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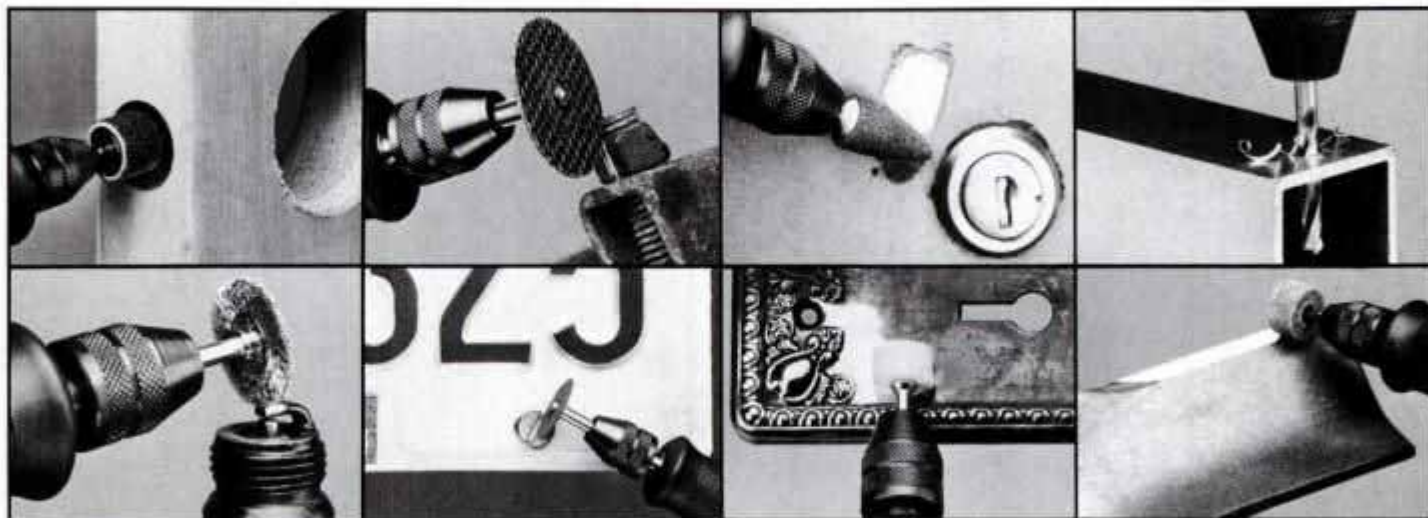
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Better known as the Dremel Moto-Tool.[®] A tool that tackles dozens of different do-it-yourself projects quickly and easily.

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THE DREMEL MOTO-TOOL.[®]



DREMEL[®]
Gets the job done bit by bit.

This One



6DR3-01B-CFU4

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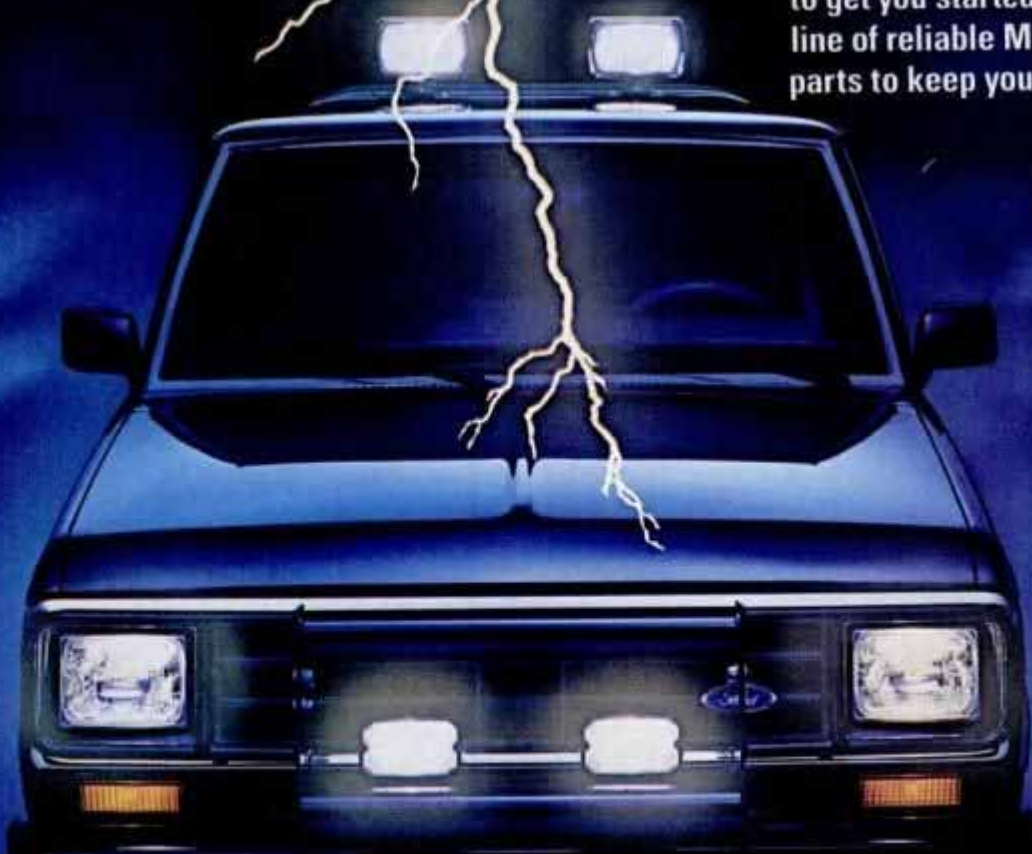
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Motorcraft from Ford

EXCEEDS THE NEED



70 COVER STORY

With a team of aviation experts to help, PM tackled the design of an affordable entry-level sportplane that could some day replace the Piper Cub for the next dozen generations. Read all about how we did it and what we came up with starting on page 70.

—PM Illustration by Mark McCandlish



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INTRODUCING A FULL-SIZE CHEVY.

Flush-mounted glass to reduce wind noise. For a quieter truck.

More shoulder room, more total cab room than Ford.

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Massive new frame bigger and heavier than before.

Shift-on-the-fly Insta-Trac standard on 4WD models.



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1988 Chevy Extended Cab. More power under the hood, more room inside than Ford.

Welcome to the roomiest, most powerful, half-ton extended-cab pickup* you can buy – the 1988 full-size Chevy.

With the available fold-down rear seat, six adults can sit comfortably facing forward. There are new 60/40 split front bench and new contoured buckets available. And behind all that room and comfort is the convenience of a full 8-foot cargo box.

Test drive this roomy, powerful new extension of our lean new full-size Chevy. It's built new from the inside out. To be a whole new animal.

*Excludes other GM products.

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GM 6/60
QUALITY COMMITMENT PLAN

See your Chevrolet dealer for terms and conditions of the new limited warranty

Let's get it
together...
buckle up.

THE
Heartbeat
OF AMERICA



TODAY'S CHEVY TRUCKS

Материал подготовлен на основе информации производителей

Editor's Notes



One look around the conference table in the offices of Scaled Composites in Mojave, California, and I knew. This was going to be a very special day. At the head of the table, Burt Rutan, legendary aircraft designer, holding our attention, telling us the way it could be. The rest of us responding, throwing out ideas, sometimes good ones, sometimes not such good ones. Us being Wally Schirra, one of the original seven astronauts and a longtime Navy test pilot; Frank Christensen, the last of the independent aviation manufacturers; J.P. Tristani, also a former Navy test pilot, currently on duty in a 757 for Eastern; Fred Mackerodt, private pilot and public writer for this publication; Bud Davisson, ditto; Mark McCandlish, one of the country's top aviation artists; Tim Cole, our Science/Technology/Aerospace Editor; and me. A fantastic group to gather together in one place at one time for a single purpose—to design a plane. The idea originated about a year before in my office in a conversation between Mackerodt and myself. We were lamenting the demise of general aviation. There were just no new pilots coming along. No new planes. Entry-level aircraft were out of date, obsolete, extraordinarily expensive. "Why don't we design a new plane," Mackerodt said, "something that would be the Piper Cub of the future?" Indeed, why don't we? As you can see by this month's cover and the story beginning on page 70, we did. With a lot of help from our friends. We think the POPULAR MECHANICS *Scorpion* is revolutionary, sporty, hot, practical, strikingly handsome and we'd love to own it. Maybe we'll build one. What do you think? . . . **Back on the ground**, we found that there's no quicker, neater way to get in touch with a car than to drive it hard for 10 hours straight. That's exactly what we did several months ago in a brand-new 1987 Corvette Roadster, pushing the black missile in from Detroit to New York on Interstate 80 in 10 hours. Once in New York, the Corvette joined a 4-wheel-drive Ford Tempo and a Dodge Shadow Turbo in our long-term test fleet, where it'll spend the next several months. You can read our initial reports on page 53. Suffice to say now that the Corvette is one of the quickest and fastest cars we've ever tested, the Shadow is a fun little pocket hot rod, and the Tempo wishes there was lots of snow on the ground. . . . **If you're already bored** with summer, how about a beautiful furniture project that will not only get you back into the shop, but maybe even result in a family heirloom? Check out *Secret Secretary* on page 76. . . . 'Til next time.



Rutan, the master, led the PM *Scorpion* design group.



The Mojave Eight: Oldham, Schirra, Mackerodt, Davisson (top row); Christensen, McCandlish, Cole, Tristani. Yes, that's the real Voyager behind us.


Joe Oldham

Popular Mechanics

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When ESCORT was introduced in 1978, its radar warning was merely astonishing. Then the improvements began

"If you can imagine the Turbo Porsche of the radar detectors, this is it!" That was *Car and Driver's* verdict on the first ESCORT.

The comment referred to ESCORT's astonishing performance, but it anticipated something more. Just as Porsche keeps refining its classic 911, our engineers now have nine years of technical advancements built into ESCORT.

More power under the hood

While car makers talk about horsepower, engineers measure a detector's radar-finding ability in dB. Today's ESCORT is significantly more powerful than the one that drew superlatives from *Car and Driver* nine years ago: 10 dB more sensitive on X band, 13 dB on K band.

Our engineers never stop researching, and when they make a breakthrough, it goes into production immediately. Consequently, ESCORT performance is always at the forefront. In its most recent test of ESCORT, *Road & Track* wrote, "... it is highly recommended."

Since then, our engineers have added an extra 2 dB to ESCORT's sensitivity on both bands. Imagine what *Road & Track* would say now.

Rashid rejection too

Of course, there's more to detection than simply issuing a long-range warning. The warning must be real. No false alarms.

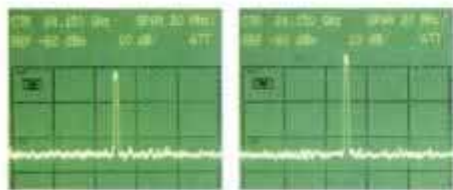


Figure 1: A digital spectrum analyzer scanning the entire width of K band can't see the difference between radar and Rashid.

When the FCC cleared the Rashid VRSS collision warning system for operation on K

band, there was no known way to distinguish between Rashid and radar. But our engineers came through again. Our AFR™ (Alternating Frequency Rejection) circuitry automatically isolates and neutralizes Rashid signals, yet leaves ESCORT's radar detection capability undiminished for your protection.

The full radar report

In addition to long-range warning, ESCORT also pioneered a full-disclosure warning system that tells you everything you need to know about the radar it finds. At first radar contact, the alert lamp responds and the analog meter indicates radar strength. Simultaneously you will hear an audio warning—pulsing slowly when radar is weak, quicker as you near, then constant as you approach range.



Power-ON LED and Sensor

Signal Strength Meter

Highway/City Switch

ESCORT also provides separate warning tones for each radar band. And we've added a Mute function for your convenience: once you've noted the warning, touching a switch mutes the audio warning, yet leaves the detection circuits fully armed for the next encounter.

Character reference

Our policy of continuous refinement has prompted the experts at *Road & Track* to say, "Externally, the ESCORT has changed hardly at all over the years; internally, it has undergone several major revisions, each establishing new performance standards in the field."

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So take heart. A dose of courage might be all your car needs to perform better.



Letters



Surfacing For A Snapshot

The most intriguing thing about your April submarine cover was the fact that the photo was not a United States Navy handout. It's credited to Skip Gandy and is also referred to as a "PM photo." How did you get the closeup cover shot and the other photo of a nuclear-powered sub on the surface for your excellent story?

HENRY SAAMUNDSEN
LST 1006 BEACHCOMBER
U.S. NAVY, WWII
NEW PORT RICHEY, FL

All it took was pinpoint navigation, which is routine for the U.S. Navy, but was not routine for the pilot of our chartered helicopter—at least not when the navigating involves finding a pinpoint on the ocean 42 miles off Cape Canaveral. As we hovered at the right spot, we waited for the right time—the time the U.S. Navy said the USS Nevada would surface and give us a half hour of shooting. At precisely the prearranged time, a spot on the surface of the ocean began to swell and Capt. William Stone's sub broke the surface. Using VHF radio communications, we coordinated our swoops with the Skipper's porpoising and got a fabulous "take."

All the while, the Nevada never deviated a degree from its mission: steaming to the Indian Ocean.

I thoroughly enjoyed *Run Silent, Run Deadly* (page 86). Lt. Southard presented an excellent, unclassified explanation of the Navy's nuclear submarine fleet.

LT. R.G. THOMPSON JR.
U.S. NAVY
CHARLESTON, SC

The excellent photography on your April cover and the subject of "America's Nuclear Stealth Subs" prompted me to buy the issue. The story was terrific,

but let me properly identify the Soviet subs in the photo on page 89.

The subs are not Victor IIs, but are, right to left: a Whiskey SS, a Juliett SSG and a Golf I SSB. The sub at the left also appears to be a Golf I SSB, but it is too far away to tell exactly.

I also can identify a Kynda CG in the background, but the other two ships which appear to be another Kynda CG and a Kotlin DD are too cropped or obscured to allow positive identification.

CHRISTOPHER P. CRAWFORD
INTELLIGENCE SPECIALIST
FIRSTEURLANT 0774, NASJAX
USNR-R

I must object to your using the sentence "America's newest submarines pack the speed and technology to win a war" as the introduction to *Run Silent, Run Deadly*. It perpetuates the fantasy that it is possible to win a nuclear war. The truth is that if any Trident sub ever uses its missiles for any reason, there will no longer be a United States of America, and perhaps not even a human race. The present nuclear standoff is dangerous enough without reckless talk of "winning" nuclear wars.

GEORGE JEDDELOH
GRANTS PASS, OR



While the survivability of a limited nuclear war continues to be debated, the Pentagon has worked out a plan for the United States to "survive" and win such a conflict. It would be horrible and, even in victory, life would be severely altered for those who did survive. But we must face the unthinkable and remember that we have

never been a nation to just give up.

The Sound Of Music

As a professional musician and do-it-myselfer, I enjoyed your article on electronic music makers (*One-Man Band*, page 106, April '87). I must point out, however, that the Simmons SDS 1000 is not exactly an amateur instrument. Price considerations aside, it requires a knowledge of musical synthesis, as it's fairly complicated to operate. All in all, the new electronic toys are making music available to everyone, and that's something that I, as a professional, like to see. Hopefully, it will encourage more people to patronize live music. Support the arts, folks. Kiss a musician!

Love your mag! Keep up the good work!

FRED WELDON
ALBUQUERQUE, NM

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can a little water do?



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Imports

BY BILL HARTFORD



Fox Waggin' Its New Tail



VW Fox GL wagon joins 2- and 4-door sedans in the lineup.

If you're lucky enough to be driving around in a new VW Fox wagon this summer, you're sure to hear a "tally-ho!" from admirers of the car—probably envious future owners who are still waiting to take delivery. Obviously, your wagon was on an early shipment from Brazil, where the wagons were last to join the 2-door and 4-door models on the assembly line. Since early spring, dealers have been taking reservations ("leave a deposit and we'll call you") for the only 2-door wagon in the country and the only one under \$7000. Our guess is the wagon will be more popular than VW anticipates. It's not a classic, low-slung sportwagon, but a sporty wagon it is. VW's

strong, 1.8-liter fuel-injected Four is an 81-hp powerplant that guarantees 0-to-60 dashes in no more than 12 seconds. And independent suspension and 70-series radials keep the vehicle squarely on its feet. Front disc brakes and rack-and-pinion steering are standard, as is a 4-speed manual gearbox (no automatics on Foxes, remember). And be sure to check the GL's standard features. Velour upholstery and full carpeting just start the list. That should dispel any suspicion you may have had that the GL wagon is VW's ploy to corner the pizza delivery market.

XT spaceship

Subaru's launch of the XT into higher orbit for 1987½ overlooked one addition: heat-resistant, ablative tiles for the nose cone. The nose did get another reinforcement, however: a new bumper that increases protection and deflects up to 2.4 in. before deforming. And it's so well integrated into the front-end styling that the XT retains its slippery 0.29 C_d . The



Fox cargo volume is 61.8 cu. ft. when the rear seat is folded.

XT pulls more Gs, too, as a result of boosts to the turbo and normally aspirated 1.8-liter ohc opposed Four engines. Hp is 115 and 97, respectively. Power is coupled to the XT's drivetrain through a new 4-speed electronic automatic transmission, called 4EAT. It improves performance and economy, and its "power pattern" lets you shift for sporty driving. On-

Demand and Full-Time 4wd systems let you blast off down the most vicious roads.

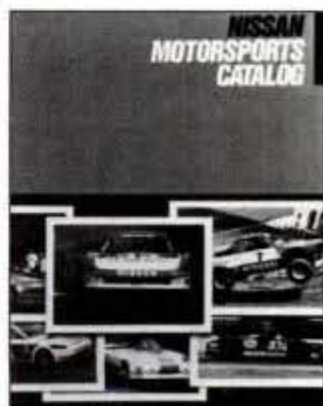


Subaru redesigned XT module so commander and crew can take higher Gs.

Power Parts

Healthy horsepower numbers are respectable again. And a whole new herd of V8s are under development to crank 'em out. While you're waiting for Nissan's small-block V8, you don't have to sit idling. You can swap hardware on your current or classic Nissan—1600 sports car, sedan or truck. You can run faster now. The 66-page Motorsports Catalog—the biggest ever for Nissan with more than 1800 parts—is now at dealers for \$10.

Or you can order directly



from Nissan Motorsports Dept., P.O. Box 191, Gardena, CA 90247.

Vive Citroën!

Oui, oui, the Citroën is being imported again—from another planet. France.

Swift and surreal, the CX is a cultural artifact. After they made this one, the creators probably ate the foie gras mold and hydropneumatically hummed down the road in a reverie scored by Erik Satie.

The reappearance of the unique Citroën is courtesy of Cx Automobiles, Inc. (Box 325, Lebanon, NJ 08833). The independent importer federalizes the CX model for

emissions and safety and distributes the car through several dozen dealerships. Price of the sedan starts at \$29,800, with an easy \$10,000 added to that if you order ZF automatic transaxle, cruise control, electric sunroof, leather interior and CD player. Also available is the CX Estate, or station wagon in American English. Smart stuff like antilock brakes and dual air-conditioning units are other options. But remember, you can buy a CX only if you have a high IQ, or Idiosyncrasy Quotient. **PM**



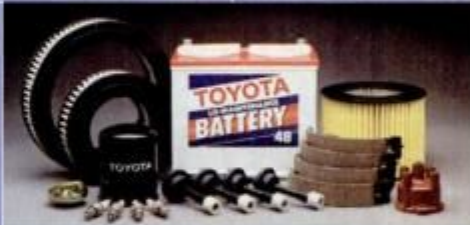
Citroën CX flattens bumpy roads with hydropneumatic suspension.

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Only Toyota Quality can maintain Toyota Quality. Protect the reliability you bought in the first place, with parts and service designed for your Toyota. Genuine Toyota Parts. Authorized Toyota Service. Only at your Toyota dealer.

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WE'VE GOT MORE FOR YOU! **TOYOTA** PARTS AND SERVICE

Aviation



BY FRED MACKERODT

Piper Then And Now



An early version of the Piper J-3 Cub restored: Fabric, dope, easy to maintain powerplant—and a liberating simplicity.



The Piper Malibu: 50 years later and again Piper comes up with the right airplane at the right time.

What do the Piper J-3 Cub and the Piper Malibu have in common? At first glance, nothing more than their first names and the fact that both of them are single-engine airplanes. But as airplanes, they couldn't be more dissimilar.

The Malibu will cruise at 25,000 ft. at 250 mph. The J-3 is more comfortable at 65 mph, and if all of the owners I've spoken with are telling me the truth, it's normal operational altitude is more like 500 ft. The Malibu will haul six people in cabin class comfort. The J-3 will carry two, but no Weight Watcher candidates need apply, and as far as comfort is concerned, just

getting in is like trying to fit 6 pounds of round bologna into a square 5-pound bag. The Malibu is pressurized. The Cub is the opposite of pressurized—in fact, it's closer to open cockpit in ambience.

With the notable exception of the F-16, Malibu is the ultimate single-engine airplane made today. The J-3 wasn't ever near the ultimate performing aircraft, even in the '30s when it was new.

In its day, the J-3 ranged in price from \$999 to a top of \$2000. A fully equipped Malibu costs \$400,000—200 times as much as the J-3 in its most expensive iteration.

The Super Cub, which succeeded the J-3, was produced

from 1949 to 1983. When the line finally shut down, these 180-hp Cubs sold for \$55,000 each.

So what can these two airplanes have in common? They both were and are tremendous sales successes, because they were and are the right products for their respective times. They captured prospective owner's interest with honest claims of performance, and delivered that promised performance in day-to-day use.

They also almost shared a less-than-happy distinction: The Piper J-3 was Piper's first airplane. The Piper Malibu could have been Piper's last. It was touch and go with Piper Aircraft for a while, with the accent on go. One scenario had parent Lear-Siegler folding Piper or selling its assets, including rights to the Malibu, to another manufacturer.

But now word has come down that all of the assets of Piper have been sold to a California entrepreneur named Stuart Millar. A long time Piper devotee who first soloed in a J-3 and now flies a Piper Aerostar, Millar says that he will keep Piper in business as Piper Aircraft and, in fact, is looking into the possibility of manufacturing a full line of general aviation aircraft. We wish Millar well and hope he will be able to save Piper and the fantastic Malibu from going down the proverbial tube.

One Fun Investment

You say you don't have \$400,000 for one of the last Pipers? Well, how about \$4000 for one of the first?

I'm told there's a basket-case J-3 up around Buffalo someplace that can be had for that low figure, less engine and front cowling.

But I'm also told that you can get a fairly decent J-3 for between \$5500 and \$7500.

And you can buy one in nearly mint condition for between 10 and 15 grand. Of the 14,125 Piper J-3 Cubs built, about 4300 are flying today, kept in the air by avid enthusiast owners and companies like Univair Aircraft in Aurora, Colorado, which manufactures new parts for the Cub.

If you're in the market for a good, usable airplane that will go up in value each year you own it, look into latching onto a J-3.

The only question you have to answer is whether you want to buy one restored or do the restoration. Glenn Rizner, the director of information services for the Aircraft Owners and Pilots Assn., just finished restoring the yellow Cub seen on these pages and has some tips. Glenn's plane—with serial No. 13375—started life in February 1945 as all J-3s did during World War II as a military L4. One of its 16 prior owners

(Please turn to page 14)



Details of the exquisitely restored Cub, from the top left and moving clockwise: Original instruments let you know the VFR basics, an engine meant for flying low and slow, elemental cockpit controls, and the lower right, fabric and dope tail section.



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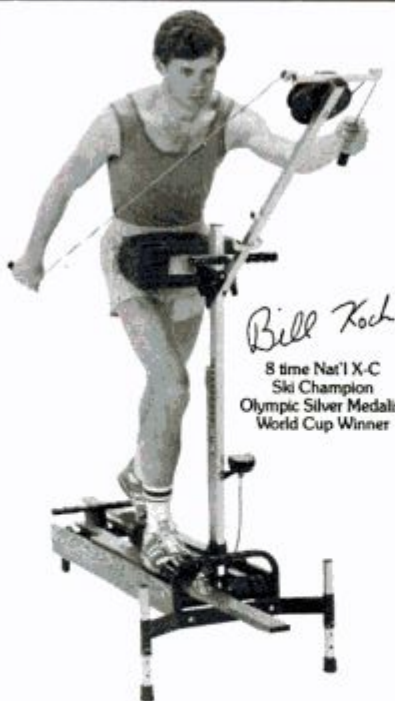


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AVIATION

(Continued from page 12)

converted it back to a J-3, although today that would not be advised. The L4s in their original military dress bring much more than J-3s on the market.

Rizner says a special rule applies when you're restoring an airplane. He calls it his "times four" rule.

The restoration will always take four times as long as you estimate and cost four times as much.

Glenn has the figures and the bills to support his rule. He bought the Cub damaged for \$4000. He estimated it would cost \$4000 to restore.

It wound up costing \$16,000. He also figured it would take a little more than a year. It took almost five.

Would he do it again? Sure. "There are a lot of things you can't add up in dollars and cents. I learned a lot while restoring my airplane, like working with fabric and dope. And I met a lot of great people, like Clyde Smith Jr., who probably knows more about the J-3 than anybody in the world."

Clyde Smith Sr. was one of Piper's first test pilots, and both father and son live in Pennsylvania near Piper's old Lock Haven facility.

This is also the site of the annual Cub convention, Sentimental Journey (July 10 through 19 this year), which in 1986 attracted 252 airplanes. Clyde Smith Jr., who is one of the organizers of the event, estimates they will have five times as many planes this year.

For more information on owning a Cub contact the Cub Club, P.O. Box 2002, Mt. Pleasant, MI 48804.

New Answer For Ice

We were level at 10,000 ft. in Aztec N87A last spring over Charleston, West Virginia, honking on down to Nashville, Tennessee, to visit that genius of aerobatics, Leo Loudenslager. We had just popped into the clouds when the windshield began frosting up. I turned on the windshield heat and prop heat.

A little later, the props began throwing off ice, and the noise of the chunks slamming into the front of the airplane made me remember that I was going to have the Aztec repainted anyway. A good bit of milky rime ice was forming on the wings. I asked Center for 12,000 ft., which was forecast to be on top, and the friendly controller cleared us right away.

By the time we punched out of the clouds at about 11,500, I had to flex the pneumatic boots twice to clear the accumulation on the leading edges of the wings and tail surfaces, and I could see icicles hanging down from the engine cowlings and the wing root, which stayed with us most of the way to Nashville.

Airframe ice will get your attention,

especially if you haven't experienced it before. And when you're in most single-engine airplanes, all you can do is pray and try to get out of it by going up where it's too cool for ice to form, or down where it's hopefully warm enough for the ice to melt.

But now single-engine airplanes are finally getting protection. The Cessna Centurion has been available with boots for years, and Piper's Turbo Saratoga and Malibu have factory installed boots, too. Now Kohlman Aviation Corp. of Lawrence, Kansas, has gotten a Supplemental Type Certificate to install a unique system on the Beechcraft Bonanza utilizing ethylene glycol antifreeze. The TKS system, which was designed in England during World War II to protect bombers, is standard equipment on the British Aerospace 125 and Cessna Citation SII business jets, and will be standard on the Beech Starship. But this is its first U.S. application to single-engine airplanes.

The glycol is stored in a 7.5-gallon bladder tank. When activated by a cockpit switch, the system pumps the glycol to the porous metal panels which form the leading edges of the wings and tail. The glycol oozes out, melting ice that's already formed, and inhibiting the build-up of new ice. The Kohlman system on the Bonanza also routes the glycol to a spraybar on the windshield and a slinger on the prop.

The hardware weighs 40 pounds and the glycol mixture adds another 60 pounds of weight to the airplane. In continuous operation, a full tank will last three hours and the installation costs \$17,900. (For comparison, B.F. Goodrich will install boots on the Bonanza for \$7500.)

David Kohlman says the company should have STC's for all current Mooney aircraft by this fall. He also has an STC for the Cessna 206. Kohlman Aviation is located at 319 Perry St., Lawrence, KS 66044.

Avionics Flash

An important item aboard the PM/Rutan airplane design featured in this issue is the heads-up navigation system that integrates loran C position with a moving display of navigation aids along the route. We've come a step closer to this remarkable mode of navigation with the brand-new Argus 5000 from Eventide. The system's extensive internal database allows the unit to access navigation information and display it on a CRT, along with a representation of the airplane. The information moves along the screen relative to the movement of the aircraft, giving the pilot precise positioning in any weather. Departure, enroute and arrival modes, along with an emergency submode, add flexibility to this unique instrument. **PM**

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Science



BY TIM COLE

Superconductors: Early Visions

Superconductors are page-1 news across America, but the euphoria doesn't surprise Stanford University physicist William Little.

In 1964, based on research by Heike Kamerlingh-Onnes, who discovered superconductivity at 0° Kelvin in 1911, and the superconductivity theories advanced by John Bardeen, Leon Cooper and Robert Schrieffer in 1957, Little proposed a polymer that became superconducting at room temperature.

When the United States was taking its first tentative strides toward the Moon, when the technology of the transistor was replacing cumbersome vacuum tubes, Little predicted his material would one day lead to magic carpets and magnetic ski slopes, trains that would glide effortlessly at 300 mph, hovercraft that would float on a cushion of magnetism and resistance-free electrical transmission lines.

Heady stuff in 1964, and a bit more than Little's colleagues in physics, mired in pragmatism, could easily digest. Their reaction to Little's hypothesis on high-temperature superconductivity was intense, critical, even derisive. So in a way, according to a Stanford report recently released on Little's vision of superconductivity from nearly a quarter century ago, all the excitement over high-temperature superconductivity is of little wonder. The excitement is William Little's vindication.

Superconductivity occurs when all resistance to the flow of electrons in a material has been eliminated. Kamerlingh-Onnes' original experiment achieved superconductivity in Mercury at 0.7° Kelvin, nearly 459° below 0° Fahrenheit. He produced the lowest temperature known to man using liquid helium. Attaining superconductivity at higher temperatures using liquid nitrogen would be easier to handle, placing the efficiency of superconductivity at the disposal of practical technology. Achieving superconductivity at higher temperatures using conventional cooling is the key to undreamed-of advancements in transportation, medical imaging, power transmission and smaller, more powerful computers.

Suddenly, early this year, scientists at IBM in Zurich, the University of Houston, Wayne State University and elsewhere began to achieve high-temperature superconductivity, moving from 40° Kelvin all the way up to 98° Kelvin—entering the realm of practicality. Everyday devices from hair driers to automobiles—hovering over highways made of superconducting magnets—could be designed to take advantage of this dramatic development.

The metallic-oxide materials that achieved the breakthrough were brewed and pressurized mixtures of lanthanum, copper and oxygen. Though brittle and difficult to work with, the material is

being hailed as the discovery of the decade, ranked in significance with transistors and semiconductors. But what causes a material to become superconducting? Back in 1964, William Little thought he knew.

In 1957, Bardeen, Cooper and Schrieffer proposed that superconductivity was caused by two electrons moving in pairs along an atomic lattice, the first presenting a pathway or indentation for the second to follow. Viewed another way, some scientists theorize that electrons in a superconducting environment race from empty space to empty space in the outer shell of a material's atomic structure. Little absorbed all the existing knowledge about superconductors and speculated that a superconductor based on a polymer with long molecules and shaped much like the helix structure of DNA could become superconducting "well above room temperature."

The notion of high-temperature superconductivity broke into the light. And with it came dramatic postulations about powering tomorrow. Little's polymer had an atomic structure shaped much like a skeleton. Two electrons, he theorized, would pass along the spine of the skeleton, pushing electrons out of the way where the spine intersected the ribs. This action of departing electrons would create a positive field that attracted additional electrons to enter the spine. The flow of electrons would flow unimpeded. Little instantly saw potential for this kind of theoretical superconductivity, according to the Stanford report. And, 23 years later, more physicists are starting to see Little's vision of efficient, inexpensive energy for a new age. But is anything ever really new?

Remember The Killer Bees?

The voracious strain of the African honey bee made headlines in the late '70s using swarming tactics that killed human victims with thousands of stings. Acciden-

tally released from a Brazilian lab in 1956, they were headed north at a rate of 300 miles a year. Panic subsided when it was learned that the African bees might be pacified when they bred with docile European bees.

But researcher Don Lessem, writing in *International Wildlife* magazine, recently reported that the killer bees have now reached southern Mexico—and there's no indication that crossbreeding has modified their deadly instincts.

A student in Costa Rica was killed last July when he accidentally stepped in front of a nest. He was stung 8000 times. At least 700 deaths have been attributed to the "Africanized" bees, so named because inbreeding has diluted—but not tamed—their primal behavior.

The U.S. Department of Agriculture has proposed stopping the bees north of their current northernmost advance—the 135-mile-wide Isthmus of Tehuantepec in southern Mexico—using drone traps to capture male bees and bait hives to attract swarms.

Test Tube Kittens

The pioneering use of *in vitro* fertilization in producing three litters of kittens holds promise for propagating endangered species. Scientists at the Smithsonian Institute's National Zoological Park say the deliveries followed two years of research and involved several steps.

First, hormone treatments stimulated ovarian activity in the female cat. Then the feline's eggs were collected at precisely the right time. Next, the eggs were deposited in a vitreous vessel containing a special solution that included sperm from a male cat. The embryo was cultured and eventually implanted in a receptive cat for normal pregnancy.

Scientists envision a time when it will be possible to collect eggs and sperm from endangered cats, fertilize the eggs *in vitro* and implant embryo in a more common species. **PM**

Tool Tests



The versatile Skil Xtra tool is really three tools in one—a drill/screwdriver, hammer-drill and power chisel. It's shown with an accessory kit: masonry drill bit, carving gouge and rigid-blade scraper.

Triple-Duty Drill

At first glance, the Skil Xtra looks like a conventional electric drill. Upon further examination, however, I discovered that it's actually three versatile tools in one—a drill/screwdriver, hammer-drill and power chisel. A control-collar, located behind the chuck, allows you to switch easily from one

function to another.

Turn the collar to the first position and the tool is a powerful $\frac{3}{8}$ -in., variable-speed, reversing drill. It operates between 0 and 800 rpm and is powered by a 3.2-amp motor. The tool performed well during standard operations such as boring in wood, drilling in metal, driving and re-

moving screws, hole sawing and drum sanding. Turn the collar to the second position and shift into the hammer-drill mode which features bit rotation and percussion simultaneously. The hammer action delivers up to 36,000 blows per minute to bore through tough masonry materials easily.

The third mode, power chisel, delivers percussion blows only, with no bit rotation. The tool accepts special wood chisels, scrapers, a carving gouge and a grout chisel. The Skil Xtra (model No. 599) costs about \$81. Contact Skil, 4801 West Peterson Ave., Chicago, IL 60646.—Rosario Capotosto



To switch operating modes, push control collar forward and rotate it to desired position.



It took just 6 seconds to hammer-drill through block. Regular drill mode took 55 seconds.



Power chisel, with V-shaped gouge, removes stock quickly. Flat chisels are also available.



The $\frac{1}{4}$ -in.-wide rigid scraper works fine on rough work like chipping off hardened concrete.

Pop Goes The Stapler

I recently tested a new stapler gun—the Pop 2000—and was pleasantly surprised by this simple tool. Despite weighing only 11 ounces, the tool packs plenty of power and it drives staples and nailpins (small headless nails). The tool drives $\frac{1}{4}$ -in. and $\frac{9}{16}$ -in.-long staples, and $\frac{9}{16}$ -in.-long nailpins. Load a nailpin strip in each side of the staple channel to drive two nailpins simultaneously. Other features in-



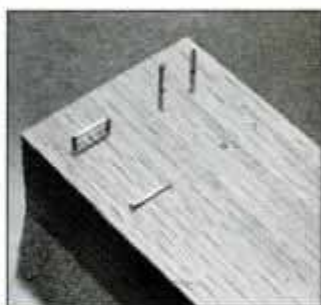
Lightweight, yet powerful, stapler gun drives two sizes of staples and nailpins. It features a tough plastic housing.

clude dual power settings, a safety lock-off and a rehammer setting. When I tried to



The stapler offers two power settings: minimum and maximum. Also a rehammer setting.

staple into oak, the staples, as expected, weren't driven fully. However, a rehammering feature allows you to drive the staples again until



Oak proved too tough for stapler. But, rehammering drives fasteners again until flush.

they're flush. The Pop 2000 costs about \$19. Contact Emhart Products, Box 3716, Reading, PA 19605.—Rosario Capotosto

Cycles

BY NORMAN
MAYERSOHN



The popular single-cylinder Ducati 250 makes an ideal vintage cycle racer. It's fast, dependable fun at a very fair price.

Racetrack Flashback

The trouble with most vintage racing events, from a purist's point of view, is that they're long on vintage and short on racing. With strict rules specifying stiff penalties for overzealous racers who spin out, or heaven forbid, bend sheetmetal, some vintage car races have been known to turn into nostalgia parades. It's a great show of history's famed and precious competition machinery, but does little to settle the question of which is fastest when they all face off on the same track at the same time.

That's not the case when a meeting of the American Historic Motorcycle Racing Assn. convenes—it's all-out competition, and only the motorcycles differ from contemporary classes. A 10-event 1987 calendar, seven races of which coincide with AMA Camel Pro weekends, offers up to 12 different vintage categories and recently, as many as 200 entries.

At the top of the schedule is the Premier 500 category, its ranks filled by motorcycling's most memorable

names of the post-World War II era: Matchless, Norton, Velocette and BSA. Prominent among the competitors is New York lawyer Rob Ianucci, whose Team Obsolete fields a pristinely restored Matchless G50. From Ianucci's perfectionist viewpoint,



Harley-Davidson by Italy's Aermacchi has been restored to full 1960s grandeur and was originally intended for AMA short-track racing.

the Matchless is unquestionably the finest racing package ever developed. A 500-cc ohc single, the G50 excels over the arch rival Norton Manx because it is less fragile, easier to work on, and does away with the Norton's messy exposed valve spring



At Laguna Seca, racing a BSA brings back fond memories.

arrangement. The price is dear, though, for top line machinery—up to \$10,000 for a properly race-prepped G50.

You certainly don't need a Ferrari Testa Rossa or Mercedes-Benz 300SLR to have a good time at the vintage auto races, though, and similarly you can be competitive with far less expensive machinery at AHMRA meets. A 1-cylinder Ducati 250 has front-runner potential on a \$3500 budget, and TD1 Yamaha two strokes are even more reasonable. BSA Gold Stars, a 500-cc Single built from 1955 through '61, are the most common Premier class entry, and are available at fair prices. Harley-Davidson flathead Twins are rising in popularity in this class.

A trio of Sportsmen class-

haust systems are okay, treaded tires are required and maximum-wheel rim width is limited to the WM3 size. Engines must remain within the class displacement limit, but otherwise, internal modification, such as increasing valve size or lightening components, is permitted.

Triumphs and BSA 441



The classic colors of a very rare Italian vintage GP machine.

Victors are the best choice for the Sportsmen classes, with the most cost-efficient choice being a 750 Triumph twin for the top displacement category. Renowned for their excellent handling, the Triumphs can be found at reasonable prices and spare parts are readily available through owner's clubs.

Already firmly established throughout Europe, vintage racing has been touted as the fastest growth segment in American cycle competition. AHMRA (Route 2, Box 212, Marengo, OH 43334) membership costs \$20 per year and individual events carry a \$35 entry fee. For the spectator, each race is a condensed history lesson. A tour through the pit area amounts to a visual treat that can't be equaled at any price. For participants, it gives all the challenge of full-bore racing at a manageable cost. **PM**



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In the summer of 1981, about a year after Mount St. Helens erupted, a retired plumber named Dale Heikes agreed to clean up all that was left of the Toutle River Boys Ranch. Under one condition. Whatever he found, he'd get to keep.

Well, considering that volcanoes have a way of destroying everything in their path, this was perfectly fine with the Toutle River Boys Ranch. So Heikes went right to work.

One day, to everyone's complete surprise, Heikes did find something worth keeping. Buried, for one year in the muck that was once the ranch machine shop, was a Stihl chain saw. Which Heikes took home, washed off with a garden hose and started. With only three pulls on the cord.

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Isuzu 4x4's became standard equip-

ment for rough roads because of their rough road standard equipment. Like a 2.3 liter engine. Auto-locking front hubs for easy conversion to four-wheel drive! Oversize tires for better traction. And independant double-wishbone front suspension for a safer and smoother ride.

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*Manufacturer's suggested retail price P.O.E., excluding tax, license and transportation fee. Prices as of 5/1/87 and is subject to change. †Only available on LS Model not shown.

The First Car Builders of Japan.

ISUZU

Freewheeling



BY WADE HOYT

Hope Springs Eternal



Built in time for the spring auto show circuit, the Riviera convertible sports hand-rubbed pearl lacquer, composite headlights, a stainless-steel mesh grille and other brightwork.

Riviera sales are down. So are those of the Toronado and Eldorado sister cars. As our *Owners' Survey* starting on page 59 shows, traditional Riv buyers think the new model is too small and sporty. Well, okay, if that's the car's image, why not sell to that image and make a real sporty package out of the Riv?

Which is exactly the thinking behind a convertible prototype from Buick Engineering's advanced concepts and specialty vehicles group. ASC, Inc., of Southgate, Michigan, did the unique soft-top installation, which combines the features of a manual and a power top. Once the top is released and dropped by hand, the power assist takes over, pulls the top down into its well, and covers it with a boot.

Unlike most ragtops, the Riv has a fixed-glass rear window and a full-size rear seat from the production model. No rear seat room has been lost to the convertible mechanism.

Equipped with the stock 150-hp, roller-lifter, 3.8-liter V6 engine and T Type suspension, lowered $\frac{8}{10}$ of an inch, this Riv has performance and handling to match its good looks. Chrome-plated T Type wheels are shod with high-performance Goodyear GT tires. Styling was the responsibility of Buick's Exterior Design Studio No. 1. The last Riviera convertible started life as a show car, so it's very possible that, eventually, we just might see this new Riv ragtop in showrooms.



Interior features hand-sewn leather and Lamborghini wheel.



Horizontal spoiler is called a "stinger" in design-speak.

Briggs & Stratton Rickshaw



4-passenger, single-cylinder runabout fills basic transport needs.

standard model will have 10 hp, but the high-performance version gets 16 ponies. The bodywork is by a French company

No, that's not its real name, but can you think of a better one for this 1-lunger developed for the Chinese market? The engine—a cast-iron, single-cylinder job—is actually being built by Briggs, the lawnmower people. The stan-

named Gateau that apparently makes phone booths. Cruising speed is 35 mph. The car is alleged to hold four adults, providing they are very close friends. And, no, it will not be imported to the U.S. to undercut the Yugo.

Some Years You Just Can't Win

In an attempt to spruce up its look-alike car lines, General Motors has a California Design Center in leased offices. The theory is that free-thinking Californians come up with the freshest new designs. But when GM took an option to buy property for a permanent

building, two active fault lines were discovered on the parcel. California law prohibits building on an active fault, which is defined as one that has moved within the past 11,000 years. What we want to know is, who keeps the 11,000-year-old record book?

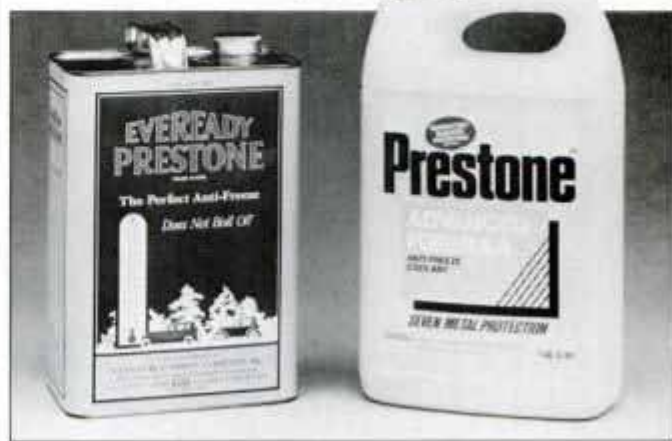
Have We Got A Deal For You!

Cars with aluminum radiators or engine parts need an antifreeze designed to be compatible with that metal. Today, most are compatible. But there are five or six other metals found in many cooling systems, including brass, cast iron, copper, steel and two kinds of solder.

Solder is the most troublesome, sometimes causing a growth called solder bloom that can block radiator pas-

sages. Prestone's new antifreeze is said to protect all seven metals so well that the company will fix your radiator if it breaks down due to coolant failure within one year, no matter how old the car.

You have to buy 2 gallons of the new Prestone and a jug of Super Flush. Send in proofs of purchase and a registration slip and you're covered. **PM**



Antifreeze has come a long way since Union Carbide introduced its nonalcohol ethylene glycol formula in 1927 (left).

Car Clinic



BY MORT SCHULTZ

Stranger Than Friction

When I noticed that the left-front tire of my 1985 Dodge Lancer was wearing bald on the inside, I took the car to an alignment shop. The mechanic said alignment was okay and showed me a bright spot on the chassis where the tire was hitting. I replaced the tire, but when I complained to the service manager at the dealership where I bought the car, he told me to complain to Chrysler. I did; subsequently, I had a meeting with the district service manager. He claimed the tire hitting the chassis couldn't cause tire wear—that Chrysler is well aware that it happens, but it's not a defect—and that if it upsets me I should ease off on the steering wheel when making hard U-turns. What nonsense. Do you know anything about this?

SAM ABRAMS
MARGATE, FL

Out of curiosity I examined the wheel wells of a dozen fwd models. I couldn't find any tire wear of the kind you describe, or any bright spots. Despite what the district service manager told you, those I spoke with at Chrysler disavow knowledge of this condition, and I have no complaints from other readers; therefore, I'm going to ask for help from readers of Car Clinic who own Lancer and LeBaron GTS models. Please examine your cars and let me know what you find. Until this survey is complete, I have to guess that in your case, Sam, there's damage to

the vehicle that caused only the left-side tire to tip in and be rubbed, or the damaged tire was oversized.

Warranties: Circa 1987

I've yet to find an article that clearly spells out the new multiyear/multimileage warranties of the Big Three. Could you do a brief summary of what's covered, so we who are thinking of buying new cars will have prior knowledge? THEODORE K. KOERNER
EARLETON, FL

Can I do it? Sure! Can I do it briefly? No! They differ

from one manufacturer to the other. That's why we'll split up the summary you ask for. Here's GM; we'll do Ford and Chrysler/AMC in Sept. and Oct., respectively.

■ *Basic coverage is in effect for 12 months or 12,000 miles, whichever occurs first. GM covers everything except tires, which are covered by tire manufacturers.*

■ *Perforation rust-through corrosion protection is for six years or 100,000 miles, whichever occurs first.*

■ *The air conditioning—the sealed refrigerant portion of the system, that is—is covered for 12 months regardless of mileage.*

■ *Power train protection lasts for six years or 60,000 miles, whichever occurs first. Engine parts covered are the cylinder block and head and all internal parts, intake manifold, timing gears, timing gear chain or belt and cover, flywheel, harmonic balancer, valve covers, oil pan, oil pump, engine mounts, seals and gaskets, water pump, fuel pump, turbocharger housing and internal parts, turbo valves, seals, gaskets.*

■ *Transmission parts cov-*

ered are the case and all internal parts, torque converter, vacuum modulator, seals and gaskets, transmission mounts and, where applicable, transfer case and its internal parts plus seals and gaskets.

■ *Front-wheel-drive parts covered are final drive housings and all internal parts, axle shafts, constant velocity joints, front hub bearings, seals, gaskets.*

■ *Rear-wheel-drive parts covered are axle housings and all internal parts, axle shafts, bearings, supports, propeller shafts, U-joints and seals and gaskets. If the vehicle was built prior to 3/1/87, powertrain coverage is extended to second and subsequent owners free of charge for 36 months or 36,000 miles, whichever occurs first. If the vehicle was built after 3/1/87, powertrain coverage is extended free of charge to second and subsequent owners for 24 months or 24,000 miles, whichever occurs first. In either case, transfer of the warranty for the full term may be obtained by paying \$100 to GM within 90 days of the purchase date.*

■ *Emissions control systems parts performance is guaranteed for 24 months or 24,000 miles, whichever comes first; protection against defective parts is in effect for five years or 50,000 miles, whichever occurs first. There's a fine line between a system failing because of a "performance" deficiency or a defective part, so if something goes wrong you should pursue the matter. Here's what's covered (groups of parts in parenthesis means that coverage is for 24 months or 24,000 miles):*

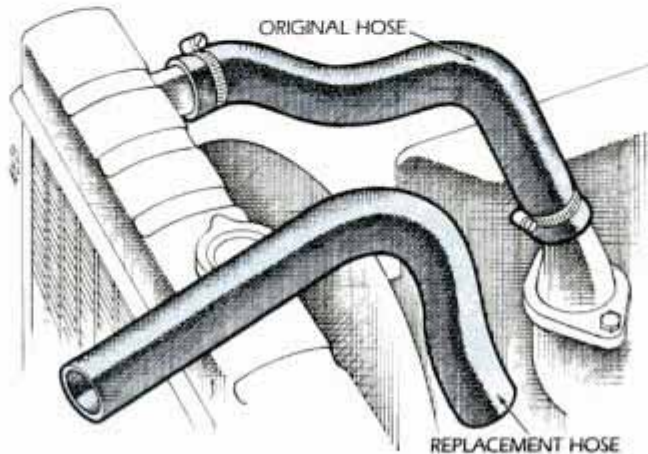
(Thermostatic air-cleaner switch, control valve and associated parts); air injection reactor pump, air distribution units and valves; pulse air injection reactor valve and associated parts; PCV valve and associated parts; EGR valve and associated parts; choke switch-

(Please turn to page 26)



Still A Good Match

The hose the guy at the parts store gave you in no way, shape or form resembled the hose you were replacing. So you took it back, got a refund and left the old hose on the engine. Bad move. According to Gates Rubber Co., "As a result of parts consolidation by aftermarket suppliers, one hose is being made to fit a number of different engines; therefore, it often won't look like the hose that's being replaced." Some hoses even must have substantial portions trimmed off. The thing to make sure of when installing a nonlook-alike replacement hose is that it won't touch a hot or moving part, or a sharp edge. If it does, the hose has to be modified by trimming or bending.



WARNING:

THIS PRODUCT
MAY CAUSE GUM
DISEASE AND
TOOTH LOSS



Good Company.

Copenhagen[®] satisfies.
And it's been doing that
since 1822.



CAR CLINIC

(Continued from page 24)

es and carburetor parts; Computer Command Control; (early fuel evaporation valve, heater and associated controls); catalytic converter, catalyst and associated parts; (distributor parts and associated controls; spark-plugs and ignition wires); fuel-tank filler cap restrictor and vapor control valves; evaporative emission control carbon canister and associated controls; emission related hoses, clamps, belts, pulleys, tubes, fittings, wiring harness, sealing devices and mounting hardware. GM will make for "reasonable related diagnostic costs."

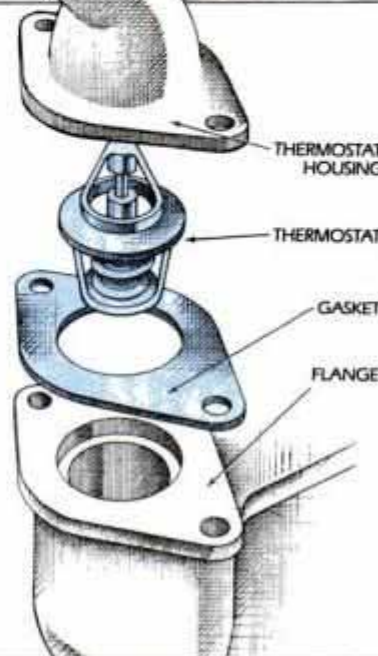
Electronic component protection is in effect for five years or 50,000 miles if a 1987 model was manufactured before 3/1/87; for 12 months or 12,000 miles if a 1987 model was manufactured after 3/1/87—a drastic reduction! Covered are the electronic instrument panel cluster including the vacuum fluorescent cluster and any driver information "telltales" and/or gauges; driver information center, including displays and modules; and electronic heater and air-conditioning control systems, including the temperature controller, programmer and power module.



Stuck Up

Your cooling system maintenance program is to replace a thermostat every so often—right? And when you replace a thermostat, you have to use gasket cement when you install the gasket—right?

Wrong! Using gasket cement can keep the thermostat from opening, because it can gum up the valve. Take a look at the photo of a thermostat that has been blocked by a liberal application of gasket sealer. A Grade A case of overheating results in what many blame on a poorly manufactured thermostat. The point is that, if you clean the engine and thermostat housing mating surfaces and if you see to it that no junk gets on the thermostat, gasket and mating surfaces as you install the new part, you don't need gasket cement... and that's the truth. If you've still got a leaker after that, maybe the thermostat housing is warped.



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Use every 3rd or 4th tankfull to clean dirty injectors, disperse moisture and insure consistent fuel burn.

Lean But Not Trim

What do you suggest I do with an expensive 1986 Ford Crown Victoria LX that has one "leg" shorter than the other? Looking at the car from the rear, you can see that one side leans closer to the ground than the other. A ruler confirms this. With tires inflated to the same pressure and the car parked on level concrete, taking measurements at the rear quarter panel on each side shows that one side is $\frac{5}{8}$ in. closer to the ground than the other. I bought the car used (1800 miles), but the dealer's reaction that "this is not significant" is still surprising. He checked the shocks and found them to be okay.

MILTON G. JOHNSON
ASHEVILLE, NC

Question: Why would someone turn in a brand new car having driven it only 1800 miles?

I don't know the answer, but in light of the fact that Ford issued a Technical Service Bulletin (TSB) warning that some 1985 Crown Victoria and Grand Marquis models had a leaning problem, it makes one a bit suspicious. That TSB—86-6-11—advised dealers to change springs for a vehicle that leans from $\frac{1}{2}$ to $1\frac{1}{2}$ in.

I think at this point you should have a Ford dealer check the car against the information in this TSB. And I'd also check to see if it is really a 1986.

Service Tips

- No way is a clatter from the 5-liter HO engine of a 1986 Ford Mustang or 1986-'87 Mark VII LSC "normal." That noise is loudest between 1000 and 2000 rpm. Have your dealer install newly designed parts contained in the valve rocker arm kit which goes by part No. E7AZ-6564-A. TSB 87-7-11 is the authorizing document.
- Should you be bugged by a no-start condition because the battery isn't charging, or battery damage because of overcharging in a 1986-'87 Buick LeSabre, Regal or Electra wagon, it will pay for you to ask your local dealer to check TSBs 87-6D-6 and 87-6D-6A for installation of an improved voltage regulator (part No. 1116423) and, if it's necessary, a new alternator.
- If you're trying to find the reason for a brake pedal pulsation and/or squeal when applying the brakes on a 1984-'85 Toyota Camry, you're going to be in trouble if you go by what you don't see. As of 12/85 Toyota started putting antisqueal springs on production models and suggests you use them, too. The part number for the brake pad kit that includes the antisqueal springs is 04491-32100.
- Want to stay happy with your 1987 Dodge Dakota? Then, be aware that whoever checks the lube level in the front driving axle shouldn't do you a favor and fill it up because it's low. It's supposed to be low—to be exact, $\frac{1}{2}$ to $\frac{3}{8}$ in. below the bottom of the filler plug hole. Any higher and foaming or overheating may result.

Can't Be Done?

My 1984 Nissan Maxima with fuel-injected L24E 6-cylinder engine hesitates when it's cold. A diagnostic test indicated a very lean mixture—everything else was normal. I was told by two different mechanics that the mixture can't be reset.

JOHN W. HODGES
ROANOKE, VA

Leanness is often caused by injector nozzles partially restricted by a build-up of contaminants in the fuel. The mechanic should use a Kent-Moore Fuel Injector Cleaner that pushes cleaning agent through injectors. If

*cleaning doesn't work, you need a Maxima service manual. Follow the steps in the EF & EC section titled "Mixture Ratio Feedback System Inspection." The heart of the procedure is rigging up resistors to override the computer, so the air-flow meter can be reset to adjust the idle mixture. The mixture is adjusted when idling CO output is between 0.2 and 4 percent. **PM***

DO YOU HAVE A CAR PROBLEM?

Just ask Mort about it. Send your question to the 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.

SELF HELP

Doing it yourself is great, but it's not always easy. Sometimes you need a little help. LubriMatic® brand products can give you all the help you need. We're the world's only manufacturer of a full line of quality lubricants, lubrication equipment and accessories. Since all we do is lubrication, we do it better. And that means better results for you. So no matter what you work on or with, if it moves, we'll keep it moving better and longer. If you'd like a little help around the house, help yourself to the LubriMatic® brand at leading automotive and hardware retailers everywhere.

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 **PIONEER**

Electronics

BY STEPHEN A. BOOTH



Science Serving Art



Denon's Dr. Takeaki Anazawa, head of recording and engineering, describing new microphone setups required for digital recording.

Madison, Georgia, a community of some 10,000 souls situated an hour's drive east of Atlanta, is a town of contrasts and surprises.

You'll find fast-food driveways astride the junction of Routes 20 and 440, and home cooking on the veranda of the Fox Hollow Inn just down the road. In town, you'll hear live music with superb acoustics in the turn-of-the-century grammar school that houses the Madison-Morgan Cultural Center. As you drive the night roads, passing horse pastures and seed farms, the phenomenon of AM skip might deflect a New York Mets ballgame and 600 miles of static to your radio.

Madison's architecture is genuinely what's described as antebellum South: Many of the homes and public buildings predate Sherman's destructive 1864 march—and survived it. Not far from these landmarks of a more

pastoral time, on Monticello Road, you'll see an edifice representative of our high-tech age. It's the new compact disc factory installed by Japan's Denon, and the subject of my visit to Madison.

Denon Digital Industries, as the plant is called, will help slake the U.S. market's thirst for CDs by producing some 18 million discs a year at the rate of 50,000 a day. In addition to musical titles sold under the Denon record label, the plant will custom-press CDs for CBS, RCA, A&M and other major labels. What this massive production capacity means is that you're more likely than before to find your record store well stocked with CDs—and the CDs you want to buy.

You're also likely to find those CDs creeping down to the popularly priced sticker of LP records, as supply catches up with demand.

This plant opening is just

the latest blow Denon has struck for the digital music cause. In fact, its April 15 grand opening coincided with a significant milestone in recording technology. On that date 15 years ago, Denon introduced the world's first PCM (pulse code modulated) digital recorder capable of high-fidelity music reproduction. It was the size of four vending machines.

That first digital audio recorder was, in large part, the brainchild of one Dr. Takeaki Anazawa, general manager of the engineering department at the Recording & Engineering Division of Nippon Columbia, Denon's corporate parent. "Recording and Engineering"—and the first word in particular—is the operative phrase here.

Too often, we get wrapped up in the process of a technology and lose sight of its purpose. In the case of digital audio, it's possible to forget that the bits, bytes, lasers, pits and algorithms are just the means to an end—and that end is reproduction of music as you might have heard it, live.

With guys like Dr. Anazawa around, we're more likely than not to get that recreation of the musical per-

formance when we spin a CD in the living room. This mathematician and physicist is what I call a hands-on guy.

Gifted with a love and understanding of music, he gets away from the lab and out where the rubber hits the road and the bullets are real—in other words, into the recording studios and concert halls where music is made. Why? Because if the microphones aren't set up just right, the music will sound just so-so.

Digital recording, Dr. Anazawa will tell you, is just the storage medium needed for sound—the best we have today. Getting the sound into cold storage is the creative part of making a recording. Situating the microphones to capture the interaction of the performers with the acoustics of the recording location is what lends ambience to a recording, the sense that it really happened live. Situating those mic's is an art: All of digital's accuracy and dynamic range is wasted if the music sounds as though it were played in a broom closet.

Because digital recording is so precise and accurate, it has raised the technological ante with regard to microphone use and placement.



CB radio manufacturer Fox is making citizens band radio easier to use by styling it like the more familiar home telephone.



Recording engineers almost have to re-learn their art. Ironically, some of the techniques now being used are throwbacks to the earlier days of electrical recording. But this is an article in itself, one I'll deal with in a future column. So stay tuned.

Mobile Senses

No, folks, CB isn't dead. But it has undergone a metamorphosis of sorts under the influence of mobile cellular telephones.

(Please turn to page 30)

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(Area Code) Phone _____

ELECTRONICS

(Continued from page 29)

Dayton, Ohio-based Fox, a manufacturer of mobile electronics gear, contends that people are familiar with telephones, and therefore ought to be more comfortable with a citizens band radio that looks and feels like a phone. Accordingly, its new CB800 has the styling of and simple operation of a phone.

On the lightweight handset, you'll find only the most-used operating controls: a channel indicator and a push-to-talk bar, along with pushbutton electronic tuning, instant Channel 9 switching and volume control. The base unit contains power and squelch controls, and may be installed underdash or on a console. To



Subminiature Fox RX-10 radar detector has a bracket that adapts for any site.

complete the illusion is a CB antenna with the pigtail look of a cellular whip.

If the new radio extends your senses of speech and hearing, Fox's subminiature radar detector can make you seem clairvoyant.

The 3/4-in.-slim RX-10 measures 2 3/4 x 3 3/4 in. in its other dimensions and weighs 5 1/2 ounces. It's got X- and K-band sensitivity. The 5-segment LED indicator can be extinguished as discretion dictates. Similarly, you can control the volume of the audible alarm. Power comes from a detachable cord that terminates in a cigaret lighter plug.

Mechanically, the RX-10 (\$300) boasts a versatile mounting bracket that twists and folds to adapt itself to fore or aft visor mounting, dashtop or windshield installation.

Coloring Films

The ink was hardly dry on April's issue (*Color-By-Numbers*, page 98) before Congress convened hearings on the subject of adding color to original black-and-white movies. As reported in our feature article that month, directors, actors and other members of Hollywood's creative community are up in arms over the alteration of original films.

Now, Rep. Richard Gephardt (D-MO) says he will sponsor legislation that would prevent the unsanctioned coloring of b&w movies—no matter who owns their distribution and exhibition rights. According to Gephardt's bill, the film's director would have the final say-so regarding any alteration made to the original. We'll keep you posted.

New universal remote control operates Drake satellite gear and other units.



Remote Satellite

Most people who own satellite TV receiving gear are also likely to own a VCR or two, and even a hi-fi music system. For this reason, sat-TV manufacturer R.L. Drake is now offering a universal remote control.

The model PRC/U (\$120) can learn the commands from any of three other electronics components that use infrared remote controls.

Additionally, Drake has introduced a new satellite receiver, model ESR2400 (\$1627) that's loaded with extras. In addition to its built-in antenna positioning system, the new model incorporates the *VideoCipher II* decoder needed to receive scrambled sat-TV programs.

Power Phone

If you're the type of person whose home boasts two separate telephone lines, you've probably got lots of outgoing numbers busting the seams of your phone book. That being the case, the AP2002 telephone from Colonial Data Technologies can make your life simpler, for \$180.

The 2-line speakerphone incorporates a memory bank large enough to hold at least 200 of those numbers, each up to 32 digits long.

All you'd have to do is remember the name of the person you're calling, and type it in (up to 16 characters) on the AP2002's keyboard.

The system works just as well if you have only one phone line. **PM**



AP2002 telephone has keypad memory for 200 numbers you can dial by name.

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New, improved Formby's Conditioning Furniture Refinisher is uniquely formulated to help condition the wood as you dissolve old varnish, lacquer and shellac.

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natural wood oils, which penetrates deep into the wood fibers to help prevent drying and cracking. And since Formby's dissolves the finish so gently, you don't have to sand or scrape.

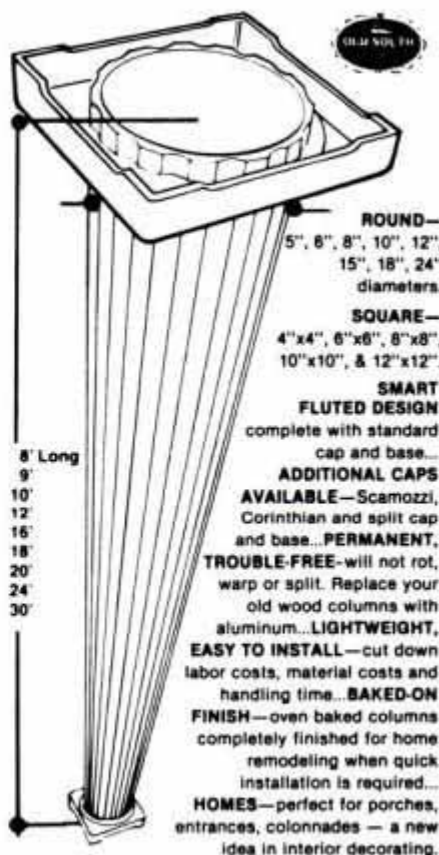
Trust Homer Formby. The best friend your wood ever had.



FURNITURE REFINISHER

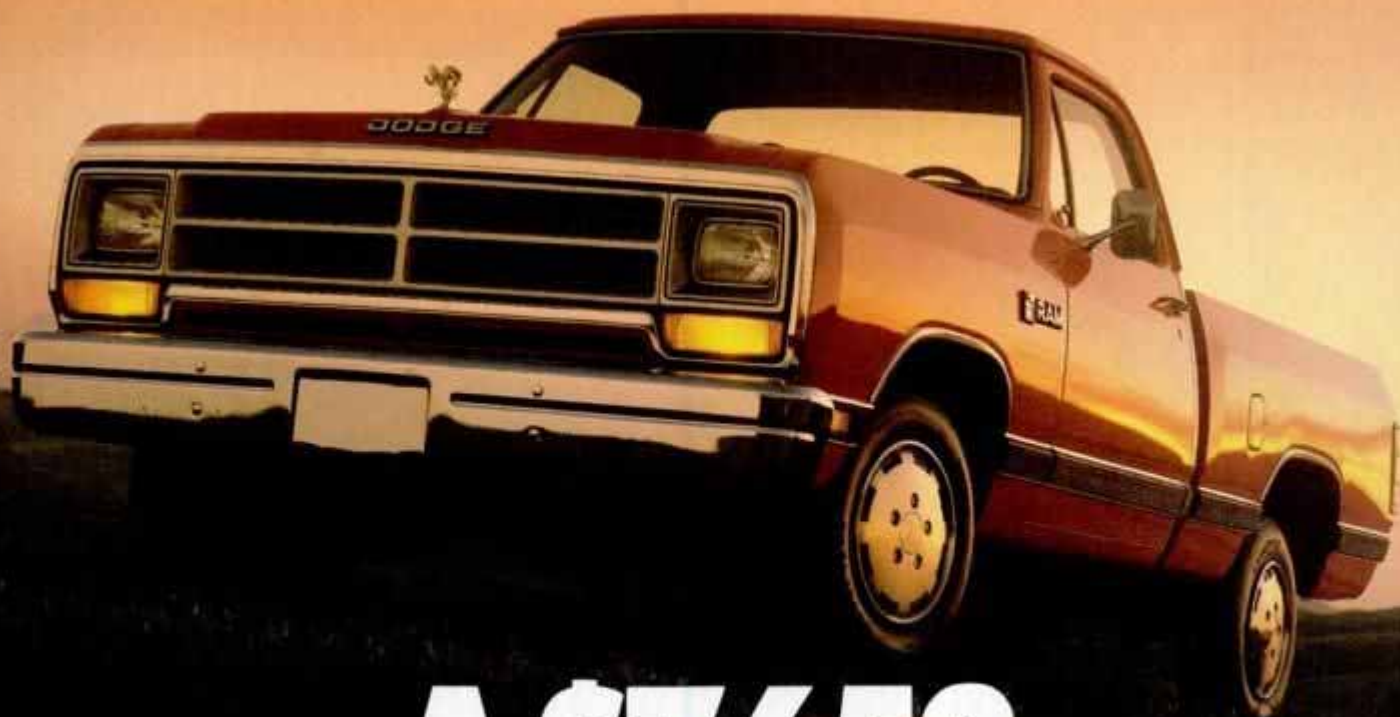
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The new Dodge Ram 100 4x2 isn't your standard bare-bones pickup. Fact is, it's loaded with features Ford and Chevy consider optional. Like wide body side moldings. Tinted glass. Plush carpeting. And more. It also has standard six or available V-8 power. A big 1,420 lb. payload and 2,500 lb. towing capacity. And the best truck warranty in America. Dodge's 7/70 Protection Plan.† But here's the kicker. Even with all this, Ram 100's base

list price is only \$7,653.** That's \$1,856 less than Ford F-150. So buy or lease a Dodge Ram 100. And leave the options lists to the other guys.

RAM 100 STD FEATURES	DODGE RAM 100	FORD F-150	CHEVY R-10
Engine	6-Cyl.	6-Cyl.	6-Cyl.
Overdrive Trans. (4-speed manual)	Std	Std	Opt
Payload	1,420 lbs	1,325 lbs	1,468 lbs
Towing Capacity	2,500 lbs	2,500 lbs	2,000 lbs
Body Side Moldings	Std	Opt	Opt
Tinted Glass	Std	Opt	Opt
Full Wheel Covers	Std	Opt	Opt
Tires P205/75R15	Std	P215/75R15	Opt
Full Carpeting	Std	Opt (in pkg)	Opt (in pkg)
Std 7/70 Warranty†	Yes	No	No
Base List Price**	\$7,653	\$9,509	\$8,503

*Based on comparably equipped list price comparisons with standard full-size pickups.
**Excludes tax & destination charge.

†See 7/70 powertrain & 7/100 outer body rust-through limited warranty at dealer. Excludes imports. Restrictions apply.

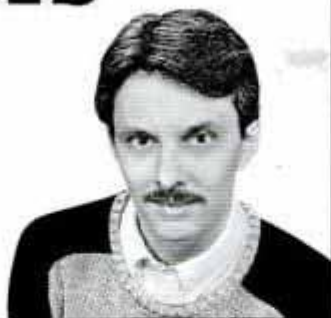
BUCKLE UP FOR SAFETY.



AMERICA'S BEST BACKED TRUCKS ARE RAM TOUGH

Outdoors

BY JOE SKORUPA



New Dazzle From Donzi



First boat of Donzi's new Ragazza line is the sprightly FC-23.

Two things are constant about Donzi Marine. One is that the company is always aggressively researching and developing eye-popping performance products, marine and otherwise. Two is the letter "Z" will dominate each new product name.

So it's not surprising *news* that Donzi, only two years after being purchased by veteran marine businessman Dick Genth, is introducing a new series of boats, the Ragazza line. The reason it's not surprising is that since Genth arrived, Donzi has become a whirlwind of activity, introducing two lines of high-performance, big-ticket boats—Z Series and Vest Pocket Fishermen—plus the Donzi Dudz line of clothing and Donzi men's cologne.

The aim of the new Ragazza line, which will be appearing in dealer showrooms this month, is affordability without sacrificing speed and versatility. First boat in the line, is the ZTC-23, a 23-ft. fishing cuddy that was tested earlier in the year and originally planned as an addition to the Vest Pocket Fisherman line. The boat has since been reconfigured to conform to Ragazza standards and has emerged as the Ragazza FC-23. Unlike other Donzi water scorches, the Ragazza line will not have Momo steering wheels and other racing/luxury features.

Ragazza FC-23 was designed to be a multi-use fishing machine. It comes with a 260 MerCruiser sterndrive, which gives it plenty of muscle for offshore wave busting or water skiing. Its extra-wide cockpit offers freedom of movement to battle gamefish, while its cuddy cabin makes it versatile enough for families. Overall length is 23 ft. Beam is 8 ft. 7 in. Gross weight is 3800 pounds.

Four other boats are currently part of the Ragazza line. They are a 186 bowrider, a 208 bowrider, a 230 cuddy, and a 250 cuddy. A fifth Ragazza, the 320, is expected to debut this month. All are part of the 1988 Donzi model line.

With so much time left in 1987 it would be no surprise to learn Donzi is hard at work on its next new product. We can only guess what it is. For more information, write Donzi Marine, 7000 Bradenton Rd., P.O. Box 987, Tallevast, FL 34270 or call (813) 355-9355.



Mercury XRI: Power and efficiency from a production EFI outboard.

Mercury's Electronic Fuel Injection

Race-proven electronic fuel injection (EFI) is now a reality for the weekend boater. Mercury's new 220-hp Laser XRI (Extra Response Injection) is a production model outboard that for the first time features EFI.

The Laser XRI is a 142-cu.-in. displacement V6. At its heart is an electronic con-

trol unit that precisely delivers fuel to the engine based on input from monitoring sensors. A unique vapor separator recycles fuel vapors into the induction manifold, so only liquid fuel is provided to the fuel pump. Write Mercury Marine, 1939 Pioneer Rd., Fond du Lac, WI 54935, (414) 929-5235.

Nike's High-Stepping Air Force

You feel the cushion of air when you first step into Nike Air Max running shoes. Firm but giving. You lace them up. You do a few jumps and stretches. Your feet want to run on their own. You take off down the road and crush the heels a few times to see if the Air-Soles bounce back. They do. You ride on the air cushion for a few miles.

Nike's super-resilient Air Max running shoe.



More on the next day.

After a few weeks, you take it for granted, but the high-flying feeling's still there.

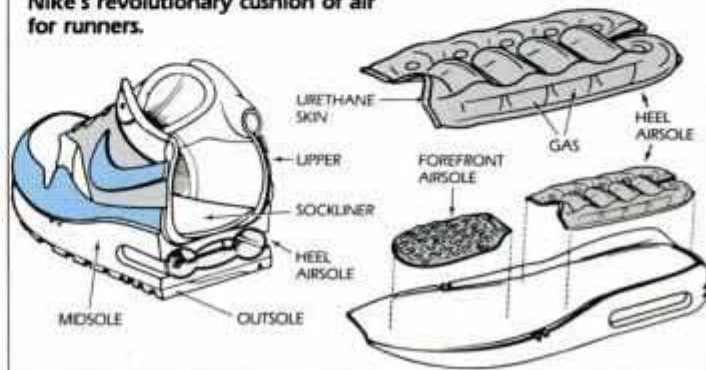
That's the secret of Nike's new, highly touted running shoe.

After 500 or more heel-pounding miles, the patented Air-Sole springs back to its original shape every time.

Unlike molded EVA, the primary cushioning component in most running shoes, the Air-Sole is a gas-filled urethane pouch. Whereas the cell walls of EVA's trapped air bubbles break down and compress, the Air-Sole maintains stable support by encasing a pressurized freon gas derivative in a tough, flexible skin. While Nike has been experimenting with Air-Soles for eight years, the new Air Max has a see-through look and the largest, most pressurized Air-Sole to date.

(Please turn to page 34)

Nike's revolutionary cushion of air for runners.

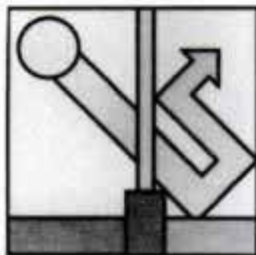


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OUTDOORS

(Continued from page 33)



Outdoorsmen light up their lives in a timely manner with the Watch-Lighter, left. Boaters get a charge from the sun, above, with glass-free solar panels.

For Hot Times

The new LCD Watch-Lighter is the latest in *hot tech*. A refillable butane lighter with an adjustable flame is built into a watch that not only gives time and date, but lights your campfire, barbecue or anything else combustible.

Outdoors watches have come a long way in recent years. Wilderness campers need only look at their wrists for determining compass direction, temperature, wind speed and, now, for a guaranteed light, even under the most adverse conditions. To prevent setting your shirt sleeve on fire, the watch's adjustable flame can only be activated by a safety button at the side of the case.

The Watch-Lighter may not set the world on fire, but it's certainly a hot idea! Handy, too.

Cost is about \$24.95. For more information, write Project Imports, Dept. PM, Suite 1200, 507 Third Ave., Seattle, WA 98104 or call (403) 239-5135, in Calgary, Alberta, Canada. (And look for a special PM report on outdoors and sports watches, "Best Of Times," in the September '87 issue.)

Flexi Solar Panels

Battery-charging solar panels aren't new to boaters, but they've always been more known for their limitations than their applications: awkward to mount in a safe and useful deck position, plus too fragile to withstand unpredictable acts of nature and man.

Solar Electric has come up with a



The handy Scout, shown in fold-up position, weighs only 21 pounds, but its 22-cc, 1.3-hp motor can cruise at 18 mph.

better mousetrap. The company's new lightweight, flexible solar panels use a special stainless-steel substrate that provides necessary reflectivity, durability and, most importantly, a complete absence of glass.

Reliability is improved through a stainless-steel toughness that resists photocell breakage. The modules are strong enough to be stepped on and flexible enough to be mounted flush with the deck. They are available in sizes ranging from a 1-watt Battery Maintainer to a 30-watt Battery Charger. For more information, write Solar Electric, 175 Cascade Ct., Rohnert Park, CA 94928 or call (800) 832-1986.

Compact Scooter

There's nothing glamorous about transportation on the vast movie sets of Hollywood. Sound stages are cavernous, but they're no place for limos. So, whenever a star, or even a technician, needs to get from one side of a studio to another, he faces a major hike. The solution? A compact, motorized scooter called the Scout, which weighs only 21 pounds and cruises at 18 mph. Although its fold-up construction makes it easy to carry and store, it's sturdy enough to handle more than 400 pounds.

The spunky motor burns a gasoline and oil mixture and has a 1-pint fuel tank. With a steady hand on the throttle, it can run most of the day on this skimpy amount. But if you're in a feisty mood, burning rubber and doing wheelies (just kidding), the 22-cc, 1.3-hp motor will eat up its fuel in a couple of hours.

While the closest most of us will ever get to a movie set is a guided tour at Universal Studios, many of us will pull into a large RV campground or marina and encounter the same transportation difficulties as members of the film community. For these occasions, the Scout is an affordable alternative at \$495.

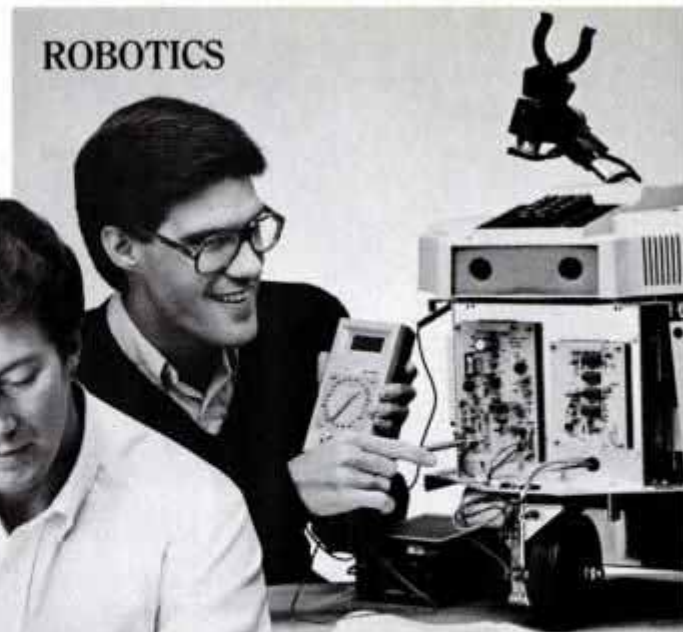
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Home Video



BY JAMES B. MEIGS

Super Slo-Mo At Home

One of the hottest features in video camcorders these days sounds like a holdover from film cameras: a high-speed shutter.

Several VHS and VHS-C camera/recorders already include this new shutter technology, and now Sanyo has introduced the first 8mm camcorder to offer this feature. These video-age shutters are quite different from those used

($1/60$ -sec.) at which the camera "captures" each new image. Trying to view the tape in freeze-frame or slow-motion is nearly pointless.

But with a high-speed shutter, each video field con-



Panasonic's VHS-C format camcorder (above) and Sanyo's 8mm model share high-speed shutters for sharp slow-motion, flying erase heads for edits.

with film movie cameras. For one thing, they're completely electronic—no mechanical curtains or other moving parts. They work by feeding the video signal from the solid-state image sensor in tiny bursts of up to $1/1800$ th of a second instead of using the normal $1/60$ th of a second conventional video.

What's the point?

These shutters offer slightly sharper moving images and drastically better slow-motion pictures when you play back tapes shot with the camcorder.

With an ordinary video camera, fast moving objects in the picture tend to blur due to the relatively slow rate

tains a crisp, clear image because it represents only a tiny instant in the object's travel. (Of course, this also requires plenty of light. In low-light conditions, the camera returns to normal shutter-speed operation.)

Obviously, not everyone needs crystal-clear slow-motion in their home movies, but I think anyone interested in shooting any type of sport will love it.

Imagine being able to analyze the arc of your golf swing or tennis backhand with step-by-step video precision.

This Sanyo model (VM-10) also includes all standard camcorder features, such as

power zoom and immediate playback, at its \$1300 list price.

Flying Erase

Another camcorder improving the look of home movies is the new PV-320 from Panasonic. It's the first VHS model to include an important extra feature called flying erase heads.

Long used in most professional video equipment, flying erase heads are the type of feature you don't notice from outside, but that makes a big difference in a camcorder's performance. Besides pro equipment, they're a standard fixture in most 8mm camcorders, including Sanyo's VM-10.

All camcorders and VCRs have a way to erase a tape before they record a new picture on it. What makes the flying-erase-head system different is that the heads that do the erasing are located right on the spinning drum with the video recording heads. Therefore, they can erase each video track with precision just before a new one is laid down.

This means that when you use the camcorder for editing your home movies, the transitions from one scene to another are almost totally clean. They appear without the glitches and rainbows that often plague home editing jobs performed with camcorders that have conventional, fixed erase heads.

Panasonic's new top-of-the-line camcorder also offers a high-speed shutter and a full complement of camcorder features.

Surround And Control



Magnavox TVs: total remote control, built-in surround sound.

It seems the day isn't far off when we will be able to do just about everything in life from the comfort of an easy chair. In the world of home electronics, that's practically true right now. The latest step in this direction comes from Magnavox, a company that has helped lead the way in remote controls.

Almost all of Magnavox's new TV sets operate with a sophisticated remote system that lets you control virtually every function of the set from across the room. No more reaching behind the set to find tiny picture control knobs. With Magnavox's Total Remote System (and similar systems from other companies including RCA), you can adjust picture brightness, color, tint and so on from the position in which you normally watch.

Magnavox has also unveiled an improved version of its impressive Universal Remote, now available with nearly half of all Magnavox sets. The new Universal Remote not only controls the sets, but it can also control the functions of 32 brands of VCRs and 15 types of cable boxes—no more juggling three remote controls just to turn on a TV program.

(Please turn to page 40)

Panasonic's newest VCR uses bar-code scanner to program events.





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HOME VIDEO

(Continued from page 38)

If versatile remote control doesn't ring your bell, perhaps audio Surround Sound will. That's what Magnavox has built into three of its new TVs (two 27-inchers and a 31-in. console). The amps and signal-processing circuits, plus stereo speakers, are incorporated in the TVs' chassis.

To get theatrical Dolby surround, all you need to do is add two small loudspeakers for placement in the rear of your viewing area.

Passing The Bar

Bar-code readers—the latest twist in VCR programming—might be a case of a solution in search of a problem.

Nevertheless, Panasonic has announced two new VCRs (PV-4722 and PV-4761) that use a special digital scanner to read time and channel information from printed bar codes.

What's the point? In Japan, where some TV program guides are already published with the necessary bar codes, it makes programming the deck as simple as waving the wand over the page. But in the U.S., with its profusion of stations and cable channels (and multiple time-zones), it seems unlikely that we'll see a bar-code version of *TV Guide*.

Panasonic's new VCRs come with a bar-code "function sheet" featuring generic codes for times, dates and channels. But will using these really be any easier than just punching in the numbers yourself? I have my doubts. I'd suggest trying out the model for yourself, but I suspect this may be a case of technological overkill.

On Your Mark...

What's the most annoying thing about using a VCR? One item high on most people's lists is that irritating delay between the time you hit PLAY and the time the picture actually appears.

Owners of the Beta VCRs have long pointed to this minor problem as one more sign of Beta's technological superiority over VHS. In Beta, the loaded tape is immediately wrapped around video head drum as soon as the cassette is loaded. This means Beta decks can switch into Play without any delay. In VHS, on the other hand, the loaded tape isn't wrapped around the head drum until you hit the PLAY button. So, it takes a few seconds for the VCR to wrap the tape around the drum.

Though it might seem silly to worry about such a short lag, anyone who spends a lot of time editing or shifting in and out of Fast Forward with a VHS VCR knows how aggravating it can become.

After more than 10 years, VHS has finally solved the problem. Akai has just introduced what it calls the "Quick

Start" VHS VCR, model VS-M930U-B (\$849). By keeping the tape fully loaded around the drum at all times, it allows a nearly instantaneous shift from Stop to Play.

This top-of-the-line model also includes Hi-Fi audio, an MTS stereo TV decoder, digital circuitry for special effects and picture enhancement, and a new universal remote control. Akai is also offering the Quick Start feature on two less expensive decks. Toshiba plans to introduce fast-loading VCRs sometime later this year.

Digital Advance

While Akai has refined the VCR's mechanical performance, NEC continues to break new ground in using digital technology to improve the video picture. NEC's new DX-5000 offers the latest version of the company's digital video-noise reduction system. Video noise is the cause of the random graininess and snow that often distort video images. This model's noise-reduction system helps combat noise in both



"Quick Start" VCR from Akai permits nearly instantaneous Play/Record in VHS decks.



NEC's DX-5000 employs digital circuitry to remove noise, improve color in video image.

the color and the brightness portions of the video signal. The result is a very visible improvement in picture quality on any tape that suffers from excessive noise, particularly older tapes or tapes recorded at the slowest recording speed. Kudos to NEC for using digital technology for more than gee-whiz special effects.

Super Update

The "Super" VHS system reported in June's issue (*Home Video*, page 21) has arrived here earlier than expected.

By the time you read this, the first Super VHS VCRs should arrive on retail shelves. They'll be joined by other models in September, and by the first Super VHS camcorders.

The system, which promises 420 lines of horizontal resolution when connected to a hi-res TV, makes its debut in JVC's HR-S7000 VCR (\$1200). S-VHS decks from Zenith, Hitachi and RCA will hit the boards soon. Next month, JVC will bow a "Super" camcorder with 450 lines of resolution, that uses a full-size VHS cassette. RCA will follow with full-size and VHS-C camcorders. **PM**

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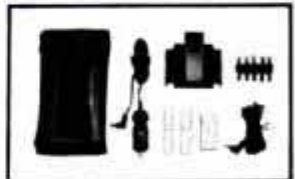
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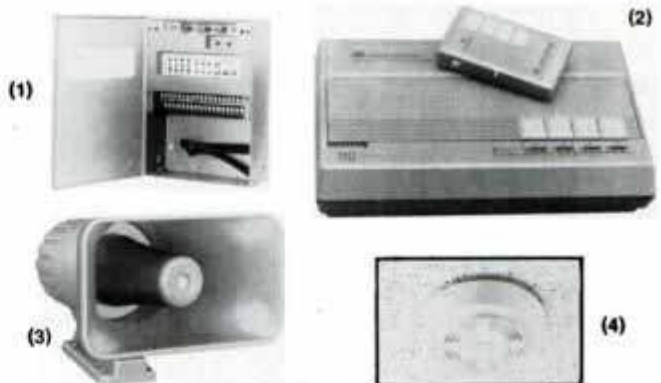
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NEW/WORKSHOP

Trim-To-Fit Doors

Here's a quick and easy way for you to remodel existing cabinets at a fraction of the cost of installing new units. Versadoor offers a full line of solid red oak doors and drawer fronts that are hand-sanded and ready for finishing. Doors are available in five widths—10, 13, 16, 19 and 22 in.—and five heights—14½, 19, 22, 28 and 48 in. Drawer fronts come in 13, 16, 22 and 36-in. widths and all are 6 in. high. Simply order the correct size replacement door or drawer front, apply a finish and install

it. The Versadoor system will accommodate odd-size cabinets, too. The doors and drawer fronts can be trimmed to fit virtually any cabinet. First, rip the door to width using a fine-tooth saw blade. Then, cut off the oak trim, crosscut the door to length and reattach the trim to the door's end. A 16 × 28-in. door costs about \$37. A 16



The contemporary, European-style red oak doors and drawer fronts have V-grooved surfaces and integral, continuous oak pulls.

× 22-in. door is \$29. A 6 × 16-in. drawer front is \$14. Versadoor, Box 2959, Winter Haven, FL 33880.



To make custom-fit doors, first rip the door to desired width using a portable circular saw.

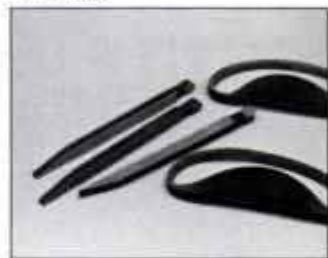


After sawing off the oak trim, cut the door to length. Reattach the trim with glue and nails.



Finally, apply a finish such as stain, paint or varnish. Note the continuous pull on door end.

Smooth-Sanding Sticks



Sanding stick has tapered nose for sanding in tight spots. Abrasive belts are sold in 10-packs.

Now it's easy to sand small, hard-to-reach areas thanks to the sanding stick kit from Woodcraft, 41 Atlantic Ave., Box 4000, Woburn, MA 01888. The ¼-in.-wide × 6¼-in.-long sanding stick accepts a ¼-in.-wide × 12 7/8-in. abrasive belt. The stick's spring-loaded end holds the belt firmly in place. The kit (\$27.50) consists of three sticks and 30 aluminum-oxide abrasive belts. Extra belts cost \$8.50 per 10-pack.

Go-Anywhere Soldering Iron

Weller's new Pyropen is a pencil-grip, cordless soldering iron. The slim, 9½-in.-long tool operates on butane and holds enough fuel for a 3-hour job. Inexpensive butane refills are sold at hardware stores and smoke shops. But, the Pyropen is more than a soldering iron.

It can also be used as a torch to braze metals and

make jewelry, and as a heat gun to shrink tubing, weld plastics and cure adhesives.

The tool comes with a soldering tip, hot-air tip, torch ejector, tip-cleaning sponge and steel carrying case. It costs about \$61 at hardware stores and home centers. For more information, contact Weller, Box 728, Apex, NC 27502.



Cordless soldering iron has an adjustable temperature range between 392° and 932° F. Several optional tips are also available.

Plug-In-And-Go Nail Driver

If you're looking for a quicker, easier, more efficient way to drive nails, then try Duo-Fast's new Electro-Drive 1 electric nailer. This easy-to-use, plug-in-and-go nailer eliminates the need for a compressor and air hose. The tool (model EFN-764) drives 16-gauge finishing nails in lengths from ¾ in. to 2 in. The nails have T-shaped heads and come in strips of 60 nails. The tool's easy-to-load magazine holds two nail strips (120 nails). The electric nailer is designed to handle most finish-nailing applications such as paneling, cabinetmaking and window and door trimwork.

It features a safety yoke that must be depressed



Electric nailer provides a quick, easy way to drive T-head finishing nails. It accepts nails that range in length from ¾ in. to 2 in.

against a workpiece before the tool will fire. The 9-pound tool comes with a carrying case, safety glasses and operator's manual. The nailer costs about \$695 and is available at hardware stores and Duo-Fast dealers. For more information and details, contact Duo-Fast, 3702 River Rd., Franklin Park, IL 60131.

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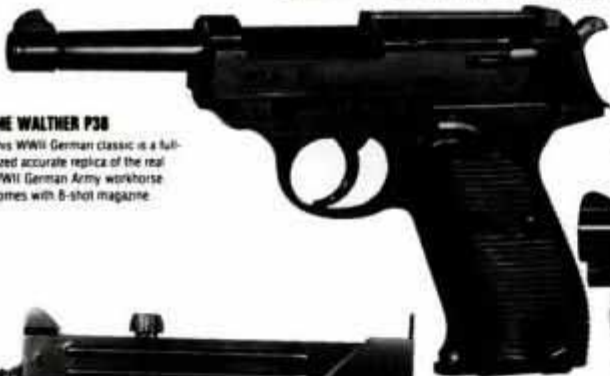
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Inside Detroit

BY JIM DUNNE



Aerostar Pullback



Triangular windows gone.

Less extreme in appearance is this future Ford Aerostar. But the changes make the small van look more modern than the current design. A major change is the windshield. It wraps around at the sides so that the triangular windows can be eliminated. Also new are the vertical door handles that will make it easier to open and close the sliding door. It is uncertain whether the sliding door actually operates on this model, or is just dummied in. Note that there is no visible slide bar along the middle of the body. Wraparound tail-lights update the view of the rear. If this styling prototype

is okayed, Ford will not have it in production before the 1989 model year.

Chrysler's Hottest Engine

It will be in the Chrysler-by-Maserati 2-seat convertible next fall when this made-in-Italy luxury barge hits the showrooms. Maserati took the basic 2.2-liter Chrysler Four, added goodies like double overhead cams, 16-valve breathing and a turbocharger with intercooler. Output is 200 hp, with 220 lb.-ft. of torque at a relatively slow 3200 rpm. A Getrag 5-speed manual transmission is the only gearbox that can handle

this output. For more leisurely driving, a lower-power version of Chrysler's Turbo II engine will be available with automatic transmission.

New Faces At Chevy And GMC

A minor facelift is planned for Chevy Astro and GMC Safari vans next year, a move aimed more at a fresh look than toward functional improvement. Headlights use aero-shaped lenses, and the grille has a different bar pattern. Ford has a slightly altered grille appearance for its 1988 Aerostar van.

Grand Prix Rollout

Final prototype testing of the 1988 Grand Prix put this car out on the public streets where it was seen and photographed by chance. The car is completely new, except for its drivetrain. Unitized body structure replaces separate frame and body. Front-wheel drive with a 2.8-liter V6 replaces rear-drive V8. Independent suspension replaces the rigid axle at the rear.



Chevy and GMC minivans get new grilles and aero-lights.

Ford, are slated for balance shafts to make them run with less vibration and noise. The engines are top of the line, 3.8-liter models that go in midsize and full-size sedans. Ford will put the new 3.8 in its 1988 luxury Lincoln Continental, while GM has wide applications for its 3.8. First installations in GM cars will be in the Electra-LeSabre-98-88 and Riviera-Toronto lines for 1988.

The balance shafts—which spin at twice the speed of the engine in the opposite direction of the crankshaft to offset imbalance—are currently used on a limited number of 4-cylinder engines by Chrysler, GM, Mitsubishi and



New front-drive '88 Pontiac Grand Prix will have a 2.8-liter V6, which it will share with fwd Buick Regal and Olds Cutlass.

This is the first major change in the Grand Prix since 1978, and should help restore the sporty Pontiac to its historic position as one of GM's top-selling models. Drivers will note a tighter body, more supple suspension, and a tauter, quicker feel overall. The use of a 2.8-liter engine, however, may be a mistake. Buyers will miss the performance of GM's big V8s in this model.

V6s Get The Shaft

Two families of V6 engines, one from GM, the other from

Porsche. The planned use by GM and Ford in V6s points out the fact that those engines, even with offset crankshafts, are not as smooth as straight Sixes or V8s.

No Surprises

Chrysler Corp.'s new-for-'88 front-wheel-drive flagship sedans are traditional in design and use mostly off-the-shelf drivetrain and chassis parts. Four models will be built, two under the Chrysler New Yorker brand and two as the Dodge Dynasty. One engine, a 3-liter V6 made in Japan,

(Please turn to page 47)



Next-generation Ford Aerostar minivan will be a 1989 or '90 model. For 1988, the current body will get a minor grille restyle.

Designer Label.

Most brand-name auto parts are good. But that isn't good enough for Mr. Goodwrench. He recommends the *designer* label: Genuine GM Parts.

GM parts are designed by many of the same people who designed the original parts on your GM car.

They're engineered to work together as complete units with your GM car's various systems. And built to strict GM quality standards. Including GM Goodwrench branded parts, which are available only at GM dealers.

So whatever GM car you

have—and whatever GM parts you need—see Mr. Goodwrench.

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AMBERVISION™ REVOLUTIONIZES EYEWEAR

As part of an enormous publicity campaign to prove that we have the absolute lowest prices available in the nation, the giant new home shopping club "USA Buyers Network" will give away one million pair of its most expensive vision enhancement glasses — the nationally advertised Ambervision™ Super-Glasses, for the unbelievable "competition-buster" price of just \$10 only to those who write to the company address (below) before Midnight, Aug. 30, 1987.

**Not \$100, Not \$59.95 —
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For Only \$10!**

Similar vision enhancement eyeglasses have been nationally advertised by others in leading media at \$59.95 each. In fact, you would think that high-tech vision enhancement Super-Glasses like these would sell for well over \$100.00. But during this nationwide publicity campaign, you don't pay \$100.00 — or even \$59.95. You pay an incredible give away price of just \$10! But this offer is for a limited time and only available through THIS nationwide publicity campaign if you respond before the deadline above.

High Technology Disguised As High Fashion

Don't be fooled by the appearance of these glasses! These are not ordinary sunglasses. They may look like high fashion sunglasses (in fact, they are designed after some of the most expensive brand names on the market today — e.g. Porschetm, Carreratm, etc.) — but are actually the latest breakthrough in sunglass technology. Ambervision's™ scientific design filters out blue and ultraviolet portions of the light spectrum that have been proven to be harmful to your eyes. By filtering out these dangerous rays, not only are your eyes protected from damage, but your vision is enhanced to a new level of perceptual eyesight!

A New World Through New Eyes

Just imagine what it would be like to look through glasses that make the world seem sharper, more vibrant, more alive and more cheerful. Slip on a pair of these sleek designer sunglass "look alikes" and you'll notice a marked improvement in your vision. The world will seem so crisp, so clear, that you'll feel as if someone had just given you a new set of eyes. This vision enhancement experience is so incredibly phenomenal that it has been widely publicized by others as a "Vision Breakthrough". You literally "won't believe your eyes!" Thousands of professional golfers, hunters, and skiers have already discovered and reaped the benefits of these indispensable Super-Glasses — now you too can experience the excitement of ENHANCED EYESIGHT!

What About Sunglasses

The unbelievable truth is that ORDINARY sunglasses may be dangerous to your eyes. Everybody knows that your eyes automatically adjust to light. When you wear plain darkened lenses, your pupils open wider to adjust for darkness — but this becomes harmful because your eyes are now letting MORE dangerous UV rays in.

Ambervision™ lenses are graduated to help shield against overhead light. These glasses are made with one of the finest lens materials available for

sunglasses — cast in CR-39™ with UV400 protection, even an optometrist would be impressed! The lightweight frames are designed for ultra comfortable wear and tear and the molded nose rest is designed to rest comfortably on your nose. The hinge design of these frames allows them to be the perfect "one size fits all" eyeglasses. Your "Super-Glasses" even come complete with a luxurious black suede-like protective pouch. No wonder these are the most popular and fastest selling sunglasses ever sold by this giant new home shopping club!

These Ambervision™ Super-Glasses will not be sold to any wholesalers, dealers, or retailers at this price. They are only available through this special publicity campaign for a limited time. There is a limit of two (2) pairs per address at this price, but requests that are mailed early enough (before Aug. 20) may request up to five. Each pair of Super-Glasses is covered by a full one year money back guarantee.

TO ORDER: Send your name, address and \$10 for each pair. Add only \$3 for FIRST PRIORITY shipping, handling and insurance no matter how many pairs you are requesting. Please specify glasses or clip ons. MC & Visa users please supply Account No., Expiration Date and Signature. Allow up to 60 days for shipment. Mail to:

**USA Buyers Network,
Dept. SG1134,
One American Way,
Roanoke, VA 24016-8001**

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**USA BUYERS
NETWORK**

INSIDE DETROIT

(Continued from page 44)

will be offered. It will team with a Chrysler automatic transmission as the only powertrain available.

Olds Down To One

After 90 years of building rear-wheel-drive cars, and a proud history of V8 engine leadership, Oldsmobile is down to a single model, the Custom Cruiser station wagon, that offers those features. With the introduction of the new Cutlass Supreme for 1988, all the other car lines will be front-drive designs that use 4-cylinder or V6 powerplants. However, Olds plans to build the Custom Cruiser at least through 1992. By that time, according to Olds insiders, the division will have a new V8 in production, a small one of less than 4 liters.

Solve This One

Pontiac was troubled with the problem of putting power steering in the Fiero until a solution was found that will show up in the 1988 models. Because the engine is in the rear of this car, long hydraulic lines had to be run from the pump, mounted on the engine, all the way up to the front of the car where they attach to the steering gear. Space for housing the lines, and the extra weight

needed to make that system work, made the whole setup awkward at best.

Solution: Put an electric pump for the hydraulic system in the front of the car right next to the steering gear. Let the electric motor take the place of the engine-mounted V-belt. Now there are no long lines snaking from the engine up to the front. And, the feel of the new setup is more precise in control, with less feedback from road bumps.

In Reverse Order

Pontiac will use only 4-cylinder engines in its Grand Am models starting next year. Base engine will be the 2.5-liter Iron Duke that Pontiac designed a decade ago. First upgrade will be the Olds-designed 2.3-liter Quad Four. The Brazilian-made 2-liter turbo rounds out the lineup. An unusual twist: The smallest engine, the 2-liter, is the most powerful and sells at the highest premium. The biggest engine, the Iron Duke, is standard and is the least powerful.

Secret Carburetor?

For many years you've heard claims about a miracle carburetor that can double your mileage, and at the same time produce cleaner exhaust. But, so it's said, oil companies have suppressed the invention in order to keep gas sales from turning their profit sheets red.

There are no miracles. Mileage improvements come in small steps. The nearest thing to a miracle carburetor that I've seen is a new type of fuel injector being developed by a joint venture of Orbital, an Australian research company, and Walbro Carburetor Group of Cass City, Michigan. The injector, when installed in a 2-cycle engine, is said to boost power by 40 percent, deliver slightly better fuel economy, and emit equal or lower exhaust emissions. Engine complexity can be cut by 200 parts, and weight reduced 30 percent.

The key is a fuel injector that premixes gas and air, just as a carburetor does. This premix, in a 3:1 air-to-fuel proportion, is spurted into the normal combustion chamber where it combines with the regular inlet air. The result is more complete burning of the fuel from gas particles that are one-third the size of those in a carbureted engine. Because of the air-fuel injection, the fuel particles tend to keep their small size, and don't readily combine with other particles.

Walbro officials figure that the soonest this injector can be produced for an automobile is 1995, and that would only be true if the decision were made today by an auto company to adopt the whole 2-cycle system. Currently, Ford and GM, among others, are researching the "miracle injector." **FM**

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NRI shows you how to service mowers, garden equipment, snow blowers, chain saws, outboards, motorcycles and more. Then shows you how to start and run your own business.

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No need to quit your job or travel to night school. NRI trains you right at home. You learn with "bite-size" lessons that show you how to service almost everything that uses small motors. And you learn at your convenience.

Train on 5 HP Engine

As part of the NRI Master Course, you get a brand-new, 5 HP Tecumseh engine plus a power generator to train on. You learn to troubleshoot, do tuneups, even tear down for valve and ring jobs. You learn using professional tools like a complete wrench set, inductive tachometer, volt-ohm-milliammeter, overhaul equipment, and more.



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NEW/HOME

Build A Spot In The Sun

The Sunspot is a compact and affordable sunroom that is designed for easy do-it-yourself construction. The 8 x 11-ft. structure is comprised of extruded aluminum frames and interlocking panels of insulated glass. There are 34 major components, no part weighs more than 70 pounds and, according to the maker, two people can construct the Sunspot in about 12 hours using common hand and portable power tools. Build the room on a foundation of concrete, bricks, block or wood. Check with your local building codes for requirements.

The basic Sunspot costs about \$7500. Some of the many options available include bronze-tinted glass, low-E glass, sliding door, operable skylight, awning window, ventilating fan, quilted



Easy-to-build solarium features extruded aluminum frame and interlocking glass panels. It's shown with optional sliding door.



After attaching the rafters to the wallplate and the front rail, install the purlins. Simply push down to lock the purlins in place.

shades and blinds. For more space, you can add on optional 30½-in.-wide sunroom modules. For more information and details, contact ODL, Inc., 215 E. Roosevelt Ave., Zeeland, MI 49464.

Automatic Water Watcher

Water conservation is an important issue in many communities and this simple device can help you save both water and money. True Temper's water controller (\$14) delivers water for a desired length of time and then shuts off the flow automatically. Simply attach the device to the hose bibcock (as shown), at the sprinkler or in the hose line, adjust the control dial and turn on the water. It will deliver between 85 gallons and 595 gallons of water depending on the setting. Contact True Temper, Box 3500, 465 Railroad Ave., Shiremanstown, PA 17011.



Set dial for desired water flow—between 85 and 595 gallons. Device shuts off automatically.

Cooking With Class

Weber's new Genesis line of gas barbecues features a new cooking system that uses no lava rocks. Instead, two layers of porcelainized steel bars, called Flavorizer bars, are between the burners and the grill. The L-shaped bars distribute heat evenly and virtually eliminate flare-ups. Other features include stainless-steel burners, pushbutton ignition, 540 sq. in. of cooking area and porcelain-on-steel grill. The Genesis II grill, shown, costs about \$505. Other models range between \$350 and \$576. Contact Weber Products, 200 E. Daniels Rd., Palatine, IL 60067.



Genesis II has a swing-up work surface and a 20-pound LP tank.



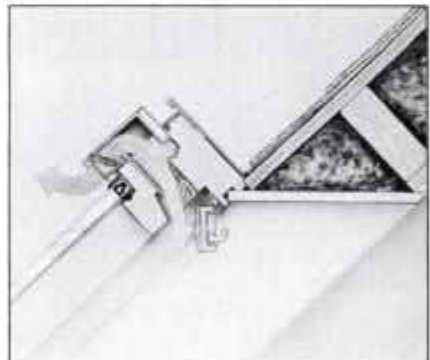
Flavorizer bars replace lava rocks and help to reduce flare-ups. Bars are dishwasher safe.

Great View And Fresh Air, Too

Velux has introduced a new skylight that has a ventilation flap—a feature unique to fixed skylights. Open the flap, located near the top of the unit, to exhaust stale, hot room air and admit fresh air. A protective shroud covers the vent to permit use come rain or shine. A removable, easy-to-clean filter keeps out dust and insects. Operate the vent with a pull cord or an optional control rod. The unit has a wood frame and aluminum step-flashing that requires no caulking. Copper flashing is also available. The model FSF skylight comes in six sizes from 21½ x 27½ in. (\$123) up to 44¼ x 46½ in. (\$232). Each unit has double-insulated clear glass. Glass options include low-E, bronze or gray tinted and laminated. Velux, Box 3268, Greenwood, SC 29648. **FM**



Optional control rod makes it easy to open and close flap. Unit comes with a simple pull cord.



With the ventilation flap open, stale, hot air is exhausted as fresh air enters (arrows). A filter keeps out dust and bugs.

Save Gas, Save Engine with "POLY"

The following introduces one of the most fully tested and proven gas saving, friction-reducing engine treatments ever to reach the market!

The Secret is "Poly"

"Poly" is short for polytetrafluoroethylene (TFE), the slipperiest substance known to man. (1981 Guinness Book of World Records). Petrolon Corporation, makers of Slick 50, invented a way to permanently bind this slippery chemical to your engine with one treatment. Just one quart of Slick 50 can reduce engine friction, increase gas mileage and horsepower and reduce engine operating temperature, causing your oil and engine to last longer. . . plus it reduces metal wear, defraying costly overhauls.

Years of Testing and Use Have Proved It True!

Slick 50 has been thoroughly tested in independent laboratories and out on the road: The March/April 1982, p. 35 issue of "Consumer Digest" magazine stated, "Slick 50 does reduce engine heat and ordinary wear, and our informal tests indicate that it will improve gas mileage by about 2 or 3 miles per gallon."

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."

"Dune Buggies & Hot VWs" magazine April 1983 issue records the results of their one year testing of Slick 50. "We can indeed say scientifically that Slick 50 does work, and that it does reduce engine wear! . . . for the price of one treatment when compared to engine rebuild, we feel that you'd be money ahead using Slick 50."

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 decreases fuel consumption in tests done at the university."

The Space Shuttle Columbia uses the chemical "poly" in its gears and bearings because it is the only chemical lubricant which can withstand the heat and corrosive elements of space.

Perhaps most dramatic of all is a torture test overseen by the Automotive Services Council for Pennsylvania and shown on WTVE television. Three cars with 75,000 to 129,000 miles on them were treated with Slick 50. Six months later the oil was drained from each vehicle, and the cars driven without the oil plugs for about a half hour. The water temperature never rose and the engines sustained no apparent damage.



There isn't room here to tell you about the dozens of other tests proving that Slick 50 is everything we say. However, if you're still skeptical, send \$2.00 to cover printing and postage costs, and we'll send you detailed test results plus actual letters from users who report how Slick 50 saved their engines and saved them money!

It's Easy to Treat Your Engine

A few minutes before oil and filter change, add the engine flush you get free with each order to clean out the engine. Let the engine idle for 5 minutes. Then drain the oil, change the filter and add the proper amount of oil, less one quart. Add one quart of Slick 50, drive for 30 minutes, and leave it in the crankcase for at least 3,000 miles. As the engine operates, the oil carries the "poly" between the parts where it is burnished into the pores of the metal.

Only One Treatment Necessary

It's permanent, so you do it only once, not each time you change oil. One quart of Slick 50 will treat all standard 4, 6 and 8-cylinder gasoline and diesel engines.

Works with Most Oils

Slick 50 will work with all petroleum-based oils and all synthetics compatible with petroleum-based oils with the exception of graphite oils. However, once an engine is treated, you can go back to a graphite type if desired.

4 Ways Slick 50 Saves You Money

Your actual percentages may vary depending on your driving, vehicle condition, weather and geographic location, but no matter what your conditions, Slick 50 can:

1. Increase mileage
2. Increase horsepower (small economy cars and large RV's really need this)

3. Reduce operating temperatures, thus increasing the lubrication and life of the oil and engine

4. Minimize or eliminate costly overhauls by reducing engine wear

Up to 90% of the engine wear on a car can be caused by lubrication starvation cars experience when first started before the oil begins to circulate. Slick 50 can eliminate this problem for less than the cost of two tanks of gas.

Slick 50 Will Not Affect Your Warranty

Slick 50 is suspended in an excellent grade of petroleum oil which meets or exceeds every manufacturer's engine warranty requirements. In addition, this oil carries an American Petroleum Institute service classification SF-CC-CD.

There's No Risk with Our Money Back Guarantee

Use Slick 50 for 3000 miles. If you don't notice an improvement in engine performance, return your invoice with a short note telling why, for a prompt full refund — no questions asked.

Profit from Selling Slick 50 Yourself

Here's an opportunity to make handsome profits. Having such solid test results from major institutions make Slick 50 easier to sell than many other products. Free dealership information is sent upon request.

For purchase or further information call toll-free 1-800-525-8624, ext 8 (in California 1-800-233-9559) or send to: Progressive Energy Corporation, 255 South Bent Avenue, #B-1, Dept. PM887, San Marcos, California 92069.

Yes, I want to improve my car's performance and save my engine — rush me risk free

One Slick 50 at \$39.95 + \$4.00 shipping and handling. Calif. Residents add 6% Sales Tax.

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NEW/AUTO

Stand On It!

Remember how easy it was to work on that little MG Midget? You could just open up the bonnet and sit

down on the tire while you adjusted the valves. Quite a change from leaning and stretching to tinker with the

pickup truck. E-Z Mechanic Step I adjusts to fit over tires from 8 in. to 14 in. wide. The treated wooden slats are spaced to let the mud fall through. It collapses completely for storage and is easily portable for on-the-road maintenance. Sold direct for \$39.95 plus freight (check or money order only) from B&B Products, P.O. Box 244, Wampum, PA 16157, (412) 535-8840. Also available is E-Z Mechanic Step II for cab-over and stake trucks. It costs \$59.95 plus freight.



E-Z Mechanic Step I hooks over the top of your truck tire, giving you easier and safer access to your engine compartment.

Dial That Lash, Then Jam

Lashing valves can be a tough job, especially after the end of the valve stem gets worn and concave. Then the flat feeler gauge tells you that the clearance is correct, but your ear will prove that wrong after you start up the engine. A dial indicator is best, but how do you keep it on the valve retainer? Clamp Adjust-a-

Valve's locking pliers on the adjuster nut, loosen the nut, and then adjust the setscrew. Tip the locking pliers up and down to get a true value for the clearance, then tighten the nut. Adjust-a-Valve costs \$69.95 plus \$3.50 for shipping and handling. It's available from Hainline Development, P.O. Box 14960, San Luis Obispo, CA 93406, (805) 543-3242.



Adjust-a-Valve will take all the hit-or-miss out of valve adjusting by holding the jam nut while indicating clearance.

Electronic Hound Dog

Refrigerant leaks in automotive air-conditioning systems are tricky to find sometimes. Unlike refrigerators, the hoses and components all have seals and joints where Freon can sneak past slowly. It's a good idea to assume that any part that has been removed leaks. The \$82.50 (includes postage) PE 608 Automatic Leak Detector will sniff out even very small leaks. From Prestige Electronics, 23375 Dequindre, Hazel Park, MI 48030, (313) 545-1757.



The PE 608 will sniff out even the smallest Freon leaks.

Rust Never Sleeps



Clobber rust with 3M's Rust Avenger corrosion eraser.

Painting over rust just hides what's going on until it has eaten through the panel completely. Rust Avenger's formula, applied with this pen-shaped device, converts rust chemically into a paintable primer within a minute or two. Repeat the application, allow the area to dry for 45 minutes and proceed with painting. It's \$5 wherever 3M retail automotive products are sold.

Just A Little Pick-Me-Up

The \$5.99 Mini-Vac is small enough to fit in the palm of your hand, or better yet, in your car's glove compartment. If you're really messy, there's one that plugs into your cigaret lighter. It's made by Counterparts Automotive, P.O. Box 650, Glen Cove, NY 11542.



The battery-powered Mini-Vac helps you stay ahead of dirt.

Ouch!

Avoid the tell-tale signs of parking your car next to less than considerate people. DUR-GARD's magnetic bumpers offer 6 ft. of protection for each side of your car and stow in their own bag in the trunk. Order from Poly Protection, P.O. Box 813, Vernon, CT 06066, (203) 871-6762. They're \$29.95 plus \$3.50 shipping. **PM**



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All the specs, features and prices on 25 '87-'88 sport/utility vehicles.

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We pick the best of the newest feature-packed, specialized sport watches. And they tell time, too.



Garden Tractor Shootout

We compare five 16 to 18 hp tractors costing from \$3000 to \$8000. How hard do they work and which ones give the best value?



Machine Gun 2000

Line up the sights and squeeze the trigger of the M-249 squad automatic weapon—the newest shoulder-fired enemy tamer for the American foot soldier.

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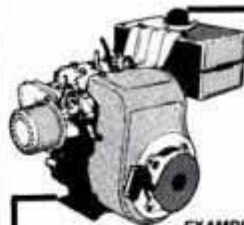
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**‘‘I‘M AN EASY GUY TO SATISFY.
I ONLY WANT THE BEST.’’**

**INTRODUCING SIERRA:
THE ULTIMATE PICKUP
FROM GMC TRUCK.**

You demand a lot of your possessions.

To fit your life, a vehicle must do more than simply fit in your driveway. Now there’s a new truck to meet your highest expectations — and exceed them: Sierra, the all-new full-size pickup from GMC Truck.

Full-size outside.

Sierra is clearly a new concept in pickup design. But it’s still a full-size pickup designed to do a full-size job. There’s a choice of 6½’ short-bed or 8’ long-bed models. And the long-bed can still accommodate a 4’ x 8’ sheet of plywood between the wheelhousings. Complementing the room is a big choice of powerplants. The amazing 4.3-liter Vortec V-6 engine is standard (except on 3500 models which feature a standard 5.7-liter V-8), or you can select from a wide choice of available V-8s, including a diesel. Thanks to electronic fuel injection, standard on every gasoline engine, Sierra offers instant starting response and outstanding over-the-road performance

— all the power you need for full-size jobs, like towing. When properly equipped, Sierra can move up to 19,000 lbs, including itself, passengers, trailer, equipment and cargo.

Yet, with the available five-speed manual overdrive transmission and Vortec engine, a two-wheel-drive Sierra is rated at a thrifty EPA estimated MPG city 17 and highway 23.

Full-size inside.

There’s room for three adults inside Sierra’s handsomely appointed interior, and even more shoulder and leg room than previous full-size pickups from GMC Truck. And Sierra’s advanced aerodynamics help enhance its quiet, comfortable ride.

Built to be driven.

Sierra features a new independent torsion bar front suspension on 4 x 4 models, and a newly improved two-wheel-drive front suspension. And there’s a new standard rear-wheel anti-lock brake system (operable only in the two-wheel-drive mode on four-wheel-drive models). The Insta-Trac system on four-wheel-drive models allows convenient shifting from two-wheel to four-wheel drive without stopping. When you take the wheel of the new Sierra, you’ll be driving a full-size pickup with handling as advanced as its looks.

And Sierra has a warranty to match. Every new Sierra has a 6-year/60,000-mile warranty on the powertrain and a 6-year/100,000-mile warranty on outer-body rust-through. See your GMC Truck dealer for the terms and conditions of this



limited warranty.

Built to pass your toughest test.

If you’re satisfied with only the best in life, buckle up and visit your GMC Truck dealer. (You’ll find a listing in the Yellow Pages, under “Truck” or “Automobile.”)

See the new Sierra for yourself. It’s everything you expect from a GMC truck. And like nothing you’ve ever expected in a full-size pickup.

Unless, of course, you expect only the best.

GMC TRUCK
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ANYMORE.**

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PM's LONG-TERM TEST REPORTS



At the conclusion of our last installment (page 78, July '87), we had returned our Taurus wagon and Delta 88, given away our Nissan Hardbody pickup in a contest, and were virtually wheel-less. But Motown has come to our rescue in a big way with three new, high-tech models: Corvette's brand-new convertible, Chrysler's low-buck hot-rod Dodge Shadow Turbo, and Ford's first 4-wheel-drive sedan for the U.S. market. Each is satisfying in its own special way, although each one did have

CORVETTE ROADSTER
Happiness is going topless.

DODGE SHADOW TURBO
Can we torque?

FORD TEMPO 4WD
All-wheel drive
hits the road.

some minor teething problems. Their performance runs the gamut from torrid to tepid.

1987 Corvette

As soon as the Corvette convertible (or Roadster, for you purists) was announced, we asked Chevrolet to supply one to us for a long term test. Our Firsthand Drive Report (page 74, Feb '86) seemed only to whet our appetite for more. We had reported on a 1985 Corvette coupe over an 11,000-mile period and it seemed most appropriate that

LONG-TERM TESTS

we now sample the open-air version of one of our favorite cars.

It took over a year and a half for Chevrolet to honor our request for a long-term test car, so popular has been the convertible with buyers, and so limited the production of the ragtop Corvette (only 7315 out of 35,109 Corvettes sold in 1986).

But now we have the car and it was delivered almost exactly as we ordered it. We asked Chevrolet to build one for us in black with a black softtop and graphite interior. Options we asked for included leather seats, automatic transmission, Delco-Bose premium stereo system, power everything and all the amenities known to man.

One thing we did ask for that was not on our test car was the optional 3.07 performance axle ratio. Someone on the Bowling Green assembly line forgot to include it, so we have the standard 2.73 axle ratio in the car. Total sticker price was a cool \$36,125.

When we picked up the car in Detroit, Michigan, it had been left out on a February night and was covered with ice. It started immediately even while looking frozen and a little forlorn. We immediately began the drive back to New York City. The car had 906 miles on it.

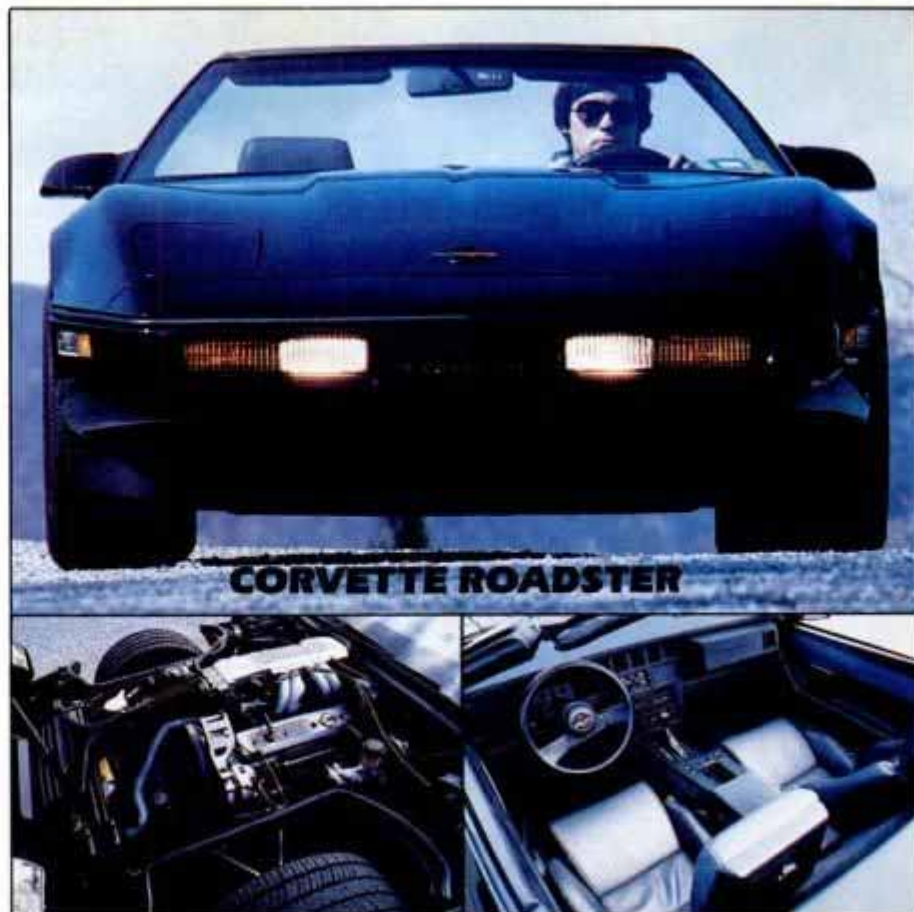
By the time we hit Interstate 80 and headed east out of Michigan, three things were already clear. First, the suspension on the convertible was a lot softer than the suspension we had on our last test Corvette. Second, this car was a lot quicker in acceleration compared to the last one. It's real easy to get speeding tickets in this car. Third, the Corvette gets terrific fuel mileage for a high-performance sports car.

First, the suspension. Our '85 test car had the base (soft) suspension with the optional Bilstein shock absorbers. Despite the relatively soft springs, the Bilstein shocks gave our '85 coupe a very firm ride and some harshness and unpleasantness around town on rough city streets. But the car had extremely stable handling at speed. The convertible can't be fitted with any optional suspension parts at the factory. You must take what the Corvette engineering staff gives you.

Frankly, we think the car is tuned for too soft a ride at the expense of some stability at higher speeds.

Second, the acceleration. It's strong. Real strong. In fact, this car is substantially quicker than the last Corvette we tested and one of the quickest cars we've ever tested.

The only engine change since '85 has been to go to roller lifters in the 350-cu.-in. V8 for less internal friction. The horsepower rating of the engine was



Topless Vette is the only way to go in the summer. The 350 V8 has a potent 240 hp for '87, making it one of the fastest cars we've tested. Interior is soft, luxurious gray leather.

kicked up accordingly, to 240 from 230 in '85, still at 4000 rpm. Torque is rated 345 lb.-ft. at 3200 rpm. So despite a slightly higher weight for the convertible compared to the coupe (extra chassis bracing is added to maintain torsional rigidity when the roof is cut off), our convertible test car ran like the wind. At Raceway Park in Englishtown, New Jersey, we ran off quarter-mile elapsed times of 14.17, 14.20, 14.15, 14.11, 14.10, 14.09 and, finally after a long cool-down period, 13.96 seconds. Our best speed in the quarter mile was 96.14 mph.

Just to put these times in perspective, when we did our muscled car shoot-out in the November 1985 issue (page 76), the best elapsed time for the quarter mile was a run of 13.93 seconds. That was from a 1970 Oldsmobile W30 442 with a 455-cu.-in. engine. You can see how much progress Detroit has made in 17 years.

The third thing we found out very quickly is the outstanding fuel mileage of this Corvette. On the 700-mile trip from Detroit to New York, we averaged 24.2 mpg despite cruising speeds that ranged up to 90 mph for some stretches.

So far, in about 2000 miles of driving, our overall average is 18.2 mpg. For a sports car with the capability of going 150 mph, that is fantastic. Technology

is a wonderful thing. It allows you to have your cake and eat it too.

Speaking of speed, the Ohio State Police were just as interested in our test car as we were. No sooner had we hit I-80 over the Ohio border than one of their representatives asked us to pull over for a thorough inspection of the vehicle. In fact, he thought our test car warranted a special citation for outstanding over-the-road performance.

One other change from our '85 test car is the incorporation (in 1986) of an antilock brake system. One of the on-board computers senses if the wheels are about to lock up in a hard-braking situation and automatically modulates the pressure on the brakes up to 15 times per second to prevent lockup and loss of control. So far, we haven't needed to use the system, but it's nice to know it's there.—J.O.

Dodge Shadow

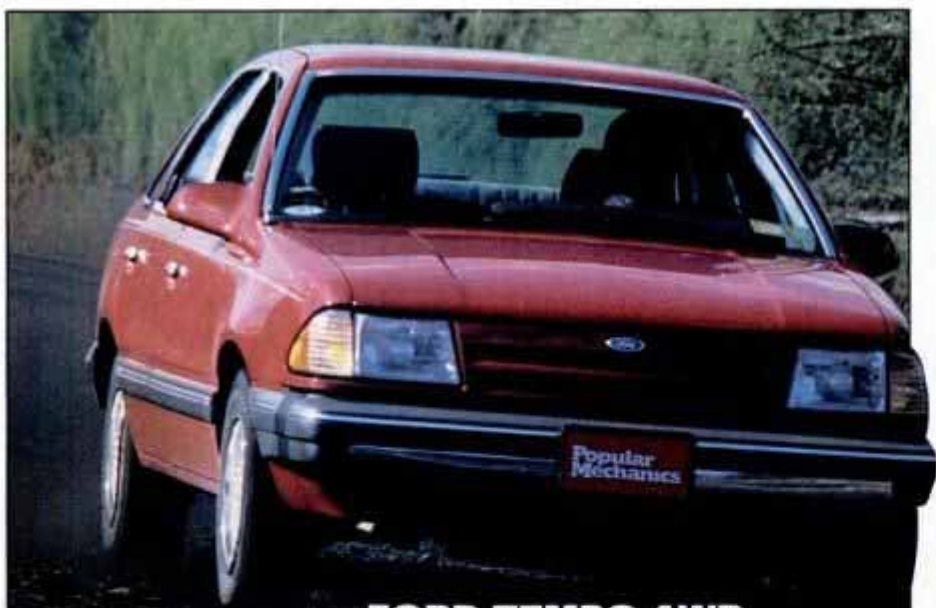
Chrysler Corp.'s seemingly infinite variations on the 10-year-old K-car theme somehow manage to produce vehicles that are startlingly different in character. The Turbo Shadow is its latest street racer, our extremely red test car being quick and nimble, at least on smooth pavement. Shod with P205/50VR15 Goodyear gatorbacks on very attractive alloy wheels, it has the spring rates to match, giving it excel-



**DODGE
SHADOW TURBO**



Dodge Shadow ES Turbo is a bargain-basement hot rod with lots of performance but unsettling handling. Turbo 2.2-liter Four makes 146 hp. Driver's seat now creaks.



FORD TEMPO 4WD



Tempo is the latest small sedan to offer a 4x4 option for use when roads are slick. On dry pavement, 94-hp Tempo is tepid. Driver's seat upholstery is puckering on our test car.

lent cornering response to match the port-injected 2.2-liter turbo motor. Unfortunately, the damping rates aren't up to the stiff spring rates, necessitating smooth, careful entry to corners. The motor, in spite of its faintly agricultural idle, is ample to spin the tires easily in first and delivers its power over a wide powerband, with 146 hp at 4200 rpm and 170 lb.-ft. of torque at 3600 rpm. This means that downshifting for passing or hills becomes more a matter of taste than necessity.

On any but the smoothest roads, the suspension is simply inadequate, hopping from the top of one bump to the next with no directional stability. And if you've got your foot into the turbo, watch out!

On glass-smooth roads, however, there's still that taut jiggle to the suspension, which seems quite in character with the boy-racer character of the car. The light steering does help to keep your thumbs attached to your hands when accelerating over bumps, but the tradeoff is little or no road feel and steering so quick as to be almost darty.

The base Shadow 2-door liftback starts at a very reasonable \$7499. The Shadow ES turbo package adds \$1791. A sunroof, tinted glass, a/c and a \$244 premium sound system brought our total up to \$11,181.

Within the first 3550 miles, our Shadow developed a mildly balky shifter, causing us to sometimes get Neutral or Fourth when shifting down from Third; a broken window winder handle that can be blamed on parking attendants climbing in and out of the window in packed Manhattan garages; and a major coolant leak at the turbocharger. It also gave between 15 to 18 mpg in commuter service, about 21 on the freeway, and used only half a quart of oil.—M.A.

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FOUR- WHEELING INTO YOUR FUTURE

All-wheel drive has come a long way from trucks to racing cars. Your car may be next.

BY JOHN RETTIE

All-wheel drive has finally come to race cars. The usual route for radically advanced automotive technology is from race cars to high-tech sports cars to everyday sedans.

But in the case of 4-wheel drive, the progress has been just the opposite, from pickup trucks and Jeeps to the AMC Eagle to the Audi Quattro to World Cup rally cars. But now that the glam-

our of international racing has masked 4-wheel drive's humble agricultural beginnings, it's fast becoming the hot setup for a new generation of road cars from Porsches to Subarus.

The rumors began in 1979. Audi, then producing conservative sedans, was planning to introduce an exciting new 4wd sports sedan. The German company was also going to enter the car in the tough competition of international rallying, though 4wd had never been competitive

in any form of motorsport.

At first, nobody really believed the rumors. Many companies had experimented with 4wd race and rally cars. Ford, in particular, had tried rallying 4wd Capris in 1971 with little success. Innovative Lotus, too, had no success when it tried 4wd on the race track, in the famous STP turbine cars at Indy and in its Formula 1 racers.

Audi introduced its Quattro in March 1980. Although essentially a straightforward, permanent 4wd car, little different in theory from a Jeep or a Toyota Land Cruiser, the Quattro's major breakthrough was its use of standard components from the regular front-drive sedan. Instead of using a heavy transfer case, the drive to the rear wheels was taken out of the regular gearbox through the center of a hollow main shaft (see *Driving The Audi 4000S Quattro*, page 101, Apr. '84).

This cut down transmission losses and kept ground clearance the same as that of the standard sedan. Audi discovered there was no loss in performance



New 4wd entry, Ford Tempo, has part-time system with 50-50 torque split.



Porsche's 200-mph 959 uses a complex, computerized system to vary torque split between front and rear depending on traction.

or fuel consumption, and the gain was improved adhesion under adverse conditions and better handling at all times.

In its first few rallies, the Quattro, driven by the Finnish ace Hannu Mikola, immediately proved to be faster than any competing car. Since then, the Quattro has spawned a raft of wild rally cars with 4wd. Most successful has been the Peugeot 205 Turbo 16, an all-out race car bearing no resemblance—other than side profile—to the road-going Peugeot 205 hatchback. The rally car has a turbocharged 4-cylinder engine of nearly 400 hp mounted transversely amidships and driving all four wheels via a drivetrain that is unique in the way power is transmitted. Instead of half the power going to each end, a planetary gearset splits the torque so that a third goes to the front wheels and two-thirds to the rear. Instead of manual mechanical differential locks, the Peugeot has automatic viscous couplings.

Audi's success, and then Peugeot's, spurred other companies into producing 4wd rally cars,

including Ford's RS 200, the Lancia Delta S4, Opel Kadett Rally, Porsche 959, Citroën BX14 and MG Metro 6R4. All use a power split biased toward the rear, though with different configurations. This hairy Group B class was dropped from international rallying last year following several horrendous accidents and unfortunate spectator deaths along the poorly policed rally routes. But 4wd monsters had proven a point: 4wd had been a dud on the racetrack, but was an overwhelming success on the real-world roads used in rallying.

50/50 split

The Audi Quattro, AMC Eagle, several models of Subaru, Ford Tempo, Colt Vista, Honda Civic Wagon, Toyota Tercel, and the vast majority of 4wd vehicles now for sale have a system that splits the engine's torque so that 50 percent of the power goes to the rear wheels and 50 percent to the front. For the sake of argument, we can call this the first generation of 4wd vehicles. Some vehicles in this category have manual differential locks.

In the Quattro, there are two such differentials—one for



Audi Quattro 4wd system, meant for full-time use, also has 50-50 split.

PORSCHE PHOTO BY JEFFREY R. ZWART

VOLKSWAGEN OF AMERICA

4-WHEELING INTO YOUR FUTURE

the drive between front and rear and one for the rear axle. In extremely slippery conditions, the driver has to pull a knob on the dashboard in order to lock the differentials for maximum grip. In the latest version of the Audi 4000 Quattro, which goes on sale later this year, the center differential has been replaced by a Torsen limited-slip design, which locks automatically.

34/66 split

Ford was the second company to produce road-going 4wd sports sedans with the introduction of the Sierra and Scorpio XR4x4 in Europe. Their 4wd system, however, differs in many areas from the Quattro. For a start, the torque is split 34 percent to the front wheels and 66 percent to the rear.

According to Ford this gives handling with a strong rear-drive bias, which many sporting drivers prefer.

Audi, on the other hand, says its 50/50 split is better, as it provides a car with some understeer, similar to that of a front-drive car, which is generally considered safer for most drivers. The choice becomes a matter of individual preference—average drivers tend to prefer some understeer, sporty drivers often like more neutral handling.

'Honey can' differentials

It's the differentials that make the European Fords significantly different from the Quattro. Like most rally cars, the Ford system uses viscous couplings instead of manually lockable mechanical differentials. A viscous coupling, known as a VC, is a simple sealed, can-shaped unit.

The outer case is attached to one

driveshaft. The other driveshaft passes through the opposite end of the unit. Inside there are many thin interleaving metal discs, half of which are attached to the inside of the case and the other half to the inner shaft. The discs do not touch and the two halves of the unit can rotate independently.

The inside of the unit is filled with a viscous silicone fluid with the consistency of honey. When one shaft starts to rotate at a different speed from the other, the thick fluid shears and the resulting increase in friction between the plates causes the unit to lock up, halting the speed differential between the two shafts. In effect, it is a hydraulic limited-slip differential instead of a mechanical one. The beauty of the VC is that it doesn't need any driver input—it works completely automatically and also acts as a shock absorber, cushioning transmission components and tires from wear.

These ingenious VC units have been around for many years. The idea of a viscous coupling was actually invented by an American in 1917, but it was too far ahead of its time and the idea never caught on.

In 1970, it was re-invented by an engineer at an English company, now known as FF Developments, that had been involved in 4wd for many years.

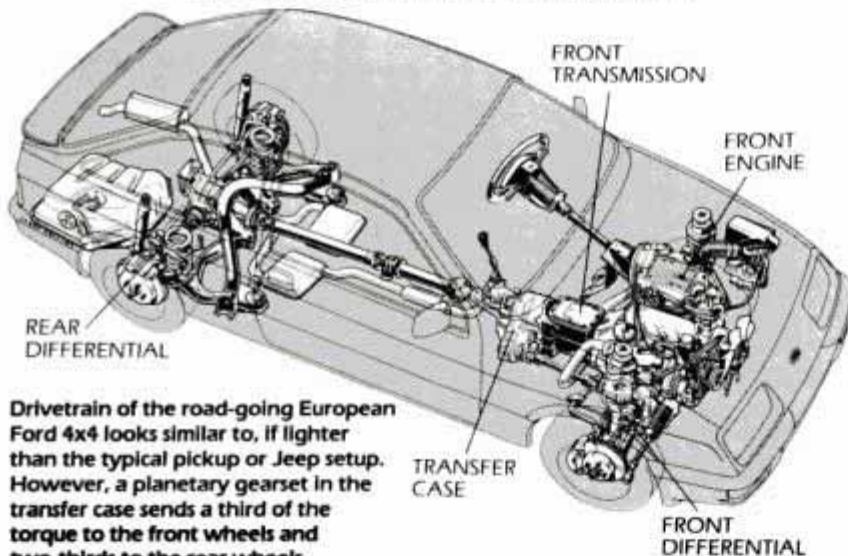
In 1960, FF developed the "Formula Ferguson" concept of 4wd with the 34/66 percent power split ratio now being so widely adopted. This Formula Ferguson was tried in many race cars, including Andy Granatelli's famous turbine-powered Indy cars. The best road car to utilize the FF 4wd system was the Jensen FF sports sedan, produced in small quantities between 1966 and 1971. This Chrysler V8-powered British car also had antiskid brakes, so it was far ahead of its time. With the development of the VC, the FF system improved still further. The first production car to use the complete FF system, including the VC, was the AMC Eagle in 1979. The first U.S. 4wd sports sedan is being developed by FF for a Detroit automaker and will be introduced later this year.

Torsen differential

For several years, the Gleason Co. in New York has sold the Torsen differential, which produces much the same effect as a viscous coupling. When a wheel starts to slip, torque is automatically transferred to the one with the grip. Audi has replaced the manually locked center differential in the latest Audi 4000 Quattro with a Torsen differential. This allows continuous operation of ABS braking at all times, and the driver doesn't have to manually lock the center differential.

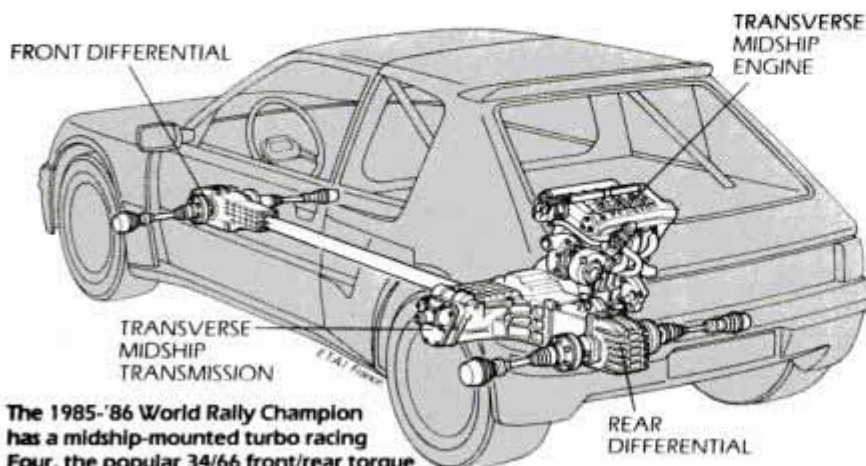
(Please turn to page 98)

FORD SIERRA XR4x4



Drivetrain of the road-going European Ford 4x4 looks similar to, if lighter than the typical pickup or Jeep setup. However, a planetary gearset in the transfer case sends a third of the torque to the front wheels and two-thirds to the rear wheels.

PEUGEOT 205 TURBO



The 1985-'86 World Rally Champion has a midship-mounted turbo racing Four, the popular 34/66 front/rear torque split and two FF viscous couplings that act like limited-slip differentials.

— PM OWNERS REPORTS —

ASK THE MAN WHO OWNS ONE



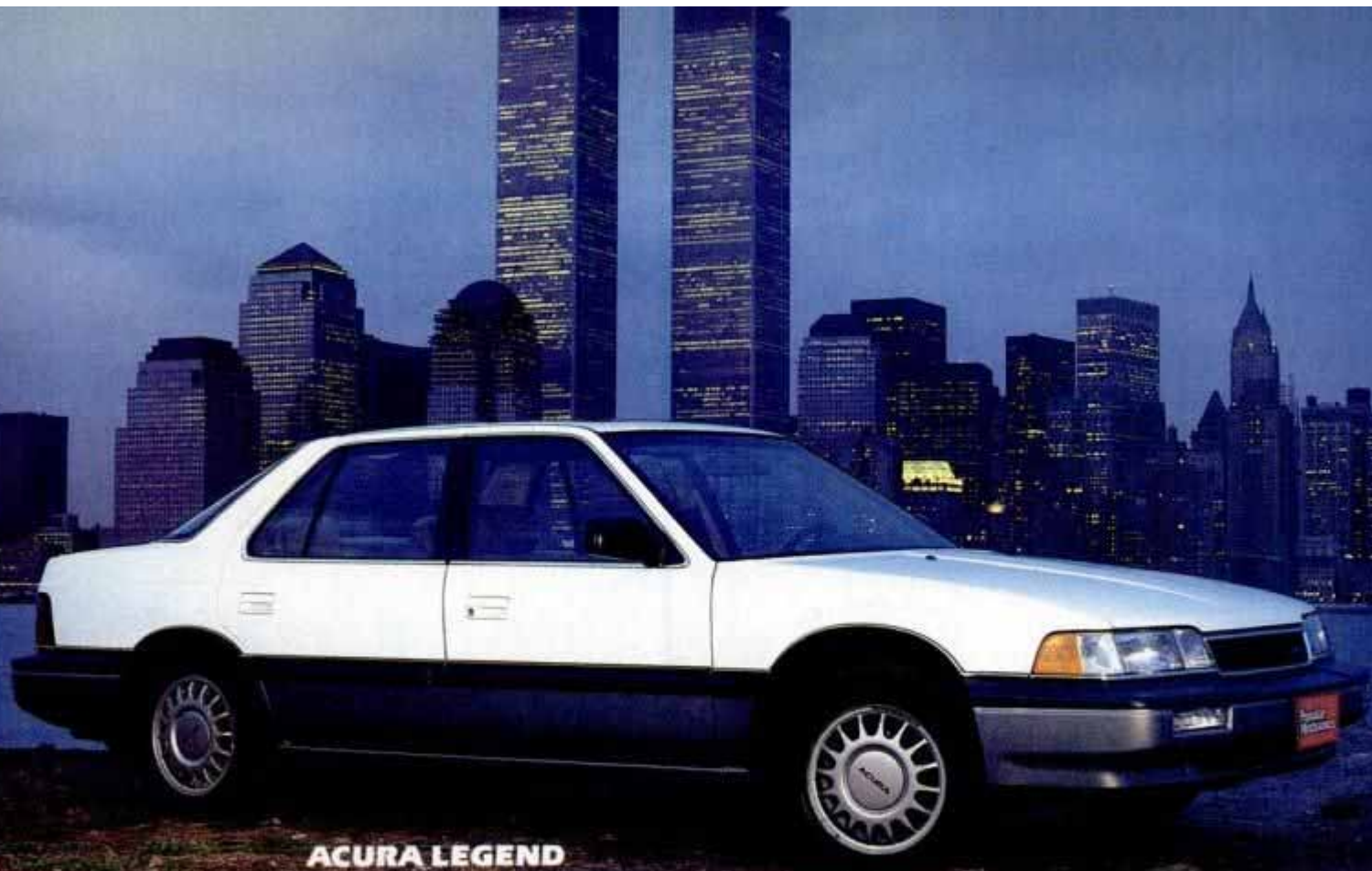
What do all these car owners have in common?
They told all to PM.

BY MICHAEL LAMM, Contributing Editor

Miles driven by their owners: 4,204,500. That's the total taken from the odometers of these cars at the time we surveyed the drivers. Here's what they discovered while logging those miles.

BUICK RIVIERA
DODGE SHADOW
PLYMOUTH SUNDANCE
ACURA LEGEND

Buick Riviera
Buick totally redid the Riviera for 1986, and a lot of traditional Riv buyers aren't thrilled with the results. We noted two basic reactions to the new Riviera: Younger owners generally liked the



ACURA LEGEND

car's high-tech aspects while older buyers didn't. Consider, for example, the Riviera's Graphic Control Center (GCC), an interactive touchscreen video display in the middle of the instrument panel. Basically, older drivers didn't much care for the GCC while younger ones thought it was just great.

A retired Californian, aged 71, said: "The Graphic Control Center has great possibilities as a toy or to keep the kiddies occupied, but it's not really practical. Not only do you have to take your eyes off the road to work it, but if you hit the wrong spot on the screen, anything can happen." But a 39-year-old Arkansas school teacher added, "The diagnostic feature of the GCC is most helpful. It's the first time I can be sure the mechanic isn't feeding me a lot of hokey."

Older people—those 50 and over—made up the majority of Riviera buyers in our survey (52.7 percent). But because Buick is trying hard to appeal to a younger crowd, the touchscreen—along with other high-tech engineering features—are calculated to sell the car to younger drivers who feel comfortable with high technology and computers.

So traditional Riviera purchasers (and 36.4 percent in our sampling had owned Rivs before) told us they felt left out. Overall, 46 percent of our respondents loved the car's styling, and 53.2 percent bought the Riviera mainly for that reason. Others, though, agreed



Legend owners thought their Honda clones were well worth the money—100 percent rated workmanship good to excellent. A few found the automatic jerky, the V6 weak.

with a gentleman from Michigan, who emphasized: "Too small. They've tried to make it into a sports car."

Well, that's precisely one of the qualities younger owners liked about their Rivs. A Wisconsin salesman observed, "I admire the way it handles and hugs the road. It corners much like our Corvette."

On the topic of comfort, a Florida hospital administrator told us, "Drove from Florida to Arizona, 2500 miles, in 48 hours with no discomfort in back or legs. Now that's good seating! Very quiet, too." An Illinois electrician: "Doesn't have that boaty ride of the larger cars. The T Type suspension is tight and hard, which I like."

As for quality and workmanship, the overall opinion was extremely favorable. No fewer than 52.4 percent rated the Riviera's workmanship excellent, with another 35.9 percent giving it a mark of good.

Dealer sales and service departments likewise rated high in Riviera

owners' opinions. We heard very few complaints about dealers' sales policies and, in fact, many owners pointed out that Buick's sales personnel went out of their way to help them master the Riv's touchscreen.

Of assorted mild annoyances, a Minnesota manager pointed out, placement of the ashtray toward the rear of the console makes it impossible to use (9.6 percent concurred). And the beeping turn signals can be "irritating waiting at traffic lights." An Illinois bus driver added: "When I open the doors, the hidden gutters let snow and rain drip down on the seats."

But despite minor grumblings, most Riviera owners heaped unrestrained praise on their cars. An Ohio teller told us, "This 1986 Riviera is by far the best example of the marque that I've owned, and I've owned the 1982, '83 and '84 models." A West Virginia office manager: "I believe the 1986 Riviera was changed with the career woman in mind. It's no longer a family car. It's

BUICK RIVIERA OWNERS REPORT

Total miles driven	1,195,578	Specific dislikes:		Average	4.5	Average	14.8
Average miles per gallon:		No complaints	12.6%	Poor	1.4	Poor	5.3
In town	18.9	Not enough styling distinction	10.0	Rear seats:		Number of vehicles owned:	
On the highway	26.2	Ashtray location	9.6	Excellent	38.8%	This car only	29.4%
Series choices:		Quality of materials	7.8	Good	43.5	Two cars	44.4
Riviera (standard)	79.1%	Comfort (harsh ride)	7.8	Average	14.2	Three cars	14.0
Riviera T Type	20.9	Size (trunk & rear seat too small)	7.8	Poor	3.5	Four or more cars	12.2
Major accessories & options:		What changes would you like?		Had any mechanical trouble?		Makes of other cars owned:	
Performance package	48.6%	No changes	23.0%	Yes	52.5%	Buick	36.6%
Theft deterrent system	29.3	More distinctive styling	10.1	No	47.5	Chevrolet	33.7
Electric sunroof	16.0	Relocate ashtray	8.5	What type of trouble?		Pontiac	15.3
Why did you choose the Riviera?		Larger size	5.2	Electrical	24.3%	Ford	13.4
Styling	53.2%	Better workmanship	4.8	Transmission	12.2	Oldsmobile	10.9
Past experience	36.4	Less plastic	4.4	Computer electronics	11.5	Would you buy a Riviera again?	
Computerized systems	12.3	How much did you pay?		Air conditioner	8.8	Yes	63.3%
Performance	11.2	Average	\$21,565	Fuel-injection system	8.1	No	11.0
Handling	9.3	Range	\$17,600-\$25,000	Did you repair it yourself?		Maybe	25.6
Specific likes:		Workmanship opinion:		No	95.9%	Would you buy Buick again?	
Styling	46.0%	Excellent	52.4%	Yes	4.1	Yes	67.9%
Handling	42.2	Good	35.9	Dealer repairs satisfactory?		No	25.1
Ride	33.1	Average	10.3	Yes	68.4%	Maybe	7.0
Comfort	32.3	Poor	1.5	No	31.6	Age distribution of owners:	
Performance	26.2	Comfort opinion:		Dealer service opinion:		Under 29 years	5.3%
Computer systems	24.0	Front seats:		Excellent	40.2%	30-49	42.1
Digital instrument panel	21.7	Excellent	67.8%	Good	39.8	50-plus	52.7
		Good	26.2				

DODGE SHADOW/PLYMOUTH SUNDANCE OWNERS REPORT

Total miles driven	1,312,562	Price	37.6	Average	2.4	Dealer service opinion:	
Average miles per gallon:		Size	19.6	Poor	0.8	Excellent	41.5%
With EFI & 5-speed manual:		Handling	12.9	Comfort opinion:		Good	40.4%
In town	23.8	Warranty	10.6	Front seats:		Average	10.1
On the highway	30.1	Specific likes:		Excellent	55.0%	Poor	8.0
& automatic transaxle:		Styling	51.4%	Good	41.6	Number of vehicles owned:	
In town	23.3	Handling	47.0	Average	2.3	This car only	38.3%
On the highway	28.9	Comfort	29.9	Poor	1.1	Two cars	35.6
With turbo & 5-speed manual:		Economy/fuel mileage	27.1	Rear seats:		Three cars	16.7
In town	21.8	Ride	23.1	Excellent	17.1%	Four or more cars	9.6
On the highway	28.2	Specific dislikes:		Good	48.0	Makes of other cars owned:	
& automatic transaxle:		No complaints	15.1%	Average	29.3	Dodge	25.5%
In town	20.8	Not enough rear legroom	10.8	Poor	5.7	Chevrolet	22.4
On the highway	25.8	Poor comfort in rear seat	8.5	Had any mechanical trouble?		Plymouth	18.6
Engine choices:		Not enough horsepower	6.6	No	64.8%	Chrysler	12.4
EFI 2.2-liter Four	70.1%	Poor fuel mileage	6.1	Yes	35.2	Oldsmobile	10.6
Turbo 2.2-liter Four	29.9	What changes would you like?		What type of trouble?		Would you buy this car again?	
Transmission choices:		No changes	24.1%	Electrical	28.6%	Yes	66.7%
Automatic	80.3%	More rear-seat room	8.6	Induction system	14.3	No	7.4
5-speed manual	19.7	More rear-seat comfort	5.5	Wipers	11.0	Maybe	25.0
Series choices:		Less firm seats	5.5	Starter switch	7.7	Would you buy Chrysler again?	
Dodge Shadow	56.1%	Less road noise	4.5	Speedometer/Heater	6.6	Yes	78.6%
Plymouth Sundance	43.9	How much did you pay?		Did you repair it yourself?		No	18.7
Body-style choices:		Average	\$9896	No	88.0%	Maybe	2.7
4-door sedan	99.2%	Range	\$7500-\$13,000	Yes	12.0	Age distribution of owners:	
2-door coupe	0.8	Workmanship opinion:		Dealer repairs satisfactory?		Under 29 years	24.2%
Why did you choose this model?		Excellent	53.5%	Yes	77.8%	30-49	39.3
Styling	64.7%	Good	43.3	No	22.2	50-plus	36.5

ACURA LEGEND OWNERS REPORT

Total miles driven	1,696,360	Specific dislikes:		Average	4.5	Poor	2.8
Average miles per gallon:		No complaints	17.7%	Poor	1.0	Number of vehicles owned:	
With 5-speed manual transmission:		Not enough headroom	12.3	Rear seats:		This car only	17.8%
In town	21.0	Rough shifting (automatic)	7.3	Excellent	65.5%	Two cars	43.8
On the highway	24.9	Hard to shift (manual)	6.2	Good	32.6	Three cars	25.7
With 4-speed automatic:		Wind noise at speed	5.0	Average	1.6	Four or more cars	12.7
In town	19.7	What changes would you like?		Poor	0.3	Makes of other cars owned:	
On the highway	24.8	No changes	17.0%	Had any mechanical trouble?		Honda	35.5%
Transmission choices:		Power-seats**	12.8	No	82.4%	Chevrolet	13.9
4-speed automatic	78.9%	More headroom	10.8	Yes	17.6	Ford	11.6
5-speed manual	21.1	Leather upholstery**	8.7	What type of trouble?		Nissan	10.8
Why did you choose the Acura Legend?		Better braking	4.9	Induction system	11.1%	Toyota	10.0
Styling	36.9%	More horsepower**	4.9	Shifting	11.1	Would you buy a Legend again?	
Reputation	31.5	Tilt steering wheel option	4.9	Electrical/Transmission	9.3	Yes	84.2%
Performance	24.7	How much did you pay?		Did you repair it yourself?		No	0.6
Handling	17.9	Average	\$19,490	No	98.2%	Maybe	15.1
Quality	16.9	Range	\$17,000-\$23,059	Yes	1.8	Would you buy Honda/Acura again?	
Price	16.6	Workmanship opinion:		Dealer repairs satisfactory?		Yes	76.0%
Specific likes:		Excellent	86.0%	Yes	76.7%	No	2.7
Handling	46.1%	Good	14.0	No	23.3	Maybe	21.3
Performance	37.5	Average/Poor	0.0	Dealer service opinion:		Age distribution of owners:	
Styling	36.9	Comfort opinion:		Excellent	64.2%	Under 29 years	2.0%
Comfort	35.8	Front seats:		Good	28.5	30-49	49.8
Ride	31.1	Excellent	66.9%	Average	4.5	50-plus	48.4
		Good	27.7				

*Percentages might not equal 100% due to rounding or an insufficient amount of data.

**Not offered in 1986 but available for 1987.

PM OWNERS' REPORT

stylish and impressive and definitely not for everyone. It's so smooth and quiet out on the road that I find myself going 70-75 mph without realizing it!"

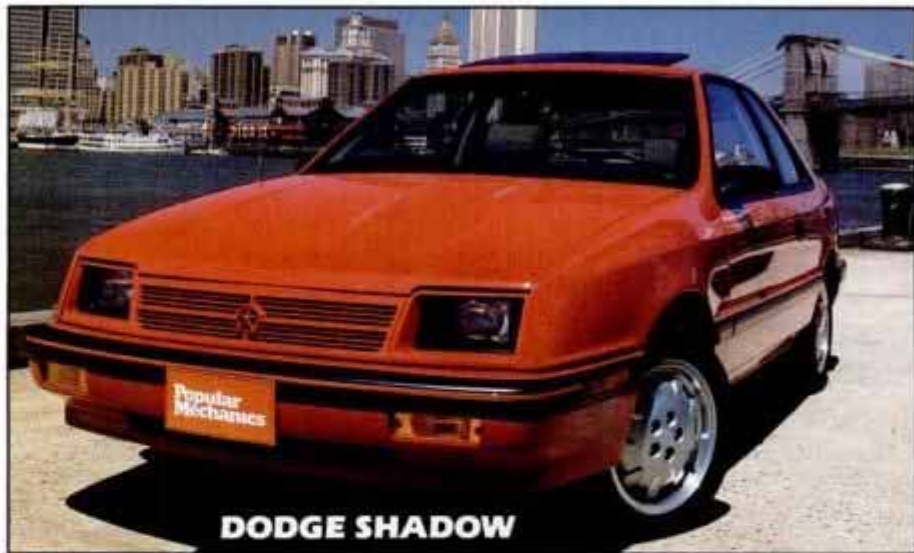
And with the Graphic Control Center in mind, a New York salesman proclaimed, "The 1986 Riviera is the car of the future!"

Sundance/Shadow

A California business manager told us he viewed his Plymouth Sundance as "an affordable, slightly smaller version of the LeBaron GTS." In a lot of ways—appearance, mechanicals and overall flavor—that's exactly what Chrysler's new subcompact turns out to be.

It unashamedly borrows the H-Car's styling and uses the same fwd 2.2 engine/transaxle combos, including the Turbo as an option, and uses the Dodge Daytona's 97-in.-wheelbase floorpan. Chrysler originally conceived the Sundance/Shadow twins as replacements for the corporation's aging Omni/Horizon price leaders. It became clear that the low end of the auto market would be getting more and more crowded by Yugos, Hyundais, Sprints, Justys and so on, so MoPar planners wisely decided to kick the P-Car upstairs and into contention with GM's J-Cars and FoMoCo's Tempo/Topaz.

At that time, Chrysler added such standard touches to the P-Cars as deluxe interiors, AM/FM ETR radios, power steering, styled steel wheels, front and rear stabilizer bars, wider than normal tires, and remote outside



DODGE SHADOW

Sundance/Shadow owners were impressed by the performance per dollar of their cars.

mirrors. Options include a Shadow ES package with, among many other items, 6 x 15-in. alloy wheels and P205/50VR-15 tires. Chrysler then pegged the Shadow's base price at \$7499 (and \$7599 for the Sundance versus \$7255 for the cheapest Cavalier or \$7338 for the least expensive Tempo) and sent it out to dealers.

By now, according to the owners we surveyed, the evidence strongly suggests that Mr. Iacocca did it right again. "It's been a long time," beamed a California salesman, "since I've bought a car that's this much fun to drive, and I've owned more than 50."

As with the LeBaron GTS/Lancer, workmanship and overall quality of the Sundance/Shadow brought out some of the best marks we've registered re-

cently for a U.S. car. In all, 53.5 percent rated workmanship *excellent*, with another 43.3 giving it a score of *good*. That's up there in Japanese territory. Part of the reason for so few new-model teething problems comes with all that off-the-shelf hardware.

When glitches did occur, 28.6 percent tended to be electrical, but these were often just minor annoyances like blown fuses. Nearly everyone praised the P-Car's interior roominess. An Illinois housewife: "The Sundance has an unbelievable amount of cargo space. We brought home our Christmas tree in it; also put nine boxes of stereo components inside, including two large speakers. It's become our family workhorse, yet outside, it's a classy little sedan."

A majority of buyers (64.7 percent) listed styling as the car's main attraction, and an Alabama payment analyst confided, "What sold me on the Sundance was a combination of sleek sport-sedan looks plus the hatch with split folding rear seats and all that room!"

Performance and handling also came in for high praise. "Lots of get-up-and-go," noted a Colorado housewife. "I really didn't expect this much zip from a 4-cylinder engine."

"It's a small car without the small-car ride," observed an Alabama clergyman, and a California retiree added, "Excellent steering response. The car resists being blown around by heavy sidewinds and large trucks. Great traction on ice thanks to the front drive."

Yet some Shadow owners felt that the Shadow's ES suspension tended to be harsher than they were used to, with not enough rear-wheel travel. A California manager wasn't alone in noticing that "the suspension, while firm, bottoms out too easily." The bottoming occurred mostly on very rough roads.

In judging seating comfort, owners reported that the front buckets felt

(Please turn to page 91)



BUICK RIVIERA

Riviera owners were split into two camps. Younger buyers appreciated the car's performance and high-tech CRT; older buyers said new Riv was too small. Seats pleased most.

LATE BLOOMERS



VOLKSWAGEN FOX

New-car introduction time used to be confined to the fall, with imports out in early winter. Then came mid-year intros, and today it's every company for itself, with new models popping up all through the year.

Here are the latest.

VW Fox

Rushing headlong into one of the most hotly contested segments in the automotive world, Volkswagen is challenging the other under-\$7000 cars with its German-engineered, Brazilian-built 2- and 4-door price-buster sedans and 2-door station wagon (see *Imports*, page 10). A close look at the Fox reveals another

Automakers save their best shots for mid-year introduction.

BY STEVE PARKER, West Coast Editor



Familiar 1.8-liter VW engine sits front-to-back under the Fox hood, rather than transversely.

incarnation of VW's ubiquitous 4-banger, driving the front wheels longitudinally, rather than transversely as in the Golf. The Bosch CIS injection gives 81 horses at 5500 rpm, good for a top speed of 99 mph. Acceleration from 0 to 60 took us 11.5 seconds, putting it ahead of most of the competition, except Ford's Festiva (see *Asian Invasion*, July '87, page 90). The 4-speed transmission, the only one available, is the same unit used on the VW Quantum, minus Fifth gear. No automatic transmission will be available in the foreseeable future.

Inside, the car is well laid out with lots of room for a subcompact. The interior is Teutonically clean and

LATE BLOOMERS

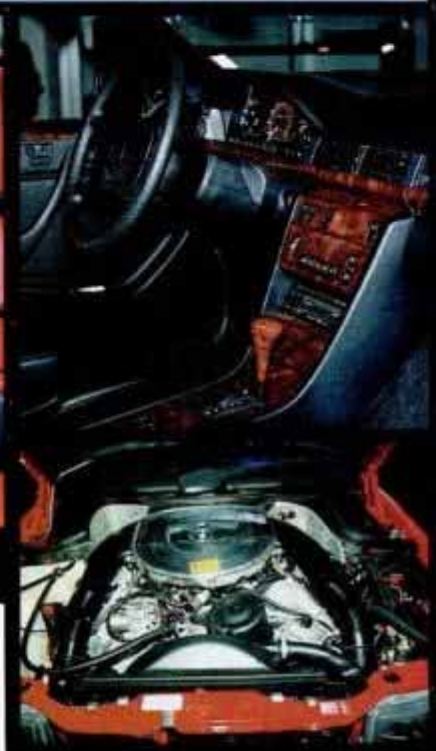
well planned, with nice touches like door pockets, full carpeting, and lights in the trunk and glovebox. The dashboard has large, readable analog gauges, with several of the controls on the binnacle surrounding them, although using these controls calls for very long fingers or removing your hand from the steering wheel. Interior ventilation is excellent, with heat and air conditioning vents placed to blow air to the front and rear of the car.

Fox GL versions come well-equipped, with the only options being air conditioning, metallic paint, radio and rear wiper for the wagon.

Acura Legend Coupe

Acura's Legend Coupe blurs the distinction between European and Japanese cars forever. It's the highest base-priced Asian import ever offered in this country (prices will range from \$22,000 to \$26,000). It's equipped with a complete list of features and options, from antilock brakes to driver's side airbag, which clearly puts it in the class of BMW and other European performance-oriented cars.

The Coupe is powered by a beefed-up version of Acura's 2.5-liter V6. The engine now displaces closer to 2.7 liters (2675 cc), thanks to increasing the bore by 3 mm, but still seems lacking in low-end torque.



Enlarged 2.7-liter version of the Honda V6 gives new Legend Coupe more power. Coupe roofline styling suggests that of several BMWs, the new Acura's target audience.

Twin-cam, 4-valve AMG cylinder heads help AMG to hammer out a stunning 375 hp.

The front suspension sports a double wishbone arrangement, mounted lower in the Coupe than in the Legend sedan. At the rear you'll find a fully independent double wishbone/trailing arm set-up. Gas-pressurized shocks all around and Michelin 60-series VR-rated tires help the Coupe through its paces.

The progressive power steering at higher speeds feels lighter than we would have liked, as it does in the Legend 4-door. The maximum assist available at low speeds should drop off more quickly as the car approaches highway cruising speeds.

Both a 5-speed manual and 4-speed automatic transmission are available, and Honda's ALB antilock brake system provides straight-track, skidless braking from even the highest speeds. Gauges are large and easy to read. Fingertip controls for important functions are simple to work.

Seating both front and rear is quite comfortable, soft without being too plush. There's enough stiffness in the



MERKUR SCORPIO



Enlarged 2.9-liter European Ford V6 needs more than 144 hp to move 3240 pounds of Scorpio. Extensive instrumentation and controls are a joy to use.

seating to remind you that you're in a sports car, and you won't have to see your chiropractor after a lengthy trip. The Legend Coupe is a fine attempt by Acura to create a Japanese niche in the expensive luxury performance market.

AMG Hammer

It's somehow heartening to know that wretched excess does indeed still exist in the automotive world. Germany's AMG started business in 1967 by offering aerodynamic bolt-ons for Mercedes matched to a car's paint scheme. This monochromatic look became what is now the most popular way worldwide to customize luxury sedans.

To create the Hammer, AMG takes the engine and drivetrain components from a large S-class Mercedes and stuffs them into the smaller, lighter 300E model. Thanks to the blueprinting, polishing and balancing of the aluminum engine, the powerplant can make full, efficient use of the AMG 4-valve heads. And with 32 valves, Bosch K-Jetronic fuel injection and chain-driven double-overhead cams, the Hammer is happy to stay at or near the redline all day long. The 5.6-liter V8 engine is massaged to produce 375 hp at 5500 rpm.

AMG has managed to keep the comfort factor in the handling equation. Gas

pressure front struts, rear tubular shocks, antiroll bars front and rear, and springs that lower the car 1½ in. provide not only a fine-handling high-speed tourer, but a sharp-looking one as well. Pirelli VR-rated 17-in. tires on color-keyed AMG wheels play a key role in the Hammer's handling ability.

The suspension is stiff enough to keep the 300E body flat and neutral during the hardest cornering. This is one vehicle that doesn't know the term body roll.

Acceleration is nothing short of head-snapping. We're talking about 0 to 60 in 5 seconds flat and a quarter mile at 107 mph in 13.5 seconds. You'll find zero in 165 ft. from 70 mph.

Remember that German drivers like their cars and their seats stiff. We can at least say that the Hammer is, at speed, as comfortable and as easy on your back and kidneys as any other Germanic high-performance touring sedan. Even at \$145,000, there are options. Be sure to specify the maple wood paneling, Recaro seats and leather-covered steering wheel.

Merkur Scorpio

Scorpio is a fine-handling, mediocre-powered sedan that will sell for between \$22,000 to \$26,000. It's built in Cologne, Germany to join the Merkur

as Lincoln-Mercury's second captive import sales car.

The interior of the car is a standout. The rear seatbacks recline electrically 15°. It's a nice touch. The car offers probably more rear legroom than any other Euro import in its price range.

Ford is also offering a fleet-like guaranteed resale value program on Scorpio: If you trade it in on another L-M product 24 to 48 months after you buy the Scorpio, L-M guarantees the car will retain the same percentage of its original price as a Mercedes 190E owned for the same time.

L-M execs expect the car mix to be 86 percent automatic and 14 percent 5-speed. It will get the 6/60 L-M warranty, and sales are expected to be biggest in metropolitan areas of the country. Dealers hope to sell 5000 to 7000 Scorpions for the balance of the year. By 1988, L-M hopes for 11,000 Merkur XR4Ti and 15,000 Scorpio sales per year.

A front-engine, rear-drive classic configuration gives the Scorpio its sweet handling characteristics. The 2933 cc V6, unfortunately, doesn't give the 3240-pound car the get up and go of its competitors, including Audi 5000, Volvo 760 and Saab 9000. But the car soaks up every bump in the road. Progressive power steering provides good road feel to the driver. Stopping the car is no problem. There's a standard ABS system on-board.

Inside, the car is plush and more comfortable than any of the competition. Attention to interior detail is indeed a Scorpio highlight. Controls are all easy to use and understand. Gauges are big, white on black, and placed where they can be easily seen. The steering wheel is almost adjustable, and the driver's seat is too. Too bad the car doesn't have more engine. **PM**



PM PHOTOS BY BRIAN KOSOFF
RODNEY DANGERFIELD, FROM "BACK TO SCHOOL"; COURTESY OF ORION PICTURES

3-D TV COMES HOME

The screen door needs fixing, but all you want to do is watch the latest action movie from your local video store. You slide the movie into your video player and then, instead of turning on your TV set, you put on a sleek, high-tech headset with goggles and headphones.

For a moment you see nothing through the opaque lenses, but when the system comes to life you find yourself in the cockpit of a jet fighter. Your ship shudders through a stomach-wrenching turn to shake the enemy fighter on your tail. You can see your hand on the stick, the Earth below and even the tracer bullets hissing above your canopy—all in three frighteningly real dimensions. Your world spins dizzily as you whirl through a tight barrel roll, dive and come up behind the enemy plane. You hit the firing button, watch the air-to-air missile streak away from your wing and the enemy plane disappears in a cloud of smoke and debris.

Wow! Stripping off the headset you reacquaint yourself with the familiar objects in the room. It's hard to believe you never left your chair.

For years, critics have dismissed 3-D imagery as a hokey gimmick associated with horror movies such as "Creature From The Black Lagoon" and "Bwana Devil". But 3-D is starting to make a video-age and computer-age comeback. Advanced 3-D home entertainment systems like the one described above are still several years away, but an experimental version of such a system already exists.

In fact, the first 3-D systems for the home have

3-D is getting new respect with video gear that puts you right in the act.

BY JAMES B. MEIGS, Contributing Editor



Sharp's prototype 3-D home video system uses a conventional TV and VCR. An adapter (right) connects to these and to LCD glasses (left) to synchronize left/right views on 3-D videotape.

er-aided design and make flight simulators for military pilots even more lifelike.

One of the factors fueling the recent explosion in 3-D technology is the increasing reliance on video equipment both in home entertainment and in professional applications.

Historically, film has been the medium for 3-D, from the 1903 experiments by cinematography pioneers Auguste and Louis Lumiere to the recent George Lucas/Francis Coppola/Michael Jackson extravaganza, "Captain EO", for Walt Disney. Despite its somewhat lower image quality, video is more practical than film. On video, 3-dimensional images can be easily recorded, copied, even transmitted to remote locations.

According to 3-D researcher and consultant Stephen Hines, who developed the 3-D camera system largely used to shoot "Captain EO", 3-D technologies can be ranked in terms of how easily they make the transition to video.

"The system with the lowest impact is regular

already arrived. Viewers in Japan can buy 3-D movies for their video-disc players and, in this country, Sega and Atari both offer 3-D computer games. These are just some among a growing number of 3-D technologies that could, as one researcher puts it, help change television—literally "seeing from a distance"—into "tele-experience". But before 3-D technology takes over the home, it will have an even bigger impact on the imaging systems used by business, government, the military and scientists. It could help doctors perform delicate operations, enable sophisticated robots to operate in space or below the ocean, revolutionize the process of comput-

3-D TV COMES HOME

'anaglyphic' 3-D," says Hines. Anaglyphic 3-D is the familiar 3-D technique that requires you to wear simple glasses with one red and one blue (or cyan) lens. It has been used for numerous theatrical 3-D movies, and can be copied easily to videotape or even broadcast on TV. In fact, this is the system generally used during the occasional broadcasts of 3-D movies on television. One advantage of the anaglyphic approach, says Hines, is that viewers who don't have the proper glasses can still see a watchable TV image (though the picture will be afflicted with ghosts around the edges of objects).

The anaglyphic approach is relatively crude compared to some of the more recent 3-D technologies, but it serves as an excellent example of the basic principles of 3-D.

The human eye and brain use a whole host of clues to determine the distance of objects—everything from an object's size and shading, to the way one object moves in front of another as your perspective changes. But the key to experiencing a sense of depth (as opposed to simply knowing that one object is farther away than another) is stereopsis, the brain's ability to reconstruct a total scene from the slightly different perspectives provided by each eye. When you watch a conventional TV or movie image, both eyes see exactly the same perspective. The crucial element in virtually all 3-D systems is presenting two perspectives—one view intended for the right eye and the other for the left—and making sure that each eye sees only its own view.

Anaglyphic movies provide the two perspectives by using two separate cameras, spaced a few inches apart, to shoot each scene. During projection, one view passes through a red filter, the other through a blue filter. (On TV or video, both views, with proper filtering, are superimposed on the screen.) Appropriately colored glasses ensure that you get only the correct view in each eye.

The result is a 3-D effect simulating what you actually would have seen if you had been standing in the place of the camera rig.

To be quite precise, this type of image should be called "stereo"—because it relies on "stereoscopy", the use of two views—rather than 3-D. A true 3-dimensional image, such as a hologram, is one that you can see different parts of, from different angles. But since 3-D is the commonly accepted term for any sort of stereo image—even experts often use it—we'll stick with it in this article.

The anaglyphic system has some serious drawbacks. Television engineer-

ing consultant Mark Schubin, writing in the professional journal *Videography*, points out that the colored lenses make it difficult to achieve full, true colors in the anaglyphic approach.

The dark lenses also drastically reduce the brightness of the image and yet still fail to separate to two views completely. Finally, because the color on each home's television set is adjusted differently, most viewers will see ghosts of the alternate-eye images in the final picture.

A more promising approach relies on polarizing filters, like those in certain types of sunglasses, to separate the images. Stephen Hines points out that polarizing systems are also fairly easy to adapt to video. In fact, it has been done in a variety of ways.

Field-sequential 3-D

Tektronix, a Beaverton, Oregon, firm that specializes in professional video equipment, offers a 3-D system that works with ordinary TV cameras and monitors. Two cameras shoot right-eye and left-eye views, but instead of superimposing the two perspectives on the screen, the different views appear one after the other each time a new TV field emerges on the screen.

This technique is called the field-sequential system. In front of the screen, a large polarizing filter, combined with an LCD (liquid-crystal dis-

play) panel, serves as a kind of electronic gatekeeper. When the LCD panel is switched on, only light with a specific polarity can pass through the filter. When it's off, a different polarity passes. A special controller makes sure that the panel alternates between the two settings at exactly 60 times per second, thus matching the alternation between left-eye and right-eye views. Finally, the viewer wears a pair of simple, polarized glasses. These are designed so that one eye can accept light of only one polarity, and the other eye sees only the other polarity.

The final result is an almost total isolation of right- and left-eye views, and a striking 3-D effect.

The Tektronix system isn't ready for home use yet: The 12-in. version costs more than \$3000. But it's already starting to make an impact in some professional imaging systems. In particular, designers find it useful to add depth, as opposed to mere perspective, to computer-generated graphic models.

Despite its advantages, the basic Tektronix approach has a serious limitation. Although it operates at the conventional TV field rate of 60 images per second, each eye only sees every *other* image—a field rate of only 30 frames per second. That translates into a serious case of image flicker, enough to be annoying to most viewers at first.

There is a simple way to get rid of the

NASA'S 3-D HELMET—A WORLD BEFORE YOUR EYES



What's the opposite of tunnel-vision? It's NASA's Virtual Environment Workstation, a 3-D theater in a helmet that uses wide-angle LCD goggles to send the correct perspective to each eye. Images can come from dual video cameras or from prerecorded 3-D sources.

SEGA'S 3-D VIDEOGAME—THE OPPOSITION UPS THE ANTE



The first practical 3-D entertainment system to reach U.S. homes will be an accessory to Sega's Master System videogame. The system uses LCD shutter glasses (left) that connect to game console

via interface board. Joystick and target pistol let the user interact with 3-D games stored in program cartridges (right) and displayed on a TV. We found the 3-D effect to be quite pronounced.

flicker problem, but it means giving up compatibility with the American television standard. A San Rafael, California, company called Stereographics uses a similar system of LCD panel and polarized glasses, but doubles the 60-cycle field rate using custom-designed monitors and other specially modified components. This results in a flicker-free 3-D image, but it's an approach that would be prohibitively expensive for the home and even for many businesses and other applications. (The Tektronix System can also be modified to operate this way.) In the future, digital image-processing could make the system feasible and affordable.

In Japan, 3-D enthusiasts are already enjoying 3-D movies at home, and they're doing it with a system remarkably similar to the Tektronix approach.

Late last year, JVC began selling 3-D movies, including "Jaws 3-D" and "Friday The 13th Part 3—3-D", on VHD videodiscs. (VHD, which stands for Video High Density, is a videodisc format not available to U.S. consumers.) Buyers can play these 3-D discs in special VHD disc players. But in order to see 3-D, they need one extra component: a pair of LCD glasses that connects to the disc player with a thin cable. These glasses sell for the equivalent of about \$80 a pair.

Owners of older VHD players also

need to buy a simple adapter to synchronize the glasses. The video signal on the disc, as in the Tektronix System, alternates between left- and right-eye views with every video field, or 60 times a second. But instead of putting the LCD panel in front of the screen, the JVC system puts an LCD directly in front of each eye.

3-D VCRs

These LCD panels, made of the same material used in LCD TV sets and watches, are able to switch from being transparent to becoming totally opaque when jolted by a tiny electric current, thus forming very efficient electronic shutters. (Some earlier 3-D systems used PLZT ceramic lenses as shutters, but these are quite expensive and require dangerously high voltages to operate.) A signal from the disc player (or the adapter) synchronizes the LCD shutters with the alternating left- and right-eye views. When the left-eye view is on the screen, the right lens turns opaque, blocking the image. For right-eye fields, the process is reversed. Like the Tektronix system (and unlike most anaglyphic 3-D techniques) this approach manages to keep the two perspectives totally separate, resulting in excellent 3-D imagery.

Though JVC chose to introduce its 3-D system as an accessory to its VHD

disc players, the system works just well with ordinary videocassette recorders.

Sharp Corp., which helped JVC develop the system in Japan, is considering introducing a similar version in the U.S. that will work with ordinary VHS-format VCRs. Sharp's system uses a simple adapter that plugs into both the TV and the VCR, and has connections for up to four pairs of LCD glasses. (Wireless glasses are also in the works.) Though Sharp expects to offer the technology first to professional customers, the target price for the adapter—under \$100—certainly puts it in the range many home users would find acceptable. The company is already talking to a wide range of potential customers. Some eye doctors, for example, think the technology might make it easier to demonstrate and learn complex medical procedures. The system also has potential in computer-graphics systems. In fact, Sharp in Japan sells the LCD glasses and an interface board that allows home and business users to create their own 3-D graphics on certain Sharp computers.

The advantage of JVC/Sharp approach, like the Tektronix system, is that it doesn't require scrapping today's TV and video equipment.

"This can be handled just like regular video," explains Sharp engineer Peter

(Please turn to page 88)

This looked like an event history was going to treat kindly. Wally Schirra was on my left and Frank Christensen, the ultimate aviation entrepreneur, was on my right. Burt Rutan was busy bantering with jet jockey J.P. Tristani and POPULAR MECHANICS' own Fred Mackerodt was tossing in his 2 cents.

Guys like these don't spend a lot of time sitting around with their feet up unless there's a really good reason. And here they were, sequestered in Rutan's conference room at his Scaled Composites, Inc., skunk works in California's high desert country outside Mojave. None of them would stand in line for \$100 bills, but they had dropped everything and journeyed from all parts of the country because they felt the subject was important. They had come to spend a complete day pooling their knowledge and experience to design an airplane. Not just any airplane, but the Piper Cub for the next dozen generations.

Designing the Cub's replacement in a single day is a mighty tall order. For one thing, since 1936 the Piper J-3 has been the standard by which all other trainer and entry-level airplanes have been judged. That's an amazing fact when you remember the Cub represents the ultimate in low-tech engineering. But for people who yearned to fly, the Cub made it possible—forming a connection between thou-

sands of pilots and the exhilaration of flight.

The luminaries gathered at Mojave had come to do more than simply design an airplane. They had come because aviation is ailing, and a new-generation Cub would be part of the cure. The number of student starts has declined steadily, not to mention the number of new pilots who buy small airplanes. Certainly, one of the contributing factors is the appalling increase in the cost of flight instruction and training aircraft.

The cause for the increase is a complex interplay of inflation, labor, FAA certification costs and, most of all, product liability insurance. Product liability has had such a damaging effect on aviation that the Mojave Pow Wow decided it was best to ignore the regulatory problems of liability and FAA certification and



TAIL-MOUNTED ENGINE



BIPLANE



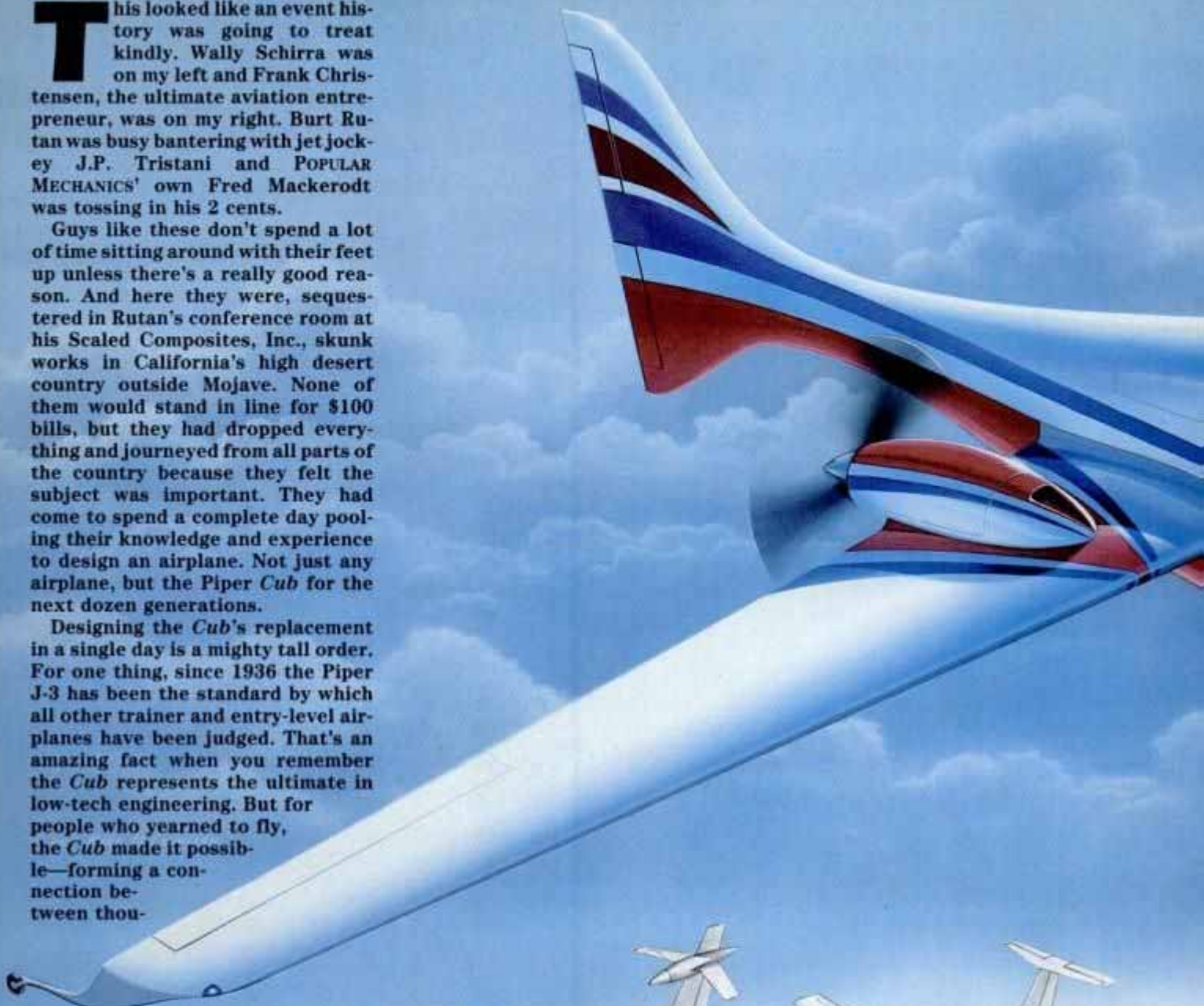
MODIFIED BOXPLANE



JOINED WING

Several revolutionary concepts for the light plane of the future evolved from PM's aviation think tank. Among them (top left) was a plan for mounting the engine in the tail; a contemporary biplane (top right);

a NASA inspired boxplane (bottom left); and a radical joined wing (bottom right). The final aircraft (illustration) was a synthesis of ideas drawn from the leading edge of contemporary aviation technology.



WINGS FOR TOMORROW

Burt Rutan and a panel of aviation experts help PM design an affordable entry-level sportplane for the 21st century.

BY BUDD DAVISSON; Illustrations by Mark McCandlish



do its design work in a vacuum.

When tackling the project, PM selected the following team and turned it loose: Burt Rutan, world reknown designer of a wide variety of airplanes, including the *Starship* and *Voyager*; Wally Schirra, Navy test pilot and the only astronaut to hitch rides in all three of America's early space vehicles—Mercury, Gemini and Apollo; Frank Christensen, industrialist/entrepreneur who owns the factory that cranks out Christen Eagles, Pitt Specials and soon the Husky bushplane; Fred Mackerodt, aviation journalist and experienced pilot; J.P. Tristani, commercial airline captain and former Navy test pilot; and Mark McCandlish, one of this country's foremost aviation illustrators. Rounding out the list were PM's Editor-in-Chief Joe Oldham and Science/Technology/Aerospace Editor Tim Cole. I was there to serve as referee.

As we finished breakfast around the conference table, we laid down our only two hard and fast guide-

lines: First, the airplane was supposed to be of revolutionary design. Anything less, we felt, would fail to breathe life into aviation. Revolutionary versus evolutionary... we soon had to chant it to ourselves to keep on the right track.

The second guideline was really a definition of the mission. The airplane was to be an entry-level training platform that removed all hardware barriers between flight and the average man on the street. It was to be the most user-friendly airplane ever designed.

"Revolutionary versus evolutionary" was a bigger challenge than most of us anticipated. We sailed right through the second subject of discussion—the number of seats. Two was the unanimous answer. Then, I posed the question of whether the seats would be tandem or side-by-side. The military types preferred tandem. As an instructor, I pushed for side-by-side.

Then Burt spoke.

"Why does it have to be either?"

It was like throwing on a light

switch. Burt made the case for staggering the seating—setting the right seat back approximately 15 in. and overlapping the left seat by about 6 in. This gave a bundle of benefits: narrower fuselage, the instructor could still read the student's face for signs of panic, the instructor was closer to the student's line of sight so their visual references were almost the same, and the right seat passenger/instructor had unrestricted access to the small payload bay behind the pilot. Most important, staggering the seating gave passenger and pilot plenty of elbow room—a pretty dear commodity on a lot of 2-place airplanes with athwartship seating.

The PM *Scorpion* was taking shape from the inside out. The seating discussion led to flight controls and from there to the instrument panel. Everybody in the room agreed that a side stick on an armrest at the side of the seat was the best way to control the airplane. At the same time, it was argued that the left seat—the command/student seat

WINGS FOR TOMORROW

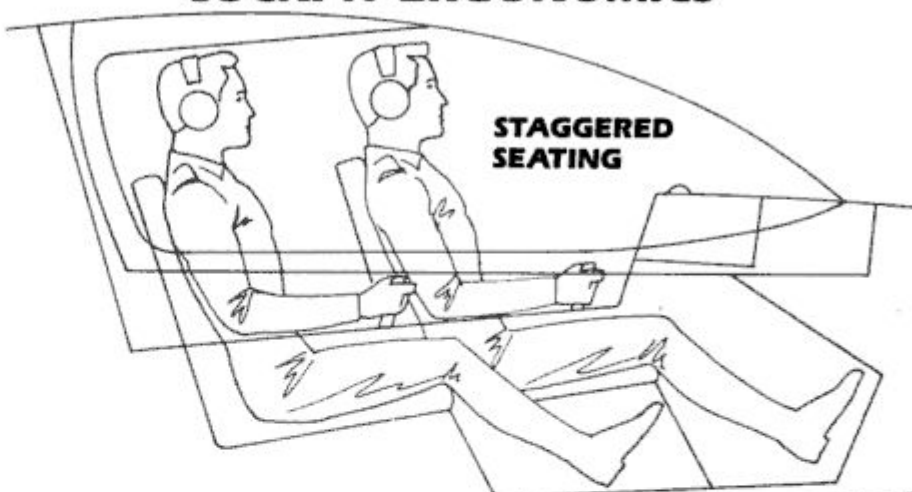
—should have a conventional Cessna/Beech/Piper type of control yoke. Then Burt once again pointed out the difference between revolutionary and evolutionary. Even though we liked side sticks, we had clung to our evolutionary upbringing and reasoned the yoke was needed to allow pilots to make an easier transition to the older and, as we were learning, terribly traditional designs. If we tied our thoughts to them, our *Cub* of the future would be just another link in the evolutionary chain of today.

So it was side-stick controllers for both pilots.

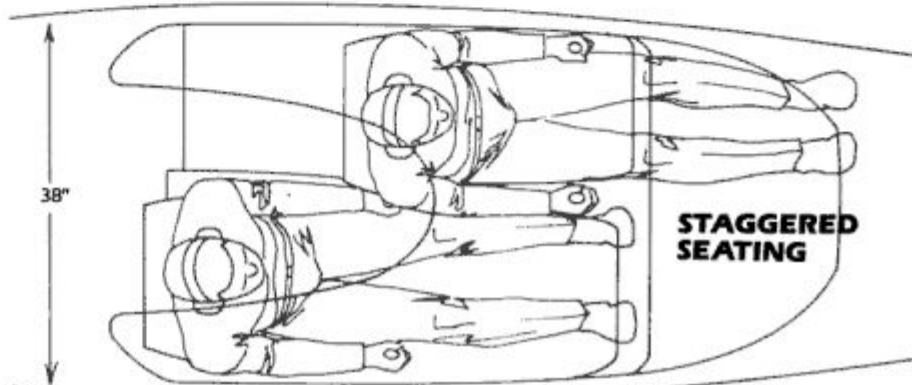
By the time we progressed to the instrument panel, everyone was brimming with revolutionary ideas. We quickly concluded that nothing on an airplane's panel makes any sense in today's world. The instrument panel on a modern light plane looks the way it does because that's the way it looked in 1950. And 1940. And 1930. And the instrument panel looks the way it does because instruments were invented one at a time. Somewhere back in aviation's dark ages someone wanted to know how fast they were going so the air-speed indicator was invented. Then, they wanted to know how high they were flying so along came the altimeter. The process continued until the panel was covered with individual dials giving individual bits of information. As a result, nothing on a typical airplane panel is direct and to the point. Indeed, we argued that one reason so many people don't learn to fly is because the panel itself is so intimidating.

The Mojave approach was to create a system that boiled down every single piece of important information to one visual display that took no talent to decipher. Since we were ignoring how it had been done in the past, the information and control problem was coupled with today's technology. And it was immediately decided that the heart of the *Scorpion's* avionics would be a redundant pair of inexpensive microprocessors. The processors would collect all flight information, do all the ingesting and extrapolating and feed the results into a menu-driven graphic control display that would be projected on the lower part of the windshield. The windshield itself would be light-sensitive—automatically tinting slightly in bright sunshine for readability, becoming clear in bad weather. Individual menus would cover navigation information (like heading, loran C waypoints, and so on), flight control data (like airspeed and altitude), engine parameters (like rpm, manifold pressures, temperatures), and a miscellaneous menu for such information as airport approach directories. The pilot would

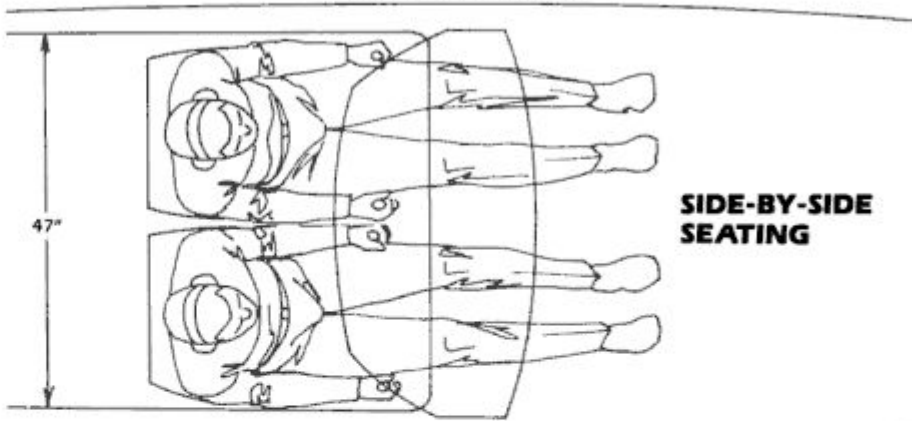
COCKPIT ERGONOMICS



Staggered 2-place seating is one of *Scorpion's* most striking features. In profile view above, passenger and pilot can still interact, and passenger has access to small payload bay behind left seat.



Elbow room, in this top view, is enhanced even though fuselage is narrower. Engines can be placed closer together to counteract asymmetrical thrust with one engine out.



Comfort suffers in a typical 2-place trainer with side-by-side seating, even though the cabin is typically wider. *Scorpion* concept is tighter, but more comfortable.

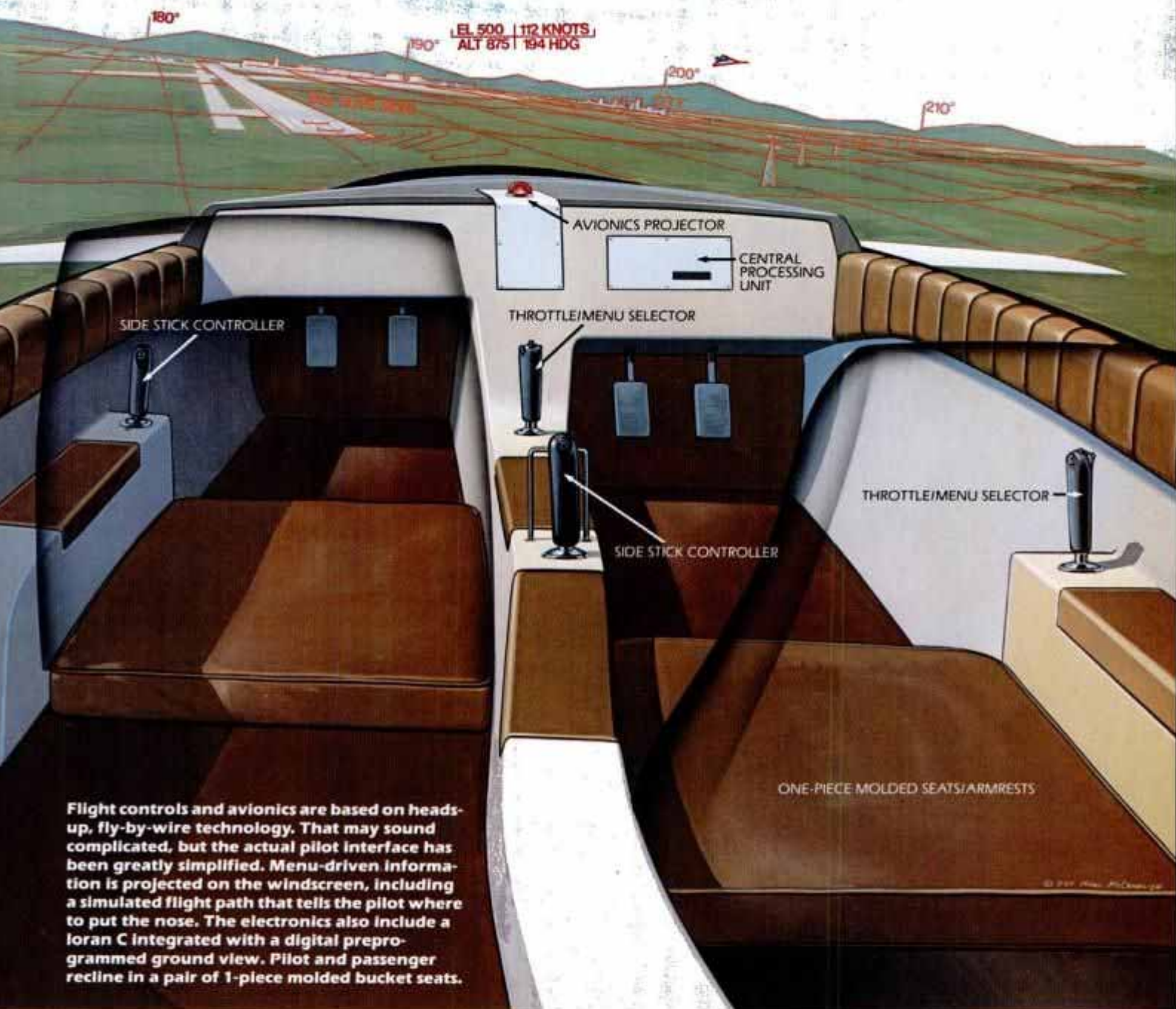
flip through the menus with a button or trigger on the throttle and could even choose a split-screen format.

The displays wouldn't be numbers or figures—just simple graphic designs or iconography that immediately conveyed all the information normally found on all those little dials found

aboard a more traditional aircraft.

It was also decided that there was no reason for the control presentation to differentiate between VFR (visual flight) and IFR (instrument flight) conditions. The same information would control the display in all weather conditions. It was also agreed that much of the collision avoidance and routing

VIEW FROM THE COCKPIT



Flight controls and avionics are based on heads-up, fly-by-wire technology. That may sound complicated, but the actual pilot interface has been greatly simplified. Menu-driven information is projected on the windscreen, including a simulated flight path that tells the pilot where to put the nose. The electronics also include a loran C integrated with a digital preprogrammed ground view. Pilot and passenger recline in a pair of 1-piece molded bucket seats.

work would be performed by the microprocessors, with relevant information displayed on screen. The discussions concerning our Heads Up Display (HUD) didn't end with simply presenting raw data to our pilot. We wanted to give him or her real "attitude control" that guided the airplane in all conditions. The initial concepts centered around a set of cross hairs or a "flight envelope box" that would be projected onto the windshield with an outline of an airplane, as seen from behind, superimposed over it.

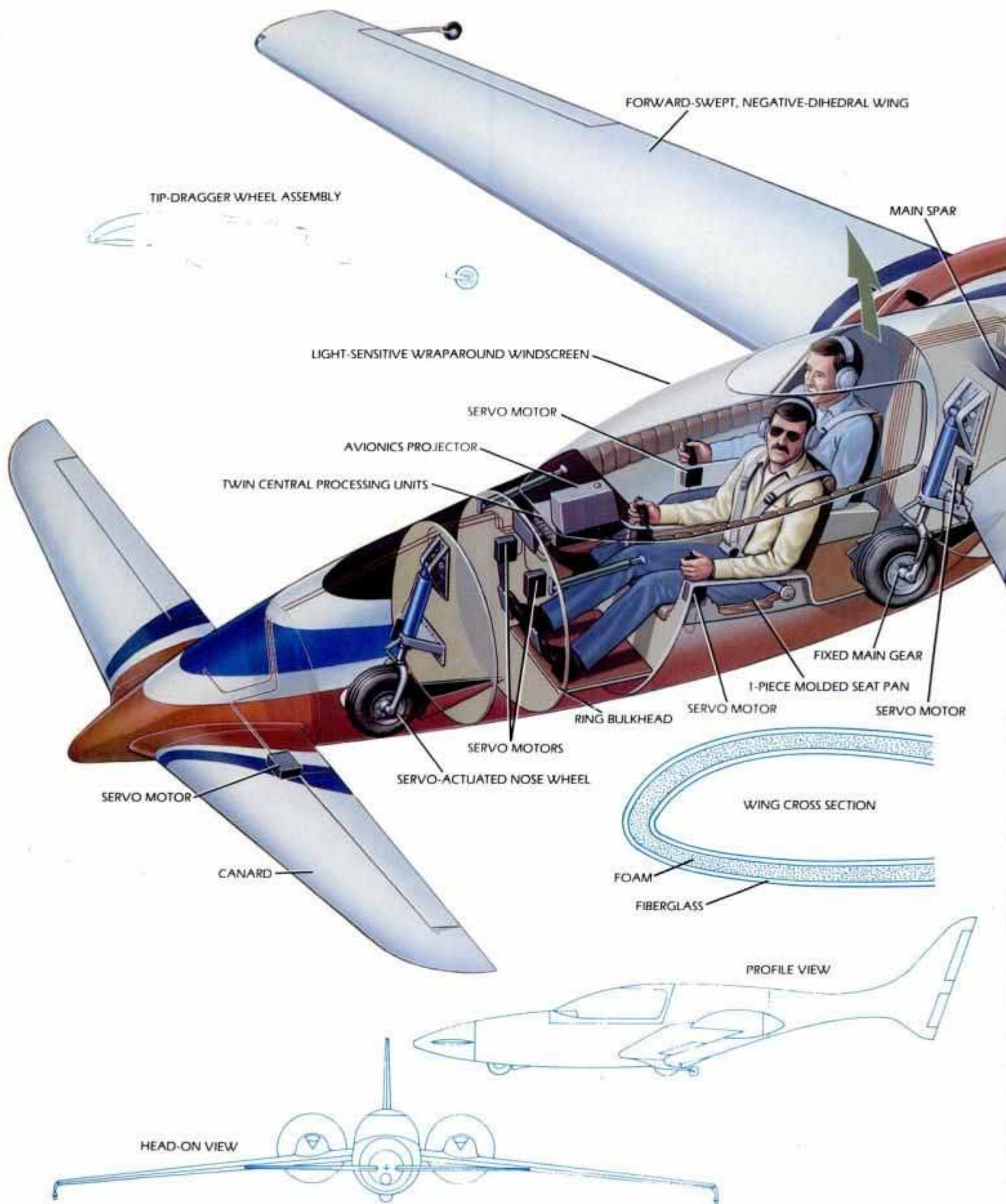
But that too seemed evolutionary. The final HUD was a graphic presenta-

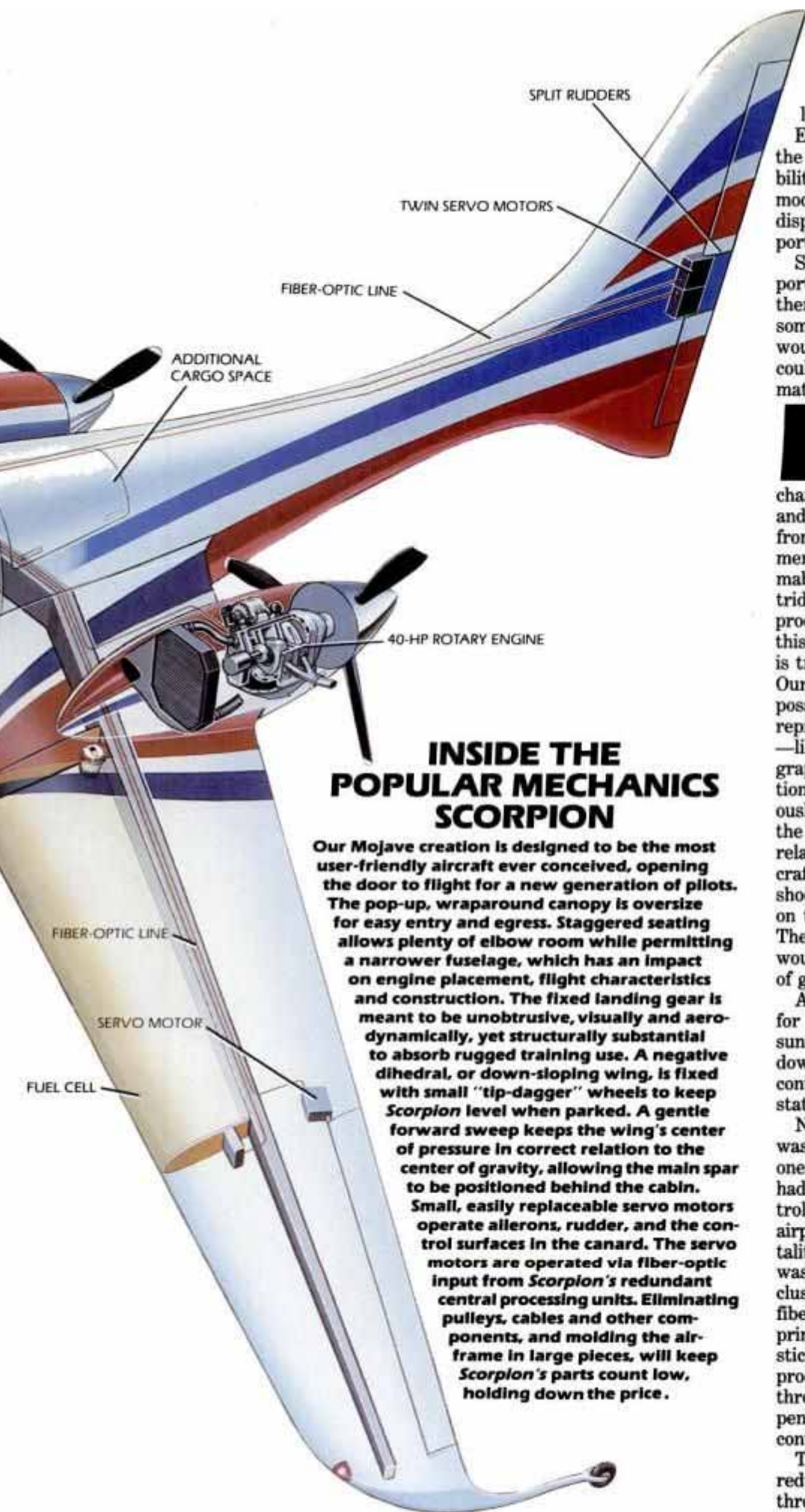
tion of the horizon with an aerial highway or railroad track running down the center. The pilot's job would be to keep the plane positioned so that it appeared as if he was flying down the center of the highway and just above it as it receded into the distance. Parallel bars running across the railroad track would give the pilot a quick visual reference of speed and distance.

The processors would be crunching flight numbers and would move the railroad track according to where the plane should be headed, thereby telling the pilot what ought to be done with the

airplane's nose. In other words, navigation information would be fed into the HUD, which would guide the pilot left, right, up or down.

An alphanumeric keypad mounted on the forward end of the console between the two pilots would provide a means of plugging navigation and other raw data into the central processing units. We assumed that loran C coverage will expand to eliminate the current mid-continent gap and we determined that most navigation would be by that method. This would allow the pilot to climb in the bird, punch in a 3-character alphanumeric designator the FAA uses





INSIDE THE POPULAR MECHANICS SCORPION

Our Mojave creation is designed to be the most user-friendly aircraft ever conceived, opening the door to flight for a new generation of pilots. The pop-up, wraparound canopy is oversize for easy entry and egress. Staggered seating allows plenty of elbow room while permitting a narrower fuselage, which has an impact on engine placement, flight characteristics and construction. The fixed landing gear is meant to be unobtrusive, visually and aerodynamically, yet structurally substantial to absorb rugged training use. A negative dihedral, or down-sloping wing, is fixed with small "tip-dagger" wheels to keep *Scorpion* level when parked. A gentle forward sweep keeps the wing's center of pressure in correct relation to the center of gravity, allowing the main spar to be positioned behind the cabin. Small, easily replaceable servo motors operate ailerons, rudder, and the control surfaces in the canard. The servo motors are operated via fiber-optic input from *Scorpion's* redundant central processing units. Eliminating pulleys, cables and other components, and molding the airframe in large pieces, will keep *Scorpion's* parts count low, holding down the price.

to identify his destination airport, and let the digital railroad track lead him there. No muss. No fuss.

Existing loran units already allow the pilot this kind of navigational flexibility as well as having various backup modes such as a single button that displays the location of the closest airport.

Some also display runway and airport information. In short, getting there by airplane has already taken some fabulous strides. The Mojave bird would integrate existing systems that could simplify all phases of flight information and control.

In addition, some loran units currently evolving in the marine community merge position with environmental information like channel markings, depth, obstructions, and so on. This information is digitized from charts prepared by the government and installed on small programmable read-only memory (PROM) cartridges that plug into a loran's central processing unit. It won't be long before this kind of technology (technology that is truly inexpensive) reaches aviation. Our group concluded that it will soon be possible to project a visual digitized representation of ground features—like airport runways, towns, topography, TV towers and other obstructions—using simple icons. A continuously updated loran position would shift the unfolding scene on the windscreen relative to the movement of the aircraft, allowing the pilot to visually shoot approaches in any weather based on the image on his own windscreen. The flight envelope railroad track would pass over visual representations of ground features.

And remember, for pilots who yearn for VFR simplicity on those bright sunny days, all displays could be shut down while the central processing units continued to silently monitor engine status and position.

Naturally, since the conversation was homed in on microprocessors, no one around Rutan's conference table had any trouble getting rid of the control cables and pulleys usually found in airplanes. In fact, the fly-by-wire mentality that permeated the discussion was carried through to its logical conclusion when someone suggested using fiber optics cast into the structure for primary control. Input from the side sticks would integrate with the microprocessors, which would send signals through the photonics to small, inexpensive servo motors mounted in the control surfaces.

The concept of incorporating certain redundancies into the design surfaced throughout our discussion. Both Schirra and Tristani outlined the back-

(Please turn to page 100)



Secret Secretary

A chest of drawers and desk combination that is both beautiful and utilitarian.

BY RALPH S. WILKES

This unique piece of furniture is ideal for apartment dwellers, students and space-conscious homeowners. It combines the functions of a desk and chest of drawers in a compact package that will complement any traditional decor. Sometimes called a butler's desk, this chest has its roots in early American domestic life where the butler used it as a place to keep track of household operations. Although few of us today can afford such service to handle our domestic affairs, the butler's desk remains an attractive solution for household organizing. Our version was designed specifically with the home craftsman in mind. Constructed of solid cherry and tastefully finished, this piece could very well become an heirloom in your family.

Starting construction

The large side panels, fixed desktop and case top must be made by gluing together narrower stock. Depending on the widths available to you, you may also need to glue-up the drop-leaf desktop. Start by selecting the wood for each panel, paying particular attention to grain pattern and color. Check the growth rings that appear on the ends of the boards and try to arrange the wood so that the rings alternate—facing down on one board and up on the next. This tends to even out the cupping tendency of flat-sawn boards as the humidity changes. Mark the wood so it's not mixed up at assembly time. Crosscut the panel pieces and drawer fronts about 1 in. longer than their finished dimensions.

Prepare the panel pieces for assembly by first jointing one edge on each. Then rip each piece $\frac{1}{4}$ in. wider than necessary and joint the sawn edges. Hold each mating surface together and

check for a good fit. Apply glue to the mating surfaces, lightly clamp the pieces together, and remove the excess glue. Use straight pieces of scrap stock lightly clamped across each end to keep the panel flat. These should be waxed to prevent them from being glued to the panel. Check that the panel has no twist, tighten the clamps and allow the glue to dry overnight. Repeat this procedure for desktop and cabinet top.

After the glue has dried, dress the



Fold up and close the top of our solid cherry butler's bureau and it transforms from efficient desk into an elegant dresser.

surfaces with a hand plane or sander. Then, hand sand with a block and 220-grit paper. Rip the side panels about $\frac{1}{16}$ in. oversize and remove this excess with the jointer or hand plane. Then cut to length. Next, make a template of the side panel leg cutout. Transfer the profile to the inside surface of each side panel. Cut to the line with a sabre saw and clean up with a drum sander.

Lay out the $\frac{3}{16}$ -in.-deep dados and top-edge rabbet that house the five frames on the inside faces of the panels. To ensure that all the dados will be straight, square to the edge, and the correct size, construct a jig to guide the

router and straight bit.

Lap join and nail 1x2 stock to make a rectangular frame that spans the width of the side panel. To determine the inside short dimension of the frame that will produce a $\frac{13}{16}$ -in. dado, subtract the router-bit size from the dado width and add the diameter of the router base. If you're using a $\frac{1}{2}$ -in. bit and your router base is 6 in. dia., the inside spacing will be $6\frac{5}{16}$ in. Test the jig on a scrap piece of wood to make sure the dado width is correct. Clamp the jig squarely on the side panel and attach a stop block at one end so the housings end $\frac{3}{4}$ in. from the panel edge. After they're cut, square the stopped ends with a sharp chisel. Then, rout a $\frac{1}{4}$ -in.-deep \times $\frac{1}{2}$ -in.-wide rabbet on the back inside edges of the panels for the $\frac{1}{4}$ -in. plywood back. Stop this rabbet 6 in. short of the panel bottom.

Making the frames

Select the stock for the frames and joint, rip and crosscut each piece to exact dimensions. Next, set up the router table with a $\frac{1}{4}$ -in. straight bit to cut the mortises in the long frame members. Clamp a stop block to the router table fence so the cuts extend in 2 in. from the end. Make several passes, increasing the depth of cut each time, to create the 1-in.-deep mortises. Use a sharp chisel to square the mortise ends. You can cut the tenons on a router table or table saw. Before cutting them in the final stock, make a test on scrap $\frac{13}{16}$ -in. stock, and check the fit with the mortises. Make sure shoulders are square and tenon length is $\frac{15}{16}$ in.

The frames are fastened to the case sides by screws. Bore $\frac{13}{64}$ -in. screw holes in the end frame pieces as shown in the drawing. The rear holes in each piece should be slotted to allow for movement in the side panels as the humidity changes. Bore two holes close together and clean away the waste with a chisel to make the slots. Glue and clamp the frames and check for square.

Color photo: J.R. Rost
Black-and-white photos: Ralph S. Wilkes
Technical art: Dyck Fledderus
Photo stylist: Gabe Herrick

Secret Secretary



1 Make the wide panels by jointing and gluing narrower stock. Clamp straight scrap stock across the panels to keep flat.



2 Lay out and cut a template for the leg profiles on the side panels. Saw to the line with a sabre saw and sand the edge.



3 Dress the laminated panels with a hand plane or sander and finish with hand sanding. Be sure to keep the surface flat.



4 Use a router with straight bit to cut the dados and top-edge rabbet. Guiding jig ensures straight and consistent width.



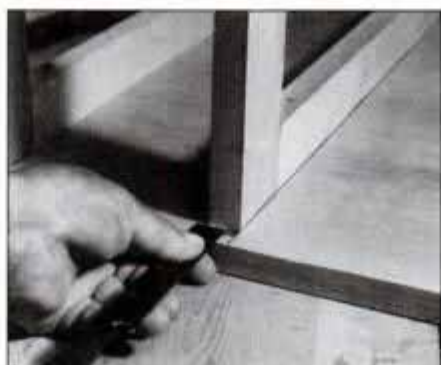
5 Cut the frame mortises with a 1/4-in. bit mounted in the router table. Make several passes to reach the desired depth.



6 The frame tenon cuts are guided by the miter gauge in the router table. Use 13/16-in. scrap to test cutter depth.



7 Test fit the mortise and tenon joints. The fit should be snug with a 1/16-in. gap at the mortise bottom for excess glue.



8 After the frames are assembled, seat them in the side panel dados and use a chisel to mark the front-edge notches.



9 Mark the profile for the clearance channel in the desktop frame. Make successive passes with a corebox bit to make the cut.

Fitting the frames

The frames must be notched at the front to fit the stopped dados. Place each frame in its groove and use a chisel to mark the frame front-edge notch line. Cut this notch 3/4 in. back from the front edge. It's a good idea to number each frame so they're not mixed up. After the notches are cut, place each frame in its dado and mark the screw pilot-hole positions on the side panels. Then bore 3/32-in. pilot holes 1/2 in. deep. Wrap a piece of tape around the drill or use a drill stop to ensure that the hole doesn't break through the outside panel surface. Next, bore the holes in the top two frames for fastening the cabinet top and inside desktop, slotting the rear ones. The front holes are countersunk for flathead screws and the rear ones are recessed so the roundhead screws won't interfere with drawer operation.

The front piece of the desktop frame must be channeled out to allow clearance for the fold-down top. Lay out the channel profile on the frame end as shown in the drawing, and use a corebox bit mounted in the router table to cut to the line. Make several passes to achieve the final profile.

Set the table saw to rip at a 45° angle and trim the edges of the fixed and drop-leaf desktops. Reset the saw to 90°, rip the panels to width, and then crosscut to length. Then, lay out the hinge mortises and cut with a sharp chisel. Bore screw pilot holes for the hinge screws and mount the hinges. Now, lay the desktop in position on the desktop frame and check to see that the leaf opens and closes properly and that its outside face is flush with the frame edge when closed.

Begin to assemble the case by first

applying glue to the front 3 in. of each dado and the upper-edge rabbet. Then, screw each frame to the case sides with 2 1/2-in. No. 10 rh screws. Avoid over-tightening the screws in the rear slotted holes. Check that the cabinet is square and allow the glue to set.

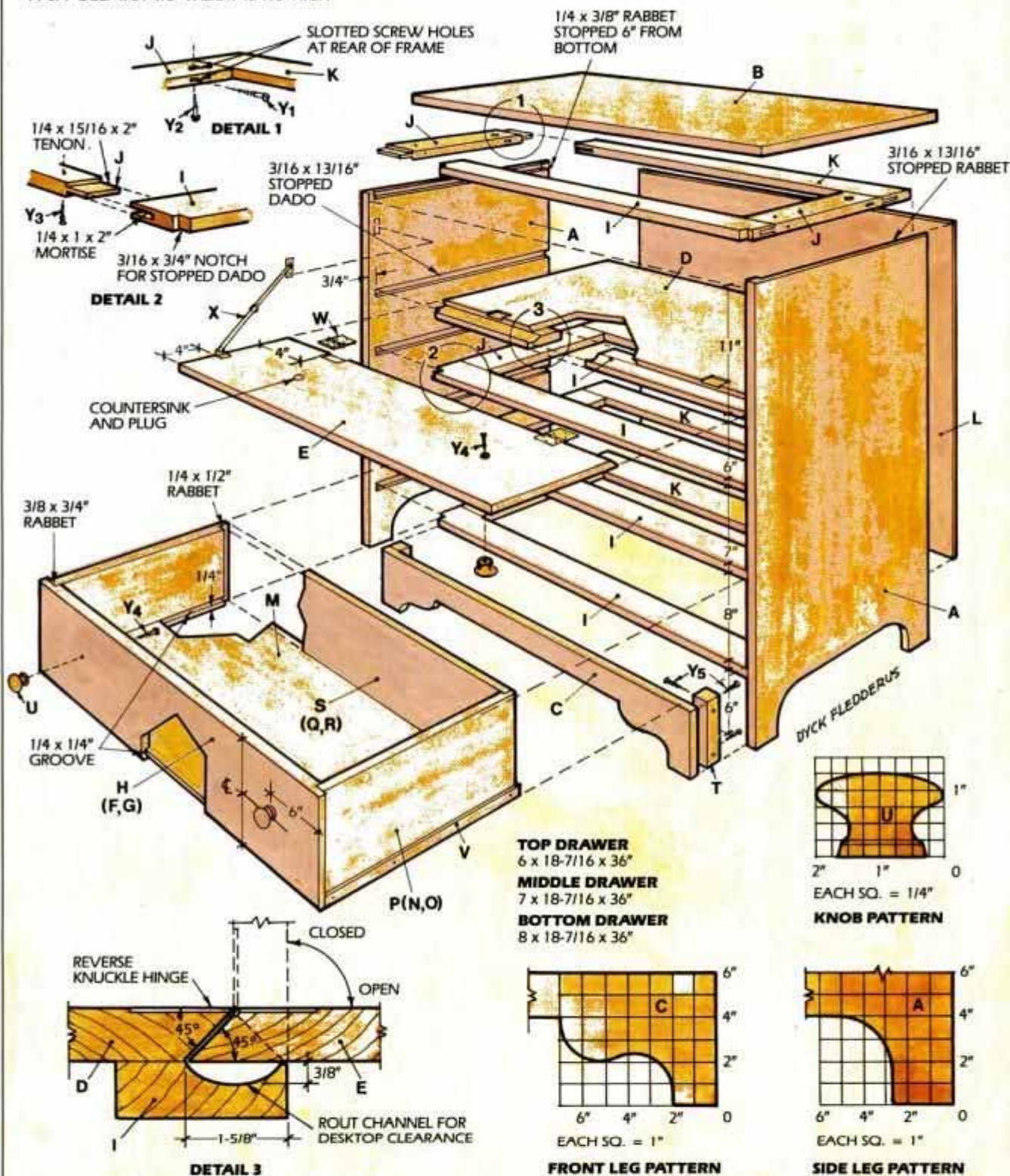
When the glue has dried, temporarily install the desktop to the desktop frame and install the leaf supports. Check that it pivots freely and is flush when closed. Then remove the desktop pieces to be stained and finished separately.

Completing the case

Cut two corner blocks for fastening the front apron and attach them to the case sides with 2-in. No. 10 fh screws. Cut the apron to size and make a template for the apron leg profiles as shown in the drawing. Trace the outline on the apron and cut with a sabre saw. A drum

BUTLER'S DESK

19-3/4" DEEP x 39-1/8" WIDE x 42-7/8" HIGH



Key No.	Size and description (use)
A	2 13/16 x 19 x 42 1/8" cherry (side panels)
B	1 13/16 x 19 1/2 x 39 1/4" cherry (top)
C	1 13/16 x 6 x 36" cherry (apron)
D	1 13/16 x 17 15/16 x 36" cherry (fixed desktop)
E	1 13/16 x 11 x 36" cherry (drop front desktop)
F	1 13/16 x 6 x 36" cherry (top drawer front)
G	1 13/16 x 7 x 36" cherry (middle drawer front)
H	1 13/16 x 8 x 36" cherry (bottom drawer front)
I	5 13/16 x 2 1/2 x 36 1/2" cherry (front frame)
J	10 13/16 x 2 x 16 1/2" maple (end frame)
K	5 13/16 x 2 x 36 1/2" maple (back frame)

MATERIALS LIST—BUTLER'S DESK

L	1 1/2 x 36 1/2 x 36" lauan plywood (back)
M	3 1/2 x 35 x 17 1/2" lauan plywood (drawer bottom)
N	2 1/2 x 6 x 18" plywood (top drawer side)
O	2 1/2 x 7 x 18" plywood (middle drawer side)
P	2 1/2 x 8 x 18" plywood (bottom drawer side)
Q	1 1/2 x 5 1/2 x 35" plywood (top drawer back)
R	1 1/2 x 6 1/2 x 35" plywood (middle drawer back)
S	1 1/2 x 7 1/2 x 35" plywood (bottom drawer back)
T	2 1 1/2 x 1 1/2 x 6" cherry (corner block)

U	8 2-in.-dia. cherry (knob)
V	6 1/2 x 13/16 x 18" cherry (guide strip)
W*	2 1 1/2 x 2 1/2" reverse knuckle desk hinge Paxton No. 4100
X*	2 10" lid support Paxton No. 5016
Y1	20 2 1/2" No. 10 rh screw
Y2	4 1 1/4" No. 10 rh screw
Y3	4 1 1/4" No. 10 fh screw
Y4	8 2" No. 8 fh screw
Y5	8 2" No. 10 fh screw
Misc.	3d finishing nails, 1/4" wire brads, glue, 220-grit sandpaper, Minwax cherry stain No. 235, satin polyurethane finish.

*Available from Paxton Hardware Ltd., 7818 Bradshaw Rd., Upper Falls, MD 21156.

Secret Secretary



10 Set the table saw for a 45° cut and rip one edge of the desktop fixed and pivoting panels. Guard retracted for clarity.



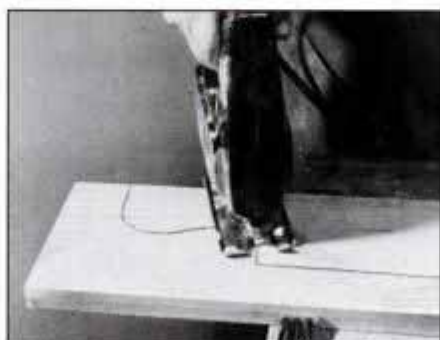
11 Lay out the reverse knuckle hinge positions on the desktop pieces and carefully cut the mortises with a sharp chisel.



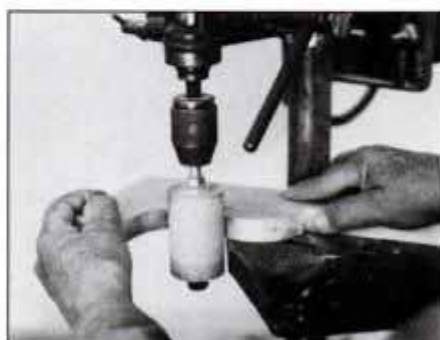
12 Temporarily assemble the pivoting desktop and desktop frame. Make sure front section clears the frame channel.



13 Assemble the frames to the cabinet sides with screws. Use glue at the frame fronts only. Slot the rear frame screwholes.



14 Lay out front apron leg profile on scrap 1/4-in. stock. Use this template to mark apron ends and cut with a sabre saw.



15 A drum sander mounted in a drill press smooths the apron leg profiles. Clean the inside corners by hand sanding.



16 Assemble the drawer components with glue and finishing nails and apply 1/4-in.-thick hardwood guide strips to sides.



17 Use a lathe and minimum 2-in.-thick stock to make the blanks for the knobs. Turn four knobs from each blank.



18 Thoroughly clean cabinet and wipe with a tack cloth. Then apply stain followed by three coats of urethane varnish.

sander mounted in a drill press is useful for cleaning up the saw marks. Hand sand the inside corner of the profile where the drum can't reach. Then fasten the apron in place. Position the case top on the top frame flush with the back case edges and with equal overhang on the sides. Mark and bore screw pilot holes in the top and set it aside for finishing. Cut the 1/4-in. plywood back panel and test fit in the case. Set it aside to be finished before assembly.

Making the drawers

Joint one edge of each drawer front. Set the table saw to rip the finished dimension of the first drawer and rip the front and sides. Then set the saw to rip 1/2 in. less and rip the drawer back. Repeat this with the two remaining drawer sizes. Then cut the drawer bottoms to size. Using the router table or table

saw with dado blade, cut the 3/8 x 3/4-in. rabbets in the drawer fronts and 1/4 x 1/2-in. rabbets in the sides. Then, with a 1/4-in. straight bit or dado blade, plough the 1/4-in.-deep groove in the front and sides of each drawer. Fasten the drawer front, sides and back with glue and finishing nails and slide the drawer bottoms in place. Nail these to the drawer backs with 3d nails.

Before installing the guide rails, slide each drawer into the case and check drawer front fit. Adjust where necessary and install the guide rails on the sides. Bore the screw holes for attaching the knobs and countersink for 2-in. No. 8 fh screws.

The knobs are turned on the lathe from minimum 2-in. stock. Prepare two blanks about 8 in. long. Each blank will make four knobs. Center the stock on the lathe and turn the knobs to the

profile shown in the drawing. Counterbore the knob screw holes in the pivoting desktop for 3/8-in.-dia. plugs and attach the two knobs.

Final finish

Before finishing, sand all parts with 220-grit paper. Thoroughly clean the surfaces and wipe with a tack cloth. We used two coats of Minwax cherry stain followed by three coats of satin urethane varnish.

Thin the first coat as per manufacturer's instructions. Between coats, sand lightly with 220-grit paper and wipe with the tack cloth.

When the finishing is completed, attach the cabinet top with 1 1/4-in. No. 10 rh screws and install the back panel with 3/4-in. brads. Screw the drawer knobs in place and install the desk surface complete with leaf supports. **PM**

SCREWS

A workshop guide to choosing and using screws.

BY JOSEPH TRUINI, Shop And Tools Editor
Photos by Brian Kosoff

During the third century B.C., when an inclined plane was modified into a twisting spiral to lift water for irrigation, the screw was born.

Through subsequent centuries, the original screw design evolved to become a fastener of parts. Different styles were developed as screws became more and more popular.

Today, the ubiquitous screw is available in hundreds of styles and sizes to satisfy virtually all fastening jobs. However, selecting the correct fastener from a sea of choices is sometimes a little tricky. To help you make the right choice, we've gathered together various screw styles that every do-it-yourselfer should know about. Note that the styles shown include wood screws, sheetmetal screws, machine screws and a few specialty screws, too.

There are several factors to consider when selecting a screw, including the type and thickness of the material being fastened, style of screwhead and threads, and screw diameter and length. Also, if the fasteners are going to be exposed to moisture, be sure to use weather-resistant screws to prevent rusting.

Screws are made of various materials depending on strength, appearance and corrosion-resistance requirements. Most screws are made of zinc-plated steel. The shiny plating is attractive and it offers minimum resistance to rusting when the screw is



WOOD SCREWS



exposed occasionally to moisture. Brass, aluminum, silicone-bronze and other nonferrous metals are also used as screw stock. These metals are softer, and therefore, weaker than steel screws. Nonferrous screws are chosen usually for their corrosion-resistance and appearance.

Stainless-steel screws are strong and extremely weather-resistant, but they're also expensive. A more economical type of rust-resistant fastener, is the electroplated galvanized screw. Galvanized coatings are available on several different screw styles, including thin-shanked deck screws, machine bolts and lagscrews.

Screwhead styles

The screws used most often by do-it-yourselfers are slotted and Phillips, with either a flat or round head. However, there are several other styles that are worth noting. Shown along the bottom of this page are profiles of nine common screwhead styles. They include (left to right): flat, round, oval, panhead, fillister, carriage bolt, thumbscrew with shoulder, brass knurled finger screw, and hexhead with sealer washer. Shown on the facing page, are the seven most common screw-drive styles (from top to bottom): slotted, Phillips, Torx, Robertson, hex-head, hex socket and a 1-way security screw.

Torx screws are found on late-model cars and trucks. Robertson screws, also known as square-drive screws, have become popular recently with cabinetmakers because of their nonslip head and thin shank. Tamperproof 1-way screws are driven with a standard screwdriver, but can't be removed with conventional tools. Remember, screw designs

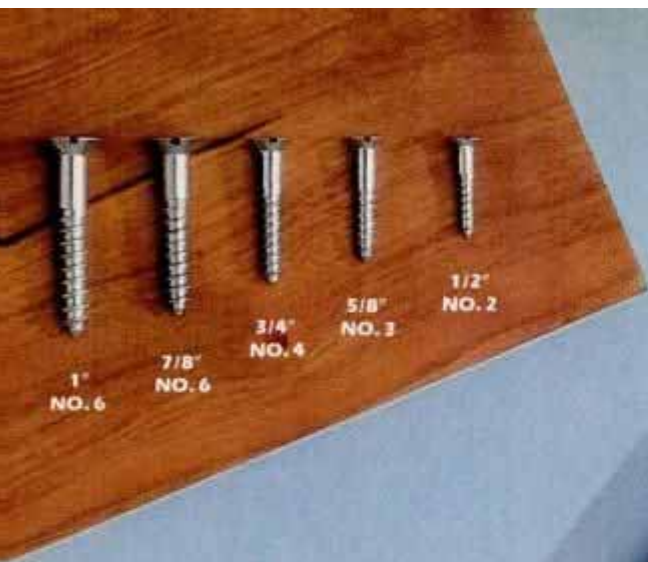
LAGSCREW



COMMON SCREWHEAD STYLES

Shown below are profiles of nine common screwheads (left to right): flat, round, oval, panhead, fillister, carriage bolt, thumbscrew with shoulder, finger screw and hexhead with sealer washer.





CAPSCREW

SCREW-DRIVE TYPES



and head styles are available in a wide variety of combinations. For example, wood screws come with a slotted flathead, Phillips roundhead and Robertson panhead, just to name a few.

Screw specifics

The most common screws are wood screws. They're designated by length in inches, gauge number (shank diameter) and screwhead style, for example: 1½-in. No. 8 fh (flathead) screw. Shown above, are 14 flathead wood screws ranging in size from a 4-in. No. 18 to a ½-in. No. 2. The higher the gauge number, the larger the screw shank. However, each gauge number comes in several lengths. Therefore, a 1-in. No. 12 has a thicker shank than a 3-in. No. 8 screw. Wood screws are commonly available with flat, round, and oval heads in slotted, Phillips and Robertson styles. Also, screw lengths are measured from the screw tip to the part of the head that is flush with the wood. Measure a flathead screw to the top of the head. A roundhead screw is measured to the bottom surface of the head.

Wherever possible, screw through the thinner piece of wood and into the thicker board. As a general rule, two-thirds of the screw's length should be driven into the thicker board. Here's the proper method of installing a wood screw. First, bore a pilot hole to a depth equal to about three-quarters of the screw length. The pilot hole must be slightly smaller in diameter than the threaded portion of the screw. Next, bore a screw-shank clearance hole through the first, thinner board only. Finally, countersink the hole and drive the screw. If you're going to drive the screw below the surface and conceal it with a wood plug, then counterbore a shallow plug hole *before* boring the pilot hole.

When standard wood screws are too small, move up to lagscrews. These long, large-shank screws, also called lagbolts, provide extra holding power when joining large-dimension lumber. Lagscrews have hexagonal or square heads that are driven with a socket or wrench. To transfer pressure over

a larger area, use a large diameter washer.

Lagscrews are commonly available in diameters ranging from ¼ in. to ¾ in., and in lengths from about 1 in. to 8 in. The hexhead lagscrew shown is ½ in. dia. x 4 in. long.

A cousin of the lagscrew is the capscrew. Like its relative, a capscrew has a hexhead and large-diameter shank. However, capscrews have machine-screw threads for use in tapped holes or with individual nuts. All machine-screw fasteners are designated by gauge, threads per inch, and length in inches. This includes capscrews, machine screws, carriage bolts, machine bolts, stove bolts and threaded rod stock. For example, the capscrew shown is ½-13 x 2 in. That is, ½ in. dia. with 13 threads per inch and 2 in. long.

Machine-screw threads are designated as either National Coarse (NC) or National Fine (NF). NF screws have more threads per inch than NC screws and, therefore, have greater holding power. However, NC screws are sufficient for most typical home and shop applications.

It's also worth mentioning that capscrews are manufactured in three strengths. A standard-strength capscrew, indicated by a plain, smooth-surfaced head, has a minimum tensile strength of about 74,000 psi (pounds per square in.). Medium strength screws are rated to a minimum of 120,000 psi, and are identified by three raised hash marks on the screwhead. Six hash marks identify a high-strength screw that's rated to 150,000 psi. Again, standard-strength capscrews are sufficient for most home and shop jobs.

Specialty screws

Each of the following screws (No. 1 through 10) is designed for a specific application. The first two are 2½-in. No. 8 drywall screws. They're used to attach gypsum wallboard to wood and metal studs. Both screws feature a thin shank and a Phillips, self-countersinking bugle head. The difference between the screws is their points.

Shown above are common screw-drive types (top to bottom): slotted, Phillips, Torx, Robertson, hexhead, hex socket and the 1-way security screw.

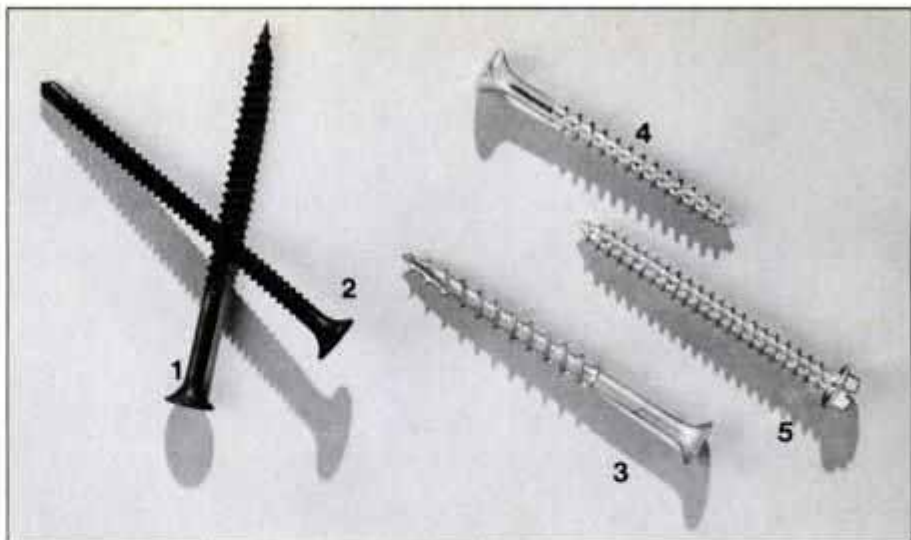
SCREWS

Screw No. 1 has a sharp, needle point for use in wood and thin metal (it's also excellent for general woodworking and cabinetmaking). The second screw (No. 2) has a self-drilling point for driving through metal studs of 20 gauge or heavier. Drywall screws are designed to be driven with an electric screwgun, but you can use a Phillips screwdriver just as well.

For your next outdoor project, try FasTap Plus exterior-grade screws (No. 3). These screws, similar in design to drywall screws, have self-counter-sinking bugle heads, thin shanks and sharp self-starting points. A special Dacrotized coating, made of a tough polymer and zinc compound, provides superior protection from moisture, salt spray and corrosive chemicals used in treated wood. FasTap Plus screws are available in sizes ranging from 1½ in. No. 8 to 6 in. No. 10. For details contact Faspac Inc., 17903 Arenth Ave., Industry, CA 91748.

The next screw (No. 4) is designed specifically for use in particleboard. It features a thin shank and deep, wide threads that provide greater holding power than standard wood screws. Made of heat-treated, zinc-plated steel, the screw has a Robertson-drive flat-head. Shown, is a 1¼ in. No. 8; 2-in. and 3-in. lengths are also available. For details on particleboard screws and other Robertson-style screws, contact The Woodworkers' Store, 21801 Industrial Blvd., Rogers, MN 55374.

Self-tapping screws (No. 5), more commonly known as sheetmetal screws, tap their own threads in light-gauge metal and wood. Most self-tapping screws have panheads or roundheads. The 2-in. No. 10 screw shown has a slotted hexhead with a built-in



Here are five screws that are invaluable to home and shop projects: 1. drywall screw; 2. drywall screw with self-drilling point; 3. FasTap exterior-grade screw; 4. particleboard screw with Robertson head; 5. self-tapping screw, also called sheetmetal screw.

washer. It can be driven with a slotted screwdriver or socket. Self-tapping screws are available in sizes ranging from ½-in. No. 4 to 2-in. No. 14.

Unlike a conventional screw that has one head and a threaded shank, a hanger bolt (No. 6) has no head and two threaded shanks. This unusual fastener has machine-screw threads on one end and wood-screw threads on the other. To install a hanger bolt, thread two nuts, side-by-side, onto the machine-screw end. Then, bore a pilot hole for the wood-screw threads. Now place a wrench on the nut closest to the bolt end and turn the screw into the wood. Hanger bolts are most often used to attach table legs to tabletop assemblies. The bolt shown is 5/16-18 x 3 in.

Another unusual-looking fastener is the hanger screw (No. 7). It features wood-screw threads and a flattened

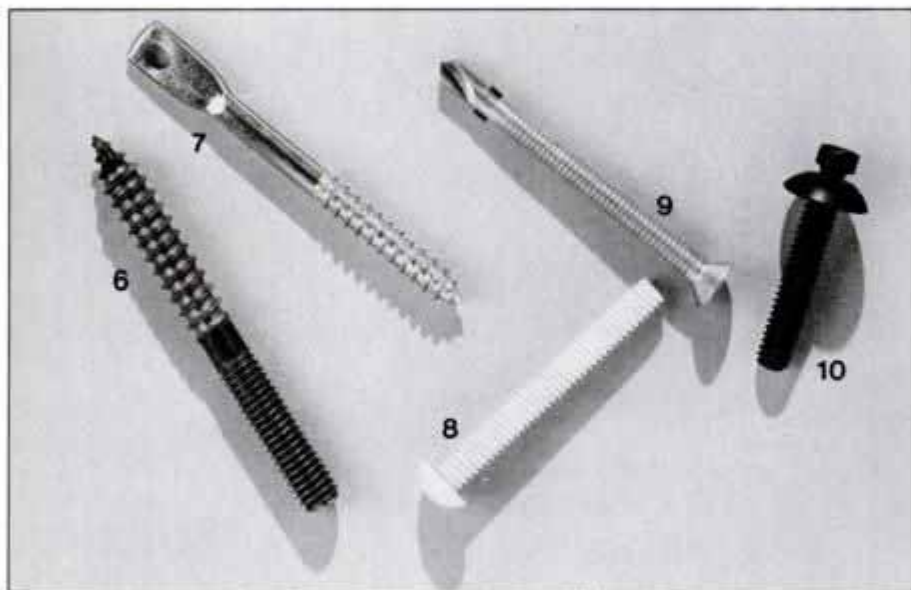
head with a hole drilled through it. Hanger screws are used primarily for installing suspended ceilings. The wires that support the ceiling are attached to them.

The flat head allows you to drive the screws with locking pliers or an adjustable wrench. You can also turn in the screws using a nailset stuck in the screwhead's hole. The easiest method I've found to install hanger screws, though, is with an electric drill. Chuck the screwhead in the drill and power-drive it in. The screw shown is ¼ in. dia. x 3 in. Hanger screws are available in lengths that run up to about 5 in.

The widespread use of plastics created a need for nonmetal fasteners. Conventional steel screws tear out plastic threads too easily. Nylon screws (No. 8) are used to join together plastic parts and assemblies. Nylon is lightweight, strong and, of course, rustproof. The slotted roundhead machine screw shown is ¼-20 x 2 in.

The next screw (No. 9) features a self-drilling point that will bore and ream wood and tap steel in one operation. The 2½-in.-long screw has a large No. 3 Phillips flathead, 12-24 machine screw threads and two cutting wings that protrude from the screw tip. The wings bore and ream wood and then break off as the self-drilling point taps the steel. Use this style screw to fasten plywood and 2-by lumber to metal .089 in. thick or thicker. Drive the screws with an electric screwgun.

Security screws are designed to be virtually impossible to remove. Screw No. 10 is a roundhead breakoff security machine screw. After the screw is driven tight with a hex socket, the protruding hexhead can be snapped off with a hammer blow. The ¼-20 x 1¼-in. screw shown is made from solid bar steel with a black oil finish.



These unusual screws are designed for very specific fastening jobs: 6. double-ended, headless hanger bolt; 7. hanger screw; 8. nylon machine screw; 9. self-drilling machine screw with two wood-cutting wings; 10. tamperproof security screw with break-off hexhead.

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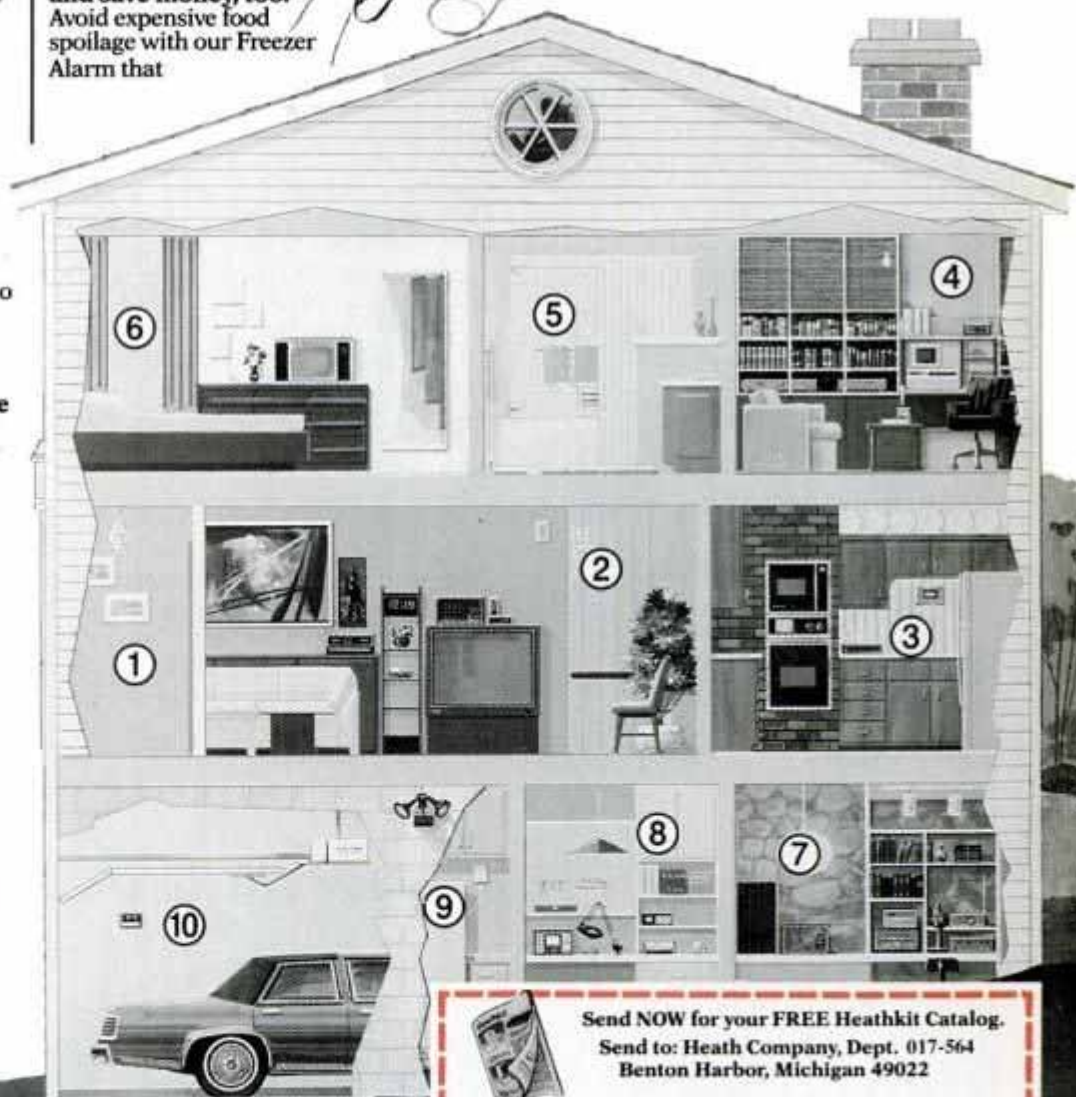
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3-D TV COMES HOME

(Continued from page 69)

Gloeggler, "on a regular VCR, TV, over the air, whatever." But this advantage is also a limitation, since it holds the system to the 60-field-per-second rate of the American TV standard, creating the same flicker problem seen in the Tektronix system.

Sharp tries to minimize the noticeability of the flicker by building a neutral-density filter into the LCD glasses. This helps, because the human eye seems less sensitive to flicker at lower light levels. But it also reduces the brightness of the image, which has already been dimmed by the polarizing filters themselves. Choosing between flicker and dim pictures is, as Gloeggler admits, "a delicate balance."

Japanese 3-D fans aren't the only people who can buy this system. The computer-game company Sega has just introduced a 3-D add-on package for its popular Sega Master System home videogame. As an option, Sega System owners can purchase a pair of LCD-shutter glasses almost identical to those used by JVC and Sharp in their 3-D systems. The glasses plug into a small interface board that synchronizes the LCD shutters with the game computer. The computer sends alternate left- and right-eye views to the TV set with every video field.

Viewed through the glasses, the 3-D effect is quite pronounced. When PM tried out a prototype of the system, only one game, an outer-space target game called "Missile Defense 3-D", was fully operational. But Sega is working on a variety of 3-D game concepts, including 3-D racing, golf and Ping-Pong, and hopes to have at least six 3-D games available by the end of this year.

This system could be the first high-quality 3-D entertainment system ever to make its way successfully into American homes. Moreover, Sega of America Research and Development Manager Steve Hanawa points out that since the system uses essentially the same technology as Sharp and JVC, the Sega LCD glasses ought to work with those systems if either 3-D video system becomes available here. Besides Sega, videogame maker Nintendo of America, based in Redmond, Washington, will offer LCD glasses and 3-D games.

The LCD-glasses approach is also opening 3-dimensional doors for users of more sophisticated computers. For example, San Francisco's Antic Software publishing company is offering "Stereotek" LCD glasses to work in conjunction with the Atari ST 520 and 1040 computers. The glasses were developed by Tektronix-subsi-dary LC Technologies.

Using the same field-sequential tech-

nique employed by Sega and others, Antic's glasses let a programmer design real 3-D graphics either in color or in higher-resolution monochrome. One of Antic's first programs for the system, dubbed "CAD 3-D, 2.0", allows amateurs or professionals to create sophisticated, moving 3-D designs of the sort once only possible with high-powered graphics computers. In Japan, Sharp offers a similar system using glasses for certain Sharp computers.

Major video manufacturers aren't the only people interested in 3-D television. Experimentation in 3-D is almost



All 3-D images yield a sense of depth by providing two perspectives as seen separately by the left and right eyes. To replicate this perspective for 3-D video, Sharp and others use two cameras spaced a few inches apart just as human eyes are.

a cottage industry in the U.S., and enthusiasts even have their own magazine, *Stereo World*. Many of the 3-D approaches developed by amateurs are mere backyard curiosities, but then so were the first movie cameras.

Even the best TV-based 3-D systems are, as one researcher says, "like looking through a window at a distant place." A few 3-D visionaries are trying to create systems that will take you through the window and, he continues, "make you feel like you're present in that distant place."

NASA researcher Michael McGreevy calls this concept "advanced telepresence," and he believes he and his fellow researchers are close to being able to achieve it. To some extent, they already have.

At NASA's Ames Research Center, McGreevy and others have developed a prototype 3-D system that can transport the viewer into completely alien environments. Instead of having the viewer look at an image on a screen, the NASA system has two small LCD TV screens mounted in a helmet, one directly in front of each eye. Separate left- and right-eye views, either from cameras or from a 3-D computer-graphics program, are fed directly to the appropriate screen. Special optics en-

(Please turn to page 90)

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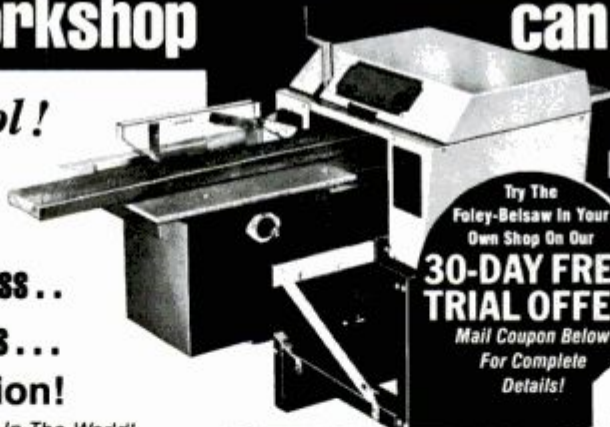
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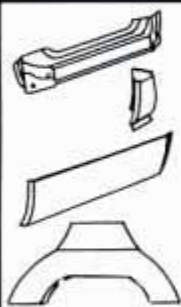
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3-D TV COMES HOME

(Continued from page 88)

sure that the two views overlap properly, and spread the image over a reasonably wide field of view. The helmet also includes head-tracking sensors that follow any movement of the viewer's head and adjust the flow of images to correspond to whatever direction the viewer is looking. Stereo speakers over the ears complete the illusion.

NASA wasn't the first to build a 3-D helmet display: Military prototypes have been built that use high-intensity CRTs (cathode-ray tubes) to supply the image. But building CRTs into a helmet creates problems with unwanted radiation and excess weight. In fact, one early helmet had to be lifted into place with a rope and pulley. The NASA system sacrifices the higher resolution of CRTs for the practicality and wider viewing angle that flat LCD screens provide. NASA's current helmet uses slightly modified versions of the same LCD screens used in Citizen-brand pocket televisions.

NASA calls the world inside the helmet a "virtual environment." Why virtual? Because, says McGreevy, "It looks like an environment, it walks like an environment, it sounds like an environment. It's just not real."

The applications for the helmet, called the Virtual Environment Workstation, are limitless. One obvious use is to facilitate human control over robots operating in space, undersea or in other inhospitable environments (such as near the cores of nuclear reactors).

McGreevy hopes the system might also help astronauts preview different environments before they make the arduous trips to explore them. In a down-to-Earth example, he recalls that one researcher took the 3-D camera rig home with him and walked it through the rooms of his house, talking to family members, even meeting the dog.

After watching the tape, McGreevy says, "When I went to his house, I felt like I'd already been there—I knew my way around."

The worlds explored by the Virtual Environment Workstation don't even have to exist. Connected to a sophisticated computer-design system, the helmet could be a powerful tool for previewing proposed environments even before they are built. Using the system, McGreevy points out, "an architect could walk through a building he intends to build."

And at Ames, researchers are hoping to use the system to get closer looks at computer-generated models of aircraft during supersonic wind-tunnel simulations. And application is also possible in the operating room where it can assist a surgeon "traveling" through a patient's

body (see *Fantastic Voyage*, page 63, Dec. '86.)

It doesn't necessarily take NASA's budget to experience virtual environments. A North Carolina company called Space Robot Services, in Winston-Salem, is working to bring a very similar system to consumers.

At this writing, the company has a black-and-white prototype system of LCD goggles almost identical in concept to the NASA approach. The system can be used to view live 3-D images generated by a pair of remote-controlled video cameras, existing 3-D movies converted to video, or computer-generated material. A special adapter processes the signal for 3-D viewing in the goggle display. As the company's name implies, Space Robot Services is also hoping to get NASA contracts to help build robotic systems for space. In the meantime, the company promises to demonstrate its home version of the LCD goggles this summer. Eventually, says company President John Gallagher, a system that will allow consumers to shoot their own 3-D home video movies may be possible.

3-D's future

So far, all the 3-D video systems that seem to have a chance of making it into U.S. homes are really "stereo" systems. Though they give a sense of depth, they can't really show 3-dimensions. In other words, you can't move your head to see *behind* an object.

Is there any hope of seeing *true* 3-D in the near future? Possibly.

The Japanese electronics giant Matsushita has demonstrated a video system that can show true 3-D to some extent. But since it requires a whole complex of cameras and monitors to work, it hardly seems practical. 3-D expert Stephen Hines says he's working on a true 3-D video system as well, but concedes it's too early to tell whether it could be applied to home use.

Of course, the ultimate 3-D image is a hologram. A great deal of today's research focuses on ways to record and play back moving holograms. Researchers in the Soviet Union are said to be particularly advanced in this area. And this spring, Japan's electronics industry banded together at the behest of that country's Ministry of Posts and Telecommunications to develop 3-D TV systems that won't require glasses. Holograms will be the prime focus of the group's research and development.

The idea of holographic movies in the home might seem like a pipe dream today, but 40 years ago the idea that ordinary homeowners would someday have their own video recorders and advanced computers seemed just as remote. So, don't touch that dial. Stay tuned.

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PM OWNERS' REPORT

(Continued from page 62)

fine, even to those with lower back problems. But most agreed that the rear bench wasn't adequate for grown ups: too short back to front, and not enough legroom. Tall drivers, too, sometimes had a hard time seeing the instruments.

Our survey showed that the P-Car's real-world fuel mileage came in at 2 to 4 mpg below the EPA estimates of 25/33 city/highway. Our respondents reported averaging around 23/29 mpg. Turbo-charged cars paid an additional 2 to 3-mpg penalty. Most owners, though, praised overall economy and felt they'd gotten good value for their dollar.

The great majority of owners echoed that sentiment. A California teacher said, "I narrowed my initial buying choices to a Honda Accord and the Chrysler LeBaron GTS. While at the Chrysler dealer, I saw the Sundance, which looked to me like a baby LeBaron. I test-drove both the GTS and the Sundance and was impressed. What clinched the deal, though, was that, for \$12,000, the Sundance gave me everything I wanted in a new car. Similarly equipped, the Accord and LeBaron would have cost a lot more. I haven't regretted my choice."

Acura Legend

The Legend seems well on its way to becoming one in its own time. In the 17 years I've been writing PM's Owners' Reports, I've rarely heard so many raves and so few negatives. Owners absolutely love this car. People praised the Legend with lavish enthusiasm.

Try as they might, most owners couldn't find a thing wrong with their Legends. Fully 100 percent rated workmanship good to excellent. The few drivers who did suffer mechanical problems (a mere 17.6 percent) complimented Acura dealers for quick and lasting first-time fixes. Those are all rare testimonials. "I'm in awe of this car," confessed a Maryland physicist. "I can stand in front of it with the hood open and the engine running and not hear a sound. I can place a glass of water on top of the engine and not see any surface ripples. What makes the Legend all the more pleasing is that, after 5500 miles, I have yet to find the first flaw . . . not so much as a loose screw or the tiniest squeak."

The fun factor loomed large in many drivers' opinions. "I haven't had this much fun since I sold my 1957 Chevy convertible," said a Kentucky fast-food supervisor.

Nor did ride and comfort take a back seat. A California transportation director: "Ride is spectacularly quiet and

(Please turn to page 92)

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PM OWNERS' REPORT

(Continued from page 91)

comfortable. The Legend is fast, maneuverable and competent. Interior roominess is more than ample. Exterior fit and finish are flawless. This car is better than the BMW we used to own."

That's not to say that everybody applauded everything about the Legend, but complaints were rare and fairly minor. Tall, bulky drivers seemed to have trouble getting into and out of the front seat, and 12.3 percent pointed to a lack of headroom. "Headroom for people over 6 ft. tall is cramped, both in the front and back," remarked a California real estate agent. A Maryland dentist: "Lots of legroom fore and aft, but there's just barely enough headroom for my 5-11 frame."

The 4-speed automatic transmission, with lockup in 2-3-4, annoyed 7.3 percent of our drivers by being jerky between shifts. "Acceleration is breathtaking," said a California retiree, "but it might be accompanied by more subtlety from the transaxle."

And while most owners raved about the Legend's acceleration and flashy performance, a few noticed the V6's weak low-end torque. A Florida pilot pointed out that, "There's a flat spot in top gear at 55 mph. This gives an objectionable lag until the automatic transmission downshifts and the engine exceeds 3000 rpm. When I'm climbing long hills, the transmission continually hunts between Second and Third."

A relatively low 40 percent of Legend owners were attracted by the car's styling, and 36.9 percent listed appearance as the car's third-best-liked attribute (after handling and performance). A number of respondents were downright unhappy with the look of the Legend. "The design is too close to the Accord's," said a Maryland teacher.

Even so, the final tally told of a car matched by the level of dealer attention and service. Dealer service was given a rating of good to excellent by no fewer than 92.7 percent of our respondents—a record number. The Acura went on sale in 1986 with a base price of \$19,753, yet 66.5 percent of the people we surveyed reported paying less than that for their Legends—some as little as \$17,000. The average price in our survey came to \$19,490.

Because their Legends came so fully equipped—plus the factors of quality, reliability, performance, handling, luxury, comfort and dealer attention—most owners felt they've gotten very good deals. A Maryland optometrist summed it up this way: "If I'd bought a Mercedes, which I considered doing, and if the Mercedes drove and handled as well as this Legend, I would have felt I'd gotten my money's worth." **PM**

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P M TECH UPDATE

AUGUST 1987



PM ILLUSTRATION BY ED VALIGURSKY

Tilt-Rotors May Change The Way You Fly

Frequent flyers are all too familiar with the problems posed by deregulated air travel. Delays caused by flaws in the air traffic control system are compounded by congested ground transportation. But the V-22 Osprey, a Bell/Boeing tilt-rotor collaboration, may one day rise above it all.

Government and commercial entities are studying

ways to use tilt-rotor technology in a commercial setting, envisioning tilt-rotor commuter aircraft—seating up to 40 passengers—that would cut travel time from city center to city center in half. One study indicates 60-minute flight times from Washington, D.C., to the tip of Manhattan in New York City, 90 minutes from Washington to the center of Boston (inset chart).

The aircraft is shaped like a fixed-wing plane, but instead of a standard engine-

prop arrangement, tilt rotors have two engines mounted on the ends of a wing. The engines, bearing oversize variable-pitch propellers, turn upward for vertical flight and level for a 300 mph cruising speed at altitude. With more power per pound of payload, the tilt rotor is more expensive initially than conventional fixed-wing aircraft, but the flexibility of vertical operation and improved speeds could mean lower costs per payload-mile.



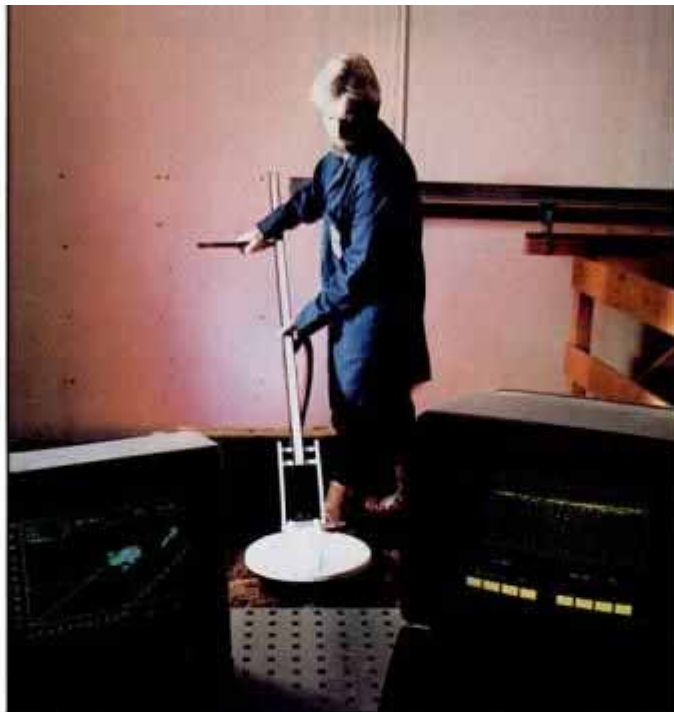
PM ILLUSTRATION BY GEORGE RETSECK

Tilt-rotor commuter aircraft could make short-haul flights between city centers feasible.

Editor: Tim Cole
Contributors: Ed Valigursky,
William Sluru, John Busick,
George Retseck

Measuring Up

The device is called a polarized neutron reflectometer and it measures magnetic fields over microscopic depths on the surface of materials. Scientists at Argonne National Laboratory say the instrument could lead to improvements in digital sound recording and computer data storage. Recently the instrument helped discover magnetic penetration in new superconductors.



ERA echo locator presents digital map of subsurface objects.

Plastic Mine Detector

A defense against the menace of plastic antipersonnel mines—which foil conventional detection—has been developed by ERA Technology Ltd. of Leatherhead, England. The detector emits a burst of radio waves lasting a billionth of a second, and echo patterns from subsurface objects are analyzed and charted on a computer terminal. A cross-section grid of the terrain in question can be generated, right, or an image of the mine can be created, left. Also, the echo characteristics of any mine, regardless of shape or material, can be preprogrammed to aid detection.



A scientist measures magnetic fields on the surface of materials using a new device called a polarized neutron reflectometer.

Eagle Packs A Punch

The design of Sikorsky Aircraft's S-76B commuter helicopter has been reconfigured for a military attack role and designated the H-76 Eagle. In recent armaments testing, Eagle scored solid hits using cannon, rockets and machine guns mounted on pitch-compensated armament pylons. Eagle can be easily adapted for attack, support, medical and other missions.



The military version of the Sikorsky S-76 reduces workload and improves accuracy.

Getting Inside Max Headroom

Peter Wagg, the producer of the hot new TV show, would only tell PM that Max is the result of "a layer of video, audio and computer" technology. "We won't give too much away," Wagg says, "because we want to maintain the illusion." But discussions with computer graphics professionals at the major TV networks give an insight into the creation of America's first, true (quite literally) video personality. Prevailing theories hold that Edison Carter (played by actor Matt Frewer) is outfitted with a plastic headdress, sunglasses and other make up and filmed on video. Edison's image is then run through a digital video effects (DVE) system, reportedly manufactured by the English firm Quantel. The machine removes each intervening frame to give Max jerky head movements and exaggerated facial reactions. The DSE also gives the image a "digitized" look, adding to the illusion that Max Headroom is a computerized entity—not just a reconstituted actor. The only true computer-generated image is the background behind Max. Computer graphics designers use a keyboard, tablet with mouse, an input camera and monitors to create an image and freeze it on a disc. The animation comes last when start and stop points are assigned to key frames.

A scientist measures magnetic fields on the surface of materials using a new device called a polarized neutron reflectometer.





Instructor oversees nurse trainee as she practices giving injections to molded arm. Simulated blood flows through synthetic vessels.

Injection Trainer

This plastic appendage, cast from a live arm, is intended to show nurses, medical students and anesthetists how to give intravenous injections and take blood. The synthetic skin allows natural palpation of the veins and synthetic blood concentrate flows through clearly defined dorsal, cephalic, median cubital and basilic blood vessels. The veins are self-sealing so the arm can be

used over and over again. The key feature of this arm simulator is purely tactile. It duplicates exactly the sensation of penetrating real tissue. It is also fitted with all the relevant landmarks in order to simulate intramuscular injections.

Tip Vortex Harnessed

Pressure differentials between the top and bottom of an airplane wing provide aerodynamic lift. But there's a downside. Converging air flows at the wingtips cause vortices, which create fuel-robbing drag. Now, researchers at Sunstrand

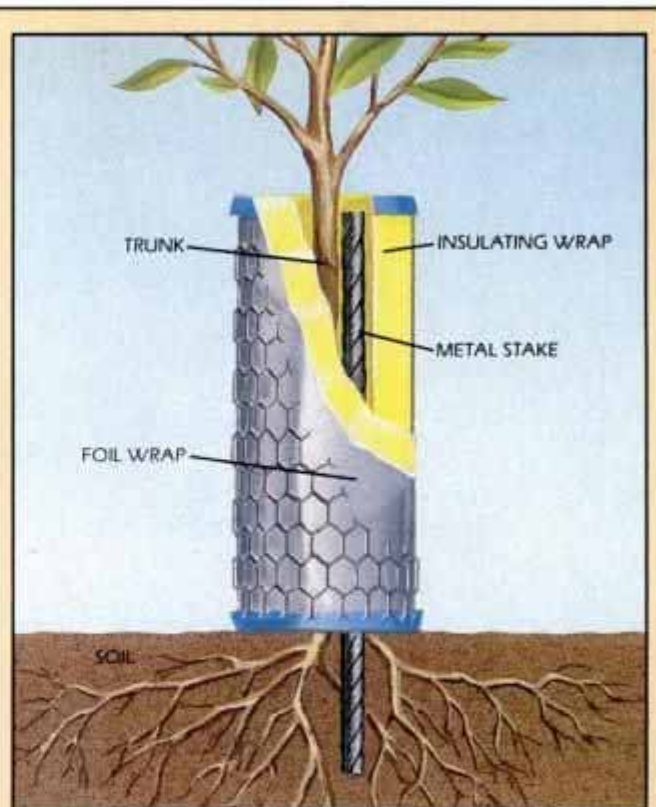


Aviation in Rockford, Illinois, have extracted some of the lost energy the vortices represent.

Wind turbines have been installed on the wingtips of a light plane. The blades are connected to on-board generators. In tests, 14 additional hp were needed to overcome drag. Using wind turbines, three of those hp were recovered and put to use. Engineers predict as much as 400 hp could be generated on a similarly-equipped Boeing 747.



Wind turbine generators harness energy lost from a wing's tip vortex.



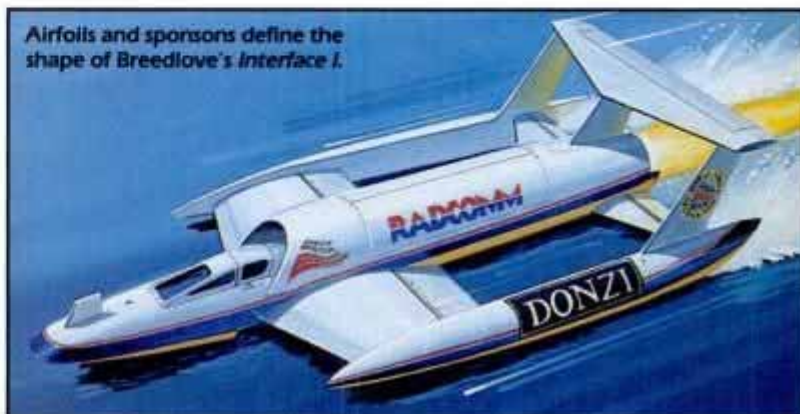
Soil's Heat Protects Trees

Frost action can destroy whole groves of citrus trees. So Associate Professor Lawrence R. Parsons of the University of Florida has devised a way to protect the lower part of a tree by extracting heat from the soil. A metal rod (illustration) conducts heat between the Earth and a tree's budunion (the graft junction between the rootstock and scion). An insulating wrap made of fiberglass and foil surrounds the stake and trunk. Parsons and his colleagues have achieved a 3 to 7° F warming with the simple system and are currently testing how stake thickness, root depth and other factors affect tree protection. Simple design and readily obtainable materials can now save young trees.

Breedlove's Record Attempt

Speed demon Craig Breedlove—five times world land speed record holder—will change mounts for an upcoming crack at the world water speed record of 317.596 mph, held by Australian Ken Warby. Breedlove and his 3-man design team plan to create *Interface I*, a tandem-winged, twin-

sponsored jet hydroplane for the effort. Part boat, part bird, the new *"Spirit of America"* incorporates movable surfaces for aerodynamic control, and a J-79 General Electric turbojet scavenged from a Lockheed F104. The J-79 is capable of producing 11,000 pounds of thrust—and a speed of 500 mph.



Airfoils and sponsons define the shape of Breedlove's *Interface I*.

PM ILLUSTRATION BY ED VALIGURSKY

Материал, защищенный авторским правом

Mean Machine

How do you create the most menacing car in the world? If you're producing a movie called "The Running Man" starring Arnold Schwarzenegger, just released, you call in production designer Jack Collis. Collis assembled vehicles and equipment used by four "Stalkers" who perpetrate mayhem upon a band of innocents for a futuristic



What the bad guys drive in "The Running Man."

TV game show. The plot pits Schwarzenegger against the Stalkers. The most fearsome

Stalker drives a lethal car (pictured) that's actually fabricated from sheetmetal and

dune buggy parts. Body sections are stressed over tubular steel framing and a VW engine supplies the power—a sheep in wolf's clothing. In addition, Collis developed stretched motorcycles, a bad guy who uses a chain saw as a prosthesis, an ice hockey Stalker who uses a hockey stick with serrated edges, and a flame-throwing Stalker. The production team also converted garbage trucks into imposing security vans, stretch limousine pickup trucks, and gravity-drive rocket sleds. But how will they go with popcorn?

Robot On Guard Duty

The *Sentry I* by Denning Mobile Robotics of Woburn, Massachusetts, tirelessly roams office or shop floor and reports irregularities to security personnel. The prime task of the 4½-ft., 3-wheeled robot is to spot intruders, but *Sentry I* also has several other useful functions. For instance, it sees objects in its path by using a ring of 24 ultrasonic sensors. Infrared sensors detect heat, and other detectors sense smoke. Motion is picked up by microwave. *Sentry I* navigates from a preprogrammed floorplan, and when batteries are down, *Sentry I* returns to a special alcove and plugs into a recharging receptacle.



Sentry I senses movement and heat from intruders, and reports to security personnel. Unit stores in control panel alcove, which contains a socket to recharge *Sentry I*'s 12-volt batteries.



Industrial robotics with a high-tech aviation twist: Moving head increases drilling precision and efficiency while cutting tooling and labor costs.

Automated Plane Builder

A robotic carousel head used to fasten airplane wings together can fasten skin clips to hold stock, drill holes and remove burrs from both sides—all on computer command. The system—created by Britain's Taylor-Hitec Ltd.—also eliminates hard tooling and has a drilling accuracy of plus or minus .01 inch. The drilling steps are initiated when an electronic probe in the system reads the surface to be drilled and references the airframe to a computer program.



Dr. Zheng and *CURBi*: A robot that walks like a human pushes closer to robotic autonomy.

Robot Biped

Tracked, wheeled and stationary robots are becoming familiar sights in the American workplace. But practical biped robots that walk like humans have so far eluded scientists. Until now. Dr. Yuan Zheng of Clemson University recently completed a robot biped named *CURBi* that can take one step at a time. Metal legs, 25 in. tall, incorporate four \$1000 joints and are joined at the top by a platform. Scientists foresee a time when bipeds will perform hazardous work at nuclear power plants and in fighting fires.

PM ILLUSTRATION BY ED VALIGURSKY

LONG-TERM TESTS

(Continued from page 55)

Ford Tempo 4x4

When Ford introduced its all-wheel-drive version on the Tempo and Topaz to the press in the summer of 1986, the idea was to start selling them to the public that fall, as 1987 models. We put in an order for one of the very first ones off the assembly line, so we could see how well it performed on snow and ice.

Unfortunately, production glitches cropped up and our car didn't roll off the assembly line until early February. It was then in the pipeline for more than a month before it was delivered to us in mid-March, well after all the serious snow had left the area. This was a pity because, without any snow to play in, this Tempo is just another Tempo—that is to say, okay transportation, but nothing to write home about.

The \$10,194 all-wheel-drive version is about as luxurious as a Tempo can get, with such standard equipment as the fuel-injected, 94-hp version of Ford's 2.3-liter pushrod Four, 3-speed automatic transaxle, AM/FM stereo, power steering and brakes and high-line trim. The options on our test car brought the sticker to \$12,570.

Ford showed great courage by delivering the car with only 6 miles on the odometer, not the 1500 or so of break-in and fine-tuning miles that go into many press cars. Our Tempo had a few rough edges that are probably typical of the cars delivered to ordinary folk. The engine was idling at almost 2000 rpm when we got it and, at about 45 miles, the speedometer and both odometers quit.

The idle adjustment was fixed overnight and the cable patched while a replacement was ordered. The Band-Aid came off the cable almost immediately, and we drove with our fingers crossed and without a speedo for a couple of weeks until the new cable arrived and was installed.

We were only able to calculate gas mileage for one tankful after the odometer got going again, and that was a disappointing 16.4 mpg, no great shakes for a compact 4-cylinder with lackluster performance that's seldom been used in 4-wheel drive (Ford's is a part-time system that shouldn't be used on dry pavement). We hope to do better on future fillups.

Besides the speedo cable, our only other gripe is the upholstery on the driver's seat, which is starting to bunch and pucker up.

So far, no one is too crazy about the all-wheel-drive Tempo. It's not a whole lot of fun, not especially comfortable, and we're not likely to get much use out of its one unique feature—4wd. We'll let you know if it improves with age.—W.H.

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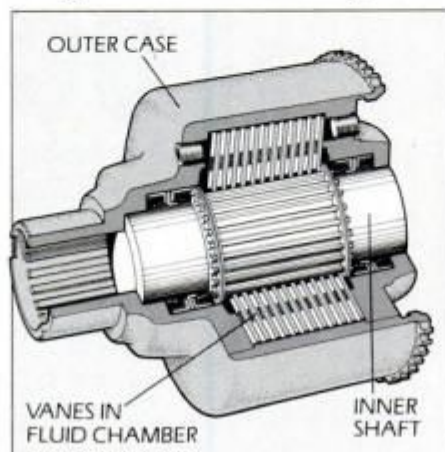
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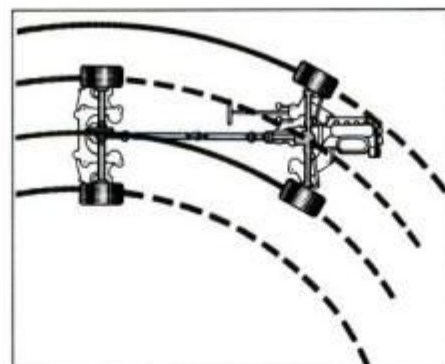
(Continued from page 58)

Variable split

There are now several second-generation 4wd cars available. Instead of having a fixed torque split between front and rear, they have a variable ratio. The first such vehicle on the market was the VW Vanagon Syncro, built for VW by Steyr-Daimler-Puch in Austria. This company has been heavily involved in 4wd vehicles for many years including development of the Mercedes G-wagen and Honda Civic Wagon.



Viscous coupling (VC) has vanes attached to the outer case and inner shaft. A thick silicone fluid between the vanes limits the amount of slip between case and shaft.



When cornering, each wheel covers a different distance. To drive on dry pavement, a 4x4 needs a differential or VC between the front and rear drive and at each axle.

The Syncro Vanagon does not have a mechanical system for splitting the torque between the front and rear wheels. Instead, the driveshaft from the rear engine is connected to the front transaxle through a viscous coupling. The size and spacing of the discs in the VC and the viscosity of the silicone fluid is such that, under normal conditions, only 10 percent of the power is transmitted to the front. If a rear wheel starts to slip, the VC tightens up and more power is transferred to the front wheels until a maximum of 90 percent is reached. The torque split is continually alternating between these two extremes to give the optimum grip.

Volkswagen has also developed its own 4wd system for use on the 4wd Golf Syncro, introduced last year in Europe. It, too, has a single VC between the front and rear drive. The latest version of the Honda Civic Wagon with full-time 4wd also uses a center VC.

Other systems

Mercedes has introduced a totally different computer-controlled 4Matic system on its 300 series, which uses sensors to detect wheelspin, then automatically shifts into 4wd with a 34/66 front/rear split. If wheelspin con-



Volkswagen's 4wd Syncro bus was tested in the Sahara. Unique 4wd system constantly varies front/rear torque split according to the traction available at each wheel.

tinues, the center and rear differentials lock. There are no VCs in the complex Mercedes system, and it can't be called full-time 4wd as the front wheels are only driven when needed.

Engineers at Steyr-Daimler-Puch are working on electronically controlled 4wd systems that will be capable of giving a variable power split from 0 to 100 percent for all driving conditions. Porsche's 200-mph 959 already has an electronically controlled variable split system. Presently, Porsche is developing a variable-ratio 4wd Oldsmobile model for 1990.

Judged by the tremendous success of 4wd rally cars, and the increasing sophistication and cheaper production costs of such systems, we can expect to see a growing number of 4wd cars offered in the coming years. When Audi first introduced the Quattro, Chief Engineer Ferdinand Piech predicted that 4wd for road-going vehicles would catch on within a decade. We're now seven years into that decade and his prediction seems to be coming true. In another three years, it will be interesting to see which system has become the accepted standard. Will it be Audi's 50/50 Torsen mechanical layout, FF Developments' 34/66 VC system or one of the variable-split systems? Time will tell, of course, but 4wd for regular road cars is here to stay, that's for sure. **PM**

Cocaine lies.

After nearly a decade of being America's glamour drug, researchers are starting to uncover the truth about cocaine.

It's emerging as a very dangerous substance.

No one thinks the things described here will ever happen to them. But you can never be certain. Whenever and however you use cocaine, you're playing Russian roulette.

You can't get addicted to cocaine.

Cocaine was once thought to be non-addictive, because users don't have the severe *physical* withdrawal symptoms of heroin—delirium, muscle-cramps, and convulsions.

However, cocaine is intensely addicting *psychologically*.

In animal studies, monkeys with unlimited access to cocaine self-administer until they die. One monkey pressed a bar 12,800 times to obtain a single dose of cocaine. Rhesus monkeys won't smoke tobacco or marijuana, but 100% will smoke cocaine, preferring it to sex and to food—even when starving.

Like monkey, like man.

If you take cocaine, you run a 10% chance of addiction. The

risk is higher the younger you are, and may be as high as 50% for those who smoke cocaine. (Some crack users say they felt addicted from the *first time* they smoked.)

When you're addicted, all you think about is getting and using cocaine. Family, friends, job, home, possessions, and health become unimportant.

Because cocaine is expensive, you end up doing what all addicts do. You steal, cheat, lie, deal, sell anything and everything, including yourself. All the while you risk imprisonment. Because, never forget, cocaine is illegal.

There's no way to tell who'll become addicted. But one thing is certain.

No one who is an addict, set out to become one.

C'mon, just once can't hurt you.

Cocaine hits your heart before it hits your head. Your pulse rate rockets and your blood pressure soars. Even if you're only 15, you become a prime candidate for a heart attack, a stroke, or an epileptic-type fit.

In the brain, cocaine mainly affects a primitive part where the emotions are seated. Unfortunately, this part of the brain also controls your heart and lungs.

A big hit or a cumulative overdose may interrupt the electrical signal to your heart and lungs. They simply stop.

That's how basketball player Len Bias died.

If you're unlucky the first time you do coke, your body will lack a chemical that breaks down the drug. In which case, you'll be a first time O.D. Two lines will kill you.

Sex with coke is amazing.

Cocaine's powers as a sexual stimulant have never been proved or disproved. However, the evidence seems to suggest that the drug's reputation alone serves to heighten sexual feelings. (The same thing happens in Africa, where natives swear by powdered rhinoceros horn as an aphrodisiac.)

What is certain is that continued use of cocaine leads to impotence and finally complete loss of interest in sex.

It'll make you feel great.

Cocaine makes you feel like a new man, the joke goes. The only trouble is, the first thing the new man wants is more cocaine.

It's true. After the high wears off, you may feel a little anxious, irritable, or depressed. You've got the coke blues. But fortunately, they're easy to fix, with a few more lines or another hit on the pipe.

Of course, sooner or later you have to stop. Then—for days at a time—you may feel lethargic, depressed, even suicidal.

Says Dr. Arnold Washton, one of the country's leading cocaine experts: "It's impossible for the nonuser to imagine the deep, vicious depression that a cocaine addict suffers from."

Partnership for a Drug-Free America

WINGS FOR TOMORROW

(Continued from page 75)

up systems they used in their respective aerial mounts during their test pilot days, and the entire table agreed on the need. So, it was decided the processors would probably be split down the centerline of the airplane with one controlling the left half and the other the right. That way a massive power failure would only reduce the rate inputs and wouldn't cause a total loss of control. Each processor would be equipped with a battery backup and it was thought a ram-air turbine (RAT) generator could be deployed. Photoelectric cells could also be molded into the upper fuselage to act as trickle chargers for the batteries in addition to dual engine-driven generators.

By the time we had thrashed through the cockpit and developed a revolutionary (for light planes, anyway) pilot environment, it was time to move to the outside of the airplane.

Since the soul of this new machine would live in the silicon recesses of dozens of microchips, the airplane could look like almost anything, and there was no reason to be restrained by convention. So the guidelines the group laid down for the design of the airframe structure itself were fairly simple: Keep the parts count low to aid in manufacturing and reduce expense. Keep it small (in other words, with approximately 24 ft. of wingspan). And make it a visual grabber.

As soon as the discussion moved to the outside of the airplane, both Rutan and McCandlish started sketching. Mark was taking what he was hearing and putting it on paper. Burt was frantically producing the visions that raced through his mind—he averaged a new airframe design every 90 seconds.

Designing the airframe in sections, the landing gear was the first order of business, but it got entwined with engine decisions almost immediately. When you think about it, landing gear really only serves two practical purposes: First, it saves belly paint and simplifies taxiing. Second, and most important, it keeps the propeller out of the dirt. In other words, trying to streamline the gear would have an impact on prop placement.

Eventually, the propeller was tried on just about every part of the airplane, including the top of the vertical tail fin, to get it out of the way. Finally, we put a pair of them on the trailing edge of the wings as close as possible to the fuselage to limit asymmetrical thrust with one engine inoperative. This cleaned up the nose of the airplane dramatically. It was argued that a pair of lightweight,

inexpensive engines would supply redundancy and, hence, peace of mind for student and experienced pilot alike. Also, two engines could carry smaller props, which would help in the ground-clearance department. Due to the inordinately high cost of aviation engines, it was automatically assumed that our powerplants would have to come from some high-volume use outside of aviation. The engines would either be automotive or industrial in origin and would probably have to be fitted with some kind of reduction unit to keep the propeller tip speeds subsonic.

The Wankel rotary being developed by John Deere appeared as if it would eventually result in a usable engine. Although Lycoming was no longer involved in the project, John Deere was still forging ahead with the Wankel as a possible replacement for expensive aircraft engines. Nothing at John Deere is currently planned in the small, 40-hp size range we thought our airplane would require. But we assumed that small rotaries (the Norton version from Teledyne Continental was also discussed) would work perfectly for our desert *Scorpion*.

From that point on, simplicity became the driving factor. With the nose cleaned up, the high-aspect ratio canard was fitted, which not only helped with stall and center of gravity control, but lowered the parts count as well. Since prop placement was no longer a consideration, the next goal was to design the absolute minimum landing gear. Gliders obviously have the minimum gear in the form of a single wheel in the middle fuselage on the centerline. But gliders are always doing a balancing act—and falling on their buns as they roll to a stop. Such activity would be far too ignominious for the aircraft we envisioned, so we adopted a bicycle-type fixed running gear with the main loading gear and shock absorber located aft of the cabin. A small steerable nose wheel was placed up front, also actuated by a servo motor with fiber-optic input via the rudder bar.

With centerline landing gear, the airplane would naturally want to fall on its side. So tip-dragger outrigger wheels were fitted on the wings, which were, in turn, given a fair amount of negative dihedral, or down slope, to keep the tips close to the ground.

This would keep the airplane nearly level when parked. The wings were also given a modicum of forward sweep, which would allow the main spar to pass completely aft of the cabin area while keeping the wing's center of pressure located correctly in relation to the airplane's center of gravity.

Between the negative dihedral, the

forward sweep and the center-mounted gear, it was beginning to look like we were designing a backyard Harrier.

The basic structure of the airplane was a theme that wound its way through all our conversations from the very beginning. However, since we were sitting in the composites capital of the world, there wasn't much doubt the airplane would be made of some sort of fiber synthetic. So the actual conversations on structures were fairly short and to the point. And the primary goal was, once again, to keep the parts count and labor costs low.

The airplane would be made in large sections, like a plastic model airplane kit. The fuselage would be in two halves, the wing another two, and the canard and assorted surfaces would bring up the rear.

Frank Christensen opted for a skinned-foam process and others discussed ways in which integral structural parts could be molded in—like the ring bulkheads fore and aft, and the 1-piece seat pan/armrest/seat-back unit.

Before we all stood up at the end of the day, we still had to talk about how much our creation would cost the consumer. After a considerable start-up investment (estimates ranged from \$150,000,000 to \$200,000,000) a realistic price was going to be a guestimate, and Rutan deferred to Christensen, who felt it would probably fall somewhere around \$25,000 for airframe, avionics and engines, including dealer markup. Remember, the group—in its blue-sky delirium—ignored product liability and other issues and concentrated on the machine itself. As airplane builder Christensen pointed out: "All the things we've talked about are possible. The injection-molding concept for the airframe panels is here. Certainly, the electronics are easy. All that stuff is here in one form or another. The engines could be here soon."

Modern manufacturing and contemporary materials now in everyday use would be the key to putting the average man back in the air.

Still, we found that the drawings only showed a fraction of what went on that day as the sun went down and a January chill gripped the high desert. There were things we couldn't even make a dent in. FAA certification would still be necessary and it would be expensive. Ditto product liability insurance. But none of these considerations existed in a closed room inside Burt Rutan's shop. All that did exist was a freeform think session that produced a feasible solution for at least one of general aviation's most pervasive dilemmas. Now, it's up to our legislative bodies to find a cure for the other problems. **PM**

YARD POWER

The latest in labor-saving lawn and garden power equipment.



CLOSE SHAVER

Rear-wheel steering and front-mounted mowing deck give Simplicity's new SunRunner the edge when cutting around obstacles. Shown with the optional woodside transporter, the SunRunner comes with an 8-hp gas engine featuring a 36-in. mowing deck. A 12-hp, 42-in. cutting capacity model with manual or automatic transmission is also available. Sold through power equipment dealers, the SunRunner costs about \$1800 for the 8-hp model. Contact Simplicity Manufacturing Inc., Marketing Dept., 500 North Spring St., Port Washington, WI 53074.



FEATHER-LIGHT SPRAYER

This season treat your garden and yourself to the new Solo Jetpak model 435 backpack sprayer. Combining comfort, portability and utility, the lightweight Jetpak features an anatomically designed 5-gallon plastic tank, adjustable shoulder straps and weighs about 10 pounds. Solo claims its low-maintenance Jetpak requires minimum effort to maintain uniform pressure levels and spray patterns. Achieve up to 90 psi with the high-quality, hand-activated piston pump which is equipped with long-lasting Viton seals and gaskets.

Intended primarily for the application of pesticides and liquid fertilizers in gardens, hotbeds and greenhouses, the Solo Jetpak also sprays disinfectants for sanitizing swimming pools, stables and shower stalls.

You can buy the Jetpak model 435 at lawn and garden retailers and farm suppliers for about \$135. For additional information, write to Solo Inc., 5100 Chestnut Ave., Newport News, VA 23605.



EASY ON THE ARM

Power-to-weight ratio and a sensitive inertia chain brake make this Stihl model 034 chain saw stand out for both home and light professional use. The Stihl 034 weighs about 15 pounds and the 3.44-cc engine delivers 4.1 hp. Stihl warrants its Bosch electronically controlled ignition for the life of the saw. It's available with a 16-, 18- or 20-in. bar. Features include an antivibration system, safety throttle-lock, chain catcher, chainguard and front and rear handguards. The Stihl 034 costs about \$455 with an 18-in. bar. It's sold through Stihl dealers. For more information, contact Stihl Inc., Public Relations, 536 Viking Dr., Virginia Beach, VA 23452.

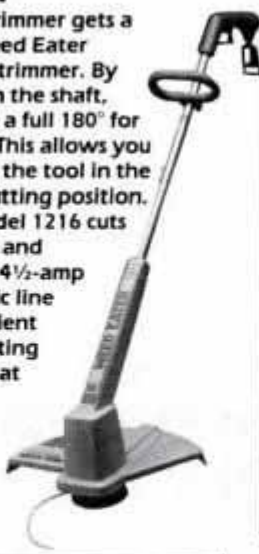
(Please turn to page 102)

YARD POWER

(Continued from page 101)

HEAD TURNER

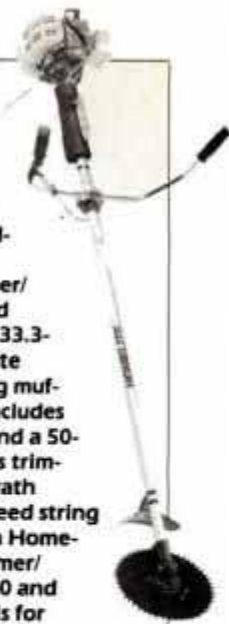
The familiar string trimmer gets a new twist in the Weed Eater model 1216 electric trimmer. By loosening a knob on the shaft, the head will rotate a full 180° for edging operations. This allows you to continue holding the tool in the most comfortable cutting position. The Weed Eater model 1216 cuts a 16-in.-wide swath and features a powerful 4½-amp motor and automatic line advance for convenient renewing of the cutting string. It's available at home centers for about \$60. Contact Beard-Poulan/Weed Eater, Box 9329 Shreveport, LA 77139.



LAND TAMER

Put away your chain saw for branches less than 3 in. dia. and tackle all your land-clearing chores with the Homelite model HK-33 trimmer/brushcutter. The 18¾-pound package features a 2-cycle, 33.3-cc gas engine with solid-state ignition and spark-arresting muffler. Standard equipment includes an 8-in.-dia. Tri-Arc blade and a 50-tooth brush blade. For grass trimming, cut an 18-in.-wide swath with the optional manual-feed string trimmer head. Sold through Homelite dealers, the HK-33 trimmer/brushcutter costs about \$360 and the string trimmer head sells for about \$48.

Contact Homelite-Extron, 14401 Carowinds Blvd., Charlotte, NC 28217.



CLEAN CUT

Mow a 38-in.-wide path with the new model HTR3811 riding mower from Honda. The mower is equipped with an 11-hp overhead-valve gas engine, low-oil warning buzzer, and a 5-speed automatic-clutch transmission. Designed with safety in mind, the engine won't start unless the transmission is in neutral and the blades only rotate while the driver is seated. The model HTR3811 has high-traction tires and its mid-engine design provides excellent stability. Shown with the optional grass catcher (\$320), the Honda HTR3811 riding mower costs about \$2100 at Honda power-equipment dealers.

For more information, contact American Honda Motor Co., 100 West Alondra Blvd., Gardena, CA 90247.

MULE POWER

The tried-and-true wheelbarrow is reborn as WheelBurro—a 1-wheel 4½-hp tractor. The Briggs & Stratton engine sends power to the wheel through a chain and sprocket friction drive with a final ratio of 48:1 for speeds of 1 to 3 mph. The WheelBurro has a maximum payload of 500 pounds and is capable of powering up 45° inclines. Featuring a unique pivoting dumped for stable off-loading, the WheelBurro is currently available with the familiar bucket-type dumped or flatbed and can be optionally equipped with 8-in.-dia., pneumatic castors for 3-wheel rolling. The WheelBurro costs \$750 from the manufacturer. Write to HP WheelBurro Co., 8791 Blue Jay La., Dept. PM, Salt Lake City, UT 84121.



LIGHT GENERATOR

At only 51 pounds, the Kohler 950 portable generator is said to be the most powerful of its size. Designed for camping and home standby use, the Kohler 950 also powers light-duty tools. This 900 continuous-watt generator features an engine-protecting low-oil shutdown, circuit breaker with manual reset, and brushless design for simplified maintenance. In addition to the two 120-volt AC outlets, the 950 has a built-in 12-volt battery charger that can be used simultaneously with AC appliances.

The Kohler 950 costs about \$545 wherever Kohler products are sold. For more information, contact Kohler Generators, Kohler Co., Kohler, WI 53044.

BACKPACK PAINTER

There's no need to be tethered to a paint can on those large spraying jobs with the new Sears Paint Pack. A capacity of 1½ gallons allows you to paint or stain up to 600 sq. ft. nonstop. For convenience, the Paint Pack has a large mouth to ease filling and cleaning and adjustable shoulder straps. The Paint Pack may be used with all Craftsman airless sprayers and most Wagner models, too, according to Sears. It's available in the Sears 1987 Power and Hand Tool Catalog for \$29.99. Contact Sears, Roebuck and Co., Sears Tower, Dept. 703PM, Chicago, IL 60684.

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Indoor Air Quality UNDER THE MICROSCOPE

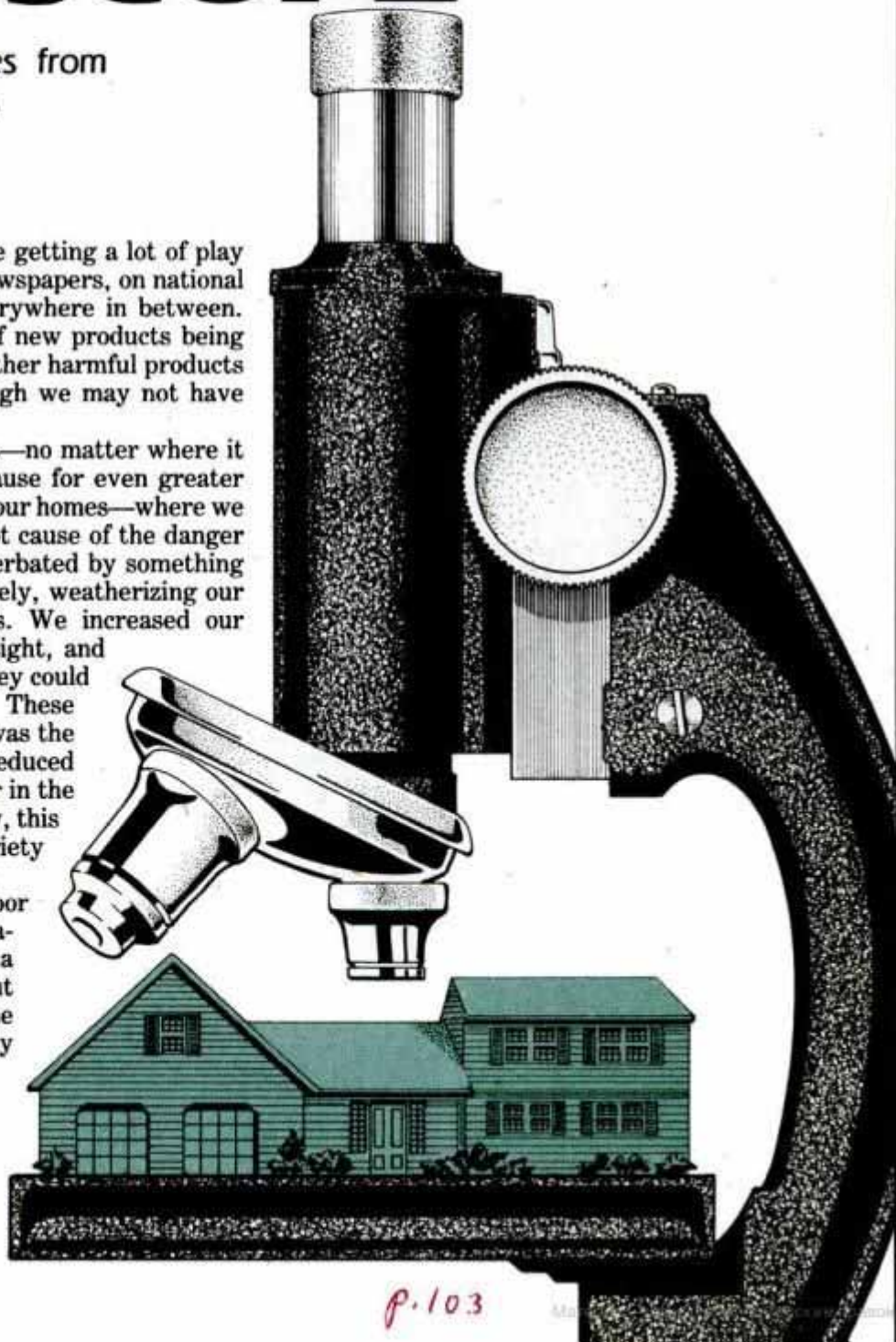
Where indoor pollution comes from and what you can do about it.

BY DAVID EATON

Stories about indoor air pollution are getting a lot of play these days. We see them in local newspapers, on national TV newscasts, and just about everywhere in between. Many of these problems are the result of new products being introduced into the home environment. Other harmful products have been with us for a long time, though we may not have realized their dangers.

Of course, exposure to these pollutants—no matter where it occurs—is a problem. But the issue is cause for even greater concern when these substances surface in our homes—where we spend so much of our time. While the root cause of the danger changes with the substance, all are exacerbated by something most of us did in the 1970s and '80s: namely, weatherizing our homes in response to the energy crisis. We increased our insulation, tried to caulk everything in sight, and weatherstripped windows and doors so they could function like air locks in a submarine. These measures reduced air infiltration, which was the whole point. But at the same time, they reduced ventilation, and in the process trapped air in the house for longer periods of time. Naturally, this resulted in higher concentrations of a variety of harmful gases and other substances.

Until recently, laying the blame for indoor air pollution on the doorstep of weatherization was common practice. And there's a good bit of wisdom in this point of view. But current research suggests that even the most conscientious weatherstripper only cuts air infiltration by about 25 percent. There's still a lot of air moving through our homes and, because of this, more attention is being paid these days to trying to eliminate the sources of pollution, instead of relying on ventilation to solve the problem.



We do bring some dangerous substances into our homes ourselves, such as various cleaning agents and solvents. We also have some habits that harm indoor air quality, such as reducing the concentration of oxygen—and increasing the carbon monoxide—by using open flame space heaters without proper ventilation. Yet, once we realize the danger of these practices, we can stop quickly. There are, however, some things over which we have little control, namely radon, asbestos and formaldehyde. These three are essentially “built-in” to our homes and as such require special attention.

Radon

Radon is a problem and a product of nature. Uranium gives off this odorless, colorless gas during its natural decaying process. The gas, which is found in the soil, penetrates the house through cracks in the foundation, and around plumbing and electrical openings. Once inside, the gas decays again into particles that attach to dust. If inhaled, the particles can lodge in the lungs and cause lung cancer. The Environmental Protection Agency says radon exposure is responsible for 5000 to 20,000 lung cancer deaths a year.

The reason radon gets into our homes in the first place is because of the difference in air pressure between the ground and the inside of the house. Generally, the lower pressure in the home—caused by a variety of factors, including the use of indoor air by furnaces, stoves, clothes dryers and other appliances—draws the gas into the living area.

Radon is not a problem in all homes. Certain areas have higher uranium deposits than others. One example is the Reading Prong, a swath of real estate extending from eastern Pennsylvania, across western New Jersey and into New York. Nationwide, radon may be a problem in 12 million homes. Because we can't sense radon, we need help to find out if it is entering our home, and at what concentration.

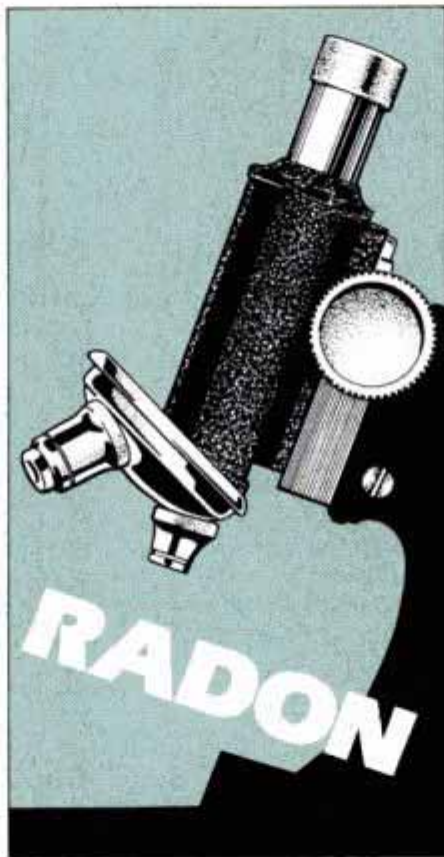
“People should call the environmental Radiation Office in their state,” says Melissa Wing, problem assessment specialist for the EPA office in New York. “We want the state to serve this function because there are too many variables that create a hazardous environment. Five houses on a block may have high levels of radon, yet another five may not. And houses on the other side of the state may share the problem. The individual states have a better

idea of the areas that have problems right now.”

The state Radiation Office will put you in contact with a laboratory that tests for radon. The EPA has developed the Radon/Radon Progeny Measurement Proficiency Program, a bureaucratic title for a project that tests independent laboratories for their ability to measure radon levels.

These labs aren't accredited, but they do meet the criteria for doing the necessary analysis.

The labs can provide a variety of radon detectors. The detectors and the analysis range in cost from \$10 to



“Uranium gives off radon, a colorless and odorless gas, during its natural decaying process.”

\$10,000. Some are as simple to use as opening a package and placing the detector on a shelf, while others require a trained operator.

The EPA recommends that homeowners screen their homes with one of the less expensive models if they suspect a problem. You can send for one of two types of detectors—charcoal canis-

ter or Alpha track. These are placed in your home according to the manufacturer's instructions and, after a period of time, you send them back to the lab for results.

There are disadvantages to any detection method. The charcoal canister is sensitive to temperature and humidity, and the Alpha track must be in place for three months. But either is a logical first step in taking a radon reading.

Generally speaking, you should place the screening device you choose in the lowest livable part of the house since the lowest area is usually the entry point for radon. Close doors and windows for 12 hours before the test, and keep them closed as much as possible throughout the test period. The results will tell you if there is a potential radon problem. Additional measurements will determine the severity of the problem.

Depending on the type of detector used, results are reported in one of two ways: Working levels (WL) measure radon decay products and picocuries per liter (pCi/l) measure the concentration of radon gas. The EPA considers 0.02 WL or 4 pCi/l an average measurement for homes. Anything above these levels requires attention. The higher the radon reading, the higher your risk. Based on studies of uranium miners, a reading of 1 WL or 200 pCi/l exposes those in the house to the same risk as someone who smokes four packs of cigarettes a day.

Keep in mind that estimating actual risk is a tricky business. The EPA calculations assume a person will spend 75 percent of his or her time in the house for 70 years—something very few people actually do. The scientific community simply uses the available data to estimate the statistical risk, just as they can give us statistical odds on being in a car accident every time we turn the ignition key.

A number of techniques will reduce radon levels. Basically, they are divided into two categories: Those that remove radon, and those that prevent radon from entering the home.

Ventilation removes radon. Opening basement windows may work fine for houses with levels below 0.2 WL or 40 pCi/l. But even this simple technique must be done correctly. If you open one window, balance it by opening another on the other side of the house. If not, you will decrease the pressure in the basement and actually draw radon into the building.

You can ventilate by installing a window fan or an air-to-air heat exchanger.

Both can cut radon levels by 90 percent. The fans are inexpensive and could cost about \$100 a year to run.

But besides exhausting radon, a fan also expels the heated—or cooled—air from the room. Even if you tried to isolate the basement from the rest of the house by insulating the basement ceiling, you still have to face the prospect of freezing pipes in colder regions during the winter.

An air-to-air heat exchanger costs between \$500 to \$1500 and an additional \$100 a year in electricity costs, but you save about 70 percent of the heat in the area. The exchanger pulls air from inside the house and air from outside the house into a single, divided unit. As the two streams pass, the warm air from the house heats the cool air from outside, thus reducing your heat loss as you gain fresh air and expel radon-laden air to the outside. The installation for whole-house units requires duct work and proper sizing. Window-mounted units for individual rooms may help for low concentrations of radon, but usually won't work for houses with densities above 0.2 WL or 40 pCi/l.

Other techniques prevent the radon from coming into the house. They vary from sealing cracks in the foundation to surrounding the house with drain tiles and connecting the tiles to a pipe equipped with a fan. The fan exhausts the radon before it enters the building.

Sealing cracks used to be the prescribed radon treatment, and many more complicated methods require this first step. But, "sealing cracks is probably the least successful technique," says David Grimsurd, program leader for the Indoor Environment Program at the Lawrence Berkeley Laboratory. "Our experience with energy conservation methods shows that sealing all the cracks is extremely difficult. The concentrations of radon are so small that you must seal *everything* to be effective."

Lawrence Berkeley Laboratory studied a variety of techniques in 15 houses with radon problems in the Pacific Northwest. Grimsurd says that slab ventilation and overpressurizing the basement rank as the best techniques from this study. Each of these methods reduced radon levels by 95 to 99 percent.

In slab ventilation, pipes are installed vertically through the slab into the ground below. (LBL tested this system only on houses that rested on aggregate or highly permeable soil.) The pipes are then connected to an

outside vent equipped with a fan that draws the radon from the aggregate or soil below the house before it can enter the living area. This system costs between \$1000 to \$2000 to install, plus electricity to run the fan all year.

LBL also experimented with overpressurizing the basement in four of the 15 houses it studied. Researchers found that since radon enters a building because the air pressure is usually lower in the house than it is outside, if they increase basement pressure they can keep out radon. This method calls for completely sealing off the basement from the rest of the house and then



"Asbestos is a natural substance that has found its way into about 300 different home products."

delivering air from the upper floors to the basement. It was used only on houses with forced-air heating systems. Researchers sealed the basement cold-air return and installed a fan in the cold-air return coming from the rest of the house. This forced cold air, part of which was diverted to the basement on its way to the heating system, in-

creased the air pressure in the basement area. A small increase in pressure does the trick. This is one of the newer ideas, but it worked for this series of tests.

All of the techniques available have drawbacks. In some cases, you will be trading clean air for higher heating bills. There can also be problems with freezing pipes, noise from fans and condensation. The solution you choose will depend on the location and severity of the problem.

For more information on radon in homes, contact your state Radiation Protection Office or the EPA regional office nearest you. They offer the following booklets for free: "A Citizen's Guide To Radon: What It Is And What To Do About It," "Radon Reduction Methods: A Homeowner's Guide," and "Radon Reduction Techniques for Detached Houses." The last booklet is also available from the U.S. EPA Center for Environmental Research Information, 26 West St. Clair St., Cincinnati, OH 45268. Specify publication EPA-625-5-86-019.

Asbestos

Asbestos is another product of nature that found its way into about 3000 different home products, including pipe insulation, roofing, siding, flooring and appliances. The material is durable and *very* heat resistant. In the '60s and '70s, problems experienced by people who manufactured the product—and some who installed it—began to surface. The result was a series of highly publicized court cases and a proposed ban on all products containing asbestos.

If breathed in and lodged on lung tissue, asbestos can cause cancer and mesothelioma, a cancer of the chest and abdominal lining. The EPA attributes 3000 to 12,000 cancer cases a year to the material. What makes matters worse is that an asbestos-caused disease can take as long as 40 years to develop.

In January 1986, the EPA proposed an immediate ban on the manufacturing, processing and importing of some asbestos-containing products, and a 10-year phase-out of the rest. But even with the ban, and the fact that the use of asbestos has declined in recent years, there are still places where it can be found in homes, especially older homes. The dangerous situations are where the asbestos is exposed and friable—where it can be crumbled into dust.

In this state, microscopic fibers are released into the air and become breathable. However, most asbestos-

containing products found in the home have the fibers encapsulated, so there is no danger unless the capsule is broken. An asbestos floor tile in good condition is not a threat, but sawing or sanding it—thus releasing the fibers—is a problem.

It is a good idea to identify the asbestos-containing products in your home and check their condition. The most typical examples are around hot water—or steam—pipes and around furnace duct work. In these cases, the substance was used for insulation and often looks like white corrugated paper. A plumber or heating contractor should be able to spot an asbestos-containing insulation by looking at it. Also, the EPA has a number (800-334-8571, ext. 6741) where you can get the name of a laboratory that will analyze a sample. The analysis will cost about \$35 and the lab will explain how to obtain and package the sample. If you find asbestos, don't try to remove it. Tampering with it could release the fibers.

You may, however, be able to encapsulate the material. But, in most cases, a qualified asbestos-abatement contractor should deal with the material either to seal it or remove it. Some states have asbestos contractor certification programs. To remove the material, these contractors wear special clothing and respirators. First, they seal off the area containing the asbestos from the rest of the house, then they spray the area with a fine mist of water to keep the dust down. They remove the asbestos and dispose of it according to guidelines established by local health officials. The area is then cleaned with wet mops, sponges or rags. A typical home vacuum cleaner is never used because the fibers are so small they could pass through the cleaner and be blown into the air. Some contractors do, however, use specially designed vacuums for cleanup. The cost of asbestos removal depends on the amount of the material and how it was installed.

Formaldehyde

Formaldehyde is a resin used in products which account for about 8 percent of the U.S. Gross National Product. Some of these products include urea formaldehyde insulation, hardwood plywood used in wall paneling, particleboard used as an underlayment, and medium density fiberboard used in furniture, countertops and cabinets. Problems with the insulation led the Consumer Product Safety Commission to ban it. The ban was later overturned in

court, although by the time this happened, the insulation business was essentially dead.

Experiences with formaldehyde show that some people are sensitive to the fumes emitted from the material. Fumes can cause burning eyes and irritation of the mucous membranes. Formaldehyde does cause cancer in laboratory animals, and recently, the EPA determined that it was the probable cause of cancer in humans.

Four years ago, the Consumer Federation of America petitioned the CPSC to regulate the formaldehyde emission rates of structural products



"Formaldehyde is a resin used in products that represent about 8 percent of the United States GNP."

used in homes. The commission looked at construction techniques: where the boards are used, how they are installed, and how much formaldehyde escapes into the air.

"We found that in conventional housing, using conventional construction techniques, there is no great risk from formaldehyde," says Ron Medford,

project manager, Household Structural Products, CPSC. The products are changing and, "there has been a declining use of particleboard among builders. Many are going to single-floor systems that require exterior-grade plywood, which has a different resin in it." These studies have, however, prompted many manufacturers to use less formaldehyde in their products. The National Particle Board Assn. and the Hardwood Plywood Manufacturers Assn. developed voluntary standards to reduce the substance in their products. The amount of formaldehyde released depends on the surface area containing formaldehyde and the volume of the house. Smaller houses and mobile homes, which contain a lot of these boards, have a likelihood of higher emission rates. Formaldehyde emission rates do lessen over time. This, coupled with the fact that many products adhere to some guidelines, means even recently built houses should not have a problem.

But if someone in your family is sensitive, you can ventilate the area and paint the surface of the formaldehyde-containing product with any paint that acts as a vapor retarder.

This is especially important in the case of medium-density fiberboard. This product is the highest emitter of formaldehyde and is not governed by voluntary standards.

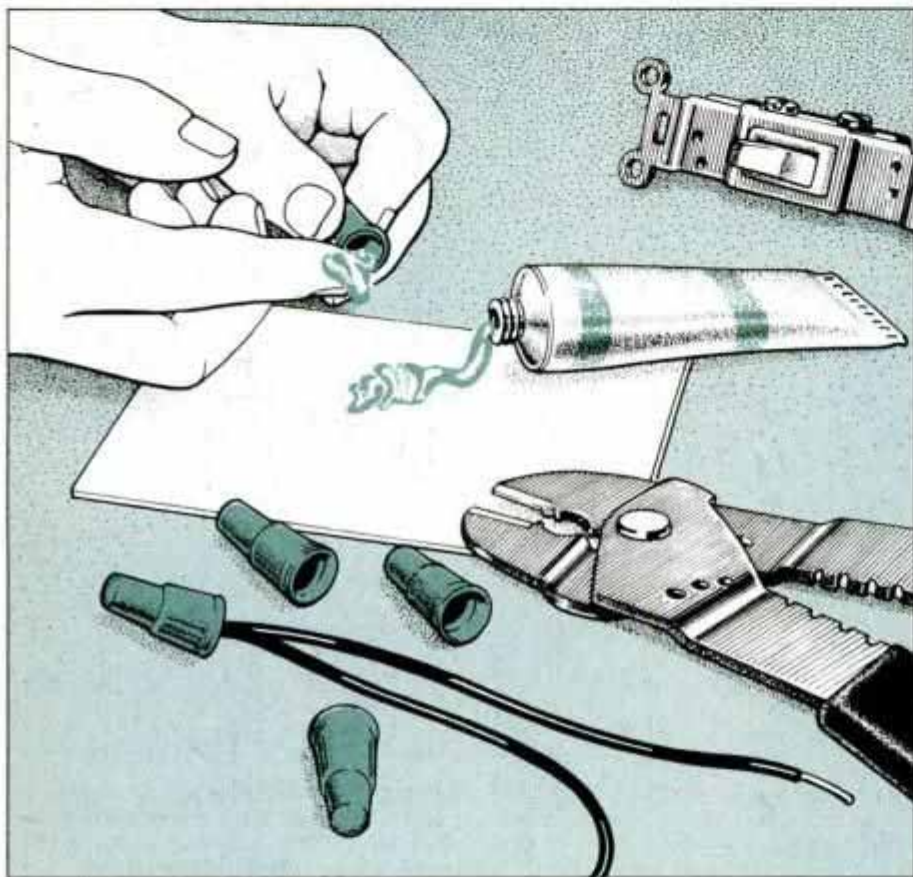
For your home improvement projects, be sure to look for particleboard and hardwood plywood that conforms to the standards of the associations mentioned above. Or use products that follow the Housing and Urban Development standards for mobile homes. Some manufacturers print a warning label on the boards. But again, this is a voluntary step.

"The problem is a consumer may see the label on one board, go to another and not see the label and assume there is no formaldehyde in it. We don't want that," says Medford.

The CPSC has not acted on its study. Medford says the commission will probably work with manufacturers in setting voluntary guidelines, rather than developing mandatory emission standards. The CPSC believes a level of 0.1 part per million of formaldehyde in the air is a safe level.

A level of 0.1 part per million is a little lower than the voluntary standards in effect right now. "But we think it is well within reach of site-built homes, although it is harder to achieve in mobile homes," says Medford. **PM**

How To Defuse The Hazards Of ALUMINUM HOUSE WIRING



A few feet of insulated electrical cable, good wire strippers, a variety of wire nuts and some anti-oxidation paste are all that's required to upgrade your aluminum wiring.

BY MERLE HENKENIUS
Illustrations by George Retseck

If your home is between 15 and 40 years old, you may be living with a fire hazard buried in your walls, namely aluminum wiring. It was used widely after World War II because it was inexpensive and copper supplies were inadequate. The shortcomings of aluminum weren't fully realized until the mid-1970s, after hundreds of thousands of homes were already wired improperly.

The trouble with aluminum is that it's not as good a conductor as copper. As a result, it expands more than copper when carrying a charge and contracts more than copper when not carrying a charge. This doesn't harm the wire

itself, but eventually it can loosen terminal screws on receptacles, switches and some light fixtures. These loose connections cause increased resistance which in turn creates heat and sometimes sparks which can start fires.

Another problem with aluminum wire is oxidation. When dissimilar metals are joined—for instance when aluminum touches brass screws or copper wires—electrolysis results which corrodes the connections, further increasing resistance. To correct the oxidation problem, electrical component manufacturers started making copper-clad aluminum wire. This improvement, however, did little for the expansion-contraction problem. So finally, the industry responded by making switches and receptacles rated to accept alumi-

num and copper-clad wire as well as the traditional copper wire.

Because these newer devices are readily available, you can upgrade your aluminum wiring by simply replacing your old ones with new ones. Unfortunately, this is a relatively expensive undertaking. Your better choice is to splice new insulated copper pigtails between your aluminum or copper-clad aluminum wiring and the switch, receptacle or light fixture terminal screws. To avoid corrosion where the copper and aluminum meet, just pack each wire nut with anti-oxidation paste.

Identifying dangerous connections

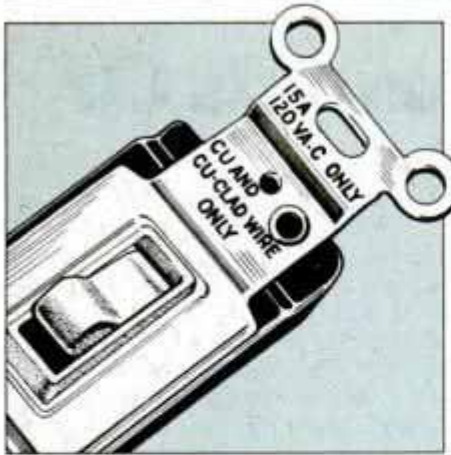
The first thing to do is investigate your present situation. Shut off the power to a specific circuit at your fuse box or breaker panel. Then remove the cover plate from a receptacle and inspect the metal yoke that is screwed to the wall box. This yoke (see drawing No. 1) should have a wire rating stamped into its surface. If you see the letters CU-AL (copper-aluminum) this means the receptacle was designed for both copper and aluminum wire so it doesn't make any difference what type of wire was used in your home. If you see CU and CU-CLAD this means the unit is rated only for copper or copper-clad wire.

If, however, no designation appears, then the receptacle is appropriate only for solid copper wire. To find out what wire you have, pull out the receptacle and inspect the wire ends. If you see aluminum colored wire or aluminum colored wire encased in a copper jacket, the receptacle must be upgraded with copper pigtails.

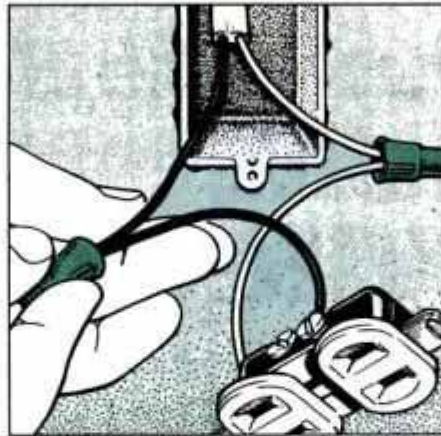
The way you install the pigtails, depends on what type of electrical cable is coming into the metal fixture boxes inside your walls. The drawings on the following page show the two different cables you are likely to encounter. The first is 2-wire cable without ground, which means just a black (hot) wire and a white (neutral) wire. The second type is 2-wire with ground which has the same black and white wires but also has a bare ground wire along for the ride.

Making conversions

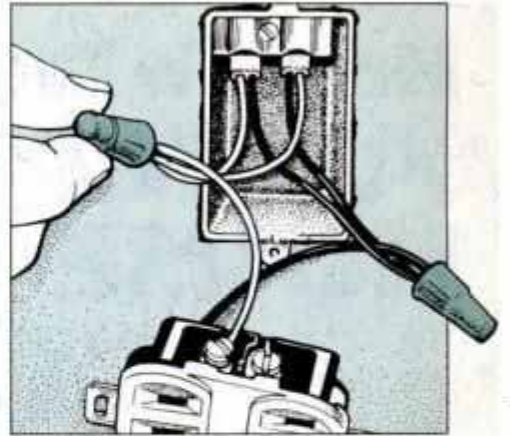
To make the conversion, begin by shutting off the power to one circuit at the main service panel. Remove the cover plate and receptacle from the outlet box and disconnect the wires. Then cut 6-in. lengths of insulated cable that are the



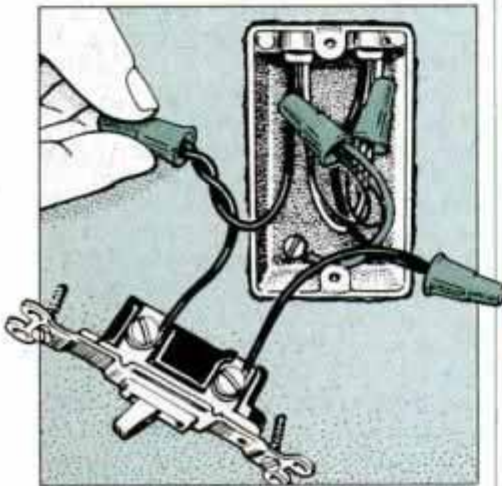
1 Newer switches and receptacles bear rating stamps indicating types of wire they accept. Switch above is rated for copper and copper-clad aluminum, not solid aluminum.



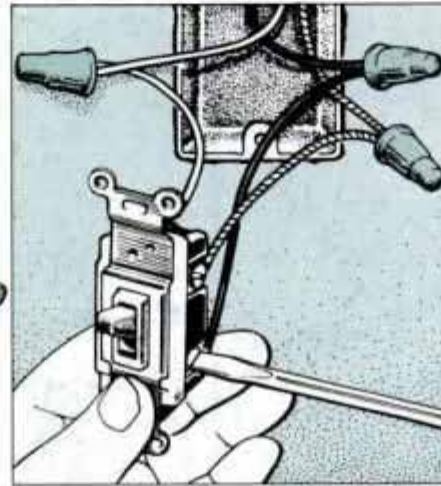
2 To adapt an ungrounded, end-of-circuit receptacle, splice new copper pigtails between terminal screws and aluminum wires. Use paste-filled wire nuts on wire ends.



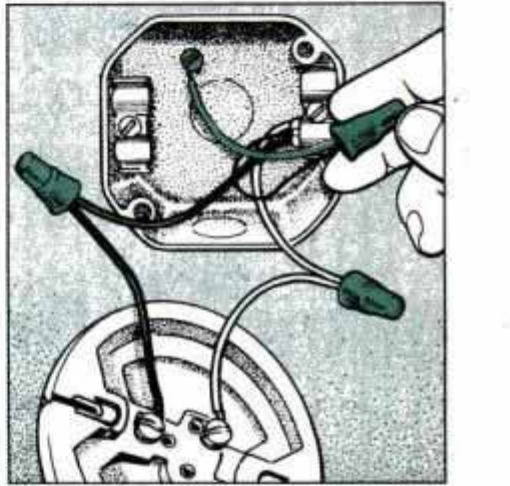
3 To adapt an ungrounded, middle-of-circuit receptacle, splice the new copper pigtails between each pair of like colored wires and their proper terminal screws.



4 Because only the black (hot) wires are attached to a normal switch, add the pigtails only to the black wires. The other connectors in the box remain the same.



5 3-way switches have three different colored wires. To avoid error, adapt only one wire at a time, making sure in each case that the pigtail goes to the original screw.



6 Most light fixtures have copper pigtails in place. But simple porcelain ones don't. Add pigtails to the terminal screws and between the bare ground wire and metal box.

same gauge as the wiring used in your house. Usually this will be 12 gauge, though some circuits, are still wired with 14-gauge cable.

Next, strip about $\frac{3}{8}$ in. of insulation off both ends of the black and white pigtails. Then join these pigtails to the terminal screws on the receptacle. Be sure to note which side of the receptacle was attached to the black wire and which was attached to the white wire. When in doubt, remember that the black (hot) wires should always go to the brass-colored terminal screws.

With the receptacle ends attached, pack appropriately sized wire nuts with anti-oxidation paste and join the new copper pigtails to the ends of the existing aluminum wires, keeping the colors consistent: black-to-black and white-to-white. Make sure the wire nuts are turned down firmly on both wires. If a

bare aluminum ground wire is present inside the box, just join a copper pigtail to this wire and then attach the other end of the pigtail to the back of the box using a grounding screw driven into the hole provided for it.

If there are two cables coming into the box, two white and two black wires, the retrofit is the same idea, except you'll have to use larger wire nuts that can accommodate two aluminum wires and the pigtail at the same time.

When upgrading switches, remember that the switch unit is wired only between the black (hot) wires. The white wires should already be joined together in the box. Leave the white wires undisturbed and simply add the pigtails between the ends of the black wires and the terminal screws on the switch.

If you are adapting 3- or 4-way switches you may find a red wire, or a white

wire with black tape on it, inside the box. This coding is a matter of expedience to electricians, but it looks like a can of worms to just about everyone else. To keep from making a mistake, adapt only one wire at a time.

All but the simplest light fixtures—the inexpensive porcelain utility lights—come with copper-stranded leads that are attached to the circuit wire with wire nuts.

All that's required to adapt these fixtures is to simply remove the existing wire nuts, fill the nuts with anti-oxidation paste and reinstall them.

One last note: Not all circuit breaker or fuse connections are a problem with aluminum wire. It depends on how the individual service panel was designed and outfitted. Inspecting and retrofitting these panels are jobs better left to a licensed electrician. **PM**

Homeowners' Clinic

BY NORMAN BECKER, P.E.

Loose Sills

I live in a house built in 1926. The mudsills are not bolted to the poured concrete foundation. If what I read about earthquakes is true, I'd better get them fastened down. I've been told that there's no simple way to do this. How can I secure them without jacking up the whole house to get the bolts in?

A.K. HAMLIN
MONROVIA, CA

For those not familiar with the term, the mudsill, or sill plate, is the lowest member of an exterior wood-frame wall which rests on the foundation and supports the joists and upright portions of the frame. The term mudsill originated from the procedure of correcting irregularities in the top of the masonry foundation by embedding the sill in a layer of grout or fresh mortar. Normally, this sill is anchored to the foundation wall.

I agree that you should fasten the mudsill to the foundation. In the event of an earthquake, the house could slide, shift or even overturn. Because of the limited space, installing anchor bolts in the top of the foundation would be difficult and costly. Jacking up the house is not a practical solution and not recommended. I suggest that you have an ironworks shop fabricate iron angle brackets. The brackets should have a small spike on the short end which can be hammered into the sill plate to prevent sliding. By mounting brackets on all of your house exterior walls, you will adequately secure the structure. Specifications as to the bracket size and spacing will depend on your locale. So, check with a licensed professional engineer in your area specializing in structural design.

Hot-Water Heating

During the next nine months, I will be building a 1850-sq.-ft. home. I like the idea of a hot-water heating system, but living in the Southwest, I find no information or products available for this.

Is there a good reason why this type of heating is not used in my area? Where can I find the information for designing the system? I will be cooling the house with a fan and plan to use lots of insulation.

DOUGLAS W. LAURSEN
CHINO, CA

The only reason that I can think of is one of economics. In many parts of the country, especially in the Sun Belt, central air conditioning is no longer a luxury, it's a necessity. Installing central air conditioning in a home that's heated with hot water is more costly than one heated with warm air where the ducts and fan from the heating system can be used by the air-conditioning system. Also, in many warmer states, heat pumps are used, again because of economics, to supply both heat and air conditioning.

All heating systems have advantages and disadvantages, and you should select the type that best satisfies your needs. If you do not intend to centrally air condition the house, or if installation costs are not a consideration, then by all means, use baseboard hot water to heat the house.

You can obtain information on hot-water heating systems from The Hydronics Institute, Inc., 35 Russo Place, Box 218, Berkeley Heights, NJ 07922. The Institute offers a 3-day course for \$175 on the Design of Hot Water Heating Systems, which includes: calculating heat losses, selecting heat distributing units, determining boiler size, piping size and layout, and selecting the expansion (air cushion) tank and circulator pump. The course is given in different cities throughout the United States. You can write for a schedule of course dates and locations.

In the meanwhile, if you have a question you can call John Woodworth, technical director of the Hydronics Institute, at (201) 464-8200.

Well-Pump Information

I am very interested in learning about 2-in. and 4-in. water wells and pumps. Do you have any information on this subject?

DICK ADAMS
GRAND JUNCTION, MI

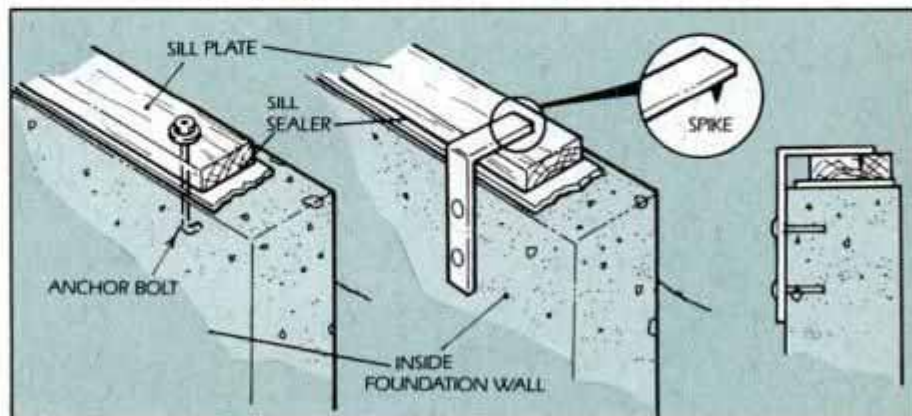
Gould Pumps, Inc., manufactures 2-in. and 4-in. submersible and jet pumps for wells. They offer a booklet on the subject titled *Pump Fundamentals*. For your free copy, write to: Gould Pumps, Inc., Seneca Falls, NY 13148, Attention: Mary Brennan.

Service Tip

The American Society of Home Inspectors (ASHI) has just published an illustrated brochure titled *All About Roofs*. In a recent survey of ASHI members, roof problems were one of the more frequently cited items found during an inspection. The brochure discusses the 11 most frequent causes of roof leaks and contains diagrams of roof styles and roof components.

For your copy, send \$1 and a self-addressed, stamped envelope to: ASHI, 1010 Wisconsin Ave., N.W., Suite 630, Washington, D.C. 20007. **PM**

Do you have a home-maintenance or repair problem? Send it to Homeowners' Clinic, Popular Mechanics, 224 West 37th 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.



Sills are usually secured during construction with anchor bolts as shown at left. Secure unbolted sills with iron brackets spiked to the sill and fastened to the foundation wall.

Appliance Clinic

BY STEVE TOTH

Latched Tight

I have a Kitchen Aid dishwasher model No. KDC-17A. The soap dispenser has two pie-shaped cups. One cup is for the prewash and the other for the main cycle. The latter is covered with a trip latch. More often than not the trip latch fails to open and I'm left with a soapy residue on the final rinse. Can you explain this? STANCIL E.D. JOHNSON SACRAMENTO, CA

Sounds as if the detergent dispenser is binding. Possibly there's a rust build-up on the metal shaft that goes through the center of the dispenser and operates the pie-shaped cover. This rust may be the result of a leaking O-ring water seal. To check the seal, first unplug your machine and open the door. Then, while holding the front panel from underneath, remove the four panel retaining screws. Close the door and pull the panel out at the lower edge of the door and then down to remove it.

With the panel out of the way you'll see the back of the detergent dispenser with its bimetal release mechanism. Check the area around the steel shaft and bimetal for a white, powdery substance or other signs of water seepage around the shaft. These conditions indicate the O-ring seal is worn. This seal is a nonrepairable item and the only solution is to replace the entire detergent dispenser. While you've got the chance, check the bimetal for burns or rust. You'll want to replace this part if it's in bad condition.

Both the detergent dispenser (\$20) and bimetal (\$7) are available at any Kitchen Aid or Whirlpool parts distributors. The bimetal is Kitchen Aid part No. 108676, and the dispenser is part No. 115152. To remove the dispenser, first take off the bimetal assembly which is held in place by a Phillips head screw. Remove all the screws around the dispenser, open the door and lift the unit out. Clean both sides of the dispenser-mounting hole and be sure the surface is dry before installing the new dispenser and gasket. Next, install the bimetal and adjust it so that the white control arm, when pulled back, is as close to the point of release as possible. Finally, replace the front panel and make a test run. You should notice a difference.

Low-Speed Noise

My 1985 Maytag model No. LA512, serial No. 142631PA, washing machine squeals when the spin cycle starts. When the unit reaches maximum speed, the squeal stops. I've traced the noise to the motor area but haven't yet found the cause. LOUIS MOUIS AURORA, IL

The sound is probably coming from the drive belt slipping on the motor pulley as it tries to get the tub up to spin speed. Once the maximum speed is reached, the starting load on the belt is eliminated and the belt no longer slips. The motor-drive pulley and belt have become glazed and should be replaced. The Maytag part for the drive

pulley is No. 2-816. It costs about \$10. The drive belt is part No. 2-11125. It's about \$7.50. They are available at any Maytag parts distributor.

To replace these parts, first unplug your machine and pull it about 2 ft. out from the wall. Place a blanket or towel over the control console and tip the washer back so it leans against the wall. Prop up the front at each corner to keep the machine off the ground. Under the machine, you'll see two belts. One connects the motor with the water pump on the right and the other belt goes to the center-drive pulley. Slip these belts off the pulleys.

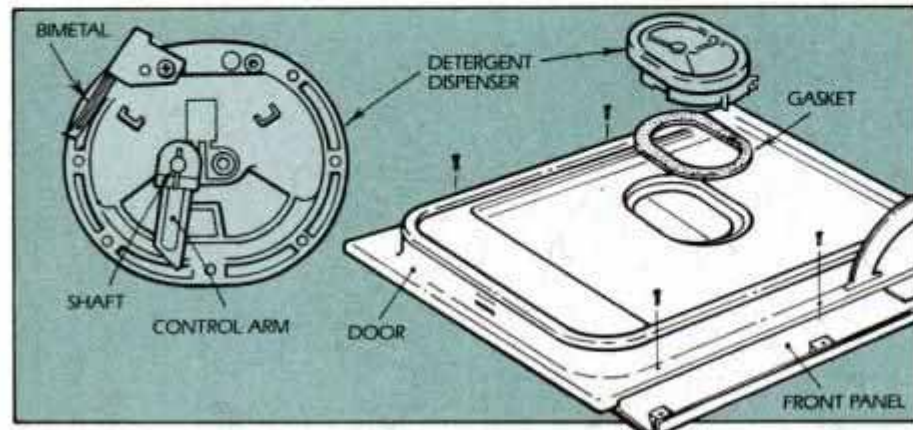
Remove the motor pulley by loosening the Allen setscrew in the pulley side. Check the other pulleys to be sure there's no oil or water on them. Slide the new pulley on and tighten the setscrew. Install the belts, let the machine down, and test run it.

Continuously On

I have an older Westinghouse electric stove model No. KS330RDG4, serial No. KRH19993. The thermostat no longer controls the oven heat. The heat is always on. Can the thermostat be repaired and, if not, where can I get a replacement? JOHN M. FREKOT DOYELSTOWN, PA

Call a few of your local appliance parts dealers to see if they can rebuild your thermostat. If not, you can get a new thermostat from White Consolidated Industries for about \$89. The Westinghouse part number is Q162225. Place your order with Consolidated Sure Service, 1610 Republic Rd., Huntingdon Valley, PA 19006.

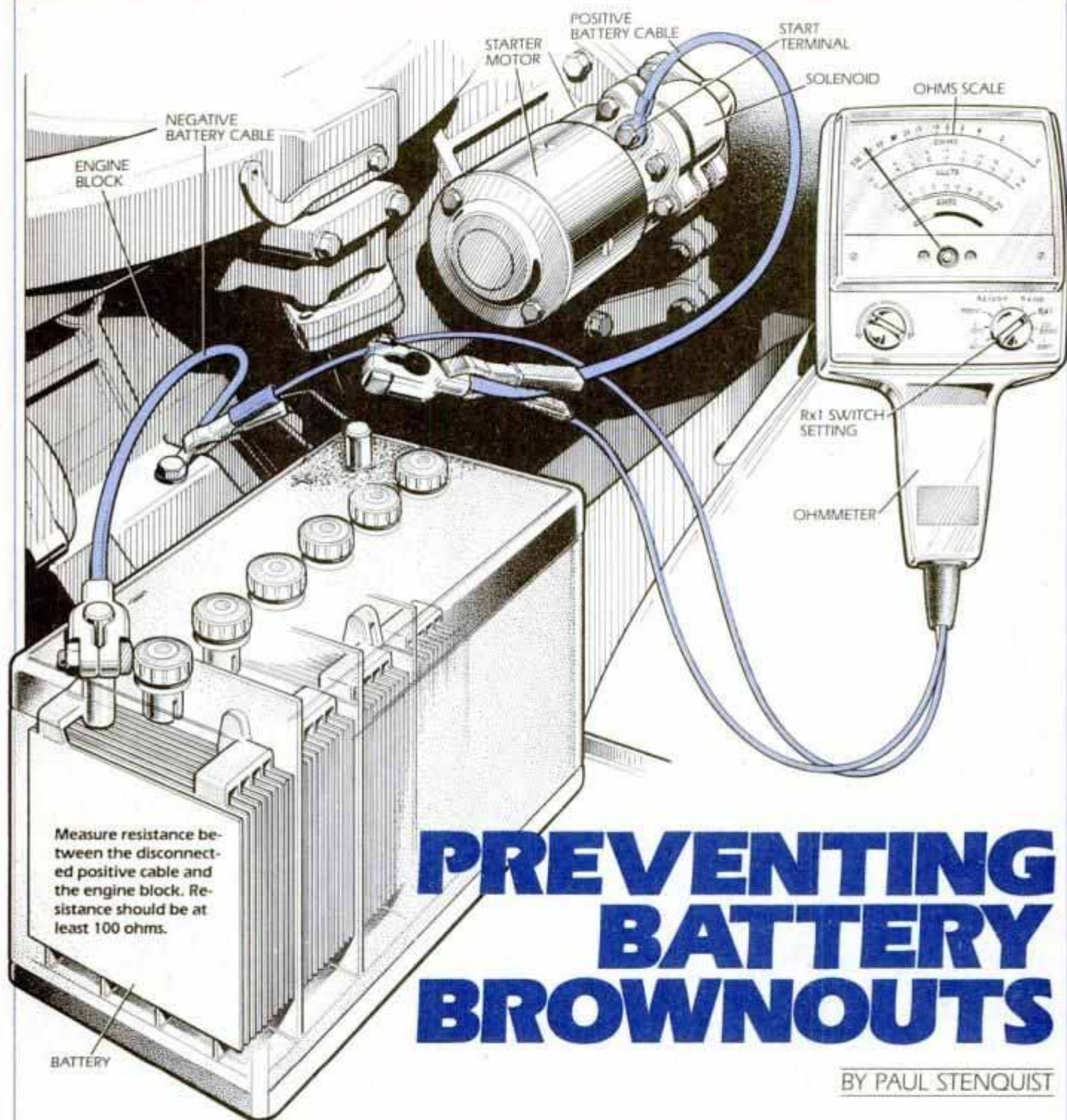
*Those readers who own a White Consolidated Industries Group appliance can get parts and service information at the following toll-free numbers: Tappan (800) 447-2881, (800) 322-4400 in Illinois. Frigidaire, Kelvinator, Gibson and White-Westinghouse (800) 245-0600, (800) 245-0580 in Pennsylvania. **PM***



Remove the door front panel to examine the soap dispenser mechanism. Check for signs of corrosion around the control arm shaft that indicate water seepage.

If you have a problem with any appliance, send your question, along with the 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.

SATURDAY MECHANIC



PREVENTING BATTERY BROWNOUTS

BY PAUL STENQUIST

Millions of dollars have undoubtedly been wasted replacing batteries that were still in their prime. On the other hand, there are probably millions of batteries in service that should have been dumped long ago. If a battery barely starts the car on cold mornings and gradually has more and more of a problem rising to

the task, it probably won't crank the engine at all on really freezing mornings. If the battery is more than 3 years old, it could very well have failed. If it's almost new, increasingly high resistance somewhere in the starting circuit is a good possibility.

On the other hand, if a battery performs with vigor all of the time, but

then suddenly loses its pep, chances are the problem is not the battery but rather the charging system. The same applies to a situation where the charging light suddenly comes on while you're driving, or the voltmeter or ammeter suddenly start dropping. All indications of battery discharge. Inside the battery are lead plates immersed in

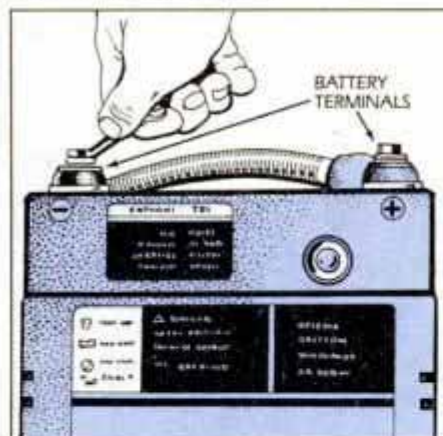
an electrolyte. The chemical action of the electrolyte removes electrons from one plate and adds them to the other, causing the plates—and the terminals connected to them—to become oppositely charged. As current flows, the acid content of the electrolyte diminishes, and the active metals on the plates are replaced with lead sulfide until the battery becomes fully discharged.

By applying current to the battery larger than the rate of discharge—with your alternator—this equation is reversed and the battery charges. Eventually, however, the plates will become covered with lead sulfate and the battery will no longer take a charge. Overcharging or frequent full discharge speeds up the sulfating of the plates.

An excessive starting circuit load (high resistance in the circuits, a tight engine, or bad starter) can make you think the battery is bad by causing slow cranking. In the following sections, we'll outline some simple checks that can help you determine if your battery is ready for the scrap heap or just in need of a little tender loving care.

Battery clean-up

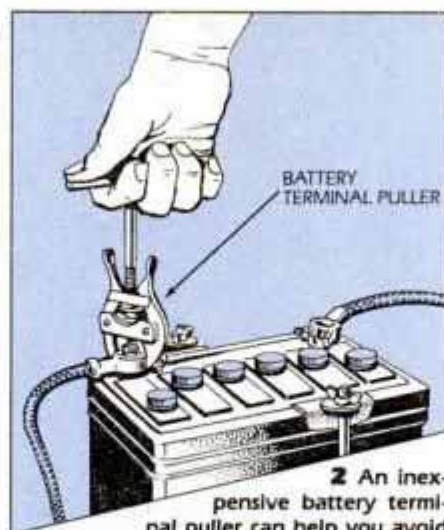
Battery scrub down and terminal cleaning should precede any attempt to determine the cause of a discharge, but also should be part of your 15,000 mile maintenance procedure.



1 Disconnect the negative battery terminal before doing any electrical work.

Before unbolting the terminals of a conventional battery, cover the vent holes with a rag. Always disconnect the negative battery cable first. If you unbolt the positive terminal first, you might ground it accidentally, causing a short circuit that can ruin other components and/or cause a battery explosion.

Wear protective eyewear and work gloves when handling the battery, and



2 An inexpensive battery terminal puller can help you avoid damaged battery posts.

avoid touching it to your clothing. Use a $\frac{5}{16}$ -in. socket or box wrench to disconnect most side-mount battery terminals (Fig. 1). Most top-post terminals require a $\frac{1}{2}$ -in. or $\frac{9}{16}$ -in. wrench. Some may be metric. Use a terminal puller to remove the terminals from top-post batteries (Fig. 2). This can prevent damage to battery posts caused by prying or twisting terminals. Once both terminals have been disconnected, free the battery from its hold-down clamps.

Scrub the battery and posts with a solution of baking soda and water and a good stiff brush. Then use a battery cleaning tool or pen knife to remove corrosion from both the terminals and posts. If your battery has side-mount terminals you can use the wire brush end of the cleaning tool to scrub them, or you can scrape them with the knife (Fig. 3). If your top-post battery has 2-part terminal ends—the type that clamp the cable under a bolted-on strap—disassemble them and clean all the parts. These terminals are prone to high resistance, so it's better to replace the assembly with cable that has molded terminals.

Checking battery charge

By measuring the specific gravity of the electrolyte with a hydrometer, you can determine how much of the acid has been changed into water by the discharge process.

First, however, make sure that the electrolyte/water solution fully covers the plates of your battery, providing it is not a maintenance-free type with no access to the plate area. Unless the level is below the plates, delay topping off until you've checked specific gravity as described below. But don't forget to fill the cells to the recommended level

before you charge. Some batteries that are disguised as maintenance-free types actually have plugs that can be removed with a screwdriver or socket-head wrench in order to add water. These are sometimes sold as "low-maintenance" batteries. Check water level every time you check oil and top off as needed with distilled water on any battery that does not have a fully sealed case. Don't be misled by attempts to pass off a conventional battery as a maintenance-free battery. You'll need a hydrometer to check state of charge on conventional batteries. The more expensive type of hydrometer uses a float inside a large "turkey baster" tool to provide a reading of specific gravity. The hydrometer will probably have a scale that indicates how level of charge relates to specific gravity and temperature (Fig. 4). At 80° F, a specific gravity of 1.26 indicates 100 percent charge.

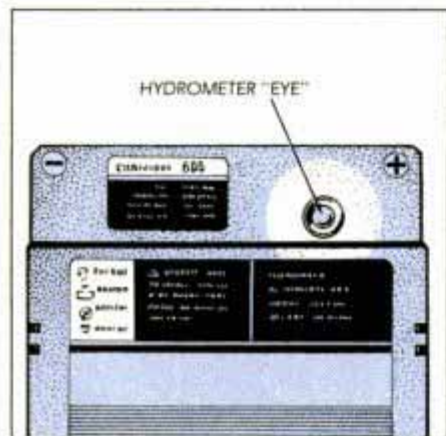
There are also inexpensive hydrometers available that provide a less accurate but still useful estimation of charge. This tool looks like a miniature turkey baster with five colored balls inside the glass tube. If the concentration of acid is sufficiently high, all of the balls will float, indicating a fully charged battery. These tools are accurate at approximately room temperature, so it's important that you test under these conditions.



3 Use brush of battery post cleaning tool to scrub side mount terminals and connectors.

When testing, draw a sample from each cell and record the number of balls floating or the specific gravity reading. The readings should be about the same. If this is not the case, at least one cell is badly sulfated or otherwise damaged and the battery should be discarded. If all cells float only a couple of balls, the battery should be charged slowly until all the balls will float.

Most modern maintenance-free batteries are equipped with an "eye" hydrometer that indicates state of charge at a glance (Fig. 5). Found on top of the battery, the eye changes color as the specific gravity of the electrolyte changes. A bright green eye usually indicates that the battery is at least 75 percent charged. A dark or black eye



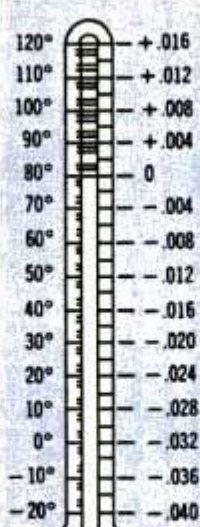
5 Green eye indicates 75 percent charge, a dark eye indicates charging is necessary, and clear eye means electrolyte is depleted.

indicates that the battery is in need of a charge. A light or yellow eye means that the electrolyte level has dropped below the plates and the battery must be discarded. Attempting to charge or jump start a battery in this condition can be very dangerous.

Charging the battery

If your hydrometer reading was below 1.120 specific gravity at 80° F, or if one or no balls were floating in the tube of your inexpensive hydrometer, the battery is deeply discharged.

Since a maintenance-free battery's hydrometer doesn't indicate how deeply discharged the battery is—as a conventional hydrometer does—you may want to check voltage on the maintenance-free battery before you begin charging. Simply attach the negative and positive cables of your voltmeter to the respective battery terminals and set the voltmeter range switch, if applicable, to the 20-volt position (Fig. 6). If the battery reading is below 10 volts at approxi-



4 Hydrometer Temperature-Correction Scale

The specific gravity readings of the hydrometer give battery's state of charge, but they must be corrected for temperature. At 80° F, specific gravity of 1.26 equals 100-percent charge. When temperature is higher or lower, however, specific gravity must be corrected (plus or minus) by the numbers shown at the right of the scale.

mate room temperature, it is almost fully discharged.

A fully discharged battery won't take much of a charge for the first few hours of charging, even at room temperature. Outside, on a cold day, the results will be even worse. While a slow charge is desirable, it will take a good 30-amp shot to get the electrolyte regeneration process started. However, by bringing the battery to room temperature, most trickle chargers can do the job.

Cover the vent holes of a conventional battery with a rag before attaching the charger. Don't plug the charger in until both cables have been connected to the appropriate battery terminals. As the battery charges, keep checking its specific gravity from time to time to

determine when it has reached full charge. On maintenance-free batteries with the hydrometer eye, you may have to shake the battery slightly before the eye will turn green. But don't expect immediate results. GM notes that a fully discharged maintenance-free battery may not even begin to take a charge for up to 16 hours.

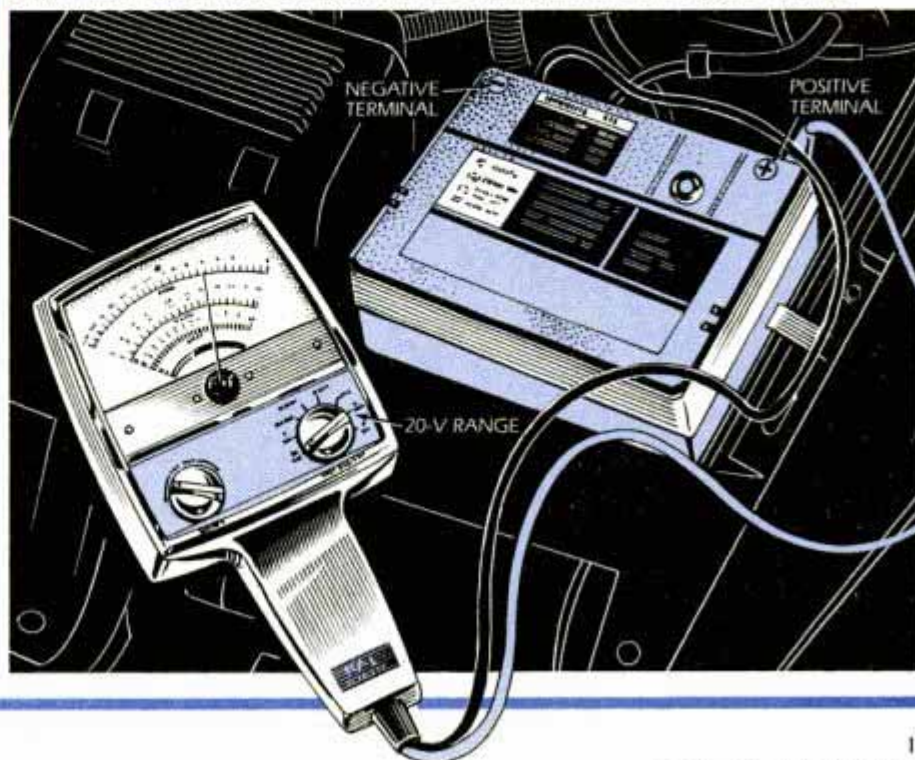
You can tell whether or not the battery is taking a charge by checking the reading on your charger's ammeter. If the meter indicates that no current is being passed to the battery, it's not taking a charge. If after extensive charging, the ammeter still indicates no charging current or if your hydrometer readings show that the battery never comes within spitting distance of full charge, it's a goner.

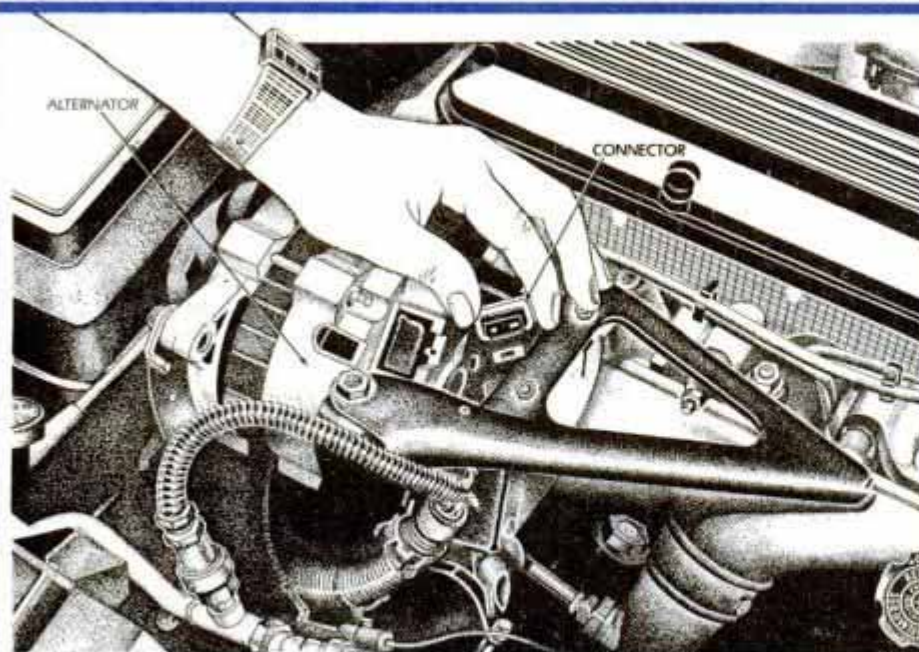
Charging system check

If your battery takes a full charge but then discharges when you drive your car, the charging system is probably at fault. Start with the most obvious: Is the alternator belt tight enough to make the alternator spin without slippage? If not, correcting this will probably make your problems go away. Otherwise, you can perform a simple charging system test using only your voltmeter.

With the battery full charged, connect the positive and negative probes of your voltmeter to the battery posts, and set the range switch to the 20-volt position. Record battery voltage. At 70° F it should be at least 12.5 volts and 13 to 13.5 volts at full charge. Connect a

6 Measure voltage with the engine off and then again with the engine running.





7 Don't condemn alternator or regulator without checking for corrosion at connectors.

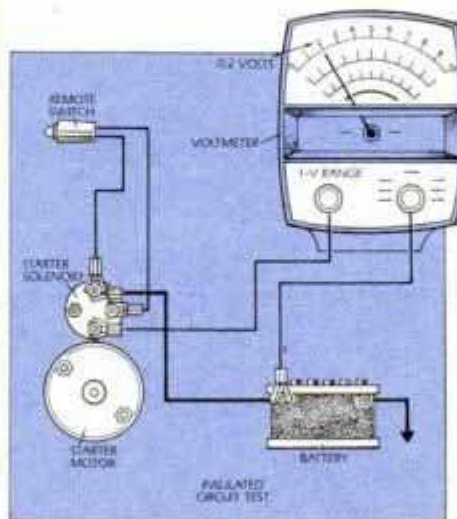
tachometer if your car doesn't have one, then start the engine and run it at 1500 rpm. Take a second voltage reading after the engine has run for approximately 5 minutes. It should exceed the base reading by less than 2 volts. If your reading is below the base reading, the system isn't charging the battery due to either bad wiring, or a defective alternator or regulator.

Before condemning any components, unplug the alternator wiring connections and the connections at the bulkhead, and check for corrosion (Fig. 7). If they're not bright, bare metal, clean them with electric contact cleaner or a pen knife before reattaching them.

If your reading is above the base by more than 2 volts, the system may be overcharging the battery. But before you jump to this conclusion, charge the battery again and make sure your base reading was taken at full charge. Overcharging is almost always caused by a bad voltage regulator. It will be accompanied by spewing of acid from the battery, frequent loss of electrolyte on conventional batteries and premature failure of maintenance-free batteries. If your charging system checks out so far, test to see if it can charge the battery with a heavy load imposed. Connect the voltmeter and tachometer as above and start the engine. Turn on all electrical accessories including the headlights. Turn the heater motor to the high-speed position and check battery voltage. It should exceed base by at least 0.5 volt. If it does, the charging system is capable of keeping the battery charged. If it doesn't, check and clean

the alternator wiring as described above before condemning the unit.

If your car is equipped with an external regulator, as many Fords and Chryslers are, you can "full field" the charging system to see whether the regulator or alternator is causing the lack of charging current. Turn off the engine and disconnect the negative battery terminal. Then, on Fords, disconnect the regulator connector and connect a jumper wire between A and F terminals of the plug. On Chryslers, disconnect the green field wire that connects the alternator field terminal to the regulator at the regulator. Then connect a jumper wire between ground and the contact in the field terminal plug that is attached to the green wire.



8 Use voltmeter as described in text to check for starting circuit resistance.

Reconnect the negative terminal, start the engine and perform the load test as described above. If voltage now exceeds base by 0.5 volt or more—and it didn't previously—the regulator is defective. If voltage is still less than 0.5 above base, the alternator is probably bad.

Current drains

A current drain is a device or "load" in the car that doesn't shut off when you or the automatic switching device turns it off. When the engine isn't running, the device drains the battery. To check for leakage, turn off all accessories and close the doors and trunk. Make sure all lights are off, and remove an underhood lamp, if any.

Disconnect the negative cable's terminal from the battery. Then disconnect the positive terminal and reattach the negative terminal. Set the dial of your tester to the ohmmeter position and measure resistance between the disconnected cable end and the vehicle's engine block (see lead illustration). If resistance is less than 100 ohms, a leak of .1 amp or more is draining your battery and must be corrected.

Starting circuit resistance

If your battery is fully charged, but all systems behave as though it's dead (slow cranking and so on), high circuit resistance is probably the cause.

If you'd like to check circuit resistance, connect the positive lead of a voltmeter that reads in tenths of a volt to the positive battery post. Connect the negative lead of the voltmeter to the starter terminal where the positive cable attaches (Fig. 8). On starter motors with an external solenoid mounted next to the case, connect it to the large copper connector that joins the solenoid to the starter. Crank the engine. The voltmeter should show less than 0.5 volt if resistance is within limits.

If voltage is in excess of 0.5 volt and the starter has an external solenoid, repeat the test, but this time attach the negative probe of the voltmeter to the terminal on the solenoid where the cable attaches. If voltage is now less than 0.5 volt, the solenoid is the source and should be replaced.

To check ground-circuit resistance, connect the negative voltmeter lead to the negative battery post and the positive lead to bare metal on the starter housing. With the key in the START position, the voltmeter should read less than 0.2 volt. If voltage exceeds this figure, the ground cable is not providing a good connection or the starter is insulated from the engine block. **PM**

YARD POWER

(Continued from page 102)

UP TO PRESSURE

Now homeowners, farmers and construction workers have a new light-duty pump in the Honda WB15. Honda powers the WB15 with a rugged 2.2-hp gas engine that features a chrome-top piston ring, cast-iron cylinder sleeve and a ball-bearing supported crankshaft for durability. A new maintenance-free electronic ignition system, automatic decompression and self-priming feature combine for easy starts. The 27-pound unit is capable of pumping 3000 gallons per hour and it comes equipped with hose bands, strainer and antivibration pads. The Honda WB15 water pump is sold through Honda power equipment dealers and costs about \$400. Contact American Honda Motor Co., 100 West Alondra Blvd., Gardena, CA 90247.



MID-RANGE POWER

John Deere offers the models 1800, 2300 and 3200 mid-range generators for both portability and power. The generators produce 1600, 2000 and 2900 continuous watts, respectively, and feature circuit-breaker protection, choke assist with automatic compression release for easy starts. The models 1800 (\$745) and 2300 (\$840), shown, are powered by a 5-hp gas engine. A 7½-hp engine with manual (\$1100) or electric start (\$1190) is found on the 3200. They're available wherever John Deere products are sold. Contact John Deere Portable Generators, 1400 Third Ave., Moline, IL 61265.

CITY SLICKER

Small-plot gardeners and urban farmers now have a scaled-down tiller-cultivator available from Mantis Manufacturing. The Mantis Electric features a specially designed Briggs & Stratton 3-speed motor and it's capable of cultivating a 9-in.-wide swath to 8 in. deep. For lawn maintenance, Mantis offers attachments such as a dethatcher and soil aerator. A special option for tilling furrows is available, too. To ensure operator safety, the 26-pound Mantis electric has double-insulated motor, spring-lever throttle and a key ignition-lock to prevent unauthorized use. The Mantis Electric is available from Mantis Manufacturing, 1458 County Line Rd., Huntingdon Valley, PA 19006, for about \$365, shipping is extra.

(Please turn to page 116)



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YARD POWER

(Continued from page 115)

AIR FORCE



Homeowners who need compressed air power for light-duty work will welcome the Sears Craftsman 3/4-hp electric air compressor. Rated at 2.7cfm and 40 psi, this unit can power a variety of Sears attachments including a spray gun, sand blaster, power caulking gun and air brush, or you can use it simply to keep your tires inflated. Featuring oilless design for maintenance-free operation, the Craftsman 3/4-hp electric air compressor comes with 15 ft. of 1/4-in.-dia. hose and air chuck. It's available in the 1987 Sears Power and Hand Tool Catalog for about \$110. For more information, write to Sears, Roebuck and Co., Sears Tower, Dept. 703PM, Chicago, IL 60684.

ELECTRIC PERFORMER

Powered by a 1000-watt Briggs & Stratton motor, Snapper's 19-in. electric HI-Vac lawnmower is designed to vacuum your lawn as it cuts. Standard equipment includes a trap-door grass catcher, or you can install the optional side discharge unit to disperse the clippings. The HI-Vac has a specially designed blade that lifts the grass for a cleaner cut and the short wheelbase helps prevent scalping on uneven terrain. Wheels are mounted on durable solid-steel axles and can be adjusted individually for cutting heights of 1 to 3 in. The 19-in. electric HI-Vac costs about \$280 at Snapper dealers.

Contact Snapper Power Equipment, Box 777, McDonough, GA 30253.



SINGULARLY FORCEFUL

Ever notice that you use only one piece of equipment at a time? Well, Solo has designed the Multimot to reduce your investment in idle machinery by producing one motor that does it all. The heart of the Multimot system is a lightweight 1 1/2-hp, 2-cycle gas engine that can be connected to a wide assortment of tools, including a chain saw, compost shredder, string trimmer, rotary gardener and water pump by a convenient self-activating

mount. The 7 3/4-pound engine is totally enclosed in a fiberglass housing and an electronic ignition ensures easy starts. The hedge-trimmer unit shown below is available with a 20-in. (\$135) or 28-in. (\$145) bar length. Also shown is the leaf blower attachment which costs about \$100. The Multimot powerplant lists for about \$215 and the system is distributed through Solo dealers. For more information, contact Solo Inc., 5100 Chestnut Ave., Newport News, VA 23605.



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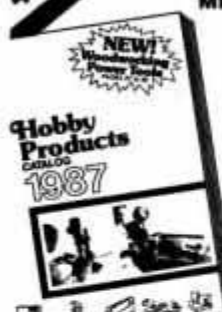
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BORDER GUARD

Keep your lawn in line with this lightweight Weed Eater model 1720 bladed edger. The 12½-pound unit features a 22.2-cc top-mounted gas engine. A vertically rotating 7-in.-dia. reversible steel blade cuts to 2 in. deep and an edging guide helps insure uniform results. Power is transmitted to the cutter via an all-steel gear and a centrifugal clutch. A 180° blade guard protects the operator from flying debris. The Weed Eater model 1720 costs about \$160 at hardware stores and home centers. For more information, contact Beaird-Poulan/Weed Eater, Box 9329, Shreveport, LA 71139.

HIGH-TECH TORQUE

According to Briggs & Stratton, its new Quantum gas engine is designed to be the longest lasting, easiest starting and most troublefree lawnmower powerplant available. At 164-cc displacement, Quantum is said to be the largest in its class developing 3½ hp and achieving maximum torque at 1400 rpm for extra-heavy grass cutting. Briggs & Stratton claims Quantum will run up to 40 percent quieter due to a new composite camshaft, contoured cylinder walls and large muffler. The new design also has better heat dissipation, stronger crankshaft and larger valves. It's available on many major-brand lawnmowers. Write to Briggs & Stratton Corp., Box 702, Milwaukee, WI 53201, for more information. (Please turn to page 118)



Making an Extra \$20,000

May Be Easier Than You Think!

—Did you know that dozens of men and women, all across America, are quietly making an extra \$20,000 a month; some never even set foot out of their homes to do it.

My name is Steven Houseman and if someone had told me two years ago I would be part of a select group of men and women who bring in an extra \$20,000 a month operating out of their homes, I would have never believed them.

Let me share our secret with you. It has often been said that anything is easy to do once you know how. And this is especially true of making money, because becoming financially independent is really knowing how to spot just one "unique" money-making opportunity in your lifetime, and knowing how to take advantage of it.

- **Start and Stop the program whenever you need extra money.** When you need up to \$5,000 put the program into operation. When you have made the \$5,000 stop the program. It's that simple.
- **Make up to \$10,000 in Two Weeks Then Take Two Weeks Off!**
- **Bring in up to \$4,000; Weekends Only!** Or just operate in the Evenings if you like!

Before I go on, let me make this clear!

This program is honest, legal and moral in every sense of the word. If it wasn't, believe me, I wouldn't be involved in it.

Start The Program Part-Time!

I know not everyone wants to quit their job and start working this program full time. You may have been at your job for a long time and don't want to give up the seniority you have built up over the years.

Start The Program "Short-Term!" Pay off some overdue bills and Stop the Program! It's That Simple!

Maybe you're looking for something "short-term" not long-term. Perhaps a money making program you can put into operation for the next two months, to pay off some overdue bills. That's okay. You can put the program into operation only when you need an extra two or three thousand dollars.

You Don't Need A Lot of Money To Start This "Extra Income" Program.

This money making program can be started with limited funds. In fact, right now, I know dozens of people, from small towns all across America, who are making thousands of dollars in their spare time using this program.

I have received dozens of phone calls and several letters from people all over the country thanking me for sharing this new program with them.

- One man from a rural town in Iowa is already making an Extra \$4,000 a month.
- Another man from a small city in California, said over the phone, his extra income just went over the \$5,000.00 dollar mark this month.
- A woman in Florida told me she is currently running a \$2,000 Dollar-A-Week operation out of her home, with one kitchen table as her desk, one typewriter, and two filing cabinets.

(Here are copies of actual letters on file.)

I made \$3,000.00 Extra.

Your money making program is the best information I have ever read on how to make money at home. It's truly different, complete and easy to put into operation. I made \$3,000.00.

A.R., Landover, Maryland

I Am on My Way To \$12,000.00.

You shared your program with me and today after applying your program for only thirty days I am well on my way to making \$12,000.00 in the next two weeks. Thank you. L.G., Raleigh, North Carolina

Making an Extra Income of \$14,500.00

"Within months after applying your program we were making an income of \$14,500.00 a month. Thank you for everything you have done for us."

S.R., Pennsylvania

I Earned Over \$17,000.00 Part-Time.

Even today it's hard for me to believe that I earned over \$17,000.00 dollars by applying your system part time. Thank you. J.P., Aldie, Virginia

These actual Letters are on file in my office, for anyone to see. All of these people started with very limited funds, and I personally didn't have a lot of money to start this program either. That's why I designed it with you in mind. I wanted everyone, like yourself, who wanted to improve their own standard of living, to be able to learn how to make an extra \$20,000 a month without a large investment.

Here's What you are going to receive!

It's titled: "The Best Kept Secret of The New Rich", and it is written in a 150 page Step-By-Step format to make it easy to read and easy to follow.

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What if I don't like it? — You can Return it!

I'll give you a full 90 Day Money-Back Guarantee. If at any time after receiving "The Best Kept Secret of The New Rich" you want to return it, for any reason, do so. I will immediately refund your \$12.95, in the next day's mail.

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Dear Steve, please RUSH me your new "Money Making Program" titled "The Best Kept Secret of The New Rich!" only with the understanding that I have a full 90 days to test the Money Making Program. If I am not satisfied, for any reason, I may simply return "The Best Kept Secret of The New Rich!" and you will immediately refund the full purchase price to me. On that basis here is my ~~\$12.95~~ New Special Price: \$5.00

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How many undeserved radar tickets were issued last year?

- a) 1,012,317
- b) 649,119
- c) 0
- d) No one knows

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Our engineers are radar experts. They had to know every detail about traffic radar before they could design ESCORT and PASSPORT, the most respected names in radar detection and warning. *Road & Track* called us, "The industry leader in detector technology."

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YARD POWER

(Continued from page 117)

CULTIVATING INTEREST

Featuring a unique reciprocating cutting action, the Green Machine electric weeder-cultivator model 770 is claimed to dig in tough, compacted soil. Twin spring-steel tines are powered by a 1/4-hp overload-protected motor through a 5.4:1 gear-drive ratio for a speed of 1900 strokes per minute. In addition to light-duty tilling, the model 770 functions as a sod-cutter and garden edger and can be used to prepare soil for transplants. Sold at lawn and garden centers, the weeder-cultivator costs about \$100. Contact Green Machine, HMC, 20710 South Alameda St., Long Beach, CA 90810.



SENSITIVE MOWER

Your self-propelled lawnmower won't run away from you if it's the new Lawn-Boy electric-start Automower. This 20-in. mower adjusts to your walking speed by sensing pressure on the control handle. Powered by a 2-cycle, 4-hp gas engine, the Automower features electronic starting and an alternator for recharging the battery. Other standard features include a cast-aluminum deck and rear grass catcher. The Lawn-Boy Automower is sold through power equipment dealers for about \$550. Contact Lawn-Boy, Box 181120, Memphis, TN 08181-1120. **PM**



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Malm Chem. Corp sells a blend of imported carnauba waxes in easy to apply liquid form. It's formulated for a very high gloss and color enhancement.

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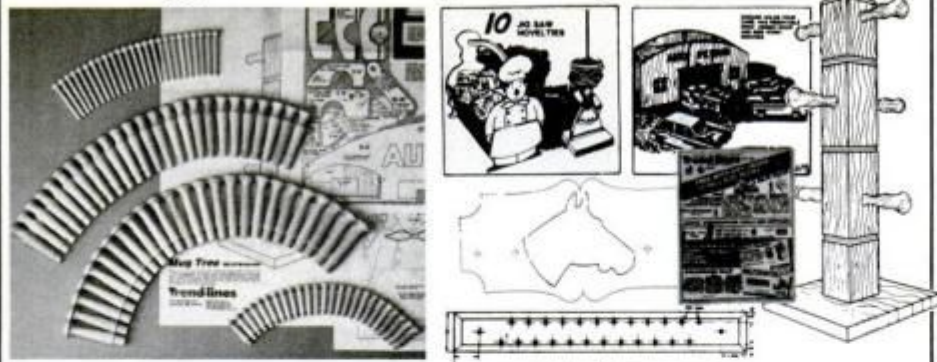
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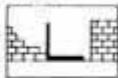
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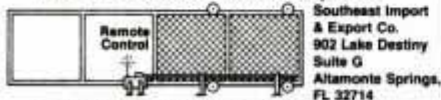
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TELEPHONES Sales-Service (American Made) Write: Telephones, Box 6M, Simpson, PA 18407

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HOW TO COUNT WORDS: Name and address must be included in counting the number of Words in your ad. Each initial or number used counts as 1 word: J.J. Smith, 224 West 57th Street, New York, New York 10019: 9 WORDS. Zip codes are not counted. Phone #: 2 Words, Symbols used as keys are charged for. City or State count as 1 word each: New Brunswick, New Jersey: 2 words. Abbreviations such as C.O.D., F.O.B., R.P.M., U.S.A., P.O., 5x7, 16mm are counted as 1 word. (P.O. Box 392 counted as 3 words) Webster's International Unabridged Dictionary will be used as our authority for spelling, compound words, Hyphenations, abbreviations, etc. Please make checks payable to **POPULAR MECHANICS**.

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22-\$154.00	23-\$161.00	24-\$168.00	25-\$175.00	26-\$182.00	27-\$189.00	28-\$196.00
29-\$203.00	30-\$210.00	31-\$217.00	32-\$224.00	33-\$231.00	34-\$238.00	35-\$245.00
36-\$252.00	37-\$259.00	38-\$266.00	39-\$273.00	40-\$280.00	41-\$287.00	42-\$294.00
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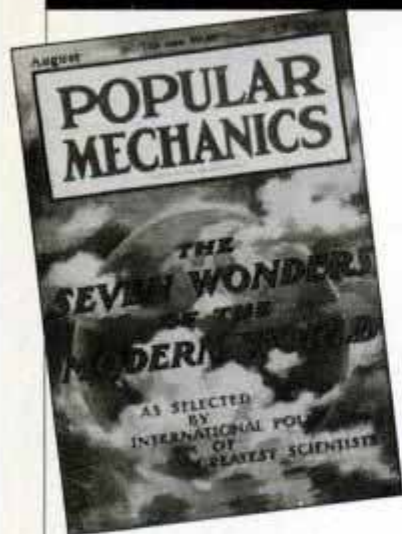
FREE CATALOG!! Your Complete Guide To Home Brewing — Wine And Beer — Supplies, Recipes, Instructions. Home Brew International, Box 4547-PM8, Fort Lauderdale, FL 33338.

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TIME MACHINE

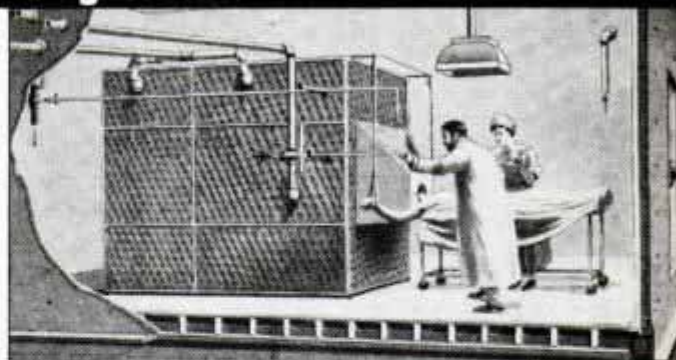
75 YEARS AGO: August 1912



Focus on science.

A Gathering Of Greats

Demonstrating a talent for producing special issues, PM polled the world's leading scientists to determine The Seven Wonders of the Modern World. This ambitious undertaking resulted in tightly focused treatments on the telephone, the wireless, the X-ray, the airplane, radium, antiseptics, antitoxins and spectrum analysis. According to PM's founder H.H. Windsor, the original Seven Wonders proposed by the Greeks, were badly in need of revising.



Operating Under Pressure

It was thought that air pressure differentials led to collapsed lungs during chest operations. Two pressure chambers were built—one in-

side the other. The patient's head would remain under positive pressure inside while surgeons opened the chest in the outer chamber.

50 YEARS AGO: August 1937



Transformer outside L.A.

Powering America

A mighty transformer the size of two upended boxcars adorned PM's cover. The giant device was used to help produce 132,000 volts of electricity for Los Angeles. After traveling more than 270 miles from the 15-generator hydroelectric project at Boulder Dam, the voltage was stepped down from 270,000 volts at seven identical transformers outside L.A.

Our story saluted the dam as a public works spectacle, creating the 101-mile-long Lake Mead and producing 1,250,000,000 kilowatts a year.



RV Forerunner

The teardrop-shaped, 3-wheeled recreational vehicle had an icebox, a studio couch for two, and a table.

What's more, it could double as an 8-passenger "garageable" automobile when not in camping mode.

A rear engine kept noise and odor away from the pas-

senger compartment and a steel unibody was touted as being crash resistant and aerodynamically efficient.

Instrument Landing System

Using instruments to guide airplanes was in its infancy, but already avionics pioneers were experimenting with ILS (Instrument Landing System). Just like the system used daily throughout the world, onboard receivers guided the pilots to the airport runways along electronic pathways created by ground signals.

25 YEARS AGO: August 1962



A supersonic chopper.

Early X-Wing

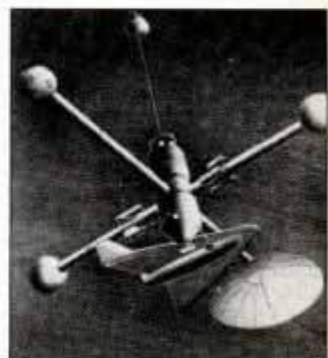
The concept calls for supersonic flight by an aircraft that can take off and land vertically. Sounds like the X-Wing prototype that NASA is flight testing now. Similar to the contemporary X-Wing, the PM cover subject would lock its delta-shaped rotor in mid-flight, transforming it into a supersonic lifting surface. The aircraft also featured movable rotor tips that could adjust the angle of attack in helicopter mode, or conform to the wing's shape when the vehicle transitioned to fixed-wing operation.

Space Station Dream

The notion of living and working in space was beginning to find momentum following successful U.S. satellite launches and the continuing evolution of Project Mercury. One concept involved ferrying men and material to low Earth orbit with a winged space plane, which would dock at the station's center command and nuclear power-plant module.

Living accommodations for the crew and communications bays would be positioned inside spheres at the ends of

long arms. Scientific research was the goal, but the possibility of using the space station as an orbiting military command post was not dismissed. **PM**



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