

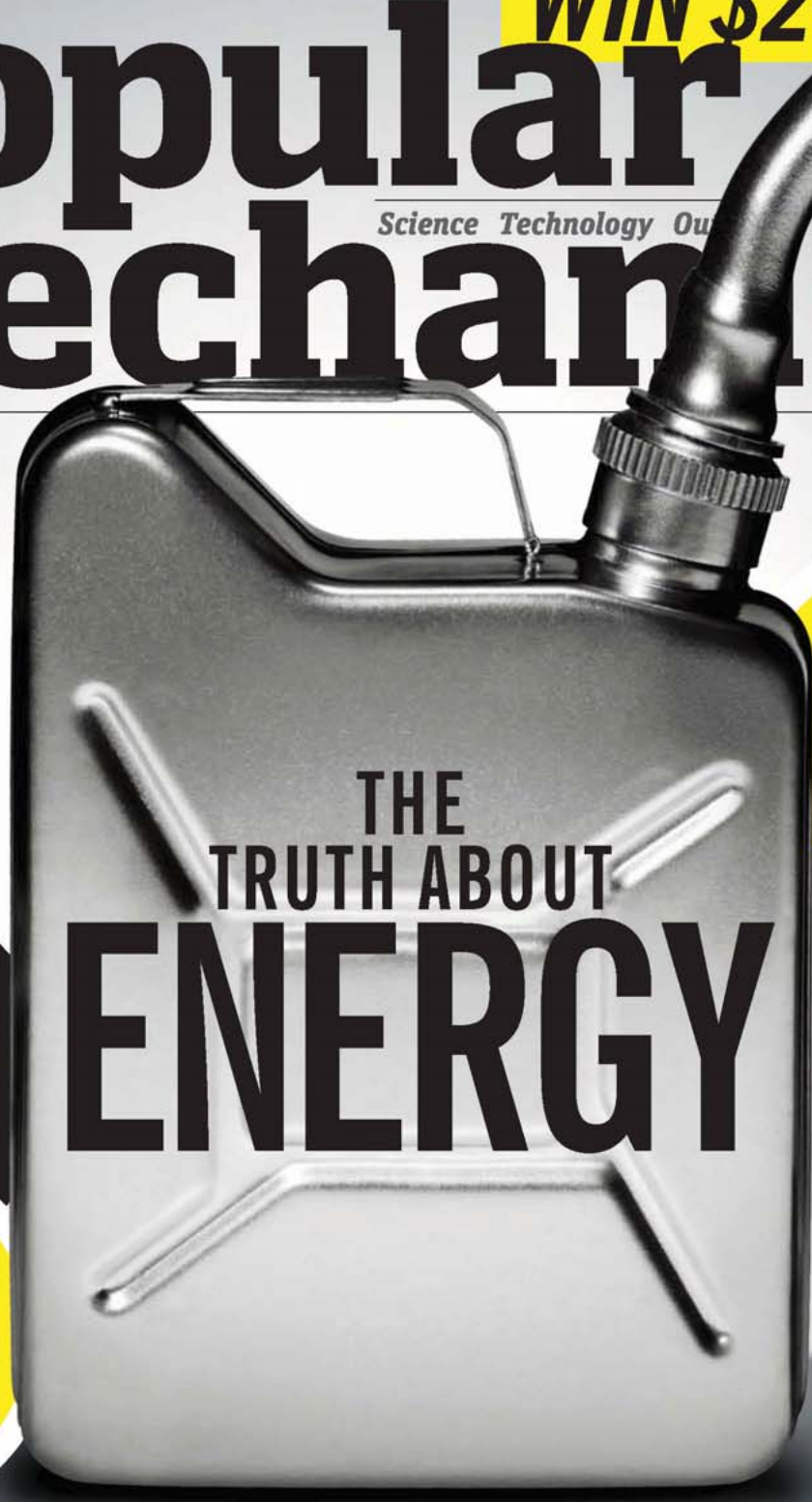
HOW TO BE AN INVENTOR

WIN \$250,000 CASH!

TO ENTER, SEE PAGE 37

# Popular Mechanics

Science Technology Out Automotive Home



PM ANALYSIS:

## NO MORE HYPE

REAL-WORLD IDEAS TO POWER OUR FUTURE

DEBUNKING MYTHS ABOUT:  
WIND POWER, SOLAR, SHALE OIL, BIOFUELS

### THE "CLEAN COAL" BOONDOGGLE

### WHY NUKE POWER IS SAFE (REALLY)

PLUS ENERGY TIPS YOU CAN USE NOW!



#### RESCUE RISKS

WHY MEDICAL HELICOPTERS KEEP CRASHING

#### HELIUM MAN

WE FLY A MODERN ZEPPELIN

#### DIY PROJECTS

3D CAMERA FRONT-YARD FLAGPOLE STARTER MOTOR FIX

**POWERFUL NEW DESIGN. 63.9 CU. FT.  
OF STORAGE.\* 32 HWY MPG RATED.  
DON'T TELL SMALL IT CAN'T DO BIG.**



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\*With second-row seat folded. Cargo and load capacity limited by weight and distribution. \*\*Excludes other GM vehicles. †Whichever comes first. See dealer for details. ††Based on EPA estimates. ©2010 General Motors. All rights reserved. GM® GMC® GMC logo® Terrain™ WE ARE PROFESSIONAL GRADE®



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TERRAIN



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**Nicorette®**  
Makes quitting suck less

\*Stop smoking lozenges. Speed of release does not infer speed of craving relief.



2010

July

PM FEATURES  
VOL. 187 NO. 7

56

**Inventor's Handbook**

Do you have a great idea, but no clue what to do with it? Follow this five-step guide—with advice from successful inventors—to get your eureka moment off the back of a napkin and onto the store shelf. **BY JIM GORMAN**

64 **Factory Chopped**

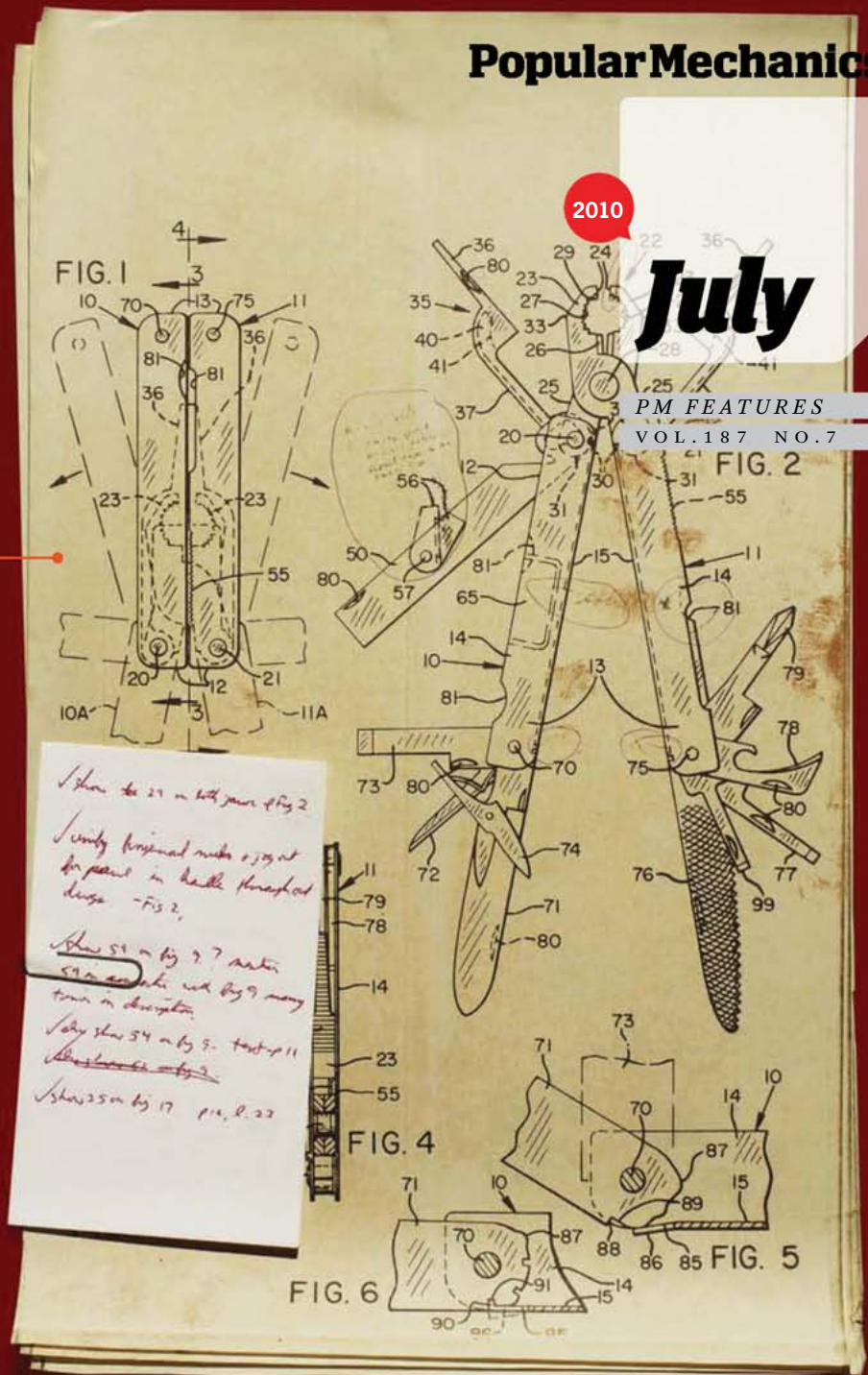
Customized bikes are great to look at, but riding them can be a pain—literally. Don't suffer. We test four factory-bred two-wheelers that provide riders with both style and maximum comfort. **BY BEN STEWART**

70 **Energyland**

True or false? Coal can be clean. Wind power is far too unreliable. Shale oil will end foreign dependency. PM drills deep to uncover the truth about 10 pervasive energy myths. **BY ELIZABETH SVOBODA**

80 **Critical Condition**

Medical helicopter pilots and paramedics are on call to save lives—but navigating dark and foggy skies with ill-equipped craft often puts both crew and patient in jeopardy. The technology to make these craft safer is available, so why isn't it mandatory? A PM special report. **BY CHRISTOPHER MAAG**



A blueprint from Tim Leatherman's archives shows an early version of the first Leatherman tool. Photographed for POPULAR MECHANICS by Dwight Eschliman.

ON THE COVER

For PM's cover story, photographer Mark Hooper and stylist Birte von Kampen modeled the board game Energyland to represent the United States' energy options and the misconceptions that surround them. The gas-can game piece is featured on the cover.



# Before you on a laptop, you might



## 1 IN 3 LAPTOPS FAIL WITHIN 3 YEARS<sup>1</sup>.

**YIKES!** Technically, it's only 31%. Lucky you. But as prices of laptops have fallen in recent years, does it seem like reliability has too? We don't think a laptop should be a "disposable purchase." Because the way we see it, all the speeds and feeds in the world don't do you much good if your laptop is DOA.

**LEADING RELIABILITY.** Recently, the people at SquareTrade Warranties wanted to know whose laptops were built to last. And guess what? They discovered what we already knew: Toshiba laptops have the highest reliability rate out of the top five leading laptop manufacturers<sup>2</sup>. And we're 23% more reliable than the industry average<sup>3</sup>.

## WHAT MAKES A LAPTOP LAST?



You can't just learn how to build a better laptop in a lab. You have to watch and learn how real people really use their technology—in the real world. If you don't, you end up stuffing cheap bells and whistles in where they don't belong. That's just technology for technology's sake. We believe in meaningful, cutting-edge innovations that have been researched, designed and tested to help you actually do more—and that last longer. It's how we've been building laptops since 1985, and it's what makes us different.

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<sup>1</sup> 2009 Laptop Report from SquareTrade, the leading Direct-to-Consumer Warranty Company. [www.squaretrade.com/html/pdf/SquareTrade\\_laptop\\_reliability\\_1109.pdf](http://www.squaretrade.com/html/pdf/SquareTrade_laptop_reliability_1109.pdf). Pg 3.

<sup>2</sup> Leading manufacturer is defined by most updated market share available from IDC WW Quarterly PC Tracker, Historical as of February 16, 2010.

<sup>3</sup> 2009 Laptop Report from SquareTrade. Pg 3, 6.



# spend \$700 want to consider these 2¢.

## 3-D PROTECTION FOR YOUR 3-D

**WORLD.** Most laptops

lock your hard

drive when

you drop

them, right?

Well...sort of. Some

laptops only detect

when they're falling

straight down. But is

that how things fall in your

world? That's why we developed

a line of laptops that lock your

hard drive no matter what direction

they fall.



## MORE THAN A LAPTOP. A LAPTOP

**EXPERT.** We believe laptops should be

intuitive, easy to use and powerful. But

it won't matter unless your laptop is also

reliable. So look for innovation that makes

your laptop—and your wallet—work

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NEW TOOLS  
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diy

pm do-it-yourself



✦ HOME

**87 Cookout à la Cart**  
Use our plans to build a rolling cedar prep station and take the mess out of summer cookouts.

**90 Homeowners Clinic**  
Whip a weathered metal door into shape. **Plus:** Installing perfect lighting for any room.

**92 How Your House Works**  
Tankless water-heating systems are energy- and cost-effective. Should you make the switch?

**98 PM Saturday**  
Raise a salute-worthy flagpole in six easy steps.

✦ AUTO

**101 Saturday Mechanic**  
Tips and tricks you can use to diagnose—and replace—a busted starter motor.

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Sony's PlayStation Move controller creates more accurate motion-sensing gaming. **Plus:** We shoot, smash and snip padlocks in our Abusive Lab Test; a campsite-ready iPod dock.

✦ NEW CARS

**35 Pint-Size Goodness**  
The compact Ford Fiesta gives downsizing a good name. **Plus:** Lamborghini's Gallardo Superleggera sheds pounds to boost speed.



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✦ COLUMNS

**46 Jay Leno's Garage**  
Designed with input from flight pioneer Orville Wright, Chrysler's 1934 Airflow was decades ahead of its time. Jay pays tribute to the innovations that helped transform the industry.

**52 Zeppelin 101**  
PM takes control of America's only Zeppelin airship for an outing over Silicon Valley. Flying the 246-foot machine isn't as easy as it looks.

IN EVERY ISSUE

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**\$233**



## Other vacuums keep costing

Other machines are still designed to need replacement bags, belts and filters – which can be tricky to find, let alone replace. Over five years the average maintenance cost could be \$233.\*

## Dyson vacuums keep working

With Dyson vacuums there are no bags, filters or belts to buy. Dyson uprights and canisters are also guaranteed for five years so they don't cost a dime to maintain.

\*Average five year maintenance cost of top eight selling upright vacuum cleaners by dollar sales (excluding Dyson vacuums) according to NPD data for 12 months ending October, 2009. Total maintenance cost over a five year period is based on recommended filter and belt replacement information provided by each manufacturer.

Dyson proves no loss of suction using the IEC 60312 Cl 2.9 test standard.

**dyson**

The vacuum that doesn't lose suction.



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## WHAT THEY'RE DOING



### × BUZZ ALDRIN

Buzz Aldrin hopes his plan to have humans on Mars in 25 years will guide experts and government leaders as they continue to discuss NASA's budget and the future of space exploration. Gunning for better science education for children and adults, the former astronaut has created the Buzz Aldrin Portal to Science and Space Exploration iPhone app, bringing historical and current information about space within arm's reach.





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recent story on Toyota, the statement about "the ghost in the machine" is too simplistic and ignores the fact that bugs can exist in embedded software (firmware) in all systems—no matter how completely the quality control has been executed.

During more than 25 years of developing firmware, I've learned that there is [always] one last bug still waiting to be discovered. Redundant voltage paths don't mean much if they are sensed and acted upon by the same firmware module. Systems need independent, redundant software modules developed by independent teams. Then redundancy may actually mean something.

**FRANK MCGIRT**  
ALBUQUERQUE, NM

### Treehouse Connection

I'm currently serving in Iraq with the U.S. Army, and today I picked up a copy of your magazine. As I leafed through it, a picture of a cardboard treehouse ("Family Tree," April '10) caught my attention. In 2003, I built a treehouse for my nieces

and nephews utilizing a similar pattern. Fascinated, I began to read the story. Imagine my surprise when author Logan Ward mentioned Dayton, Va., where I grew up, and Martin's Native Lumber, where I bought lumber for the treehouse.

Stunned by the coincidence, I felt compelled to write. Having suffered through the same bumps, scratches and pitfalls, I can truly appreciate the level of quality and hard work put into the project. Watching my nieces pull items up into the house with a rope and bucket for their "night in the treehouse" makes it all worthwhile. Thank you for the excellent article.

**STEVE**  
(LAST NAME WITHHELD)

### Orbiting Space Planes

I greatly enjoyed your story on the X-37B space plane but must point out that, in November 1988, the unmanned Soviet Buran orbited and executed an automated landing, making it (not the X-37B) the first unmanned space plane to complete an orbital mission.

**MIKE JENNE**  
TRUSSVILLE, AL

**EDITOR'S NOTE:** *The reader is correct—the Buran orbited Earth twice during its only flight and landed using autopilot. The craft was designed to carry people, but the Soviets didn't install a life-support system for the flight.*

### Acceleration Frustration

I read your Car Clinic, "Toyota's Woes," on sudden unintended acceleration [SUA] with great interest. I am an ASE Certified Master Technician and have served as an expert witness for a number of acceleration cases. Not once, in any of the cases I've been involved with, have I found that the engine-management control unit could have caused a case of SUA. It is most often driver error or a mechanical issue (lack of maintenance, floor mats, etc.). I do not know who Toyota made angry, but the company has been tried and convicted out of ignorance and malice. The "ghost in the machine" does not exist.

**ANGELO D. ROBERSON**  
REMLAP, AL

While I appreciated the technical discussion of engine management systems in your



ISSUE

05/10

**x**  
Readers responded to an analysis of braking systems, our report on the X-37B space plane and an April story about building a treehouse.

**what do you think?**



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\* Comparison based on ISO 4548-12 testing against a leading economy filter.





× JULY

## Fun & Games



**DIY BACKYARD GAMES** From horseshoes and bocce to croquet and volleyball, PM has detailed plans to help turn your lawn into the perfect court for midsummer barbecue entertainment. [popularmechanics.com/home/how-to-plans/](http://popularmechanics.com/home/how-to-plans/)

**MUST-SEE MOVIES** PM's Digital Hollywood reports on the latest visual effects, stunts and CGI that make the action sequences rumble in summer's most explosive blockbusters. [popularmechanics.com/technology/digital/](http://popularmechanics.com/technology/digital/)

**VIDEO GAMES** Will Microsoft's Project Natal and other motion-capture systems make handheld controllers obsolete? We try our hand at them all to find out. Plus, sign up for myMod, our online modder community, for advice on the best parts for gaming computers and for step-by-step instructions on console hacks and upgrades.

*For extra photos and video from our editors, follow Popular Mechanics on Twitter at @PopMech and on Facebook at facebook.com/popularmechanics.*

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Songs

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# Tech Watch

**STEP 1**

The proposed Reusable Booster System separates from the second stage and payload.

**STEP 2**

The system uses its main engine to flip over in a "rocket back" maneuver to reorient the booster toward Earth.

**STEP 3**

Flight control surfaces on the booster's wings enable an autopilot to steer during the empty tank's unpowered glide to a runway.

## Rocket, Return Home

The Air Force is designing a rocket stage that can land on a runway instead of falling back to Earth with a parachute, saving the cost and time of ocean retrieval. A prototype could fly by 2013.

**AMERICA'S NEW NUKES**

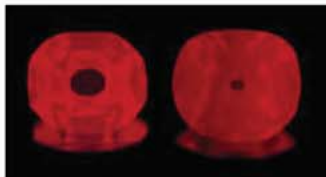
+ The Obama administration's 2011 budget request contains a program that might surprise the Norwegian Nobel Committee: a new nuclear-capable missile. Launched from long-range bombers, the missile would carry existing nuclear warheads. The development plan allots \$800 million through 2015, starting with \$3.63 million in technical studies in 2011. The administration also intends to upgrade submarine-launched nuclear missiles and increase funding to facilities that make nuclear weapons material. Some in the arms-control community say these steps violate President Barack Obama's public push toward global nuclear disarmament. The administration and many in Congress say modernization is necessary to maintain the quality of nuclear weapons while reducing the overall number in the stockpile. Congress will vote on the defense authorization bill this fall. — JOE PAPPALARDO

**CHILI GRENADE**

+ The Indian military has weaponized the world's hottest chili pepper, the bhut jolokia, or "ghost chili." The infamous pepper



rated at more than a million Scoville units, the scientific measurement of a chili's heat. In comparison, jalapeño peppers max out at 8000



## Priceless Paternity Test

+ Scientists disproved claims that two famous blue diamonds, both found in the same region of India in the 17th century, were cut from the same stone. The Hope Diamond, a 45.52-carat diamond at the Smithsonian's National Museum of Natural History in Washington, D.C., and the 31.06-carat Wittelsbach-Graff Diamond, also on display at the museum until August, have strikingly similar blue color caused by traces of boron and emit nearly identical red-orange phosphorescence under ultraviolet light (shown above). But chemists at the Naval Research Laboratory, working with the Smithsonian, found differences in the atomic structures that prove they aren't related, ending decades of speculation. — ALEX HUTCHINSON

units. Compounds from the chili will be used in a hand grenade that, like tear gas, can overwhelm an aggressor.

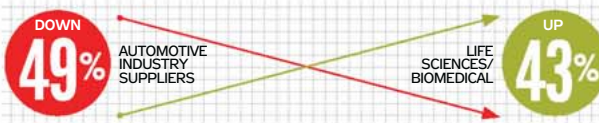
**ROBOT RECESSION**

+ Overall sales of robots in North

America declined by 25 percent from 2008, according to the Robotics Industries

Association. While suppliers to the automotive industry cut orders, lab and

hospital use is on the rise, a sign of growing interest in commercial robotics.



# Battle of the Heavyweights

→ The talk of the commercial aviation world has been dominated for years by the sales conflict between Boeing's 787 Dreamliner and Airbus's A380. Now both planes are finally airborne—the A380 flying for airlines, the 787 in test flights. Here's how the airplanes match up in the global marketplace. —DAVIN COBURN

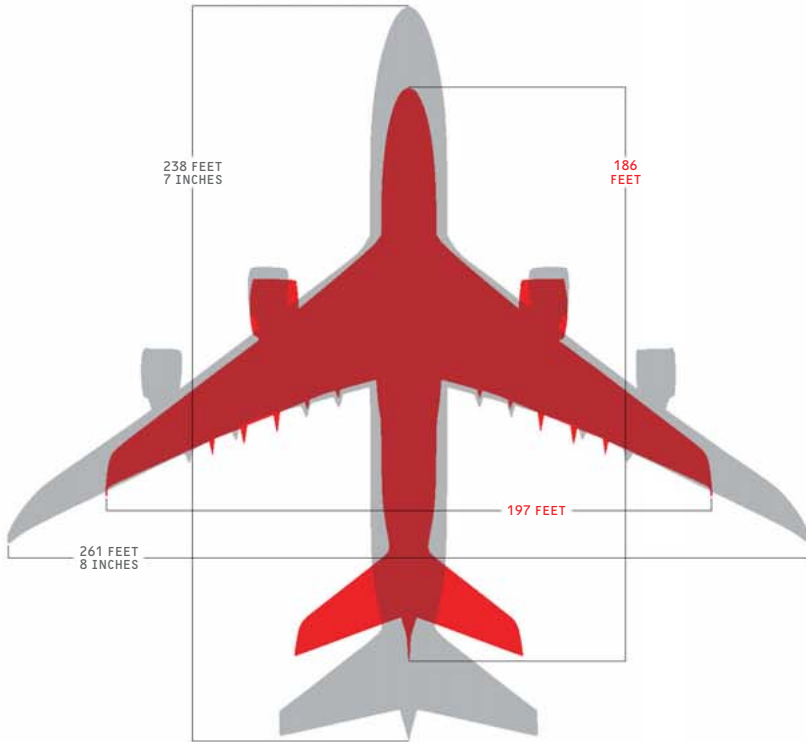


**AIRBUS A380**

**BOEING 787 DREAMLINER**

The world's largest passenger plane has proven to be the most expensive civilian airplane ever developed. Airbus claims its fuel efficiency, control system and sound-reduction technology also make it the most advanced airliner ever built. The first-class section sets standards in luxury, but the A380 began service during a global recession. "They're going to see years of losses before that [luxury] market fully materializes," says investment consultant Paul Nisbet, president of JSA Research. Some carriers deferred airplane deliveries, while Qantas ripped out its first-class A380 cabins for ones with cheaper seats.

The Dreamliner travels the same distance as the A380 at the same speed but carries half the passengers. The airliner's \$10 billion development suffered from more than two years of delays, costing the company orders and credibility. Regardless, the versatility of Boeing's airplane has interested a steady stream of buyers. The Dreamliner's small size, quick flight-turnaround times and fuel economy account for its sales advantage over the A380. With a maiden flight under its belt in December 2009 and a crucial wing test passed in March, Boeing could deliver its first 787 by the end of this year.



AIRBUS A380	<>	BOEING 787
525	PASSENGERS	250
\$13 billion	DEVELOPMENT COST	\$10 billion
27	PLANES IN SERVICE	0
202	ORDERS (THROUGH APRIL)	963



Scientists long believed that places without oxygen could not permanently host life more complicated than viruses or bacteria. But a team of European researchers taking core samples from the 11,000-foot-deep L'Atalante basin in the Mediterranean Sea discovered three new species of *Loricifera* that proved otherwise. Instead of mitochondria—the power plants of most cells, which use oxygen to transfer cellular energy—the newly found creature has organelles that use hydrogen. They are the first multicellular organisms ever found that don't need oxygen to thrive. —J.P.



A new species of *Loricifera*.



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# The Practical World of Plasma

SCIENTISTS FIND NEW WAYS TO CONTROL THE FOURTH STATE OF MATTER. BY DAVID HAMBLING

## → When English physicist

William Crookes first discovered plasma in 1879, he did not propose any use for the stuff.

Crookes found that he could make gas behave differently than other forms of matter by stripping electrons from it with electrodes. What we now call plasma is used in arc-welding torches, neon signs and high-end television screens.

Scientists are still finding novel ways to manipulate plasma. For example, Jamey Jacob, an aerospace engineer from Oklahoma State University, has replaced mechanical parts on the wings of aircraft with arrays of tiny actuators. The actuators form **jets of plasma (right) that can speed up airflow across the surface to increase lift or, if the plumes are pointed into the airflow, increase drag.** Jacob is testing the system on small unmanned aerial vehicles.

## IN DEVELOPMENT

● **WHAT** Communications Antenna

**WHO** Haleakala Research & Development

### HOW IT WORKS

A high-bandwidth plasma antenna, resembling a cluster of neon tubes, is smaller and more sensitive than metal antennas and can be instantly reconfigured by altering an electric field or voltage.

**NEXT STEP** Smart digital TV antennas for rural areas may be the company's first product, with plasma WiMax antennas providing wide-area Internet coverage soon after.

● **WHAT** Heat Shield

**WHO** EADS Astrium

### HOW IT WORKS

A magnetic field can influence the hot, ionized gas that envelops a spacecraft during atmospheric re-entry. Superconducting coils generate a field that forces hot plasma away from the aeroshell.

**NEXT STEP** EADS engineers are designing a system for a Russian Volna rocket that could fly within three years.



● **WHAT** Emergency Fire Extinguisher

**WHO** DARPA

**HOW IT WORKS** Flames are a form of partially ionized plasma and can be manipulated with electric fields. Devices based on this principle may be able to **bend flames to create escape corridors;** researchers have already shown that electric fields can put out methane fires.

**NEXT STEP** DARPA hopes to build a prototype electric fire-suppression system for the compartment of a Humvee-size vehicle.



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# Unprepared for the Worst

THE NATION'S LEVEL OF EARTHQUAKE READINESS DOES NOT ALWAYS MATCH THE RISKS.  
BY LOGAN WARD

→ **A worldwide spate of earthquakes** this year demonstrated that preparedness makes the difference between a disaster and a catastrophe. So how would U.S. buildings fare in the next big quake? The answer begins with the U.S. Geological Survey's hazard maps, which gauge the probability and intensity of future earthquakes. Statisticians combine global seismic readings of faults with historic records and soil conditions, then plot the data to a probability curve. "This allows them to forecast future ground motions," USGS seismic hazard mapping chief Mark Petersen says. To meet the International Building Code, a structure must be able to withstand two-thirds of the force of an earthquake with a 2 percent chance of occurring in 50 years (see map, below). It's up to local officials to adopt these provisions and ensure that builders follow them.

**PEAK GROUND ACCELERATION (PGA) MEASURES HOW HARD THE GROUND SHAKES DURING A TREMOR**



**G-FORCES**

### WEST COAST

As in Chile, California's experience with past earthquakes has left it better prepared. Because they are caused by strike-slip faults, Southern California quakes typically top out around magnitude 7.0 on the Richter scale. But a different kind of tectonic plate boundary, the Cascadia Subduction Zone, undercuts the U.S. coast of Washington,

Oregon and Northern California. These earthquakes are expected only every 600 years, but they have a much greater capacity for destruction—the last major one, in 1700, would have registered 9.0. The most vulnerable structures along the West Coast are unreinforced masonry or concrete buildings constructed before the mid-1970s, when updated building codes went into effect.

### MIDWEST

Most places in the United States east of the Rocky Mountains ignored seismic codes until about 1989, when scientists from local universities convinced St. Louis officials of the threat posed by the New Madrid Seismic Zone. The 150-mile-long fault, which runs south from Missouri into Arkansas, unleashed some of the strongest quakes in U.S. history in the early 1800s. Earthquakes here can top magnitude 8.0, but the fault

does not produce regular tremors. That lack of shaking has led to apathy, common in many low-probability, high-consequence seismic areas. For example, developers in Memphis have opposed adopting seismic engineering because of the added cost.

### SOUTHEAST

Seismologist Steven Jaume of the College of Charleston in South Carolina says the ground acceleration map shows "two bull's-eyes" in the East. One is the New Madrid fault, and the other is the Middleton Place/Summerville Seismic Zone, centered 22 miles northwest of Charleston, S.C.—100 miles from Burke County, Ga., where \$8.3 billion in federal loans were just approved for two new nuclear reactors. On average, this fault

produces a large earthquake every 500 years. The last one, in 1886, is estimated to have been magnitude 7.3; it killed more than 100 people. A recent engineering analysis found five Charleston schools vulnerable to collapse in a relatively mild, 5.0-magnitude quake, prompting officials to reinforce the buildings.

### BEHIND THE NUMBERS

Richter scale	2.0–2.9	3.0–3.9	4.0–5.9	6.0–6.9	7.0 and higher
PGA (g's)	0.17–0.27	0.27–0.35	0.35–0.59	0.59–0.65	0.65–1.0
Ground effects	Hardly felt, but detectable by seismometer.	Vibrations akin to the passing of a big truck.	Slight damage; windows and chimneys break.	Major damage in old or substandard buildings.	Many buildings shift off their foundations.



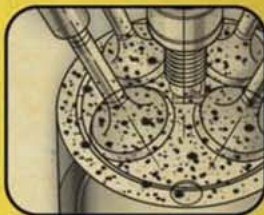
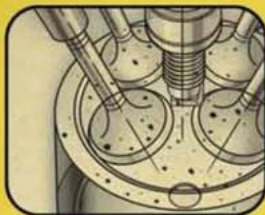


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# Air Race at the Edge

Every Red Bull Air Race is a struggle—not just among competitors, but between pilots and the course. For June's championship, the first to be

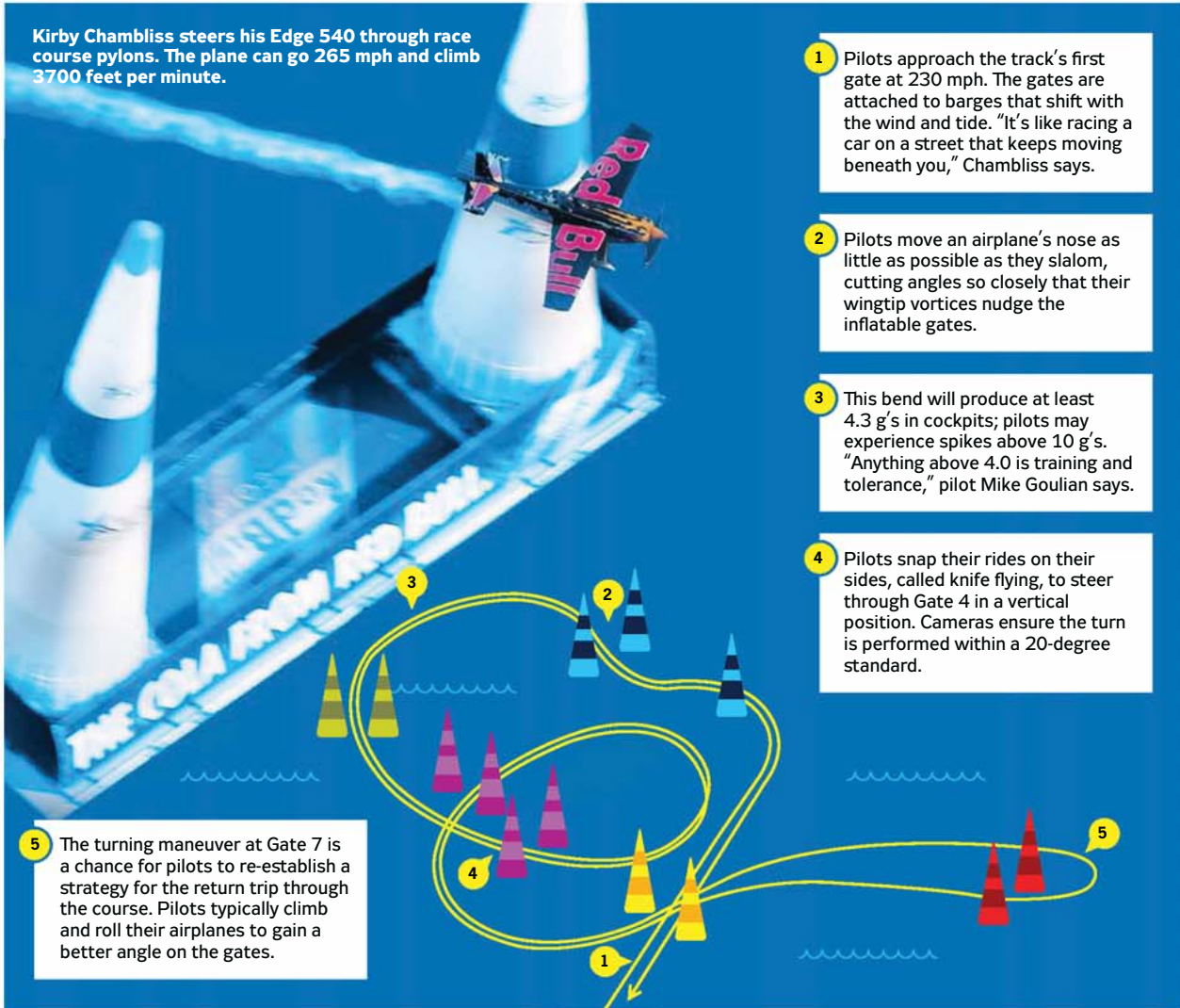
flown in New York City, race director Jim DiMatteo crafted a high-g's course along the Hudson River near the Statue of Liberty. DiMatteo's team calculates the planes' speeds, turn rates and turn radii to ensure the pilots are not exposed to g-force spikes greater than 12. They also use simulations to ensure spectators won't be hurt by debris in the

event of a crash. As in downhill skiing, the act of turning slows the racers. "We never pull the throttle back," pilot Kirby Chambliss says. Racers push the track's limits by taking smart, risky turns.

"Pilots who win don't go through the gates straight," Chambliss says. "I'm going through them at a crazy angle."

— JOE PAPPALARDO

Kirby Chambliss steers his Edge 540 through race course pylons. The plane can go 265 mph and climb 3700 feet per minute.



**1** Pilots approach the track's first gate at 230 mph. The gates are attached to barges that shift with the wind and tide. "It's like racing a car on a street that keeps moving beneath you," Chambliss says.

**2** Pilots move an airplane's nose as little as possible as they slalom, cutting angles so closely that their wingtip vortices nudge the inflatable gates.

**3** This bend will produce at least 4.3 g's in cockpits; pilots may experience spikes above 10 g's. "Anything above 4.0 is training and tolerance," pilot Mike Goulian says.

**4** Pilots snap their rides on their sides, called knife flying, to steer through Gate 4 in a vertical position. Cameras ensure the turn is performed within a 20-degree standard.

**5** The turning maneuver at Gate 7 is a chance for pilots to re-establish a strategy for the return trip through the course. Pilots typically climb and roll their airplanes to gain a better angle on the gates.

**q+a**

Can wine be carbon dated?

→ Yes, but only courtesy of atomic bomb testing. **Aboveground nuclear bomb blasts from 1945 to 1963 boosted the amount of C-14 in the atmosphere.** Since 1963, the year the tests halted, the ratio of carbon-14 to the more common carbon-12 isotope has been slowly declining, allowing researchers to determine the date of wines to within a year, according to a new study from the University of Adelaide in Australia. The telltale carbon atoms in the soil are incorporated into the grape plants and, eventually, into the wine. The technique is aimed at detecting wine sold under faked vintage years—a problem some experts estimate affects up to 5 percent of fine wine sales. — ALEX HUTCHINSON





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**BEATS**  
**“ I WILL ”**  
**ANY DAY**

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safe alternative to cigarettes.**



Because the M8's transport craft exploded, animators added charring to its exterior.

Computer-modeled parachutes reacted accurately to bullet fire.

To create the illusion of speed, artists simulated clouds the tank could fall by and through.

## Drop Zone

IN *THE A-TEAM*, ARTISTS CREATE A DIGITAL VERSION OF A MILITARY OPERATION. BY ERIN MCCARTHY

→ **It's called a heavy drop:** The military parachutes heavy equipment out of an airplane and into a war zone. For the filmmakers behind *The A-Team*, released June 11, it was the perfect way to end the prison break of four ex-Special Forces operatives wrongly accused of a crime. The complicated sequence called for a C-130J military transport aircraft holding a tank-like Armored Gun System (AGS) to explode, ejecting the machine at an altitude of 20,000 feet. The AGS then deploys three parachutes, but two are shredded by bullet fire from MQ-9 Reaper UAVs, leaving the vehicle in near free-fall.

The art department began by pulling together the visual elements for its AGS, the never-deployed M8. "Director Joe Carnahan chose it because it was designed to be an air-droppable vehicle," visual-effects supervisor James Price says. Next, designers built a full-scale exterior replica—complete with working

machine gun—that actor Bradley Cooper could act against on-set. Animators at Los Angeles-based VFX house Rhythm & Hues built the digital M8 using the art department's reference and photos of the replica. The digital vehicle had multiple moving parts, including a rotating turret and a hatch that opened and closed. In some cases, filmmakers left the on-set replica in the shots, but usually they replaced it with the computer model. "All that's real in most shots is Bradley and the gun he's firing," Price says. Animators also watched a video of dragsters to determine how the parachutes would behave under extreme forces.

Though visual-effects artists studied footage of actual drops, this isn't an authentic scenario. "When the military does a real drop, they don't do it from a high altitude," Price says. "And they have an extraction chute that inflates and pulls the object out of the plane. That wasn't appropriate for us because our plane was blowing up, so we took some liberties to tell our story." Animators even altered the altitude and velocity at which the M8 fell from shot to shot. "If it looked good falling at terminal velocity, we did that," Price says. "But if it looked better falling at 200 mph, then we did that too. As long as the audience believes it's all one thing, we can cheat a lot to make it more dramatic."

IF WE KNEW ANY MORE ABOUT FISHING, WE'D HAVE GILLS.

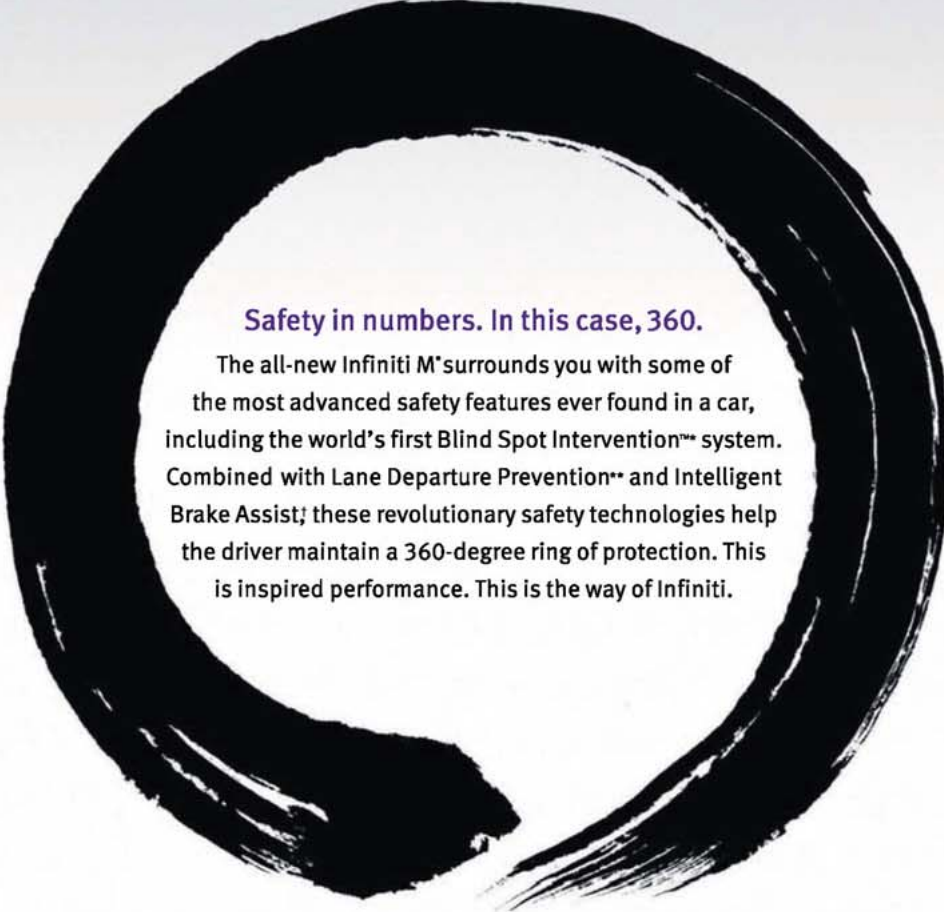
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 Shodo art by Masako Inkyo



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# Upgrade

## Smooth Move

→ When it came out four years ago, the Nintendo Wii's motion-sensing controller seemed revolutionary. Today, it just seems dated. The **Sony PlayStation Move Controller (price not set)**, which arrives this fall, picks up where the Wii left off. Like the Wii, the PS3-specific controller detects movement and relative position. Where it trumps the older tech: It can also pinpoint the precise location of the controller in relation to the TV. The secret is a TV-mounted camera that tracks a glowing orb jutting from the tip of the controller. In tests, onscreen motion mimicry was instant and accurate. And while there will surely be plenty of Move-specific games, the key to the controller catching on could be Sony's willingness to integrate optional Move compatibility with big-budget blockbusters. While the controller will have the ability to enhance these games, owning it will not be a prerequisite for playing them.

— SETH PORGES



### Save It for Later

→ TiVo may have mainstreamed the DVR, but the venerable brand has struggled in an age of ubiquitous on-demand content and cheap cable-company-supplied DVR boxes. Its latest effort is **TiVo Premiere (\$300 and up)**, which can be seen more as a fully featured Web-connected set-top box (flush with the usual video-streaming suspects, such as Netflix and YouTube) than as a straightforward DVR. The best part: a search function that seamlessly prowls both TV and Internet listings as it seeks out shows and movies.

### WiMax Power

→ On paper, the **HTC Evo 4G Phone (price not set)** is a doozy: 4.3-inch multitouch display, 8-megapixel camera (which can also shoot 720p HD video), blazing 1-GHz processor. The Evo is also the first phone capable of tapping into Sprint's WiMax network (which offers data speeds many times faster than 3G). This is especially useful given the phone's ability to serve as a mobile hotspot, transforming the WiMax network into a signal that any Wi-Fi device—from laptops to iPads—can use to get online, anywhere there's a cell signal. And while the WiMax network doesn't quite cover the whole country yet, it is expanding rapidly.



### Middleweight Mauler

→ Milwaukee's biggest Sawzall dominated a recent reciprocating saw test, in which PM pitted seven tools against a brutal test rig of copper wiring nested inside armored cable, steel pipe, PVC, ABS and AstroTurf. That was the 15-amp. It remains to be seen whether the new **Milwaukee 12A Corded Sawzall (\$120)** can keep up with its big brother, but the compact version has advantages: a short  $\frac{3}{4}$ -inch stroke for tight areas, roughly 25 percent less weight and about \$40 off the sticker price.





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## PADLOCKS

► A padlock can be all that stands between a burglar and a shed or lockbox full of property. But how well can it really handle the tools of a determined thief (or years of bad weather, for that matter)? To find out, we enlisted the expertise of our friends at Minnesota's Environ Labs testing facility, where we put four models—from cheap hardware-store finds to a \$115 "all-weather" model—through an unforgiving battery of tests. *BY SETH PORGES*



Franklin Laminated Steel Padlock (\$11)



Medeco All-Weather Shackle Guard (\$115)



Master Lock Magnum M930XKADLH (\$24)



OnGuard 5101 Beast Padlock (\$34)

the locks

the tests

## SHOCK TEST

To measure the locks' resilience against brute force—the kind they'd feel from a sledgehammer—we used an MTS Systems shock test machine to drop a 32-pound weight on them.

**FRANKLIN:** One drop from 55 inches (the machine's max height) popped the lock.

**MEDECO:** Three drops and the lock was reduced to a cloud of plastic and steel shrapnel.

**MASTER:** The toughest lock slowly pulled apart over the course of four drops from max height.

**ONGUARD:** Just one drop smashed the lock's plastic shell and unlatched the shackle.

**WINNER:** Master

## BOLT-CUTTER TEST

Bolt cutters can be a burglar's best friend. We used a platform scale to measure how much force bolt-cutter handles needed to snap the shackles.

**FRANKLIN:** Applying just 95 pounds of pressure to the bolt cutter's handles snapped the weakest shackle.

**MEDECO:** It took 110 pounds of force to snip the shackle.

**MASTER:** The second-toughest shackle broke after 200 pounds of squeeze.

**ONGUARD:** The toughest lock was the only one to survive this test—after 270 pounds of pressure, the bolt-cutter teeth began to bend, but the shackle was left with just a small groove.

**WINNER:** OnGuard

## TENSILE TEST

How much force does it take to pull the shackle out of the cylinder? We used an Instron tensile testing machine to find out.

**FRANKLIN:** The shackle on the weakest lock was pulled free with just 1024 pounds.

**MEDECO:** The runner-up met its end with 6436 pounds of force.

**MASTER:** It took a whopping 7745 pounds of force to pull the winner loose.

**ONGUARD:** 3072 pounds of pull and the lock was sprung.

**WINNER:** Master

## SALT-FOG TEST

To simulate sitting outside a shed through years of acid rain and environmental exposure, we left the locks in a chamber for an intense weeklong onslaught of sulfur-dioxide salt fog.

**FRANKLIN:** A week of sulfur dioxide left the Franklin permanently stuck shut.

**MEDECO:** We had high hopes for Medeco's "All-Weather" lock. And although it survived the sulfur dioxide, curiously, it wouldn't open after seven days with a weaker, nonsulfuric salt fog.

**MASTER:** The Master left the test looking like it had been submerged on the *Titanic* for a century, but it still opened.

**ONGUARD:** This lock finished looking like we'd plucked it from a swamp but still working.

**WINNER:** Tie between Master and OnGuard





All tests were conducted by the professional staff and equipment of Minnesota's Environ Laboratories environmental testing facility.



#### GUNSHOT TEST

*In Hollywood heists, burglars frequently shoot open locks. To see how these padlocks handle bullets, we shot the cylinders with a rifle from 80 feet away.*

**FRANKLIN:** Although centered shots passed right through the lock, it took an off-center bullet from a .243 Winchester to actually spring it.

**MEDECO:** A single centered shot from a .25-06 Remington left this lock unlatched—and with a large exit hole.

**MASTER:** Behold, the bulletproof lock—the Master stopped .243 Winchester and Remington .25-06 shots in their tracks. Not even a pair of bullets from a .300 Winchester Magnum could pass through or open this lock.

**ONGUARD:** After one off-center shot from the .25-06 Remington, we were able to pull the lock open by hand. As with the Franklin, centered shots passed through the cylinder but failed to actually open it.

**WINNER:** Master, by a mile

#### BOTTOM LINE

The smash-proof, weatherproof, bulletproof Master lock dominated most of our tests. Still, if bolt-cutter-armed thieves are your primary concern, the OnGuard can't be beat.





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**Canon**  
*image*ANYWARE





## Rugged Dock

→ iPod docks are typically ill-suited to wilderness excursions. The **Etón Soula iPhone/iPod dock (\$200)** could be a camper's best friend. Its built-in solar panels ensure an endless stream of songs (or at least 3 hours of music from 10 hours of sun), and the rubberized, splash-proof exterior is designed to handle a downpour or drop.

P  
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## Ramped-Up Router

→ Wireless routers are typically background players, content to do the dirty work of dispersing a Wi-Fi signal while flashier gadgets get all the glory. Not the dual-band **Belkin Play Max Wireless Router (\$130)**, which features built-in apps that make it smarter (and more useful) than the average router. To back up data, jack in any external hard drive—no need for a specialized network-attached storage device. To print wirelessly, plug it into any printer—no need for an expensive Wi-Fi model. Here's our favorite feature: If you shut down your computer overnight, this router can continue making downloads directly to an external hard drive.



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# New Cars

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INSIDE

## Pint-Size Goodness

Ford's 2011 Fiesta has joined the fight for hearts and minds in what is becoming a hotly contested small-car arena. Already selling well in Europe, the Fiesta crosses the pond with more refined features and 40 mpg highway. A comprehensive package of sound deadening and an acoustically insulated windshield do a fantastic job of minimizing road noise. The standard 1.6-liter four-

cylinder produces 120 hp and 112 lb-ft—plenty to motivate the Fiesta's 2600-pound mass. Complementing the five-speed manual is an optional dual-clutch six-speed automated gearbox. Its shifts are graceful, but it sadly lacks paddles for manual operation. The electrically assisted

steering provides almost psychic interpretation of driver intent, and the overall feel of this car walks a sporty but not-too-firm line. Interior room is generous and offers leather seats and Sync. Downsizing has never been so appealing.  
—BARRY WINFIELD

2011  
**FORD  
FIESTA**

BASE  
PRICE:  
\$13,995



++ PM TEST DRIVEN



## Not Quite a CRX

The model name of the 2011 Honda CR-Z could double as a psychological diagnosis. Is it a sport coupe? Is it a fuel-efficient hybrid? Americans will find out firsthand when the car goes on sale in the U.S. late this summer. After our first drive, we can say for sure that while the two-passenger CR-Z looks like a reincarnated CRX coupe, it doesn't quite match that car's frisky behavior. Residing between the 1.5-liter gas engine and the six-speed manual or CVT, an electric motor seamlessly assists acceleration, regenerates power while braking and smoothly restarts the engine at traffic lights. Altogether, the powertrain delivers 122 hp and 128 lb-ft of torque (123 lb-ft with the optional CVT) to the front wheels, moving the 2700-pound car to 60 mph in under 10 seconds and to a top speed of 124 mph. That's not exactly sporty. Even more disappointing is that it's not especially fuel-frugal either. Honda estimates mpg in the mid-30s, which is less than the far more practical Civic hybrid. Plus, it'll cost slightly more than the \$20,510 Insight. Honda's done a terrific job integrating the hybrid system—the brakes lack the typical hybrid's numbness—but after our quick spin we were left wondering if Honda's as confused about this car's mission as we are. —ANDREW ENGLISH



## CRUZZING ALONG

The Cruze is proof that Chevy has finally gotten serious about small cars. On a recent drive at GM's Milford Proving Ground, the Cruze's overall refinement was simply astonishing, besting its main competitors, the Honda Civic and Toyota Corolla. The Cruze is built on GM's new Delta architecture, which also

underpins the upcoming Volt. It boasts generous interior dimensions, 10 standard airbags, and available goodies such as a navigation system and heated seats. Underhood, there are two available engines, a base 138-hp 1.8-liter and a turbo 1.4-liter with the same power but more torque. Auto and manual transmissions

sport six ratios. A fuel-economy special—dubbed Eco—uses lightweight Volt hardware, shutters that block the grille and decrease drag, and a gearbox with tall ratios to achieve 40 mpg. All models feel solid, and the turbo motor offers satisfyingly prompt throttle response. It should start at around 15 grand.

—LARRY WEBSTER




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 NEWS  
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**THE LIGHTEST LAMBO**

As Lamborghini's latest track-oriented trash-talker, the Gallardo LP 570-4 Superleggera says a mouthful. Aside from extracting 10 extra hp over the base LP 560-4—the V10 now makes 562 ponies—the weight-loss regimen includes carbon-fiber replacement parts, a lightened interior, polycarbonate windows and forged-aluminum wheels attached with titanium bolts. Carbon-ceramic brakes are optional. All told, the Superleggera weighs 3241 pounds, 154 less than the base car.

And does it ever move. Stiffer shocks, stouter antiroll bars and 90 percent harder bushings make the Superleggera corner like a slot car. It'll hit 62 mph in 3.4 seconds, with a deeply satisfying wailing engine note. Lamborghini's e-gear automated gearbox is standard, but a gated six-speed manual can be substituted for free. We doubt, however, that buyers of this \$237,600 exotic will fully appreciate a no-cost option. —BASEM WASEF



2011  
Lamborghini  
Gallardo LP 570-4

**Teutonic Titan**

When it arrives in showrooms later this year, buyers in the luxury SUV market will find the 2011 BMW X5 worth more than a passing glance, and not just because of its restyled front fascia. Visual cues are subtle, but prospective customers who test-drive the new X5 will easily differentiate it from the 2010 model. Active steering and damping systems still impart stability and surprising agility to this big Bimmer. But the news is that the base X5 xDrive35i (\$46,675) now uses a 3.0-liter inline Six with a quick-spooling single turbocharger to deliver 300 hp and 300 lb-ft of torque to all four wheels. Upgrade to the X5 xDrive50i (\$59,275) and a twin-turbo, 4.4-liter direct-inject V8 adds 100 hp and 150 lb-ft of torque. The excellent 3.0-liter twin-turbo diesel with 425 lb-ft of torque remains an option. Thanks in large part to a more elastic eight-speed automatic transmission, BMW claims the 2011 X5 gets 10 percent better fuel economy than last year's model. The result is a fast, confidence-inspiring SUV that goes easier on the gas yet retains driving dynamics that belie its seven-seat practicality. —JAMES TATE



2011  
BMW X5

- ++ PM TEST DRIVEN
- ++ COP CARS
- ELECTRIC MOTORCYCLES
- NEWS
- FORD FIESTA + HONDA CR-Z + CHEVROLET CRUZE + LAMBORGHINI GALLARDO LP 570-4 + BMW X5 +
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# Soon to Be in Your Rearview Mirror

The Canadian factory that builds the Ford Crown Victoria will soon close, spelling the end of production for America's most ubiquitous police car (Crown Vics currently account for approximately three-quarters of all law enforcement fleets). So what will replace it? Several companies are poised to take a bite out of crime, as well as an annual sales market of as many as 75,000 vehicles. The following presents a handful of arresting options. — G.E. ANDERSON



1. 2010  
DODGE CHARGER

**Already available**, the rear-wheel-drive Dodge Charger is currently the Crown Vic's main competitor. Equipped much like an R/T consumer version, a police Charger comes with either a 3.5-liter 250-hp V6 or a 5.7-liter Hemi V8 that develops 368 hp and gives the Charger nameplate a certain truth in advertising. With the Hemi, it'll scoot to 60 mph in about 6 seconds and hang with perps all the way to 149 mph. Black wheels wrapped with wide, meaty tires and standard stability control mean the Dodge can also hang in the curves. Thanks to cylinder deactivation, the Hemi Charger returns 16/25 mpg.

2. 2012  
CARBON MOTORS E7

**The E7** cop car from newcomer Carbon Motors features rear-hinged doors that make it easy to get uncooperative passengers in and out. Scheduled for assembly in 2012 in Connersville, Ind., the E7's aluminum frame is draped with composite panels to minimize weight. This purpose-built patroller uses an efficient 3.0-liter inline six-cylinder BMW diesel engine to generate over 400 lb-ft of torque and maximize mileage (estimated at 30 mpg highway). The company believes it can dramatically decrease fuel bills, a goal it must achieve—carbon-fiber bodies and aluminum frames don't come cheap.

3. 2011  
CHEVROLET CAPRICE

**The front-wheel-drive** Impala will soon be phased out of police fleets to make way for a new rear-wheel-drive Chevrolet Caprice, a model that once filled police fleets. Built on GM's Zeta sedan platform by Australian subsidiary Holden, the Caprice will initially feature a 355-hp 6.0-liter V8 with 384 lb-ft of torque. It should catapult the car to 60 mph in less than 6 seconds. A less brawny 256-hp 3.6-liter V6—from the Cadillac CTS—will become available in 2012. Chevy plans to offer an undressed undercover version, but since the Caprice will not be available to the general public, it will only be incognito to non-car aficionados.

4. 2012  
FORD POLICE INTERCEPTOR

**Scheduled for production** in Chicago in late 2011, the Ford Police Interceptor is based on the new Ford Taurus and will be available with front- or all-wheel drive. No longer available with a V8, it will instead use Ford's twin-turbocharged EcoBoost V6, which delivers 365 hp and 350 lb-ft while achieving a respectable 25 mpg on the highway (a 3.5-liter 263-hp V6 will also be available for meter maids). The shortcomings are literally that: The 112.9-inch wheelbase is shorter than competitors', which translates to relatively tight quarters inside. For extra utility, however, Ford will introduce a police-ready SUV later this year.

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# Electric Avenue

When it comes to EVs, motorcycle companies are way ahead of carmakers. There are around a dozen credible e-bikes on sale today that offer near-silent operation, cheap running costs and little maintenance. Of course, this makes sense: Motorcycles are far lighter than cars and don't require expensive and heavy batteries. Plus, to many riders, a 50-mile range isn't a deal breaker. For more EV bikes, check out **popularmechanics.com**.

— WES SILER

## **Brammo Enertia**

**GOOD** Great price, slick packaging and sold through West Coast Best Buy stores. Feels well-made, with solid craftsmanship that's a step above the competition.

**BAD** It's not quite as entertaining as the Zero, nor is it for sale nationwide. But that will change soon.

**BASE PRICE** \$7995

**STREET LEGAL** Yes

**POWER** 18 hp

**BATTERY** 3.1-kwh li-ion

**BOTTOM LINE** A comfortable and agile bike that's well-engineered.



## **Quantya Track**

**GOOD** Well-suited to motocross riding with a sturdy, well-suspended frame. Tops out at 55 mph, weighs under 200 pounds and runs for about 2 hours.

**BAD** Long run time comes at the expense of acceleration—the Quantya could use more thrust.

**BASE PRICE** \$9975

**STREET LEGAL** No

**POWER** 16 hp

**BATTERY** 1.9-kwh li-ion

**BOTTOM LINE** As off-road riding areas close because of noise restrictions, the Quantya is a pain-free alternative.

## **Vectrix VX-1**

**GOOD** Friendly and practical, the Vectrix boasts range-extending regenerative braking. Quicker than most gas scooters. Still has storage space for a meal's worth of groceries despite the large battery.

**BAD** If you drop it, there's 515 pounds to lift back up. The company's ownership has been in flux, so buyer beware.

**BASE PRICE** \$9495

**STREET LEGAL** Yes

**POWER** 27 hp

**BATTERY** 3.7-kwh NiMH

**BOTTOM LINE** A perfect electric urban runabout.

## **Zero DS**

**GOOD** Suitable for both on- and off-road, the DS weighs less than many scooters and boasts superbike-taunting torque.

Between 10 and 50 mph, it can beat most street bikes.

**BAD** The throttle tuning is slow, which leads to sluggish takeoff. The range is only about 50 miles, and it's not yet ready for long highway runs.

**BASE PRICE** \$9995

**STREET LEGAL** Yes

**POWER** 26 hp

**BATTERY** 4-kwh li-ion

**BOTTOM LINE** An able handler in all terrain.



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↑  
**Mazda Diesel**

At the New York Auto Show, Mazda announced that it will sell a new diesel engine in the U.S. in two years. While we wait, we took a spin in a CX-7 diesel that's already available in Europe. The current 2.2-liter turbodiesel is different from the upcoming version, but we still learned a few things. For one, torque is your friend. With 295 lb-ft available at just 2000 rpm, the CX-7 diesel pulls effortlessly in any gear. As with other modern diesels, there's no exhaust smoke or smell, and the grumbling engine note is hardly intrusive. The U.S. version should only improve these traits and will not require a urea-injection system to reduce oxides of nitrogen, thanks to a new catalyst. Mazda has only hinted that the U.S. diesel will be a midsize car—probably the Mazda6 sedan—but did claim that it will achieve about 43 mpg. —KEN GROSS

↓  
**APTERA UPDATE**

The slick two-seater is still alive and kicking, but delays have pushed back its release. Aptera now says the electric 2e is about a year away, but guarantees at least a 100-mile range and a mid-20s price.



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## Five Ways New CAFE Rules Will Change What We Drive

++ The Corporate Average Fuel Economy (CAFE) regulations (CAFE) were recently stiffened by the largest degree in over two decades. Also, fuel-economy

targets will be based on the car's footprint—the area defined by multiplying the vehicle's wheelbase by the track width—and every model must

improve. It's estimated that these changes will increase new-car fuel economy by about 24 percent by 2016. Here's what automakers will do to get there.

→ **More Tech**  
Expect wider use of variable valve timing, smaller

turbocharged engines, hybrids and maybe even exotic combustion cycles.

→ **More Gears**  
Six gears will be the norm, but CVTs and eight-speed gearboxes will also proliferate.

→ **Less Weight**  
Expanded use of

high-strength steel, aluminum and composites will cut hundreds of pounds.

→ **Less Drag**  
Slippery bodies decrease air resistance.

→ **More \$\$** Expect these changes to add about \$1000 to the sticker price.





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## AHEAD OF ITS TIME

> BY JAY LENO  
> PHOTOGRAPHS BY JOHN LAMM

# B

**ack in its day**, my 1934 Chrysler Imperial CX Airflow was considered unattractive, which was a painful surprise to the Chrysler engineers and designers. This styling and engineering masterpiece represented Chrysler's moonshot at greatness. The company broke from that era's traditional design—flat-front radiators, big fenders, separated headlights and imposing, squared-off bodies—in favor of a more rounded shape combined with several engineering innovations.

Yet it was a sales disaster.

It's hard to sell something before its time, and car buyers simply weren't ready for the Airflow's slick shape.

The Airflow owes its existence to Carl Breer, one of Chrysler's most celebrated engineers (the others were Fred Zeder and Owen Skelton). Breer spent six years researching and developing the revolutionary car. In consultation with aviation pioneer Orville Wright, he conducted wind-tunnel

tests that showed the average car in the 1930s was 30 percent more aerodynamic going *backward*.

Besides its streamlined shape, the new Airflow tried to sell safety, but auto safety just didn't sell cars back then. Most auto ads in that era were not instructional. They were poetic, like the 1923 ad for the Jordan Playboy that appeared in *The Saturday Evening Post*. The illustrated ad, titled "Somewhere West of Laramie," mentions little about the Jordan's mechanical attributes, but describes how a stylish cowgirl—who's taming a bucking horse—would find kinship with the Playboy. Or the famous "He Drives a Duesenberg" ad, where they never even showed the car and instead featured an obviously wealthy man seated in a private library.





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## JAY LENO'S GARAGE/// AMERICAN CARS

It was all about lifestyle.

In contrast, Chrysler produced a widely viewed promotional film that showed an Airflow being pushed over the side of a cliff. When it landed, the reinforced roof hadn't collapsed, all the doors still opened, and a guy got in it and drove it away. It had survived a crash that would probably have demolished other cars of the era, which still used wood in their bodies. The Airflow had many other safety features. Its steering column goes right into the dashboard—not between the clutch and brake pedals—so the shaft doesn't interfere with the driver's feet. The body had 40 times the rigidity of previous Chryslers; a strong tubular frame meant you were essentially driving in a steel cage.

Other innovations included wraparound windshields on the top-line CWs, but they were hard to install and many broke on the assembly line. Before air conditioning, carmakers tried to get lots of air circulating through the cabin. The vent and side windows open, and at the flip of a switch the entire frame goes down. Even the windshield cranks open. You can get a lot of air flowing through this car and stay quite cool.

The passenger compartment has so many art deco touches, it looks like you're sitting in the Chrysler Building in New York. It had such wide, upright seats that Chrysler had to produce them on a special assembly line. The front-engine layout locates all occupants optimally between the front and



The Airflow's rounded waterfall grille resembled a streamlined locomotive. Top: Jay's CX sedan has an extra-long front door from the Airflow coupe.

rear axles. The chassis was designed with long, soft leaf springs that provide an incredibly comfortable ride. Chrysler, which did anything it could to get prospective buyers to go for a convincing test drive, called it the Floating Ride.

My Imperial Airflow is wonderful to drive—more like a car from the 1940s or early 1950s than the '30s, due to its smooth ride. It came with a 323.5-cid, 130-bhp straight Eight and automatic overdrive. You lift off the gas at 38 mph

and step on the clutch, and fourth gear automatically engages. Like the Duesenberg, it's one of the few cars from the '30s that you can drive 70 mph on the freeway and not feel rushed or pushed. And you know it's aerodynamic, because there's virtually no wind noise.

For years, nobody wanted Airflows. Prices were quite reasonable, and still are to this day. There's an Airflow club that's very active. But not many cars survive. Chrysler sold only 11,292 Airflows in 1934, and just 67 were CX Custom Imperial eight-passenger limos like mine. They designed a new hood and a conventional grille for the 1935 models to make them look more like the other cars on the road, but it was all for naught, and production ended in 1937 after only four years.

Which just goes to show that it's hard to sell something before its time. The Airflow was a complete change from its predecessor, and the styling was so extreme that people were really shocked. To them this round thing looked like something from another planet. It still does. The 1933 Chrysler Imperial resembled a Duesenberg or a Packard. In 1934, the new Airflow looked like a giant jellybean.

And that's why I like it.

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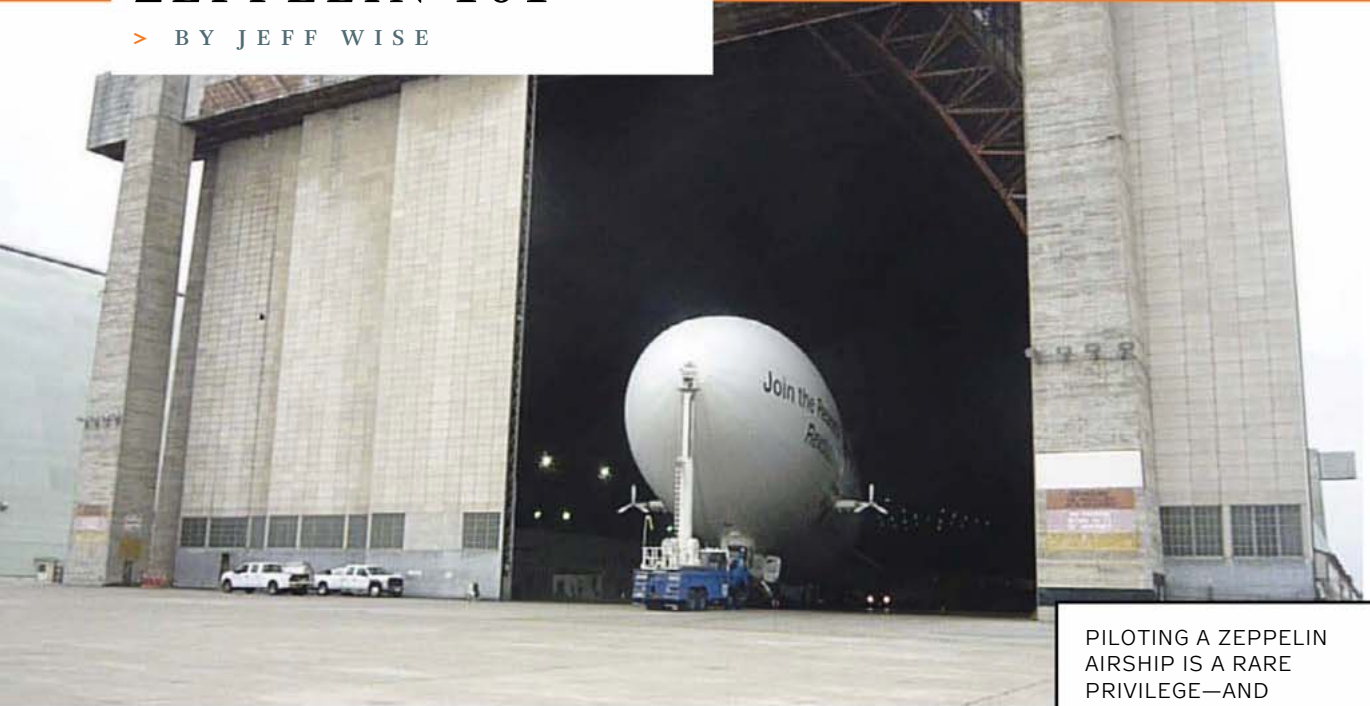
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# ZEPPELIN 101

> BY JEFF WISE



PILOTING A ZEPPELIN AIRSHIP IS A RARE PRIVILEGE—AND HARDER THAN IT LOOKS.

*Eureka* zeppelin exits its San Francisco hangar.

**F**loating through the air 200 feet above the ground, I glide past a cluster of buildings, a stand of trees, the shoreline of a shimmering bay. A golf driving range drifts into view. Four men stop swinging their clubs and stare up, open-mouthed. In an age that's jaded by wall-to-wall entertainment, they're experiencing an all-too-rare sensation: pure awe. A giant oval shadow moves over them, and I'm gone.

If the guys at the golf club think a low pass by a 246-foot airship is impressive, they should check out the view from the pilot's seat. That's where I am, getting flight training in a zeppelin. It's an incredibly rare privilege. There are fewer licensed zeppelin pilots in the United States than there are Supreme Court justices. And there is only one zeppelin airship in the country.

For most people, the word *zeppelin* evokes one indelible image: the *Hindenburg's* flaming crash in 1937. That catastrophe struck the death knell for commercial airship travel, but the Luftschiffbau Zeppelin company, which owned the doomed airship, hung in there. Out of the wreckage of postwar Germany, it prospered in a variety of ventures, among them selling and servicing Caterpillar construction equipment. Then

it got back in the airship business, launching a helium-filled model called the Zeppelin NT (for "new technology") in 1997. Since then, the company has built three more airships, now flying in Japan and Europe.

To see the American zeppelin up close, I travel to San Francisco, where a company called Airship Ventures operates the Zeppelin NT *Eureka*. Mostly, *Eureka* earns its keep by carrying passengers on short sightseeing jaunts. A year ago, however, the company also began offering zeppelin-piloting classes. Customers who have a private pilot's license can spend two days learning about the zeppelin, including 3 hours riding as a passenger and a half-hour as the pilot.

At noon on a sunny Monday, I arrive at the front gate of Moffett Field, a former Navy base. I go to a classroom





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ZEPPELIN SCHOOL

with five other students and chief pilot Fritz Günther, a severe-looking former flight instructor in the East German air force who introduces us to *Eureka's* basic principles. He explains that a Zeppelin NT is designed to fly a bit heavier than air, which makes it easier to handle on the ground (airships of the *Hindenburg* era required hundreds of men to hold them down). To get off the ground, the zeppelin is equipped

Günther in the co-pilot's chair to his right. The engines increase in pitch. Smoothly, we begin to rise vertically into the air. We start to move forward as well, as though ascending a giant escalator. The expanse of the airfield falls away, and soon we are coasting along at 1000 feet over Silicon Valley.

Those of us who aren't at the controls roam around the gondola, admiring the view. The windows slope outward, so we can look straight down and watch the scenery scroll beneath our feet. I open a window and stick my head out into the 40-mph slipstream

pitch the nose up and down or to yaw side-to-side. On top of that, there are numerous switches and levers and toggles to control the pressure of the helium and the distribution of ballast. Helpfully, Günther tells me what to do; if I'm too slow, he reaches over and moves the control himself.

Up we go, climbing and gaining forward speed. I focus on the stick as I try to keep the enormous lumbering craft under control. With three engines, four propellers and a bag of helium gas whose buoyancy constantly changes depending on the temperature and pressure, piloting the zeppelin is like flying an airplane and making a scuba dive at the same time. As I try to figure it all out, *Eureka* bucks and weaves through the California sky like a spastic humpback whale.

As we reach 25 mph, Günther switches the ship to flight configuration. Now we're using the fins, not the engines, to control the ship's motion. I'm starting to get the hang of it. Part of the trick is to fly the zeppelin like you'd steer a sailboat, anticipating corrections by a few seconds. But I still can't seem to stop the ship from unexpectedly rearing up or shifting to one side. "Remember, it's not just you moving the ship," Günther says. "You've got air currents and lift from thermals."

I keep trying. Precision flying, this is not. But I've reached my moment of Zen: No matter how badly I fly this thing, it's still going to keep bobbing along. You can't flip a zeppelin upside down; you can't dive-bomb it into the earth. The ship is inherently stable. That's comforting to know. And the golfers below certainly seem more than impressed.

My time is almost up. I head back toward the airfield and start coaxing *Eureka* down, angling the thrusters forward and back, toggling the throttle, easing us slowly toward the tarmac and the waiting ground crew. A few yards off the ground, the ship hangs, hesitant, then a nudge of thrust brings the front wheel down. The crew grabs a line hanging from the nose, and we're back on the ground. I unstrap and climb out of the pilot's seat, still feeling lighter than air. **PM**



← The author at the controls of the zeppelin *Eureka*.  
↓ *Eureka* on the ground, just before takeoff. Unlike its predecessors—which were filled with lighter-than-air hydrogen—the ship is slightly heavier than air.

PILOTING A ZEPPELIN  
IS LIKE FLYING AN  
AIRPLANE AND MAKING  
A SCUBA DIVE AT THE  
SAME TIME.



with propellers that can swivel up and down to provide vertical thrust. Then, when the ship is in the air and moving at speed, it shifts into "flight configuration," in which the engines swivel to horizontal. In effect, the highly maneuverable Zeppelin NT is a cross between a dirigible and a tilt-rotor aircraft like the V-22 Osprey.

The next morning we finally get to climb aboard. Inside, the gondola is spacious, more like the interior of a yacht than an aircraft. It feels like a yacht too—even on the ground, the gondola's slow rolling motion reminds me of an ocean swell. The first student straps into the pilot's seat, with

like a dog on a road trip. Mountains lie to the west, the bay to the east, all of it soft and gauzy in the morning's lingering haze. As an Airship Ventures staffer hands out snacks and drinks, I feel like I'm at a party that happens to be dangling a quarter-mile up.

*Eureka* returns to the airfield and touches down; now it's my turn. I strap in and put on a headset. Almost immediately I'm struggling to keep up as Günther talks me through the controls. There are so many of them. One lever controls the angle of the two forward propellers; a nearby pair changes their thrust. A joystick on my left-hand side commands the rear propellers to



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### Evolution of an Invention: the Leatherman

The now-iconic multifunction tool first found physical form as a series of cardboard cutouts (A) that inventor Tim Leatherman

fashioned in the mid-1970s. He then migrated to wood carvings with integrated metal parts. Leatherman began to refine his idea with a metal milling machine. He experimented

with several versions of dual-function plier jaws (B). "I was trying to make needle jaws pivot out of regular pliers," he says. "It was painstaking, because I have to make

things to figure out how they should work." The prototype that Leatherman patented (C) combined his dual-action pliers with an integrated locking-clamp feature. Every

knife- and toolmaker he approached rejected it. He continued to add to the design, working in scissors and refining the jaw mechanism (D). But it was

feedback from a mail-order catalog company that convinced him to streamline the tool—simplifying the pliers and ditching the scissors and clamp to reduce cost.





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**BY JIM GORMAN**  
PHOTOGRAPH BY DWIGHT ESCHLIMAN  
POPULARMECHANICS.COM JULY 2010

# THE METAPHORICAL LIGHT BULB

above Tim Leatherman's head clicked on while he was touring Eastern Europe on the cheap in 1975. Desperate for a way to turn a stripped radiator handle in his freezing hotel room, the 27-year-old, unemployed, newly married mechanical engineer looked long and hard at the overmatched Boy Scout-issue knife in his hand.

"Wouldn't it be something if I could add a pair of pliers to a pocketknife?" he asked himself. Fast-forward 35 years and 40 million multitools sold, and today Tim Leatherman embodies the dream of financial and creative freedom that motivates independent inventors everywhere. The Portland, Ore.-based company bearing Leatherman's name employs 500 people and dominates a \$200 million worldwide market for pocket tools that he pioneered.

The tool was hardly an overnight sensation. Years of experimentation, false starts, dead ends, rejection and frustration marked Leatherman's course. Looking back, he claims he wasn't even an especially visionary inventor and, at the outset, knew "nothing about business, sales or finance." Not that it stopped him.

Passionate, persistent inventors like Leatherman, set on seeing their creations take wing, have been a driving force in the American economy since our nation's founding. Our country's penchant for innovation is partly the result of U.S. patent law, which was designed to encourage and protect inventors. But it also reflects a national character inclined toward problem-solving and risk-taking.

For much of the 220 years since George Washington signed off on the first patent, individual inventors, not to be confused with their corporate and institutional brethren, have been the engine of American industry—mavericks like Edison, Bell and Carrier. Their breakthroughs banished darkness, projected human voices across hundreds of miles and cooled the sizzling Sun Belt. Trace back the roots of many blue-chip companies, and you are sure to find a solitary inventor who once had a transformative idea.

The drive to invent is more powerful than ever, but the road isn't always easy for independent inventors. Out of the 77,501 U.S. utility patents granted in 2008, just 6 percent went to individuals. Only a third of applications at the U.S. Patent and Trademark Office (USPTO) even earn a patent, and among patents granted, the number that become commercially viable ranges from an estimated 5 percent to as low as 0.2 percent. That's a lot of wreckage left by the side of the road.

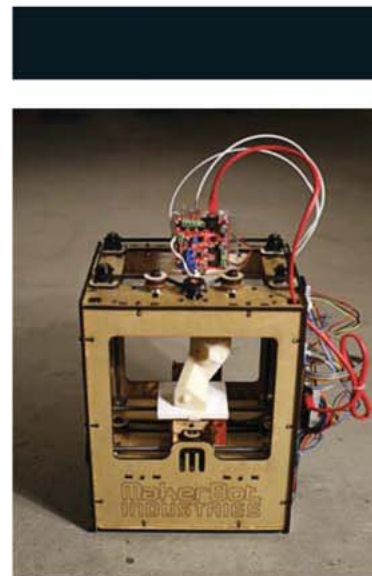
Who wins and who loses at the high-stakes game of invention can seem arbitrary. And yet our economy is studded with examples of innovators who, like Leatherman, have launched one successful product after another into an unforgiving marketplace. We consulted with a number of professional inventors to distill the secrets of the craft. Some have made careers out of invention, others have founded industries. Their consensus: No shortcut exists to success, and nothing substitutes for grit and determination. So, if you're sitting on an idea that might be the next great American invention, here's your playbook.

## 1. CULTIVATE AN IDEA

*The annals of invention* are studded with one-hit wonders, inventors whose single blockbuster idea made them a fortune. But the most prolific inventors can't turn off the idea machine. They are too restless and creative. Inventors

simply see life's many obstacles differently than the average person, according to medical-devices inventor Robert Fischell. "The key to inventing is the awareness that a problem is the trigger from which an invention can be created," says Fischell, who holds more than 200 patents for innovations such as an implantable cardiac defibrillator and improved stents. "When I'm in the operating room and a surgeon throws a tool against the wall in frustration, I say, 'Great, here's an opportunity.'"

Fischell, who at the height of his career filed a new patent application every six weeks, wastes no time in determining whether his latest idea meets the patent test of being new, useful and nonobvious. He goes right to the U.S. Patent and Trademark Office's database of issued patents ([patft.uspto.gov](http://patft.uspto.gov)) and performs a search. "If you read a patent and



MakerBot Industries sells small computer-controlled desktop fabs for the masses. The CupCake CNC kit costs only \$750 and can print small 3D objects.

**SPIRIT OF INVENTION:**  
A CULTURE OF CREATIVITY  
HAS INSPIRED 220 YEARS OF  
PROFESSIONAL ENGINEERING  
AND BASEMENT TINKERING.



# LESSON

## FABRICATION NATION

Inventors have traditionally turned their ideas into prototypes with plenty of sketches and endless iterations in wood, clay or metal. But the digital age has introduced a totally new toolkit.

Computer-aided design (CAD) software allows rapid and highly precise blueprinting, computed numerical control (CNC) milling and routing equipment transfers that precision to the physical world, and 3D printers can create fully formed objects on demand.

Plus, the cost of both hardware and software has fallen dramatically. Free programs, such as BRL-CAD (which was developed by the military for weapons design) and Blender, can

create 3D objects onscreen.

Open-source invention organizations, such as NextFab Store and MakerBot, sell 3D desktop printers and kits through their websites, ranging from \$750 to \$4175. Alternately, you can download plans from Fab@Home for free and source the parts yourself.

But if you don't want to own your own machine, look up local invention facilities such as TechShop, in Portland, Ore., and San Francisco; or NextFab Studio in Philadelphia. These high-tech shops operate like neighborhood boxing gyms, offering unlimited access to their equipment and staff for around \$100 per month.

someone has already solved the problem, then you're still an inventor. You just got there late," he says.

If, after a preliminary search, your idea proves novel, then continue developing it. But be realistic about what you're getting into. "The time you devote will be double what you think it will be, and the dollar amounts you commit will be four times what you thought," Leatherman says.

Make rough sketches, perform tests, flesh out concepts and keep detailed notes. Patent attorneys advise their clients to maintain a log in a permanently bound notebook that gets stamped by a notary public on a frequent basis. A log-book becomes important in cases before the U.S. Patent and Trademark Office involving identical innovations, as the burden of proof falls to patent applicants to demonstrate that they were the first to conceive of an invention.

At this early stage in the game, your investment of personal time and money will have been slight compared with what is around the bend. Before proceeding, you'll have to ask some hard questions about both your idea and yourself: Is my idea significantly different than any that precede it? Is there a sizable market for the product? Can it be developed and manufactured at reasonable cost? Who is the customer, and why should they buy my product and not a competitor's?



*Sometimes a happy accident, not necessity, is the mother of invention. Lonnie Johnson, creator of the Super Soaker (he's holding one of his prototypes above), came up with his invention while he was working on a heat pump that used water instead of Freon. "It shot a stream of water across the bathroom where I was doing the experiment," he says. "I thought to myself, 'This would make a great water gun.'"*

ILLUSTRATIONS BY DON'T WAKE ME UP

### HARD-WIRED FOR INNOVATION

Patents are built into the Constitution. "To promote the Progress of Sciences," the U.S. government can grant inventors exclusive rights to their discoveries.



### SOLO FLIGHTS OF FANCY

"Be alone—that is the secret of invention: Be alone, that is when ideas are born." — Nikola Tesla, who invented the alternating-current motor

And finally, am I willing to commit myself fully to making this idea succeed?

Inventors who have been through the process caution not to underestimate the emotional and psychological fortitude required. “Can the invention fail and not the person?” asks Dean Kamen, inventor of numerous medical devices, the Segway and the iBOT all-terrain wheelchair. “If you can’t afford emotionally and intellectually to fail, if your ego would be wiped out, then don’t do it.”

metal until he settled on an advanced design. “By working with my hands,” he says, “I learned about obstacles to functionality and manufacturability.”

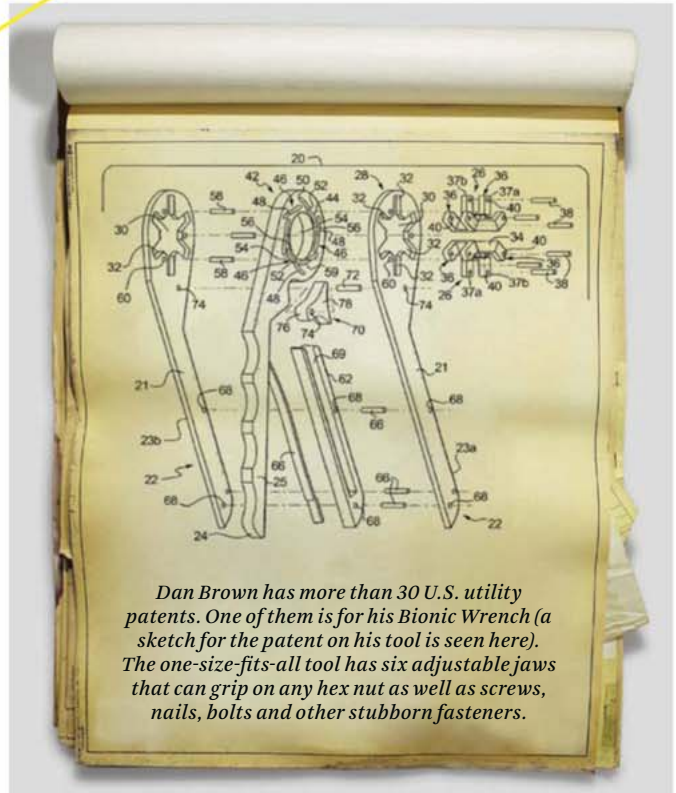
Once you have your prototype, it’s time to troubleshoot your invention.

## 2. BUILD A PROTOTYPE

*With the availability* of powerful computing and computer-assisted design software like Autodesk Inventor and SolidWorks 3D CAD, inventors today live in what Kamen refers to as “the ultimate candy store.” The earliest versions of Kamen’s first invention, a wearable infusion pump that delivers precise doses of medications such as insulin, sprang to life not on a computer screen but in a workshop set up in the basement of his parents’ home on Long Island, N.Y. Kamen was a teenager at the time.

Even when designed in a highly precise digital CAD environment, a product eventually has to make the leap to the real world in the form of a prototype. For a sizable fee, specialty prototype firms translate drawings into molded plastic or steel. Or you might try your luck with a local machine shop. Depending on the materials involved and the complexity of an invention, the cost of making a quality prototype can empty a bank account and force an inventor to seek funding at a very early stage.

Tim Leatherman advocates taking a DIY approach. During a trial-and-error phase lasting three years, he built prototypes of his groundbreaking multitool from cardboard, wood and



*Dan Brown has more than 30 U.S. utility patents. One of them is for his Bionic Wrench (a sketch for the patent on his tool is seen here). The one-size-fits-all tool has six adjustable jaws that can grip on any hex nut as well as screws, nails, bolts and other stubborn fasteners.*

# B.

LESSON

PATENTS DEMYSTIFIED

Gaining a patent requires money, time and perseverance—and that’s when everything goes smoothly. We asked attorney **Richard Beem**, of Beem Patent Law in Chicago, to flag some of the most common blunders that can trip up many fledgling inventors.

→ **Filing a patent at the concept stage.** This is the biggest mistake I see. Inventors file before they’ve made their invention. I always ask them, have you tried it out? Have you made a prototype, preferably in secret? The prototype doesn’t have to be pretty,

but if you haven’t made one, you’re not ready.

→ **Filing a patent yourself.** New inventors lack objectivity and experience with the process. They either make the claims too broad or too specific. A well-drawn claim is an abstraction that captures the

essence of an invention to distinguish it over prior art. You really need a patent attorney for that.

→ **Failing to put enough detail in the patent.** The truth is, the more detail you put in, the broader the final patent will be. We front-load the process by writing

**THE KNOWLEDGE BASE**  
“The more you learn, the more you are able to see. When you see a different pattern ... it’s that ‘Eureka!’ moment.”  
— Post-it inventor Art Fry

**POWER OF PERSISTENCE**  
“I made 5127 prototypes of my vacuum; 5126 were failures. But I learned from each one. That’s how I came up with a solution.” — James Dyson





Get outside your own head and go to experts in the field, Fischell recommends. “Ask them, ‘Do you think my idea has commercial merit? Would you use it?’ But make them sign a confidentiality agreement,” he says. For inventors, the prospect of intellectual property theft is very real, but too much caution can become immobilizing. A confidentiality, or nondisclosure, agreement allows you to field-test in confidence.

Feedback from Mario Salazar’s target audience—carpenters—compelled the Colorado Springs inventor to fine-tune his digital miter gauge. The mechanical prototype he built in the basement with a soldering iron, an oscilloscope and a milling

thoroughly in the application.

→ **Assuming that a cheaper, easier, provisional patent will do.**

Some inventors think that because a provisional patent doesn’t require the same technical detail as a formal application, they can write down a few words, add a sketch or two and their idea is protected. A provisional application is garbage in, garbage out. In a year it goes poof!

→ **Waiting for a patent to sell itself.**

“Patent pending” is like staking a claim to a gold

mine. You still have to dig. Once you file, get out the door and sell, and try to make some money on the invention.

→ **Getting discouraged by patent rejection.**

I’d say 90 percent of the first Patent Office actions are rejections. We interpret that as the examiner saying, “You haven’t convinced me yet. Explain again why your claimed invention is different from prior art.” Your patent attorney will then negotiate with the examiner. Most of the time the second Patent Office action is an allowance.

machine picked up on eBay worked smoothly and felt right to Salazar, but the tradesmen wanted it bigger and more affordable. “You can’t fall in love with your invention,” he says. “Get feedback and make alterations accordingly.”

### 3. FILE A PATENT

*In the rough-and-tumble business world*, a patent protects the inventor by granting the exclusive right to exclude others from making, using or selling his invention for a 20-year period. That’s the theory. In practice, a patent gives the inventor a head start against the wolf pack. “When other people see you making money, your patent will be the only means you have for maintaining control of the market,” says Lonnie Johnson, founder of Johnson ElectroMechanical Systems and inventor of the Super Soaker water gun.

**Patent law is complicated stuff**, so get an experienced patent attorney to write and file your patent application. Expect to pay between \$3000 and \$10,000. “Hire a patent attorney who also has a degree in the field you’re applying for a patent in and who knows your market,” Salazar advises.

A skilled lawyer can draft a broad patent that protects an invention against infringement from any angle. In the case of Richard Phillips, owner of International Survival, his well-crafted patent application made it impossible for anyone to copy the thin, shock-absorbing material he developed for his protective paintball vest. “My lawyer spread the patent out so far above and below my laminated foam material’s properties that a competitor’s vest would have to be so heavy the wearer couldn’t walk or so light that the vest falls apart when hit,” Phillips says.

On average, patent approval takes three years and may require going back and forth several times with patent examiners. From the moment a patent application arrives at the USPTO until it is either issued or abandoned, an invention is covered by patent-pending status. In the case of John Marsden, who invented Pour ‘N Store, a bartending system of plastic bottles and pour spouts for drink mixers, a pending patent amounted to a suit of paper armor. “One company said, ‘If you don’t sell us the patent we’re going to compete with you.’ I didn’t have enough money to fight them in court. We eventually made a deal, and they paid me royalties for years.”

According to Salazar, any inventor has to be ready to do battle. Having a good lawyer in your corner is a must. “If your idea’s good, then someone is going to steal it. If no one’s trying to steal it, then the idea’s probably no good,” he says. “I’ll have my lawyer send a cease-and-desist letter if someone infringes on my patent. If it continues, I give them the diplomatic option to buy a license from me. If diplomacy doesn’t work, then that’s when the money goes out the door in legal fees. And in the end, a patent is only as good as the thickness of your wallet.”

### 4. TEST THE MARKET

*Once the patent application* is complete, the inventor must switch from building an idea to building a business. Rare is the creative genius behind an invention who also has the business chops—or the interest—to oversee the manufacture, marketing and selling of his creation. So even the brightest creative minds can fall victim to the numerous scams and questionable invention-promotion firms whose ads litter the Internet. Most professional inventors urge caution with any outfit that asks for money up front to shop your ideas around.

A safer route when you’re in the thickets is to find a partner whose skill set complements yours. Mario Salazar, a born salesman, teamed with Jay Burgan,

#### SCRAPPY ENGINEERING

Frank Zamboni, inventor of the ice-resurfacing machine (1949), built three prototypes using old tractors, jeep components and war-surplus parts.



#### PATENTS ARE A VIRTUE

When Samuel Hopkins received the first U.S. patent in 1790 for his improved method of making potash, George Washington himself presided.

who has an engineering and software background. Tim Leatherman accrued crucial know-how in business and manufacturing by joining with Steve Berliner. It didn't hurt that Berliner's dad owned a metalworking business. John Marsden, the Pour 'N Store developer, partnered early on with business school graduate Ed Harrigan. "If I hadn't had Ed, I probably wouldn't have made it," he says.

With a solid business team set up, the next step is market research and test marketing. Marketing studies—perform your own or commission a market research firm—will give you data about market trends and customer demographics. There is no substitute, however, for putting your invention in front of potential customers as well as manufacturers, suppliers and distributors to get a sense of its market value. For the inventor, this is an anxious time. As Robert Fischell learned, thick skin helps. "For many of the inventions I've done, somebody always said, 'It'll never work.' I went to a famous doctor at a major medical center with one of my early stent designs. He told me there's no future in stents. Well, that's a \$6 billion market now."

Salazar is a big believer in showing your wares at trade shows. "You'll find out who is doing what, whether you'll be able to compete and if someone is willing to buy what you have," he says. "But you're also dropping your drawers and everyone will see what you've got. Your product had better be 95 percent complete. Be ready to answer questions: How big is the market? Who's going to buy it?"

## 5. SELL IT OR MAKE IT

**Inventors make money** in two ways: collecting royalties by licensing the right to manufacture their invention or manufacturing, distributing and marketing the invention themselves. Sooner or later, all successful inventors reach this fork in the road and must decide for themselves which route to pursue. Louis J. Foreman, founder and chief executive of Enventys, a product design and engineering firm in Charlotte, N.C., and author of *The Independent Inventor's Handbook*, has personally faced that dilemma multiple times as the holder of 10 patents and has advised numerous inventors as lead judge on the PBS program *Everyday Edisons*. "The first thing to do is build a pro forma income statement. Figure out what kind of revenue you could generate versus the overhead and expenses selling that product," Foreman says.

Then it's time to ask yourself another round of questions: First, is there enough upside potential to merit the risk of **bringing the product to market yourself**? "Factor in opportunity costs too," Foreman says. "If you have to give up a job that pays \$100,000, can you make enough to offset that?" Second, do you have the financial resources to pull it off? If you don't, then where is the money going to come from? And finally, do you have the competence to run a business? "It's one thing to come up with an amazing product, but are you comfortable selling it, can you distribute it, replenish it and fulfill orders if Walmart gives you a 5-million-piece purchase order?" Foreman says.

There is no doubt that licensing is the easier route to getting an invention to market. It requires less devotion of time and up-front capital and frees inventors to do what they do best: invent. But expedience comes at a cost. Royalty rates on patents—formulated on list price, production run and other factors—average less than 2 to 7 percent of retail sales. Still, for a first-time inventor short on



### YOUR FIRST TRADE SHOW

A trade show can give a view of the competition and access to potential clients, but for an inexperienced inventor, it can be an object lesson in chaos and expense.

After attending a trade show with premature technology, **Mario Salazar**, inventor of the ProMiter-100 digital miter gauge, realized he couldn't rush success. "You know you're not ready when you have to do some smoke and mirrors to get through the presentation," Salazar says. So he fine-tuned the design, improving his gauge's accuracy. At the next show, he sold the license. "It was a much more finished product," he

says. "The less work buyers have to do, the more likely they're going to buy it as is."

It's also important to focus on whom you're trying to reach at the show. **Bernardo J. Herzer**, inventor of the Lehr propane string trimmer, worked to get his product in front of retailers. And when you do get an audience, listen as much as you talk. "You're not going to get a yes every time," he says. "But whenever you meet with somebody, you've got to learn something. Listen to their objections."

Finally, scout the show itself. When he first decided to show the Pocket Radar handheld

#### APPLIED ORIGINALITY

"Anything that won't sell, I don't want to invent. Its sale is proof of utility, and utility is success." — Thomas Edison



#### PROFIT FROM EXPERIENCE

A 1999 survey of patent holders in the Midwest found that the more patents an inventor had, the higher his financial success rate with new inventions.





*Mario Salazar, who created his ProMiter-100 digital miter gauge when he couldn't find a tool that could quickly make precisely angled cuts, has some words of caution for would-be inventors. "If you think you're the only one coming up with this idea, you're wrong," he says. "If a big company comes up with the same idea, you're gonna get left in the dust."*

speed-detection device at the Consumer Electronics Show, **Chris Stewart** was overwhelmed by the logistical challenges of a trade-show booth. "Talk to someone who has already worked that

particular show," he says. Stewart's PR rep—a CES veteran—found the crew a high-traffic booth location. "It was an eye-opener when we saw the terrible location we would have picked on our own," he says.

prototype, they said, 'That's not a knife. That's a tool.' So then I went to tool companies, and they said, 'That's not a tool. That's a gadget.'"

Leatherman began to get discouraged, and took a job as an outside salesman for a welding products company. He worked there for four years before Berliner, a friend from college, stepped in and said, "We need to start our own company."

Rejections continued to pile up. They started shopping the invention around to mail-order catalogs, but got no yeses. Finally, they took it to a mail-order company out of Seattle. "And instead of just kicking us out the door," says Leatherman, "they sat us down and said: 'How can we make this less expensive?'" He and Berliner went back to the drawing board, simplifying the prototype in an effort to lower the manufacturing cost from \$40 per unit to \$24. Then they resolicited the catalog companies with their pared-down tool.

"Later we got a letter from Cabela's," Leatherman says. "Inside was a purchase order for \$12,000 for 500 tools. You can't believe how happy I was." **PM**

#### **PARTNERSHIP MATTERS**

Coach **Bill Bowerman** made running shoes for years. But it took the business savvy of one of his runners, **Phil Knight**, to create the Nike brand.



#### **THE PATENT PROTECTOR**

**Jerry Lemelson** famously fought for his 600-plus patents in court. From 1954 to 1997, he collected more than \$1 billion in licensing, royalties and settlements.

BY BEN STEWART

PHOTOGRAPHS BY  
GREGOR HALENDA

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HARLEY-DAVIDSON  
SOFTAIL ROCKER C  
HONDA FURY  
VICTORY VEGAS  
JACKPOT  
YAMAHA RAIDER S





# FACTORY CHOPPED

FOUR BIKES THAT LOOK SO GOOD YOU'D THINK THEY WERE CUSTOMS, BUT THESE RELIABLE AND EASY-RIDING MACHINES ARE BUILT BY MAINSTREAM MANUFACTURERS.

PHOTO DRIVEN

THE IMPOSSIBLY LONG, LOW LOOK OF A CUSTOM CHOPPER IS UNMISTAKABLE. These bikes are two-wheeled jewelry, the rides that put personal style and attitude above all else. To hardcore bikers, of course, a factory-made custom chopper is an oxymoron. After all, where's the sweat equity? The first customizers—returning World War II servicemen—began to “chop” or strip the bikes down by bobbing the fenders and removing parts to make them appear less cluttered. It was a homegrown, rebellious movement that gained serious traction in the early 1970s thanks to the 1969 movie classic *Easy Rider*.

But a lot has changed, most notably the rise of made-for-TV bike builders like



Jesse James and Orange County Choppers who craft gorgeous, meticulously detailed rides—for six-figure price tags. Thanks to the tube, the popularity of this genre has skyrocketed, so naturally the mainstream manufacturers have jumped in. Nowadays, playing Hells Angel can be as easy as walking into a dealership. And trust us, this is a good thing. A radically cool, old-school custom chopper is typically terrible to ride. The raked-out forks make the bike tough to maneuver at low speeds and cranky on curvy roads. The steamroller-wide rear tire snugs tight to the seat with little or no suspension movement. And the stretched handlebar position quickly tires shoulders. As in the world of high fashion, comfort and functionality take a back seat to style.

Thanks to solid engineering, combined with an eye for design, a factory-made custom dramatically reduces those annoyances. Nor do these bikes empty wallets like a night in Vegas. None of the ones we tested—the Victory Vegas Jackpot, the Harley-Davidson Softail Rocker C, the Yamaha Raider S and the Honda Fury—costs more than 21 grand.

We spent a week covering over 450 miles around Southern California on highways and back roads. In addition to our usual PM test crew, professional rider Danny Coe ran each bike through instrumented tests at Auto Club Speedway in Fontana, Calif. Instead of ranking the bikes in a finishing order, we rated the machines based on six categories that are listed in the specification boxes. One observation became abundantly clear: It's never been so painless to cruise in high style.

## YAMAHA →→ **Raider S**

The Yamaha Raider really straddles two genres—the power cruiser and the custom chopper. Between the frame rails sits a massive and incredibly potent V-twin that Yamaha borrowed from the Roadliner and the Stratoliner. With 106 lb-ft of peak torque, it's phenomenally easy to reel in just about any car or bike on the road with a casual flick of the wrist. This thing is brutally quick and blasted through the quarter-mile in only 12.34 seconds. Only the Victory was quicker—yet it costs over \$5000 more. Despite the price difference, most thought the Yamaha's engine was far more polished and sophisticated. The Raider doesn't compromise function for flash. Indeed, this was the only bike here with twin front-disc brakes. The rear passenger pillion was the largest and most comfortable seat of this group. And the Yamaha was the only bike with a real fuel gauge. The Raider is a big and hefty bike—719 pounds—that feels overweight only when you lift it off the side stand. With a low seat height and modestly sized tires, it's surprisingly maneuverable at low speeds. In the canyons, the Raider is comfortable pushing speeds higher than most bikes in the test could achieve and was quite happy in the curves. Overall, it's a well-rounded motorcycle. Tester Mike Allen said, "If I had to pick one bike to ride across country, I'd pick the Yamaha." Downsides? The Raider looks far too tame. Type "cruiser motorcycle" into Google and the generic image would probably look a lot like the Raider. There's just not enough uniqueness to this design. It's a terrific bike to ride, but it lacks enough visual character and slightly misses the point of these bikes.



### YAMAHA RAIDER S

PRICE • \$14,790  
 ENGINE/TRANS • 1854 cc  
 air-cooled V-twin/5M  
 REAR-WHEEL HP • 84  
 WHEELBASE (in.) • 70.9  
 SEAT HEIGHT (in.) • 27.4  
 WEIGHT (lb) • 719  
 FINAL DRIVE • belt  
 SUSPENSION TRAVEL,  
 F/R (in.) • 5.1/3.5  
 BRAKES F/R • 11.73-in. discs/  
 12.2-in. disc  
 TIRES F/R • 120/70R21/210/40R18  
 0-60 MPH (sec) • 3.83  
 40-70 MPH (sec) • 3.05  
 QUARTER-MILE • 12.34 @ 106.35 mph  
 60-0 BRAKING (ft) • 124.1  
 FUEL ECONOMY (mpg) • 44.7

#### [RATINGS]

LOW-SPEED AGILITY / HANDLING /  
 VALUE / COMFORT / PERFORMANCE



## HARLEY-DAVIDSON →→ **Softail Rocker C**

If anyone but the most well-versed motorcycle enthusiast caught an eyeful of the Harley Rocker from the rear, they'd swear it was a one-off custom chopper. From the little bullet taillights to that fender stretched tightly across the fat rear tire, this bike looks like it must have been welded together by a guy slathered in tattoos. That makes sense considering that more choppers over the past 65 years have been based on Harleys than on any other bike. So the boys in Milwaukee should know how it's done; yet the Harley was the quirkiest of the four bikes here.



PM TEST DRIVEN



HARLEY-DAVIDSON SOFTAIL ROCKER C

PRICE • **\$19,499**  
ENGINE/TRANS • **1584 cc**  
**air-cooled V-twin/6M**  
REAR-WHEEL HP • **61**  
WHEELBASE (in.) • **69.2**  
SEAT HEIGHT (in.) • **27.4**  
WEIGHT (lb) • **686**  
FINAL DRIVE • **belt**  
SUSPENSION TRAVEL,  
F/R (in.) • **5.0/3.1**  
BRAKES F/R • **11.5-in. disc/  
11.5-in. disc**  
TIRES F/R • **90/90R19/240/40R18**  
0-60 MPH (sec) • **4.73**  
40-70 MPH (sec) • **4.00**  
QUARTER-MILE • **13.55 @ 95.13 mph**  
60-0 BRAKING (ft) • **124.58**  
FUEL ECONOMY (mpg) • **43.0**

[RATINGS]

LOW-SPEED AGILITY /  
HANDLING / DESIGN



Unlike with the others, it feels as though you're sitting on top of this bike, not nestled down deep behind that V-twin. Indeed, the Rocker tied for the tallest seat height of the group. And that firm seat was not the most comfortable for longer hauls. But once our testers got used to this riding position, the Harley was an easy bike to fall for. Despite its long wheelbase, it felt nimble around town and quick and eager on long, sweeping curves.

The six-speed transmission shifts with a slickness and ease that bettered every bike here. And riders really appreciated the tall sixth gear for relaxed highway cruising as well as the lighted transmission gear display. Twist the right grip and run through a few gears, and Harley's big 96-cubic-inch twin exhales with a deep, satisfying growl. But the Rocker's bark was more aggressive than its bite. It was about a second behind the Victory and the Yamaha on the dragstrip's quarter-mile. On the open road, that performance gap felt much less significant. Credit the Harley's generous torque. The Harley looks the most like a true custom, but it's also priced like one. At nearly \$20,000, this is not an inexpensive machine. Still, if you yearn for that authentic Harley-Davidson chopper experience in a reliable factory package, there's only one choice.

### **VICTORY →→ Vegas Jackpot**

The 2003 Vegas was arguably the first factory-made custom, and it arrived with instant street cred because Victory enlisted motorcycle legends Arlen and Cory Ness to help design it, a relationship that continues today. The company offers what could be the most complete line of custom-inspired bikes of any manufacturer; one that now tops out with the Vegas Jackpot. Our test bike was dipped in a crowd-gathering coat of Tequila Gold with tribal graphics, and nearly every square inch of metal is chrome-plated. Subtle? Yeah, right. If the paint doesn't grab your attention, perhaps the extreme tires will. Up front is a spindly little 90/90R21 tire. Out back, the Jackpot has a monstrous 250/40R18 slab of rubber that's just about wide enough to be fitted to the rear axle of a muscle car. It certainly looks menacing.

At the dragstrip, our tester found that the rear tire was oh so effective at putting power to pavement. The Jackpot rocketed down the track, passing 60 mph in a scant 3.74 seconds and smoking the quarter-mile in only 12.19 seconds. It was the quickest bike in the group. The Victory's 1731-cc V-twin belts out a steady wave of turbodiesel-like torque. Trouble is, this powertrain has all the refinement of an 18-wheeler. Transmission shifts are clunky, with neutral particularly difficult to find, which is frustrating in stop-and-go traffic. The engine sounds a bit less sophisticated than the others here too. In slow-go city riding, the Jackpot's wide rear tire and skinny front require an experienced hand. The width of that tire wants to push the bike over and turn more sharply than one might want. The rider does get used to it, and once clear of the city limits, the Jackpot really begins to shine. The Victory provides easy-chair comfort on the open road and surprisingly competent handling on twisty roads, thanks to the relatively short wheelbase. But, of course, like all these machines, the handling limits are determined by the foot pegs. So plan on scraping them often if you ride this bike hard. Even in this grouping of bravado bikes, the expensive \$20,249 Victory is the extrovert. It's flashy, slightly crude and incredibly powerful. For some riders, that's the perfect formula.







### HONDA FURY

PRICE • \$12,999  
 ENGINE/TRANS • 1312 cc  
**liquid-cooled, 52-degree V-twin/5M**  
 REAR-WHEEL HP • 56  
 WHEELBASE (in.) • 71.24  
 SEAT HEIGHT (in.) • 26.7  
 WEIGHT (lb) • 663  
 FINAL DRIVE • shaft  
 SUSPENSION TRAVEL,  
 F/R (in.) • 4.0/3.7  
 BRAKES F/R • 13.23-in. disc/  
 11.65-in. disc  
 TIRES F/R • 90/90R21/200/50R18  
 0-60 MPH (sec) • 5.14  
 40-70 MPH (sec) • 4.22  
 QUARTER-MILE • 13.79 @ 93.29 mph  
 60-0 BRAKING (ft) • 121.92  
 FUEL ECONOMY (mpg) • 48.8

[RATINGS]  
**LOW-SPEED AGILITY / VALUE**  
**DESIGN / COMFORT**

PM TEST DRIVEN



### VICTORY VEGAS JACKPOT

PRICE • \$20,249  
 ENGINE/TRANS • 1731 cc  
**air-cooled V-twin/6M**  
 REAR-WHEEL HP • 79  
 WHEELBASE (in.) • 66.3  
 SEAT HEIGHT (in.) • 25.7  
 WEIGHT (lb) • 652  
 FINAL DRIVE • belt  
 SUSPENSION TRAVEL,  
 F/R (in.) • 5.1/3.0  
 BRAKES F/R • 11.81-in. disc/  
 11.8-in. disc  
 TIRES F/R •  
**90/90R21/250/40R18**  
 0-60 MPH (sec) • 3.74  
 40-70 MPH (sec) • 2.88  
 QUARTER-MILE • 12.19 @  
**107.16 mph**  
 60-0 BRAKING (ft) • 128.88  
 FUEL ECONOMY (mpg) • 46.0

[RATINGS]  
**HANDLING / DESIGN**  
**COMFORT / PERFORMANCE**

## HONDA → Fury

Since debuting last year, the Honda Fury has provided a string of surprises. Yes, it's still shocking that conservative Honda decided to build a radical factory chopper. What's cooler is that it has created a wild, stretched-out chopper profile on a bike that's just as docile, good-natured and pleasant to ride as any Honda cruiser. The Fury is perfect for a novice or moderately experienced rider who wants something unique. Climb aboard the Honda and you'll settle into a very comfy riding position. Your body tucks in nicely behind the beautifully tapered fuel tank and provides a windbreak so effective it's as if Honda tested the Fury's aero signature in a wind tunnel. At city speeds, the Honda feels exceptionally light, easy to thread through traffic and smooth-riding over moderately sized bumps. However, on the tight sweeping canyon roads, the Honda's low cornering clearance and long wheelbase meant it wasn't as sporty as the other three. But hey, it's a chopper, not a sportbike. And it's certainly fun to look down and see the liquid-cooled V-twin exposed by the svelte fuel tank. The 1312-cc motor feels plenty powerful—until you ride the other bikes. When it comes to thrust, the Honda was not so furious. Yet the Honda's excellent throttle response made it feel quicker than its numbers suggest. The Fury's smaller motor also delivered the best fuel economy (48.8 mpg). Our test bike looked sinister and tough finished in flat gray paint with black wheels. The hand of a minimalist designer must have penned the Fury, because there's no extra flash or fluff. We dig it. Okay, we've got one beef with the Fury's bodywork: Almost all of it is plastic. Call us old-fashioned, but we want metal fenders. That said, perhaps that particular material choice helps keep costs in the basement, because, at \$12,999, the Honda was the least expensive in our test—and one of the best values in the motorcycle world.

PM



TURBINE FOREST

NUCLEAR VALLEY

CORN COUNTRY

NET GEN ALLEY

CARBON CAPTURE WAY

# Energyland

THE RACE TO CHEAP, SUSTAINABLE POWER



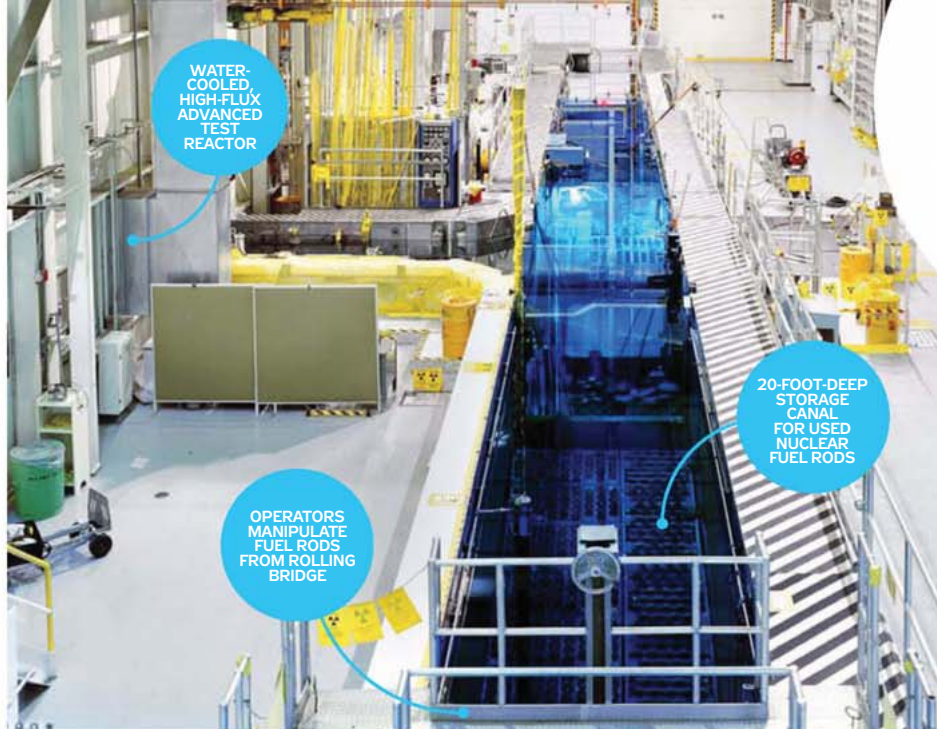




**BY ELIZABETH SVOBODA**  
PHOTOGRAPH BY MARK HOOPER  
GAME BOARD BY ILLUSTRATION FARM

**THE ROAD TO CLEAN ENERGY** is full of enticing opportunities—and perilous pitfalls. Picking the best path requires avoiding both starry-eyed hype and cynical fatalism. In this special report, PM debunks 10 of the most pernicious myths that could derail our progress.





WATER-COOLED, HIGH-FLUX ADVANCED TEST REACTOR

OPERATORS MANIPULATE FUEL RODS FROM ROLLING BRIDGE

20-FOOT-DEEP STORAGE CANAL FOR USED NUCLEAR FUEL RODS

At Idaho National Laboratory, fuel for next-gen nuclear reactors is blasted with radiation, then cooled in an adjacent canal.



## THE TRUTH ABOUT ENERGY

### Myth No. 1

## NUCLEAR POWER ISN'T A SAFE SOLUTION

In a recent national poll, 72 percent of respondents expressed concern about potential accidents at nuclear power plants. Some opinion-makers have encouraged this trepidation: Steven Cohen, executive director of Columbia University's Earth Institute, has called nuclear power "dangerous, complicated and politically controversial."

During the first six decades of the nuclear age, however, fewer than 100 people have died as a result of nuclear power plant accidents. And comparing modern nuclear plants to Chernobyl—the Ukrainian reactor that directly caused 56 deaths after a 1986 meltdown—is like comparing World War I fighter planes to the F/A-18. Newer nuclear plants, including the fast reactor now being developed at Idaho National Laboratory (INL), contain multiple auto-shutoff mechanisms that reduce the odds of a meltdown exponentially—even in a worst-case scenario, like an industrial accident or a terrorist attack. And some also have the ability to burn spent fuel rods, a convenient way to reuse nuclear waste instead of burying it for thousands of years.

Power sources such as coal and petroleum might seem safer than nuclear, but statistically they're a lot deadlier. Coal min-

### Myth No. 2

## SURE, CORN ETHANOL IS PROBLEMATIC—BUT SWITCHGRASS WILL SAVE THE DAY

The renewable energy movement's darling for years, corn-based ethanol has fallen out of favor for not making good on its promises of efficiency. Cellulosic ethanol—made from plant parts containing cellulose, such as grass and wood chips—seems poised to be the

next star of the biofuel circuit. Its fuel crops require less fertilizer and use water more efficiently than corn. Plus, it can be created from waste products like lawn clippings and tree branches.

But the upstart fuel will have to surmount sizable environmental and financial challenges. For one, it takes a tremendous amount of cellulose to produce ethanol in industrial quantities, which means a lot of land would still have to be devoted to fuel production. "The

low density of the supply is a problem," says Tad Patzek, a chemical engineer at the University of Texas at Austin. "To supply fuel to, say, the Bay Area, you would need an area of switchgrass that is larger than all the agricultural land in California."

And since cellulose is tough and fibrous, it

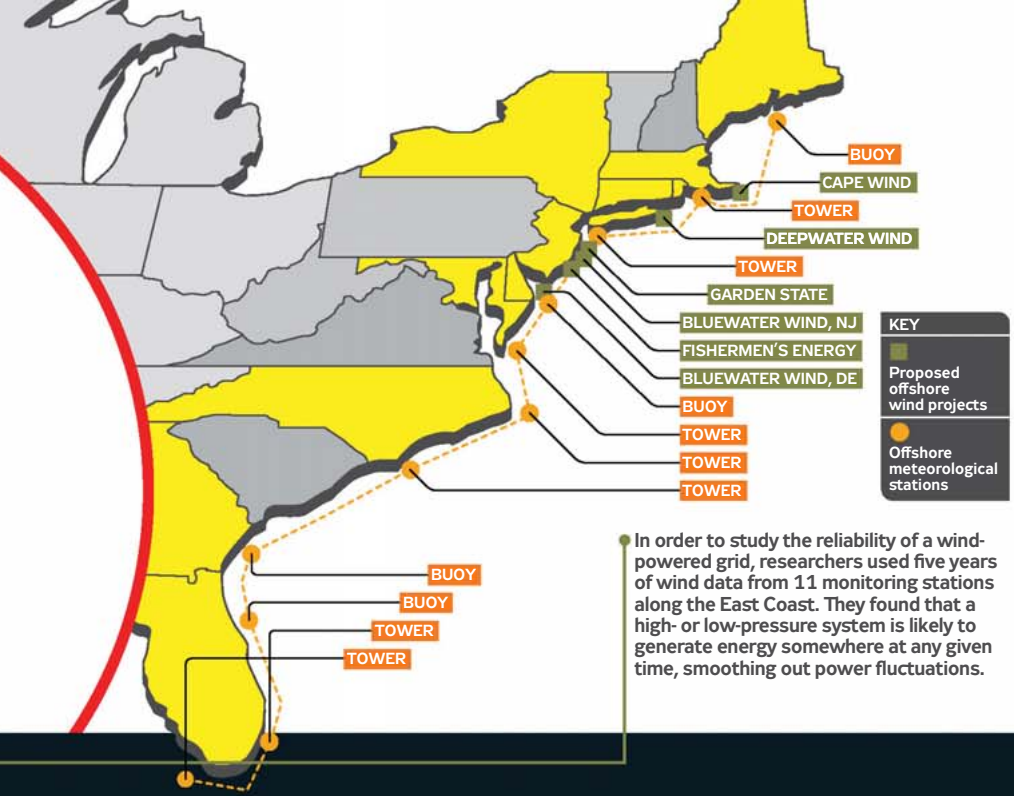
requires heavy-duty enzymatic decomposition processes to convert the plant matter into simple sugars that can be fermented into ethanol. These processes consume large amounts of energy and are so pricey that a study in *Bioresource Technology* last year concluded that cellulosic ethanol

kills several hundred people annually—mainly from heart damage and black lung disease, but also through devastating accidents like the April mine explosion in West Virginia. The sublethal effects of coal-power generation are also greater. "The amount of radiation put out by a coal plant far exceeds that of a nuclear power plant, even if you use scrubbers," says Gerald E. Marsh, a retired nuclear physicist who worked at Argonne National Laboratory. Particulate pollution from coal plants causes nearly 24,000 people a year to die



## ETHANOL EMISSIONS

According to a USDA life-cycle analysis, corn-based ethanol results in only a 20 percent reduction in greenhouse gases relative to gasoline. Cellulosic ethanol, in contrast, can achieve an 86 percent reduction. It also requires only a quarter of the irrigation and fertilization of row crops.



### Myth No. 3 WIND POWER IS FAR TOO UNRELIABLE

won't be competitive with gasoline unless oil prices remain above \$90 a barrel.

When that day comes, cellulosic could play a modest role in boosting supplies. And that's worth more research today. But hopes that grass clippings will end our oil habit are overblown.

**First things first: Wind power is intermittent; it's just the nature of, well, nature. Due largely to the unpredictability of weather, turbines typically generate only about one-fifth of the energy they'd make if they actually ran 24/7. That said, energy planners have devised tactics to make wind power reliable.**

One of the best ways to balance wind's now-it's-here-now-it's-not quality is to construct grid connections between different regions of the U.S. "We have monitoring systems that show us the winds as they proceed through different regions," says George Van Hoesen, a managing partner at Global Green Building, an environmental consulting firm in Missouri. "We understand the currents and the flows." Armed with this data and computer models, utilities can plan to shunt surplus power generated in one part of the country to areas that need it.

Science supports that strategy. A recent Stanford University study found that when many wind farms are interconnected through the grid, about one-third of the electricity they generate can be counted on as a reliable source of around-the-clock power. (Less reliable wind energy sources can still be put to profitable use—to charge batteries for electric vehicles or produce hydrogen transportation fuel, for example.) And a University of Delaware study published this spring concluded that an offshore grid, connecting wind generators along the East Coast, could provide relatively stable output. Over a simulated five-year period, power never petered out entirely.

prematurely from diseases such as lung cancer. Petroleum production also has safety and environmental risks, as demonstrated by the recent oil spill in the Gulf of Mexico.

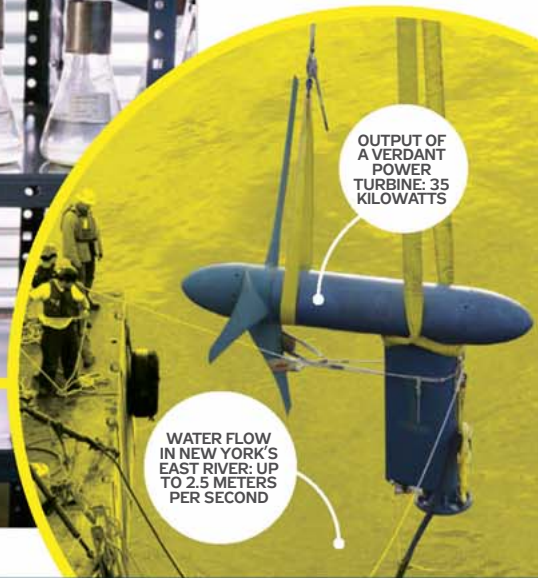
INL nuclear lab's deputy associate director, Kathryn McCarthy, thinks the industry can overcome its stigma. "It's been a long time since Chernobyl and Three Mile Island," McCarthy says, "and people are willing to reconsider the benefits of nuclear energy." Nuclear plants emit only a tiny fraction of the carbon dioxide that coal plants do, and a few hundred nuclear facilities could potentially supply nearly all the energy the United States needs, reducing our dependence on fossil fuels.

"In the eastern United States, storms typically move along the coast," says Willett Kempton, a lead author. "Thus, if offshore wind farms are connected by a transmission line, the power from the whole set is more consistent."

Still, even the savviest grid connections have limits. The most optimistic projections calculate that wind can supply about 30 percent of the planet's electricity by 2030, so power sources like nuclear, hydropower and solar will be needed as supplements. It might not be a great idea to place all bets on wind, but with the latest turbines able to generate pollution-free electricity at less than 5 cents per kilowatt-hour, it wouldn't be smart to let wind go by the wayside while we invest in less sustainable fuels, either.



The algae collection at the University of Texas at Austin contains over 3000 strains, which it frequently provides to biofuel researchers.



#### Myth No. 4

### ALGAE GROWS ANYWHERE, SO TURNING IT INTO FUEL WILL BE CHEAP

It grows in ponds. It grows in streambeds. It even grows in your sink if you forget to scrub it. Algae is so omnipresent that startups like Solix and Aurora Biofuels make it easy to envision the microscopic green organisms meeting all the transportation needs of the planet at pennies a gallon for eternity.

But in-depth experimentation suggests that algae-fuel supremacy isn't going to come easy. The strains of algae that work best for biodiesel are specialized lipid-producers that won't thrive in just any circumstances.

Algae-fuel researchers have tried growing the organisms in open ponds for decades, but the water often becomes contaminated with native algae, which quickly outcompete lipid-rich strains.

Closed bioreactors come with their own set of issues. "Even relatively inexpensive ones are going to add dramatically to capital costs," says biochemical engineer John Sheehan, who worked on a stalled National Renewable Energy Laboratory algae-fuel project. Plus, as bioreactors scale up, decreased surface-area-to-volume ratios often

make it difficult for all the algae to get the solar energy they need, making them subpar for fuel production. Algae fuel may eventually take off, but it's going to require a lot of testing, technical tweaking and expensive infrastructure to get there.

#### Myth No. 5

### TIDAL POWER IS A LOST CAUSE

As the sea level rises and falls, tides roll in and out twice a day, unfailingly. It's hard to imagine a more predictable source of power. Yet tidal power's showcase project in the United States, an array of underwater turbines anchored in the East River in New York City, hasn't exactly been an overnight success. Two initial turbine designs flopped over the course of several years; blades and hubs snapped off because they weren't strong enough to withstand the near-constant force of the water.

Still, it's too soon to give up on tidal power. The Rance tidal power plant in France has an installed capacity of 240 megawatts and has been in continuous operation for more than 40 years. Its axial-flow turbines are capable of operating as the water flows in both directions. And after several false starts, Verdant Power's array operated for more than 9000 hours in a 2008 trial, delivering 70 megawatt-hours of energy to two end-users. This summer, the startup Natural Currents Energy Services plans to install proprietary turbines in two projects that will power marinas in New Jersey.

"We're talking about the entire ocean moving in one direction or another," says Global Green Building's Van Hoesen. "The sheer volume of energy makes it very attractive."

PHOTOGRAPH BY JASON FULFORD (ALGAE)

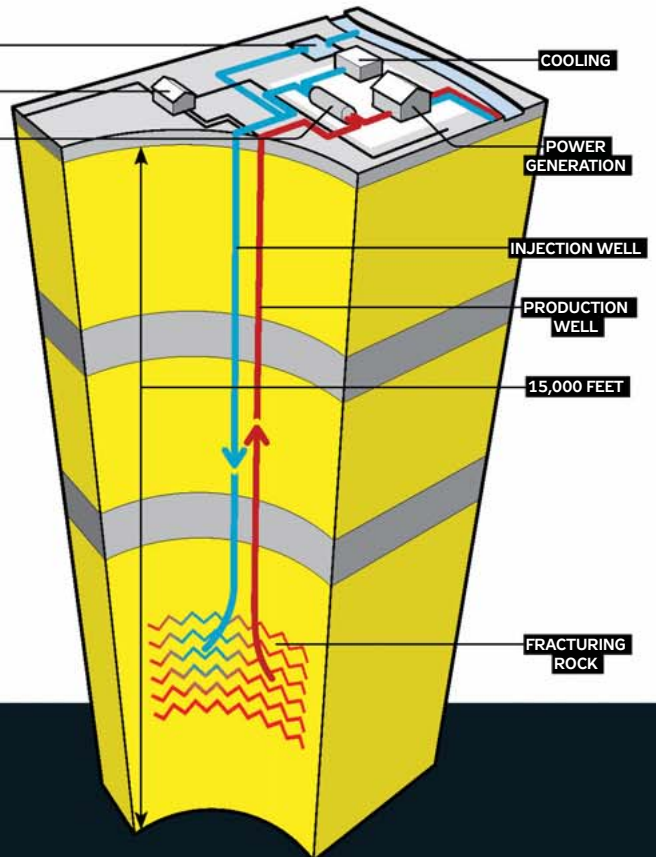


## COAL CASUALTIES

Abt Associates found that U.S. power plant pollution causes more than 38,200 heart attacks and 554,000 asthma attacks per year. The health cost of such pollution is \$167.3 billion annually.



Unlike ordinary geothermal power generation, which involves harvesting energy from steam beds that form up to a few thousand feet below the surface, deep geothermal involves injecting water into hot bedrock roughly 3 miles down. The high pressure and the flow rate fracture the rock, and after flowing through the cracks hot water is drawn back up through a second drill hole. If the fracturing rock intersects an active fault line, minor earthquakes can result.



### Myth No. 6

## CLEAN COAL CAN CLEAR THE SKIES OF EMISSIONS

The phrase “clean coal” has recently entered the argot of energy planners and political candidates, implying that coal—in addition to supplying cheap, reliable base-load power—can be an environmentally friendly energy source. Energy Secretary Steven Chu endorsed this viewpoint, announcing that the Department of Energy would spend more than \$3 billion to fund facilities that capture carbon dioxide from coal and stash it underground, reducing air pollution.

Unfortunately, clean, cheap coal is still a pipe dream. According to the National Energy Technology Laboratory, the cost of capturing carbon dioxide from coal plants and storing it in underground locations will increase the price of electricity from 30 to 100 percent, depending on the method used. In addition, coal-fired power plants that perform sequestration burn one-quarter more coal than their unimproved counterparts to produce the same amount of electricity. That means more destructive mining operations, more CO<sub>2</sub> emissions from transportation and more coal ash, the toxic byproduct of all coal-burning. “We have implemented some technologies that are cleaning the air,” says Mary Fox, an environmental scientist at Johns Hopkins University, “but that has led to a displacement of some of those waste products into solid waste.”

### Myth No. 7

## THE RISK OF EARTHQUAKES MAKES DEEP GEOTHERMAL UNREALISTIC

Horror stories about deep geothermal drilling began circulating after a series of earthquakes shook the city of Basel, Switzerland, in 2006. And, in fact, a scientific analysis concluded that a geothermal system likely set off the quakes, causing a similar project in California to be scuttled.

But deep geothermal, also called enhanced geothermal, has distinct advantages too. Because it taps into the hot, dry bedrock miles below the surface, drilling could be widespread. A recent study led by MIT identified 200,000 exajoules of extractable deep geothermal energy, which could supply more than 2000 times the nation’s annual energy use.

Odds are very low that enhanced geothermal power would ever cause a



quake on the scale of, say, the recent shake-up in Chile, says Colin Williams, a geophysicist on the U.S. Geological Survey earthquake hazards team. Even the largest quake in Basel, a 3.4 on the Richter scale, caused only minimal damage. And experts say that if enhanced geothermal plants are constructed

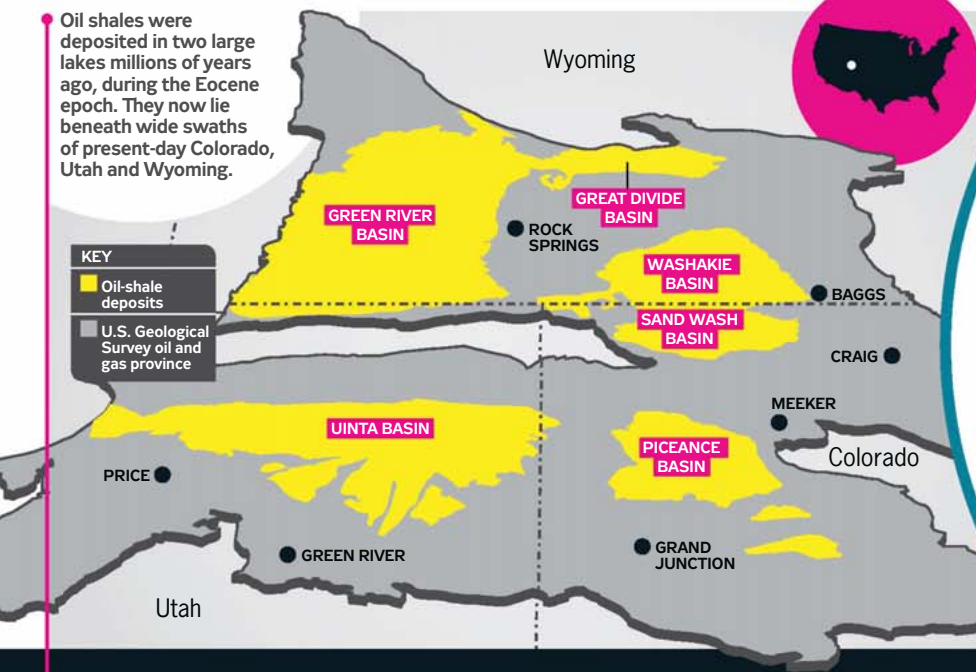
farther away from cities—in rural areas of Europe or the western U.S., for example—any induced seismicity would have even less effect on the human population. “Should we say the technology is dead?” says scientist Domenico Giardini, who analyzed Basel. “Absolutely not.”

That displacement can lead to serious health consequences, as in the case of the coal-ash slurry that broke through a dike in Tennessee, sullyng water supplies with mercury, lead and arsenic. Disposing of

toxic ash responsibly could cost in excess of \$5 billion annually, so efforts to pass more stringent federal controls on solid waste have stalled. For better or worse, coal produces roughly half of the nation’s electricity, so technology for next-gen facilities is worth developing. But no breakthrough will cause the nearly 500 plants already operating in the U.S. to magically clean up their act.

Oil shales were deposited in two large lakes millions of years ago, during the Eocene epoch. They now lie beneath wide swaths of present-day Colorado, Utah and Wyoming.

**KEY**  
 Oil-shale deposits  
 U.S. Geological Survey oil and gas province



## SOLAR STATS

A photovoltaic cell needs to operate for about four years to recoup the energy that went into manufacturing it. With the newest thin-film solar cells, you can recover your investment in less than a year.



### Myth No. 8 U.S. SHALE CAN PROVIDE ENERGY INDEPENDENCE

Shale oil hasn't gotten too much attention since the oil crisis of the 1970s. But today, proponents are once again pointing out that there are more than a trillion barrels of oil locked in the shale deposits of Colorado, Utah and Wyoming, more than all the proven crude-oil reserves on the planet. That would be enough to meet current U.S. oil demand for an entire century.

The problem, then and now, lies in the financial and ecological costs of extracting the oil. Shale oil naturally occurs in the form of kerogens, solid, waxy substances with a texture similar to that of ChapStick. Once the kerogens are heated to over 500 F, they exude hydrocarbons, which must be treated with hydrogen in order to be processed into usable fuel—a highly energy-intensive process that releases large amounts of CO<sub>2</sub>.

And just to get at these kerogens, energy companies would have to mine and process millions of tons of shale from the earth—leaving behind toxic heavy metals and sulfates that could seep into groundwater. "There's a water contamination issue," says Olayinka Ogunsola, an engineer at the Department of Energy. "There's also a land reclamation issue—

### Myth No. 9 SOLAR ENERGY WILL NEVER PAY FOR ITSELF

Solar panels are certainly expensive—about \$100 per square foot for a typical installation—but eventually, you're destined to end up on the positive side of the equation. According to the California Solar Electric Company, it may take from eight to 12 years to recoup in saved energy costs the

investment put into a basic residential photovoltaic (PV) solar array. But this estimate varies greatly depending on factors like the size of the array and the amount of sunlight that hits it, and advances in PV technology continue to shorten the payback period.

"The shortest payback with new thin-film cells is less than a year," says Burr Zimmerman, a chemical engineer and co-founder of the Kairos Institute, which ushers new

technologies into the marketplace. Thanks to ramped-up production and cheaper materials, up-front costs continue to plummet as well; the price of solar cells has fallen fifteenfold since 1980. After a solar array's initial payback period, you start to reap

some serious financial benefits. Assuming solar cells have an average life expectancy of 30 years, more than 50 percent of the power solar cells generate ends up being free. "There are maintenance issues," Zimmerman says, but over time, "solar cells are definitely making you money."

[mining] would create a lot of disturbance in the area." Mining and processing shale also require vast amounts of water—producing 2.5 million barrels of shale oil per day would require 105 million to 315 million gallons of water daily. That might be the biggest deal breaker of all for parched western states.

So while extracting the oil from U.S. shale may be technically possible, the scale of such an enterprise, as measured in acres and natural resources, may never make it worthwhile.



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## 5 HOME ENERGY MYTHS

**Myth**

**Wood stoves are dirty and polluting.**

**Truth**

Old wood stoves spewed 20 to 40 grams of particulates per hour. New wood and pellet stoves emit less than 1. And they replace heating oil with a renewable fuel that grows almost anywhere.

**Myth**

**Old single-pane windows are bad. Replace them.**

**Truth**

A properly operating single-pane wood window with weatherstripping and a storm window has an R-value of about 2. That's roughly equal to a double-pane wood window's R-value of 1.61 to 2.04.

**Myth**

**Coasting to a stop in neutral saves gas.**

**Truth**

A car actually consumes more fuel coasting in neutral than it does in gear. That's because absent any throttle input, an engaged engine reduces the flow of fuel to the injectors.

**Myth**

**Cordless lawnmowers are zero-impact.**

**Truth**

While cleaner than two-stroke gas engines, cordless mowers rely on carbon-intensive electricity. Propane-burning lawnmowers emit up to 70 percent fewer hydrocarbons than small gasoline engines.

**Myth**

**Driving with the a/c off and windows open saves fuel.**

**Truth**

It takes 2 to 8 hp to run the a/c, so when driving at city speeds, turning it off does save energy. But on a highway, open windows can significantly increase drag.

### Myth No. 10

## WE HAVE TO DRILL OUR WAY OUT OF THE ENERGY DILEMMA

Discussions of America's energy future tend to focus on increasing production. There's no question that more mining and drilling can modestly increase overall supply—but, as recent accidents have shown, at a steep human and environmental cost. Renewable sources show promise but will take time and money to implement. "I'm a big advocate of renewables, but I'm also an advocate of common sense," says David Hughes, a fellow at the Post Carbon Institute. "Radical conservation has to be number one."

The U.S. Energy Information Administration projects that, under existing policies, total energy consumption will grow by 14 percent by 2035. That doesn't have to be the case. A report published last year by McKinsey & Company calculates that widespread deployment of energy-efficiency measures can *decrease* consumption by 23 percent of projected demand by 2020. What's more, such measures would result in \$1.2 trillion in savings, far more than the \$520 billion investment required to implement them. The corresponding reduction of greenhouse gas emissions would be like taking an entire U.S. fleet of passenger vehicles off the road.

Personal actions certainly help: A 2008 trial by Baltimore Gas and Electric showed that customers who had smart meters reduced their energy use by up to 37 percent during peak periods. And semiconductor-powered light-emitting diodes (LEDs) have the potential to reduce lighting-related energy consumption to one-sixth of its current level. The DOE estimates we could be well on our way to that goal by 2025, cutting lighting energy use by 29 percent—and collectively saving \$125 billion.

There's also ample room for industry to streamline its energy consumption. If plants like oil refineries and steel mills convert exhaust heat into electricity via cogeneration, they could reap an extra 100 gigawatts, reducing CO<sub>2</sub> emissions by about 400 million metric tons. Energy saved, it turns out, is the cheapest new source. **PM**



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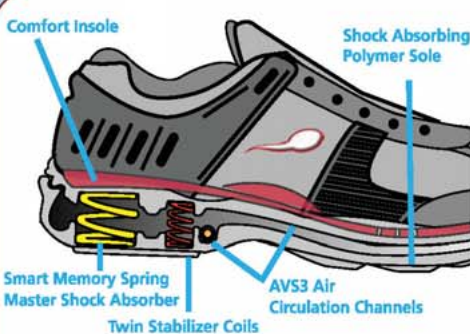
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# TICAI CONDITION

**MEDICAL HELICOPTERS ARE SUPPOSED TO SAVE LIVES.  
TOO OFTEN, THEY PUT BOTH FLIGHT CREW  
AND PATIENTS IN DANGER INSTEAD.**

by **CHRISTOPHER MAG**  
photograph by **TIMOTHY HOGAN**

**rooper Stephen Bunker died** flying a mission that never should have happened, looking for a hole in the clouds that never appeared. Shortly after 11 pm on Sept. 27, 2008, Bunker's phone rang inside the Maryland State Police aircraft hangar at Andrews Air Force Base. Two young women were injured in a car crash in Waldorf, Md. They needed transport to Prince George's Hospital Center. Would Bunker accept the flight?

It was a warm and soupy autumn night. Weather reports showed thick clouds descending to 800 feet, the minimum for night flights in state police helicopters. The area 1 mile north of Prince George's Hospital was completely fogged in. Bunker hesitated.

"Well, maybe they'll change their minds," he told George Noyes, the state police flight dispatcher.

Noyes had a hunch that wouldn't happen. The call came from Charles County, where a 17-year-old EMT on the scene requested helicopter service. "When I heard it was Charles County, I knew it was gonna be Waldorf," Noyes says, "because those guys never want to



drive to the hospital.”

In Maryland, emergency medical service (EMS) guidelines specify that police helicopters rescue patients from accident scenes, while private air ambulance companies handle runs between hospitals and back up police. Over the radio Bunker heard that MedSTAR Transport, a private company, had just completed a job nearby.

“If they can do it, we can do it,” Bunker said.

He lifted off from Andrews at 11:10 pm. Thirty-four minutes later, with both patients and two paramedics onboard, he radioed air traffic control at Ronald Reagan Washington National Airport. “Uh, yes, sir, we just ran into some heavy stuff,” he said. “I don’t think we’re going to be able to make it all the way to the hospital.”

Blinded by fog, Bunker diverted to Andrews. Three-and-a-half miles short of the runway, flying at 1900 feet, he sent Trooper 2 into a dive. The helicopter was not equipped with flight recorders, so it’s unknown why he descended. But investigators believe that because he was familiar with the surrounding area, and because the sky immediately over Andrews was clear when he took off, Bunker probably thought he could duck under the clouds and land by sight.

There was nowhere to duck. Traveling at 106 mph, Bunker slammed into a tree in Walker Mill Regional Park. One patient, Jordan Wells, fell free of the aircraft and survived. Bunker and three others died.

**M**edical helicopters accept the most dangerous missions in commercial aviation. They fly unplanned routes a few hundred feet above the ground, often below radar. They land on highways, mountains and farms, miles from the nearest airport weather station.

Yet Trooper 2 was typical: Most medical helicopters lack basic safety equipment mandatory on other commercial aircraft. The majority have no autopilot

system or co-pilot to assist the pilot in emergencies. Medical helicopters are not required to have terrain awareness and warning systems (TAWS), night-vision goggles, flight data recorders, detailed weather reporting or ground personnel in charge of flight dispatch and in-flight tracking.

As a result of flying ill-equipped into risky conditions, medical helicopters crash at twice the rate of other air taxis and are exponentially more dangerous than commercial airliners, according to a 2009 study by Ira Blumen, medical and program director of the University of Chicago Aeromedical Network. Air ambulances have crashed 264 times between 1972 and 2008, killing 264 people. The first three months of this year

kicked off with two more fatal crashes, leaving six dead (half of whom died during a military EMS simulation).

In fact, working onboard a medical helicopter is the most dangerous profession in America, Blumen found, with a higher fatality rate than that of fishermen, loggers or steelworkers.

“Most people think medical helicopters are like airliners, that they all meet the same standards,” says Thomas Judge, executive director of LifeFlight of Maine. “Yet here we take injured passengers, with no choice of carrier, and subject them to this huge variation of standards that airline passengers would not accept.”

Often, helicopter evacuations are not even needed to save a life. “Medics call





helicopters just so a ground ambulance can stay on call,” says Bryan Bledsoe, an emergency room doctor and a professor at the University of Nevada School of Medicine, who participated in an expert study of Trooper 2’s crash. “Helicopters fly medically unnecessary flights every day.”

The reality is that Trooper 2 did not have to crash. Since 1988, the National Transportation Safety Board (NTSB) has known that most fatal medical helicopter accidents occur when pilots unexpectedly encounter poor visibility or bad weather and become disoriented. Since

then, the board has urged the Federal Aviation Administration (FAA) to require improved safety equipment on medical helicopters, to little effect. “We’ve been killing ourselves the same way for 30 years,” says Ed MacDonald, lead pilot for PHI Air Medical, one of the nation’s largest helicopter ambulance operators.



**O**ne of the most important advances in medical helicopter safety should happen on the ground. Pilot Mark Bumstead decided it was safe to fly on an overcast night in February 2006 by walking outside and looking up, then quickly checking weather reports. He saw lightning and encountered clouds immediately after takeoff, and 3 minutes later crashed in Chesterfield, Ind. The NTSB found Bumstead’s

- ↑ The medical helicopter industry has more than quadrupled in size, from 200 craft in 1988 to 850 in 2009. The fatal-accident rate has remained the same.
- ↓ Three crew barely survived this crash in Chesterfield, Ind., on Feb. 2, 2006. An NTSB report released eight days earlier warned of loose safety standards.

## INDUSTRY SAFETY: HOW TO IMPROVE THE ODDS

*Medical helicopters crash unnecessarily every year. These four technologies could save lives.*

### Terrain Awareness

#### Incident

Ten feet higher and Steve Lipperer would have lived. The night sky over La Crosse, Wis., had fair visibility when Lipperer left La Crosse Municipal Airport on May 10, 2008, with a surgeon and nurse onboard his Eurocopter EC-135. Lipperer flew fast and low, using city lights to see. But dark fog concealed a 1160-foot ridge southeast of the airport. The helicopter slammed into trees atop the ridge. All three people aboard died.

#### Solution

**Terrain awareness and warning systems measure the distance to the ground and emit loud warnings if the pilot flies too low.** Older models, designed for airliners, gave helicopter pilots too many false warnings. New versions are specialized for low-flying craft; they should be mandatory. “We know these systems save lives,” Robert Sumwalt of the NTSB says. “This is not rocket science.”

### Night Vision

#### Incident

Pilots called it the “black void,” a section of night sky south of the Woodrow Wilson Bridge in Washington, D.C., where city lights faded into complete darkness. Pilot Joseph Schaefer flew into the void on Jan. 10, 2005, and became disoriented. Seconds later, his Eurocopter EC-135 slammed into the Potomac River. Flight nurse Jonathan Godfrey survived; Schaefer and a paramedic died.

#### Solution

Medical helicopters often fly at night at low altitudes and in poor weather, with little help from air traffic control. **By gathering and amplifying ambient light or using infrared imaging, night-vision goggles help pilots detect and avoid obstacles, even in low-light conditions.** “I flew without night vision for 35 years, and now I never fly at night without them,” pilot Ed MacDonald says.





preflight weather check “inadequate.”

In other crashes, pilots saw nothing but clear skies before takeoff, only to encounter storms midflight. Suddenly, they had to climb to a safe altitude, hunt for a map or consult GPS, radio for help, plan an escape from the cloud and look out the window for obstacles or a cloud break, all while watching the instruments to maintain steady flight.

Bunker’s accident happened near Washington, D.C., some of the world’s most highly monitored airspace. He depended on air traffic control to assist him in a dangerous situation. But when Bunker called Andrews and asked for turn-by-turn directions after becoming disoriented in fog, the controller told him she wasn’t trained for that. Fifty seconds later he dropped from the radar.

The nation’s aviation system was designed for high-altitude flights along planned routes. Traffic controllers help decide when it’s safe to fly. They use GPS and radar to warn pilots about bad weather ahead and can guide planes to

safe landings. But the system wasn’t built to track small weather events at low altitudes and in remote locations, where medical helicopters sometimes fly, says John Allen, director of the FAA’s Flight Standards Service. Air ambulances may land in canyons 50 miles from the nearest airport weather station, where intense storms have room to hide and air traffic controllers are powerless to help.

A 2006 NTSB report analyzing all air-ambulance crashes between January 2002 and January 2005 (air ambulances include small fixed-wing planes) found that improved flight risk assessment and dispatch and tracking systems could have prevented nearly half. “There’s universal agreement that we built a really safe flight system that goes airport to airport and flies high in the sky,” Judge says. “In the air medical world, we don’t have that.”

Every year the NTSB releases a “Most

**WORKING ONBOARD A MEDICAL HELICOPTER IS THE MOST DANGEROUS JOB IN AMERICA. “WE’VE BEEN KILLING OURSELVES THE SAME WAY FOR 30 YEARS,” ONE PILOT SAYS.**

Wanted” list detailing critical changes needed to make the nation’s waterways, railroads, highways and airways safer. Since 2008, mandating flight dispatch and tracking systems for medical helicopters has been on that list.

Although the FAA doesn’t require medical helicopter companies to install advanced safety technology or hire trained dispatchers, some operators choose to do it anyway. Voters in Maine have agreed to spend \$4 million since 2003 to install remote weather stations and GPS-based instrument approaches, improving safety for the state’s LifeFlight system. It has never had a serious crash.

Air Methods, the nation’s largest

**In-Flight Tracking**

**Incident**

The cloud that killed Wayne Kirby didn’t appear on radar. When Kirby left Huntsville Memorial Hospital in east Texas on June 8, 2008, the sky was clear. Two minutes later, he flew into small, dense clouds hovering over Sam Houston National Forest. With Kirby flying blind and disoriented and without an exit plan, the Bell 407 helicopter crashed, killing Kirby, a patient and two medical crew members.

**Solution**

Flight tracking centers can help pilots escape dangerous situations. Staff are equipped with direct data feeds from inside the helicopter, weather information overlaying digital topographical maps and the FAA’s HEMS Weather Tool, which tracks storms at airport weather stations and interpolates conditions in between. “We can see what’s going on and tell pilots exactly how to get out of there,” says Dennis McCall, aviation compliance manager of Air Methods.

**Data Recorders**

**Incident**

No one saw the helicopter carrying flight nurse Erin Reed crash into Puget Sound. The Agusta A109A hit a cold front as it flew north from Seattle on Sept. 29, 2005. But an investigation couldn’t determine whether the crash was caused by weather or some other factor, because the helicopter was not equipped with a black box to record flight data. Three people died. “We’ll never know what really happened,” says Stacey Friedman, Reed’s sister.

**Solution**

Black boxes record aircraft data such as airspeed and angle of flight. Some also capture video and audio from inside the cockpit. With this information, crash investigators could determine exactly what causes each crash and improve pilot training to avoid similar accidents in the future.

**PERSONAL SAFETY: WHAT YOU SHOULD KNOW**

**+** Should you turn down a rescue flight? Probably not. In a crisis, questioning the judgment of trained personnel could waste time, hurting your chance of survival. But you can take steps to protect yourself now, before disaster strikes.

Find out who provides helicopter emergency medical services (HEMS) in your community. Call the providers to ask if they use night-vision goggles, terrain awareness and warning systems and other safety gear recommended by the NTSB and if they’re accredited by the Commission on Accreditation of Medical Transport Services. If not, it may be wise to go by ground ambulance if you have a choice.

Check your insurance plan to make sure it covers ambulance and helicopter services. Also check the limits on coverage. If you decide to buy a special plan to cover air medical evacuation, find the company with the best safety record and equipment.

Before going on vacation, make sure your insurance covers emergency care where you will be traveling. Vet the HEMS provider at your destination with the questions above.



Flight nurse Jonathan Godfrey, who survived a crash in 2005, at a public hearing to review medical helicopter safety.



medical helicopter company, tracks all 313 to 330 of its aircraft from an operations control center in Englewood, Colo.

Operational control specialists watch flights using weather reports overlaid on digital topographical maps. If pilots experience weather or other problems, the staff can zoom in for a 360-degree look, patch themselves into pilots' headsets and discuss alternative routes.

"Once pilots get into a flight, there's really no way for them to get ongoing updated info," says Dennis McCall, aviation compliance manager of Air Methods. "We want to look over their shoulders and help them make decisions."

**W**hen the helicopter landed in his yard, Larry Strittmatter didn't think about the cost. His wife Dana had accidentally burned her leg with boiling water. Instead of driving her to one of six hospitals within 15 miles of their house near Fort Worth, Texas, paramedics called a helicopter to fly Dana to the Parkland Hospital Burn Center in Dallas.

Shortly after Larry arrived, the doctors gave his wife a bandage, a prescription for Tylenol with codeine and a swift escort to the lobby. The hospital refused to admit her for such minor injuries, leaving the Strittmatters with a \$17,000 flight bill. "The doctors said they were shocked and dismayed when they saw a helicopter landing," Strittmatter says. They had been in touch with EMTs at the scene, and after hearing Dana's injuries described had advised that she should be transported by ground ambulance.

In Arizona, 43 percent of patients transported by helicopter to hospital ERs were discharged within 24 hours, suggesting most didn't need a helicopter at all. In Maryland, the 24-hour discharge rate for patients transported by state police helicopters was 41 percent prior to 2008.

After Trooper 2 crashed, Maryland barred all but seriously injured patients from state helicopters, which it predicted would reduce the number of flights by 67.2 percent without affecting patient mortality. "If you're getting close to a 50 percent discharge rate within 24 hours, I think that's too high," says Dan Hankins, an emergency-medicine physician at the Mayo Clinic and president of the Association of Air Medical Services.

Academic studies disagree on whether medical helicopters improve EMS response times and patient survival rates. Besides severity of injury, the key factor may be flight time. Helicopters are significantly faster than ground ambulances when retrieving patients more than 45 miles away from a hospital, according to a study published in the *Journal of Trauma* in 2005. But closer than 45 miles, ground vehicles are just as fast—or faster—than helicopters, because helicopter crews need more time to start engines and secure equipment.

Efforts are under way to improve training for paramedics on whether or not to request helicopter transports, Bledsoe says. Meanwhile, industry insiders say that medical helicopters are overused because, in too many cases, money

trumps medicine. There were 330 medical helicopters in the United States in 1997 when Congress mandated new Medicare reimbursement rates for air ambulances. Since then, the number of helicopters has nearly tripled, to 850. The industry's explosive growth is a direct result of Medicare's pay raise, says Deborah Hersman, chairman of the NTSB.

Missouri has 5.9 million people and 33 medical helicopters. Canada has 33.4 million people and 20 medical helicopters. "In many places, the [motivation] isn't medical necessity," LifeFlight of Maine's Judge says. "It's to find ways to put more people in helicopters, because otherwise we're not going to make enough money to stay in business."

**O**n Jan. 10, 2005, Jonathan Godfrey was on duty as a flight nurse when his Eurocopter EC-135 medical helicopter, flying low and fast over Washington, D.C., entered a dark area south of the Woodrow Wilson Bridge that pilots referred to as the "black void." Twenty seconds later, he woke up on the bottom of the Potomac River, still strapped to his seat. After groping for the belt, Godfrey popped to the surface, and an hour later Trooper 2—the same helicopter that would crash near Andrews in 2008—picked him up, a broken bone poking through the arm of his flightsuit. Two others, the pilot and a flight paramedic, died.

Night-vision goggles, scheduled for installation on Godfrey's helicopter, hadn't yet been delivered. Pilots agree that goggles make a difference. In a 2008 survey by the National EMS Pilots Association, 88 percent of 382 pilots said using night-vision goggles "provides a significant safety advantage." But 40 percent said their companies didn't supply them. In the survey's comment section, one pilot says of the years he spent flying at night over the mountains of Kentucky, "We must have been out of our minds."

Of the 55 crashes reviewed in the 2006

CONTINUED ON PAGE 123





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## Cookout à la Cart

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diy

## Home

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After the feast, the slide-out pans, the cutting board and the condiment tray come inside for cleaning while the cart stays outside with your grill.

### What You'll Need

Our cart is built of vertical-grain red cedar, a rot-resistant wood that's easy to work with. To build exactly what we've got here, you will need a table saw and, ideally, a portable planer. Those attractive red cedar slats that form the shelves start out as ½-inch-thick pieces ripped from a cedar 2 x 4 using a table saw. They are then planed or sanded. You'll also need a biscuit joiner to bind the top pieces and a router to put a gentle curve on each slat edge and around the hole in the cutting board.

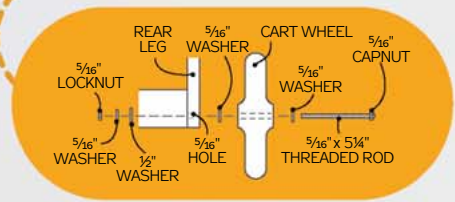
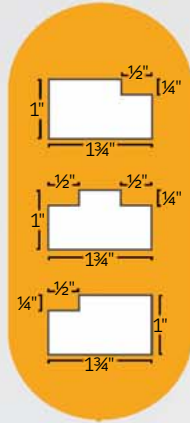
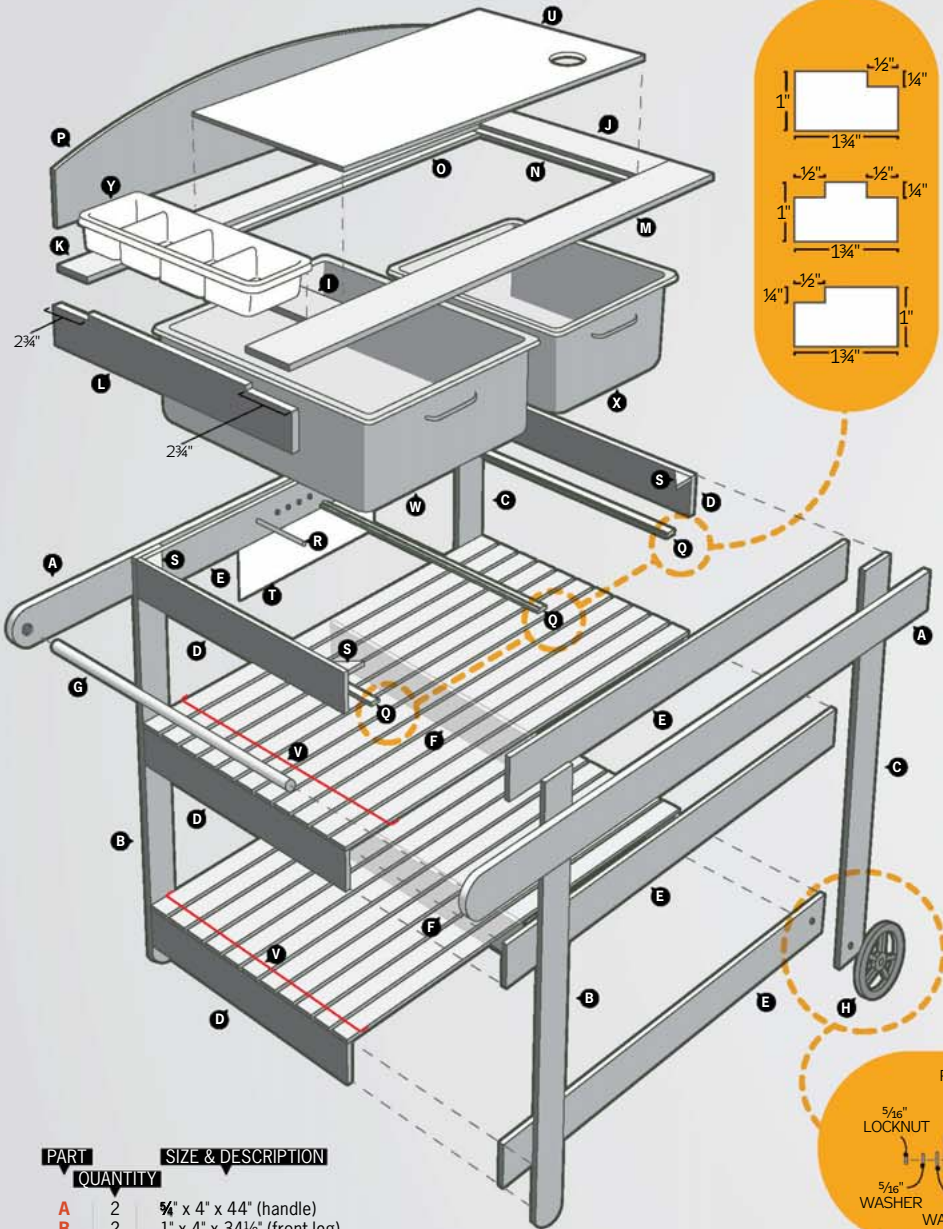
That's a lot of equipment to build a little cart. Suppose you don't own those tools—simplify. Use a circular saw and edge guide and substitute dowels or pocket screws for biscuits. To avoid planing, make the slats from 1 x 2 cedar or have an old-fashioned lumberyard plane the material for you.

INSIDE

FRONT-DOOR UPGRADE + FLAGPOLE HOW-TO + WORKSHOP LIGHTING

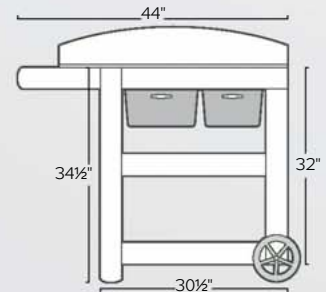
## COOKOUT ON A ROLL

The PM cookout prep station is all about efficiency—in use and construction. Most of the cart is simply 1 x 4 lumber. In other cases it's dimensional softwood, such as a 1 x 6, that's ripped to width. It's a great project for an ambitious beginner.



PART	QUANTITY	SIZE & DESCRIPTION
A	2	5/4" x 4" x 44" (handle)
B	2	1" x 4" x 34 1/2" (front leg)
C	2	1" x 4" x 32" (rear leg)
D	6	1" x 4" x 22" (frame end)
E	6	1" x 4" x 30 1/2" (frame side)
F	2	1" x 4" x 20 1/2" (frame, stretcher)
G	1	3/4" dia. x 24 1/4" (steel handle)
H	2	8" dia. (cart wheel)
I	1	1" x 4" x 17 1/8" (top, center) (actual width is 4"; rip from 1 x 6)
J	1	1" x 4 1/4" x 17 1/8" (top, end) (rip from 1 x 6)
K	1	1" x 3" x 37 1/4" (top, back) (rip from 1 x 4)
L	1	1" x 4" x 23 1/2" (top, stretcher)
M	1	1" x 4 1/4" x 37 1/4" (top, front) (rip from 1 x 6)
N	2	1" x 1 3/4" x 20 1/2" (top, cleat) (rip from scrap or 1 x 4)
O	2	1" x 1 3/4" x 22 1/4" (top, cleat) (rip from scrap or 1 x 4)

PART	QUANTITY	SIZE & DESCRIPTION
P	1	1" x 6 1/4" x 37 1/4" (backsplash) (cut from 1 x 8)
Q	3	3/4" x 1 3/4" x 22" (pan runners)
R	6	3/8" x 2 1/2" (dowels)
S	4	1" x 2 1/4" x 2 1/4" (corner block)
T	2	1/8" x 8" x 14" (knife shield)
U	1	3/4" x 17 3/4" x 23 3/4" (cutting board)
V	22	3/8" x 1 1/2" x 31 1/8" (shelf slats)
W	1	6" x 12 3/4" x 21" (large pan)
X	1	6" x 10 1/2" x 12" (small pan)
Y	1	3" x 5" x 18 3/4" (condiment tray)







#### CONSTRUCTION NOTES

##### 1. Clamp, then screw

Crosscut the parts for the three frames. Clamp the parts together and bore countersunk pilot holes. Apply waterproof glue to the joint to add a little strength and to seal the end grain. Next, drive 1¼-inch galvanized or stainless-steel screws into each joint.

##### 2. Install the legs

Crosscut the two rear legs, apply waterproof glue to the joint and fasten the legs using 1¼-inch screws driven into pilot holes.

##### 3. Add safety

Make a knife shield from two pieces of acrylic plastic cut to shape with a jigsaw. Drill and countersink three screw holes into each piece. Then screw one to the outer surface of the upper frame. Attach the other to the inner surface of the wood handle.

##### 4. Hide the screws

Fasten the cart's wood handle to the upper frame with glue and deck screws. Drive the screws from the back so they'll be hidden. Make sure that the square end of each handle is flush with the rear legs.

##### 5. Dowels make knife slots

To create five partitions to hang knives, start by drilling six holes through the upper frame and both acrylic panels, and into (but not through) the wood handle. Insert a dowel into each hole, then trim it flush.

##### 6. Rip the slats

Rip the slats from a cedar 2 x 4 and sand or plane them smooth. Shape their top edges with a router and a rounding-over bit. Using a pneumatic finish nailer, fasten the slats to the frame, spaced ⅝ inch apart.

##### 7. Build the top

Rip and crosscut the top parts and test fit the cutting board in it. Next, use glue and biscuits to assemble the top and clamp the assembly. Screw the cleats to the bottom of the assembly.

##### 8. Add runners

With the cart upside down, screw on the runners, which will support the two stainless-steel pans.

##### 9. Fasten the backslash

Rip and crosscut the backslash from a cedar 1 x 8, then cut the gentle top curve using a jigsaw. Finally, fasten it by driving deck screws through pilot holes into the back of the top assembly.



## Homeowners Clinic

by Roy Berendsohn

Q+A

WORK BETTER

### Door Prize

*A door that's clean and well cared for provides a welcome entrance to your home.*

#### Brush

→ Use a siding brush. Its long, soft bristles do a good job of scrubbing off dirt, and they're flexible enough to follow contours.

#### Wash

→ The cleaning solution will slop over onto the lawn, so I use a biodegradable product like Simple Green All-Purpose Cleaner. Wipe the back of the door to remove drip marks.

#### Hinge

↓ Take out the hinge pins with a drift punch. Do the center hinge last.



## Front-Door Upgrade

**Q** I have a metal front door and I'm wondering about how to clean or paint it. Is it easier to do this work with the door on its hinges, or should I take it off? Also, the kickplate is tarnished. Can I replace that? I don't see any screws holding it in place.

**A** Yes, take the door off its hinges. Lay it on some sawhorses with old towels or pieces of carpet on them to protect the inside face of the door.

If the door is weather-beaten, cleaning won't be enough to restore its luster.

You'll have to paint it. First, remove the kickplate. There are three ways these plates are held: with a magnetic strip, with screws or with a peel-and-stick backing. The last is the most difficult to remove. Some of these plates are very strongly bonded. Test one corner. If you can't take up the plate with a putty knife, you're probably better off just screwing the new plate on top of the old. Whichever type of kickplate you choose, wait until you're done painting the door to install it. For the ultimate in weather





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resistance, choose a kickplate with a PVD (physical vapor deposition) coating.

Next, clean the door with a soft-bristle siding brush and a gentle household cleaner dissolved in warm water. Rinse the door and let it dry. Use masking tape to protect door hardware or remove the hardware before applying primer.

If the door's paint is severely faded and it has developed a dusty film, known as chalk, use an alkyd primer applied with a 2½-inch trim brush and a small velour paint roller. If the door is only moderately weathered, use an acrylic primer. Whichever primer you choose, use an exterior-grade one. If the door is dented, use an exterior-grade metal filler such as Bondo or a multisurface material such as DAP CrackShot Spackling Paste. Sand the filler smooth and prime the filled surface with an acrylic primer.

Topcoat the door with two coats of acrylic gloss or semigloss trim enamel. For the ultimate in a smooth finish, lightly wet-sand the first coat with waterproof sandpaper (800- to 1100-grit), wipe the door clean, and, when it's dry, apply the second coat.

Finally, if the door has a worn internal weatherstrip, remove and replace it.

## Popping Bricks

**The faces pop off the bricks on my house's chimney. What causes that, and what can I do to stop it?**

The condition is called spalling, and it's the result of trapped moisture. There are two causes. One is that the chimney's masonry cap is cracked and admitting moisture, which leaks down into the chimney wall. The brick and mortar absorb the moisture; when it freezes, the expansion cleaves the face off the brick.

The other source of the problem is common on very old chimneys on which an inappropriate portland cement mortar was used for repair work. Old mortars (pre-1870) are much softer than the modern equivalent because they are made with a large proportion of lime, not portland cement. Repairing the chimney with a harder portland cement mortar

will trap moisture, resulting in the condition described above. It can also create a bond that is much harder than the brick itself. When the brick expands because of temperature and moisture, it can crack as it gets squeezed between the rock-hard mortar joints.

Begin the repair process with a thorough inspection of the chimney. A cracked cap will be obvious, as will repaired mortar joints, which are a different color and texture than surrounding mortar. You'll need to replace damaged bricks by cutting them out and installing new ones, along with the appropriate mortar. It's a tremendous amount of work, but the alternative is to allow the chimney to continue to crumble.

## Edge Banding

**I know this is a simple question, but what is the best way to attach solid-wood edge banding to a shelf made of ¾-inch maple-veneer plywood?**

"The fastest and most accurate way to do this is not to measure," PM contributing editor Joe Truini says. "Mark the edge band directly from the shelf, and transfer the measurement from the back of the piece to its front using a combination square. Then cut on the mark, front to back. If any splintering occurs, it will be on the back." And Joe should know. As a former finish carpenter and cabinetmaker, he's installed miles of edge banding in his career.

Next, to attach the edge banding, Joe first wipes a thin layer of carpenter's wood glue on the edge of the plywood, then uses a pneumatic finish nailer and 18-gauge nails that are 1½ to 2 inches long. "Keep the nails at least 1½ inches from the ends of the piece to avoid splitting," Joe advises.

If you hand-nail the edge band to the plywood, predrill the nail holes, apply carpenter's glue and use 4d finish nails to attach the pieces. Carefully set the nailheads, overfill the cavity slightly, and sand the filler smooth with 120-grit sandpaper. Select the filler's color,

*Continued on page 96*

HOW YOUR HOUSE WORKS:  
→ Tankless Water Heater

# Tankless Job

FOR HOT WATER APLENTY FROM AN INFERNO THE SIZE OF A SUITCASE, GO TANKLESS.

BY HARRY SAWYERS

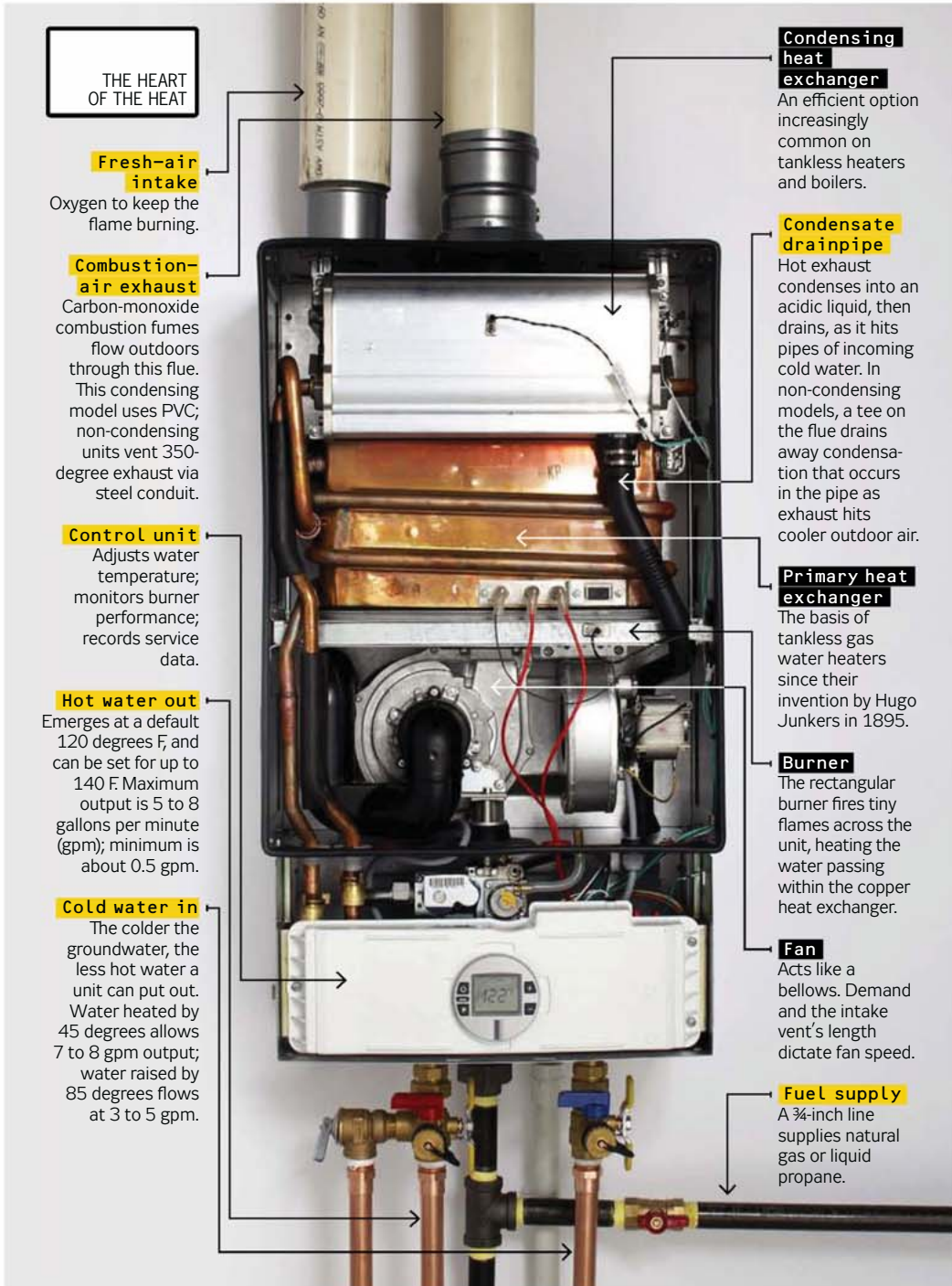
→ Tankless water heater advocates are quick to criticize the cylindrical tenants of American basements. "It's a soup can on a candle," tankless manufacturer Takagi's Eric Muff says. It's true that tankless heaters' endless hot water and incendiary Btu ratings are impressive. Efficient new condensing models recycle heat that would be wasted as exhaust. Some machines' settings can even be altered via remote control. But tankless tech isn't for everybody. Hard water tends to jam the machinery, and urban layouts can make the necessary venting impossible. So it's no surprise that contractors typically install tried-and-true tank-style heaters. But a little learnin' can fix that. Here's how to know if tankless works for you.



### INSIDE

→ COPPER COMBUSTION CHAMBER  
→ FUEL-SUCKING VENTURI → PRICE BREAKDOWN → INTAKE, EXHAUST  
→ FIRE BURNING AT 2200 DEGREES





**THE HEART OF THE HEAT**

**Fresh-air intake**

Oxygen to keep the flame burning.

**Combustion-air exhaust**

Carbon-monoxide combustion fumes flow outdoors through this flue. This condensing model uses PVC; non-condensing units vent 350-degree exhaust via steel conduit.

**Control unit**

Adjusts water temperature; monitors burner performance; records service data.

**Hot water out**

Emerges at a default 120 degrees F, and can be set for up to 140 F. Maximum output is 5 to 8 gallons per minute (gpm); minimum is about 0.5 gpm.

**Cold water in**

The colder the groundwater, the less hot water a unit can put out. Water heated by 45 degrees allows 7 to 8 gpm output; water raised by 85 degrees flows at 3 to 5 gpm.

**Condensing heat exchanger**

An efficient option increasingly common on tankless heaters and boilers.

**Condensate drainpipe**

Hot exhaust condenses into an acidic liquid, then drains, as it hits pipes of incoming cold water. In non-condensing models, a tee on the flue drains away condensation that occurs in the pipe as exhaust hits cooler outdoor air.

**Primary heat exchanger**

The basis of tankless gas water heaters since their invention by Hugo Junkers in 1895.

**Burner**

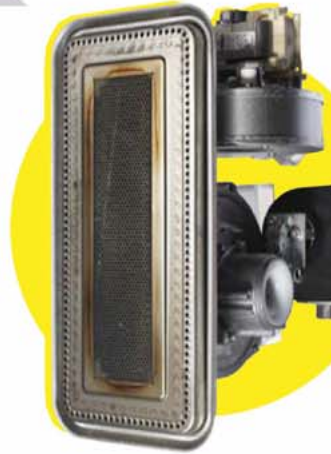
The rectangular burner fires tiny flames across the unit, heating the water passing within the copper heat exchanger.

**Fan**

Acts like a bellows. Demand and the intake vent's length dictate fan speed.

**Fuel supply**

A 3/4-inch line supplies natural gas or liquid propane.



**Burner and fan**

→ Fuel and air simultaneously enter the burner, which sets the mixture aflame at 2200 degrees F. In this Bosch GWH C 800 ES, a venturi meters the fuel intake and a variable-speed fan regulates air.



**3 WAYS A TANKLESS PAYS**

**MASSIVE DEMAND**

→ A dormitory can use 15 showers simultaneously and never run out of hot water.



**VACATION HOMES** → Why heat a tank of water all month if you're only going to use it one weekend?



**SPACE-SAVING**

→ Sometimes water heaters are in the way—say, when installed in a rental apartment's kitchen. A wall-mounted tankless machine frees up wasted floor space.



**Primary heat exchanger**

→ Water gets hotter as it passes back and forth through this copper honeycomb combustion chamber. Heat flows from the flames to the fluid through a stack of slim fins sitting straight above the burner.

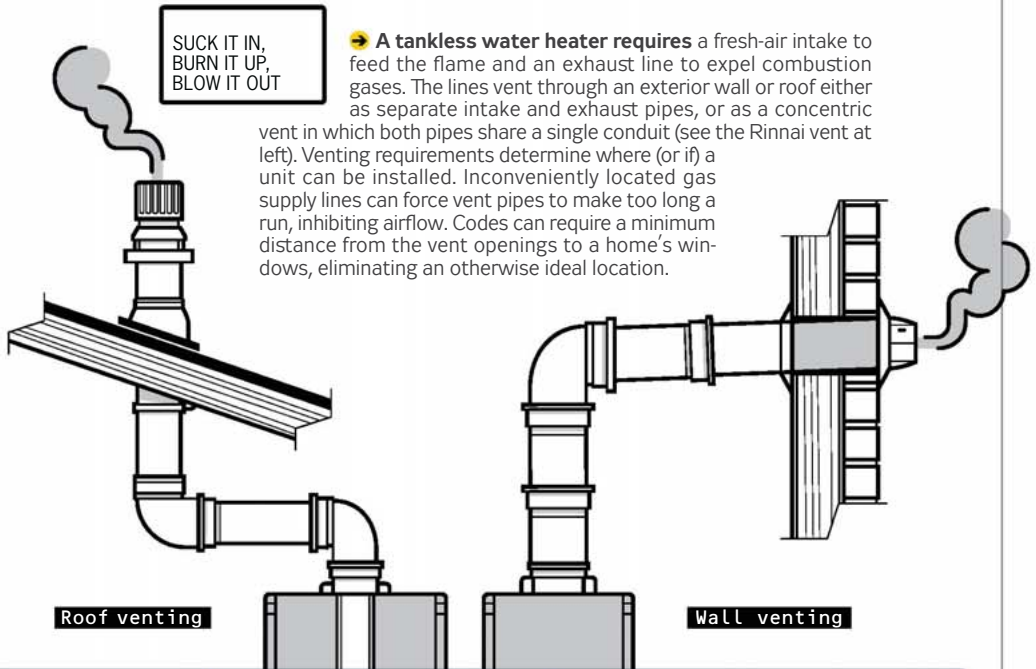


**Condensing heat exchanger**

→ Maximizes efficiency by using 350 F exhaust gases to preheat cold water before it enters the primary heat exchanger. The gas exits at below 150 F, cool enough to pass through PVC.

**COST & CONSUMPTION COMPARISON**

TANK	TANKLESS
capacity (gallons)	
40 (GAS), 52 (ELECTRIC)	UNLIMITED
typical cost of unit	
\$337 (G), \$312 (E)	\$750-\$1800
average full-tilt burn rate	
40,000 BTU (G) 15,354 BTU (E)	179,000 BTU
average standby fuel loss	
350-500 BTU/HOUR (G) 150-200 BTU/HOUR (E)	0 BTU
typical life expectancy	
12 YEARS	20 YEARS
approximate annual operation costs	
\$281 (G) \$492 (E)	\$223
typical size (pounds; cubic inches)	
320; 14,765	50; 3640



**3 WAYS IT TANKS**

**HOT TRICKLES** → Some heaters "sandwich" pockets of cold water when a small hot-water draw doesn't fully fire up the tankless flame.

**TIGHT VENTS** → Urban row houses present venting challenges—if you can't run a short chase out the back, forget about it.

**HARD WATER** → Calcification plagues heat exchangers in hard-water areas. Residents must soak parts in vinegar or install a water softener.



There's nothing half  
so pleasant as  
coming home again.  
—Margaret Elizabeth Sangster

Jack 2-10  
Jane 11-18  
Jack 6-29  
Jane 11-27  
Jack 11-18  
Jane 11-27  
Jack 11-27  
Jane 11-27

## There's a reason homeownership is the foundation of the American Dream.

Over time, owning your home has proved to be a good decision. And while lately the economy has presented some challenges, it has also helped us focus on what matters most. It's reminded us that home is where we make memories, build our future and feel comfortable and secure. When you're ready, a REALTOR®, a member of the National Association of REALTORS®, can help you find the home that's right for you. REALTORS® are prepared—to answer your questions, show you options and guide you home.



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Continued from page 92

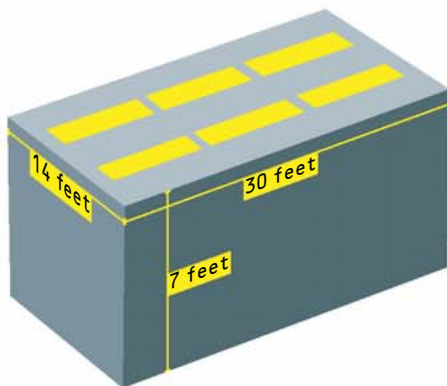
keeping in mind that it will darken slightly after the finish is applied.

It's also worth noting that the joint between the shelf and the edge band has to be perfect. There are many ways to ensure that both the shelf edge and the edge band are straight, square and smooth. One of the easiest is to rip the plywood and edge banding to rough size with a combination blade, then clean up the edge on the table saw using a glue-line ripping blade. This should produce perfect mating surfaces. Still, whatever method you use, first make some test pieces. You want to work out any problems before committing the project to glue and nails.

## Lighten Up a Dark Garage

**The lights in my garage don't do the job. It's a 14 x 30-foot building with four two-bulb fluorescent fixtures, each 4 feet long, running lengthwise down the center of the 7-foot-high ceiling. The walls and the ceiling are bare wood framing. How many fixtures should I add? Will it help if I paint the wood white?**

Adding more light is easier than painting bare wood framing or covering the ceiling with drywall. Investigating how much



**DIMENSIONS:** 14' x 30' x 7'  
**CEILING REFLECTIVITY:** 20%  
**WALL REFLECTIVITY:** 20%

Six fixtures = 49 foot-candles



■ WHEN DISASTER STRIKES



## How to Save Your Home From a Wildfire



**As wildfire season looms** in California, homeowners can take solace knowing that the last decade's devastating blazes have led to the adoption of strict, statistically effective house- and life-saving building codes. Per these code changes, which appeared in 2008 for wildfire-prone regions statewide, a marketplace has developed for blaze-beating construction materials. "Some of the products are new, and others, such as clay roofing tiles, have

been modified through the addition of fire retardants," says Steve Quarles, a University of California cooperative extension advisor. Combined with vegetation management to reduce flammable material near the home, these items can make a real difference in the Golden State and elsewhere in helping homes survive a wildfire. —ADAM HADHAZY

light you need, I found that the references I keep here in the office weren't much help. When my search for a direct answer ground to a halt, I called Dave Canio, a salesman at Enterprise Lighting Sales in New York City. "Don't guess," he said. "Use a lighting calculator to find out what your reader really needs."

With that tip, I went looking for lighting calculators on the Web. The most helpful and specific one I found was at Cooper Lighting; it allows you to enter the dimensions of the space and adjust all the variables in it, such as reflectivity.

Looking under the industrial version of the company's Metalux brand, I entered the dimensions of your garage. It showed that your setup of four two-bulb fixtures, right up the center of the garage, would provide 42 foot-candles of lighting. That's acceptable, but not great; 50 foot-candles would be better.

The calculator also showed that the illumination depended on having the ceiling reflect 80 percent of the light and the walls reflect 50 percent. That's an unrealistically high amount of reflectivity

for wood framing. When I cut the ceiling reflectivity to 20 percent, it called for adding a fifth fixture. When I also cut the walls to 20 percent, the calculator showed that six fixtures are needed—three evenly spaced lights in two rows running down the length of the garage.

Sure, adding fixtures is adding cost, but the good news is that this design provides 49 foot-candles of illumination, a better level of light for a work space.

## Check the Oil

**The owner's manual for my tractor isn't clear about whether I need to screw the dipstick all the way down to check the oil. Do I?**

Many manufacturers, such as Troy-Bilt, for example, recommend that you remove the dipstick, wipe it clean, screw it all the way down and then unscrew it to check the oil level.

Still, the lack of clarity in owner's manuals is annoying, and it isn't confined to small-engine equipment. When I asked PM senior auto editor Mike Allen about it, he said that ambiguity in oil-



**REACTIVE ATTIC VENTS** → Studies of homes destroyed by fires have shown that the biggest chink in a home's armor is often the air vents from an attic that let in burning embers. Vulcan Vent, made by Gunter Manufacturing, keeps the embers out by using a special coating that swells a vent's air-admitting cells shut when exposed to heat. Vulcan Vent's coated, self-closing, ¼-inch-honeycomb aluminum is also available by the sheet, so homeowners can custom-cut retrofits for their existing vents.

**DECKING ON DEFENSE** → For Californian homes built after 2008 and those undergoing major deck renovation projects in some jurisdictions, codes now require decking materials to pass flame-spreading and "under-flame" tests. Trex, a company based in Winchester, Va., now makes a line of wood-plastic deck boards called Accents: Fire Defense, which exceed these tough fire regulations. An eco-friendly, proprietary additive in the product allows the deck boards to withstand flames and causes them to self-extinguish in high heat.

**COVERS FOR GUTTERS** → Another vulnerable spot for wildfire-threatened homes is debris-strewn roof gutters. Code mandates that gutters be free of flammable tree litter. Building officials in the field have interpreted this to mean that gutters must be covered, Quarles says. One option is the Gutterguard, a hardened, anodized aluminum frame that completely caps a gutter. Its stainless-steel filtering mesh excludes pine needles and leaves, easing cleaning and allowing rainwater to drain.

**FLAME-BLOCKING GELS** → Before a wildfire forces evacuation, homeowners can spray down their homes with products such as Barricade's Fire Blocking Gel. This absorbent polymer, sprayed from a jug attached to a garden hose, traps water molecules in a bubble-like suspension that shuts out flames and heat. The protection lasts up to 36 hours on treated walls, windows and roofs, then washes off with water. To effectively use these gels as part of a fireproofing plan, combine with fire-retardant roofing, siding, doors and windows—plus vegetation management. "These things can work," Quarles says. "They can certainly help."

check procedures—as well as the lack of an auto-industry standard—creates a small but steady stream of mail from readers asking him about this.

## Killer Trees

**I have about 5 acres of woods, and, thanks to wood-eating insects, I don't have to cut up any standing trees for firewood. Trouble is, not all the trees make it to the ground. Some get hung up and lean at a 45- to 60-degree angle. How can I take these down?**

There's virtually no safe way for an amateur to take down such a tree. It's not that we've suddenly become risk-averse at PM. Many of our readers own and use firearms, fell trees, drive fast cars and fly planes that they've built. But some jobs are so inherently dangerous that they are best handled by professionals in almost all situations. That's what you've got here, unfortunately. Trees that get hung up as the result of a wind storm, insect damage, fire or ice are among the most difficult to deal with, and the forestry industry spends a lot of its time

teaching professionals how to remove them. Foresters call them widowmakers, killer trees, hazard trees and a few names we can't print here.

So what should you do? Well, pros sometimes make a wedge-shaped cut in the trunk that gets the tree to fold in on itself. That can cause the tree to fall free of the hang-up. It's among the most dangerous cuts a logger can make. Other times they use a log skidder, a winch, a tractor or an earthmover to drag the tree so that it falls free of obstructions.

Having a forester do this will be more expensive than the value of the wood. But it will create a safer woodlot, one you can enjoy, not avoid. **PM**

### Got a home-maintenance or repair problem? Ask Roy about it.

Send your questions to [pmhomeclinic@hearst.com](mailto:pmhomeclinic@hearst.com) or to Homeowners Clinic, Popular Mechanics, 300 W. 57th St., New York, NY 10019-5899. While we cannot answer questions individually, problems of general interest will be discussed in the column.



## RAISE YOUR HOMEOWNER IQ.

Go to [HouseLogic.com](http://HouseLogic.com) for smart ways to manage, maintain and enhance your home.

HouseLogic provides free info and tools to help you become an expert in areas like home improvement, maintenance, taxes, finance and insurance. Learn how to protect and increase the value of your home by becoming a more confident homeowner.



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Save \$350 a year by sealing air leaks.



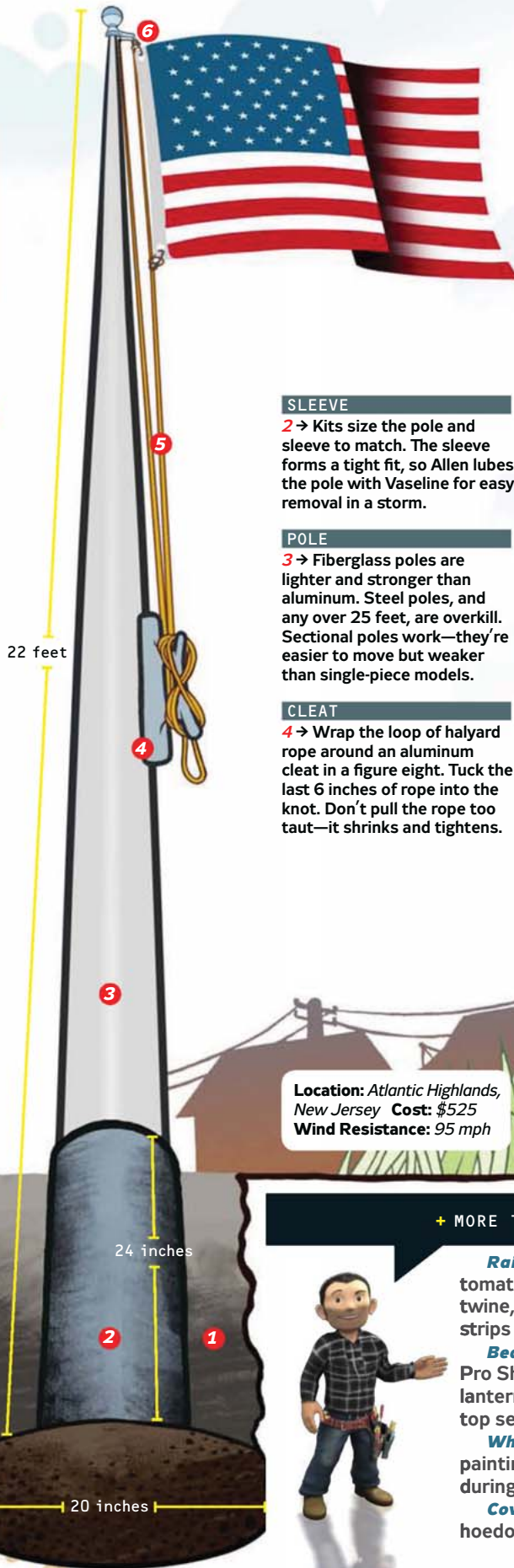
+ ONE-DAY PROJECT

# Plant a Flagpole

WHEN PM SENIOR AUTO EDITOR MIKE ALLEN BOUGHT HIS HOUSE ON THE JERSEY SHORE, THE FLAGPOLE OUT FRONT LEANED LIKE THE MEMORIAL TO IWO JIMA. HERE'S HOW HE GOT IT TO STRAIGHTEN UP AND FLY RIGHT.

### FLAGPOLE HOLE

**1** → Allen started from scratch with a new hole and fresh concrete. Pro flagpole installer Tony Clayton recommends planting the pole as Allen did: by sinking 10 percent of the pole's height into a PVC sleeve. A 6-inch crushed-stone setting bed and an 80-pound bag of ready-to-mix concrete hold the sleeve in place. Set the pipe on gravel, add half the mixed concrete, and plumb the sleeve with a 4-foot level, reading the level flush against two points in the sleeve. Add the rest of the mix, check plumb while tamping the concrete, and wait 48 hours.



### SLEEVE

**2** → Kits size the pole and sleeve to match. The sleeve forms a tight fit, so Allen lubes the pole with Vaseline for easy removal in a storm.

### POLE

**3** → Fiberglass poles are lighter and stronger than aluminum. Steel poles, and any over 25 feet, are overkill. Sectional poles work—they're easier to move but weaker than single-piece models.

### CLEAT

**4** → Wrap the loop of halyard rope around an aluminum cleat in a figure eight. Tuck the last 6 inches of rope into the knot. Don't pull the rope too taut—it shrinks and tightens.

### HALYARD

**5** → Use double-braid marine-grade nylon rope, not single. Join rope ends in a sheet bend between the flag clips to stop the rope knot from snagging in the pulley. The slack should dangle just above the ground.

### CLIPS + FLAG

**6** → Clayton hangs the flag on plastic clips or sheathed metal clips. "Otherwise, the clanging will drive you crazy," he says. Site the pole with power lines and branches at least 5 feet from the extended flag's edge.



**Location:** Atlantic Highlands, New Jersey **Cost:** \$525  
**Wind Resistance:** 95 mph

+ MORE TO DO IN JULY



- Raise Stakes** → Support ripening tomato vines by tying them, using twine, jute or old nylons, to 1 x 2 furring strips driven 12 to 14 inches into soil.
- Beat Bugs** → Larry Whiteley of Bass Pro Shops says portable ThermoCell lanterns, holstered in a belt clip, are a top seller in skeeter season.
- Whitewash** → Win the annual fence-painting competition in Hannibal, Mo., during Tom Sawyer Days on July 1–4.
- Covet Rides** → At the annual hot-rod hoedown in Saugerties, N.Y., July 11.

CHARACTER BY AXEL DE ROY; THANKS TO HEAD'S FLAGS, TAMPA, FLA.



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170 pc SET



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This gear-reduction starter (top) is a lightweight drop-in replacement for the older starter that failed. By spinning the armature faster and reducing its output speed with a planetary gearbox, it's possible to get the same starter power in a smaller, lighter package.

diy

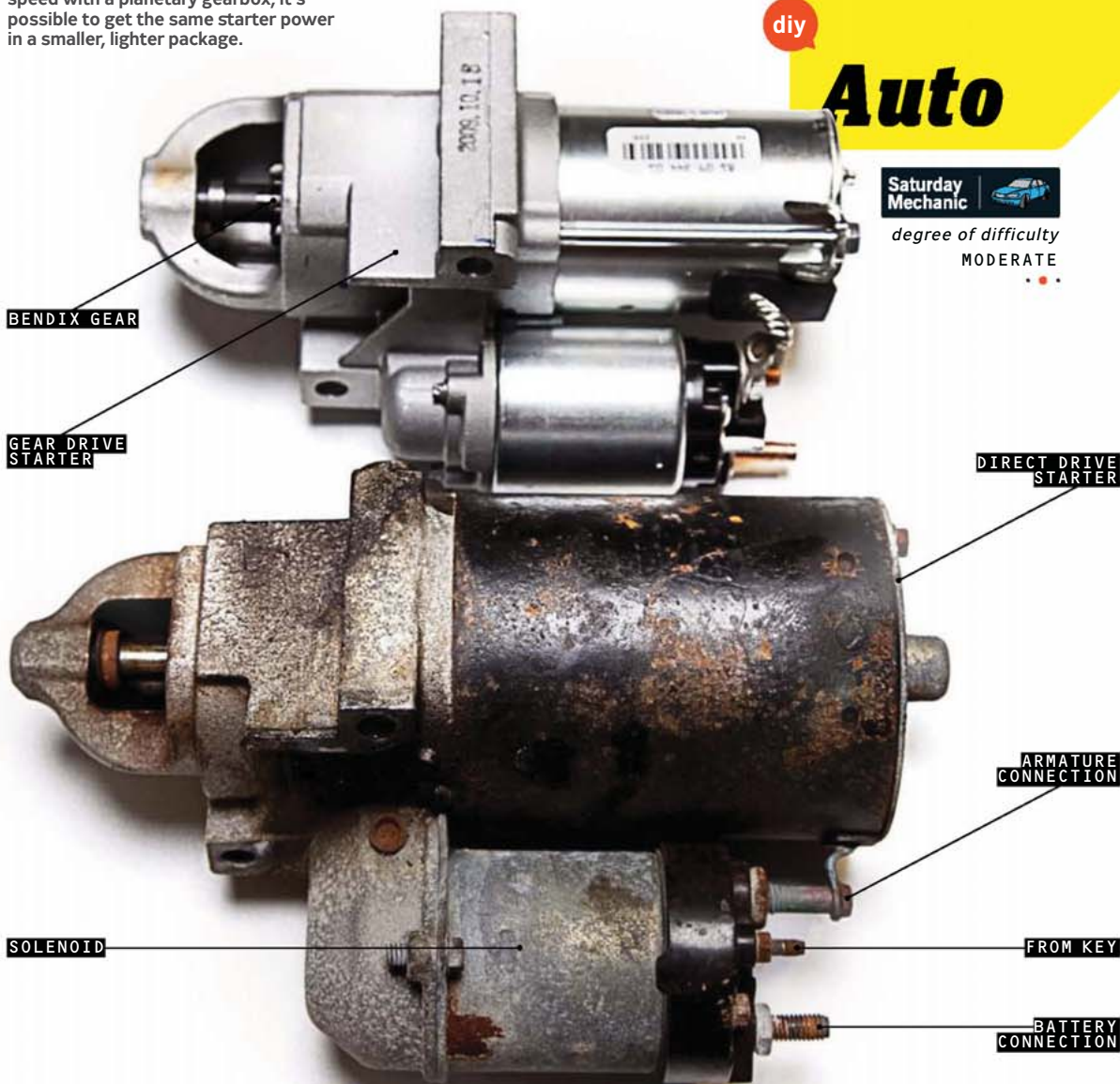
# Auto

Saturday  
Mechanic



degree of difficulty

MODERATE



## Start Me Up

REPLACING A STARTER MOTOR IS USUALLY A STRAIGHTFORWARD BUT INCONVENIENT JOB. BY MIKE ALLEN

→ **Click. Click. Click.** That's the noise your car makes when you twist the key. A few more clicks and now you've got a metallic screeching that makes all the dogs in the neighborhood start to bark. The dash lights are plenty bright, the headlights don't dim much when the key is twisted, but obviously something is wrong. With the clock

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## PM DIY AUTO /// STARTER MOTORS

ticking, you resort to that old standby: a jump-start. A few more screeches grating enough to make you cringe, and the engine finally spins merrily.

After work, it's the same story: Clunking and clicking, a few bars of the "Ballad of the Tortured Ring Gear," and you get to drive home instead of ride in the cab of the tow truck.

You've got a bad starter motor. Time to fix it before you're on the bus.

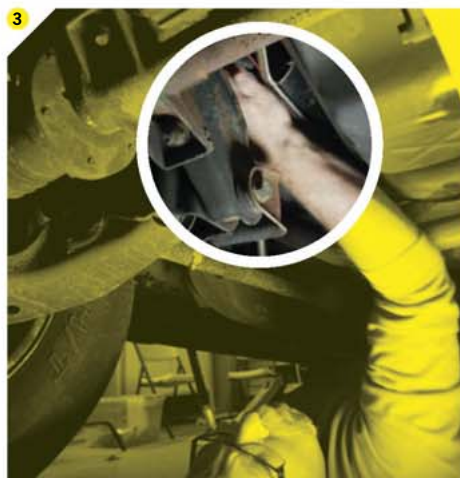
### The Way It Works

→ **Saturday morning you** give your battery and charging system a full investigation. Even swapping in the new battery from your other car doesn't help.

Nope—the screeching has become the only symptom you can elicit. That ban-shee wail is the teeth on the starter motor's bendix gear clashing against the ring-gear teeth because it's not completely engaged.

The solenoid, or on some starters, just a threaded part of the armature, pushes the bendix gear forward an inch or so until it meshes with the ring gear, allowing the starter motor to spin the engine over until it starts. When the engine rpm exceeds the cranking speed, the bendix automatically retracts, preventing the engine from spinning the starter too fast.

At least that's how it works in theory. Starter motor failure is rarely caused by a blown or shorted motor itself—usually it's a problem with the bendix



**1.** Yes, there's a starter motor hiding up there. On most front-engined vehicles like this Suburban, it's well and truly buried under and behind the engine and next to the transmission.

**2.** Prepare to get dirty and uncomfortable getting it out. Front-wheel-drive cars with sideways-mounted engines may have the motor mounted above the trans, where you can reach it from above.

**3.** If you have ramps, they should provide enough clearance. If you need to jack up the car, use jackstands and chock the wheels. Stuck off-road? Dig a trench under the vehicle to crawl into, which is actually not horrible if it's dry.



1

More auto manufacturers choose Mobil 1 as factory fill than any other oil.



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mechanism or the solenoid. And frankly, most people will never need to replace a starter motor for the life of their vehicle. Intrepid but underfunded Saturday Mechanics might actually dismantle a malfunctioning starter and repair it themselves. You can still find auto parts stores that can get you new bearings, brushes and bendix assemblies. Generally, I just exchange the old starter for a new or remanufactured one, because

repairing one doesn't save much money. On the other hand, if you have a rare or hard-to-find starter it might be necessary to fix what you have. Usually, auto electric shops can rebuild or repair a starter with a bad armature, shorted field windings, bad brushes, a bad commutator, or even a bad solenoid if there is no alternative. Be prepared to wait a few days or more.

### Is Your Starter Motor Really Bad?

→ **Before you get all greasy** under the car, here are some tips for diagnosing a bad starter:

1. If you twist the key and the dash lights come on dimly, the solenoid buzzes or clicks, or nothing at all happens, it may well be the battery or the cables, not the starter motor. Charge the battery. Your voltmeter should read at least 12.6 volts with no electrical drain on the battery and the charger disconnected for an hour.

2. Check the battery capacity. I use a resistance-type battery load tester. A good, charged-up battery should deliver 150 amps for 15 seconds without dropping below 10.5 volts, and should recover nearly to the aforementioned 12.6 volts within a minute.

3. If the battery checks out okay, look for poor electrical connections to the starter or solenoid, as well as the battery and chassis connections. Accept no more than a 0.5-volt voltage drop between the battery post and the starter hot post. Ditto between the battery negative post and the engine block.

4. Bottom line, there should be 9 to 10 volts at the starter motor hot post when cranking. Don't forget to put the car in neutral or park and block the wheels so you don't run yourself over.

5. Battery cables okay? Try jumping—with jumper cables—directly from the battery positive terminal to the starter motor's solenoid post. If the solenoid pulls in and the starter turns over the engine, you've got a wiring problem.

6. If the solenoid doesn't pull in and energize the armature, try jumping directly to the motor's armature post, bypassing the solenoid. If the armature spins, the problem is in the solenoid or its wiring.

7. Don't forget that some antitheft systems will still disable the starter even if the crooks hot-wire the ignition key. And when something goes wrong with that alarm, you're stranded. It gets worse—it's usually difficult or impossible to disconnect the alarm, in order to keep the car thieves from doing so. Be prepared for serious reading of the factory shop manual or, if your alarm is aftermarket, a return to the alarm installer.

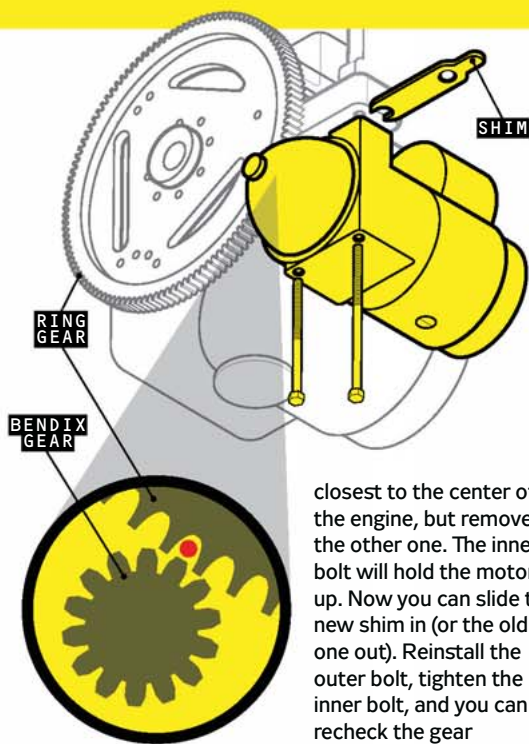
### No More Excuses

→ **Regardless, you've determined** that the starter is fried. Time to get to it. You might get lucky, especially if you have an FWD vehicle, and be able to

#### ■ NOW YOU KNOW

### Shim This

Some older GM cars may drop a couple of shims in your face when you remove the starter. While most starter motor replacements can simply be bolted on right out of the box, GM engine blocks and starters are dimensionally inconsistent enough to require shimming for proper tooth engagement. Improper tooth engagement leads to a myriad of maladies: The clearance will be too tight or the teeth may not engage fully, giving you gnashing teeth instead of the hummingbird whir of a cranking engine. The best place to start is to replace the shim or shims that came out with the old starter. Don't even bother to hook up the wiring yet. Remove the sheet-metal cover over the bell housing so you can visualize the starter's teeth and the ring gear on the flywheel or flex plate. With a screwdriver, pry the bendix gear forward to engage it with the ring gear. While keeping the gears meshed, measure the gap between the



teeth with a 0.032-inch wire gauge. Surprise—there might have been such a gauge included in the new starter's box. If not, a paper clip is pretty close. If the gap is less than 0.032 inch, add a shim. If it's more, remove one. You don't need to remove the starter motor to do this—that's why the shims have a slotted end. Loosen the starter bolt

closest to the center of the engine, but remove the other one. The inner bolt will hold the motor up. Now you can slide the new shim in (or the old one out). Reinstall the outer bolt, tighten the inner bolt, and you can recheck the gear engagement.

Occasionally, a starter motor will have proper radial clearance but still exhibit incorrect engagement. It also may be necessary to shim the bendix gear to get full engagement. I'll refer you to the shop manual.



# Do you have constant **RINGING** in your ear?



Finally, new discovery for quiet relief!

*A breakthrough by a rock drummer finds combination of scientifically advanced ingredients combined with homeopathy to relieve the ringing, which could save thousands from risky and expensive treatments.*

Every night for almost 18 years, if I couldn't find a fan, turn on a tv or find loud static from a vacant radio station, then sleeping was impossible. The high-pitched ringing, buzzing and humming kept me up at night. Sluggishness, tiredness and lost energy would be my nemesis the next day. I couldn't take it - it was a major problem. I couldn't sleep. I couldn't concentrate. I heard it constantly, I couldn't hide from it...It drove me nuts! Headaches, depressive mood swings, testiness, constant state of anxiety. Due to the tenacity of Tinnitus (the ringing in the ears from exposure to loud noises, or in my case, pounding on drums and loud distorted guitar amps behind my head for years), I was determined to find real, pure, silent relief and I did with Quietus™...

## Tinnitus - Who's at RISK?

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- Mining, Drilling & Farming
- Firearms Enthusiasts
- Residential Landscapers
- iPod Users
- Machine Operators
- Night Club Workers
- Musicians

The symptoms of Tinnitus are real. I had what 1 out of 6 Americans get: the symptoms associated with Tinnitus (*ti-nahy-tuh s*) from loud noises that worsen as you age, and in many cases lead to hearing loss.



## Silence is now music to my ears.

I tried everything from hearing aid sound generators to ginkgo biloba, zinc and magnesium mineral doses to bio feedback. Some of these things helped reduce the ringing, but nothing worked short of expensive, risky surgery. Not until I discovered the active all-natural ingredients of my new homeopathic product Quietus, did my prolonged ear ringing finally silence.

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No other treatment that I know of matches the relief that Quietus provides with effectiveness, speed and convenience. With Quietus, the ringing stops and the comfortable silence will peacefully lull you to sleep at bedtime. When the ringing stops, remembering people's names becomes easier. Mental clarity becomes your calling card. Intense focus becomes your edge...

*Bernard*  
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Quietus is not available in stores. To protect its proprietary homeopathic formula, as well as your risk-free trial, Quietus is available by special request directly from our lab for a limited time for Popular Mechanics readers. I am so confident in the advanced technology of Quietus and I want you to experience the same life-altering relief I did, that you'll receive a special **30-day RISK-FREE trial\*** by calling us direct! Ask how to receive a **FREE Supply** with your order.



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## PM DIY AUTO /// STARTER MOTORS

swap starters from above the car. If not, the starter usually lives in a really remote location well underneath the car, somewhere near the side of the transmission. Don't try to do this on a hot car—which might seem to be superfluous advice if you can't even get it started—but invariably the exhaust system is nearby, and burns hurt. Also, protective eyewear is de rigueur, because you'll be dropping flakes of rust and underhood dirt from directly above your head into your baby blues. While you're waiting for the car to cool off, chock the wheels and jack it up a foot or so. Ramps will work, but I prefer a pair of sturdy jackstands. On the other hand, I've also been forced to do this in the middle of a muddy field by scooping out a trench to lie in.

Remove the battery ground. Now you can go below and remove the wires to the starter. There will be a fat wire from the battery or, if your car uses

one, an external solenoid. There will also be one smaller wire, either a ring lug on a stud or a spade lug, from the ignition key. Older vehicles with points-and-distributor ignition may have a third wire to the coil, bypassing the ballast resistor. Don't get them confused.

Now get a socket and ratchet and probably an extension, and remove the bolts holding the starter to the block. You may also need to remove a heat shield, brace or sheet-metal cover to get everything loose. Don't drop the starter onto your head as the last bolt comes out; it's as heavy as a bowling ball.

Don't get out from under the car just yet. Mark one tooth on the ring gear with some spray paint or even chalk, and inspect every single one of the 140 to 160 teeth by turning the engine over with a big screwdriver for one full revolution. Seriously damaged teeth will require replacement of the flex plate or flywheel, which commences with removing the transmission from the vehicle. Fear of the necessity of this should motivate you to fix a balky-but-still-barely-working starter before it

damages the teeth. Labor to remove the transmission and replace the flex plate or flywheel will be 6 to 8 hours, more if you have four-wheel drive. Add in the cost of parts and a ring gear replacement could easily reach a thousand dollars or more.

Take your old starter motor to the auto parts store and exchange it. Don't be surprised if the new starter bears only a faint resemblance to the older one. The industry has been transitioning to smaller, lighter gear-reduction starters that use a higher-speed motor coupled to a planetary gearset to spin your engine faster while using less current. The new starter will have grease already in places where it's needed, so no further lubrication is necessary or desirable.

Replacement of the new starter is straightforward, at least if your vehicle doesn't require shimming the new starter (see page 104). Snug up the mounting bolts, reinstall any braces, covers or heat shields, and hook up the wiring. All you need to do now is reconnect the battery ground, take the vehicle off the stands and start 'er up. **PM**

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## Car Clinic

by Mike Allen

Q+A

### All Wound Up

**Q** I broke the window-winder handle off the driver's door on my van. I'd like to buy a new handle, but I can't figure out how to get the old handle off to match it up.

**A** There are two ways that window-winder handles are customarily attached to their axles. If there is a removable plastic trim piece in the center of the handle, pry it up. Then you can unscrew the Phillips-head bolt and take the handle with you to your local parts counter. Many older cars use a different system, with a large-diameter wire clip that slips over the end of the axle and drops into a slot. It won't be immediately obvious how to remove it. There's usually very little clearance between the winder and the door panel, so it's impossible to see what's going on. I've used a small screwdriver, a bent coat hanger, a rag and even a big fish-hook (don't ask) to remove these diabolical devices. The simplest way is with, of course, a special tool, which you can pick up for cheap at the auto parts store.

And yes, it's a good idea to use the tool to remove the winder even if all you really need to do is get it out of the way to service something inside the door. Guess what? They also make other special tools to remove the clips that hold the door panel to the door.



**REMOVING WINDOW WINDERS**  
Just slip this special tool behind the window-winder handle to release the clip that anchors it to the axle.

If you're not fussy about matching the original, you can find a serviceable replacement at the auto parts store or even in the auto department at many mass merchandisers without having to pay the dealer's outrageous prices.

### Water Crisis

I purchased a 2006 Nissan Pathfinder SE with an automatic transmission in November 2009. I noticed a slight

vibration coming from the rear that I thought was probably caused by a tire imbalance. A month ago, on a long trip, I noticed that the transmission was vibrating and dragging down the speed whenever I let up on the gas pedal. A quick Internet search revealed case after case of the same vibrating problem from other Pathfinder owners. It was determined that water from the radiator was somehow



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**seeping into the transmission, ruining it and, worse, voiding the drivetrain warranty as a result. I have three questions: One, how would water from the radiator enter the transmission? Two, is there any way to correct this problem before it ruins the transmission and radiator, requiring expensive repairs and/or replacement? And three, why hasn't there been a recall for this problem by Nissan?**

Virtually all automatic transmissions are cooled by a loop of tubing routed through one of the radiator end tanks. A failure in this cooling tubing will allow coolant (not water) to be forced into the transmission fluid. This mixture of ethylene glycol and water emulsified in the mineral-based transmission fluid will rapidly damage most everything inside the trans, from the organic friction material in the clutch packs to the rubber O-rings and seals to the steel gears and bearings.

Nissan had issues with a number of radiators supplied to them and may or may not cover the radiator and transmission repairs under warranty. Recalls are generally for safety-related problems, not durability. In this case, there should be at least a service bulletin, but there isn't. Nissan has replaced some radiators and repaired some of these transmissions for free, but many owners have been forced to pay part or all of the cost. Most of the affected vehicles seem to be 2005 and 2006 Pathfinders. Estimates to rebuild the transmission run somewhere between \$2200 and \$5000. Ouch.

Those readers with potentially affected vehicles should regularly check the coolant and transmission fluid for signs of cross-contamination. (Actually, everyone should.) This will be tough to do for the transmission, as the dipstick is held down with a 10-mm nut, precluding checking the fluid while refueling unless you carry a 10-mm socket and

ratchet in the glovebox.

More paranoid readers may wish to replace the radiator pre-emptively or to disconnect the original trans cooler and hook up a bypass cooler in front of the radiator. I would recommend against the bypass cooler, at least in the winter, as the transmission cooler in the radiator will warm the transmission up properly when it's cold out. It's just as important that the trans temperature is warm enough for proper operations as it is to keep it from overheating.

## Hot Time in the Old Town Tonight

**I've read a lot about electric and hybrid cars, but one question I haven't heard answered is how they supply heat or cooling to the passengers. Using the batteries to operate an electric heater or air conditioner would drain them and shorten the already limited running time.**

Exactly. Running the heater, heater fan and defroster (which includes the a/c compressor to dehumidify the air passing through the heater core and blowing onto the windshield), the wipers and headlights will substantially reduce the range of electric vehicles driven in winter climates. Ditto for EVs used in places like Vegas, Phoenix or Houston due to the increased a/c load. Some PHEVs (including, supposedly, the Volt and Prius PHEVs) let you precondition the cabin while they're still on their charger in the morning, but still.

## Correction Factor

**When the auto manufacturers design cars, they design them with a certain-size wheel. However, dealers nowadays order them with larger-diameter wheels. What effect (plus or minus) does this have on the speedometer? I had a VW Beetle once, and put on larger tires—the speedometer reading was off by 10 miles an hour, enough to get me a ticket.**

Larger-diameter tires travel farther over the road for a single revolution of the wheel, so the speedo will read slower than the actual road speed. How far off is directly proportional to the difference in circumference of the tire. Generally, the optional tire sizes available on a new car are lower in profile as well as

### TOOL OF THE MONTH

## Simple Spark Tester

**Your (insert internal-combustion-operated device here) won't start.** You've worn down the battery, pulled the starter rope, hand-propped or jumped on the kick-start until you're blue in the face. Sure, you've got sophisticated electronic scan tools for diagnosing virtually anything wrong with your new OBD-equipped automobile, but where do you plug that \$400 scan tool into the dirt bike or snowmobile? The first thing to check



for is spark. The time-honored way is to pull a plug wire and use a spark tester or the spark plug itself to visualize a tiny 0.022-inch spark jumping a plug gap. Getting this wrong can make the spark jump to your arm, which, I assure you, really freakin' hurts.

There's a middle ground. Our pals at Graham Tool ([grahamtool.com](http://grahamtool.com)) sent us this simple-to-use \$15 inline spark tester. Just pull the high-voltage wire from the spark plug and put the tester in series with the plug and coil using the short high-voltage jumper cord. Crank the engine, and if there's spark, the tester will flash. It works even on distributor-less ignition systems.





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wider, with a rolling radius that's very close. For instance, a typical 205/60-16 tire is very close in overall circumference to a 225/50-17. The 16-inch tire is rated at 815 revolutions per mile while the 17-inch is rated at 801 rpm. That's only a 1.7 percent change, smaller than the error caused by the reduction in diameter as the tires wear.

If you must swap for a size that isn't equivalent, mechanically driven speedos can have a gear swapped out in the transmission to account for significantly different sizes. Electronically driven speedos can sometimes be reprogrammed by the dealership to the same end. Check the shop manual for the exact procedure.

### Old Habits Die Hard

**Finally, at age 60, I bought my first vehicle with an automatic transmission (2008 F-150, no manual offered), and I'd like your wisdom on the care**

**and feeding of modern automatics. In a manual, I always ease it out of gear as I come to a stop without using the clutch, and I never sit at a light with the clutch depressed. Should I put the automatic in neutral when waiting at a light and then shift into drive when the light changes? I also use hills and gravity to turn around and pull into parking spaces: With a manual, I back uphill into a space and then put in the clutch to drift forward with the transmission in reverse and then back up into the space to straighten out. I do this in my new truck too, but I wonder if I'm doing any damage as I drift forward (downhill about 30 feet) with the transmission in reverse. Should I always have the transmission in the gear direction I'm actually moving in? Finally, what do you recommend for periodic TLC so the transmission will last the 200,000 miles I expect from this truck?**

It's not necessary to put an automatic trans in neutral while sitting at a traffic light, and I'd prefer you leave it in drive while approaching the light as well. It'll use less fuel and leave you with the ability to rapidly move out of the way of trouble if needed. Less fuel? Yup, the injectors are shut down completely when coasting in gear, while idling in neutral still consumes fuel.

On the other hand, I'd be happier if you used neutral or drive while rolling downhill, even if you're on a slope that's steep enough to force the vehicle ahead while it's still in reverse gear. The transmission computer may get a trifle confused if the vehicle speed sensor tells it it's going forward while it's in reverse gear, turning on the Check Engine light and setting a trouble code.

And in spite of the recommendations of the car companies that transmission fluid is fill-for-life, I recommend changing the ATF regularly—every 30 K miles, unless your car uses \$12-a-quart synthetic ATF, in which case I'd double that.

### They Call Me the Wanderer

**I have a 2008 Volvo C30 T5 with 20,000 miles and recently heard what sounded like a thumping tire. All four tires have a slight cupping on the inside tread. These tires have been rotated every 6000 miles. Toe-in and camber were slightly off on the front, but the rear was in spec. My mechanic said the only way to eliminate this cupping problem is to rotate the tires every oil change (3000 miles). This sounds a bit much. Can you shed some light on this? Even the tire manufacturer recommends around 6500 to 7000 miles for rotation.**

A small amount of toe-in is normal, to compensate for the slight alignment changes that occur as the suspension wears and slightly sags. Typically, suspension wear makes the tires toe out, which will cause a wandering feeling and, you guessed it, cupping on the inner edges. I doubt that your suspension is worn out after only 20,000 miles. I'll assume your alignment technician checked the integrity of the tie-rod ends, control-arm bushings and ball joints, front and rear.

Some tires, mounted on some vehicles, are more prone to cupping. I'd

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suggest changing to a different brand of tire and setting the toe-in, front and rear, to the maximum end of the range specified in the shop manual. And set your tire pressures to the high end of the range recommended in the owner's manual.

### His Cup Runneth Over

**Last spring my 2008 Buick met with a snow bank due to icy roads. Upon return from the shop for some collision repairs on the complete front-bumper assembly, I noticed that the lower air dam was missing. The collision shop manager told me that the new replacement bumpers have no provisions for attaching the air dam so he leaves them off. I'm assuming these have a purpose, as they are on a new vehicle and if it wasn't required GM would not put them on. Will this affect anything?**

Of course it will, or, as you say, GM wouldn't have put it there. That lower air dam keeps air from getting under the car, and its absence will, at least slightly, increase drag and fuel consumption.

More importantly, it may reduce the amount of air flowing through the radiator and make your car run hotter. The shop should have drilled the appropriate holes for the correct fasteners and reinstalled the air dam for a proper repair.

### Runnin' Hot

**I have a 1963 Corvair with a 1965 engine. I am having trouble with it vapor-locking when running at slow speeds, or sitting in a parade route. What do you suggest to stop this?**

The simple answer would be to recommend some 1965 gasoline, but I doubt you can find any. Here's the problem: The vapor pressure of gasoline is much higher today than it was when your car was manufactured. We're using more of the barrel of crude oil than ever, and some of those hydrocarbons are more

volatile and boil at lower temperatures. Fuel-injected cars aren't as sensitive to this, because the fuel is pressurized to 30 to 60 psi in the fuel rail, not at atmospheric pressure in the carburetor's float bowl. At low speeds or in parades, the engine compartment temperatures are highest, and the fuel literally boils in the fuel lines, fuel pump or float bowl. Some '70s vintage cars used a bypass line that returned fuel to the tank to keep fuel temps down, but you'd need to add another fitting to the tank for the return

line to achieve this.

Changing from the mechanical engine-mounted fuel pump to a remote electrical one might help. So might insulating the fuel lines and float bowl with some aluminum-faced insulation. I know a fellow who rigged up a windshield-washer pump to a cooler full of ice and water in the cab of his motorhome. When his engine started to stutter as it went up a hill, he'd squirt some ice water on the float bowl. It gave him a place to keep some cold drinks on ice, too. **PM**

#### Got a car problem?

Ask Mike about it. Send your questions to [pmautoclinic@hearst.com](mailto:pmautoclinic@hearst.com) or over Twitter at [twitter.com/PopMechAuto](https://twitter.com/PopMechAuto) or to Car Clinic, Popular Mechanics, 300 W. 57th St., New York, NY 10019-5899. While we cannot answer questions individually, problems of general interest will be discussed in the column.



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# Tech

## Make Your Own 3D Epic

WHO SAYS 3D MOVIE-MAKING IS THE PROVINCE ONLY OF HOLLYWOOD PROS? WITH A FEW HUNDRED DOLLARS YOU CAN SHOOT AND EDIT EYE-POPPING 3D VIDEO.

BY ANTHONY VERDUCCI

➔ **I may not have access** to the custom-designed 3D camera rigs or \$300-plus-million budget that James Cameron had for *Avatar*, but that shouldn't mean I can't produce my own movie with breathtaking—well, okay, at least passable—3D effects. True, the task may seem daunting and expensive at first. After all, the

Using \$330 in equipment and parts, the author built a 3D camera system on a homemade Steadicam mount.

INSIDE x WINDOWS PHONE 7 + USB CHARGING

cheapest 3D camcorder on the market right now is Panasonic's \$21,000 AG-3DA1, and even that requires a constellation of specialized equipment and software to deliver usable 3D footage.

What's more, the gear that electronics manufacturers are just now introducing to the market to edit and play 3D content requires an almost total replacement of your existing computer and AV equipment. I don't really want to buy a new graphics card, computer screen, HDTV (which I just got, thank you very much), home theater receiver and Blu-ray player, but I do kind of like the idea of making a cheap and easy 3D action flick starring my cat.

Fortunately for me, a hobbyist subculture has sprung up to address the unmet need for low-production-value at-home 3D moviemaking—a movement dedicated to the art of building stereoscopic camera rigs using two off-the-shelf inexpensive camcorders mounted on a rail. It started when husband-and-wife team Ron and AmyJo Proctor, both students at Weber State University, posted instruc-

tions for bolting together two Kodak Zx1 camcorders. "We kind of built it on a lark," says Ron. "We wanted a Flip-style video camera for chasing our 2-year-old. They were so affordable that we decided to buy a pair. Once we had those, the jump to 3D was natural." The Proctors used a 157-year-old process that is known as anaglyph 3D, which uses the same iconic red-and-blue glasses that turned 1950s comics into virtual pop-up books.

The anaglyph process works by filtering the vision of a viewer's left eye through a red filter and the right eye through a cyan (blue) filter. Each frame of video is produced with two superimposed images that have been stereoscopically separated, then subjected to color subtraction in a computer image-editing program. When viewing these superimposed images through anaglyph 3D glasses, the brain interprets and combines the complementary colors, creating the illusion of depth.

The process sounds a lot more complicated than it actually is in practice. It is certainly far simpler than the two

other major 3D processes currently employed by Hollywood and the electronics industry. Most 3D movies in the theater use a specialized screen and polarized glasses to deliver 3D projection, while the new 3D home theater gear generally relies upon shutter glasses that are synchronized to a TV that runs at a high frame rate.

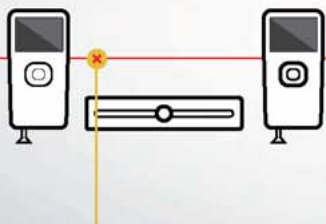
True, the anaglyph editing process can tint the color of your video, but it works with equipment you probably already own—requiring no major investment to play back the video. Perhaps that is why it is often employed by movie studios for their own home video releases. Recent Blu-ray movies such as *Coraline* and *My Bloody Valentine* used the red-and-blue-filtered glasses.

### Stereoscopic Optics

➔ **Actually making** the 3D rig is the easy part. As Ron Proctor describes it: "You can just drill some holes in a bit of scrap metal and bolt your cameras on." A 1/4-20 bolt will thread into the tapped tripod mounting hole in most cameras. If you're mounting to a metal bar or plate, we'd suggest cutting slots to allow for fine adjustment of the distance between the video cameras. Ideally, the distance between the two camera

## Balancing Act

CREATING A HOMEMADE 3D STEADICAM RIG IN THREE (SORT OF) EASY STEPS.

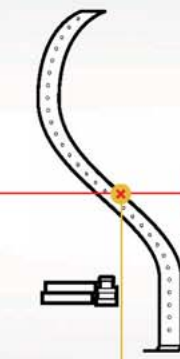


**STEP 1:** Setting up a 3D camera system is the easy part. Just cut a channel in either metal or wood, then mount two inexpensive video

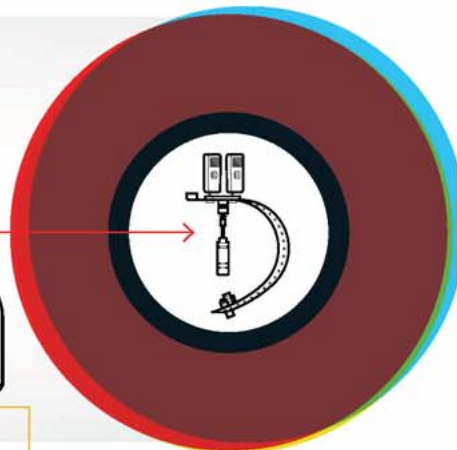
cameras using two standard 1/4-20 bolts, washers and some wingnuts. Try to match the distance between human eyes—2.48 inches.



**STEP 2:** My Steadicam rig featured a makeshift gimbal formed from a skateboard bearing and a modified RC car's



U-joint. I installed the bearing inside a piece of PVC tubing, then ran a 5/16 bolt through the length of the tube, threading it into the plastic



U-joint. To cover the PVC pipe, I used a rubber bicycle handle grip.

**STEP 3:** This part was tricky. I built a counter-

balance from punched steel flat stock trimmed and hand-bent into a crescent, then carefully weighted it with various-size magnets.



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lenses should match the stereoscopic separation of human eyes, which is typically 2.48 inches. Adjustments to this separation allow for a variable depth of field, but too much separation will result in an unresolvable image.

Once you've created a mounting bracket (it doesn't need to be metal; you can also use wood or plastic), it can be affixed to almost anything—tripod, bicycle, car hood, helmet—with whatever hardware or adhesive you prefer. I wanted maximum mobility and minimum camera shake, so I decided to complicate the project for myself by designing and building a homemade Steadicam.

The company that makes Steadicams, Tiffen, sells the Merlin, a very nice camcorder-friendly version of its professional camera stabilizer, for \$850 (the company also has in the works a Steadicam for iPhones that should cost less than \$200). But I was looking for a solution that was more in the \$30 price range. I attached the camera bracket to a makeshift gimbal I constructed by combining a plastic U-joint from an RC

car with a ball bearing mounted in a ½-inch PVC handle. To keep the camera level, I bent a 36-inch-long piece of steel flat stock into an arc to act as a counterweight, then I made fine adjustments by attaching various weight magnets to the bar. Because of the ball bearing, the entire apparatus was able to rotate freely relative to the handle, while the U-joint allows the cameras to maintain position horizontally.

To be honest, it takes quite a bit of tinkering to get this thing perfectly level, and then keeping it level is another skill set entirely. Even with a professional Steadicam, you need to keep your arms held close to your body and walk smoothly to get the best effects.

### In-Depth Editing

➔ **When you are done** recording, you should have two separate video clips that need to be uploaded (make sure to save one as "left" and the other as "right" to keep yourself organized). To edit the footage, I used Sony Vegas Pro 9 (\$600), but many less expensive video-editing packages can do the job.

The first step is to load both clips into your video-editing software. Next you want to trim the video so that both clips start on the same frame. Then search for the menu option that lets you adjust color controls (your software might call this levels or channels). You'll know you're in the right menu when you see sliders for the colors red, green and blue.

Anaglyph video editing is essentially an exercise in color subtraction. For the left-eye footage, dial down or turn off the blue and green channels. For the right eye, subtract the red channel.

Once that's complete, you need to create a composite of the two clips. (Again, the language differs with the software: Some call the process overlay or blending.) That should merge the left-eye and right-eye tracks together into one. You're probably going to want to throw on some anaglyph 3D glasses to make sure you've done it right.

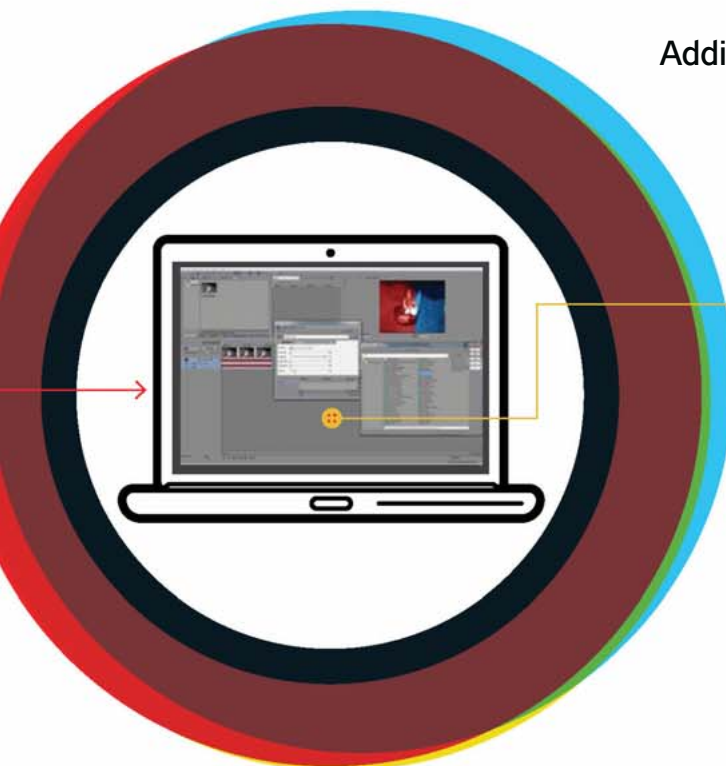
Which brings up the question: Can you do it wrong? And the answer is, sort of. You may find that, after all of your work, the 3D isn't that apparent in your clip. Most video-editing programs allow you to artificially separate the left- and right-eye channels a bit by cropping the images slightly, then redoing the composite. By skewing the stereoscopic separation, you can add depth to the resulting video without reshooting.

(After this lengthy explanation, it's worth noting that this fall, a Roxio-branded 3D software suite from Sonic Solutions will completely automate the 3D editing process.)

In the end, my 2-minute feline flick isn't going to break any box-office records, but the 3D effect worked. And I can easily share my anaglyph 3D clips by posting to YouTube, so that anyone with a pair of red-and-blue 3D glasses can enjoy them.

And by the way, those glasses are ridiculously cheap and easy to acquire. On Amazon.com, 50-packs of paper and cellophane glasses can be had for \$30. Or, if you think that 3D video production may become a lifestyle for you, opt for the fancier, hard plastic kind for around \$6 each—they're more durable, and about as fashionable as red-and-blue-tinted eyewear can be.

PM



### Adding Dimension

Transforming video of my cat into an anaglyph 3D movie was surprisingly simple. I converted the left video clip to red (by subtracting blue and green) and the right clip to blue (by subtracting red). To make the finished frame, I overlaid left and right into a single composite image, tweaking the position slightly to get better stereoscopic separation. Now, seen through 3D glasses, my cat leaps off the screen.



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## Digital Clinic

by Seth Porges

Q+A

# What You Need to Know About Windows Phone 7

**Q** I'm excited about the upcoming Windows Phone 7 cellphones. What's new about the operating system? Can older Windows Mobile phones be upgraded to run it?



### A New Type of Mobile Interface

→ In Windows Phone 7, the phone screen feels like a window looking onto a single, large panel. As you swipe the screen, that window moves fluidly over this virtual space.

**A** I'm kind of excited too, but before we get carried away, let's pause for some background.

When it comes to discussing Windows Mobile (a name Microsoft has ditched for the seemingly more marketable "Windows Phone"), let's just say that it's always been pretty difficult for me to hold my tongue. While other mobile operating systems such as Google's Android, Apple's iPhone OS and Palm's webOS brought intuitive and user-friendly interfaces to smartphones, Microsoft's mobile platform seemed stuck in the technological dark ages—cumbersome, unintuitive and apparently designed to frustrate.

This frustration was compounded by the fact that Microsoft was clearly

capable of producing a fantastic mobile user interface. After all, this was the company behind last year's brilliant Zune HD portable media player, which had a UI that was both easy on the eyes and simple to navigate—a fact that had critics (myself included) wondering why Microsoft didn't just stick a phone in the darn thing.

Well, with the new Windows Phone 7 line of cellphones, which is coming out late this year, the company has basically done just that. The new phone platform is a complete reboot—it bears little resemblance to previous versions of Windows Mobile and cribs the best elements of the Zune HD's interface.

The new OS looks promising for two key reasons. First, it attempts to bridge

together various features from across the massive Microsoft ecosystem—Windows Phone borrows the Zune HD's music- and movie-playing abilities and even integrates Xbox Live, allowing the user to access his gaming achievements and friends list and do a little bit of multiplayer gaming directly on the handset.

The other cause for excitement: the platform's interface. Most touchscreen smartphones are navigated by flipping through distinct screens. With Windows Phone 7, the phone screen feels like a window looking onto a single, large panel. As you swipe the screen, that window moves fluidly over this virtual space. The result is a welcome departure from interfaces that seem





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more concerned with mimicking the iPhone experience than creating something new.

So can older Windows Mobile phones be upgraded to run the new OS? No. In fact, Microsoft has issued strict guidelines by which all Windows Phone 7 devices will have to abide. These rules—which govern everything from what kind of touchscreen these phones can have, to how many physical

buttons they can be peppered with—are an attempt to create consistency and make sure all Windows Phone 7 devices are able to run all of the platform's programs without a hitch.

Of course, it's still a couple of months before the Windows Phone 7 handsets actually come out, and a lot of questions remain until then—we still don't know how good third-party apps will be, how long the phones' batteries

will last or whether there will be any unforeseen bugs. But, at least on paper, Windows Phone 7 seems like it could definitely be a winner.

## Picking Power Cords

**My phone can charge through either a USB connection or an AC adapter. Will using one or the other cause my phone to charge faster?**

Not all connections are created equal. Take the ubiquitous USB cord: It typically draws a charge from a computer at a maximum current of 500 milliamps—significantly less than the 750 mA allowed by a lot of phone AC plugs. So yes, charging with an AC adapter will often get the job done quicker than using a computer-plugged USB cord.

PM

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## Medevac

(CONTINUED FROM PAGE 85)

NTSB report, night-vision goggles may have prevented 13. TAWS might have prevented another 17: In the 7 seconds before Bunker's helicopter hit trees, such a system would have detected that he was flying too low and given him three loud warnings to pull up. A September 2009 NTSB report recommended every medical helicopter also be equipped with a flight data recorder, plus either autopilot or two pilots.

After his injuries healed, Godfrey climbed into a helicopter and returned to work. He was on duty the night Trooper 2 went down nearly four years later. He heard air traffic controllers calling Bunker by radio, heard the empty static of no reply. He even drove to Walker Mill Regional Park to try to assist at the scene. Watching his friends die in machines that are supposed to save lives—twice—galvanized him. "That was a turning point for me," Godfrey says. "I wasn't going to shut up."

He began talking with the media about the industry's shoddy safety practices. He became the chairman of Vision Zero, reviving a dormant effort by the Association of Air Medical Services to raise the safety awareness of flight crews. Godfrey still pulls on a flightsuit three nights a week and tries to save another life, but he refuses to fly in any helicopter without flight dispatch, in-flight tracking, a terrain awareness and warning system and night-vision goggles. "If this industry is unsafe," he says, "no one benefits."

Since 2005, the FAA has issued guidelines encouraging medical helicopter companies to install safety technology voluntarily. In 2006, the safety board again urged the FAA to tighten regulations, and the administration refused.

Eight fatal crashes killed 29 people in 2008, the deadliest year yet. In April 2009, Allen announced the agency would write official safety rules. Since then, as this article went to press, eight more medical helicopters had crashed, leaving 12 dead.

"The problem is that in 2006 we heard that most of these things were going to be done voluntarily, and four years later we're still seeing the FAA talking about starting the rule-making process," Hersman says. "It's just too slow." **PM**

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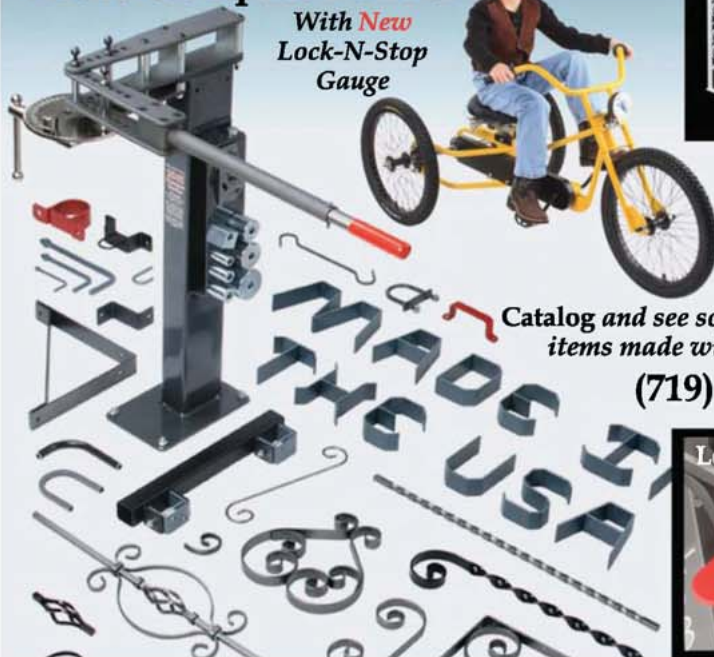
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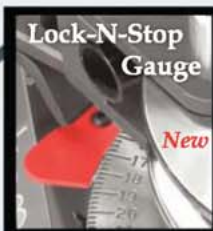


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Location: CHELSEA, MICH.

Age: 23

Years on Job: 4

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× **Chance Mikkelson learned his trade** the old-fashioned way. "I built my first engine—a Chevy V8—with my dad when I was 14," he says. In 2007, Mikkelson opened his own shop, Dexter Manufacturing, and works on engines of all vintages and size. "One day I'm assembling the heads of a Maserati V8, and the next I'm resleeving a lawnmower cylinder." During off-hours, he might be fabricating a fuel-injection system for a Ford Model A. Often, he completes projects for frustrated DIYers. "When guys buy a bunch of go-fast parts," he says, "the engine rarely runs right. You have to figure out which parts work best together. That's the fun part." —LARRY WEBSTER

### ENGINE REBUILDING IN FIVE STEPS

#### 1. DISASSEMBLY

During disassembly, Mikkelson relies on hand tools so he can feel a stripped thread or loose bolt. "A lot of times an engine blows a head gasket because a head bolt was loose," he says. A careful teardown reveals the engine's failure mode and wear characteristics. He sorts parts according to their position on the block. Another tip: "Start from the top."

#### 2. CLEANING AND INSPECTION

Elbow grease and an automated steam cleaner remove built-up crud. To reveal tiny cracks in a part, Mikkelson magnetizes it, applies a magnetic fluorescent powder to its surface and illuminates it with a black light. The powder collects inside cracks that are invisible to the naked eye.

#### 3. MACHINING

After carefully measuring every part, Mikkelson works pieces that are out of spec or worn with grooves—like a scored crankshaft—back to proper dimensions. Warped heads like the one pictured are ground back to flatness. Mikkelson often finishes surfaces by hand.

#### 4. ENSURING ACCURACY

After machining, Mikkelson again pulls out micrometers, a straight-edge and bore and feeler gauges to inspect and measure every part. "Seventy-five percent of my time is spent measuring," he says.

#### 5. REASSEMBLY

As with disassembly, Mikkelson uses only hand tools to reassemble the engine. He vacuum tests the heads to check the valves and uses assembly dressing so parts are lubed at startup. Then he fires every engine on an engine stand. "Hearing an engine fire for the first time never gets old."





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