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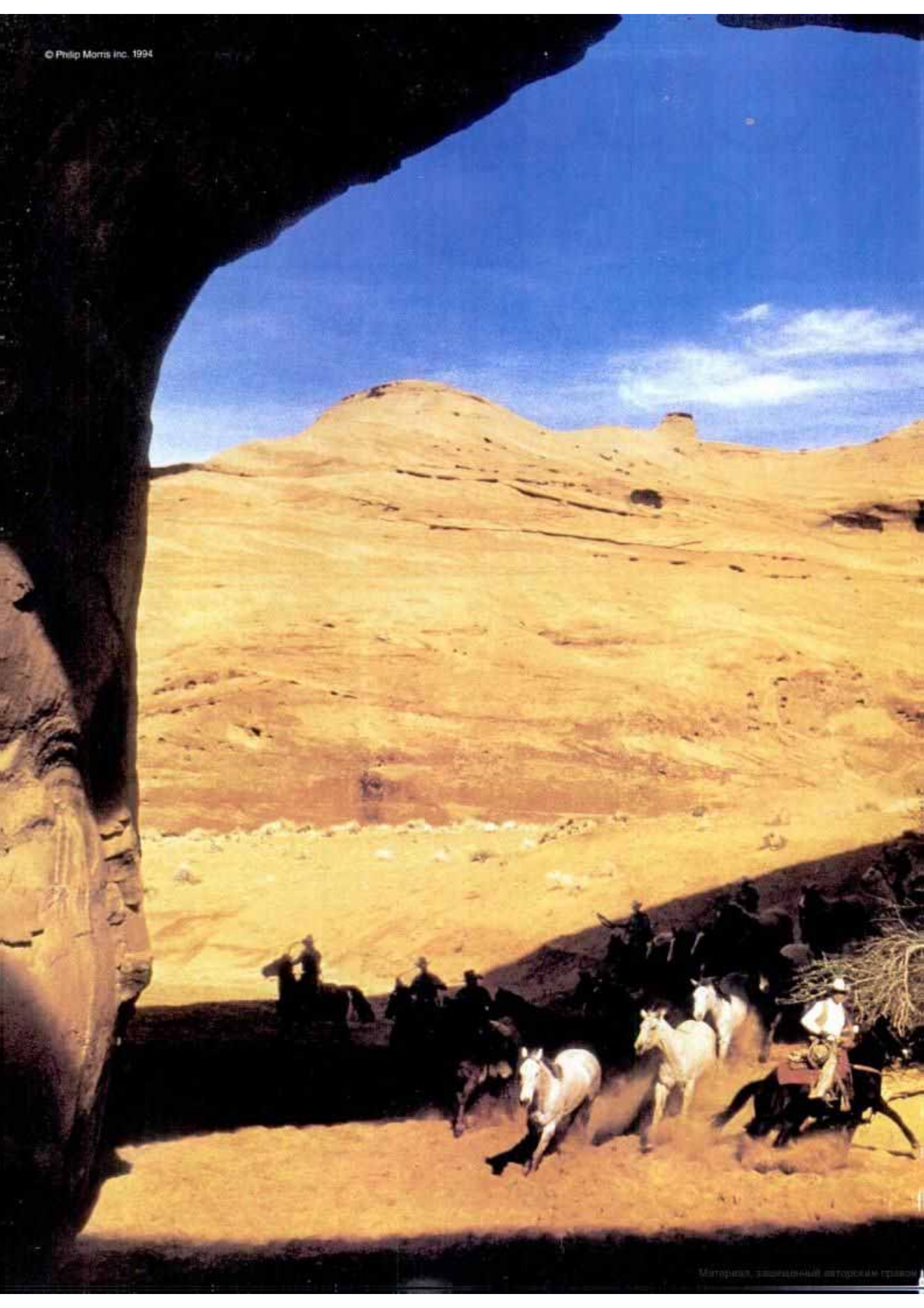


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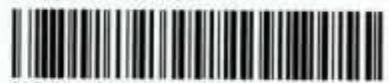
Lumber



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Popular Mechanics®

AUGUST 1994
VOLUME 171
NO 8



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The new Air Max^{2™}

shoe's dual air pressure technology modifies the ride so it matches the movement and impact of the foot.

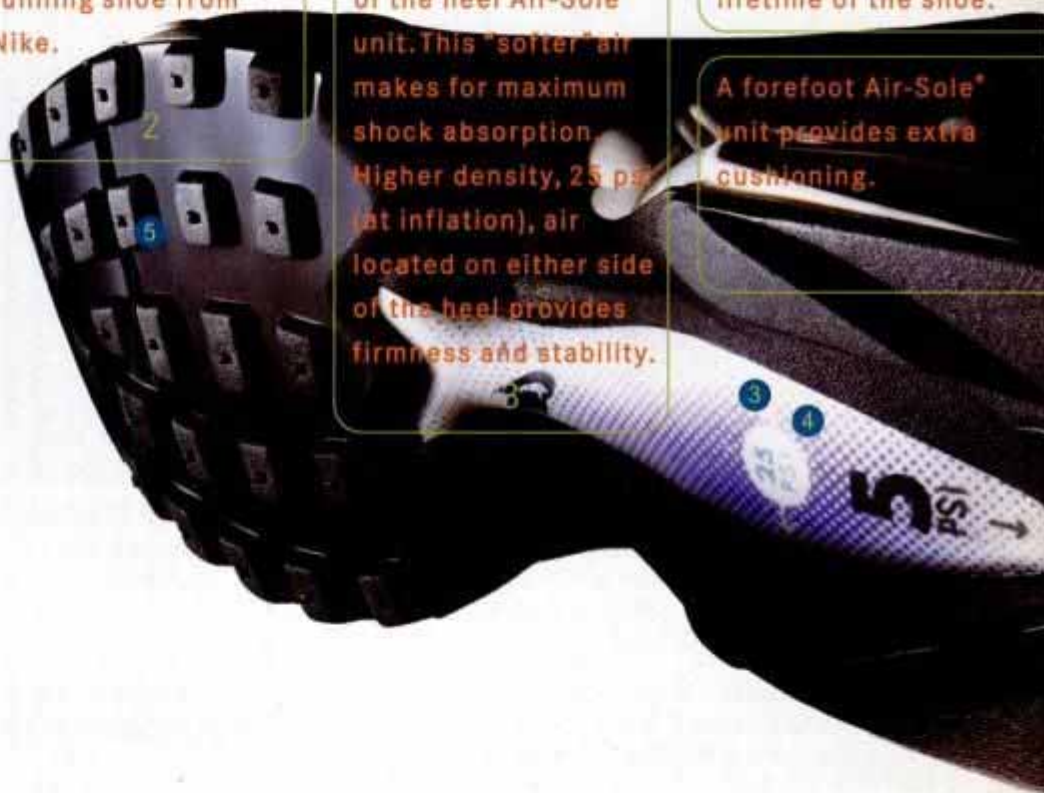
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Kevin Young, track and field athlete, wears the Air Max² running shoe from Nike.

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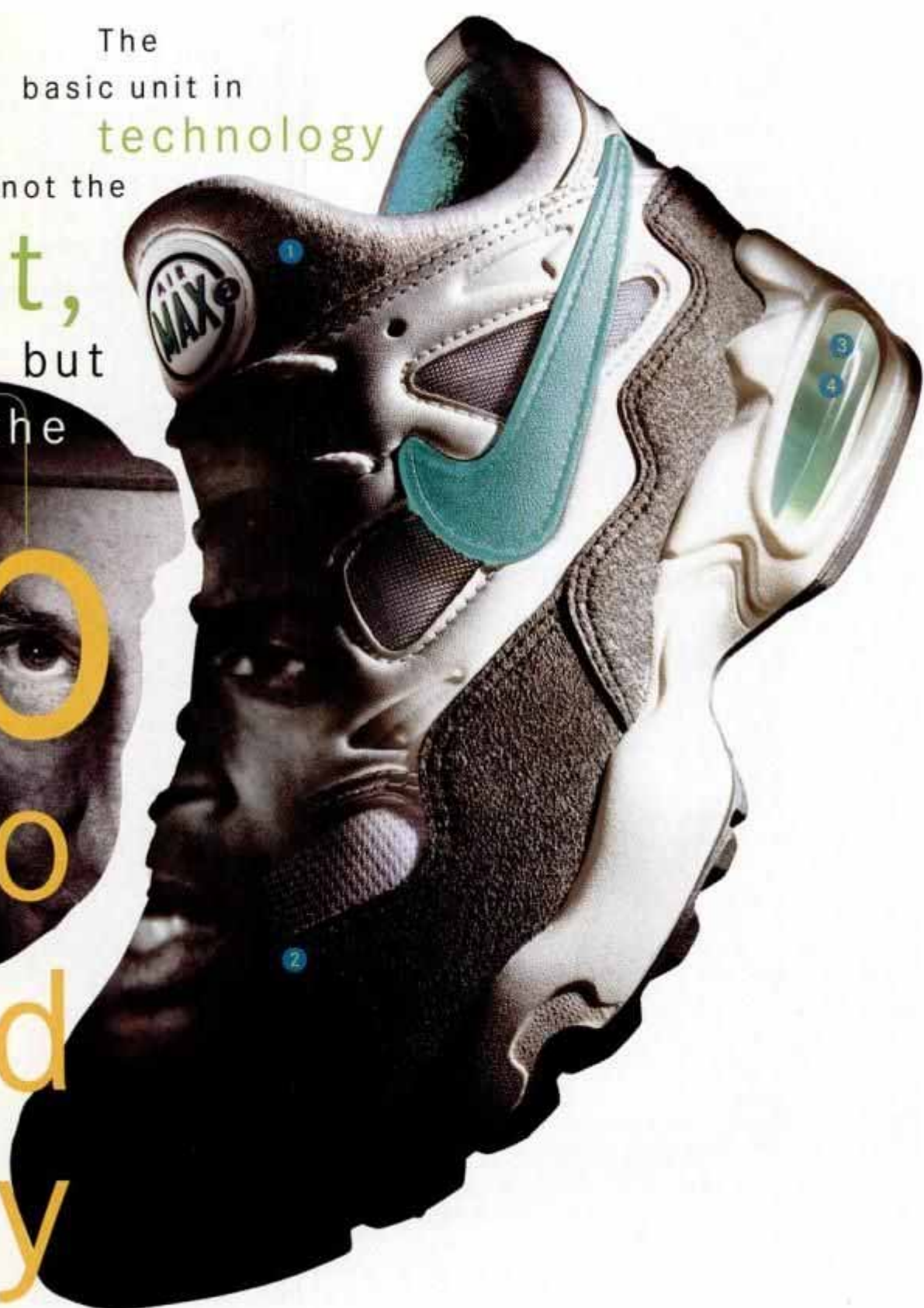
NIKE

The
basic unit in
technology
is not the

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5
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EDITOR'S NOTES

● When we decided to run this month's cover story on a plane that you can legally drive on the street (or is it a car that flies?), it made me wonder how many times POPULAR MECHANICS had done similar stories since our inception in January 1902. One night when everyone else had gone home and it was dark and quiet in the PM offices, I wandered back into our Reader Service Department where all the back issues are kept. I had skimmed through less than 10 years of issues and I had already found 10 articles on similar craft—cars that could fly (or is it planes that you can drive?). I gave up the search at that point, but I had already confirmed what I suspected. This is a dream that a lot of people have had, and so far no one has made it work. The most famous example of a car-plane, and the one that came closest to success, is a resident of the Boeing Museum in Seattle. Our cover story, which begins on page 33, documents the latest attempt at creating an aircraft that can legally be driven on public roads (or is it an automobile that has been certified for flight?). . . . They could have simply rented a ballroom in the New York Hilton, put on a big spread of food, had a vehicle up on the stage in a blaze of spotlights, made a couple of speeches, handed out a press kit, and let it go at that. Yeah, the guys at Land Rover could have introduced the new Discovery sport/utility vehicle the same way so many other new vehicles see first light. But that's not the style of Charlie Hughes, Bill Baker and the gang that runs Land Rover. Instead, they sent a fleet of Land Rover Discoverys to Belize, invited a bunch of magazine journalists down, sat them in the Discoverys, pointed them toward the jungle and let them go at it. The result was a new-car preview the hard way and our own Outdoors Editor, Joe Skorupa, was right there for us. His mosquito-bitten report begins on page 40. . . . **When I think of wood, I think natural.** Organic. Pristine. The last thing I think of is high tech. Yet, today, engineered wood rather than the natural stuff that comes from trees might be a better choice for your next building project. The modified stuff is stronger, more stable and, in some cases, actually less expensive than natural wood. But does it smell as good? To find out, check our report on page 64. . . . **New materials that stop bigger, more powerful slugs** are finding their way out of the laboratory and onto the backs of our law enforcement community (see "The Slug Stops Here," page 50). Bulletproof vests that can cope with the increased firepower out there on the street are now available—and not a moment too soon. Till next time.



Joe Skorupa at the Guatemalan border.

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Joe Oldham



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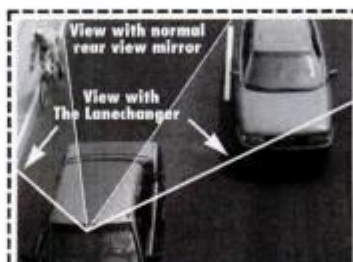
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LETTERS

Just Plane Stupid



In regard to the "Doomsday Plane," Hitler had one, too—it didn't save him. Why do we continue to spend our lifeblood on excess defense projects and neglect the real issues?

GEORGE W. COOK
PARK RIVER, ND

Charged Up

I am amazed at the almost universal ignorance concerning electric cars, batteries, power generation and pollution. All the energy the human race will ever need is the untapped deep hot-dry rock geothermal, which is steady, readily available, self-renewing, totally nonpolluting, and it requires no new technology or equipment. Of course, it would make the petroleum-based and nuclear power industries obsolete.

W. YOUNG
OKLAHOMA CITY, OK

And we'd have to dig a hole the size of Ohio to tap into it.
—Ed.

The response you received to your article about the GM Impact seemed to me to be rather narrow-minded. While it's true that fossil-fuel plants produce pollution, the quantity of pollution is far less per unit

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

of energy produced because of the more efficient method of combustion used. The most efficient internal combustion engine is less than 30% efficient, whereas an oil burner used in a home furnace today is more than 90% efficient. While I think fossil fuels are a dead-end proposition, the electric auto is, in the end, the far lesser of two evils.

BARRY FLYNN
CAMDEN, AR

The requirement that 2% of cars sold in California after 1998 must be "non-polluting" is a figment of the California legislature's imagination. Few or none of them are scientists or engineers who understand the practical limitations in building electric-powered cars. Only a breakthrough in battery technology and a reduction in cost will make the electric car competitive with the gasoline-fueled car. And scientists will tell you that a breakthrough is unlikely in the near future because of inherent limitations on materials required to build the batteries.

JAMES E. GINGRICH
LAFAYETTE, CA

Battery systems just won't cut it. Why is no one really checking out alternatives like hydrogen? Existing engines can be modified to use it, and though storage systems may be bulky, overall range is much more practical. Electric batteries aren't the only answer.

ANDREW LaROY
LEWISTON, ID

The only downside to it is that I really don't want to have to "plug" in my car four or five times a day.

BRANDON WEINSTOCK
SHERMAN OAKS, CA

Once again the insightful knowledge passed on to your readers flew right over the heads of some of your more vocal fans. Let's set the record straight: First, by mandating electric vehicles, the carmakers are being dragged into the 21st century. Second, the technology derived from these crash-course-in-efficiency vehicles are transferable to more mainstream vehicles allowing them to be more efficient and responsive as well. Third, the transference of pollution from "the tailpipe to the smokestack" theme is of limited consequence, since it is much easier to control sulfur, hydrocarbons and carbon monoxide with increasingly efficient pollution-control equipment. Pie in the sky? Consider a letter to the editor 100 years ago regarding horseless carriages.

JOHN KRAMER
COLD SPRINGS, CA

Deafening Fun

Your May article titled "Rough Riders" fails to address one thing about waterbikes in general: When are the manufacturers going to do something about the awful noise they generate? Until something is done to muffle their noise, waterbikes will continue to be one of the most intrusive machines ever created.

LEO KRUSACK
GLEN ELLYN, IL

Bang, Bang

I enjoyed your article on the Winchester 94. Smokeless powder, however, is not "fast burning." The great advantage over black powder is the controlled rate of combustion. By slowing it down, first the inertia of the bullet is overcome. Then, after the projectile is on its way, the pressure is increased, thereby attaining much greater acceleration.

BIRKLE ECK
CLAYTON, MO

Reader Project Of The Month



Since I was a kid, riding on the milk crate that was our passenger seat in my big brother's 1956 Ford panel truck selling snow cones off the back, I have had a love of '56 Ford trucks and almost bought one several times, but something always kept me from it. Well, some 25 years later I spotted Mark Smith's '56 F-150 in your May 1991 issue and couldn't wait any longer. By August, I had found and purchased my truck. After two years of original frame-off restoration, it is finally done. Thanks, POPULAR MECHANICS, for your great magazine. It ignited the spark in me to finally fulfill my dream.

DAVID HAYES
LONGVIEW, TX



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1. This symbol is used by what car manufacturer?



A) Ferrari. B) Maserati. C) Lamborghini. D) Peugeot.

2. What Model Chevrolet was the first to receive the Super Sport designation?

A) Impala. B) Camaro. C) Nova. D) Chevelle.

3. What is the characteristic of the new Miller cycle engine that's used in the 1995 Mazda Millenia S?

A) Late intake valve closing. B) Supercharged. C) More power from smaller displacement. D) All of the above.

4. Which of the following '60s muscle cars was known as a "wing car"?

A) Ford Talladega. B) Dodge Daytona. C) Mercury Cyclone Spoiler. D) All of the above.

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5. Which of these statements is true about current Indy race cars?

A) Aerodynamics create 3 tons of downforce. B) Standard engine is a 2.6 liter V8. C) Can attain over 240 mph on the straights. D) All of the above.

6. Which of these cars is available through your local dealer as a special Showroom Stock race model?

A) Dodge Viper. B) Chevrolet Corvette. C) Dodge/Plymouth Neon. D) Mazda Miata.

7. The first car to come with a seat belt was the:

A) 1955 Hudson. B) 1956 Ford. C) 1950 Nash. D) 1957 Chrysler.

8. The first domestic front-wheel drive car since the Cord was the:

A) Cadillac Eldorado. B) Oldsmobile Toronado. C) Plymouth Reliant/Dodge Aries. D) Chevrolet Vega.

9. The source of high voltage energy to produce a spark to ignite the fuel mixture in a gasoline engine comes from the:

A) Ignition coil. B) Alternator. C) Battery. D) Spark plug.

10. Normal oil pump pressure in an engine is:

A) 3 to 7 psi. B) 10 to 60 psi. C) 100 to 150 psi. D) 180 to 210 psi.

ANSWERS
1. D 2. A (1961) 3. D 4. B 5. D 6. C 7. C
8. B (1966) 9. A 10. B.

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TIME MACHINE

90 YEARS AGO: AUGUST 1904

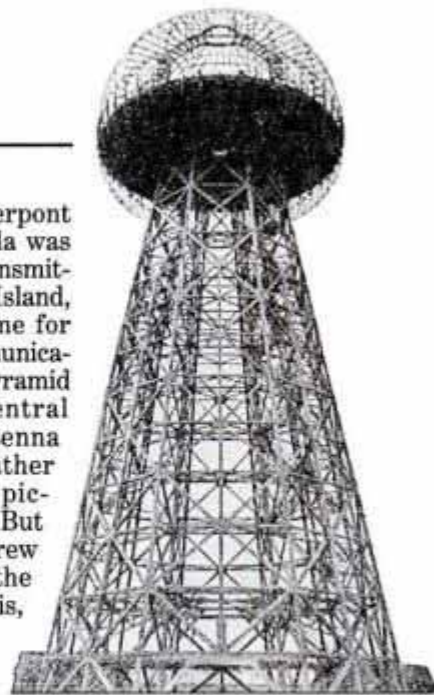


Glass Roots

Nothing exemplified turn-of-the-century decorative industry as clearly as cut glass. Although mass-production technology would soon shatter the traditions of glassmaking, back then blowers still raised pipes to their lips and shaped molten glass with lung power. Then three tiers of craftsmen—roughers, smoothers and polishers—carved glass blanks into finished works of art. In places like Toledo, Ohio, these glassworkers enjoyed sparkling lifestyles.

Air Tower

Bankrolled by J. Pierpont Morgan, Nikola Tesla was building a 185-ft. transmitting tower on Long Island, the hub of his scheme for global wireless communications. The 8-sided pyramid would house the central powerplant and antenna for sending out weather and stock reports, pictures and messages. But when Morgan withdrew his support during the coming financial crisis, Tesla had to abandon the project.



60 YEARS AGO: AUGUST 1934



Gold Diggers

Easy money always appeals, and no more so than during the Great Depression. Back then, treasure seekers were galvanized by thoughts of galleons rotting in the Caribbean, with Spanish doubloons spilling out their sides. Old ship registries and other documents authenticated these dreams. Fortunately, subsea exploration was catching up with gold fever. Diving bells, submarines and other apparatus were opening up Davy Jones's locker.

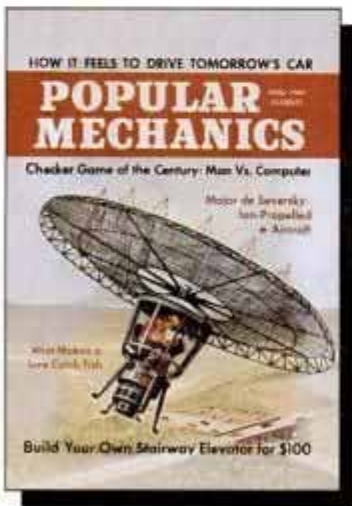
Shot Lifter

The 10-year "naval vacation" stipulated by the Treaty of Washington was over, and America's navy yards were back at work. The Puget Sound Naval Shipyard in Bremerton, Washington, was home to a titanic crane that could easily lift and move six or seven 50-ton guns like so many match-

sticks. Decked out with nine 8-in. naval guns, the *Minneapolis*-class cruiser *Astoria* was among Puget Sound's latest progenies.



30 YEARS AGO: AUGUST 1964



Wire Hanger

Like a diabolically levitated bedspring, a mesh of wire floated as the proof of principle for Maj. Alexander de Seversky's Iono-craft. The principle? A surge of electrons from electrodes mounted above the mesh would ionize air. Charged particles would rush toward the mesh, triggering a downdraft that lofted the device. The trick, of course, was to shrink the source of electric current—something Seversky never mastered.

Kilobytes And Kings

The pride of Yorktown Heights, New York—IBM's Model 7094 computer—went

head-to-head with checkers champ Robert Nealey in a classic duel of wits. Digesting 100,000 mathematical operations a second, the computer played Nealey to a draw five times, losing only once. While the machine had a psychological edge—having no nerves to fray—it played methodically and proved vulnerable in midgame. **PM**





3⁹⁶
Every Day

Popular Mechanics™ Power Outlet Strip

Ideal for home, office or shop. Six outlets and a 15 amp push-to-reset circuit breaker. #701

MADE IN THE USA

Popular Mechanics

6⁹⁶
Every Day

Popular Mechanics™ 165 Surge Protector

Six surge-protected outlets handle TVs, VCRs, stereos and other home electronic equipment. LED indicator shows surge protector is working. 165 Joules of surge dissipation. With EMI/RFI noise protection. #713

MADE IN THE USA

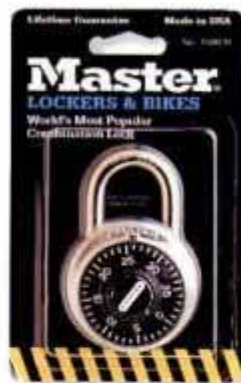


5⁷⁴
Every Day

Lights of America® Under Cabinet Light Fixture

Energy-saving 18" fluorescent light fixture provides 60 watts of light for only 15 watts of electricity. Features easy on/off sliding switch and hideaway cord. Just plug in and turn on. Replaceable fluorescent bulb is included. #7000-1

MADE IN THE USA



2⁹⁶
Was \$3.76

Master® Combination Lock

Case-hardened 9/32" steel shackle protects against cutting and sawing. With unconditional full lifetime guarantee. #1500

MADE IN THE USA

“We can help you brighten a room or protect your valuable electronic equipment.”

Wal-Mart has a full line of electrical products for your home. And that's just a small part of our Hardware Department.

WAL★MART

Always.



Steve

Steve
Sales Associate
Hardware



GE Bright Stik®

25" fluorescent lighting unit puts warm, pleasant light where you need it. Needs no fixture or special wiring. Just plug in.
#FB525/WX

99¢

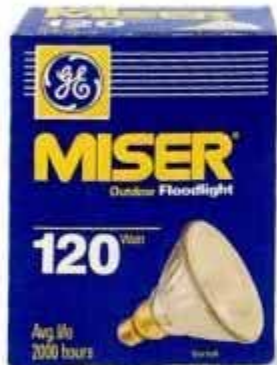
Was \$11.96

25¢
Every Day

**GE Shoplite®
Fluorescent**

Twin-pack of 48" 40 watt fluorescent bulbs for home or work areas.
#F40SHOP/2pk

MADE IN THE USA



47¢
Every Day

GE Miser® Outdoor Floodlight

Gathers stray light that standard floodlights waste and redirects it into the useable beam. 120 watt bulb with an average life of 2000 hours. For driveways, entrances, patios and gardens.
#150PAR/FL/120WM

MADE IN THE USA



21¢
Every Day

**GE Ceiling Fan
Light Bulbs**

Two 40 watt bulbs with rugged filaments that resist fan vibration. Blunt tip crystal protects against breakage.
#40BMCD/2

MADE IN THE USA



19¢
Every Day

**GE Standard Night
Light Bulbs**

4 watt all-purpose bulbs. Available in 4-packs of clear or white bulbs.
#4C7/W/SCD/4
#4C7/SCD/4



22¢
Every Day

GE Medium Base Globe

Decorative clear or white globes are available in 25, 40 or 60 watts.



24¢
Every Day

**GE Soft White Security
3 Way Bulb**

Features 15-135-150 watt settings. Use 135 or 150 watts for soft, pleasing room lighting, 15 watt for night light/security light.
#15/150-Sec

MADE IN THE USA



“Just a few well-placed lights can make your home a lot safer.”

For proper lighting, both inside and outside your home, come to Wal-Mart. We carry just about any kind of light you need for your home. And we'll have it for less. Every day. Always!

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Steve

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Sales Associate
Hardware

TECH UPDATE

News Of Tomorrow's Technology Today



NASA PHOTOS

Space Radar Shows Earth In A New Light

PASADENA, CA—Ecologists and geologists are gorging on a cornucopia of data reaped by NASA's Spaceborne Imaging Radar (known as SIR-C) during last April's shuttle mission. And if plans hold out, by the end of August—when a second shuttle radar run is scheduled—they'll have twice as much to digest. Already researchers predict that they'll be gleaming insight from the images for decades to come.

Why so much acclaim for SIR-C? After all, Japan and Europe are now operating radar satellites, and the shuttle flew a radar mission as far back as 1981.

Unlike those single-frequency efforts, however, SIR-C bounces three distinct wave bands—each polarized twice—off the Earth's profile. The resulting pictures compare to standard radar images as color photography compares to black-and-white.

What radar "photographs," of course, is a subject's capacity to reflect radio waves. And hidden in measurements of radar reflectivity are myriad scientific tidbits. Radar can reveal the water content in soil, the health of



Unlike photo (top left), imaging radar (top right) discerns ash (red) from mud flows (brown) on the Philippines' Mount Pinatubo.

vegetation, distinctions in geology and the type of snow packed in mountains. What's more, it can pierce cloud

cover—and even the Earth's surface—to extract this information.

Radar falls short only in resolution. Because its wavelength is longer than that of light, radar can't see as much detail—nothing smaller than 100 ft., in the case of SIR-C. Still, in theory, computers could manipulate the data to reveal individual cars, although they cannot pick out a Pontiac from a Porsche.

In addition, when NASA flies the second SIR-C mission, the shuttle will perform some precision maneuvers to pass nearly—but not quite—over the same sites twice. Using interferometric techniques, computers will meld the two out-of-register data sets to create topographical maps with an accuracy of 3 ft.—far sharper than most ground-based surveys.

Highlights This Month

- **Scope On A Rope**—Observatory dangles from airship.
- **Seeing-Eye Bullets**—Smart rounds home in on targets.
- **NATO's Newest**—Flying the Eurofighter 2000.
- **Escape The Drill**—Virtual reality in the dentist's chair.
- **Rail Cooker**—Locomotive runs on natural gas.
- **Big Wheel**—Return of the velocipede.
- **Good Wood**—Dimpled baseball bat is a home run.

Editor/Writer: Gregory T. Pope
Reporters: Philip Chien, Mike Dillon, Scott Gourley,
Francis Hamit, Bonni Price, Barry Rosenberg,
Bob Scheier, Richard Schrader

Dreadful Sorry, *Clementine*



ALEXANDRIA, VA—Despite the ringing success of *Clementine's* lunar-mapping mission (see "Beyond The Moon," page 96, July '94), gremlins have scotched the remainder of the little probe's adventure. On its way to meet an asteroid last May, *Clementine* inexplicably decided to empty its attitude-control thrusters' fuel tanks. Mission controllers are blaming the mishap on *Clementine's* housekeeping computer—oddly, one of the most tried-and-true components on the spacecraft.

After malfunction crippled attitude control, *Clementine* is spinning too fast to allow sensors to lock on to asteroid.

Without directional thrust, the probe can no longer control its orientation. In fact, the spacecraft—designed to be stabilized along all three axes—has tumbled into a spin, ruining any chance that it could use its sensors to home in on the asteroid.

Instead, project managers have returned *Clementine* to Earth orbit and will simply monitor the endurance of its sensor suite.

Telescope On A Rope

BALTIMORE, MD—Although astronomers like putting their telescopes far above sea level, parking one in space means paying an astronomical price. A nice

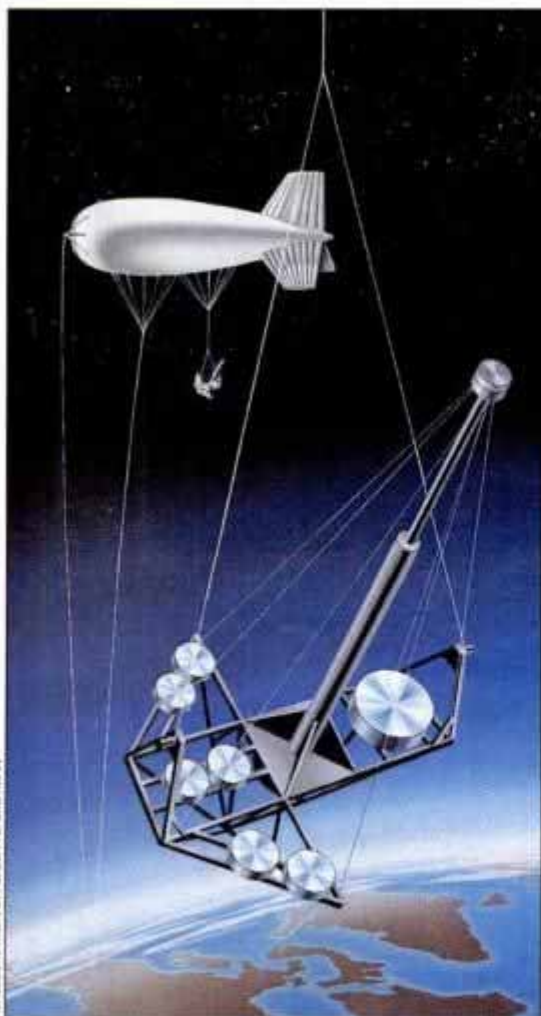
compromise: viewing from the cold, dry stratosphere 7 miles above the North or South Pole.

Researchers from the Space Telescope Science Institute and the University of Colorado are proposing such an inexpensive setup, calling it POST, for Polar Stratospheric Telescope.

The instrument itself would hang from a tethered aerostat. But to lighten weight, the telescope wouldn't use a single large mirror. Instead, an arrangement of six 3-ft. reflectors and one 6-ft. mirror would gather light.

Then newly developed computer techniques—invented to compensate for the Hubble Space Telescope's former flaws—would come into play. These modeling programs would combine readings from the small mirrors to simulate the resolution of a mirror 20 ft. across—twice the size of Hubble's primary reflector.

POST would rival airborne and orbiting telescopes at a fraction of their expense.



Things To Do Today: 1. Fix Hubble...

HOUSTON, TX—Astronauts do practically everything by written procedure, from preparing breakfast to performing experiments. But they find it unwieldy to clutch a paper checklist while out space-walking around the shuttle's payload bay on an extravehicular activity (EVA).

So Johnson Space Center has developed an arm-strapped Electronic EVA Checklist. Looking like a giant Dick Tracy TV wrist-radio, the unit can store 500 pages of information and features a 320 x 220-pixel liquid-crystal display—touch-sensitive so that space-suited astronauts can flip through menus.



EVA checklist can receive updates from the shuttle laptop if spacewalk plans change.

Russian Horse, Western Rider



Proton rocket and Inmarsat-3 satellite are overcoming incompatibility.

BAIKONUR, KAZAKHSTAN—Now that Russia's Proton rockets will begin lofting Western satellites, engineers must mate two mismatched space programs. The biggest contrast: Western satellites fire apogee motors to get to geosynchronous orbit, but Russian ones don't, riding instead on the Proton's fourth stage.

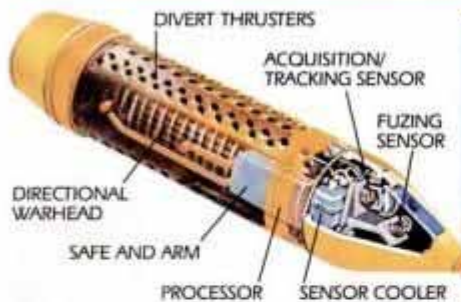
Solutions are already occurring to Martin Marietta, first to book a payload on the Proton. The company's Inmarsat-3 satellite will lose its apogee motor in deference to the Proton. And the Proton's fourth stage will execute a new "rotisserie maneuver," spinning periodically to keep the satellite from frying in the Sun.

SURGEON GENERAL'S WARNING: Smoking Causes Lung Cancer, Heart Disease, Emphysema, And May Complicate Pregnancy.

700 CAMELS SMOKIN' UNDER ONE HOOD.

Forget horsepower. CAMELPOWER is here. Smokin' Joe's Racing Team has hit the NASCAR Winston Cup Series. So look for it. Because when this car hits the track, things are gonna be smokin'.





AEROJET ILLUSTRATIONS

Bullets Find Their Targets

AZUSA, CA—Always worried about maneuverable sea-skimming missiles, the Navy fears an increase in such threats now that its ships operate closer to shorelines in post-Cold War scenarios. By way of defense, naval planners are hoping that ships' guns can down these dodgers with equally agile shells.

Aerojet is developing one such projectile under the Navy's Gun Weapon System Technology Program. The round guides itself autonomously to a moving target. To steer, the spinning projectile fires rows of solid-rocket divert thrusters.

The shell needn't hit to kill. Rather, a bidirectional kill

Homing antimissile bullets guide themselves with sensors, triggering divert thrusters to zero in on zigzagging targets.

mechanism uses two fragmenting warheads on the projectile's flanks to destroy the target.

Prior "homing bullets" have faltered because electronic components couldn't survive the g-forces associated with gun launch. But that challenge has been overcome. In fact, because the Aerojet bullet weighs less than a conventional 5-in. round, it will fly faster from the gun's barrel.

Satellite Dish On Wheels



AIR FORCE PHOTO

HANSCOM AFB, MA—The military works its satellite terminals hard. Not only must they tie into superhigh-frequency defense channels, but they also must use civilian bands. No wonder they've hitherto been sprawling fixed installations, rarely deployed in the field.

But no longer. The Air Force has developed a Lightweight, Multiband Satellite Terminal specifically for mobile operations. The trailer-mounted equipment can roll out of a cargo plane and start working in 30 minutes.

A quarter the size of previous gear, terminal weighs only 6500 pounds.

Jack-In-A-Box Control Tower

HANSCOM AFB, MA—The Air Force is tired of lugging around its heavy, bulky mobile air-traffic-control tower. Not only has the equipment fallen out of

date, but to transport the complete setup ties up two C-130s. So a slimmer version, sized to slip into a single C-130, is now under development.



AIR FORCE ILLUSTRATION

Tower Restoration Vehicle deploys instant air-traffic-control center from the back of a Hummer.

Called the Tower Restoration Vehicle, or TRV, the platform will simply pop up from the back of an M-1097 "Heavy Hummer." Once its roof is raised, the TRV provides seven ground-to-air radios. In contrast to the messy cabling in the old mobile tower, TRV messages route through one transmit and one receive antenna.

Seaport Sonar's Intruder Alert

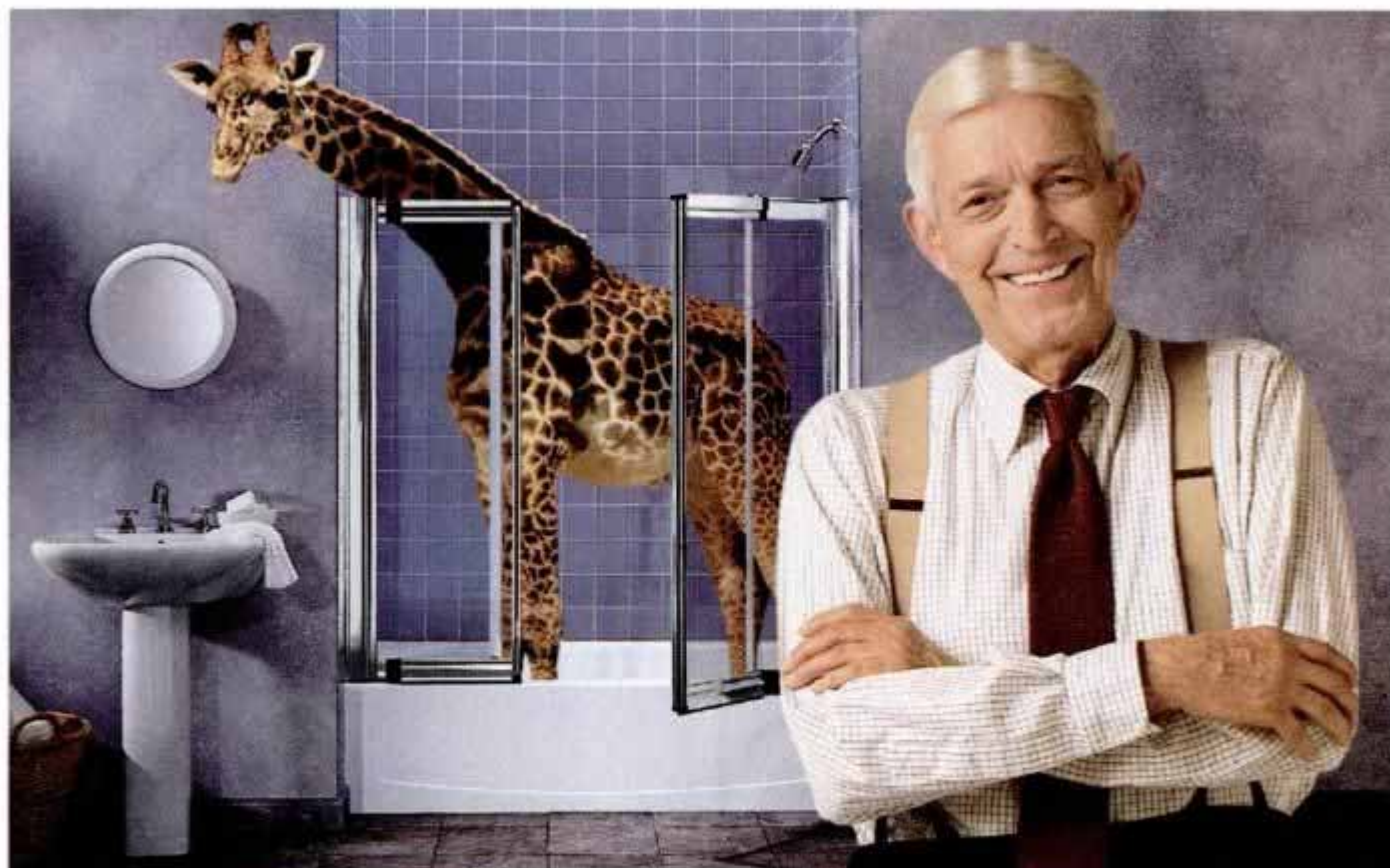
CORNWALL, ONTARIO—The Swedes, who loathe submarine incursions of territorial waters as much as anyone, are investing in a unique harbor-surveillance sonar system.

Although Sweden won't say how many units it is buying, the sonar can stand alone to guard a port or can line up in a series to protect a coastline. Made by C-Tech Ltd., the CSAS-80 system boasts the sophistication of shipborne and sub-carried sonar, yet is easily relocatable. The underwater pingers can detect and track targets automatically, filter out background echoes and zoom in without sacrificing resolution. Each unit has a circular range of roughly 1.25 miles, sending out an array of 256 rapidly scanned acoustic beams.



C-TECH LTD. ILLUSTRATION

Harbor-surveillance sonar provides 360° coverage with rapidly scanned beams.



*"Getting him in and out is simple.
Getting him to wash behind his ears is the hard part."*

-Sam Davis, Sterling Vice Chairman

Okay, so Sam's demonstrations tend to be a little on the wild side. We know that. But you have to admit, the guy does make one heck of a shower door.

We call it "FreeStyle," and its revolutionary features not only beat other shower doors hands down, they make clumsy, impossible-to-clean curtains obsolete.

For instance, it has no tracks. No tracks above to hit your head, and no tracks below to collect water, mildew or bacteria.

And you see those four doors? The inner two slide easily into the outer two; then

the outer two swing in or out to give you an opening you could drive, well, a nine-foot giraffe through.

Of course, seeing that you probably have more children than giraffes, all that room makes it a lot easier for you to clean them, too.

The new FreeStyle" shower door. Easier to get in and out, easier to clean, and, since it's from Sterling, easier to buy.

Which makes sense for just about everyone. Even lazy giraffes who don't clean behind their ears. For more information on Sterling products call 1-800-895-4774.



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Quality faucets and fixtures at reasonable prices.

Europe's New Prize Fighter

WARTON, ENGLAND—Four European allies are keeping a close watch on the Eurofighter 2000, which made its maiden flight on March 27.

Great Britain, Germany, Spain and Italy teamed up on the multirole fighter, which is destined to replace those nations' aging jets, including F-4 Phantoms and F-104 Starfighters. Its debut delayed by 2½ years, the Eurofighter remains something of a mystery plane—each nation's choices of avionics, jammers and other internal equipment are still up in the air.

On the outside, though, the jet is a daredevil hot rod, with twin engines putting out a push of 40,000 pounds. Like the F-22 and Sweden's new Grippen—both of which have already crashed in tests—the plane gains wild agility from its aerodynamic instability.



The Eurofighter 2000 boasts a thrust-to-weight ratio greater than 1:1.

Inside, streams of information will flow from advanced pulse-Doppler radar and an infrared search-and-track sensor. Software will analyze

and present this data to avoid overtaxing the pilot. Other workload-reducing goodies include an auto-stabilizer and voice-recognition input.

Gnat Is Flying Weather Station



TONKAWA, OKLAHOMA—Seeking traces of global climate change, an unmanned aerial vehicle has been buzzing over the Great Plains.

The little Gnat-750 is the same species of drone that the CIA lofted last winter to reconnoiter the Balkans (see Tech Update, page 16, April '94). But this time, instead of spy

sensors, five radiometers ride aboard the robot. The devices gauge radiant energy passing through the atmosphere at altitudes between 1500 and 22,000 ft.

The effort dovetails with the U.S. Department of Energy's ground-based Cloud And Radiation Testbed (see Tech Update, page 19, July '93).

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radiant energy passing through the atmosphere at altitudes between 1500 and 22,000 ft.

The effort dovetails with the U.S. Department of Energy's ground-based Cloud And Radiation Testbed (see Tech Update, page 19, July '93).



Gnat-750 takes climate instruments to the sky, gathering data that ground equipment cannot pick up.

Bombproof Baggage Box



FARNBOROUGH, ENGLAND—No sane person wants a repetition of the 1988 disaster over Lockerbie, Scotland, when a terrorist bomb brought down a Pan Am jetliner, killing hundreds. Now Royal Ordnance may have a safeguard in its Protective Cargo Container.

The baggage container is designed to stifle a blast's pressure spike. Some of the energy attenuates into an inner lining of undisclosed aerospace material, while the rest ricochets downward into the container's base and the aircraft's bilges. Finally, external straps girdle the container's shape as the explosion distends its sides.

Protective Cargo Container swallows the blast of a Lockerbie-caliber explosion.

Protective Cargo Container swallows the blast of a Lockerbie-caliber explosion.



Maybe The Merlin



MESA, AZ—The Marines may have to wait 15 years before they have a fleet of V-22 Osprey tilt-rotors at their disposal. Meanwhile, their venerable CH-46 Sea Knights, the double-rotored choppers they've flown since Vietnam, keep getting older.

One possible stopgap: the EH-101 Merlin—the big, quiet transport helicopter coproduced by Britain's Westland and Italy's Agusta. McDonnell Douglas has been given the go-ahead to market the copter in America. British and Italian navies are already switching to the EH-101.

Merlin may serve as an interim replacement for the CH-46 until new tilt-rotors become available.

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The all-new POWER STROKE™ 7.3L DI turbo diesel outpowers the rest.*



Ford continues to be a safety leader with a new standard driver's airbag.**



A redesigned rear seat improves legroom and comfort.

*Available on models over 8,500 lbs. GVWR. **Available on models under 6,500 lbs. GVWR. Always wear your safety belt. Free 24-hour Roadside Assistance. 3 years/36,000 miles. See dealer for details.



Southern Tech, USC and Texas-Arlington (left to right) entered machines in aerial robotics contest, now a festival of futility.

Can't Anybody Win This Crazy Contest?

ATLANTA, GA—You'd think that after four years the country's top propeller-heads would have it figured out. But no. Once again, a \$10,000 grand prize remains unclaimed. Such was the dismal result at the 1994 International Aerial Robotics Competition.

Sure, the rules sound simple. College-sponsored flying machines must find and pull metal discs from one bin, fly

autonomously and find the bin. Then it crashed. From the University of Texas at Arlington came a tailsitter vehicle, known for its out-of-control pogo-stick antics in years past. This year it crashed spectacularly.

Winner by default was the University of Southern California, with a 29-second flight time. Frustrated organizers say they might hold the contest underwater next year.

them across a barrier and deposit them in another bin—all without direct human intervention.

In previous years, teams at least managed parts of this task (see [Tech Update, page 30](#), Nov. '92). But this time no one even came close.

Georgia Tech's 4-rotor Heliquad did take off

Biopsy Without Surgery

KNOXVILLE, TN—Instead of snipping away tissue samples to test for cancer, physicians are shining light in order to make an instant diagnosis.

Known as optical biopsy, the technique has emerged at the Thompson Cancer Survival Center, with help from Tennessee's Oak Ridge National Laboratories. So far, it's proved 100% accurate in detecting cancer of the esophagus.



Probe detects cancer by analyzing light emissions from tissue in question.

A probe made of optical fibers travels through a slim, flexible tube that's inserted down the patient's throat. Some of the fibers emit low-energy laser pulses. Inside the tissue to be tested, molecules absorb these pulses and radiate their own light, in wavelengths that tell of

health or disease. Other fibers in the probe carry this light to a computer for spectral analysis—and diagnosis.

Virtual Eyeballs For The Surgeon

ATLANTA, GA—To keep their skills honed, ocular surgeons must practice, practice, practice. But donor eyeballs



from cadavers are less than ideal for such training, because they don't retain the texture and elasticity of live ones. Surgeons rely on these tactile sensations to guide their scalpels.

Seeking to duplicate the touch and feel of living eyeballs, Georgia Tech and the Medical College of Georgia have developed a prototype eye-surgery simulator using virtual reality.

The trainee grips a simulated scalpel linked to three small motors that give realistic force feedback as the device moves. A tracking system monitors hand motion, and a stereo display provides visual feedback through an operating microscope.

Eye surgeons can stay proficient, learn new techniques or rehearse difficult procedures with virtual-reality simulator.

Dental-Chair Distractions

REDMOND, WA—What sounds like more fun, exploring virtual reality or listening to a dentist's drill explore your rotten molar? If you prefer the former, a "patient viewing system" from Virtual Vision Inc. may see you through your next visit.

Equipped with hi-fi earphones, the



Virtual Vision Rx engrosses dental patients with videogames or TV programs.

Virtual Vision Rx visor can replace the sounds and sights of the dentist's office with television programming or a videogame. Magnified color liquid-crystal-display images appear at a comfortable focal depth of 6 ft.

The hardware sports disposable splash and debris guards and a germ-resistant coating. It will even accommodate a nitrous-oxide mask if the TV hasn't dulled your senses enough.

Learning Machine Breakthrough!

Amazing new technology teaches you foreign languages, reprograms your mind for success & launches you into virtual fantasy experiences

BY DANE SPOTTS



THE FIRST TIME I plugged my mind into the Learning Machine™ I was reminded of the '50s sci-fi classic *Forbidden Planet*. If you've never seen the movie, an astronaut on the planet Krell discovers an incredible learning technology — a helmet hooked up to a super sophisticated computer that downloads knowledge directly onto your brain cells. Impossible? Maybe not.

A revolutionary breakthrough, the Learning Machine stimulates your mind and opens your learning centers. Like magic it pours in new information and skills. And it's super entertaining.

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Let's say you want to learn a foreign language, quadruple your reading speed, or increase your math skills. Or give your children a powerful edge in school, learning 300%-500% faster than their peers.

You select a specially programmed Learning Disc™ in the area you want to study. Plug it into any ordinary CD player. Then attach your Learning Machine digital headset into the headphone jack. Push play and a few moments later your mind is launched into a pre-programmed learning session. In a fun, almost effortless way, the Learning Disc lesson plan unfolds its program and transfers the knowledge into your mind.

Learn foreign languages at lightning speed. Plug your mind into Basic French, Spanish, German, and Italian. (4 CDs—\$200 Value FREE)

Amazing Light-Sound Matrix Stimulates Your Mind

How does it work? A digital program embedded in the CD, called a Learning Matrix™, sends a combination of light and sound instructions through the Learning Machine digital headset to stimulate the optimum mind-state for learning.

During your learning session you'll be asked to listen to audio instructions while you review written materials. While this information is still fresh in your mind, the narrator instructs you to lower your Light Pulse Shield, and the Learning Disc fires an amazing light-sound matrix that instantly relaxes you. This highly relaxed mind-state helps lock the new information into your memory.

Learn Foreign Languages, Speed Reading, and More

Learning foreign languages, or anything for that matter, at rocket speed can be very empowering. And I'm going to include a ton of valuable Learning Disc software with your Learning Machine so you can get immediate results from this new technology. You'll receive 4 basic language courses — French, German, Spanish, and Italian. A Super Vocabulary course, a Super Memory course, and for your kids, a SuperPhonics™ reading



Amazing digital headset stimulates your mind and opens your learning centers. Like magic it pours in new information and skills in a fun, effortless way.



Heighten mental awareness, enhance psychic functioning, and stimulate imagination, creativity, and intuition with 10 mind expansion programs. (3 CDs—\$150 Value FREE)

program. Over \$200 worth of Learning Discs make this the deal of the century. But I also want to show off its other amazing powers.

3-D Mind Sync Induces Virtual Fantasy Experiences

So I'll include the 3-D Mind Sync™ Library, with 10 whole brain synchronization programs on 3 CDs, to turn your Learning Machine into a meditation, self-hypnosis, and virtual fantasy computer. You'll receive the following titles: *Creativity Booster, Quick Energy, Stress Zapper, Brain Tune-Up, Virtual Visualization, Imagination Stimulator, Learning Accelerator, Super Intuition, Lucid Dreaming, and Super Zen States.*

A \$150 value, this extensive collection is a super added bonus. But what's even more exciting is how this same machine can be used for habit control, success conditioning, and eliminating self-defeating attitudes.

Zap Your Mind with Success

Let's say you want to transform a loser mind-set into a winning one. Or you'd like to quit smoking or lose weight. Pop in an InnerMind™ Programming Disc. The light-sound matrix opens a window into your unconscious mind.

Then by infusing your "inner mind" with positive programming, you can rescript negative, self-defeating behavior. I'm including 18 awesome InnerMind programs. From success conditioning to weight control this is another \$150 value.

\$200 Instant Rebate

Plus in addition to the Language Library, the SuperPhonics, Super Speed Reading, Super Memory, and Super

18 titles erase fear and condition your mind for success. (3 CDs—\$150 Value FREE)

Vocabulary programs, the Mind Sync Library, and the InnerMind Programming Library (a \$600 combined value), I'm offering you a \$200 instant rebate off the list price. I figure you'll be so impressed, you'll use the extra \$200 to buy more Learning Discs.

The list price for the Learning Machine is \$499.95. But you can have it for \$299.95 plus shipping. Remember, in addition to the \$200 rebate, I'm including hundreds of dollars worth of free Learning Discs, making this an incredible offer.

30-Day Risk Free Trial

Try the Learning Machine risk free for 30 days. Sample 4 languages, triple your reading speed, boost your vocabulary, improve your memory, and reprogram one or two bad habits.

Now imagine what you can do during the second month! But hurry. This is a limited introductory offer, so reserve your Learning Machine now.

To order, call toll free or send your check or money order for \$299.95 plus \$12 shipping & handling to the address

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InnerMind™ Programming Library (\$150 Value) 18 programs on 3 Learning Discs program success behaviors into your subconscious. Titles: *Building Self-Esteem, Eliminate Fear & Anxiety, Projecting a Winner's Image, Attracting Love Relationships, Health & Healing, Expanding Psychic Powers, Attracting Prosperity & Wealth, Time Management & Organization, Creativity & Problem Solving, Effective Public Speaking, Increase Focus &*

Concentration, Super Memory & Learning, Stay Fit/Exercise Motivation, Permanent Weight Loss, Eliminate Procrastination, Quit Smoking Now, Meet Your Deadlines, Always on Time.
Super Speed Learning™ Beginner's Pak (\$59 Value) 4 accelerated learning programs, Super Speed Reading, Super Memory, Super Vocabulary, and SuperPhonics (for kids K-6) teach you learning skills you'll use for life.

COMPLETELY

KOOL

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Smoke Contains Carbon Monoxide.

Kings, 17 mg. "tar", 1.1 mg. nicotine
av. per cigarette by FTC method. © 1994 B&W T Co.



no doubt about it.

MORRISON KNUDSEN PHOTOS



Locomotive Cooks With Gas

BOISE, ID—Just like trucks, diesel trains face pressure to cut pollution, particularly in big-city switching yards. With that in mind, Caterpillar and Morrison Knudsen have teamed to produce the world's first locomotive fueled only by liquefied natural gas (LNG).

Now entering service in Los Angeles rail yards, the MK1200G features an innovative fuel-storage and delivery system. Superinsulated tanks store 1400 gallons of LNG at -260° F. From these tanks, the liquid flows through piping to a vaporizer, which



FM ILLUSTRATION BY DON MANNING

MK1200G switcher locomotive burns natural gas carried in cryogenic storage tanks.

taps hot water from the engine jacket to warm the liquid into a gas. The gas is then injected into Caterpillar's 16-cylinder powerplant, a spark-ignited conversion from a diesel engine.

Although the MK1200G turns only 1200 hp, that's plenty for shuttling

cars between trains in rail yards. More important, the locomotive puts out one-tenth the emissions of an equivalent diesel. Also, if railroads invested in yardside cryogenic LNG storage facilities, the low cost of natural gas could ultimately save money.



AMERICAN PHOTO

Ohio's Space-Age Bridgework

WEST CHESTER, OH—Instead of bombing bridges into oblivion, the Air Force is looking at ways of pro-



Decaying infrastructure, such as this Ohio bridge, could benefit from composite reinforcements.

longing their useful lives. Materials engineers at Wright Laboratories hope to combine aerospace composites with low-tech concrete to save two crumbling road bridges in Ohio's Butler County.

The project was born of an effort to stiffen concrete's resistance to bomb blasts. Engineers are bonding panels of carbon-fiber-laced plastic to concrete beams, then gauging how much the composite materials lend in the way of strength and rigidity. If the panels check out, composite strips will reinforce decking on the bridges.

The Air Force engineers also hope to build the country's first all-composite pedestrian footbridge in Akron.

Iron Works Becomes Time Machine

RICHMOND, VA—Cannons, naval torpedoes and armor plates for the ill-fated ironclad *Merrimac* once rolled out of this Confederate munitions factory. Today, the Tregear Iron Works has been transformed into a museum that delivers history with a barrage of technology.

Now called the Valentine Riverside, the museum features two one-of-a-kind exhibits. In one building, five large liquid-crystal screens stand next to windows that

Restored Confederate iron-works building becomes backdrop to history.

offer views of Richmond's skyline. Touch-screen controls allow visitors to summon digitally manipulated



VALENTINE RIVERSIDE PHOTOS

archive photographs that present the same views, but in historic times.

At night, twin 6000-watt Pani projectors, using newly developed image scrollers, light up the building facade with 60 x 80-ft. images. During the show, subterranean woofers rumble to enhance Civil War battle sequences.

Missile Targets Walk The Tightrope

U.S. ARMY PHOTO



WHITE SANDS MISSILE RANGE, NM—Stretching between Oscura and Little Burro Mountains, it may look like the world's longest clothesline,

but this 3-mile Kevlar cable was strung to hang out targets for next-generation missiles. Called the Aerial Cable Test Range, the rope will pro-

vide a runway for moving captive vehicles, made of fiberglass and propelled either by gravity or small rockets.

This technique should prove much cheaper than building and destroying one-shot jet-powered scale models. What's more, the vehicles can slide down the cable to rain submunitions on ground-based test articles, or serve as launch platforms for their own missiles. The facility could even drop-test planetary landers.

Built by Nielsen's Inc., the cableway will conduct 400 tests per year and should be fully operational by the end of the summer.

Velocipede Rides Again

DETROIT, MI—The rage of the 1880s, the velocipede often tossed a high-riding pedaler headfirst if its oversize front wheel hit a pothole. Now, a new-fangled velocipede could revive the big wheel's mechanical advantage—and put the cyclist closer to the ground.

Mocked up as a concept bike by Center for Creative Studies



CENTER FOR CREATIVE STUDIES PHOTO

designer Michael Stapleton, the vehicle puts the rider inside a hubless rear wheel. Bearings around the wheel's circumference keep an inner seating frame level and stationary while an outer rim turns. A gear train links pedals with an enormous drive sprocket inside the wheel. Steering and braking work the small front wheel, via cables from handles at the rider's sides.

Recumbent velocipede would have no more moving parts than a typical mountain bike.

Hydraulics Without Headaches

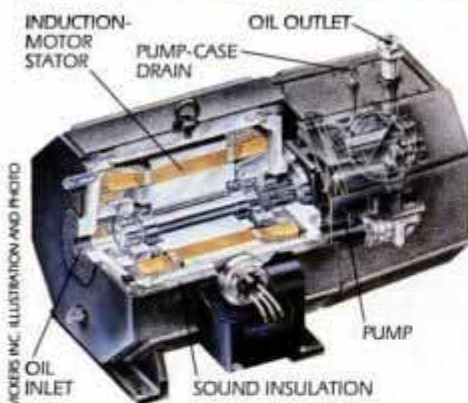
MAUMEE, OH—Anyone who's been jerked awake at 3 am by a garbage truck's racket knows what a din hydraulic systems can generate. Now, Vickers Inc. has muffled the roar with its Integrated Motor Pump (IMP), a fluid-power unit encased in sound insulation.

Because air cools a conventional hydraulic motor, whirling fans and



Before hitting pump, hydraulic oil flows through motor and whisks away heat, permitting complete sound insulation.

openings for airflow contribute to its noise. By contrast, in the IMP, the hydraulic oil itself cools the motor. Not only does this allow complete enclosure, but oil cooling also means that a powerful motor can be squeezed into a small package.



VICKERS INC. ILLUSTRATION AND PHOTO

Dimples Make Sluggers Smile

CAMBRIDGE, MA—To get around on a fastball, a swinging baseball bat must battle aerodynamic drag. To put a little extra mustard in a hitter's kitchen, a Massachusetts Institute of Technology instructor has devised a way to shave drag off a swing. The secret: dimples.

Small indentations—pressed rather than drilled into the wood—work like the dimples on a golf ball.

They churn up the boundary layer of air around a moving bat. Normally, this thin layer hugs the bat instead of getting out of its way. But the dimples create vortexes that mix this air with faster-moving air above the boundary layer.

The result: a 3% to 5% increase in bat speed, which translates into 12 ft. to 15 ft. of flight for the baseball. And the dimples neither scuff the ball nor send it off on a foul trajectory. Batter up!



Dimples cut drag and boost bat speed, as proved in wind-tunnel experiments.



MIT PHOTO



Could this be your dog?

A new breakthrough, **Radio Fence**, creates a hidden barrier to keep your dog in your yard and out of trouble. Finally, you can protect your dog from traffic and other dangerous situations without locking him in a pen.

By Charles Anton

All dog owners have the same dilemma. On one hand they want to give their dog the freedom to roam and exercise. On the other hand, they are worried about his safety.

Up until now the only solution was to install a costly conventional fence. Not anymore!

No leashes or cages. Now there's Radio Fence, the breakthrough alternative for dog owners. Radio Fence is an underground electrical barrier which works with a receiver on your dog's collar. It keeps your dog when he nears the boundary and gives him a small electrical correction if he tries to cross it. It keeps your dog safe and out of trouble without having to resort to expensive fences, runs ropes or chains that could injure your pet.

A hidden barrier. Radio Fence acts as a hidden barrier that gives your dog access to the whole yard but inhibits his movements into unwanted areas. Your prize-winning rose garden or pool will be safe. Unlike standard fences, Radio Fence does not detract from the beauty of your home or lawn.

A hidden barrier that only your dog knows is there...

- No more ugly, expensive fences
- No more restrictive enclosures
- No more ruined flower beds
- No more knocked over trash cans
- No more complaining neighbors
- No more worrying about your dog's safety or protection



Radio Fence creates a hidden barrier around your yard that safely contains your pet.

Easy training. By spending just fifteen minutes a day working with your dog, he will be fully trained in six to seven days. Radio Fence is more effective than other systems because it allows your pet to control the corrective treatment (which is definite but mild) and he soon learns to avoid it.

Safety and freedom.

Radio Fence will work with any size or breed of dog. The correction, which is similar to a static electricity charge, will not hurt your pet in any way.

Plus Radio Fence meets all FCC requirements, ensuring your dog's safety and giving you peace of mind.

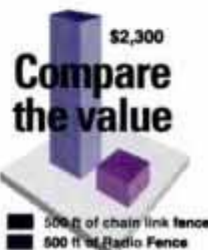
Custom boundary.

With Radio Fence, you will receive 500 feet of wire that can be easily installed in just two to three hours. The wire will accommodate up to a half-acre yard. The Radio Fence System also includes a transmitter with a signal powerful enough to broadcast to approximately two acres. If you want to expand your Radio Fence boundaries, simply order an additional roll of wire.

You can train as many dogs as you want on the same system as long as they are each wearing a receiver collar.

Affordable fence. The maintenance-free design, low initial investment, and ease of installation offer tremendous savings. Other solutions could cost you thousands of dollars. Radio Fence is the economical and effective alternative to unsightly fencing.

Radio Fence. The Radio Fence System includes transmitter, lightweight receiver for your pet's collar, 500 feet of boundary cable and complete installation and training manual. Plus, you will receive a helpful video that will make installation and training extremely simple. Extra wire is also available. It allows you to expand the boundaries of your pet containment system.



Your Pet's Best Friend

Special no-risk, no obligation offer.

Radio Fence is a great product. But we know you may still have some questions. We encourage you to call today for more information and our informative video, free of charge, with no obligation.

Of course, the best way to find out if Radio Fence is right for you is to try it for yourself. That's why we're offering our exclusive

60 day free home trial

Try it yourself with no obligation. If you're not completely satisfied, simply return it for a full refund "No Questions Asked."

Limited time. We specialize in bringing new technology to people like you. And because we offer it to you directly, there are no middle man mark-ups. So take advantage of this special offer to be one of the first people to experience this technology at its introductory price. Call today! Please mention promotional code 033-POQ105.

call for free video and brochure
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COMTRAD INDUSTRIES

2820 Waterford Lake Drive Suite 106
Midlothian, Virginia 23113

HOW DOES IT WORK?

A crystal-tuned transmitter plugs into a standard outlet and emits a radio signal that travels along an underground wire. (The wire only needs to be buried an inch or two to prevent anyone from accidentally cutting or tripping over it.) The four-ounce receiver, worn on your pet's existing collar, picks up the radio signal and alerts him as he nears the hidden boundary that you have customized for your yard. If he crosses the boundary, he will receive a small, electrical correction.

Keep your dog safe and out of trouble with the Radio Fence System.

Once your pet has learned the boundaries, the electric charge may be removed, allowing only a chirping sound to alert your dog.





BLACKTOP TO BLUE SKY

With its street-legal silhouette and switch-hitting engine, the Aircar will take you from the highway to the high frontier.

BY DAVID FREEMAN; PM Photos by Ray Hand

● The details lie in plain sight. Propeller? Check. Steering yoke? Check. Hand-operated throttle? Check. Automotive brake and gas pedals? Check. Gearshift? Check. No doubt about it, this is a genuine hybrid, deftly mixing car and plane. But something seems missing—shouldn't it have wings?

"Those *are* the wings," says Kenneth G. Wernicke, as he points to the stubby projections on either side of his brainchild—a mockup of what he believes will be the first practical flying car.

"I'm no aviation engineer," says a visitor in Wernicke's dusty workshop, "but I don't see how this thing would ever fly."

Wernicke takes no offense. "Aviation engineers look at it and say the same thing," he retorts without a trace of irony.

At present, Wernicke's Aircar exists only as a flightless work-in-progress. But it's a full-scale manifestation of his dream—a craft capable of flying and driving in the same configuration. Without, in other words, the kind of preflight surgery that other flying cars have required. Not surprisingly, those stumpy, low-aspect-ratio wings are the key to making this possible.

In contrast to the Aircar, previous flying-car designs often incorporated wings that folded up or detached for stowage on a trailer. Some early designs even went so far as to employ a detachable aircraft engine, stored off the vehicle until takeoff time.

To Wernicke's mind, impractical designs such as these explain in part why previous "roadable aircraft" failed to catch on. Making matters worse, previous flying cars tended to be woefully underpowered, with limited airspeed and insufficient range for convenient, economical use.

The Aircar's innovative design addresses not only the wing problem, but also speed and range.

Equipped with the most powerful of the several options envisioned for production models—a 475-hp racing-car engine—a 4-place Aircar will have a maximum airspeed of 266 miles per hour. With supercharging, Wernicke calculates, that could rise to 310 mph.

Range—factoring in a pilot, one passenger and 50 gallons of fuel—should be 1300 miles in the air and 2200 miles on the ground. In road mode, the Aircar should be capable of 65 mph—just enough to avoid embarrassment on the highway.

BLACKTOP TO BLUE SKY

If all this sounds plausible enough, one difficult question remains. Could wings that span only 10 ft. really generate enough lift to raise a 24-ft.-long 2800-pound machine off the tarmac?

According to Wernicke, the Aircar has proven itself in two separate wind-tunnel tests, conducted in Texas

tried to figure out how to make a real flying car, I could never come up with a satisfying answer. Then, sometime around 1965, it occurred to me that you could make a flying automobile if you used a low-aspect-ratio wing—like a paper airplane."

Fittingly, Wernicke used paper

Wernicke kept returning to the flying car. Each time, however, convinced him anew that a low-aspect-ratio flying car defied aerodynamics.

Lifting thoughts

In 1985, Wernicke had an important insight. "As I was making some calculations," he recalls, "it occurred to me that I shouldn't worry about aerodynamic efficiency. What I should worry about was simply 'Could it fly far enough to be a viable aircraft?'"

Wernicke determined that to have a range of at least 600 miles (the minimum he considered acceptable), the flying car would need a lift-to-drag ratio of at least 7.5. (Such ratios range from 12 or 13 for a private airplane up to 50 for a sailplane.)

Wernicke converted his thoughts into a little fleet of scale models, powered initially by rubber bands and then by gasoline engines. And in late fall of 1992, Wernicke tested his most successful design in the Texas A&M wind tunnel. These trials confirmed its flight performance and revealed something else to Wernicke. Because the design lacks a horizontal tail, both aileron and elevator function could combine into a single wingtip control surface called an elevon.

To prevent the roll and pitch instabilities that plague aircraft with low-aspect-ratio wings—especially at high speeds—Wernicke fitted the Aircar with winglets far taller than those commonly seen on production aircraft. Together with a set of lower winglets, these upper winglets not



At motorhome width, proof-of-concept mockup fits within confines of a parking space.

A&M's low-speed facility in College Station. And a videotape in Wernicke's possession shows a near-flawless performance by a radio-controlled scale model of the Aircar.

Bell man

These accomplishments help stifle the urge to dismiss Wernicke as a kook. What's more, the 61-year-old entrepreneur comes with credentials. Impressive credentials. His *curriculum vitae* details a long and rather celebrated career as an aircraft engineer.

Wernicke's workshop, tucked behind a sun-baked industrial park in Hurst, Texas, is a stone's throw from the vast Bell Helicopter facility. There Wernicke spent almost 35 years designing a series of vertical-takeoff production aircraft.

Wernicke cut his teeth on the legendary UH-1 "Huey" chopper, then went on to lead the engineering of the XV-15 and Bell's part of the V-22 Osprey tilt-rotor, among others. A plaque on his office tells it all: "Kenneth Wernicke, Mr. TiltRotor."

Wernicke made preliminary drawings of the proof-of-concept vehicle back in 1993, three years after taking early retirement from Bell. But his dream of building a flying car dates back to the 1950s.

"I used to tease my kids," he says with a chuckle. "I would be going down the road, and I would pull back on the steering wheel like I was going to take off. But when I sat down and

models to test his idea. They flew. But owing to their small, inefficient wings, their glide characteristics were poor—a seemingly insurmountable problem that Wernicke later confirmed mathematically. Discouraged, Wernicke put aside his flying-car project. He busied himself instead with his work at Bell—and in his free time, he built a series of playful projects, including a "flying surfboard" he towed behind his speedboat.

But over the next several years,

What Happened To Moller?

● Three and a half years ago, Paul Moller seemed ready for takeoff. Only a few months, he told us, separated his own flying car—the Moller 400 volantor—from its maiden voyage. But today, a hollow airframe remains grounded at Moller's Davis, California, plant.

Why the delay? Engine trouble. Moller's concept depended on eight novel rotary powerplants. At 530 cc, each would yield 120 horsepower from a 68-pound package. To nurture the engine's incubation, Moller struck a short-lived deal to develop a 750-cc version for the boating market. Moller figured he could shoehorn this bigger engine into the M400. Trouble was, the shoe didn't fit, forcing Moller back to his original engine size.

Today, the finished 530-cc engine drones in the background as Moller talks on the telephone. "I have an obligation to get this engine company started. If we are going to have an inexpensive aircraft we need an inexpensive engine, and that means high

volume." And what does that mean for the volantor's future? "It's still my prime focus," says Moller. "I haven't abandoned the dream—just taken a detour."

—Gregory T. Pope



Moller's single-rotor 530-cc engine, finally complete, will power his volantor.



Mockup reveals 180-hp Mazda rotary in proof-of-concept version. Cockpit includes both air and road instrumentation, dual-mode steering yoke and automobile-style pedals.

only make the Aircar more stable but also cut induced drag. They even serve as faired mounting points for the main wheels.

Split personality

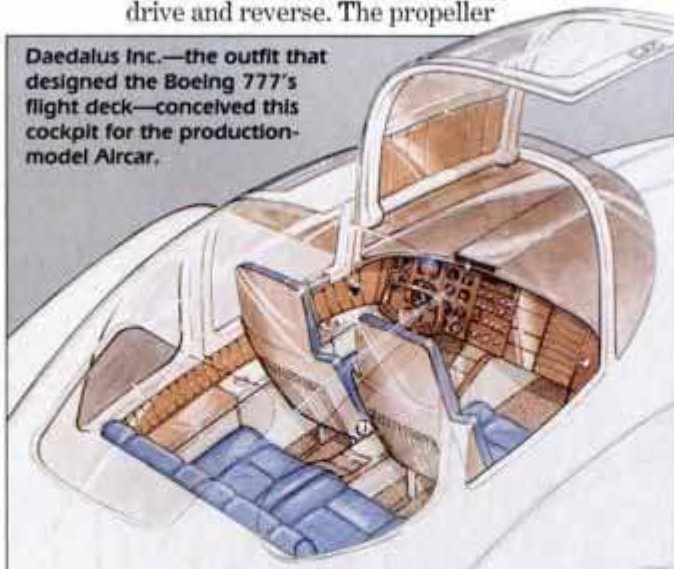
For maximum simplicity—and the attendant cost and weight savings—the Aircar will harness a single powerplant for both air and ground travel. In automobile mode, engine power is diverted from the propeller to a variable-displacement hydraulic pump, mounted underneath the cowl and directly adjacent to the engine. Depressing the accelerator pedal causes this 45-hp pump to deliver a constant pressure to a pair of 17-hp hydraulic motors. These motors, installed in the lower winglets, supply power to the main wheels via chain drives.

The Aircar has a single forward and a single reverse gear. “The torque you get,” notes Wernicke, “is the torque you get.” Acceleration on the ground will be unspectacular.

What will it be like to operate the Aircar? “You fly it just like you fly an airplane and drive it just like you drive a car,” says Wernicke.

In automobile mode, the yoke steers the front wheel, and the gearshift flips the transmission between park, drive and reverse. The propeller

Daedalus Inc.—the outfit that designed the Boeing 777’s flight deck—conceived this cockpit for the production-model Aircar.



locks into a horizontal position.

Taking to the air, the driver/pilot simply slips his feet onto the rudder pedals and switches engine power from the wheels to the propeller. Once aloft, the yoke controls the elevons, just as on a conventional aircraft.

Remarkably, all this can take place “on the fly.” There’s no need to stop beforehand or make any adjustments.

Down time

In recent weeks, a lack of funding has forced Wernicke to lay off his entire 15-person workforce, bringing work on the Aircar to a standstill.

But thanks to the steady stream of attention the Aircar gets, Wernicke remains sanguine about its prospects. Assuming he can line up an investor, he insists the Aircar will fly—perhaps within the next year. And when it does, he predicts nothing short of a revolution in transportation.

Ultimately, he says, perhaps 20 to 30 years down the road, descendants of this original Aircar design may catch on with commuters and other motorists. This all hinges, of course, on its price tag. In current dollars, that’s estimated to be between \$100,000 and \$250,000, depending upon manufacturing volume.

In the near term, the Aircar’s biggest market will be military, intelligence and law-enforcement agencies, all of which could benefit from a vehicle more versatile than an airplane yet faster and capable of greater range than most helicopters. Meanwhile, major corporations could replace their costly “bizjets” with Aircars capable of operating from runways less than 2000 ft. in length.

Of course, Wernicke cannot finish his proof-of-concept vehicles without a new infusion of cash. So if an extra \$3 million is burning a hole in your pocket, a visionary Texan awaits your telephone call.

PM

FAST CHIPS

New muscle microprocessors make computers process information faster than ever. And best of all, these new computers are affordable.

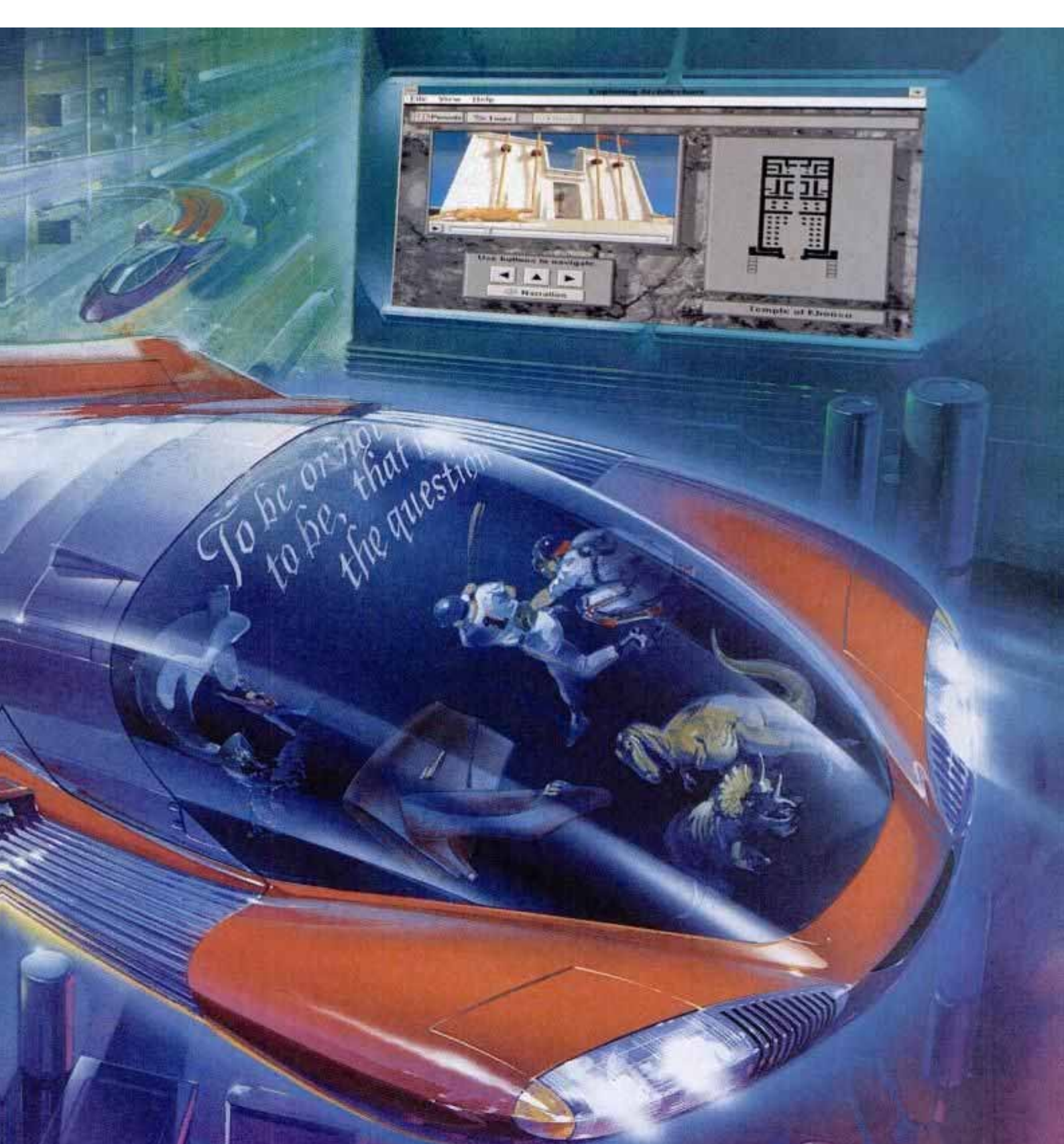


BY STEPHEN A. BOOTH, Contributing Editor
PM Illustration by Don Wieland

• Jet propulsion broke the sound barrier about the same time a room-size computer first wheezed and whirred. Yet nearly half a century later, most business and pleasure travelers have yet to fly at supersonic speeds. Meanwhile, desk jockeys on personal computers can now hack away on their machines

at what seems like Mach 1 speed compared to even last year's PCs.

The breakthrough comes from a new generation of microprocessors that gives home computers the muscle and speed once limited to engineering workstations with stratospheric price tags. Unlike some special-edition automotive speedster, these machines promise to become as ubiquitous as a Chrysler. Intel Corp.'s new Pentium chip is currently available from a



wide variety of computer makers with broad retail distribution. Its competitor, the PowerPC chip, manufactured by Motorola, is incorporated into a new line of Apple machines, and IBM plans to use the PowerPC chip soon.

What's more, you won't go broke buying one of these fast computers. Packard Bell's top-of-the-line multimedia Pentium model lists for \$2795. More basic models, though, hover around the \$2000 mark, depending upon configuration. The three PowerPC models in Apple's Power Macintosh line are available in a variety of trim levels, but a base Power Mac

(model 6100/60) lists for \$1819 without the monitor. Adding a CD-ROM drive for playing multimedia discs, for example, brings the list price up to \$2289.

The relatively low pricing of the new Pentium computers reflects the clout of Intel, which has long been the predominant developer and supplier of microprocessors for the so-called IBM-compatible PCs that make up 85% of the market. But saying "IBM-compatible" is going to be hard in the future, since IBM is also one-third of the trio behind the PowerPC chip that is challenging Intel and its Pentium chip. Apple Computer is another partner along with Motorola, Apple's

FAST CHIPS

longtime supplier of chips for the Macintosh computer line.

Clocking the speed

Compared to the previous generation of microprocessors in PCs and Macs—Intel's 80486 family and Motorola's 68040 class, respectively—the Pentium and PowerPC chips are super fast.

Comparisons vary according to other elements of computer design, but by industry-standard tests, the base Pentium chip with 60-MHz clock-speed (that's 60 megahertz—60 million cycles per second) will run existing DOS and Windows programs at least 50% faster than Intel's 486DX2/66-MHz chip, yesterday's top gun. That's "at least," and it represents Pentium running software written for older Intel chips. As programs are designed for Pentium's attributes, things will really cook.

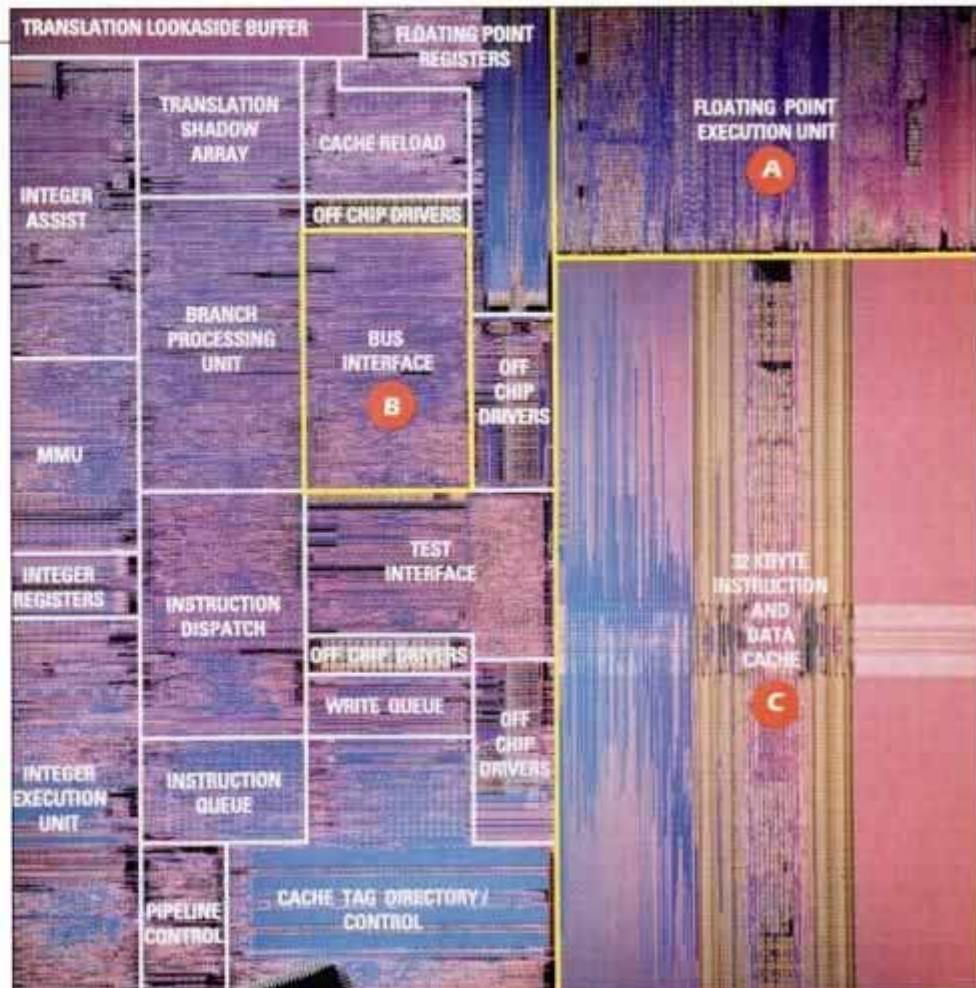
The case is somewhat different for PowerPC, as used in the new Apple hardware. The Power Macs do run existing Macintosh programs, but they won't do it any more quickly than conventional Macs with Motorola 68040-class chips. Where Power Mac promises to vaporize rubber is on so-called "native" applications—software specifically written for the PowerPC's current processing abilities. Apple states that the basic PowerPC 601 chip running "native apps" outperforms its former top-of-the-line 68040-based Macintosh Quadra by two to four times, and much more in some applications.

Also, you can expect the Intel and the PowerPC groups to play an ongoing game of leapfrog regarding performance specs. It's begun already.

Pentium was first off the block, in 60- and 66-MHz versions. The first-generation PowerPC 601 chips, for the Power Mac line, clocked in at 60, 66 and 80 MHz. Then, Intel introduced 90- and 100-MHz Pentiums and demonstrated a 150-MHz rocket. Amazingly, the new 90/100-MHz Pentiums are half the size of its 60- and 66-MHz versions and use less power. Meanwhile, PowerPC 603, 604 and 620 versions are forthcoming. Get the picture?

CISC versus RISC

To the naked eye, a Pentium 90/100 and a PowerPC 601/60 appear similar—each is about 1/2 in. square. Each also houses some 3 million transistors. But the technologies behind the rival chips are fundamentally different. Intel's Pentium, like most of the chips used in PCs to date, is called a CISC (Complex Instruction-Set Computing) processor. This means that the processor holds a wide assortment



Motorola PowerPC Keys

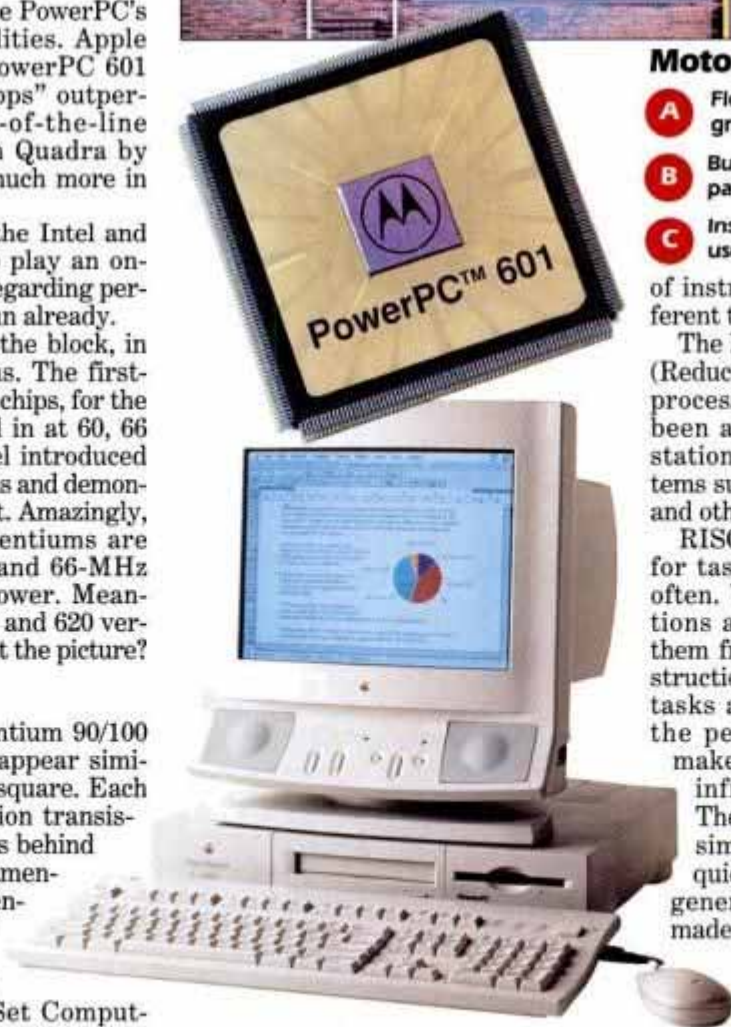
- A** Floating Point Execution Unit speeds graphics and video computation.
- B** Bus Interface provides a wide, fast pathway for data traffic.
- C** Instruction/Data Cache keeps much-used info from main memory nearby.

of instructions to execute many different tasks.

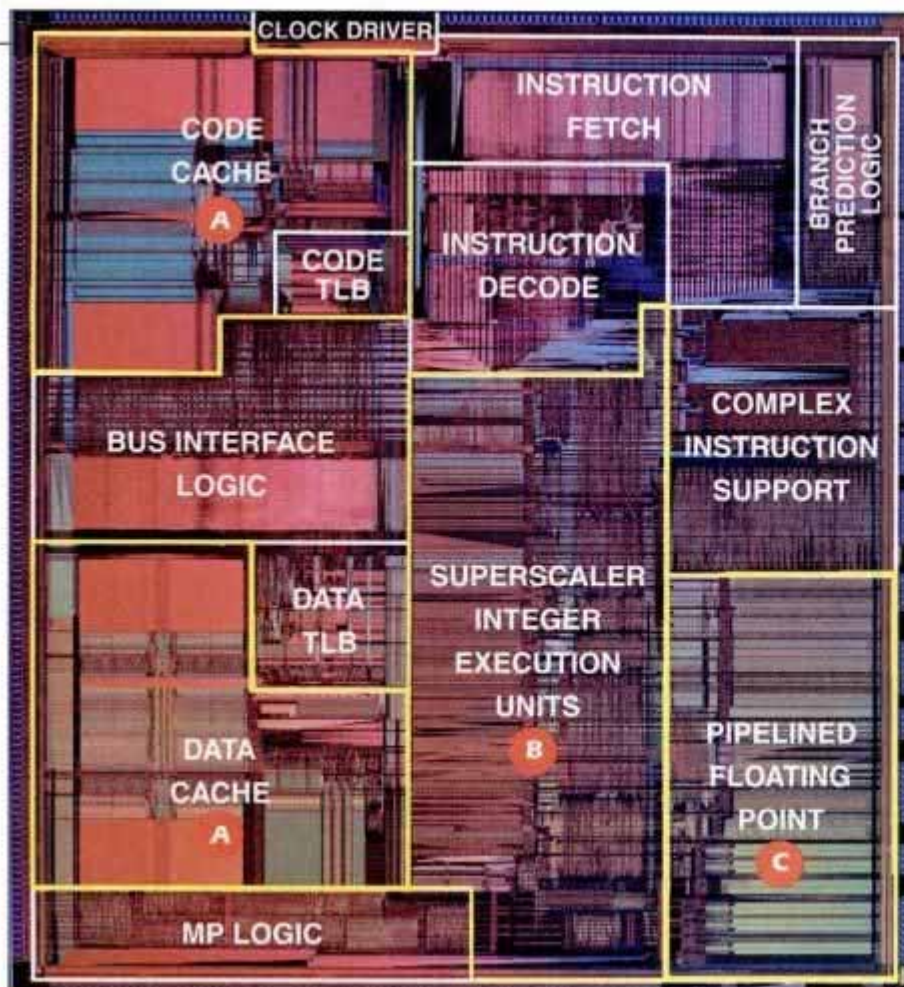
The PowerPC chip is called a RISC (Reduced Instruction-Set Computing) processor. It's new to PCs but has been around in engineering workstations, expensive videogame systems such as Panasonic's 3DO player, and other advanced computers.

RISC chips only house instructions for tasks that are performed most often. When more complex instructions are needed, the chip creates them from a combination of basic instructions. The concept is that basic tasks are executed so quickly that the performance gain more than makes up for time used to create infrequently used instructions. The contention is that the small, simple chip can ship data more quickly, consume less power and generate less heat—and it can be made more cheaply.

Be that as it may, Intel states it's confident that CISC is up to the task. The design incorporates RISC-like elements—for example, instruc-



Apple's 6100/60 Power Mac (above) with multimedia CD-ROM drive costs \$2289.



Intel Pentium Keys

- A** Code and Data Caches do same chores as PowerPC Data Cache.
- B** Superscaler Units provide pipelines to execute two jobs at once.
- C** Pipelined Floating Point speeds math for complex graphics.

tion pipelining that enables the chip to execute most instructions in a single clock-cycle. Additionally, so-called cache memory built into the chip keeps essential information close at hand, so time isn't wasted fetching it from the computer's slower main memory. As for cost, Intel's plants in California and Ireland are stamping out Pentiums at a rate that makes low-pricing no object.

Common ground

In the long run, the differences between Pentium and PowerPC might be less important than what they have in common.

One shared characteristic is their superscaler design. These are instruction pipelines that perform independently so that more than one instruction can be processed simultaneously. Current Pentiums have two such pipelines, while PowerPC has three.

Another common attribute is a very wide data path to conduct traffic around the computer. This 64-bit data "bus" keeps things

moving a lot more quickly than the 16- and 32-bit paths of past PCs. Just think of what doubling the number of lanes on a highway would do for your commuting time.

All this will be apparent when you're running video-heavy multimedia applications—calculations much more complex than word-processing tasks.

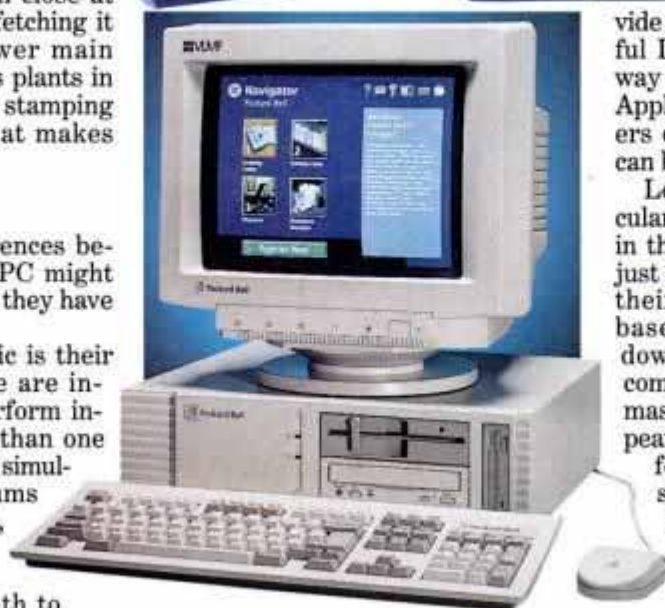
As important as a computer's microprocessor is to basic operation, other factors influence a computer's performance—and these will vary from brand to brand. To cite an example, Packard Bell's top multimedia computer incorporates two items that help the Pentium chip realize its potential. One is an Intel component called PCI Local Bus, a set of chips that, among other things, provides a wider data path to speed up multimedia graphics applications. The other helper is Microsoft's Windows for Workgroups—which runs applications faster compared to the basic Windows 3.1 system.

Apple's Power Macs provide another example of brand differences. The company is exploiting the PowerPC's potential with a neat function called SoftWindows. This upgrade option (\$299, plus \$499 for another necessary

8 megabytes of random-access memory) lets the Power Macs run DOS/Windows programs written for IBM-compatible PCs. It can't run them as fast as Pentium—execution is about the same as a basic 486-based PC. But it's a way to provide

Mac users access to the many useful DOS/Windows programs—and a way to lure IBM-PC buffs to the Mac. Apple also offers upgrade kits so owners of current Motorola-based Macs can bring them up to PowerPC speed.

Lower prices for faster, more muscular PCs is about the only certainty in the world of computers. It's taken just a year for Pentium PCs to drop to their current prices, whereas 486-based PCs took four years to get down to \$2000—the level Pentium computers ought to be at by Christmas. Computer price reductions appear like a reverse-image of PC performance increases, and the two seem to be moving apart at warp speed. With this kind of bang for the buck, you can splurge for a flight on the Concorde—or join Chuck Yeager in the Bell X-1 via virtual-reality computing. Either way, fasten your seatbelt. **PM**



Packard Bell's top-shelf Pentium multimedia PC comes loaded at \$2795.



THE HARD WAY



Land Rover rolls out the new Discovery amid tropical rain forests, lost Maya ruins, howler monkeys and the darkest heart of Belize. And we go along for the ride.

BY JOE SKORUPA, Boating/Outdoors Editor
PM Photos by Gunnar Conrad

● It's your typical Central American border crossing. Guards armed with too much firepower. Children armed with too many souvenirs. And "fumigación" squads armed with too much insecticide.

The fumigators spray each of our vehicles—brand-new Land Rover Discoverys—with industrial-strength bug juice. Keep in mind, we're in the middle of the jungle, somewhere between Belize and Guatemala. Vast insect armadas are creeping, crawling and flying across the border in

countless numbers on either side of the road. But the fumigación men are only interested in hitchhikers, the undesirables of the bug world, apparently.

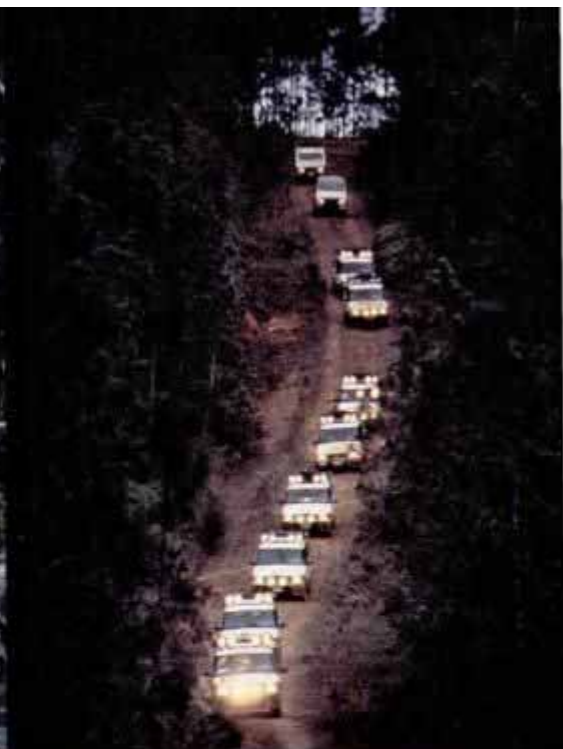
To foil these dreaded hordes, our wheel wells are sprayed with a juice that dries a striking shade of blue. And so, with suitably blue wheels and cargo nets full of souvenirs, the guards allow us to pass into Guatemala. Next stop: the center of the ancient Maya universe, Tikal.

This is the fourth day of our expedition on La Ruta Maya, or the route of the Maya, an impressive eco-tourist region that encompasses centuries-old Maya sites in Belize (formerly British Honduras), Guatemala, Mexico, Honduras and El Salvador. I'm here because this is Land Rover's way of introducing the Discovery, a new sport/utility vehicle, to the North American market.

As co-sponsor of the famed off-road Olympics, the Camel Trophy, Land Rover isn't the type of company to do a new-model rollout the easy way. A ride-and-drive through the desert Southwest or the Rocky Mountains won't cut it for a company that has a jungle-taming image to uphold. As a



THE HARD WAY



result, the British company (which was recently sold to BMW) decided to treat a dozen journalists to a week in the darkest heart of Central America, which by most standards is doing a product introduction the hard way.

Each of the past three days was spent on the road from 7 am to 7 pm in a convoy of eight showroom-spec Discoverys. Driving was divided between 2-lane paved roads and dirt trails, which served to demonstrate the Discovery's capabilities as a smooth operator and an off-road warrior—dual roles it carried off with aplomb.

The days are long and the accommodations, well, clean. Typically, the lodges lack air conditioning, phones, TV, laundry service, rugs, window screens and too many familiar amenities to name. But who's counting? The payoffs are spectacular.

Yesterday, for example, we explored the newly excavated Maya city of Caracol and climbed its partially overgrown pyramids. Today, we head for Tikal, the most magnificently restored lost city in the Yucatan. And tomorrow, back in Belize, we will visit the Maya outpost of Xuantunich and, later, spend the night in a temple plaza at Chan Chich amid jaguars, parrots, coati-mundi and howler monkeys. With an itinerary like this, who needs TV and turn-down bed service?

The road to Chan Chich

"Belikan Beer: It's not just for breakfast anymore," says Dixie Bowen, as she hands me a cold bottle of Belize's finest brew.

"What do you think?" asks Barry Bowen, Dixie's husband, who's the owner of both the Belikan brewery and the Chan Chich Lodge. "Should it



PHOTO BY JAC VICKERSON

be our next slogan?"

The convoy appreciates the joke and everyone laughs. It's late, we're tired and we haven't eaten. In addition, most of us are covered in a thick layer of mud from the waist down. Some are covered from the neck down. Ah, the glorious life of a journalist.

To get to Chan Chich, we had to slog through 20 miles of door-deep,

wheel-clogging gumbo. The first 100 yards took us 2 hours to traverse, and it didn't improve from there.

In many ways, the road to Chan Chich is what owning a Discovery is all about. It's not a road you're likely to encounter on the way to the shopping mall or to pick up the kids at school. But just in case anything happens—snow, ice, Midwest floods, California earthquakes—Discovery drivers know their versatile 4x4s will get them through.

During the first 2-hour hazard, the convoy employed complicated side winches, tow-strap snatches and human-powered haul-outs. It was a lot of fun, in a perverse sort of way, but we decided to speed up the convoy by actually using the Discovery's well-conceived off-road capabilities. With sweep vehicles bringing up the rear, the forward vehicles raced ahead until they got stuck, at which point help would eventually catch up from behind. Progress was immensely improved, at least for the lead vehicles.

At midrange rpm, the Discovery's 241-cu.-in. 182-horse V8 engine produces stump-pulling torque, and it was needed to power the vehicles through long stretches of thick, deep muck. Nine-inch ground clearance and a twin live-axle/coil-spring suspension (with long-travel shocks) gave



Discoverys drive over rivers and trails (opposite page top left and right), and onto a hand-winch ferry (above left). Posing prettily in Tikal (above). Inset photos, left to right: Center console has controls for windows, transmission. Dash is redesigned for U.S. market. Roof conveniences include two sunroofs. With jump seats deployed, there's seating for seven. With seats folded, there's 69.9 cu. ft. of cargo space. Photos below, left and right: A spider monkey watches from above, while artifacts are returned to Caracol.

the wheels maximum articulation to avoid getting high-centered on obstacles. Full-time 4wd with locking center differential delivered impressive traction in conditions that would have tested a John Deere tractor.

With all of these advantages, why did we get stuck? Typically, it occurred when the Discovery slid off the crown of the road and settled into a chassis-deep bog. Driver's error typically had something to do with this, but most of us blamed the tires—standard 235/70R16H Michelin M+S Radials. Aggressive-lug mud tires would have helped, but they wouldn't have been a foolproof solution. Conditions were that bad.

Luckily, I was in one of the lead vehicles when the convoy split up. I made it over the Chan Chich road in 5 hours. Vehicles in the back took eight.

Discovering Discovery

Although new to the United States, the Discovery has been on the world market since 1989. In fact, I drove one in Borneo last year. It was there as the official Camel Trophy vehicle, a role it's played for the past four years. What impressed me then and now, in addition to its jungle-beating toughness, is its unique interior.

Two jump seats, complete with seatbelts (optional), are placed in the rear

cargo area to give the Discovery a whopping 7-person carrying capacity (twin buckets in the front and a 60/40 split seat in the back). Headroom is extremely generous throughout the Discovery and was achieved by giving the roof a distinctive bilevel profile. The bonus space is used to mount the rear seat higher than the front, which



ensures that all passengers have an unobstructed forward view. In another thoughtful decision, air and light are maximized by the installation of two electric sunroofs (optional) and twin nonopening side-roof windows.

To complete the package as a people-friendly vehicle, the Discovery comes with dual airbags, side structural support, ABS brakes and a base

sticker of \$29,000. For the first time, Land Rover has a well-positioned family model that can compete on the same playing field as other top-of-the-line sport/utility vehicles.

One of the most important stops on the Belize itinerary was the impressive Maya city of Caracol, which is being excavated by archeologists Arlen and Diane Chase. Here, the convoy delivered weatherproof re-creations of stone artifacts that had been carefully pieced together at the University of Pennsylvania.

Few in the convoy realized how difficult archeological work is (politically, financially, physically), how fragile the ruins and how rare the gains. While most of us thought dropping off fiberglass knockoffs of original artifacts was a minor deed, the archeologists thought it was a significant moment in their life's work.

It took awhile for this to sink in, and when it did I had to give Land Rover credit for doing a product rollout the hard way. It not only provided a group of unworthy journalists the opportunity to witness the rarely seen beauty of La Ruta Maya, but to be a small part of its renewal. I also had to give credit to the Discovery. It not only conquered jungle roads to deliver the precious archeological cargo, but survived a week of journalist driving. **PM**

AMERICAN CLASSICS

ZIPPO LIGHTER

Introduced more than 60 years and 250 million units ago, the Zippo lighter is the same today as it was then—matchless.

BY ROBIN AMSTER
PM Photo by Spencer Jones



Zippo lighters earned cultural-icon status in war, the movies and as specialty commemoratives bearing business and event logos. Left to right on this page: Daytona Speedway and the Sears Tower are contemporary specialty lighters, which surround a Vietnam-era Zippo with typical wartime engraving. Other specialty lighters include the Vultee classic from 1941, the contemporary Budweiser model and the 10K-gold Hertz lighter from 1965. Right page: A set of four engraved brass lighters plus a key ring and tin make up the current Allied Heroes Set, which honors D-Day.



• A lighter. Maybe the last thing you'd think of as an American Classic. Yet, that's just what the Zippo lighter is. Since the first distinctive click of a Zippo was heard in 1932, the company from Bradford, Pennsylvania, has produced more than 250 million lighters, all with lifetime guarantees. Just as impressive, the lighters are based on a design that's remained fundamentally unchanged from its original concept, an achievement virtually unmatched among 60-year-old products. But what really sets Zippos apart is a distinguished history of service in war and starring roles in classic movies that have made "the lighter that works" a true American icon.

From Pearl Harbor to the beaches at Normandy to the taking of Berlin and Tokyo, Zippo's exploits in World War II fired the American imagination. Service-

men returned home to tell war stories about how Zippo lighters started campfires in European forests and Asian jungles, cooked soup in helmets, acted as rescue beacons in open boats, illuminated high-altitude instrument panels in damaged aircraft, and even stopped bullets. Zippos followed successive generations of servicemen into Korea, Vietnam and the Persian Gulf to earn their stripes and become an integral part of military legend.

But becoming a legend wasn't a glimmer in '32 when founder George Blaisdell, a former oil company executive, encountered a friend lighting a cigarette with a clumsy-looking Austrian lighter. Blaisdell asked the man why he didn't buy a decent-looking lighter, to which the man replied, "Well, George, it works."

Inspired by the incident, Blaisdell purchased the

ZIPPO LIGHTER

U.S. distribution rights to the Austrian lighter, but it proved to be as clumsy as it looked. Undaunted, Blaisdell redesigned it and started over.

First, he streamlined the chrome-plated brass case, fashioning a smooth rectangular shape that fit comfortably in the hand. Then he used a spring-loaded hinge that enabled users to flick open the top. Finally, he surrounded the wick with a windscreen that had a precise arrangement of holes to protect the flame against wind but still allow for sufficient airflow. Inspired by the catchy name of a recent invention, the zipper, Blaisdell called his new lighter the Zippo.

Inside the case, it uses a piece of absorbent material to make contact with the fuel, which then makes contact with the wick. To ignite the wick, a striking wheel spins against a tiny piece of flint.

Since 1932, Zippo has made few changes to the original model, which

had square corners and a hinge soldered to the outside. After a few years of production, the design was changed

by shortening the case a quarter of an inch, placing the hinge on the inside and rounding off the corners. The only major internal change made over the years was with the manufacture of the striking wheel, which was brought in-house after 1946 to solve a problem with substandard suppliers.

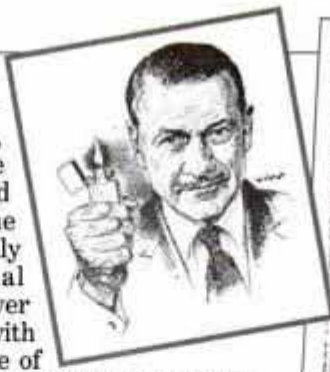
Blaisdell's concern about quality control is embodied in his famous lifetime guarantee. If any Zippo fails to work, regardless of age or condition, the company pledges to fix it free of charge. This causes little concern, since most returned Zippos need only a new hinge. Some customers, however, push the guarantee to its limit

its by sending in lighters that have been crushed in washing machines and by bulldozers. Even then, Zippo honors its guarantee by returning new lighters to the owners and placing the old ones in the company museum.

After WW II, when Zippo had established its reputation, the lighter achieved cultural-icon status by appearing in numerous Hollywood movies. Naturally, Zippos appeared in movies made about WW II, but the lighter also became familiar in Humphrey Bogart-style film noir classics. Nothing better conveys hard-bitten character than the well-timed flick of a Zippo.

Interestingly, Zippos have proven to be durable stars, racking up impressive credits over the decades. A Zippo saved Harrison Ford and Sean Connery from certain death in "Indiana Jones And The Last Crusade." And Arnold Schwarzenegger flicked a Zippo while delivering the line "Hasta la vista, baby" in "Terminator 2."

A relatively new role that Zippos have taken



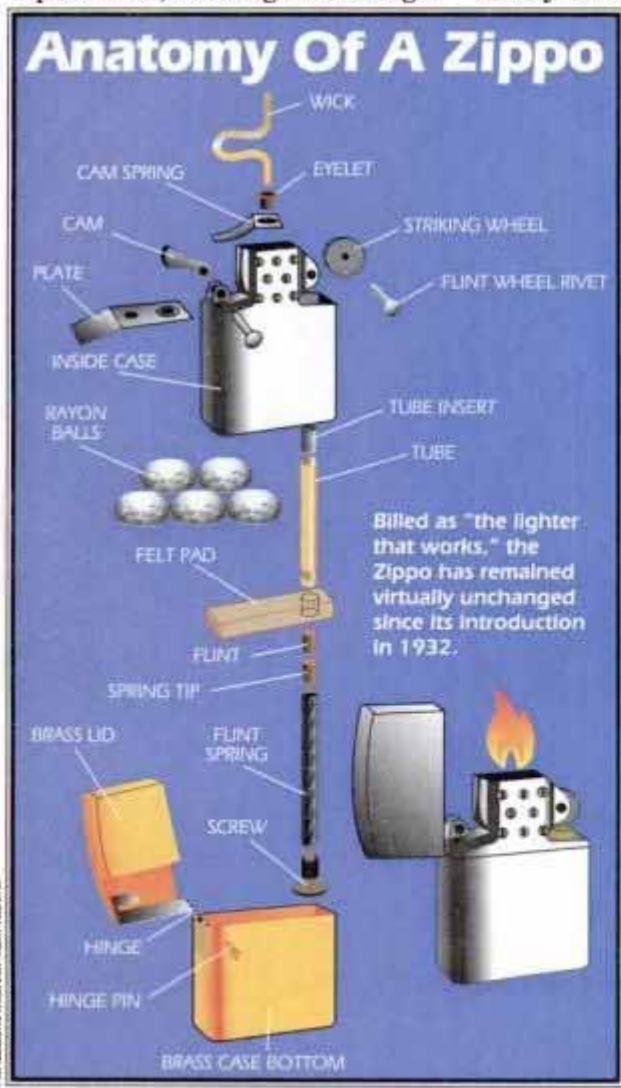
Promotions from the 1930s and '40s: the Zippo Man, George Blaisdell (top left); the Vargas girl (above); and the Zippo car (left).

on is as a sought-after collectible. Since the 1958 production run, the bottom of every Zippo has had a series of dots and slashes that are matched to a manufacturer coding chart to help collectors determine the year it was made. As a result, pre-1958 units are particularly valuable. Without doubt the most sought-after Zippos are Blaisdell's original design with the hinge outside the case. Today, they can fetch more than \$1000. Probably the most popular Zippo is the classic WW II lighter with its distinctive black-crackle finish. These are still affordably priced at \$35 to \$50.

In 1992, Zippo fueled the collectible market by producing a limited-edition 60th Anniversary Commemorative lighter in a collectible tin. The huge response prompted the company to introduce new collectibles each year. Last year's limited-edition lighter featured an engraving of Zippo's famed Vargas girl illustration of the 1930s.

This year's collectible is the 1994 D-Day Commemorative (\$24.95), which comes in a gold tin and has a vintage black-crackle surface. It also bears an antique brass emblem patterned after the sleeve patch worn by Allied troops. A second collectible is Zippo's Allied Heroes Set (\$82.75), which features four brass lighters with engraved portraits of Gens. Dwight Eisenhower, Bernard Montgomery, Charles de Gaulle and Lt. Gen. Omar Bradley. The set of lighters come in a tin bearing scenes of the Normandy beaches.

The 1994 limited editions are particularly fitting for Zippo. They serve as a tribute to the extraordinary accomplishments of American fighting men in World War II, and remind us again of Zippo's own special role in the war and in American culture. **PM**



PM ILLUSTRATION BY KURT NOVAK

INSIDE BELL LABS

Want to talk to your computer? Want to be interactive with everyone? Want a machine with brains? Here's where these ideas take shape.

BY STEPHEN A. BOOTH,
Contributing Editor

• The massive glass pyramids dominating Murray Hill, New Jersey, are a far cry from the cramped studio where Alexander Graham Bell's musical telegraph first sang. The sky-structure another 45 miles south in Holmdel, New Jersey, is an offbeat corporate shingle too, resembling the kind of flying saucer on stilts last reported in New Jersey's cornfields by Orson Welles on Halloween 1938. But hey, this is AT&T's Bell Labs—home of tireless invention since 1925. So if they want to build a water tower that looks like the first transistor, they've earned the privilege. And maybe Aleck's first phone would have looked like tomorrow's wristwatch communicator if he'd worked under any of these roofs.

Guests should expect a little idiosyncrasy when they visit a place that's been averaging a patent a day for nearly 70 years, including those for the laser, transistor, digital computer, solar cell, cellular phone, movie soundtrack and stereo recording. And visitors do beat a path to what is one of America's foremost think tanks.

Arriving this day is China's Vice Premier Zou Jiahua, accompanied by a few divisions of Secret Service agents, to do a little high-tech shopping. The masses of young women

A working prototype of Bell Labs' wristwatch telephone. Earpiece deploys from strap into cupped palm, letting you keep an ear to the world.

INSIDE BELL LABS

parading around the campus aren't his flower girls. They outrank Zou's VIP status, at least where the future's concerned: children of Bell Labs' researchers on hand for "Bring Your Daughters To Work Day."

Some of the parents still haven't recovered from the previous day's activities—a marathon, 6-hour telecast of "Live From AT&T Bell Labs." This science TV program reaches some 40 million schoolkids and includes celebrities such as magicians Penn and Teller, and ex-MTV veejay Martha Quinn. It's the fifth "live" broadcast, but what makes this one especially lively is its global transmission by computer to a worldwide audience via the Internet. A less-ambitious outfit might have used satellites.

This premiere telecast of multimedia programming through the international network of computers is an exciting preview of the future of cyberspace—it also provides a sobering perspective on the hard work still required to build the electronic information highway. Here at Bell Labs, there's work in progress on materials engineering, communications logistics and the other technologies needed before rubber can hit the road on the information highway envisioned by politicians and financial pitchmen.

"People talk about the highway but



Technician Minghwei Hong monitors Bell's molecular beam epitaxy (MBE) process. MBE permits atom-by-atom design of material structures not found in nature.

overlook the on/off ramps we'll need to prevent backups and congestion," says Pat Parseghian, a technician in the research computation department where Bell is developing traffic-control equipment for the infobahn.

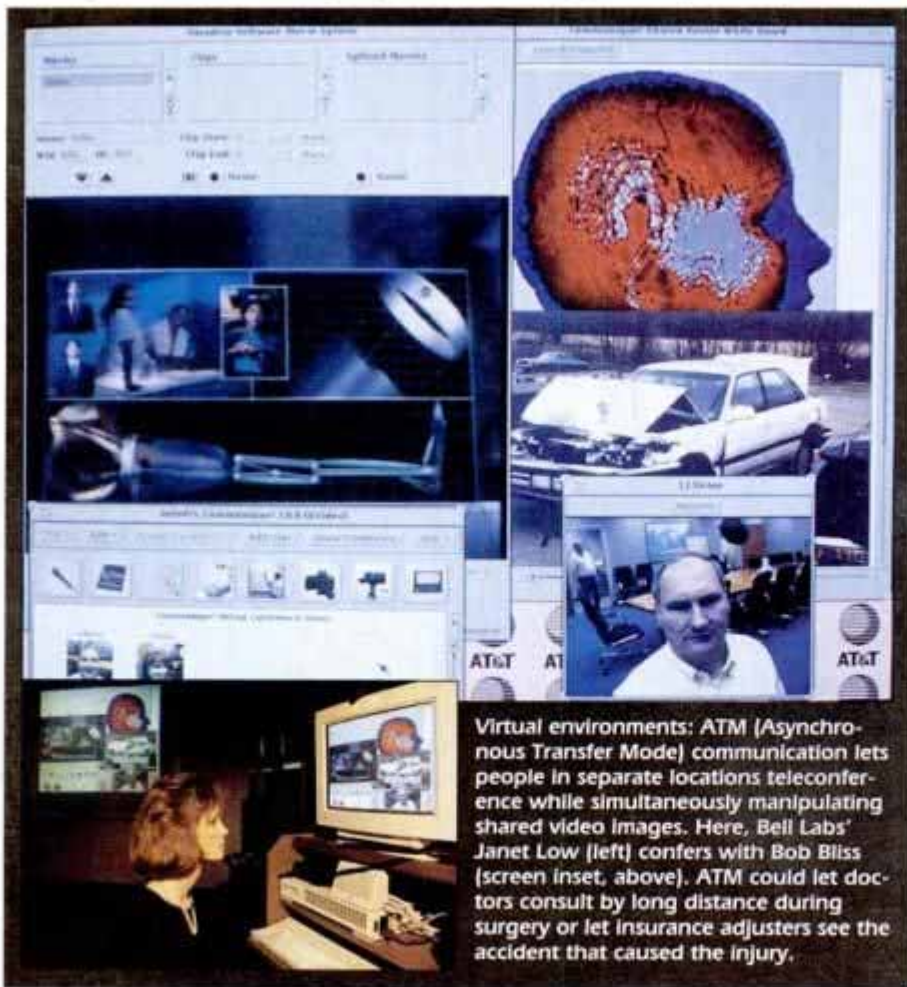
Parseghian explains that it takes

lightning-fast data rates to successfully transmit the vast amount of computer bits that make up video's moving pictures. Even with the high-capacity fiberoptic speedway in place, bottlenecks could develop when telephone switching equipment designed for less-challenging applications wouldn't be able to process the traffic. Even on the faster sections of the Internet, the 1.5-megabits-per-second (Mbps) data rate delivers just one TV frame per second. That's what PC viewers of the "live" telecast saw—compared to the usual 30 frames per second of U.S. broadcast TV.

Traffic control is what Parseghian studies. Her test track is XUNET, the Experimental University Network, which links Bell Labs and nearby Rutgers University to the Lawrence Livermore Labs in California, with a stop along the way at the University of Illinois' Urbana campus. Compared to the 1.5-Mbps speed limit of Internet, Parseghian and her XUNET colleagues joyride on 45- and sometimes 622-Mbps lines through custom-made switches.

The difference is visible. On a split-screen monitor, we view the computer equivalent of a 4-wall racquetball game played with multiple balls. On the 45-Mbps line, the balls carom freely. On the Internet side of the screen, game play is halting as the system calls timeout to regroup and catch up.

A transmission from Lawrence Livermore Labs is also telling. It's an aerial weather map of the United States whose colored cloud swirls resemble a van Gogh. But the impressionistlike "painting" becomes surreal



Virtual environments: ATM (Asynchronous Transfer Mode) communication lets people in separate locations teleconference while simultaneously manipulating shared video images. Here, Bell Labs' Janet Low (left) confers with Bob Bliss (screen inset, above). ATM could let doctors consult by long distance during surgery or let insurance adjusters see the accident that caused the injury.



Pam Parseghian (left) researches high-speed switching networks needed to keep traffic moving on the infobahn. Weather map with complex graphics (above) travels on fiberoptic lines.

Chris Burges (left) performs Neural Networks research to give machines humanlike senses. Optical recognition of handwritten numbers on personal checks (above) would let computers read.

as the weather patterns move at alternating speeds—again a function of the traffic the switches can bear.

The promise of the infobahn is more apparent at the Bell Labs facility in Holmdel, site of the transistor-shaped water tower. Here, Bob Bliss and Janet Low demonstrate what their ATM global network can do.

Although Bell Labs has some technology that applies to banking, ATM in this case means Asynchronous Transfer Mode—a way of shipping lots of different packets of electronic data down a shared line so that all the right pieces arrive in the right place at the right time.

Using Mosaic, a software package for navigating the Internet, Bliss and Low simulate a video teleconference that might take place between doctors in different venues. In one corner of the screen, there's an MRI scan of a patient's cranium. Another screen window shows motion images of Bliss and Low, playing neurologist and radiologist, conferring in real time. Other windows let them work together on a shared image—during surgery, for example. If lawyers or insurance adjusters were online instead, they could examine photos of the accident that caused the injury.

What we see is computer simulation through custom-built switching gear in an adjoining room. But to make a reality of this simulated communication over wide-area networks, the ATM staff will run experiments

with Japan's KDD system to learn what gear needs to be built for error-free, real-time operation.

"What we really have to do is make the Internet faster," says Bliss. "The backbone's already there, the fiber-optics. We just need to improve it."



Jay Simpson works to get fiberoptics to move more data faster.

Fiberoptics is a specialty at Bell Labs, along with the lasers that propel hundreds of thousands of phone calls simultaneously through the hair-thin silica strands. In the optical fiber research department, engineer Jay Simpson explains that improvements in the traffic capacity and speed will come from new laser technology.

In the past, for example, "regenerators" along the trans-Atlantic fiber cable converted the optical signals back to electrical, cleaned them up and reconverted them back to optical for the next stage of the journey. Today regenerators are passé: New laser-based optical amplifiers keep the signal in the near-infrared light

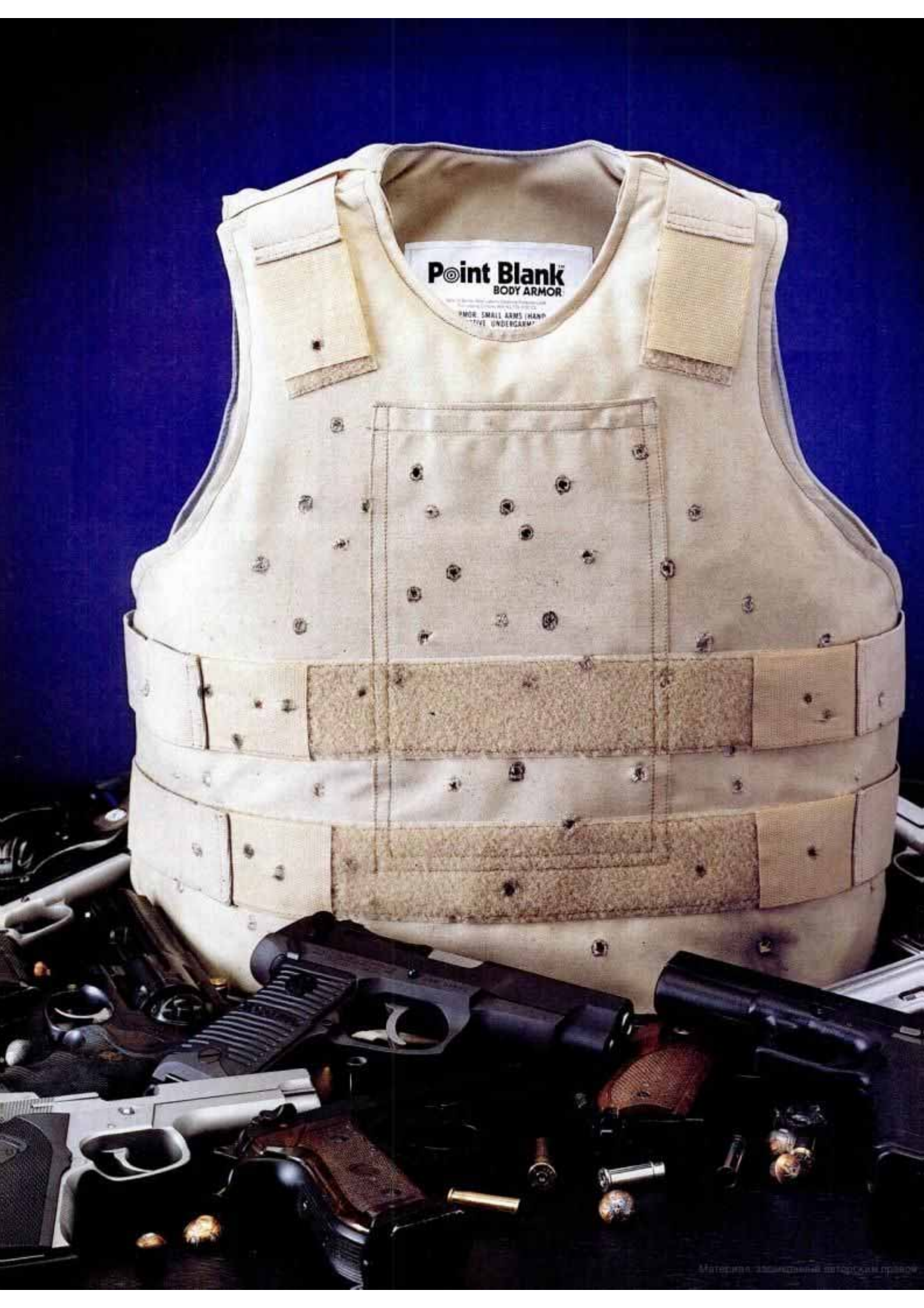
zone all the way. Upgrades for the future could entail using new lasers that transmit light at different wavelengths, or sending a variety of wavelengths simultaneously through the same fiber.

This is where Dr. Alfred Cho's department comes in. The director of semiconductor research won the National Medal of Science in 1993 for Bell's work in molecular beam epitaxy (MBE). It's a way of building things, an atom at a time, that nature cannot create.

Lasers are on Cho's mind. As Cho explains it, the limitations of natural materials usually determine the types of lasers—meaning the wavelengths of their operation—that can be built. Because MBE enables the creation of man-made material structures, nature's no longer an obstacle.

The result is the Quantum Cascade (QC) laser, invented by a team of Bell scientists this spring. It's the first laser that can be fine-tuned to emit light at specific wavelengths over a very wide range of frequencies, from the mid- to far-infrared part of the spectrum. This is done by using MBE to vary the thickness of the laser, using easy-to-process materials. In comparison, the construction of regular semiconductor lasers, such as those used in CD players and optical communications, limits their operation to the near-infrared to visible-light wavelengths.

(Please turn to page 99)



Point Blank™
BODY ARMOR

ARMOR SMALL ARMS (H&M)
"TIVE UNDERGARMENT"

THE SLUG STOPS HERE

The newest bulletproof vests are countering today's threat of big-caliber large-capacity automatic weapons on the street.

BY CLIFF GROMER, Contributing Editor

• The bullets are bigger, the magazines larger and the bad guys badder. That's what law enforcement officers are facing on the streets today. The challenge for protective body armor, the traditional bulletproof vest, is to stay ahead of the threat. It's one thing to have someone winging .22- or .38-caliber bullets at you with a revolver. It's another when they're blazing away with a platoon-stopping Uzi or MAC-10 automatic, and the air is thick with 9mm slugs.

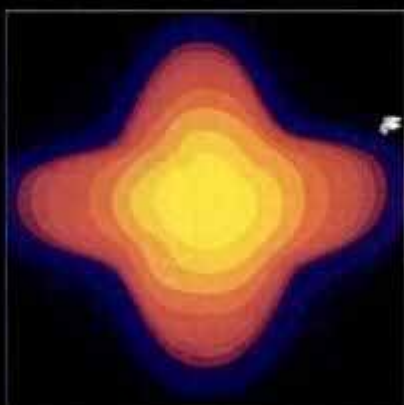
There's no magic to stopping bullets. Strap a steel plate over your torso and you could collect a weekly paycheck working as a target in a shooting gallery.

The trick is to come up with an effective, soft body-armor system that's lightweight and flexible yet able to keep bullets at bay. The ideal, from a comfort standpoint, is a bulletproof deodorant stick. But that's a long way off. Right now, as always, vest makers depend on the large chemical conglomerates to develop and refine the raw materials for ballistic packages—high-strength, lightweight fibers. The

building blocks of bullet barriers include polyaramids, such as DuPont's Kevlar and Akzo's Twaron, and high-strength polyethylenes (same chemical family as your plastic milk jug), such as Allied Signal's Spectra Shield.

Polyaramids and polyethylenes can be extruded and spun into fibers that, pound for pound, boast a higher tensile strength than steel. But ballistic fibers also need a degree of flexibility, called modulus, which allows them to absorb the bullet's energy as they stretch. As the bullet mushrooms because of the resistance of the vest, it engages more and more ballistic fibers that in turn absorb more energy, slowing the bullet until it stops.

But the vest has another job besides stopping bullets from penetrating, and that's to soften the bullet's wallop, or trauma, to a safe level.



Energy dispersion of Spectra Shield covers a wide rounded area, flattening the bullet by sending energy across the surface at super-high speeds.



THE SLUG STOPS HERE



A vest's ability to reduce the trauma or "punch" from stopping a bullet is determined by its backface signature. Firing the bullet at the vest mounted on a clay block produces a dent in the clay, which must measure no more than 44mm deep to be acceptable.



Ballistic fibers must have a high strain-wave velocity, or be able to transfer energy quickly along the fiber away from the point of impact. The standard test here is to fire a bullet into a vest that's set on a clay block. The maximum allowable dent, or backface signature as it's called, is 44mm deep.

Ballistic fibers—essentially the heart of the vest—are woven into fabric. In the case of Spectra Shield, a 2-layer grid of polyethylene fibers with each layer set at a right angle to each other is sandwiched between two sheets of thin poly film. The film has a higher ballistic strength than a woven polyethylene fabric, but it's stiffer. One vest manufacturer, Point Blank, of Amityville, New York, has been able to soften this rigid film and make it flexible without compromising its ballistic properties. Point Blank calls its product Spectra Flex. Vestmakers may use layers of a single product, such as Kevlar, in varying combinations of yarn thickness (denier) and weave densities (threads per inch) to construct their ballistic panels. They may also combine various layers of polyaramids and polyethylene to achieve their own performance/comfort ratio.

There are no miracle designs in this business. It takes a certain density (weight per square foot) of ballistic material to stop a given bullet traveling at a given velocity. Performance

standards set by the National Institute of Justice define levels of protection by requiring a vest to stop a group of specified rounds. Class 2 armor, for example, requires protection against rounds such as a .357 magnum, while Class 3A ups the ante to stop a .44 magnum. Most Class 2 armor runs in the 16- to 18-ounces-per-square-foot range, while most 3A armor tips the scales at 20 to 22 ounces per square foot.

The panels are designed to stop the big street threat soft-core handgun

rounds, which mushroom when they meet resistance. A round that mushrooms inside the body usually does more damage—and has more stopping power—than a hard-core rifle bullet that can possibly just bore a neat hole through you without hitting any vital organs.

The vest itself consists of an outside shell, or carrier, which contains the ballistic package, and a strap or fastening system. The carrier can be designed with a pocket for a steel or ballistic plastic insert for added protection against both penetration and trauma. Traditionally, the vest was fastened by straps attached to the carrier. This worked well until today's high-probability multi-hit scenario. Bullets hitting the vest cause the ballistic material to bunch up or pull in toward the point of impact. Enough hits can cause the panel to shift out of position leaving portions of the torso exposed.

Quilt-stitching the panel makes it stiffer and resistant to bunching. But this makes the vest less flexible—and less comfortable. Point Blank's multi-impact suspension system in its Genesis line of vests keeps the ballistic panel in position by attaching the straps to the panel instead of to the carrier.

As the threat on the street looms ever larger, body armor technology will have to keep pace. Because like parachutes, if it doesn't work the first time, you won't be able to return it for a refund. **PM**

Inside The Genesis Vest



Ranger Body Armor

● When the U.S. Army's elite 75th Ranger Regiment arrived in Somalia in the fall of '93, one item put to the test was a ballistic vest that has become known as Ranger Body Armor (RBA), credited with saving a number of lives. The most impressive incident involved a Ranger who was struck in the chest by an RPG-7 antitank rocket. Although the rocket did not explode, the impact blasted the soldier through a wall. He survived the action and was able to return fire. The vest also stopped 7.62mm rounds.



Ranger Body Armor has been credited with stopping an antitank rocket.

The RBA vest system is composed of 30 layers of DuPont's new Kevlar KM2 aramid fiber. The 850-denier yarn, containing 560 filaments, reportedly has a 13% higher tenacity and 20% higher toughness than the 1500-denier Kevlar 29 that has been used in a number of military vests and helmets. Frontal protection is further enhanced by the addition of a removable ceramic (aluminum oxide) plate.

—Scott Gourley

MAZDA RX-7



Rave responses to Mazda's hot ride.

BY MICHAEL LAMM, Contributing Editor; PM Photos by Rich Cox

● Mazda's RX-7 has always marched to a different drummer. Throughout its three generations, the RX-7 has stubbornly championed the Wankel, or rotary, engine. Mazda is, in fact, the world's last automaker to offer a rotary. The current RX-7 has a 1.3-liter 2-rotor model, with two sequential turbochargers.

The rotary's 80 cu. in. deliver 255 hp at 6500 rpm. How does so small an engine achieve such unbelievable power? The twin turbos account for a lot of the punch, and in a clever way. At low engine rpm, the first turbocharger receives the total exhaust stream that, at higher rpm, feeds both turbos. Thus, there's faster throttle response at all speeds, without turbo lag.



Performance is stunning, thanks to a better power-to-weight ratio than that of even the alloy-body Acura NSX. The new RX-7 has recorded 0-to-60-mph acceleration times in the 5.3-second range, 14 seconds at nearly 100 mph in the quarter-mile and a top speed of 160-plus mph. These are hardly usable figures, but they do say something about the RX-7's purity of purpose.

According to the owners we surveyed for this report, the RX-7's outstanding features include sheer performance, handling and braking. These categories received higher ratings than for any car we've ever surveyed. Never have we heard raves like these. Engine power and braking both received a

MAZDA RX-7



Instruments and controls got good marks.

Cockpit was a bit snug for some owners.

Twin-turbo rotary pleased 93.3%.

rating of excellent from 93.3% of our respondents. The score for handling was even higher—96.2% excellent.

Engine response, handling and braking are all tied into one engineering nuance that Mazda calls its "powerplant frame." It's a laminated steel girder that runs the length of the car and bolts at both ends. This beamlike

subframe, pioneered in the Miata roadster, connects the engine, transmission and differential and makes them one rigid unit. By doing so, it minimizes axle windup and increases both traction and braking adhesion. Traction is also aided by the RX-7's standard Torsen limited-slip differential, and braking is helped by the

standard antilock system working through huge disc brakes with vented rotors at all four corners.

The RX-7's front suspension consists of aluminum upper and lower A-arms up front, with lower lateral links, trailing links and toelinks plus upper A-arms in back. The R-1 option package, ordered by 27.5% of our

SUMMARY OF MAZDA RX-7 OWNERS REPORTS*

Total miles driven	1,491,264	Excellent	93.3%	Tire, suspension noise, rattles	10.2	Repair it yourself?	
Average miles driven	6687	Good	6.2	Poor stereo sound quality	9.1	No	96.8%
Purchase price:		Average	0.0	Doors hard to shut	7.5	Yes	3.2
Average	\$30,358	Poor	0.5	Fuel economy lower than expected	7.0	Dealer repairs satisfactory?	
Range	\$25,000-\$37,000	Overall performance:				Yes	56.1%
Why did you choose the RX-7?		Excellent	92.8%	Suggested changes:		No	43.9
Styling	71.3%	Good	6.2	Chip-resistant paint	13.8%	Dealer service opinion:	
Performance	45.5	Average	0.0	More powerful engine	11.5	Excellent	35.5%
Handling	24.4	Poor	1.0	Smaller speaker system	9.2	Good	38.3
Power	18.7	Control layout:		Reduce noises and rattles	8.6	Average	17.5
Price/value	18.2	Excellent	79.4%	Improve interior plastic	7.5	Poor	8.7
Previous Mazda/RX-7 ownership	11.5	Good	18.2	Improve seat comfort	6.9	Dealer sales policy:	
Avg. mpg, city/hwy:		Average	1.9	Softer ride	5.7	Excellent	36.6%
5-speed manual	16.3/21.2	Poor	0.5	Workmanship opinion:		Good	43.5
4-speed automatic	16.8/20.8	Instrumentation:		Excellent	54.6%	Average	13.9
Transmission choices:		Excellent	79.9%	Good	40.6	Poor	6.0
5-speed manual	89.8%	Good	19.6	Average	3.9	Number of vehicles owned:	
4-speed automatic	10.2	Average	0.5	Poor	1.0	This vehicle only	20.5%
Options/Accessories:		Poor	0.0	Comfort opinion:		Two vehicles	25.6
Leather seats	69.0%	Driver sightlines:		Excellent	48.8%	Three vehicles	27.0
Touring package	60.6	Excellent	45.5%	Good	44.2	Four or more	26.9
R-1 package	27.5	Good	42.1	Average	5.6	Principal driver:	
Cellular telephone	10.4	Average	11.0	Poor	1.4	Male	84.4%
Engine power:		Poor	1.4	Any mechanical trouble?		Female	14.6
Excellent	93.3%	Specific likes:		No	58.7%	Equal	0.9
Good	5.8	Styling	79.2%	Yes	41.3	Age distribution of owners:	
Average	1.0	Handling	51.9	What type of trouble?		Under 29	19.1%
Poor	0.0	Power	49.5	Weak air conditioning	16.3%	30-49 years	64.2
Handling:		Performance	45.8	Engine stalling	16.3	50-plus	16.8
Excellent	96.2%	Braking	11.3	Wheel alignment	10.9	Based on your experiences, would you buy a Mazda RX-7 if you had it to do over again?	
Good	2.9	Specific dislikes:		Engine-management computer	7.6	Yes	62.5%
Average	0.5	Paint chips too easily	18.8%	Miscellaneous electrical	7.6	Maybe	31.5
Poor	0.5	Interior plastic looks cheap	12.9	Engine hesitation	6.5	No	6.0
Braking:		Limited storage	10.2	Transmission	6.5		
		Harsh ride	10.2				

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

respondents, includes firmer shock settings, additional chassis bracing, Z-rated 16-in. tires, a front airdam, a rear spoiler and dual engine oil coolers. The R-1 package is probably more at home on the raceway than on the freeway, and the 10.2% of our respondents who grumbled about the RX-7's harsh ride were mostly R-1 owners who didn't realize the extent of this option's ride firmness.

Those who'd ordered the Touring package—with its softer shock settings, V-rated tires, more sound insulation and leather seats—were not bothered by the RX-7's ride.

Not surprisingly, owners expressed their greatest delight with the RX-7's body design. The taut surfaces, marvelous C-shaped door cuts, cozy interior and purposeful controls became the main selling points for 71.3% of our respondents.

Driving the RX-7, however, was not a trouble-free experience for 41.3% of our owners. Of those, a weak a/c system and stall problems afflicted 32.6%. The engine stalls were caused by a computer malfunction, and dealers replaced the ECU under warranty. Poor wheel alignment plagued another 10.9%.

However, many owners were far from pleased with the service their dealers provided. More than 25% rated dealer service in the average to poor range. A mere 56.1% reported successful first-time fixes—not a good showing for a \$30,000 car.

A number of quality-control complaints surfaced under the Specific Dislikes heading of our survey: "easily chipped paint," "scratch-prone console" and "hard-to-close doors." Doors were hard to shut with the windows up because of the tight cockpit seals (like the old VW Beetle). A few owners also commented on the fragile sheetmetal. Mazda lightened this car partly by using comparatively thin body panels and an aluminum hood.

General workmanship rated quite high, however, with 95.2% scoring the RX-7 good to excellent in this category. The materials used inside the car, on the other hand, weren't up to everyone's standards.

And the car's limited storage space drew fire as well, particularly when the car was equipped with the super-duper Bose sound system.

The minority gripes and grumbles, though, didn't come close to overshadowing overall owner enthusiasm. A Texas engineer summed it all up: "I bought this car in a fit of temporary insanity," he said. "It was the prettiest thing I'd ever seen. Whether I could afford it or not never crossed my mind. And it's unbelievably fast." Amen. **PM**



Although the RX-7's bold styling helped get signatures onto dotted lines, owners also praised its sizzling acceleration and outstanding all-around performance.

EDITORS REPORT

Endangered Species

● To me, the curious thing about the ratings in the performance section of the RX-7 data panel is not that the owners gave their cars such a resounding endorsement. No. The oddity is that anyone could find the RX-7's power, handling, braking and overall performance anything but outstanding.

It's also pretty interesting that 11.5% of our respondents thought they'd like a little more horsepower.

Well, there are those who will always say there's no such thing as too much horsepower. We've even said it ourselves. But as far as the RX-7 is concerned, it does seem that there's plenty—at least for any public road driving application we can imagine. Any way you measure it—all by itself, against its contemporaries or against the entire history of its breed—this is an exceptional sports car.

That term—sports car—is important. Historically, it describes a race-capable car that can also be driven on the street. And in the not-so-distant past, it included a pretty primitive level of comfort.

The RX-7 is far from primitive, of course. And changes for 1994 have softened its hard edges. But this is still a real sports car—with far fewer compromises than most passenger cars, even those with sporty aspirations. Anyone who signs up expecting the kind of leather-lined hedonism they'd encounter in, say, a Lincoln Mark VIII is in for a disappointment.

To their credit, most of the owners in our survey seem to have accepted

this covenant. And most of their complaints—paint quality, tacky interior plastics, insufficient small-object storage, difficult door closure—are valid within the terms of this compact. Mazda, as you'd expect, is busily working to improve the perceived shortfalls.

Complaints about dealer service departments, of course, are another matter entirely. While we can't comment on this from personal experience, we can say that when 43.9% of the respondents say no to the question about satisfactory dealer repairs—and 25% rate dealer service as average to poor—the manufacturer has a problem.

However, as far as the car is concerned, we have few criticisms. Yes, we agree that the premium sound system is too bulky. Yes, driver sightlines in the rear quarters—where highway patrolmen are going to be sneaking up—are a little restricted. Yes, it has a thirst—a thirst that becomes prodigious when both turbos are pumping full-tilt boogie. But if you love performance, these are compromises you're willing to make.

This car belongs to a breed that is becoming increasingly difficult for manufacturers to justify. Thanks to our statistical-probability friends out there in insurance land, the RX-7 and its contemporaries are endangered species. So if you've always yearned for a true sizzler of a sports car, well, here it is. Get it while you can.

This is one of the great ones.

—Tony Swan

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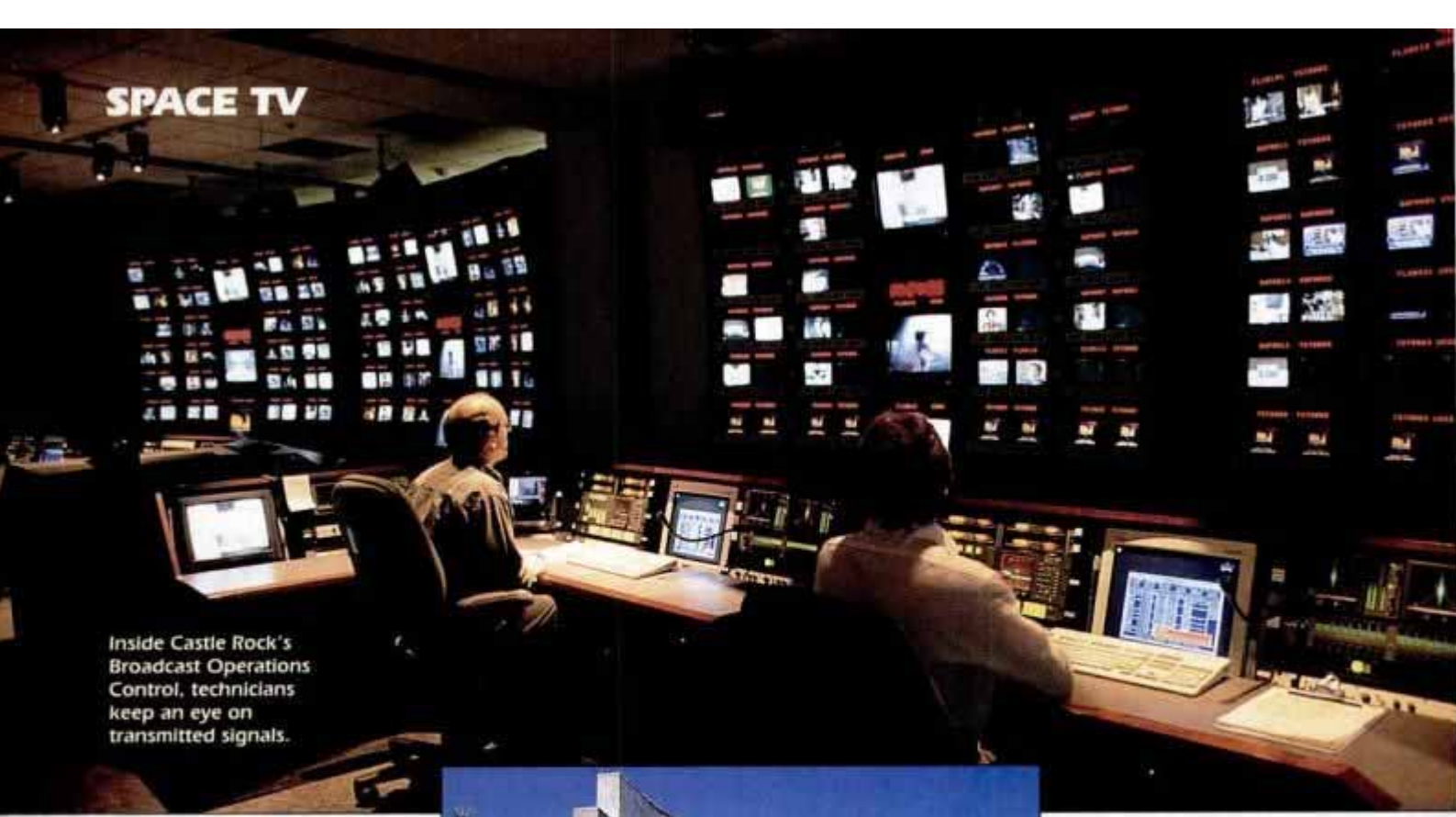
BY GEORGE MANNES
PM Photos by Michael Peck

• The three major broadcast TV networks, based in New York City, sometimes go by Stone Age nicknames. NBC, at 30 Rockefeller Plaza, is referred to as Thirty Rock. CBS, headquartered in a brooding marble-and-glass edifice, is known as Black Rock. And in the 1960s, ABC, home of a seminal Top-40 radio station, got the name Hard Rock.

Now comes Castle Rock. This year, high-powered, direct-to-home satellite broadcasting is scheduled to debut in the United States on a national scale. For the first time, homeowners will be able to put a pizza-size satellite dish on their windowsills, point it skyward and receive a multitude of television channels. Most of that programming will be offered by a company called DirecTV, a unit of General Motors' defense subsidiary, GM Hughes Electronics. And in a quiet valley in Castle Rock, Colorado—a small town 30 miles south of Denver—DirecTV has built a broadcast facility that will operate 24 hours a day, seven days a week, beaming about 150 channels of TV shows, movies and sporting events to homes throughout the nation.

The Castle Rock Broadcast Center was built from scratch to become the heart of a direct-to-home satellite service, unlike anything that TV viewers in the United States have seen before. Befitting





Inside Castle Rock's Broadcast Operations Control, technicians keep an eye on transmitted signals.

the importance that DirecTV's management thinks the service will one day have in America, the company spared little expense in making Castle Rock a state-of-the-art broadcast center. Equipped with the latest in digital VCRs and safeguarded with millions of dollars worth of backup gear, the Castle Rock facility cost \$100 million to build. Behind a sandstone and blue-glass facade that combines prairie ruggedness with geometric precision, the broadcast center is preparing to usher the United States and Canada into a new era of satellite broadcasting.

To watch DirecTV programs, consumers will first have to buy reception gear called the Digital Satellite System (DSS); RCA-brand DSS equipment will start at \$699. Then, with a properly aimed 18-in.-dia. satellite dish, viewers will be able to receive programming from a pair of communications satellites orbiting close to one another. (One went into orbit last December, and the other was scheduled to launch in July.) DirecTV will use more than 80% of these satellites' capacity. Another programming provider, United States Satellite Broadcasting in St. Paul, Minnesota, will use the rest to offer a different lineup of channels to DSS owners.

About a third of the 150 channels that DirecTV plans to offer will be devoted to pay-per-view movies. But



Castle Rock: By The Numbers

- 3** 1.5-megawatt backup generators
- 4** 13-meter broadcast antennas
- 6** quality-assurance rooms
- 35** employees per shift
- 42** planned fiberoptic lines (25 already in place)
- 150** television channels
- 300** Sony digital video machines
- 20,000** gallons of fuel for backup generators
- 50,000** tapes (11,000 currently)
- 55,000** sq. ft. of space
- 500,000** pounds of concrete for each 13-meter antenna foundation
- 2,000,000** ft. of audio and video cable
- \$100,000,000** total cost

though 50 channels might be set aside for pay-per-view, this doesn't mean that subscribers will have a choice of 50 different movies at any given time. An especially popular movie might play on eight different channels, with starting times staggered so that one airing begins at 8 pm, the next at 8:15, the next at 8:30, and so on. That way, viewers wouldn't have to wait more than 15 minutes to start watching it.

Let's take a movie that might ap-

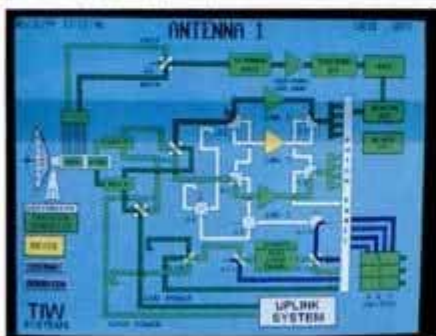
pear on DirecTV and track its passage through Castle Rock. Imagine that Paramount licenses "Beverly Hills Cop III" for pay-per-view. Once a videotape copy of the movie arrives at Castle Rock, the first step is to assign it a bar-coded sticker. Then the tape is filed in the facility's media library, where each slot of each shelf has a distinct bar-coded label. A librarian scans the bar codes on both the tape and the slot it's filed in so that a computer can subsequently locate that particular tape—rather important in a library that has a current capacity of 11,000 tapes.

The next stop for "BHC III" might well be one of Castle Rock's six quality-assurance rooms: a small viewing suite where a technician can inspect the master tape.

Assuming there's nothing wrong with Castle Rock's copy, the tape would eventually go to the multiformat dubbing room, where the tape would be copied onto a digital

house master formatted with DirecTV's standard opening—the equivalent of a movie theater's 10-second introduction of "Our Feature Presentation." This house master, in turn, would be used to clone, say, 16 copies of "BHC III" simultaneously.

Why so many copies? To show a movie on eight different channels, you need eight different tapes. And for each tape that goes out on the air, Castle Rock will be rolling a backup



Antennas stand near the building (top). Inside, a screen displays satellite data (above). tape in unison. If something goes wrong with the main copy, a technician or machine can switch over to the backup feed.

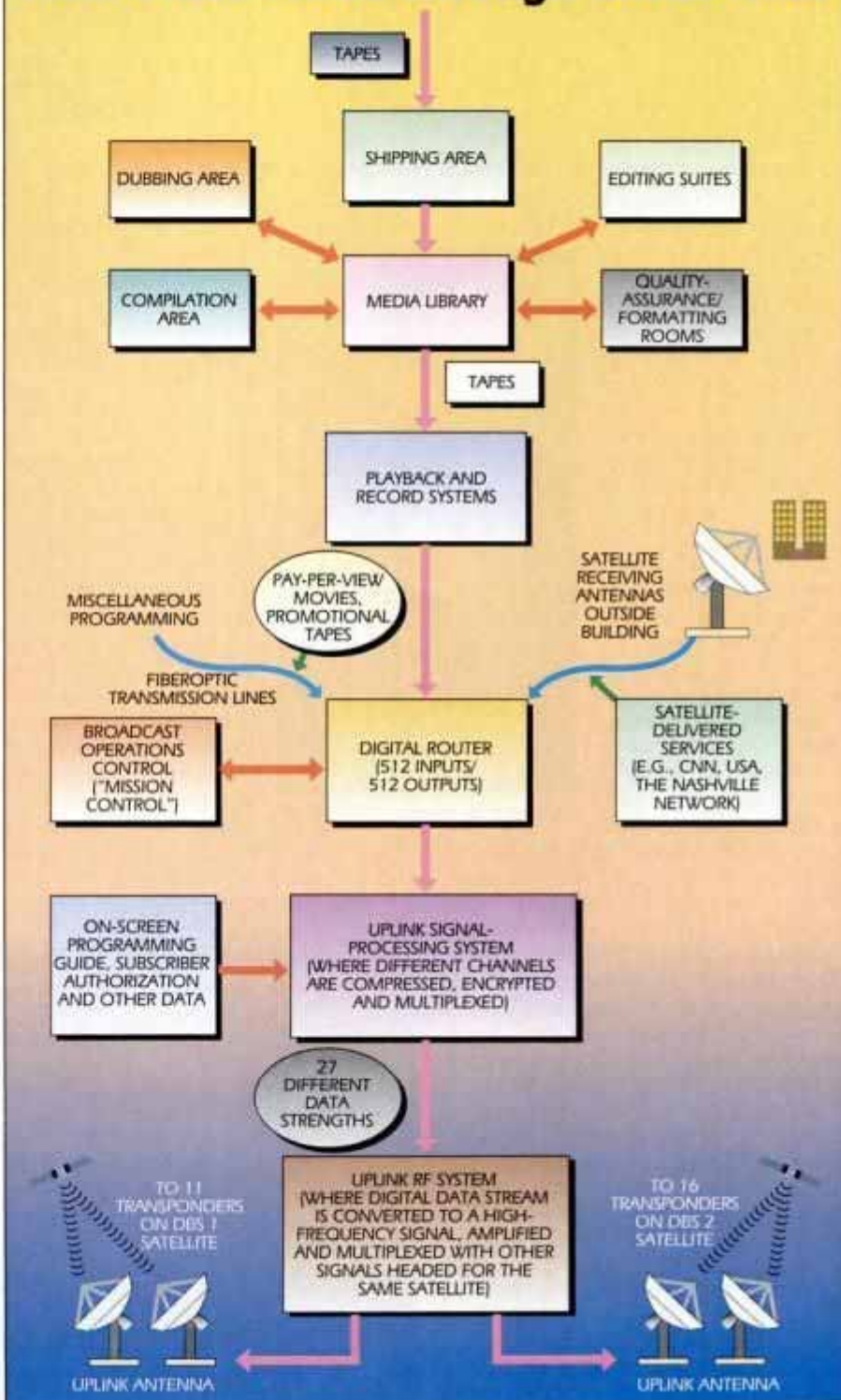
When it's time for "BHC III" to debut on pay-per-view, the necessary copies of the tapes are loaded into Flexicart systems in Castle Rock's Playback And Record Systems (PARS) area. There are 56 of these Flexicart devices at Castle Rock, each behind its own protective glass door. Inside each Flexicart are four VCRs and 15 slots for holding tapes. A robotic arm can read the bar codes on each tape and load the tapes into a VCR as dictated by a schedule generated in DirecTV's corporate headquarters in El Segundo, California.

The tape format used throughout the broadcast center is Sony's Digital Betacam, a distant relative of the Betamax home VCR format. Recording television signals as a collection of computerized bits (or 1s and 0s), Digital Betacam's data rate is 270 megabits per second—more than 180 times the rate of digital information read from an audio compact disc. TV programming travels throughout Castle Rock at this 270-Mbps rate.

As it is being played back in the PARS area, the signal from the "BHC III" tape is sent through a router—a large distribution center like a telephone switchboard. As it passes through the router, it is monitored in Broadcast Operations Control (BOC)—a room filled with hundreds of TV monitors and looking like something out of Mission Control. Here, technicians can inspect every piece of programming that goes out on DirecTV.

DirecTV expects that about 40

How Video Flows Through Castle Rock



The material for DirecTV's broadcasts comes from its own film library, via satellite and fiberoptic cable. The signal is converted to a digital format before being transmitted.

SPACE TV



The multiformat dubbing room can produce multiple copies of a tape simultaneously.

channels in its lineup will be familiar cable services such as CNN, USA, The Nashville Network, TNT and The Discovery Channel. These channels, which are themselves distributed nationally via different satellites, are received at Castle Rock through eight satellite reception antennas that are as big as 6.1 meters in diameter. Inside the building, they're converted from traditional analog signals to 270-Mbps digital signals before they're retransmitted to subscribers.

DirecTv also plans to offer about 40 channels of sporting events. Fiberoptics are often used to transmit telecasts of games from arenas and stadiums. Castle Rock currently has 25 fiber-optic lines for receiving overland transmissions and expects to add 17 more.

After the movies, sporting events, cable channels and other specialized programs pass through BOC, they have to go through several more stages before they can be beamed up to DirecTv's pair of satellites. First, each signal has to be compressed from a data rate of 270 Mbps to a rate that varies continuously between 2.7 and 5.4 Mbps. Each channel is encrypted so that only subscribers who pay for a particular channel can receive it. And groups of four to eight video channels are combined to fit on one transponder—a receiver/transmitter on a satellite that takes a signal beamed up from Earth and beams it back down over a wide area. In traditional satellite broadcasting each transponder can relay only one channel

at a time, but with this level of video compression, DirecTv's 27 transponders could theoretically transmit 216 channels.

Other signals are compressed and combined with video signals. Among them are the various audio-only services that DirecTv will be offering and data for an on-screen programming guide.

After compression, encryption and multiplexing, the combined signals are converted to a high-frequency signal, amplified and then fed to four 13-meter-diameter transmission dishes. Two uplink antennas are aimed at each satellite.

One of the most extraordinary things about Castle Rock is the number of safeguards prevent-

ing interruption of service. Should power fail, a battery backup can power the operation for 10 minutes. That gives Castle Rock's backup generators plenty of time to kick in, because they need only 25 seconds to start up. Any two of Castle Rock's three 1.5-megawatt generators can keep Castle Rock broadcasting. The facility stores enough backup diesel fuel for several days of power.

The video path throughout the plant has plenty of backups, too. Each backup pay-per-view movie on tape travels to the system's main router on a separate cable from the main signal. Each satellite-delivered programming service (such as CNN) travels on two separate chains the moment the signal enters the building. Each channel traveling through the router is paired with a backup signal. One-third of the 2 million ft. of wiring in Castle Rock is backup circuitry.

Though only 27 sets of machinery are necessary to compress, encrypt and multiplex the signals for 27 transponders, Castle Rock has 56. Each compressor has its own backup, and there are two more to spare. The same logic applies to Castle Rock's upconvertors and high-powered amplifiers: There are 56 of each.

Is all this extra equipment reflective of nothing more than the mindset of a defense contractor?

DirecTv's argument is no, this is prudent. If something were to go wrong, they could have millions of angry customers calling in at the same time to complain about blank TV screens—not the few thousand customers that might be affected if a local cable system were to go down.

"Our emphasis in year one—in 1994—is quality, quality, quality," says DirecTv president Eddy Hartenstein. "We have one chance to get it right, and that's the first chance." **PM**



A 4-ft. dish checks the signal.



In a quality-assurance room, movies on tape are checked for audio and video glitches.

SUBARU LEGACY



A great favorite with America's dauntless couriers.

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

● We noticed something unusual when we began crunching numbers for the Legacy data panel. A lot of owners had ordered the station wagon version of this car with righthand drive. Whoa! The Subaru option book doesn't even list righthand drive. Who needs it?

Turns out rural letter carriers do. Letter carriers aren't uncommon among our Owners Report respondents, but this was the first time some 25% had marked "righthand drive" as one of the main reasons they bought a particular car.

Why so many mail carriers? The answer turns out to be simple. Subaru offered a special 1993 deal to postal employees: new Legacy wagons with a combination of righthand drive, full-time 4-wheel drive and an automatic transmission. Righthand drive puts a driver on the correct side of the vehicle to stuff those roadside mailboxes. Subaru and Jeep seem to be the only two automakers catering to RFD drivers.

This fall, Subaru is introducing an all-new Legacy. The '95 Legacy is longer, taller and wider than the model that's the subject of this report. But it retains all the virtues of the older Legacy—including the availability of righthand drive.

The Subaru Legacy we report on here came in five trim levels: L, LS, LSi, Sport and Touring. Each amounts to a major option package. The LSi, for instance, is the Legacy's luxury series, with leather interior and an AM/FM/cassette/CD sound system. For the performance-minded, there's the Legacy Touring wagon or Sport sedan, with a 160-hp turbocharged version of the 2.2-liter flat-Four, plus firmer suspension and specific trim.

But even the lowest-price Legacy L offers a large number of standard items and an extremely short option list. Standard L equipment includes air conditioning, power steering, power 4-wheel disc brakes,



SUBARU LEGACY



all-independent suspension, cruise control, electric locks, power windows with one-touch down, an AM/FM/cassette stereo, a tilt steering wheel with memory, an adjustable lumbar bolster for the driver's seat, dual electric outside mirrors and a 5-speed manual transmission with hill-holder.

Next up, the Legacy LS adds Subaru's electronically controlled 4-speed automatic, 4-channel antilock brakes, power glass sunroof, alloy wheels, height-adjustable driver's seat, plus a raft of minor accessories.



There's also a righthand-drive version.



Flat-Four engine has optional turbo.

Above that, there's the aforementioned LSi series and the turbocharged Touring wagon and Sport sedan.

ABS comes standard in all other

Legacys except the base L, though it was an option on the L wagon.

On the safety front, every '93 Legacy had a driver's airbag and motor-

SUMMARY OF SUBARU LEGACY OWNERS REPORTS*

Total miles driven	1,547,709	Poor	0.0	Motorized shoulder harness and lapbelt	7.9	Electrical system	11.6
Average miles driven	6190	Braking:		Noises and rattles	6.3	Front-end alignment	9.3
Purchase price:		Excellent	57.4%	Uncomfortable seats	6.3	Repair it yourself?	
Average	\$17,654	Good	39.4	Not enough ground clearance	5.8	No	97.7%
Range	\$13,500-\$24,000	Average	3.2	Paint seems to chip easily	4.7	Yes	2.3
Why did you choose the Subaru Legacy?		Poor	0.0	Suggested changes:		Dealer repairs satisfactory?	
For its 4-wheel drive	39.0%	Overall performance:		Better fuel mileage	9.7%	Yes	77.1%
Owned Subarus before	28.7	Excellent	54.9%	Friendlier shoulder harness and lapbelt	7.9	No	22.9
For righthand drive**	24.7	Good	43.3	Fewer noises and rattles	7.3	Dealer service opinion:	
Subaru reputation	11.6	Average	1.9	More comfortable seats	7.3	Excellent	48.4%
Price/value	9.2	Poor	0.0	No changes, leave as is	6.1	Good	42.3
Antilock brakes	8.8	Layout of controls:		Greater ground clearance	6.1	Average	7.1
Body style choices:		Excellent	47.4%	More headroom	4.8	Poor	2.2
4-door station wagon	70.9%	Good	44.2	More legroom	4.8	Dealer sales policy:	
4-door sedan	29.1	Average	7.4	Workmanship opinion:		Excellent	48.3%
Model choices:		Poor	0.9	Excellent	54.0%	Good	42.1
L	38.5%	Instrumentation:		Good	43.1	Average	6.6
LSi 4wd	33.9	Excellent	49.1%	Average	2.0	Poor	2.9
LS	13.1	Good	43.0	Poor	0.0	Number of vehicles owned:	
Touring turbo wagon 4wd	8.6	Average	7.0	Comfort opinion, front seats:		This vehicle only	20.6%
Sport turbo sedan 4wd	5.9	Poor	0.9	Excellent	50.6%	Two vehicles	42.1
Average mpg, city/hwy:		Driver sightlines:		Good	39.4	Three vehicles	23.0
With 5-speed manual	23.6/27.6	Excellent	51.4%	Average	8.0	Four or more	14.3
With 4-speed automatic	20.0/25.0	Good	41.2	Poor	2.0	Principal driver:	
Transmission choices:		Average	6.5	Comfort opinion, rear seats:		Female	58.2%
4-speed automatic	73.5%	Poor	0.9	Excellent	28.5%	Male	36.9
5-speed manual	26.5	Specific likes:		Good	39.4	Equal	4.8
Engine power:		4-wheel drive	44.9%	Average	13.6	Age distribution of owners:	
Excellent	50.5%	Handling	33.0	Poor	1.7	Under 29	5.8%
Good	43.1	Comfort	23.8	Any mechanical trouble?		30-49	48.5
Average	5.6	Engine power	22.5	No	82.7%	50-plus	45.6
Poor	0.9	Styling	22.5	Yes	17.3	Based on your experiences, would you buy a Subaru Legacy if you had it to do over again?	
Handling:		Righthand drive**	13.2	What type of trouble?		Yes	66.5%
Excellent	61.1%	Riding qualities	12.8	Brakes	20.9%	Maybe	29.9
Good	36.6	Specific dislikes:		Air conditioning	11.6	No	3.6
Average	2.3	No complaints	13.7%				
		Mpg lower than expected	12.1				

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

** Our survey included a number of rural postal carriers who had ordered their Legacys with righthand drive.

ized front shoulder harnesses. The hill-holder keeps the vehicle from rolling backward on an incline as you engage First without keeping your foot on the brake.

The standard Legacy engine is a twin-cam 2.2-liter horizontally opposed Four with multipoint fuel injection and distributorless ignition. It delivers 130 hp and drives the front wheels through a 5-speed manual transmission. There's also a 4-speed automatic available.

The Legacy was available with one of two versions of full-time all-wheel drive: Continuous and Active. Subaru's Continuous 4wd comes with the manual 5-speed only, and Active is for Legacys with the electronically controlled 4-speed automatic transmission.

Continuous 4wd (5-speed) uses a viscous center differential to distribute and equalize power fore and aft. Active 4wd (automatic trans) substitutes an electronically engaged hydraulic multiplate clutch for the viscous center differential. Rear-wheel sensors in the Active system are shared with the ABS and register differences in wheel speed.

Nearly 40% of our respondents bought the Legacy specifically for its 4wd. This feature, in fact, turned out to be the Subaru Legacy's single strongest selling point.

The biggest complaint we heard about the Legacy concerned fuel economy. Just over 12% of our owners said they had expected better. Keep in mind, though, that 73.5% owned automatics. And 25% were letter carriers who do a lot of gas-gulping stop-and-go driving.

Only 17.3% reported any sort of mechanical problem. Of those, 77.1% got their cars repaired correctly the first time.

What owners liked best about their Legacys were the benefits of all-wheel drive. Engine power, performance, handling and braking also all scored quite well.

The Legacy was judged to be comfortable in the front seats, but less so in the rear. Taller people complained that there wasn't enough headroom or rear legroom.

Nearly 30% of our respondents had owned Subarus before, and 66.5% said they'd buy a Legacy if they had it to do over again.

The final word came from a Wisconsin county clerk. "When we went shopping for a new car," his letter read, "we'd intended to also try the Taurus, Accord and Camry, but we got no farther than the Subaru dealer. This car is fun to drive! With the turbocharged engine, this 4-cylinder car has more zip than our Olds Regency Ninety Eight." **PM**



Styling was not high on the list of likes. Handling, 4-wheel drive, interior comfort and engine performance were attributes more important to our sampled owners.

EDITORS REPORT

A Legacy Of Engineering

● Fuji Heavy Industries, the parent corporation of Subaru, doesn't count on selling cars to have any significant effect on its bottom line. It's into aircraft, manufacturing and, well, heavy industry. Maybe that's why Subarus have always been a little offbeat.

But the Legacy is less unconventional than its predecessors. While it retains the flat-motor configuration, it somehow manages to be a lot like any number of other small economy sedans. We drove a '94 4-wheel-drive turbo Legacy with an automatic. During several days of good weather, we never managed to trigger the active 4wd system, but the turbo motor makes more than enough power to deal with traffic.

Die-hard Subaru aficionados won't be turned off, however. We've used the hill-holder found on manual trans Subarus—and it's neat, but the handbrake is almost as convenient if you know how to do it. One thing they used to do right was the express-down and express-up power windows—but apparently someone in product planning decided the express-up wasn't a valuable feature.

We can understand complaints about poor rear-seat headroom—it's cramped back there. But our size 12s found it plenty cramped up in the driver's footwell, too. Admittedly, the Legacy falls in the smaller end of the spectrum for this class of cars.

We found the ride and handling to be excellent, although understeer is

the limiting factor when pushing the limit in cornering. That's consistent with the Legacy's mission of dependable family transportation.

We're glad to see the '95 Legacy has made the transition to airbags and normal 3-point front seatbelts. We find the motorized belts just as annoying as our readers do.

As far as complaints about ground clearance, those have got to be from those RFD letter carriers driving over heavily rutted country roads. I'd stack Manhattan's pothole-infested 11th Avenue up against any properly maintained road in the country. The Legacy manages to ride reasonably well there, and never did bottom out over some of the lumps and dips that strike sparks from taxi frames.

We've always enjoyed Subaru cars (and trucks—remember the Brat?). Well, enjoyed might be the wrong term—appreciated, perhaps. It's obvious they were designed by the engineering staff and not the product planners. That's in some ways good, and in some ways bad. The buzzphrase in the industry nowadays is "serving the needs of the customer," which is not the same as building the best car the engineering staff knows how. The Legacy retains its strong engineer's appeal with features like the flat-Four engine, hill-holder and automatic 4wd. But it does so while still appealing to Just Plain Folks, whether they were Subaru converts before or not. —Mike Allen

BUILDER'S GUIDE

Engineered Lumber

Man-made structural timbers offer cost-effective strength on jobs big and small.

BY NEAL BARRETT; PM Illustrations by George Retseck

● Perhaps you've noticed, while walking through a church, theater or municipal building, a graceful arch or vaulted ceiling supported by large wooden beams or rafters. And maybe you've wondered how wood can be made to perform in situations such as these that seem to stretch the limits of the material's natural characteristics. Most of the time, especially in newer construction, these are examples of engineered lumber.

The concept of manufacturing structural lumber is by no means a recent one. Floor and roof trusses, for example, have long been used in both residential and commercial construction projects. These products generally incorporate lower grades of lumber in items that, by their design, maximize the structural value of the material. For truss construction, southern yellow pine—a hard, brittle and relatively inexpensive wood—is most often used. Glue-laminated beams—large beams composed of stacks of 2-in. stock laminated under pressure—have also been used to dramatic effect for at least 80 years.

In applications that are nonstructural, the engineered approach has yielded finger-jointed stock for many years. In this process, short lengths of wood are joined end to end for paint-grade work, such as baseboards, casings, door-jambes, window

jambes, siding and porch decking.

Today, however, the term engineered lumber includes a larger list of products that are fabricated from either veneers, strands of wood or lengths of solid lumber. These materials are assembled with adhesives, under great pressure, to form products that exceed the physical and structural characteristics of simple dimensional lumber.

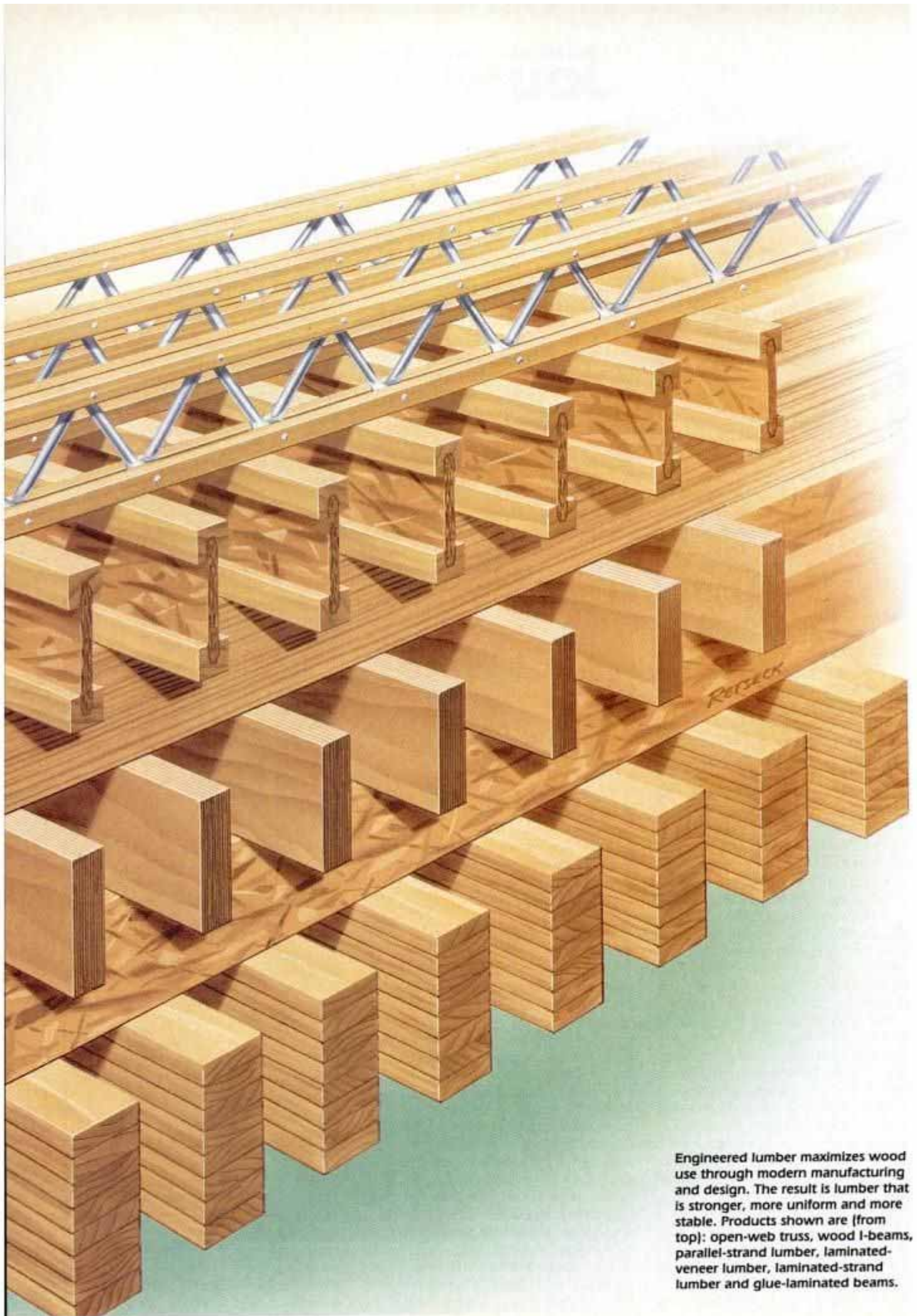
Types of engineered lumber

The products that are considered engineered lumber take a number of different forms and are constructed using different techniques. Here's a quick summary of what's available and the major differences between the products.

The **gluelam**, or **glue-laminated beam**, was among the first engineered lumber products. These beams are generally used for rafters, floor support beams or stair stringers when the structural members are meant to be exposed to view. They are constructed by gluing and then applying great pressure to a stack of 2 × 4 or 2 × 6 stock to form a beam up to 30 in. in depth. On special order, these beams can be fabricated to curved shapes for supporting arched roof structures.

Laminated veneer lumber, or **LVL**, at first has the appearance of a plywood





Engineered lumber maximizes wood use through modern manufacturing and design. The result is lumber that is stronger, more uniform and more stable. Products shown are (from top): open-web truss, wood I-beams, parallel-strand lumber, laminated-veneer lumber, laminated-strand lumber and glue-laminated beams.

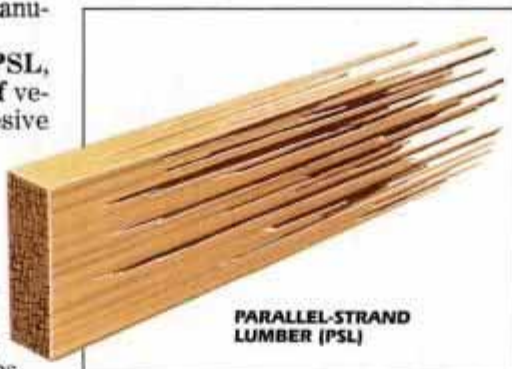
beam. Instead of alternating the direction of the laminations, however, LVL is made of $\frac{1}{10}$ -in.-thick veneers that are all aligned in one direction and bonded under pressure. LVL is most commonly used for beams and



LAMINATED-STRAND LUMBER (LSL)

headers when the load exceeds what can be supported by a solid wood beam of comparable size. This product is generally available in a $1\frac{1}{4}$ -in. width, ranging from $9\frac{1}{2}$ in. to 18 in. in depth and up to 45 ft. in length. Larger sizes may be available from certain manufacturers on special order.

Parallel-strand lumber, or PSL, is made from 8-ft.-long strands of veneer that are soaked with adhesive and bonded under pressure to form long blocks, up to 66 ft. This material is appropriate for exposed use as posts and beams, offering an alternative to gluelam products. In addition, pressure-treated PSL beams are available for outdoor applications such as porches, decks and gazebos.



PARALLEL-STRAND LUMBER (PSL)

Laminated-strand lumber, or LSL, is a relatively new product on the market, constructed from $\frac{1}{2} \times 1 \times 12$ -in. strands of wood that are bonded with a polyurethane adhesive. LSL is available in $1\frac{1}{4}$ -in. and $3\frac{1}{2}$ -in. thicknesses, with varying depths up to 16 in. and lengths to 35 ft. This product is used for shorter door and window headers, rim joists for floor construction and as a core stock for flush doors with a veneer overlay. In traditional solid-wood framing techniques, a carpenter builds headers on site from nominal 2-in. stock and plywood, a slow and inefficient task. When using headers of solid LSL, the material can be ordered precut to specified length or can be cut to size on the job site. In either case, there can be a substantial savings in labor cost.

Wood I-beams look much like a steel I-beam. A central web of plywood, oriented-strand board (OSB) or LVL is enclosed between top and bottom webs of solid lumber or LVL. These beams are typically used for

floor and roof framing, and have the notable feature of providing additional room for insulation and plumbing or electrical runs because of the recessed web. Since the top and bottom flanges are considerably wider than a conventional solid-wood joist or rafter, they provide additional surface area for securing floor or ceiling material. Some of these beams are available with a cambered construction—a feature that provides a uniform upward crown to the beams to maximize the load-bearing capacity of the floor structure, especially on long spans.

Open-web trusses use both wood and steel technology. Top and bottom chords of solid wood or LVL enclose an open web of steel tubing to form an extremely strong support for both floor and roof applications. These trusses are generally used in commercial construction projects, and are designed as an alternative to either steel trusses or gluelam beams. Open-web

trusses are usually custom designed for a particular project to maximize truss performance while keeping material use to a minimum.

Benefits of engineered lumber

Manufactured lumber makes wood a realistic alternative in situations that might previously have called for other materials. Some of these materials, such as steel, are manufactured from resources that are not renewable, so it's valuable to set them aside for situations where they are truly needed. Also, using structural steel on a project often requires specialized tradespeople and equipment, which can add considerably to the cost of a job.

Because engineered wood uses raw materials of short length and width, trees that would normally be considered weed trees—useless for construction or trimwork—can be cut up and used to make engineered lumber. These trees, aspen being the

most common, are plentiful and grow quickly. Using these trees for structural products opens up a new, readily renewable source of raw materials.

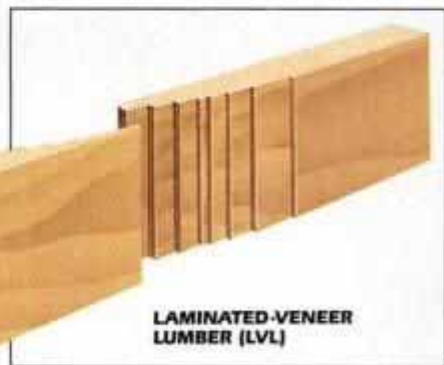
Natural defects that occur in the wood, which would normally cause a piece of lumber to be rejected for structural use, are either cut out or spread randomly throughout the re-assembled beam. This technique generates a much higher yield of usable material from any given tree. And because there is so much concern about the prudent use of our forest resources, any innovation that optimizes wood use is a positive development.

Another feature of engineered lumber is dimensional stability. In a conventionally framed house, it's common to experience squeaky floors and drywall or plaster cracks that result from shrinkage of the floor joists. Engineered joists are manufactured from kiln-dried materials that have been saturated with a resin-based adhesive. This yields a product that is extremely stable and will not change dimension either by picking up or losing moisture.

Engineered lumber can contribute in other ways to better constructed buildings. Anyone who works with wood is familiar with warped, twisted and split lumber. These solid-lumber problems not only decrease cost effectiveness, but can also compromise the integrity of a structure. And defects have become more prevalent as lumber suppliers have had to turn to faster-growing species to keep up with demand. Since manufactured lumber is dimensionally stable, it resists these problems, providing a more uniform and predictable product.

Design, cost and end use

Engineered beams have opened up new possibilities for architects as well



LAMINATED-VENEER LUMBER (LVL)

as builders. The ability of wood I-beams to carry greater loads than comparable-size solid-wood joists provides increased flexibility in placing bearing walls and support beams,

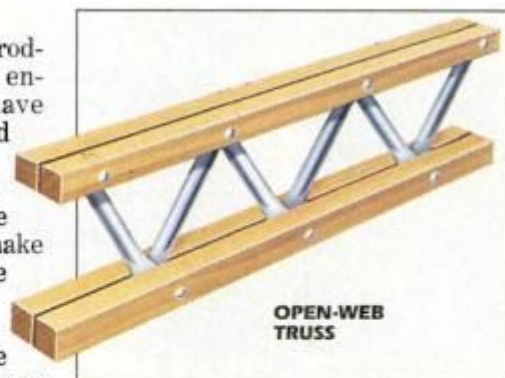
while maintaining a relatively thin floor structure. The result can be a more expansive floor plan—one in which the client's lifestyle can be a greater factor in the ultimate design.

As you might expect, the benefits of these products do not come without cost. Typically, engineered wood items are priced about twice that of a comparable length of solid lumber. The manufacturers of these products

the higher cost of the product.

The introduction of these new products has not met with universal enthusiasm, and many builders have been slow to accept engineered lumber. The combination of increased material costs and new construction techniques has made some professionals reluctant to make the leap of faith required to use these materials. However, many builders, by now, have encountered projects where engineered lumber has been specified, and they are becoming familiar with its use. In addition, the phenomenal rise in lumber prices just over the past two years, along with solid-lumber shortages throughout the country, has been a deciding factor in persuading builders to make more frequent use of these products.

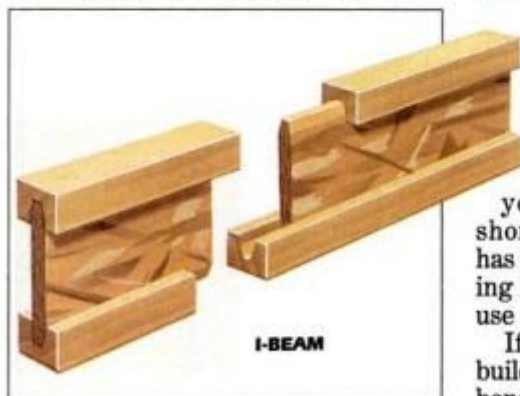
If you are planning a remodeling or building project that you think might benefit from engineered lumber, consult an architect or engineer to compare product specifications with the load-bearing requirements of your project. In some cases, the structural capacity of engineered lumber allows



OPEN-WEB TRUSS

greater spacing of supports in a floor or roof providing that the decking material is able to span the distance. These substitutions should not be made casually, and the time and money spent on a professional consultation is a good investment.

In shopping for engineered lumber products, a bit of local research will be necessary. Several companies manufacture these items, and the particular products available will vary with the distribution network, and market, in your area. In most cases, you will have the option of special ordering items that are not carried as stock material. **PM**



I-BEAM

are quick to point out, however, that the combined factors of less waste, greater strength, faster installation and lighter weight per unit length all contribute to savings that offset

NEW TOOLS

Makita Drill Accessories

● These days, a portable power drill is a necessity, and cordless drills are fast following suit. However, if you really want to turbocharge your drilling and driving chores, it's time to look at accessories, and these two offerings from Makita should top the list.

The first is the Quick/Driver 10—a drilling and driving tool that eliminates fussing with a chuck and loose bits. In the drilling mode, bore a pilot hole and a countersink or plug counterbore for No. 10 screws. Then, simply slide forward the collar, flip the bit cartridge around, and it's ready to drive the screw (Photo 1).

The second accessory is the Vision Finder/Driver—a screw-holder, driving tool. This device holds the screw in a clear plastic tube. As the screw is driven, the tube slides back (Photo 2).

The Quick/Driver 10 costs about \$10.75, and the Vision Finder/Driver retails for about \$8.75. Both work with any power drill. Contact Makita U.S.A. Inc., 14390 Northam St., La Mirada, CA 90638. —Thomas Klenck



Makita's Vision Finder/Driver (top) holds screws while they're started. The Quick/Driver 10 (bottom) has a reversible bit cartridge that holds a drill/counterbore on one end and a standard driving bit on the other.



1 After boring a pilot hole with the drill bit, slide forward the collar and flip the cartridge around to access the driving bit.



2 To use the Vision Finder/Driver, first load the screw in the clear plastic tube. The tube retracts as the screw is driven.



COMPARISON TEST

Random-Orbit Sanders

We test today's hottest sanding tool for homeowners and pros.

BY THOMAS KLENCK, Associate Home Improvement Editor

• If you like to sand, you're in the minority. It's tedious, time-consuming and, let's face it, downright boring at times. On the other hand, if you skip the job you're likely to end up disappointed when the finish is applied—and then all the real work goes unnoticed. Fortunately, tool manufacturers have come to the rescue with a range of power tools designed to abrade wood fast and effortlessly. And the undisputed leader for fine finish sanding and fast stock removal is the random-orbit sander.

About the tools

A random-orbit sander is actually a combination of two sanders—a disc sander and an orbital sander. The sanding pad is mounted slightly offset in relation to the motor-driven shaft. When the shaft turns, the ec-

centric pad moves in small orbits. Unlike an orbital sander, however, the pad spins freely while orbiting around the main shaft. The speed of the freewheeling disc varies with the pressure applied to it. This helps to create a less obvious sanding pattern.

To attach the sandpaper disc to the pad, you have two alternatives: PSA (pressure-sensitive adhesive) discs or hook-and-loop (Velcro-type) discs. Most tools use the hook-and-loop system, although you can sometimes buy PSA sanding pads as an option. We think the hook-and-loop system has a great advantage over PSA discs because you can reattach a disc after it has been removed.

Because the freewheeling disc spins at a fairly high speed, it can easily gouge the wood when it's brought into contact. Therefore, it's best to start the tool on the wood. Some manufacturers install a brake to limit disc speed and provide greater control.



RYOBI RS115



MILWAUKEE 6125



BOSCH B7250



PORTER-CABLE 7336



BOSCH 1370DEVS



SKIL 7384



RYOBI RS112

AEG TXE 150

The 3.5-amp TXE 150 is a smooth-running tool that features a 6-in. sanding pad for fast surfacing. The free-spinning disc speed is held in check by a flexible ring inside the housing that maintains slight contact with the disc.

It's the only tool that has a paper filter inside the dust-collection bag, and there's a foam gasket that seals the bag against the dust port. We found dust control to be very good.

Its variable-speed range is controlled by a speed dial mounted under the trigger. The relatively slow top speed of this tool, along with the disc brake and large disc size, all add up to a sander that feels very stable and vibration free on various surfaces.

Black & Decker BD5200

We found this B&D Quantum tool well balanced with minimal vibration. To control disc over-spin, the sander has a spring-loaded brake that bears against the pad. Although a little slow to come up to speed, the tool is

easy to handle and shows a minimal tendency to gouge.

Dust collection is adequate, but isn't as good as the AEG. Variable speed is controlled by a dial conveniently located on the top of the handle over the trigger. The trigger-lock button is at the back of the handle. An

adjustable front handle is mounted on a ring clamp around the housing.

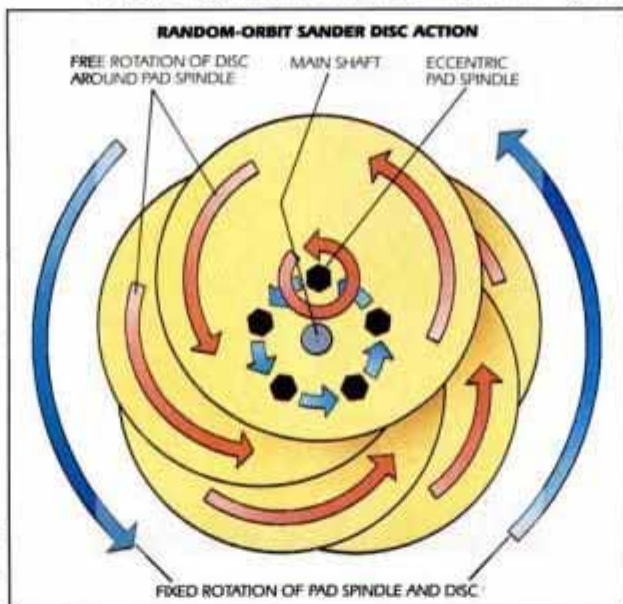
Bosch B7250

With a top speed of 11,000 opm and no disc brake, the B7250 definitely needs to be started on the wood to prevent gouging. We also noticed an oscillating vibration at maximum speed—it didn't seem to affect surface quality, but it made the tool feel less stable.

Variable speed is trigger controlled with a dial under the trigger, and the trigger-lock button is well placed. The front handle is an adjustable bail-type handle that can be moved up and down. If brand allegiance isn't an issue, Skil offers the identical tool with two fixed speeds as the model HD7750. You will also find this sander, with a few industrial perks added, as the Bosch 3283DEVS.

Bosch 1370DEVS

What makes this heavy-duty 5-amp tool special are its options for controlling disc spin. Under the sanding pad is a reversible plate that links the pad to the



Blue arrows indicate powered rotation of main shaft. Eccentric pad and disc create orbital pattern. Red arrows indicate free-spinning disc. Speed varies with pressure.

RANDOM-ORBIT SANDER SPECIFICATIONS

MANUFACTURER	MODEL	PRICE ¹	AMPS	DISC SIZE	SPEED RANGE	BRAKE ⁴	DISC ATTACHMENT	DUST COLLECTION	NOISE LEVEL ⁷	WEIGHT (lb.)	CORD LENGTH
AEG	TXE 150	\$275	3.5	6"	4000 to 5500	Yes	H & L	Bag ⁶	86	5.4	9' 11"
Black & Decker	BD5200	\$90	2.8	5"	7500 to 10,000	Yes	H & L	Bag	80	4.3	8'
Bosch	B7250	\$169	2.3	5"	8000 to 11,000	No	H & L	Bag ⁶	86	4.2	8' 4"
Bosch	1370DEVS	\$427	5	6"	4800 to 12,000	Yes ⁵	H & L	Bag ⁶	90	5.6	13'
Makita	BO5000	\$120	1.7	5"	10,000	No	H & L	Vac Port	80	2.7	7' 2"
Milwaukee	6125	\$209	5.5	5" ²	10,000	No	PSA	Vac Port	91	5	8'
Porter-Cable	333	\$135	1.7	5"	12,000	Yes	H & L	Canister ⁶	70	3.5	8' 10"
Porter-Cable	7336	\$250	3.7	6" ³	2500 to 6000	No	PSA	No ⁶	82	5	9' 10"
Ryobi	RS112	\$90	2	4 1/2"	11,000	No	H & L	No	79	2.4	6'
Ryobi	RS115	\$136	2	4 1/2"	0 to 11,000	No	H & L	Box	85	3	6'
Skil	7384	\$91	1.8	4 1/2"	11,000	No	H & L	Bag	81	3.4	8' 4"

1. Suggested retail price; most of the tools sell for less. 2. Available with a 6-in. pad. 3. Available with a 5-in. pad. 4. Brake limits disc speed. 5. Also fixed-speed disc action. 6. Vacuum attachment available. 7. Free-running noise level as measured on dBA scale.



AEG TXE 150



MAKITA BO5000



PORTER-CABLE 333



BLACK & DECKER BD5200

housing. In one position, teeth around the circular plate engage teeth on the tool frame. This holds the pad at a fixed speed, regardless of pressure, for aggressive sanding.

Flipping over the reversible plate replaces the geared drive with a brake that prevents overspinning. In this mode, the sander is suitable for fine work. The tool has loads of power and is impossible to stall.

The 1370DEVS has a sliding switch with a lock-on position, a speed dial on the rear of the motor housing, an auxiliary handle that mounts on the left or right and a 13-ft. power cord.

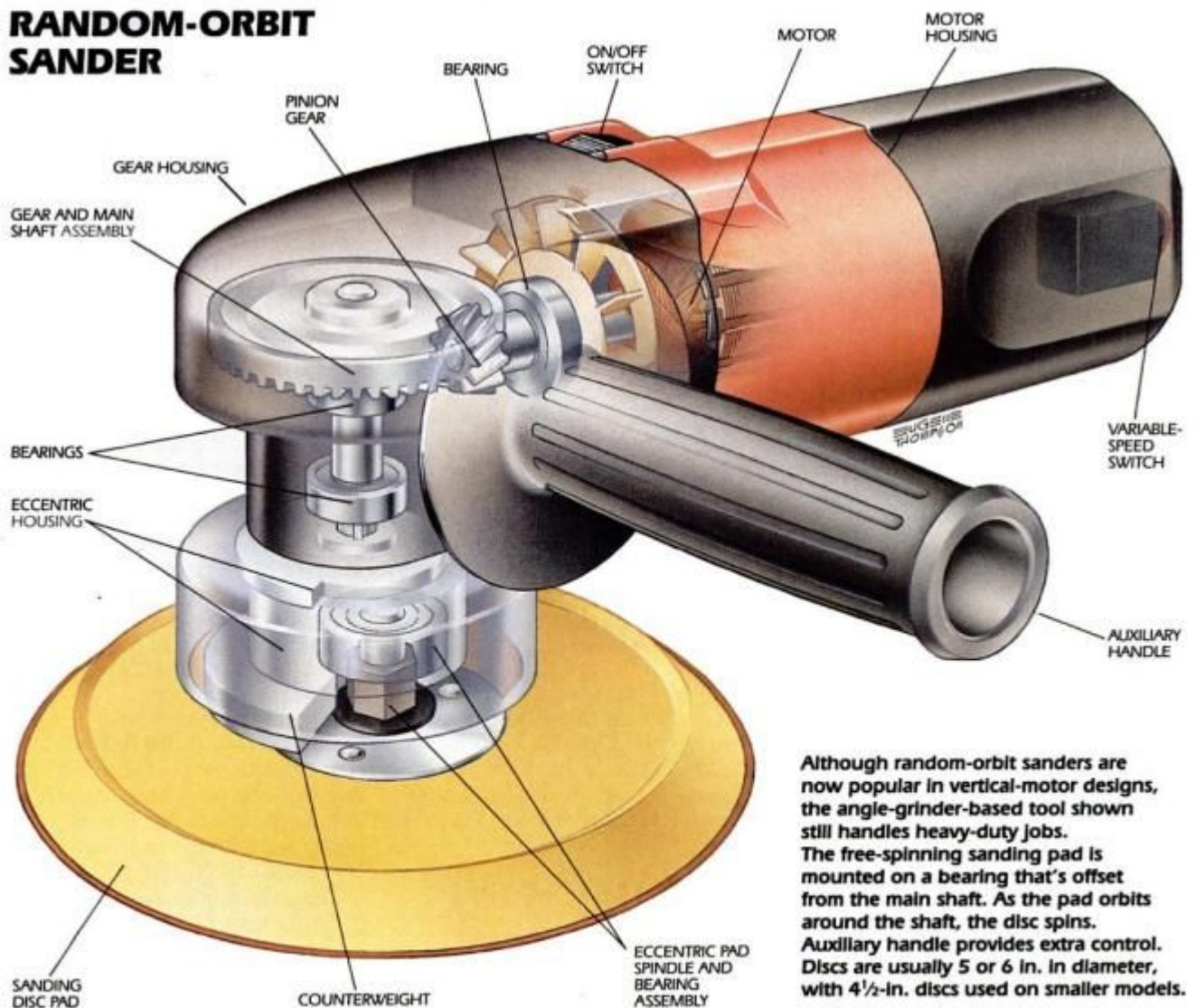
Makita BO5000

This small, palm-grip model is easy to hold, although we found the housing material a little slippery. It features a simple toggle switch and a fixed speed

of 10,000 opm. The tool doesn't come with a dustbag, although there's a dust port on the back for hooking to a shop vacuum.

Like the Bosch B7250, you definitely need to adhere to the manufacturer's warning about starting the tool before bringing it in contact with the wood. Without any disc brake, this tool literally bounces around the surface before it settles down.

RANDOM-ORBIT SANDER



Although random-orbit sanders are now popular in vertical-motor designs, the angle-grinder-based tool shown still handles heavy-duty jobs. The free-spinning sanding pad is mounted on a bearing that's offset from the main shaft. As the pad orbits around the shaft, the disc spins. Auxiliary handle provides extra control. Discs are usually 5 or 6 in. in diameter, with 4½-in. discs used on smaller models.

PM ILLUSTRATIONS BY EUGENE THOMPSON



Most sanders use the hook-and-loop system for securing the disc. The holes in the disc and pad carry dust away.



The speed-control dial on the B&D tool is well placed over the trigger. Some tools have a small dial on the trigger.



Single-speed palm-grip sanders have a rocker-type switch. The tool is held on top, or around the narrow waist.



The Milwaukee has a paddle switch. The other right-angle designs have a sliding switch that can be locked.



Most tools have a dustbag that's spring clamped to a dust port. The bags are fairly effective in containing dust.



The P-C 333 uses a permeable rigid canister to collect dust. A vacuum can be connected to the dust port, as well.



To control disc speed, the P-C 333 uses a plastic belt. Other tools use varying designs to slow down free-spinning disc.



The Bosch 1370DEVS has a reversible drive plate. Geared position fixes disc speed for aggressive sanding.

Milwaukee 6125

This 5-in. Milwaukee model comes with a dust port for connecting a shop vacuum—a dustbag is not available. With its unbraked disc and 5.5-amp motor, we found this sander to be a very aggressive, fast-cutting tool. It features a paddle switch mounted under the motor housing. While the switch is convenient and well placed, there's no facility for locking the tool on. Milwaukee random-orbit sanders use only PSA discs.

Porter-Cable 333

Frankly, this tool makes the others look like they're still in the developmental stages. It's quite simply the smoothest, quietest and easiest to handle of the lot—and it does its job.

In terms of innovation, P-C has traded a dustbag for a rigid permeable canister. It effectively traps dust and can be removed for connecting to a vacuum. The sanding pad is kept in check by a plastic belt that controls speed. You'll have to buy unconventional 5-hole hook-and-loop discs, however.

Porter-Cable 7336

Rank this tool with the Milwaukee 6125. It's a basic, heavy-duty machine

that's fairly aggressive, and the large 6-in. disc makes it a good flattening tool. It has a sliding switch with a lock position like the Bosch 1370DEVS, a 2-position auxiliary handle and a 6-position variable-speed dial.

This tool has no holes in the pad and no built-in dust collection, although a dust-collection pad and vac attachment are available.

Ryobi RS112

Ryobi's palm-grip entry is a no-frills single-speed tool for light-duty sanding. Although it has holes in the sanding pad, they're for suction only—there's no dust-collection bag. The toggle switch has a dust cover.

We found the tool a little on the unruly side in terms of control—perhaps because of its light weight and unbraked pad. And like its big brother, the RS115, it uses a small 4½-in. disc. On the other hand, we found it more comfortable and easier to use than the comparable Makita offering.

Ryobi RS115

Mechanically, the RS115 seems to be the same tool as the RS112—with the addition of a front knob, handle and a dust-collection box. The box is noteworthy because you can see the dust

collecting inside. It's neatly tucked away under the handle. Like the RS112, this tool is a little difficult to control at times, but the handle helps.

Skil 7384

This so-called consumer-level tool—designed for light-duty home use—is actually a fairly well-mannered and effective sanding machine. The design is a step down from the Bosch B7250 and features a similar dust-collection bag. The differences are a 4½-in.-dia. pad, a front knob instead of an adjustable handle and a smaller motor.

Our only gripe with this tool is that it's underpowered. However, with a gentle touch, the tool does the job surprisingly well with little vibration and control problems.

Choosing a sander

Our favorite tool is the Porter-Cable 333. It's compact, very smooth, quiet and easy to handle. For aggressive heavy-duty sanding, we pick the Bosch 1370DEVS for its two sanding modes and the dustbag. The leader in non-palm-grip vertical-motor sanders is the AEG TXE 150, with the B&D BD5200 not far behind. And, for light-duty work, the Skil 7384 performs very well.

PM

NEW PRODUCTS

Coming Home

Great goods that make home projects easier.

BY ROY BERENDSOHN, Assistant Home Improvement Editor

Teamwork

Pella and Velux have teamed up to offer plans for four sun room additions (below). The plans consist of 3-page sets that detail roof and wall framing, end and front elevations, and provide a list of materials. The plans cost \$5 to \$15 at Pella window dealers.

Among the millwork products you might choose to install in the sun room is an insulated window with louvered blinds sandwiched between two or three glass panes (right). This feature keeps the blinds dust free. The blinds can be raised and lowered from inside the room, and the louvers are adjustable as well. The 29-in.-wide x 73-



in.-tall casement window shown costs \$425 to \$500 with the slimshade option (the blinds alone for this window cost \$125). Write Pella Corp., 102 Main St., Pella, IA 50219 or Velux-America Inc., P.O. Box 5001, Greenwood, SC 29648.



Coverup

If your walls or ceilings are in tough shape, consider this textured vinyl wall covering. It's installed like wallpaper, and you can roll a coat of latex paint over it or leave it unpainted. Aside from covering drywall, it can be used over paneling and concrete block, says its manufacturer. The covering is sold in double-roll bolts that cover about 56 sq. ft. A bolt costs about \$25 depending on style and is sold at home centers. Write Borden Home Wall Coverings, 1280 N. Grant Ave., Columbus, OH 43201, or call (800) 626-7336.



Play It Safe

The manufacturer of this safe says it offers up to 2 hours of fire protection at 1850° F. The safe's door is secured by six bolts, and the safe body has outer seams that are butted together. The door seals are flush to the safe body to resist prying. The wall cavity is filled with a concrete-based material that is a poor thermal conductor. Also, the manufacturer will replace the safe if it's destroyed in a fire. The UL-listed safe costs about \$250 at office supply stores, hardware stores and home centers. Write Sentry Group, 900 Linden Ave., Rochester, NY 14625.



As Time Goes By

A smoke detector is only as good as its power source. The manufacturers of this detector equipped it with a 6-year battery. And they designed the unit so it is impossible to close the lid if the battery is missing. To increase its convenience in the kitchen, it's equipped with a nuisance shutoff button that will allow you to turn it off for 10 minutes while you're cooking. However, if heavy smoke is detected, it sounds anyway. Like other smoke detectors, this one has a low-battery warning chirp. But it begins to chirp 30 days before the battery is worn out. The UL-listed device comes with a battery and costs about \$20 at hardware stores and home centers, or from the manufacturer. Write Ultralife Batteries Inc., 1350 Route 88 S., P.O. Box 622, Newark, NY 14513.



That's A Switch

This window is designed to give you privacy with the flip of a switch. The window uses liquid-crystal technology that converts the glass instantly from clear to frosted. A film of liquid crystals is sandwiched between the sheets of glass. When the switch closes the film circuit, the crystals line up and the glass is clear (the window uses 1 watt per square foot of glass in this state). When the switch opens the circuit, the crystals are unaligned and the window is frosted. Although the frosted state allows



nearly as much light to enter as when clear, its manufacturer says it filters out 99% of ultraviolet light. It's available on a variety of windows, and maximum pane size is 36 in. wide x 120 in. tall. The option adds about \$85 per square foot of glass. It's sold at Marvin dealers. Write the company at 2020 Silver Bell Rd., Suite 15, St. Paul, MN 55122.

Off The Beaten Track

If you find cleaning shower/tub door tracks a nuisance, when it's time to remodel you should look at this trackless door. The door uses a rising cantilevered hinge design that lifts the door as it's opened. A magnetic strip at the bottom of each door segment ensures the door seals tightly to cast-iron tubs. The product is built with corrosion-resistant components and tempered safety glass that can be clear or etched. Its aluminum frame is available in silver or gold finishes. Prices range from \$400 to \$625 for shower doors and \$560 to \$625 for tub doors. Both are sold at kitchen and bath showrooms and home centers. Write Sterling Plumbing Group, 2900 Golf Rd., Rolling Meadows, IL 60008.



In A Minute

If you have a storage problem and you want to solve it now, then these locker modules are for you. These snap-together products are available in taupe and white, and are made from dent-resistant plastic panels that assemble without tools. The wall-hung cabinet shown costs about \$80, and the free-standing cabinet about \$150. Both feature adjustable shelves, and are sold at hardware stores and home centers. Write Consumer Service, Rubbermaid Inc., 1147 Akron Rd., Wooster, OH 44691.

Dry Front Moving In

This ducted fan removes dampness from bathrooms to reduce mold growth and odors. It mounts on the wall outside the bathroom, and you connect to it with as much as 25 ft. of flexible dryer duct, allowing you to put the fan's intake anywhere in the room. Because the fan is outside—and operates at low air movement (75 cfm)—its manufacturer claims it's nearly inaudible. And it has a lighted switch to alert you that it's on. The Preventilator is capped by a motorized, insulated cover that is sealed with a rubber gasket. The device costs about \$300 through electrical supply houses, and heating, ventilation and air-conditioning suppliers. To locate a retailer, contact Tamarack Technologies, 15 Kendrick Rd., P.O. Box 490, West Wareham, MA 02576.



Full Speed Ahead

If your fan/light control won't let you run the fan at full speed and 100% brightness, consider this device that lets you do that and more. With a 3-speed fan that has pull-chain speed control, preset the fan to the desired maximum speed and then "fine tune" it to the desired rpm using the control. Also, the light can be adjusted to any level of brightness. The FLC300 costs about \$20 at hardware stores and home centers. Write Lamson Home Products, 25701 Science Park Dr., Cleveland, OH 44122.



Interesting Entry

Homeowners looking for a unique entryway might consider these doors in their search. The door on the left is Simpson's Ovation. Its frosted center lite is double glazed. The



Prairiefield (below) is inspired by the sparseness typical of the Prairie School of architecture, and features a grainlike motif etched into the triple-glazed lite.

Both doors are built from Douglas fir and Western hemlock. A 6-ft. 8-in. Ovation costs about \$740; the same size Prairiefield, \$840. Both

are sold at lumberyards and home centers. Write Simpson Door Co., P.O. Box 210, 400 Simpson Ave., McCleary, WA 98557.



The Next Wave

Trex may be the next wave in decking materials. It's a plastic/wood fiber composite that works the way wood does, says Mobil Chemical Co., its manufacturer. The product is designed to be more stable during changing humidity without producing splinters the way wood decking can. It weathers to a silver-gray color, and can be painted or stained. Incidentally, the deck's support posts and joists



are built from pressure-treated lumber.

Trex is sold at lumberyards and at building supply houses in nominal 5/4 x 6 x 16-ft. pieces (about \$20). For information, write Mobil Chemical Co., 800 Connecticut Ave., P.O. Box 5445, Norwalk, CT 06856.



Waste Not

These lights were designed to eliminate the energy loss associated with recessed lights. They remain cool enough that



attic insulation can cover their double-wall aluminum housing. Not only is this thermally efficient, it prevents condensation from collecting on the housing. Also, they have a peel-back self-adhesive gasket that seals the joint where the housing penetrates the drywall. The lights come with sliding bar hangers, each with a captive-ring shank nail. Slide the hanger tab against the ceiling joist and nail it home. The lights are sold through lighting showrooms, and electrical supply houses and contractors. Prices vary widely but start at about \$40. Write Juno Lighting, Customer Service Department, P.O. Box 5065, Des Plaines, IL 60017.



Step Out

The Cabrio is a roof window in which the top opens like a standard roof window, but the bottom opens to form a balcony. The product is the size of a large roof window (about 37 in. wide x 100 in. long) and works on roofs with slopes from 35° to 53°. The window has a low-E, argon-filled glazing, and the upper section rotates inward for cleaning. It costs about \$2600 (roof flashing included) at Velux dealers. Write Velux-America Inc., P.O. Box 5001, Greenwood, SC 29648.

Weathertight Tilt

Tilting windows are easier to clean than conventional double-hung types, and this product improves on the design, says its manufacturer, by providing weatherstripping on all four sides of each sash. To tilt the windows, you push aside a pair of small wedges at the base of the lower sash then tilt down the lower sash. The upper sash can then tilt in.



The window is available with a clear pine interior frame (the outside is vinyl clad). To further increase the window's versatility, it can be ordered with different glazings to suit your climate or budget. The windows are sold at Andersen dealers and cost from \$200 to \$300, depending on size. Contact Andersen Windows, Bayport, MN 55003.



Triple Play

If you're looking for a versatile vacuum, this machine is worth a look. Its dual-tank design allows you to switch instantly between wet and dry vacuuming without removing its cleanable filter. On each of the two deluxe models, you can detach its power head (the impeller and motor assembly) and use it to blow leaves—all without the aid of tools. The vacuum's pivoting casters are positioned away from the canister to make the machine difficult to tip. It's available in sizes from 6 to 16 gallons, from \$50 to \$130 at hardware stores and home centers. Write The Hoover Co., 101 E. Maple St., North Canton, OH 44720. **PM**





HOME IMPROVEMENT

Pour A Concrete Sidewalk

TEXT AND PHOTOS BY MERLE HENKENIUS

● If you've been thinking that a new sidewalk would solve some traffic problems around the yard, take heart. Pouring a concrete walk is a manageable do-it-yourself project. Yes, it can be hard work, and it will require careful planning and some friendly help, but concrete can be made to behave the way you want it to behave—both at the time of installation and after it's cured. The key is in understanding its peculiar properties.

Concrete is made up of sand, gravel, water, gypsum and, its key

ingredient, portland cement. Portland cement is made from crushed limestone that is fired in a kiln. When water is added to cement, a chemical process called hydration begins. The cement becomes a paste and in short order turns into a rocklike mass, provided that sand and gravel are mixed with it.

We should add that very little water is needed to make this recipe work. The more water you add beyond what is necessary for hydration, plus some for workability, the weaker

the cured concrete will be. Do not ask the delivery driver to add more water to the mix to improve its workability.

It's better to order concrete with a superplasticizing agent. This makes the concrete looser without reducing its strength. It's well worth the \$4 to \$8 cost it adds to each cubic yard of concrete.

Concrete basics

Concrete expands and contracts with freeze/thaw cycles, and to cushion this movement, you should install expansion joints where the walk begins and ends or in any situation where concrete is placed between two other concrete slabs. A good rule of thumb is to use 1 in. of expansion material for every 30 ft. of sidewalk.

One of the unalterable truths about

concrete is that it cracks. The best we can do is encourage it to crack on our terms by cutting control joints into it. The cracks will form under the control joints. Mixing concrete by hand is prac-

tical only for small jobs, so we will assume that you are going to have the concrete delivered.

Ordering concrete is easy. Estimate the cubic feet you need and convert it to cubic yards. Request a 3000-pounds-per-sq.-in. mix (referred to as a 6-bag mix, for six bags of portland cement per cubic yard of concrete). Also make sure that the concrete has entrained air, which is standard these days but still worth mentioning. Entrained air results from foaming agents being added to the mix. This disperses millions of tiny air bubbles throughout the concrete. The bubbles form air pockets that cushion the ex-

pansion caused by moisture that penetrates the surface and freezes.

Commercial concrete prices vary widely, but \$50 to \$70 a cubic yard (for 7 cu. yd. or more) is common. A substantial surcharge is applied to smaller quantities—1½ cu. yd. cost us \$125.

Installing forms

We wanted our sidewalk to be about 38 in. wide × 24 ft. long, including a curved section. Because of space restrictions, we had to pour it right against the house foundation. Keep in mind that there are two schools of thought in placing a sidewalk next to the house. One holds that it's better to leave a grass strip or flowerbed be-



1 Begin the sidewalk installation by stripping the sod from the form area. Dig a trench just deep enough for the forms.



2 Drive 1 × 2 pine stakes next to the form lumber. Align the stakes using a string pulled taut between two stakes.



3 Drive a double-headed nail through each stake and into the form behind it. This kind of nail is easily removed.



4 Join form lumber end to end by driving a deck screw through the edge of one piece and into the end of another.



5 The first step in installing a curved form is to drive a grade stake. Use a level to check that the stake height is correct.



6 Notch the end of the 2 × 4 form where the curved section will meet it. Screw the curved hardboard form to the notch.

tween the walk and the foundation to reduce the amount of rainwater that will splash from the sidewalk onto nearby surfaces, particularly siding. The other school says that a flower-bed could cause dirt splatters to stick to the siding after a rain. Since dirt holds moisture, this could be a problem for wood or steel siding. Based on that reasoning, the sidewalk should be placed next to the house.

For our forms, we used 2 x 4 lumber for straight sections and hardboard siding, ripped to 4-in.-wide lengths, to form the curve.

We began by snapping a chalkline 1 in. below the siding along the length of the foundation. This line marked the grade of the sidewalk along the house and became our reference point. We positioned the 2 x 4 form 1 in. lower than the chalkline. This gives the sidewalk a slope that would shed water away from the foundation.

Begin by digging a shallow trench for the form itself (Photo 1). We find that digging a shallow trench for the form first, then removing the soil for the form bed, reduces the tendency to over-excavate. Remember, if you dig too deeply you'll have to fill low areas with sand or gravel. You can't just shovel soil back into the space because it will settle and take the sidewalk down with it. If concrete fills the void, you'll encourage a crack where the concrete changes thickness.

Next, drive two stakes and stretch a string between them to mark the form's outside edge. Place a 2 x 4 against the string, and drive stakes along its edge every 36 in. (Photo 2).

Drive stakes below the top of the form, then nail through the stakes and into the 2 x 4 using double-headed nails (Photo 3). Use 3-in. deck screws to join form lumber end to end (Photo 4).

We installed the curved form last because we needed to fasten it to the straight 2 x 4 form. Drive a grade stake that will mark the top of the form. Check the height of the grade stake with a level (Photo 5).

To make a seamless appearance where the straight and curved concrete meet, cut a 1/2-in.-deep notch on the inside edge of the 2 x 4 form. Screw the hardboard to the notch using 1 1/4-in. deck screws (Photo 6). Next, bend the hardboard and drive a stake there. Space stakes along the curve at 18-in. intervals (Photo 7).

Shave off enough soil to get close to the finished grade then drag out the finished grade with a 2 x 4 (Photos 8 and 9). Finish the form bed by placing sand at low spots, then grade the



7 Support the curved form with stakes spaced 18 in. apart. The 2 x 4 form is supported every 24 in.



8 Use a pointed shovel—held at a shallow angle—to shave excess soil from the form bed. This prevents over-excavation.



9 The form bed depth should be consistent. Use a 2 x 4 to drag the bottom of the bed until the same depth is achieved.



10 Put the finishing touch on the form bed by filling in the low spots with sand. Don't fill these spots with soil or concrete.



11 Drive screed stakes along the length of the form. Drive a pair of angled nails into each stake to hold the pipe in place.



12 The screed pipe must be positioned above the opposite form to produce a slight slope. Check this with a level.



13 Use heavy-duty wheelbarrows to haul concrete to the forms. While one person hauls, another spreads the concrete.



14 Once all the concrete is in the form, saw a screed board across the form. This strikes off excess concrete.



15 Every 5 to 6 ft., withdraw the screed pipe from the concrete. Leave the screed stakes buried in the slab.



16 Use a shovel to sprinkle new concrete into the gap left by the screed pipe. Work this rough concrete smooth using a float.



17 After all the concrete is poured, use a wooden or magnesium float to bring water and cement paste to the surface.



18 Use an edger to round the concrete perimeter. This looks nicer and is less likely to chip than a square edge.

bed again with a 2 × 4 (Photo 10).

The final step is to install a screed. This is only necessary if you are pouring concrete against a surface other than a form, such as a foundation. We used 3/4-in. black pipe as a screed and installed it on top of stakes spaced 3 ft. apart. Drive sixpenny nails into each stake to hold the pipe (Photo 11).

Set the pipe on the stakes so it's level with the chalkline, and check it with a level (Photo 12).

Pouring and finishing

A concrete truck is heavy enough to crack a driveway, so we had the truck park on the street, and we hauled the concrete with heavy-duty wheelbarrows (Photo 13). With several loads of concrete in the form, we used a straight 2 × 4 as a screed board to strike off excess concrete (Photo 14).

After we had about 6 ft. of concrete in the form, we pulled the screed pipe back and sprinkled new concrete into the gap left by the pipe (Photos 15 and 16). We repeated this until all the concrete was poured.

Next, work over the surface with a hand float (Photo 17) to bring water and cement paste to the surface. Follow this by running an edger around

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TOUGH TOOLS FOR TOUGH JOBS.

the walk's perimeter (Photo 18).

Next, cut control joints with a groover at about 40-in. intervals using a 1 x 4 as a guide. Every few inches cut through the slab, along the control joint, using a pointed trowel (Photos 19 and 20). Finally, smooth the top edge of the cut with the groover.

Knowing when to trowel is critical. If the trowel leaves gray water and bubbles in its wake, then wait 20 minutes and try again. This moisture is called bleed water because it is the excess that bleeds from the concrete. Allow it to evaporate before troweling or you will produce a weak surface. Work with the trowel held flat, and place slightly more pressure on the trowel's trailing edge than on the front edge (Photo 21). This technique ensures that the trowel will move smoothly over the surface without catching on pieces of gravel. Most surfaces require two separate trowel passes.

After the troweled finish begins to set, draw a soft-bristle broom over the surface to produce a slip-resistant finish (Photo 22). Cover the concrete with plastic sheet for about six days to help it cure slowly. This greatly increases its strength. Finally, gently pry the form away from the concrete using a claw hammer.



19 To make a control joint, lay a 1 x 4 down as a guide, then run a groover along it. Place a control joint every 40 in.



20 Cut into the control joint every few inches with a pointed trowel. This ensures that cracks will be under the joint.



21 Hold the trowel flat and apply more pressure to its trailing edge to prevent it from chattering. Sweep it in wide arcs.



22 Use a broom to rough the surface for better traction. Cover the concrete with plastic for six days to keep it moist.

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TOUGH TOOLS FOR TOUGH JOBS.



Homeowners Clinic

BY NORMAN BECKER, P.E.,
Contributing Editor

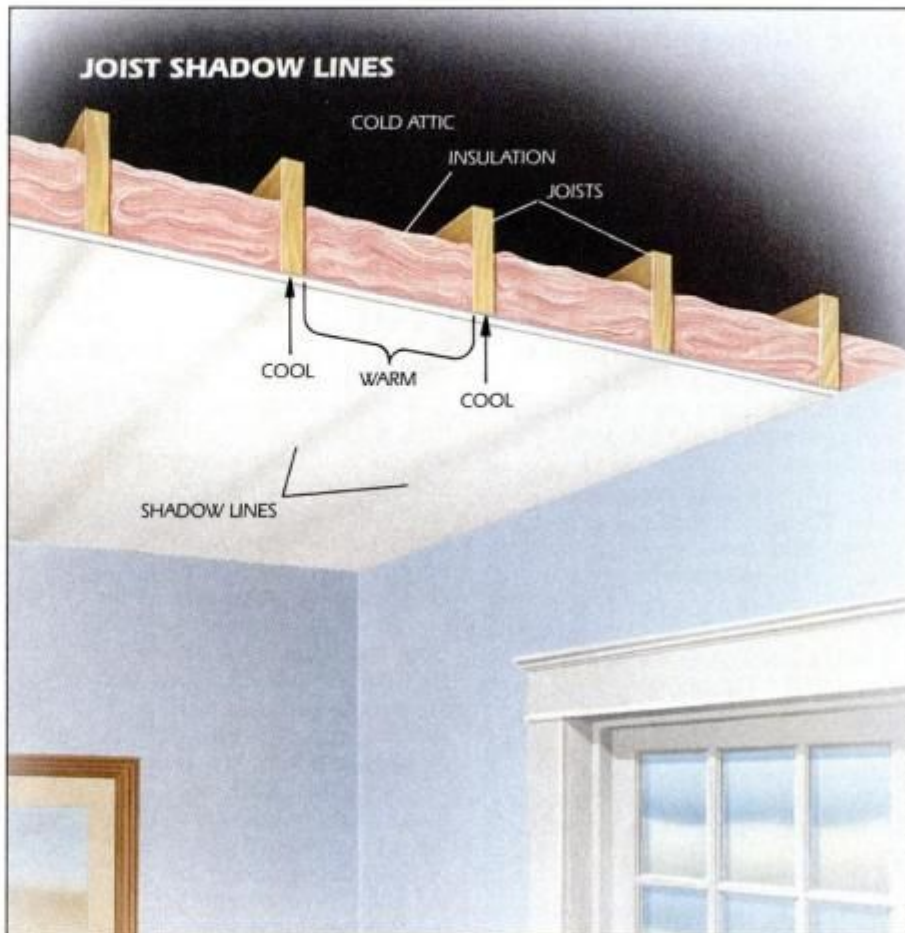
Joist Shadow Lines

There are dark lines on the drywall ceiling below the attic in my house. The lines coincide with the ceiling joists. Someone suggested it is because of a lack of insulation. However, we have 6-in. batts in the attic. Do you have a cure for this problem?

BOB MAZZA
BURLINGTON, MA

Although you have insulation between the joists in the attic floor, the tops of the joists are exposed to the low winter temperatures in the attic. Since the wood joists are not effective insulators, they act as thermal bridges. Consequently, the temperature at the underside of the joists (at the drywall ceiling) is lower than the adjacent sections of the ceiling that are covered with the insulation batts. Because of the lower temperature below the joists, condensation (however slight) tends to form along these areas. Over time, the moisture traps dust and also results in mildew growth, which shows up as shadow lines.

To prevent this from recurring, first paint the ceiling. Use a paint containing mildewcide. Next, install insulation batts over the exposed ceiling joists. Ideally, the insulation should fill the spaces between the joists and cover the tops of the joists as well. This last layer of batts is



Moisture condenses on the cool area below each joist. Over time, this condensation collects dust and forms mildew, which appears as dark lines.

installed perpendicular to the joists.

However you install the insulation, make sure to use a type that does not have a foil or kraft-paper vapor barrier. And be sure additional insulation does not cover soffit vents or recessed light housings (unless the housings are IC types rated for direct contact with insulation).

Asbestos Siding

We own a 1950s-era house that has asbestos shingles on the sides and back and vinyl siding on the front. The shingles are in good condition, but we are concerned that they will be a factor in selling our home. If the shingles are removed, will their disposal be difficult?

JOHN O'SHEA
YORKTOWN HEIGHTS, NY

Although the shingles are referred to as asbestos, they are really asbestos cement shingles. That is, the asbestos fibers are encapsulated in cement. As long as the shingles are in good condition, there is no problem. However, if they are abraded or sawn, asbestos fibers can be released into the air.

If the shingles are in good condition, they are generally not a factor when the home is sold. Nevertheless, there will always be buyers who try to make the shingles a part of the sales negotiation. Even if the shingles are in poor condition, they don't have to be removed. You can install new siding over them.

Removing the shingles is expen-

Low-Cost Info

● Maytag offers a pair of buying guides that can help you shop for a washer or dryer. They offer both general information and Maytag's opinion on how an appliance should be built.

For example, the washer guide advises you to inquire about the inner shape of the washer's agitator cone. If the cone's inner cavity is cone shaped, says Maytag, it will trap an air bubble that prevents water from reaching the driveshaft seal. You can bet Maytag machines have this feature, and we think this is a point worth discussing with an appliance dealer.

The dryer guide covers topics such as drum finishes and propane



conversion kits for gas dryers. Send 25 cents per guide to: Maytag, Consumer Information Center/How-To-Buy Booklets, Newton, IA 50208.

—Roy Berendsohn

Free Paint Help

● This is the next best thing to a neighbor helping you paint your house. If you have questions about a painting project, call Sears. It's not widely known, but Sears operates a toll-free line to answer painting questions. The number, (800) 972-4687 (800-9-paints), fields an astounding 120,000 calls a year. The line operates Monday through Friday, 9 am to 7 pm Eastern time, and Saturday, 10 am to 5 pm.

Here's a quick look at the top five questions asked of Sears' paint technicians.

1. Can I paint latex over oil?

Yes. Clean the surface and dull glossy surfaces using sandpaper. Remove dust before painting.

2. Do I need a primer?

In some cases, yes. Use exterior primer if an outside surface is bare or chalked. The company recommends using its latex primer before painting interior drywall that has an existing coat of paint in poor condition or on bare drywall.

3. How do I prepare a surface to paint?

*A. Clean the surface (Sears recommends its Wall and Ceiling Cleaner, No. 62814, for interior surfaces and Heavy-Duty Cleaner, No. 62826, for exterior surfaces).
B. Dull glossy surfaces.
C. Check that the surface is dry.
D. Otherwise, follow the directions on the can label.*

4. What are the best weather conditions to paint in?

It's best to apply paint at 65° to 85°F. Avoid painting in direct sunlight, or in cold or rainy weather. Likewise, don't paint if a heavy dew is likely before the paint can cure or if the weather will turn cold before the paint can cure.

5. How do I remove mildew?

Make a solution of 1/3 bleach, 2/3 warm water. Apply the solution, let it stand for 10 minutes then hose it off. Really dirty areas may require some scrubbing. Use a paint that contains a mildewcide, which will inhibit mildew growth.

—R.B.

Adjusting An Electric Range Thermostat

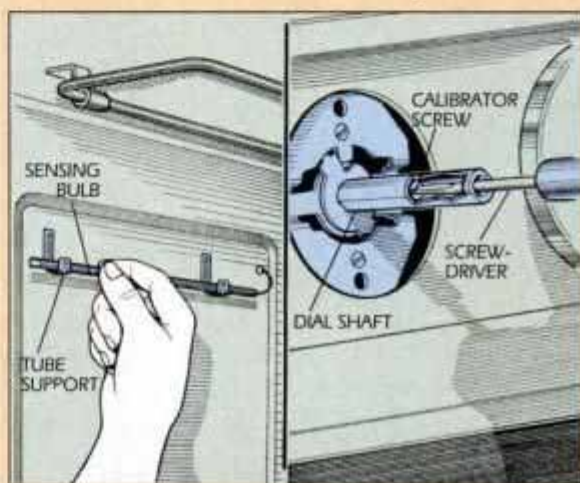
● An electric range should operate with the oven control dial matching the oven temperature. Adjusting the appliance to do this is not difficult and is a good way to get more consistent baking performance.

Begin by checking the sensing bulb. Look to the rear of the oven, and you will see a long, thin bulb attached to the oven wall. Check that it is not loose. Next, use a mercury oven thermometer (available at large hardware stores) placed in the center of the oven to check the temperature. Set the oven dial to 400°F, and let the appliance cycle on and off several times. Record the temperature with each cycle.

Average the temperatures. It should be within 25°F of the dial setting. If it isn't, adjust the oven thermostat. To do this, on the most common calibration mechanism, first remove the oven control dial. Then, using a thin-blade screwdriver, move the calibration screw at the bottom of the shaft while holding the shaft with pliers. A quarter turn of the screw changes the oven temperature about 25°F. A clockwise turn increases temperature and counterclockwise decreases it.

Check the oven temperature as before. If after several tries you cannot get the temperature to match the dial setting, replace the thermostat.

—Steve Toth



sive, since the work must be done by a licensed asbestos removal contractor. The waste will have to be disposed of in a landfill designed to take this material.

Garage Door Control

My daughter has a 10-year-old garage door opener that needs repair, but the repairman says the manufacturer told him replacement parts are no longer available. Can you help?

ROY RAASCH
EUCLID, OH

Even if the parts were available, the repairman might not want to install them because the door does not meet current safety standards. The garage door opener does not comply with recent guidelines established by Underwriters' Laboratory (UL

Standard 235). This is important because, between 1982 and 1988, 48 children between the ages of 2 and 14 died from being trapped under garage doors that were operated by automatic openers.

Federal law mandated that as of Jan. 1, 1993, all new residential garage doors must comply with UL 235. This requires that garage door opener assemblies include a photoelectric sensor or other device that will reverse the door if it comes in contact with someone or something as it is closing. It also requires the apparatus to automatically disable the opener should the sensor malfunction.

There are no federal restrictions on repairing older residential garage door openers, but several states require that these older devices be brought into compliance with UL 235 at the time repairs are made to them.

PM

DO YOU HAVE A HOME-MAINTENANCE OR REPAIR PROBLEM?

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

BUZZWORD

● ● ● Air Handler

● You might think "air handler" has to do with flying dirigibles. Actually, heating contractors use it as a general term to describe a mechanical

device or assembly that moves air. The term encompasses devices such as blowers, filters and dampers.

—R.B.

CAR CARE

CAR CLINIC

BY MIKE ALLEN,
Associate Automotive Editor

Off The Rim

I'm trying to replace the brake shoes on the rear end of my pickup truck. After 85,000 miles, they're finally down to the rivets—at least judging by the grinding noise they make they are. I got the brake drum loose from the hub after some banging, but I can't seem to get it off all the way. I disconnected the handbrake cable, thinking that the handbrake might be partially on. The drum feels loose, but it won't come off.

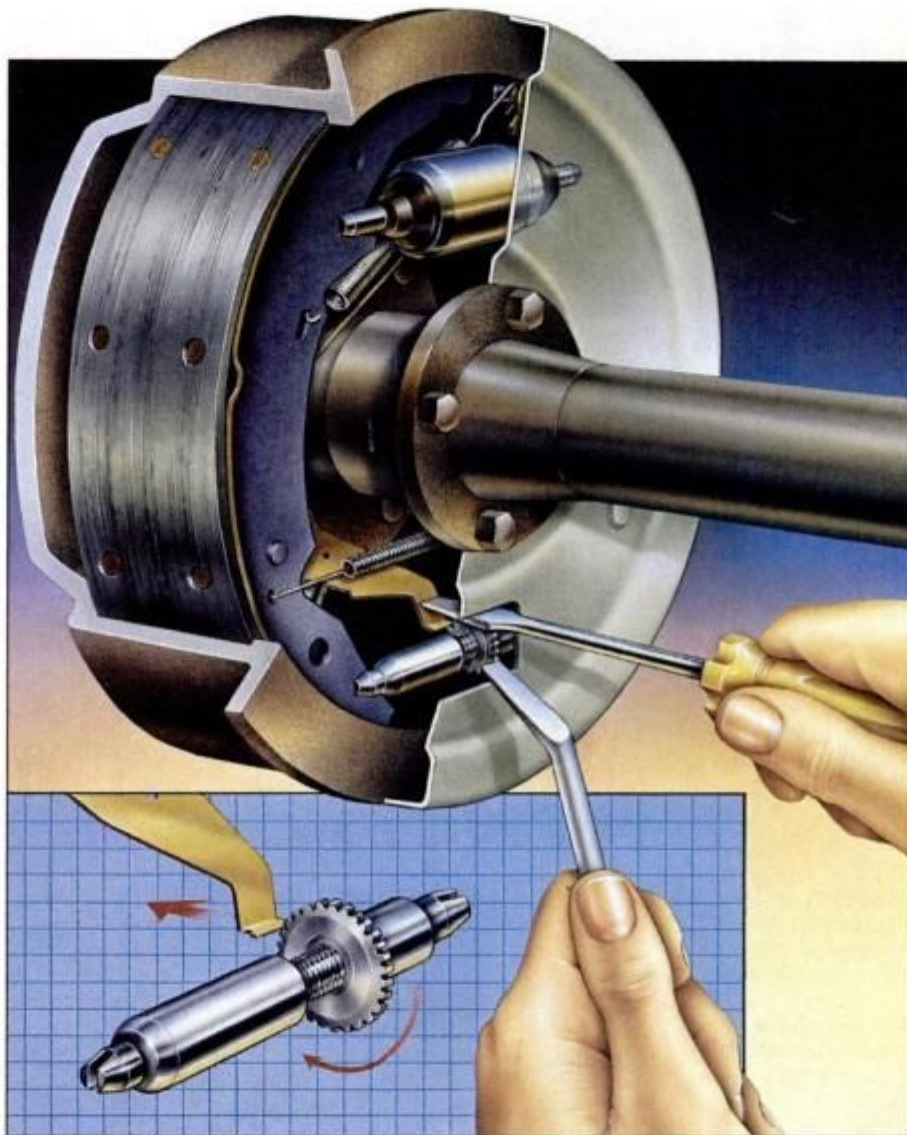
JOHN LONGACRE
STAMFORD, CT

You need to retract the brake shoes' self-adjusting mechanism. When the drum is worn, there's a lip that remains inboard of the area where it contacts the shoes. The self-adjuster expands the shoes to take up the slack, and when you want to remove the drum, the lip won't fit over the brake shoes.

Your particular truck may vary slightly from the illustration, but the principle is the same. With the truck up on safety stands and the wheel removed, crawl underneath. There's a hole in the brake backing plate, probably with a rubber dust cap. Remove the dust cap and insert a screwdriver into the hole to push the self-adjuster lever back to clear the teeth on the adjusting drum. While you're holding the lever clear, insert another tool and ratchet the toothed drum to retract the shoes. I've shown a special brake-adjusting tool, but you could just bend the end of a cheap screwdriver.

Which way to turn? Well, if you turn the wrong way, the drum will lock up as the shoes expand. It may take more than a dozen turns in the correct direction to clear the lip.

If the drum has a lip, it almost certainly needs to be machined to true it and remove the lip. If the lip is really bad, you may need to replace the drum—the machine shop can tell you if there's too much wear.



Broken, Or Just Broken In?

While on a recent 1800-mile trip in my new car, I was passed by a number of cars going considerably faster than the 55 miles per hour I was maintaining to break in my new engine. What struck me about some of the cars passing me was that they had dealer plates, and judging by the cleanliness of the undercarriage, were being ferried from one dealer to another.

Aren't new engines likely to be harmed or permanently damaged by such treatment? What problems might arise for the unsuspecting buyer of a new car?

D.C. LUCAS
HENDERSONVILLE, NC

I don't recommend abusing a new engine. But the manufacturing process is considerably improved from a generation ago. Clearances and tolerances inside engines are much tighter, and the tradition of running in a new motor is hardly necessary. With axle ratios, in the interest of fuel economy, as high as they are, a late-model car is probably running at a lower rpm at 75 mph than your '55 Chevy ran at 55 mph when it was new.

The best thing for a new motor is to avoid running it hard until it's warmed up. I'd wait 1000 miles or so before towing much of anything. And I don't think I'd wait until the factory-recommended mileage for the first oil change, either.

Water Baby

I bought a '93 Pontiac Grand Am with a 2.3-liter engine. While checking the fluids, I noticed water in the oil (coffee-color sludge on the dipstick). The dealer and the customer satisfaction hotline say this is normal for this engine.

Just because it's designed this way doesn't mean it's right—my concern is for the life of my engine.

HOWARD SCHEMMELE
CONCORD, OH

The problem of water in the oil relates to the fact that coolant occasionally will find its way past a head gasket or a crack in the block or the cylinder head and then down into the oil pan. The water and glycol in the cooling system will turn your oil into an acidic mayonnaise—that is, a mixture that doesn't lubricate, and it corrodes everything it touches. This is, as former President Bush said, "Bad, bad, bad."

In all likelihood, this is probably not what's happening to your engine. There is a certain amount of condensation inside your engine, especially in colder areas such as the dipstick tube or around the oil-filler neck. The detergents in the oil emulsify this water into a light-brown sludge that mimics the aforementioned pseudo mayonnaise. This is particularly likely to happen during colder weather and short-trip driving, when there isn't time for the engine to warm up fully and drive off the moisture by evaporation.

If you're really concerned you've got a leaky head gasket or some other serious problem, oil analysis will spot it instantly. Water is a normal contaminant of crankcase oil, but the spectrograph used for oil analysis will spot the chemicals in coolant right away, even in concentrations smaller than a spoonful in your oil system. And if you do have coolant in the oil, an engine tear-down is next. **PM**

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DO YOU HAVE A CAR PROBLEM?

Just ask Mike about it. Mail your question to Car Clinic, Popular Mechanics, 224 W. 57th St., New York, NY 10019. While letters, faxes or phone calls cannot be answered individually, problems of general interest will be discussed in the column.

SERVICE TIPS

- If your Ford Ranger or Explorer has a knocking noise at startup that's more audible at lower temperatures, it may not be piston slap or loose lifters. There's a revised fuel-line assembly to cure knocking noises associated with hydraulic knocking inside the fuel system.
- Got a 1990-93 Cavalier, Corsica, Beretta, Lumina or Lumina APV with a 3T40 transaxle? Does the trans sometimes start off in second gear when the gearshift is in D2 and the engine is still cold? Chevrolet says the condition is caused by thick, cold ATF and goes away when the trans warms up. Therefore, no service is necessary.
- Does your 1993 Mazda 626 or MX-6 miss or hesitate whenever you corner hard and the fuel tank is nearly empty? Mazda has a fuel pump pickup repair kit to fix this without having to replace the more expensive fuel-pump assembly completely.
- Pontiac says not to use penetrating oil or WD-40-type lubricants on sticking door locks, as they may wash off the original thicker lubricant. They specify GM No. 1234-5120 lube, 5W30 motor oil or silicone spray for sticky locks.

MAINTENANCE BASICS

CHANGING ENGINE COOLANT

BY DON CHAIKIN,
Automotive Editor

● One of the constants of auto care is the need to flush and refill your engine's cooling system at least every other year. Better still: Inspect the entire cooling system and replace the coolant each year.

Besides keeping your engine from overheating, a properly working cooling system ensures that the engine is operating at its most efficient temperature. In addition, your warmth and comfort inside the car depend on the engine's cooling system.

Be sure that the engine is cool before beginning.

● Squeeze all of the hoses—upper and lower radiator hoses, as well as heater hoses. They should all feel firm yet pliable.

● Replace any that are brittle, mushy, bulging or cracked. Replace any hoses that are more than four years old.

● Check the radiator cap by inspecting its rubber sealing gaskets and spring.

● Check the coolant overflow reservoir for pinholes, cracks or any other signs of leakage.

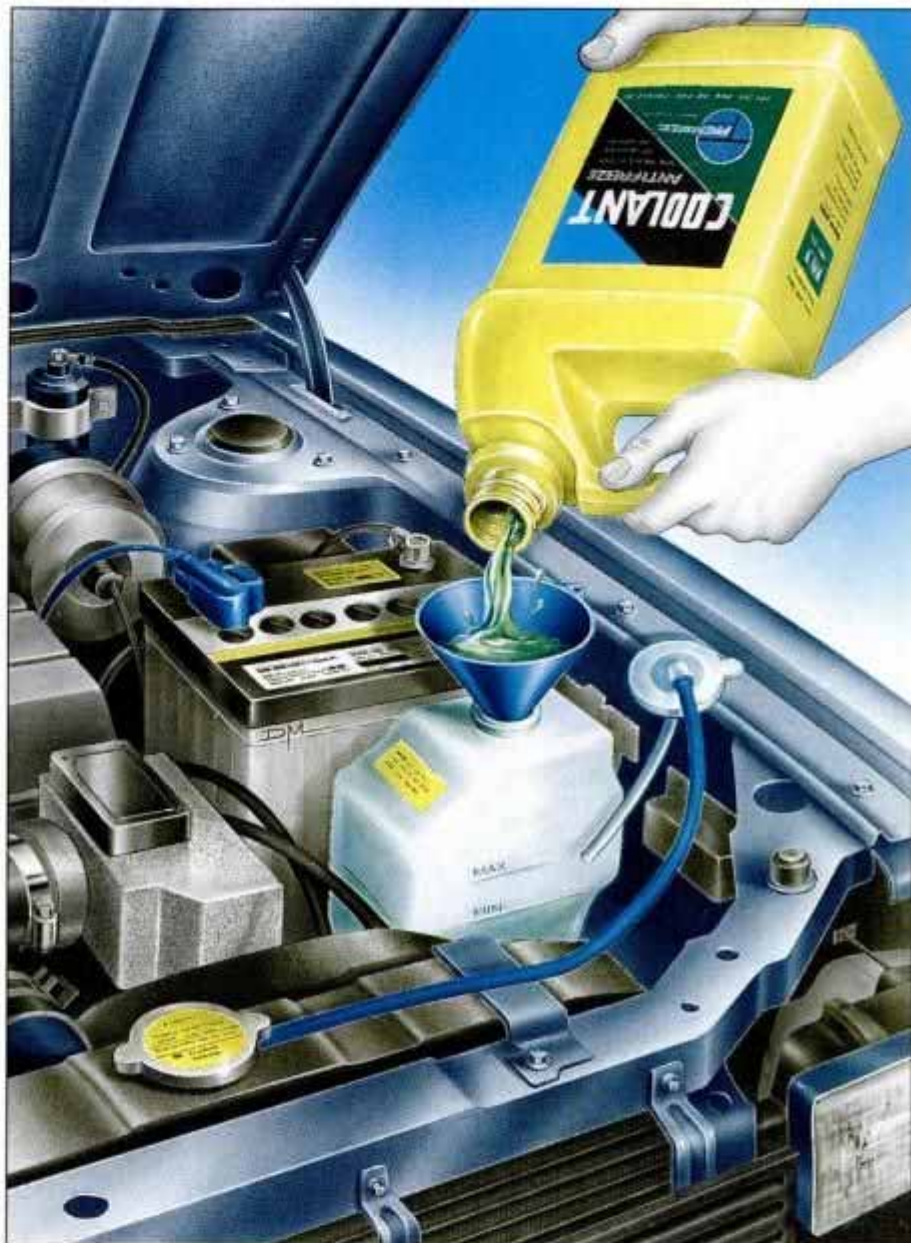
● Check each hose end to see that the clamp is snug and that there are no signs of leakage.

Next, drain the old coolant into a large catch basin. Engine coolant is poisonous, so take care not to let children, pets or wildlife lap up your drained coolant. Thoroughly hose away any spillage.

Also be aware that though engine coolant is biodegradable, some of the contaminants in used coolant are not. Do not pour old coolant onto the ground or down a storm drain. Take your old coolant to a repair shop that has the equipment to clean and recycle the coolant, or take the coolant to a recycling center.

● Place a large basin (at least 2 gallons) under the radiator. Loosen the petcock or remove the drain plug at or near the bottom of the radiator.

● If you can't find the drain or if it's stuck, loosen the lower radiator hose.



● Open the radiator cap and move the heater control valve on the dashboard to maximum HEAT.

● Slowly run cool water from a garden hose into the open radiator. When clear water is coming out of the radiator, the radiator has been drained of most of its coolant. Shut off the water and let the radiator drain.

This method only partially drains the cooling system. A more effective way of flushing the system involves using a special reverse-flushing kit. These simple-to-use kits cost less than \$10 at auto parts stores and large discount department stores that sell auto supplies.

The kit includes a T that is spliced into the heater-inlet hose. A garden hose is attached to the T and water flows through the engine, heater core and radiator.

Regardless of how you flush the cooling system, be sure to tighten the petcock or replace the drain plug. Be sure all hose clamps are snug. Then refill the cooling system with a mixture of fresh antifreeze and water.

● Pour the coolant in slowly, allowing air to escape. You may have to do this several times—possibly over a period of a few days—to allow all the trapped air to escape.

A 50/50 mixture of water and antifreeze/coolant is fine for most cars.

If you live in an extreme climate, you may opt for a stronger mixture with more antifreeze/coolant. Do not exceed the maximum strength as listed on the antifreeze container.

● Replace the radiator cap securely.

● Check the coolant level daily over the next week or two until you're certain that the level is stable.

FM

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SATURDAY MECHANIC

PLUGGING LEAKS

BY PAUL WEISSLER

● The sweat pours down your brow as you lift the hood while gasoline gurgles into your tank in the self-serve lane. Through the shimmer of heat that escapes from underhood you lean over to check the level of bright-green coolant in the translucent overflow tank. Empty, again.

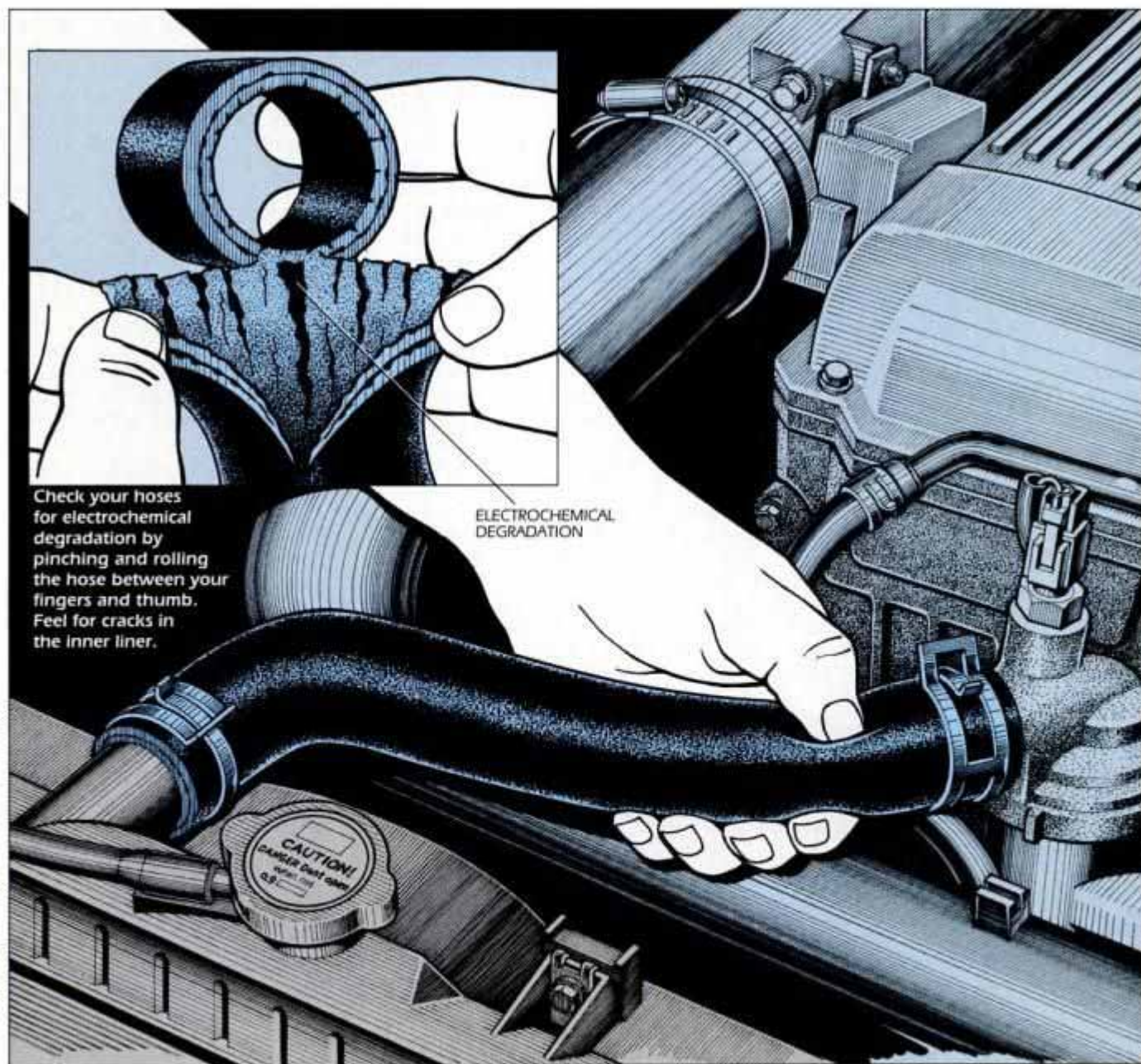
You've topped it up a few times—but the last few tankfuls it's been dry inside. In fact, coolant seems to be

disappearing at an accelerating rate. The weather is getting hotter, and you're about to take a vacation. It's time for some action.

It should be easy to prevent most major coolant leaks since they usually occur when a hose fails. And you should be able to spot the bad hose before it bursts by those telltale signs of heat cracking and other deterioration, right? Wrong. While coolant

hoses near the end of their useful lives used to show the classic warning signs, they no longer necessarily do. Today's hoses are so much better you can't tell only by looking.

You should also be able to easily spot a coolant leak, even a small one. After all, the antifreeze contains a green dye that leaves a stain. Well, the truth of the situation is that your current model engine may have



Check your hoses for electrochemical degradation by pinching and rolling the hose between your fingers and thumb. Feel for cracks in the inner liner.

ELECTROCHEMICAL DEGRADATION

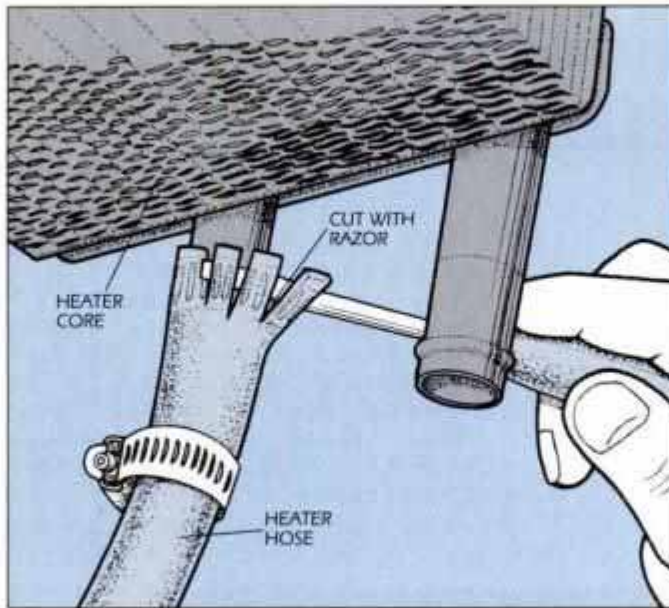
more than a dozen hose connections—and other joints sealed by gaskets and O-rings—and many of them are buried. To top off the problem, there are ways that coolant can escape from the system without leaving so much as a trace.

Even when you find the leak, it may take some special steps to fix it. Result: Finding, fixing and preventing future coolant leaks involves a lot more than it used to. But if you take the time to do the job right, you'll be able to avoid the repeated need to top up the system, and the disaster that would occur if you forget.

Fixing obvious leaks

If a leak is obvious, such as a leaking radiator, cracked hose or badly leaking joint, that's great—a solid starting point. If it's an O-ring type at a coolant pipe, clean the groove if necessary with ultrafine sandpaper or steel wool. Wipe clean, and then replace the O-ring, lubricating it with antifreeze. Leaky radiator? Check with a radiator shop, and you may get away with an inexpensive repair.

It might be possible to resolder a split seam or a leaking joint at the neck/tank junction without even removing the radiator from the car. Even leaky plastic-tank radiators can sometimes be repaired by replacing the O-ring between the end tank and the aluminum core. This is definitely a task to leave to a professional, however. It's a hose? If the clamp is not tight, and the leak is from the hose end, perhaps the hose has taken a compression set under the clamp. Try a simple retightening—but don't overdo it, or you'll distort the hose and neck, and just end up with a worse leak than you had.



Remove a stubborn hose by carefully slicing it. Don't nick the pipe it fits over. Heater cores are prone to being damaged easily.

Tightening the clamp doesn't help? Replace the hose. Uh-oh, it's stuck. Grab it with pliers and twist? Not unless you want to crush the hose neck and make it impossible to seal properly. Better to cut it off instead.

With a razor blade, slit the leaking end of the hose at several points around the circumference, gently pry up each slice, then peel the rest of the hose end. Don't nick the spout on the radiator or engine, or it'll never seal again. Clean the neck—on the radiator, engine, heater core, connector pipe or whatever—with a wire brush and wipe clean. Then install the replacement hose, using fresh antifreeze as a hose lubricant.

Radiator necks are generally pretty sturdy, but heater-hose pipes are usually very fragile. Twisting and prying to remove a hose—or replace it later—can easily break the seal between the pipe and the heater core's tank. And removing a heater core to repair or replace it can involve removing half of the underside of the dash-

board—an operation that can consume a dozen hours or more. Use caution.

Unless there's lots of slack in the hose, don't try to trim the cut end and reuse it. What's left probably will kink and ultimately restrict coolant flow.

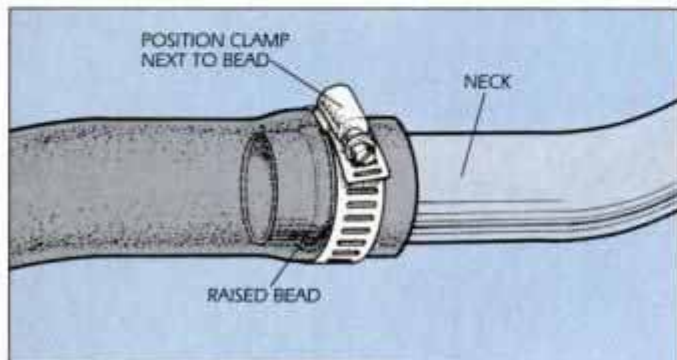
Use a new clamp and position it correctly for a leak-free connection, being extra careful if there is any damage or distortion to the hose neck. The two best types of clamps are the constant-tension spring band and the 360° adjustable double-band. A decent-quality, worm-drive tangential-force clamp, with a slotted band that won't dig deep into the hose rubber or cut it when you tighten, also does a good job. The screw-

tower clamp, widely used as original equipment, is tolerable for a brand-new system, but is about the least effective for resealing.

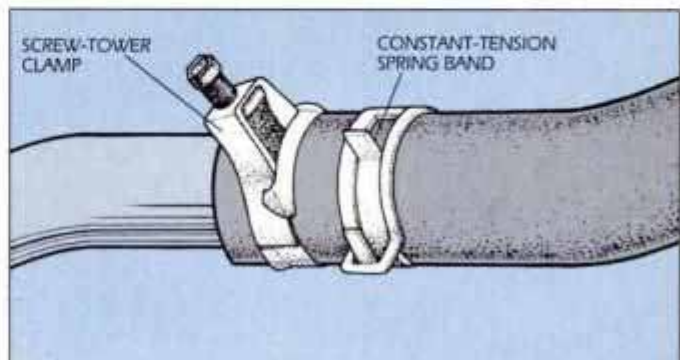
Install the hose as far as possible on the neck, and if there's a stop, right up to it. Position the clamp carefully so that it's about midway between the end of the hose and the end of the neck, typically about 1/2 in. or more from the end of the hose. If there's a raised sealing bead on the neck, position the clamp flush against the back side of it. If it's any distance away, it won't seal as well and it will force a crevice between the hose and neck. Coolant will collect and stagnate in the crevice, accelerating corrosion (and erosion) of the neck, eventually resulting in a significant leak. If a hose neck is badly distorted or eroded, get it reshaped or repaired by a radiator shop if you expect it to seal.

Finding hidden leaks

Sure, you have to look hard to inspect all the hose connections, O-rings and



Don't give coolant a place to collect between the clamp and the sealing bead, or you'll give corrosion a place to start.



OEM screw-tower clamps don't seal nearly as well as spring clamps. A regular worm-drive clamp provides a tight seal, too.

gasket joints, but you can get some help if you first pressurize the system with a cooling-system pressure tester. Pump up the system to its rated pressure plus a couple of psi. If the gauge reading holds for 2 minutes or so, the cooling system isn't leaking—at the moment. However, you may still be losing coolant.

Does the gauge's reading start dropping almost immediately? That tells you the system isn't holding pressure, and if you start looking you should see leakage from the offending joint or possibly the water pump's weep hole. All water pumps seep a minor amount of coolant (there's no such thing as a perfect seal), but if you see steady dripping or more, the pump seal is bad. Replace the pump.

Okay, the pressure gauge reading

you are really looking for them.

- The engine periodically runs so hot that coolant fills the overflow reservoir and overflows it. Or the pressure-cap valve is weak, so that coolant flows from the system into the reservoir even under normal operating temperatures. Check the coolant level in the reservoir immediately after getting stuck in heavy traffic. If coolant is ready to pour out of the reservoir vent, pressure-test the cap to see if it's holding the specified pressure.

On systems where the reservoir is pressurized, inspect the radiator-cap valve seal for deterioration. A bad seal can allow coolant to be lost by evaporation.

If the cap is good, next check the antifreeze concentration with a hydrometer. If the percentage of anti-

rial, combined with the coolant, form an electrical cell that produces a low DC voltage, particularly at high coolant temperatures. Over a period of time, the electrical flow is enough to cause fine cracks to develop inside the hose, starting at both hose ends and working along the length of the hose. Eventually, the hose develops a pinhole leak or may even burst.

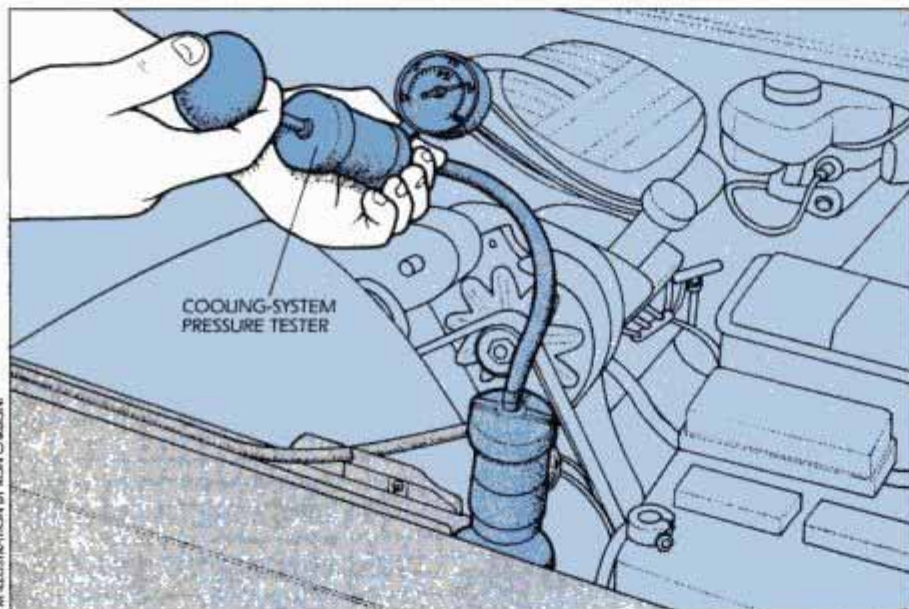
You can't see this damage, but you can feel it. Wrap your thumb and two or three fingers (not your whole hand) around the hose at the end and feel with your fingertips for soft "channels." Run your fingers around the hose to develop a mental picture of what the inside circumference of the hose must look like. Work your way from each hose end toward the center of the hose, and if the hose feels more solid as you approach the center, it's probably suffering from ECD. According to studies by Gates Rubber Co., most upper radiator hoses, for example, are ready to leak (if they haven't already) after about four years of service.

So if any of your cooling system hoses fails this fingertips test, drain the system, cut the hose and peel it off. And install new premium hoses designed to resist ECD. You can get silicone hoses, but newer designs of another synthetic, EPDM, are less prone to tearing and are designed to resist ECD. Secure them with good-quality clamps and your engine should keep its cool.

If you're topping up your system after a leak, all you really need to do is add a 50/50 mixture of coolant and water to the radiator. But if you've been topping up with water, you have no real idea of the relative concentration of the two fluids. Perhaps you've been using water from some roadside ditch or rain puddle—a better proposition than walking or melting an engine for sure, but one that requires you to drain the cooling system completely and flush it.

If you've flushed the system for whatever reason, don't just start pouring 50/50 coolant into the radiator. There are still several quarts of water in the system that won't drain, and they'll leave you with a low concentration of glycol. Instead, look up the capacity of your cooling system in the owner's manual or the shop manual. Add half that amount of undiluted coolant, and top it all off with pure water.

You did collect the spilled, toxic coolant for proper recycling or disposal, didn't you? **PM**



Pump your system up to a couple of pounds higher than the rating on the radiator cap to check for leaks. You can rent the tool for an afternoon.

hardly bugged, and you're still losing coolant. Now the diagnosis gets a bit tougher, because there are these possibilities:

- The leakage only occurs with a hot system. Run the engine to warm up the system and retest.

- There is minor seepage from many joints and it all adds up. If your engine's cooling system has a lot of connections, inspect them all for even the slightest trace of coolant staining. Simple retightening of all the hose clamps may do the job.

- The leakage is from the overflow reservoir, which is at atmospheric pressure and isolated from the pressurized part of the cooling system. Hairline cracks in reservoirs often result in leaks that travel along body seams and are detectable only if

freeze is low (below 50%), the coolant will boil at a lower-than-normal temperature and contribute to the problem. If the problem is the coolant running too hot, a poor cooling system condition may be responsible. This would include low coolant level, an electric fan coming on too late (or a mechanical clutch fan slipping), a defective water pump, a plugged radiator or even something as simple as a bug-and-road film coating on the front of the condenser or radiator. Such a coating blocks the cooling airflow.

Preventing future leaks

Today's hoses fail more often from the inside, because of a problem called electrochemical degradation, the catchy ECD for short. The metals of the cooling system and the hose mate-

WATCH YOUR BACK!

Smokey is sneaking up on you from behind, laser gun in hand. This new radar detector lets you know.

BY REBECCA DAY

● It's the end of the month, and you're cruising down the interstate at a clip that's between a quarter and a half dollar over the speed limit. The laser/radar detector on your dash is chillin', your tunes are crankin', and it's

just a matter of minutes between you, a brew and a ballgame. Life's great, you're thinking. Then you're zapped.

You had everything covered but your backside. The cop sitting on the entrance ramp with his laser gun targeting your taillights just met his quota, and your town is going to make budget this month thanks to you. You never had a chance because conventional laser detectors only point forward, they can't protect you from being shot from behind. Until now, that is.

A new line of speed-trap busters from Bel-Tronics, manufacturer of laser and radar detectors, defends you from both front and rear laser shots. Called the Plus series, the detectors pack a periscope-like device that extends above the housing of the unit, senses the laser from either the front or the rear, and channels the information to laser diodes inside the unit.

Unlike radar guns, which scatter radio frequencies in all directions, around corners and over hills, lasers have a narrow bandwidth and require a direct hit in order to nab their targets. Ideally, a patrolman needs to set the laser gun on a tripod and point it through an open window in favorable weather so that neither windshield glass nor moisture interferes with the beam. A laser gun must be trained on its target either from the front or



from the rear, and according to Donal Rich, vice president of sales and marketing at Bel-Tronics, the rear lights provide better reflectivity and therefore more accuracy.

When operated optimally, a laser gun is very accurate and very fast

beam. The Bel-Tronics models have off-axis coverage that provides a 130° field of view, which the company claims is the broadest coverage of any laser detector on the market.

The suggested list prices for the Bel-Tronics Plus series start at \$279 for the BEL 610i-P and go up to \$499 for the 645STi-P. Prices go up along with range and features. The top-of-the-line BEL 645STi-P boasts 40% more range than the midlevel 635i-P (\$359). Range is determined by the strength of the gun being used and by environmental conditions. The top model also incorporates Shadow technology, which is electronically immune to detection by police radar-detector detectors.

All five detectors in the product line cover all of the frequency spectrums that the FCC has made available for speed detection, including X band, K band, the recently allocated Super Wideband Ka and laser. Rich says the Plus series is like having three radar detectors in one housing because, unlike certain radar detectors on the market that use a fundamental frequency and its harmonics to detect K and Ka band radar signals, the Plus units use a separate fundamental frequency for each of the three bands. The result is fewer false alarms, he says.

The Plus detectors are made by Tracor Aerospace in Austin, Texas, which is best known for the laser detectors it has devised for the military. U.S. Apache helicopters used Tracor laser detection during the Gulf War to monitor Iraqi laser-guided surface-to-air missiles. **PM**



An eye for the back of your head.

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Laser guns aren't strictly line of sight. Just as certain infrared remote controls will work when pointed in the general direction of a component's infrared sensor, laser guns may be somewhat off-axis when targeting a car. To compensate for this, laser detectors incorporate off-axis detection to sense energy outside the main laser

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Crazy 'Bout Bikes

BY JOE SKORUPA, Boating/Outdoors Editor



● At some point in the not-too-distant past, bicycles became as standardized as refrigerators. Sure, there are a couple of different styles, such as drop-handlebar racing bikes, fat-tire mountain bikes and hybrid bikes that combine features of both. But let's face it, these are variations on the same theme. It raises the question: Is that all there is?

Not necessarily. Out of a total universe of 100 million bikers in the United States, a solid core remain devoted to speed (à la racing bikes) and ruggedness (à la mountain bikes), but a growing minority like to ride for the simple joy of riding. Fast-twitch leg pumping is fine if all you want is to turn the great outdoors into a workout room. If, on the other hand, you want to appreciate the scenery and enjoy yourself, then you're probably not too thrilled by the current state of bike design.

Bike builders have gradually begun to recognize this situation, and some new products reflect a change in direction. Specialized, for example, recently



introduced the Globe series of bikes (\$299 to \$429), which features retro styling and user-friendly features.

For starters, Globe models sport simple 3-speed or 7-speed gearsets, which are all most people need. Second, they're equipped with features that had once

seemed gone with the wind, such as a sit-up riding posture, fenders, a chain guard and a handlebar bell. Some have rear carrying racks.

With distinctly 1950s lines and features, the Globe series is definitely a niche product, but this is exactly what's needed to pump new life into a market that seems to be a victim of arrested development. These are products that have personalities as opposed to Xerox copies.

Cannondale also has a niche-market bike, the C2000, which is the flagship model in the company's new Commuter series. According to Cannondale, there are from 2 million to 3 million commuters who pedal to work regularly. Naturally, these commuters need a bike they can call their own, one with a rear carrying rack, kickstand, bell, upright seating and (I'm not kidding) biodegradable wooden fenders.

In addition to the retro features, the C2000 has such high-tech amenities as a 21-speed gearset and an adjustable, shock-absorbing Headshok-CMT suspension fork. It also has a cushioned-suspension seat post. Suggested retail is \$1699.

But while these bikes are interesting from an evolutionary perspective, there are some companies and designers currently at work that are truly revolutionary. One of these is the Montague Corp., which designed a bike that fits in a suitcase. This is no easy feat, especially since the bike—the TriFrame Tandem (shown above left)—is an 8-ft. 2-person model.

Typically, when an engineer tries to alter a product that performs beautifully (such as a high-performance mountain bike) and make it perform a second function (such as folding into a suitcase) the result is a hybrid that performs neither operation well. Montague was determined not to let this happen with the TriFrame.

The company had already solved some of the technical problems years ago with its successful folding moun-



The Linear Aluminum Recumbent offers comfort and power.

tain bike, the BiFrame. This high-performance riding machine folds by use of a hingeless tube-within-a-tube system Montague calls Concentrus. Basically, the Concentrus system works by using a seat tube that's composed of several rotating chromemoly steel tubes within tubes. Strategic components of the seat tube are welded to unbroken top tubes and bottom tubes to form a sturdy frame. Far from weakening the frame, the tube-within-a-tube configuration actually strengthens the seat tube.

However, an 8-ft. tandem carries twice the weight of a normal bike and at the same time adds weight-bearing responsibility over the center of the frame instead of simply over the wheels. The typical solution is to run an additional support tube across the frame from the head tube to the bottom bracket. However, Montague wanted to be able to fold the bike into three triangular components, and a continuous crossframe tube would make this impossible. The solution was to add two crossframe tubes (one front and one rear), which greatly increased the complexity of the Concentrus system on the front-seat tube.

After six years of research and development, the Montague TriFrame Tandem is now ready to market, and it retails for \$1995. In addition to sporting a high-performance folding frame, the TriFrame Tandem features a top-of-the-line Shimano Deore LX set of components and a 21-speed gearset connected to cutting-edge Grip Shift controls. To cap off its unique achievement, Montague built the TriFrame so that it can be folded or unfolded in minutes without the use of tools. Masterful use of quick-release clips accomplish the whole process.

Like tandem bikes, recumbent bikes are nothing new. What's new is the level of interest in them. It seems that many riders of a certain age are tired of having sore butts from hard seats and sore backs from low handlebars.

Recumbents, like the Linear Aluminum Recumbent bicycle, eliminate these problems by allowing riders to recline in chairlike seats that are not only comfortable but produce power more efficiently. Few upright leg churners acknowledge this fact, but recumbents actually give riders a performance edge over racing bikes. In fact, recumbent bikes hold all the human-powered speed records.

What makes the Linear stand out among recumbents is that it raises the frame enough to put riders at the same eye level as on conventional bikes. Also, it uses standard bike-shop components. The bikes come with 21-speed gearsets and either under-seat handlebars or conventional handle-

bars. Suggested retail is \$1200.

Now for the ultimate in comfortable bike design, the CoPed Pedersen Roadster (\$1200 to \$2000). This is a bike that's easy to love because it takes care of first things first. The seat is suspended on a flexing system of springs and wires that run between the head tube and seat tube. It literally puts your butt in a sling, which isn't such a bad idea if comfort is your top priority.

This unique bike, which also features Campagnolo components and a full upright riding position, is the brainchild of Danish inventor Mikael Pedersen,

who designed the bike more than 100 years ago. He is reputed to have said, "Free the buttocks and the mind will follow." I can't argue with that. **PM**

SOURCE LIST

- Cannondale Corp., 9 Brookside Pl., Georgetown, CT 06829; (800) 726-BIKE.
- CoPed USA Inc., 345 N. Canal St., Suite 1001, Chicago, IL 60606; (800) 755-8671.
- Linear Manufacturing, RR 1, P.O. Box 173, Guttenberg, IA 52052; (319) 252-1637.
- Montague Corp., 432 Columbia St., Cambridge, MA 02140; (617) 491-7200.
- Specialized Bicycle Components, 15130 Concord Cir., Morgan Hill, CA 95037; (800) 245-3462.

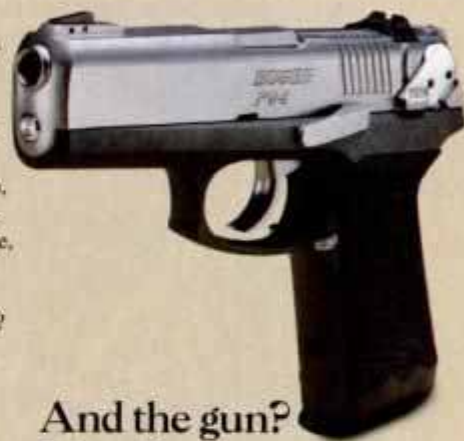
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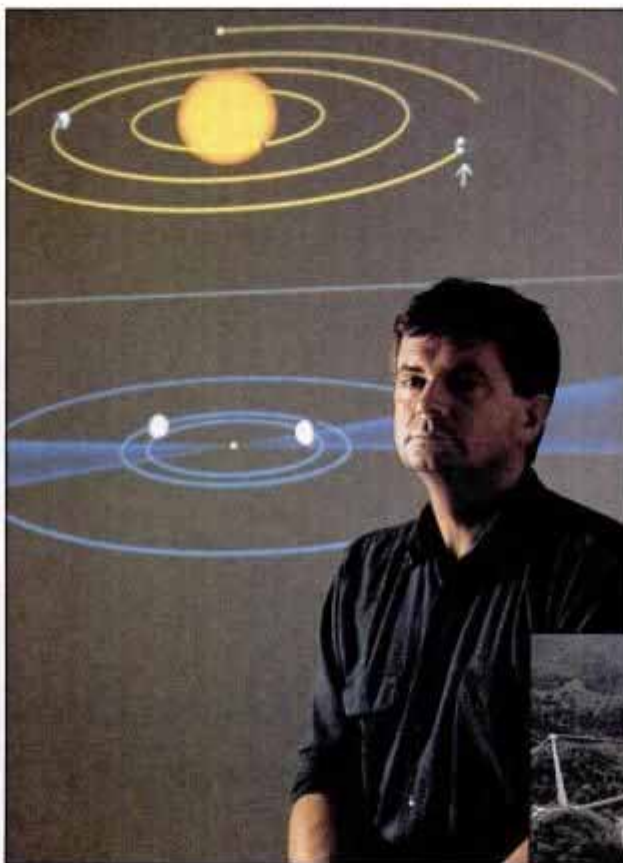
Arms Makers for Responsible Citizens

Worlds Apart

BY GREGORY T. POPE, Contributing Editor

● Deep in the constellation Virgo, 1500 light-years distant, beats the heart of a long-dead star. Called a pulsar—PSR B1257+12, to be precise—this 12-mile-wide powerhouse beggars the imagination. For one thing, it's so dense that a dime-size sliver from its face would outweigh an earthly mountain. For another, it whirls like a cosmic dervish and radiates furiously. The pulsar's immense magnetic field hones the radiation into a double beam, like a lighthouse beacon that whips around 160 times a second.

Sensed from Earth, this beam is a pulsing radio signal, as regular as the ticking of an atomic clock. When the pulsar was first detected in 1967, in fact, a few scientists misinterpreted its signal as a message from some alien broadcaster. As it turns out, the beam from PSR B1257+12 is sending an equally exciting message. Hidden in the radio pulses is the first clear-cut evidence that planets exist outside our solar

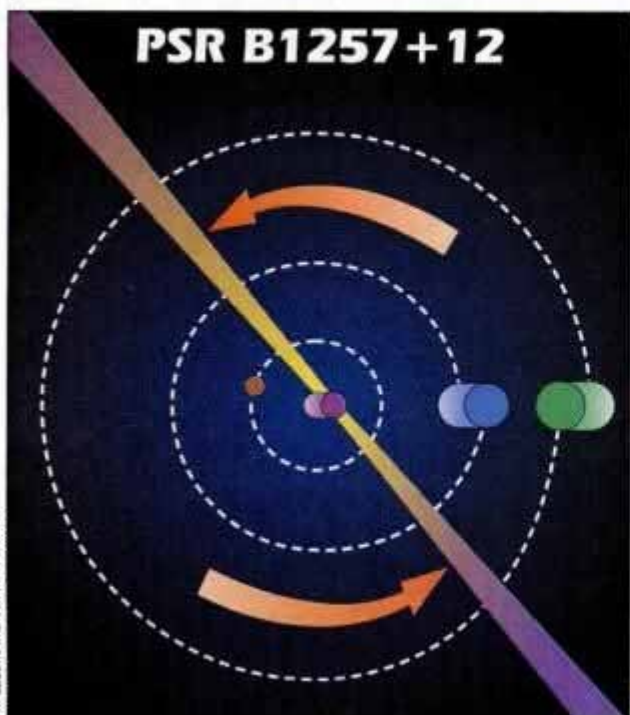


Four years ago, Wolszczan began tapping into PSR B1257+12 through the huge radio telescope at Arecibo, Puerto Rico. The 1000-ft. antenna funneled its reception into a specialized processor called the Princeton Mark III, which yielded an odd analysis. The radio pulses weren't always rock-steady. Over time, they appeared to be syncope, arriving split seconds before or after the beat, like the rhythm of a funky drummer.

PSR B1257+12 is not the first pulsar to exhibit this irregular heartbeat. In the past decade, astronomers have thought similar perturbations in other pulsar signals to be the work of planets. As planets



Wolszczan found his planets via the Arecibo radio telescope (right).



Planets pull spinning pulsar off center, wobbling regular sweep of radio beams. As they pass, planets also pull at each other, adding subtle perturbations to pulsar's spin.

system. At least three, in fact, are orbiting the pulsar.

The man who made this discovery is Penn State University radio astrophysicist Alexander Wolszczan. He spoke with POPULAR MECHANICS from an apt locale: Torun, Poland—the birthplace of Copernicus, who gave us the proper view of our own planetary system. Unlike Earth's neighbors, Wolszczan's planets are too far away for optical telescopes to spot directly. But they give themselves away through a telltale signature buried in the pulsar's radio signal.

orbit, the pull of their gravity should wobble a pulsar this way and that. By thus speeding and slowing the pulsar's apparent pulse rate, planets would disrupt the pattern of radio pulses as detected from Earth.

In each case, however, the astronomers' interpretations proved short-lived. "The planet discovered in 1991 turned out to be our own Earth," notes Wolszczan wryly. "They hadn't quite removed the effect of Earth's movement from their analysis."

Nevertheless, Wolszczan and colleague Dale Frail of the National Radio Astronomy Observatory went public with their own analysis in 1992. The variation in the pulsar signal, they believed, spoke of two planets. One, about 3.5 times the mass of Earth, orbited every 66.6 days. The other, 2.8 times Earth's mass, completed an orbit every 98.2 days.

The roughly 3:2 ratio of the planets' orbital periods alerted theorists to an intriguing way of backing up Wol-

szczan's claim. At predictable intervals, the planets would have to approach each other as they circled the pulsar. And when they passed each other, the play of gravity between the planets would tug them out of their orbital paths. These variations in their orbits would, in turn, modulate the effect of the planets' gravity on the pulsar itself. The dance of the planets should therefore show up as subtle subrhythms in the first-order synchopation of the pulsar's beat.

Subtle is the operative word. "The first-order effect is reasonably big," says Wolszczan, "but if you start looking for interaction between planetary masses, you go down three orders of magnitude." And it took three years of recordings from PSR B1257+12, fed through the Princeton Mark III, to sift out the evidence. But Wolszczan is now convinced he has planets. He's even plucked the effects of a third planet from the recordings—a Moon-size body closer to the pulsar. And the data hints that a fourth planet may be wheeling around in a much wider orbit. Wolszczan will let more recordings from Arecibo pile up to erase uncertainty about this body, along with some potential asteroids.

Meanwhile, Wolszczan's conclusions have already met widespread agreement among other astronomers. But while they accept the planets' existence, scientists predictably have found something to debate in this new discovery.

What sets them at odds is the planets' unlikely location. It's quite a surprise that the first remote planets should reveal themselves around a pulsar, of all things. Astronomers have traditionally looked for planets in less dangerous neighborhoods. Theory has it that pulsars are the collapsed kernels of giant stars that have blown off their outer layers in a supernova explosion. How could a planet survive such an apocalypse?

Already a handful of competing hypotheses have arisen to explain the phenomenon. Some involve the accretion of planetary material from a second star, while others place the planets far enough from the supernova to withstand the explosion.

Which is right? "That remains to be established," says Wolszczan. "But the discovery of a second system will be as important as the first. It will be telling us that we are facing a new class of objects."

It makes sense to continue scrutinizing pulsars, he adds, looking for that second system. After all, nothing can match the precision with which a pulsar's radio signals betray the gravitational effects of planets.

Optical telescopes certainly can't

discern such detail. It's true that telescope instruments can detect the shifts in light wavelength from Sun-like stars wobbled by planetary gravity. Using this technique, they could theoretically pick up the presence of Jupiter-size bodies. In fact, NASA has earmarked observing time on the Keck Telescope to do just that. But optical telescopes have yet to measure stellar wobbles with enough exactitude to find Earth-scale planets.

That's unfortunate. For unlike worlds near a living star, the planets around a pulsar are surely barren of life, poisoned by the radiation from

their hostile sun. It's also ironic that the Arecibo facility should have found these dead planets. The big radio telescope is scheduled to begin scanning the heavens soon for signals from extraterrestrial civilizations. The survey will take place under the privately funded Phoenix project, which has risen from the ashes of NASA's Search For Extraterrestrial Intelligence program.

But Wolszczan's discovery does lend hope to the search for alien worlds. "It confirms that planets are quite common in the universe," he says. "We just have to keep looking." **PM**

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New Cars



Subaru Legacy

● Care to take a guess at what was last year's best-selling import station wagon? How about the year before that? Okay, then, before that? How about for the last 12 years, in fact?

Well, those of you who said "Subaru" may take a giant step right up here to the head of the class.

Perhaps a trifle to the left of mainstream in its engineering and outlook, this Japanese marque has carved itself quite a solid niche among those who prize traction and utility in a passenger car.

To help maintain its grip on that niche, Subaru is introducing an all-new Legacy for 1995. Naturally, like all Subarus, the new Legacy is available with all-wheel drive and 4-wheel-disc antilock brakes. In addition, though the advertising blitz for the car may not admit to it—and your local dealer may not have one readily available—the new Legacy is also available with front-wheel drive for about \$1000 to \$1500 less than its better-appointed and better-equipped awd brethren.

For those of you who may not want awd but who still want more traction than the standard front-driver offers, Subaru has developed a sophisticated traction-control system for the front-drive Legacy—which oddly enough goes for the same price as awd.

Sitting atop a longer wheelbase, the '95 Legacy has been restyled from

stem to stern and from top to bottom. The car is longer, wider and taller than the previous model. The station wagon, in fact, looks very tall with a lot of sheetmetal above the tops of the windows.

Under the sloping hood is the same sohc 2.2-liter horizontally opposed 4-cylinder engine as in the previous model. Now equipped with sequential



Body by Karmann Coachworks, drivetrain by VW, the Cabrio is the newest Volkswagen.

electronic fuel injection, distributorless ignition, roller rockers and other goodies, the flat-Four has a slightly greater output than before: 135 horsepower and 140 ft.-lb. of torque.

Refinements to the car's fully independent, strut-type suspension and attention paid to increasing

structural stiffness have paid off all around. The new Legacy offers a quiet, well-controlled comfortable ride. The car's handling—especially with awd—is well balanced and eminently predictable.

The base price is about \$14,000 for a front-drive Legacy. A full-tilt LSi is upward of \$22,000.

—Don Chaikin



Volkswagen Cabrio

Following the grand tradition begun generations ago by the you-have-to-look-at-me-and-smile Karmann Ghia, Volkswagen has introduced the 1995 Cabrio. Like the more recent Cabriolet and Rabbit Convertible droptops, the Cabrio is essentially a convertible version of VW's bread-and-butter family car, in this case, the Golf III. And like all the VW convertibles, the Cabrio is built for Volkswagen by Karmann Coach-

works in Innsbruck, Austria. As with each of its predecessors, the Cabrio's strongest feature—other than the appeal of its folding top—is its styling. Though the Cabrio is based on the engineering



The last of the Saab 900 models, the convertible, has now arrived.

of the Golf, its lines are unique.

The folding soft-top is six layers thick for quietness and comfort. The car sports a fixed rollbar to provide the rollover safety of a steel roof. In addition, the rollbar is the anchor for the front seatbelts and also serves as a support for the roof when it's closed.

To further ensure the exclusivity of the Cabrio's styling, Volkswagen offers the car in just six colors: black, red, white, as well as the trendy aqua, violet and green. Each body color has a single color for its top.

The top is manually operated, but despite its thick insulation it is easily opened or closed by one person in less than a minute.

VW tags Cabrio at just under \$20,000—a price that includes free scheduled maintenance for the first two years or 24,000 miles and a powertrain warranty of 10 years or 100,000 miles.

—Jim Dunne

Saab 900 Convertible

Yuppies the world over can now breathe a sigh of relief—Saab is reintroducing the Saab Convertible. The new 900, launched last year to replace the elderly (originally introduced in 1979) car, didn't include a soft-top version. Like many other small-scale manufacturers, Saab has contracted with U.S.-based ASC to engineer and manufacture convertible-top mechanisms.

Controlled by a microprocessor, the folding soft-top relies on electric motors and microswitches to raise the top and to lower and stow it beneath a smooth tonneau cover. The driver only needs to deal with the two clamps at the top of the windshield. The new top mechanism even includes a heated, glass rear window.

In an effort to cure cowl shake caused by the convertible structure—without a fixed steel roof—Saab's engineers have increased the car's torsional rigidity by 70%. The examples I drove through the Irish countryside over some poorly paved roads were tight and squeak-free. There was some occasional annoying resonance in the steering column, however.

The new Convertible, like the hard-top versions, is available with one of three powerplants and a manual 5-speed or 4-speed automatic. Engine choices—and prices—begin with the 150-hp dohc 16-valve 2.3-liter Four (\$31,990) and climb to the 185-hp turbocharged 2.0-liter engine, at \$37,990. If you're ordering the \$895 automatic transmission, I'd recommend that you opt for the torquier 170-hp 2.5-liter V6.

—Mike Allen

PM HOTLINES

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We're trying our best to make it easier for you to communicate with us. Here are four ways you can do it.

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INSIDE BELL LABS

(Continued from page 49)

The different wavelengths now accessible through QC lasers promise many applications. These include free-space point-to-point communications, medical diagnostics, pollution-control monitoring of automotive engines, even collision-avoidance radar.

Cho points out that besides the QC laser, MBE will make it possible to build microprocessors that work on optical signals instead of electrical ones. Eliminating the bottleneck of copper promises reductions in size, heat generation and energy consumption in this new generation of chips.

To lure traffic to the future info-highway, one point where pundits agree is that computer and communications gear must become easier to use. Bell's got a grip on the wheel in this area, too.

One field of study is Neural Networks technologies that will let machines operate with humanlike senses—vision, for example.

At the Holmdel lab, supervisor Charles Stenard and researcher Chris Burges demonstrated gear for reading and recognizing handwriting. One system now in field operation dopes out the hand-numbered digits on personal checks. Accuracy is 75% and this should hit 95%, says Stenard, when the machines can also read the handwritten amounts. The implication here for personal electronics is another way to input information, beyond the traditional keyboard or mouse.

Voice-recognition is yet another area where Bell is looking to make machines easier to use. David Roe, supervisor of the applied speech research department, displayed several applications where text is converted to speech, or voice instructions operate a device.

Perhaps the most important was an automotive cellular telephone that could understand and execute some 60 voice commands. Although its immediate application is for hands-free operation in the car, this hands-off technology is a must-have for the "personal communicators" of the future—such as Bell's wristwatch telephone that's already a working prototype.

"These devices will be small, probably too small for anyone to operate conveniently with conventional buttons," says Roe. "Voice control is a most important development if these kinds of dream products are to succeed."

AT&T says that although Bell Labs' wristwatch phone could work today, customer demand will determine when such products hit the market.

Ring! Ring! Hello, Central?

PM

Detroit Spy Report

BY JIM DUNNE, Detroit Editor



Pontiac Grand Am GT

● Admittedly, the extent of the difference may not be great, but its visual impact is. This prototype Pontiac Grand Am GT has a totally different grille insert than the current car has, which gives the car's front end a whole new appearance. Your eye is automatically

station wagon and sedan captured here both show smooth sheetmetal panels over the doors—without the door-lock bulges seen in the earlier test models. The overall shape of the next Taurus is completely new, rather than merely a minor revision of the current body. The upcoming design strongly indicates Ford's intention to at least match the current styling trend leader—the Chrysler LH sedans—

prototype Taurus station wagon. Pay special attention to the car's cowl height, which is noticeably lower than the current model's, as well as the roundness in its hood, window frames and side sheetmetal. What you cannot see in these photos is an oval grille opening, the high placement of the wagon's third side windows and a distinctly rounded shape to the glass in the rear hatch.

Ford's Very Small-Block V8

In two years, Ford will have a new V8 engine ready for not just the new Taurus but the Lincoln Continental as well.

The potent new motor boasts a 60° V aluminum block and aluminum cylinder heads. The engine will be available in both sohc and dohc versions. Despite its modest 3.4-liter displacement, its power output will match some 5.0-liter V8s on the market now. You can look for a 250-hp version of this engine to replace the Yamaha V6 currently used in the Taurus SHO.

GM's Big Vans

Both Chevrolet and GMC will roll out restyled versions of their full-size vans this coming fall. The 1995 models



attracted to the car's smoother face, which wears a somewhat more focused, aggressive look. Behind the new nose of the Grand Am GT, Pontiac will offer an improved version of the 2.3-liter Quad 4 engine. The refined motor has balance shafts to help offset the engine vibrations that have plagued the Quad 4 since its inception.

'96 Taurus Wagon And Sedan

Ford has entered the final stages of testing the designs of its next-version Taurus, due as a 1996½ model. The

Taurus in both sedan (above right) and wagon once again becomes a styling trendsetter.

while leapfrogging right over more conservative competition, namely the Chevrolet Lumina.

Despite the bra on its nose and cape over its rear, you cannot fail to appreciate the general contour of this

will be completely revised on the outside, sporting larger windows and a grille that strongly resembles the styling theme that began on GM's full-size pickups—in fact, when seen

(Please turn to page 103)





head-on, these vans are nearly dead ringers for the big pickups. Dual headlights and centered grille openings with the Chevy bow-tie or GMC logo are taken almost directly from pickup styling. Viewed from the side, the doors and glass areas are similar to GM's smaller M-vans. At the rear, taillights are set high up in the D-pillars, à la GM's front-wheel-drive plastic-bodied minivans. Beneath the skin, safety improvements include airbags and side-impact protection. This redesign marks the first major overhaul to the Chevy Sportvan and GMC Vandura in 23 years.

Still More Aluminum

Look for a surge in the use of aluminum in cars over the next five years. That's the outlook of Ford insiders who say they are not alone in making the change from steel and iron parts. Yes, aluminum is about twice the price of steel, but it weighs about half. The advantage of light weight is critical to the all-important goal of improving fuel economy. By replacing all the steel used in a Ford Taurus body shell with aluminum, the car's weight is cut by 400 pounds. That kind of reduction translates into a 2-plus mpg fuel economy boost. That would bump a Taurus up to the 30-mpg class. But the cost of an aluminum body over steel is about \$2000 more, and the automakers are not certain they can sell its fuel-economy advantage at that price.

Driving By Wire

Ford will be the first American carmaker to offer a type of drive-by-wire system when the nonmechanical device is offered on Ranger diesel pickups next year. Ford's system connects the accelerator pedal to the engine

through a wire—no cables, no links, no levers. A sensor on the accelerator pedal measures its position. This information is transmitted to a fuel-flow device on the engine. The system duplicates the action of a mechanical connection. A similar system has been used for a few years on expensive German luxury sedans sold in Europe.

4-Door Problem

It's no secret that Chrysler will build a 4-door minivan for 1996. The extra door is a sliding type that mirrors the door on the right side. But Chrysler engineers found an unexpected problem. The new door slides right across the front of the fuel-filler door. If you slide open the door while gassing up, the door will smack into the filler door and gas nozzle. Naturally, the engineers also found a solution to the problem: The

Coming right at you, GM's big vans look much like the company's big pickups. Going away, they look like new vans.

tice the similarity of this to the Mercury Cougar design, as well as to the 1994 Lincoln Continental. In addition to the new grille, the Grand Marquis also flaunts some minor changes in the front fascia while benefiting from new headlight technology, which helped the designers create the car's headlamps.

A Baker's Dozen

A prototype car seat made by Johnson Controls can adjust to just about any comfort fitting thanks to its 13 separate air chambers. The chambers—



Like the Cougar, the Grand Marquis sports a front-end treatment similar to the Lincoln Continental's.

side door automatically locks closed when the fuel-filler door is open.

Refreshing The Grand Marquis

Our photo of the 1995 Mercury Grand Marquis shows the car's undeniable new front end. For next year, Mercury extends its badge-style grille covering to the big sedan. You will no-

or bladders, if you prefer—individually inflate and deflate according to your personal tastes. A push-button control panel directs the settings. Separate buttons for the left and right sides adjust the seat and backrest bolsters. I found the seats can hug you tightly, as in a racing-car cockpit, or be as relaxing as those in a cushy limousine.

PM

Commuting Made Easy

BY FRANK VIZARD, Electronics Editor

● Perhaps the best way to cut down on your drive time is to figure out where the traffic isn't—and the sooner you know the better. It would also be a big help if you knew the best way to go and a couple of alternate routes, as well.

For many drivers, though, all this is wishful thinking. Faced with a mind-numbing traffic crawl, many drivers simply wait out the situation, wishing they were on another road but not knowing any alternate route to their destination.

A way out, however, may be just around the corner. A number of companies are developing car navigation systems that will make point-to-point commuting easier. Here's a look at some of these projects.

During the next two years, Oldsmobile is rolling out a system that uses both a computer database and orbiting GPS (Global Positioning System) satellites to determine the car's precise location. The driver simply enters



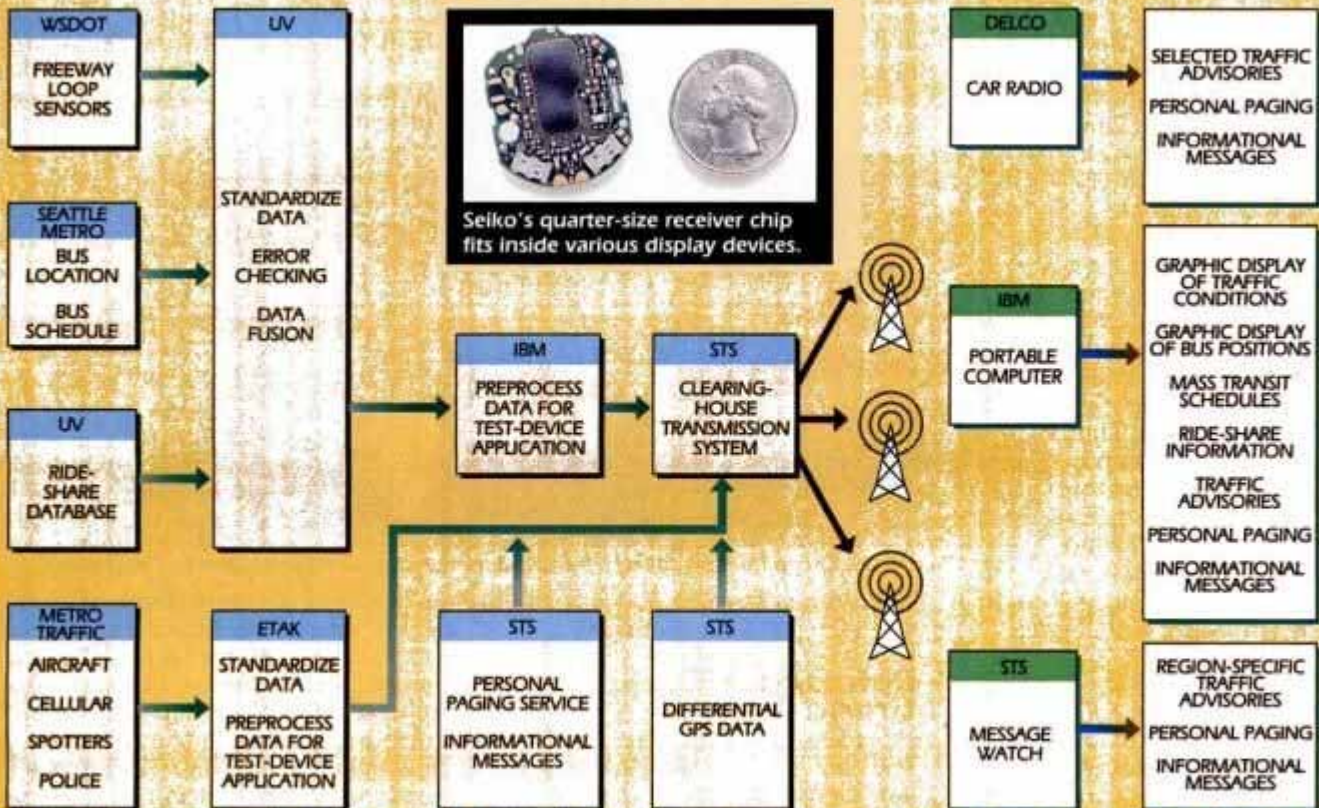
the desired address or landmark and the computer calculates the most efficient route. While en route, a voice prompt advises when a turn is required. This system has been successfully tested by Avis Rent-A-Car. The system will become available as road-

way databases are compiled for specific geographic areas—a process that should be completed by the end of next year.

Instead of entering a request manually, the AudioNav system being developed by Amerigon Inc. allows the driver to ask the system for directions by spelling out street or landmark names. This process could be as time-consuming as manually entering the request, depending upon the quality of the voice-recognition software. Navigation data is contained on a compact disc that plays on the car's CD player, which in turn is linked to a small box containing the navigation hardware.

Perhaps the most ambitious undertaking comes from a group called the Seattle Consortium. Composed of IBM, Delco Electronics, Seiko, Etak, and a variety of state and local government agencies, the Seattle Consortium is testing how to use an FM subcarrier frequency to broadcast

A Chip For Getting Around The Block



The Seattle Consortium is testing ways to transmit traffic information and other data to wristwatches, computers and car radios.

FM ILLUSTRATION BY KURT NOVAK



Light passes directly from the lenses, through the CCD image sensor, to the viewfinder of JVC's GR-SZ7 for brighter pictures.

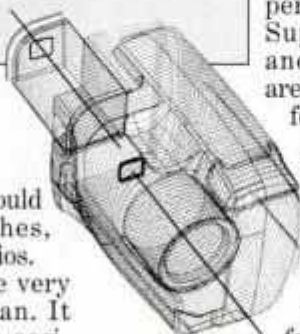
traffic information. This data would be displayed on wristwatches, portable computers and car radios.

The data available would be very comprehensive under the plan. It would include information on accidents, construction projects and major highway traffic, city maps with mass transit route and location data, GPS positioning data, material on ride-share programs and a variety of personal information services such as paging, weather, sports scores and lottery numbers.

The actual receiver of all this information is a small Seiko chip called the Advanced Communication and Timekeeping Technology (ACTT) receiver. The test is to be conducted in Seattle over the next two years.

Straight Shooters

Because of their superior picture quality, Super VHS-Compact and Hi8 camcorders are the models of choice for the serious videographer. Some new products from the Super VHS camp again demonstrate that there's more to these formats than just better tape formulations.



One model of note is JVC's new flagship camcorder, the GR-SZ7, listing for \$1600. As the top-end model, the GR-SZ7 packs a ton of features. These include digital image stabilization to correct shakiness, a menu of special effects, a 100x digital zoom and a color LCD viewfinder.

All the camcorder's bells and whistles tend to make you overlook some design choices that are just as important as the features. Perhaps the most important is that the GR-SZ7 has a straight optical axis, meaning that there is a direct line of sight between the eye and the subject. By contrast, other camcorders send the subject image bouncing around a number of internal mirrors before you see it in the viewfinder. In the GR-SZ7, light from the lens hits the CCD image sensor squarely in the center, giving the CCD superior light-gathering characteristics. One benefit to this arrangement is the remarkable ability of the GR-SZ7 to record viewable images in virtual darkness. The GR-SZ7 sees things the human eye cannot see.

Taking a larger tack, meanwhile, with its video heads is Panasonic. Both its new Super VHS-C (\$1700) and VHS-C (\$1500) camcorders—the PV-S64 and PV-54, respectively—sport a standard VCR-size video head even though there's no appreciable increase in the size of the camcorder.

Both camcorders use the company's DynAmorphous heads already in use with Panasonic VCRs. This technology reduces tape-to-head contact and boosts the signal-to-noise ratio, thereby noticeably improving picture quality. **FM**

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SMOKE 'EM OUT

These new antitheft systems are alternatives to noisy car alarms.

BY FRANK VIZARD,
Electronics Editor



● Back in the Old West, when varmints were holed up in some impregnable hide-out, a posse would often attempt to apprehend the bandits by smoking them out with fire. A modern-day twist on this old theme is a new car alarm that puts a smoke barrier between the thief and the vehicle. A second alternative, meanwhile, makes a high-tech posse just a phone call away.

The smokier of the two security systems is called Dragon, and it works in two stages. First, a perimeter sensor detects the initial attempt at a break-in, immediately putting the Dragon into standby mode. At this point, any light touch activates the Dragon.

Once activated, things start to look smokier than the inside of an Old West saloon on a Saturday night. Within 5 seconds, the entire car interior is filled with smoke. The smoke is emitted by a small cartridge, which can be placed anywhere in the vehicle. Each cartridge is good for 100 activations, says the manufacturer, Technology Source Inc. of Irvine, California. The smoke is harmless, approved by the U.S. Food & Drug Administration, and safe on the car's interior, according to the company.

Once the vehicle fills with smoke, an intruder should be unable to see anything in the car, much less drive it

away. The shroud of smoke should be enough of a deterrent for any would-be thief. The smoke will continue to discharge as long as the thief is in the car. Dragon also makes the car lights flash on and off. With the car attracting this type of attention, it shouldn't be long before the posse comes riding to the rescue.

List price for the Dragon is \$375. Smoke cartridges list for \$29 each. The system also has a number of optional accessories. One is a voice mod-

ule that says: "Attention. The vehicle defense system has been activated. Do not attempt to enter vehicle."

Dragon can also be coupled to existing siren-based alarm systems for a double-barreled impact. In this age when most siren car alarms are viewed simply as noisemakers, a little smoke may be all that's needed for an effective car security system.

Instead of waiting for the posse to appear, though, you can call it. Audiovox Corp. is offering a security system that is linked to the Posse Communications Center. If a thief should steal your car, the Posse remotely activates the car's headlights and horn, and once the car is turned off it can't be started again by the thief. List price for the alarm system is \$599. The Posse works for free the first year and charges \$60 per year thereafter. The Posse will also warm up your car on a cold morning or unlock the door if you've misplaced your keys. Call (800) 645-7750 for more information, but try not to ask for the sheriff. **PM**



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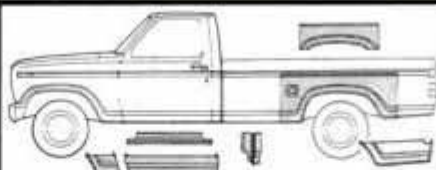
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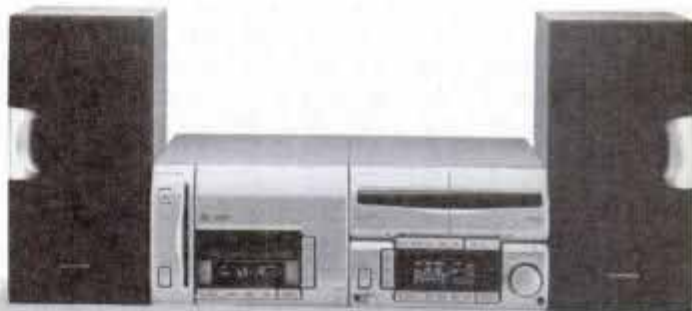
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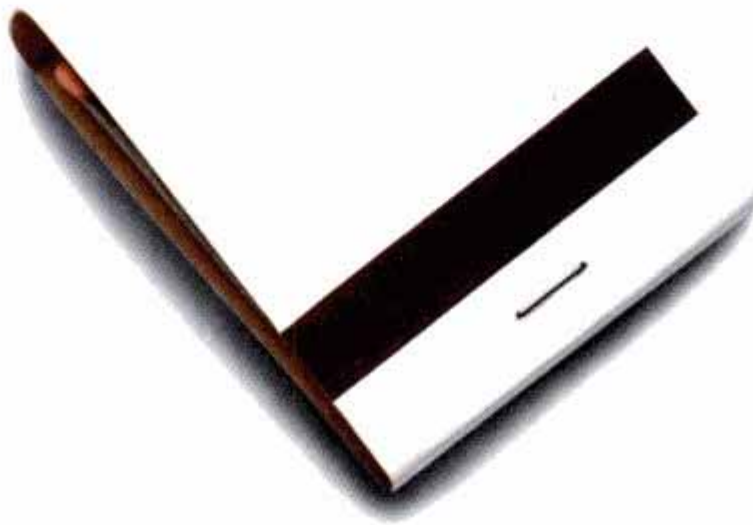
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