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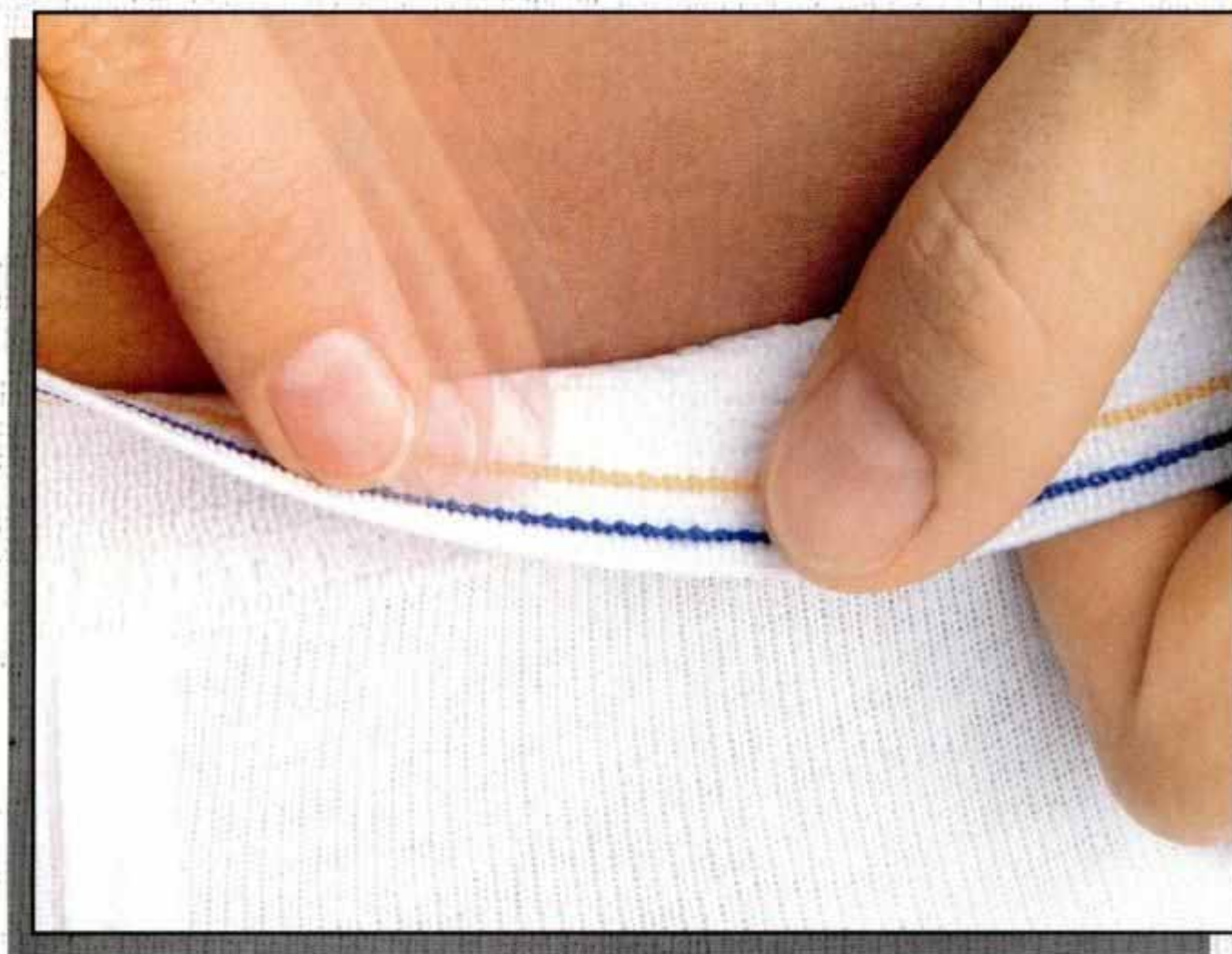
This One



TN92-HA0-Z3BH

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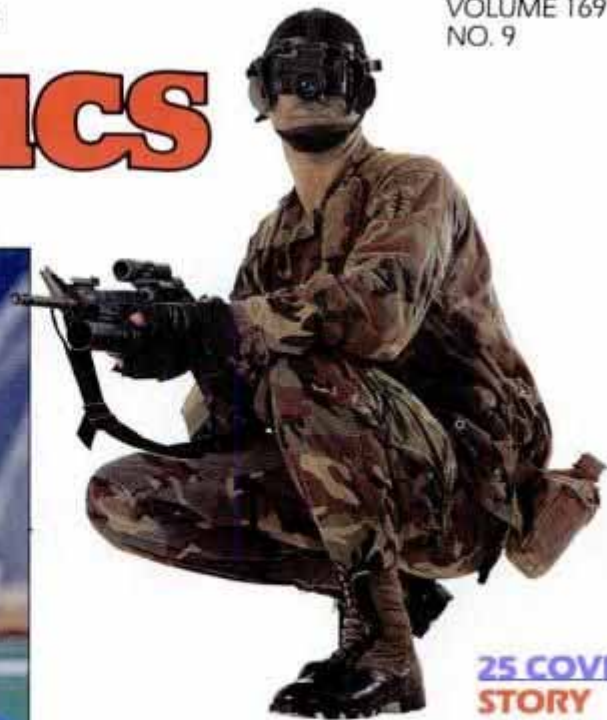
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FOCUS ON SPORTS PHOTO

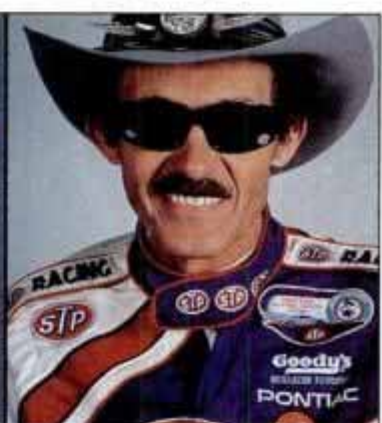


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EDITOR'S NOTES

● Is it great to be a winner or what? In only the second race of the season, in only the second race of our Dodge Daytona Trans-Am race car's life, driver Tommy Archer punched through to the winner's circle in Detroit at the Motor City 100. Brother Bobby finished third after running 1-2 much of the afternoon. The full story is on page 112 of this issue, but suffice it to say here that victory is very, very sweet. . . . It's the fourth quarter. The New York Giants trail by two points and there are 2 seconds left on the clock. Time out is called. Matt Bahr, the Giants' place-kicker, and holder Jeff Hostetler trot out onto the field. The fans are going wild. The teams line up. The ball is snapped.

Bahr takes a step, his right leg coiled back. Hostetler catches the ball, spins the stitches away from Bahr and places it down on its point, all in one deft motion. A second ticks off the clock. Bahr's right leg is a pendulum as it swings down and through the ball. The final second of the game is gone. The ball is up and the kick is. . . Wait a minute. Did you ever wonder what actually happens when a kicker boots one through the uprights—or worse yet, misses? It's a lot more than a foot meeting an inflated piece of pigskin. It's science and physics and trajectories and timing. Most of all, it's interesting reading, especially when Matt Bahr himself is the storyteller. Check page 36. . . . We've known a little about the U.S.



PHOTO BY ROY ATTAWAY

PM editor Frank Vizard worked with Matt Bahr—literally—on our field goal story.

Army's Special Forces since the Vietnam War. But not much. Even less has been officially revealed about the Navy SEALs—if it wasn't for the Charlie Sheen movie last year, few people would even know of their existence. And, only a handful of people know that there are elite special warfare forces in the Air Force and Marines as well. Now, Science/Technology Editor Abe Dane and photographer Brian Wolff blow the lid off America's elite commando forces in what is surely the most comprehensive report ever published on this subject. We hope you find this month's cover story, which starts on page 25, as interesting and revealing as we did. . . . Richard Petty, all-time great stock car driver, hangs up his helmet after this season. Our tribute begins on page 48. Till next time.



PHOTO BY GEOFFREY HEWITT

Tommy (left), Bobby and I share the victory stand in Detroit.



PHOTO BY BRIAN WOLFF

PM's Abe Dane discusses high altitude, high opening jumps with SSG Paul Petit of the 5th Special Forces Group at Ft. Campbell.


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LETTERS

Earth Mover



Bravo! Your article on the Humvee brought back fond memories of my days of slushing around in waist-high mud at Fort Campbell, Kentucky. We worked real hard while on field exercises, but the Humvee made it seem like play time.

JASON CURRY
MEMPHIS, TN

The Civilian Hummer article brought a big smile to my face when I read of a 0-to-60 time that was three full seconds longer than I get in my loathed Toyota Land Cruiser, which is considered to be an agricultural implement rather than a sport/utility.

And to think of 16 in. of ground clearance!

DAN MORTON
RALEIGH, NC

The new Hummer may be the military's Jeep replacement, but Willys-Overland Motors, Inc., was not "more or less responsible" for the design of the original Jeep, as stated in your article. In U.S. government hearings from 1943 to 1948, the Federal Trade Commission found that the American Bantam Car Co. of Butler, Pennsylvania,

created and developed the Jeep. The first Willys-Overland design was rejected by the Army because it was overweight. The FTC ordered that Willys-Overland "cease and desist" from presenting itself as the creator and designer of the Jeep.

MICHAEL SALEMI
LIVONIA, MI

The Humvee is far more than just a Jeep replacement. Despite its defects, the Humvee is the most advanced and, likely, the most mobile light 4x4 around. The M151 Jeep had severe problems in engine power, load capacity and stability. It had a nasty habit of rolling over if driven around a corner too fast, thanks to its swing-arm rear suspension. AM General should have commercialized the Hummer a long time ago.

BRIAN P. DUMAS
EASTON, CT

Treasured Chest

I built this reproduction of an American Chippendale

chest from the shop project plans you published in December. Although you mentioned substituting other types of lumber, I chose cherry wood to achieve that same classic, traditional look.

HARRY E. WAECKER
TOWNSEND, DE

Comparos Compared

Your recent comparison test of 14 4-door family sedans did not fairly evaluate the Dodge Spirit/Plymouth Acclaim relative to its competitors. The Spirit/Acclaim is not only an outstanding value with excellent engineering, it has the most spacious interior in its class. Your comment that the "rear-seat legroom is a little tight" conflicts with your own data table showing the Spirit/Acclaim rear-seat legroom at 38.3 in., as best of the 14 models tested. The table also lists rear hiproom at 35 in. instead of its actual published value of 52 in. You mention "modest" trunk space with high lift-

over for the Spirit/Acclaim while commending the Honda Accord for "plenty of room" in the trunk with "low liftover." Our data indicates that the Spirit/Acclaim at 14.4 cu. ft. has the same trunk volume as the Honda Accord, while our liftover is 1.7 in. lower than the Accord.

J.E. THOMPSON
EXECUTIVE ENGINEER
CHRYSLER CORP.

I find all the emphasis on larger, more powerful cars to be very disconcerting. For instance, the redesigned Toyota Camry featured in your comparison test is heavier and less fuel efficient than its predecessor. Yet, it's assumed to be a better car because it's more luxurious.

Who defines "better?" People forget that petroleum is a finite resource and the price of gasoline—upon which car-design trends are apparently based—is just a temporary economic condition.

ALEX CAMERON
SACRAMENTO, CA

People define "better." The new Camry is selling at double the rate of the previous model.
—Ed.

Your comparison tests are always very interesting, but as the electronics systems in these cars become more complex, the less valuable these cars are to more than 3 million potential buyers. My new 1992 Toyota Camry LE is of no use to me or my wife. For many years we have used 2-way radio equipment in our vehicles, both business band and amateur band. But with the new family of computers, radios in the '92

(Please turn to page 12)



Reader Harry Waecker built this classic, reproduction cherry chest.

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

The Buick Regal Gran Sport. A car as rewarding on pavement as it is on paper.

	Buick Regal Gran Sport	Lexus ES 300
Engine	3.8-litre V6	3.0-litre V6
Transmission	4-speed automatic (std)	4-speed automatic (std)
Touring Suspension	4-wheel independent	4-wheel independent
Brakes	Anti-lock disc	Anti-lock disc
Wheels	16" aluminum alloy	15" aluminum alloy
EPA Est. MPG	18 city/28 hwy	17 city/23 hwy
M.S.R.P.*	\$21,240	\$26,150

*Manufacturer's suggested retail price including dealer prep. Destination charge, tax, license and options additional. Levels of equipment vary.
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BUICK

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Camry are restricted to less than 10 watts of output. This also applies to five other brands of cars I've checked. With 500,000 amateur radio operators and 2½ million business band radios in use today, we are forced to drive pickup trucks or used vehicles built before 1988. I'll continue to drive my 1990 pickup truck with radio equipment and trade in my new Toyota Camry for an older car.

JOHN C. HARMAN
TAVARES, FL

Lost Squadron Revisited

Charles Vactor's letter in the June issue boggles my mind, to borrow his expression. Mr. Vactor decried the effort to recover the airplanes in Greenland and suggested alternate uses for the money spent. The recovery effort invoked and rewarded the employment of technology and scholarship. The same may be said of cancer research, one of Mr. Vactor's proposed alternative uses for the money. But, can the same be said of his other two alternatives: increasing the dole for people already locked into dependency on the government; and giving the money to a federal government which has shown chronic fiscal irresponsibility.

KENNETH BRYANT
NASHVILLE, TN

The negative comments made by Charles Vactor were inappropriate and in poor taste. They reflect his lack of knowledge as exemplified by the statement "dozens of this airplane" are parked at Davis-Monthan Air Force Base in Tucson, Arizona. Those beautiful aircraft went the chop/smelter route long ago. By the 1950s, they had become lawn furniture, roofing, pots and pans—mute testimony to the lack of foresight existing at that time. These aircraft were near-new when lost, and salvageable components may permit restoration and reconstruction of several vintage birds for future generations to enjoy, appreciate and remember.

RICHARD BOUTIN
TALLAHASSEE, FL

Escort Service

After touring California in a rented Ford Escort LX and then reading your Owners Report, I must say how much I agree with your assessment. I was impressed with this car in many respects, but the No. 1 factor was fuel economy. I covered 2602 miles and used 68.6 gallons of gas, averaging about 37.9 mpg. This is remarkable considering that the car was an automatic, carried three adults with luggage, had the a/c on most of the time and drove up a number of mountain

passes. I should also mention the L.A. traffic we got stuck in.

DAVID LAUNCHBURY
EASTLEIGH, HANTS, UK

Correction



The address of Experimental Aviation Corp. was printed incorrectly in the August issue. The correct address is: Experimental Aviation Corp., 3025 Airport Ave., Santa Monica, CA 90405; (310) 391-1943. **PM**

NICKS. NICKS. NICKS. NIX.



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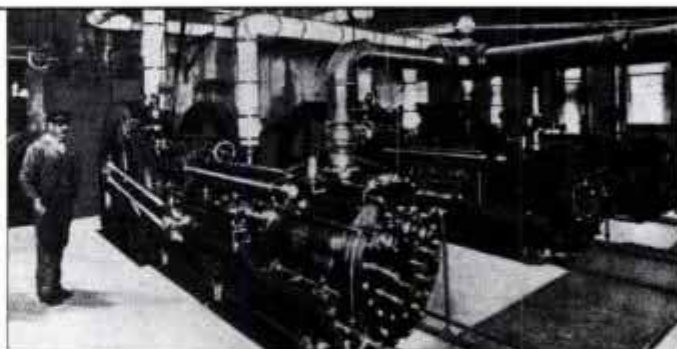
TIME MACHINE

90 YEARS AGO: SEPTEMBER 1902



Port Of Coal

The cargo vessels that chugged between Chicago and Buffalo ran on gigantic reciprocating steam engines. A single voyage through the Great Lakes burned hundreds of tons of coal, and the Chicago harbor hosted 18,000 ships a year. To feed the hungry freighters, traveling derricks with 5-ton buckets bustled back and forth on tracks along the dock. They proved to be the swiftest means to move prodigious weights of coal during the shipping year.



Manhattan Moles

Below New York, monstrous machines were burrowing through the bedrock, carving out the first 58 miles of the subway system. Huge air

compressors powered pneumatic drills that opened holes to be stuffed with explosives. The subway-building contract, inked in 1900, totaled a mere \$35 million.

60 YEARS AGO: SEPTEMBER 1932



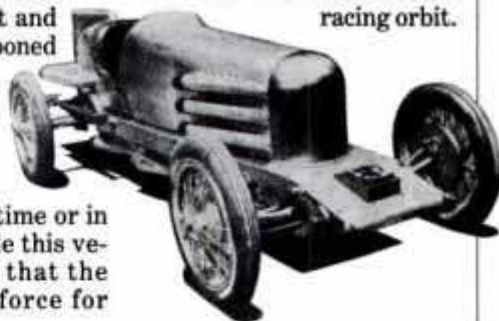
Drill Rig

To speed submarine rescues and salvage missions, a Chicago inventor conceived a submersible drill big enough for divers to ride. The torpedo-shaped machine would descend from its mother ship on a cable and touch down on spring skids. While magnets on the skids gripped the sunken craft's hull, divers would work the drill, which sported a variable-angle chuck. A single rear-mounted motor would drive drill, propeller and air pump, either separately or all at once.

Blast Of Fast

While Goddard and von Braun struggled to tame rocket power for space transport, rocket-action cars were already blazing around dirt tracks in the Midwest. Sig Haugdahl built and drove a racer festooned with 32 rocket tubes, each with a cylinder of explosives, which Haugdahl could detonate one at a time or in groups. What made this vehicle unique was that the rocket kick lent force for

steering, especially sharp turns, rather than straight-ahead propulsion. But rocket racers, belching sparks and smoke, remained on exhibition tracks, and never reached the mainstream racing orbit.



30 YEARS AGO: SEPTEMBER 1962



Inner Sanctum

"Housing '62" featured an ancient theme freshened up by a Florida location. Our plans detailed the House of Care-free Living, built around a 725-sq.-ft. atrium. Overhead, the roof sloped up to an open-frame pyramid, paneled only by screens, to allow sun and rain into the atrium (for Northern climates, glass or plastic panels were specified). In the version we built for Palm Beach Gardens, the atrium floor was a lawn, complete with putting green and barbecue grill.



Meter Made

For 40 years, Checker had been cranking out no-nonsense cabs designed to survive 150,000 miles of rough big-city streets. How did their new "civilian" versions,

both sedans and station wagons, measure up? Checker sacrificed both performance and fuel economy for comfort and sheer durability—marked by that high-riding X-frame undercarriage. **PM**

*I bought it because
I adore brass.*



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*I bought it because
I can't stand leaks.*

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Considering

everything your

air goes through,

don't you think it

should go

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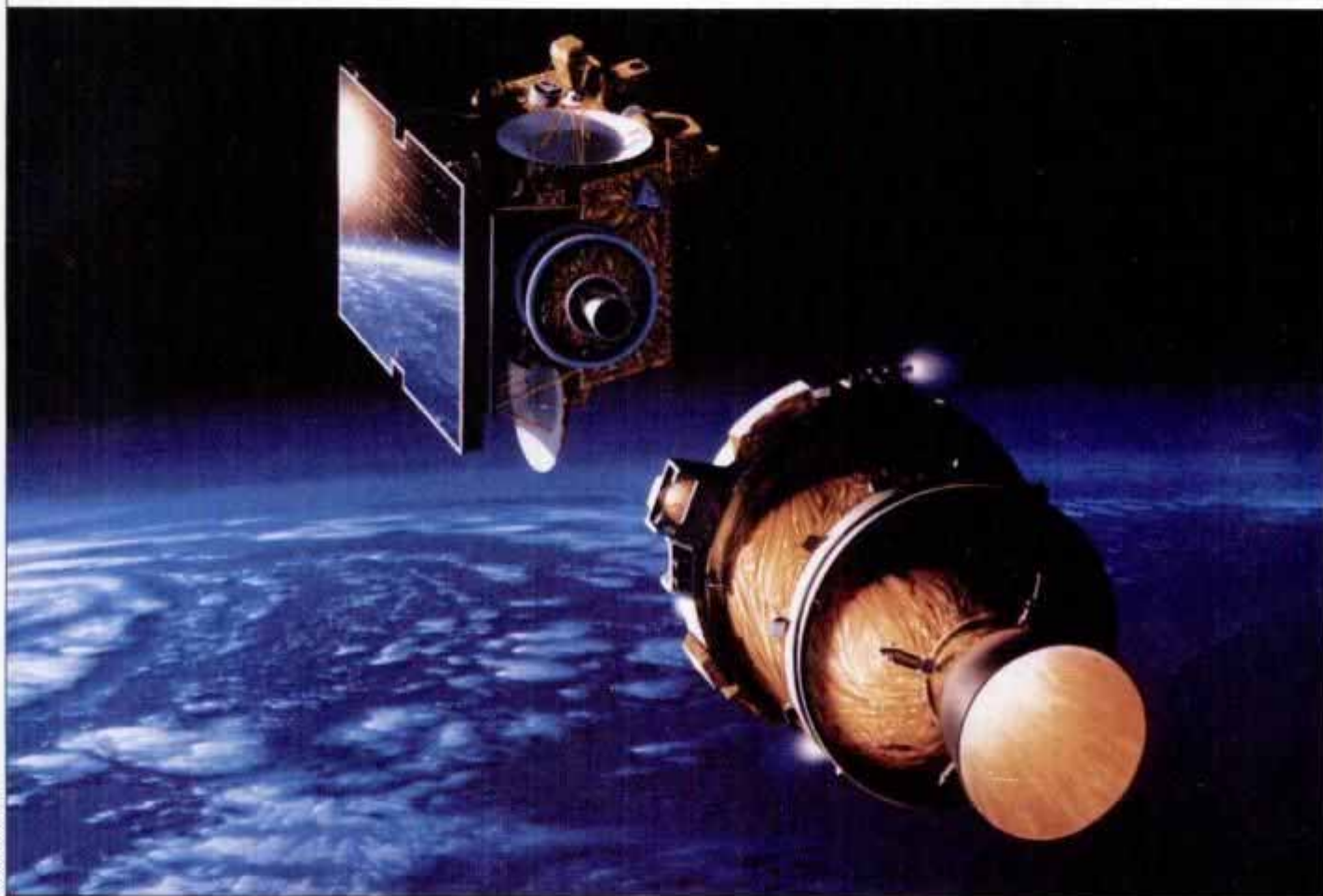


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TECH UPDATE

News Of Tomorrow's Technology Today



NASA ILLUSTRATION

Mars Observer Set For Trek To The Red Planet

CAPE CANAVERAL, FL —For the first time in 15 years, an American spacecraft is poised for the year-long flight to Mars. Not only will *Mars Observer* re-open exploration of our planetary neighbor, but the mission will mark a fundamental change in the way NASA carries out space science.

NASA's last Martian odyssey starred two custom-built orbiters and two landers. Had it been funded in 1992 dollars, the project would have cost more than \$3 billion. In contrast, *Mars Observer* is an off-the-rack General Electric TV satellite tailored with electronic systems from military weather satellites. Total cost: only

\$550 million—a shoestring effort compared with recent research packages like the \$1.4-billion Jupiter probe, *Galileo*.

But the little *Observer* will pack a big scientific punch. Beginning in 1994, Earthlings will view Martian landscape pictures that are 10 times as sharp as those from the *Viking* spacecraft. Objects only 10 ft. across will stand out, even though *Mars Observer* won't dip below an altitude of 218 miles. Six other instruments will probe atmospheric chemistry, radiation, evidence of climate change, topography and

Editor: Abe Danc
Assistant Editor: Greg Pope
Contributors: Philip Chien, Mike Fillon

soil composition.

Mars Observer is scheduled for launch this month on a Titan III.

Mars Observer separates from transfer orbit stage at beginning of year-long journey.

Highlights This Month

- **Dante's Inferno**—Mountaineering robot to probe steaming volcano.
- **Tower Of Power**—Huge rocket-service building moves itself.
- **Road-Crew Robot**—Autonomous crack-sealer operates from truck.
- **Sharp-Eyed Apache**—Longbow improvements take off.
- **High-Voltage Howitzer**—Latest on electric armaments.
- **World's Biggest Boom Box**—Sonic assaults batter home.

Dante Versus The Volcano

PITTSBURGH, PA—Late this fall, when summer breaks over the frozen continent, a mountaineer will rappel down the throat of a live Antarctic volcano.

No daredevil human, but rather an 8-legged robot named Dante will descend into the inferno. Designed and built at Carnegie Mellon University, Dante will get a piggyback to the rim of Mount Erebus on an 8-wheeled autonomous land vehicle named Virgil.

But it's all downhill from there. Dante will pick its way to the crater floor guided by vision sensors—stereo cameras and a laser rangefinder. A tether will serve as rappelling cable, data link and power cord from Virgil's diesel generator.

Dante's body comprises two concentric frames, each with four legs that walk in pairs.

Once at the bottom, Dante will park itself near outgassing vents and collect samples, its instruments operated remotely via the data link. After a day on the crater floor, Dante will spend another 16 hours crawling back up to Virgil.

The most tortuous quest a robot's ever undertaken, the Erebus project will challenge the technology planned for Moon and Mars rovers.

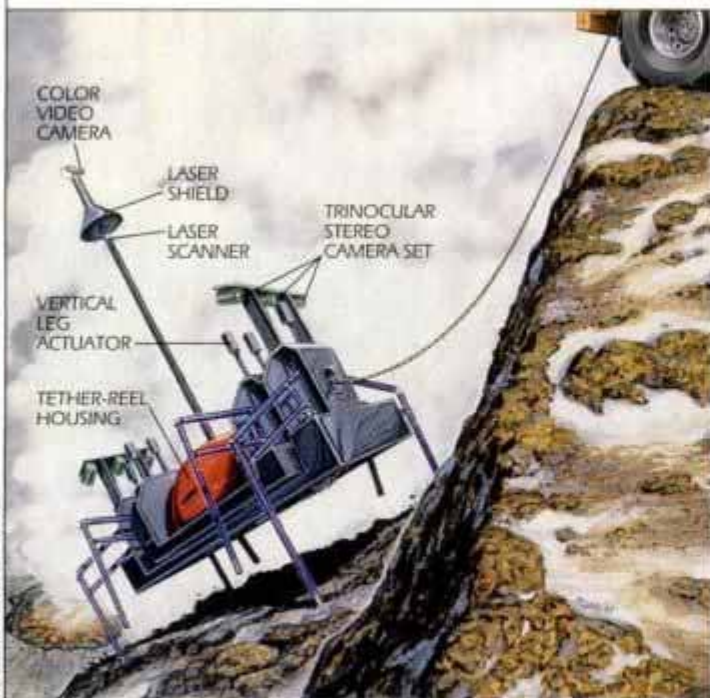
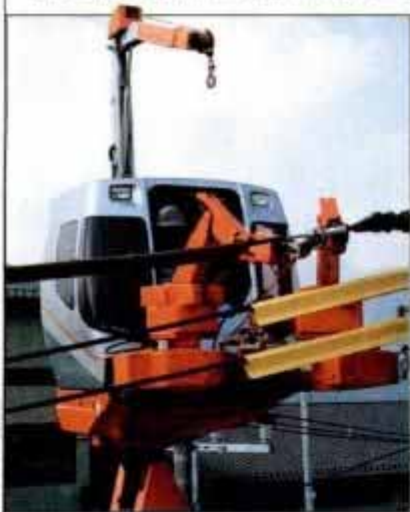


ILLUSTRATION BY JEFF MANNING

Robotic Bubble Bucket Truck



GUNMA, JAPAN—Many of Japan's electric companies aren't using bucket trucks anymore. Instead, their linemen work from enclosed, windowed cabins fitted with twin telerobotic manipulator arms.

The cabins are built by Aichi Sharyo Co. The arms, supplied by Kraft Telerobotics of Overland Park, Kansas, extend and retract from the cabin's base. The operator uses force-feedback joysticks to move

the arms, which, although hydraulically actuated, are controlled via fiberoptic cables. Also at the lineman's disposal is an overhead boom winch, which can hoist objects up to 300 pounds for the arms to put into place.

The entire system is insulated so the user can operate on live lines or work during storms.

The Canadian utility Hydro Quebec has developed a similar system using the Kraft arms. Meanwhile, Pacific Gas & Electric recently bought several Kraft manipulator systems and may come up with its own version.



Japanese linemen guide robotic arms from insulated bubble cabs.

World's Heaviest Roller

CAPE CANAVERAL, FL—The Air Force's new mobile service tower for Titan rockets is, at 11.4 million pounds, the heaviest thing ever to propel itself along railroad tracks.

The tower at Launch Complex 40 is essentially a 23-story building mounted on custom railroad cars. The structure rolls in to envelop the entire launch pad, screening the rocket from the elements. Designed by Bechtel Corp., it can withstand hurricane-force winds.



Inside, work platforms support inspection teams, while payload processing goes on in a clean-room.

For a moving vehicle, the tower boasts some impressive statistics. Six-and-a-half miles of piping snake through the complex, and there's

enough wiring and cable to run from Washington, D.C., to Baltimore and back again.

The tower will get its inauguration this month when a Titan III, carrying *Mars Observer*, blasts off. Titans are the backbone of the Air Force's rocket fleet, and the service tower is designed for a minimum 15-year life span.

Massive 23-story launch-prep tower for Titans was built on rolling stock.



AIR FORCE PHOTO

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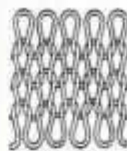
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Seeing-Eye Cessna

GREENBELT, MD — A Cessna 402B rigged with a forward-looking infrared and head-up display (HUD) is testing the technology for foul-weather landings by commercial passenger jets. Northwest Airlines is spearheading the effort.

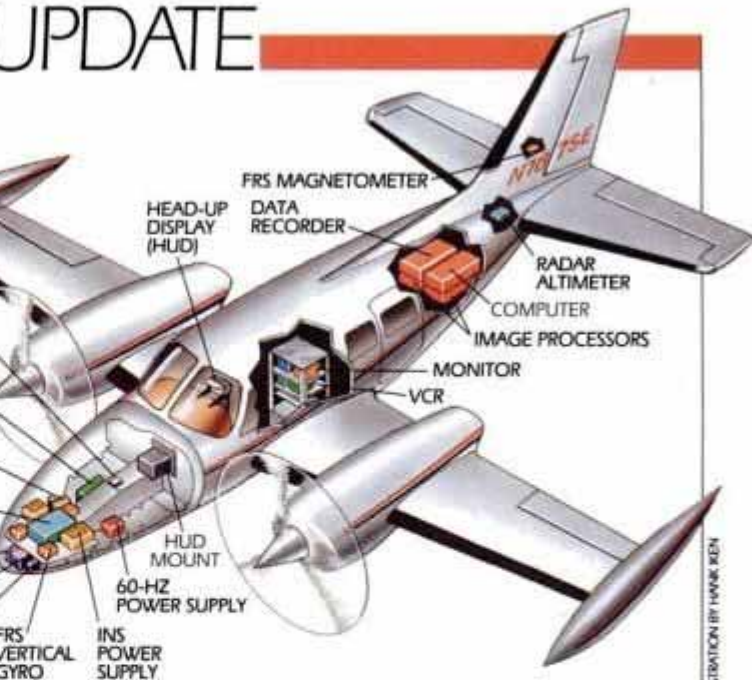
The testbed, outfitted by the Maryland Advanced Development Laboratory, will evaluate a variety of enhanced-vision hardware, including HUDs from F-16 fighters and Airbus transports, a millimeter-wave radar and several different infrared scanners.

The objective: to come up with a combination of sensors and displays that show the

pilot his runway (and anything on the runway) during a low-visibility approach. Instrument data would flank the image on the HUD, so the pilot could quickly switch from instrument to visual approach.

Northwest is considering the installation of enhanced-vision hardware on its DC-10 and 747 fleets.

That, of course, is assuming that the equipment will be certified for several differ-



Cessna 402B previews enhanced-vision technology destined for future Northwest Airlines jumbo jets.

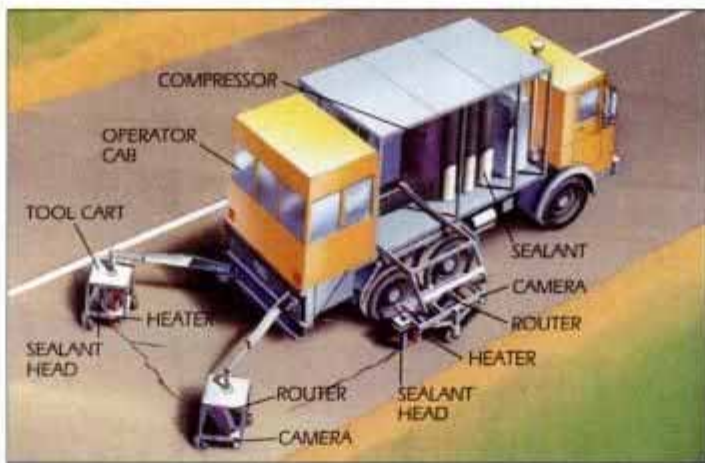
ent categories of instrument runway approaches. If all-weather landings became

possible, it would substantially boost the flexibility of airport operations.

Robotic Road Repair

SACRAMENTO, CA—Machines that autonomously spot, scrub and seal road cracks are under development courtesy of the Strategic Highway Research Program. Teamed on the effort are Bechtel Corp., the California DOT and University of California at Davis.

The robotic hardware would ride on a manned truck, along with a camera to



scan the road for defects.

For seam cracks, a rolling tray unfolds from the truck. A closeup camera confirms the crack, then router, heater and sealant dispenser go to work as the truck inches forward. For free-form cracks, the truck halts, and two robotic arms push carts.

Engineers aim to field a prototype vehicle by 1993.

Rear-mounted arms roll carts to mend spidery road cracks. For straight-line cracks, machinery deploys from truck's flank.

Chameleon Falcon



WRIGHT-PATTERSON AFB, OH—The Air Force has a new flying testbed, an F-16D outfitted to mimic the handling qualities of other jets.

The Variable-stability In-flight Simulator Test Aircraft, or VISTA, supplants a 41-year-old T-33. The fighter's combat avionics and weapons systems have been

replaced with computers that tie into the F-16's fly-by-wire computer.

The Air Force will use VISTA to train test pilots, probe flying qualities and test new cockpit software and hardware. The F-22 and X-30 programs will be prime beneficiaries.

Destination Moon

HOUSTON, TX — Men haven't set foot on the Moon since 1972, and it looks like another manned mission is decades away. Unmanned probes like the Lunar Resources Mapper will have to do for the time being.

The satellite, another of NASA's off-the-shelf probes, will scan the lunar surface for titanium, aluminum, sodium, magnesium and hydrogen. These elements could come in handy if NASA ever establishes a permanent Moon base.

Lunar Resources Mapper will be the first U.S. Moon probe since Apollo 17.

The Mapper is scheduled for Delta-rocket launch in 1995.



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Apache's New Arsenal

MESA, AZ—The "D" version of the AH-64 Apache—known as the Longbow—took to the air for the first time last April.

The mushroom-shaped radar perched over its rotor masterminds an astonishing new avionics system. Long-

bow can engage multiple targets, both on the ground and airborne, and hand some of them off via data radio to other Apaches. The pilot watches all of this on a new video-game-like tactical situation display.

Longbow radar works in



MCDONNELL DOUGLAS PHOTOS



Displays surround copilot (left) and pilot (right) in new Apache Longbow. Chopper first flew with mast-mounted radar April 15.

millimeter wave-lengths and, according to developers Martin Marietta and Westinghouse, can penetrate fog, smoke and rain.

As if that weren't enough, the new AH-64 Apache comes with radar-guided, fire-and-forget Hell-

fire missiles and will carry air-to-air missiles as well.

McDonnell Douglas will produce three more flying prototypes. The Army wants to convert 227 Apaches into the "D" configuration and upgrade the remaining AH-64s to cooperate electronically with the Longbows.

Electrothermal Weapons Show Some Spark

PICATINNY ARSENAL, NJ—The Army continues to sponsor work on electromagnetic guns, in which prodigious jolts of current accelerate projectiles. But despite progress, engineers are years from shrinking the necessary power supply to fit a self-propelled platform. In the meantime, a similar, nearer-term technology may bridge the gap.

Although electrothermal chemical (ETC) propulsion doesn't offer the same hypervelocity punch of electromagnetic propulsion, it demands only a quarter of the power. Channeled into the gun breech, the current flash-vaporizes an aluminum-based propellant



FMC PHOTOS

behind the projectile. The round rides out a smooth, prolonged acceleration through the barrel and emerges at

a higher speed than an explosively fired shell.

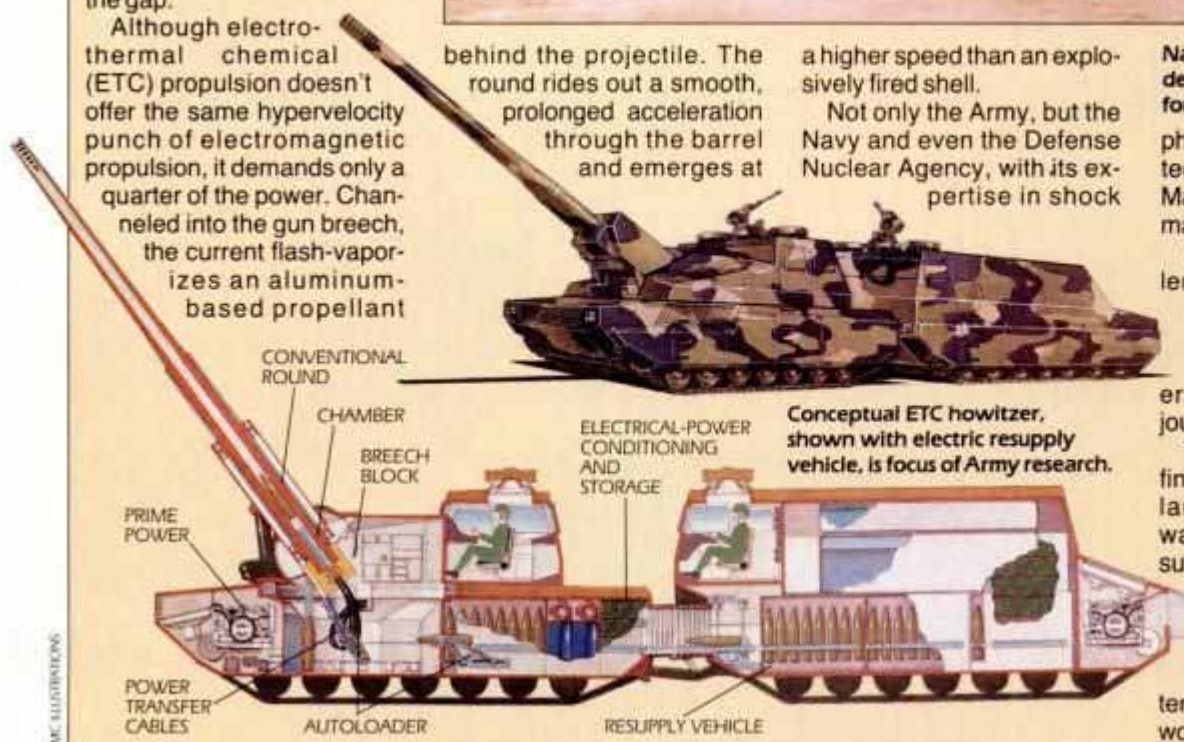
Not only the Army, but the Navy and even the Defense Nuclear Agency, with its expertise in shock

Navy's 60mm close-in gun demonstrates ETC propulsion for potential Phalanx follow-on.

physics, are researching this technology. FMC Corp. and Maxwell Laboratories are the major contractors.

Army efforts center on artillery scaled down to 30mm. The Defense Nuclear Agency shot a 50-pound shell from a 5-in. gun, generating a record 14 megajoules of muzzle energy.

The Navy's interest is to find a successor to the Phalanx close-in weapons on warships. ETC propulsion suits this missile-defense application, for an intriguing reason: The projectiles will contain electronic guidance systems that an explosive launch would damage.



Conceptual ETC howitzer, shown with electric resupply vehicle, is focus of Army research.

FMC ILLUSTRATIONS

A Spin Through Earth's Tail

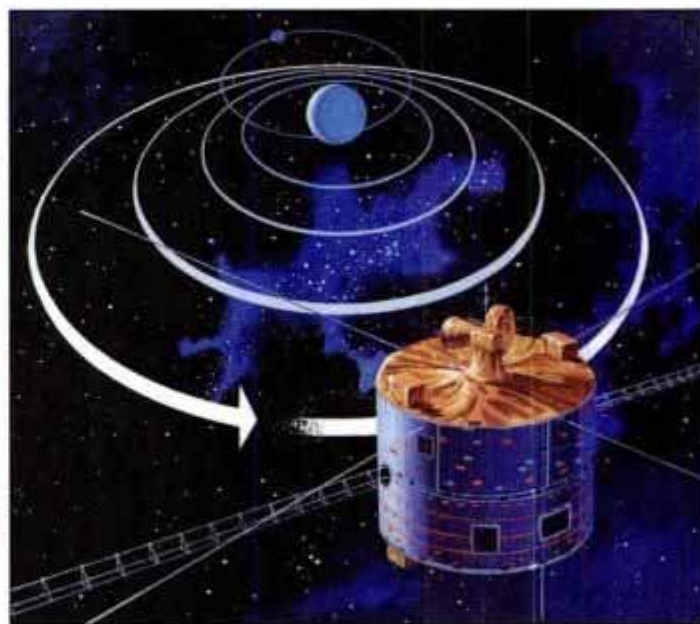
SAGAMIHARA, JAPAN—A little satellite has begun exploring Earth's magnetotail, the magnetic field behind our planet. Solar wind, the stream of charged particles from the Sun, stretches this field into a tail hundreds of thousands of miles long.

Geotail, built by Japan's Institute of Space and Aeronautical Science, swoops through this tail in a series of eccentric orbits. Each time Geotail passes the Moon, lunar gravity catapults the spacecraft farther behind Earth. Scheduled for a July 14 launch via Delta 2 rocket, the

spacecraft carries sensors to measure electromagnetic fields, particles and plasma.



Japanese-built Geotail will use lunar gravity assists to venture up to 872,000 miles from Earth.



DAS PHOTO, PM ILLUSTRATION BY ED VALKURSKY

Berth Of Freedom

HUNTSVILLE, AL—Development of Space Station Freedom has reached a critical juncture—the simulated

berthing of two major pressurized components.

At NASA's Marshall Space Flight Center, Boeing engineers have suspended a prototype lab module and a connecting node. Both components are riddled with sensors to gauge the performance of their connecting mechanism. Testers will subject the module and node to heat, pressure and vibration.

If the design passes the berthing test, Boeing believes workers can start building hardware. Scheduled launch of the first Station element is only three years away.



Station module and node swing from overhead beam during berthing tests.

BOEING PHOTO

T-REX, King Of The Wasteland

BETHESDA, MD—Robotic excavators, a prime research focus in construction automation, may also prove to be a force in hazardous waste cleanup. For exam-

T-REX hoists drum. Five on-board cameras guide remote operator.



ple, Martin Marietta is building a \$3.3-million Teleoperated Robotic Excavator, called T-REX.

The 18-ft. vehicle will swing a 36-ft. manipulator arm. Among five possible end effectors is a drum grabber. The claw must pick up fragile old drums of toxic material without bursting them. The operator needn't sweat bullets—he'll be miles away, controlling T-REX via a fiberoptic data link. In addition, sensors all over the claw manage the fine motions of the robotic hand.

T-REX will go to work first at tainted Department of Energy sites in Idaho.

MARTIN MARIETTA ILLUSTRATION

World's Biggest Boom Box

MARIETTA, GA—Using a diabolical noise machine, Georgia Tech is unleashing simulated sonic booms and other megasounds.

In a custom system built by Intersonics, Inc., conventional speakers blast sound above 100 Hz. Sound between 30 Hz and 100 Hz emerges from a monstrous servomotor-driven subwoofer.

But the true bottom (3 Hz to 30 Hz) comes from a newly developed servovalve speaker.

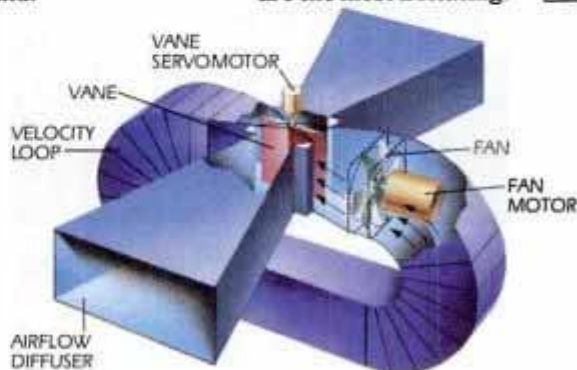
er. Inside, two giant fans blow air around a conduit known as a velocity loop. At



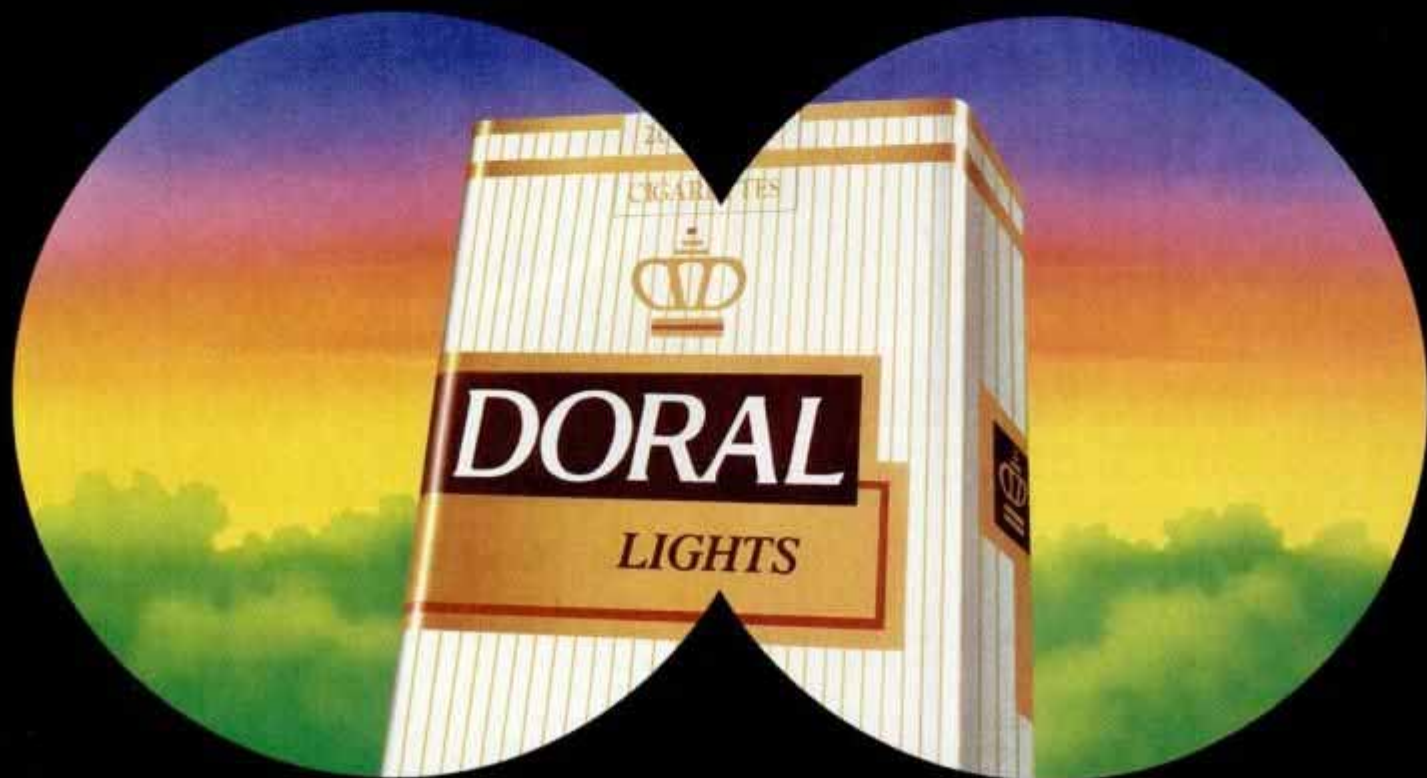
Sonic-boom simulator features servovalve speaker (right) for super-subwoofer.

the top of the loop, the air escapes through a motor-driven vane, which modulates the airflow to produce super-deep sound.

The researchers are inflicting the noise on willing experimental subjects, aiming to find out which sounds are the most irritating. **TV**



GEORGIA TECH PHOTO, PM ILLUSTRATION BY ADRIENNE BROTHMAN



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AMERICA'S SECRET COMMANDOS

Trained to infiltrate, observe and fight under any conditions, special operations forces are becoming our first line of defense in a complex, post Cold War world.

BY ABE DANE,
Science/Technology Editor
PM Photos by Brian R. Wolff

● A small band of elite warriors crouches beneath the sands of Western Iraq. Buried in their carefully constructed hide site, the Green Berets are visible for no more than a few yards, but they command a clear view of passing enemy traf-

fic. Their mission is special reconnaissance, giving the XVIII Airborne Corps eyes and ears in the desert.

Half a world away, and several months later, a detachment of Navy SEALs sneaks into Haiti. Top aides

Navy SEALs, masters of stealth, undergo cold-weather training in Alaska.

to the country's democratically elected president Jean-Bertrand Aristide are threatened by the military strongman who now holds power. Someone has to get them out.

In Panama, a few minutes into Operation Just Cause, Delta Force



SECRET COMMANDOS



storms Modelo Prison, where American Kurt Muse is being held by Gen. Manuel Noriega. Unless rescued, Muse, arrested for running a secret radio station, could become the focus of a heart-rending hostage drama.

Scenes like these are enough to make many in the American military wish for the quiet tension of the Cold War. To protect American interests, they must now be ready to react whenever and wherever a crisis may occur. And the reaction must be swift, decisive and precisely tailored to the situation at hand.

Stepping into the breach is an elite breed of soldier originally trained to fight on the fringes of full-scale wars, but now more likely to bear the brunt in conflicts where stealth and cunning outweigh brute force. Collectively known as special operations forces, these often secretive soldiers work in small, cohesive fighting groups, travel light and fast, use the most exotic weapons and equipment, and are masters of infiltration and escape. Most important of all, they must be able to adapt, cooking up their own "field expedients" when, as inevitably happens in war, they encounter problems that no amount of training or equip-



SEAL infiltration methods include the 24-ft. Rigid Inflatable Boat (top), SEAL Delivery Vehicle (above), and swimming with the LAR V closed-circuit breathing apparatus (left).

ment can prepare them for.

As a result, the tools and tactics of these special warriors are as diverse as their missions. But with the creation of the United States Special Operations Command (USSOCOM) in 1987, they have found a unified and newly prominent identity. Members of the Army, Navy and Air Force now work together within this structure, complemented by select Marine Corps units. Together, they form a

coordinated yet uniquely flexible fighting force. Many consider it to be our best hope for stability and safety in the new world order.

USASOC

The Army makes up the largest component of the USSOCOM forces. Under the authority of the U.S. Army Special Operations Command (USASOC) are the Rangers, the Special Forces groups, the 160th Aviation Regiment, and Civil Affairs and Psychological Operations units. Best known among these, and most representative of the special warfare concept, are the Special Forces, otherwise known as the Green Berets.

The Green Berets are trained to function in 12-man units called operational detachments (ODAs), or A-teams. Organized as tiny, self-sufficient armies, A-teams thrive on specialization. Two on each team are experts in weapons, two specialize in combat engineering and demolition, two are medics, and two handle communications. The doubling up in each area means the detachment can break up into two "split teams" and retain the same range of expertise.

COMMAND STRUCTURE

USSOCOM encompasses Army, Navy and Air Force components totaling about 45,000 men.



U.S. SPECIAL OPERATIONS COMMAND



AIR FORCE SPECIAL OPERATIONS COMMAND



JOINT SPECIAL OPERATIONS COMMAND



AIRBORNE
U.S. ARMY SPECIAL OPERATIONS COMMAND



UNITED STATES DEPARTMENT OF THE NAVY
NAVAL SPECIAL WARFARE COMMAND



20 RECON BN
MARINE RECONNAISSANCE BATTALIONS

SEALs in overwhites train for cold weather using M14s and cross-country skis.

Green Berets have a lot more leeway than conventional forces in deciding what they'll carry on a mission. But they tend to stick to a small stock of well-proven arms, many of which are also used by the special operations forces of the other services.

Guns

Two snipers provide the long-range firepower of an ODA. Each is issued the Army's M24 sniper system, which builds around a highly modified Remington M700 rifle, firing 7.62mm match-grade ammunition. About all that remains of the original civilian gun is the bolt-action firing mechanism. The stock is made of Kevlar graphite, and a heavy, stainless-steel barrel has been fitted. The barrel floats freely within the stock to prevent irregular vibrations that could compromise accuracy. Sighting is through a 10-power Leupold scope.

Snipers almost always work in pairs—one shooting, the other watching through a 20-power spotting scope. The spotter follows the air vortices that trail each round and calls out corrections for the next shot. Officially, the effective range of the M24 is 800 yards. But Green Berets I spoke to said that a well-trained sniper should be able to make consistent hits out to 1000 yards.

An innovative, ferocious weapon that has broadened the sniper's role is the Barrett 82A1 .50-caliber semi-automatic rifle. Firing the ammunition of a heavy machine gun, the "light fifty" can stop light armor at more than 2000 yards yet weighs less than 30 pounds. A unique muzzle brake jets propellant gases backward, reducing recoil to about that of a 12-gauge shotgun. Eleven rounds can be squeezed off from the detachable box magazine before reloading.



Despite their broad experience with unusual arms, most Special Forces express surprising affection

for the standard-issue M16A2 as an all-around assault rifle. Bugs that plagued earlier M16 variants are apparently ironed out, leaving it a rugged, reliable, easy-to-handle weapon. Usually, two members of an ODA will pack M16A2s, with M203 40mm grenade launchers mounted under the barrels. The breech-loading launcher can lob explosives up to 400 meters.

Special Forces' weapons proficiency must encompass foreign arms, as well. From early on, an important part of their mission has been to train the troops of friendly nations. That means they must be prepared to instruct in the use of whatever weapons happen to be around. The Soviet AK-

SEAL Fast Attack Vehicle in Kuwait bristles with M60 machine guns, grenade launcher and anti-tank missile launcher.



AGENCE FRANCE PRESSE PHOTO

SECRET COMMANDOS

47 assault rifle (called the AK-74 when in the U.S. inventory) is one of the most common. Special Forces soldiers compare the AK-47 unfavorably to the M16, faulting its heavier weight, shorter range and wildness in full automatic mode. Other weapons Special Forces may use on training missions include the heavy German G3 assault rifle and the Israeli UZI submachine gun.

Sights and optics

Making every shot count is key for Special Forces units, so they rely on advanced optical equipment to find and fire upon their targets. For general use in night operations, each ODA is issued four sets of AN/PVS-7As, the latest generation of night-vision goggles. They amplify light efficiently enough that objects 300 to 400 yards away are visible even on moon-

less nights. In pitch darkness, a small infrared illuminator switches on, providing short-range visibility.

Laser aiming lights are coming into wider use for night work. Aligned with the rifle's barrel, the laser projects a dot of light that marks exactly where the round will hit. Special Forces use the AN/PAQ-4, a lightweight, cylindrical unit that throws out a flashing infrared beam visible only with night-vision goggles.

Light-amplifying devices such as night-vision goggles don't help in seeing through smoke or fog. Such conditions require much larger and more complex devices that pick up tiny variations in temperature. During Operation Desert Storm, Special Forces used the AN/TAS-6 thermal acquisition sight. Although it weighs close to 70 pounds and requires the regular replacement of batteries and

liquid-nitrogen coolant bottles, it proved to be highly effective for fixed observation posts. With magnification reaching 12-power, users report being able to spot rats a mile away.

Another optical device that proved itself in Desert Storm is the AN/PAQ-1 laser target designator. This rifle-like ray gun helps artillery and attack aircraft find their marks by illuminating them with a beam that laser-guided munitions can follow. Waterproof and a little under 15 pounds, the PAQ-1 can easily be carried on infiltrations behind enemy lines. Three knobs are used to dial in prearranged codes that make sure the right projectile tracks the right target.

Communications gear

Advancing electronics technology has made it easier for Green Berets to stay in touch without compromising



Beached SEAL wears LAR V oxygen-recycling breathing gear, and carries Heckler & Koch MP5 submachine gun.

For cold weather, SEALs wear overwhites and snowshoes, and carry the old but highly accurate M14.

SEAL snipers prefer a specially built McMillan 7.62mm M86 rifle, accurized throughout and equipped with fiberglass stock.

security. For example, all an A-team needs to maintain contact with state-side commanders is a 12-pound sat-com radio called an LST-5C. In a few minutes, a spring-loaded folding antenna is deployed, aimed with a compass, then hooked to the radio with a coaxial cable. After a few signals are bounced off the satellite to fine-tune the aim, the system is ready.

Compact as the LST-5C is, teams carry it only on missions that absolutely require real-time contact with their home base. Usually, they get by with lighter VHF and HF radios from the conventional military inventory.

Vehicles

Special Forces train to get to and from their objectives by just about any means imaginable. Recently, new transport hardware has opened new options.

Parachute drops are a preferred method of infiltration, but Green Beret capabilities go well beyond the en-masse static-line jumps practiced by normal airborne units. Wing-like ram air canopies adapted from sport parachutes entered service in the mid-'80s. Their accuracy and flexibility are crucial in high altitude low opening (HALO) and high altitude high opening (HAHO) jumps. HALO is a way of dodging detection by jumping from an altitude of up to 25,000 ft., then freefalling to about 4000 ft. before opening the canopy. HAHO keeps the aircraft out of harm's way. It involves pulling the ripcord a few seconds after jumping, then gliding several miles to the drop zone.

For HALO and HAHO jumps, Spe-



AN/TAS-6 thermal sight sees through smoke.

cial Forces use the MT1-XX, a highly modified civilian ram air chute that can glide at airspeeds up to 25 mph.

For the high-altitude leg of a HALO or HAHO deployment, jumpers breathe from two compressed oxygen "bailout bottles." A chest-mounted magnetic compass



LST-5C satellite radio folds down into a compact, 12-pound unit, but can reach any spot on the globe.



Green Beret sniper's ghillie suit is made of an old flight suit, camouflage net and shredded burlap.



Green Beret HALO and HAHO jumpers strap their rucksacks to their thighs, and breathe from bailout bottles.



AN/PVS-7A night-vision goggles are used with an AN/PAQ-4 aiming light to help aim this Green Beret's M203.



normally guides them to the drop zone on HAHO jumps, but recently, compact Global Positioning System (GPS) satnav units have tested favorably. Rucksacks are strapped around the thighs during descent, then kicked loose about 10 ft. off the ground.

In the wake of the disastrous Iranian hostage rescue attempt in 1980, tremendous effort has been devoted to modifying helicopters and training their pilots to insert and extract men under the most adverse conditions. The Army's 160th Aviation Regiment has spearheaded this research for more than a decade. Crews go through a harrowing selection process and then fly at the very edge of the envelope for night and foul-weather operations. The cost has been high, with many helicopters and crews lost in training, but the result is capability



Green Berets practice concealment and Klepper kayak tactics for riverline combat.

that simply didn't exist a decade ago.

The 160th recently took delivery of two new helicopters configured specifically to their requirements. The MH-60K is a variant of the UH-60 Black Hawk utility copter, packed to

the gills with advanced avionics. It has terrain-following radar and a forward-looking infrared sensor for all-weather nap-of-the-earth flight through hostile territory. An air-to-air refueling boom, and two fuel tanks extend range. Displays in the custom-built cockpit are designed for ease of use with night-vision goggles.

The MH-47E swings into action for heavier cargo. The venerable twin-rotor Chinook airframe is barely recognizable beneath a load of special equipment. Avionics are similar to the MH-60K's, while internal fuel tanks give it the longest un-refueled range of any Army helicopter.

To provide air support as mobile as a Special Forces unit, the AH-6J Special Attack Aircraft was developed. Based on a small, 2-seat civilian helicopter, the AH-6J fits aboard a C-130

A COMMANDO'S ARSENAL



M24 SNIPER SYSTEM

M203 LAUNCHER WITH AIMING LIGHT

AK-74 ASSAULT RIFLE

UZI SILENCED SUBMACHINE GUN

BARRETT 82A1 .50-CAL. RIFLE

MP5 SD2 SILENCED SUBMACHINE GUN

BARRETT PHOTO



Green Beret mobility team maneuvers (top) then pauses to aim laser target designator (above). M122 firing device (right) sets off demolition charges by radio.



cargo plane, and can be unpacked and ready to fly 5 minutes after arrival. Armament includes 2.75-in. rocket pods and Gatling-type 7.62mm miniguns.

Overland transport tactics have also been updated. Special mobility ODAs are now entering service, each equipped with four HMMWVs (better known as Hummers), three trailers and two lightly modified Kawasaki KLR-250 enduro motorcycles. Brimming with spare parts and fuel, the units are self-sufficient over ranges up to 1200 miles. In their primary mission—insertion and extraction of Special Forces teams—they can carry a fully equipped ODA in addition to themselves. To help manage the heavy load, the Hummers' doors are removed and their bulletproof Kevlar tops strategically cut away. The motorcycles offer high speed over rough terrain. They are used primarily for advance scouting and linkups with other units.

For waterborne infiltration, Green Berets recently adopted the Klepper folding kayak. It can carry two men and hundreds of pounds of equipment silently at 5 miles per hour. On land, it disassembles in 5 minutes into an 80-pound package portable by one man.

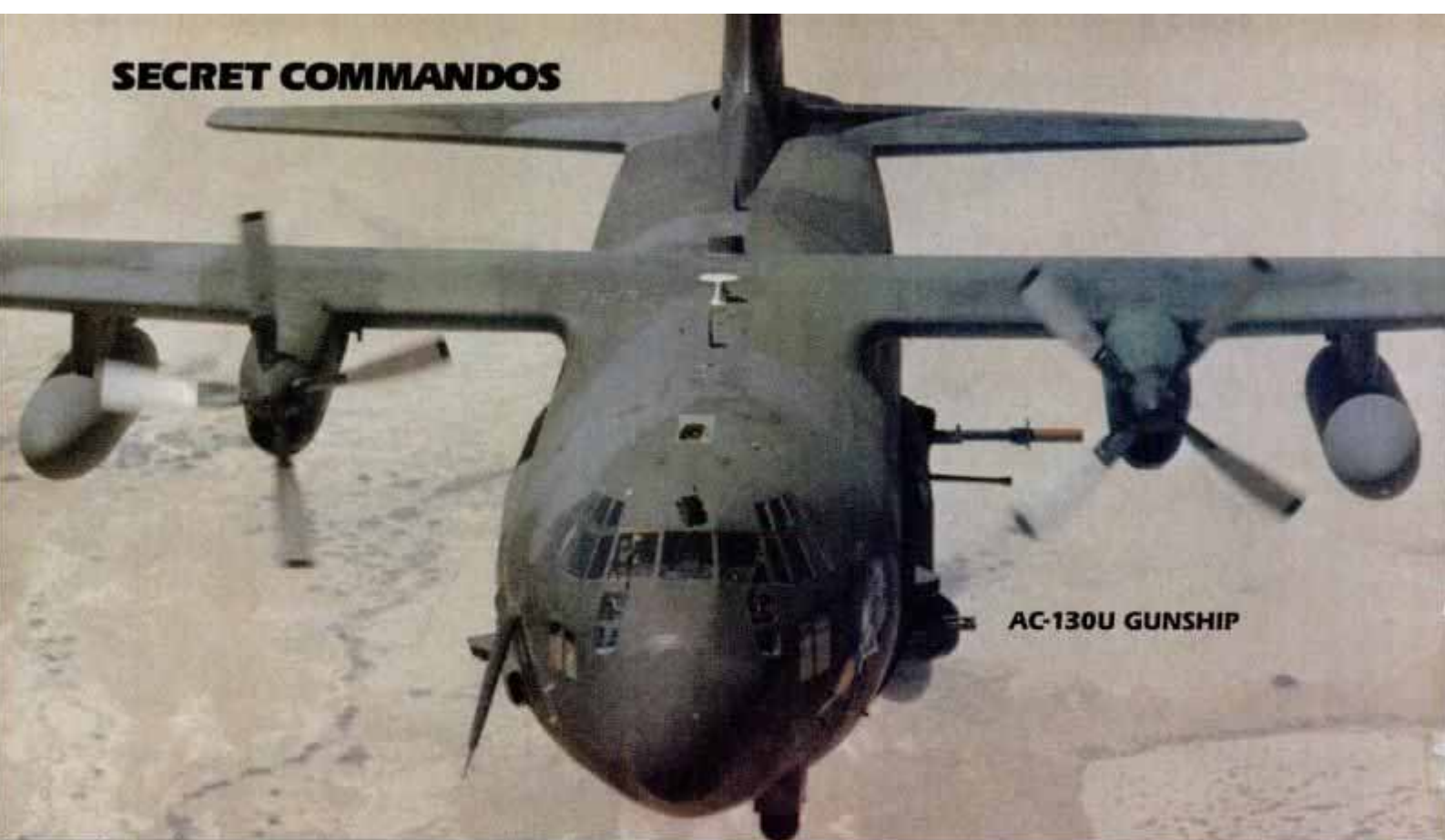
In addition to the Special Forces and the 160th Aviation Regiment, USASOC oversees the 75th Ranger Regiment. The Rangers are essentially cream-of-the-crop light-infantry soldiers. Their specialties include ambushes, urban warfare and lightning attacks to temporarily seize key objectives. They also share many of the Special Forces' infiltration skills.

Navy SEALs

Navy SEALs (SEa-Air-Land units) came into being in 1962, an outgrowth of the earlier Underwater Demolition Teams (UDTs). As the name suggests, they are versatile special warriors trained for just about any environment. Like the Special Forces, SEALs operate in small groups of individual specialists. The standard platoon has 14 to 20 men, and can break down into two squads, or boat teams.

The SEALs' forte is infiltration. In keeping with their frogman roots, they have the most extensive combat swimmer training in the armed forces. It begins with the 25-week

SECRET COMMANDOS



AC-130U GUNSHIP



MH-60K



MH-47E CHINOOK

Basic Underwater Demolition/SEAL course (BUD/S), an ordeal that has no match in the U.S. military. Boat crews carry 300-pound logs on 14-mile beach runs and go for six days on 3 hours of sleep. Those that survive possess tremendous mental and physical endurance, and a keen appreciation for the power of teamwork.

In addition to infiltration by swimming, the SEALs learn HALO and HAHO parachuting, and are proficient in tactics involving aircraft, boats, land vehicles and submersibles. Their bread-and-butter play is the Rubber Duck Op, in which a squad and its combat rubber raiding craft (CRR) parachutes into the water from a C-130. They then fire up the boat's specially silenced 35-hp outboard and head for land, guns trained on the shoreline.

They may also approach the objective underwater. Standard breathing apparatus is the LAR V (Lambertson Amphibious Respiratory unit), which emits no telltale bubbles and can sustain a diver for hours. SEALs usually wear a standard wet or dry suit, an

Air Force AC-130U fires broadside to support ground troops. MH-60K and MH-47E fly in all weather at low level. Cockpits are compatible with night-vision goggles.

inflatable buoyancy compensator to keep them swimming at the desired depth, and a black balaclava for warmth and camouflage.

SEAL weaponry is chosen to make engagements short, sharp and overwhelming, since platoons can't carry enough ammunition for sustained fighting. Accordingly, they like weapons that quickly put a lot of lead in the air. For close-in fighting, the Heckler and Koch MP5 series of sub-machine guns ranks high, because of its accuracy and rate of fire. Since Vietnam, the pump action 12-gauge shotgun has also been a SEAL trademark, especially the Ithaca Model 37 and Remington 870.

Other commonly used weapons include the M16A2 with M203 grenade launcher, and the M60E3 7.62mm machine gun, a lightweight variant of the standard-issue M60. To dispatch sentries, the standard Beretta M9 9mm

pistol may be equipped with a silencer and subsonic ammunition. Interestingly, the SEALs may be the last U.S. force still using the old M14 rifle, which fires truer farther than the M16, and works well when wet.

Vehicles

Besides the standard CRR, SEALs use various watercraft. One of the newest is the 24-ft. Rigid Inflatable Boat (RIB). With a fiberglass hull ringed by an inflatable gunwale it can stay upright and afloat in incredibly heavy weather. Its 165-hp turbo-diesel engine propels it at better than 30 mph. A 4-man SEAL element usually rides with the 2-man crew.

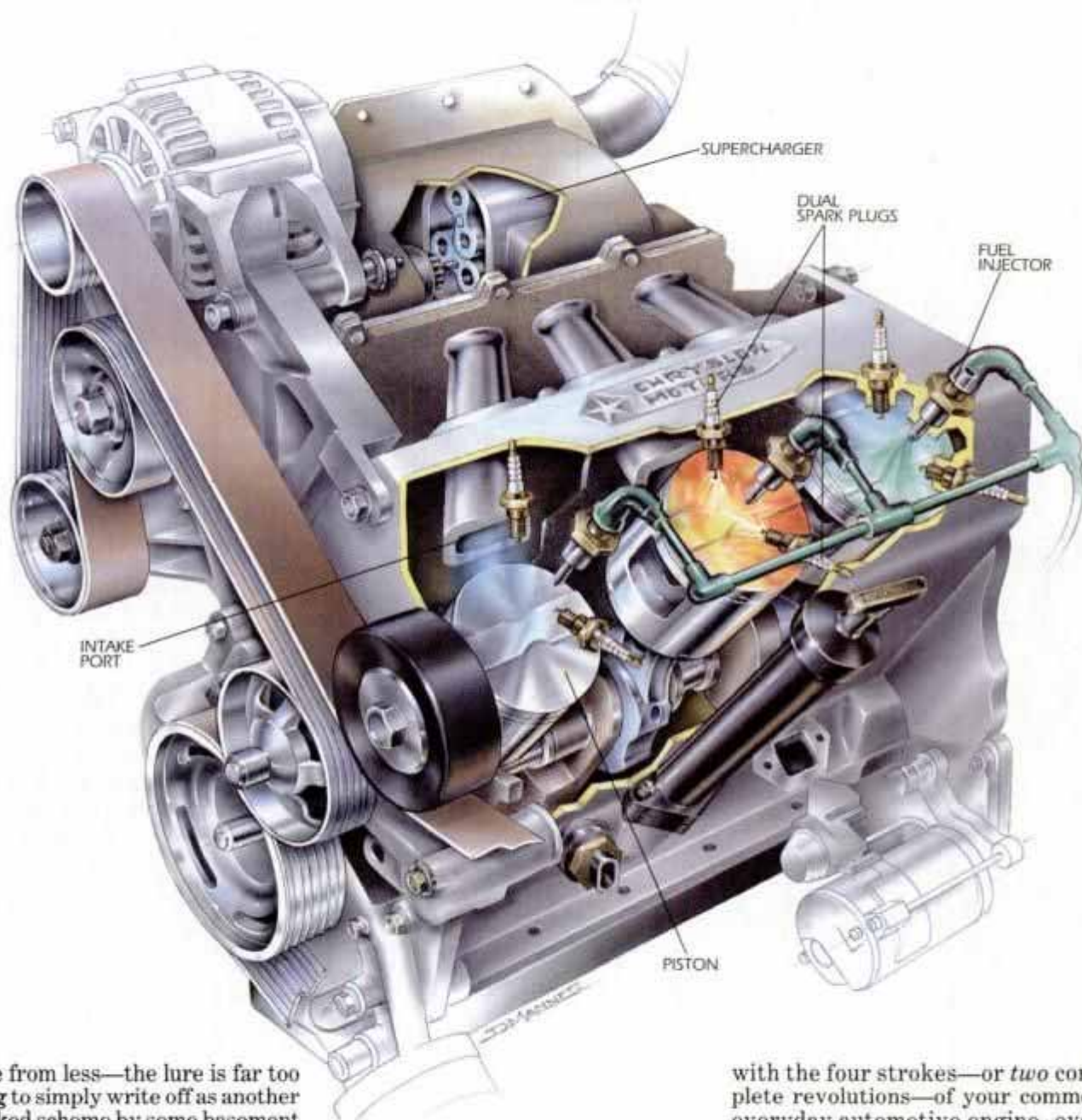
The SEALs' most peculiar mode of transportation is probably the SEAL Delivery Vehicle (SDV). Launched from surface vessels or submarines, these tiny, free-flooding submersibles let SEALs travel faster and farther underwater than they could by swimming. The 21-ft. SDV Mark VIII is the most widely used. Powered by rechargeable batteries running a DC

(Please turn to page 116)

DOUBLE WHAMMY

Detroit's plunge into 2-cycle technology will downsize your engine without reducing its output.

BY PAUL VAN VALKENBURGH; PM Illustrations by Don Mannes



● More from less—the lure is far too enticing to simply write off as another half-baked scheme by some basement tinkerer. And in today's fiercely fought automotive market arena, any engineering advance that might leapfrog one maker's cars over the competition is going to be subject to serious scrutiny. It is no wonder then that the term "2-stroke" is being bandied about in technical center corridors from Detroit to Yokohama.

The concept of the 2-stroke engine is not novel to the automotive industry. After all, the idea behind the con-

cept is too obvious to have been ignored these many years: An engine that fires once every revolution has twice as many power strokes as one that fires every other revolution. But refining that seemingly simple premise so it works in today's emissions and fuel-economy ruled automotive world is another matter entirely.

For starters, it requires a lot of sophisticated science to cleanly get the intake gases in and exhaust gases out

with the four strokes—or *two* complete revolutions—of your common everyday automotive engine, even one equipped with four valves per cylinder. The same task must be done twice as quickly—in just *one* revolution—without the help of valves.

In fact, the problems facing developers of viable 2-stroke powerplants are the same as those of 4-stroke engine makers. The hurdles, in approximate order of priority, are: emissions, fuel efficiency, long-term durability, acceptable levels of noise and vibration, cost, size, weight and the buying

DOUBLE WHAMMY

public's perception of value.

As with most emerging technologies, the key players—all three American carmakers, as well as Japanese and Australian companies—are searching for solutions in different directions. And, as usual, each has its own claimed advantages over the others, as well as some distinct disadvantages.

Scavenger

In its most primitive form—as is still found on model airplanes—the unregulated 2-stroke really requires only three moving parts: piston, connecting rod and crank.

However, for the engine to have enough power to pull more than its own weight, it's a good idea to use the changing volume of the crankcase (which changes with the up and down motion of the piston) to positively pump a fuel/air mixture—called scavenging—into the combustion chamber. A one-way reed valve is the simple mechanism for allowing air into the crankcase as needed.

Before fuel economy and emissions concerns, this simplistic engine design was used in a few basic automobiles, as well as motorcycles and power equipment. Modern versions use electronically regulated fuel injection to improve efficiency and ecological impact.

Generally state of the Motor art

The latest showcase 2-stroke engine technology is the 3.0-liter V6 from GM. That engine produces 220 hp—from a considerably smaller and 25% lighter package than its 4-stroke equivalent. GM engineers used such sophisticated techniques as computerized fluid dynamics to design this engine—from the inside out. First they designed the combustion chambers, then the scavenge ports, the cooling system and, finally, the exterior. The engine shows variable exhaust-port obstruction valves for optimum exhaust flow and “cross-stuff tuning” to provide boost up to two times atmospheric pressure. Of

course, the need for six reed valves in the engine's upper valley requires some tricky porting down to the six separate crankcases and back up to the cylinders.

Going into Orbit

The Orbital Engine Co. of Australia has developed, during the last couple of decades, a number of innovative solutions to traditional 2-stroke engine problems.

The key element is better control of fuel injection and better fuel atomization. In a 2-stage process, first the fuel is sprayed into a pre-mix chamber of compressed air, then this mixture is injected directly into the cylinder. This creates a “stratified charge,” or layers of different fuel mixture ratios in the cylinder. The mixtures range from very rich (but finely atomized) near the spark plug for easy ignition, to extremely lean and clean-burning out near the chamber surfaces. Another assist to engine smoothness over a wide rpm range is the use of a variable exhaust-port obstruction, which is wide open at high engine speed and nearly closed at idle.

Chrysler, unlike Ford, has opted to follow its own path—the path of highly developed conventional technology. Chrysler is trying to get a reliable 2-stroke on the market quickly by using a separate blower to charge the cylinder rather than scavenging through the crankcase and also very high-pressure (1000-psi) fuel injection. The air pump, a relatively well-known piece of hardware, is used instead of intake reed valves and a crankcase scavenging system. But rather than operate like a 4-stroke engine's power-improving supercharger, the pump is essential—the engine will not run without it. By forcing air directly into the cylinder above the piston, Chrysler can use a conventional wet-sump crankcase and standard crankshaft bearing shells.

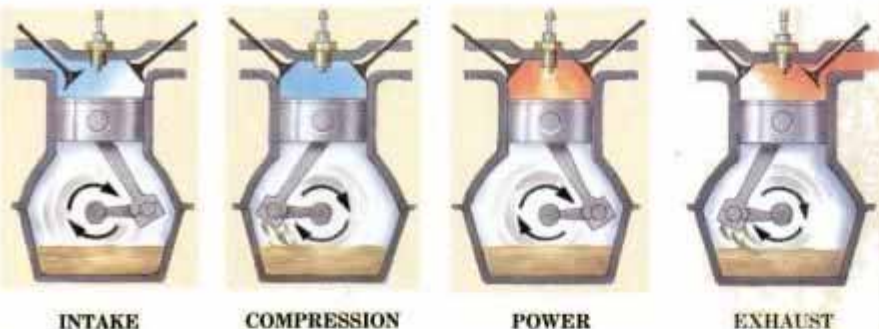
Super!

Supercharging is a convenient—and readily available—method of charging the cylinder. Subaru, for one, has produced a supercharged 2-stroke by placing a Roots-type blower in the middle of a 1.5-liter V4 layout. Rotary exhaust valves prevent the loss of boost pressure when the intake and exhaust ports are both open. Unlike Orbital's exhaust restrictors, these valves open and close with each cycle, yet are simpler than the familiar 4-stroke poppet valve.

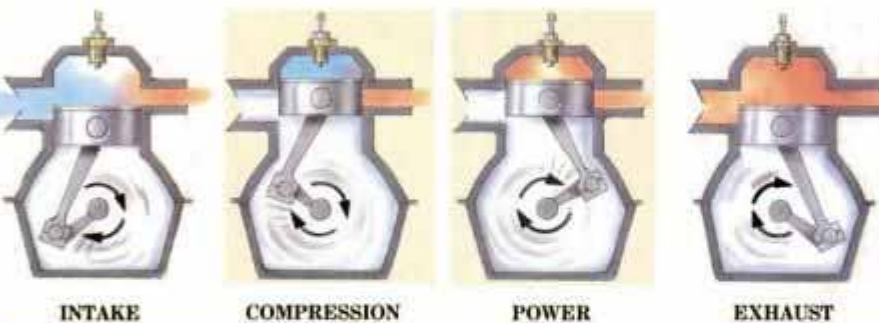
Toyota also uses a supercharger and actually comes full circle with a 2-stroke, 3.0-liter inline 6-cylinder that is based on a 4-stroke engine.

Half The Total Strokes, Twice The Power Strokes

4-CYCLE: TWO REVOLUTIONS PER POWER STROKE



2-CYCLE: ONE REVOLUTION PER POWER STROKE



● The basic 2-stroke engine accomplishes, in just one revolution of the crankshaft, all that a 4-stroke does in two. With a simple 2-stroke, the intake charge enters the combustion chamber through an open intake port. The rising piston seals the intake port while pushing the intake charge upward toward the combustion chamber.

This upward movement of the fresh intake also forces exhaust out—or

scavenges the exhaust—through the open exhaust port. The moving piston next seals the exhaust port and compresses the trapped intake charge in the combustion chamber. Then, as in a 4-stroke engine, the spark plug ignites the compressed mixture driving the piston back down, generating power. As the piston continues down, it clears the exhaust port, allowing the exhaust gases to begin flowing out.

Toyota's effort has some of the best and worst features of both configurations. The engine uses a conventional cylinder head, with overhead cams and four valves per cylinder, but the valves operate at crankshaft speed—twice the "normal" 4-stroke camshaft and firing speed—to get power on each revolution. This mandates a supercharger to get the gases in and out fast enough.


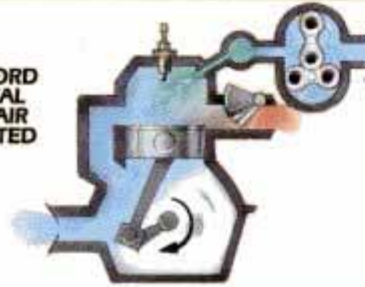
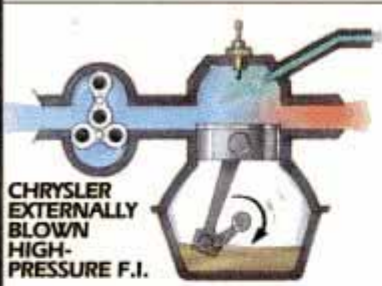
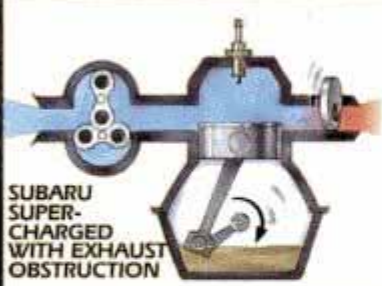
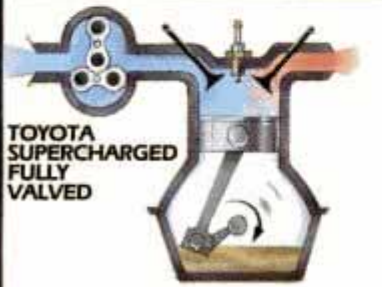
Closing in

Despite the stalwart efforts of these major contenders, we still do not have any production 2-stroke automobiles. As one engineering problem is conquered, it seems that another one crops up somewhere else in the design. And, in the meantime, the venerable 4-stroke engine remains a seriously agile "moving target," with more engineers personally involved

in keeping it alive than in killing it.

And of course, the electric and hybrid people aren't sleeping either. Maybe what we need is some sort of a 2-/4-stroke hybrid that operates in whichever mode is most appropriate. Given the needs and mandates of our environment and the desires of the driving public, the next several years will be very interesting indeed as far as engine development goes. **PM**

What's Good And Bad About Today's 2-Stroke

Maker/Configuration	Advantages	Disadvantages
<p>COMMON CRANKCASE-SCAVENGED 2-CYCLE</p> 	<p>Primarily the "power density," or output per weight and volume, which applies to most 2-stroke variations. There is also better efficiency from reduced friction—piston rings don't have to seal as tightly, roller-bearing crankshaft spins more freely and, in most cases, there's no power loss to activating a valvetrain or piston-pumping. A smaller, more efficient engine means a smaller, lighter car.</p>	<p>Complexity in cylinder casting and porting counterbalances the simplicity of fewer components. Piston/ring scuffing past cylinder ports counters the problem of valvetrains. Roller cranks are expensive. The lack of precisely controlled valves means difficulty controlling airflow—more sophisticated fuel atomization systems are required. An oil-free crankcase means the need for lost-oil lubrication systems.</p>
<p>GM/FORD ORBITAL FUEL/AIR INJECTED</p> 	<p>Orbital has tried—apparently quite successfully—to match the efficiency and "cleanliness" of a 4-stroke with less mechanical complexity. While test drivers have been giving glowing reports about power, response, smoothness and mileage—especially when the entire vehicle is designed to exploit the 2-stroke advantages—the crankcase-scavenged engine is relatively simple.</p>	<p>Emissions remain a problem. The lean-burning, stratified charge creates marginally acceptable NO_x emissions. There is some added complexity in the 2-stage injection, requiring a 100-psi air pump in addition to a fuel pump, and an inherent limit to injection time when cylinder pressure rises above that 100 psi. Also, the variable exhaust-restrictor valve is a potential durability peril.</p>
<p>CHRYSLER EXTERNALLY BLOWN HIGH-PRESSURE F.I.</p> 	<p>This is a coarse but effective way to scavenge the cylinders more cleanly. Blowers are available technology, and their low-pressure nonsupercharged output doesn't absorb a lot of power. High-pressure fuel-injection technology should transfer easily from diesel engines. Wet crankcases are familiar to customers and servicemen and avoid the cost/complexity/noise problems of roller-bearing crankshafts.</p>	<p>The blower adds some driveline drag, weight, volume and reliability handicaps. It also returns to the inefficiency of tight oil-sealing rings and piston-pumping in the crankcase. What may be the greatest problem, however, is the high-pressure injection system—it still has not been demonstrated that it can make the necessary fine atomization last over time—as required by emissions regulations.</p>
<p>SUBARU SUPER-CHARGED WITH EXHAUST OBSTRUCTION</p> 	<p>The use of valves in the exhaust ports makes it possible to generate considerably more boost than simple unrestricted ports. By using rotary valves, it means that the valves themselves are not subject to the same type of structural limits for high engine speeds as are poppet valves. Rotary valves do not pass as much gas as poppet valves, but at least they won't pound themselves to destruction.</p>	<p>Rotary valves have sealing problems. While sealing is less of a problem downstream of a piston/port seal in a 2-stroke, there is still the question of lubricating the rotary valve under such serious heat and carbon buildup conditions. The V4 layout prevents the exhaust-manifold tuning that is better suited to three adjacent cylinders. Plus, there are the drawbacks of blower and piston/ring drag.</p>
<p>TOYOTA SUPERCHARGED FULLY VALVED</p> 	<p>It would sound as though they ought to get twice as much power this way, in addition to the increase from supercharger boost. In fact, there is a considerable increase at low rpm—ideal for use in light-truck applications. This layout also has the advantage of being very economical to produce, using essentially the same design and assembly as the common 4-stroke, as well as familiar maintenance.</p>	<p>In practice, however, there are severe limitations due to the basic laws of physics. Opening and closing valves twice as fast at 6000 rpm is equivalent to a racing engine operating valves at 12,000 rpm. It's not impossible—just an expensive challenge in design and materials. Of course, a full valvetrain loses the 2-stroke's fundamental advantages of weight, volume and simplicity.</p>

THE MECHANICS OF A FIELD GOAL

How a football goes from zero to three points in 1.2 seconds.

BY MATT BAHR; PM Illustrations by Paul Kratter

● One of the great paradoxes of football is that the player who spends the least amount of time on the field is the player who often determines whether his team goes home the winner or the loser of the game.

Kickers, it can be argued, may have become unintentionally prominent on the field, and perhaps some of the original spirit of the game has been lost due to the impact kickers can have on the outcome of a contest. As the game stands now, though, there will be many instances during the course of the season when all eyes will be focused on the kicker.

Yet, while kickers are the subject of great attention, a kicker is only one cog in a well-oiled machine that performs its job in 1.2 seconds. The other key elements in the equation are the

center's snap, the hold and the protection. Without these, there's no kick.

Centers are big people who can pass a ball like a quarterback upside down and then be immediately blasted by a defensive lineman. Most National Football League (NFL) centers are able to snap the ball so that the laces are facing forward when it reaches the holder. For a field goal, the center snaps the ball backward 7 to 8 yards depending upon the kicker's preference and how quickly he can elevate the ball. As the ball reaches the holder it should still be on the rise. The snap has to have pace, but it can't be hiked so hard that the holder has to fight to hold it.

The holder, meanwhile, wants to meet the ball and bring it down with him. The best position in which to catch the ball is with the back knee up and the front knee down. In this position, the holder can move to the ball if the snap is off without really getting

out of position. The back knee acts as a back-stop and also as a guide for positioning the ball. Holding the ball with the left hand (for a right-footed kicker) allows the holder to spin the ball laces forward if necessary with his right hand. This also gives the kicker a good view of the ball. Quarterbacks tend to be the best holders because they handle the ball the most and have an even temperament. A calm holder keeps the kicker calm. Receivers, by contrast, tend to be more neurotic and have their heads on a swivel looking for tacklers.

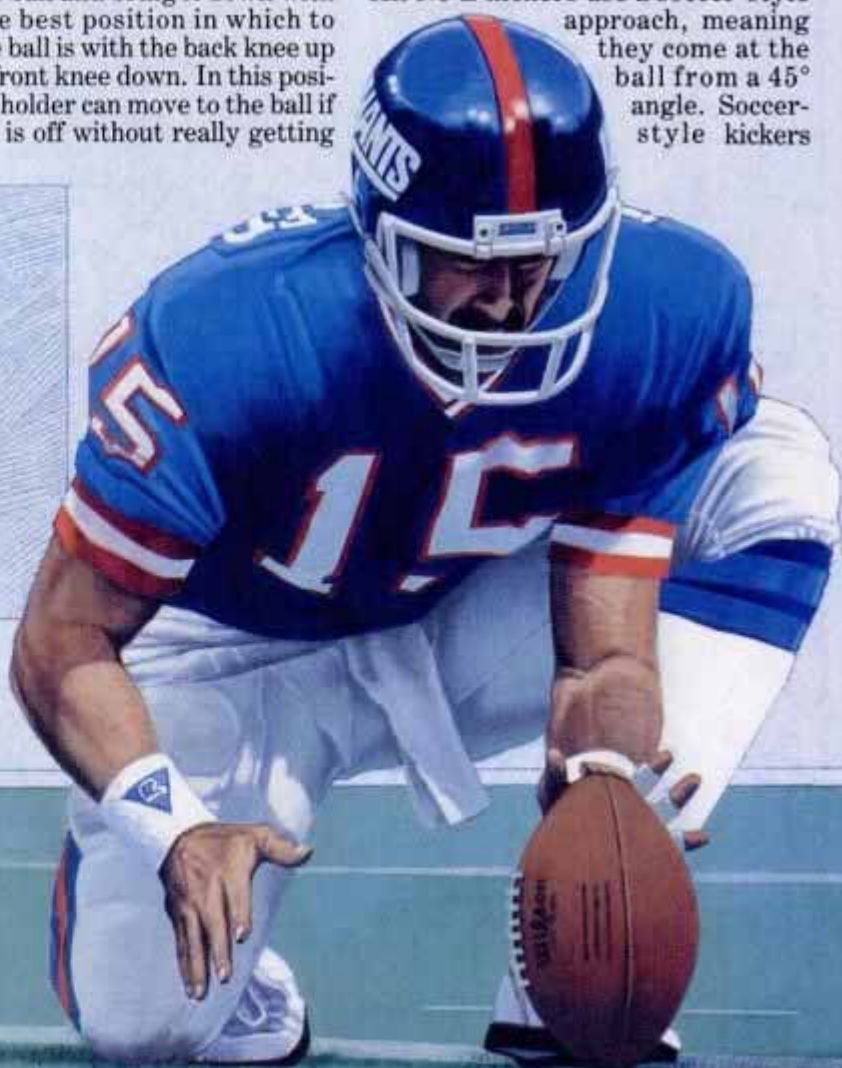
Preparing to kick

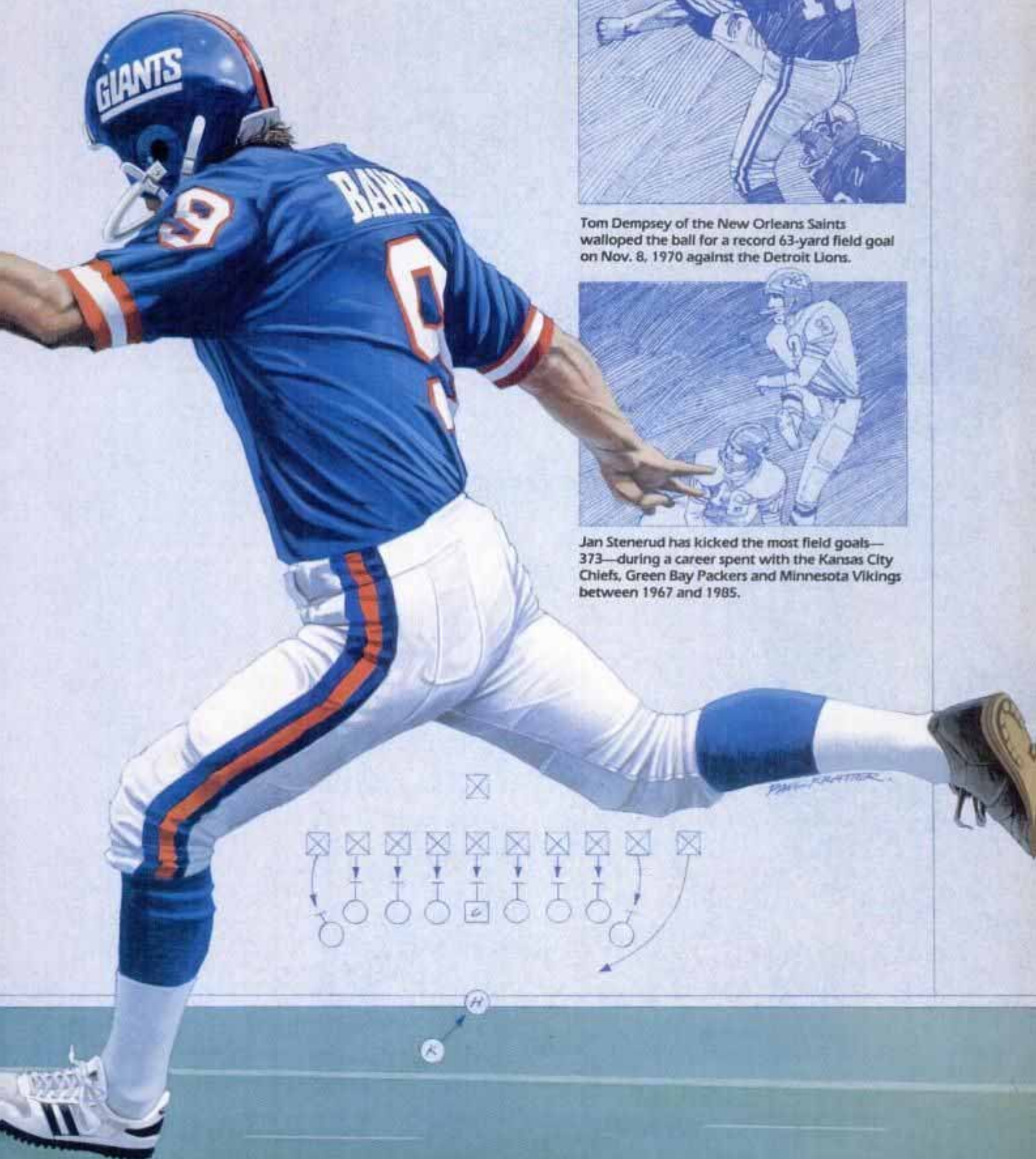
All NFL kickers use a soccer-style approach, meaning they come at the ball from a 45° angle. Soccer-style kickers

Matt Bahr works on Sunday for the New York Giants. Bahr has kicked 221 field goals in 309 attempts in 13 seasons.



Hungarian-born Pete Gogolak is credited with popularizing soccer-style kicking. Gogolak (Buffalo 1964-'65, New York Giants 1966-'74) led the American Football League in field goals in 1965.

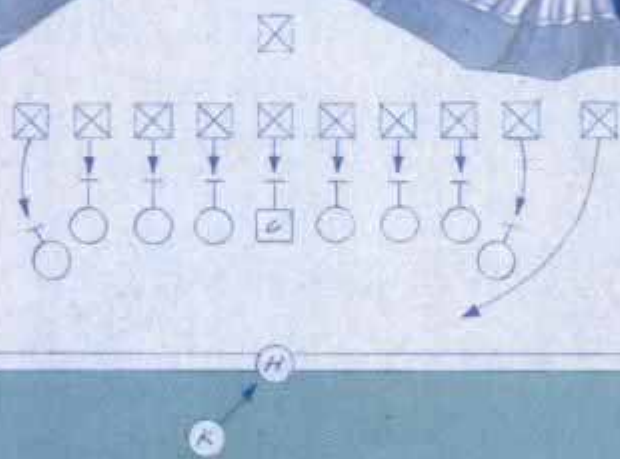




Tom Dempsey of the New Orleans Saints walloped the ball for a record 63-yard field goal on Nov. 8, 1970 against the Detroit Lions.



Jan Stenerud has kicked the most field goals—373—during a career spent with the Kansas City Chiefs, Green Bay Packers and Minnesota Vikings between 1967 and 1985.

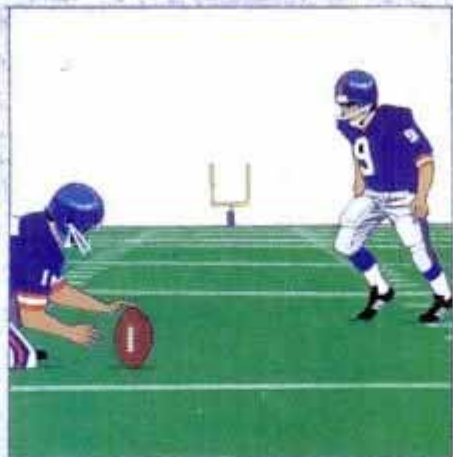


THE MECHANICS OF A FIELD GOAL

dominate the league because they are more accurate than straight-on style kickers. The accuracy comes from getting more of the foot's surface area on the ball. Having small feet is an advantage since you get more of your foot on the ball. A soccer-style kicker hits the ball with a large rectangular area of the foot as opposed to a single point. Your foot also doesn't have to be angled as severely to hit the ball correctly.

One great exception, of course, is Tom Dempsey, formerly of the New Orleans Saints and holder of the record for the longest field goal at 63 yards. While Dempsey kicked straight-on, his club foot was like a war mallet, affording him plenty of surface contact with the ball. Today, the only straight-on kickers in the NFL are emergency backup kickers who normally play other positions.

As already mentioned, the ball is held by the holder 7 yards behind the line of scrimmage, 8 yards if he drives the ball. The kicker assumes, however, that the offensive line will be pushed back 2 yards. This means the ball must rise 10 ft.—the height of a lineman with his arms extended upward—within 5 yards or 15 ft. Placing the ball farther back allows the world-class sprinter at the end of the defensive line to run in a straight line to block the kick. Forcing the defensive

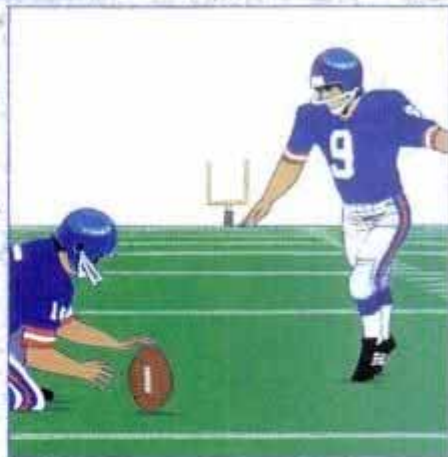


Soccer-style kickers approach the ball from a 45° angle. The planted foot, toes pointing toward the target, is a foot-length away from the ball as the kicking foot makes contact. The ball is kicked toe-down on the upper part of the shoelaces. A quick skip keeps the hips from turning. Forward momentum, therefore, stays directed at the target. Hips and shoulders are aligned toward the target during the follow-through.

cornerman to run at the ball in a bow pattern slows him down. The idea is to get as far away from the line of scrimmage as possible without giving the defensive corner a line to run on. A fast defensive cornerman can run to the block point in 1.4 seconds. That's why you practice kicking in 1.2 seconds. At 1.3 seconds, a kicker is pushing the ragged edge. At 1.4 seconds, you eat the ball.

Splitting the uprights

I start my move to the ball as soon as it hits the holder's hands. For me, it's



two steps and a little hop to get the motion going. As I approach the ball my supporting leg is planted a foot's length away from the ball. You should be able to draw a straight line from the ball to a point between the arch and heel of the planted foot. The toes of the planted foot are pointed at the target, the target being some point through and beyond the goal posts. Your body weight is over the ball and this puts you in position to maximize your follow-through.

The best place to hit the ball is in the sweet spot just below the center of

Just One Kick Is All It Took

● Since a football is not perfectly round, the aerodynamic forces influencing its flight path depend significantly on the alignment of the football's axis with respect to its path toward the target.

For a field-goal kicker, getting the football to spiral nose first is an impossibility. The best alternative is to make it spin end-over-end around a side-to-side axis. While the aerodynamic drag is greater than it would be for a normal spiral, the ball will at least have a gyroscopic action, giving its spin axis a constant direction in space. On an ideal end-over-end kick, the spin axis of the ball should be horizontal and parallel to the yard-lines as the ball travels toward the goal post. If there's no wind, the ball will not drift

or curve sideways.

To achieve maximum distance, a field-goal kicker should launch the kick at about a 45° angle. To prevent the kick from being blocked, the ball should be at least 10 ft. above the ground 2 yards before the original line of scrimmage. This is ensured if the kick is launched at an angle of 35° or more. Finally, the ball must be hit with enough force to clear the crossbar, 10 ft. above the ground. This means that the actual landing point of the trajectory must be at least 3 to 4 yards beyond the goal post.

Professional field-goal kickers are frequently called upon to perform this difficult task under exceptional pressure in the closing seconds of the game with a win—or



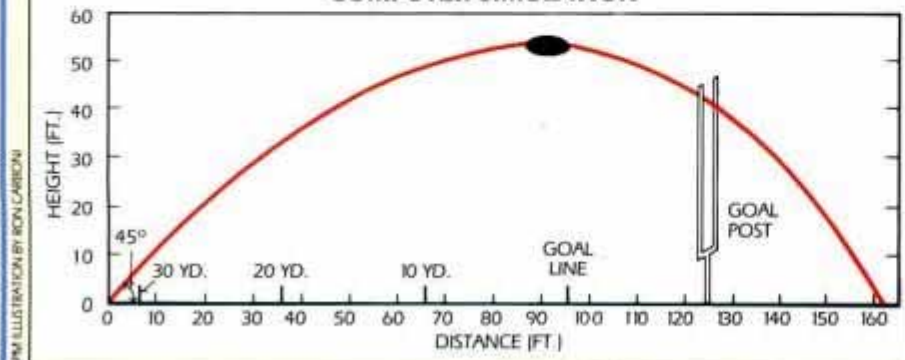
even the championship—on the line.

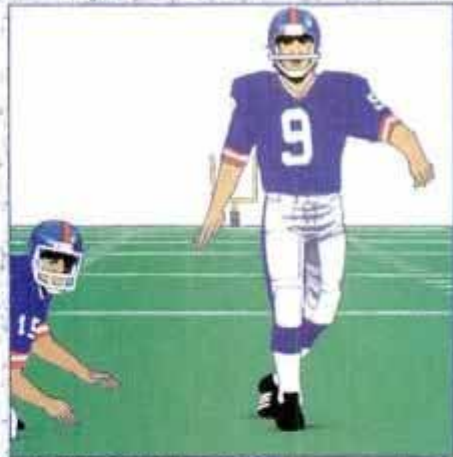
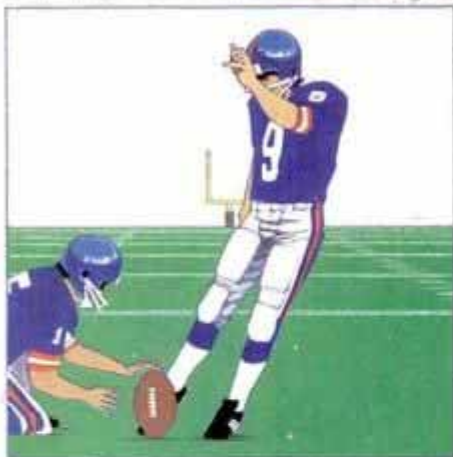
One of the classic examples is Matt Bahr's 42-yard field goal (above) with 3 seconds left on the clock that defeated San Francisco for the NFC championship and sent the Giants to the Super Bowl in 1991. Bahr's kick was straight and true, with a perfect end-over-end rotation.

A close examination of the videotape showed that Bahr's kick cleared the crossbar by a considerable margin, landing about 12 yards behind the goal posts. Thus, the overall distance was about 54 yards. The hang time measured out to 3.6 seconds. A computer simulation, taking the effects of air resistance into account, indicates that the kick was probably launched with an initial speed of about 65 miles per hour, at an angle close to 45°. The computed trajectory is shown at the left.

—Peter Brancazio,
Professor of Physics, Brooklyn College

COMPUTER SIMULATION





the ball. When I make contact, I'm hitting the sweet spot with the top part of my foot—on the shoelaces—with my toe pointing downward. The ball goes up, not because you're lifting it, but because you're hitting it just below the center axis.

For me to hit the sweet spot effectively, the holder should position the ball at about a 5° angle toward his body rather than straight up and down. Because of the angle at which your foot is hitting the ball, this slight tilt actually creates a more perpendicular alignment between the foot and the ball. This positioning reduces the tendency of the ball to hook off-target while it's in the air. Footballs hook when your hips and shoulders open up too much and your kicking foot comes across the ball.

Hitting the ball with the laces forward is ideal. Hitting the ball with the laces facing back is the next ideal. Of course, with the laces back you don't get the desired compression of the ball, because the laces are in the way. Laces facing to either side screw up the ball's rotation. With the laces to the side, the mass of the ball shifts as does the position of the sweet spot.

Older balls are better to kick than new balls. With wear and tear, the ball becomes a balloon. The ball becomes easier to kick because there's more compression and it goes farther. In a game, every ball is new, but the home-team ball boys will give an official a ball that's a little less new than others. The difference between kicking a new ball and an older ball may mean as much as an extra 10 yards in distance. Every little bit helps.

Body motion

As I'm planting my left foot, my kicking leg is already cocked—so much so that it looks like I'm kicking myself in the back. The knee is bent at a 45° angle and the lower portion of the leg is virtually parallel to the ground. By

bending the knee and whipping your leg toward the ball, you get the foot speed necessary to kick the ball for distance. For a split second, neither of my feet are on the ground. My kicking leg has to be cocked before the other foot is planted because there's no time to do it any other way.

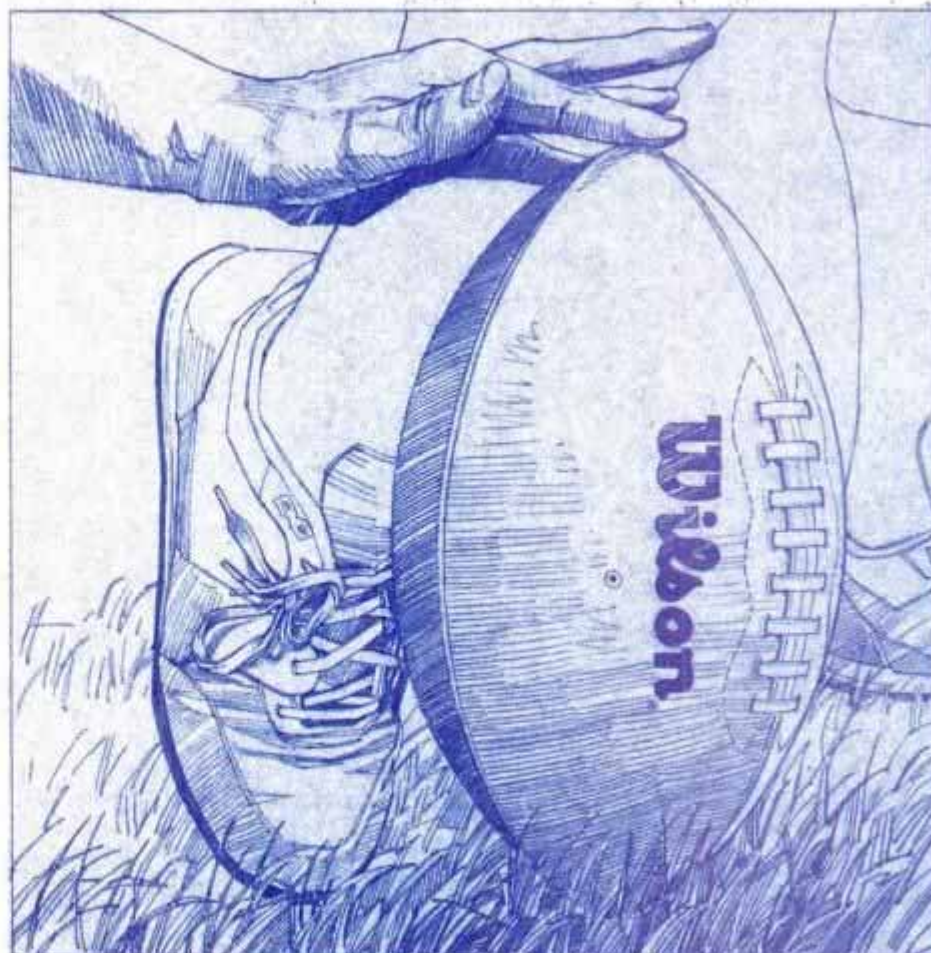
As I'm planting my foot, the holder is putting down the ball. During the kick, the lower back and stomach muscles are moving toward the ball even before my foot is.

I'm more of a mechanical kicker than a natural kicker. This means that I try to do the same thing every time whether it's a 45-yard field goal or an extra point. There are no chip shots.

The difference between a natural kicker and a mechanical kicker is most

evident during the follow-through. A natural kicker will add a little distance by turning his hips away from the target after contact. I work on taking my hips all the way through the kick. However, I stop my hips from turning and instead direct my momentum toward the target. At this point, I'm skipping through the ball and my left ankle looks like it will break if I come down on it. The hop prevents me from spinning and keeps me aligned toward the target. This way if I mis-hit the ball, the momentum of the follow-through still gives me a chance to make the field goal. By contrast, when a natural kicker mis-hits the ball, you'll see an audacious hook or a lot of rotation because he's under the

(Please turn to page 113)



The contact point is the football's sweet spot 1 in. below the center axis of the ball.

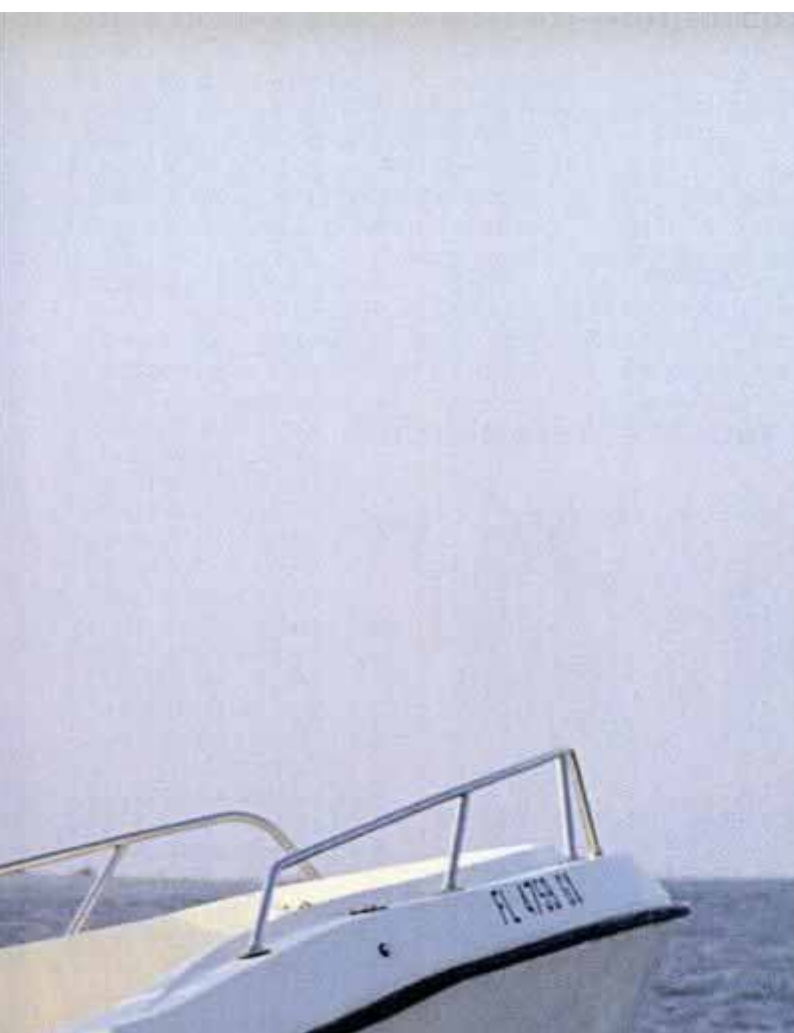
BOATING

CLEAN MACHINE

Honda's breakthrough 45-hp, 4-stroke emits less emissions than any other outboard afloat.

BY JOHN WOOLDRIDGE, Contributing Editor



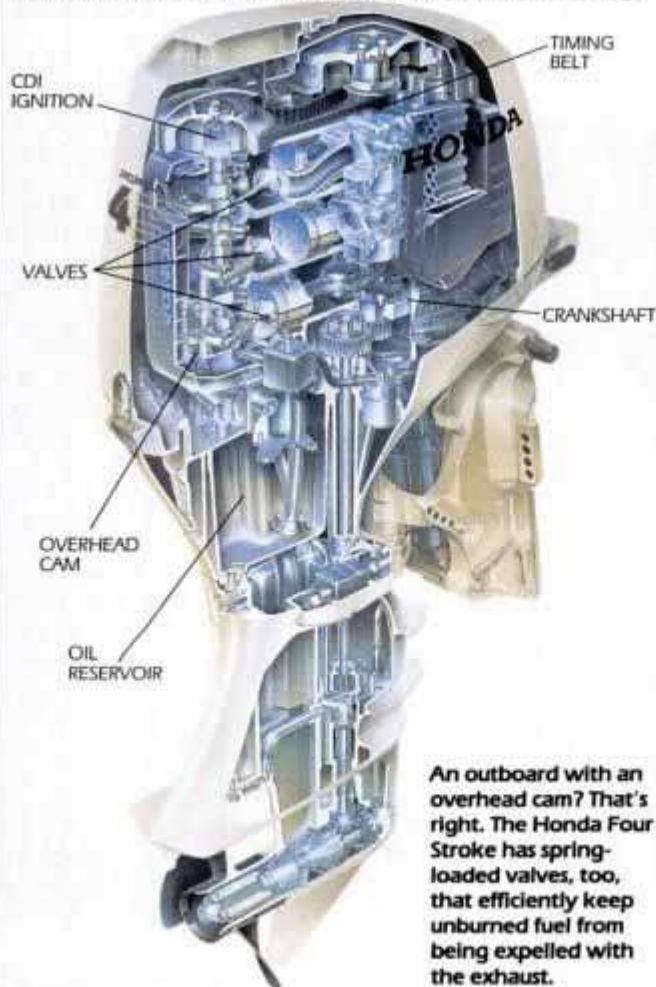


● Green is a popular color these days among marine engine manufacturers, and none more so than Honda. I'm not talking about designer graphics here, but environmentally friendly engines, especially clean-burning outboards that will rule the waterways before the end of the decade. Market forces play a major role in this trend—every company wants to be viewed as fighting the good fight—but fear of coming Environmental Protection Agency (EPA) regulations is a factor, too.

In the fall of 1991, the EPA released preliminary studies indicating that off-road equipment—including lawnmowers, chain saws, tractors and boat motors—account for 12% of carbon monoxide (CO) pollutants in the air. Automobiles and trucks were said to contribute 79%. More significantly, the study focused on two other findings: 1. That off-road engines were responsible for 17% of oxides of nitrogen (NO_x) emitted into the air compared to 33% for the more numerous cars and trucks, and 2. That off-road engines contributed 15% of volatile organic compounds (VOC) compared to 33% for cars and trucks.

What does all this mean? Probably, that the emissions-control spotlight is about to shine on off-road engines, especially 2-stroke outboards which are the largest segment and the most emissions intensive due to their large size and vast numbers. In an effort to get ahead of the curve, Honda has developed a new engine that uses technology that's been around for years, but is unique to midsize outboards. The new engine is called the Honda Four Stroke.

INSIDE HONDA'S FOUR STROKE 45



An outboard with an overhead cam? That's right. The Honda Four Stroke has spring-loaded valves, too, that efficiently keep unburned fuel from being expelled with the exhaust.

Two versus four

There's nothing inefficient about 2-stroke technology, but it does have its quirks. The invention of the 2-cycle outboard engine, by Ole Evinrude in 1907, launched the modern era of recreational power boating, and ever since, the huge waterway market has been sold on 2-strokes.

There's a lot to like about 2-stroke outboard engines as compared to 4-stroke inboard and sterndrive engines. For one, there's more power output per pound of engine weight. Secondly, 2-strokes don't require systems necessary to work four distinct piston cycles and are, therefore, mechanically simpler.

But these benefits don't come without a price. The beauty of the 2-stroke is that each cycle performs a dual function—intake and compression on the upstroke, and power and exhaust on the downstroke. This produces a power stroke on each revolution of the crankshaft (as opposed to every other revolution in a 4-stroke), but it also allows a small part of the unburned gas/oil/air charge to jet out with the exhaust prior to combustion. It's a tiny amount, but at 5500 rpm, it quickly adds up and elevates hydro-

CLEAN MACHINE

carbon emissions from 10 to 20 times higher than comparable 4-strokes. (See "Double Whammy," on page 33, for a look at new 2-stroke engines for automotive applications.)

Power in tune with nature

In 1973, Honda exported its first 2-cylinder, 4-stroke outboard to the United States, so there's nothing new about the basic technology. But until recently, it was only available in outboards up to 15 hp, which were aimed at owners of small fishing boats and sailboats. Although available for years, these small 4-strokes have hardly made a dent in the overall market.

But with the recent introduction of the Honda Four Stroke 35-hp and 45-hp outboards, interest has soared. These midsize outboards have opened up 4-cycle technology to a whole new world of boaters. Still, PM wondered how well midsize 4-cycle outboards would work in the real world, so we decided to put one to the test. We selected a Four Stroke 45 mounted to a deep-V Kenner 16V center-console fishing boat and took it out in Miami's Key Biscayne. We put it through our typical battery of tests and the results, quite frankly, were impressive.

At 3500 rpm, with the boat up and running on plane, we recorded a 2.5-gph (gallons per hour) fuel burn at 17 mph. These are fairly typical figures for a small-boat rig, so there were no surprises here. What surprised us was that boat and engine speed virtually doubled from this point to wide-open throttle (33 mph and 6000 rpm at top end), yet fuel burn peaked at only 4.5 gph. At the 4000-rpm level, the fuel burn actually dropped to 2 gph from 2.5 gph at 3500 rpm.

We've tested 40-hp and 50-hp outboards in the past and the Four Stroke 45's marks are among the lowest we've recorded. Typical range is 5 gph to 7 gph for engines and rigs of this size. Incidentally, the Honda's top speed of 33 mph is also among the best, with typical marks running from 29 mph to 34 mph.

In addition to fuel efficiency, another low-impact, "green" characteristic of the Honda Four Stroke is its effective damping of engine noise. Two-stroke engines are inherently noisy due to the opening of the exhaust port

while the piston is still on the downstroke and the cylinder is under maximum pressure. In a 4-stroke, valves open a full cycle after combustion, when the piston has descended and the cylinder pressure has been reduced. We recorded a quiet 64 dBA at idle speeds of 1000 rpm, a pleasant 80 dBA at 3500 rpm, and an impressive

scales at 203 pounds, while competitors run the gamut from a no-frills 170-pound unit to more than 200 pounds for models equipped with options similar to the Four Stroke.

The 3-cylinder engine accomplishes its weight efficiency by using a thin-wall, aluminum die-cast block design inspired by Honda's lightweight front-wheel-drive cars. Low-zinc alloys are also used to help reduce weight and stop corrosion. Valve seats are constructed of an unusual aluminum-bronze alloy that was selected for its durability in the marine environment.

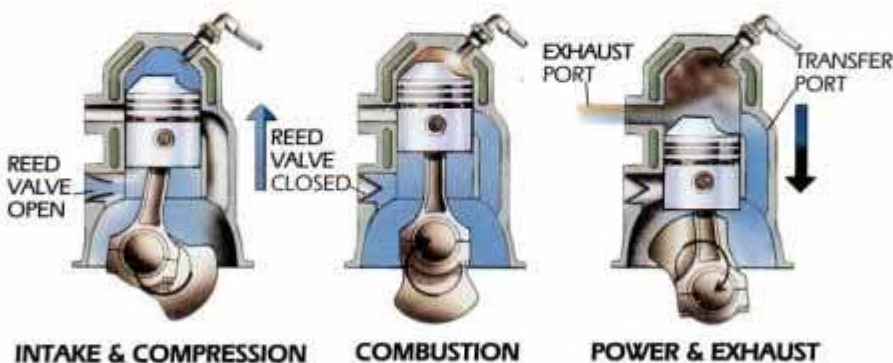
Other systems that are unique to Honda's midsize Four Stroke powerhead include: a

recirculating oil system that feeds lubricant under pressure to the crankshaft and incorporates a dipstick and an oil filter, a timing belt that turns the camshaft at half the crankshaft speed, two spring-loaded valves per cylinder that are pushed open by rocker arms, a capacitive discharge ignition (CDI) system that reads off the camshaft pulley, three side-draft carburetors inspired by technology perfected on Honda motorcycles and automobiles, and aluminum intake and exhaust manifolds.

Currently, neither 4-cycle nor 2-cycle engines are regulated by EPA-established emissions regulations. But 4-strokes are likely to have an edge against conventional 2-stroke technology. Hydrocarbon emissions (VOC) of the Honda 45 are only 6% of those produced by a comparable 50-hp 2-stroke.

Nov. 15, 1992 is the congressionally mandated deadline for final rule-making. Most marine-power manufacturers have already laid the groundwork for major and minor changes that will be required in order to meet the coming emissions regulations. Many of the competing outboard builders are reportedly tooling up to introduce midsize 4-strokes in the near future. Honda, of course, is already there, and if rumors are true, the company is set to introduce a big 4-stroke in the 100-hp class by the end of the year. Much like the horsepower wars of the '60s and '70s, the clean-machine race of the '90s has exploded from the starting blocks, and Honda has jumped out to an early lead. **PM**

2-STROKE CYCLE: DOUBLE TROUBLE FOR EMISSIONS



Open exhaust and transfer ports in 2-strokes permit unburned charge to escape.

90 dBA at 6000 rpm. Typical readings for comparable engines and rigs are 90 dBA to 93 dBA at WOT.

Innovative systems

While it's true that 4-stroke technology comes with an inherent weight penalty compared to 2-strokes, the Four Stroke 45 stacks up fairly well against comparable 50s. It tips the



Specs And Test Data

Honda Four Stroke 45

Displacement	49.3 cu. in. (808 cc)		
Bore & stroke	2.8 in. x 2.8 in.		
Compression ratio	9.2:1		
Horsepower	45 hp at 5500 rpm		
RPM	Speed	Fuel Burn	Sound Levels
2500	4 mph	1.0 gph	74 dBA
3000	6 mph	1.5 gph	77 dBA
3500	17 mph	2.5 gph	80 dBA
4000	22 mph	2.0 gph	83 dBA
4500	25 mph	3.0 gph	85 dBA
5000	28 mph	3.5 gph	87 dBA
5500	30 mph	4.0 gph	89 dBA
6000	33 mph	4.5 gph	90 dBA

Price as tested \$5315

Honda Marine, 4475 River Green Pkwy., Duluth, GA 30136; (404) 497-6066.

Kenner 16V Center Console

Length	16 ft. 7 in.
Beam	6 ft. 10 in.
Weight	800 lb.
Kenner Mfg., P.O. Box 100, Knoxville, AR 72845; (501) 885-3171.	



HONDA CIVIC

Twenty years and five generations later, still a winner.

BY MICHAEL LAMM, Contributing Editor; PM Photos by Ron Hussey

● The first Civic came to America in 1972. Remember that funny little roller skate of a car? Whatever people thought of its looks, though, the timing was inspired—just ahead of the 1973-'74 gas crunch. Suddenly Honda wasn't able to import Civics fast enough as fuel economy became America's No. 1 buying priority. Customers practically beat down the doors of Honda dealers trying to thrust wads of money at happy Civic salespeople.

People lucky enough to get a Civic soon found out that they had bought a package filled with surprises. Thrifty, of course. Cute, yes. Fun to drive, ditto. But Civic newcomers also found that their little cars were well engineered, surprisingly roomy, ergonomically on target, well made and anxious to please.

So here we are, 20 years later and into the Civic's fifth generation. For 1992, Honda offers two Civic body styles—a stylish 4-door sedan and a 2-

door hatchback. A 2-door coupe version is due this fall.

In 1991, 68% of all Civics sold in this country were made in North America. Civic Sedans are now being produced in East Liberty, Ohio, and contain 75% local content—enough to be counted as U.S. domestic automobiles. Hatchbacks come from Honda's assembly plant in Ontario, Canada. So while most of us still think of Civics as Japanese cars, most of them—like most Honda Accords—are actually hybrid transplants.

The top-of-the-line Civic EX and Si models come with 4-wheel disc brakes, and the EX also lists antilock braking as standard equipment. Adding to every Civic's safety quotient are a driver's airbag and 3-point shoulder harnesses.

The fifth generation seems to continue the Civic's "spirited economy car" tradition. As in our earlier surveys, Civic owners saw their cars as inexpensive to buy and operate, fun to

drive and technologically advanced.

From the beginning, Honda has never skimped on practical innovation and high technology. An example of this is the new Civic sheetmetal, which is now 80% galvanized—which means that the unitized body won't look like salted Swiss cheese after two or three years.

Another example: Two of the Civic's 4-cylinder engines—the 92-hp high-mpg lean-burn VTEC-E 1.5-liter (VX Hatchback) and the hot 125-hp VTEC 1.6-liter (Si Hatchback, EX Sedan)—borrow variable valve timing from the midengined Acura NS-X sports car. These two VTEC Civic Fours use single overhead cams and four valves per cylinder. At low rpm, the cam followers open only one of the two intake valves. But above 2500 rpm, a freewheeling secondary part of the cam lobe locks against the main lobe and opens the second intake valve for added power. The net result is a high-economy 3-valve engine up

OWNERS REPORT



Civic instrumentation and control layout continue to be among the best.

to 2500 rpm and a 4-valve hot rod from 2500 on up to the 7000-rpm redline.

The other two engines available for the Civic family are a 70-hp 8-valve sohc 1.5-liter and a straightforward



A few owners complained about lack of lumbar support in front seats.

16-valve 1.5-liter rated at 102 hp. Each engine mates to a specific 5-speed manual transaxle with gearing tailored to either economy or performance, depending on the model.



Civic Si Hatchback is powered by snappy 125-hp 1.6-liter sohc 16-valve VTEC Four.

And a 4-speed automatic is available as an option.

Most of the owners in our survey chose the 102-hp versions without variable valve timing. And a surpris-

SUMMARY OF 1992 HONDA CIVIC OWNERS REPORTS*

Total miles driven:	1,066,892	Excellent	38.9%	Low operating costs	52.5	Good	53.0
Average miles driven:	5230	Good	48.6	Handling	38.5	Average	9.5
Purchase price:		Average	11.6	Comfort	26.0	Poor	0.0
Average	\$12,604	Poor	0.9	Performance	19.5	Mechanical trouble?	
Range	\$9960-\$16,103	Handling:		Ride quality	18.0	No	81.1%
Why did you choose the Civic?		Excellent	60.6%	Engine power	16.0	Yes	18.9
Styling	30.5%	Good	34.7	Roominess	13.0	What type of trouble?	
Economy	27.6	Average	3.7	Specific dislikes:		No statistically significant complaints	
Reputation	26.2	Poor	0.9	Road and wind noise	12.6%	Repair it yourself?	
Past experience	24.3	Braking:		Restricted vision	10.9	No	92.5%
Reliability	14.8	Excellent	52.8%	Seats lack lumbar support	8.7	Yes	7.5
Performance	12.9	Good	40.7	No complaints	8.7	Dealer service opinion:	
Quality	12.4	Average	6.0	Price too high	6.6	Excellent	48.4%
Model choice:		Poor	0.5	Insufficient power	6.0	Good	37.4
Civic LX Sedan	56.0%	Overall performance:		No headlight-on reminder	5.5	Average	11.8
Civic DX Sedan	37.5	Excellent	55.6%	Restricted headroom	5.5	Poor	2.6
Civic CX Hatchback	0.5	Good	40.7	Suggested changes:		Number of vehicles owned:	
Civic Si Hatchback	0.5	Average	3.7	Improve rear vision	12.7%	This vehicle only	33.0%
Avg. mpg, city/hwy., EPA est.:		Poor	0.0	Larger console	10.8	Two vehicles	45.0
70-hp 1.5-liter, 5-speed	42/48	Control layout:		Improve seating comfort	7.6	Three vehicles	12.8
92-hp 1.5-liter, 5-speed	48/55	Excellent	60.7%	No changes	7.6	Four or more	9.3
102-hp 1.5-liter, 5-speed	35/40	Good	36.9	Conventional headrests	7.0	Principal driver:	
102-hp 1.5-liter, 4-speed automatic	30/36	Average	2.3	Make ABS standard	7.0	Female	60.6%
125-hp 1.6-liter, 5-speed	29/36	Poor	0.0	More engine power	6.3	Male	38.0
125-hp 1.6-liter, 4-speed automatic	27/34	Instrumentation:		Workmanship opinion:		Equal	1.4
Engine choices:		Excellent	57.5%	Excellent	68.1%	Age distribution of owners:	
102-hp 1.5-liter	66.9%	Good	36.9	Good	29.2	Under 29	28.4%
70-hp 1.5-liter	13.7	Average	5.1	Average	2.3	30-49 years	47.4
125-hp 1.6-liter	12.2	Poor	0.5	Poor	0.5	50-plus	24.1
92-hp 1.5-liter	7.2	Driver sightlines:		Comfort opinion, front seats:		Based on your experience, would you buy a Honda Civic if you had it to do over again?	
Transmission choices:		Excellent	48.4%	Excellent	55.6%	Yes	62.7%
4-speed automatic	50.0%	Good	37.1	Good	37.5	Maybe	26.3
5-speed manual	50.0	Average	11.3	Average	5.6	No	11.1
Engine power:		Poor	3.3	Poor	1.4		
		Specific likes:		Comfort opinion, rear seats:			
		Styling	55.5%	Excellent	37.5%		

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

ingly small number of our respondents chose Civic Hatchbacks. The new Sedan is obviously a hit.

The biggest complaint by Civic Sedan owners had to do with the driver's view of the road behind. Shorter drivers said the car's high parcel shelf restricted their view out the rear window. They also told us that it's hard to tell where the car ends in backup maneuvers.

The Civic's headrests are equipped with fairly thick side-mounted stanchions, and these also interfere with side and rear vision for some drivers.

Finally, some of the less expensive Civic models have no righthand outside mirror. Owners who did have right side mirrors complained that the mirror design allowed dust and/or mud to build up on the window glass, obscuring the mirror.

There were also a few complaints about comfort—12.6% mentioned road and wind noise, observing that earlier Civics were quieter, and 8.7% cited lack of lumbar support in the front bucket seats as a problem.

However, Honda's usual attention to detail showed good results—97.3% of our owners were impressed with overall workmanship, and fewer than one in five reported mechanical difficulties that required dealer attention. Moreover, of the few problems reported, no single set of maladies stood out.

Unfortunately, the few owners who did experience problems weren't pleased with the service of their Honda dealer, and more than one-third had to go back a second time for the same repair.

Nevertheless, the owners found plenty of things to like about their new Civics. Styling led the list, followed closely by operating economy, and these two were also cited as the main reasons owners decided on Civics to begin with. Honda's reputation and past Honda ownership also scored high among determiners in Civic purchase decisions, proving once again that Honda is on the right track.

As one Civic owner remarked, "Honda excels because Honda *wants* to excel. Everything about this car says quality. I'm not sure if this is an economy car with outstanding performance, or a performance car with outstanding economy. Whatever, it's without equal."

Looking at the bottom line—the number of owners who, based on their experiences, would buy this same car again—it seems that most members of our survey group agree. Almost 63% gave an unqualified yes—and only 11.1% said no. Maybe brand loyalty isn't dead after all. **FM**



Stretched wheelbase improves ride quality and interior volume of both the Civic Hatchback (160.2 in. overall length) and the stylish new Civic Sedan (173 in. overall).

EDITORS REPORT

A Lesson In Civics

● It's not easy being the standard by which all others are judged. Besides going 110% to keep your competitive advantage, your critics tend to survey your efforts with an exceptionally hard eye, simply because you've continually raised their expectations.

Honda has met this challenge through every renewal of its Civic series, and continues to be the benchmark of its class. And if the new Civic lineup isn't as startlingly innovative as some of the past iterations, it is certainly improved in every respect.

To refresh our Civic experiences, we spent a few days hustling around Los Angeles in an arrest-me-red Si Hatchback. Powered by Honda's nifty 1.6-liter sohc 16-valve VTEC Four, this is the hot rod of the family, thanks to its weight advantage (about 150 pounds lighter) versus the similarly powered EX Sedan. Although this setup doesn't produce the dramatic mpg numbers as some of the other Civic powertrains, it's certainly the most fun to drive.

Excellent powertrains notwithstanding, the biggest improvement in the Civic lineup is that it's bigger. This is particularly welcome in the 4-door, which has been stretched 4.7 in. on the wheelbase (to 103.2 in.) and 4 in. overall (to 173 in.), which adds up to better ride and more rear seat legroom.

Hatchback dimensions have also increased. The wheelbase is 101.3 in. (from 98.4 in.) and overall length is up

by 3.1 in. to a still-tidy 160.2 in. The Sedan is clearly better for anyone anticipating rear seat passengers, but the Si Hatchback is tough to beat as a 2-passenger runabout that can also deliver sports car fun. We also like the clever horizontal clamshell hatch opening—just the thing for stowing groceries.

Don't think we're making a sedan versus hatchback comparison here. Perhaps the most striking thing about these new Civics is their diversity. The Sedan is much roomier than its predecessor, and strikes us as the new style leader in its class. The Hatchback continues to be distinctive, as well as a mini-masterpiece of interior design.

Both Civic series offer improved ride quality and their handling—always a Civic strength—is as good as anything in the small car spectrum. And we think Honda continues to be on the cutting edge when it comes to control layout and small-object storage.

Civics have long commanded premium prices, a trait exemplified in our Si test car—almost \$13,100 with options (a/c, \$720, and premium AM/FM/cassette sound system, \$420). We should point out that the basic Si price—\$11,900—includes power locks, power windows, power mirrors, a driver's-side airbag (standard on all Civics) and a power sunroof. And anyway, who ever heard of best-in-class also being cheapest?

—Tony Swan



POSSIBLE DREAMS

From X-rays to gamma rays, invisible forces have fascinated us for 97 years.

BY MARY SEELHORST

● The crackle of a Geigercounter poised over an old glow-in-the-dark watch testifies to the presence of invisible rays—unlike the emperor's new clothes, these unseen threads are real. The incessant sputter adds a tad of reality to the instruments displayed in the "Invisible Rays" section of Henry Ford Museum's exhibit "Possible Dreams: POPULAR MECHANICS and America's Enthusiasm for Technology."

Mary Seelhorst is curator of the "Possible Dreams" exhibit at Henry Ford Museum & Greenfield Village in Dearborn, Michigan.

An exhibit about things invisible? The project team joked about merely displaying an empty case labeled "Invisible Rays." But instead, the museum staff assembled devices for everything from X-rays to microwaves to lasers, illuminating them with a collage of PM headlines, quotations, covers and graphics. Here, museum visitors get a dose of the fascination and fear that has surrounded the development of all kinds of rays throughout the past 90 years.

An induction coil used in Thomas Edison's laboratory to power his early X-ray tubes is on display. Edison, al-

ways looking for practical, profitable applications of science, was one of the earliest X-ray experimenters in America. He was also quick to recognize the dangers.

"I am through with X-rays, radium and everything of the kind," he wrote in a 1903 PM article. "Not only is my left eye badly affected by the Roentgen ray, but I am having all kinds of trouble with my stomach—due, I believe, to leaning over an X-ray machine while experimenting."

While Edison thought the research was not worth the risk, others persisted. On display is a 1912 PM report on a new shoe designed for the U.S. Army, "after four years of extensive experimentation, including a liberal use of the X-ray," which proved that "the army shoes in use did not truly follow the lines of the average foot." We wonder if anyone thought to ask the soldiers if their feet hurt.

Watches, like the popular Radiolite brand on exhibit, were made to glow by adding a small amount of radium to the paint. A 1917 Radiolite advertisement is also on display, along with one hawking "Luminous Paint" for the do-it-yourselfer. Yet, in 1929, PM re-

(Please turn to page 101)

Quality Performance begins with quality parts. Motorcraft Quality Parts.



Motorcraft 

QUALITY PARTS FOR QUALITY CARSSM

THE KING'S LAST LAP

Racing legend Richard Petty winds up his final season as the winningest driver in stock car history—and a genuine American folk hero.

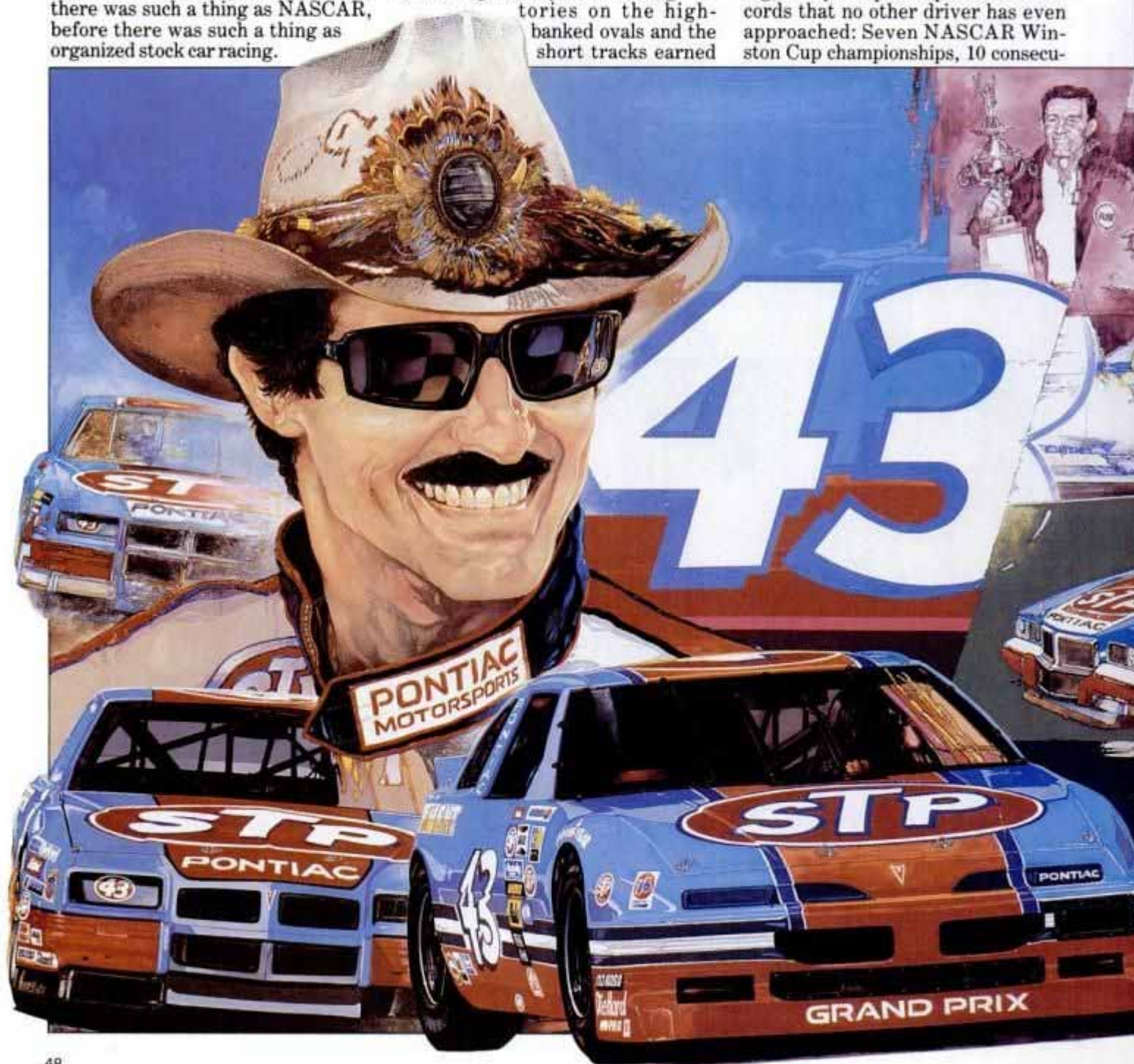
BY CLIFF GROMER

● Understand that Richard Petty was there at the beginning—before there was such a thing as NASCAR, before there was such a thing as organized stock car racing.

Richard has seen it all and done it all, from wrenching on race cars to becoming the winningest driver in stock car racing history. His blazing victories on the high-banked ovals and the short tracks earned

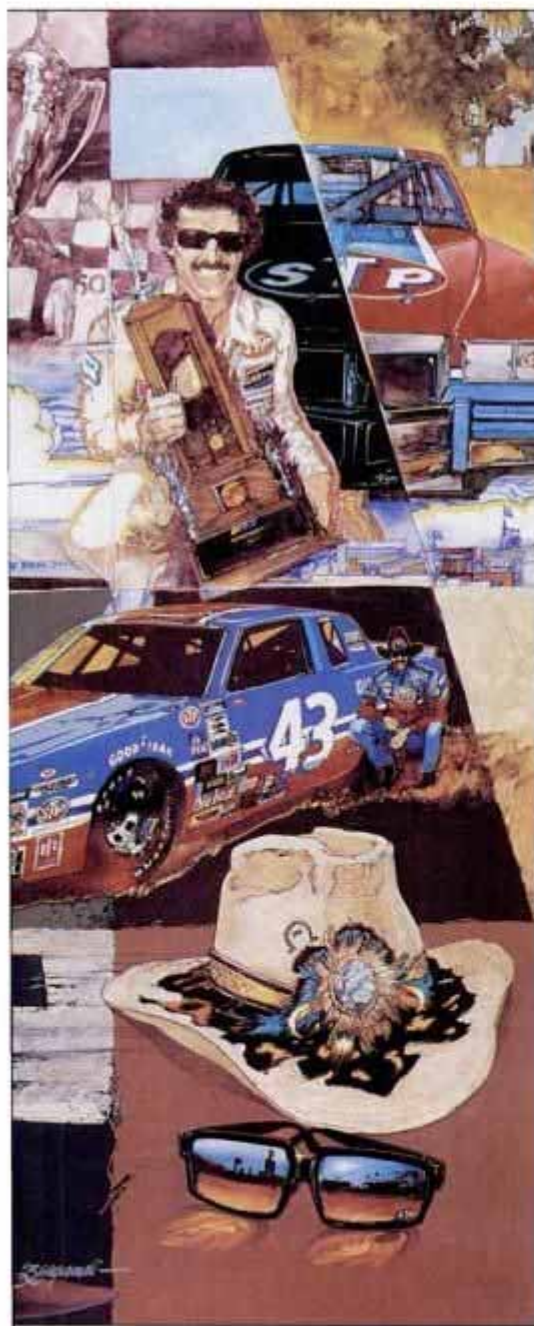
him the name “King Richard.” And with good reason.

In his 35 years of professional racing, Petty has piled up a stack of records that no other driver has even approached: Seven NASCAR Winston Cup championships, 10 consecu-





While the king has driven Ford and GM products, he really made his mark behind the wheel of Plymouth and Dodge cars.



tive first-place finishes, 27 wins in a single season, 200 wins in 1156 NASCAR Winston Cup races entered and, in the Daytona 500—the World Series of stock car racing—Petty has checked into the winner's circle no less than seven times. And those are just the highlights.

Petty has been to the bank even more than he's been to the winner's circle with career earnings of more than \$7 million.

But, it's over. This season is his last. Petty is hanging it up as a driver after the last race of '92, and he's calling this last lap of the Winston Cup circuit his Fan Appreciation Tour.

The first time Richard Petty strapped on a crash helmet was in 1958. He drove a '57 Olds convertible in a 100-mile race on a dirt track in Columbia, South Carolina, finishing sixth. The following year, Petty began a long association with Plymouth. In his first outing on the high banks of the superspeedway at Daytona in 1959, Petty ran the high groove near the fence while most of the traffic was down low taking the shortest route around the course. The high groove, Petty figured, offered a couple of advantages. First, there was less traffic. Then, if you got out of shape, you'd most likely hit the wall sideways rather than head-on. But there was another reason, Petty's Plymouth was down on power compared to the competition. By starting

high, he could come charging down off the banks to keep the engine wound up in its power range. It also made for an easier turn into the corner than running low and turning left. There was less rolling friction, which put less strain on the tires, car and driver.

Petty really felt the power disadvantage when GM unofficially entered racing in 1961 by



Petty switched from Plymouth to Dodge in 1973 and won six races, including a fourth Daytona 500.



backing a hot Pontiac. Those 421-cu.-in. Ponchos of the early '60s were good for 465 horsepower, and not much could touch them. Ford and Chevy started upping their horsepower to catch up, and they had some 480- to 500-cu.-in. engines on the drawing board when NASCAR put a 428-cu.-in. limit on engine size. When Ford and Chevy both showed up in '63 at Daytona with 427-in. powerhouses under their hoods, Petty in his 413 Plymouth might as well have stayed home. The Plymouth had a better chance on slower tracks where handling was a factor, but it was

hopelessly outclassed running at full bore.

But the Mopar camp was cooking up its own surprise for the '64 season—the 426-hemi engine. And they waited for Daytona, with its room for vroom, to bomb the blue-oval troops (Chevy and Pontiac having bowed out of racing the previous season). Ford didn't know what hit it.

Petty qualified in the 50-mile pole position race at an incredible 174.418 mph, bettering the track record by al-

THE KING'S LAST LAP



Petty set a record with seven victories in the Daytona 500—the World Series of stock car racing—including 1964 (top), 1966 (center) and 1971 (bottom).

most 10 mph. Another hemi-powered Plymouth driven by Paul Goldsmith qualified for the pole at 174.910 mph. The fastest Ford could muster was only 169 mph. When the flag dropped, Petty jumped out in front and stayed there in all but 16 of the 200 laps. He was more than a lap ahead of the No. 2 Plymouth when he got the checkered for his first superspeedway win.

Plymouth had walked away with Daytona, finishing 1, 2 and 3. Because of the g-forces in the turns, Petty had to prop up his body with a 2 x 4 wrapped in foam rubber. He said it was the best improvement the team had ever made to a race car.

But the monster hemis weren't without their problems—the biggest being the oiling system and bearings

which had to be pinned to prevent spinning. Petty's crew made their own oil pans and rerouted the oiling system, eventually going to a dry-sump system. Even more horsepower was coaxed out of the engine by reducing piston-to-valve clearance to raise compression.

Ford protested the hemi and NASCAR banned it in '64. Chrysler gathered up its marbles and went home, pulling out of the circuit in '65. With roundy-round action on hold, Chrysler built Petty a drag car for the quarter-mile. He was quite successful with it until the suspension broke on a run, knocking out his steering and braking control. The car plowed into the stands, killing an 8-year-old boy.

When Chrysler ended its NASCAR boycott, Petty returned to his familiar spot in the winner's circle, with 1967 being his all-time banner year. By the end of the year, though, Plymouth was losing its advantage and Petty wanted to run a Dodge. Chrysler said no, but Ford was eager to welcome the champ into its camp. Petty won in '69 at Riverside—his first time out in a Ford.

Chrysler finally got on the stick in '69 and built a new breed of race car—the winged warrior Plymouth Superbird and Dodge Daytona. The needle-nose front ends and sleek bodies made for great aerodynamics, and the huge, adjustable rear wings made the cars stick like glue. Still, the Petty team found room for improvement, shaving down the door handles and making the windows fit flush for even better aero numbers. Stopping power was beefed up by using Ford Thunderbird front disc brakes adapted to the Chrysler spindles.

To get the Superbird to go where Petty pointed it, the steering geometry had to be reworked. Everyone does this now, but Petty was the first to discover that the hot setup was to have a true arc at the steering-arm pivot points. They modified the linkage by shortening the pitman and idler arms and lengthening the steering arms.

The Plymouth years ended in late '72, and Petty drove a Dodge from '73-'78. In August 1978, Petty came to the GM fold and buckled himself into a Chevy. It was to be a winless season. Petty made a great comeback in '79 driving an Oldsmobile, and then went more upscale to the Buick in '81 and finally Pontiac in 1982.

When Richard Petty cuts the ignition in his blue-and-red STP Pontiac at the end of the 1992 Daytona 500, he will have closed a chapter in NASCAR history. And stock car racing won't be the same without him. **PM**



Chrysler 426 hemi for NASCAR used one 4-barrel carb. Street versions used two.

PM PHOTO BY CLIFF GROMER

ELECTRONICS

POWER TV

New amplified indoor antennas boost television reception. Here's how they rate.

BY STEPHEN A. BOOTH, Contributing Editor
and FRANK C. BARR, President, APEL
PM Photos by Brian Kosoff

TERK TV20

● While a television graces nearly every home, not every household has a good rooftop mast antenna. Those who must go without—for whatever the reason—suffer lives of not-so-quiet desperation as they fiddle with ungainly rods of rabbit-ears antennas that sit in mockery atop the television.

A good outdoor antenna mounted above the house offers the advantage of height and multiple signal-grabbing elements. By contrast, indoor antennas often yield indifferent results, especially if the household is on the fringe of the transmitting footprint. Even in strong signal areas, set-top indoor antennas, known as dipoles, can be adversely affected by metal in a structure and movement within a room. You know the scene: The TV picture looks great while you're adjusting the antenna, and reverts to hash the moment you step away. The old home remedies seldom work, and we've seen them all: paper clips, metal foil, even a kid brother sentenced to grip the antenna for the duration of a program.

Now comes a class of amplified indoor antennas promising some relief to dipole sufferers. The premise is relatively simple. Usually, what is considered a bad TV picture is a noisy picture. The TV is receiving a signal, but it is weak: snow afflicts the video, hiss accompanies the audio and, sometimes, picture and sound fade in and out. In theory, an amplified antenna should help clean up reception by boosting the incoming signal strength above the threshold of noise.

To find out how much water this theory holds, PM rounded up five powered antennas for lab testing and in-home evaluation. These set-top transducers should be of interest to cable households, too. Besides their usefulness during the occasional cable outage, they can

haul in stations that the local cable system might not carry—those UHF frequencies that offer interesting programming but are sometimes hard to get, for example. One model, the Terk TV20, even has adjustable amplification for cable signals.

The five antennas selected all cost less than \$100 and are widely available through retail or mail-order outlets. Each of them works on VHF (Very High Frequency, channels 2-13) and UHF (Ultra High Frequency, channels 14-83) signals.

Additionally, four of the five will act as FM radio antennas while the aforementioned Terk TV20 accepts cable TV signals. All five operate on AC household wiring and come with the appropriate power converter. All five hook up to the TV through a coaxial cable that terminates in the round F-connector used for the antenna/cable input on modern TVs. Each antenna also comes with a spade-lug adapter for older TVs with screw-on terminals. Details and test results can be found in the accompanying chart.

Looking for gain

At the Advanced Product Evaluation Lab (APEL) in Bethel, Connecticut, we wanted to learn how much gain, or amplification, each antenna applies to the incoming broadcast signals. Gain is measured in decibels (dB) and the more of it, the better.

All of the manufacturers specify gain in their literature and packaging but shoppers cannot use these figures for comparison because the test methods might vary from brand to brand. APEL, though, applies a uniform test to all models—so the measurements in the chart let you compare brand to brand.

In every case, the lab measurements show the amount of gain available compared to a passive, unamplified dipole antenna. The test is performed in a free-field environment where no reflected RF (radio frequency) waves can add interference. Here, APEL generates VHF, UHF and FM signals and transmits these to a passive, half-wave dipole located 1 meter

(39.3 in.) away from the transmitter. The transmitter output is regulated to produce a 1-millivolt input at the dipole, as measured by a digital signal-strength meter.

This 1-millivolt level is then specified as 0dB, and becomes the point of comparison for all the amplified antennas. In other words, when each model is measured by the digital signal-strength meter, the number of decibels by which its amplifier boosts the 1-millivolt signal is the "gain" as compared to the signal received by a passive set of rabbit ears.

What the numbers mean

Here, it might help to explain what those decibels signify in terms of the relative rankings. In RF testing, the dBs don't represent a linear progression in signal strength, but a logarithmic change. For example, while 0dB equals 1 millivolt, it takes 6dB of amplification to double the signal strength to 2 millivolts. At 9dB, signal strength only increases to 2.8 millivolts and 12dB of gain nets four times the original input. Signal strength is boosted 10 times, to 10 millivolts, when an amplifier exerts 20dB of gain. Along these lines, 35dB of gain yields about 10 times the signal strength found at 15dB.

Again, the bottom line is the more dB, the better, but you'll notice two sets of measurements in the chart—Minimum Gain and Maximum Gain—as well as some negative figures.

With the exception of the Archer antenna, all the models here offer variable gain, meaning you can adjust the amount of amplification until you see the best picture. Usually, this is done with a dial. Minimum Gain describes the amount of amplification available at the lowest setting, Maximum Gain shows the reading the lab got, pedal to the metal.

The negative numbers represent the opposite of gain—namely, loss. They indicate the degree of attenuation the antenna exerts on the incoming signal—that is, the amount, in decibels, by which it weakens or cuts

the signal instead of boosting it. Because this is relative to a passive dipole, these negative numbers would seem to indicate that the amplified antenna in question performs worse than a conventional set of rabbit ears.

They do.

Is it a bad thing?

Yes and no—mostly yes.

There is such a thing as too much signal, a condition that would overload the TV's tuner and cause an otherwise good picture to deteriorate. This is visible as an image that begins to look like an abstract artist's painting: wavering and losing sharply defined shapes, too-bright colors and color smearing. Sound might become a raspy or an even buzz.

This condition might exist if you live in the shadow of a TV broadcasting transmitter. Because indoor antennas are marketed predominantly to city apartment dwellers, where it is possible that such strong signal conditions exist, some manufacturers will contend that an antenna needs this kind of adjustment range to provide the best picture.

It's a stretch: Most people don't buy an antenna, especially an amplified one, to weaken a signal. But if the negative measurement is found at Minimum Gain, you can probably live with it so long as the antenna also offers ample Maximum Gain. When evaluating amplified antennas, keep the following in mind: If you've hooked up everything correctly and the powered model gives you worse performance than the passive dipole you've been using, then assume something is defective with the amplified antenna. In other words, a powered antenna may not help—the signals you receive might be just too weak. But it shouldn't hurt.

For example, we suspect a manufacturing defect in the Recoton PowerWave TV500 model tested here. Even



TERK TV20



RECOTON POWERWAVE TV600

ANTENNA TEST RESULTS

BRAND/ MODEL	ARCHER CS-200	GEMINI G2000	RECOTON PWTV600	RECOTON PWTV500	TERK TV20
PRICE	\$ 59.95	\$ 89.95	\$ 89.95	\$ 69.95	\$ 99.95
APEL LAB TESTS					
VHF GAIN (dB)					
Minimum	+ 6.0	+ 5.0	+ 13.0	- 30.0	- 30.0
Maximum	+ 19.0	+ 37.5	+ 25.0	+ 17.0	+ 20.0
Manufacturer's Specifications ¹	+ 20.0	+ 45.0	+ 28.0	+ 28.0	+ 35.0
UHF GAIN (dB)					
Minimum	0.0	+ 2.0	- 29.0	- 27.0	- 17.0
Maximum	+ 10.5	+ 28.0	+ 13.0	- 1.0	+ 18.0
Manufacturer's Specifications ¹	+ 20.0	+ 30.0	+ 15.0	+ 15.0	+ 35.0
FM GAIN (dB)					
Minimum	+ 3.0	- 4.0	+ 7.0	- 40.0	NA ⁴
Maximum	+ 20.0	+ 29.0	+ 21.0	- 5.0	NA ⁴
Manufacturer's Specifications ¹	+ 20.0	+ 25.0	+ 29.0	+ 29.0	NA ⁴
VIEWING TESTS² (Passive/Amp'd)³					
VHF (07/00)	07/08	07/08	07/08	07/07	07/08*
UHF (11/00)	11/11	11/12**	11/11	11/11***	11/11

1. Denotes the amount of gain, or amplification, that the manufacturer claims for the product. It is not known what test method(s) the various manufacturers employ. APEL measures all models uniformly by comparing the amount of amplification to a passive, half-wave dipole antenna that is assigned a value of 0dB when fed a 1-millivolt signal. 2. Whereas APEL's measurements are made under laboratory control, these viewing comparisons represent specific residential conditions. 3. Using passive rabbit ears, the home TV receives seven VHF and 11 UHF stations with varying quality, from viewable-but-noisy to excellent. Comparisons were not made for FM radio. 4. Although the Terk antenna does not offer FM radio reception, it does receive and amplify cable TV signals. APEL measured minimum gain at -8dB and maximum gain at +10dB. The manufacturer claims +19dB of gain.

* With deterioration on three stations compared to passive antenna. See text.

** Brought in one additional station and, at times, two others. See text.

*** All with deterioration compared to passive antenna. See text.

after bench-testing a second sample, APEL obtained negative figures for Maximum Gain in UHF and FM reception. In VHF, Maximum Gain (at +17dB) was much lower than the manufacturer's claim of +28dB. Usually, the claimed specifications aren't so far off the mark when compared to lab measurements.

We suspect a manufacturing flaw because the TV500 shouldn't have performed much differently from the very good PowerWave TV600—both share technology by famed RF engineer Larry Schotz. Besides cosmetic design, the two models differ in that the TV600 has separate gain controls for VHF and UHF, while the TV500 has a single ganged control.

Home viewing

Before detailing the performance of specific antennas, a word about

APEL's testing and PM's hands-on evaluation is necessary.

The clinical results obtained in the lab should be borne out in the home viewing tests. On a weak signal, for instance, the difference among antennas with 0dB gain, +15dB and +30dB should be visibly obvious. In every case, what we saw on TV tracked with the lab's findings.

For the record, the home viewing evaluations were conducted in a residence located in the suburbs of New York City, about 35 miles from the transmitter atop the World Trade Center. The home receives seven VHF and 11 UHF stations regularly, with quality that varies from noisy-but-viewable (two VHF, four UHF) to good (four VHF, three UHF) to excellent

(one VHF, four UHF). Additionally, this location is on the fringe of the service area for one VHF and three UHF stations.

For all its problems in the UHF band, where it even degraded reception of the four best signals, the Recoton PowerWave TV500 did improve the two noisy VHF channels at its full +17dB gain. Lesser amounts of gain cleaned up the four good stations. The more powerful +25dB gain of the TV600 made the two noisy VHF stations quite good, and pulled in the additional distant VHF station. A little tweaking above the +13dB Minimum Gain setting improved the four good stations, but higher settings for these and for the one excellent channel did overload the tuner. In UHF, the four weakest stations looked better at the +13dB Maximum Gain mark. Nothing was viewable at the -29dB

(Turn to page 110)



ARCHER COLOR SUPREME 200



GEMINI G2000



RECOTON POWERWAVE TV500

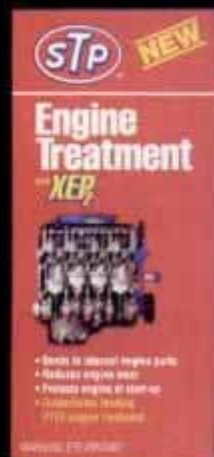
**IT STARTS EACH DAY
COLD, NAKED AND
VIRTUALLY
UNPROTECTED.**



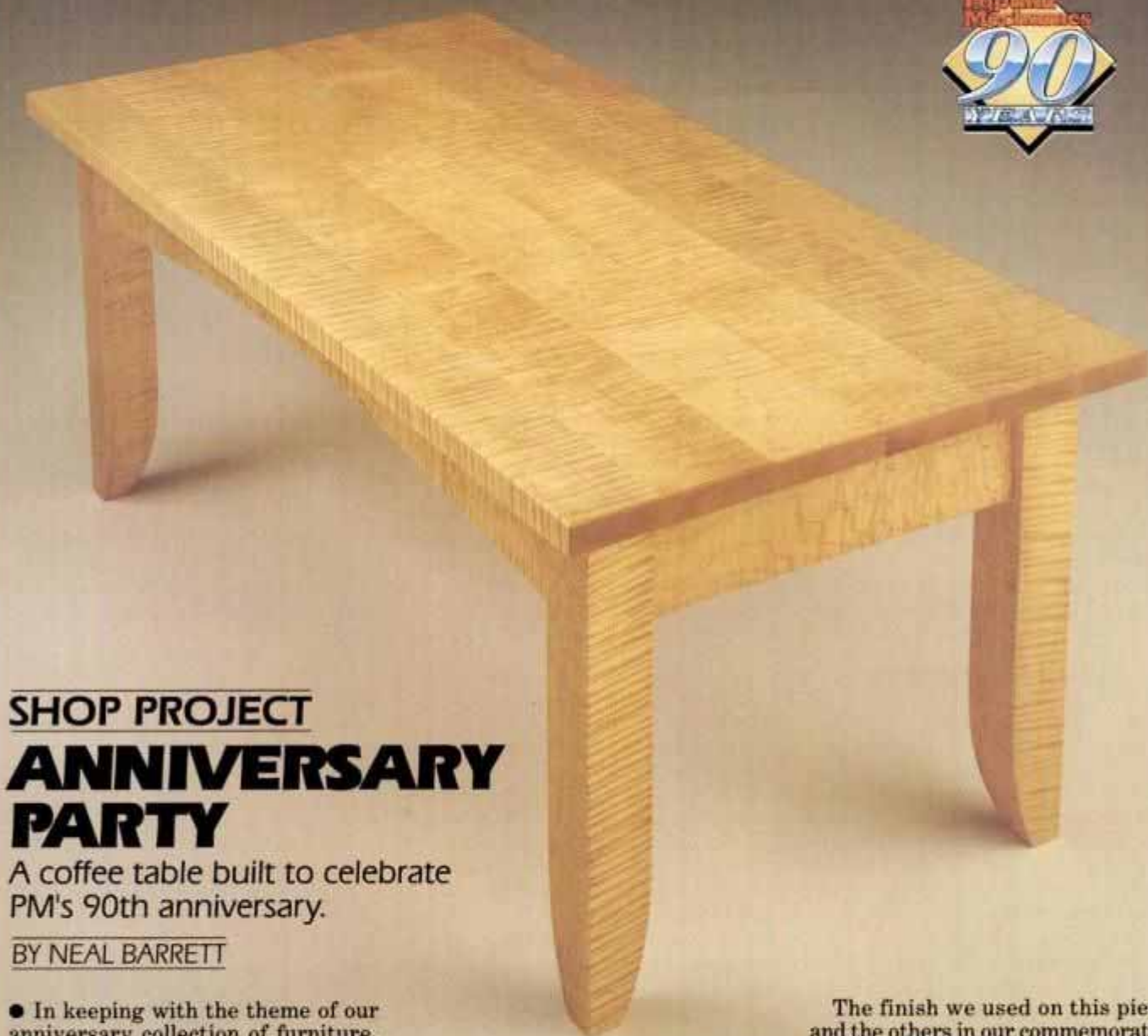
Your poor engine.

At start-up, it's only protected by a thin film of oil. It has to wait precious moments for more oil to be pumped up from the pan. The result? Friction and metal-to-metal contact. In fact, most engine wear occurs at start-up. Help stop it by using new STP® Engine Treatment with XEP2™. This breakthrough formula actually bonds to internal engine parts providing protection from the moment you turn the key. Durable protection proven in independent lab tests to stay put, start after start. Don't send your engine out into the world without new STP Engine Treatment. Help stop engine wear before you start.

B WALSH



**HELP STOP IT
BEFORE YOU START.**



SHOP PROJECT
ANNIVERSARY
PARTY

A coffee table built to celebrate PM's 90th anniversary.

BY NEAL BARRETT

● In keeping with the theme of our anniversary collection of furniture, the design of this coffee table has its roots in the Arts-and-Crafts tradition. With its strong yet simple lines, this table of curly maple complements a wide variety of furniture styles.

Should you need an end table, kitchen table or worktable, the dimensions of the legs, aprons and top can be modified easily to suit different needs.

And, because the table is a reasonably simple design, it is an ideal

project for a woodworker with intermediate-level skill, who has a well-equipped workshop that includes a table saw.

The table's top is glued-up and forms a solid panel. Its legs are cut from thick slabs of curly maple—and to make your job easier, we've located a national supplier of this beautiful and unusual wood in extra-thick sizes. This company will ship it right to your door. More about this later.

The finish we used on this piece, and the others in our commemorative furniture suite, couldn't be easier to apply. It consists of three coats of hand-rubbed Waterlox Transparent finish. This oil finish builds up to a thin coating. It produces an invitingly soft sheen and brings out the figure in the curly maple without having to use stain. The finish imparts a slightly amber tone to the wood.

Color photo: John Griebisch
How-to photos: Neal Barrett
Technical art: Eugene Thompson

Making The Top

Begin by selecting the 5/4 stock for the tabletop. Note that the top is glued-up from six 4-in.-wide strips. In selecting the wood for the top, try to match the pieces for color and grain pattern so the piece will have a uniform appearance.

Joint the edge of each board, rip each one to about 4 1/4 in., then joint the boards again to remove the saw marks and crosscut them about 2 in. longer than the finished dimension (Photo 1). Check to be sure that each joint is tight and square along its entire length. Mark the stock for joining plates spaced about 6 to 8 in. on center, then cut the slots with the plate joiner (Photo 2). Use a flat tabletop or a saw table as a worksurface. Be sure to hold both the workpiece and joiner tightly to the table as you cut the slots.

Spread glue on the board edges and in the plate grooves, insert the joining plates and assemble the top. Use bar clamps to pull the joints tight. After about 20 to 30 minutes, scrape off any excess glue squeeze-out from the surfaces of the panel, then let the glue cure completely.

Trim the tabletop to length, using either a sliding table jig on the table saw or a circular saw with a straight-edge clamped to the top.

Next, hold the top between bench dogs and lightly plane the top to remove any small irregularities left



1 Joint one edge of each board used in the top. Rip the board slightly over width, then joint the sawn edge smooth and straight.



2 Cut the joining plate slots in the edge of each board. Work on the table saw or another clean, flat surface.



3 After glue-up, use a razor-sharp plane to remove irregularities in the top. Work diagonally or across the top.



4 Before sanding the top, use a cabinet scraper to remove small areas of tearout from the hand plane.

from gluing the stock together (Photo 3). Use a razor-sharp plane and work diagonally across the panel. As figured woods have a tendency to tear out, take a very light cut. If you still have trouble with tearout, you can

plane directly across the panel's width, although this will require more sanding later.

Use a freshly sharpened cabinet scraper to finish smoothing the tabletop (Photo 4).

Making The Aprons

Rip and crosscut the stock for the table aprons to finished size. While the tenons can be cut in a number of ways, including using dado blades and by hand with a backsaw, we chose to use a shopmade tenoning jig on the table saw. Numerous commercial jigs are available, but most operate on the same principle of passing the workpiece vertically over the saw blade to cut the tenon cheeks.

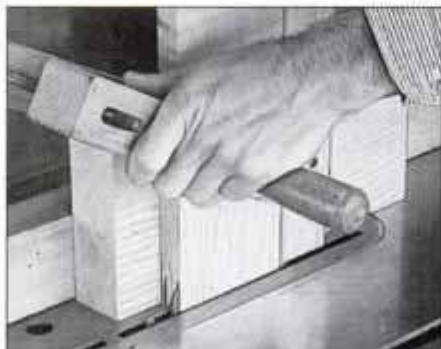
The jig consists of a block of wood with a long, narrow piece of scrap screwed to it. The block rides against the table saw fence and the long, narrow piece acts as a backrest for the piece being sawn. The backrest is screwed to the block at 90°. The dimensions of the pieces used to make the jig aren't important as long as they provide adequate support for the workpiece. This means that the block should be long enough to accommodate the apron and backrest, and wide enough to provide an adequate bearing surface for a clamp to secure the workpiece.

It is important that the two pieces that form the jig have square edges. Any deviation from square in the jig will result in a tenon that does not fit the mortise properly.

Make a test cut on scrap before sawing the tenons. To do this, clamp a piece of scrap against the jig so its end rests on the saw table and its back edge butts to the backrest. Adjust the saw blade height carefully, and run the test piece over the blade. If the

saw cuts are correctly located, parallel and the right depth, you can cut the tenons (Photo 5). If the test cuts are out of parallel, it means the jig is out of square. Any other adjustments can be made by moving the saw fence or changing the blade height.

Before cutting the shoulder cuts on the aprons, screw a long piece of straight scrap to the miter gauge to form an extension fence. Fasten a clamp to the extension fence to act as a



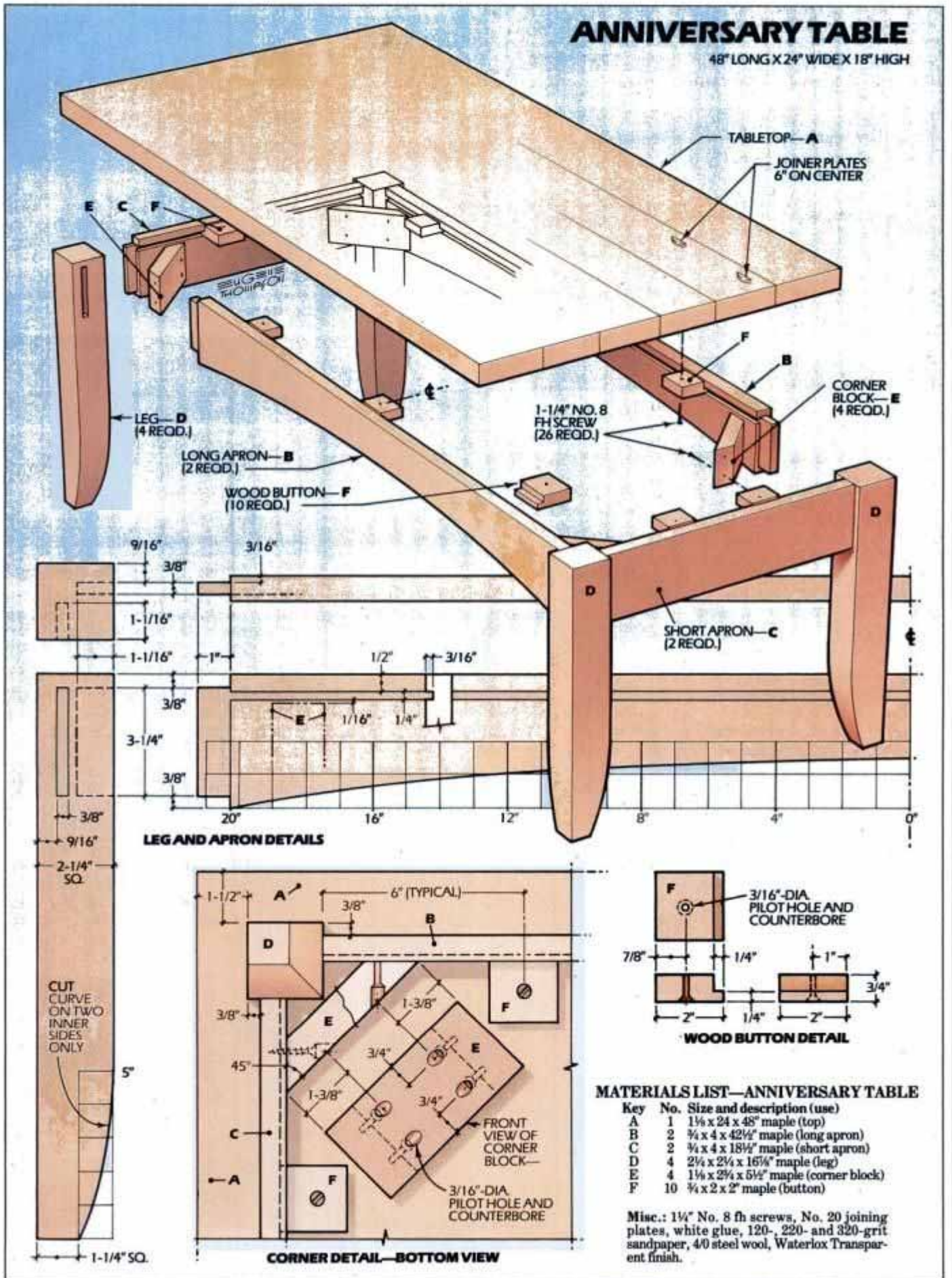
5 Cut the tenon cheeks with a shopmade tenoning jig. Use a parallel jaw clamp to hold the apron to the jig.



6 Saw the tenon shoulders with a miter gauge and extension fence. Note the parallel jaw clamp that acts as a stop.

ANNIVERSARY TABLE

48" LONG X 24" WIDE X 18" HIGH



LEG AND APRON DETAILS

CORNER DETAIL—BOTTOM VIEW

WOOD BUTTON DETAIL

MATERIALS LIST—ANNIVERSARY TABLE

Key	No.	Size and description (use)
A	1	1 1/2 x 24 x 48" maple (top)
B	2	3/4 x 4 x 42 1/2" maple (long apron)
C	2	3/4 x 4 x 18 1/2" maple (short apron)
D	4	2 1/4 x 2 1/4 x 16 1/2" maple (leg)
E	4	1 1/2 x 2 1/4 x 5 1/2" maple (corner block)
F	10	3/4 x 2 x 2" maple (button)

Misc.: 1-1/4" No. 8 screws, No. 20 joining plates, white glue, 120-, 220- and 320-grit sandpaper, 4/0 steel wool, Waterlox Transparent finish.

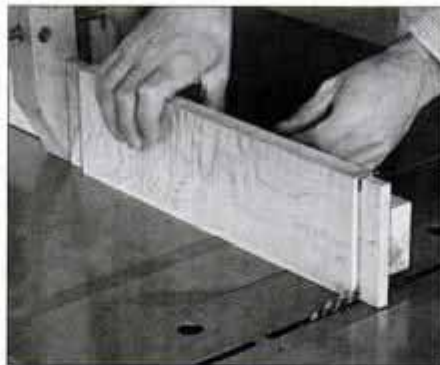
stop, and test the setup on a piece of scrap before making the shoulder cuts. Saw the tenon shoulder first (Photo 6), then saw across the apron's edge (Photo 7).

Sawing the narrow shoulder in this way leaves a small piece of waste attached to the tenon. Remove this by cutting with a dovetail saw, or cut off the waste on the band saw.

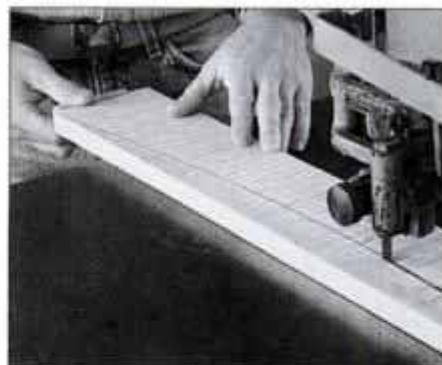
Make a template from cardboard or hardboard of the curved bottom profile on the long aprons. Trace the shape on the apron, and use the band saw or a sabre saw to cut the curved shape (Photo 8). Keep the saw blade barely to the waste side of the line as you cut.

We cleaned off the saw marks on this edge and refined the curve by clamping the apron upright on the bench and taking short strokes with a sharp spokeshave (Photo 9). If you are careful, you can accomplish the same thing using a sanding drum on a drill press. Use light pressure on the drill press to avoid burning the wood or leaving crescents. Take fine cuts if you are using the spokeshave to avoid gouging. With either method, work down to the line in several passes.

Using dado blades in the table saw, cut the groove on the top inside surface of the apron pieces (Photo 10). This groove will house the lip on the wood buttons for fastening the top to the base. Even a narrow dado blade has a tendency to push a workpiece off



7 Cut the small shoulders with the apron on edge. Cut the waste piece off the tenon with a dovetail saw or band saw.



8 Mark the curve on the long aprons, and saw just outside the line using a band saw or sabre saw.



9 Remove the saw marks and smooth the apron's curve with a sharp spokeshave, or use a sanding drum on a drill press.



10 Cut the groove in the aprons with dado blades in the table saw. The small lip on each button fits the groove.

the saw table, especially if the dado blades are dull. To avoid this, feed the workpiece slowly, and use a pushstick at the end of the cut to keep your hand clear of the dado blade. And, of

course, use sharp blades.

If you find that the workpiece is riding up, despite these steps, try cutting the groove in two shallow passes.

Making The Legs

The table legs are unusual in that they are made from stock far thicker than you find at an average lumberyard. You may be able to buy or order curly maple for the rest of this project at a local lumberyard that sells hardwood, but chances are such a yard will have difficulty finding curly maple that is this thick.

Fortunately, we've located a lumberyard in the heart of Pennsylvania's Dutch Country that specializes in curly maple. Contact Sandy Pond Hardwoods, 921 A. Lancaster Pike, Quarryville, PA 17566. This business is refreshingly service minded and will ship the stock to your house by truck or United Parcel Service.

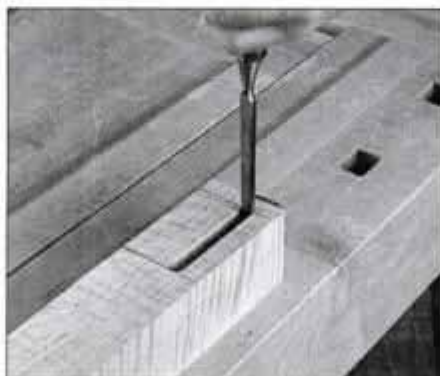
Note that the stock will arrive with

rough-sawn surfaces. You need to have the stock planed to thickness at a lumberyard or plane it yourself.

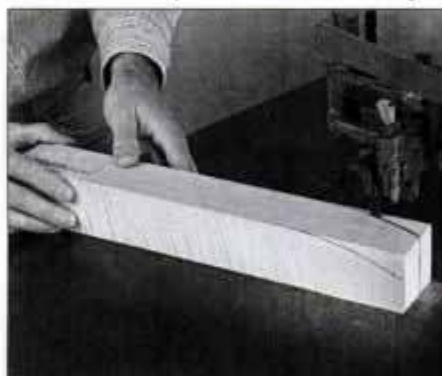
If you plane the stock by machine, put a set of sharp knives in your planer. If you use hand planes, get ready for some exercise and sharpen your tools well before and during the operation. Either way, take very shallow cuts. The less you tear out the maple



11 Cut the mortises with a plunge router and fence. Place a scrap piece next to the leg blank to support the router.



12 Square the mortise ends with a chisel. If the mortise is bored on the drill press, its sides must be pared flat.



13 Cut the leg blanks to shape on the band saw. The curved profile is cut on the inside surfaces of each leg.

while planing it to thickness, the less cleanup you will have later with scrapers and sandpaper.

If you have the stock planed at a lumberyard, expect to pay a premium for this work—the yard may have to install a fresh set of knives and take extra time with the stock.

Once the stock is the correct thickness, rip and joint the leg blanks to 2¼

Assembly

To begin assembly, rip a strip of ¾-in.-thick stock to 2 in. wide, and crosscut it at least 24 in. long for making the wood buttons that fasten the tabletop to the base.

Use the dado blades in the table saw to cut a ¼-in.-wide × ½-in.-deep rabbet along one edge of the strip. As was the case with cutting the groove in the aprons, the workpiece may have a tendency to move away from the blade. If necessary, cut the rabbet in two passes.

Crosscut each button to length using an extension fence on the miter gauge (Photo 14). Mark the length of the buttons with a strip of tape on the table-saw table. Slide the workpiece up to the edge of the tape and move it over the saw blade.

Bore and counterbore pilot holes in the buttons for the screws that attach them to the top:

Test fit the legs to the aprons without glue. If a joint is too tight, pare the tenon to fit with a sharp chisel, or use a chisel and block plane. If a joint is too loose, glue a veneer shim to the tenon cheek.

Once all the joints fit correctly, begin the assembly of the table base by joining the short aprons to the legs. Apply glue to both mortises and tenons and use a bar clamp to pull the joints snug. Compare opposite diagonal measurements of the assembly to check that it is square, and adjust the clamps if necessary (Photo 15).

After the glue has cured, glue and clamp the two ends to the long aprons. Be sure to do this on a flat surface in order to avoid imparting any twist to the base.

Cut pieces of 5/4 stock for the corner blocks. Use either the table saw and miter gauge or a miterbox to cut the 45° angle on the block ends.

Bore and counterbore pilot holes in the blocks on the drill press (Photo 16). It makes the process easier if you clamp a fence, 45° base and stopblock to the drill press table.

Next, screw the corner blocks to the aprons with 1¼-in.-long No. 8 fh screws (Photo 17). The screws will go

in. wide and crosscut them to length. Draw the position of the mortises on the leg blanks using a sharp pencil and square, or use a mortise gauge. Hold a leg between bench dogs, and use a plunge router and edge guide to cut the mortises (Photo 11). You can also bore out the bulk of the mortise on a drill press, then pare the sides flat with a chisel. Either method will re-

quire that you also pare the mortise ends square (Photo 12).

Make a template of the curved section of the leg and trace the curve on each leg. Note that the legs curve only on the inside faces. Cut the legs to shape on a band saw, staying just to the waste side of the line (Photo 13). Clean up the curved face with a plane or a belt sander.

on all sides, then install the wood buttons and bore pilot holes in the top. Attach the base to the top by screwing through the buttons with 1¼-in.-long No. 8 fh screws. **PM**

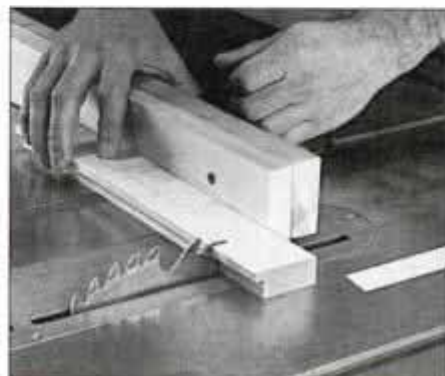
in easier if you lubricate them with a little wax.

Carefully sand all the parts with 120-, 220- and 320-grit sandpaper. Then dust off everything thoroughly with a tack cloth.

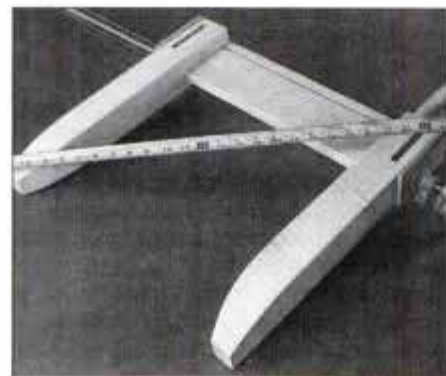
We applied three coats of Waterlox Transparent finish to the table. Apply the finish with a clean rag, allowing only a thin film to remain on the surface. After overnight drying, scuff the finish lightly with 320-grit paper, wipe it off with a tack cloth and apply the next coat. Repeat the process on the next coat. When the last coat has fully cured, rub it out with 4/0 steel wool and polish it with a soft, clean cloth.

To assemble the table, place the top upside down on a padded surface, then place the inverted base over it. Adjust the base for an equal overhang

on all sides, then install the wood buttons and bore pilot holes in the top. Attach the base to the top by screwing through the buttons with 1¼-in.-long No. 8 fh screws. **PM**



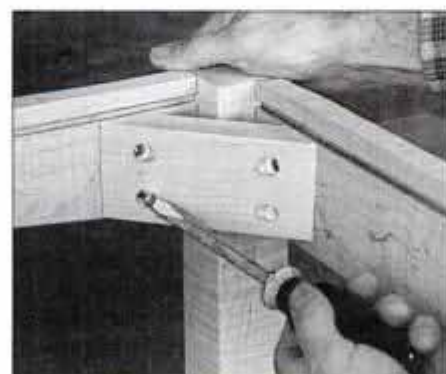
14 Crosscut the buttons on the table saw using the miter gauge. A piece of tape on the saw table acts as a guide.



15 Glue and clamp the short aprons to the legs. Measure diagonals to check the assembly for square.



16 Clamp a stopblock and backrest to the drill press. Bore, then counterbore, the pilot holes in the corner blocks.



17 Lubricate the screws that hold the corner blocks to the aprons with a little wax. Screw the blocks to the aprons.



18 Invert the leg-apron assembly on the top with equal spacing all around. Screw the buttons into the top.

HOME IMPROVEMENT

RADIANT BARRIERS

BY MERLE HENKENIUS
PM Illustrations by Eugene Thompson

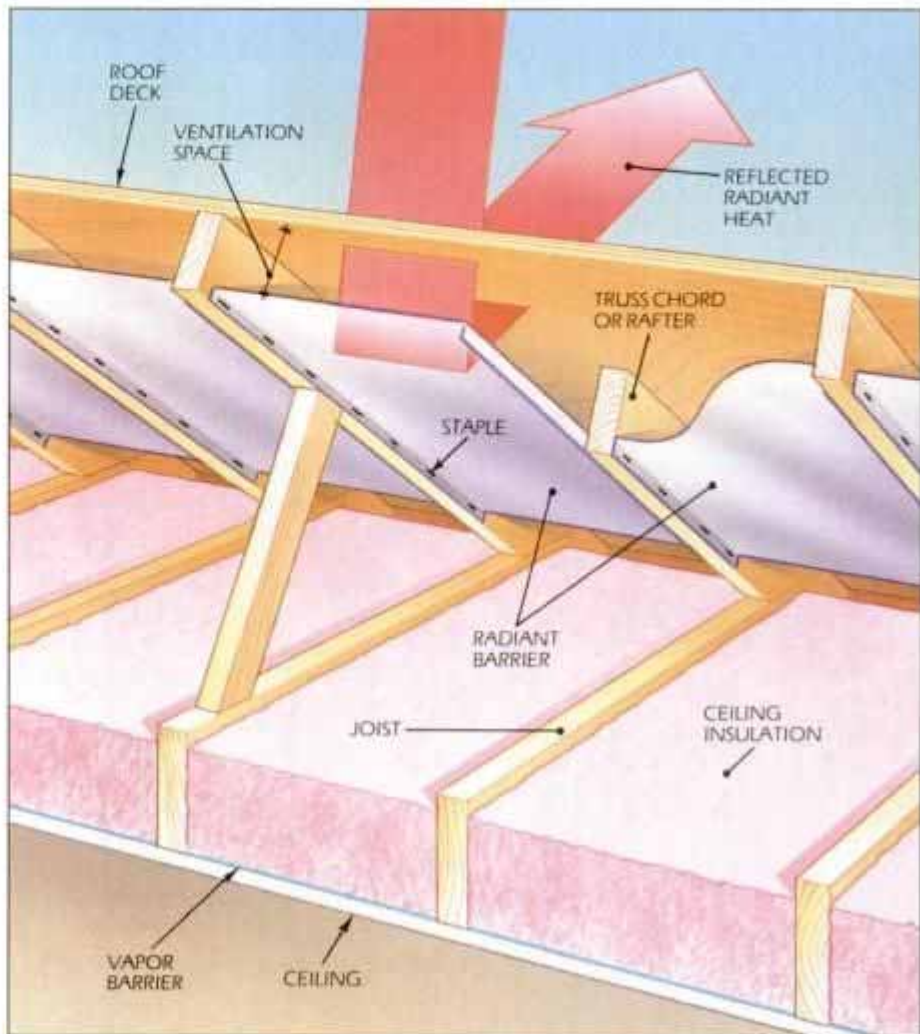
● If you've owned your home for a long time, you probably remember hearing about sheets of reflective foil that could save you up to 40% in energy bills. You may also recall thinking that these claims were simply too good to be true. As it turned out, a lot of other people thought so too—among them, state attorneys general, EPA enforcers and a respectable collection of scientists across the land. And, not surprisingly, the insulation manufacturers took a vigorous interest as well. The outcome, of course, left the hucksters looking for work, while traditional insulation held its dominant position when it came to controlling heat and saving money.

However, at the center of the fray was a more reasonable proponent of radiant barriers. These folks preferred better research and more modest claims—and accepted the modest prices those claims would fetch. They've since managed to hold their own among competing interests, and their product has withstood some fairly hostile scrutiny.

About radiant barriers

Radiant barriers are sheets of reinforced reflective foil that are installed in attics to check the flow of radiant heat into the attic space. Radiant barriers come in a variety of forms, but most consist of a paper or mesh substrate with aluminum foil on at least one side. The reflective foil side is turned up to face the roof. Several installation methods are common. In new construction, the foil can be draped over the rafters before the roof deck is installed. On retrofits, the foil is generally stapled near the bottoms of the rafters or truss chords. In cathedral ceiling construction, radiant barriers are installed between the rafters on the roof side of the insulation, with a space left between the barrier and roof deck for ventilation.

In some cases, the radiant barrier is laid directly on top of existing insulation on the attic floor, often using perforated material to allow moisture to pass through. This method is strongly



Radiant barriers reflect heat from the sun to keep attic space cool. In typical retrofit installation (shown), reflective sheets are installed between the roof framing.

discouraged by RIMA (Reflective Insulation Manufacturer's Association), as tests indicate that dust accumulation reduces the barrier's effectiveness. And even with perforated foil, trapped moisture can be a problem.

The real debate pivots on whether or not radiant barriers are more effective in controlling heat migration than simply increasing the insulation on the attic floor. While reflective barriers are generally cheaper, insulation offers the added benefit of keeping your home warm in the off-season. While radiant barriers offer a slight bonus in the winter, they're best at keeping the heat out in the summer.

To the opposition, primarily MIMA (Mineral Insulation Manufacturer's Association), radiant barriers are just another fad virus sweeping the country at the consumer's expense. To proponents, radiant barriers solve a specific problem in a way that insulation cannot. Besides, they add, there are times when insulation isn't practical—when an attic floor is used for storage, for example.

Radiant barrier theory

From a summer cooling standpoint, the object of either insulation or radiant barrier is to block the heat that migrates from a sun-struck roof to your living space. Conventional attic insulation blocks heat conduction through the attic floor, and is rated by R-value. A radiant barrier also reduces the flow of heat into your home, even though it has no effective R-value. Instead, foil barriers reflect radiant heat away from the house before it reaches the attic floor. With less heat in the attic, less insulation—and energy—is required to maintain a cooler indoor temperature.

As a case in point, one radiant barrier test installation revealed an attic temperature that was within 3° of the outdoor temperature. Under normal conditions, a sunny, 90° F day can produce peak attic temperatures of 120° to 140° F when no radiant barrier is present.

This is a formidable problem. The Department of Energy estimates that 20% of a home's heat gain in the sum-

mer comes through the ceiling. In other words, one-fifth of your cooling bill can be attributed to handling the heat that moves into your home from your attic.

Practical issues

At the simplest level, the questions for the homeowner become: "Will a radiant barrier work in my home? And if it will, which will cost more, a radiant barrier or more insulation?" While these are reasonable and essential questions, they often yield incomplete answers.

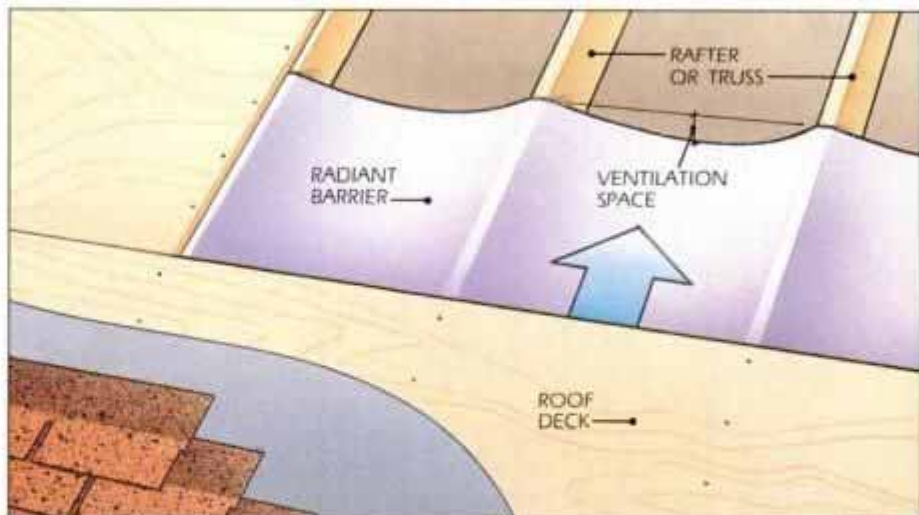
The problem is one of quantifying radiant barrier effectiveness, and more importantly, qualifying that effectiveness in terms of geographical areas with varying climatic characteristics. And, with no useful R-value, it's hard for building-code committees to create appropriate standards.

This is especially true when some versions of the Model Energy Code are applied. In such codes, each negative feature in a home's design, such as a window, must be compensated for by a positive feature. This is a simple plus/minus equation that works well at the levels of design and code enforcement. But, throw in a wild card like radiant barriers—no matter how effective in a specific case—and the formula becomes less certain. A universal energy factor for radiant barriers is hard to achieve because dozens of site-specific factors must be considered. Here are a few:

Does the house face east, west, south or north? Is it shaded by trees? Does the roof have continuous soffit and ridge vents, or isolated vents? Is the roof black or white? Will the barrier be installed on new construction or as a retrofit? Is the prevailing summer climate hot and dry, or hot and humid?

The last point is no small matter. While homeowners in hot, dry climates will throw open the windows at dusk to take advantage of the cooler evening air, those in humid climates won't. For them, running the air conditioner also serves to control humidity.

To muddy the waters even further, the radiant barrier industry has been tainted by the unethical and illegal marketing practices of a handful of companies. In the recent past, exaggerated claims were often used to support



Installation in new construction is simpler than retrofits. Here, the radiant barrier is draped over the roof framing before the roof deck is installed.

inflated prices that could never be recovered through energy savings—we heard of extreme cases where \$3 per sq. ft. was charged. Today's prices will range between 12 and 30 cents per sq. ft. If it's a retrofit, these prices may double to take into account the more difficult installation.

Official consensus

Florida has already found a way to factor radiant barriers into its building-code energy equation, and efforts at establishing a workable model in California have even greater implications as other states often follow California's lead.

The Department of Energy holds the middle ground between MIMA and RIMA, and has commissioned and monitored studies on radiant bar-

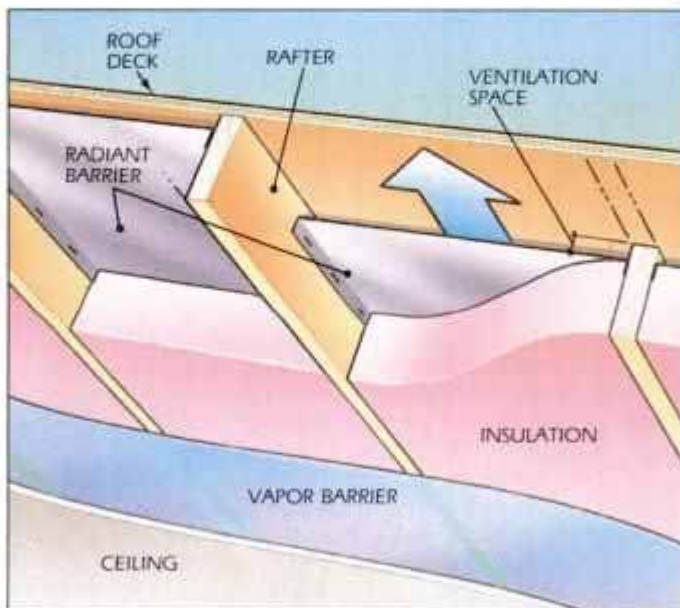
rier effectiveness. The final results should include cost-versus-payback projections for a variety of locations and thorough explanations of what radiant barriers can be expected to do under a wide range of situations.

In the mean time, cost effectiveness is ours to judge on an individual basis. On average, a radiant barrier will cost less than 6 in. of insulation. As for which is the better investment, here are some useful figures.

Recent studies suggest a potential reduction of 25% to 30% of ceiling heat migration with a radiant barrier. That doesn't equate to a 30% reduction of your total cooling bill, it just means that the heat coming into your house through your ceiling is reduced by 30%. Because only about 20% of your cooling bill is spent on heat from your attic, what you actually save is closer to 5% or 6% during the summer months.

How long it takes to pay back the installation will vary with your climate. While a \$250 installation in Florida would pay for itself in less than 10 years, a similar installation in Minnesota would be difficult to justify. In the north, a \$450 insulation upgrade would be more cost effective than a \$250 radiant barrier, in light of the insulation's benefits during the longer heating season.

In short, radiant barriers are better suited to the southern states, particularly the more humid area from Florida to Texas. The further north you live, however, the more imposing the payback becomes. **PM**



In cathedral ceilings where insulation exists between rafters, radiant barrier is placed on the top side of the insulation, but spaced away from the roof deck to allow for ventilation.

NEW PRODUCTS

10 GREAT HOME APPLIANCES

BY ROY BERENDSOHN, Assistant Home Improvement Editor



The Next Step

General Electric's Profile line of refrigerators has taken the next step in refrigeration—serving food, not just storing it. The model shown has two sliding Quick Serve storage dishes. Pull them out of the refrigerator or freezer, pop them into the microwave and from there, into the dishwasher. Also, a compartment called the Refreshment Center is contained in the refrigerator door. Just swing down the compartment's door and you have



access to the containers of liquid or snacks on the other side. The compartment door doubles as a work surface. Other nice features include sliding dividers in the door bins, slide-out freezer baskets and refrigerator storage shelves that slide back to make room for tall items. The Model TFXW27FR (27 cu. ft.) shown costs about \$2000 at GE appliance dealers. For more information, write Dept. PM, GE Appliances, 4700 Allmond Ave., Louisville, KY 40209.



Clear The Air

The Sensaire fan/light is one of the surest ways we've seen of lighting and ventilating a bathroom. Its light is motion activated, and its fan is activated by humidity, motion or both. The device can be separately wired with an on/off wall switch. With the motion sensor only, it costs about \$200; with the humidity sensor only, about \$220; and with the two combined, about \$240. They are sold at home centers. For more information, write to Broan Mfg. Co., Inc., 926 W. State St., Hartford, WI 53027.

On A Different Plane

This compact Swedish dishwasher is unusual for several reasons, not just that it is installed at countertop level. Its manufacturer says it uses 5.3 gallons of water to wash a full load of dishes, compared to a minimum of 8 gallons typical of domestic makes. It can wash bulky pots and pans because it doesn't use a central water tower. Also, its manufacturer says it's quieter and more durable because it uses small separate motors to drive the circulation and drain pumps. Its inner casing, filters, pipes and spray arms are made of stainless steel. The Model 770 costs about \$750 at Asko appliance dealers. Call (800) 367-2444; or write Asko, Inc., 903 N. Bowser, Suite 2000, Richardson, TX 75081.



Runs Hot And Cold

Elkay's deluxe Water Centre filters water then chills it to 45° F, dispenses it at room temperature, heats it to 190° F or turns it into ice cubes. Put your glass under the dispenser funnel and press a square on the touch control panel. For ice, slide out a tray next to the water dispenser. It produces 5 pounds of ice at a time. Shaped like a dishwasher, it measures 24 in. wide x 24 in. deep x 34 in. high. The appliance features snap-out filters, a child-resistant hot-water safety switch and a bypass switch that cuts off hot-water flow entirely. The Water Centre costs about \$2000 (without the filter option, about \$1500). For your nearest distributor, write Elkay Mfg. Co., 2222 Camden Court, Oak Brook, IL 60521.





Through The Wall

Air conditioning usually requires a wall sleeve or a window—but not this model, all it needs is a 3-in.-dia. hole in the wall. The compressor/condenser is positioned outside the house, above or below the indoor console by as much as 20 ft., and refrigerant is fed to the interior console via flexible refrigerant tubing. The system is thermostatically controlled and also functions as a heater via electrical resistance coils or a heat pump with coil backup. The Slant/Fin SP costs about

\$1300 (installation costs about \$500) through heating/cooling contractors. Write to Technical Service Dept., Slant/Fin Corp., 100 Forest Dr., Greenvale, NY 11548.

Three In One

The Ariadni is three switches in one. It's a standard toggle switch and a slide-operated dimmer switch. The slide is next to the main toggle and it dims the light by 75%. And, with the night-light option, the toggle switch and dimmer slide are also backlit. It's available as a single pole switch or as a 3-way switch and in 600- and 1000-watt models. It fits standard electrical boxes and takes a standard faceplate (not included). It costs about \$18 at hardware stores and electrical distributors. Low-voltage and fluorescent models are also available. Contact Lutron Electronics Co., Inc., 7200 Suter Rd., Coopersburg, PA 18036.



Come Clean

Take dirty dishes right off the table and put them directly into this dishwasher, the people at Robert Bosch Corp. say. They claim the dishes will come out clean and it will use only 5.4 gallons of water. Compared to using a domestic dishwasher under typical household conditions, this one saves about 1500 gallons of water a year, as well as the electricity that would be used to pump more water in and out, Bosch says. To top it off, the company says the appliance is whisper quiet, with a decibel rating eight times less than comparable American washers. It costs about \$850 to \$1100, depending on the model, at major appliance dealers. Call (800) 866-2022 or write Robert Bosch Corp., 2800 S. 25th Ave., Broadview, IL 60153.



So Long To Water Cooler Gossip

KitchenAid's bottled water pump will deliver bottled water to the water/ice dispenser on your refrigerator or to a special faucet installed on the counter. Install the bottle in a cabinet, garage or closet—the pump can move water 50 ft. from the bottle. The pump is made from food-grade plastics and is UL listed. It costs about \$180 at KitchenAid appliance dealers. Write KitchenAid, P.O. Box 558, St. Joseph, MI 49805.



Suspended Ventilation

You can bring cooled or heated air to a poorly ventilated room with a suspended ceiling using this kit. It consists of 10 ft. of flexible aluminum duct, a ceiling diffuser that installs directly into the ceiling tiles and a collar to tap into the main duct. The \$30 kit is designed for do-it-yourself installation, according to the manufacturer, and is sold at hardware stores and home centers. For more information, write Deflecto Corp., P.O. Box 50057, Indianapolis, IN 46250.



Warm Up

Take the chill off a floor by stapling this flexible heating element to the floor joists below it. The element consists of a polyester film with heating circuits of carbon ink printed on it. It comes as a kit containing 30 ft. of heating element, connectors and a crimping tool. To install, cut it to length, make the electrical connections and staple it to the joists 2 in. below the subfloor. Insulate below the element and wire it to a wall switch, thermostat or clock timer. The UL-listed kit costs about \$200 (plus shipping) from Flexwatt Corp., 2380 Cranberry Hwy., West Wareham, MA 02576. **PM**



HOMEOWNERS CLINIC

BY NORMAN BECKER, P.E., Contributing Editor

Downspout Dry Wells

I can't find plans or information on building a dry well for my downspouts. I have looked in "how-to" books and magazines, and have contacted the POPULAR MECHANICS reader service department. I would appreciate any information that you can supply. Thank you.

GLEN LEVINE
OSSINING, NY

A dry well is often just a large hole in the ground covered with boards and filled with rocks to keep the sides from collapsing. A better dry well, however, is a clean steel or plastic drum buried 18 in. below grade at least 10 ft. from the house's foundation. Do not bury the drum closer, because runoff seeping from it could enter the house's basement through cracks in the foundation.

Drill numerous holes through the drum with a 1/2-in.-dia. drill bit, and fill the drum with medium-size stones. Make the drum's lid from pressure-treated lumber or a thin slab of concrete reinforced with wire.

This design is better than a rock-filled hole because it is less likely to fill with silt eroded from the soil.

A dry well should work in most situations because its large surface area allows water to percolate into the ground before the drum is filled with water. However, if your area has high ground water levels in some seasons, or year round, there will be

times when the drum is filled with water and can't accept runoff.

Also, a dry well can become ineffective if it fills with debris that washes out of a house's gutters, so keep your gutters clean.

Bubble Trouble

I have an aluminum level made by Johnson Level & Tool Mfg. Co., Milwaukee, Wisconsin. One of the bubbles is broken and I need a replacement. Can you help me?

EMMETT VAUGHN
ARABI, LA

I called the people at the Johnson Level & Tool Mfg. Co., and they said that if you could supply them with the level's model number, they would try to supply you with a replacement part at no cost. Readers with Johnson levels can reach the company at 6333 W. Donges Bay Rd., Mequon, WI 53092.

Sweaty Water Tank

We have well water. Is there something I can put around the water storage tank to keep it from sweating?

BILL TOUVE
LOSTINE, OR

The cold water storage tank is sweating because its surface temperature is below the dew point of the air in that room. This causes the moisture in the air to condense on the tank. You can cover the tank with blanket insulation and then cover the insulation

with a vapor barrier of plastic sheeting. Cover all joints in the vapor barrier with plastic tape. An alternative is to buy a water heater blanket, available at home centers, and cut it to fit your tank.

Duct Location

I want to install central air conditioning in my home. Since I have hot-water heat, I will have to install air ducts. Is it more efficient to put the ducts in the ceiling or in the floor?

Would I lose cooling efficiency if the ducts are installed in the attic? It gets extremely hot up there.

CLIFFORD CRUMRINE
NEW BAVARIA, OH

Don't worry about the loss of cooling efficiency from the warm attic. As long as the attic is adequately ventilated and the ducts are insulated, the heat that the ducts gain will be minimal. If you want to reduce the heat load in the attic, install a thermostatically controlled power ventilator in the roof.

The best place for the supply registers is on the ceiling or high on the wall. Cool air leaving the register will sink and displace warm air, which rises. The return grille should also be in the ceiling or high on the wall. By installing the supply registers and return grilles in this way, the air currents will mix. This prevents layers of warm and cool air from forming.

In many cases, central air conditioning is installed using heating ducts to move cool air. Although this saves the cost of installing a set of air-conditioning ducts, it is not as efficient. The cool air entering through registers at floor level forms a cool layer with warm air above it.

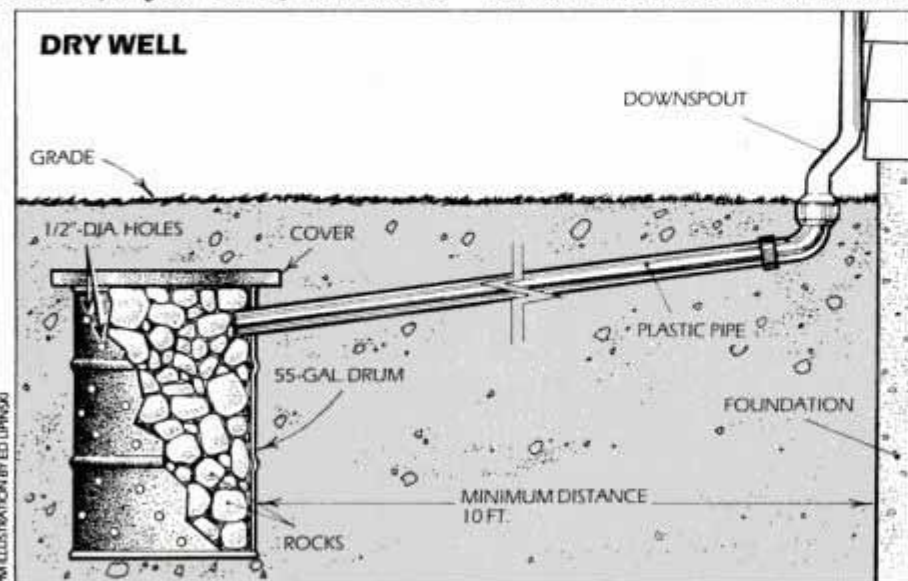
A better installation, though more expensive, is to have ducts installed in the walls with high/low registers. In this system, there is one register slightly above floor level and another high on the wall. Heated air is discharged near the floor, while cool air is discharged near the ceiling. Airflow is directed to the appropriate register by moving a damper that is part of the high/low system.

PM

DO YOU HAVE A HOME-MAINTENANCE OR REPAIR PROBLEM?

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re



An effective dry well for downspouts consists of a 55-gallon drum with drain holes drilled through it. The drum is filled with rocks and covered with a lid.



HOME IMPROVEMENT

BATH AND UTILITY ROOM BUMP-OUT

Sometimes just a small addition can make a world of difference in how a couple of rooms feel.

BY MIKE McCLINTOCK

● More than 60% of the 80 million single family homes in this country are over 20 years old. And most of these are tiny compared to the excessive, 5000-sq.-ft. monsters we so often see in architecture and design magazines today. But these basic, child-tested,

bread-and-butter houses aren't obsolete, though often they are a little short on pleasant amenities, like sufficient closet space and some extra elbow room at the bathroom sink.

While some shortcomings can be expensive to change, others, like this simple bath and utility room bump-out, won't break the budget and add bonus space, right where it's needed.

Some of our preliminary plans were pretty ambitious, and expensive. One even sported an outdoor shower enclosure and a special 8 × 8-ft. alcove for an oversize, all-season whirlpool bath. After that first design splurge, though, we decided on a more sensible plan. First we wanted a little more room in the bath, so that two could use the vanity at the same time. Second, we wanted a lot more all-purpose storage space in the utility room.

Along the way we also decided to improve our mechanical systems. The utility room held a Rube Goldberg maze of plumbing connections, an old inefficient furnace and a large interior

flue that made any layout changes very difficult.

Our final plan is what you see here. The back house wall was bumped out only 5 ft. 4 in. The bathroom was immediately more comfortable, and the previously dark and cramped utility room now has an airy feel with tons of closet space. And, we installed a new back patio door that opens onto a small covered entrance deck. This lets the utility room do double duty as an all-purpose mud room.

We also have a modern heating system, instead of an old white-elephant furnace, plus all-new plumbing and wiring. And because this furnace model has such a high efficiency rating, we could use a PVC vent to release combustion gases, not the typical masonry flue. So, away went the annoying interior flue and in its place is an alcove for our washer and dryer.

By cutting down our square-foot-

Photos: J.R. Rost
Technical Art: George Retseck

age requirements, we enjoyed two other benefits: First, we had more money to devote to better windows, doors, bath fixtures, appliances and heating equipment. And second, the small bulge on the house's footprint hardly raised an eyebrow at our local building department. So here's a blow-by-blow description of our project.

The bath

While the hardcore mechanical guts of this job are in the utility room, the nicest touches are in the bathroom. Even though it's difficult to keep even a modest bath remodeling like this from eating up the budget, after the demolition, digging and disruption—which are so much a part of the job—you should include a couple of extras just to take the edge off the hassles that are bound to occur.

One good approach is to splurge a little on color and pattern. We used a



mosaic of ceramic tile on the floor which followed the outline of the room's perimeter. This created some subtle visual interest in an otherwise still small and subdued room. The color on the cabinetry complemented the floor, but remained light so the room felt airy and expansive.

The previous bathroom only accommodated two people if one was in the shower. Now two can comfortably use the vanity.

Because we wanted the room flooded with exterior light but didn't want to sacrifice our privacy or the only wall for an oversize vanity mirror, we chose the narrow windows shown. These frame the sides and top of the mirror which reflects light into the room. Also, with the fixed unit above, this makes the room seem even larger. The fixed unit above lets in the most light. But the two casements on the sides do provide lots of light and great ventilation. We still have some privacy, and room for two at the vanity.

This job also gave us the opportunity to change plumbing fixtures, opting for ones that were a neutral color. In the future we'll be able to change the room by simply changing the decorating, not the fixtures. And we bought top-of-the-line faucets and

(Please turn to page 70)

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other hardware with the money we saved by building a smaller room.

We also installed an exhaust fan on a timer switch. It is vented directly to the outside and does a great job of ridding the room of excess moisture. Once we're dry from bathing, we simply turn on the switch for 10 minutes and leave the room. We don't have to stand there in a cool breeze wondering if there's a better way.

One last grace note in the bath: We preplanned the exact location of all our towel bars so we could add framing between the studs at these locations. By doing this, the screws from the bar brackets can be driven directly into solid framing. If these bars come down, so will the wall.

The utility room

Our old utility room was dark and dingy. We had just one small window over the washer and dryer. In our new utility room, wall space was



Extra square footage in the utility room allowed for more efficient placement of the washer and dryer and a wall of storage closets.

full screen door slides across the opening. Although a sliding door would have had many of the same advantages, we liked this version because it's easier to operate, looks great and locks more securely than standard sliding glass doors.

The door opens onto a small covered back porch, which creates a nice transition between the house and the backyard. Not only does it break up what would otherwise be a flat facade, it also shields the door from the weather. So during most rainstorms, the door can remain open to catch cooling breezes.

again too precious to award to windows, but we did make room for a patio door that gave us great access to our backyard, a huge amount of screened ventilation in the summertime and a great source of natural light all day long. The door has two panels of equal size, one center-hinged to swing back on the other. A

To make room for our patio door we had to find a new location for the washer and dryer, which we did by creating an alcove along the bathroom wall. This layout change was possible once we removed the interior flue that our old fuel-guzzling furnace re-



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quired. When we closed in the new furnace, the resulting alcove allowed our new washer and dryer to recede from the center of the room for a built-in custom look. Another nice touch is the removable box shelf we placed behind them. This gave us room to make all the mechanical connections and still avoid the cavern behind most washers and dryers that always seems to gobble up socks.

The wall cabinet above the washer and dryer offers room for general-purpose storage, and its lower rail extends far enough below the cabinet floor to hide a fluorescent fixture, right over the machines. The last touch in the appliance alcove is a narrow cabinet between the washer and dryer, just wide enough to store detergent and other laundry supplies.

Once the washer and dryer had a new location and the patio door was in place, we could eliminate the old en-

trance door, winding up with a full wall for storage closets behind lowered doors. These doors are harder to paint but make the wall look more interesting than a succession of flat doors. We also added an overhead light in each closet.

But some of our most interesting improvements are hidden behind the doors to the furnace space. Here, we shoehorned into a very tight spot our new furnace, air cleaner, water softener and water heater.

The 94%-efficient furnace, called a combo heater, is a 2-unit fixture but still a space saver for remodelers. A heavily insulated hot-water tank feeds our domestic hot-water lines and a heat exchanger coil above the furnace fan. This system is so efficient that a stainless-steel exhaust coil in the water tank gives up the last drop of gas heat and produces a tepid exhaust that's vented through PVC

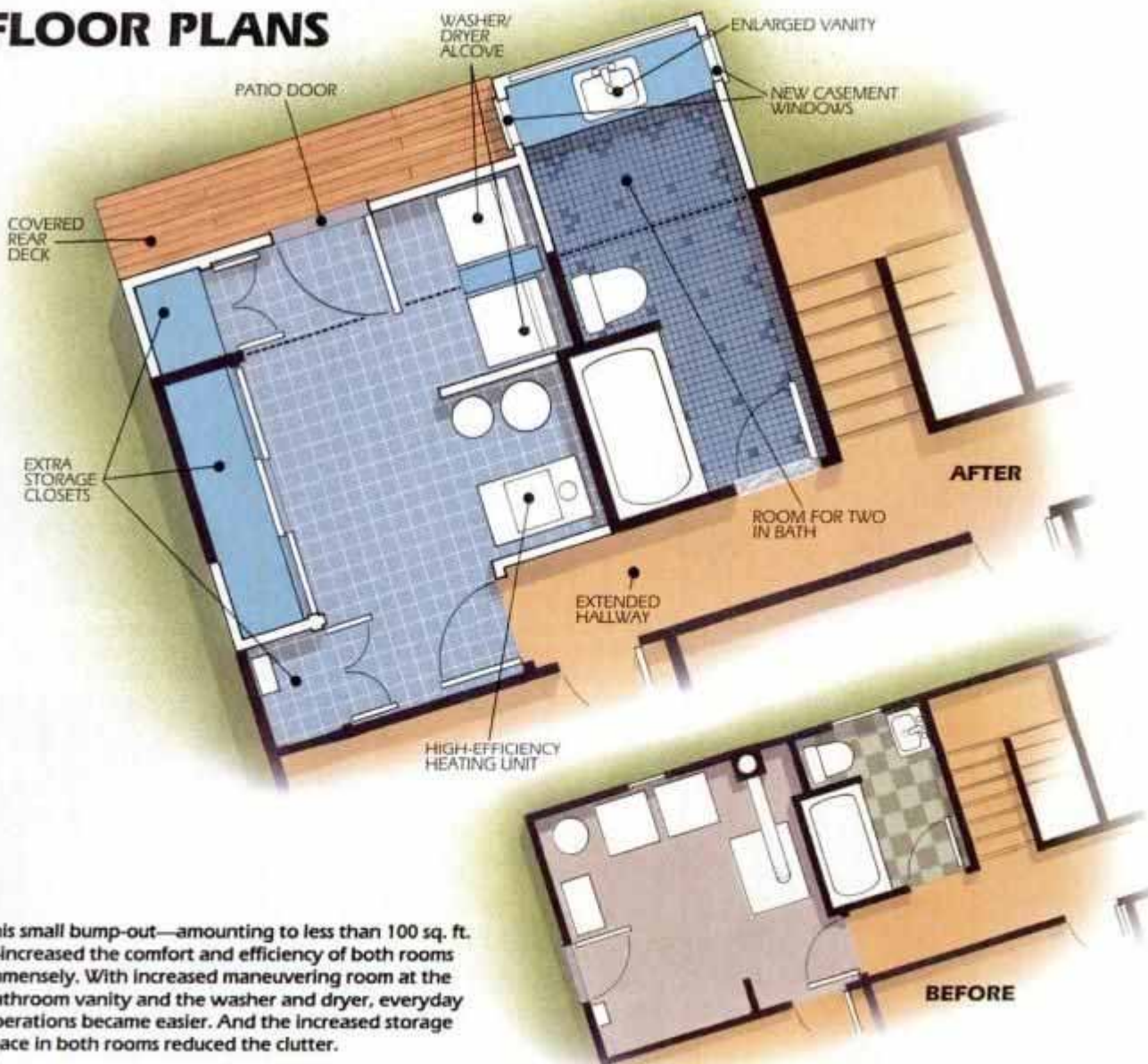
pipe. We also added an electronic air filter—to cut down on dust accumulations in our house—just below the fan in the return air plenum. And, we completed the tight jigsaw puzzle fit with a special-ordered tall but slender water-softening unit.

One bonus of the whole project was the chance to right a wrong we'd been living with for years. The entrance to a small workroom—now converted to a home office—had always been through the old utility room. By extending the hall a few feet farther, as shown in the drawing below, the room now opens directly into the hall, the way it always should have been. **PM**

SOURCE LIST

Windows and doors: Marvin Windows
Bath fixtures: Elger Industries
Tile: American Olean
Locks and towel bars: Baldwin Hardware Co.
Washer and dryer: Whirlpool Appliance Group
Furnace: Mor-Flo Industries, Inc.
Air cleaner and thermostat: Honeywell, Inc.

FLOOR PLANS



This small bump-out—amounting to less than 100 sq. ft.—increased the comfort and efficiency of both rooms immensely. With increased maneuvering room at the bathroom vanity and the washer and dryer, everyday operations became easier. And the increased storage space in both rooms reduced the clutter.

TOOL TEST

**SKIL
 BELT/DISC
 SANDER**

TEXT AND PHOTOS
 BY ROSARIO CAPOTOSTO,
 Contributing Editor

● Benchtop tools are the answer for anyone with limited space, but also an appetite for serious machine performance. And as far as sanders go, Skil's model 3370 Combination Belt/Disc Sander is functionally very similar to the floor models that you're likely to find in commercial shops. To handle most home-shop sanding jobs, the tool features a 4-in.-wide belt and a 6-in.-dia. disc.

Although relatively small in size, this tool has a substantial cast-iron base and tips the scales at 45 pounds—one reason for its solid feel and almost vibration-free operation. When I first tried the tool, however, disc wobble and vibration were problems. After looking inside, I found three loose screws in a retaining plate that secures the disc sander shaft. Once these were tightened, the tool's performance was very good.

A 1/2-horsepower induction motor drives the belt at 2000 fpm (ft. per minute) and the disc at 3100 rpm—ideal speeds for rapid stock removal and smoothing without scorching. A 6 x 9-in. die-cast aluminum table tilts from 0° down to 45° and can be used with the disc or belt. The table also has a miter gauge slot that's handy for beveling, mitering and chamfering operations. In combination with the tilting feature, compound angles can be shaped and smoothed. The sanding belt can be positioned either vertically or horizontally, and dust-collection capability is provided by means of vacuum hose connection ports on the belt and disc covers.

I tested the sander on small pieces, long stock, miters and curved cuts, and obtained fine results. The belt sander has a stop at one end to help keep your work in place. To sand longer pieces, remove the stop and back cover so your work passes over the belt without being obstructed.

While convex shapes can be sanded on either the belt or disc sander, concave shapes are handled by removing the belt sander cover and using the

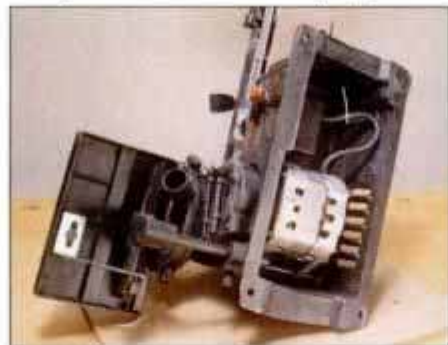


The Skil model 3370 Sander has a 4-in. belt and 6-in. disc. It features a tilting table that can be used with the belt or disc, and the belt can be positioned horizontally or vertically.

portion of the belt above the roller. Replacing the belt is accomplished by releasing the tension with the belt tension lever, and tracking is adjusted with a belt tracking knob. To prevent accidental startups, the sander has a double-action switch that must be pulled down and then out in order to start the motor.

If you're interested in buying a ver-

satile, stationary sanding machine without paying a lot of money, the Skil model 3370 Combination Belt/Disc Sander is worth consideration. It retails for about \$170, and comes complete with necessary wrenches, miter gauge and 120-grit disc and belt. For more information, write to Skil Corp., 4300 W. Peterson Ave., Chicago, IL 60646. **PM**



The heavy, cast-iron base contributes to stability and vibration-free performance. A 1/2-hp induction motor supplies power.



Dust collection is facilitated by vacuum hose ports—one at the belt cover and the other at the disc cover under the table.



The belt sander has a stop at one end to hold small pieces in place. For longer work, stop and belt end cover must be removed.



Miter gauge and tilting die-cast aluminum table enable accurate sanding of bevels, miters, compound miters and chamfers.



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Richard Petty #3

—Richard Petty

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APPLIANCE CLINIC

BY STEVE TOTH,
 Contributing Editor

Lack Of Use Killed It

We rarely use our GE dishwasher, model No. GSD400W-01AD (once every six to eight months). Recently, we decided to run it in order to keep the seals from drying out because the water that normally stands in the bottom of the tub had evaporated. The dishwasher filled with water and the heating element worked, but the motor would not run—it would just hum.

WILLIAM KELCHNER
 WARRENTON, VA

The water probably evaporated because the dishwasher was not used for a long period of time. The minerals that are left after the water evaporates, combined with detergent residue, grow into a very hard crust on the faces of the seals inside the pump assembly. The crust is sometimes referred to as scale.

This crust causes the seals to stick together, and this prevents the motor from turning. The dishwasher will fill with water, but it can't go into the wash cycle because the motor is stuck. Instead, the motor heats up and clicks off when overloaded.

To correct this, remove the standing water at the bottom of the tub using a turkey baster. Then, dissolve 2 ounces of citric-acid crystals (which are available from drug stores, hardware stores or a GE parts center) in 2 cups of hot water.

Pour the mixture over the sump cover. Let the solution soak in for about 20 to 30 minutes. It should be able to dissolve the crust in that amount of time.

When the time is up, latch the door, and start the machine through a cycle. It should run. If the motor doesn't start, you will have to turn over the motor by hand. Disconnect the power to the dishwasher, and remove the lower access panel by backing out the two Phillips-head screws at each lower corner.

Use a flashlight and look under the machine for the motor. The right side of the motor is bullet shaped. The left side of the motor, next to the pump assembly, has some air holes through which you can grip its L-shaped fan blades and turn over the motor. Grip these blades with your fingers and "walk" them around. Turn one blade down, then grab the next and turn it down. Keep turning until you feel the fan blade snap free.

Now, reinstall the access panel and reconnect the power to the dishwasher. Fill the detergent cup with citric-acid crystals as you would with detergent, but don't put any dishes in the machine. Now, run the appliance through a wash cycle. The citric-acid crystals will dissolve the remaining scale on the seals.

To prevent this from happening again, you might try running the machine with the citric acid after long periods of disuse.

Side By Side

How do I clean the mildew off the door gaskets on my side-by-side refrigerator/freezer? I have tried several cleaners and none of them have worked. I

believe I caused this by leaving on the energy-saver switch, even during the summer. PEARL L. SCHAEFFER
 SANTA MONICA, CA

Remove the mildew with a solution of household bleach and water by dipping a rag or an old soft toothbrush into the solution and running it over the discolored gasket. Wear rubber gloves when you apply it, and don't get any on your clothes. But first, unplug the refrigerator and remove the food to prevent the smell from getting into the food.

The energy-saver switch controls the heater that runs around the door opening of the appliance's metal cabinet. It keeps moisture from condensing on the outside of the refrigerator. When the switch is on, the heater is deactivated, so the appliance does not use as much electricity.

Keep the switch off during humid weather, usually in the summer. If humidity is a problem elsewhere in your home, you might consider installing a dehumidifier.

During the winter months, turn the switch on. Humidity is generally lower in most areas of the country during the winter, and it's less likely that mildew will form during periods of low humidity.

Brushed Off

I have an old floor waxer that is in good condition but has no brushes or pads. It is a Clarke Floor Maintainer, model No. P-11, serial No. 8530. I can't get parts locally. Can you help?

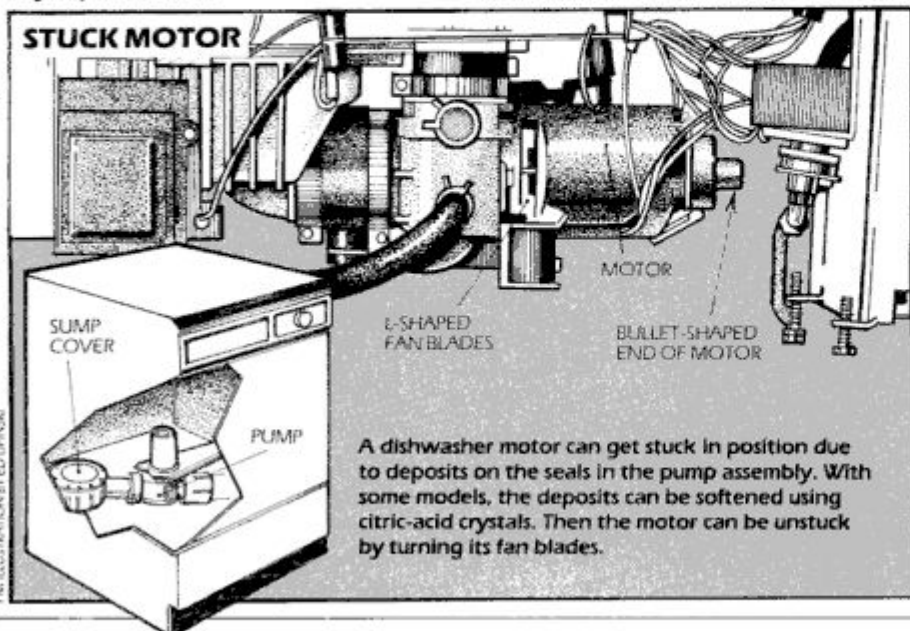
JOHN MAHONEY
 STAMFORD, CT

I contacted Clarke Industries in Springdale, Arkansas, using the company's toll-free number: (800) 356-7274. I learned that it stopped making your model floor waxer in 1958. Clarke still stocks some parts for your waxer, but not the brushes.

Contact Malish Brush & Specialty Co., 4260 Hamann Parkway, Wiloughby, OH 44094. Malish should be able to refer you to a janitorial supply company that has a brush or pad to fit your machine.

According to the customer service department at Malish, this is a brush with a 9-in.-dia. block, to fit an 11-in. Clarke machine. **FM**

DO YOU HAVE AN APPLIANCE PROBLEM?
Just ask Steve about it. Send your question, along with the model and serial numbers, to Appliance Clinic, Popular Mechanics, 224 West 57th St., New York, NY 10019. While letters cannot be answered individually, problems of general interest will be discussed in the column.



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HOME
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BY GENE & KATIE HAMILTON
PM Illustrations by
George Retseck

● Old, worn-out double-hung windows are the largest source of drafts and energy loss in many older houses. Replacing even a modest double-hung window may cost as much as \$250, but it can be renovated for a fraction of the cost using a jamb liner kit, which typically costs about \$50.

Years of opening and closing, the settling of the house and the effects of the weather take their toll on a window. Wood sashes are durable, but the jambs they ride in wear out. The sash becomes loose in the jamb, and large gaps develop at the center meeting rail, allowing air to leak between the jamb and the sash and between the inner and outer sash.

Although the damage done to the window may have been years in the making, the renovation takes only a couple of hours per window.

Jamb liner kits made of vinyl or a combination of aluminum and stainless steel provide fully weatherstripped channels for old sashes to ride in. These replacement jambs, teamed with a high-quality exterior storm window, give the window a heat-loss efficiency equal to many double-glazed replacement windows.

The new replacement jambs have weatherstripped tracks that fit old window sashes snugly. Friction holds the windows open, eliminating the need for sash weights. This makes it possible for you to insulate the sash-weight compartments, and stop another source of air infiltration.

Measuring

The jamb liner must be at least as long as the existing window jamb is high. The manufacturer of your jamb liner may have specific instructions about measuring for the liner. For instance, one manufacturer asks that you measure the glass area of your window and then consult a chart to determine the correct size of the liner to purchase.

If you have a nonstandard site-built



window or one with different-size sashes, measure the distance inside the window channel between the bottom of the sash (not the window sill) and the top of the sash. Purchase a jamb liner kit that is at least as long, or longer than, this measurement.

Preparing the jamb

Remove the inside stop, inside sash and parting stop, in that order. You will reinstall the inside stop, so remove it carefully.

Use a stiff putty knife or small pry bar to remove the inner stop (Fig. 1).

Push the blade between the stop and jamb, and gently pry up. If the stop is covered with many coats of paint, try to drive a putty knife between the stop and window jamb from the window track side of the stop. Be careful—if the sash-weight cords are broken or the window is very worn, the sash can fall out of the jamb when you remove one of the stops.

The outer sash is held in place by the parting stop in the center of the window jamb. This piece of molding is usually set into a groove cut in the sash. If the outside window sash is not



1 Remove the inside sash by prying off the inside window stop. To prevent breaking the stop, pry where it is nailed.



2 The parting stop holds the outside sash in place. Remove it by prying it out of the slot in the jamb or chisel it flush.



3 If the sash cords are still in place, cut them off with a utility knife and let the sash weight pull them through.



4 Back out the screw or nail at the top of the sash-weight door, then remove the door. Take out the sash weights.



5 Remove the screws that hold the sash-weight pulleys, and pry the pulleys from the jamb using a screwdriver.



6 Stuff fiberglass insulation into the jamb weight cavity. Tear the insulation into pieces, and use a pushstick.

painted shut, you may be able to remove it by prying it out of the groove (Fig. 2). Don't worry about breaking this molding—it gets discarded.

You can also chisel the parting stop flush with the jams. You don't have to remove it from the slot, just carve off the protrusion so the outside sash can be removed. Remove one stop, and pull that side of the sash toward you to remove it. If the window won't budge,

it's probably because it's painted in place. In that case, you must break the bond between the paint and window from the outside.

When both sashes are out, cut the sash cords with a utility knife (Fig. 3). Then, lift out the access doors to the weight compartment located in the lower section of each side of the jamb (Fig. 4). Some are held in place with a screw, others with nails.

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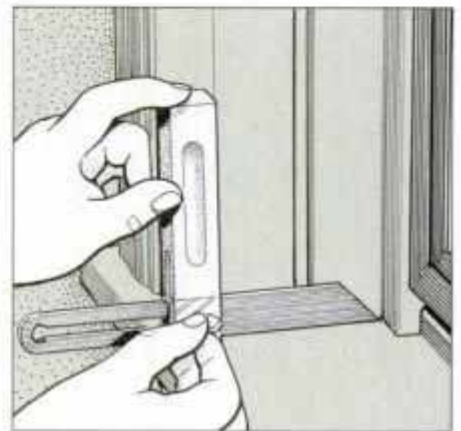


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7 Scrape and sand off paint globs, and remove embedded hardware that might interfere with the jamb liner.



8 On old windows, you may have to cut the jamb liner to fit the sill angle. Copy the sill angle with a sliding bevel gauge.



9 Use the bevel gauge to copy the sill angle on the back of the jamb liner. Be sure the angle slopes the right way.

Next, remove the screws holding the pulleys in place. Some pulleys are nailed down, in which case you will have to pry the pulley loose. Pry each pulley out of its mortise with a screwdriver (Fig. 5).

Remove the old weights and fill this cavity with insulation. The easiest way is to pull apart a piece of fiberglass insulation and push small pieces of it into the cavity with a small stick

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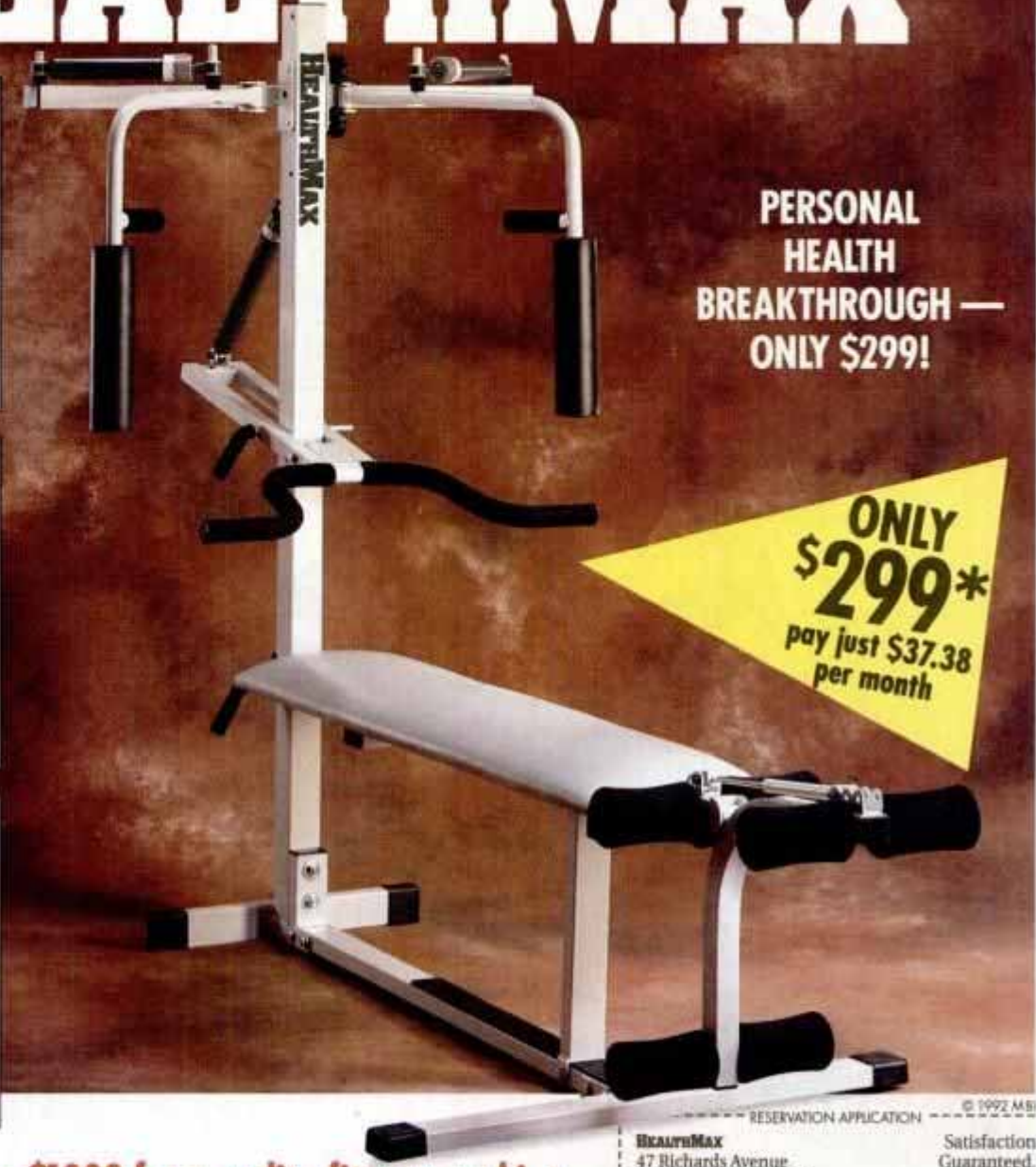
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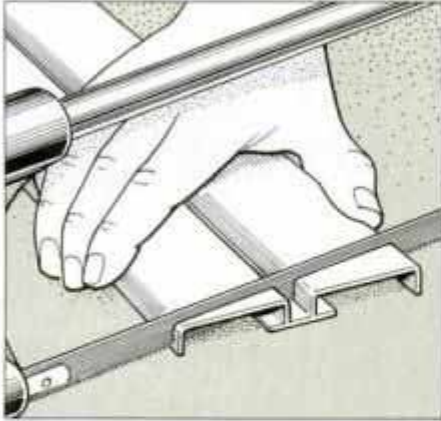
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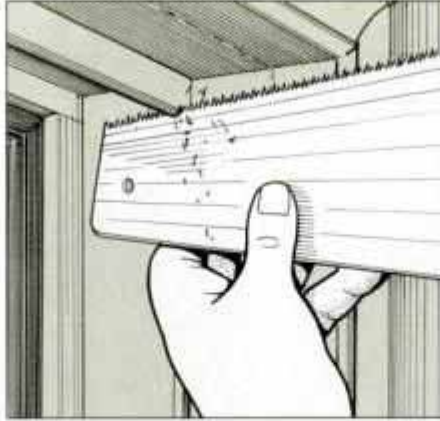
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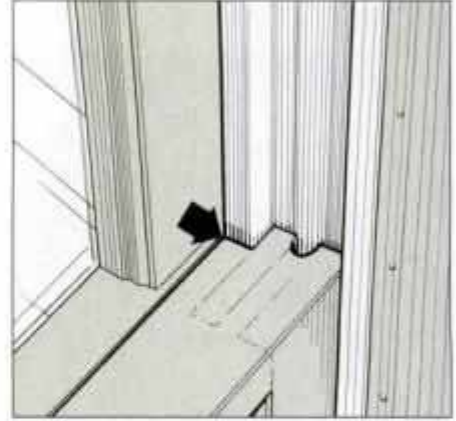
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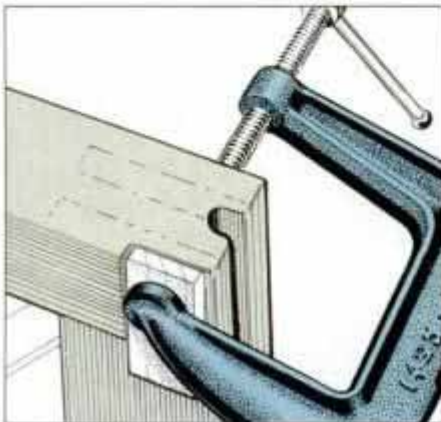
10 Cut the jamb liner to length with a hacksaw. Other fine-tooth saws, such as a backsaw or dovetail saw, also work.



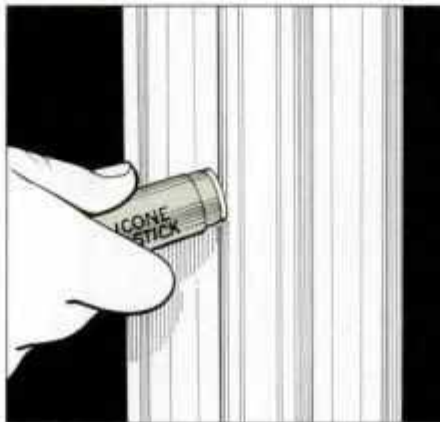
11 Cut the parting stop at the top of the jamb to accommodate the new parting stop in the jamb liners.



12 Old windows wear out where they rub against the parting stop. If there is a large gap at the arrow, repair the sash.



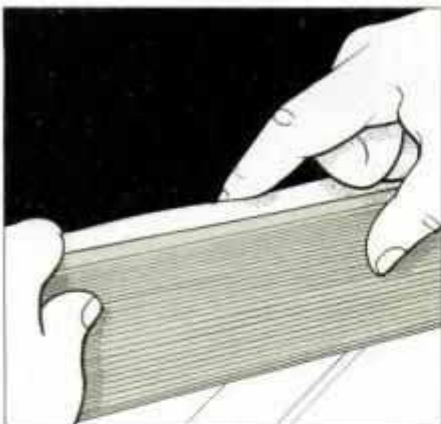
13 Glue a small piece of wood on the sash where it rubs against the parting stop. Shape the block to fit the stop.



14 Rub a stick of silicone lubricant (supplied with the jamb kit) on the jamb liners so the sash slides easily.



15 Place the inside and outside sash in the jamb liners. Set the assembly on the window sill and push it in place.



16 Apply vinyl V-strip weatherstripping to the top edge of the outside sash. The point of the V faces inside.

(Fig. 6). Pack the insulation in tight. Your goal is to stop air infiltration through the opening. When the weight pockets are full, reinstall the access doors.

The face of the jamb must be flat. Scrape away old paint and weatherstripping, and remove any embedded hardware that interferes with the new liners (Fig. 7).

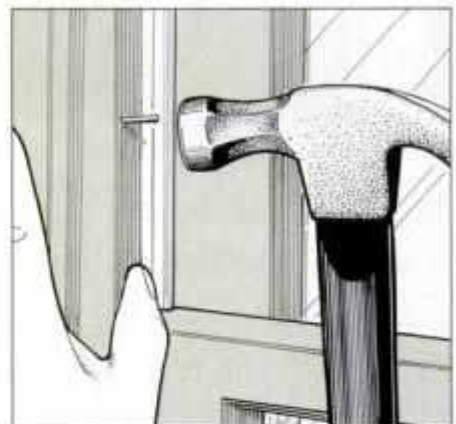
The liners are cut to fit the jamb.



17 Pull down the outer sash, and apply V-strip weatherstripping to the outer sash meeting rail. The weatherstripping must point up.

Their bottoms are cut at an angle to match the slope of the sill. The angle at the bottom makes the jamb liners fit either the right or left side, so be careful to cut off the square end of the jamb liner. Also, double-check that you are cutting the correct piece if the sides of your jamb are different lengths.

If the windows are very old, the angle of the sill may not match the pre-



18 Renail the inner stops snug—but not tight—against the inside window. Set the nailheads and putty the holes.

cut angle on the bottom of the jamb liners. In this case, copy the sill angle of your window and transfer it to the bottom of the jamb liner with a sliding bevel gauge. Cut the bottom of the liner to match the sill angle using a hacksaw (Figs. 8, 9 and 10).

The top parting stop must be notched at the jamb by about $\frac{1}{2}$ in. to clear the parting stop on the new jamb liner. Measure the exact height of the



19 A jamb liner with a spring-loaded channel on the left side of the window allows the window to be removed.

center parting stop and weatherstripping on the new liner. Then, measure from the jamb toward the center of the window and mark the stop. Cut through the stop with a handsaw (Fig. 11), and knock out the small piece with a hammer and chisel.

Put the two sides of the liner in place and check the fit. They should not be too tight. This is especially important for the vinyl jamb liner because it may bow away from the jamb and make the window difficult to operate. Don't secure the jamb liners yet. The sash must be inserted before the liners are permanently installed.

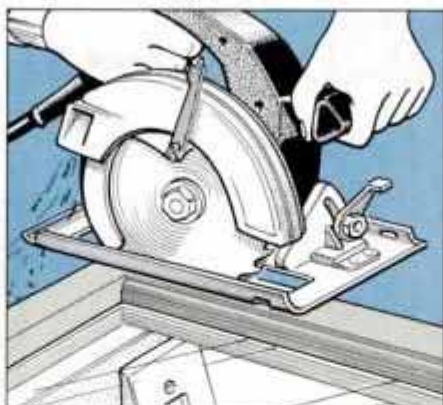
Preparing the sash

Remove the window weight cords from the sash if they have not fallen off. Some are nailed in place, others are held in place by a tight-fitting knot pushed into a slot.

Scrape off old paint from the sides of the sash, especially in the area that will be in the jamb liner track. Since the sash is out of the window and easy to work on, it's a good time to replace any broken glass, repair the putty and paint the sash if necessary.

Place the sash in the jamb liners and check the fit. If there is paint buildup on the sash, it will probably fit very tight. Sand the sides of the sash so they make a snug fit in the jamb liner, but they should not fit too tight.

Check the fit of the inside and outside sashes at their meeting rails. The sashes often wear at the point where each meeting rail rubs on the parting stop. The weatherstripping on the jamb liner may seal this gap. If a large gap exists because the jamb liner has a smaller parting stop than the one you removed, then you will need to correct this (Fig. 12). To fill the gap, glue a small block of wood to the sash in the area and shape it to fit the new parting stop (Fig. 13).



20 Use a circular saw to rip about 3/4 in. off the left side of the sash to accommodate the spring-loaded jamb liner.

Prime and paint all exposed wood before you reinstall the sash. If you are in a hurry, seal the bare wood with a fast-drying shellac or pigmented shellac primer.

Installing the jamb liners

To install the new liners, first lubricate the edges of the jamb weatherstripping with the silicone lubricant provided in the kit (Fig. 14). Next, place the windows in the jamb liners and check that the angled bottom of each liner faces down. Slide the windows together to the center of the jamb liner, then place the bottom of the liner into the old jamb (Fig. 15).

Raise up the jamb liners and windows so the pointed end of the liners are as far forward as possible in the old jamb and rest against the outer stop. When the liners are fully upright, temporarily secure the top of the jamb liners with a nail or screw—but don't drive the fastener home.

Slide the windows up and down, and check their fit in the jamb. They may be difficult to move at first, but the jambs will loosen after some use. If everything checks out, fasten the jamb liners to the old jambs with a nail or screw driven through the top of the jamb. The inside stop holds the jamb in place, so these fasteners are needed only until you install this stop.

Weatherstripping the sash

V-strip, self-adhering vinyl weatherstripping is the easiest to apply and does a good job of sealing the window. The spring brass version of this weatherstripping is more durable but harder to install. In either case, apply the weatherstripping to the upper edge of the outside sash with the point of the V facing in (Fig. 16).

Next, apply a strip to the back edge of the meeting rail of the outside sash (Fig. 17). Keep the point of the V-

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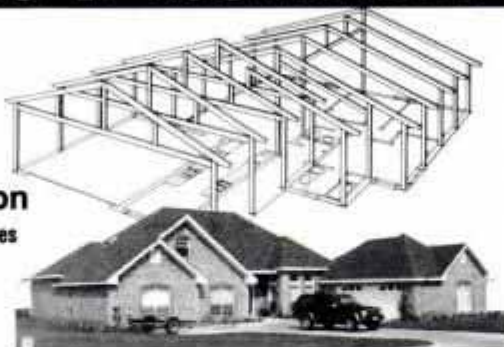
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HOME&SHOP JOURNAL



21 Push the sash against the left jamb liner to compress the springs, then push the window into the track on the right.

strip facing up. Then, apply weatherstripping to the bottom of the inner sash with the point of the V facing in.

Trimming out the window

Before you install the inner stop, run a light bead of a latex silicone caulk along the joint between the jamb liner and the old jamb. Also caulk the joints between the liner and jamb at the top and bottom. Caulk any gap between the parting stop on the liner and the top parting stop. Wipe up any excess caulk with a damp rag before it has a chance to set up.

Renail the inner stop. Use longer finish nails or reposition the nails so they will hold the stop firmly (Fig. 18). Check that the windows still move smoothly after renailing the stop. Set the nails, putty over the nail holes and paint the stop.

Installing jambs for take-out sash

Installing spring-loaded jamb liners allows the sashes to be removed for cleaning and repair. This job is only a little different than installing standard replacement jambs. These jamb liners are made from aluminum with a stainless-steel wear strip. They are not available in vinyl.

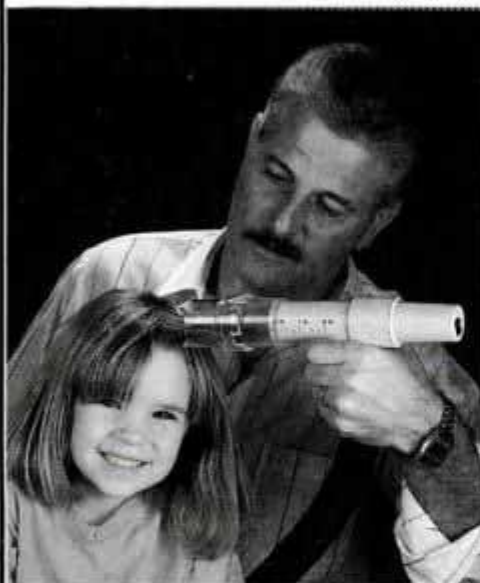
The spring-loaded channel is screwed or nailed to the left side of the existing jamb (Fig. 19). A jamb liner is snapped into place on top of this, and a standard jamb liner is installed on the right jamb.

Next, to accommodate the increased thickness of the spring-loaded channel, cut off about 3/4 in. from the left side of the sash (Fig. 20).

Push the sash against the left jamb liner to compress the springs, then push the window into the track on the opposite side of the jamb (Fig. 21). Spring tension keeps the sash in place.

PM

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CAR CARE

CAR CLINIC

BY MIKE ALLEN,
Associate Automotive Editor

The Guiding Light

I took the cylinder heads from my pickup truck down to a machine shop for a valve job last week. I just picked them up, and according to the repair order that they stuffed into one of the exhaust ports, they didn't replace the valve guides, as I expected they would have to. It says here that they knurled the old guides. Is this okay?

JOHN SHERMERHORN
NEWAGO, MI

Knurling a valve guide consists of running a tool that looks much like a tap through the valve guide. The teeth on the knurling tool don't really cut threads, though. Instead, they upset the soft metal of the guide as they thread through, and actually raise the metal near the knurled slot higher than the bore of the guide. Then the raised metal is reamed to the correct size, much as a new guide must be reamed.

The effect is to restore the inner dimension of the guide to fit a stock-size valve stem. And it works pretty well, especially if you're cost-conscious about the work. The real advantage is that the original valves can be reused if the wear is only in the guide and the head of the valve can be dressed properly to seal against the seat without being ground too thin.

The disadvantage is that the thin helix of upset metal of the guide isn't in 100% contact with the valve stem, and will wear out more rapidly. If you're just doing the heads on an engine, this may be an economical option. The bottom end of most big American V8s will usually last longer than the heads, and you can probably get it to last as long as this cheapie valve job, with original valves running in knurled guides.

But if I were doing the rest of the engine with new rings and bearings, I'd go a different way. I'd either press in new guides or find some valves with oversize stems and ream the old



guides to match. This will mean replacing all of the valves, and you may not feel it's necessary.

Hole In One

I'm having a problem with the oil pan leaking on my 1990 Acclaim after changing to a synthetic oil. A new drain plug gasket didn't help.

I remember reading that you had a similar problem on your long-term Dodge Dakota in the May issue, but you really didn't go into detail as to how this problem was corrected.

STEVE McCARNEY
NO ADDRESS GIVEN

The Dakota had a 318 V8, and didn't use synthetic oil. I simply found that someone at the engine plant or dealership had never fully tightened the drain plug—I could spin it with my fingers. It never leaked fast enough to be more than an annoyance, and was discovered and corrected when we made the first oil change.

Your problem is unrelated. You probably don't have a leaky drain plug if tightening it or replacing it didn't help. More than likely, there is another leak somewhere above the drain plug that's leaking down the side of the block and dripping off the

plug. It's probably the pan gasket or oil filter—I've found that a valve cover leak would be more likely to drip from the front or rear of the engine (or in your case, left or right). In this case the oil runs into, and then along, the raised part of the block at the pan rail and mimics a leaky front or rear seal.

Is this from using synthetic oil? Lubrication engineers tell me no. Synthetic oil used to be a lot thinner than conventional dinosaur oil. That's no longer really true—car manufacturers are now recommending 5W-30 oil. So there should be no reason for the thinner synthetic to leak more rapidly through an existing hole than mineral oil. These same lubrication engineers tell me that the seal-swell characteristics of a synthetic are similar to mineral oil. This means that rubber parts, which normally swell up slightly when immersed in hot engine oil, don't change in dimension when bathed in synthetic oil instead.

However, I've found that some engines, dry ones, turn into real leakers when changed to synthetics. Any engine that leaks even a little seems to leak a little more. I have no explanation for this, except to assume those engineers are wrong.

This brings up the entire topic of synthetic oils and why you might need to use them. Synthetics, potentially at least, are superior products to mineral oils. But at \$4 to \$5 per quart, the temptation is strong not to change them as often. No matter how good the oil is, it still picks up airborne dirt, wear particles, carbon and blowby from the combustion chamber and a witch's brew of hydrocarbons, acids and moisture. The only way to remove these contaminants is to drain the oil.

I don't recommend synthetics unless you have evidence that mineral oils aren't doing the job. Synthetics are better performers at extremes of heat. Towing a heavy trailer during the summer is one example—but if your oil temp is chronically too high you'll be better off in the long run if you install a good gauge and an oil cooler to keep engine temps in line.

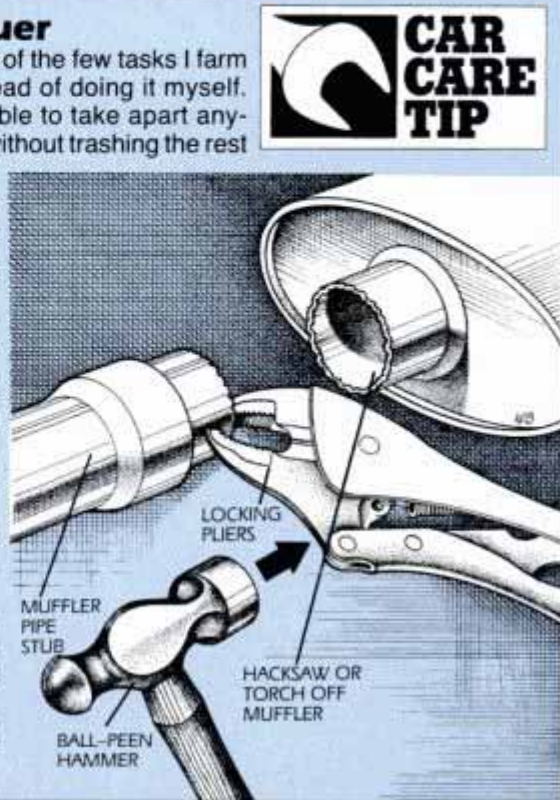
Cold weather is another story. If you routinely see weather of -10° F, then a synthetic will do two things for you. First, it improves cold-weather cranking, permitting your engine to start. Second, and more importantly, synthetics don't thicken as much, providing oil pressure and flow earlier during a cold-weather start.

Divide And Conquer

● I hate muffler work. It's one of the few tasks I farm out to other mechanics instead of doing it myself. Somehow, it seems impossible to take apart anything on the exhaust system without trashing the rest of the pipes.

Sometimes it's necessary for you to separate a salvageable portion of pipe from a corroded chunk. For instance, the pipe from the back of the catalytic converter is usually a corrosion-resistant or stainless steel. But it still manages to get permanently attached to its mate after a few years. And with the price of catalytic converters, it's imperative that you separate them without damaging the connections.

The secret is to sacrifice the part of the pipe that is corroded. Hacksaw or torch off this part. Then use locking pliers and a hammer to pull out the leftover pipe stub.



Should you change back to mineral oil to make the leak go away? No. I've also found that once an engine starts leaking on synthetics that changing back doesn't help—which would make no sense if there were really no difference in seal-swell. But the experts insist I'm wrong.

Turn, Turn, Turn

I would like to know what the rear end ratio is for my car. How can I find out?

HARLOW STARKSON
ROBBINSDALE, MN

The easiest way is to ask the dealer. He should be able to tell you what rear axles were available for your car. From the other equipment installed, he may be able to pin down exactly what gears were installed.

For vehicles too old for the dealer to have information about, or if there were several axle ratios available for your car, there are several foolproof methods. If you have a couple of friends who are willing to get dirty, here's one foolproof way:

Put the rear axle up on jackstands.

DO YOU HAVE A CAR PROBLEM?

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



Make a chalk mark on the sidewall of one rear tire. If the car has a manual transmission, put it in high gear and turn the engine over with a socket on the bolt on the front of the crankshaft.

SERVICE TIPS

● Some 1988 Pontiac Firebirds equipped with the 5.0-liter V8 and throttle-body fuel injection may suddenly starve for fuel. According to TSB 89-6-33, the problem may be caused by the in-tank fuel pump becoming disconnected from the fuel-sender assembly. Reattach the pump, and use an additional clamp and washer.

● Rattling or squeaking from the rear of a 1988 Honda Civic may be due to a loose or missing spring-silencer tube allowing the spring coils to rub against each other. To cure the problem, you must first remove and disassemble the spring-dampener assembly.

Remove any original silencer tubes and thoroughly clean the spring coils. Install new silencer tubes to the spring, using weatherstrip adhesive. TSB 88-030

● A clogged a/c evaporator drain tube may be dripping water into the passenger compartment of your 1989 Ford Probe. To stop the drip, TSB 89-16-7 recommends cutting 1 in. to 1 1/4 in. of the end of the drain tube ahead of the dash panel.

● If your 1988-'89 Chevy C/K truck has a clunk from the rear, check the rear shock absorber mounting nuts. One—or both—may have loosened and need to be re-tightened. TSB 89-104-3D recommends retorquing both to specifications.

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CAR CARE

Turn the crank until the rear wheel rotates exactly one turn. While you rotate the crank, have someone watch the driveshaft, counting the number of turns it rotates. The number of turns is the numerical axle ratio. If you have an automatic tranny, you'll have to unbolt the driveshaft from the axle and turn that over until the wheel rotates one turn.

Got a car with front-wheel drive? If it's a manual trans, no problem—turn over the engine with a wrench as described. Got a car with fwd and an automatic trans? Big problem. Turning over the engine won't turn the trans over because of the torque converter.

Try pulling all the plugs, painting a bright orange spot on the torque converter through any convenient access hole and rotating the rear wheels to turn over the engine while you count turns.

Fortunately, most cars with fwd have only a single rear-axle ratio available. See your dealer—if you can't find it in the owner's manual.

As an alternative, you could pull off the differential cover and count the teeth on the ring and pinion gears. Divide the number of teeth on the ring gear by the number of teeth on the pinion gear to get the ratio.

Black Is Beautiful

My car bumpers used to have black vinyl inserts. But someone waxed them, and now they have a gray appearance. I've used a vinyl dressing on them, but this only lasts a few days and then they are right back to the gray color. Any suggestions?

BILL CURTIS
ELIZABETH CITY, NC

Remove the last vestiges of wax with lacquer thinner and a clean rag. Be careful not to get any thinner on the painted surfaces, especially if the car has been repainted—it will remove the paint. It may take a few iterations to get all the wax.

Follow up with Armor-All, STP Son-of-a-Gun or a similar protectant. That should do the job if the discoloration is on the surface, as you say.

If the vinyl is bleached, use black vinyl-top wax, which is applied like paste shoe polish. Do not use black shoe polish, as it will melt on warm days and leave ugly black stripes on your knees. (Don't ask how I know about this.) As a last resort, your local auto parts store should have in stock flexible vinyl paint that comes in a spray can.

PM

MAINTENANCE BASICS

HOW TO USE A VACUUM GAUGE

BY DON CHAIKIN,
Contributing Editor

● As your engine's pistons go down during the intake stroke, they cause a drop in air pressure inside the intake manifold. That drop in pressure, or partial vacuum, draws in the air your engine needs to mix with fuel for combustion. In fact, the speed of a gasoline engine is controlled by regulating the flow of air into the engine. The accelerator pedal is attached to a throttle plate in the intake airstream. The more air, the more fuel to mix with it for more power and speed.

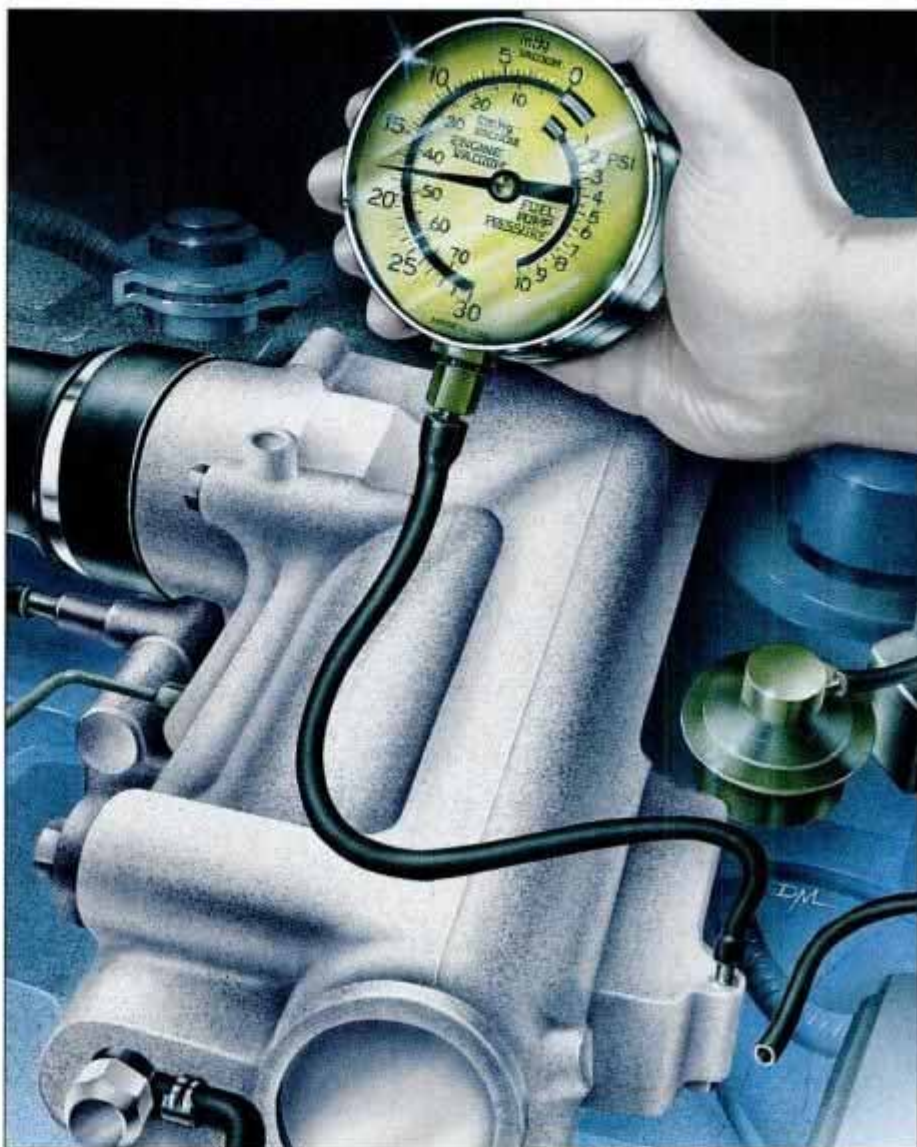
Thanks to the throttle plate, you can measure the partial vacuum created by a running gasoline engine. And that measurement is an accurate and handy indicator of the engine's condition. All you need is a vacuum gauge. Most automotive vacuum gauges are packaged with a length of vacuum hose and various adapters. The adapters allow you to connect the gauge to engine vacuum hoses of varying inside diameters.

Vacuum is measured as inches of mercury and the gauge is marked "in.-Hg." with the scale typically running from zero to 30. Many vacuum gauges also double as low-pressure testers, for checking mechanical fuel pumps, and have a second scale marked in psi. However, the pressure scale has no bearing on vacuum.

Here's a step-by-step guide for using a vacuum gauge:

- For an accurate reading, attach the gauge to a hose that is subject to the engine's full vacuum—one connected to the intake manifold between the throttle plate and the engine. Good choices are the hose to the distributor and power-brake booster. Bad choices are components that don't get vacuum all the time—such as various emissions controls.

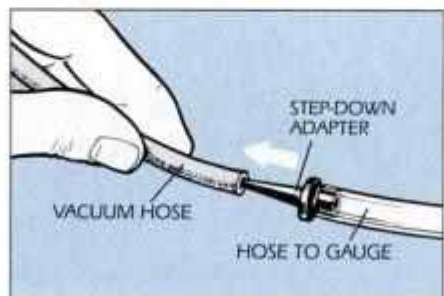
- To ensure that the engine is running properly with the gauge attached, splice the gauge connection into the vacuum source hose with a T-connection. If you must disconnect the vacuum source hose from a component to attach the gauge, disconnect it



from a component that is not related to engine performance, such as the power-brake booster. Remember to reconnect the hose when you're done.

- With the gauge attached and engine fully warmed and idling, whip open the throttle briefly and let it snap shut while watching the gauge. The needle should drop to about 5 to 7 in.-Hg. and then quickly rise to its reading.

A healthy engine reads about 16 to 22 in.-Hg. (check your car's service manual) at sea level. Deduct 1 to 2 in.-



An adapter allows the gauge's larger hose to connect securely to a smaller vacuum hose.

Hg. for every 1000 ft. of altitude. If the gauge reads steady but appreciably lower—about 5 to 7 in.-Hg.—look for a vacuum leak. Recheck the gauge connections. Then look at the intake manifold and other vacuum hoses.

A steady but low reading in the 10- to 14-in.-Hg. range indicates low compression—as from worn piston rings—or incorrect ignition timing.

- A reading that is steady but higher than about 22 in.-Hg. could indicate a blocked air intake. Remove the air cleaner element and retest.

- If the gauge needle swings back and forth wildly, between about 10 to 20 in.-Hg., there is probably a problem with the engine's valves.

A smooth fluctuation of the needle—in cadence with the engine's idling—points to a leaking head gasket and lost compression.

- If the vacuum drops to nearly zero and then climbs back to near normal after you whip the throttle, check for exhaust system restrictions.

HOW IT WORKS

TORQUE CONVERTER

BY DON CHAIKIN,
Contributing Editor

● The fact that a vehicle with an automatic transmission can sit at a stoplight with the transmission in gear and the engine running is as important to your driving ease as the automatic's ability to shift gears for you.

This relatively unnoticed but significant driving convenience is made possible by the fact that an automatic transmission, unlike a manual one, does not have a mechanical connection between it and the engine. Instead, an automatic transmission is mated to the engine by a fluid coupling. The device that makes this fluid connection work so well in a car is called the torque converter.

Total immersion

To easily understand the basics of a fluid coupling, simply picture two household electric fans facing each other, about an inch apart, one running and one not. The nonworking fan soon starts spinning, driven by the breeze of the other. Instead of using air, however, a torque converter uses hydraulic fluid, which you know as automatic transmission fluid (ATF) to get one fan to drive the other.

The torque converter is in the transmission's bellhousing between the engine and the transmission. The converter unit itself resembles a big steel doughnut. Inside its sealed housing are three basic components—the impeller, turbine and stator, all bathed in hydraulic fluid.

The impeller and turbine look much like halves of a grapefruit, with the fruit scooped out but the dividing membranes left in place. However, instead of membranes, the impeller

and turbine are partitioned by metal blades, or vanes. However, the vanes themselves are scalloped near the impeller and turbine centers to create room necessary for the stator—which loosely resembles a fan—to fit between them.

The impeller is solidly attached to the engine—when the engine runs, the impeller spins at the same speed. The turbine is attached to the transmission shaft—when the turbine spins, the transmission shaft does too. The stator rides on a one-way clutch on the transmission's shaft. The only thing that connects each of these

components to the other is the transmission fluid.

An impelling case

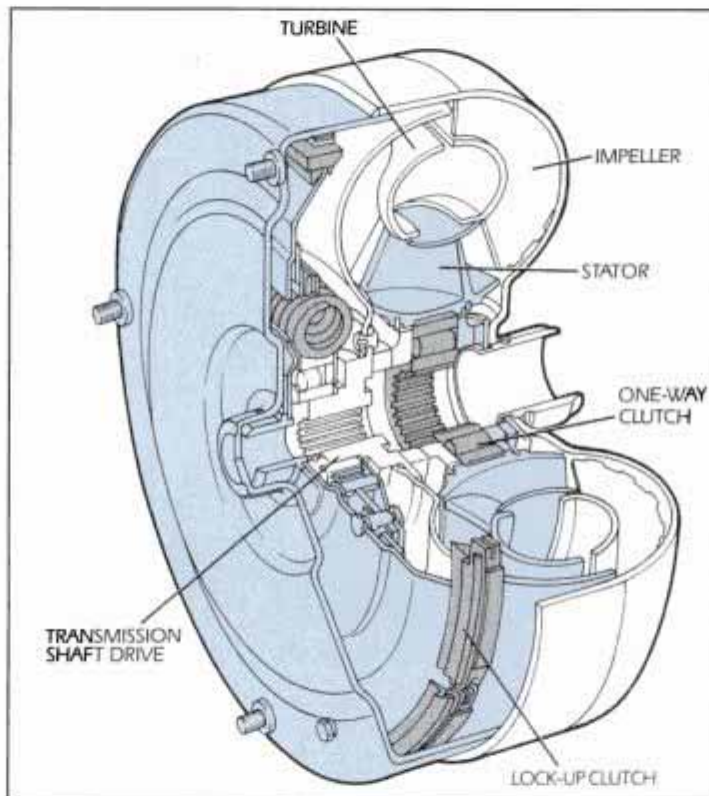
As the impeller spins along with the running engine, the impeller's vanes throw fluid at the turbine. However, at slower engine speeds, idle and slightly above, the fluid is not thrown with enough force to get the turbine to move—especially if the car's brakes are applied. This is called slippage and it allows the vehicle to sit in gear with the engine running.

However, as engine speed increases, so does the force behind the thrown fluid. Soon the fluid is hitting the turbine blades with enough force to start the turbine spinning along with the impeller, causing the vehicle to move.

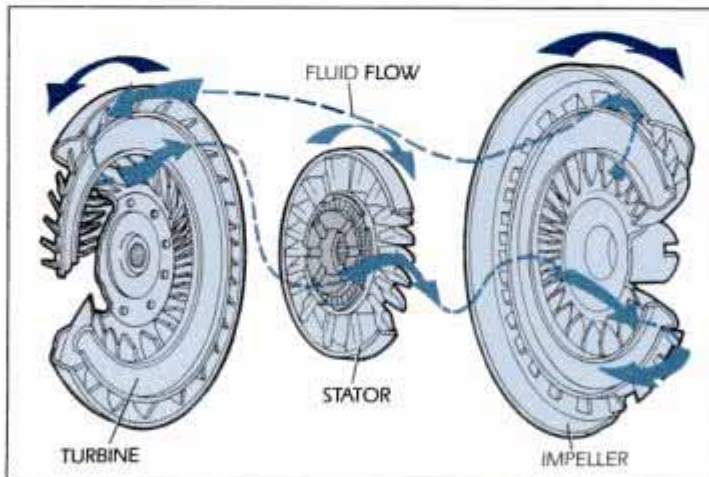
However, after the fluid is thrown at the turbine blades, it bounces back toward the impeller. If this fluid were to come right back at the impeller—trying to drive the impeller in the opposite direction it is spinning—efficiency would be greatly decreased. Instead, the fluid that's flung by the turbine blades is thrown at the stator. The blades of the stator are shaped so they redirect the fluid at the impeller in the same direction that the impeller is moving and already throwing fluid. The stator improves performance and increases the force of the fluid inside the torque converter.

As speeds increase, however, the centrifugal force inside the converter housing gets the fluid swirling, so the blades are no longer throwing it back and forth. When this happens, the stator freewheels inside the housing, thanks to its one-way clutch.

However, at peak efficiency, a fluid coupling still exhibits some slippage—operating, perhaps at only 98% of capacity—which hinders highway fuel economy. For maximum efficiency, many torque converters are equipped with a mechanical clutch, which locks the turbine and impeller above certain speeds. **PM**



Most modern torque converters have a lock-up clutch which solidly couples the impeller and turbine for highway fuel efficiency.



The stator increases torque at lower speeds by changing the direction of the fluid flow from the turbine blades back at the impeller.

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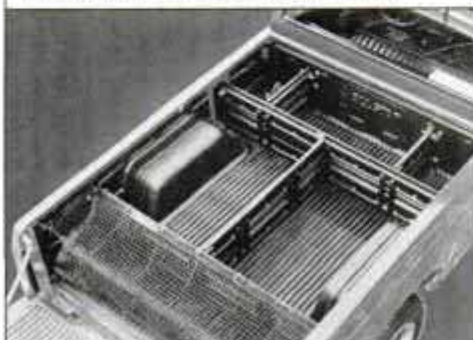
Hanger Extender

There are times when your car's coat hook just does not have enough capacity to hold as much as you would like. This simple, snap-together plastic hook, Hangthing, increases that capacity. Hangthing sits on the car's coat hook and cantilevers a short plastic arm perpendicular to its base. The weight of the clothing on the arm—the manufacturer claims it can hold up to 20 garments—secures the gadget into the car's coat hook. Cost is under \$3, from Ultimate Concepts, Inc., 16666 Northchase Dr., Suite 300, Houston, TX 77060; (713) 873-6338.



Cargo Bed Divider

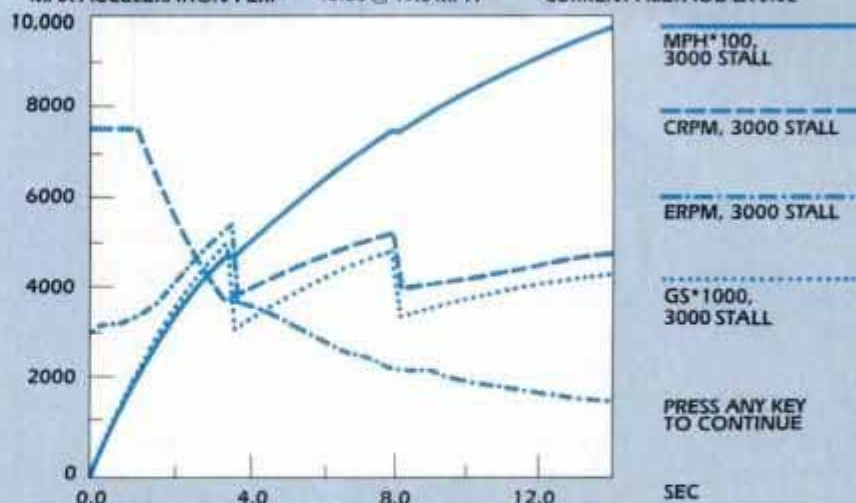
Unless you do something to restrain them, smaller packages—like sacks of groceries—roll and bounce all over your pickup or van's open cargo bed as you drive. An interesting way to utilize that cargo space is with the Martector bed divider system. Various length plastic panels attach to each other—without the need to drill holes in your truck—to form various size and shape bins. In addition, a bed-width plastic basket can be attached to the panels. Prices run from \$129.95 to \$399.95, depending on the sophistication of the system. Available from NMS/Martek, P.O. Box 585, Plymouth, MI 48170; (313) 454-2505.



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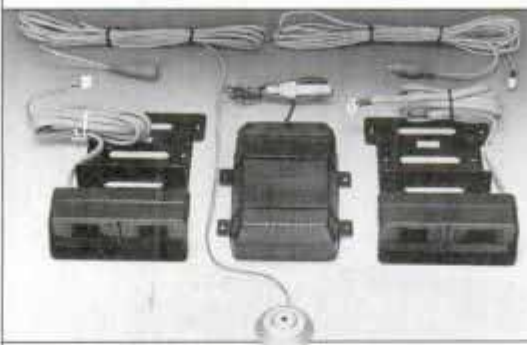
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gine Analyzer program for IBM, Apple II and Commodore 64 computers can help. This program predicts torque, horsepower, fuel flow and volumetric efficiency based on bore, stroke, valve size, cam timing and other factors. The Performance Analyzer costs \$119.95, and the Engine Analyzer, \$99.95. From Performance Trends, Inc., P.O. Box 573, Dearborn Heights, MI 48127; (313) 473-9230.

Ultrasonic Rear View

Short of having a spotter guide you, backing up in any size vehicle—from a subcompact to an RV—can be an anx-

ious operation. However, an electronic proximity sensor with a dash-mounted alarm, like this Hindsight 20/20, can ease the anxiety. The unit

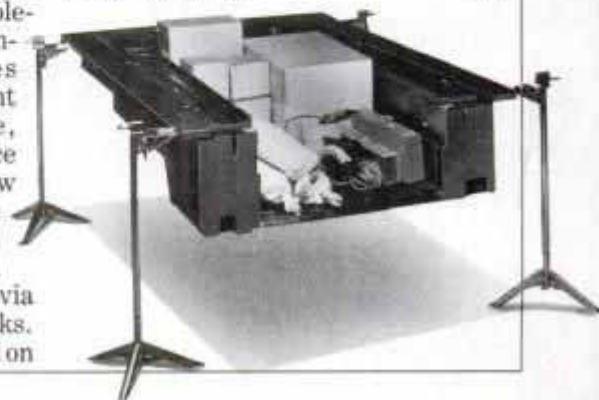


consists of an ultrasonic sensor—two sensors for wider vehicles—which spreads a 4-ft.-deep ultrasonic wave field. When any object breaks the field, the alarm sounds. The alarm changes pitch and intensity when the object is within 1.65 ft. Price is \$149.95, plus shipping, from EBI, Inc., 12411 McCann Dr., Santa Fe Springs, CA 90670; (310) 941-7696.

Slide-In Bed Liner

An innovative twist on the pickup bed liner is this lightweight plastic slide-in liner which has several cargo bins molded into it. The one-piece, double-walled Load Liner from Pawnee Industries has long storage boxes along both siderails, two watertight lockable bins at the front edge, which offer 13 cu. ft. of storage space and many grooves and lips to allow you to further compartmentalize the space. The unit slides into the bed of any full-size pickup and can be removed—even when loaded—via its special tripod-mount crank jacks. A camper shell can also be mounted on

top of the liner. Price is \$799. From Pawnee Industries, 5370 W. Hwy. 12, P.O. Box 147, Maple Plain, MN 55359; (612) 479-3160. **PM**



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DETROIT SPY REPORT

BY JIM DUNNE, Detroit Editor



Who Is That Masked Mustang?

● When Ford's new Mustang hits the showrooms as a 1994 model it will really have to stretch its legs to make up the ground lost to the new Camaro, which will enjoy a 6-month sales advantage (see "The Next Camaro," page 88, July '92). The rebodied pony-car, shown here dressed up for our cameras in prototype "Lone Ranger" disguise (front bra, rear diaper, tape stripes) will maintain its gallop with mostly carryover mechanicals—5.0-liter V8 engine, rear-wheel drive and solid rear axle.

The Mustang stable will continue to consist of two body styles—coupe and convertible. Unlike the current practice of farming out convertible conversions to an outside vendor, Ford will build the softtop in its own assembly plant.

Dual Ranger Pickup

The 1993 Ranger pickup will come in two nameplate versions—one labeled Ford and the other Mazda. The plan is similar to the Explorer/Navajo agreement between the two companies. Mazda will drop the B2000 imported



Next-generation Ford Ranger will also wear Mazda badges.

pickup and depend on Ford to supply its light truck needs. Like the Explorer/Navajo twins, exterior styling will be almost identical, with just the grille texture and badging separating the two lines.

That's The Way The Buick Benz

Note the German (Mercedes) influence in this view of a 1993 Buick Regal. The new front-end styling shows a boxed air intake that appears to be connected to the hood, so that both the hood and grille lift together as a single unit. Benefits here include better-fitting front-end pieces and more underhood workspace. This also contributes to Regal's smoother, simpler overall appearance.

Strut Away

Look for strut front suspensions to disappear from many mid- and full-size cars within five years. In their place will be old-fashioned upper and lower control arms. Automakers will change for two reasons: better ride control and lower cowl heights. The new suspensions will improve ride and steering control with their wide-open design,



as compared with the restricted layout of struts. And cowl heights will be lowered—for improved driver vision, sleeker styling, and improved aerodynamics—when the strut towers are removed.

No Noise Is Good Noise

Electronic mufflers that use a bread-box size container with loudspeakers that produce sounds to cancel out exhaust noise (see New Products, page 74, March '92) will start showing up on 1995 model cars. The system won't be cheap and will first be installed on luxury cars.

One system, currently under development by exhaust specialists at Arvin Industries, uses an electronic muffler in conjunction with a glass-



Front end of Buick's popular Regal for 1993 shows suggestion of Mercedes-Benz influence in one-piece hood and grille treatment.

pack muffler. The combination cuts down on power-choking backpressure, with a claimed benefit of 6% in power output.

Cost considerations aside, we can say the idea definitely works. At an Arvin research garage, I saw and heard low-frequency noise waves from a Taurus engine offset—and canceled—by frequency noise waves broadcast from the speakers.

Overseas Olds

Note the black space in the center of the bumper on the slightly revised front end of this Oldsmobile Silhouette. That space is for a European-style license plate. Does this mean GM is planning to export their plastic-bodied minivan to Europe? We think



Revised front end suggests possibility of European export for Olds Silhouette minivan.

so, especially since all of General Motors' APVs—including TransSport and Lumina—are selling below expectations in the United States. An added market like Europe would boost production and make the APV line more profitable.

Toronado Lives

Toronado fans needn't despair about Oldsmobile's announcement earlier this year that they would be dropping the Toro (and Custom Cruiser) from its lineup at the end of the 1992 model year. What Olds will bring into the lineup, in late 1993 as a '94 model, is a luxury sports 4-door model (no coupe plans at this time) in the mold of the original Toronados.

While the nameplate won't say Toronado, the car will boast a high-output V8 engine, probably a detuned version of Cadillac's 4.6-liter dohc Northstar V8. The front-wheel-drive system will also be shared with the Cadillac sedans. Styling will be unique with uncovered headlights, and the roofline will be similar in profile to Ford's Crown Victoria.

Easy Riders

Sport/utility vehicles will soon be getting the same kind of sophisticated ride-control suspension benefits now offered to luxury sports sedan owners. Ride control can provide extra advantages in sport/utility vehicles. Instead of giving a medium-firm ride for all conditions, the control system can create a cushy, sedan-like ride for most driving, then switch to an extra-firm ride at high speeds, in turns or when traveling on rough road surfaces. Ride-control systems of the future will be more elaborate than those in use now. They include a computer, four gas springs and a number of sensors. Look for this technology to make its initial appearance in 1994 sport/utes as an extra cost option.

Bullish On Taurus

Ford's Taurus is hardly a year old in its present styling, and already Ford stylists have come up with a totally

new look for the next revision of the bread-and-butter midsize sedan, due as a 1995 model. Pillars will be narrower, and fenders, hood and deck will show even softer curves. Up front, hoods will drop sharply above a thin band of driving lights. Overall, the styling will be more like that of upscale Japanese models—the Mazda 929, the latest Lexus cars and the Infiniti J30.

Bag Blowup

In a recent demonstration, I had a Ford airbag blow up in my face. It all happened in a quick (2.5 milliseconds) sequence of events. A noise like a shotgun shell exploded in my ears, the bag inflated to the size of a bed pillow, and I was left with a limp piece of smoking nylon in my lap. For another 15 seconds or so, the smoke continued to rise from vent holes in the bag. This smoke results from the heat of the inflation propellant burning the talcum powder in the bag. Talcum keeps the folded nylon bag from sticking together. Right after the demonstration, I noticed deafness in my left ear, which cleared up in 15 minutes.

Ford reports that its vehicles have



Asked for comment after airbag demo, Detroit Editor Dunne says, "What?"

had 23,000 face-protecting airbag deployments. By 1999, the company plans to install airbags as standard equipment on all of its cars, vans and light trucks.

Crowd Control

Think it's crowded under the hood now? Wait, it's going to get worse on future models. The newest piece of hardware automakers are planning to shoehorn into the shrinking engine bay is an exhaust preheater, placed adjacent to the exhaust manifold, just ahead of the catalytic converter.

The preheater warms up the exhaust in cold engines quickly, so that catalysts can do their jobs earlier for improved emissions. Cold-start exhaust is the last gap left in gasoline engine emissions. An electrical heater warms up the preheaters for 5 seconds or so before the cold engine is started.

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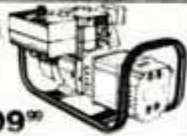
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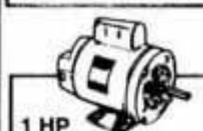
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OCEAN OUTBOARDS

BY JOE SKORUPA, Boating/Outdoors Editor

● With two-thirds of the Earth's surface covered with water and just a tiny fraction of it fresh, it would seem to make sense for builders to design outboards specifically for brine. Unfortunately, it's cheaper and easier to build for the less hostile freshwater environment, and most builders take the easy way out. However, about 18 months ago, OMC decided to tackle the rough stuff. It assigned a design team the task of creating new 200-hp and 225-hp saltwater outboards. The result is the birth of a new outboard class—a V6 Ocean series—called the Johnson OceanRunner and Evinrude OceanPro. These engines were unveiled recently at a site near OMC's test center, in Stuart, Florida, where I was impressed by the achievement, and found further evidence that the Waukegan, Illinois-based company is on a technological roll.

The new 200-hp and 225-hp OceanPro/OceanRunner engines bristle with advanced technology. But equally interesting is the fact that they signal an end to plain-vanilla OMC outboards in this horsepower range. It's either the Johnson GT/Evinrude XP 20-in. shaft freshwater engine or the new 25-in. and 30-in. saltwater OceanPro/OceanRunner.

Are plain-vanilla V6 engines dead at OMC? Quite possibly. For 1993, OMC will shuffle the 150-hp and 175-hp classes, too. Here the choices will be either the high-tech Johnson SilverStar/Evinrude Spitfire, the



bass-specific SilverStar FastStrike/Spitfire Intruder, or the Ocean series in 25-in. shaft lengths.

To me, OMC's new thrust makes a lot of marketing sense. The vast majority of boaters looking for big V6 outboards fall into two categories: 1. Serious fishermen and 2. The slick and quick. But several years ago OMC made a decision to stop courting the smoke-on-the-water crowd. Since this trimmed the size of their potential market, it became necessary for OMC to strengthen its focus on the group that was left. So, fishing's in, plain-vanilla's out.

Salt shakers

An offshore fisherman wants three things in a big outboard: 1. Ability to handle harsh environments, 2. Reliability and 3. Solid performance. To tackle these, the Ocean-series engineering team applied advanced technology and sound principles.

The first thing you notice about the Ocean-series outboard is its smooth, aerodynamic cowling and powerhead. Careful sculpting here represents more than a simple rejection of the squarish, macho contours of the horsepower-wars era. The new de-

sign serves a purpose: It's fishing friendly with no protrusions or snag points. Sleek, clean engine lines mean safe, unsnapped monofilament lines.

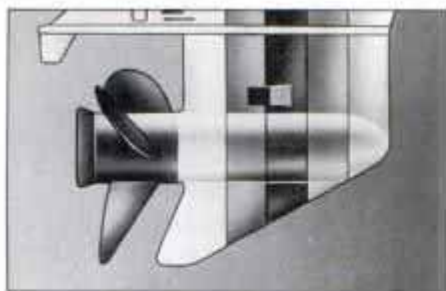
Beneath the cowling, a great deal of effort has gone into maximizing corrosion resistance. Some of this effort is visible, but most isn't. A good example is found in the coating schedule for the drive-leg's midsection and gearcase. Here, a unique electro-deposition (ED) paint process is used to uniformly apply a critical coating to all internal passageways and structures.

The ED process is appropriately named, because the parts are zapped by a charge of electricity during the painting process. Paint is suspended in a water bath, parts are dipped in and a charge of electricity is added, which attracts the paint in an even layer. The beauty of the ED process is that even the most difficult-to-reach crannies receive their fair share of corrosion protection.

Another interesting process, used on the exterior of the gearcase housings, involves an automated sanding/grinding process that turns hard edges into smoothly rounded corners. OMC engineers found that paint adheres so poorly to sharp corners that



Two finger-size ports fine-tune induction on OMC's new Ocean-series outboards.



Gearcase coating includes electro-deposition paint, plus primate, primer and topcoat.

protective coatings applied here are often microscopically thin. The sanding/grinding process smooths out the edges and solves the problem.

Another step taken by the engineers is the addition of more corrosion-resistant stainless-steel components, including the propshaft, the thermostat, all exposed bolts on the powerhead, and the critical steering arm and pivot shaft.

To further deal with the harsh saltwater environment, the engineers also: coated all internal exhaust housing parts with a high-temperature paint, modified the split line between the exhaust housing and gearcase to reduce chafing along adjoining surfaces, added two positive-locking clamps to the cowling to form a watertight seal and added two full-length ducts inside the cowling to direct water coming through the air inlets down to the lower pan and away from vulnerable components.

One of my favorite saltwater-specific components on Ocean-series outboards is the built-in flushing system, which is becoming an OMC trademark. This component, which should be mandatory on all saltwater engines, features a threaded adapter that attaches to a garden hose. Turn on the tap and the flushing system purges the water jacket of saltwater, either with the engine on or off. OMC debuted this system on the Johnson SilverStar/Evinrude Spitfire engines, and continues using it on the Ocean series. This idea's time has come.

More power to ya

It took OMC a little longer than planned to bring out finger-ported cylinders, first talked about a couple of years ago, but they're finally here. In addition to the standard transfer ports, Ocean-series outboards feature cylinders with two small ports designed to improve induction. These additional ports don't increase total volume of the charge, but aim it more precisely so that exhaust gases are better expelled and compression is more efficiently controlled.

Like all gains in outboard engine ef-

(Please turn to page 100)

TEAMWORK

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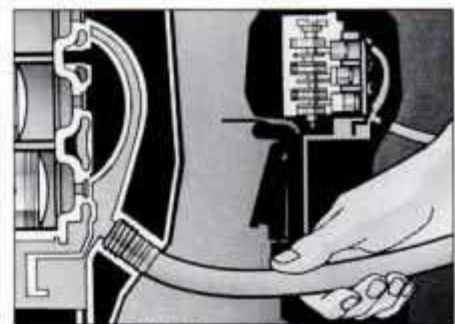
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BOATING (Continued from page 99)

iciency within a certain horsepower range, the desired result isn't more overall power. An engine said to put out 200 hp can't deliver 250 hp. Safety and legal considerations are the reason. But power can be increased throughout the powerband. The finger-port design adds power to the critical lower rpm range and fattens or flattens out the power curve. A poorly designed outboard has a power spike centered over the high-rpm range. This thin power curve provides little torque where it's needed most—in the low-rpm range where it's used to get a boat up on plane.

To further increase low-rpm power, Ocean-series powerheads have huge 183-cu.-in. displacements—by far the largest in this class.

Other notable features include individually calibrated and milled combustion chambers in the cylinder heads, 3-into-1 header-style exhaust, a unique crankcase drainage system that pushes unburned fuel toward the cylinder through a one-way check valve and a fully integrated block,



A unique built-in hose adapter enables easy flushing of the engine's water jacket.

made by using the high-tech lost-foam-casting process, of which OMC and Saturn automobile builders are the world's foremost practitioners.

Out on the water, I tested both the 200-hp and 225-hp Ocean-series outboards in twin-engine installations. The quiet-running engines lived up to their billing and showed impressive low-end power. With just a single engine in the water, either powerhead was able to pop a 25-ft. HydraSport fishing boat on plane. Comparison runs were made with similar HydraSport rigs equipped with twin Merc 200s and Yamaha 225s. Neither of these rigs was able to get up on plane using a single engine. This wasn't surprising, according to an engineer riding with me. The old OMC 200s and 225s couldn't do it either.

Following quickly on the heels of '91's breakthrough SilverStar/Spitfire outboards and '92's unique Quiet Rider inboard-mounted outboard, OMC's engineers appear to be on a roll that's taking the rest of the boating industry along for the ride. **PM**

ported on a Washington conference seeking ways to reduce the death rate of dial-painters, who had been licking their brushes to form a point.

Journalists loved sensational headlines that played up the polarized potential of various rays. A 1938 photo essay on the benefits and dangers of radium outlines its many medical uses, calling radium "The Deadly Life-Saver." A 1904 article said of radium, "It burns forever, and yet it is not fire; it will poison and it will cure; it will produce blindness and it will restore lost sight."

The documented healing powers of certain rays lent an air of respectability to other, more dubious claims. "Its magic rays pass through every cell and tissue, creating 'cellular massage,'" claimed a 1920 PM advertisement for the "Violet Ray" machine on display. The velvet-lined case filled with oddly shaped glass electrodes is one of the most unusual-looking devices in the exhibit.

More familiar to visitors is the microwave technology on display. One of the many uses of these very short radio waves—once called "microrays"—is represented in the exhibit by an early domestic microwave oven from 1957. Called a "radio stove" in PM, this dinosaur of the microwave era is as large as a conventional oven.

Even microwave technology, so widely accepted today, has sparked a fair amount of concern about safety. Yet no rays have engendered more controversy than atomic rays. In November 1945, PM reported, "The fact is that the dreaded but alluring atomic age is already here. Whole nations have grasped that fact almost with the speed of light. They may cringe before it—but they want it for its advantages and in spite of its dangers."

Many museum visitors will recognize the bomb shelter provisions on display along with PM shelter plans. A few might be familiar with the large beta-gamma monitor once used in atomic powerplants, complete with an employee's nickname for it, "Zapometer," scrawled across the front. But nearly all will recognize the clicking of the Geigercounter, our constant companion in the search for the atomic dream.

Enthusiasm for technology has carried many people into dangerous zones, from boiler explosions to auto wrecks to nuclear war. The tradeoffs that are demanded by our technological dreams are nowhere more visible than in the development and applications of invisible rays. And nowhere has the challenge been greater to PM's old slogan, "Written So You Can Understand It."

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LIGHT YEARS

BY FRANK VIZARD, Electronics Editor

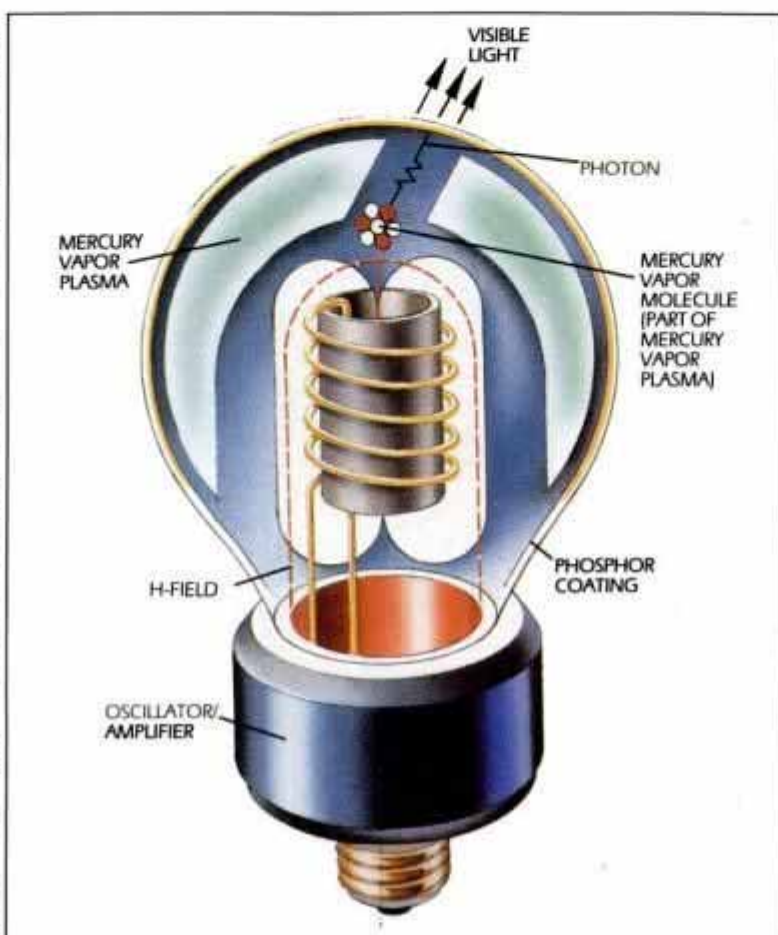
● When someone has a bright idea in cartoon land, a light bulb appears above his head. Bright ideas have come and gone, both in 'toon world and in real life, but the light bulb has always remained the same. Now, finally, the light bulb is about to change. Presumably, cartoonists will take notice.

Due on the market next year, the new E-Lamp's most remarkable attribute is its longevity. The E-Lamp has a life of about 20,000 hours. This compares with 750 to 1500 hours for a common incandescent bulb and 7000 to 10,000 hours for compact fluorescent bulbs.

In theory, and assuming a normal usage of about 4 hours per day, the E-Lamp would last about 14 years before it began to dim. At that point, the E-Lamp would lose about 30% of its lighting capability. The E-Lamp would then continue to dim slowly over time. In practical terms, the dimming process would add years to the E-Lamp's usable life.

Since Edison's time, light bulbs have basically worked by heating a filament until it glows. Most of the energy used to produce the light, however, is wasted as heat. Fluorescent bulbs tend to be more energy efficient, producing light by exciting a phosphor coating on the inside of the glass cylinder. Fluorescent lighting is used in many offices, but it never really caught on for homes because the bulbs are too large for many fixtures and they can't be used with dimmer switches.

The E-Lamp, as developed by Intersource Technologies and Diablo Research Corp., works in a substantially different way. The E-Lamp derives its name from the fact that it works electronically. An amplifier in the base of the bulb is linked to a



small, coiled antenna that produces radio waves inside the sealed bulb. This electronic energy interacts with a cloud of mercury-vapor gas along a magnetic line, dubbed the H-field. The gas transforms into a plasma which emits light outside the range of normal visibility. When this invisible light strikes the phosphor coating on the inside of the bulb, a visible light is produced.

Producing light in this manner isn't a new notion. The difficulty has always been in shielding the bulb so that the radio waves don't leak out and interfere with other electronic devices.

The developers say they have solved this problem, but so far, they're not saying how it's done.

Considering the E-Lamp's longevity, the cost is pretty reasonable. Company officials estimate the initial price will be between \$15 and \$20, comparable to the price of compact fluorescent bulbs. The operating cost

for a 25-watt E-Lamp is estimated at 9 cents per week versus 11 cents per week for a 25-watt fluorescent bulb, assuming a 4-hour-per-day usage. A 100-watt incandescent bulb costs about 30 cents per week under the same operating conditions. A 25-watt E-Lamp provides the same amount of light as a 100-watt incandescent bulb.

And, unlike fluorescent bulbs, E-Lamps can work with existing fixtures since they are roughly the same size and shape as incandescent bulbs. E-Lamps also work with dimmer switches, don't have problems operating in cold weather and can be placed vertically, horizontally or at any other angle.

The E-Lamp works on an environmental level, as well. It's estimated that each incandescent bulb replaced by an E-Lamp would reduce carbon-dioxide emissions from electric generating stations by about 1 ton, thereby reducing the greenhouse effect. This has intrigued utility companies, particularly American Electric Power Co. of Columbus, Ohio, which helped bankroll the project. They say that the E-Lamp is a useful tool in what they call "demand-side management." This philosophy stresses a more efficient use of electricity, rather than the building of new powerplants.

It'll be some time yet before there are enough E-Lamps available for the estimated 1.5 billion light sockets in the United States. With mass production, the price of an E-Lamp will probably go down—as it does with many other electronic devices. In time, the electronic component of the E-Lamp will be built directly into lamps themselves. Then, by simply replacing the bulb, costs could be reduced by 75%.

The E-Lamp appears to be destined

to replace the incandescent bulb. Considering that it's been 113 years since Edison lit up the world with his invention, it's probably about time.

Hail Newton

Newton is a new technology being promoted by Apple Computer, Inc., that offers the power of a computer in a handheld device that you operate with a pen. If the notion catches on, the pen may prove to be not only mightier than the sword, but also mightier than the keyboard.

The idea, being endorsed by a myriad of companies as diverse as Sharp Electronics and Pacific Bell, is to develop a device that reflects how people actually gather information—mostly in bits and pieces. With Newton, you'll be able to jot down phone numbers and notes, send faxes, draw pictures and do computations just as you would using paper. Newton reads your handwriting, organizes and stores the information or performs a desired function. For example, if you want to fax a note, just write "fax Joe O." on the screen. Newton will look up Joe O.'s fax number, create a cover sheet, change your handwritten scrawl into neat type and then send the fax once you've connected Newton to a phone line. Newton will also work with wireless communication devices.

The heart of Newton is a new breed of RISC (Reduced Instruction Set Computing) processors with the power of desktop computers and the battery power consumption of small flashlights. The Newton architecture also allows you to add "intelligent" cards to increase storage capacity or add more functions. Keep a look out for Newton in the first half of next year. Newton technology will be applied to many devices. **PM**



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SCIENCE

BACKYARD MONSTERS

BY ABE DANE, Science/Technology Editor



● While many have talked about the potential of robots as tools of industry, and as a way to get work done in hostile environments, little has been made of their ability to act like giant bugs. That has now been set right by an extraordinary new exhibit touring science museums around the country. Titled "Backyard Monsters," the show magnifies the bizarre yet barely visible creatures all around us into a set of tremendous, realistically animated models.

A unicorn beetle (shown above) stands 12 ft. high, making meticulously true-to-life movements. An 8-ft. praying mantis glowers like an evil alien. Most fearsome and complex of all, a mammoth scorpion prepares to attack, swaying from side to side and raising its fully articulated tail.

Why so big?

Although all this might seem a dramatic distortion of scale, the point is really to put insects into their proper perspective. "Seventy-five percent of the animals on Earth are insects," points out Dr. Arthur V. Evans, director of the Insect Zoo at the Los Angeles County Natural History Museum. Evans served on the project as

entomology consultant to Creative Presentations, builder of animatronic robots for Universal Studios theme parks and other prominent customers. The technology was developed by former NASA engineer John March, who worked on the *Mariner*, *Viking* and *Voyager* spacecraft.

Evans' first step was to choose bugs with broad appeal. Since ultimately the exhibit is expected to tour Europe and Japan, as well as the United States, they couldn't be unique to any particular part of the world. The selected creatures also had to have a life cycle that fit in with the timetable of the project so that live, full-grown specimens would be available for study. In the end, a black widow spider and a carpenter ant were chosen for reproduction, along with the praying mantis, unicorn beetle and scorpion already mentioned.

Evans took his samples to a Creative Presentations art director, who photographed them, dissected them, photographed them some more, then reassembled them to see how the parts worked together. It was a learning process for both Evans and the art director. "I saw things I had never seen before," said Evans.

From the photographs, sketches were made. Sculptors referred to these in making clay models, which in turn were used to make molds for the final parts. The Backyard Monsters differed from earlier animatronic robots in that they mimicked creatures that rely on an external exoskeleton for structural strength, rather than internal bones. As a result, the exterior parts had to be made from relatively rigid fiberglass and plastic, connected at the joints by silicone bellows that simulated natural membranes.

They live!

After a supporting frame of steel was built inside the bugs, the really difficult part began—bringing them to life. "The trick is not just to make them move. Anyone can do that," says Creative Presentations chairman Gene Bullard. "The thing is to simulate life."

In close consultation with Evans, technicians installed pneumatic actuators at as many as 20 joints in each bug's body. Eyes roll, mandibles pinch and entire bodies sway. The movements are coordinated by a computer control unit which puts each through a repeating 5- to 6-minute routine.

The physical stress of these movement sequences presented some tricky engineering problems. The praying mantis, for example, has a very powerful but very thin arm. On the unicorn beetle, the entire Volkswagen-size body had to move. But solutions were found, within the bounds of realism.

"The one thing we did not do is compromise the body shape and size of the insect," said Bullard. All involved came away with a much better appreciation of the marvelous natural engineering that goes into the typical bug.

The exhibit, which is now at Chicago's Field Museum and the Cranbrook Institute of Science in Detroit, also includes a variety of educational, interactive exhibits and a collection of more than 1000 real insects and arachnids. It opens at the Natural History Museum in Los Angeles County on Sept. 1, at the Atlanta Zoo on Sept. 11, and at Philadelphia's Franklin Institute on Oct. 2.

PM

PM HOTLINES

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HOW TO RESTORE AN OLD CAR

Part 2: Starting The Bodywork

BY RICH TAYLOR, Contributing Editor; PM Photos by Jean Constantine

● Last month, we reduced our 1967 Camaro convertible to a firewall, a pair of rocker panels and some miscellaneous bits. That part was easy. This month, we start the not-so-easy task of rebuilding the Camaro's unibody, from the rockers up. We're only showing you one particular car, but everything we've done is applicable to restoring any automobile ever built. The techniques are the same—only the applications vary.

The most critical part of such a major rebuilding is to keep all of the dimensions accurate. Our first step was



Our Camaro convertible is resplendent in all-new unibody panels and primed with "Yellow Death" (top). Don Breslauer grinds welds on a quarter-panel filler (above).

to get a copy of the original General Motors 67 Camaro Assembly Manual sold by Camaro restoration suppliers. This shows every critical meas-

urement. Similar manuals are available for most cars. If you can't find one for your model, make your own table of dimensions as you go along.

We used the remaining bit of inner body structure as our baseline, then carefully and repeatedly measured everything from there. Every dimension was checked longitudinally, laterally, diagonally, horizontally and vertically. The old carpenter's motto of "measure twice, cut once" is especially appropriate when you're working with a quarter-panel that costs \$340.

(Please turn to page 108)

Cutting, Bending And Welding Gear

● We used three big spools of welding wire on this Camaro and two Size E tanks of C-25 gas. That's a lot of welding, but our Daytona Mig 220-volt, 140-amp welder handled it with aplomb. A Mig welder uses thin wire instead of rod to fill the weld, with a constant



Our homemade cart carries the Daytona Mig welder and all supplies.



Ken Barnes cuts a sheetmetal patch with our throatless Beverly Shear, then bends it to fit.

flow of inert gas (usually 75% Argon, 25% CO₂) to keep out impurities.

Compared to old-fashioned "stick" welding, it's easy to do, neat and remarkably distortion-free. The trick is to get the wire speed and gas flow adjusted properly for the thickness of material you're welding, then push the wire rather than pull the nozzle, as seems more logical to most beginners.

Most small Mig welders incorporate a rack for a small gas bottle. I built a rolling cart out of scrap lumber and inexpensive casters to hold the welder, a big gas bottle, welding supplies, extension cord and fire extinguisher. It's probably the most useful tool in our shop.

—R.C.T.



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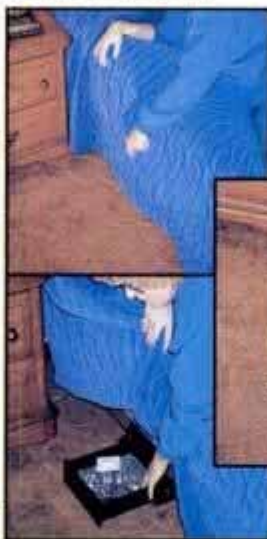
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(Continued from page 106)

We assembled the trunk floor, the inner and outer rear valances, the quarter-panels and the inner and outer wheelhouses using aircraft-style "blind" panel holders and locking C-clamps to hold everything in position. Then we started the tedious job of snipping, grinding and hammering until everything lined up properly. This entailed assembling and disassembling all of these panels a dozen times until we were satisfied.

General Motors still has rear quarter-panels, the outer rear valance and outer wheelhouse panels available. Almost every other part is available as a reproduction. Genuine GM parts are noticeably superior to the reproduction parts.

Genuine GM parts for any GM car are available through any General Motors dealer—you can order Camaro quarter-panels through your Cadillac dealer, for example. The genuine GM parts are dimensionally more accurate than "repro," and are made from 2-sided galvanized steel which has better corrosion protection. Most of our troubles in fitting the rear bodywork on our Camaro came because the repro parts from overseas required a great deal of trimming.

Some reproduction parts, particularly the replacement rear frame

rails, were spectacularly out of whack. We had to cut and reflare them by more than 1 in. on both sides to make them fit. Ultimately, some parts—particularly in the area of the leaf-spring front perches and the rear sections of the rocker panels—were simply unobtainable. We fabricated them from scratch out of sheet steel.



Ken Barnes reads the GM 67 Camaro Assembly Manual for dimensions, then Mig welds a replacement top for the dashboard.

When the whole rear of the body had been fitted, it was all taken apart and then Mig-welded in place, starting with the frame rails, then the wheelhouses and rear valance, the rear shock towers, the seven separate panels that make up the trunk floor and finally the rear quarter-panels.

With everything dimensionally stable again, we welded in reproduction floor pans and a new dash top, both commonly rusted items on any early Camaro. When we were done, the only original body parts were the trunklid and the upper panel that fits between the top and the trunklid.

There was one more difficult task that we put off until last. GM sells new quarter-panels—but only for the Camaro coupe, not the convertible. As the photos indicate, these come with the C-pillar in place and they have a very different contour from the convertible fenders. We had to cut off these C-pillars, relieve the top of the quarter-panel by slicing it like a grapefruit, hammer it into position to fit the base of the convertible top, then carefully fabricate and weld in filler pieces.

The convertible's quarter-panel has a different line along the base of the rear quarter window on each side. This very complicated piece is not available in reproduction. Master

HOW TO RESTORE AN OLD CAR



Sometimes it's easier to get right into your work and talk about what to do (left). Genuine GM parts are distinguished from repro by glossy black primer, heavier feel and better fit. Notice the left quarter-panel still has its coupe C-pillar (large photo below). The right side has been trimmed off and the missing chunk has been fabricated.



metalworker Don Breslauer took the one crumbling old piece we had and fabricated a new one to match, then a second mirror-image piece for the other side. These were then hammer-welded to the quarters.

Everything else we did is within the mechanical abilities of most PM readers. But fabricating a mirror-image part with complicated compound curves isn't something you want to try at home without 20 years of experience. If you need something like this, talk to your local bodyshop and find the local expert fabricator.

When everything was finally weld-



ed together and ground smooth, we sprayed the entire unibody inside and out with Dupont 615S Variprime self-etching primer. Painters call this stuff "Yellow Death" because of its hue and mind-warping vapors, but it's tops for protecting raw steel.

SOURCE LIST

The following is a list of some of the suppliers for this project:

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- Chevrolet Division, General Motors Corp., 30007 Van Dyke Ave., Warren, MI 48090; (313) 492-8855 (Engine and transmission)
- Coker Tire, 1317 Chestnut St., Chattanooga, TN 37402; (800) 251-6336 (Reproduction old-style tires)
- Daytona Mig, 1821 Holsonback Dr., Daytona Beach, FL 32117; (800) 331-9353 (Mig welder)
- D&R Classic Automotive, 31 W. 208 Diehl Rd., Suite 107, Naperville, IL 60563; (708) 369-2030 (Camaro restoration parts)
- DTS, 22250 Scheman Rd., Warren, MI 48089; (800) 521-0628 (Rear axle ring, pinion)
- Eagle Equipment Co., 23 Wetherill Place, Plainville, MA 02762; (800) 535-0016 (Lift)
- The Eastwood Co., 580 Lancaster Ave., Malvern, PA 19355; (800) 345-1178 (Specialized restoration tools)
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- General Motors Service Parts Operations, 6060 W. Bristol Rd., Flint, MI 48554; (313) 635-6980 (Body, suspension and trim parts, plus a free consumer guide to restoring GM vehicles)
- Goodyear Tire and Rubber Co., P.O. Box 9125, Akron, OH 44305; (216) 796-2490 (Contemporary tires)
- Kanter Auto Products, 76 Monroe St., Boonton, NJ 07005; (800) 526-1096 (Springs, shock absorbers)
- Minisport, Jackson Hill Rd., Sharon, CT 06069; (203) 364-0311 (Complete auto restorations)
- OEM Glass, P.O. Box 362, Route 9 East, Bloomington, IL 61702; (800) 283-2122 (Auto glass)
- PST, P.O. Box 396, Montville, NJ 07045; (800) 247-2288 (Suspension bushings, antisway bars)
- Sharon Auto Body, Route 343, Sharon, CT 06069; (203) 364-0128 (Finish bodywork and painting)
- TIP Sandblasters, P.O. Box 649, Canfield, OH 44406; (800) 321-9260 (Sandblaster, bead blast cabinet, paint sprayer)
- Wurth USA, 93 Grant St., Ramsey, NJ 07446; (800) 526-5228 (Fasteners, i.e. nuts and bolts)



Although reproduction floors are available, difficult spots in the floor were fabricated (left). The doors were so rusted they were literally unsalvageable (above).

It probably still doesn't look like much to you, but after nearly 500 man-hours of fitting and welding, our '67 Camaro has passed its biggest hurdle on the road to becoming a car again. It has gone from a rusty derelict to being a solid unibody on which we can erect a wonderful machine. By the time we're done next month, it will be back on its wheels, with its engine and running gear in place—ready for final bodywork and paint. **PM**

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POWER TV

(Continued from page 53)

Minimum setting. A word to the wise: The position of the VHF dipoles does affect UHF reception. The reception is best when the elements are extended and vertical, or retracted and horizontal.

The Archer Color Supreme 200, a Radio Shack antenna, is unique among the group that we tested in that it has a fixed, nonvariable gain for all frequency bands. It's either off, applying a Minimum Gain of +6dB in VHF and 0dB in UHF, or it's on, yielding 19dB (VHF) and 10.5dB (UHF). There's also a fine-tuning adjustment for all bands.

In the OFF position, it had an effect on the weak VHF or UHF stations. For VHF, the ON position greatly improved the weak stations and dragged in the distant one—but was on the verge of causing an overload on the already good signals. Also at this Maximum Gain setting, the four noisy UHF stations improved, but we didn't see much change in the strong ones. For the record, the plastic reflector in the UHF loop is window dressing, and its position has no effect on reception.

Hands down, the best antenna in this group is Gemini's G2000. It provided the greatest Maximum Gain in all bands, and the numbers translate visibly on-screen.

The G2000 has separate gain controls for VHF and UHF, and you'll use them. The respective gains of +37.5dB and +28dB will overload the tuner on strong signals, but the controls are so responsive that it was possible to improve even the excellent VHF and UHF signals before overload occurred. The noisiest stations became a pleasure to watch. Moreover, the G2000 made a distant VHF and UHF station viewable regularly, and two other UHF channels occasionally (atmospherics were probably at work here).

Flat panel wonder?

The last antenna in our comparison group proved to be a disappointment—but having said that, we'll grant the Terk TV20 some extenuating circumstances.

The Terk TV20 is unique among all indoor antennas in that it doesn't use dipoles. Instead, the TV20 has two rotating, perforated panels arrayed horizontally and parallel to the TV top. The panels occupy only 24 in. of diameter and the antenna is just over 5 in. tall.

If this seems like a dream-come-true for households tired of unsightly rabbit ears, it should be. According to

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Terk, the rotating panels represent a Complementary Symmetry principle that should require only minimal rotation—90° or less—to achieve proper tuning. Moreover, the antenna's configuration is designed to employ both E-waves (electromagnetic) and H-waves (horizontally polarized) to form an electrical signal for the TV's tuner. Most home antennas, says Terk, use only one wave or the other. As an added benefit, Terk says the horizontal array is not affected by proximity to human bodies—a claim our testing bears out.

With a buildup like this, we expect nothing short of excellent results—especially since Terk is a premier manufacturer of FM/AM and cellular telephone antennas. The results, as the chart shows, are unexceptional—and actual viewing performance was even worse.

At Minimum Gain, even the best VHF and UHF frequencies were attenuated. At Maximum Gain, the weak UHF stations looked a lot better and the stronger ones were slightly cleaner than what we got with the Archer and TV600 models. The real problems were in VHF.

Here, at +20dB Maximum Gain, the distant station appeared viewable and the noisiest local station improved—but not so much as with the Archer and TV600 models, which offer less gain. Moreover, at variable gain levels performance degraded significantly on two good stations, and became slightly noisier on an excellent one. These deficiencies correlate with some that Terk told us to expect in the low-band channels.

The company states that the three antennas supplied to PM and APEL are part of its first production run of 36, and that manufacturing errors afflicted this lot.

Terk assures PM that all of these errors have been corrected, and that none of the initial 36 will ever reach a customer. We're inclined to believe this, on the basis of the company's past track record and reputation, and because its diagnosis of the TV20's flaws came without any prompting from the lab.

It's too bad that we pulled three lemons for this test—Terk supplied these early samples eagerly, because just about no publication tests indoor antennas. And it's unfortunate that corrected models weren't available in time for our press deadline. You might want to give the Terk TV20 a try when it arrives in stores, but keep your eyes peeled for the problems that are described here. The size and design of this antenna make it worth a chance.

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MOTORSPORTS

DODGE DAY IN DETROIT

BY TONY SWAN, Automotive Editor



Tommy Archer's Dodge Daytona (3) leads Jack Baldwin's Camaro en route to victory in Detroit Trans-Am. Tommy Archer (center, above) shared victory stand with Greg Pickett (left) and brother Bobby.

● When we visited our friends the Archer Brothers last month, they were at the Mid-Ohio Sports Car Course, scratching their heads over handling mysteries in their Dodge Daytona race cars.

Although Tommy and Bobby Archer aren't the kind to be discouraged, there was concern. Their cars were quicker than some at the Mid-Ohio test session, but distinctly slower than the Camaro of veteran Paul Gentilozzi. And, the cars weren't responding to any combination of the many adjustments available.

But the next time we saw them, the boys from Duluth were in the winner's circle of the Motor City 100, round two of the 1992 Sports Car Club of America Tide Trans-Am Tour. Tommy finished first, defeating the Camaros of Jack Baldwin and defending champ Scott Sharp, and Bobby came home third.

They had obviously found some answers to the handling questions raised at Mid-Ohio, thanks in part to brand-new Bilstein shocks. They'd also found a bit more horsepower in the destoked (from 318- to 310-cu.-in.) Dodge V8, thanks to the efforts of engine-builder Joey

Arrington. While the Baldwin-Sharp Camaros still seemed to have an edge in power, it wasn't as pronounced as it was in the series opener at Long Beach.

One other factor was the new Detroit Grand Prix course, set up in the city's Belle Isle park. With insufficient curing time, the Belle Isle track surface broke up as the weekend progressed, spreading crumbled asphalt marbles off the racing line—just the thing for two guys who spend their off-seasons racing on frozen lakes.

"The track kept changing," said Tommy, "and the marbles had a lot to do with how the race came out.

"But the most gratifying part for us

is that we didn't just inherit our first win. We went out there and won it."

25-year drought

They couldn't have picked a better venue for their first win. With the Big Three all involved in the '92 series, Belle Isle was packed with Motor City auto execs cheering for their respective makes. When the dust had settled, the guys from Dodge hardly dared to believe what they'd seen—Mopar's first Trans-Am victory in 25 years.

Portland pole

Just in case anyone might think their Detroit performance was a fluke, the Archers put on another show at Portland International Raceway two weeks later, capturing the pole position (Bobby) and running 1-2 throughout the first third of the race. However, two caution periods bunched the field together again, and on the re-start, Gentilozzi picked off first Tom-

my and then Bobby. Then a small bump from behind spun Bobby at turn one late in the race. Tommy went on to finish second, and left Portland with a 10-point lead in the driver's championship.

Bobby charged back for eighth. Stay tuned. **FM**

1992 TRANS-AM CALENDAR

Aug. 8	Watkins Glen, NY
Aug. 16	Trois-Rivières, Quebec
Aug. 22	Elkhart Lake, WI
Sept. 12	Lexington, OH
Sept. 27	Juarez, Mexico
Oct. 4	Sears Point, CA



Bobby Archer started fifth and finished third, setting the race's fastest lap in the process.

MECHANICS OF A FIELD GOAL

(Continued from page 39)

ball or because it slid off his foot.

As a kicker, you want the ball to have a slow rotation. You can tell from the rotation where the ball was kicked. Hit the sweet spot and you'll see a slow end-over-end rotation. If the ball spins like a top, then the kicker has hit way under the sweet spot.

At one time, kickers had to worry about things like leapers—defensive players who took a running start from behind the line of scrimmage and then jumped into the air. Offensive linemen bet on whether they could make leapers do a 360° or 540° spin in the air. To prevent injuries, the defense is no longer allowed to jump from behind the line of scrimmage.

Today, a kicker's biggest adversary is the weather. Cold weather can cut your range by 5 to 10 yards because you don't get as much compression of the ball as you kick. Wet weather forces you to shorten your stride. The biggest problem, though, is the wind.

The wind can kill your kick but you never want to give up the goal posts to compensate. You never want to choose a target that would take the ball on a natural trajectory outside the goal posts. The wind can die just as quickly as it can start up.

A wind coming straight at the kicker will kill the ball distance-wise, but it doesn't push the ball to either side. A wind coming from the left doesn't cause many problems because you're kicking through a cross section.

However, a wind coming diagonally from the right is murder because if you have any hook on the ball, the wind exaggerates it—pushing the ball too far to the left. If you hit into the wind you won't get any hook, but you'll miss to the right. Under these circumstances, making an accurate kick is very difficult.

The wind does help if you have it at your back. You'll get about three-quarters of the range that you lose when the wind is in your face.

Let's say I can normally make a 50-yard field goal. If a strong wind is in my face, it will reduce my range to about 40 yards. With the wind at my back, my range will increase about 7½ yards, so there's a chance I'll make a 57-yarder.

Adversity is part of the game, however, so it can't be offered as an excuse for a missed field goal. Kickers are always about three misses away from retirement. The key to longevity is to kick the ball in a natural and comfortable way with as much leg speed and accuracy as you can muster. **PM**

PM editor Frank Vizard assisted in the preparation of this article.

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HOME VIDEO

CREATING SPECIAL EFFECTS

BY STEPHEN A. BOOTH, Contributing Editor



● "F/X" is the kind of slang you don't usually hear around the house, but that's about to change. It's studio techie's jargon for special effects—all the razzle-dazzle stuff that juices up the images and soundtracks of TV and movies. You've seen and heard them on MTV and even major league baseball: flashing, stroboscopic pictures, titles and statistics that roll across the screen, the sounds of screeching brakes and canned laughter.

When it comes to sophisticated visual effects, Panasonic's WJ-AVE3 Digital Effects Generator (\$1100) brings home many of the best tricks of studio consoles costing \$10,000 or more. In all, the WJ-AVE3 creates eight special effects that can be combined for even more stunning visuals.

One of the WJ-AVE3's special-effects features is Digital Still and Strobe. This function grabs moving images from your home video, freeze-frames them, then lets you flash them at various speeds for a stroboscopic effect. Digital Mosaic breaks your pictures into hundreds of squares, for an abstract look. Negative/Positive Reversal swaps the light and dark portions of an image to deliver a psychedelic experience.

In addition to these rock 'em, shock 'em effects, the WJ-AVE3 offers Art and Paint functions. The first lets you splash any of eight colors onto the bright portions of a picture. The Paint function is

Panasonic's WJ-AVE3 Digital Effects Generator (left) dresses up your home videos, Hollywood style. Sima's ScreenWriter (right) lets you add text simply and easily.

much more artistically sophisticated. Here, your video is transformed into something that looks like a 19th-century impressionist watercolor. Normally sharp video images are rendered with a soft, brushstroke-like appearance.

Other features of the WJ-AVE3 include a Squeeze function that reduces the image to one-quarter of the screen size and lets you place it in any of nine positions on the screen. There's a built-in, 2-page title memory that lets you superimpose letters or graphics on your video. A built-in audio mixer lets you overdub a soundtrack from three different sources, including a microphone. You can synchronize the

effects to the beat of the accompanying music.

In the category of sound effects, the Boing Box (\$179) from Videonics is like having a staff of zany studio whiz-kids at your fingertips. This barrel of laughs, formally titled the Videonics Sound Effects Mixer, gives you 60 different digitally recorded noises that you can program in sequence and dub into your movie. You really get more than 60 sounds because you can vary speed and pitch to create others, such as a foghorn from a car horn. Unfortunately, you can't combine sounds simultaneously.

No home-Hollywood production is complete without credits and titles.

Sima's ScreenWriter (\$320) is a simple-to-use character generator that superimposes attractive lettering in four different sizes. You create your titles on its typewriter-style keyboard, then store up to seven pages of text in the ScreenWriter's memory. You can program the titles in sequence so you can superimpose them in the order you like as you roll through your video. Once they're on-screen, you can rearrange the word order for the best appearance. What's more, you can zoom the titles or scroll them up or across the screen for that ultimate Hollywood look.



Add sound effects like creaking doors with the Videonics Boing Box.

Multistandard VCR

If you have friends or relatives living in foreign countries then you'd probably like to exchange videos with them. Incompatible standards, however, often make what should be a pleasure into a chore. Things are getting a little easier, though.

Aiwa is re-entering the video market, joining a short list of companies that supply multistandard videocassette recorders. The HV-M110 VCR converts the NTSC format used in the United States to the PAL format used in Europe, Asia and the Middle East. It will also convert PAL to NTSC. List price is \$500, placing it among the least expensive VCRs of its kind.

Aiwa, based in Mahwah, New Jersey, is also offering a stand-alone converter for a list price of \$400. The HC-MX3 converts NTSC, PAL and SECAM formats. It also features three input/output terminals.

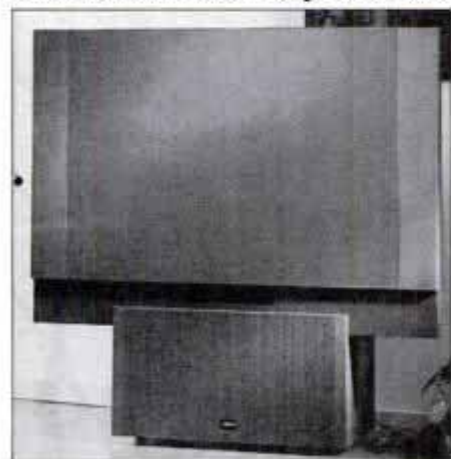
Slimmer Projection TV

If you like the large screen size of projection television but are put off by the sheer physical size and boxy look of the product, then you might want to look at the new crop of projection televisions coming this fall.

From a design standpoint, the RCA P52152ST model is a radical and welcome departure from conventional projection television styling. The 52-in. screen appears to be slotted into a smaller base. The screen, therefore, appears to hang in space in a lightweight fashion. The P52152ST is finished in gray vinyl, can be built into a wall, and lists for \$2899.

From the front, the new projection televisions from Mitsubishi and Sony may not be terribly revolutionary. If you look at them sideways, though, progress becomes apparent. They are remarkably thin.

Mitsubishi's new 50-in. model is just a fraction deeper than 22 in. This is 30% smaller than its predecessor



RCA's new 52-in. projection TV heralds a new design philosophy.

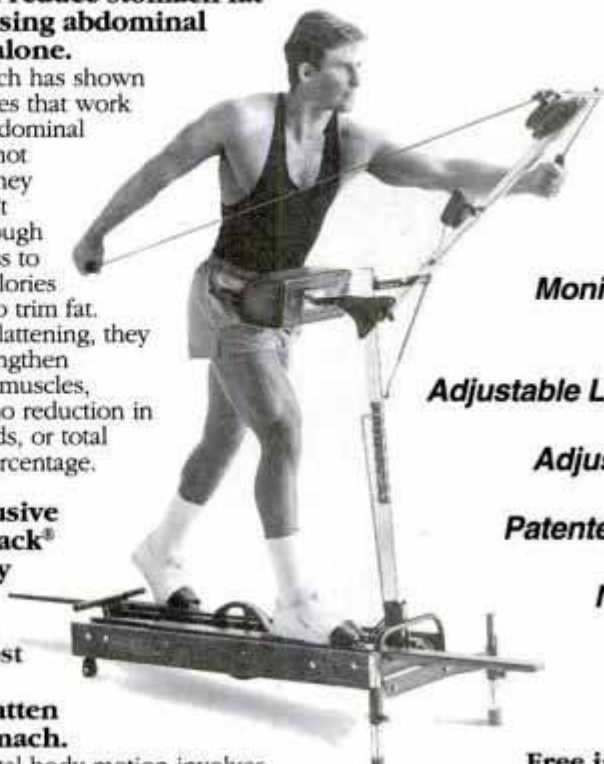
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and only 4 in. larger than a 26-in. direct-view TV.

Even thinner is a 41-in. projection TV from Sony that measures only 20 in. from front to back. The slimmer cabinet design comes from the use of a new Micro-Beam CRT and a 4-element lens assembly. These new developments work to shorten the focal distance light must travel, yielding a brighter picture with more detail in the process.

Collectively, Sony is calling this technology the Advanced ProOptic System, and it's also used in new 46-in. and 53-in. models. Both of these

models borrow some interesting features from Sony's new flagship XBR² direct-view television, also debuting this fall. One feature worthy of note is the program palette, which lets you adjust the performance parameters according to the type of material you're watching. For instance, the game mode enhances colors to make videogames more vibrant. A news mode, on the other hand, enhances voice reproduction. The XBR² direct-view TV also uses a flatter screen, a technology previewed in PM in January (see "Flat Not Fat", page 46).

—Frank Vizard

motor, it carries four SEALs, a pilot and a navigator in fully enclosed compartments. Computerized Doppler navigation sonar and obstacle avoidance sonar guide the crew.

SEALs also have their own unique way of traveling over land. The Fast Attack Vehicle, which first saw service in the recapture of Kuwait, is essentially a Chenoweth 2-wheel-drive off-road racing vehicle. Light and agile, it can handle most of the same terrain as the 4wd Hummer, but at higher speed. It is well armed, with a Mark 19 automatic grenade launcher,

a .50-caliber machine gun, M60 machine guns, a 30mm cannon and an AT-4 anti-tank missile launcher.

Air Force Special Operations Command

The main role of the Air Force in special operations is to transport men and materiel, often into hostile territory and under harsh conditions. Several fixed-wing and rotary-wing aircraft have been modified for the purpose.

Two new pieces of hardware are the MC-130H Combat Talon II and the AC-130U Spectre gunship. The Com-

bat Talon is outfitted for low-altitude, deep-penetration transport missions with an aerial refueling boom, explosion suppressive fuel tanks, an AN/APQ-170 terrain following radar, and just about every type of navigational device imaginable. On missions where vertical takeoff and landing are required, the mammoth MH-53J Pave Low IIIIE takes over the heavy lifting. The 42,000-pound helicopter is air refuelable and its avionics are every bit as comprehensive as the Combat Talon's.

Like its predecessors, the Vietnam-era "puff" gunships, the AC-130U is designed to bring enormous firepower to bear in support of ground forces. But where the earlier craft simply saturated whole areas with projectiles, the new aircraft uses state-of-the-art sensors and fire control equipment to steer its 105mm howitzer, and 25mm and 40mm cannons with great precision.

Joint Special Operations Command

Headquartered at Pope Air Force Base, North Carolina, the JSOC is a small USSOCOM component comprising elements from the Air Force, Army and Navy. Its ostensible mission is to ensure standardization among the special operations forces of each service, but it also has responsibility for SEAL Team 6 and Special Forces Detachment Delta (better known as Delta Force), two highly secretive counterterrorist units.

Marine Reconnaissance Units

The Marine Corps is of two minds about the concept of special operations forces. On one hand, they contend, the run-of-the-mill Marine meets standards that would qualify him for special warfare duty in another branch of services. On the other, there's always room for people with extra training in key areas.

Although surveying and preparing a beach for an amphibious assault is a SEAL responsibility, the Marines also have their own units devoted to that role. The Marine Reconnaissance Battalions receive special training in infiltration, hydrographic reconnaissance, surveillance and spotting for Naval gunfire. Unlike the SEALs, their missions are generally limited to observation, and they generally avoid contact with the enemy. There are, however, Marine units known as Force Recon Companies that support amphibious assaults by carrying out raids and demolition activities similar to those of the SEALs and Green Berets.

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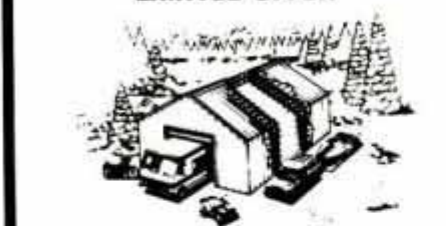
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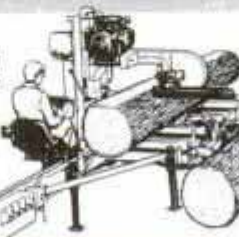
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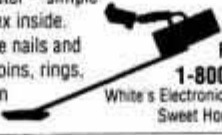


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A photograph of three Ford cars driving on a wet road at dusk. The cars are in motion, with their headlights on and reflections on the wet pavement. The sky is dark with some clouds. The cars are arranged in a line, moving from the background towards the foreground. The car in the foreground is a Taurus SHO, the middle one is a Thunderbird SC, and the one in the background is a Mustang GT. The overall mood is dramatic and emphasizes the cars' performance in adverse conditions.

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