamps into the track then twist in place. Manufacturer's instructions will explain how to maintain proper polarity.

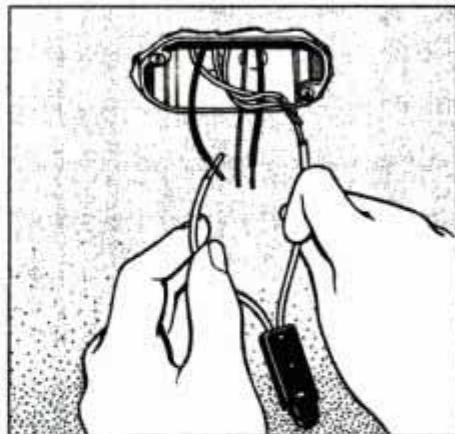
sure that the other ends of the pigtails run through the hole in the back side of the hot cap.

Finish the assembly by sliding the lamps into the track and twisting them in place (Fig. 5). The manufacturer's directions will explain the proper way to do this so you maintain electrical polarity. At this point you should also install the toggle bolts—used for attaching the track to the ceiling—in the track.

Electrical connections

Before you remove your existing light fixture, be sure to turn off the power to the circuit. Either switch off the breaker or back out the proper fuse. Make sure to test the circuit by turning the wall switch *ON and OFF*. When satisfied that the power has been cut, remove the light fixture and once again test for power, this time using a current tester (Fig. 6).

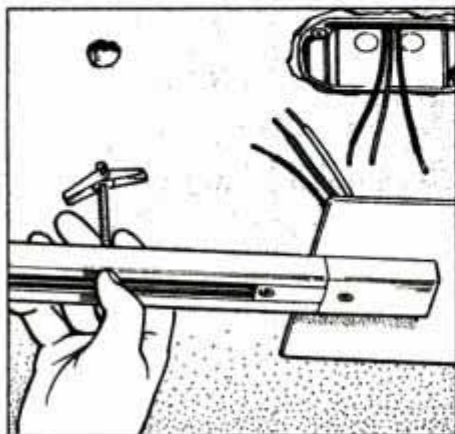
Depending on your home's wiring scheme, you will be confronted with two different situations: either two black wires and a ground wire will be



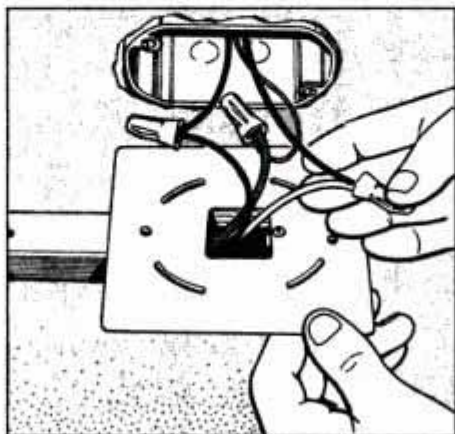
6 Turn off power and remove existing fixture. Using tester, check for current from each black wire to the white wires.

sticking down from the box—which indicates that the power supply is coming into the ceiling box—or a white, black and a ground wire will be there—which indicates that your switch box is receiving the power and your ceiling box is getting one 2-wire with ground cable from the switch. In the latter case, the white wire should be coded with black tape or black ink mark. This designates that the white wire has been changed to function as a black (hot) wire. Be sure to check for current between the black (hot) wires and the white (neutral) wires with your tester. When satisfied that no current exists, you are ready to attach the track.

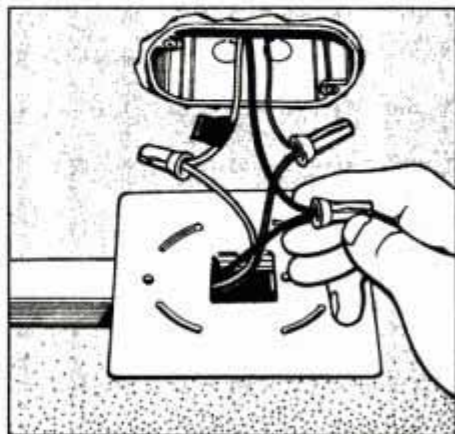
To do so, just bore a couple of holes in the ceiling for the toggle bolts, then push the bolt ears into the holes. Let the track dangle until you've made the connections as shown in Figs. 8 and 9. Be sure to use proper-sized wire nuts. Then stuff all the wire connections into the box and tighten the toggle bolts. Turn on the power and you're done. **PM**



7 Lay out and bore ceiling holes for the toggle bolts. Install the bolts, push the ears through the holes, and let track dangle.



8 Using the proper-sized wire nuts, join black and white pigtails to the black wires in box, and green pigtail to ground wire.



9 Sometimes a box will have a black wire and a white wire, coded with black tape or ink. Just treat the white wire as black.

Homeowners' Clinic

BY NORMAN BECKER, P.E., Contributing Editor

Faster Hot Water

In my gas-heated hot-water system, the shower head is the most distant point from the hot-water tank. It takes an annoyingly long time for the hot water to arrive. My question concerns how to install a return line in the system to shorten the time it takes for hot water to arrive. What's the proper method to do this?

V.E. PETE PETERSON
BAKERSFIELD, CA

A recirculating line in a domestic hot-water system is a nice feature in that it provides almost instant hot water at the fixtures. However, it will cause your fuel bill to increase.

Whether you can easily install a recirculating system depends upon the pipes' accessibility. To convert your system, connect a 1/2-in.-dia. pipe to the hot-water supply pipe at the fixture that's farthest from the water heater and run it back to the heater.

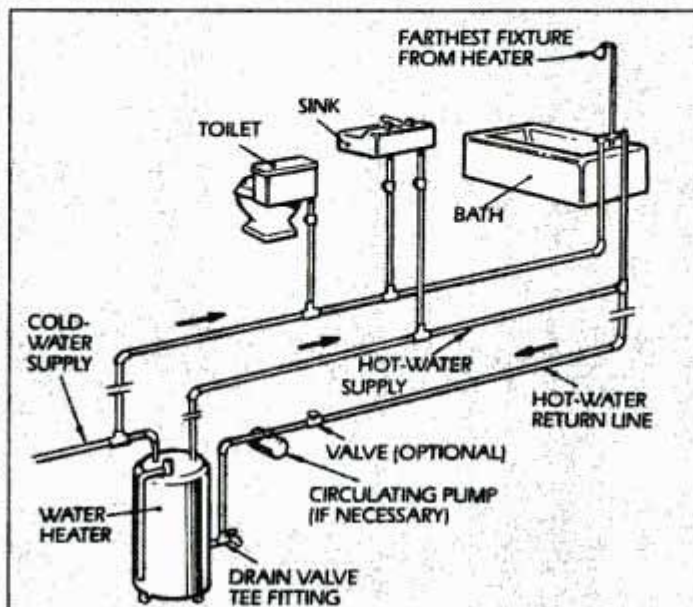
Remove the drain valve at the bottom of the heater and install a tee fitting in the opening. Reconnect the valve to one end of the tee and connect the return line to the other end.

In a 2-story house, the hot water will circulate without the aid of a pump because the difference in elevation between the fixture and the heater is sufficient to allow the less dense hot water to rise and force the cooler water down. However, a 1-story house without a basement may require a pump in the return loop to force circulation. Installing a valve in the return line will enable you to turn off the flow during the summer and save on your fuel bill.

Upgrading Receptacles

I have an older home that was wired before the days of 3-wire grounded circuits. Would it be safe to replace the old receptacles with new, 3-slot receptacles and simply use a short wire to connect the grounding screw to the neutral wire?

ROBERT D. STEWARD
ROCKTON, IL



Hot-water return line provides fast hot water, but will increase your fuel bill. Valve in line allows you to turn off flow during summer.

Your proposed solution is unsafe and can result in severe electrical shock. It definitely should not be used. Although the neutral line is grounded at the panel box, it is not a grounding wire and, in fact, is a current carrying wire under normal load conditions. By connecting the grounding screw on a receptacle to the neutral wire, you are making the appliance chassis electrically hot. The potential exists for an electric shock that could be fatal.

Having 2-slot receptacles doesn't mean that your receptacles are not grounded. Unless knob-and-tube wiring or old 2-wire Romex was used, your receptacles are probably grounded. You can check it out with an inexpensive neon circuit tester available at home centers and electrical supply stores.

Put one leg of the tester on the receptacle faceplate screw. If necessary, scrape off any paint to make good contact. Put the other leg in the hot slot.

If the receptacle is grounded, the neon bulb will light. In this case, a simple 3-slot adapter will do the job. Plug in the adapter and connect the pigtail to the faceplate screw.

If your system is not grounded, then I recommend rewiring those receptacles that are used for appliances.

Aging Roof Shingles

My home has a 15-year-old white asphalt-shingled roof. There are terrible looking black streaks forming on some areas. How do I know when the shingles need to be replaced short of waiting for a leak?

DON DANNA
KINGSPORT, TN

Whether shingles need to be replaced depends on their overall condition rather than the appearance of a leak.

Asphalt shingles are made by impregnating either organic felt mats or Fiberglas mats with asphalt and covering the top surface with mineral granules.

The granules provide color and protect the shingles from being damaged by the ultraviolet rays of the sun. Most asphalt shingles have a projected life of 17 to 22 years. Longevity depends on shingle weight and exposure to the sun. Because southerly exposures get more sun, shingles on the south side will generally deteriorate more rapidly than those facing other directions.

As shingles age and weather, they become brittle and their corners curl. This makes them vulnerable to wind damage. Aging shingles also develop surface cracks and pitting due to granule loss.

Continued granule loss exposes the mat which leads to further deterioration and leaks.

Whether you should replace your shingles depends on their age and the extent to which they've deteriorated. You can always patch and coat a roof to extend its life. However, if about 30 percent of the shingles have deteriorated, I recommend that the roof be reshingled. **PM**

Do you have a home-maintenance or repair problem? Send it to Homeowners' Clinic, Popular Mechanics, 224 West 57th St., New York, NY 10019. Letters cannot be answered individually, but problems of wide interest will be discussed in the column. For more home-repair and maintenance help, get PM's Home Care Guide, \$2.45 postpaid. Send your order(s) to Popular Mechanics, Box 1014, Radio City Station, New York, NY 10101.

Appliance Clinic

BY STEVE TOTH, Contributing Editor

Ice Maker Fix

When I press the ice dispenser in my Montgomery Ward refrigerator, some ice cubes go into the glass, but others drop into the freezer compartment. Is there an adjustment I can make to prevent this? The refrigerator is model No. HMG249667B, serial No. 58G34274523. ANTHONY SPEHAR
CHANTILLY, VA

It sounds like you need to install an impeller guard and sleeve kit. This kit (part No. 69462170) includes step-by-step instructions and is available from any Montgomery Ward parts distributor. Or, call (800) 323-1965 and have your charge card ready. The kit costs about \$4.

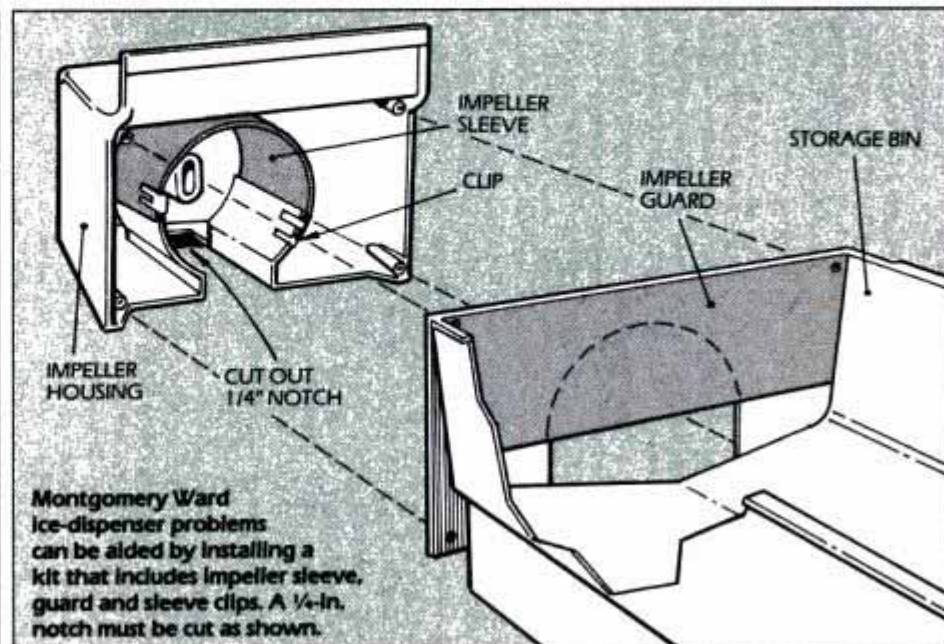
To install the kit, you'll first need to remove the storage-bin assembly. Then, detach the impeller housing and cut away the front lip 1/4 in. as shown in the instructions. Attach the plastic impeller sleeve to the housing with the supplied clips and reassemble. Before attaching the housing to the bin, however, install the plastic impeller guard. Then, secure the housing to the bin with the four mounting screws.

Gas Range Relic

I have a problem with my Chambers gas stove model 90C, serial No. 1-16051. It leaks gas and I've been told that the valves need to either be replaced or repacked. The stove, however, has not been made for years and no one seems to know how to repair it. I can't find a part number on the valves to order new ones. Can you supply the valve part No. and instructions for replacing or repacking the valves? PEGGY C. MASTROPAOLO
NEW ALBANY, IN

Unfortunately, your model-C style-90 Chambers Gas Range hasn't been made since the '50s and new parts are no longer available. All is not lost, however. Macy's Texas Stove Works, 5515 Alameda Rd., Houston, TX 77004, (713) 521-0934, should be able to help.

They buy and sell older ranges and stock parts for older gas units. The company can supply you with a reprinted copy of the original service manual for your range. In addition to



Montgomery Ward ice-dispenser problems can be aided by installing a kit that includes impeller guard and sleeve clips. A 1/4-in. notch must be cut as shown.

providing other information, the manual explains how to remove, disassemble and lubricate the top burner gas valves. The cost of the manual is \$9.50 plus \$1.50 for shipping and handling.

The company can also supply rebuilt top burner valves on an exchange basis. The cost for each valve is \$18.50 plus \$3.50 for shipping and handling.

Send your old valves to Macy's after the rebuilt ones are installed. If you prefer, you can have a local technician remove the gas manifold with valves intact and send it to the company. They can test the assembly and rebuild the valves for about \$120.

Wringer Repair

My Maytag wringer washer, model No. E2LPS, is in very good shape except that it leaks oil. Can you tell me where I can get a repair manual to help me fix the problem myself?

E.B. CORNELIUS
LATROBE, PA

The repair manual for your machine is still available from Maytag. You can order it from your local Maytag parts dealer or write to Maycor, 240 Edward St., S.E., Cleveland, TN 37311, Attn: Publication Dept.

Ask for wringer-washer service manual Maytag part No. 56127. The price of the manual is about \$3.

Needs Pulley

I need a motor pulley for my Norge electric clothes dryer model No. DEK1822B-17, serial No. 223842. My local parts supplier told me that the pulley is no longer available. Do you know where I can get it?

STANLEY DALTON
HARRIMAN, TN

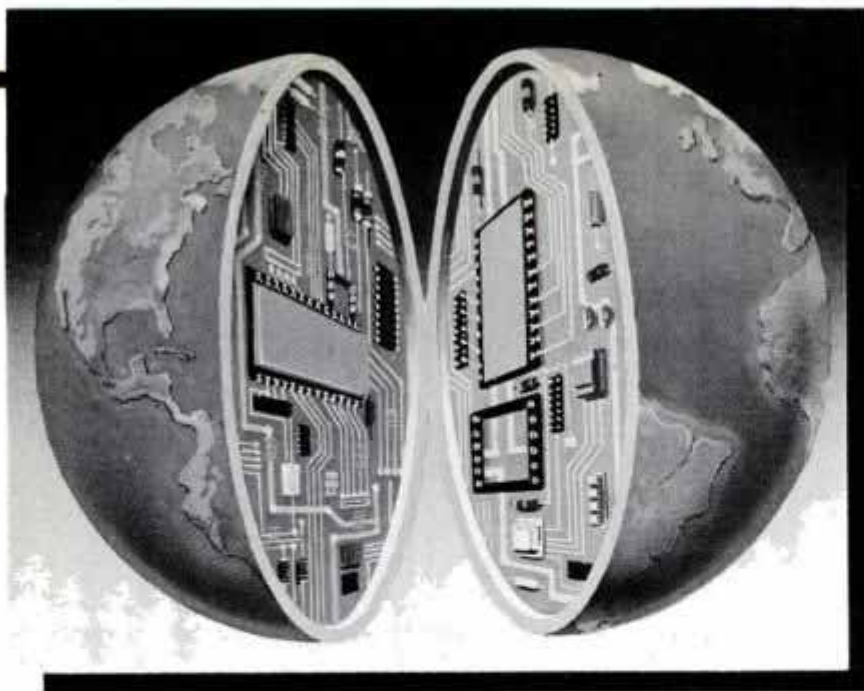
The motor pulley that drives the drum belt is still available from the manufacturer. The Norge part No. for the pulley and clutch assembly is 63-3160. It costs about \$24 plus tax and shipping.

To locate an authorized factory parts distributor in your area, write to Maycor Appliance Parts and Service Co., 240 Edwards St., S.E., Cleveland, TN 37311. Or, call the company toll free at (800) 255-2370. **FM**

Service Tip

A light application of silicone spray lubricant on refrigerator hinges ensures quiet operation. And, spraying silicone on the door gasket will help prevent it from drying out. Always wipe away the excess.

If you have a problem with any appliance, send your question, along with model and serial numbers, to Appliance Clinic, Popular Mechanics, 224 West 57th St., New York, NY 10019. Sorry, but letters cannot be answered individually. Problems of wide interest will be discussed in this column.



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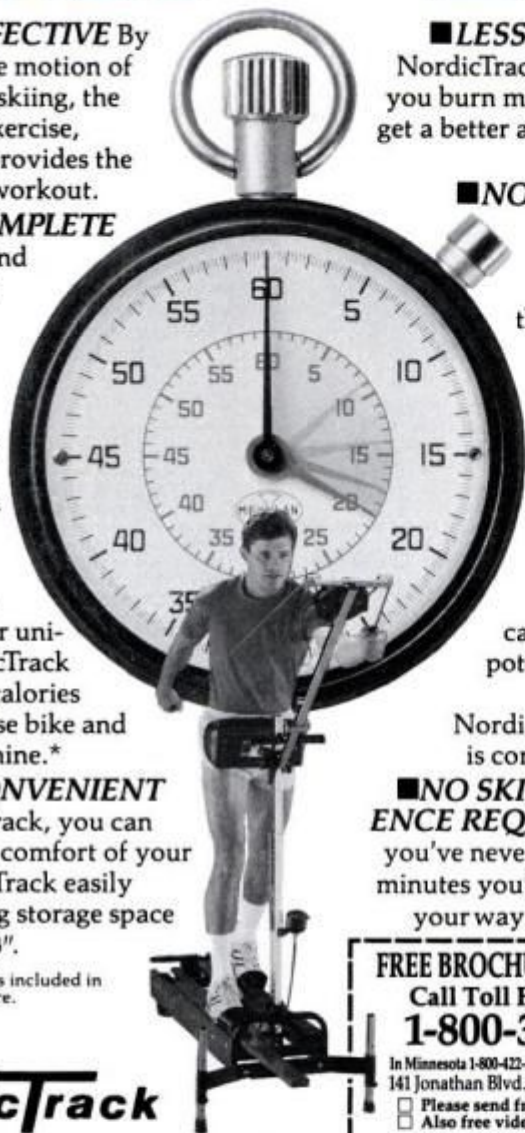
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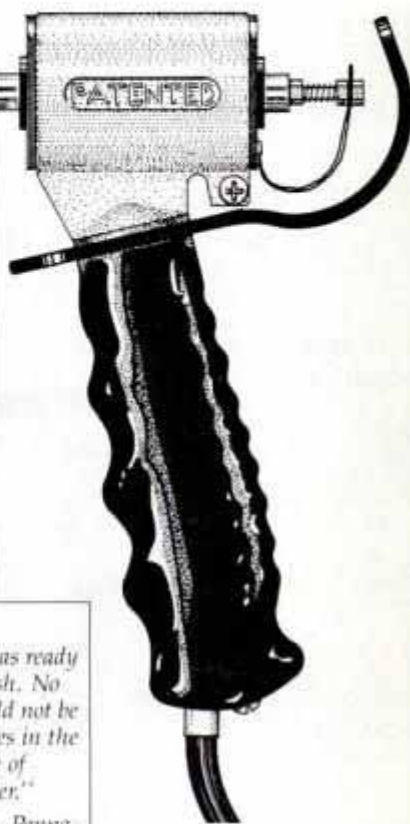
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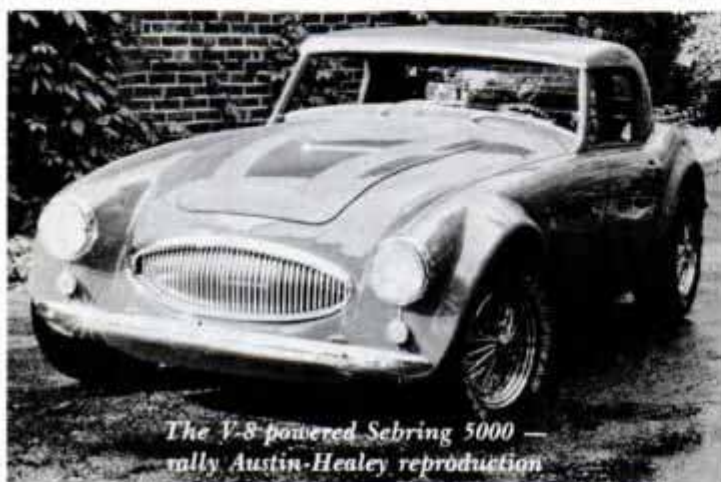
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

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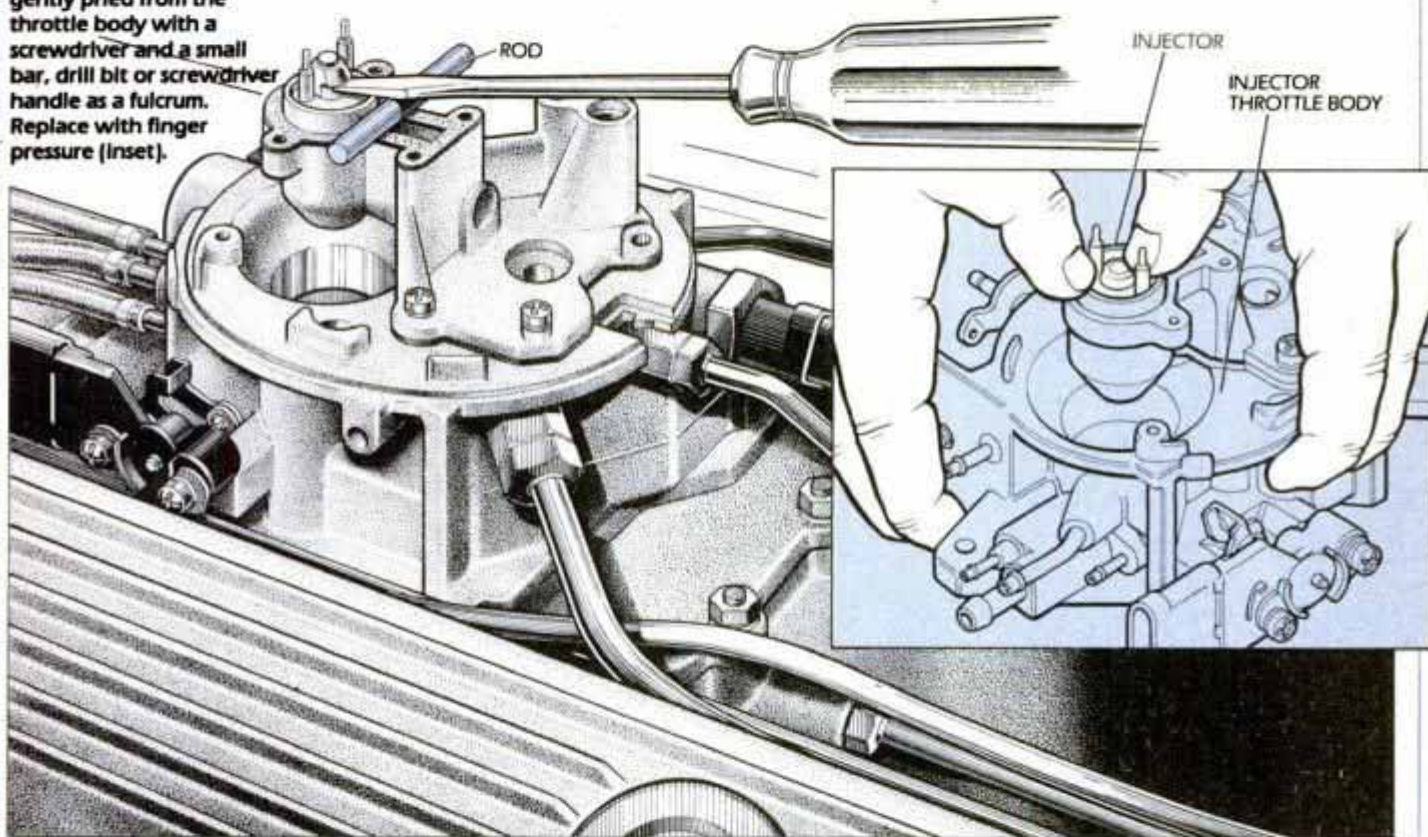
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Troubleshooting THROTTLE BODY FUEL INJECTION

BY MORT SCHULTZ, Contributing Editor
PM Illustrations by Fred Wolff

Stubborn injectors can be gently pried from the throttle body with a screwdriver and a small bar, drill bit or screwdriver handle as a fulcrum. Replace with finger pressure (inset).



IF YOU THINK troubleshooting Throttle Body Injection (TBI) is too complex for the Saturday mechanic, you're wrong. It's a relatively simple system to handle. And test instruments cost only about \$60.

However, before you turn your attention to a TBI system in hopes of solving a performance problem, be sure to check other possibilities, such as vacuum loss, bad electrical connectors and ignition-related malfunctions. These cause trouble much more often than the TBI.

Similarities and differences

On the surface, TBI looks like a carburetor system (Fig. 1). It's mounted on the intake manifold as a carburetor

would be, and it may have that large familiar-looking air cleaner over it, as a carburetor does. Once you remove the air cleaner, the differences become apparent.

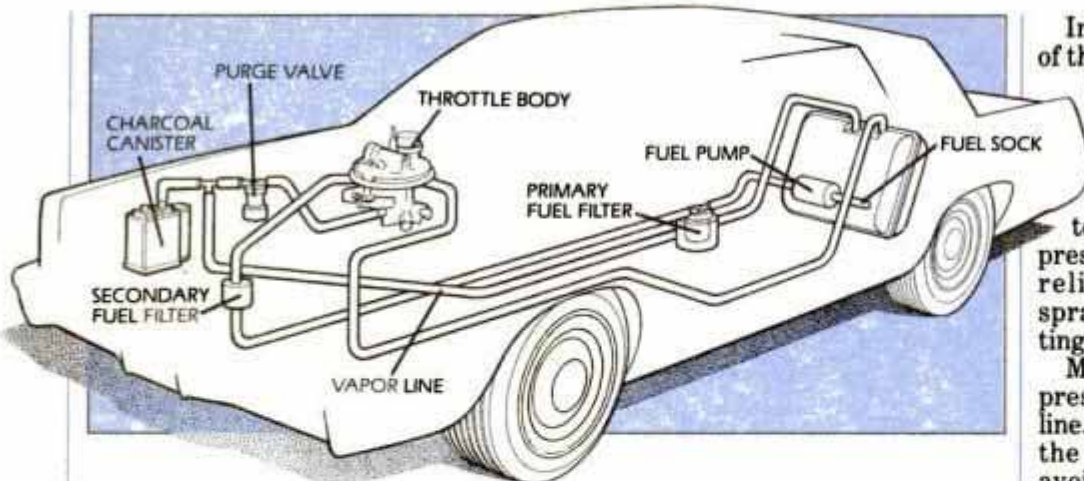
When the throttle body is uncovered, you notice one (single-point) or two (dual-point) fuel injectors. Or you might see two throttle bodies, each with one fuel injector (Fig. 2).

In addition to the fuel injector(s), there are other parts of a TBI system that can be troublesome: in-line fuel filter between the fuel tank and throttle body, fuel-pressure regulator, electric fuel pump, fuel sock in the fuel tank and the idle-speed control.

In addition to these, you can't approach TBI without considering the

electronic system that controls it.

The electronic system calculates the fuel requirements of the engine and gets the fuel injector or injectors to deliver the amount of gasoline necessary for the engine to run efficiently. When considering the TBI as a possible cause for an engine performance quirk, the important point to remember about electronics is that a malfunction with the control unit (computer) or with a sensor can cause the same problems that a fault in the TBI system can cause. Therefore, if the tests described below result in a clean bill of health for the TBI, check out the electronics. If the CHECK ENGINE light on the dash is lit, refer to the manual for the procedures for



1 Throttle-body injection layout is similar to carburetor systems.

interrogating the computer for its diagnostic codes before you try any troubleshooting on your own.

Lighting the way

When your TBI-equipped engine won't start, first determine whether the fuel injector is being energized so it opens and sprays gas into the engine. An accurate, easy-to-use test instrument is the TBI Injector Harness Tester (Fig. 3). This test light costs less than \$10, and you can order one from Borroughs Tool & Equipment Corp., 2429 North Burdick St., Kalamazoo, MI 49007 or from Kent-Moore Tool Group, 29784 Little Mack, Roseville, MI 48066.

To use the test light, disconnect the wire harness that connects to the fuel-injector electrical terminal and plug the test light into the wire harness connector. Crank the engine. If there are two fuel injectors, test both.

Does the test light give pulsating flashes? If not, there's an electrical

failure or a problem with the electronic control system.

But if the light flashes, the reason the engine doesn't start lies with the injector itself, fuel pump, in-line fuel filter or fuel sock. To get a line on which it is, check the tip of the fuel injector as someone in the car cranks the engine.

You should see gas spraying from the fuel injector, but look closely because it's sometimes difficult to pick up the spray. If you don't see gas spraying, the problem is with the fuel-delivery system.

Furthermore, if you're having a performance problem—something other than the engine not starting and the spray of gas from the fuel injector is not in the shape of a well-defined cone, there is a TBI-related problem. TBI-related performance problems can include hard starting, stalling, hesitation, rough idle, fast idle, dieseling (engine run-on), lack of power and poor mileage.

In testing to determine which part of the fuel-delivery system is causing the trouble, establish whether the malfunction is with the injector or another component. You can do this by analyzing fuel-system pressure, but to do this test you may first have to relieve pressure in the system. If you don't relieve the pressure, you'll get sprayed with gas as you loosen fittings to connect the pressure gauge.

Most manufacturers have a fuel-pressure diagnostic valve in the fuel line. If your car has one, you can tap the pressure gauge into the valve, avoiding the need for relieving fuel-system pressure.

Relieving fuel-system pressure

Although manufacturers suggest different ways of doing this, you won't go wrong following this procedure:

1. Place an automatic transmission in Park—a manual gearbox in Neutral—and engage the parking brake.
2. Remove the fuel pump fuse from the fuse panel if there is a fuel pump fuse. If not, look for a wire harness connector near the fuel tank. Pull apart the connector to disconnect the electric fuel pump.
3. Start the engine. When the engine stalls, crank it for 5 seconds.

That's it, except for these few tips: ■ Although fuel pressure has been released, a little gasoline may spray when you disconnect a fuel fitting, so wrap a cloth around your hand and the wrench to collect it.

■ Whenever you reconnect a fuel fitting, don't reuse the O-ring seal. A used seal might cause a leak. Buy several new ones, because you may have to disconnect the fitting a few times during the course of TBI servicing.

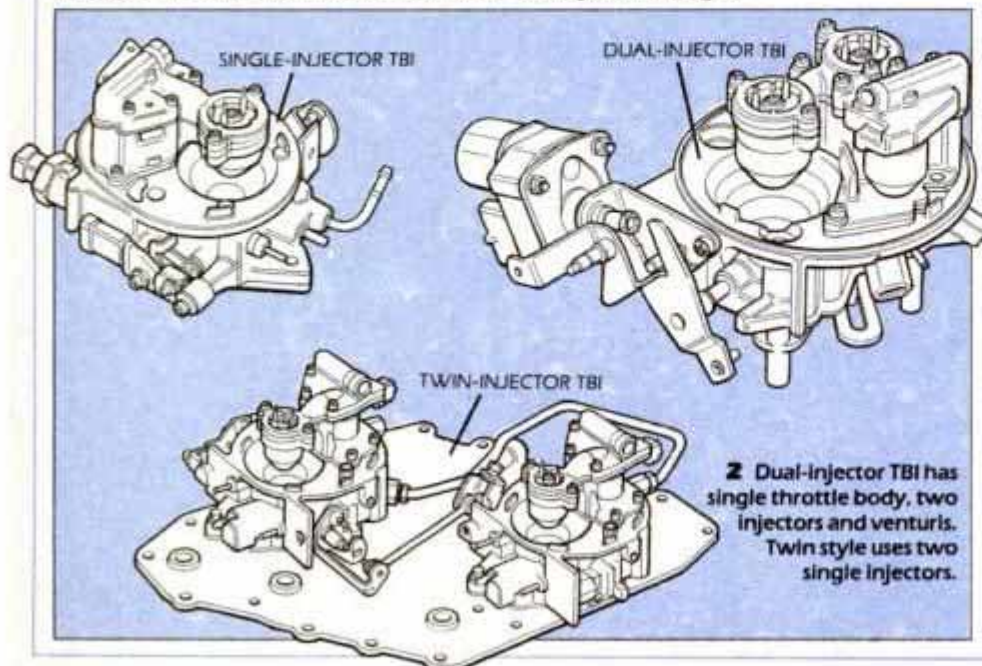
■ Keep in mind that once you allow fuel-system pressure to build up, you have to release it before disconnecting any part of the system again.

Fuel-system pressure test

A fuel-system pressure gauge should cost you less than \$50 from an auto parts dealer or from one of the two companies mentioned above.

You'll need specific data concerning the pressure developed by your TBI system. This spec is in the service manual. Don't guess at it. Depending on the system, pressure can be between 9 and 39 psi. Make sure the gauge is appropriate for the fuel-pressure spec for your system.

Do the test in the following way. (If your system is equipped with a fuel-pressure diagnostic valve, you can



just attach the gauge to it, rather than depressurizing the system and disconnecting lines to insert a gauge.)

1. If you disconnected a vacuum hose from the throttle body when you removed the air cleaner or air inlet duct, block the vacuum port to prevent vacuum loss as you crank the engine. Vacuum loss can result in a false reading.

2. Disconnect the fuel-inlet line from the throttle body. That's the one coming from the in-line fuel filter. The other line you see at the throttle body is the fuel-return line. More about this one later.

3. Connect the fuel-pressure gauge between the end of the fuel inlet line and the throttle body (Fig. 4).

4. With the fuel pump reactivated, turn on the ignition switch but do not crank the engine. Wait 2 seconds,

Zero fuel pressure

The malfunctions which result in a zero fuel-pressure reading are a damaged fuel line, breakdown in the fuel pump electric circuit, including the fuel pump relay, bad fuel pump and clogged fuel filters.

Examine the fuel line for damage first. Doing this is relatively easy—look for a kinked or crushed line.

Then check the fuel pump fuse. If it's blown, and you replace the fuse only to have it blow again, there's a short in the fuel pump circuit.

Listen to the fuel pump. After the ignition switch has been off for several minutes, put your ear close to the fuel tank as someone turns the switch back on. Or, you can jumper the pump as described earlier. Do not crank the engine. If you hear humming or whirring, even momentarily, the fuel pump and fuel pump relay are okay. Turn your attention to the fuel filters.

Relieve fuel-system pressure and take another pressure test, but this time place the pressure gauge between the outlet side of the in-line fuel filter and fuel line. If pressure is now normal, a part of the fuel line from the filter to the throttle body which you can't see is crushed or kinked.

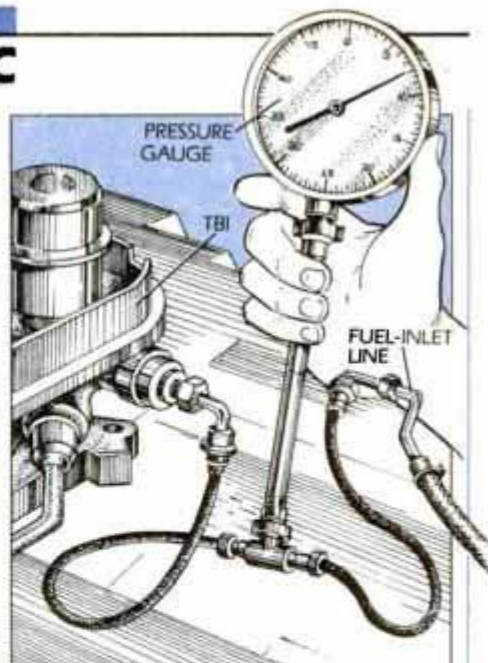
If pressure is still zero and the in-line fuel filter hasn't been replaced in awhile, do that now.

The in-line filter can be found under the rear of the car on the frame rail, against the outside of the fuel tank or in the engine compartment. If you can't spot it easily, trace the fuel-inlet line back from the throttle body.

To replace the filter, relieve fuel pressure and disconnect the fuel line from each side of the filter. Make sure the new filter comes with seals for the fuel-line fittings. Screw the fittings to the filter by hand and give them a quarter-turn with a wrench. Turn on the ignition switch and check for leaks. If replacing the in-line filter doesn't help, then there's the fuel sock to consider. It's on the end of the fuel pickup in the gas tank and will have to be removed to be serviced (Fig. 5). The fuel sock is supposed to be self-cleaning, but they have been known to foul and cut off the supply of gas.

Suppose you get no response from the fuel pump when you listen to it. Then, check the fuel pump relay before diving into the gas tank to replace the pump. A wiring diagram from the car's service manual will make it easier to pinpoint the relay.

Once you find it, disconnect the wire connector to see if terminals are clean and tight. Use a test light to make sure current reaches the relay.



4 Disconnect fuel lines (shown), or use test fitting to attach pressure gauge.

Push the probe of the test light into the connector so it makes contact with the terminal. Turn on the ignition. If the test light doesn't glow, there's an electrical failure. But if the test light shows that current is reaching the relay, check the relay output to the pump. If voltage is present at the pump contacts, then you'll have to replace the pump.

Low fuel pressure

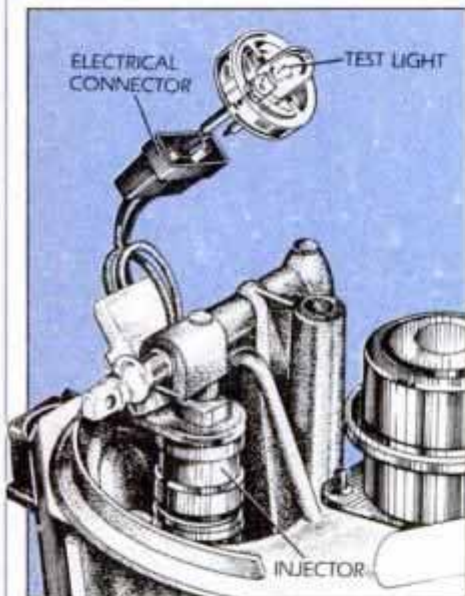
Conditions which will cause a low fuel-pressure reading are a clogged in-line fuel filter, restricted fuel-delivery line, a dirty fuel sock and a faulty fuel-pressure regulator. If the in-line fuel filter hasn't been replaced in some time, that's a good place to begin.

It's easy for a fuel line to be damaged, so examine it along its length from the fuel tank to the throttle body.

If you've still not found the reason for low fuel pressure, the next step is to service the fuel sock. Some vehicles have an access port through the trunk floor, but you may have to drop the tank. Empty the tank safely first, and remember that gasoline fumes are dangerously explosive.

High fuel pressure

Suppose you get a fuel-pressure reading in excess of what the manual stipulates. It doesn't happen too often, but when it does there are two good reasons. The fuel-return line is kinked somewhere between the throttle body and fuel tank and is restricting the flow of gas back to the tank. This results in high pressure and flooding. Or, the fuel-pressure regulator is defective, and not bleeding off excess pressure back to the tank.



3 This inexpensive test light will flash if TBI electricals are okay.

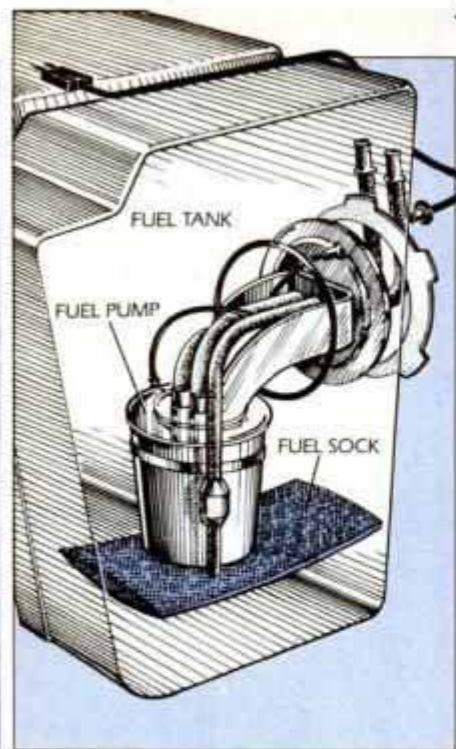
note the pressure-gauge reading and turn off the ignition switch. Or, you can jumper 12V to the fuel pump with clip leads. On most GM cars, you can jumper to the ALCL connector under the dash. At any rate, the reading will be one of the following:

(a) A reading in line with the normal specification, indicating that there's nothing wrong with this TBI system except maybe the fuel injector (see below).

(b) A zero reading, in which case the engine won't start.

(c) A reading lower than that specified, in which case the engine has one or more of the aforementioned driveability problems.

(d) A reading higher than that specified, in which case the engine will flood.



5 In-tank filter sock and pump may require tank removal for service.

Fuel Injector

Performance problems often associated with a malfunctioning fuel injector are hard starting, rough running and black exhaust smoke when the engine finally starts—also dieseling (engine run-on). Dieseling indicates that an injector may be stuck partially open.

When the fuel-pressure test shows a normal reading but there is a problem that could be fuel system related or when the spray pattern you observe while watching the injector is suspect, add a fuel-injector cleaner to the fuel tank. Use one recommended by the manufacturer of your car.

Using a cleaner is often an easy, inexpensive way to get rid of dirt in the injector that is gumming up the works. However, if this doesn't resolve the problem and testing ignition, vacuum and so on, turns up nothing, you may want to remove the injector(s) for testing by a shop that has an injector tester. Here is what's involved in removing the injector(s):

1. After relieving pressure in the system and removing the air cleaner, disconnect the electric connector from the fuel injector.

2. If the injector is held by a bracket, remove the screw to free it.

3. Try to pluck the injector from the throttle body with your fingers. If the injector doesn't come out, get something to use as a fulcrum, such as a small screwdriver or a round piece of metal stock. You also need a screwdriver with a fairly long shank. Place the fulcrum across the front of the injector, put the screwdriver over the fulcrum so the tip of the screwdriver engages the ridge around the injector and press down. The injector will pop out (see lead illustration).

To install a new injector, lubricate the O-rings with automatic transmission fluid. Then, look for a guide pin on the injector, line it up with the crevice in the throttle body, and push.

Other components

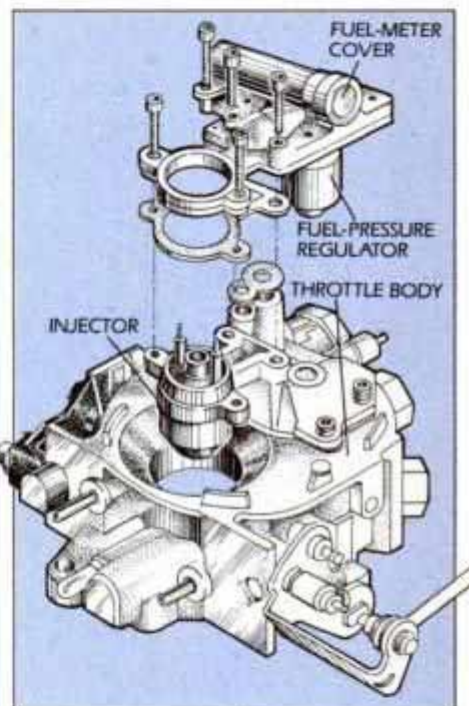
Three other parts you may have to deal with are the fuel-pressure regulator, idle-speed control and throttle-position sensor.

■ The fuel-pressure regulator is set at the factory. When it goes bad, the reason is usually a tear in its diaphragm (Fig. 6). A damaged fuel-

pressure regulator will often leak gas and cause the engine to flood. Indications of a bad regulator (in addition to a performance problem) are gas odor and sparkplug tips wet with gas.

The fuel-pressure regulator is part of the fuel-meter cover on top of the throttle body (Fig. 7). Up to now, the entire cover assembly of many TBI units had to be replaced when the regulator failed. Now, manufacturers are issuing replacement diaphragms.

■ A faulty idle-speed control causes rough, unstable idle and stalling at idle. This is one component of most throttle-body injection systems that will put a trouble code into the computer when it fails. To replace a bad



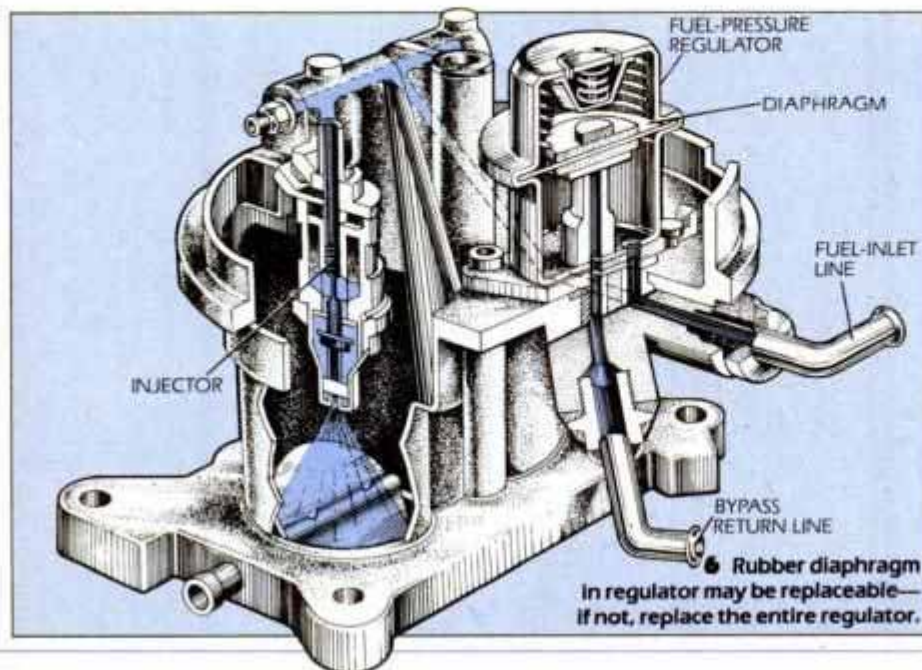
7 Remove fuel meter cover for access to regulator or fuel injector.

idle-speed control, disconnect the wire terminal and unbolt the device.

■ Although the throttle position sensor (TPS) is a part of the electronic control system and not the throttle-body injection system, it's attached to the throttle body and is usually associated with it.

If the TPS goes bad, the air/gas ratio is disrupted and an overly rich fuel mixture will occur. This includes rough idling, stalling or hesitation on acceleration from a standstill, black smoke and poor fuel economy.

The TPS is screwed to the side of the throttle body. Unscrew it and install a new one, but just be sure you get the correct TPS for the kind of throttle body on the car. It may need to be adjusted to spec, but some vehicles are self-adjusting.





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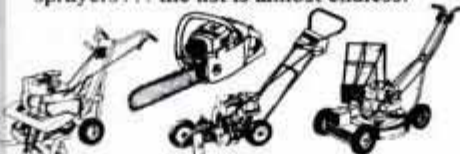
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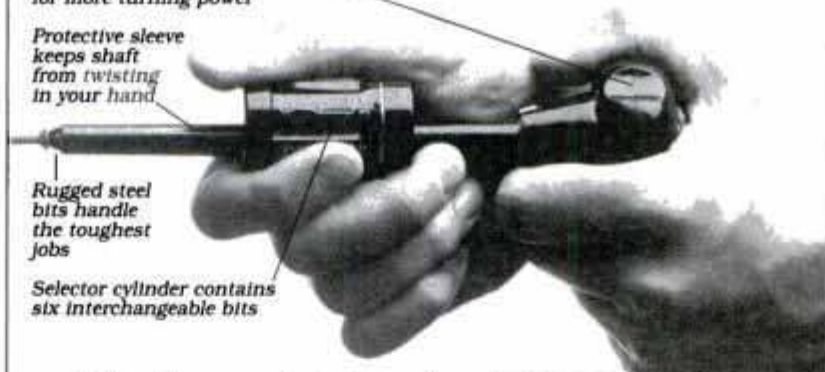
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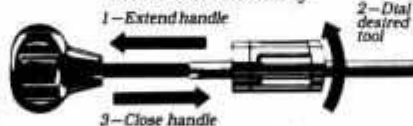
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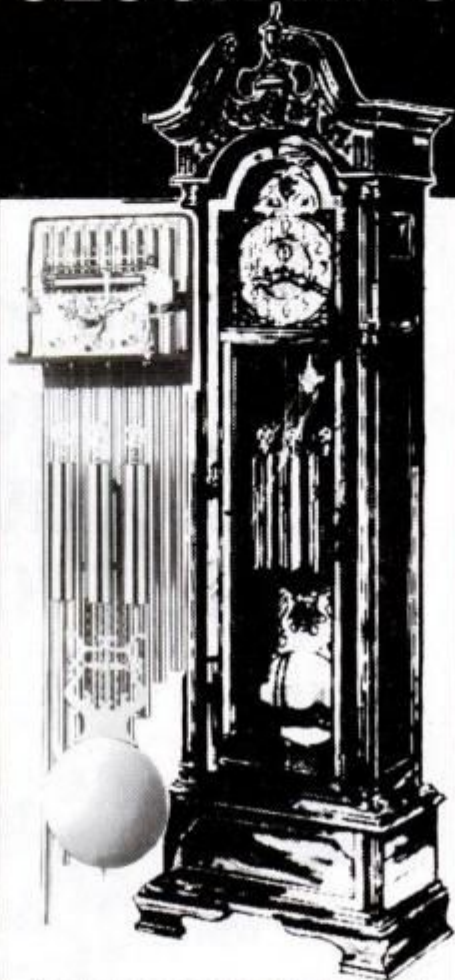
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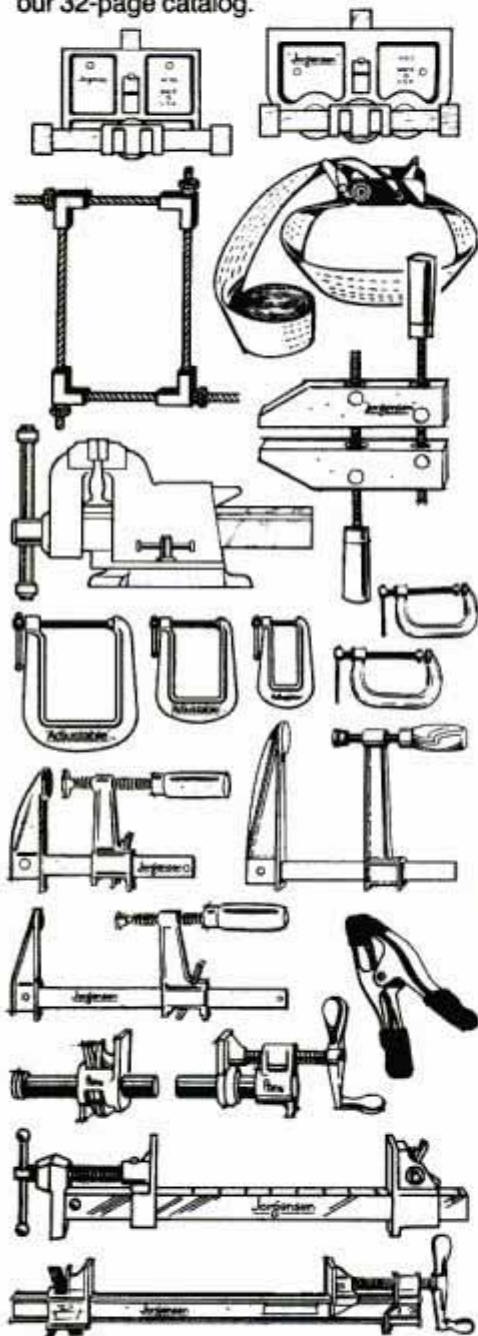
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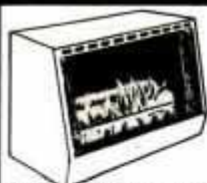
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Escape aboard super cruise ships with trihull designs, built-in lagoons, recreation centers and on-board helicopter and plane service.

Christmas Village Project

Thrill the kids (and yourself) by building a model village complete with circus wagon and train from our plans.

Treasure Trains

That old toy train set you threw out could have been worth \$2000. Here's the inside track on collecting these toys.

Battle Of The Camcorders

The ultimate camcorder shootout. Our no-holds-barred exhaustive lab test compares models in each format to find a winner.

Ski-Whiz

Ski like you were born on the slopes with the latest hi-tech gear. Plus, new location detector helps find you after an avalanche.

Import Car Buyers Guide

Don't buy a new import without first checking our complete '89 Import Car Guide. Compare prices and new tech features.

FREE PARTS
FREE LABOR
FOR LIFE



Ford maintains that the best car repair guarantee in America is one that money can't buy.

Peace of mind is your Ford and Lincoln-Mercury dealers' Lifetime Service Guarantee. Once you pay for a covered repair, it's guaranteed with free parts and free labor for life.

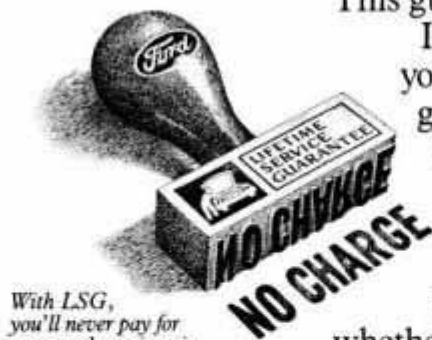
This guarantee is solid as a rock.

If your participating dealer repairs your Ford, Lincoln or Mercury, he guarantees that if the covered repair ever has to be fixed again, he'll fix it free, for as long as you own your vehicle.

It doesn't matter where you bought your car or light truck, or whether it's new or used. And LSG covers thousands of repairs. Only Ford Motor Company dealers have it. Only Ford, Lincoln and Mercury owners can get it.

Nobody guarantees car repairs longer. Nobody guarantees car repairs better. And this limited warranty is backed by certified technicians and quality Ford Parts.

Ask your participating dealer for a copy of the Lifetime Service Guarantee.



*With LSG,
you'll never pay for
a covered repair twice.*

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Available in 100's and
New King Size.

SURGEON GENERAL'S WARNING: Smoking Causes Lung Cancer, Heart Disease, Emphysema, And May Complicate Pregnancy.

Filters and Menthol: 16 mg. "tar", 1.3 mg. nicotine;
Lights and Lights 100's: 9 mg. "tar", 0.8 mg. nicotine;
100's: 14 mg. "tar", 1.2 mg. nicotine; Menthol 100's: 12 mg. "tar",
0.9 mg. nicotine av. per cigarette by FTC method.