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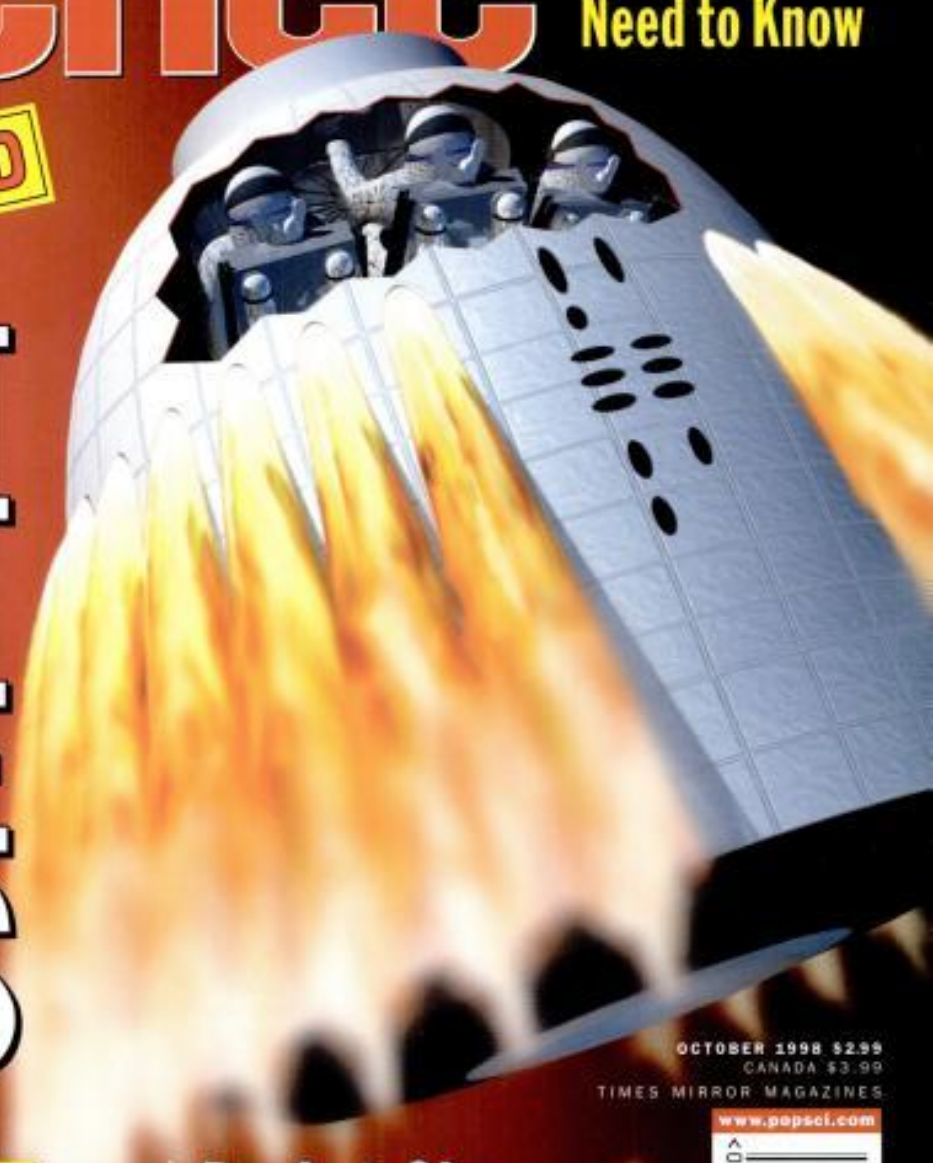
THE WHAT'S NEW MAGAZINE

Popular Science

**YEAR
2000
PROBLEM**
What You
Need to Know

DECLASSIFIED

**SECRET
SOVIET
SPACE
SHIPS**



**CURES
FROM
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**NIGHT
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YOUR CAR**

**Pocket-Size
SATELLITE
PHONES**



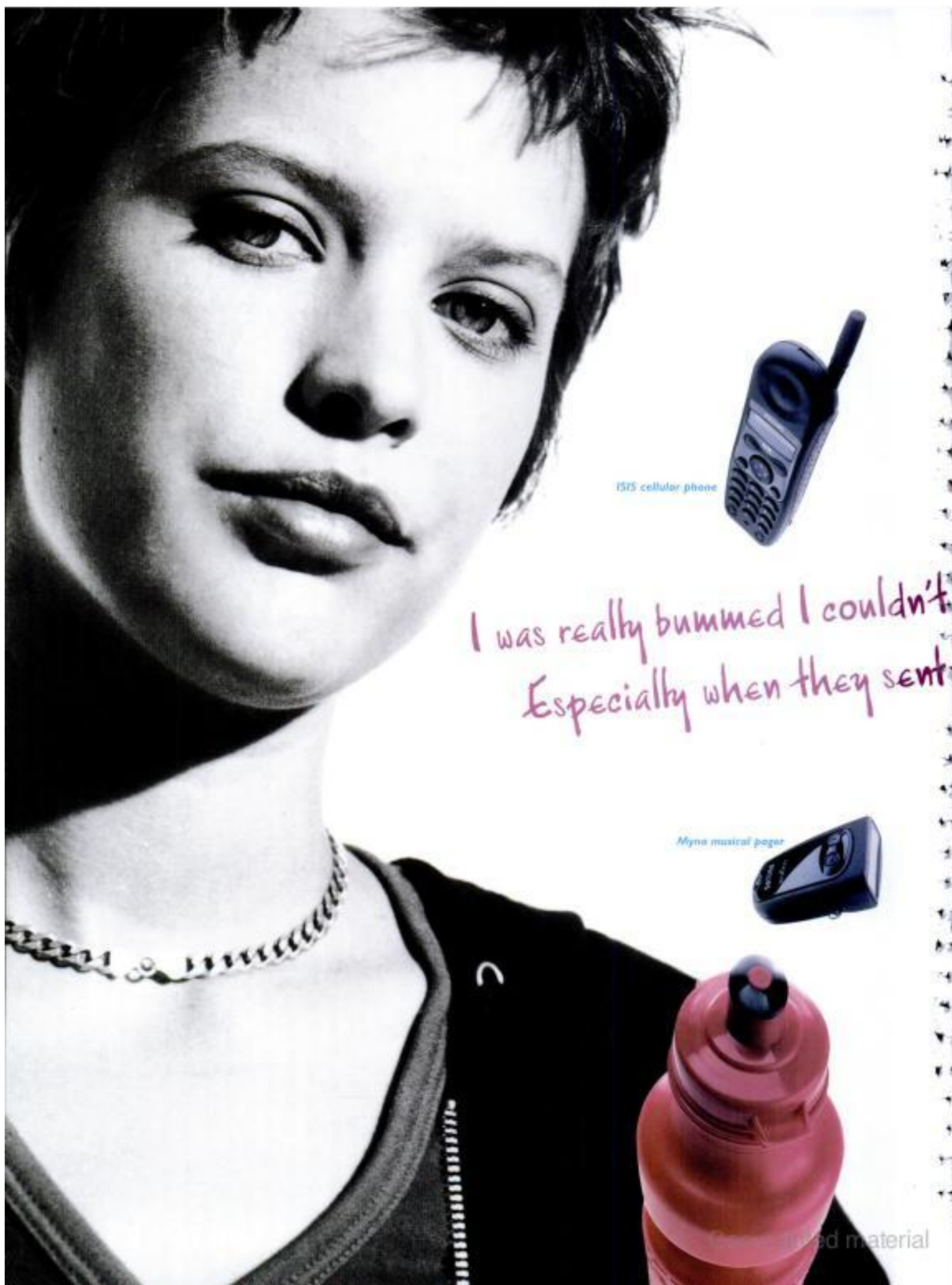
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Especially when they sent



Myna musical pager



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OCTOBER 1998

THE WHAT'S NEW MAGAZINE
Popular Science

Founded in 1872 • Volume 253 • Number

R2
Moon Lander
Cosmonauts sighed
in relief when this
craft was scrapped.

COVER ART
BOB SAULS/
JOHN FRASSANITO
& ASSOCIATES
Inset: JOHN B. CARNETT



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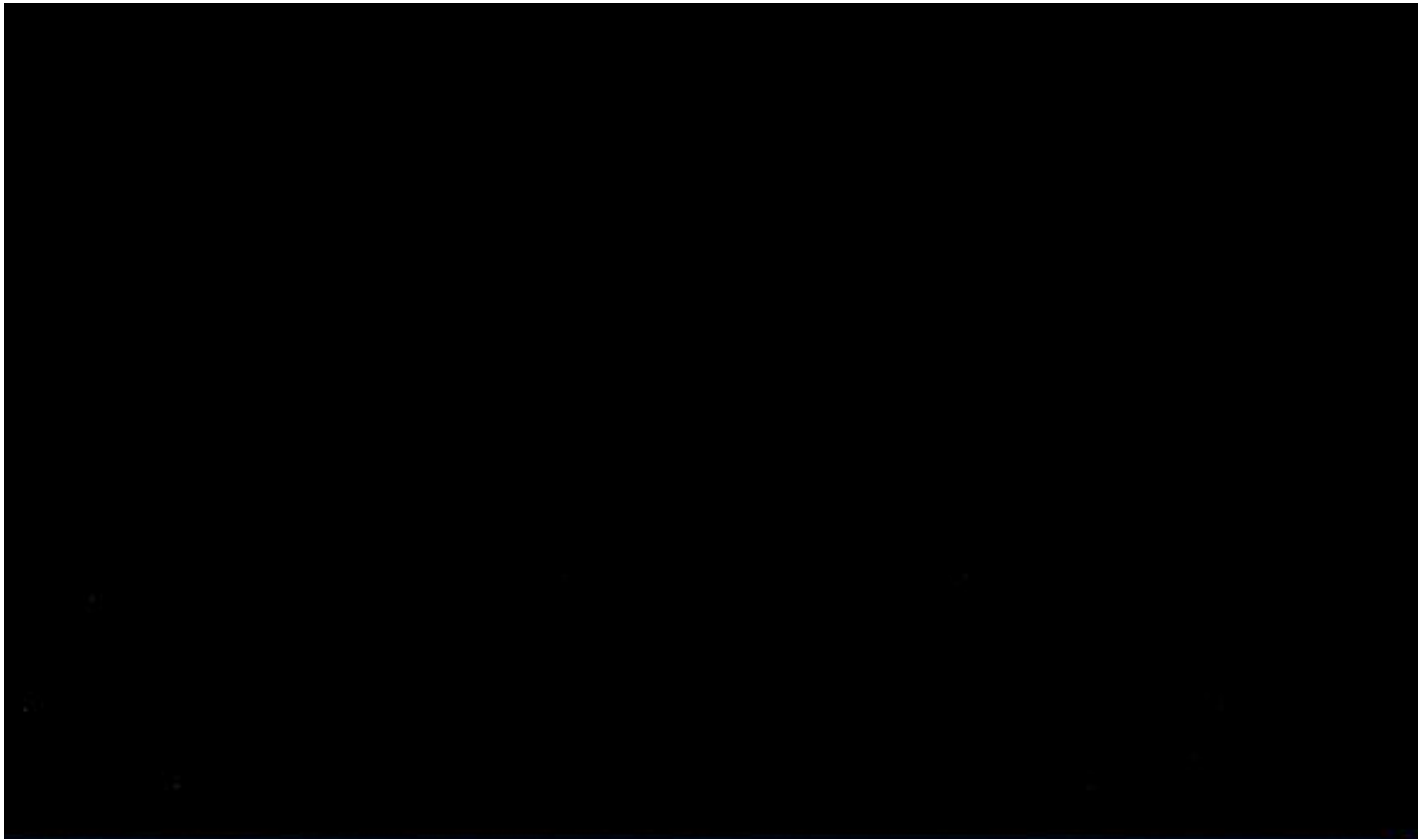
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AUTOMOTIVE



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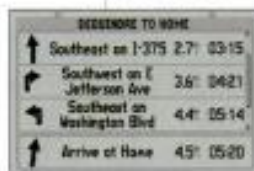
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FROM THE EDITOR-IN-CHIEF



Rewriting the Past and the Future

OUR COVER STORY THIS MONTH WILL INTRODUCE you to Zarya, Polyus, and Zond. No, these are not characters from a forthcoming Superman sequel. Rather, they are a few of the recently revealed super-secret space vehicles of the former Soviet Union. Historians are having a field day with this new information and the dissemination of until-now hidden drawings and photographs. A virtual rewrite of the history of the cold war is in the offing. A rewrite of the future, meanwhile, is taking on feverish proportions among programmers working on the so-called Y2K (Year 2000) bug, which has been targeted as a ticking time bomb for computers large and small come the new millennium. Managing Editor William G. Phillips reports on the fixes that are in the works, but tells us that many will be short-lived—merely shortcuts to patch a problem that was itself caused by a shortcut. There are simply too many machines and not enough time to fix and test them all. Worse, some computers could come down with Y2K complications well ahead of the next century—as early as April 1999.—Fred Abatemarco

No Sweat

I FOUND INTRIGUING the relationship between hot foods and climate in "Some Like It Hot" [Science and Technology Newsfront, Aug.]. The researchers stated that hot foods may be linked to hot climates because the foods' antibacterial properties allow longer, safer keeping. I have noticed, however, that such foods also create a sweating response—and sweating cools the body. Have people living in equatorial regions also used spices to help keep cool?

Matt Applegate
Columbus, Ohio

Scientists have considered this theory. But, according to Paul Sherman of Cornell University's department of neurobiology and behavior, recent studies of people in equatorial regions have shown that many spices, such as garlic, onion, ginger, lemongrass, and even chili, do not cause them to sweat. Besides, sweating burns a lot of energy and depletes the body of water. "You're better off simply sitting in the shade," he says.

Saving Fuel—Again

"FUEL-SAVING COMBO" [Automotive Newsfront, Aug.] discussed how BMW and Citroën are plan-

ning to use the old idea of combining the starter and alternator in an automobile engine to save fuel. We remember this idea well: Our 1958 BMW Isetta 300 had a combination starter/generator mounted directly on the crankshaft. The combination worked on the little car's normal 12-volt battery.

John and Sherry Bumgarner
Morgan Hill, Calif.

What Millennium?

I WAS SURPRISED that your introduction to "Life in the Extreme" said the millennium was a mere 17 months away. Because there was no year zero, the current millennium ends on December 31, 2000—not on December 31, 1999.

Ken Paulson
Duxbury, Mass.

Mathematically, you are correct. By common consensus, however, people throughout the world have chosen the year 2000 to mark the new millennium, with celebrations and events scheduled for that year. We are simply following suit.

I LIKED your science-fiction short story "Life in the Extreme" [Aug.]. It was a break from the world of technology and gave me something

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to ponder. Please include more stories like that in upcoming editions of the magazine.

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Choppers Save Lives

THANK YOU for the excellent coverage of helicopters and tilt-rotors and their importance in rescue missions ["Choppers to the Rescue," June]. As Igor Sikorsky said in 1947: "If you are in trouble anywhere in the world, an airplane can fly over and drop flowers, but a helicopter can land and save your life." Nothing but a helicopter, also, could have lifted the Freedom statue from the dome of the U.S. Capitol in 1993 and then returned the refurbished statue unharmed. They are truly incredible inventions. To learn more about helicopters, readers might visit our Helicopter Association International Web site at www.rotor.com.

Frank L. Jensen Jr.
President Emeritus
Helicopter Association Int'l.
Alexandria, Va.

A Life of Invention

YOUR STORY about Jacob Rabinow ["Gadget Master," Aug.] brought back memories of my early days at the National Bureau of Standards. There, I worked for Rabinow as an experimental machinist. As I read your story, I couldn't help but remember many of his early ideas that have now become practice: how he tried many different types of oil seals on the magnetic fluid clutch; tested ways to move film through high-speed motion picture cameras that projected across the room; and developed a proximity fuse for rockets that sensed acceleration and gauged time as well before detonating the rocket. Rabinow always recognized a need before there was a requirement. In my book, he's in a class with Thomas Edison.

peterbee@aol.com

Home Energy Redux

YOUR ANSWER about how many solar panels a person would need to reduce his electric bill to nothing [Letters, Aug.] is in error. You said the average household uses 6 kilowatt-hours (kWh) of electricity per day. I think the number is closer to 30.

O.R. Detraz
Fort Wayne, Ind.

Manufacturers and designers typically do not include HVAC systems, water heaters, and washer/dryers when citing energy requirements, because these appliances—depending on if they're electric or gas—may not draw power. Leaving them out of the equation, the average older home uses about 15 kilowatt-hours of electricity per day, says Joseph Wiehagen, an engineer with the National Association of Home Builders Research Center in Upper Marlboro, Maryland. Newer homes use about half that.

Photovoltaic (PV) makers typically cite even lower requirements because they assume homeowners interested in PV would have a newer home and insist on the latest in energy-efficient lighting, appliances, windows, and so on. These homes could use only 6 kWh per day, says Wiehagen.

However, when you include all appliances and average it out for the entire nation, usage comes to about 27 kWh per day, says the Edison Electric Institute in Washington, D.C.

Ship Shape

THANK YOU for your interesting article "Long on Luxury" [July]. Having just completed a cruise on the newly stretched Norwegian Wind in Canada, I enjoyed a fantastic opportunity to see the work up close.

Anthony Testino
Jamestown, N.C.

CORRECTION: The length of the Pony Express mail-service route was 2,000 miles [Looking Back, Sept.].

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WHAT'S NEW

EDITED BY SUZANNE KANTRA KIRSCHNER

Research by Jackie Couillard
and Becky Orfinger



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Card-size Camera

THE WORLD'S tiniest 24mm APS (Advanced Photo System) camera, the Endeavor 1000ix MRC Tiara is about the size of a credit card—and it's only as wide as a roll of film. Its tough titanium shell slides open to reveal the lens and flash. While the Endeavor is tiny, it's full featured: APS capabilities include mid-roll change, print quality improvement, and print format selection. Price: \$479. Fuji Photo Film U.S.A., 555 Taxter Rd., Elmsford NY 10523.



Dinos of a Feather

TWO SPECIES of dinosaur recently found in China's Liaoning province —*Protarchaeopteryx robusta* with its feathered tail plume, and *Caudipteryx zowi* (reconstruction shown) with distinct feathers on its tail and forearms—strongly support the theory that birds evolved from dinosaurs. But beyond the dinosaur feathers, what cinches it for some scientists is that the fossils are more similar anatomically to birds than any other dinosaurs found to date. www.nature.com





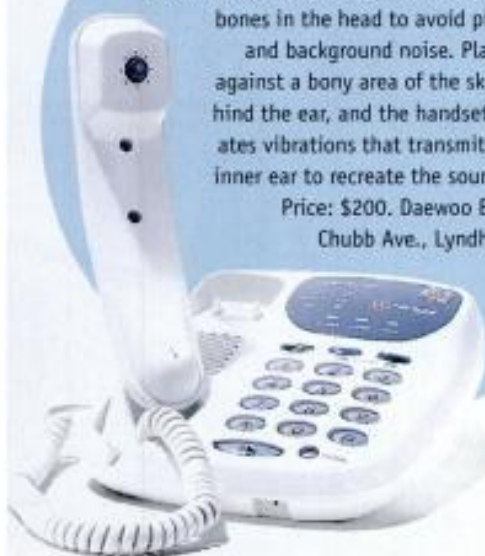
Quieter Blower

THE QUIETECH corded electric blower/vac is the first to feature a muffler. Foam padding in the blower tube plus a padded intake reduce noise by 50 percent—from 70 to 63 on the exponential decibel scale. The 7.5-pound blower produces airspeeds of 195 mph, which makes it one of the fastest as well. Price: \$79. The Toro Co., 8111 Lyndale Ave. S., Bloomington MN 55420.

Bone Phone

NOW THAT'S USING your noggin': Unlike other phones for the hearing impaired that amplify sound, the Miracle Phone transmits the sound through the bones in the head to avoid picking up static and background noise. Place the handset against a bony area of the skull, such as behind the ear, and the handset's pulsator creates vibrations that transmit straight to the inner ear to recreate the sound of the caller.

Price: \$200. Daewoo Electronics, 120 Chubb Ave., Lyndhurst NJ 07071.



Note Card

FIRST CAME the Rex PC Companion, a clever PC Card display and storage device for contact and calendar information ["Best of What's New," Dec. '97]. Now the Rex Pro moves from a display-only program to a package that lets you enter appointments and addresses, making it a fully functional electronic organizer. Price: \$230. Franklin Electronic Publishers, One Franklin Plaza, Burlington NJ 08016.

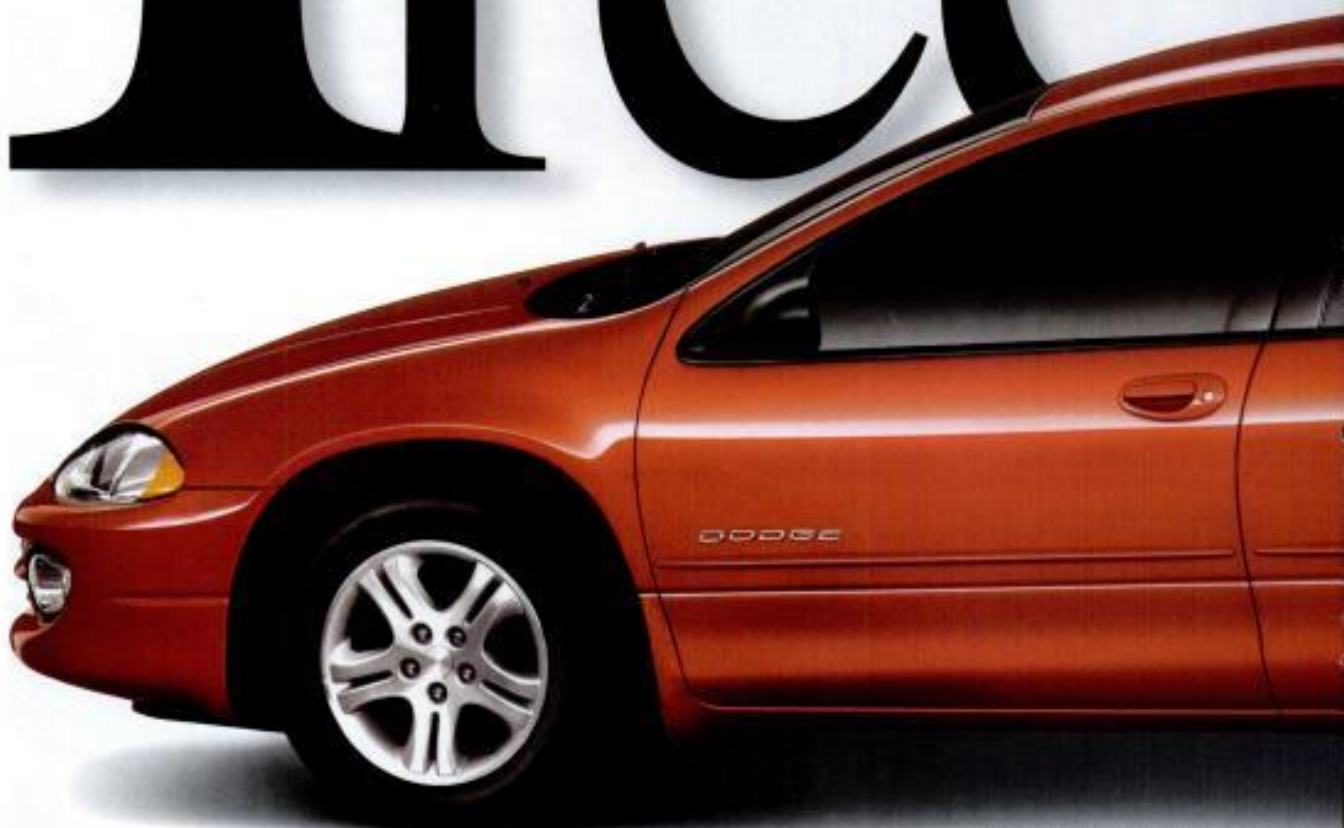


Compact Powerhouse

A NEW SHAFT DRIVE system, wider transmission ratios, and an improved continuously variable automatic transmission make Kawasaki's Prairie 300 all-terrain vehicles simpler to operate and better able to claw up steep hills and tow heavy loads than other 300cc-engine ATVs. And while ATV owners have long complained that grate-style cargo racks let small items fall through, the Prairie 4X4's table-style composite racks can carry even your lunch safely. Price: \$5,299; two-wheel-drive version costs \$4,499. www.kawasaki.com



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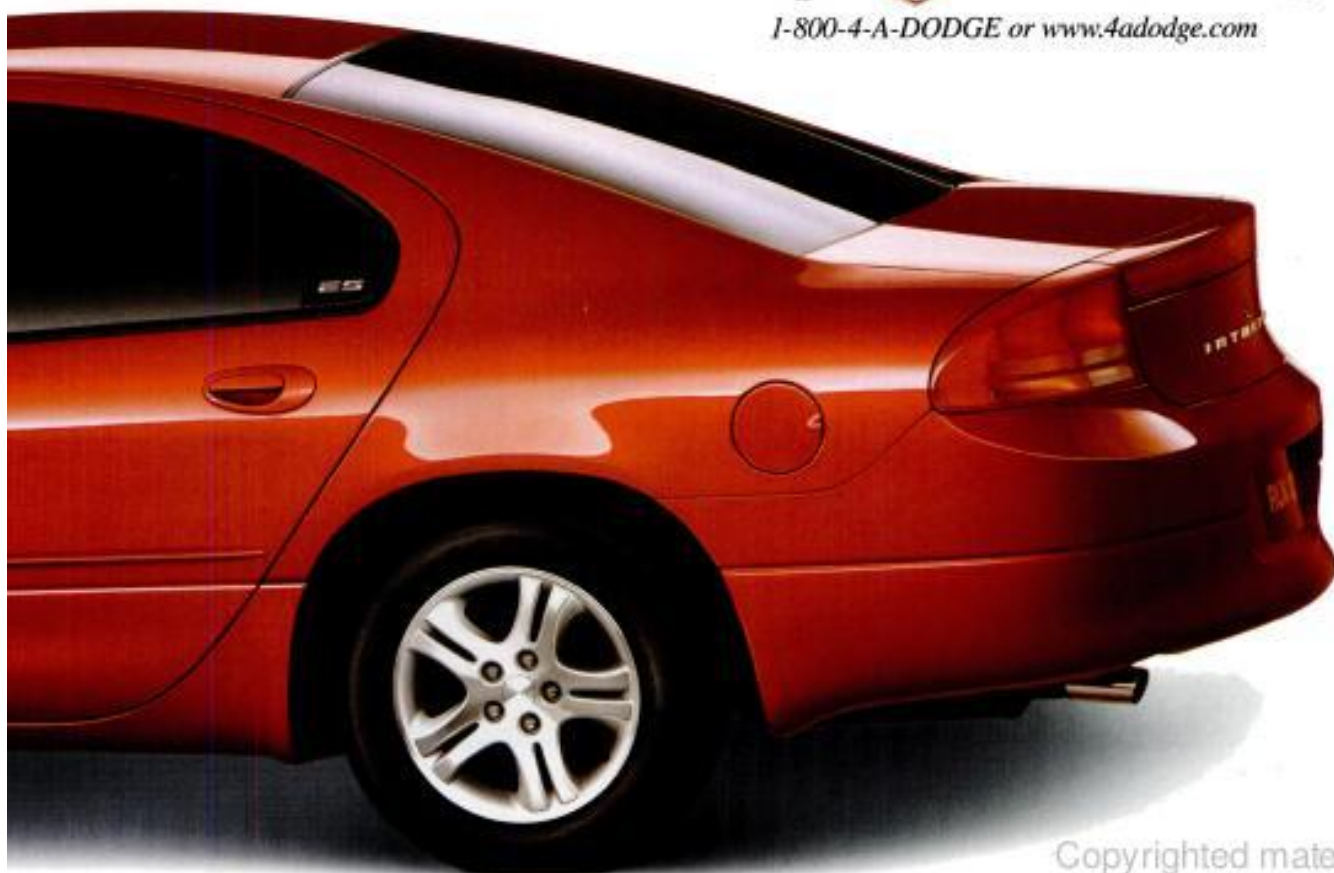
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Intrepid ES' aluminum powerplant generates a stout 225 horsepower from a lean 3.2 liters of displacement. Its aerodynamically taut metal skin stretches smoothly over the most advanced example of cab-forward architecture yet conceived, the thrift of the car's form belying the abundance of space within. Its passenger cabin is ergonomically efficient, fitted with bright, white analog driving instruments, and tastefully free of plastic-wood veneer. The exterior is free of excessive chrome and extraneous geegaws. The entire automobile is stuffed with innovative thinking.

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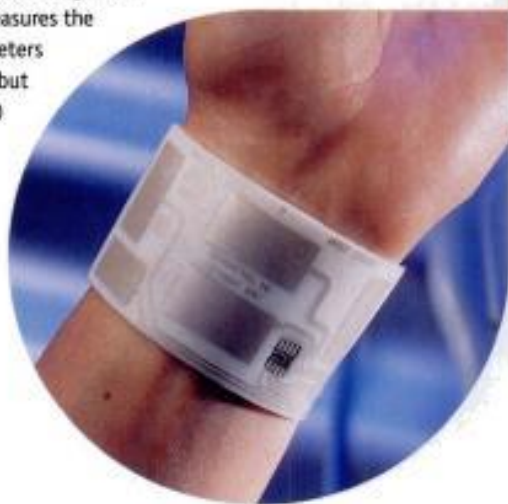


Big Little Car

TOYOTA'S Progrès is a compact sedan with big-car luxury. Measuring a mere 177 inches long, it has a 109-inch wheelbase—more than the 11-inch-longer Camry—so go ahead and stretch your legs. Options include a radar cruise control that maintains a set distance from the car ahead, and curtain-style side airbags ["Fighting Whiplash," What's New, Aug.]. Available only in Japan. Price: \$23,800.

Wrist Checker

CARPAL TUNNEL SYNDROME—damage to the nerves in the wrist—is difficult to diagnose, often masquerading as a sprain or arthritis. But NC-stat checks for damaged nerves near-instantly by sending an electric current down the wrist and into the hand via a flexible strip embedded with electrical sensors and a tiny micro-processor. The strip measures the reaction speed—60 meters per second is normal, but it can be as slow as 30 along CTS-damaged nerves. Available to physicians from NeuroMetrix Inc., of Cambridge, Massachusetts, later this year.



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Finally: A DVD-Quality TV

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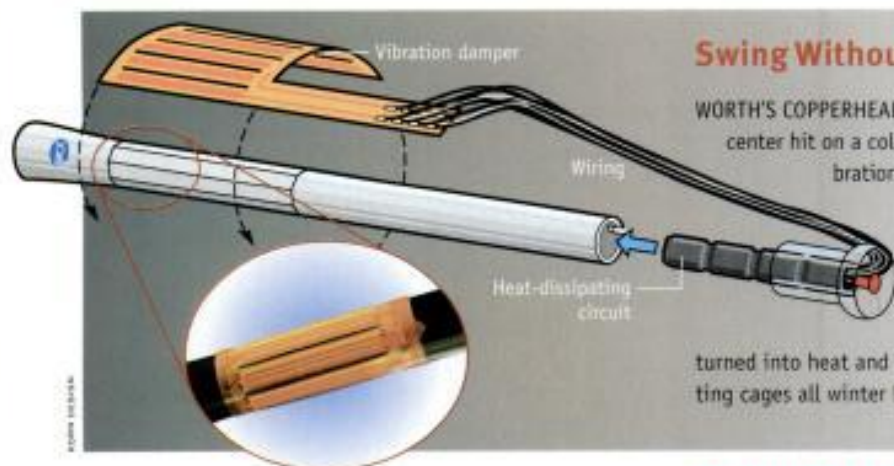


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Swing Without Sting

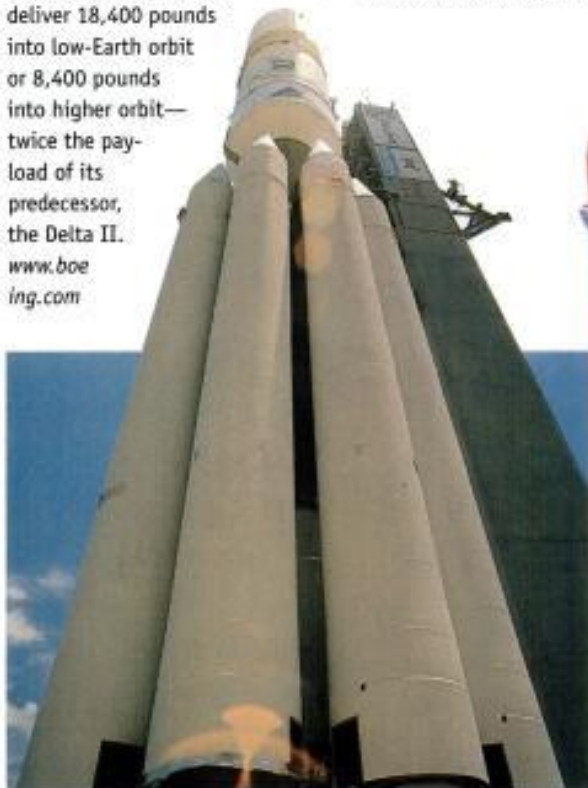
WORTH'S COPPERHEAD ACX BAT takes the sting out of an off-center hit on a cold day with the world's first electronic vibration damper in a bat. The electronic shock absorber, a modified version of technology already applied to skis and bike shocks [What's New, Feb.], converts the mechanical vibrations into electrical energy. This energy is then turned into heat and dissipated. So now you can hit the batting cages all winter long. Price: \$300. www.worthinc.com

Flattest Speakers

Bigger, Better Booster

THE FIRST new expendable booster made in the United States in decades, the Boeing Delta III will make its maiden flights this year. With more powerful strap-on solid rocket motors and a cryogenically propelled single-engine upper stage, the 128-foot launch vehicle can deliver 18,400 pounds into low-Earth orbit or 8,400 pounds into higher orbit—twice the payload of its predecessor, the Delta II. www.boeing.com

MEASURING A MERE quarter-inch thick, the three-piece x-Space speaker system from Mission Electronics of England is the flattest hang-on-the-wall system in the world. It employs technology developed by NXT ["Best of What's New," Dec. '97], which uses complex vibration patterns spread over a panel surface to reproduce music. The two x-Space satellite speakers are 8½ by 12 inches, and the subwoofer is about the size of a laptop computer. Available this fall. Price: \$899. Denon Electronics, 222 New Road, Parsippany NJ 07054.



Pickup for Passengers

SCHEDULED FOR THE 2000 model year, Nissan's concept Frontier pickup truck marries car comfort with pickup practicality. Four forward hinges—a first for a compact truck—and an over-size cabin make passengers feel like they're riding in a car. The vehicle will likely be powered by a 3.3-liter V6 engine. Nissan North America, Box 191, Gardena CA 90248.

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Hydrofoil Trimaran

IN 10 KNOTS OF WIND, THE HYDROPTÈRE cruises along like a trimaran; at 15 knots, it rises out of the water on three foils. The unique 60-foot vessel has a 90-foot mast and 2,700 square feet of sail and can attain speeds of 40 knots. Under development by Frenchman Alain Thébault since 1994, it's now ready to cross the Atlantic—maybe even later this year.

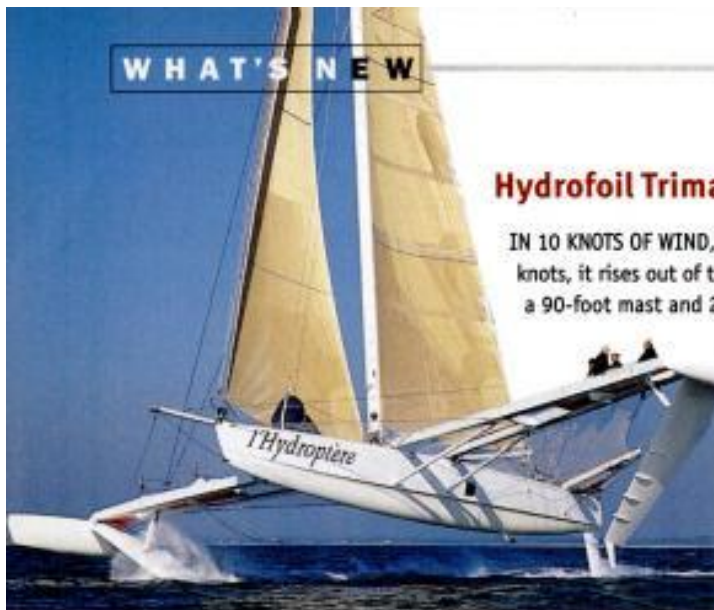
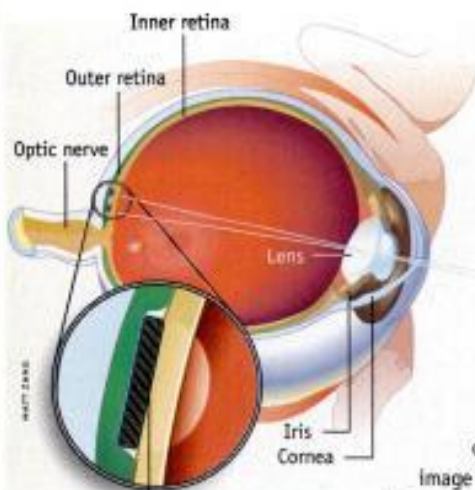


ILLUSTRATION: ALAIN THÉBAULT

Bionic Eyes

SOMEDAY, artificial light receptors, or photoreceptors, may be inserted under damaged retinas to help patients regain sight. Normally, the brain creates images by interpreting signals relayed from

the retina via the optic nerve; the signals contain information about color and brightness. Now researchers at Optobionics of Wheaton, Illinois, have demonstrated in animals that their artificial receptors can transmit image information to the brain. Human trials are expected within a few years.



Implant in subretinal space



Going Steady

CANON'S VISTURA DIGITAL CAMCORDER is the first to use the company's recently developed lens shift technology that optically—for greater accuracy—rather than digitally corrects for inadvertent body motions that cause your videos to blur. The camcorder operates in two modes, photo and movie, and both can be downloaded to a computer via a Firewire connection. The \$1,999 camcorder comes with a viewfinder and a 2.8-inch swiveling LCD screen. Weight is less than 2 pounds.

Betta than Jetta

VOLKSWAGEN'S 1999 JETTA, called the Bora in Europe, features an all-new body and a sports suspension for better handling. Power options include a 90-horsepower turbo-diesel, a 100-hp four-cylinder, and a distinctive 150-hp V5. Safety features include seat-mounted side airbags and antilock brakes. Available in December. Price not yet set.



Big Baby

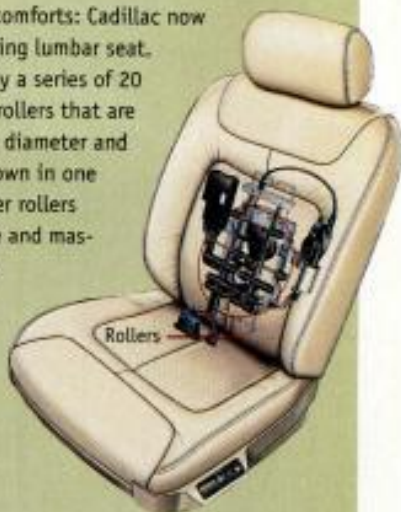
IT MAY NOT BE quite as long as Godzilla, but New York City's American Museum of Natural History has a 25-foot monster of its own, a baby giant squid. Caught last winter by fishermen in New Zealand, the squid is one of the best-preserved specimens of this rare and most mysterious animal. Scientists at the museum plan to study the squid and eventually put it on public display.



PHOTO: THE AMERICAN MUSEUM OF NATURAL HISTORY

Massage to Go

TALK ABOUT creature comforts: Cadillac now offers the first massaging lumbar seat. Your back is soothed by a series of 20 independent massage rollers that are each 19 millimeters in diameter and travel 50mm up and down in one 8.5-second cycle. Lower rollers provide added pressure and massage. Available on the 1999-model Seville STS, Eldorado Touring Coupe, DeVille d'Elegance, and DeVille Concours. Price has not yet been set. www.cadillac.com



Power Assist

SOME HOMES in Westchester County, New York, are testing a device that will save their owners one headache: In the event of a blackout, the house's Power Sentry system automatically informs the local power company, Con Edison. The credit-card-size Power Sentry, which hooks up to an outlet and phone line, calls 60 seconds after the power goes out, and then again when power is restored. Power Sentry soon could be adapted by other power companies with voice-response systems. www.coned.com

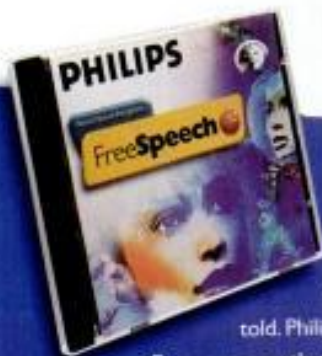
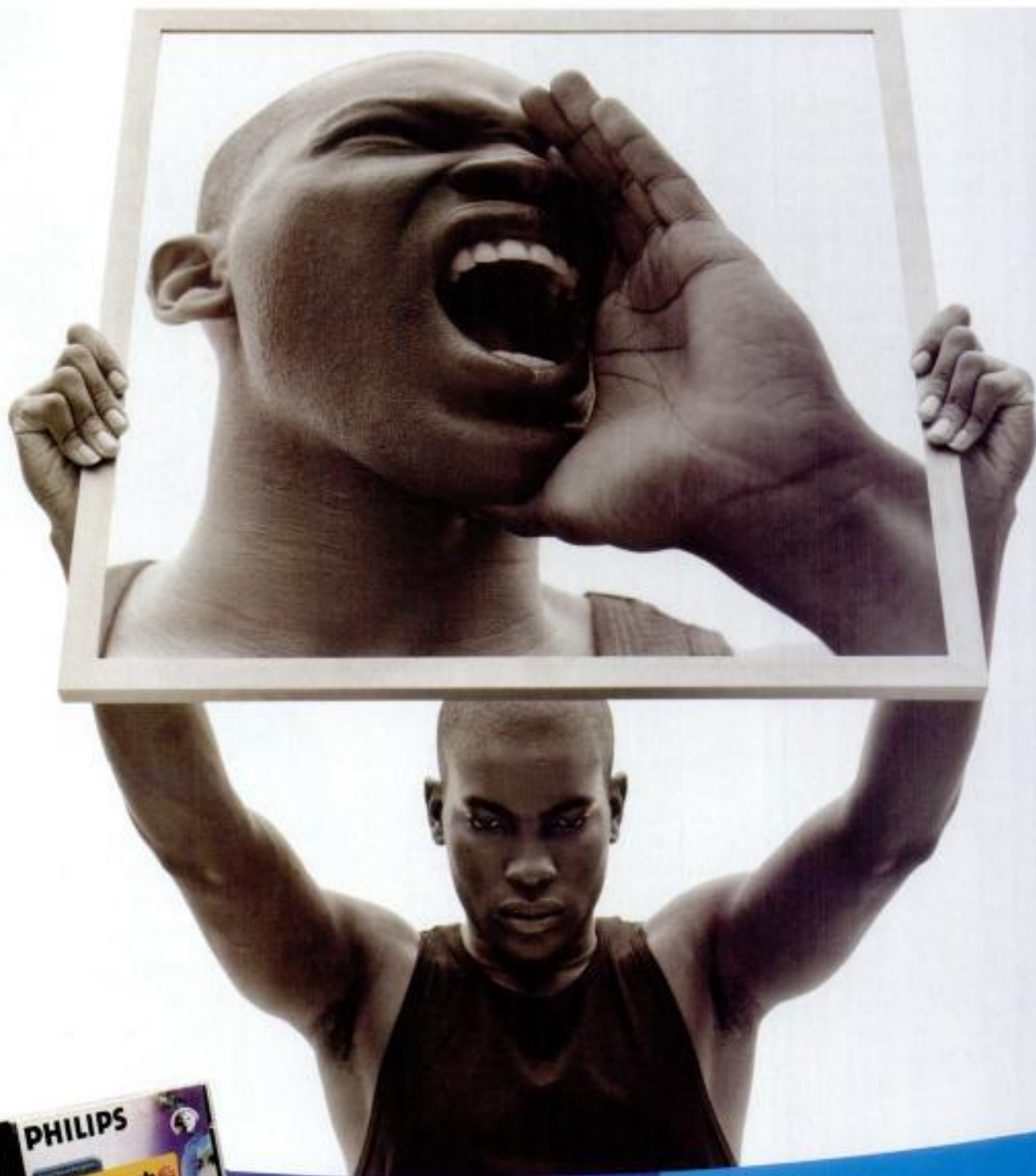


Running Flat Out

COMPAQ'S NEW Presario 5600 series marries the power of a loaded Pentium II computer with the visual pizzazz of a flat-screen display. The 5610 model (\$1,999) zips along at 350MHz and comes with 64MB of memory and an 8GB hard drive, while the 5630 (\$2,499) runs at 400MHz and has 128MB of memory and a 12GB drive. Each also comes with a Zip drive and DVD-ROM player, and USB and Firewire ports up front. The 14-inch active-matrix color LCD display adds \$999 to the total system price. www.compaq.com



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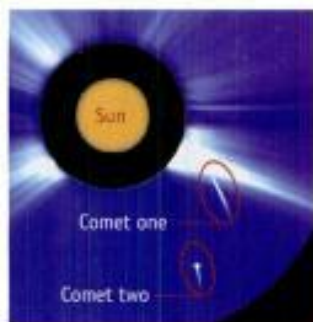
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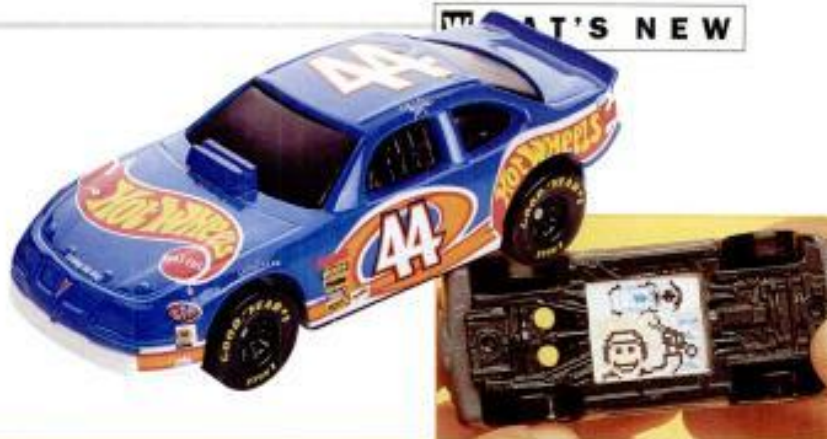
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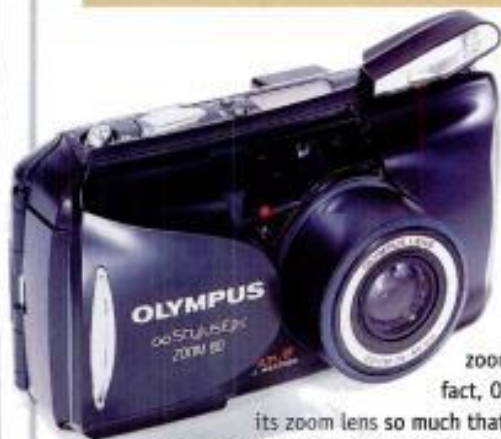
Two Comets and a Sun

IN A RARE celestial spectacle, two comets were captured plunging into the sun's atmosphere in close succession with the LASCO coronagraph on the Solar and Heliospheric Observatory, a joint project of NASA and the European Space Agency to study the interaction of Earth and the sun. Many of these so-called sungrazers have been sighted, but none in such close succession. umbra.nascomm.nasa.gov/comets/SOHO_sungrazers.html



Microcar with a Microchip

IT MAY LOOK like a typical Hot Wheels toy car, but pop the hood and you'll find a miniature computer inside. The computer calculates speed, number of laps, and reaction time, and displays them on a LCD screen embedded into the chassis (shown). The \$15 Cyber Racers come in 1/64-scale NASCAR and GT models. www.hotwheels.com



Pocket Zoom

THE Olympus Epic Stylus Zoom 80 is the world's smallest 35mm

zoom camera. In fact, Olympus shrunk its zoom lens so much that it fits into the original non-zooming Stylus body (4.5 by 2.3 by 1.6 inches). The weatherproof Epic Stylus Zoom 80 weighs 6.3 ounces without battery. Price: \$180. Olympus America, Two Corporate Center Dr., Melville NY 11747. www.olympus.com

Long-Life Disposable

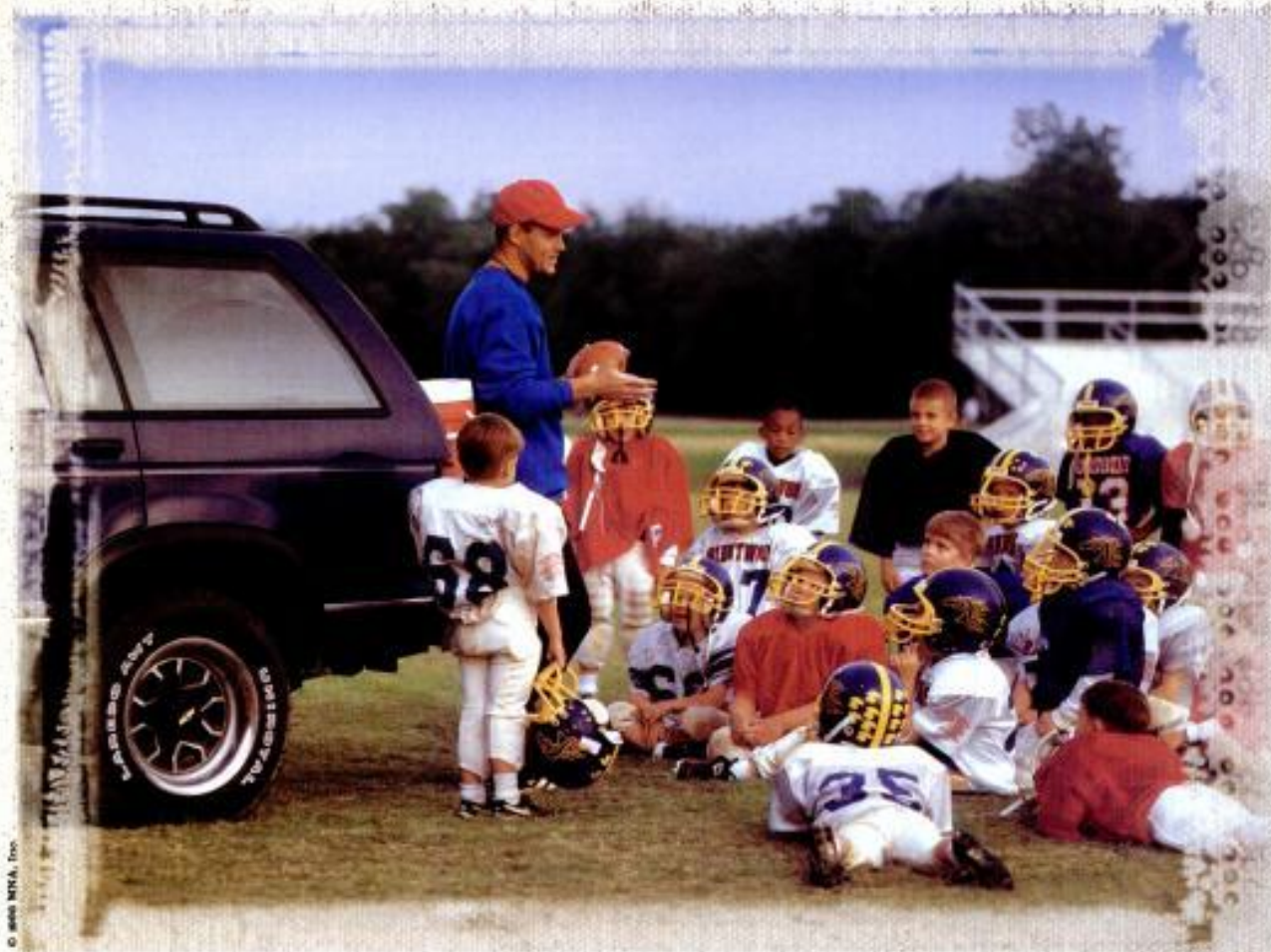
HAVE A CELLULAR phone in your car for emergencies? If you haven't been charging its battery every month, it may not work when you need it. Now Electric Fuel's zinc-air battery, the world's first disposable cellular phone battery, offers a shelf life of two years. Available this month, the battery fits Motorola flip, Nokia 2100 series, and Ericsson 300 and 600 series phones. Price: \$7 to \$10. Electric Fuel Ltd., 885 Third Ave., New York NY 10022.



Electronic Gun

DESIGNED TO KEEP POLICE and soldiers out of harm's way, the Trap T-2 rifle can be operated from a handheld remote control device equipped with a viewing screen. The rifle is more accurate over longer distances than a sharpshooter with a conventional weapon, tracks moving targets, and focuses in on multiple targets in less than 1 second. A network of weapons could be operated by a single person. Precision Remotes, 1230 Brickyard Cove Rd., Point Richmond CA 94801.





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Solar System Hot Spots

RECENTLY RELEASED DATA from the Galileo spacecraft's 1997 swingby reveals that volcanoes on Jupiter's moon Io sizzle at the highest recorded surface temperatures anywhere in our solar system, except at the sun. They measure as high as 3,100°F. Dark spots on the image at left mark the sites of current volcanic activity. Regular temperatures on Io average about minus 243°F. <http://www.lpl.arizona.edu/hyps/science>

Ambidextrous Mouse

THE INTUOS 4D MOUSE is the first mouse that's ergonomically designed for either the right or left hand. It can be tilted and locked into place on either side, so the slope on which your hand rests is exactly where it should be. Right now, the mouse (\$70) works only with an Intuos graphics tablet (\$200). Wacom Technology, 1311 SE Cardinal Ct., Vancouver WA 98683. www.wacom.com



Beep a Date

THE WEEKEND looms, but you haven't got a date. Even worse, with the opposite sex at least, you don't have a clue. But with Lovegety, now you do. If a pink (female) beeper with the same interest settings as a blue (male) device comes within 15 feet, the devices will beep. At least it may be good for a laugh, and sometimes that's all you need. Available in Japan, with a U.S. introduction planned later this fall. Price: \$22.



Sound Beauty

WHY PAY \$7,000 for the Transport 3 CD Turntable CD player? Aside from solid steel and aluminum-alloy construction and custom-made electronic components linked by high-quality military-specification wiring, its design makes a statement to anyone who's looking as well as listening. Built to resemble an old-fashioned vinyl record player, the Transport 3's five-bladed iris hatch opens to load a compact disc from the top (inset). Sonic Frontiers, 2790 Brighton Rd., Oakville, Ontario, Canada L6H 5T4. www.sonicfrontiers.com



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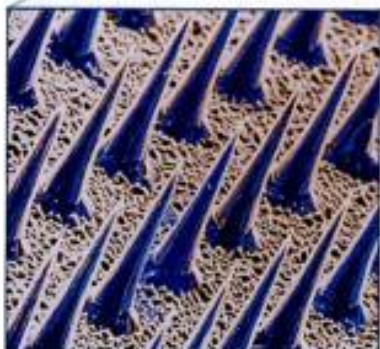
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MEDICINE

Ouch-less Injections

THE PHYSICIAN of the future may administer drugs using an array of hundreds of tiny silicon needles, each much thinner than a human hair. An injection from a microneedle array would be painless,



An array of 400 painless microneedles fits on a fingertip. Above is a colorized electron microscope image of the needles.

because the needles would penetrate only the outer layer of skin, which contains no nerve endings.

Developed by a group of researchers at the Georgia Institute of Technology in Atlanta, the microneedle arrays poke holes about 1 micron in diameter in the skin. Mark R. Prausnitz, an assistant professor at Georgia Tech's School of Chemical Engineering, says the holes are so small that bacteria have trouble squeezing through, so the risk of infection is minimal. Drugs delivered by the microneedles diffuse into the skin and are absorbed by capillaries and carried into the bloodstream.

"Preliminary tests on humans have shown that insertion of microneedles into the skin does not cause pain," says Prausnitz. He envisions microneedle arrays that would be as easy to use as nicotine patches. Patients would peel a liner off the array and stick it onto the skin.

Microneedles could prove particularly useful in delivering new protein-based drugs developed by biotechnology companies. Many of

these drugs cannot be taken orally but must be administered often enough to make traditional needle injection impractical.

The silicon microneedle arrays are made using fabrication techniques originally developed for manufac-

turing electronic circuits. Prausnitz expects that high-volume production would make the arrays cost-competitive with existing disposable drug-delivery devices.

The first use of the microneedle arrays will be for one-time injections. Prausnitz says several drug companies have expressed interest, but no agreements have yet been reached.—Edward D. Flinn

SPACE

Open House

THIS MONTH, a full-scale version of an inflatable fabric structure called TransHab (short for Transportation Habitat) will be set up inside a thermal vacuum chamber at NASA's Johnson Space Center for tests that simulate the conditions found in space. If the tests go well, a TransHab module may be sent to the International Space Station to serve as living quarters for astronauts.

Project manager Donna Fender says TransHab has a number of advantages over the Habitat module it would replace, which is a conventional steel cylinder. TransHab is lighter, yet it has 2.7 times the interior volume of the Hab, according to Fender. Engineers envision it as a future base camp for exploring the moon or Mars.

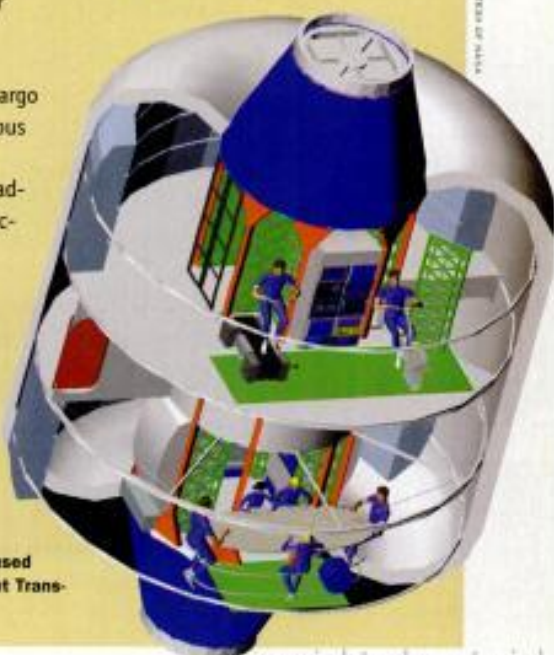
TransHab would be sent to the space station inside the shuttle's cargo bay. For protection against dangerous space debris, the module's shell is made from multiple layers of air bladders, foam, Kevlar webbing, a fabric-like material called Nextel, and Mylar. In one demonstration, the layered TransHab wall stopped a ball bearing shot at a speed of more than 15,000 mph; the bearing left a large hole in a 2-inch-thick steel wall.

The foot-thick TransHab

The TransHab design includes private crew quarters, an exercise room, and a dining area. Astronauts—used to cramped quarters—are excited about TransHab's meeting table, which seats 12.

walls squeeze down to about an inch when packed for transport, says Fender. Once in space, TransHab would be inflated, and a set of "shelves" stored in its core would be repositioned to become structural interior walls.

The public will have an opportunity to see TransHab on October 14 to 16 at Johnson Space Center's Inspection '98 in Houston. During this annual event, the center opens its doors to businesspeople, teachers, and anyone else interested in inspecting ongoing work. NASA hopes the visits will lead to spinoffs. TransHab technology, for example, could be used to create portable shelters here on Earth. More information about the event can be found at inspection.jsc.nasa.gov.—D.S.



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NEWSFRONTS

SCIENCE & TECHNOLOGY

EDITED BY DAWN STOVER

ENGINEERING

Bridge to the 21st Century

BRIDGE DESIGNERS around the world are studying a brilliantly simple concept that may allow far longer spans to be built than previously possible. An intricate spider's web of cables can permit spans of 2 miles or more, says designer Gordon Rose, a British engineer who heads the London-based firm Rose Associates. Currently, the longest suspension bridge is the 1.25-mile central span of the Akashi Kaikyo Bridge near Kobe, Japan ["A Bridge So Far," March].

Traditionally, long bridges are prone to wind and earthquake damage, so heavy decks and tall towers are required for strength and stiffness. Rose gets around that problem with a chain of three-dimensional arches made from cabling, which creates a horizontal suspension mechanism resistant to wind and earthquake forces.

The design, named Space Web, is potentially cheaper than conventional suspension bridges. "Huge, expensive piers are not required, and the road-

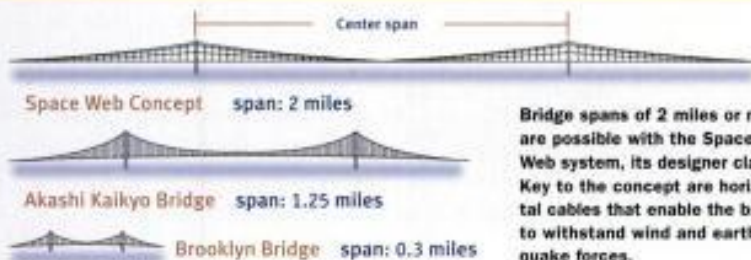
way deck can be built outward one section at a time rather than [using] the cumbersome process of towing out sections on barges and lifting them into place—a process dependent on good weather," Rose says.

He hopes Space Web will be selected to replace San Francisco's earthquake-damaged Bay Bridge.

The city's Golden Gate Bridge is already a major tourist attraction. "My design would give the city two of the most innovative designs anywhere in the world," Rose says.

Suspension bridge design has changed little since the Golden Gate was erected in the 1930s, although bridge lengths have grown steadily. But the Space Web design would make it possible to bridge huge distances, Rose says, including the 53-mile Bering Strait between Russia and the United States. Sea depths there are only 160 feet, and could be spanned by 20 Space Web arches, Rose claims. "Such a structure could change the course of history," he asserts. —Marcus Gibson

With Space Web, 3-D cabling creates a horizontal suspension mechanism that allows the bridge to better resist high winds and earthquakes.



Bridge spans of 2 miles or more are possible with the Space Web system, its designer claims. Key to the concept are horizontal cables that enable the bridge to withstand wind and earthquake forces.

NATURE

The Long Way Home

BIOLOGISTS AT Wake Forest University have used satellites to track albatrosses for almost 25,000 miles over three months, as the birds flew in search of food for their chicks. That's the equivalent of circling the globe.

In the first study that has used satellites to track albatrosses in the North Pacific, the researchers taped radio transmitters between the wings of 29 birds nesting on Tern Island, an atoll that is part of the Hawaiian Islands National Wildlife Refuge. The results so far show that the Laysan and black-footed albatrosses make repeated flights to the mainland coast to feed, sometimes leaving their chicks home alone for weeks at a time. "It's a mystery why a bird nests that far away from a continent but goes there to feed," says project leader David Anderson.

Signals from the radio transmitters are picked up by orbiting Argos System satellites and relayed to a processing station in France, which then e-mails the birds' coordinates to the Wake Forest researchers in Winston-Salem, North



Albatrosses, the largest seabirds, sometimes fly thousands of miles in search of squid and other food for their chicks.

Carolina. Thousands of schoolchildren are participating in the Albatross Project by plotting the birds' flight paths, some of which are displayed on the project's Web site, www.wfu.edu/albatross.

Supported by a grant from the National Science Foundation, the project aims to find ways to reverse worldwide declines in albatross populations. Once biologists determine where the birds are feeding, they may be able to identify what's killing them.—D.S.

ENGINEERING

Smashing Pumpkins

IT ALL BEGAN when Trey Melson and Bill Thompson challenged a friend to a pumpkin-throwing contest in Lewes, Delaware. Using machines built from pulleys, garage door springs, and other spare junk, three teams vied for the Punkin' Chunk championship. The winning distance: 128 feet 2 inches.

Now in its 13th year, the event has grown to 27 competing teams and more than 25,000 spectators. At last year's contest, Melson's winning throw was a record-setting 3,718 feet, marked by a 6-inch-deep crater.

The rules for the Punkin' Chunk are simple: The pumpkins must weigh between 8 and 10 pounds and leave the machine intact. No part of the machine can cross the starting line, and explosives are not allowed.

The two-day event will be held this year on November 7 and 8, perfect timing for the disposal of sagging jack-o'-lanterns. The fiercest competition is in the three divisions of the "unlimited" class: medieval-style catapults, centrifugal machines with whirling counterbalanced arms, and pneumatic cannons that work like giant blowguns.—D.S.

ACOUSTICS

Better Noise Barriers

MORE THAN 1,000 miles of highway sound barriers—costing \$1 million to \$2 million per mile—have been erected in the United States, most since the passage of a 1972 law requiring noise controls for new roadways exceeding 67 decibels. But even after a wall goes up, sound waves diffracted by the top edge spill over to the neighboring side.

Researchers at the University of Texas at Austin are looking at ways to make barriers more effective without increasing their imposing height and cost. A conventional 12-foot concrete barrier with a flat top can reduce noise by as much as 10 decibels, which cuts the perceived noise in half. Jagged edges, says engineer Ilene J. Busch-Vishniac, can further reduce noise by spawning random sound waves—which don't reinforce each other the way waves diffracted along a straight edge do.

Building scale models of jagged barriers, Busch-Vishniac and her colleagues improved noise reduction by as much as 7 decibels. More recently, the team has developed a mathematical model to calculate the noise heard behind a wall—saving the time and expense of building scale models. Using the mathematical model, which treats the upper edge of the wall like an array of small speakers, engineers may someday be able to customize the shape of that edge to deflect sound away from nearby houses.—Elisabeth M. Kirschner



Jagged edges may make highway barriers better at muffling sounds.

"Big" Willie Riggs

Career: Truck Driver

Passion: Bass Fishing

Watch: Casio Forester (FT200ML-5V)



Bud Petalstein

Career: Landscaper

Passion: Rock Climbing

Watch: Casio Forester (FT200ML-3V)



Richard Cranium

Career: Psychiatrist

Passion: Mountain Biking

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MILITARY TECH

Sea Assault

INSTEAD OF CAMPING its forces at allied military bases, the U.S. Department of Defense could orchestrate its next battle entirely from sea. Technology developed by the offshore oil industry could help Uncle Sam park a mile-long military base off any coastline within 30 days of deployment. Onboard would be enough room for 10,000 troops, 300,000 tons of supplies, 150 aircraft, and 3,000 military vehicles.

The Pentagon is proposing to build floating modules that could be connected at sea to create a gigantic offshore military base.

Dubbed a logistical support platform, the mobile offshore base would be the largest marine structure ever built, about 10 times as large as an aircraft carrier. Its mission: supply and launch military operations and provide logistical support for disaster relief and humanitarian efforts.

For now, the Department of De-

fense has no plans to build the base, but the Office of Naval Research is reviewing design concepts developed by several leading offshore platform manufacturers. Initial cost estimates are \$6 billion to \$10 billion.

The designs rely on multiple self-propelled modules that link to form a 5,000-foot-long, 500-foot-wide movable military warehouse and landing strip. Each section can operate independently under its own power. Hull-shaped pontoons keep each 250-foot-high module afloat en route to the battle zone. Once the module reaches its destination, the pontoons are sunk 125 feet beneath the waterline for stability.

The megaplatform can be positioned using electrically driven thrusters in the pontoons. Maximum speed for the base is 5 knots. When disconnected, each module can travel at 15 knots, about as fast as today's largest cargo ships.

To survive hurricanes and typhoons, the modules would be disconnected when waves reach 15 feet or more. Designs proposed for linking the platforms include rigid puzzle-like connectors, flexible bridges, hinges, and steel plates that rest between decks.

To date, the military has spent about \$23 million researching the possibility of floating a gargantuan mobile base. As the Defense Department finds locating foreign bases more difficult, the only choice may be to build one at sea.—Brian Fortner



ENVIRONMENT

What Turtles Hear

MYRTLE, A 550-POUND green sea turtle, is hovering in the giant ocean tank of Boston's New England Aquarium. Two speakers, one emitting a low-frequency hum, the other silent, are suspended before her. She stares at each before swimming over and touching her nose to the one making the noise. The choice earns her a prize: a piece of squid.

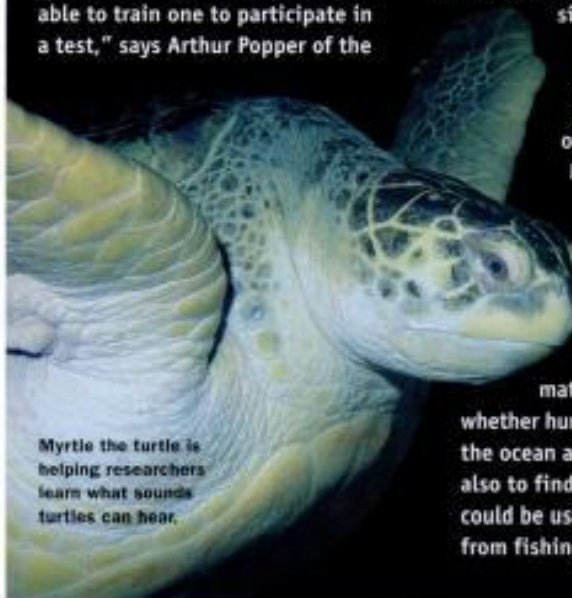
Welcome to the world's most unique hearing study. "We know almost nothing about turtles' hearing ability because we've never been able to train one to participate in a test," says Arthur Popper of the

University of Maryland. "They aren't consistent eaters, so it's difficult to give them positive reinforcement."

Enter Myrtle, who, after living at the aquarium for 28 years, is as consistent an eater as a turtle can be, allowing researchers from the University of Maryland and the aquarium staff to train her to go to a speaker when she hears it making a noise. "When she can pick out the correct speaker on a regular basis, we'll begin varying the pitch and volume of the noise to determine her full range of hearing," says Robert Dooling, also of the University of Maryland.

The training hasn't been without its problems. The hundreds of fish in the tank with Myrtle can distract her, and she has gone on occasional fasts, but her progress has nonetheless been remarkable.

The researchers' ultimate goal is to determine whether human-made noises in the ocean are harming turtles, and also to find out whether sounds could be used to ward turtles away from fishing nets.—Jerry Shine



Myrtle the turtle is helping researchers learn what sounds turtles can hear.

COMPUTERS & SOFTWARE

EDITED BY CHRIS O'MALLEY

HANDS ON

Inkjets: The Next Generation

HOW MUCH BETTER can inkjet printers get at reproducing color photos? Probably not a lot in the short term. But there's plenty of room for improvement when it comes to how quickly they print digital photos—and text—and what kind of paper is required.

Epson's new Stylus Color 850 (\$379) attempts to enhance the standard-setting 800 model, which will remain on store shelves at least through the end of the year at a lower price. The new model succeeds, albeit modestly. The 850 claims to be as much as 20 percent faster than the 800, and we did find it faster, but only slightly, especially for text pages. As with most other inkjets, many color photos still take a minute or more to print. And while an improved printhead design that produces smaller, more precise ink droplets allows you to print on

plain paper at the maximum resolution of 1,440 by 720 dots, that's usually more ink than common copier/printer papers can handle well. High-resolution photos still require thicker, coated papers to look their brightest and sharpest. As with the 800, the Epson 850 delivers skin tones and other subtleties better than most printers.



Epson's Stylus Color 850 has great photo quality like the 800, but is slightly faster.

As in previous models, Canon uses multiple ink cartridges to produce its best photos with the new BJC-5000 (\$299). And now it uses the same approach to achieve higher speeds. The 5000's flexible dual-cartridge system lets you put in two black ink



Canon's new BJC-5000 can use two black or color ink cartridges to speed printing.

cartridges that each shuttle across half the page to greatly improve monochrome printing speeds. It can do the same for color printing with two color cartridges. The best color mode, however, comes with one standard color and one "photo" cartridge, which allows for more refined seven-color printing at slower speeds. All of these cartridges can be more confusing and less convenient, but they give you more control over how you print. The 5000 promises photorealistic printing (as many as 720 dots per inch) on plain paper, but rivals film photos only on glossy papers.—C.O.

MICROPROCESSORS

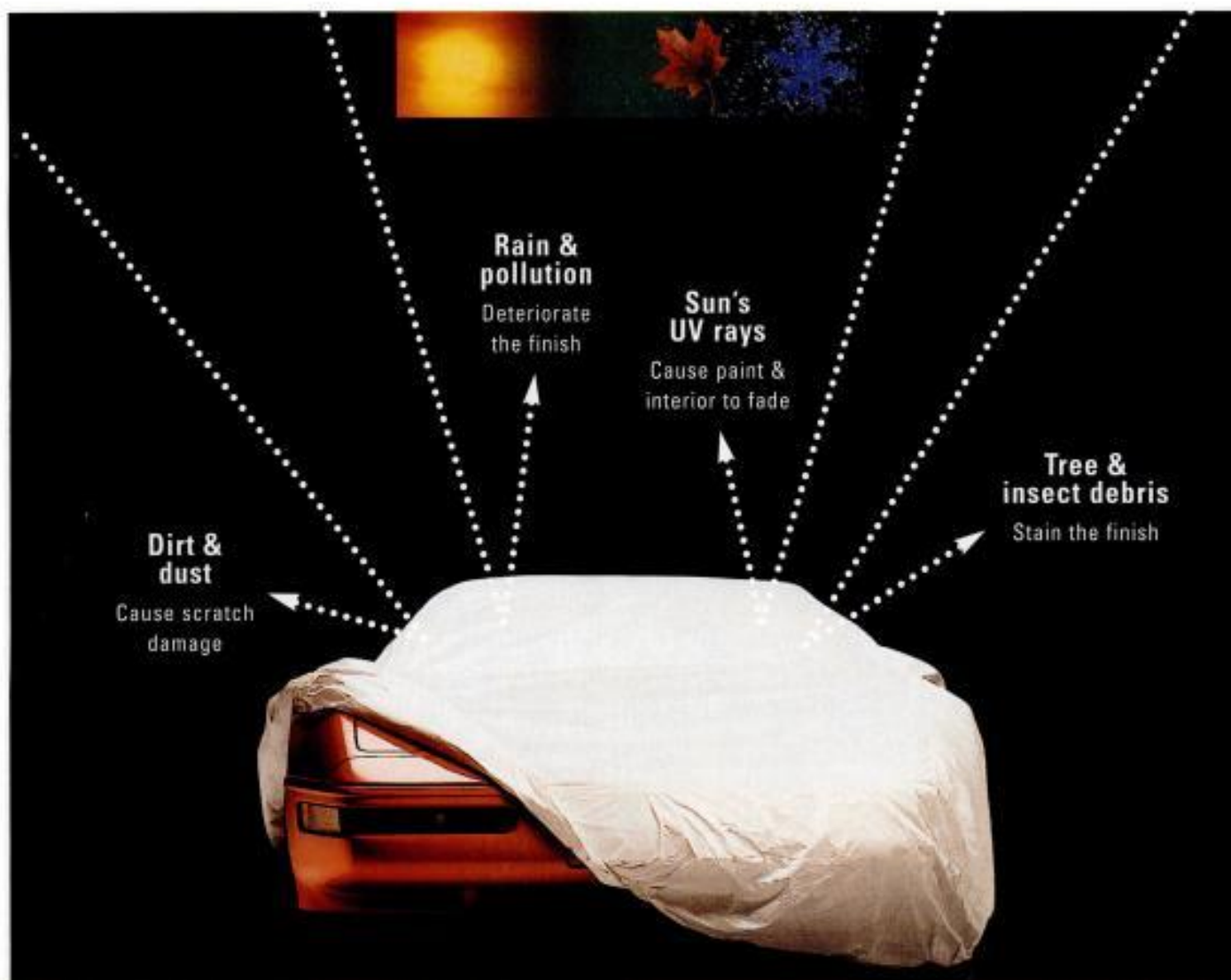
The March to 500 (MHz)

IS IT BAD LUCK to count your chips before they hatch into new PCs? With all of the new microprocessors lately, and more coming in the next six months, you may want to take stock before laying out for a new computer.

Intel has essentially divided its processors into three classes: basic, performance, and workstation. On the basic front, which Intel defines as chips being used in PCs costing less than \$1,200, the company recently introduced 300- and 333MHz versions of its Celeron processor. The top speed of its Pentium II chip, meanwhile, shifts from 400- to 450MHz,

and is expected to hit 500MHz by early 1999. And Intel is readying even faster chips, including a speedier version of its Pentium II Xeon chip and a new 3-D chip code-named Katmai, for use in workstations where chips from Sun and Hewlett-Packard are often used today.

Intel rivals AMD and Cyrix are still a step or two behind at the high end of processor speeds, but offer lower-cost alternatives to Celeron and Pentium II chips—especially for home PCs. AMD recently began shipping 300- and 333MHz versions of its K6-2 processor, and says it expects to have 350- and 400MHz chips later this year. Cyrix has new 300- and 333MHz versions of its M II processor as well.—C.O.



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HANDS ON

Organizing the Digital Shoebox

THANKS TO digital cameras and scanners, many of us are now filling hard drives and Zip disks with a dizzying array of digital pictures. But like the photo albums we keep on our shelves, new programs like PhotoRecall Deluxe 2.0 and Photo Org can help you organize your pictures—and share them in ways no paper album can.

PhotoRecall (\$50), from G&A Imaging, takes the photo album metaphor quite literally, enabling

Photo Org (\$50), from Canon Software Publishing, extends the metaphor a bit by arranging digital photos into “rolls of film” first and then into albums.

Canon's Photo Org lets you bring in photos as “rolls of film” and put them into albums.



lack a sound option and an obvious spot for captions (though you can add text anywhere on a page), but the product does have a visual editor and the ability to create and e-mail self-running slide shows, as it calls them, with a music soundtrack. Photo Org can help you create Web pages as well, and Canon even offers to post them free for 30 days on its site.

Neither program offers a direct voice-recording feature, which would be a natural complement to multimedia photo albums. But each makes organizing your digital photos an easy, enjoyable, and sharable family experience.—C.O.



You can e-mail self-running albums to family members with G&A's PhotoRecall Deluxe.

you to place pictures into onscreen albums that can be stacked on shelves and organized into libraries. You can add captions and attach sound files to your pictures, and even do some basic editing, such as changing brightness and contrast, with an easy adjust-by-example feature that lets you see how these changes affect your picture before deciding to make them. But PhotoRecall may be even better at letting you share your pictures. Its “portable player” lets you create self-running picture albums, with or without sound, that you can e-mail to others. And the program has stock page layouts you can use to publish your pictures on the Web, assuming that you have a personal site.

DISPLAYS

Really Big Screens

IF THE RULE FOR PC monitors is the bigger the better, then we've got something new to aspire to. Pixel-Vision, a flat-panel display company based in Acton, Massachusetts, recently demonstrated what it claims is the world's largest PC display, at least in pixel count: a video wall comprised of 20 separate 15-inch panels that can act as a single monitor and be driven by a single computer.

Using a technology the company calls SmartGlas, the video wall can show as many as 16 million pixels—many times what a typical PC video card can produce. In fact, PixelVision used five Matrox video cards inside a single PC to create the 4,096- by 3,840-pixel wall display. The wall can show either a single image

as a mosaic of screen tiles, or be segmented to display information from different sources or programs, which is how the company envisions Wall Street brokerages, call centers, and other businesses using such a system, for example.

PixelVision says its technology permits screen walls of almost any size. The 20-panel display would cost about \$40,000. The company's existing SmartGlas products can merge information from several computers onto a single display, or run multiple displays from a single video card inside a PC.—C.O.



Demonstrated at a recent trade show, the PixelVision video wall is constructed from 20 separate LCD panels.

WEB WATCH



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—Suzanne Kantra Kirschner

R & D

Technology Lives!

IF YOU THINK artificial intelligence—getting machines to think like humans—is a challenge, the prospect of creating artificial life is even more daunting. Still, fresh evidence suggests it may only be a matter of time before we see the emergence of what some are calling “living technology” or “cyberbiology.”

CyberLife Technology Ltd. of Cambridge, England, one of the pioneers in the artificial-life field and host of the international Digital Biota conference in September, recently announced that it has a contract with Britain's Ministry of Defence research agency to develop a simulated fighter plane that's flown and controlled entirely by an “autonomous virtual organism.”

Moving a step beyond remote control, the cyberpilot will require no human intervention and be capable of not only sustaining flight, but pursuing enemies, evading attacks, and making reasoned decisions about its mission, according to the company. It is, however, only a simulation. It may be many years before such a computer pilot controls a real plane.

In the meantime, you can live a bit of the artificial life with the sequel to *Creatures*, the popular software created by CyberLife that presents a virtual world of fuzzy characters called Norns that hatch from eggs and live in your computer. Norns in *Creatures 2* will “evolve” in more advanced ways than before. It will be published by Mindscape and is slated to be available this fall.—C.O.

INTERNET

Live on the Web

SOMEDAY SOON, being on the road may not mean you'll have to miss your son's football game or daughter's soccer game. You'll be able to watch both live, or on demand, via the Internet.

Sun Microsystems has developed an easy-to-use, low-cost video broadcast and storage system for the Internet called NetCam. Other video broadcast systems for the Internet exist, but they typically require lots of computer know-how and big bucks—usually around \$5,000, which is more than most schools, little leagues, and other small organizations can afford. NetCam costs about \$500.

The heart of the NetCam is a black box that records, compresses, and sends video to an organization's server. The video is either broadcast on the Web in real time or stored in a file that site visitors can play or download later on. To begin broadcasting, the NetCam box is plugged



Sun's new NetCam system, which may be sold by other companies, lets you do Web video broadcasting on the cheap.

into a video camera. The box is plugged directly into an Ethernet network server or connected to the server by telephone lines (a high-speed ISDN or T1 line is recommended, however).—S.K.K.

RUGER DOUBLE-ACTION REVOLVERS

Ruger mid-sized double-action revolvers are the most versatile handguns one can buy. Combining reasonable price with superior engineering and manufacturing, the GP100 and SP101 represent an unsurpassed value in today's revolver market.

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All Ruger barrels, cylinders, and frames, are manufactured from ordnance quality 4140 chrome-moly alloy steel or 400-series stainless-steel.



Ruger GP100 Revolver
GP-160



Ruger SP101 Revolver
KSP-821



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RUGER GP100 REVOLVER

Catalog Number	Caliber*	Finish*	Sights	Shroud	Barrel Length	Approx. Wt.	Price
GP-141	.357 Mag.	B	Adj.	Full	4"	41 oz	440.00
GP-141	.357 Mag.	SS	Adj.	Full	4"	41 oz	474.00
GP-160	.357 Mag.	B	Adj.	Short	6"	43 oz	440.00
GP-160	.357 Mag.	SS	Adj.	Short	6"	43 oz	474.00
GP-161	.357 Mag.	B	Adj.	Full	6"	46 oz	440.00
GP-161	.357 Mag.	SS	Adj.	Full	6"	46 oz	474.00
GPF-330	.357 Mag.	SS	Fixed	Short	3"	35 oz	457.00
PF-331	.357 Mag.	B	Fixed	Full	3"	36 oz	423.00
GPF-331	.357 Mag.	SS	Fixed	Full	3"	36 oz	457.00
PF-340	.357 Mag.	B	Fixed	Short	4"	37 oz	423.00
GPF-340	.357 Mag.	SS	Fixed	Short	4"	37 oz	457.00
PF-341	.357 Mag.	B	Fixed	Full	4"	38 oz	423.00
GPF-341	.357 Mag.	SS	Fixed	Full	4"	38 oz	457.00
GPF-840	.38 S&W	SS	Fixed	Short	4"	37 oz	457.00

*Caliber: revolvers chambered for the .357 Magnum cartridge also accept all factory .38 Special cartridges; .38 S&W is caliber .38 Special.
*Finish: blued (B); stainless-steel (SS).

All prices are suggested retail only. See your dealer.

FREE instruction manuals are available for all Ruger firearms upon request. Please specify model for which you require a manual.

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Southport, CT 06490
www.ruger-firearms.com

RUGER SP101 REVOLVER

Catalog Number	Caliber*	Finish*	Capacity	Sights	Shroud	Barrel Length	Approx. Wt.	Price
KSP-221	.22 LR	SS	6 Rnds.	Adj.	Full	2 1/4"	32 oz	443.00
KSP-240	.22 LR	SS	6 Rnds.	Adj.	Short	4"	33 oz	443.00
KSP-241	.22 LR	SS	6 Rnds.	Adj.	Full	4"	34 oz	443.00
KSP-3231	.32 Mag.	SS	6 Rnds.	Adj.	Full	3 1/8"	30 oz	443.00
KSP-3241	.32 Mag.	SS	6 Rnds.	Adj.	Full	4"	33 oz	443.00
KSP-921	9mm	SS	5 Rnds.	Fixed	Full	2 1/4"	25 oz	443.00
KSP-931	9mm	SS	5 Rnds.	Fixed	Full	3 1/8"	27 oz	443.00
KSP-821	.38+S&W	SS	5 Rnds.	Fixed	Full	2 1/4"	25 oz	443.00
KSP-821L	.38+S&W	SS	5 Rnds.	Fixed	Full	2 1/4"	26 oz	443.00
KSP-831	.38+S&W	SS	5 Rnds.	Fixed	Full	3 1/8"	27 oz	443.00
KSP-321X	.357 Mag.	SS	5 Rnds.	Fixed	Full	2 1/4"	25 oz	443.00
KSP-331X	.357 Mag.	SS	5 Rnds.	Fixed	Full	3 1/8"	27 oz	443.00
KSP-321XL	.357 Mag.	SS	5 Rnds.	Fixed	Full	2 1/4"	25 oz	443.00

*Caliber: The .357 Magnum version of the SP101 handles all .357 Magnum factory loads and is designated by an "X" in the Catalog Number. These revolvers also accept factory .38 Special cartridges.

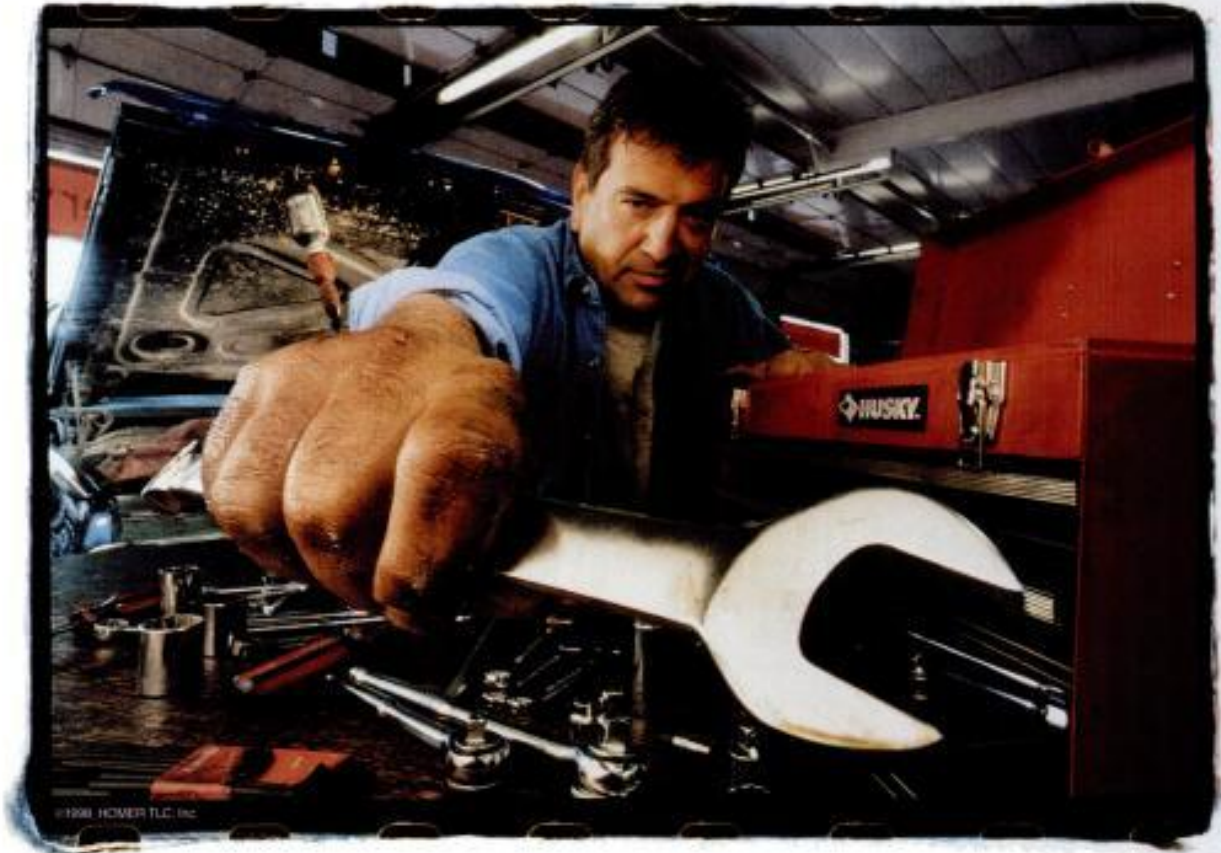
*Finish: stainless-steel (SS).

NOTE: Spurless-hammer models are designated by an "L" in the Catalog Number.



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AUTOMOTIVE

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PREVIEW DRIVE

Top-Down Porsche

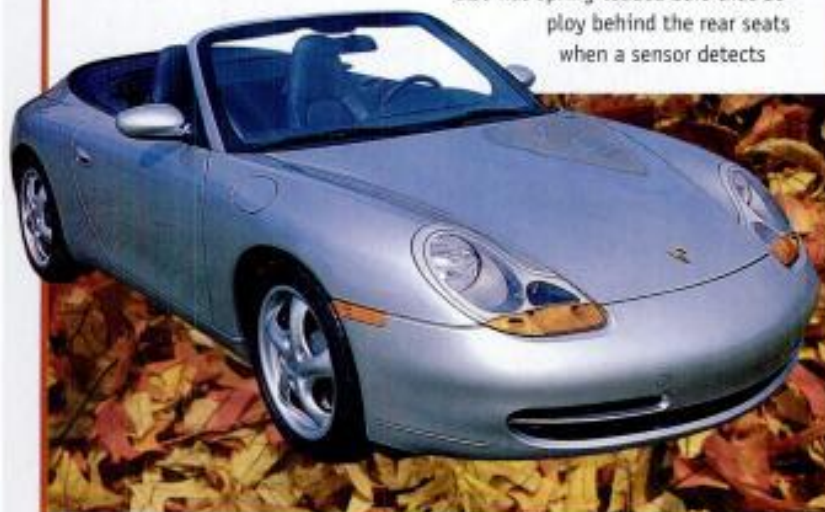
WITH BOTH the roof and the accelerator pedal in the down position, the new Porsche 911 Carrera Cabriolet provides a wind-in-your-hair driving experience like no other.

Like the new 911 Coupe, the Cabriolet is longer and wider than its predecessor. That, as you might expect, adds up to more leg- and cargo room. The basic shape is still recognizable as a 911 but is now based on the Boxster, albeit retaining the classic rear engine rather than the Boxster's midship drivetrain. Its drag coefficient has been cut from 0.34 to 0.30. Speed, how-

out the slightest hesitation. When the road flattened out a bit, and both speedometers (analog and digital) slid past 75 miles per hour, the top edge of a spoiler popped into view in the rearview mirror. The spoiler, which helps prevent the car from turning into an airplane at speeds ranging as high as 175 mph, is smaller now than in previous versions of the car.

If you buy the Cabriolet version of the 911, you'll need another person to help you remove the hardtop. But the softtop folds up automatically, tucking itself under a rigid cover in about 20 seconds.

For added safety, the Cabriolet also has spring-loaded bars that deploy behind the rear seats when a sensor detects



The Porsche 911 Cabriolet retains the chassis stiffness of its closed-top sibling.

ever, comes at the expense of amenities like rain gutters; if you happen to open the window while it's raining, you'll get drenched.

On our test drive in the Columbia River Gorge near Spokane, Washington, the 911 flowed around bends in the road as smoothly as the river itself, and climbed steep ridges with-

out the slightest hesitation.

The 911 began showing up in Porsche showrooms in mid-April, but few Cabriolets were available initially. The ragtop costs about \$9,500 more than the \$65,000 coupe. The removable hardtop and 17-inch wheels are now included as standard components.—*Down Stover*

FUEL CELLS

Not Ready for Prime Time

THE MUCH-BALLYHOODED automotive fuel cell, which would generate electricity with few byproducts by combining hydrogen and oxygen, still has a long way to go before it can compete with the internal combustion engine. So say researchers at Volvo, who recently examined the feasibility of fuel cell technology.

Volvo's study found that fuel cells are not only extremely expensive at this point (\$15,000 and up), but actually less energy-efficient than internal combustion engines—a fact that surprised the researchers. It's not that fuel cells are inefficient at producing electricity; a pure hydrogen fuel cell would theoretically use 35 percent less fuel than an internal combustion engine. Because hydrogen is difficult to store, most designs incorporate a methanol converter to break hydrocarbon fuel into hydrogen and carbon dioxide. With this system, the fuel cell would use only slightly more fuel than an equivalent internal combustion engine and offer fuel economy near 80 miles per gallon.

However, the additional weight of the fuel cell (about 180 pounds) and of the supplemental battery system necessary to overcome its slow response to driver input diminish efficiency. Taking this added weight into consideration, current internal combustion engines actually produce less carbon dioxide—a key global-warming gas—than the fuel cell. Other emission measurements, such as smog-forming gases, however, favor the fuel cell.

Is all of this bad news for the future of fuel cells? Not really. As technology improves, researchers believe efficiency will too. And they expect costs to drop.—*D.M.*

CONCEPT CARS

Test-Driving the Future

CHRYSLER IS EVALUATING new technology in a series of operational concept cars. A short turn behind the wheel of each demonstrated that the technology of the future can provide ample driving pleasure today.

The steel-bodied Pronto Spyder—powered by the transversely mounted 225-horsepower 2.4-liter dohc four from the Dodge Stratus—eventually could be made out of an inexpensive plastic called polyethylene terephthalate (PET). The material has the potential to lower

The Pronto chassis is composed of two Neon front ends, one turned around and welded to the other.

Pronto Spyder



the suspension, the diminutive roadster steers, stops, and handles almost like a showroom-ready production car.

Chrysler calls the Dodge Intrepid ESX2 a hybrid (for mild hybrid) because it relies more on the diesel engine than

typical hybrids. As we drive the ESX2, development engineer Steve Buckley monitors its systems with a laptop computer. "Right now, you're running on the diesel engine," he informs us. We accelerate. "Now the electric motor is kicking in." That is the essence of the ESX2; you use the 20-hp electric motor only when the 74-hp diesel needs help during hard acceleration. With this approach, the battery pack can be much smaller, cheaper, and lighter (133 versus 500 pounds) than what you'd find in a conventional hybrid or an electric vehicle.

The ESX2's acceleration is impressive: 0 to 60 mph in 12 seconds. The concept car is not intended to reach an especially high top speed, but its ultrasleek bodywork (coefficient of drag is just 0.19) gives it the potential to be fast.

Though the concept is made of high-priced carbon fiber, Chrysler also plans to use PET in the ESX2. Even so, the ESX2 would still cost about \$15,000 more than a similar-size sedan. That price should fall as the technology evolves. In fact, the original ESX concept was priced \$60,000 higher.

The Jeep Jeepster [Looking Back, Sept.] holds a few clues as to the future of the venerable Jeep Wrangler. The Jeepster can raise or lower itself by an impressive 4 inches, using electric ball-screw motors similar to those on aircraft to extend flaps.

Why make the Jeepster so vertically mobile? The answer has to do with the concept's *raison d'être*, which is to combine traditional off-road ability with high-speed freeway capability. The Jeepster's substantial 9.75-inch ground clearance and short front and rear overhangs give it good off-road potential. —John McCormick

Dodge Intrepid ESX2

The ESX2 is a continuation of Chrysler's research into hybrid powertrains. The latest version features a combination of a 1.5-liter three-cylinder diesel engine and a single electric motor, both mounted up front.



manufacturing costs, because the entire car could be molded in as few as six pieces. This approach also includes molded-in color, eliminating the need for an expensive paint shop. (So far, however, the finish is dull.) Using PET in a production version would keep retail pricing in the low \$20,000 range.

For a concept car to move under its own steam is unusual. But aside from some unnerving creaks and groans in

Jeep Jeepster

The Jeepster concept features double wishbones at each corner in order to cope with its unusual amount of wheel travel.



ENGINES

GM Joins the Club

THE INTRODUCTION of General Motors' new 3.5-liter dual-overhead-cam V6 engine, which debuts in the 1999 Olds Intrigue, marks something of a turning point in engine strategy for the world's largest automaker.

The new engine, which is nicknamed the "shortstar" because of design similarities with Cadillac's popular Northstar engine, is a modern high-output engine that utilizes the latest in engine technology.

The two-piece block and cylinder head are all aluminum. The twin overhead camshafts are chain-driven, which promises lifetime durability, while roller bearings on the camshaft followers reduce valvetrain



In response to customer demand, General Motors is introducing a 3.5-liter dual-overhead-cam V6 engine.

friction. A single powertrain module combines engine and transmission control and predicts oil life based on the different habits of every driver. And power from the new V6 is substantial—215 horsepower and 230 foot-pounds of torque.

In the broad scheme of things, the emergence of such a dohc engine—which differs very little from most V6 engines in today's midsize

cars—doesn't seem particularly noteworthy. But General Motors has been one of just a few automakers maintaining a large portion of simple pushrod engines. The reason? The company believes that the simplicity, compact packaging, and lower cost of these engines offset the loss of power that results from inefficiencies at high rpm.

The pushrod GM 3800 produces 200 hp; a supercharged version of it makes 240 hp with 280 ft.-lbs. of torque. Insiders at the company say that the supercharged pushrod is less expensive than the new overhead-cam engine. So why do an overhead cam, then? It all comes down to image. "People want it," says one insider.—D.M.

NEW CARS

Daewoo Set to Open U.S. Operations

DAEWOO MOTOR AMERICA is introducing three car lines this fall in 14 Southern California, eastern seaboard, and greater Chicago markets. Daewoo is a Korean automaker that once supplied Pontiac with the lackluster LeMans subcompact. The company's new effort is distinguished by its decision to offer the new cars through company-owned stores rather than conventional dealers. Daewoo is also promoting them through college "student advisors," who will sell cars in exchange for a training trip to Korea, commissions, and discounts on the purchase of their own Daewoos.

The three-model Daewoo lineup encompasses four body styles and eight trim levels. All are powered by dohc four-cylinder engines. An automatic transmission is standard in the top two editions. The Lanos subcompact [What's New, Aug.] combines a Porsche-tuned chassis with ItalDesign styling. The three-door hatchback is especially attractive. Basic dimensions are slightly smaller than a Honda Civic and the 1.6-liter engine delivers a competitive 105 horsepower. This Daewoo feels light, agile, and eager to go. The Nubira (Korean for "to go everywhere") is Daewoo's

compact offered in sedan, five-door hatchback, and wagon body styles. The exterior is a dead ringer for the previous-generation Mazda 626. Interior and exterior dimensions are comparable to a Honda Civic. Keyless entry and power assists are standard. Except for a tinny-sounding door slam and high-rpm engine noise, the Nubira is a congenial family-transportation machine. Daewoo's flagship Leganza, also styled by ItalDesign, is about the size of a Ford Contour. Rubber-isolated chassis components and an engine tuned for torque help connote a luxury mood. Unfortunately, controls for the entertainment and climate systems are needlessly complex. Prices should start at \$9,000 for a base Lanos S and top \$20,000 for the Leganza CDX.—Don Sherman



The Nubira, sitting in the middle of Daewoo's model lineup, comes as a hatchback, sedan, or wagon.

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PREVIEW DRIVE

G20 Reborn

AFTER A two-year absence, the Infiniti G20 is back. The 1999 G20, like the original, is based on the Nissan Primera sold in Japan and Europe. Its 2.0-liter dohc 16-valve 4-cylinder engine, which has a lightweight aluminum block and head, develops 140 horsepower and 132 foot-pounds of torque at 4,800 rpm.

During our test drive on the rolling hills and twisty roads near Seattle, the G20 demonstrated its surefootedness. The front independent multilink design is similar to that of the original G20. In the rear a multilink, torsion-beam axle replaces the original strut/parallel link system—which helps the car's 15-inch aluminum-alloy wheels maintain solid grip.

The G20 comes with a standard five-speed manual transmission; a four-speed automatic is optional. Despite some refinements, the automatic did some gear hunting as the car scaled the 1,300-foot Tiger Summit.

Safety improvements include a side-airbag system that protects the head and chest. There's also more rear legroom and trunk



The new Infiniti G20 features safety improvements and more space.

space—the latter partly because of clever new hinges. A Bose 100-watt audio system is standard, leather seating optional.

The G20 went on sale in July. Base price ranges from \$22,000 to \$25,000. —Murielle DiChristina



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ELECTRONICS

EDITED BY FRANK VIZARD

AUDIO

Mood Music

FEELING DOWN? Sure you can hide it from your spouse, but your stereo is onto you.

Rosalind W. Picard, a professor at the Massachusetts Institute of Technology's Media Lab, is developing the Digital DJ, a stereo with a built-in computer processor that "reads" your mood. Based on your state of mind, the stereo would then play the music you'd like to hear most—mellow for the manic, metal for the morose.

Picard's concept, which is at least several years away, could be applied to devices ranging from appliances to home computers as well, allowing these devices to react to touch, voice inflection, or a visual cue—such as a furrowed brow or a smile. "Instead of pressing a button that says you're

happy or sad," Picard says, "we're giving the computer the ability to sense it."

The Digital DJ might, for example, sense your mood from the amount of pressure you apply to the play button and then choose from among preprogrammed musical choices. The prototype gives listeners three choices for each of two moods; a production version could have as many as 12 moods. Eventually, with access to the Global Positioning System, the DJ would be able to determine what environment you're in and make a musical choice accordingly—classical music for the office or rock 'n' roll for the commute home.

Lest you worry, Picard is quick to point out that the computer doesn't

actually read your mind. Just be careful about lending out your DJ; you never know what someone might do with the information that you listen to the Spice Girls when angry.—Christopher Miller



SENSORS

Detecting Battlefield Toxins

BATTLEFIELDS DO NOT MIMIC pristine lab conditions, a point amply demonstrated during the Gulf War when, some experts believe, instruments designed to detect biological weapons proved unreliable. Engine exhaust, exhaust from weapons, spilled fuel, lubricants, and smoke all acted as background distractions, making it difficult for the instruments to distinguish a potentially deadly biological agent from nonlethal bacteria and chemicals.

Now, Oak Ridge National Laboratory is looking to remedy the problem with the Chemical-Biological Mass Spectrometer. The unit, now in prototype and set to enter production in 2001, was engineered at the behest of the U.S. Army's Chemical and Biological Defense Command, and designed—both inside and out—for real world battlefield conditions. About the size of a desktop computer, the rugged system will be capable of detecting a very wide range of

lethal chemical and biological weapons, including bacteria, toxins, and viruses, as well as such hazardous chemical agents as nerve gas and blister agents.

"I think this is a major leap," says Wayne Griest, who is project manager of the device at Oak Ridge. "It should be faster, more sensitive, able to detect a wider range of agents, and less subject to interference."

The unit works by collecting an air sample, classifying it according to size, then heating it to break down its molecules. The sample is then moved into an ion trap mass spectrometer, where its mass-to-charge ratio and its chemical signature are compared against an extensive onboard library of known toxic agents, such as anthrax and VX gas.

The folks at Oak Ridge and the Department of Defense see applications for the new device in the private sector as well. With just a few minor modifications, it could be used to test processed food and in industrial safety and health care applications.—Hank Schlesinger



SAFETY

Electronic Lifesavers

THE NATIONAL debate about gun safety continues to spawn some innovative technological solutions to the problem. One of the latest comes from a patent filed by Intraloc of La Jolla, California, and involves the use of a battery-operated trigger lock.

The Intraloc plan incorporates a three-button lock powered by a lithium ion battery into the gun handle; the lock would be operated by thumb. When the correct code is entered, a grip safety collapses, signaling that the gun is operational. Intraloc claims this sequence of events takes less than 2 seconds.

Multiple entries of the wrong code cause a complete lockout, de-

Intraloc would employ a three-button lock that would release a safety grip.

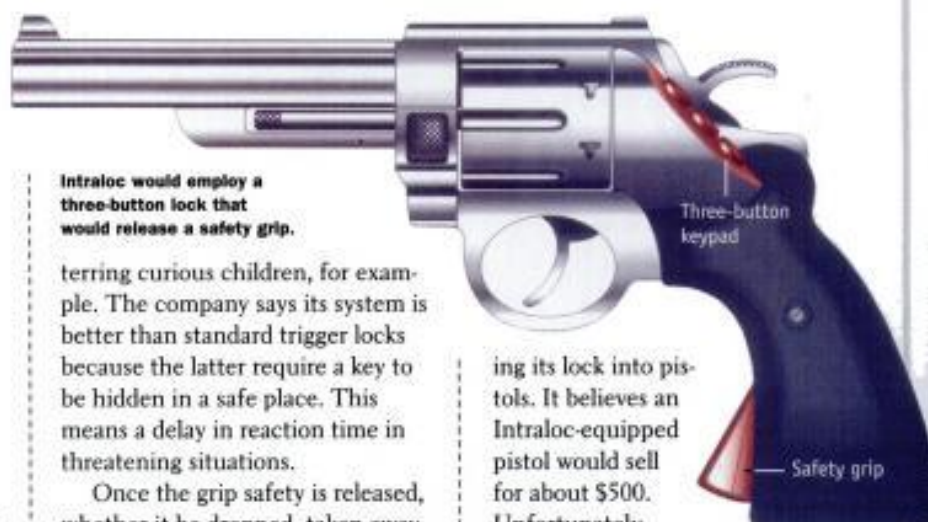
terrifying curious children, for example. The company says its system is better than standard trigger locks because the latter require a key to be hidden in a safe place. This means a delay in reaction time in threatening situations.

Once the grip safety is released, whether it be dropped, taken away, or simply reholstered, the pistol is automatically relocked. Assuming the owner is the only one who knows the code, the gun effectively can be used by one person only.

The company is currently talking to gun makers about incorporat-

ing its lock into pistols. It believes an Intraloc-equipped pistol would sell for about \$500.

Unfortunately, however, in the absence of a law compelling them to do so, "we doubt any major handgun manufacturer will adopt smart gun technology into mass-produced hand guns," says Intraloc president Robert M. Allan.—F.V.



DISPLAYS

Signs of the Future

THE DAYS OF HAVING to climb a ladder to change a printed sign will be over if a company called E Ink gets its way. Based in Cambridge, Massachusetts, E Ink is the commercial incarnation of electronic ink developed at the Massachusetts Institute of Technology ["Electric Tales," June '97]. This electronic ink can be coated onto any surface using standard printing processes. To change a message, an electronic signal is applied to the surface, so the ink can change colors and form numbers and letters, for example.

E Ink proposes to take the idea even further by linking the display to an existing paging system. Doing so

would allow a sign to be updated remotely. An E Ink display at a supermarket, for example, could be wirelessly updated to reflect changing prices or special sales. The display itself would be as thin as a sheet of paper, use very little power during updates, require no power to maintain, and be as readable as an existing sign. And because electronic ink can be printed on many different types of surfaces and the displays updated remotely, they would be advantageous in difficult-to-access spots.

E Ink ultimately hopes to develop a "radio paper" that looks and feels like a newspaper but that could automatically be updated each day—the newspaper would essentially typeset

itself upon receiving transmitted information. The company also hopes to apply the technology to such products as electronic books and magazines.—F.V.

Electronic ink displays can be thin enough to wrap around a pencil. When an electronic charge is applied, the electronic ink flips between white and dark (below) to form a desired letter.



TRANSMITTERS

Chip Radio

CAN'T FIND THE REMOTE? Just wait—it's about to get even smaller.

Micrel Inc. of San Jose, California, recently demonstrated the ability to put a radio on a single chip. The discovery could eventually reduce the size of radio-based remote controls, garage door openers, keyless entry devices, and security controls.

Micrel's new chip, inelegantly named MICRF001, does the work normally required by several discrete radio-frequency components and manually tuned circuit boards, allowing it to eliminate performance variations among similar products. The chip operates in the 300- to 450MHz radio spectrum and has a range of about 500 feet. The chip connects directly to monopole, helical, or loop antennas for use in a variety of package sizes. Best of all, the chip should reduce prices for radio-based remote controls. It costs about \$3, half that of the separate components previously used.—F.V.

BATTERIES

Predicting Failure

WHEN YOU BUY a laptop computer, a cellphone, or any other gadget with a rechargeable lithium ion battery, chances are good that you'll replace that battery sooner than you think. That's because companies test battery life span merely by taking a small portion of a group of batteries manufactured at the same time and charging and discharging them until they die. They then measure the average life span for that test group and apply it to the entire bunch.

Engineering professor Mirna Urquidi-Macdonald of Penn State University wants to make battery life more predictable. She has designed software that can "learn" to predict a battery's life span faster, more accurately, and less expensively. The software is built on artificial neural networks—mathematical tools inspired by the behavior of brain cells that can predict outcomes when given a large body of data on which to train themselves.

By referring to historical data detailing how specific characteristics such as operating temperature, applied current, time between charges, and voltage during discharge affect a battery's performance over time, the software can predict with almost 100 percent accuracy how long a battery will last, according to Urquidi-Macdonald. Right now, the software is in its "baby stages," she says, because she hasn't compared the accuracy of its predictions for batteries designed to last many years.

Upcoming experiments, however, are intended to test long-term predictions and also the software's effectiveness in predicting failure of such other rechargeable batteries as nickel cadmium and polymer-based types.

The hope is that this research, supported by the U.S. Department of Energy, will lead to the production of better batteries. —Gunjan Sinha



When did you enjoy your first sip of Jack Daniel's? Write and tell us.

A TENNESSEE HAY WAGON, seldom seen these days, reminds us of the way Jack Daniel got his whiskey business rolling.

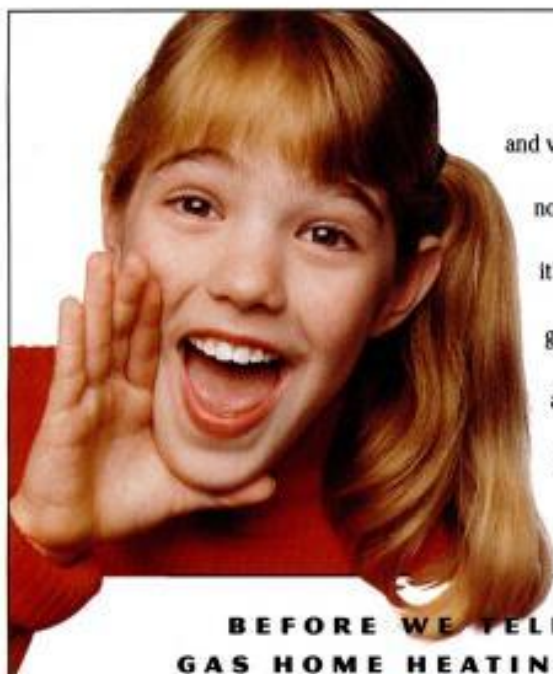
A young Jack Daniel often traveled the road to Huntsville, Alabama in a wagon much like this one. (He would hide his whiskey under the bales to protect it from highwaymen.) If you appreciate a smooth sippin' whiskey, you'll be happy to know we still make Jack Daniel's using the same methods Mr. Jack did. And, perhaps, even happier that we've found faster ways to deliver it.

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Your friends at Jack Daniel's remind you to drink responsibly.

Tennessee Whiskey • 40-43% alcohol by volume (80-86 proof) • Distilled and Bottled by Jack Daniel Distillery, Lem Motlow, Proprietor, Route 1, Lynchburg (Pop. 361), Tennessee 37352
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and venting technology, so there's no rushing air or rattling when it's turned on or running. You get reliable comfort without all the noise. We also gave it a flexible design so you can install it quickly and



COMPLETEHEAT®

supply of hot water, no matter what the size of your family or residence. And CompleteHeat's high efficiency rating of 90% means lower heating bills for you. To hear more about our versatile natural gas home

BEFORE WE TELL YOU ABOUT OUR NATURAL GAS HOME HEATING SYSTEMS, PLEASE TELL US:

DOES YOUR FAMILY TEND TO YELL A LOT?

Do they shout to be heard over a noisy furnace? Or howl when the water turns cold midshower? If so, you'll be glad to hear about



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WhisperHeat® and CompleteHeat®, two natural gas heating systems from Lennox. We engineered our WhisperHeat furnace with exclusive insulation



Clean natural gas. ^{no} in your home. Think what you'll save.

inexpensively where it fits best

And because WhisperHeat runs on clean-burning, efficient natural gas, it's economical to operate. Just like our CompleteHeat home heating system. This efficient product heats both your home and your water, giving you a virtually unlimited

comfort systems from a Lennox dealer near you, give us a shout at 1-800-9-LENNOX.



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HOME TECHNOLOGY

EDITED BY WILLIAM G. PHILLIPS

URBAN HOUSING

Affordable City Living

CITIES ARE IN again. By the year 2000, nearly 50 percent of the world's population will reside in urban areas—some by choice, others by necessity. In developing countries, where the trend is most pronounced, the population of

Tsinghua University in China, a country that—as it shifts economic emphasis from agriculture to technology—sees 60 million job-seeking peasants move to urban centers each year. The winners designed their concept for Anping County in Beijing, where many residents make their living producing mesh, wire netting, and slate.

The students designed a neigh-



The prize-winning home designs include locally produced materials like wire mesh and slate.

city is growing two to three times faster than it is in rural areas. Only one problem, and it's a big one: a worldwide shortage of affordable urban housing.

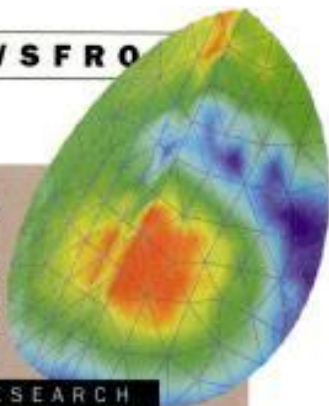
Forty-two students representing five continents—and three U.S. universities—tackled this very issue in the 1998 Global Design Challenge, sponsored by Owens Corning, while they competed for \$12,000 in prize money. The contest's goal: Design an energy-efficient concept home affordable to 90 percent of the people living in a specific area.

Taking first prize was a team from

neighborhood of homes, each containing a workspace connected to a living space by a large atrium. The homes capitalize on local industry—wire mesh holds the exterior concrete walls in place, and the courtyards are paved with slate. The 1,500- and 2,400-square-foot homes also feature solar electricity, large windows for ample daylight, shade trees, and a rooftop yard.

Though there are no current plans to build the concept neighborhood, the student designers say it could be done for about \$10 per square foot, substantially less than \$75 per square foot median in the United States.—W.G.P.

A model of an egg as it's being microwaved shows heat building in the center.



RESEARCH

Demystifying the Microwave

MICROWAVING a TV dinner could test even Julia Childs' nerves—the potatoes come out ice cold, the pasta sauce lava hot. Now Ashim Datta, an associate professor at Cornell University, along with graduate student Hua Zhang, is learning how microwave ovens heat certain foods. Their findings could someday help manufacturers produce food that cooks better in microwaves.

The team has designed comprehensive engineering models that detail the heating process of a microwave oven. The models use electromagnetic, heat-transfer, and biochemical data to image how certain foods cook. "They let us visualize microwave heating," Datta says.

Until now the process has been "cook and look," Datta says. "If you place a certain food inside a microwave in different locations, it will heat differently each time." The shape, size, and texture of food also affect the way it's heated. Spherical objects such as eggs and potatoes, Datta says, direct energy toward their centers. If heated too quickly, a buildup of water vapor pressure can make the spherical food explode. In addition, denser foods take longer to warm up, which is why potatoes often come out cold.

Along with creating foods that cook better in microwaves, Datta's models could also be used in food sterilization. By knowing how certain items cook, food processors could heat-kill bacteria with microwaves.—Christopher Miller

HANDS ON

Supermarket at Home

DON'T FEEL like trudging to the grocery store? Join the club. No wonder online grocery shopping is booming—and it's not limited anymore to local grocers who happen to offer Internet buying. The popular www.peapod.com site continues to expand, while www.netgrocer.com now delivers groceries anywhere in the continental United States and to military addresses.

NetGrocer offers a selection of more than 5,000 national brands, but perishable foods—milk, bread, meats, and eggs, for example—are not available. Peapod, meanwhile, can offer perishable and non-perishable foods because it works through local stores. After transmitting your order, the groceries are delivered right to your



door. But it's not available in all areas, including near our offices.

POPULAR SCIENCE tested online grocery shopping by buying the same 25 items from NetGrocer and from a local ShopRite, the largest chain in the Northeast United States.

At NetGrocer, the products are arranged in virtual aisles—everything from baby needs and pasta to household cleaners. Clicking "buy" loads an item into a virtual cart; a running tab

appears on the screen. Payment is by credit card, and delivery—within two to four business days—costs between \$3 and \$5.

Our virtual shopping trip took about 45 minutes, compared to well over an hour at ShopRite. The groceries arrived on schedule and were packed securely in 3 large boxes.

The bottom line? We saved \$2 at NetGrocer, including delivery charges.—Patti and William Feldman

ALLERGIES

The Mite Stuff

DOES YOUR HOME give you the sniffles? It could be dust mites, whose feces and shed exoskeletons form an allergen common in many homes. But research at Ohio State University may lead to better ways to eradicate them—and the allergies they cause.

During observation of laboratory dust mites, research associate Emmett Glass noticed that male mites tend to cluster together. This finding led him and his colleagues to speculate that the mites use chemical cues to find one another. Because dust mites thrive in humid conditions, the researchers believe clustering conserves moisture.

Now, the scientists hope to identify the clustering pheromone. If they can, it could be used by physicians to diagnose allergies. It could also be utilized for extermination—similar to a roach motel, Glass says.

In addition, by interfering with the pheromone, researchers could prevent male mites from clustering altogether. As a result, they would die of dehydration, eliminating the need for insecticides.—Becky Drfinger

PORTABLE POWER

Generation Next

YOU WOULDN'T KILL a fly with a sledgehammer, so why power a hot plate with a heavy-duty generator? Because traditional generators run at only one speed. Running slower dims lights, reduces frequency, and drops voltage, which can damage motors hooked to them.

Not a problem for the new Craftsman computer-controlled 3,600-

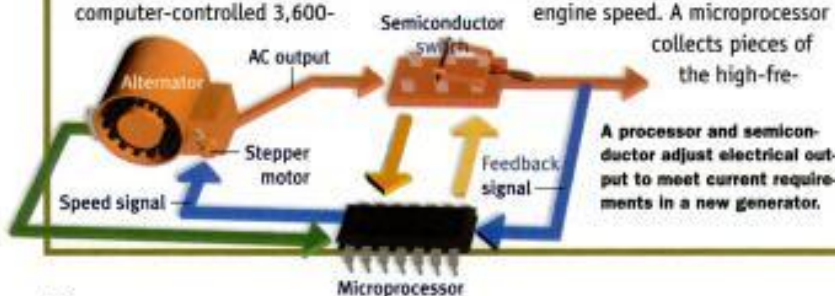
watt generator. It runs only fast enough to satisfy current electrical loads, reducing noise and saving fuel. Its secret: voltage synthesization, a fancy term that means a computer adjusts output to meet changes in demand.

The portable generator has a 16-pole permanent magnet alternator that produces between 300 and 600 hertz of alternating current, depending on engine speed. A microprocessor collects pieces of the high-fre-

quency waveforms and, with the help of a semiconductor switch, builds a 60-hertz waveform. Alternator speed is continuously adjusted to match output demand, using a tiny electronic stepper motor to position the engine throttle precisely.

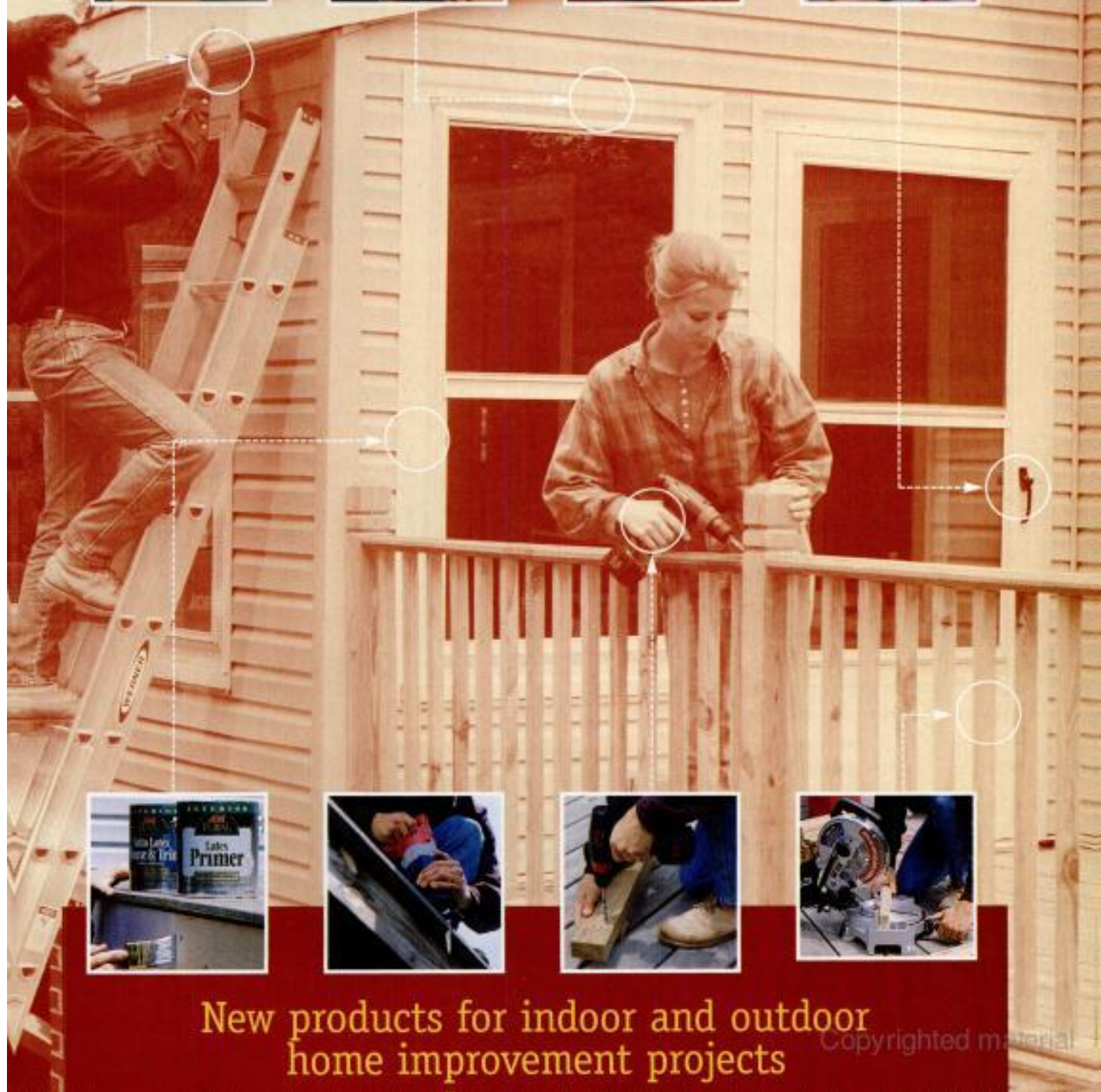
In a POPULAR SCIENCE test of loads from 100 to 3,500 watts, the engine speed varied from idle to about 3,700 rpm, but the voltage held at between 118 and 120 volts. Frequency ranged from 59 to 62 hertz, as advertised.

With the 4-gallon fuel tank, the generator will run for 29 hours on a 25 percent load, 7 hours on full load. It costs \$1,000.—Phil McCafferty



SPECIAL ADVERTISING SECTION

Home Remodeling Ideas



New products for indoor and outdoor
home improvement projects

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When days grow short, nights become crisp and other familiar signs of fall appear, smart home owners know it's time to wrap up the last few outdoor projects before the weather takes a final turn to winter. It's also a good time to start on projects that put a home's interior back into top shape for the upcoming holiday season.

Typical home improvement projects for this time of year include final repairs and touch-up painting to exterior areas, servicing or upgrading heating systems, and sprucing up interior rooms and furnishings. This special *Home Remodeling Ideas* section contains helpful tips and information on all of these projects, along with some useful new tools and products that can make the work go faster with better results.

PURPOSEFUL TOOLS

One outdoor area that should be checked carefully at the beginning and end of each season is a wooden deck, particularly if it is built at any significant elevation above ground level. Decks usually get lots of use over a summer, and all that wear and tear combined with continual exposure to the elements gradually weaken their structures. Even so-called "outdoor wood" such as redwood, cedar and pressure-treated wood are not totally impervious to the effects of weather and wear. Check for wood rot where deck boards meet joists, signs of deterioration where posts penetrate the ground, corroding metal fasteners, popped nails or loose bolts, especially at stair and handrail connections.

During our inspection, we discovered that the old handrails on our rear deck needed replacement. This can be a complicated job, but thanks to the amazing variety of materials available at The Home Depot, it turned out to be a fairly easy project. We used a handrail



The right tools increase your speed as well as precision. Accurate, repetitive cuts, including difficult miter cuts, are no problem for this Delta 10-inch Compound Miter Saw.

New high-tech tools, like this Porter-Cable Bammer cordless pneumatic nailer from The Home Depot, let you work where conditions make it most difficult. Each self-contained fuel cell (inset) fires up to 3,000 nails.



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Mounting brackets for the Rainhandler Rain Dispersal System are attached to the siding fascia board below the roof's drip edge, then the louver sections simply snap into place.



system that comes in pre-cut, premortised lengths that are quickly tailored to fit any size deck. The tools we purchased there also made assembling and installing the rails a snap.

For example, all of the balusters had to be cut to identical lengths—a tedious and time-consuming task. The right tool for this job is a Delta 10-inch Compound Miter Saw, which can breeze through repetitive cuts with absolute precision, including critical angle cuts on stair railings. And it's so lightweight and portable, it's as handy as bringing a table saw to every job. Another tool that gives all-new meaning to the term "portable power" is our Porter-Cable Bammer cordless pneumatic nailer. Air-powered nailers usually require an air hose attached to a heavy compressor. When you're on a ladder or working in a tight situation, dragging an air hose can be as impossible as swinging a hammer. The Bammer is completely cordless, however, and doesn't run on batteries. Instead, it uses a pressurized-gas fuel cell for power—up to 3,000 nails per fuel cell, which is easy to replace and delivers consistent power from shot to shot.

READY FOR RAIN

In the early spring, we removed the old gutters and downspouts along the front of our house, and installed a Rainhandler Rain Dispersal System in their place. We're so happy with their performance that we installed Rainhandlers around our new porch extension as well. Unlike conventional gutter systems, which routinely clog with leaves, twigs and other debris, Rainhandlers have open louvers that intercept rainwater and snow—or ice—melt where it runs off the roof. These louvers break up the flow into small droplets which disperse naturally away from the house walls, eliminating driplines and preventing erosion and damage to a home's landscaping.

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continued on page 54

Gutters can actually contribute to erosion and worse kinds of home damage when they become blocked, because the water has nowhere to go but over their tops or back up into the house under the roof shingles.

Rainhandlers are ingenious in every respect, including the ease with which they are installed. Each 5-foot-long louver section is held in place by a series of clips screwed to the fascia. Our Rainhandlers took less than an hour to install, and once up they are all but invisible against the house trim. Made of durable all-weather aluminum, they are available in white, brown or natural finish to match any home, and because they're virtually maintenance-free they never need cleaning.



There are some tools that do it all. Plunge cuts into plywood or precision trimming are easy with the reduced-vibration features built into the new heavy-duty Super Sawzall.



Why more pros l



It's a fact: More people who make a living with their tools buy their tools at The Home Depot®. That's because we carry all the best brands of power tools that are available anywhere. Everything from light-duty to heavy-duty.

Milwaukee

RYOBI

DEWALT

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DRIVING IT HOME

If there is one indispensable tool in everyone's tool box today, it's a cordless drill/driver. These hard-working helpmates are versatile enough to bore large holes for, say, installing a door-knob, and powerful enough to drive long deck screws into dimensional lumber. Variable-speed models give added control for precision work, while those with clutch features let you preset the amount of torque to embed screws at specific depths, such as for drywall installation. Battery power has greatly improved from earlier models, which allows longer run-time per charge and more freedom to work.

continued on page 57

With a Skill Warrior cordless rechargeable drill/driver, you have the freedom and the power to go wherever the work is, without dragging along an electrical extension cord.

Buy from our pros.

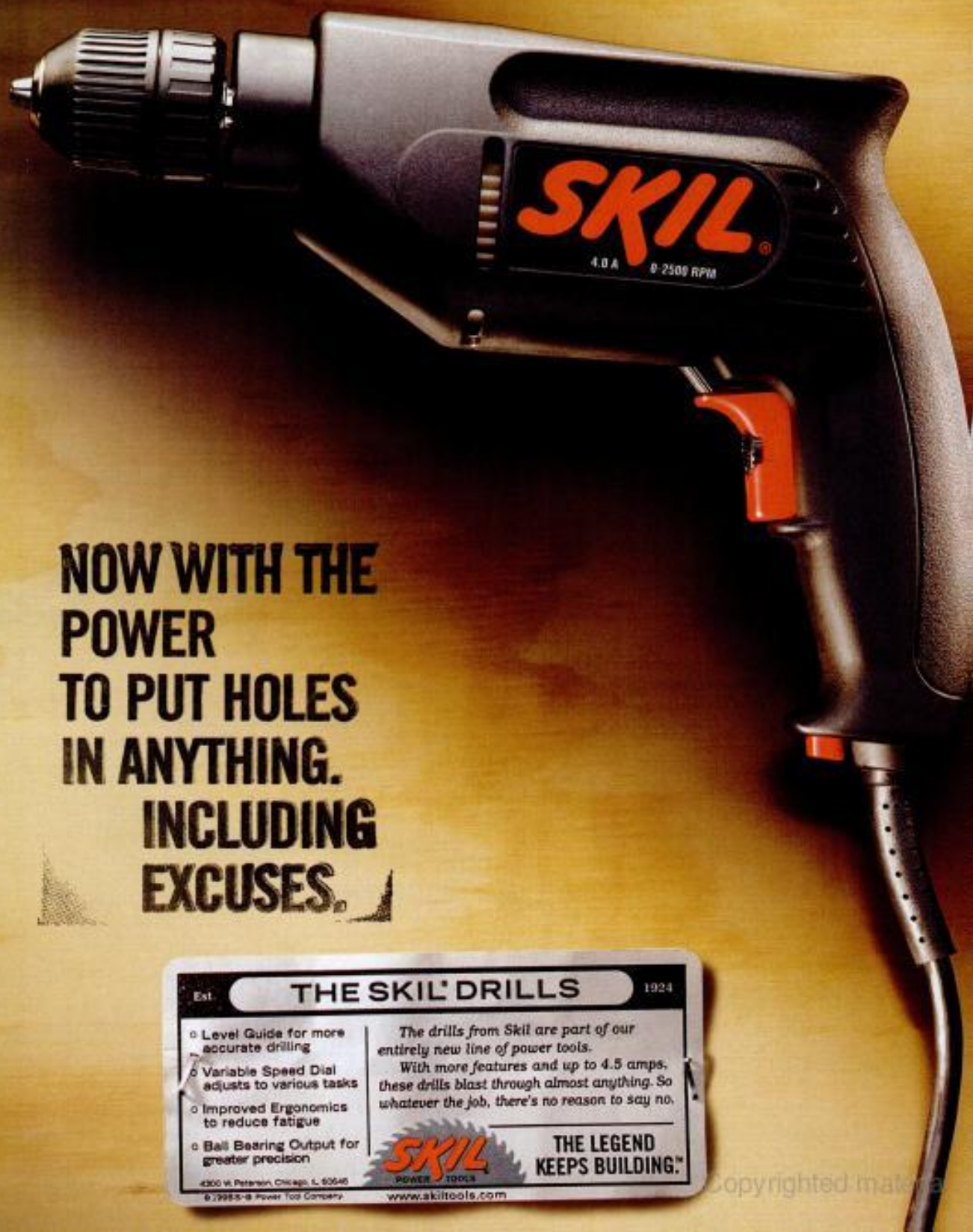


And with our everyday low price guarantee, it's easy to see why you should be shopping at Home Depot too. The place where people who know their stuff buy their stuff.

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POWER
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INCLUDING
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<ul style="list-style-type: none">◦ Level Guide for more accurate drilling◦ Variable Speed Dial adjusts to various tasks◦ Improved Ergonomics to reduce fatigue◦ Ball Bearing Output for greater precision	<p>The drills from Skil are part of our entirely new line of power tools.</p> <p>With more features and up to 4.5 amps, these drills blast through almost anything. So whatever the job, there's no reason to say no.</p> <p>SKIL POWER TOOLS</p> <p>THE LEGEND KEEPS BUILDING.™</p>	
<small>4300 W. Peterson, Chicago, IL 60646 © 1998 S-G Power Tool Company www.skiltools.com</small>		

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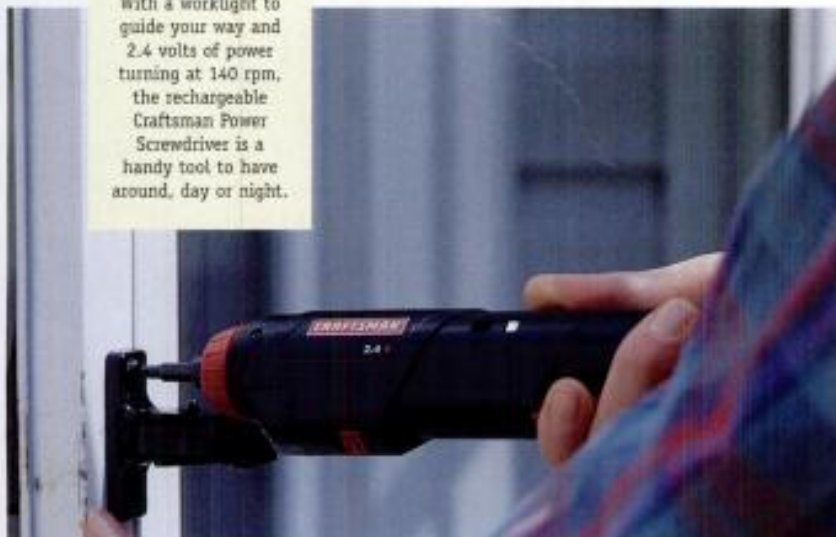
Preparation is critical whenever you paint exterior surfaces. Scrape, power-wash or clean the area well, and always use a quality primer to seal new wood before finish coating.

One of the most familiar names in power tools, Skil, recently introduced a line of Warrior Drill/Drivers that are especially appealing to home owners because they combine power and versatility with comfortable, easy-to-grip T-handle styling. Available in 9.6 volt and 12 volt models, each comes with a

long-lasting 1.3 amp-hour battery and 3-hour charger. Smart buyers will opt for the kit that comes with a second battery, so that while you work you'll always have power in reserve. These drill/drivers also have 5-position torque clutches for versatile screwdriving plus a full lock-up position for drilling.

continued on page 59

With a worklight to guide your way and 2.4 volts of power turning at 140 rpm, the rechargeable Craftsman Power Screwdriver is a handy tool to have around, day or night.



2ND ANNUAL **SKIL** AMERICAN Originals SWEEPSTAKES



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Win a mint '65 Corvette



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+5 Vintage
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To enter, look for the display at your nearby hardware store or home center, visit www.skiltools.com, or fill out the entry blank below.

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1. Complete an official entry form, or on a plain 3-1/2" x 5" postcard, hand print your name, address, zip code, telephone number and the words "SKIL SWEEPSTAKES". Each entry must be mailed separately to SKIL SWEEPSTAKES, P.O. Box 8966, New Milford, CT 06776-8966. All mail-in entries must be received by 1/15/99.
2. Grand prize (1) 1965 Corvette Convertible (est. retail value \$31,500); First Prizes (5) Premium Leather Driving Jackets (est. retail value \$450 each); Second Prizes (100) Skil Saws (est. retail value \$50 each). Winners will be selected in a random drawing from among all entries received. Drawing will be conducted by CCM, whose decisions are final on all matters relating to this sweepstakes. Odds of winning are dependent upon the number of entries received. All prizes will be awarded and winners will be notified by mail. Taxes are the responsibility of the individual winners. Winners may be required to execute an affidavit of eligibility and liability/publicity release within 14 days of notification. Entry constitutes permission to use winners' names and likenesses for promotional purposes without further compensation, except where prohibited by law.
3. Sweepstakes open to residents of the U.S. who are 18 years of age or older as of entry date, except employees and their families of S-B Power Tool Co., their wholesalers, distributors, retailers, TIMES MIRROR, their affiliates, subsidiaries, promotional and advertising agencies. This offer is void wherever prohibited.
4. For a Skil winners list, available after 4/15/99, send a stamped, self-addressed envelope to: SKIL WINNERS, c/o CCM, 470 Park Avenue South, New York, NY 10016.

Name _____
Address _____
City _____ State _____
Zip _____ Phone _____

WORK LIKE A PRO

Anything that's worth doing is worth doing right, as they used to say. And if you want to do it right, you need tools that are equal to the job. Home owners who buy cheaply made tools—thinking they'll "only need this once"—are only kidding themselves and making their work more difficult. Poor tools produce poor results, and an imitation or "knock-off" product can break when its strength is needed most, causing damage to the materials and injury to the user. Remodeling is the most demanding type of construction work, requiring hand and power tools that can withstand hard use under adverse conditions.

That's why one of the most-used portable power tools among both professional and home remodelers is the original Milwaukee Sawzall reciprocating saw. In addition to being dependable and rugged, this tool has incorporated improvements over the years that make it more versatile than ever. The new heavy-duty Super Sawzall we used on our deck and porch projects has a 10-amp motor, the most powerful available in this type of tool. A unique impact-protection gear system and patented counter-balance mechanism make this tool virtually vibration-free, even when cutting through tough, blade-resistant materials like corroded pipes and heavy plywood. And its Quik-Lok blade clamp allows for fast, wrench-free blade changes, which is especially handy when you're working under difficult conditions.

NOT JUST COLOR

The final step in most home improvement projects is adding a coat of paint to give the materials a finished look, but more importantly to protect them from weather and wear. That's why it's important to choose a high-quality paint every time. More than just decorative



There's nothing like a fresh coat of paint to brighten interior rooms. There are more than 1,000 Ace paint colors to choose from, or bring a swatch to match on the color computer.

Working in a dark corner can be difficult, especially when you're driving small screws. The new Craftsman lighted power screwdriver is a bright idea that fixes this problem.



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WARM & COZY

If your home heating costs are high and your hot water system has trouble keeping up with demand, this is perhaps the best time to do something about it. Lennox, one of the oldest and most trusted names in home heating, has introduced two new gas-fired heating systems that can improve both your household budget and your comfort level.

The WhisperHeat gas furnace offers one of the quietest, most efficient units available in forced-air heating. With direct-drive blowers, a unique heat exchanger design and exclusive insulation and venting technology, these systems virtually eliminate the rushing and rattling noises that accompany the heat in typical ducted systems. WhisperHeat's flexible design also reduces installation time and cost for further savings.



Super-quiet operation is matched with efficient energy use in the Lennox CompleteHeat gas system, a combined air-and-water heating unit that provides virtually unlimited hot water to meet all of a family's needs. With a 90 percent Combined Annual Efficiency rating, this unit has the capacity to keep pace with a steady 3 gallons-per-minute, 120-degree water demand and never run out. Think of all the showers your family takes—and then think of what you could be saving on energy bills.

10 AMP. 0-3200 SPM. IMPACT PROTECTION.

The industry's best reciprocating saw just got better. Nothing



cuts faster or lasts longer. Milwaukee's

powerful new 10-amp Super Sawzall®

features exclusive impact protection,

anti-vibration, 0-3200 spm, 1-1/4" stroke

and keyless blade clamp.

You work harder, faster and

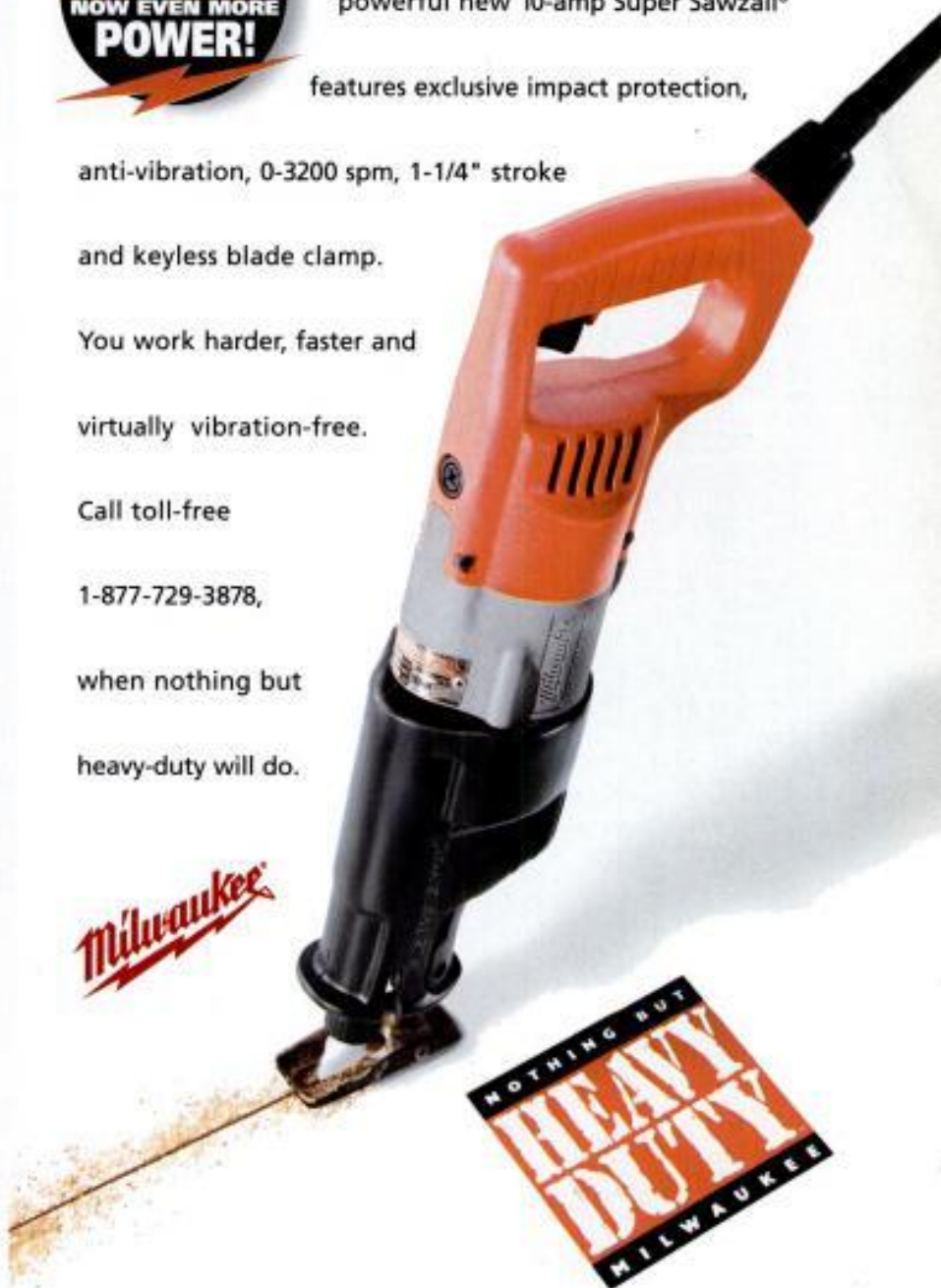
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Call toll-free

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MAY 9	EVERGREEN SPEEDWAY MORRIS, WA	TBS
MAY 23	I-75 SPEEDWAY ODESSA, MO	TNN
MAY 30	WATKINS GLEN INTERNATIONAL WATKINS GLEN, NY	ESPN
JUNE 5	TEXAS MOTOR SPEEDWAY FORT WORTH, TX	TNN
JUNE 20	BRISTOL MOTOR SPEEDWAY BRISTOL, TN	ESPN2
JUNE 27	COLORADO NATIONAL SPEEDWAY ERIE, CO	CBS
JULY 4	MILWAUKEE MILE WEST ALLIS, WI	CBS
JULY 11-12	NAZARETH SPEEDWAY NAZARETH, PA	CBS
JULY 18	CALIFORNIA SPEEDWAY FONTANA, CA	ESPN
JULY 30	INDIANAPOLIS RACEWAY PARK INDIANAPOLIS, IN	ESPN
AUG. 2	NEW HAMPSHIRE INT'L SPEEDWAY LOUDON, NH	TNN
AUG. 8	FLEMINGTON SPEEDWAY FLEMINGTON, NJ	TNN
AUG. 15	NASHVILLE SPEEDWAY USA NASHVILLE, TN	TNN
AUG. 21	HEARTLAND PARK TOPEKA TOPEKA, KS	TNN
AUG. 29	LOUISVILLE MOTOR SPEEDWAY LOUISVILLE, KY	ESPN
SEPT. 10	RICHMOND INTERNATIONAL RACEWAY RICHMOND, VA	ESPN2
SEPT. 13	MEMPHIS MOTORSPORTS PARK MEMPHIS, TN	ESPN
SEPT. 19	GALEWAY INTERNATIONAL RACEWAY ST. LOUIS, MO	TNN
SEPT. 26	MARTINSVILLE SPEEDWAY MARTINSVILLE, VA	ESPN
OCT. 11	SEARS POINT RACEWAY SONOMA, CA	ESPN2
OCT. 18	MESA MAHIN RACEWAY BAKERSFIELD, CA	TNN
OCT. 24	PHOENIX INTERNATIONAL RACEWAY PHOENIX, AZ	TBS
NOV. 8	LAS VEGAS MOTOR SPEEDWAY LAS VEGAS, NV	CBS

SCHEDULE TENTATIVE — SUBJECT TO CHANGE



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The innovative Arrow Staple+Nail Gun is equally adept at typical heavy-duty stapling jobs like installing insulation, or nailing up trim—without the damaging hammer marks.

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LIGHTING THE WAY

Yet another item that has worked its way into many home owners' tool boxes in recent years is the cordless power screwdriver. It's easy to see why. Reach for a typical screwdriver and it's often the wrong type. The number of screws on any given object often outlasts your patience. And, all too often, the one screw you can't get at easily is in some dark recess which makes it a much tougher job than you bargained for.

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Power screwdrivers, on the other hand, have interchangeable bits so you don't have to go looking for the right one. And because they're powered, they make repetitive tasks like screw-driving almost bearable. However, until recently they didn't help much when you were groping in the dark for that one hidden screw.

That's why the Craftsman Rechargeable Cordless Power Screwdriver is a real improvement over all other tools of this kind—it's got a built-in "headlight" to help you see what you're doing, and not only in the dark. Even in broad daylight, screwheads deep inside



an electrical outlet box, or under a dashboard, or in your stereo cabinet, can be difficult to see. This tool's worklight puts a focused beam of light right at the point of contact, so you can see where the driver tip is going and what it's doing. With 2.4 volts of power, reversible action, and 1-hour run time with a 3-hour recharging cycle, it's easy to see that the Craftsman cordless screwdriver leads the way.

DUAL FUNCTION

Home renovations generally require many different tools, and toting them around the house from job to job can become a job in itself. That's why tools that can do more than one task well often

make it into the kit you carry with you at all times. A typical "A" tool kit will have a hand saw that can crosscut as well as rip, multi-tip screwdrivers, adjustable wrenches and locking pliers, an all-purpose claw hammer, and so forth.

Another "staple" in this kit is a sta-

continued on page 64

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Banana Split



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Rich Mustard

The perfect color paint in the store may surprise you when it's on your walls at home. Here's a color check tip from the folks in the red vests,



your helpful hardware folks at Ace. When you think you've picked the right color, take home 3

or 4 chips and a few colors that are close. Do the same with accent colors. Tape them to different walls, next to windows and in corners. (Colors look different in different light.) Look at them by day, then by night. Now, before you buy gallons of custom mixed paint, you'll have a better idea you picked the perfect color for your taste. You'll be happier with the results, and you could save some money along the way.

Your helpful hardware folks at



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Home Remodeling Ideas

SPECIAL ADVERTISING SECTION

ple gun tacker, which comes in handy for many tasks such as putting up temporary sheeting or installing insulation.

Now there's a gun tacker that not only staples, but also switches functions instantly to become a nail driver, which adds still more versatility to this already versatile tool. The Arrow Staple+Nailer shoots six sizes

of flat-crown staples, from 1/4-inch up to 17/32-inch in length. Then simply remove the staples and replace them with a strip of 5/8-inch nails and this tool also lets you install door or window trim, build picture frames and do other close-nailing tasks without a hammer—and without the hammer marks and damage such fine work often entails.

HI, HO, SILVERADO

"Bigger, faster, stronger and smarter" is how the new-design 1999 Chevy Silverado full-size pickup is described, and a first look at this muscular yet svelte, work-and-play vehicle shows that's no idle boast. Available in both standard- and extended-cab versions, this is a pickup that can take it—whatever "it" means to you or the entire family.

How big is the Silverado? Inside, it has the roomiest cab of any 1/2-ton pickup today. Compared to its predecessor, the Chevy C/K pickup, it has bigger door openings for better accessibility, a wider frame with a longer wheelbase, and greater load-carrying capacity. It's also faster as well as stronger, in more ways than one—with smoother hauling at any speed thanks to the power and torque

of its new Vortec V8 engines, along with faster stopping due to standard anti-lock disc brakes on all four wheels.

And smart? The Silverado offers a Tow/Haul mode that lets the driver adjust the transmission to cope with demanding road conditions, and a Dynamic Proportioning System that automatically regulates rear-wheel braking to suit the payload. But as tough as this pickup is, creature comforts were not overlooked in its design. A standard curbside third door on extended cab versions, computer-controlled driver lockout and battery rundown protection, and more interior refinements than can be listed here, make this a working-class pickup that's more fun to own and drive than the family car.



Years of research and development have produced the new 1999 Chevy Silverado—a "bigger, faster, stronger and smarter" pickup than all of its predecessors.

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Pineapple Fluff

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Take better care of your antiques and collectibles with Formby's Furniture Refinisher, which conditions wood as it gently dissolves old varnish, lacquer and shellac. A hand-rubbed finish coat of Formby's Tung Oil gives the wood a soft, streak-free sheen and a natural look and feel that you don't get with other finishes.

Home Remodeling Ideas Product Information



Quality and affordability are the hallmarks of Ace Royal Paints. Ace manufactures a full line of paint products, including interior and exterior paint, wood stains and finishes, enamels and specialty products. For more information visit your local Ace Hardware store.



New for 1998 from ARROW FASTNER is their STAPLE+NAIL GUN series of tools. The 70-year old American Company offers these new items in manual and electric models. It has also introduced a unique RIVET TOOL with a head that rotates 360 degrees. The "TWISTER," lets you rivet in narrow and difficult-to-reach areas. Information on ARROW tools for the knowledgeable Do-It-Yourselfer is available from their website: www.arrow-fastner.com.

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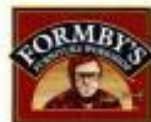
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Formby's, makers of a complete line of refinishing and wood care products, presents this attractive new 16-page, colorful booklet which includes great project ideas and tips on how to find and refinish furniture. Free. Send booklet requests to: Simple Refinishing Ideas, P.O. Box 1295, Grand Rapids, MN 44745-1295.

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A FAST FINISH

Moving indoors as the weather cools offers lots of opportunities for home improvement, and few projects are more rewarding than refinishing antique, collectible or just hand-me-down furniture. A piece doesn't have to be costly to be valuable, and there are plenty of gems to be found hidden under layers of old, age-darkened finishes.

You don't have to be a refinishing expert to get great results, either. Here's an easy test to determine what type of finish is on the wood: Dampen a cotton ball with acetone (nail polish remover), then touch it to the finish in an inconspicuous spot. If the cotton sticks or the finish softens, the piece was finished with varnish, lacquer or shellac. All are easy to remove with Formby's Furniture Refinisher. Unlike many chemical strippers, Formby's gently dissolves even stubborn finishes

yet is gentle enough to preserve the natural patina that develops in wood as it ages. This refinisher is also different from others because it contains natural oils that moisturize, condition and protect the wood against drying and cracking. And Formby's makes a Paint & Poly

Remover that's just as effective on other finishes that don't react to the cotton ball test.

For more information on products shown in this special *Home Remodeling Ideas* section, see pages 66-67.

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A photograph of three men in a workshop-like setting. The man on the left is holding a cardboard box. The man in the middle is holding a cylindrical object. The man on the right is holding an open black case containing a bomb device with wires and a yellow cylindrical component.

Matching Wits^{with} the Unabomber

The inside story of how an elite bomb squad dismantled the Unabomber's last deadly device.



The Unabomber, seen here in the now famous 1987 FBI sketch, left a live bomb in his cabin. Vic Pissano, Rod Owenby, and Chris Cherry (left to right) made up the special team that dismantled the bomb without destroying it, so the device could be used as evidence.



IT WAS THE CASE OF A LIFETIME, and it had taken nearly a generation to unfold. Federal authorities finally arrested Theodore J. Kaczynski, known as the Unabomber, in a one-room cabin deep in the Montana wilderness, after receiving a tip from his brother. For 17 years, Kaczynski, a math whiz and former college professor, had outwitted the law, waging a war against what he perceived to be the evils of technology. His battle had claimed three lives and injured 22. Many of his bombings had victimized individuals associated with universities or airlines, hence the Un-a-bomber moniker given him by the FBI.

By Frank Vizard

With Kaczynski's arrest, however, another battle of wits began, one that matched scientific genius gone astray against a three-man team of bomb disposal specialists armed with the latest in technological gadgetry. Although Kaczynski was arrested in April 1996, the role of this special bomb squad was merely hinted at when President Clinton officially thanked them for their work this past February. Only now, following the May sentencing of Kaczynski to life imprisonment, can their story be told.

The war of wits began when FBI agents peered inside Kaczynski's tiny cabin and discovered a live bomb, packaged and ready for mailing but unaddressed. Normally, this wouldn't be cause for too much excitement. A bomb disposal squad would remove the device and explode it harmlessly.

This time was different. The FBI needed the bomb defused but also intact for forensic evidence. The Unabomber had built his devices so they couldn't be linked to him, and

FBI analysis of debris fragments had yielded few clues. The only common threads were the initials "FC," for Freedom Club, inscribed on eight of the 16 bombs ultimately attributed to the Unabomber, letters from FC to newspapers, and a lengthy manifesto published by *The Washington Post* and *The New York Times* in September 1995.

To its credit, the FBI had already realized that defusing a bomb intact was beyond its capabilities. In August 1995, FBI agents turned for help to Chris Cherry, a researcher at Sandia National Laboratories, a federal weapons research facility in Albuquerque, New Mexico. Cherry, a Department of Defense veteran of classified operations, is considered by those in the secretive bomb technician community to be the dean of bomb disposal experts. For the next nine months, Cherry would be on standby in case a Unabomber device was intercepted before it exploded. Cherry's team would include veteran

PHOTOGRAPHED BY JOHN B. CARNETT

Sandia assistant Rod Owenby and Vic Poisson, a long-time friend and associate with the Riverside, California, police department.

Shortly after Kaczynski's arrest, Cherry and Poisson were on the phone discussing the case when Cherry's other line buzzed. It was 6:30 p.m. on Good Friday, and Cherry was looking forward to Easter with his wife. Cherry put Poisson on hold and picked up the other line. It was the FBI.

"We have a device," said the agent on the other end of line. "It's under the bed [in Kaczynski's cabin]."

Cherry quickly switched the line back to Poisson. "Don't hang up."

The FBI immediately dispatched planes to bring Cherry's team members and their gear to the scene. Owenby was excited on the plane. The airport pickup had been conducted like a clandestine operation. Only first names were used, and no questions were asked.

"Isn't this neat?" Owenby asked Cherry.

"It will be if we're successful," replied Cherry, who was beginning to sense the pressure. At that point, Cherry thought he would be gone from home for two days at most. He hadn't anticipated what lay ahead.

By 7 a.m. the next morning, the three men had arrived at the site in Lincoln, Montana. The cabin was a few miles south of town, 500 yards up a narrow trail through a forest. It sat astride the Great Divide of the Rocky Mountains at 6,376 feet above sea level.

The three passed through multiple checkpoints, each manned by federal agents toting machine guns. Finally, they saw the cabin in the light of a beautiful spring morning. "It looked like a storage shed at one of our houses," remembers Owenby. Since 1971, it had been Ted Kaczynski's home.

Accompanied by a FBI agent, each of the three was led one at a time to the door of the 10- by 12-foot cabin. It was crammed with books, boxes, jars, and—ominously—chem-

icals. A later inventory would reveal that the chemicals included bottles of sulfur, saltpeter, ammonium nitrate, and sodium chlorate; the boxes contained zinc, aluminum, and lead. One old cereal box contained 23 bomb igniters, each made from a piece of cord pulled through a wooden plug. Other boxes contained batteries; wiring; and pieces of metal, copper, and plastic pipe.

The cabin lacked running water, electricity, and a bathroom. It had a pot-bellied stove for heat; a table, a chair, and what appeared to be an army cot were the only furniture. The bomb was under the cot.

All three also noticed two other items lying in plain sight—the hooded sweatshirt and sunglasses depicted in the FBI's sketch of the suspect, which had been widely circulated in the media. The sketch was based on an eyewitness description following a February 1987 bombing in Salt Lake City.

The cabin and all of its contents would be saved as evidence, but the first order of business was to get the bomb out of the cabin and moved to a safe location. The bomb, like many of the Unabomber's past devices, was packaged in a rectangular wooden box, the size of a thick book, that would fit inside a mailbox.

Cherry's team constructed wooden ramps up and into the cabin, and a remote-controlled robot carefully carried the device to a nearby field. The bomb was then placed on a wooden stool; the team built an igloo of heavy timbers around the stool, covering the structure with a blue tarp held down by sandbags. Nobody was overly concerned that the bomb would detonate while it was being moved, because Kaczynski's bombs were always designed to explode when they were opened. But from this point on, the wooden structure would contain any explosion, with the blue tarp acting like a big tablecloth to capture any forensic crumbs.

The cabin, meanwhile, turned out to be a treasure trove of clues. Perhaps most important were 10 notebooks authored by Kaczynski. "His notebooks were like a technical memoir," says Cherry. "My main focus was on how he thought about explosives and bombs. He had a very elabo-

Simple but Deadly

THE UNABOMBER constructed 16 bombs, using the simplest of materials with deadly effectiveness.

BATTERIES

Four 9-volt batteries bound together and stripped of their outer casings served as the power source.



SCREWS

The bomb was placed inside a wooden box held together by screws that doubled as shrapnel.



SPRINGS

A spring-loaded triggering switch was connected to the igniter placed inside the pipe.



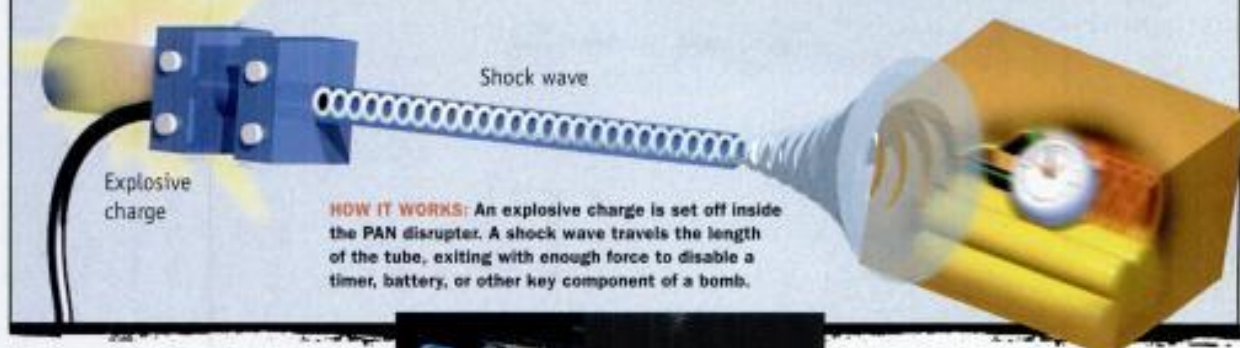
WIRE

Common multistrand duplex wire was used to make improvised loop switches.



Disrupting the Bomb

BOMB SQUAD technicians have only one scientifically tested tool, the PAN disrupter.



rate set of notes written in Spanish. It was just unbelievable."

Fortunately, Cherry was able to have Kaczynski's notes immediately translated, and what he learned helped him understand Kaczynski's approach to bomb-making and gave him great cause for concern. "His notes told me that he was a mathematician," says Cherry. "In one entry, he was trying to calculate heat transfer on a bridge wire of the type used in detonators, looking at the electric current relationship involved. He was looking at bomb-building from a scientific viewpoint. And that's what impressed us."

Cherry would soon be informed that Kaczynski had received a Harvard degree at 20, earned a doctorate at the University of Michigan, and had been a mathematics professor at the University of California, Berkeley. His mathematical treatises, published in the 1960s, were considered by his peers to be the work of a genius.

The notebooks only confirmed what Cherry already knew. Kaczynski was a formidable bomb builder who had improved his technique with each succeeding device between 1978 and 1995. Cherry also was one of the few people who realized that Kaczynski had recently achieved a



No more snip-and-run: The PAN disrupter's shock tube can be as long as 5,000 feet for remote use.

technical breakthrough that doubled the destructive power of his bombs without increasing the size of the package. Cherry says this technique was known to only a small number of people, and that number did not include any FBI agents.

"Kaczynski was right on target, technically," says Cherry. "What amazed me was that this guy was doing all this by himself. You're dealing with a guy who has no electricity. He's using hand tools. But at the same time he's producing devices that are extremely deadly. As he progresses, the fatalities increase."

Cherry was also impressed with Kaczynski's patience. Every component of his bombs was handmade. "He may have spent weeks working on one little component. He was so careful about not leaving a trace, other than the Freedom Club inscription."

Poisson agrees with Cherry's assessment. "It was very clear that Kaczynski thought out each and every minor detail, and had probably gone through extensive testing of each device. He was truly unique." Ironically, Poisson, Cherry, and Kaczynski all had the same hobby in high school: building fireworks.

The team decided that the job would be handled in two

SOLDERING WIRE

Used to make a solid connection between the actual explosive and the battery terminals.



COPPER WIRE

A pair of wires that were routed through a wooden dowel served as the bomb igniter.



STAMPS

Bombs were mailed using stamps issued years before, often with a Priority Mail label.



LEAD PIPE

A length of pipe was used as the housing for a mixture of explosive powders.



phases: The first would render the bomb inactive, while the bomb would be dismantled in phase two. "Our goal was to go backward from the completed item to what was existing on the table when it was started," explains Poisson. Phase two would be as dangerous as phase one, however, since many of the individual components were explosive. Essentially, the team was looking at bombs within a bomb.

By Sunday, the team was ready to begin disarming the bomb, but only after spending most of the preceding night arguing about how to proceed—a discussion punctuated by lack of sleep and too much coffee. Each team member had a different opinion. X-ray imaging systems had provided them with some idea of the interior layout of the bomb, but the two-dimensional pictures proved hard to interpret in three dimensions, so the exact location of the triggering device was difficult to pin down.

"The whole device was hard to interpret," says Owenby. "Things in it were odd, and the way it was put together was odd."

The team was at an impasse. The FBI liaison, Tom J. Mohnall, an explosives examiner from the FBI's laboratory in Washington, D.C., looked at Cherry. "You're in charge. You're calling the shots." Cherry's interpretation of the bomb's interior would stand.

The gear needed for the job was ready to go. The team is reluctant to reveal details about the equipment they use, concerned that such knowledge may give future bombers an edge. Much of it, however, involves remote video systems and robotic manipulators of various sizes that can be operated from a safe distance.

"The days when you see a guy cutting a red or green wire, like in the movies, are over," says Cherry. "We can do that type of task from a mile away."

One key device, in use for only a few years and invented by Cherry under an FBI contract, is called the Percussion Actuated Nonelectric (PAN) disrupter. It hovers over the bomb like a praying mantis about to devour a bug. "It basically allows us to use an explosive to disarm an explosive," says Cherry, but that is as much as he will say about it, even though it is now used by bomb squads nationwide since the FBI distributed 500 free of charge last year. As described by Patrick J. Webb, a counter-terrorism supervisor for the FBI who was also on the scene and had tracked the Unabomber since 1982, the PAN disrupter is a long narrow stainless steel tube about an eighth of an inch in diameter, through which many different kinds of high-powered charges can be fired. The shock tube, as it is called, is manufactured in lengths up to 5,000 feet, so it can be cut to any desired length, letting the bomb squad remain at a safe distance from the explosive. When fired with a basic black powder round, as was used in this case, the PAN disrupter creates a flash that looks like a bolt of lightning, signaling that a shock wave is traveling down the tube. When the device performs correctly—Webb can't recall it ever misfiring—the shock wave will disable a key component of the bomb, such as the trigger, timer, or battery. The PAN dis-

rupter, says Webb, is the only scientifically verified tool available to bomb technicians. It has been tested so many times with a variety of charges that technicians need only consult a guidebook that will correlate a bomb type to the correct charge, approach angle, and stand-off distance in which to use the disrupter. Fortunately, most bombs seen in the United States, about half of which are pipe bombs, are of simple construction. "We haven't seen a

The whole interpret

ramping up of sophisticated technology," says Webb. "We're still in the bomber Stone Age." Nevertheless, he acknowledges, the Unabomber had proved how deadly even primitive materials can be in a bomber's hands.

With the PAN disrupter in place, Cherry allowed Jim Freeman, head of the FBI's San Francisco office and who, along with Terry D. Turchie, headed the Unabomber investigation, to fire the device.

"Is it going to be loud?" asked Freeman.

"We hope it is a quiet, joyful noise," replied Owenby.

A few seconds later, a small, muffled thump caused all three team members to grin. Cherry was the first to inspect the Unabomber package. The operation was a success: The package had barely moved. "It was so surgically defused, you couldn't tell it was defused," says Cherry. Phase one was over.

As expected, phase two proved more difficult. The team had prepared a number of special tools for the task of dismantling the bomb, most of which were invented for the assignment and wouldn't be immediately comprehensible even to your average bomb technician. Again, the team is circumspect about details. "We may need certain technologies tomorrow," says Owenby.

Still, what the team knew about the Unabomber's previous bombs wasn't reassuring. "He was unusual in that most bombers have a particular way of doing business," says Poisson. "He was exceptionally difficult to deal with, because he did whatever appealed to him at the time."

Adding to the difficulty were the Unabomber's handmade components, which included even the screws. Kaczynski's homemade glues were manufactured from animal hooves and tended to react unpredictably compared with store-bought material.

In taking apart a bomb, the general idea is to apply heat extremely slowly over a period of hours, in increments of as little as one-tenth of a degree, in the hope that this will cause the components to eventually separate. The difficulty with this approach is that the bombs tend to be so tightly constructed that moving even a single element takes a precise amount of energy. Too much

heat or too much movement will cause an explosion.

Each move on the bomb prompted a lot of discussion, but slowly the components begin to peel away, one by one, much as the team had expected based on their analysis of previous Unabomber devices.

Then they hit a wall. "This guy was unbelievably clever," says Cherry. "We

sonally inspect the bomb, looking for signs of discoloration or residue buildup.

"The TV systems could give us a look but they couldn't tell us certain things," says Cherry. "We needed a three-dimensional view of how the energy was affecting the

device was hard to Things in it were odd.

trained so that when we got to any given point, we would know a certain set of tools and gear were needed. Well, guess what? He threw us for a 180-degree turn. We said: 'Now what do we do?'"

Cherry won't say exactly what the problem was, for security reasons, but he likens it to expecting to see something in liquid form, then discovering that it is reinforced concrete and that the cup you brought is useless. Nothing in the technicians' toolbox

would allow them to proceed. Cherry felt as if he were on third base, prepared to score the winning run of the baseball game, only to learn that all the bats were now broken.

Poisson, the team's primary gadget maker, was undeterred. After studying the problem for the better part of a day, Poisson stole into a nearby farmer's toolshed while its owner was away, and improvised a tool on the spot. Working with an untested tool can be extremely dangerous, and Poisson recalled the old bomb squad adage: "It's either initial success or complete failure." Nonetheless, the team decided to continue.

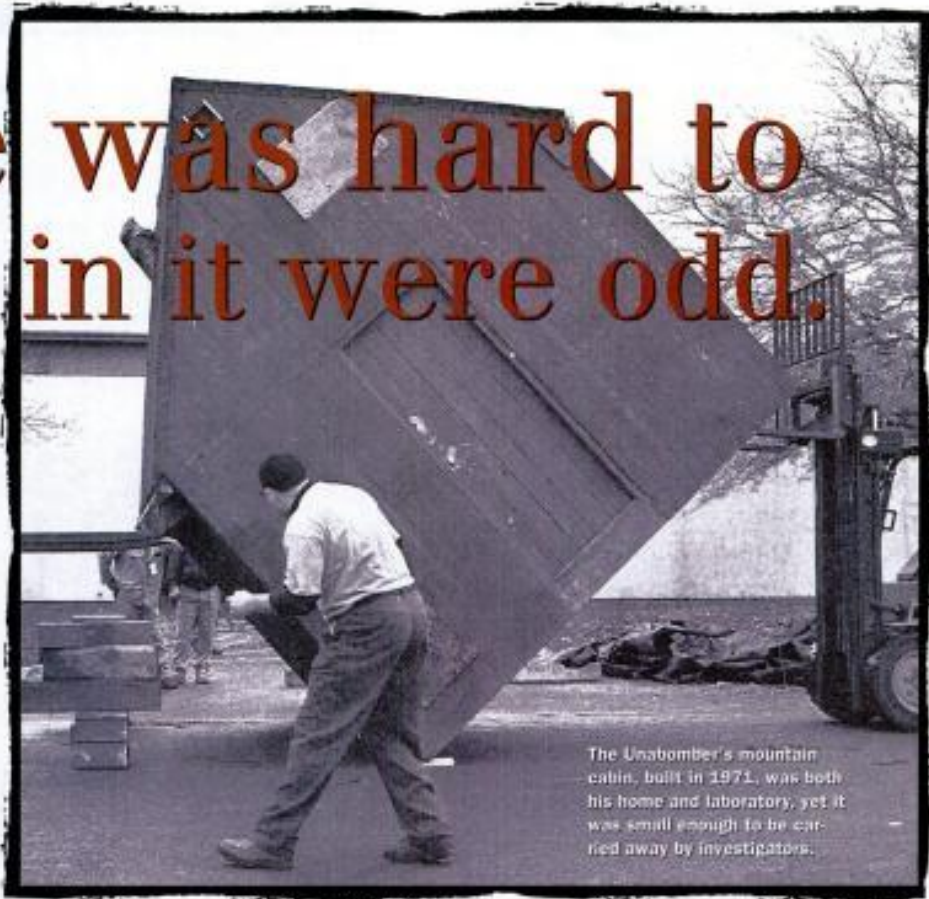
Making matters worse, the bomb began to behave erratically. An initial application of heat would yield no reaction, then suddenly there would be a spike in the temperature reading that could cause an explosion. Heat was dissipating from one part of the bomb but not from another. No one knew the temperature threshold that would cause the bomb to explode. Temperatures rose, and the team backed off until the device cooled. Again and again, they followed the same procedure. "Add energy" and "stop" became a mantra. After each pause, Cherry would per-

device. Every second, we were concerned because we were putting so much energy into something that was so sensitive. And we didn't know exactly how sensitive it was. I could only speculate on what I saw, what was in Kaczynski's notes, and what I thought we had, based on my past experience."

Slowly, over a period of hours that stretched into one nerve-racking day after another, the bomb came apart. Poisson's untested, jerry-rigged tool had worked like a charm.

Nine days had passed since the team's arrival at Kaczynski's cabin. And piece by piece, they had handed over the Unabomber's last bomb into evidence.

A little more than two years later, on May 4, 1998, Ted Kaczynski pleaded guilty in federal court in Sacramento, California, and was sentenced to life imprisonment without any possibility of parole. By agreeing to the plea, Kaczynski avoided the death penalty. The case never came to trial. The dismantled bomb was never presented to the court, and it's stored at the FBI's Washington, D.C., lab. Kaczynski's cabin now sits in a warehouse in a former Air Force base outside of Sacramento. ♦



The Unabomber's mountain cabin, built in 1971, was both his home and laboratory, yet it was small enough to be carried away by investigators.

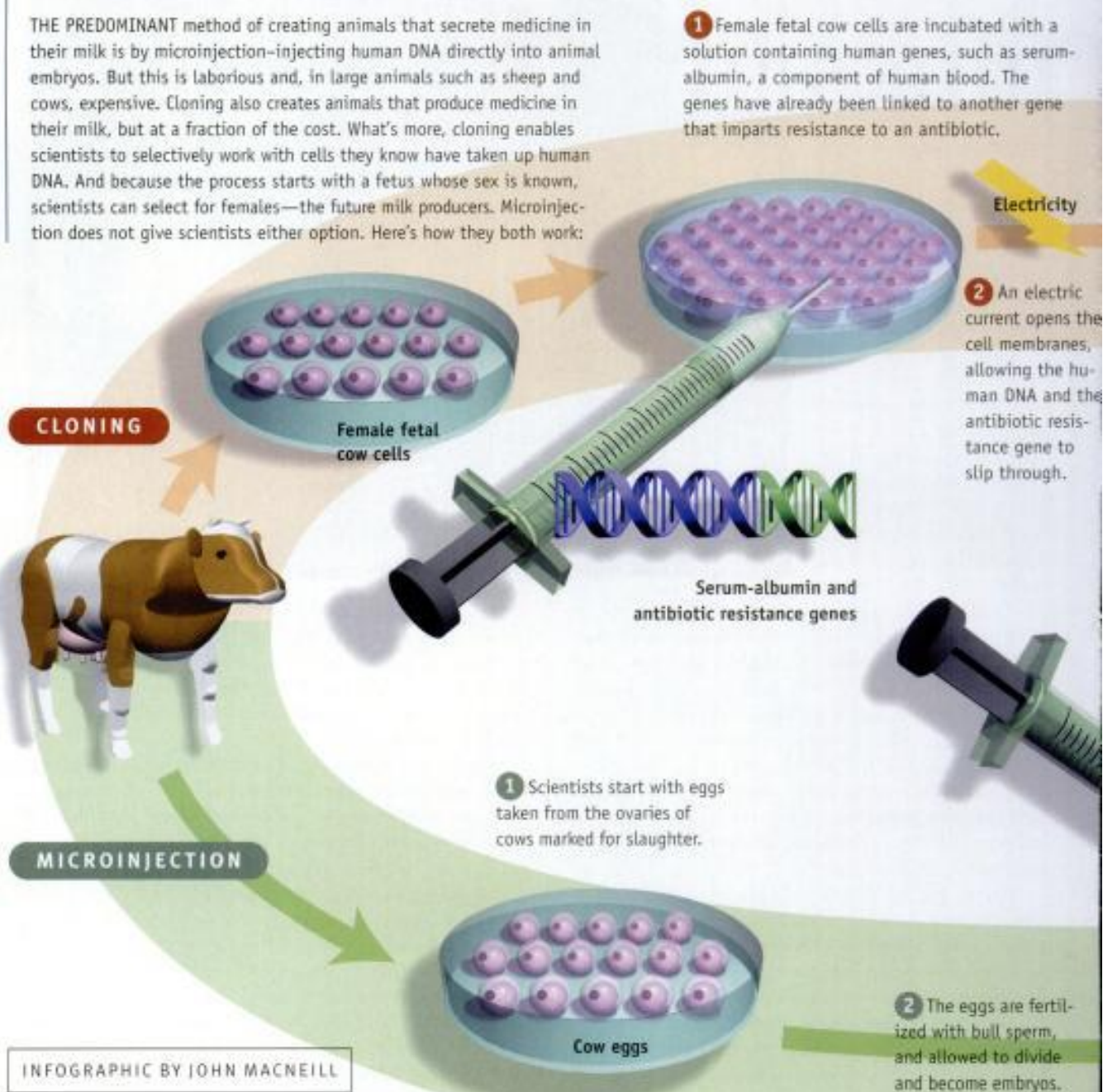


Forget Dolly. New cloning techniques Got Milk?

By Gunjan Sinha

Cloning Versus Microinjection

THE PREDOMINANT method of creating animals that secrete medicine in their milk is by microinjection—injecting human DNA directly into animal embryos. But this is laborious and, in large animals such as sheep and cows, expensive. Cloning also creates animals that produce medicine in their milk, but at a fraction of the cost. What's more, cloning enables scientists to selectively work with cells they know have taken up human DNA. And because the process starts with a fetus whose sex is known, scientists can select for females—the future milk producers. Microinjection does not give scientists either option. Here's how they both work:

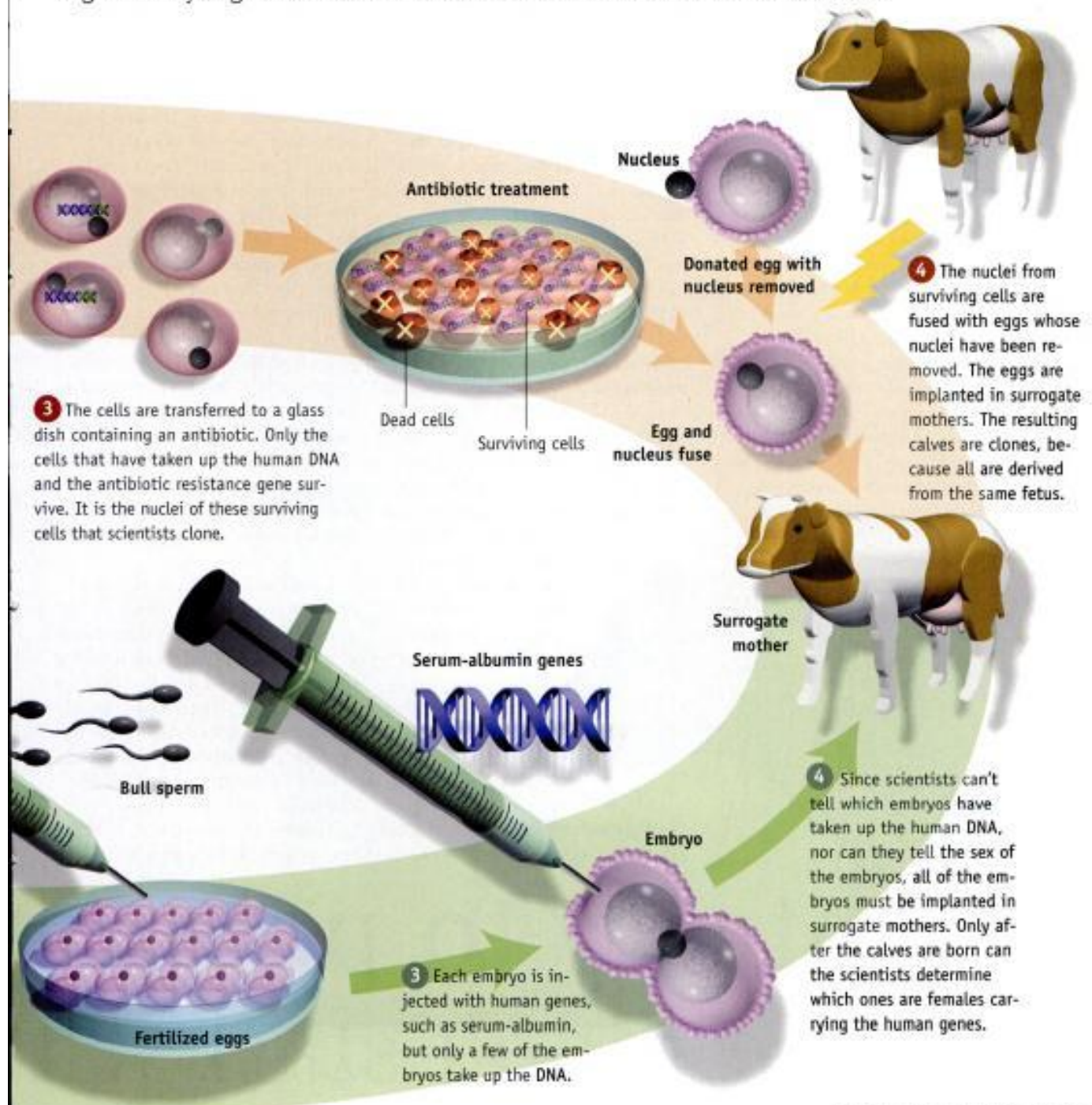


INFOGRAPHIC BY JOHN MACNEILL

produce cows with life-giving medicines in their milk.

JUST BEYOND THE GREASY burger joints lining the main street of Worcester, Massachusetts, is a laboratory where a small group of scientists is tinkering with a technology that might forever transform the way medicines are made. The scientists at this lab are creating a new kind of drug factory, one without a single piece of machinery.

It will be made from skin, bones, and udder: a very ordinary framework for a genetically engineered cow that secretes medicine for humans in its milk. ►



Steven Stice hovers over a microscope, eyeing a single bovine cell that he hopes will grow into a medicine-making cow. If this experiment is successful, the cow will join growing herds of sheep, goats, and pigs at the forefront of a revolution in biology. A combination of two new technologies—gene insertion and cloning—is making this revolution possible. It's all happening so quickly that the first drugs made from animal milk could be ready for the market within a year.

Stice and a group of fellow scientists formed Worcester-based Advanced Cell Technology (ACT) four years ago. They knew that many human diseases are caused by defective proteins, and that the blueprints for these proteins are defective genes. The scientists reasoned that if they could insert healthy human genes into a cow, and then clone that cow, they might be able to create an entire herd of animals capable of producing healthy human proteins in their milk. These proteins could then be extracted from the milk and packaged as medicines. ACT scientists chose cows because the animals pump out enormous quantities of milk and would consequently produce large amounts of medicines.

ACT's first target drug is human

serum-albumin, a protein component of blood that, among other functions, gives blood enough pressure for the heart to pump it efficiently through the body. Doctors inject the protein into patients undergoing various types of surgeries to maintain their blood pressure. The annual worldwide demand for serum-albumin is between 400 and 500 metric tons, according to Stice.

Currently, serum-albumin is extracted from human blood. But with mounting concerns over infectious human pathogens such as the HIV virus, human blood has become a suspect source. What's more, rigid screening procedures have shrunk the blood donor pool so dramatically that the protein is becoming scarce, which is driving up the cost. Stice estimates that a herd of between 2,000 and 3,000 cows could produce enough protein to satisfy the current demand at a reasonable cost, without the risk of transmitting infectious agents.

Producing medicines in animal milk holds so much promise that even non-profit agencies like the American Red Cross (ARC) are interested. ARC has recently teamed up with the Dutch drug company Pharming to produce human fibrinogen—a blood protein responsible for blood clotting—in cow milk. ARC is working with the

Virginia Polytechnic Institute in Blacksburg to incorporate fibrinogen into a sophisticated new bandage that stops bleeding almost instantly.

"We're talking about a bandage that could revolutionize emergency medical care," says William Drohan, head of ARC's Plasma Derivatives Laboratory in

Washington, D.C. "We can also formulate the fibrinogen sealant into an expandable foam or powder that could be sprayed on deep gouges to plug severe bleeding," he adds.

Fibrinogen is currently extracted from human blood, but there just aren't enough donors to supply the protein in the amounts necessary to make the sealant. The only way of producing huge quantities is to use animals that have been genetically engineered to carry the human gene responsible for the production of fibrinogen.

Milk isn't the only vehicle for producing medicine. James Petite at North Carolina State University in Raleigh is trying to insert human genes into chickens, prompting them to make human proteins in their eggs. And Bob Wall of the Agricultural Research Service in Beltsville, Maryland, is popping human genes into mice, and hoping that the mice will produce human proteins in their urine.

The ability to mix and match genes from different species—known as transgenics—has been around for more than a decade. Mice, goats, and sheep that carry genes from other species, including humans, are almost commonplace. Scientists make these animals by injecting human DNA into animal embryos, a process that involves a lot of trial and error.

Combining transgenic technology with cloning, however, speeds up the process and cuts costs by eliminating a lot of guesswork. To create a herd of transgenic cloned calves that produce serum-albumin, for example, the scientists at ACT splice human genes into fetal cow cells and then fuse the nuclei of these cells with eggs that are implanted in surrogate mothers.

Cloning also gives scientists better control over the transgenic technique



Contrary to popular cloning didn't start with

by allowing them to not only add genes, but also take them away. That could make it possible to engineer animals to produce other medically useful products—such as organs and tissues for transplantation into humans. In fact, Stice is trying to perfect a technique to genetically modify and clone pigs for precisely that purpose.

Pigs have proven good donors because the sizes and shapes of their organs match those of humans. But because porcine tissue is so different from human tissue, it immediately turns black when transplanted: Human immune cells, recognizing the pig tissue as foreign, choke its blood supply. By turning off the genes responsible for this problem, doctors might be able to transplant pig organs directly into humans without giving patients toxic immune-suppressing drugs.

Novartis Pharmaceuticals Corp. of East Hanover, New Jersey, has already had some success in transplanting genetically engineered pig hearts and kidneys into monkeys. In preliminary studies, the monkeys have been able to hold onto the transplanted organs for as long as 70 days.

Stice himself has been cloning animals since the late 1980s. "The biggest misconception about cloning is that everything started with Dolly," he says. In fact, the basic cloning techniques used today were developed more than a decade ago. At the time, the goal was to clone prized animals for agricultural purposes. Scientists hoped, for example, to clone cows with the highest milk yields, the most tender meat, and the best flavor. But most of these efforts flopped after experiments showed cloning large animals to be more difficult than anticipated. The physiology and embryology of each species varies tremendously, and the payoff

Coming Soon to a Drugstore Near You		
BIOTECHNOLOGY companies are trying to produce a variety of drugs in milk.		
Major companies	Product *	Disease/Benefit
GENZYME TRANSGENICS Framingham, Massachusetts	Vaccines against malaria, blood anticoagulants, antibodies against HIV, and blood components such as serum-albumin	The World Health Organization estimates that up to 5 million people contract malaria every year, and more than 2.5 million die. A vaccine would present the biggest boon to travelers who have no natural immunity to malaria and often need to be hospitalized upon contracting it.
PHARMING HOLDING NV Leiden, Netherlands	Proteins to treat hemophilia, muscle disease, intestinal infections, and rheumatoid arthritis	Hemophilia is a hereditary blood-clotting disorder that mostly affects males. The National Hemophilia Foundation estimates that 1 in 10,000 U.S. males are born with the disorder. Blood-clotting proteins are currently extracted from blood. Making them in animals will provide larger quantities at lower cost.
PPL THERAPEUTICS Roslin, Scotland	Proteins to treat cystic fibrosis and emphysema; proteins that help digest fats; proteins to serve as nutritional supplements for infants	The Cystic Fibrosis Foundation estimates that 1 in 3,300 people are born with cystic fibrosis, the most common fatal hereditary disease in the United States today. It causes the body to produce a thick mucus that clogs the lungs and causes fatal infections. The average lifespan of patients is only 31 years. PPL's treatment would prevent fatal lung damage caused by mucus buildup.
*Production expected within the next five to seven years		

was too low to justify the expense.

Combining cloning with transgenics to produce medicines makes better economic sense, because the end product, a drug, is worth a lot more than a prime cut of meat. In fact, Dolly herself was the result of an effort to create a sheep that would secrete medicine in its milk.

Today, a number of biotechnology companies around the world are pursuing this idea, using sheep and other animals **in attempts to produce a variety of medicines.**

Although Dolly's birth proved that an animal could be cloned from an adult cell, making copies of adult animals is not the focus of scientists trying to produce medicine in animal

milk. "Why use an adult cell when we have much greater success in making cloned transgenic animals with younger fetal or embryonic cells?" Stice asks.

But that doesn't mean scientists aren't investigating the cloning of adult cells. There are many unanswered questions about how cloning works, and the technology has other applications such as cloning endangered species, growing human tissues for transplants, and generating cloned lab animals for research. Making medicine in animal milk is simply the first application of cloning. Although some of the future applications may be ethically troubling, their potential benefits are too tantalizing for scientists not to forge ahead. ♦

Relief, Dolly.

Second Sight

By Dan McCosh

An ingenious
night-vision system
for cars illuminates
the scene beyond
the sweep of your
headlights.



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YOU DON'T WANT TO THINK about what's out there beyond the reach of your headlights on a dark road. The occasional deer, for instance, neglecting to wear the mandatory reflective garb of today's cyclist or jogger, is dead meat for a car traveling 60 mph. At that speed, the minimum braking distance is long gone by the time a driver can react to an animal's sudden appearance in low-beam headlights.

But next year, using one of the more ingenious adaptations of Vietnam-era military technology ever to trickle down to civilian use, Cadillac hopes to change all that.

warm-blooded mammals. And that's why the engineers walking around in the parking lot show up white against the dark, cool sky as they stand on a light-gray sea of asphalt slowly losing ergs accumulated earlier, in the heat of the midday sun.

It's an eerie view of the world, a new way of seeing things, and it takes some getting used to. Reflected light—everything from early acetylene lanterns and electric bulbs to today's high-intensity discharge lamps—has held sway as the proper way for drivers to see the road ahead for nearly a hundred years. This new infrared landscape, however, is generated by the heat of objects that populate it, not by what pops up in a sweeping beam of light. Trees, people, and most objects are clearly visible

on the road and off through the dark, while the warmed pavement can be seen far beyond the reach of any conventional headlight system until the road disappears over the crest of a hill ahead.

Infrared vision gained the attention of the U.S. military in Vietnam. During that conflict, nighttime helicopter maneuvers and infrared's ability to see through jungle foliage

Out There in the Dark

Normal headlights have surprisingly little range, particularly on low beam. The infrared detector can pick up objects about five times farther away than most high beam systems.



In a prototype model-year-2000 Cadillac DeVille, a head-up display floats a ghostly image in the air ahead of the windshield, just below the normal line of sight. The image is generated by heat in the infrared range, at wavelengths longer than the visible light spectrum. Though the system detects heat over a broad range of radiation, it is particularly sensitive to the heat range of

PHOTOGRAPHED BY JOHN B. CARNETT

gave the technology an impact somewhat akin to the revolutionary introduction of radar to sea maneuvers in World War II. Early infrared systems used supercooled detectors that consumed liquid nitrogen to maintain an operating temperature of about minus 200°C, which proved bulky and expensive, however.

That began to change by the mid-1970s, when work toward developing an uncooled system commenced at Texas Instruments. The system wasn't quite as sensitive as the cooled detectors, but it promised light weight and, ultimately, low cost.

The uncooled detectors use a specialized dielectric capacitor that generates a spike of voltage when

on-road use likewise began in the military. The system is currently found on military Humvees and has even been tested on an off-road race truck driven in races at the Baja peninsula in Mexico. It will be at least a year before carmakers other than Cadillac can use the Raytheon technology in their cars and trucks.

The installation of this system on the Cadillac DeVille includes a camera hiding behind the grille and focused on the road ahead. The infrared images from the camera are projected to the driver's vision via a device at the top of the instrument panel. Using a small panel on the dashboard, the driver can set the image's intensity, adjust its position,

hence barely visible when viewed with the night-vision system), you get a clear view in the screen.

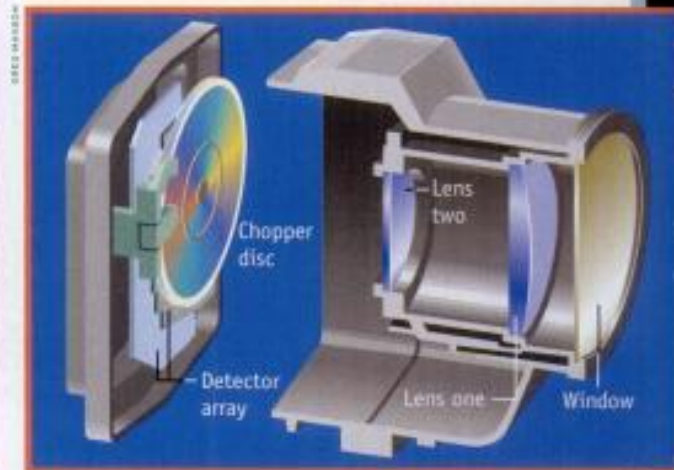
It works, with some quirks. When you look straight ahead, the view of the road is loaded with sharp detail, including the center line, which has a different heat content from the pavement. On tight curves, however, the camera presents a disconcerting blur as it pans the outside edge of the road.

After a few miles, the value of the system becomes apparent—it's sort of like a rear-view mirror, only facing forward, warning you of something that wouldn't be visible without it. Neat.

During a demonstration, a deer



The infrared camera is mounted on the front of the radiator, facing forward. Everything but the lens is covered by the grille.



A rotating disc inside the camera scans hundreds of tiny detectors to piece together the infrared image.

activated by infrared light. The detector is sensitive to about 0.1°C—enough so that a hand rested against a wall leaves a visible heat print. A tiny array of the capacitors—about an inch square—is scanned by a rapidly rotating disc to generate an image.

The first military devices, including gunsights and security cameras, began to emerge in the late 1980s. Raytheon Corp. acquired the technology from Texas Instruments and Hughes Industrial Electronics, and continued to commercialize the system, introducing cameras for police squad cars and marine applications.

The technology's adaptation for

and turn it off when it is unwanted.

"It's a driving aid. The idea is that you refer to it occasionally, when you need it," says Raytheon engineer Richard Seolane, who is working on the system for Cadillac.

OK. But the image is hypnotic. The head-up display focuses about 7 feet away, far enough so that the night-vision image stays in focus along with the normal view through the windshield. The image is sized to closely duplicate the usual perspective of oncoming cars, to show the road ahead with relatively little distortion. When you are blinded by oncoming headlights (which, surprisingly, are relatively cool, and

appeared at the edge of a nearby field, but stayed away from the road. So a couple of volunteers stood alongside a car on the shoulder and feigned changing a tire. The impact was dramatic: Although the bystanders were hidden by the glare of the parked car's headlights until we approached to within 50 feet or so, they were clearly visible for a quarter-mile away with the night-vision system.

The system also works in light fog and dust, and will reveal a person camouflaged by foliage alongside your driveway. Proving that there is more out there in the dark than usually meets the eye. ▶

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UNTIL RECENTLY, detailed information about Russian spacecraft wasn't easy to find. During the cold war, it took years for even the simplest drawings to be released, and photographs were often grossly retouched.

The past few years, however, have brought a torrent of revelations about space hardware developed in the former Soviet Union. Russian historians and journalists, no longer forbidden to investigate or publish information

By James Oberg

about once-secret space programs, are rewriting Soviet space history. Museum directors who squirreled away secret exhibits, some of which had been ordered destroyed, are now revealing their hidden collections. And Russian space organizations are releasing documents and photographs in an effort to earn the respect and trust of potential Western customers.

"All of this is aiding in the piecing together of the history of space flight," says NASA chief historian Roger D. Launius. "The Soviet Union had closely guarded information about its space activities, even to the extent of denying that there had ever been plans to land a cosmonaut on the moon, but now we are beginning to learn the full extent of the Soviet space program and its considerable capabilities. The release of documents and hardware has

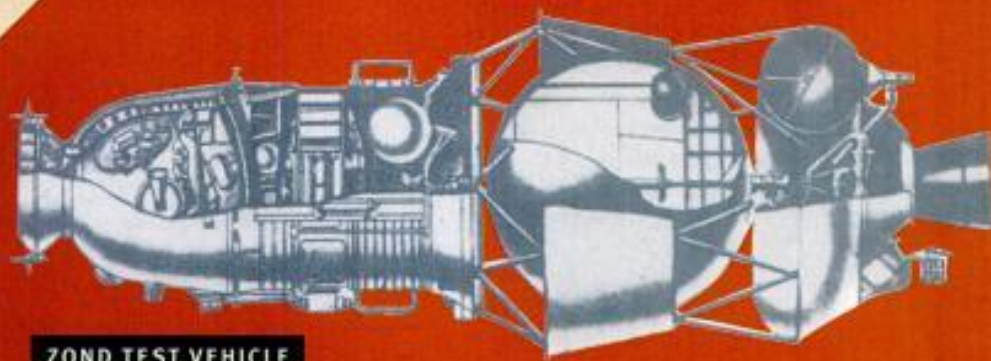
prompted a reconsideration that would have been impossible before these materials became available. The result has been a blossoming of comparative space history, as new understandings have emerged."

Soviet pictures, government reports, memoirs, and interview transcripts at last provide a full view of what went on behind the curtain of secrecy. A few of the newly released images have opened windows on secret Soviet programs that were suspected but never proven by Pentagon experts. For example, images of the Polyus-1 spacecraft confirm that in 1987 the Soviets were preparing to launch a space-based anti-satellite weapon that would have set off a massive arms race in space.

To help ascertain just how formidable the Soviet space program was and to predict what the new Russia may contribute to mankind's continuing quest in outer space, POPULAR SCIENCE has assembled a gallery of secret Soviet spaceships. Some of these craft actually flew; others existed only on paper. They represent some of the most significant space programs undertaken in the Soviet Union during the 1960s, '70s, and '80s.

SECRET SOVIET SPACECRAFT

Killer satellites, monster space stations, super spy cameras, and a trip to the moon were all on the agenda of the once "evil empire."



ZOND TEST VEHICLE



L-1 LUNAR ORBITER

ZOND ON PROTON ROCKET

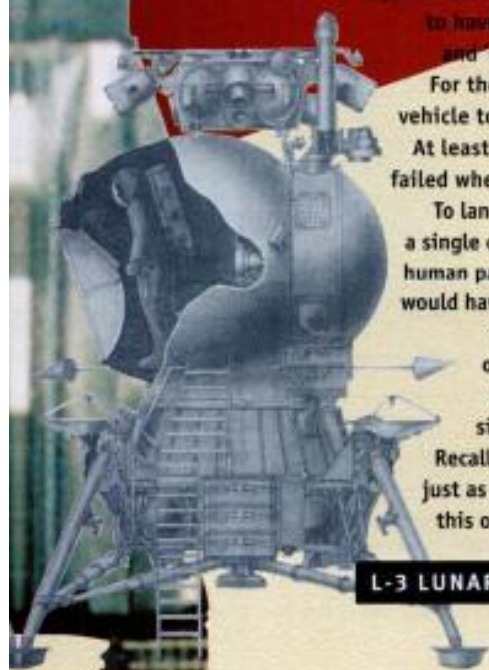
RACE TO THE MOON

The U.S.-U.S.S.R. race to the moon in the 1960s was an exciting chapter in the history of space exploration. But historians were puzzled when, after the Apollo triumphs of '68 and '69, the Soviet Union denied it had ever competed to land men on the lunar surface. That's why these pictures were top secret for decades: They show actual spaceships built by Soviet engineers in a stealthy drive to send cosmonauts to the moon ahead of American astronauts.

In the photo below right, an unmanned test vehicle called Zond sits atop a giant Proton rocket at the Baykonur space center in Kazakhstan, awaiting launch toward the moon. Zond was the precursor to an anticipated two-man follow-on flight, as evidenced by the launch escape system on its nose. Designed to pull a capsule clear of an exploding rocket, this system is found only on spacecraft that are intended to have humans aboard. But there were too many booster and spacecraft failures in '67 and '68, and the Russians never cleared the Zond spaceship for manned flight.

For their planned lunar landing mission, the Soviets upgraded their Soyuz Earth-orbit vehicle to take two men into lunar orbit and back. They called the new spaceship the L-1. At least one such vehicle was prepared for an unmanned test flight in 1969, but the test failed when the L-1 exploded.

To land on the moon, the Soviets developed a miniature lunar module that would carry a single cosmonaut. This spaceship, called the L-3, was even tested in Earth orbit without human passengers. Since the lunar landing would have relied on failure-prone rockets and would have required a cosmonaut to transfer from one ship to another in open space, even the Russian assigned to the first mission considered the assignment "sporty." Recalls Aleksey Leonov, "It's probably just as well I didn't have to actually try this on the moon."



L-3 LUNAR LANDER



ZOND

SPACE FERRY

Soviet space ambitions were at an all-time high in the mid-1980s, when the Mir space station and Buran space shuttle were being built. Looking several steps beyond these spacecraft, Soviet engineers designed a reusable eight-person ferry called Zarya, intended to fly to space stations that would be much larger than Mir. Using a scaled-up version of the tried-and-true Soyuz capsule, the engineers replaced the "burn-away" heat shield with reusable tiles like those on NASA's space shuttle, and moved the touchdown-cushioning rockets from the center of the spacecraft to the rim.

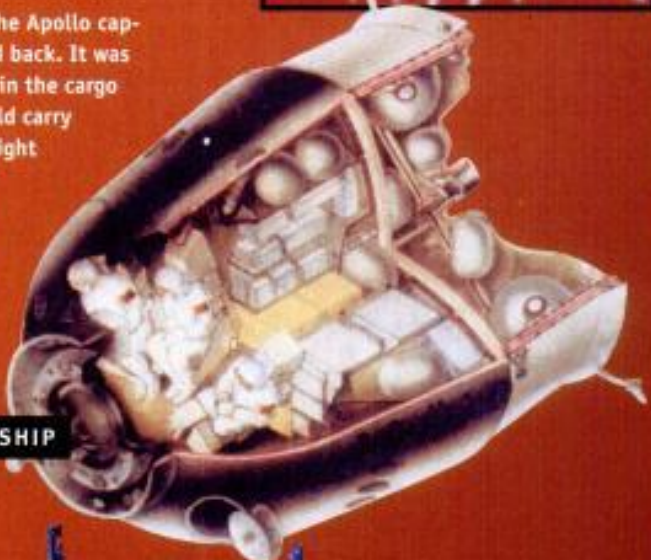
The 26,000-pound capsule, twice the weight and size of the Apollo capsule, was intended to carry crews and supplies into space and back. It was to be launched on the new Zenit rocket or carried into space in the cargo bay of the Buran shuttle. A two- or three-person version would carry 3 tons of supplies, and an all-passenger model would carry eight cosmonauts routinely and 12 in an emergency evacuation.

Begun in 1985, the project was canceled in '89 when the Soviet Union's economy began to collapse and plans for the shuttle and future big space stations were scrapped. Zarya was briefly considered as an escape vehicle for the crew on the International Space Station but was deemed too expensive even in that role.

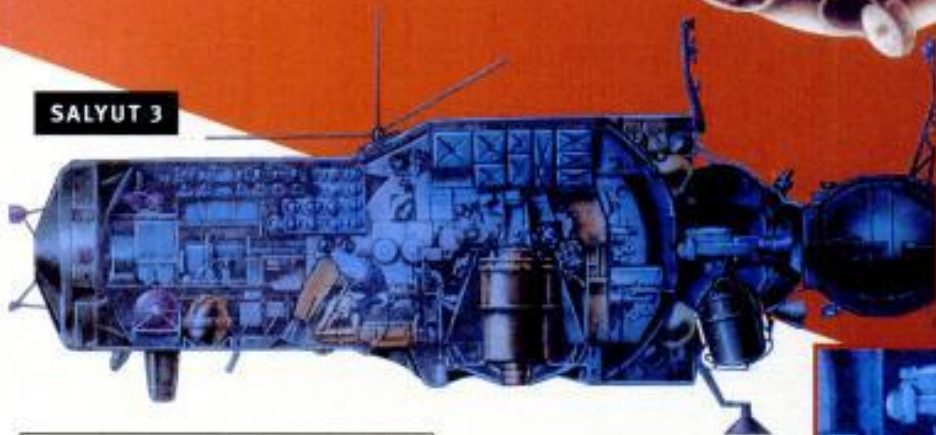
ZARYA LANDING



ZARYA SUPPLY SHIP



SALYUT 3



SNAPSHOTS FROM SPACE

In the '70s, the Soviets launched a series of 20-ton Salyut space stations on year-long orbits and sent up crews to visit them for months at a time. Western observers suspected that the Salyut name covered two separate projects, one for civilian scientific research and one for military applications, including reconnaissance. The Soviets provided vehicle drawings and onboard photographs of the civilian version, and even allowed reporters access to training mockups. But for the "other" version, only a few fuzzy televised onboard views were ever released, and it wasn't until '97—almost a quarter-century after the first flights—that Western journalists were able to see the mili-

tary Salyut ground simulators.

This recently released cutaway drawing shows why. The space station contained a massive spy camera for observing U.S. military targets. At the back end was an ejection chamber for film canisters that could deliver pictures back to Earth while the cosmonauts continued in flight. One of these canisters was auctioned at Sotheby's a few years ago, and brought \$42,500. More recently, the Russians have begun trying to find Western commercial customers for such cameras and entry capsules.



FILM CANISTER

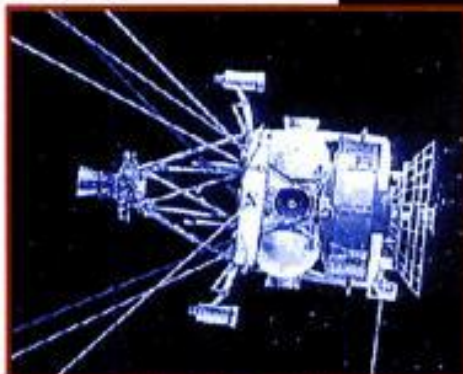
ANTI-SATELLITE SYSTEMS

Considering its history, Russia's obsession with defense against intruders is entirely understandable. So as soon as foreign satellites began orbiting overhead 40 years ago, the Russians began work on weapons to destroy them. They chose to build a "co-orbital" anti-satellite system that could fly into space to seek out and destroy target satellites.

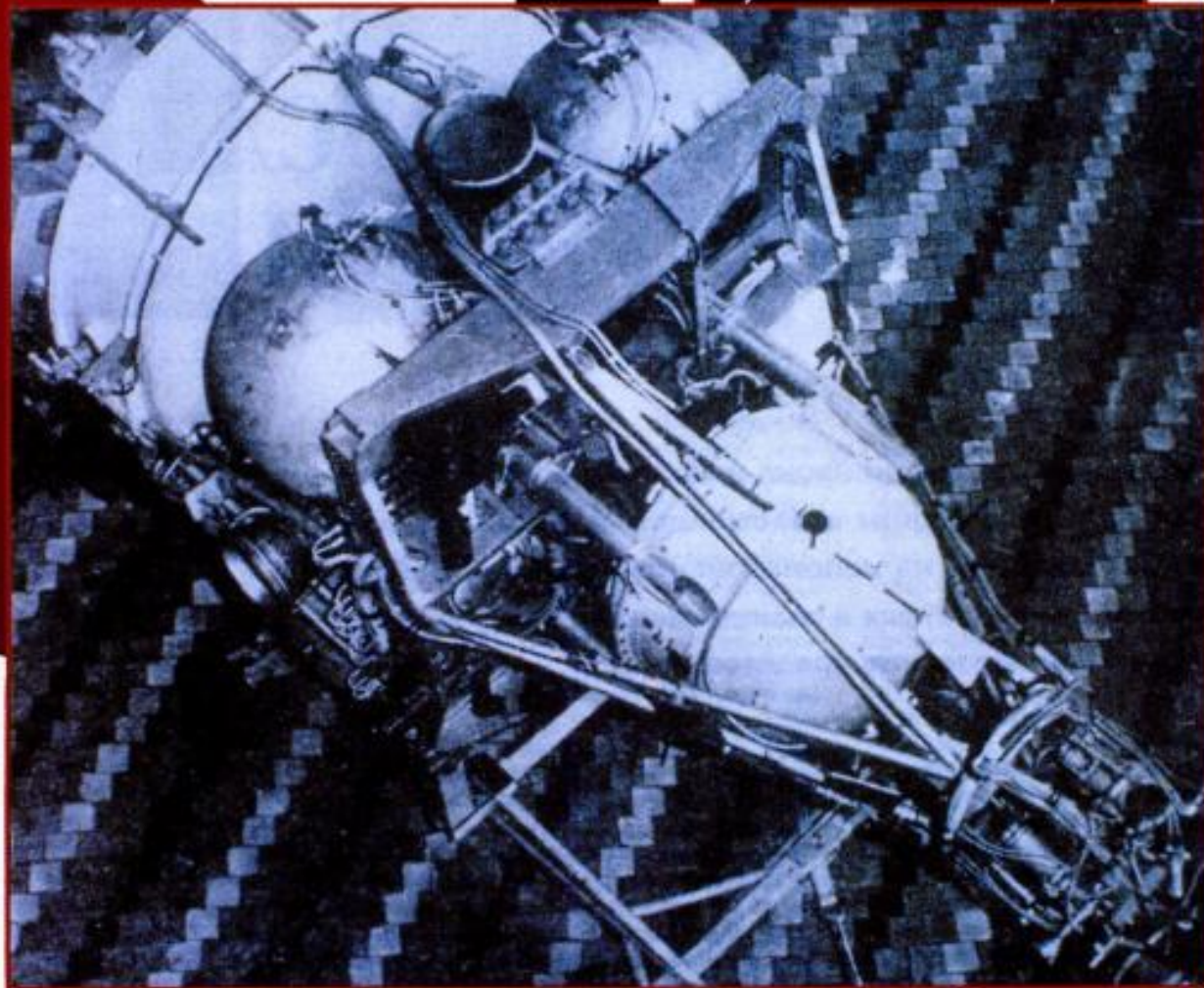
This 3,000-pound spacecraft, the world's first space weapon, was test-flown in 1963. Its military purpose was disguised. Labeled Polyot-1, the vehicle was said to be a peaceful spaceship designed to practice maneuvering in orbit. For 30 years, not a single image was ever released, until Western visitors to a Russian space factory noticed a strange object in a historical display area. After a few photographs were taken, later visitors reported the spacecraft was no longer on display.

Between 1968 and 1983, the Soviets launched a series of "killer satellite" tests, using a warhead derived from the Polyot vehicle. In public, these devices were announced as scientific research satellites, but no photographs were ever released. Only in the past few years have pioneering Russian space historians dug out and published the view shown here.

KILLER SATELLITE



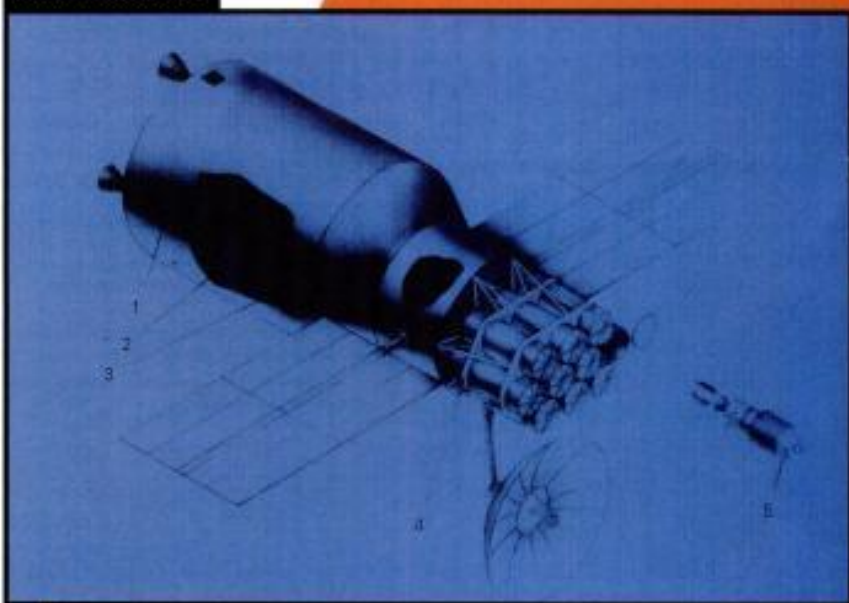
POLYOT-1



STATION DEFENSE

The Soviets always suspected something sinister from NASA's professed peaceful space exploration, which they feared hid plans to attack Soviet space vehicles. (That's because the Soviets knew that their own "peaceful" proclamations were really propaganda covers for the secret development of space weapons.) So when Soviet engineers designed the Salyut manned space stations for military missions, they included versions carrying defensive weapons, from cannons to lasers to space-to-space missiles. This drawing shows a manned space station armed with missiles. It was never built.

ARMED SALYUT



POLYUS CONCEPT



STAR WARS

Throughout the early 1980s, the Soviets were working on their own versions of Star Wars, weapon systems to be placed in space. When the Buran shuttle project was delayed, the opportunity arose to use

the first Energia rocket to instead launch a 100-ton payload of space weapons hardware. This super-secret weapons payload became known as Polyus, or Pole. When it was launched in May 1987, Soviet space officials simply called it a "size and weight dummy mockup."

Polyus was actually a black cylinder 37 meters long and 4.1 meters in diameter, with an off-the-shelf space tug at one end. Polyus possessed deployable tracking targets and large tanks of gases to be released into the ionosphere. The craft also carried a "Skif-DM" apparatus (probably an anti-satellite laser) and, according to some reports, a rapid-fire aircraft cannon.

Although the project had been approved by earlier Soviet leaders, apparently Mikhail Gorbachev was never fully briefed. When he traveled to Baykonur to watch the launch, he reportedly was horrified to discover that the Soviet Union was about to orbit a "death star" that would jeopardize his diplomatic campaigns against Star Wars. Gorbachev allowed the rocket test to proceed but ordered that the payload never be activated once it reached orbit. As it turned out, the space tug misfired, and Polyus fell into the Pacific Ocean. ◀

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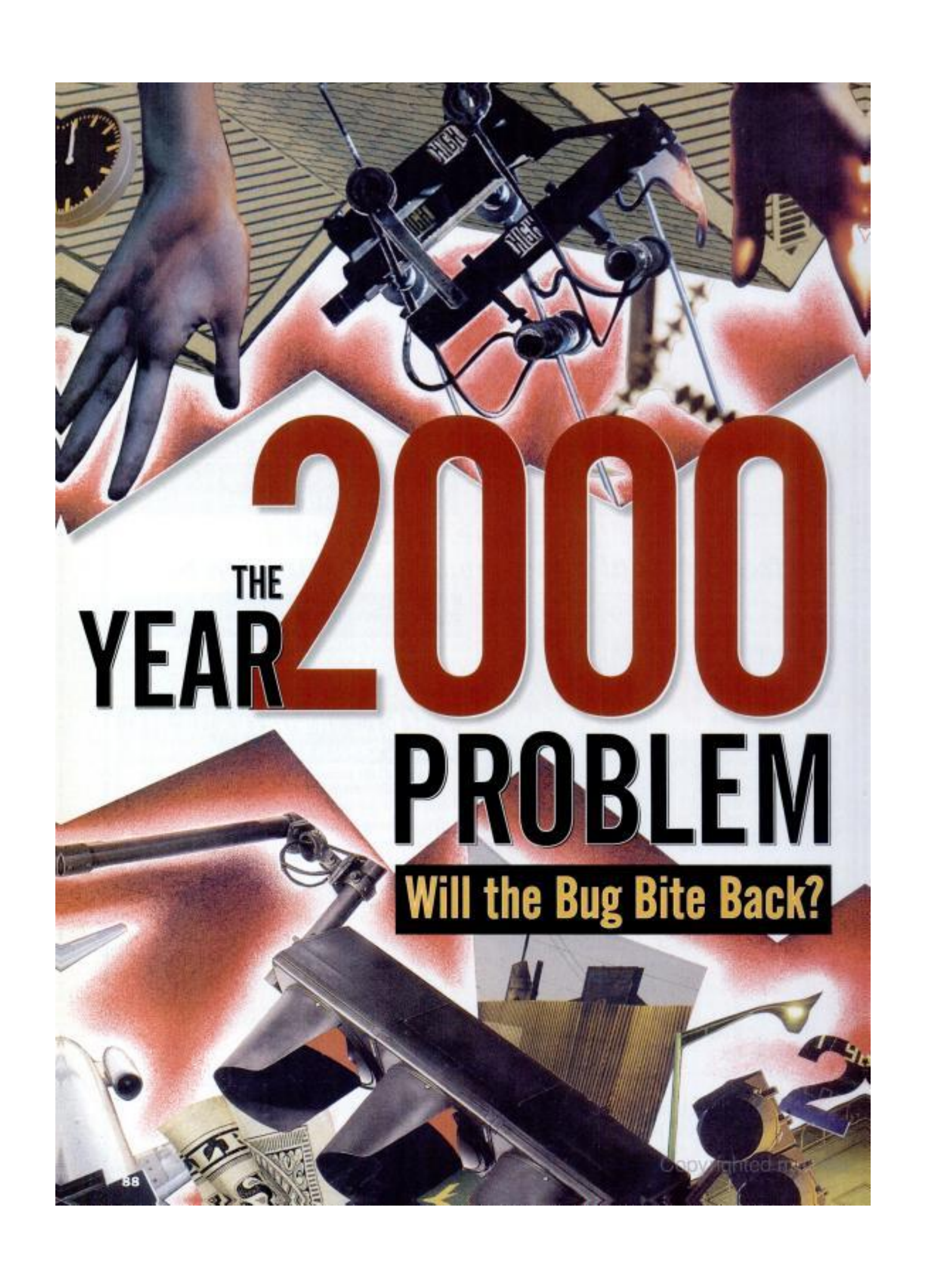
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THE YEAR **2000** PROBLEM

Will the Bug Bite Back?

By William G. Phillips

ON A CHILLY MONDAY morning in south-central Virginia, a former motel clerk and an ex-McDonald's cashier settle in at their desks. Down the hall, a recently laid-off plant manager pours coffee for a police officer who's in the midst of a career change. Just before 8 a.m., they gather to discuss the day's mission, which, as they see it, is to save the world. Or at least the state of Connecticut.

Welcome to the Software Factory's Year 2000 remediation facility in South Boston, Virginia, a town of 7,000 that no one is likely to mistake for Silicon anything. It is here, however, that a group of computer neophytes—some of whom hadn't even heard of the Year 2000 problem until a few months before—are working to ensure that Connecticut residents don't get bitten by the millennium bug on January 1, 2000.

Why South Boston? Why not? With a little more than a year to go before the change of century, companies and government agencies are working feverishly to ensure that their computer systems don't read the year 2000 as the year 1900. As the immovable deadline draws closer, however, many

programmers, mostly because of shortsightedness, used to save computer memory, which historically has been extremely expensive. It is prevalent in mainframe computer systems, many of which run on ancient (by computer standards, anyway) programming languages like Cobol, in so-called firmware (tiny chips with simple programs etched into them that, among other tasks, control many facets of manufacturing), and even in older PCs. Instead of depicting years as four digits—1998, for example—years appear in computer code as two digits: 98. The "19" is understood—even after January 1, 2000, when millions of computers around the world will read "00" as "1900."

Big deal? Actually, it is. In today's society, computers control everything from defense systems to the electric grid that powers your home. So if the thought of a huge mainframe spewing out bad data prompts a yawn, consider the consequences. Your credit card bill is suddenly 99 years overdue, you owe another century's worth of interest on your home, and Grandma gets a notice to enter kindergarten (assuming the mail is still moving). Phone lines are busy, and e-mail is down because the electricity is out. You're under a boil-water alert, and the shelves at the local supermarket are bare. And

Armies of programmers are racing to fix the Year 2000 problem, but many are using shortcuts that merely play for time.

are facing an irresistible force—there's more programming to do than programmers to do it. Most are turning to outside vendors like the Software Factory—more than 600 have materialized across the nation over the past two years alone—for help. Which underscores the essence of the issue: The Year 2000 bug is proving so pervasive that some computers will likely not be ready.

But perhaps more disturbing is this reality: In many cases, it's too late to fix the problem correctly. Instead, programmers are reaching into a bag of tricks and pulling out ways to work around the problem—a fact that has more than a few experts worried that we'll be dealing with Year 2000 issues long after the year 2000.

The Year 2000 problem, as you've likely heard, is the unfortunate result of years of shortcuts that

What Is the Problem?

JANUARY 2000 MARKS the halfway point of your 30-year, \$100,000 home mortgage, but your latest statement seems a bit high. Using this mortgage scenario as an example, here's how the Year 2000 bug could lead to loan miscalculations.

	CURRENT SOFTWARE	CORRECTED SOFTWARE
CURRENT YEAR	00	2000
PURCHASE YEAR	(-) 85	(-) 1985
REMAINDER OF LOAN (YEARS)	-85	15
UNPAID BALANCE	\$37,187,641	\$74,019

ILLUSTRATIONS BY CATHERINE PARR

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oh yeah—the money in your bank account disappears faster than it did last time you visited Vegas.

Okay, that's a worst-case scenario. But the Year 2000 bug will likely hit some people harder than their New

Year's Day hangover. Embedded chips, for example, show up in the unlikelyst of places, such as on the ocean floor (oil rigs) and in space (satellites). And though only a small percentage of them are affected by the bug—less than 1

percent—billions are in circulation; finding the susceptible ones is not easy. A single chip could, say, bring a power plant to a halt because it detects overdue maintenance. **Or, closer to home, freeze traffic lights and elevators.**

Battling the Bug

THE MILLENNIUM BUG is such a formidable opponent that programmers are concentrating on fixing only the computers critical to a business's operation. Here is where some key industries are at present.

AVIATION ✗

Though only one-third of the FAA's critical computer systems—air traffic control, for example—had been fixed as of press time, administrator Jane Garvey, insisting the organization will be ready, recently announced plans to fly across the country shortly after midnight January 1, 2000. Boeing and Airbus say their aircraft have no Year 2000 safety issues.

DEFENSE WEAPONS ✓

Missiles will not fire without warning, says Army consultant Rich Hoffman. Though these and other weapons have embedded chips, Hoffman says a malfunction would disable the weapon, not deploy it. The bigger issue, he says, is the possibility of a mistaken offensive. Recently, the Clinton administration appointed a commission to raise awareness in the international community about this issue.

ELECTRICITY ✓

Billing systems are more at risk than operations, says Steve Rosenstock of the Edison Electric Institute, which represents America's publicly owned utilities. Even if an embedded chip detected a maintenance problem, Rosenstock says, the chances are slim that it would shut down the system.

HEALTH CARE ✗

Only 30 percent of U.S. hospitals have formal remediation plans, yet the effects of Year 2000 could be dire: Not only could medical records be lost, but IV feeders could malfunction and dialysis machines could shut down. On the positive side, pacemakers and other medical implant devices are not affected, contrary to popular belief, says leading manufacturer Medtronic.

HOME COMPUTERS ✗

The Year 2000 problem could show up in two places: the internal clock or the operating system. All Macintosh computers and operating sys-

tems are compliant, but IBM-compatible PCs built before 1996 with Pentium or older chips could face millennium bug issues, depending on which version of the chip you have. As far as operating systems, Windows 98 has no problems, but Windows 3.1 and older versions of Windows 95 will need software patches. Software to test and fix these older machines and systems is available on the Internet. Also, a few software programs, such as Intuit's online banking software, have Year 2000 problems.

MONEY ✓

The major U.S. banks are well along. Small banks, however, are lagging, prompting experts to warn that some of them could be bought out as a result of Year 2000. Even so, they say, your money should be safe. But if you're looking for another layer of security, keep copies of old financial statements—along with copies of credit card, investment, loan, and tax records—just in case.

SOCIAL SECURITY ✓

The Social Security Administration began its efforts seven years ago and, as such, is the government's poster child on how to fix the problem correctly. It is also working with related agencies—the Treasury Department, Federal Reserve, and Postal Service—to ensure checks are delivered on time.

TELEPHONE SERVICE ✓

Though the major U.S. long-distance carriers—AT&T, Sprint, and MCI—expect to be ready, their transmission systems depend on the nation's 1,400 regional carriers to work properly. The Federal Communications Commission says 98 percent of U.S. coverage areas will be compliant by mid-1999. Calling international? Experts warn that some developing countries will likely not make the deadline.

WALL STREET ✓

With most aspects of the securities industry reliant on computers, Year 2000 is a top priority. In July, the Securities Industry Association sponsored a two-week test—the first example of an industry coming together to test for the bug—involving major stock exchanges and 29 brokerage firms, among others. Results are encouraging; no major glitches were uncovered.—W.G.P.



Or make them work improperly. January 1, 2000, is a Saturday, but some embedded chips—such as those used in some bank vaults and building systems—will think it's Monday, as it was in 1900, and operate on a weekday schedule. Likewise, they'll go into weekend mode on Thursday, January 6.

And if the Year 2000 problem itself wasn't challenging enough, a few related issues are complicating matters. The first is February 29, 2000. The 1900 calendar had no leap day, but the year 2000 does. Because leap days during millennial years are somewhat rare, many programmers mistakenly did not include one for 2000. As a result, even Year 2000-compliant systems must be checked for leap day compliance.

In addition, in what can only be considered a cruel joke from the patron saint of bad timing, the world could get a taste of a Year 2000-like fiasco next year. Many old-time programmers used the number 9999 as a signal to the computer that it has reached the end of a file. On September 9, 1999, dates in some code will appear as 9999; if not corrected, computers, as instructed, will quit reading the file, freezing the machine. Likewise, systems that use so-called short Julian dates (the numerical day of the year instead of the month and the day) could fail on April 9, 1999—the 99th day of 1999.

All of this has Bob Reinke preparing for the worst. The 49-year-old programmer and Year 2000 consultant has worked for a number of federal agencies in the Washington, D.C., area during his 29-year career. "I knowingly put buggy code in," he says. "And I was quite proud of the fact that I saved two bytes of memory every time a date was used. No one thought these programs would still be around." But they are, and Reinke believes history won't measure the effects in dollars. He predicts global chaos lasting as long as six months. He's stocking up on food and water, expects to be without electricity for days, maybe weeks, and plans to take much of his money out of the bank. "January 1, 2000," he says, "will be remembered as Black Saturday."

Though Reinke's dire predictions



are by no means common in the information technology (IT) world, they do underscore the complexity of a fix that—at least on the surface—seems pretty basic: Just find each date field in a piece of code and expand it to four digits. The main problem is that programmers are a wacky sort, not willingly constrained by either logic or consistency. So in a medical software program, for example, a patient's date of birth might be defined as DOB in one place and PDB in another. Or, just for fun, the programmer may have defined it as the name

of his golden retriever. Finding all these dates takes an enormous amount of time and testing.

As a result, many companies are looking at alternative approaches, the most popular of which is called windowing. In fact, it's become the preferred Year 2000 methodology around the world. With windowing, instead of expanding year fields to four digits, the existing two-digit field is assigned two windows that define the century. Windowing works as long as the data doesn't span more than 100 years, which eliminates it as a possible solu-

Testing the Assembly Lines

EACH DAY, THOUSANDS of programmers descend on America's factories to search for the tiny electronic time bombs that could shut production lines down. And nowhere in the manufacturing sector is Year 2000 remediation more daunting than at the Big Three automakers, which are scrambling not only to ensure that their own houses are in order but also those of 100,000 suppliers.

What's at stake? Recent tests offer insight: Technicians at each automaker independently set factory computers to January 1, 2000. While most manufacturing systems continued to function properly, some did not. At Ford, assembly line robots continued as though it was business as usual—except that they couldn't be reprogrammed to work on new models. At General Motors, some robots stopped completely. At Chrysler,

a line of stamping presses failed to operate, requiring a \$600,000 fix.

But no one is panicking—at least not yet. GM, Ford, and Chrysler all are midway in a multiyear effort to check every system for the bug, fix the flaws, then run tests to ensure the systems run seamlessly into the new century. (The Big Three are also testing computer controls in cars and trucks for Year 2000 problems, but so far have found none.)

Automakers are especially vulnerable to factory disruptions because computers control assembly lines, robots, paint systems, inventories, and machines that cut, grind, rout, stamp, mold, and extrude parts. They also regulate safety systems and quality control. If computers malfunction, cars could emerge with faulty welds, substandard parts, or botched paint jobs. "That's why we're checking everything," says Don Costantino, GM's Year 2000 manager.

The industry's problems are com-

pounded by its reliance on a single supplier for almost every part. "It's virtually impossible to replace a supplier on short notice," says Roger Buck, manager of Chrysler's Year 2000 effort. For suppliers who lag behind on Year 2000 efforts, automakers will insist that they stockpile parts beginning late next year.

The Big Three plan to spend most of 1999 making sure all systems are running properly. By the end of next year, GM, the world's largest automaker, will have tested more than half a million devices and fixed or replaced the flawed ones. Cost: up to \$550 million.

The automakers are confident they will make the deadline, adding that the bug may be a blessing in disguise because it's forcing industry to modernize. So come January 1, 2000, they say, Americans may wake up to a partial industrial meltdown—or a system of mass production more efficient than ever.—Doug McInnis

tion for programs that feature, for instance, dates of birth (including Social Security and IRS systems).

Freddie Mac, the multibillion-dollar mortgage buyer based in McLean, Virginia, is relying heavily on windowing. The company purchases more than one million mortgages each year, most having a life span of 30 years. Payment, term, interest, and other information about each mortgage is kept on the company's vast computer network. In its windowing scenario, numbers falling between 50 and 99 in the year field are interpreted as occurring in the 20th century, while numbers between 00 and 49 are read as the 21st century. So, for example, 09/01/98 would be interpreted as September 1, 1998, while 09/01/05 would be read as September 1, 2005.

The main advantage of windowing is that programmers do not have to find and expand every date field in the code. That's because each computer language has specific words reserved for date-related functions,

such as "sort," "difference," or "compare." Programmers search for the keywords, then program the window over these functions. (They also ensure that the 00 in the year 2000 won't mess up date-related calculations.)

For all its benefits, however, the industry's reliance on windowing is raising a few eyebrows. "It's a Band-Aid, or maybe a tourniquet, because it constrains the useful life of the system," says Robert Martin, head of Year 2000 efforts for Bedford, Massachusetts-based Mitre, a government-funded organization advising the Department of Defense and the Federal Aviation Administration. "Eventually, either the code will have to be expanded, the systems replaced, or the window moved forward." Freddie Mac, for its part, plans to phase out windowed systems in the early 2000s.

Windowing also raises complexities when interacting with external data. Freddie Mac receives electronic information from 2,300 outside sources, all of which must be Year 2000 compliant.

At each interface, the company must check that its computers read the incoming data correctly. If, for example, a particular mortgage lender has expanded date fields to four digits, then Freddie Mac must build in a software "bridge" to strip the century indicators from that data before it enters the company's system.

Drawbacks aside, there's no denying the cost and time savings of windowing. According to Michael Censky, head of Year 2000 efforts for Freddie Mac, the company is spending \$75 million to fix the bug. In addition, 10 percent of its 3,500 employees are working on the problem. How much more time and money would it take to do four-digit expansion? "I can't even guess," Censky says, adding that windowing will allow some companies to make the deadline that otherwise would not.

Rich Hoffman, a member of the U.S. Army Materiel Command's Year 2000 team in Alexandria, Virginia, agrees, but worries that there's a tendency to jump into windowing too



quickly. The Army's preferred fix is four-digit expansion, and Hoffman's team makes every effort to employ this method. However, he admits windowing is sometimes unavoidable. "It buys you time," he says. "And in cases where there's limited documentation and resources, it's the best choice."

Hoffman's bigger concern is the historic shortsightedness of the IT community. "Considering that no one thought Cobol would still be around today, I wonder how we're going to follow up after 2000. It would be easy, especially with the high turnover in this industry, to let this problem come back and bite us again." According to

and adds 28 years to outgoing data. According to Hoffman, a time bridge will likely be used to fix Autodin, the messaging system used by the military to send classified e-mail to and from the battlefield. Years mirror each other in this 28-year window until 2100, so the problem doesn't go away forever with this approach either.

Though windowing and encapsulation are the most common alternative approaches, there are several others that squeeze century information into the existing six-digit space. One method involves making the first digit a century field (where the number 1 equals 19, 2 equals 20, and so on), the next two

being hired. "We'll have a strong Year 2000 business into the next century."

But programmers on the front lines of the Year 2000 fix are not looking that far ahead just yet—there's still a lot of work to be done before January 1, 2000. According to Hoffman, the Army's systems are now more than 80 percent compliant—and on schedule to be completely fixed by the end of this year—but the organization will spend most of next year testing them. "Fixing the code is a small facet," he says. "Testing and implementation take longer than actual code renovation."

That has Martin concerned. "Even though organizations will likely address

When the dust settles, Year 2000 will be remembered as technology's coming of age.

Hoffman, the post-2000 contingency plans for the Department of Defense (DoD), of which the Army is a part, center around fixing or replacing systems that have been windowed. In the meantime, DoD plans to terminate at least 170 control, command, communications, and computer systems and replace them with equipment not infected by the Year 2000 bug.

Another sidestep approach, being employed on a lesser scale, is a 28-year time bridge. The 1972 calendar mirrors 2000's exactly. By setting computers back 28 years, programmers can ensure they operate in the same way. Often called encapsulation, this method works as long as the actual year doesn't influence the functionality of the program, such as with a key-card access system that uses only day-of-week input. If the system interacts with external sources, programmers write a software bridge that subtracts 28 years from incoming data



a year field, and the last three a Julian day-of-the-year field. The benefit of this method is that file size is not affected. The downside: Programmers still have to find all the date fields.

For vendors like the Software Factory, the IT community's reliance on alternative approaches is a boon. "The problem is not going away on January 1, 2000," says Jerry Hill, co-owner of the Software Factory, whose employees all went through a month-long unpaid "boot camp" to learn Cobol before

all their critical systems before the century

change," he says, "they may not have time to do proper testing. So the question becomes, Do we really know how our computers run?"

Bob Reinke is convinced we don't. "Year 2000 going to set the industry back 30 years," he says. "People are going to blame everything on computers for a long, long time."

Hoffman is more optimistic, but does worry that word is not getting out to small businesses. "Walk into the local grocery store," he says, "and ask them if they've checked their inventory control systems or their credit card readers. You'll be amazed at the strange looks you'll get."

But back at the Software Factory, Jerry Hill—who himself was writing buggy code as recently as 1996—sees a silver lining. "We've learned a tough lesson," he says. "After January 1, 2000, technology no longer will be an unmanaged asset."

"When the dust settles," he continues, "Year 2000 will be remembered as technology's coming of age." ♦

By Frank Vizard

FOR MORE THAN a decade now, it has seemed too good to be true: a satellite telephone system that will let you make or receive a call from anywhere in the world. And sitting in a conference room in Lansdowne, Virginia, watching a series of diagrams and charts on an

overhead projector in a conference room does little to make the age of personal satellite communications feel real. Until, that is, the manager of the facility hits a switch.

Suddenly, like a scene from a James Bond movie, a steel shutter on one side of the room rises, affording you a first look at the Iridium control center a floor below. Technicians man four rows of computer consoles, checking everything from telemetry to weather. All of them are too busy to even look up at you. Above their heads are four large screens that

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Iridium consists of 66 satellites in low Earth orbit 465 miles above the planet. The satellite array is arranged in a herringbone pattern across six polar orbits containing 11 satellites each to provide worldwide coverage. Iridium phones operate in a dual mode so less expensive terrestrial cellular service can be used instead where it is available.

The Internet Goes to Space

OVER THE NEXT FEW YEARS, the low Earth orbit (LEO) region approximately 310 to 930 miles above the planet's surface promises to become a very busy place. Many companies want to use LEO satellites to move large data files containing audio, video, and graphics via satellite while also providing Internet access. The goal is to deliver speedy gigabit-per-second (or better) Internet hookups to and from space for less than \$100 a month.

While a number of projects are in various stages for planned

deployments after 2000, the one garnering the most attention and given the best chance of getting off the ground is a 288-satellite system called Teledesic. Teledesic is backed by Microsoft's Bill Gates, among others, and is being built by Motorola. As currently planned, Teledesic would cost \$9 billion and be completed in 2002. Unlike systems such as Iridium and GlobalStar, Teledesic is targeting stationary customers in homes or businesses, and not mobile users.

Nevertheless, with Motorola also the builder of Iridium, some link between the two seems likely. Teledesic estimates the number of potential subscribers to be 20 million.—F.V.

can display data for all to see. Beneath the screens, arrayed in an arc like a glowing red headband, is a series of digital countdown clocks for the Baikonur launch site in Kazakhstan, Taiyuan, in China, and Vandenberg in California, among others. Before your eyes, the theory of a system called Iridium has become fact.

Iridium turns on the switch for worldwide commercial operation on September 23, 1998, a day likely to be remembered as an historic moment in the annals of human communication. From this day on, assuming that Iridium is granted an operating license in every country, there won't be a spot on the planet from which you can't make a telephone call or receive one using a simple handset.

Iridium is actually not the first satellite phone system. Several other companies already offer briefcase-type satellite phones for near-anywhere communication. But these are cumbersome, expensive devices that can be time-consuming to set up and tricky to use. Iridium is the first to provide truly mobile wireless phone service that works in all parts of the world.

For making a small world seem even cozier, you may want to silently thank (or curse) Karen Bertiger for this marvel of telecommunications. In 1985, Karen complained to husband Bary, then a mid-level executive with Motorola, that her cellphone wouldn't work on their remote island vacation spot in the Bahamas. Bary is now vice president and general manager of the satellite systems group of Motorola that built Iridium, named for the 77th element of the periodic table since it was originally thought that that many satellites would be needed. While the initial vision was Motorola's, Iridium is now its own company, comprised of 19 major investment groups worldwide. Motorola still owns 25 percent of Iridium and has the contract to build and operate the system for five years.

That it should take 13 years for Bary to provide his wife with an answer shouldn't be a surprise considering the scope of his reply. The Iridium system consists of 66 satellites in a low Earth orbit 485 miles into space. These satellites are positioned grid-like in a herringbone pattern across six north-south orbits. Perhaps even more daunting



than the technical hurdles—seven satellites were lost early on due to unspecified operating difficulties, which is considered part of the normal learning curve—was the price tag. Iridium cost a whopping \$5 billion.

Think of Iridium as a big telephone company in space—so big, in fact, that it has been granted its own country code, 881, which you must dial in order to place a call. Future satellite systems will have their own country codes as well, effectively lending a geopolitical identity to telecommunications systems that are not earth-bound. **In fact, the next satellite system, called GlobalStar, is due to start early next year.**

Making a call on an Iridium phone is about the same as making one on a cellular phone. Iridium phones, in fact, are dual-mode: They can operate as cellphones or satellite phones. Thanks to a series of interchangeable cartridges that slip in and out of the phone, Iridium phones will be compatible with any type of cellular system (analog, digital, or PCS). The cellular mode is the first option, since it is less expensive than a satellite call, but once you're beyond the range of a cellular system, all you need do is rotate the satellite antenna on the handset into an upright position to make your call.

Once you've dialed in the number for your satellite call, the signal travels up to the nearest satellite, each of which covers an area of about 2,000 miles, and is relayed to your home "gateway" on Earth. A gateway is basically a calling center at which you are registered for verification, call routing, and billing. The signal is relayed back to the satellite network, which then sends it from satellite to satellite until it reaches its destination—that could be another satellite telephone handset or a gateway linked

to a landline or a cellphone system.

Which way the signal goes depends upon the local gateway operator. A gateway in China, for example, might choose to have all calls from foreigners routed through the gateway for monitoring rather than allow a direct, independent connection. Either way, the entire process takes place in less than 20 seconds.

There are currently 12 gateways around the globe—the U.S. military has one to itself—with some capable of handling as many as 120,000 subscribers, although most are sized for 60,000 customers. Iridium expects about 200,000 subscribers the first year and 5 million by 2002, a startling figure since the number of people who use briefcase-style satellite phones now stands at about 170,000 worldwide.

And calling via space will not be cheap, at least in the beginning. An Iridium phone costs \$3,000, and even a satellite pager costs \$500. The price of a call is about \$1.70 per minute, plus long-distance charges. For the moment, dialing the Iridium "country" is as expensive a proposition as it is with previous satellite phones. But while Iridium costs are high now, the odds seem good that like cellphones before them, the cost of phones and service will quickly decline as more gateways are built and service expands.

Competition will be a factor, too. Along with GlobalStar, another satellite telecommunications system called Teledesic will be coming online within a few years. This 288-satellite array will also be built by Motorola, and it promises to provide broadband or high-capacity links for transmitting audio, video, and text via the Internet. Already, there is talk within Iridium about how to link itself with Teledesic, much like you would connect a cellphone to a laptop computer. Together, the two systems might loosely be termed a space net for the flow of information.

Mrs. Bertiger may have forgotten to ask her husband to make sure Iridium was affordable, much less to demand that it be linked to a high-speed information network. But eventually, she may actually get more than she asked for. ▶

An alternative to one-piece satellite phone models will be cellular phones from Kyocera that slip into a satellite phone receptacle.



Next Up: GlobalStar

IRIDIUM WON'T BE the only "country" in space offering telephone and paging services via satellite. Early next year, GlobalStar, a partnership between cellular phone maker Qualcomm and satellite builder Loral Space & Communications, among others, will have a similar—though not compatible—service.

The \$2.6 billion GlobalStar network uses 48 satellites (plus eight backups) orbiting at 881 miles. The higher orbital configuration means fewer satellites are required. But the system requires a larger number of ground stations, about 60 for worldwide coverage, to route the signal, since a call can't travel between satellites as with Iridium.

GlobalStar says its handsets will cost about \$750 to \$1,000 and will also work with cellular phone systems. The company says phone service may average about 35 to 50 cents per call, not including long-distance charges.—F.V.



Great New Products



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Is it time to close our blinds? This is the night vision you may have heard about. (If you've used old-fashioned first-gen, you're in for a mind-boggling surprise!) Fully stereoscopic, the way our eyes really see, rubber-armored, and compact. Just 8" x 8" x 2.5"! Turn them on. With a clarity never before seen in night-scopes, you - and only you - see your dark yard transformed into green-hued daylight. Magnification is a full 3 times. Enhanced image intensifiers, built-in infrared illuminator, and huge 56mm lenses. You pick out every leaf of every bush, every animal - four legged or otherwise. A cinch to operate, a breeze to focus. For nature study, home security, boating, business protection, or viewing your neighborhood. You can enjoy astonishing see-in-the-dark power, at half the price! Batteries, case, strap, and guarantee included. Science fiction just became real.

■ **Night-Watch™ Night-Vision Binoculars, #NY356**
Regular Edge Price \$699.00. Your price \$499.00

Compare our price to the \$900.00 you'll pay anywhere else. Absolutely no-one sources night-vision better than The Edge - and our savings are your savings.



New pocket laser-level. Just 6" long. Build decks, fences, cabinets. And get it right everytime.

Hang shelves or frame a whole house - without a helper! Powerful built-in 650nm laser works with top bubble-level, shoots a red dot onto targets up to 300 feet away. Use at any angle, any surface: floor, ceiling, or upright on a stud. Magnetic base even joins to iron or steelwork. Or attach the optional tripod and lay out tile lines, footings and more. Outside, the T5 aluminum housing is rain-proof. Great for stone walls or setting window openings. Try one! Complete with batteries and its own case.

■ **Aero Job-Laser, with black case, #TI-328-4 \$59.95**

■ **Optional Tripod, extend/lockable, #A-160 \$24.95**



Walls, decks, landscaping.



Windows, shelves, pictureings.



Tripod, steady, or use the magnetic base.

▼ **Go ahead. Get lost. We'll get you home again.**

If you drive an expensive luxury car, you already know how useful an on-board compass is, even on city streets. The new DEC Navigator is even more sophisticated, without having to buy the \$38,000 car. Using technology first developed for the military, the Navigator is ultra-precise, reading out not just general directions (N, S, SE, NW, etc.) but numeric compass points as well, in 5° increments. So accurate it can be used on boats and planes. Shielded circuitry eliminates tilt or magnetic interference. Water resistant. Blue back-light for night driving, shuts off automatically. Lithium battery included. Uses micro-suction-cups to mount easily on dash or glass at any angle.

■ **D.E.C. Navigator Electronic Compass, #CL288 \$49.95**



Revolutionary Iron-Eagle lighter is 100% windproof. Glass porthole even lets you know it's on.

With some windproof lighters, in bright sunlight it's hard to tell if the flame's on. The Iron Eagle solves that. Click the ignition. First, the flame is a vivid crimson. (Everyone who sees it will want one, too.) Second, fire it up and the glass porthole glows white to orange. You know it's working even in the brightest light. Curved, low profile design rides lump-free in your pocket. Adjustable flame, will fuse metal or light up your smoke. Butane powered. Great price!

■ **Iron-Eagle Windproof Jet Lighter, #X-500 \$19.95**

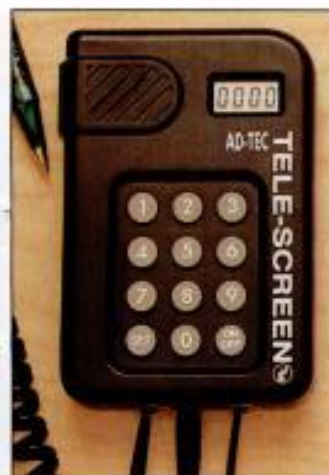


IRON EAGLE

- Windproof
- Red Jet Flame
- Fuel Port Hole

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■ Tele-Screen™ #TS-300 \$44.95

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To access the time on our best-selling Machine Watch, touch the secret release button. Gleaming pistons push and slide, and the cover raises. Click it closed, and it's protected from dust and impact. Quartz action is ultra accurate. Wear it and enjoy the compliments you'll receive – from men, women, and any cyborg you meet.

■ Machine Watch III, #0340-M \$39.95



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■ The S & W Tactical SWAT Knife, #SW3000 partially serrated blade, \$39.95

■ The S & W Tactical SWAT Knife, #SW3001 standard blade, \$39.95



New original adaptable!

Russian astronomers fold super-power reflecting scope into 7 1/4 inches!

The world's most powerful telescopes use giant reflecting mirrors to fold the light path, so they can range billions of miles to the very edges of the universe. Astonishing new Cat-Scope not only miniaturizes these celestial explorers, but folds the light path twice. You enjoy the power of cannon-sized scopes in the palm of your hand!

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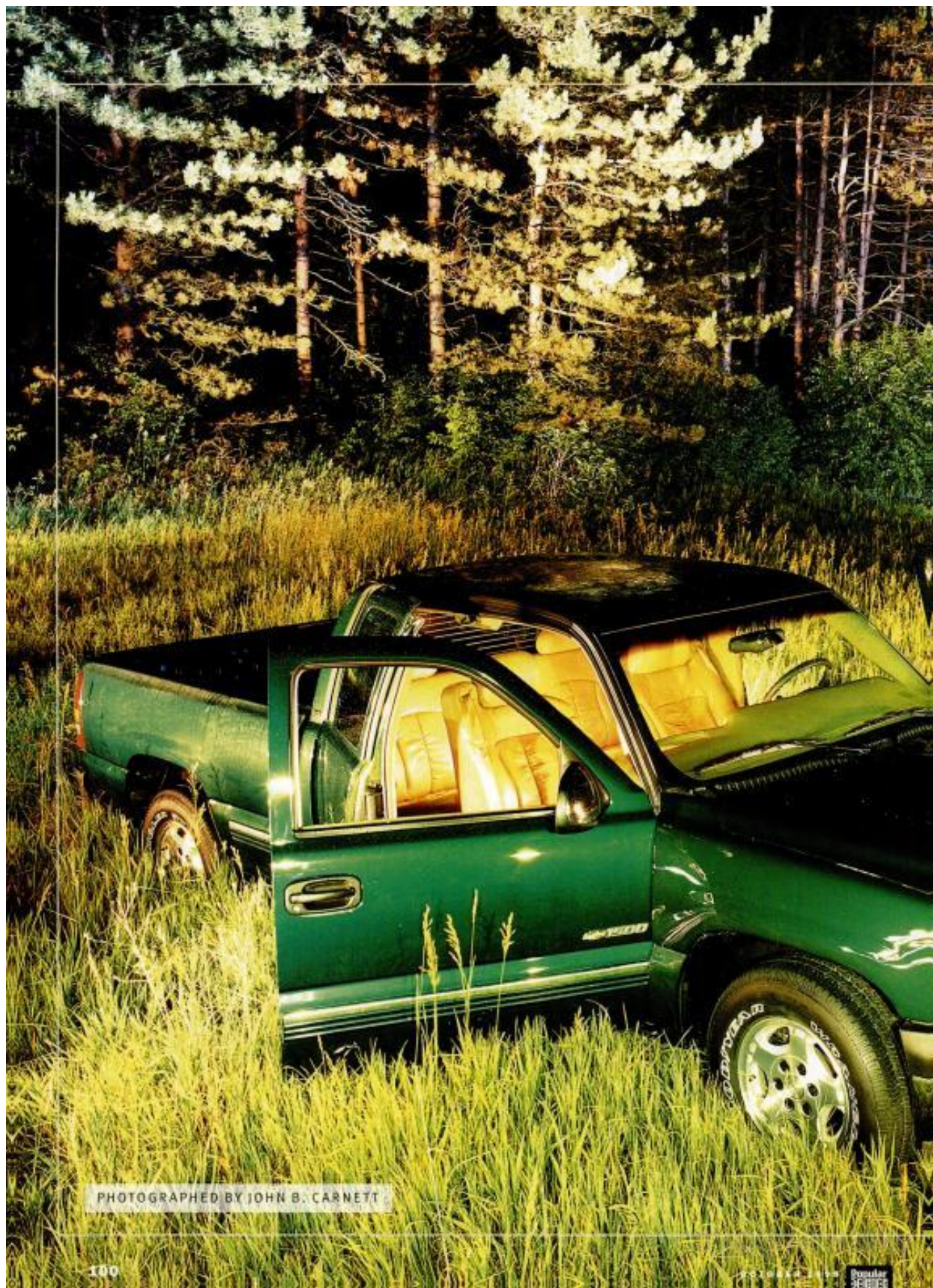


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BIG TRUCKS COME HOME

The newest family car
comes with a bed.

WITHOUT SACRIFICING the toughness needed for heavy towing or toting, the pickup truck is migrating toward the creature comforts and roominess that have been the province of family sedans. It's the latest step in the evolution of a vehicle that's something of a chameleon in today's transport world.

Configured for dirty work, full-size pickups are mandatory for ranchers and construction chiefs. Equipped with a tow package and four-wheel drive, they're perfect escape mechanisms for suburbanites yearning for a taste of wilderness. And now we have the third coloration: an alternative to those traditional full-size, rear-drive, V8-powered sedans built on full frames adequate for trailer towing.

GM had such versatility in mind this year when it re-engineered the Chevrolet Silverado and GMC Sierra, the first

Silverado (shown) and Sierra sport GM's first full re-engineering in a decade.

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ground-up change in the company's full-size pickups in more than a decade. Expanded seating for the extended cab models ranked high among the revisions in the new GM lineup.

Chevrolet and GMC are following a path blazed by their competitors. The Dodge Ram was radically redesigned in 1994 with an oversize cab. Dodge also debuted a four-door Quad Cab edition and Sport package last year. Ford took the cue, making four doors standard on its '99 F-150 SuperCab. The F-150's aerodynamic look has returned for a second season.

General Motors trails slightly in the door wars, making three standard for the '99 Chevrolet Silverado and GMC Sierra extended-cab models, with a fourth portal planned for 2000.

To compare equitably the full-size pickups—the Chevrolet Silverado LT, Dodge Ram Sport, GMC Sierra SLT, and Ford F-150 Lariat—gathered for this test, we ordered each with an extended cab, 6.5-foot cargo bed, rear-wheel drive, and half-ton chassis.

We selected a 5.2-liter powerplant for the Ram and a 5.4-liter for the F-150. We tested the Sierra with a 4.8-liter V8 and the Silverado with a 5.3-liter. Except for front-end appearance, the Sierra and Silverado are twins; if the engines in the two were swapped, our performance figures would flip-flop correspondingly.

The exterior of the Silverado and Sierra is so evolutionary that no heads were turned in the hard-core pickup truck neighborhoods we visited during our week-long evaluation. The revolution is under the skin, including several genuine innovations for this segment.

Among these are three brand-new engines, designed to satisfy demands for more power and smoothness as well as tougher federal light-truck emission standards and fuel-efficiency requirements. In addition to the 4.8- and 5.3-liter engines tested here, a 6.0-liter variation is available for heavy duty.

The two lighter-duty V8s use a deep-skirt iron block for extra rigidity, and combine it with aluminum cylinder heads to balance weight, cost, and durability concerns. (The F-150 shares this approach, while the Ram's 5.2-liter

V8 powerplant uses iron for both the block and heads.)

More controversial was GM's decision to develop and refine a pushrod valvetrain, eschewing the overhead cams

used by Ford. A free-breathing induction system is essential for hearty power, and one advantage that the overhead cam holds toward that end is the absence of pushrods. GM addressed this by making the intake ports tall and narrow to slip past pushrods vying for the same real estate.

GM also deviates from the competition in intake-manifold design, another major influence on engine output. While both Ford and Dodge engines use long-tuned-length intake runners to augment torque at certain portions of the rpm range, GM selected a simpler untuned manifold, providing a torque curve that remains fairly flat from 2,000 to 4,000 rpm.

Anticipating the new GM pickups, Ford gave its 5.4-liter V8 a major boost for '99: new cylinder-head ports, larger exhaust valves, revised intake and exhaust manifolds, and more aggressive valve timing, all aimed at better breathing. These changes yield a torque curve with twin peaks at 2,300 and 3,700 rpm and approximately 7 percent more urge across most of the rpm range.

The best way to sort out these engine designs is to measure flat-out acceleration while keeping a watchful eye on fuel economy, throttle response, and the noise generated when powertrains are asked to give their all. The improved-for-'99 F-150 blistered the track with a best-of-class 8.4-second run to 60 mph and also beat every other truck in passing acceleration except the Silverado, which won the 50- to 70-mph test by a nose. So much torque is waiting under the F-150's throttle pedal that care must be exercised on slippery pavement to avoid fishtailing when a tight turn follows a stop. Both GM pickups respond to the throttle progressively because of their table-flat torque curves. Held back by a few hundred extra pounds of curb weight, the 5.2-liter Ram picked up the tail in a near-dead-heat with the 4.8-liter Sierra.

The performance balance tips toward General Motors when fuel economy is factored in. With either engine, the



Three doors are standard on the extended Silverado cab, and the ride is improved.

CHEVY



The F-150 retains an aerodynamic exterior, while the SuperCab adds a fourth door.

FORD



GM trucks break through the 20-mpg barrier in EPA highway estimates to claim a 2- to 3-mpg advantage over Dodge and Ford. The GM V8s are quietest by far at idle but they generate the most ruckus during the run-up to cruising speed. The Ram issues a throaty rumble at idle consistent with its Sport exterior. The F-150 speaks softly when wielding its mighty torque curve.

Pickup truck ride and handling evolved throughout the '90s in response to the rising demands of former car owners. All of these trucks make excellent use of their body-on-frame construction to blunt impact harshness. They ride better than many unit-construction automobiles over moderate bumps. As the new kid on the block, GM has seized the opportunity to raise the ride-handling bar a major notch. Frames are stiffer by 23 percent and cabs are two-thirds stronger than previously, thanks to improved joints and a magnesium reinforcement beam beneath the instrument panel. While the F-150 and Ram jiggle momentarily after a major bump, the Silverado and Sierra react with a dull, highly damped thud.

Size also counts. GM stretched the extended-cab wheelbase and track widths each by approximately 2 inches in search of additional passenger space, creating the longest full-size trucks on the street. Spreading the wheels further apart yields a ride that nears limousine-like smoothness. The downside is a huge turn circle: All of these trucks require more than 45 feet between curbs to execute a U-turn. And they're a tight fit in standard garage bays.

In the past, there's been no way to reconcile a soft boulevard ride carrying no load with the stiffer suspension settings necessary when pickups buckle down to work. A novel feature on the Silverado is dual-mode, electrically controlled shock absorbers. Normal mode delivers just enough damping to quell porpoise motion after a long, deep pavement heave. When you need extra damping to snub body vibration with a weighty load in the bed, tapping a button on the dash switches all four shock absorbers into firm mode. A related feature exclusive to the GM trucks is an automatic trans-

mission tow/haul mode: Press a button on the gear lever to alter shift firmness and timing for heavy work.

GM has also upgraded braking, previously an area of glaring deficiency. While Chevy and GMC pickups have had four-wheel ABS as standard since '95 (it's still a \$500 option at Dodge and Ford), other brake problems have caused a mushy-feeling pedal and lengthy stopping distances. The new GM trucks have brakes with substantially greater capacity, along with two significant innovations for this segment: standard disc brakes in back and electronic front-to-rear proportioning to compensate for load changes typical with large pickups. The results, demonstrated by our stopping-distance tests, are tangible. Both the Silverado and Sierra stopped consistently from 60 mph in less than 160 feet with less fade than either the Ram (equipped with ABS on the rear wheels only) or the F-150. The 146 to 148 feet demonstrated by the Silverado with cold or warm brakes is comparable with the stopping distance of cars—the first time we've ever said that about a big pickup.

The Silverado and Sierra also break the mold in steering. Light-duty, 2WD versions are rack-and-pinion-equipped. The benefits are a more precise feel near the center position and a nicely linear response during turning. (Dodge, Ford, and all 4x4 or heavy-duty GM pickups use the more rustic recirculating-ball steering-gear approach.)

Consistency and predictability of response is especially helpful while wending these large conveyances through our tight handling courses. The Silverado and Sierra led the way through the cones, even though they ride on radial

tires two sizes smaller than those fitted to the Ram and one size below the F-150's rubber. The speed advantage in the slalom is slight. But the Silverado/Sierra lead in the double-lane change, which rewards a chassis calibrated with gentle and predictable understeer, is a significant 2 to 3 mph. The Silverado and Sierra would

behave even more like cars if they had a quicker steering ratio. The tall-riding F-150 was susceptible to greater roll angles and futile inside-rear-tire spin. The Ram felt clumsy, particularly when its power steering was nulli-



A wider stance increases passenger space in the Sierra, which also gets a stiffer frame.



GMC



The Ram's oversize cab design started the trend; the Quad Cab boosts four doors.



DODGE



CHEVROLET SILVERADO LT



GMC SIERRA SLT

ACCELERATION				
0-30 mph (sec.)	3.1	3.4	3.5	3.0
0-60 mph (sec.)	8.8	9.9	9.9	8.4
TOP GEAR PASSING				
30-50 mph (sec.)	3.9	4.2	4.3	3.8
50-70 mph (sec.)	5.3	6.1	6.2	5.5
HANDLING				
600-foot slalom (mph)	43.8	42.9	43.8	42.9
Double-lane change (mph)	54.3	51.7	54.1	53.2
60-0 MPH BRAKING				
Cold (ft.)	246	183	156	156
Warm (ft.)	248	168	156	173
Hot (ft.)	250	182	155	175
INTERIOR NOISE				
Idle (dBA)	42	51	42	47
60 mph (dBA)	85	67	86	85
0-60 mph (dBA)	80	73	80	77
EPA MILEAGE				
City/highway (mpg)	16/20	13/18	16/21	14/18
POWERTRAIN				
Engine	5.3-liter ohv V8	5.2-liter ohv V8	4.8-liter ohv V8	5.4-liter ohv V8
Valves/cylinder	2	2	2	2
Power (hp @ rpm)	270 @ 5,000	250 @ 4,400	255 @ 5,200	280 @ 4,500
Torque (ft.-lbs. @ rpm)	315 @ 4,000	300 @ 3,200	285 @ 4,000	345 @ 3,300
Transmission	4-speed automatic	4-speed automatic	4-speed automatic	4-speed automatic
CHASSIS				
Front suspension	Control arms, coil springs	Control arms, coil springs	Control arms, coil springs	Control arms, coil springs
Rear suspension	Rigid axle, semi-elliptic leaf springs	Rigid axle, semi-elliptic leaf springs	Rigid axle, semi-elliptic leaf springs	Rigid axle, semi-elliptic leaf springs
Brakes, f/r	Vented disc/vented disc	Vented disc/drum	Vented disc/vented disc	Vented disc/drum
ABS	3-channel	rear only	3-channel	3-channel
DIMENSIONS				
Wheelbase (in.)	143.5	138.7	143.5	138.5
Length (in.)	227.5	224.1	227.5	228.8
Width (in.)	74.0	70.3	78.5	78.4
Height (in.)	71.2	71.6	71.2	72.4
Curb weight (lbs.)	4,620	4,880	4,480	4,810
Distribution, f/r (%)	58/42	58/42	58/41	56/44
Headroom, f/r (in.)	41.0/38.4	40.2/39.4	41.0/38.4	40.8/37.8
Legroom, f/r (in.)	41.3/33.7	41.8/32.6	41.3/33.7	40.9/32.2
Shoulder room, f/r (in.)	65.2/66.3	66.0/67.7	65.2/66.3	63.8/64.7
Passenger volume (cu. ft.)	113.5	111.7	113.5	107.2
Payload (lbs.)	1,965	1,760	1,854	1,745
Fuel tank (gal.)	28.0	26.0	28.0	25.0
SAFETY FEATURES				
Airbags	Dual	Dual	Dual	Dual
Side-impact protection	Yes	Yes	Yes	Yes
PRICES				
Base price	\$19,500 (est.)	\$19,710 (1998)	\$19,500 (est.)	\$18,000 (est.)
Price as tested	\$28,000 (est.)	\$28,185 (1998)	\$27,500 (est.)	\$30,245 (est.)
Major options	5.3-liter V8, automatic transmission, LT trim	Equipment package, \$2,410; automatic transmission, \$950; Sport appearance, \$405; other options, \$2,710	SLT trim, 4.8-liter V8, automatic transmission, Sportside box	Lariat trim, automatic transmission, 5.4-liter V8



DODGE RAM SPORT



FORD F-150 LARIAT

fied by rapid turns of the wheel. Both the Ram and the F-150 demanded an occasional reverse-steering correction to restrain a wagging tail.

In addition to performance gains, GM has also fashioned a genuinely comfortable back seat. The cabin is 3.1 inches longer than last year's; the rear door opening is half a foot wider than the competition's; and front shoulder belts anchor directly to the adjoining backrest, clearing an entry path for rear passengers. (The Ram shares the belts-to-seat feature.) The extra space allows the backrest to be canted 18 degrees from vertical versus 10 degrees in the Ram and 12 in the F-150, so rear passengers don't have to assume the dreaded school bus posture. Cushions are longer and positioned higher off the floor. Except for their temporary lack of a driver's-side rear door, the Silverado and Sierra are best suited to perform like a four-door family sedan. That said, we'd suggest some additional attention to their front seats. They feel plush and inviting, but you'll start squirming a few miles down the road as you notice that the support necessary for long-distance comfort is missing. By comparison, the Ram's seats cradle your backside reassuringly.

Various other bugs are sprinkled throughout the new GM pickups. Because of inadequate clearance between the seat bolster and door panel, operating the power seat switches is frustrating. The power plug cover blocks any view of the accessory sockets contained within. The exteriors are marred by chintzy-looking rubber covers over the hood hinges. The top rear corners of the front fenders are so inadequately supported that they may be susceptible to vandalism.

These minor flaws and the tardy back door don't discredit the fact that GM has scored a major accomplishment, leaping over the competition's best efforts. Embodying major breakthroughs in chassis, powertrain, and interior design, the Silverado and Sierra are the best news in this field since pickups left the farm and moved into town. ♦

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EYQ

EDITED BY CECILIA WESSNER

Research by Jackie Couillard
and Becky Orfinger

ASK POPULAR SCIENCE

How much does Earth weigh?

Ryan Gajewski
Shawano, Wis.

STRICTLY SPEAKING, you are probably looking for Earth's mass, or density, not its weight.

What's the difference? Well, everything you see around you has mass—a measure of how many molecules, the building blocks of matter, comprise any object. Weight, as we commonly think of it, is a measure of how much Earth's gravity is pulling on our mass and on the masses of the things around us at any given place. But in outer space, where Earth resides, our common notion of weight does not apply. Just as astronauts are weightless in space, so is Earth.

But Earth still has mass, and lots of it—5.976 septillion kilograms of it, in fact. That means that Earth is heavier than more than a million billion 150-pound people and probably heavier than the combined mass of the entire world's population a million times over.

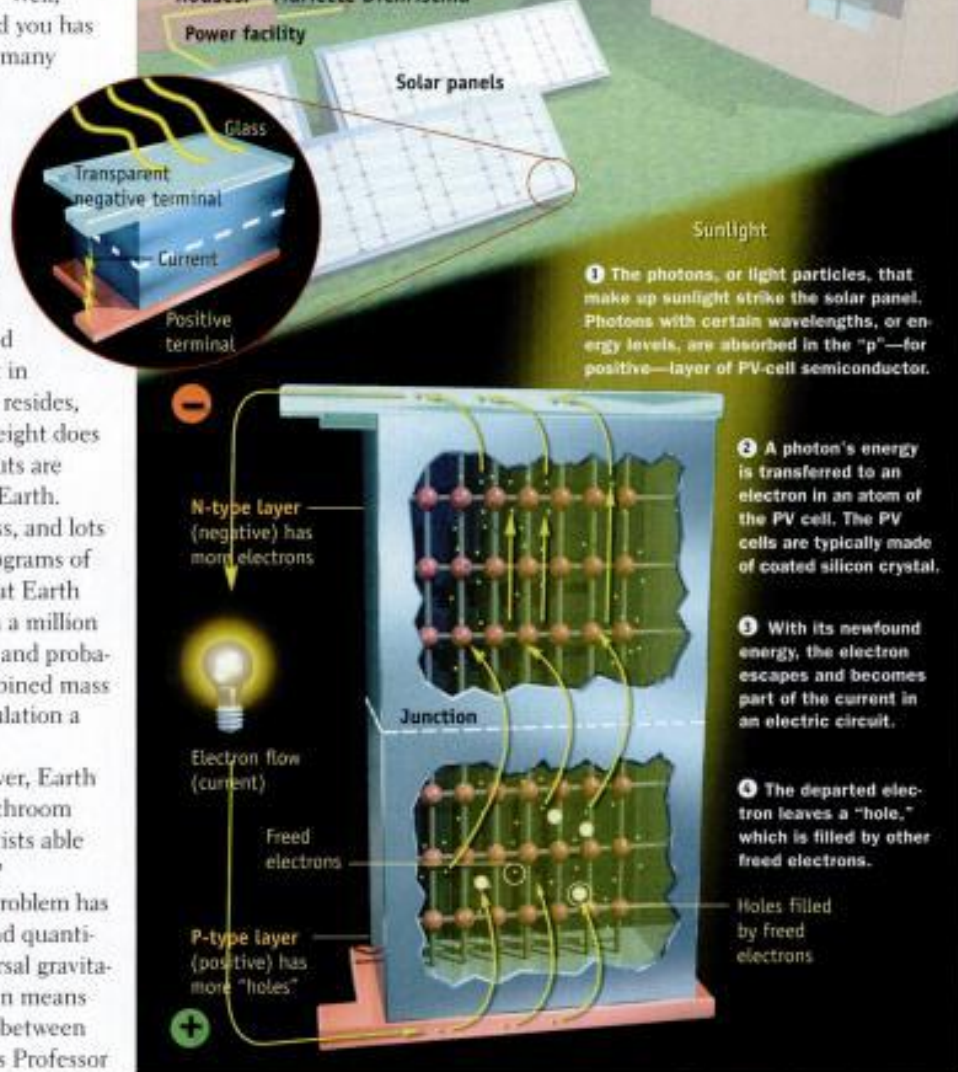
Unlike humans, however, Earth can't be weighed on a bathroom scale. So how were scientists able to compute Earth's mass?

The key to the whole problem has been in understanding and quantifying a force called universal gravitation. "Universal gravitation means that there's an attraction between every pair of objects," says Professor

HOW IT WORKS

Solar Power

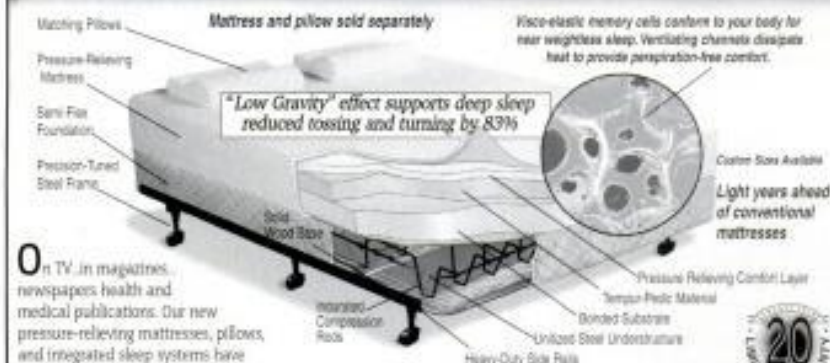
DISCOVERED IN FRANCE IN 1839, the photovoltaic (PV) effect—the process through which a solar-power cell converts sunlight to electricity—was first used to power orbiting satellites developed by the United States in the 1950s. Today, sunlight powers a plethora of products, from watches and calculators to lights and water pumps to electrical appliances and even entire houses.—*Mariette DiChristina*



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BOSE
Better sound through research®

Owen Gingerich at the Harvard-Smithsonian Center for Astrophysics in Cambridge, Massachusetts.

Since Earth could not be weighed conventionally, an equation—surprise, surprise!—was required. Sir Isaac Newton, the first scientist to attempt to determine Earth's mass, developed the necessary equation, which is called the law of universal gravitation, in his *Philosophiæ naturalis principia mathematica* in 1687. Newton was stymied, however, because he could not quantify an elusive element in his formula, a number that is known as the constant of universal gravitation.

It was not until 1774 that English astronomer Nevil Maskelyne was able to quantify the constant of universal gravitation as part of his notable experiments in finding the gravitational pull of Mount Schiehallion in Scotland. Once Maskelyne had uncovered the universal constant, he was finally able to calculate Earth's mass.

And now that scientists know Earth's mass, the sky's the limit—the same formula used to find Earth's mass also helps astronomers learn more about planets, stars, and other objects in the sky. "By knowing the constant of universal gravitation, you can know the mass of the Earth, of the moon, of the planets, of the sun, and even of our Milky Way galaxy," says Gingerich.

What is the difference between torque and horsepower?

Sahir Hoda
via e-mail

AN EASY WAY to understand the difference is to picture yourself leaning out a window on the tenth story of a high-rise building, pulling up a basket full of rocks. The most weight you can lift is torque; the speed with which you can pull it is horsepower.

Torque is a measure of static twisting force, normally measured as the force on a lever arm 1 foot from the

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OCTOBER 1998

Regular Service



"My TV reception is so clear, you'd think I had a 50-foot antenna on my roof!"

Emerson's ingenious new antennas are hard to spot, easy to install and provide clear, powerful reception of broadcast signals...without rabbit ears.



Replace your unsightly "rabbit ears" today!

I'm amazed at the way technology has improved television. Developments in electronic circuitry have resulted in TV sets that have sharper pictures, brilliant colors and clearer sound. From the smallest portables to wide-screen home theater systems, televisions continue to work better and better as optical innovations are introduced. Unfortunately, a television's picture is only as good as the broadcast it's receiving, and even the world's best televisions cannot make up for a weak or distorted signal. Antenna technology has not kept pace with television design, and the rabbit ears from the 1950's are not far removed from what's available today. Well, there's finally been a quantum leap in the design of antennas, and it's the result of two patented components developed by scientists. These improvements are the secret behind Emerson's revolutionary new antennas.

Picture imperfect. Cable subscription solves the problem of getting the signal to your television, but storms and other factors can result in cable outages. If you prefer not to pay the rising monthly fees for cable or live in an area where it's not available, your picture is likely to be weak, undefined and distorted.

One way to improve your reception would be to mount a large antenna on your roof. Unfortunately, most roof antennas are not particularly pleasing to the eye and may even be prohibited in the area where you live. Rabbit ear antennas don't improve your picture to any great degree and make your room look like something from an earlier decade. Most antennas need to be aimed at the source of the broadcast and require turning mechanisms to pick up the signal clearly.

Whether you live miles out in the country or in a concrete building next door to a broadcast tower, bad reception can rob you of the definition and color you were intended to see. The Optima antenna gives you the signal-grabbing

power of a large antenna in an inconspicuous, low-profile size.

Stealth antenna. In the past, creating an antenna with optimal reception meant making it big, with a large amount of surface area. This resulted in products that were large and unsightly or small and ineffective. Either way, the aesthetic look of your room or house suffered. Research and development tended to focus on the television, not on signal reception...until now.



Your neighbors won't know it's there unless you tell them.

Recently, a brilliant scientist in Colorado developed an antenna that would maximize reception without being overly conspicuous. Emerson, a leader in electronic technology, has now made this innovation available to the public.

At a lab in Colorado, they developed two patented design improvements that made the Optima antenna possible. First, they created a flexible circuit board with a serpentine antenna, resulting in a large surface area confined to a small space. Second, they developed a technique that converts the copper shielding on the attached cable to an additional signal receiver that results in an antenna almost 10 feet long. This greatly enhances the antenna's reception power and

Attention mini-dish owners.

If you own a mini-dish satellite system, you are aware of the off-air issue and are probably wondering how you can pick up local broadcasts. After all, what good are hundreds of channels if you can't find out who won the local city council race? The Dishmate™ harnesses the same technological innovations as the Optima TV antenna to give you a powerful omnidirectional antenna that is virtually invisible. It is compatible with a variety of systems and is easy to install.



allows you to tune the antenna by simply moving the cable! The antenna works best at a range of up to 30 miles from the signal source. We recommend an amplifier for reception up to 45 miles away. Ask your representative for details.

The handmade assembly is encased in aircraft-grade plastic and high-density foam. The weather-resistant cover is a neutral white and can be painted to match the color of the house or room. Plus, the omnidirectional design allows you to mount the unit anywhere you please. The Optima's universal design makes it adaptable to any component, and installation is a snap. So sit back, relax and enjoy the clearest picture you can get from your television.

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axis (hence, torque's measurement in foot-pounds). Maximum torque figures for cars are given with the engine speed at which they occur, such as 155 ft.-lbs. at 5,500 rpm. Horsepower is a function of torque multiplied by rpm, and maximum horsepower is usually at a higher speed than maximum torque. (Technically, a single unit of horsepower is the energy required to lift 550 pounds to a height of 1 foot within 1 second.)

An engine that develops low torque but revs at a high speed thus can be rated at the same horsepower as one with high torque but low rpm. Torque is felt by the driver as pulling power, important when hauling heavy loads. Theoretically, a transmission can make a high-speed engine feel like a low-speed, high-torque engine by multiplying torque by gearing, but friction losses prevent this from being truly efficient. ♦

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Virtual Realities

THE INTERNET WAS CREATED IN 1969, when the Advanced Research Projects Agency of the U.S. Department of Defense fired up an experimental network (ARPANET) that helped scientists with research grants share data more easily. In its infancy, ARPANET consisted of only four computers: three in California (Stanford, UCLA, U-C Santa Barbara) connected to one in Utah (University of Utah). Today the Internet is a network of networks made up of millions of computers and telecommunication systems around the world.—*compiled by Theresa Riley*

SITES LIKE YAHOO, NETSCAPE, AND EXCITE ARE CALLED "PORTALS"

and are a starting point for many Web surfers logging onto the Internet. They offer a variety of services, such as personalized news, stock research and quotes, weather, horoscopes, and sometimes free e-mail.

Nearly 77 percent of all Web users are between the ages of 18

and 49. Users between the ages of 18 and 34 make up 39 percent of the Web universe, the highest concentration of any demographic group. In contrast, only 30 percent of the U.S. population is between the ages of 18 and 34.

ONLY A QUARTER OF THE U.S.

population has earned a college degree, while 51 percent of all Web users have college degrees.

Net traffic doubles every

hundred days. More than 100 million people worldwide are now online.

ABOUT 57 MILLION PEOPLE IN

the U.S.—out of a population of 270 million—surf the Web. Radio took 30 years to reach an audience of 50 million, while TV needed 13 years. The Internet required only four years.

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Internet use is really about the growing popularity of one part of the Net—the World Wide Web. The Web was developed in 1989 by Tim Berners-Lee and researchers at CERN, the European Particle Physics Laboratory near Geneva, as a better way for physicists around the world to share data. The Web incorporates textual, visual, and audio files in individual documents that, via hypertext markup language (HTML), can be linked to other documents and accessed easily with the click of a mouse.

While 48 percent of the U.S.

population is male, men account for 56 percent of U.S. Web surfers.

MARRIED WEB USERS IN THE

United States outnumber singles; in Europe, it's just the opposite.

Estimates put the number of Web sites at about 2.6 million, and the number of Web pages somewhere between 300 million and half a billion. Because hundreds of pages are being added every day, determining the exact number of pages is difficult. Even the best search engines, like HotBot and AltaVista, index only about 40 percent of the total Web pages.

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computers than Europeans. Nearly 45 percent of all U.S. households have at least one personal computer.

According to a recent study of 50,000 American households, 10 million PC users shopped online during the first quarter of 1998, compared with 3.7 million a year ago. Among the '98 users, 5.7 million bought PC-related products, 3.9 million bought non-PC electronic products, and 7.7 million bought other consumer products or services online.

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