

JULY 1989 \$1.95

# Popular Mechanics

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THE BEST  
EVERYDAY  
CAR**  
13 Family Sedans  
Tested And Rated

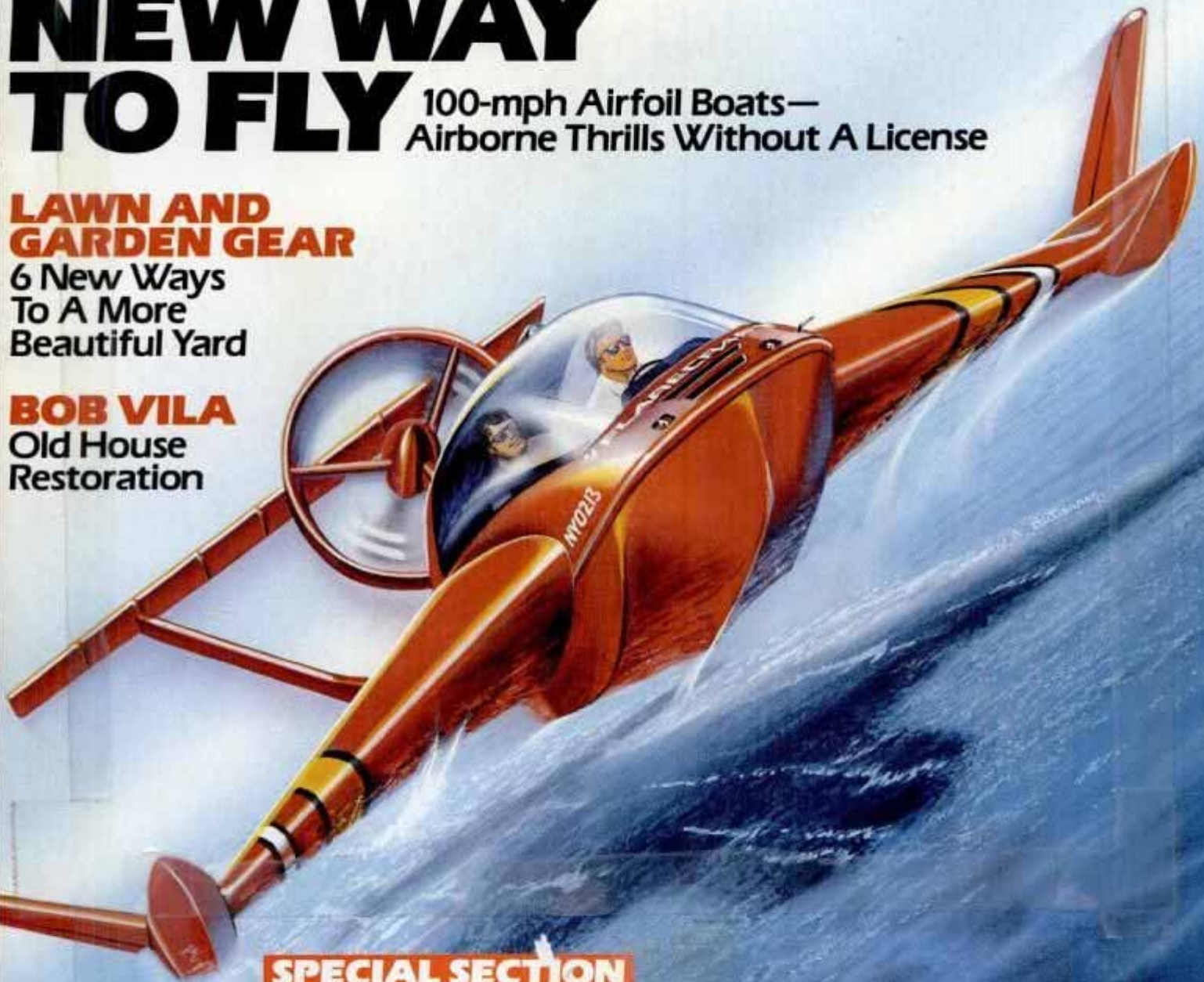
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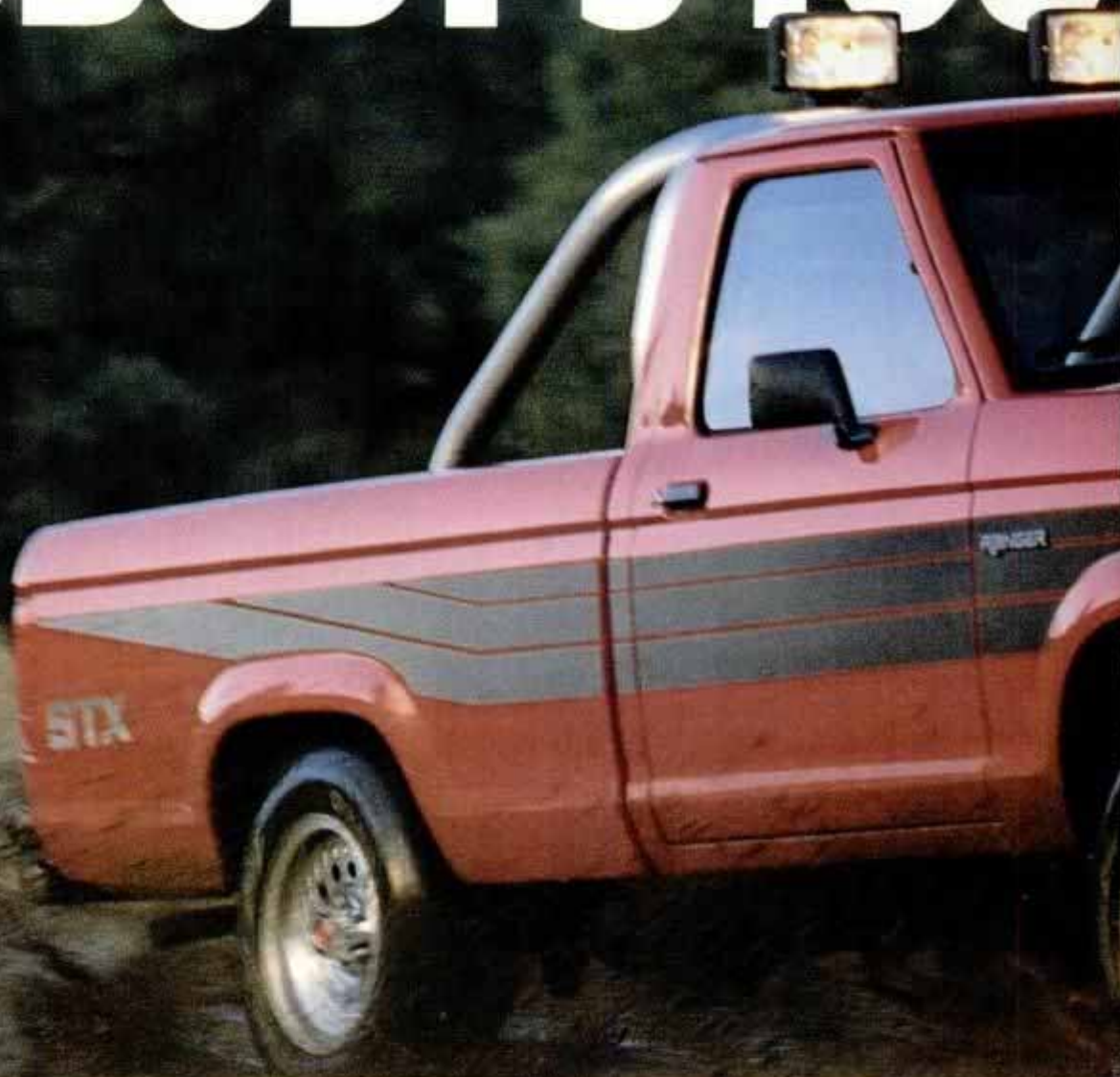
**FLYING AT THE LIMIT  
IN THE WORLD'S  
HOTTEST FIGHTER**  
A Heart-Stopping Report  
From The Cockpit

**PLUS**  
F-16 Cutaway  
Collector Poster





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## 1989 FORD RANGER STX 4x4.

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A gutsy 2.9L V-6 engine with multi-port electronic fuel injection comes standard with Ranger STX. Same for a rugged five-speed manual overdrive transmission, Ford's exclusive Twin Traction Beam Front

Suspension, P215 all-terrain tires and anti-lock rear brakes. They're all wrapped up in a body whose aerodynamic styling steals the attention from other compact trucks.

NOW "TOUCH DRIVE" 4WD IS  
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Now, thanks to Ford's exclusive Touch Drive, Ranger STX 4x4 even comes standard with the con-





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venience of 4-wheel drive at the touch of a button.

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For style, the 1989 Ranger STX 4x4 has a handsome, redesigned instrument panel. For comfort, choose Ranger's spacious available SuperCab and ride in Captain's Chairs. There's also an available column-shift automatic transmission. **FORD RANGER. THE BEST-SELLING COMPACT TRUCK IN AMERICA.**

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### MAJOR STX STANDARD EQUIPMENT

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### RANGER SPORT MODELS

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RIDERS**

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### 57 COVER STORY

Soon you'll be able to buy your own flying fish, an airfoil boat designed to speed over great expanses of water. And you won't need a license to operate it.

—PM illustration by Alan Guterrez



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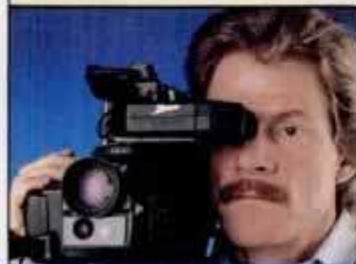
Make attention-grabbing videos with the same moviemaking techniques the pros use. Preproduction planning of a script. Shooting the big picture at the right angles. Setting the mood with directing, lighting, titles and more.

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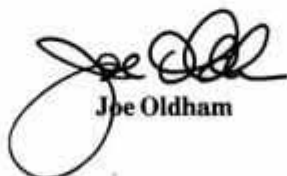


# EDITOR'S NOTES

**A** FEW MONTHS AGO, I addressed a group of people to tell them more about POPULAR MECHANICS. One of the things I mentioned was that I believe in what I call active journalism. I don't like editors who sit behind a desk and produce articles. I like the PM staff to get out there and experience what they're talking about in the pages of this magazine. Be hands on. Live it. Do it. Then you can write about it with a perspective achieved only through actually being there and doing it. This applies to just about everything we print in POPULAR MECHANICS, from car tests to shop projects; from photography to boating; from electronics to aviation. I'm constantly urging our staff editors to get out into the field and experience it firsthand. A prime example is the "road test" of the U.S. Air Force F-16 Fighting Falcon in this issue ("Bird Of Prey," page 70). Tim Cole was in the cockpit pulling Gs himself so that he could relate the experience to you firsthand. It's not Tim relating what someone *told him* it was like flying an F-16. It was Tim, up there doing it. What better way to answer the question, "What's it *really* like up there?" By the way, you can't just show up at some Air Force base one day and ask for a ride in an F-16. After months of paperwork, Cole's request was approved by the Department of the Air Force—and then the fun began. First, the Air Force required that Cole go through special training—initially, at Andrews Air Force Base, near Washington, D.C., where he underwent an incredibly detailed physical examination to determine if he was fit enough to withstand the physical abuse a flyer takes in the cockpit of a supersonic fighter; then he went through altitude training including how to use oxygen and what to do in the event of an explosive decompression. Once at MacDill AFB where he actually flew the F-16, Cole was trained in the use of the G-suit, the ejection seat, the emergency rescue equipment, and of course, how all the F-16 flight systems work. This may seem like a lot of trouble to go through for one article. And it is. But it's not unusual. This month our auto department editors flew to California to test 13 family sedans ("Best Sellers," page 60), our boating editor went to Wisconsin to lake-test aluminum bass boats ("Bass Blitzers," page 81), our electronics editor spent days in a hot lab testing CD players ("CD Player Soundoff," page 67), and we flew a crew to Germany to get our cover story ("License To Fly," page 57). But that's how we do things around here. I hope you agree that it makes a difference—and that it's worth it. 'Til next time.



Cole and "his" F-16B.

  
Joe Oldham

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Traffic radar doesn't say which car is being clocked, it merely flashes a number. The radar operator must then try to determine which vehicle produced the reading.

# Why radar makes mistakes. How to protect yourself.

**A**lthough nine different errors have been documented for traffic radar, the most common source of wrongful tickets is mistaken identity.

It's hard to believe, but traffic radar does not identify which vehicle is responsible for the speed being displayed. It shows only a speed number and nothing else. The radar operator must decide who is to blame.

#### How radar works

The radar gun is aimed at traffic and it transmits a beam of invisible radar waves. Each moving object within range reflects these invisible waves back to the radar gun. Using the Doppler principle, the radar calculates speed from the reflected waves.

#### Traffic radar is blind

Traffic radar works differently from military, air-traffic-control, and weather radars. The others use rotating dish antennas in order to track many objects simultaneously.

Traffic radar uses a far smaller, far cheaper, gun-shaped antenna. This simplification requires traffic radar to ignore all reflections but the strongest. The number displayed is speed calculated from the strongest reflection.

#### The best guess

Remember, these reflections are invisible. Truck reflections can be ten times stronger than car reflections. How can the operator know for sure which vehicle is responsible for the number?

The truth is, he can't be sure in many cases. The result is mistaken identity. You can be ticketed for somebody else's reflection.

#### Self defense

The only way to defend yourself against these wrongful tickets is to know when radar is operating near you. Others agree with this method. In his verdict upholding a citizen's right to use a radar detector, Judge Joseph Ryan, Superior Court, District of Columbia, wrote:

*"If government seeks to use clandestine and furtive methods to monitor citizen actions, it can ill afford to complain should the citizen insist on a method to effect his right to know he is under such surveillance."*

#### We can help

We specialize in radar warning. And Escort and Passport do far more than simply find radar. Upon radar contact, the alert lamp responds and the meter shows radar signal strength. At the same time, you will hear an audio warning—pulsing slowly when the radar is weak, quicker as it strengthens, then constant as you approach close range. When you know exactly how strong the radar waves are, you'll know when the radar unit is near enough to actually have you under surveillance.

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POPULAR MECHANICS • JULY 1989

Мастерская, энциклопедия, авторская техника



# Let Heil Guide you to energy savings.

## Fact And Fiction

**T**HE American Adventure section in the May '89 issue held a real surprise: I don't usually expect to find my favorite fiction writer in the pages of PM.

But John Updike erred in his reference to the St. Louis Arch as a parabola ("Sacred Places," page 26). The arch isn't a parabola, nor any conic section, but a modified catenary curve. A catenary is the shape assumed by a chain hanging freely from two fixed points. If the links of the chain are uniform, the curve will have a sharper V-shape than the Arch. But making the links progressively smaller toward the center—analagous to the tapering of the Arch—yields a more rounded curve. The Arch is in fact the exact shape it would be if it were perfectly flexible and hanging upside down, which no doubt figures subconsciously in its visual appeal.

CHARLES SOUTHWELL  
ARLINGTON, VA

## All Praise

Once again your fine magazine "rings the bell." The May issue is crammed full of exciting stories. The article on restoring great steam trains is great! The table saw techniques story is well written and illustrated, and a great help to an amateur like me.

I was especially delighted with the large section, "The American Adventure." We have visited many of the spots depicted and it was good to review them in your magazine, plus new clues on places yet to see. How do you do it? So much, so well-done. Pleasing every taste is a marvel. Thanks again, keep up the good work!

WILLIAM R. SWANGER, PASTOR  
GRACE MISSIONARY CHURCH  
ZION, IL

Reference May '89 Issue:  
Probably the best "all-around" issue of all issues. Colors, descriptions, the ads, "The American Adventure," the boat story. All articles are terrific. Beyond improvement!

DON S. GOCKEL  
BURBANK, CA

## Try Oregon

"The American Adventure" was full of very beautiful, educational, recreational, accessible and remote places to visit, in this the most awesome country in the world. However, you overlooked an area which contains all of the above mentioned attributes—one of which should most assuredly not be forgotten because it's a national monument: The Oregon Caves. This, and the Josephine County Kerbyville Museum are accessible via Highway 199, better known as the Redwood Highway which travels South out of Grants Pass.

After leaving the caves, continue south toward the California border. On

this portion of the journey, you pass through the majestic Redwood Forest and the Jedidiah Smith State Park on the Smith River. Beauty beyond everyone's imagination.

Thank you for your very enlightening May special issue.

DOUGLAS W. BLAIR  
ADMINISTRATOR  
JOSEPHINE COUNTY  
KERBYVILLE MUSEUM  
KERBY, OR



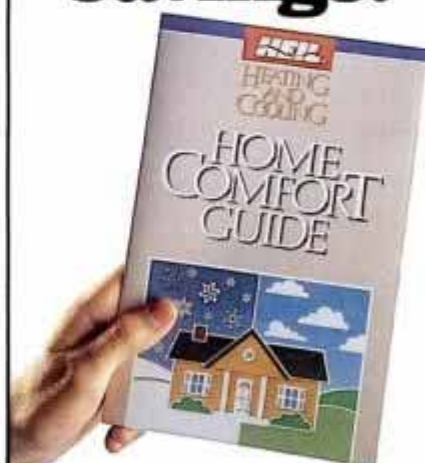
## Train Of Thought

Hooray! Because of your May cover and story, the rest of America is discovering what we rail enthusiasts have known for years about steam locomotives ("Born Again," page 117). They truly are a symbol of our earlier industrial might, and also the most magnificent of man's machines, save perhaps sailing ships.

Now, wouldn't it be nice if Amtrak were to obtain some of these locomotives (and appropriate cars), and assign them to special or scenic runs? My nominations would start with the Cardinal train in West Virginia, and also a revival of the 20th Century Limited (which would supplement the current Lake Shore Limited). No doubt there are also other runs in the West that could handle steam's appeal—perhaps other readers can suggest the best nominations.

Now, about paying for this—perhaps Donald Trump might like to be the new George Pullman?

DAVID P. LUBIC  
MARTINSBURG, WV



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# TIME MACHINE

## 75 YEARS AGO: JULY 1914



### Seagoing Cities

The tragic loss of *Titanic* was still a vivid memory for owners of ocean liners. But the predicted downscaling to smaller, more manageable and theoretically safer ships failed to occur. Instead, huge new passenger liners slid down the ways at shipyards in Belfast and Bremen. Our cover subject: The mighty *Britannic*. *Britannic* boasted such safety features as an inner hull to guard against external threats like icebergs. Designers vowed never to let *Titanic* happen again.

### Underwater Filming

Advancements in the film industry followed parallel tracks: Innovations influenced cameras, lighting and early attempts at adding voice to movement—but filmmakers also explored novel points of view for the lens. For instance, producers of an underwater film positioned camera and operator below the surface in a 4-ft.-wide sphere, connected to a boat by a telescoping tube. Pictures were shot through the sphere's porthole to add a new level of realism.



## 50 YEARS AGO: JULY 1939



### Thrillmakers

Barnstorming just wasn't what it used to be back in its post-World War I heyday. The fair-goer of 1939 wanted nothing less from their stuntmen than the potential for certain death, which left it up to people like Capt. F.F. Frakes to deliver. Frakes's act? Fly an airplane into a building consumed by fire. Our cover story also outlined other death-defying stunts—like back flips into shallow water tanks from 110-ft. ladders and driving motorcycles through plate glass.

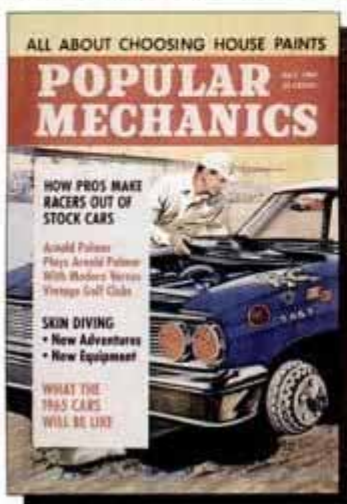
### Futurama

The 1939 New York World's Fair was the talk of the town. And no exhibit elicited such passionate approval as the General Motors Highways and Horizons show, also known as Futurama. A feat of people-moving, as well as futuristic vision, Futurama unveiled a clean and efficient cityscape of tomorrow, where ribbons of highway socialized a developing



nation. Other features included a huge circular aerodrome that made cross-wind landings unnecessary, and a Zeppelin hangar floating in oil so that it could be turned into the wind for takeoffs.

## 25 YEARS AGO: JULY 1964



### All Souped Up

Our cover piece brought NASCAR racing home by explaining how stock-car professionals transformed Detroit street machines into the fire-breathers of the high oval. The key points to these car makeovers involved engine blueprinting, suspension adjustments, frame reinforcements, heavy-duty axles, open exhaust stacks and drilled-out brake drums to promote cooling. This hop-up how-to played well among PM's growing legion of Saturday mechanics.

### Shopwork Fun

Before the days of CD players and RVs, VCRs and BMX, Americans found most of their recreation in their basement shops. And no project fired the do-it-yourself passion of PM readers like the Kid-Powered Squaris Wheel. The foot-propelled assembly offered stable enjoyment for hours. Special braking and locking mechanisms prevented use while parents were away, and safety restraints in each of four bucket seats kept children in their place.





# “Just another brake job? Not to the guy who owns this car. Not to me, either.”

*“You learn real fast in a GM dealership, behind every brake job there’s a person. Someone who depends on these wheels to get around town, go on vacations, take the kids to school. And that person brought their car to this dealership because they wanted these brakes done right. With genuine GM parts. The kind this General Motors car was designed to use.*

*“Just another brake job? There’s no such thing in my book.”*

*Stephen V. Thompson*

Stephen Thompson  
Mr. Goodwrench Service Technician  
Sycamore Chevrolet, Terre Haute, Indiana

Talk to Mr. Goodwrench and you learn very quickly, he’s a career technician. He takes pride in his GM factory training and the skills he brings to the job. So when you’ve got Mr. Goodwrench taking care of your car, you’ve got the freedom to go anywhere, anytime. And isn’t that what owning a car or truck is all about? Whether you drive a Chevrolet, Pontiac, Oldsmobile, Buick, Cadillac or GMC Truck, bring it to the man who knows it best... Mr. Goodwrench.



## Mr. Goodwrench

It's not just a car... it's your freedom.







The 1989 Car of the Year comes with a supercharged 3.8 liter V-6, over 200 bhp, a choice of fifteen options and just one make of tires.

# ONLY ON EAGLES.



A Goodyear Eagle "contact patch." Where an Eagle demonstrates its superiority.

For 1989, the *Motor Trend* magazine Car of the Year is the Ford Thunderbird SC.

And every Ford Thunderbird SC comes equipped with just one make of tires: the Eagles from Goodyear.

Because, as the engineers at Ford know, there really is a difference in performance tires.

It is a difference that ultimately shows itself in the most critical area of all: the "contact patches" of your tires where your car meets, grips, and responds to the road.

During the *Motor Trend* tests, the cars equipped with Goodyear Eagles outperformed the cars with

other tires. In acceleration, in braking, in handling, in cornering force. And in overall ride and drive.

Much of the success of Goodyear Eagle street radials comes from Goodyear's overwhelming success in worldwide racing.

Last year, competing against 12 other tire companies, Goodyear racing Eagles won 83% of the events in which they were entered.

And the knowledge we gain on the track, we apply to our high-performance street radials.

So it's no wonder that Goodyear Eagles are chosen by more car makers for their top-of-the-line performance cars than any other tires.

Or that for five of the last six years, the *Motor Trend* Car of the Year has come equipped with just one make of tires: Goodyear Eagles.

## GOODYEAR

BECAUSE THERE REALLY IS A DIFFERENCE.





# How one air conditioner handled the heat in the toughest challenge of all

by  
General Chuck Yeager, USAF Ret.  
Test Pilot



General Yeager is our nation's most respected test pilot.

The folks at Bryant say they've got a pretty fine air conditioner in their new Reliant. But I don't believe we should take their word for it.

Sure, they built it from top-quality materials, constructed the compressor valves out of hardened steel, the exterior valves from brass, the cabinet from galvanized steel. Then they checked it out and rechecked it out in one of the most sophisticated air conditioner research facilities on the planet.

## Mother Nature's Lab

Next, they torture-tested the Reliant, set it out on the beach and just left it there. That may seem strange but, you see, they figured if it could stand all that salt air, it could stand the conditions in your backyard.

## One More Test

But no matter how much they did in the lab, Bryant's engineers couldn't be really sure the Reliant air conditioner would do the job till it faced a real live challenge.

It had to pass the toughest challenge of all: the Yeager test.

Nothing too fancy, just me, a comfortable recliner and a scorching hot day. See, I don't much care how it did in the

lab if it can't take the sweat off my brow.

Let me tell you, I've tested jets for the Air Force for quite some time and I know high technology and good engineering when I see it.

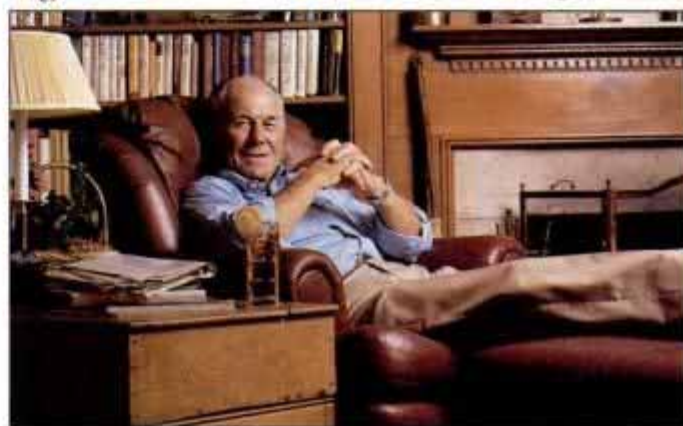
The Reliant undergoing the grueling Yeager test.



Introducing our newest air conditioner, the 1989 Bryant Reliant.



To ensure our air conditioners can withstand the elements, we expose experimental models to corrosive salt air.



And I'm gratified to report that all of the quality of the Reliant air conditioner shows in its operation.

## Thumbs Up

It's quiet (purrs like a kitten), efficient, dependable and built to last. That means it'll get you cool and keep you cool. Where it really counts, the Reliant proves it has the right stuff.

If you'd like to check out the performance of the Reliant for yourself, just stop by your Bryant dealer. For the right air conditioner at the right price, just call 1-800-HOT-SALE.



The right stuff  
to last.

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# TECH UPDATE

\$1495.00

News Of Tomorrow's Technology Today



An-225 lumbers skyward during initial flight testing in the Soviet Union. Rear view (inset) shows deployment of spoilers on touchdown, and new twin tail.

AVIATION WEEK & SPACE TECHNOLOGY PHOTOS

## Antonov An-225 Takes Heavyweight Transport Title

KIEV, USSR—Continuing its dominance in the technology of sheer size, the Soviet Union is flight testing the Antonov An-225, the largest airplane ever to fly.

Unveiled late last year under the name *Mria*, Russian for "dream," the special-purpose craft has already set payload records.

On its 44th flight, it took off from Kiev carrying 344,485 pounds, flew a 1244-mile circuit at altitudes of up to 39,400 ft., and returned 3½ hours later. The plane weighed 1.12 million pounds at takeoff, more than 200,000 pounds short of its maximum. Plans are in the works for a test with the full 551,000-pound maximum payload.

The old record was held by the Antonov An-124 *Condor*, which was first shown in the West in 1985 and had a payload capacity of 330,693 pounds. By comparison, the largest U.S.-made transport plane, the Lockheed C-5B *Galaxy* in service with the Air Force Military Airlift

Command, has a maximum payload of 261,000 pounds, and may weigh as much as 837,000 pounds at takeoff. Boeing's 747-200F freighter can carry slightly less in payloads—250,000 pounds—but holds fuel for a greater range.

Intended to transport the Soviet space shuttle and components of the *Energia* launch vehicle, the An-225 airframe is a stretched version of the 4-engined An-124. Overall length went from 228 ft. to slightly more than 254 ft., and wingspan increased to accommodate two additional Lotarev high-bypass turbofan engines. Large, faired-in external attach points on the upper fuselage are provided to carry the shuttle piggyback, and twin vertical stabilizers at ends of a wide-span horizontal stabilizer supersede the An-124's single-rudder design. The change insures controllabil-

ity even with aerodynamic interference from large external loads. These and other improvements yield a 110,800-pound increase over the An-124's payload capacity for flights of 2800 miles. The An-225's internal cargo bay loads through a flip-up nose section, as did An-124's.

In addition to transporting space vehicles, *Mria* will be used to support construction in resource-rich, but difficult to reach, areas of Siberia and the Far East. There, a high-flotation landing gear system will allow it to use unconventional runways, despite its gargantuan dimensions.

### Highlights This Month

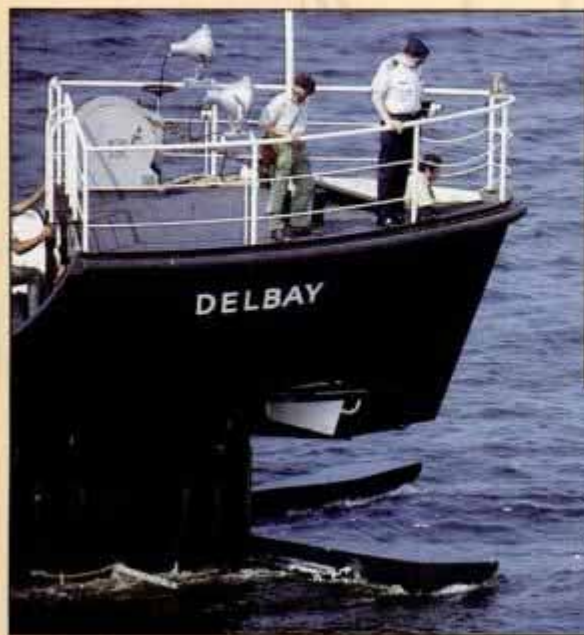
- **Alaskan Oil Cleanup**—New machines aid in the fight to save our shores.
- **New Indiana Jones Thriller**—Lucas film advances the state of the arts.
- **Sport**—Lasers and computers join forces to improve recreational shooting.
- **Battlefield Tech**—Unmanned vehicles and sensor suites for tomorrow's commanders.
- **Mars Probe**—Unique walker on the Red Planet moves on seven legs.
- **Tilt-Rotor**—The V-22 Osprey makes its first (and maybe its last) flight.
- **Nuclear Waste**—New storage techniques.
- **Superconductors**—Solving persistent manufacturing obstacles.

Editor: Tim Cole  
Assistant Editor: Abe Dane  
Contributors: Mike Fillori, Chris Caswell,  
John Fine, William Siuru



\$1121.00

# Special Report: Alaskan Oil-Spill Technology



For widely dispersed spills, the skimmer *Delbay* can be fitted with floating booms (above) pulled by tender boats (not shown). The booms funnel oil toward an opening in *Delbay's* bow (left), where a conveyor belt carries it into the hold. An oil storage barge supplements the skimmer's capacity.

VALDEZ, AK—By the time cleanup teams reached the stricken supertanker *Exxon Valdez* last spring, it was too late to contain the estimated 12.6 million gallons of crude oil that escaped into Prince William Sound.

The job of limiting damage to the fisheries and delicate wildlife of one of Alaska's most beautiful shorelines fell to an irregular brigade of men and machines marshalled by Exxon and the U.S. Coast Guard.

Specialized ships known as skimmers were called to the scene. Looking something like World War II landing craft, they use a V-shaped pair of booms to gather oil into an opening in the bow. There, an absorbent conveyor belt laps up the oil into the hold.

Other removal techniques rely on oleophilic materials that absorb oil and repel water. Loop-shaped mops formed from strings of oleophilic "pompoms" were dragged through the water while being cleaned continuously by power-driven wringing machines. Oleophilic sausage booms are used to surround and sop up slicks.

More conventional booms of plastic or vinyl are a basic tool in oil cleanup operations. Attached to skirts that extend

slightly below the surface, the floating booms can be ringed around large slicks, or may be used to shunt oil carried by moving water into containment areas.

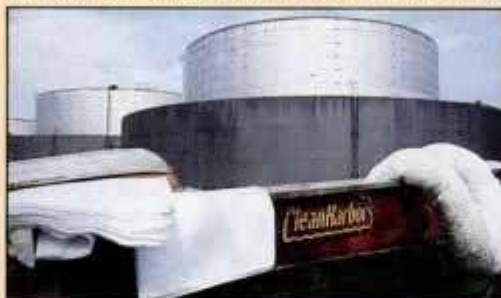
Once rounded up with booms, oil is sucked from the water with surface skimmers attached to explosion-proof, corrosion-resistant pumps made of stainless steel.

An experimental steam cleaning technique has been

applied to the problem of removing oil from the shoreline—with controversial results. Although it's more effective than cold-water cleaning, the powerful steam blasts kill beach life, which may take two years to return. Future cleaning efforts may be aided by better technology, including oil-eating bacteria now being developed by the French petroleum company Elf-Aquitaine. Also, a

recently introduced chemical called Elastol could be used to bind oil into a chewing gum-like state, so it can be easily vacuumed.

For the present, however, cleaning up a spill after containment has failed is laborious and uncertain. The fate of Prince William Sound's ecosystem will depend as much on wind, tides and other forces of nature as on any effort of man.



Sausage boom and pads made of oleophilic fiber absorb oil and repel water.



Oil-saturated oleophilic pads are then removed from water and trucked away.



Surface skimmers pick up oil contained by surface booms and pump it to interim storage tank.



Wringing machine cleans a chain of oleophilic "pompoms", which can be reused.



# SPRAY ON THE POWER.

A dirty carburetor, choke, or linkage can rob your car of some great performances.

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BEST  
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## Laser Firing Range

OULOU, FINLAND—Honing technology already used in games and combat simulators, a high-precision, bulletless training system has been developed for competition marksmen.

The Noptel ST 1000 PC system uses an optical target accurate to within one-tenth of a millimeter to detect shots from a weapon-mounted laser. The information is fed into a personal computer for storage and display.

In addition to eliminating the noise, expense and hazard of live ammo, the system helps coaches by showing the marksman's aim-points be-



PC records fine points of technique for statistical or slow-motion analysis.

fore and after firing. This allows study of breathing and gun-steadying techniques, sighting and triggering times, and follow through.

## Program Integrates Flight Data

SEATTLE, WA—A computer program devised by Boeing could make designing aerospace vehicles a more intuitive process.

Based on the Air Force's Optimal Trajectories by Implicit Simulation (OTIS) program, and Boeing's in-house geometric modeling program, it funnels tremendously complex numerical data into simple graphics.

A ribbon tracing flight path changes color to represent, for example, the pressures or heat loads on a vehicle. At points along the ribbon are 3-D images of the craft that indicate altitude and attitude. The juxtaposition of flight path, engineer-

ing and attitude data, allows engineers to see quickly the best trajectory for a given design.



Ribbon's change in color shows increasing dynamic pressure on hypervelocity plane.

## Sharp-Eyed Sensors Find New Military Applications

NEW YORK, NY—Advances in military sensing technology will make the battlefield of the future a tough place to hide.

A radar small enough to fit aboard an unmanned aerial vehicle (UAV) is now being developed at MIT's Lincoln Labs. Weighing only 100 pounds, the modular radar can see through fog and smoke that would impede infrared or optical sensing.

Downsized from a system weighing 1000 pounds, the radar retains advanced capabilities. From a height of 3000 meters, it scans a doughnut-shaped 15-km radius area, with a 5-km hole in the middle



Hughes multisensor turret sits atop trailer containing signal fusion electronics.

that's continuously filled as the UAV flies a preestablished course. It operates on the pulse Doppler principle, which permits high-resolution ground mapping, and can distinguish between tracked and wheeled vehicles.

To prevent detection and jamming, the radar transmitter has wide-ranging frequency agility, and can cut power in selected sectors of the antenna's sweep. Also, radar data is compressed and filtered on-board, reducing transmission time to the battlefield commander by a

factor of about 1000.

Another project at Hughes Aircraft combines four distinct sensing technologies. It centers around a suite comprising a passive thermal imager, a television camera, a laser rangefinder and a millimeter-wave radar.

Each has its advantages. The thermal imager works well in darkness and some types of smoke. TV is effective at long ranges when visibility is good. Both are passive, and thus difficult to detect. The laser provides highly accurate range infor-

UAV radar discreetly scans battlefield, sending target data to distant commander.

mation. And radar's strength is multiple-point ranging that covers broad areas.

A data fusion processor combines inputs from all the sensors with a digital terrain map, so all available battlefield data can be viewed on a single display. In its present configuration, the system fills a semitrailer, but plans call for a version light enough to fit on military vehicles, including the LHX helicopter.

NOPTEL KY PHOTO

BOEING PHOTO

PM ILLUSTRATION BY DEAN ELLIS



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JUL — AUTO SALE — 89



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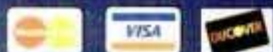
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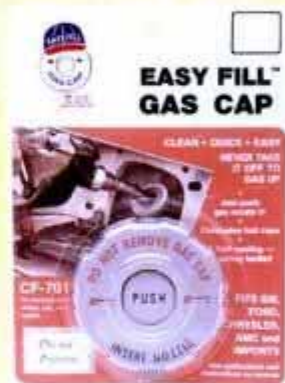
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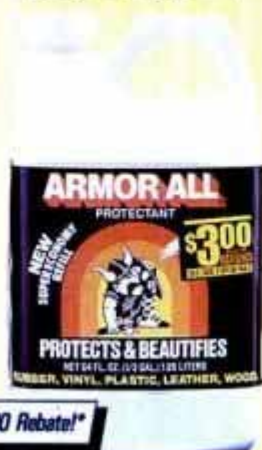
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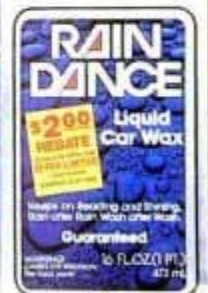
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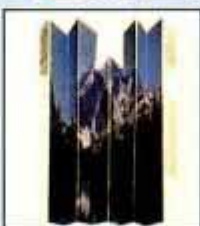


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MARTIN MARIETTA ILLUSTRATION



## Walking Beam To Rove Mars

DENVER, CO—NASA is considering a collapsible, 7-legged T-beam rover for the Mars Sample and Return Mission, scheduled for 1998.

Intended to survive a year of sample collecting, it combines simplicity and energy. **Walking beam uses laser line scanners and foot-pad sensors to navigate Martian surface.**

efficiency with the ability to step over 5-ft. obstacles and bridge crevasses without bogging down in the Martian soil. Conceived by Martin Marietta, the beam walks by sliding its center platform back and forth while four platform-mounted legs and three beam legs alternately retract and extend.

## V-22 Osprey Up In The Air

FORT WORTH, TX—Shortly before being dropped from the defense budget, the world's first tilt-rotor production prototype got off the ground.

In a 2-week period, the V-22 Osprey accumulated 2.3 hours of helicopter-mode flight time, achieving speeds

of 60 knots and altitudes of 600 ft. Although it performed well, Defense Secretary Cheney ordered funding stopped for Bell Boeing's nearly completed development program. Efforts to revive Osprey, which had been scheduled for delivery in 1992, continue in Congress.



Osprey hovers in first flight at Bell's Flight Research Center, Arlington, Texas. In airplane mode, it was expected to top 250 knots.

BOEING PHOTO

## Fusing Dangerous Weapons Refuse Into Glass

NEW YORK, NY—For more than 30 years, a vile brew of toxic chemicals and radioactive waste has been dumped around Department of Energy weapons manufacturing installations. Cleanup costs could top \$100 billion.

Now the DOE is investigating technologies that could turn acres of the most badly poisoned soil into glass.

The simplest of the tech-

niques is called in-situ-vitrification (ISV). Developed at Battelle Pacific Northwest Laboratories, it can fuse large blocks of soil into an obsidian-like mass without removing them from the ground.

Molybdenum graphite electrodes up to 40 ft. long are driven into each corner of a square area. Starter paths of powdered graphite and glass grit are laid in inch-deep

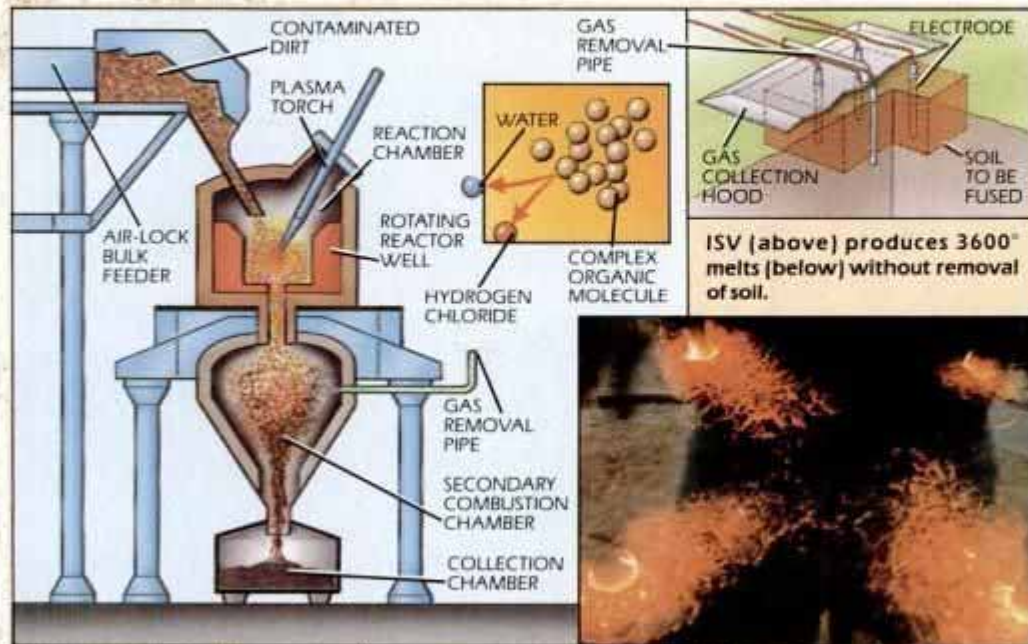
furrows between the electrodes and are covered with a gas collection hood. Then 4000 volts are applied to the electrodes at 400 amps, heating the soil to 3600° F.

The tremendous heat melts rocks, soil, metals and radioactive materials. Inorganic contaminants are incorporated into the molten mass, and organic pollutants are pyrolyzed, or broken

down into simpler components. Some bubble to the surface and burn. Resulting gasses are drawn off through the hood to be cooled, scrubbed, filtered and chemically treated before release.

Up to 1000 tons of soil could be glassified in a single melt. A Battelle spinoff called Geosafe is now manufacturing ISV units built into trailers for transport to waste sites. If contaminants are buried too deep for ISV to work, a gas plasma reactor may be used. Polluted soil is fed gradually into a water-cooled, air-tight vessel, where it falls into a rotating steel well. A plasma torch, essentially a water-cooled electrode, forms an arc against the well wall. This turns oxidizing gas inside the vessel into plasma and heats the soil to about 3000° F.

About a ton of soil is fed into the reactor over a period of an hour. Then the feeder stops and processing continues for about 5 minutes. The molten soil is released into a secondary chamber where nonmineral wastes burn off and gases are vented to a scrubber. The end product is a vitreous slag molded into ingots for storage.



Plasma reactor (above) and ISV pyrolyze complex organic molecules (top center).

PM ILLUSTRATIONS BY HANK IKEN; GEOSAFE PHOTO



\$1086.00

## Making Superconductors Work

SACRAMENTO, CA—Problems in forming useful shapes from yttrium-barium-copper oxide (1-2-3) superconductors may be solved with a technique developed for the manufacture of advanced ceramics.

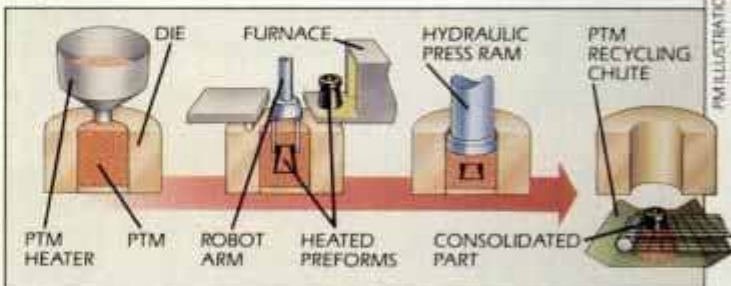
Like powder metals, 1-2-3 materials need to be condensed into solid parts after being pressed into shape. Good results have been achieved with a technique developed by Ceracon, Inc. It uses a proprietary granular pressure transmitting medium (PTM) to squeeze part preforms at controlled

temperatures and pressures that align the crystalline structure.

In tests, parts consolidated to 98-percent density have retained superconductivity up to -265° F.



PTM pours from grain heater into die.



Four-step process produces fully dense parts ready for finishing.



Robot arm inserts cold-pressed preform in PTM after heating in furnace.

## Great New Indy Jones Special Effects

SAN FRANCISCO, CA—In bringing just-released "Indiana Jones And The Last Crusade" to the screen, Lucasfilm's Industrial Light and Magic division performed some of the most sophisticated special effects yet.

In one scene, Jones (Harrison Ford) and his father (Sean Connery) are chased by a Nazi warplane. Their car ducks into a tunnel, but the plane, unable to turn, follows them. Its wings tear off and exploding fuel fills the tunnel. Tension mounts as the wingless plane gains on them.

To make the sequence,

1/5th-scale models were used, because fire can't be miniaturized realistically. Models and camera ran through precisely synchronized paces on a 220-ft. platform similar to a giant slot car track partly covered by an aluminum foil tunnel.

An electric motor spun shafts and pulleys that moved models and camera.

Photos of Ford and Connery were shot against a blue screen background and then superimposed on the tunnel footage. Motion control photography of a small model was used to create the

plane's flight before entering the tunnel. The entire sequence takes less than 60 seconds to watch, but required more than three months to film.

In another scene, a character ages in seconds to a fully decayed skeleton. A latex mold of an actor's face was fitted with hard-wired radio-control servos and stepper motors to produce lifelike movements. Vacuum bladders under the skin were deflated to hollow out the cheeks, and the eyes rolled inward to pull the surrounding skin into the skull.

FACE CONTAINING RC SERVOS AND VACUUM BLADDERS



STEPPER MOTOR FOR VERTICAL HEAD MOVEMENT

STEPPER MOTOR FOR HORIZONTAL HEAD MOVEMENT

MOTION CONTROL MODEL MOVER



MODEL PLATFORM

CAMERA DOLLY SLOT

TACHOMETER

CAMERA PULLEY

CAMERA DRIVE BELT

PLANE-PULLEY DRIVE BELT

15-HP MOTOR

Donovan model (above) is moved by multichannel computer control. Repeated test runs (below) were performed on fire tunnel platform before all was ready for a pyro specialist (left) to prep the plane to burst into flames.



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AIRPLANE MODEL

PLANE PULLEYS

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# ELECTRONICS

BY STEPHEN A. BOOTH

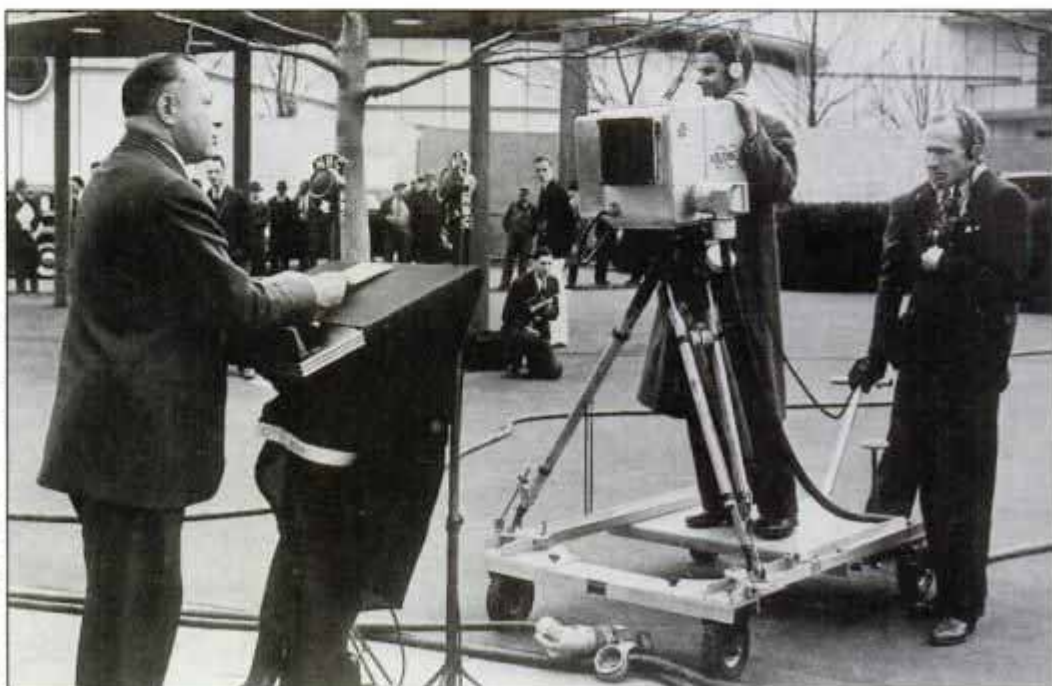
## Television—Past And Future

**A**CCORDING to eyewitnesses, the bright but overcast sky supplied perfect lighting. Posed in front of the first all-electronic camera was General David Sarnoff, president of RCA and pointman for what he then called "a new art" that added "radio sight to sound." It was April 20, 1939, opening day of the World's Fair in Flushing, New York, and also the birthday of commercial television broadcasting.

NBC—an RCA subsidiary—carried the General's speech live to some 200 televisions in the New York area. Regular broadcasting began shortly thereafter, and an amazing 1000 receivers were sold in the U.S. that year. Screens were small—about 5 in. across—although a "giant" 12-in. model was available. It could be argued that this was the first projection TV, in that the image viewers watched was reflected off a mirror.

TV has come a long way in the past 50 years. Telecasts that once were limited to a small radius around NBC's Radio City facilities now can be beamed around the globe via satellite. The sets that receive the broadcasts have changed, too. Today, tube models three times the size of 1939's giant are available. Projection monitors come even larger. At the opposite extreme, color TVs with liquid-crystal display screens can fit in your pocket. And the best is yet to come.

Even before TV's debut at the '39 World's Fair, science fiction envisioned flat display screens that resemble a picture frame suspended on a wall. These marvels are easy enough for comic-book writers to produce—so long as they don't have to actually build them. None of these



On April 20, 1939, RCA's General Sarnoff (above left) launched the TV age with a live NBC broadcast from the New York World's Fair. Today, videophones both with color and motion are in development, such as the Matsushita prototype (left).

sets has materialized over the past 50 years. It's not that engineers lack imagination, but practical constraints such as materials often put a brake on our dreams.

In engineering circles, flat-screen TV is always "five years away." That was still the case three years ago this month, when we reported on the subject ("Futurevision," page 67, July '86). Some recent developments indicate that, finally, there's some substance to the statement.

Matsushita Electric, parent of the Panasonic, Quasar and Technics brands, recently celebrated its 70th anni-

versary with an exhibition of the company's latest technology, including some works in progress from its research and development labs. Tucked among the more than 200 exhibits shown in Tokyo—everything from succulent strawberries the size of tennis balls to the full-motion color videophone shown here—was a new way of displaying images that holds big promise for flat-screen TV.

Matsushita calls the technology beam-matrix. It combines the high picture quality of conventional tubes with the active-matrix system used to address each picture element in an LCD screen.

This should not be confused with beam-index TV—a technology pioneered by Philco in the 1950s and used today in portable TVs and airline-seatback displays.

Beam-index sets still use an electron gun, though it's bent nearly parallel to the screen to save depth. Matsushita's beam-matrix system dispenses with the bulky gun. Instead, a grid pattern (or matrix) of electrodes controls each phosphor pixel on the tube's screen, in a manner similar to the active matrix that controls the liquid-crystal shutters of LCD sets.

The 6-in. beam-matrix TVs that were shown measure only 2.5 in. deep—and the technology can be applied for even larger screens. Indeed, a 16-in. model was only a quarter-inch deeper. Beam-matrixing has been in the works for 20 years at Matsushita and, in fact, is the company chairman's pet project. So don't be surprised if you see it soon—and not in a comic strip.

*(Please turn to page 22)*



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## ELECTRONICS

(Continued from page 20)

### Portable Office

Photocopying used to be limited to large, stationary machines for the office. Now, you can fit one right in your pocket.

Sony recently unveiled a line of Personal Automation products designed for folks who must do clerical tasks away from familiar office-support systems. The crown-jewel of the line is the HCP-C10 copier (\$160), a portable unit that measures 3 × 4 × 1 in. and weighs less than 5 ounces, including its rechargeable battery.

To use the copier, you pass it across a 1-in.-deep strip of text up to 8 in. long. The text is stored in memory, then printed out when you roll the unit across a piece of plain paper. The thermal printing ribbon is good for 60 ft. of 1-in. text, though the battery needs recharging after 33 ft.

A memory function in the HCP-C10 enables it to store a 1 × 8-in. block of text, for repeated printing. This saves you the trouble of rescanning the copy multiple times. You can, meanwhile, scan and print new blocks of copy while the memorized block is on hold.

Sony also has introduced a smart tape recorder. The TCM-27 (\$160) records the time, date and subject of a recording and displays the information on its LCD screen—and has an index feature that lets you zip to a marked portion of a tape without searching by ear. It also acts as a musical alarm clock.



Sony's HCP-C10 [above] is a pocket-size, battery-powered copier that stores images for reprinting on plain paper. The new tape recorder displays the time, date and subject of recordings you make [below].



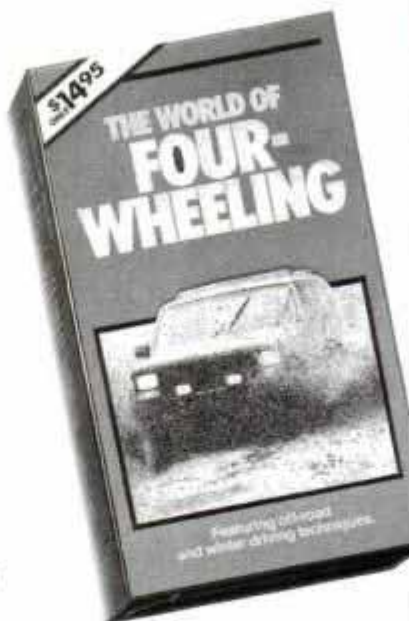
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Cutaway of cellular phone (above) shows Duracell's hybrid battery. It uses flat zinc/air cells (below) to power phone in standby mode, recharge the NiCd battery used for transmitting and eliminate AC recharging.



### Longer-Lasting Power

Portable cellular telephones use rechargeable NiCd batteries that usually provide about an hour of talk-time per charge. Now, a hybrid battery developed by Duracell could extend the length of service 14 times.

The new design couples a battery of high-energy-density zinc/air cells to the NiCd. The zinc/air discs provide power while the phone is in standby mode, reserving NiCd power for actual transmission. In the meantime, the zinc/air portion recharges the NiCds, thereby eliminating the need for AC recharging. When the zinc/air portion of the system signals that it's exhausted, it is simply replaced. Duracell says the new system should go into production soon.

### History Of TV

There are many things of interest in Washington, D.C., but if you're interested in electronics and vacationing in the nation's capital, you ought to visit the TV exhibit at the Smithsonian Institute's National Museum of American History. It's called "American Television from the Fair to the Family, 1939-1989" and runs through April 1990. Call (202) 357-2700 for information. **PM**



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# IMPORTS

BY BILL HARTFORD

## Tops Of The News

**A**S SOON as the sun was high enough in the sky—in mid-April—we wanted to put the top down and drive every model in the latest sports car pecking order. But the lineup of 1990's roadsters is still taking shape, with the top guns putting the final touches on their power-top models and other carmakers still on the drawing board.

We did get a ticket to ride where the fun begins—at the \$15,000 mark, in the MG Midget of the '90s, the thoroughly modern 2-seater that redefines the ragtop.

### Mazda Miata

Driving the electric blue MX-5 Miata with the top down was an extraordinary way to scurry into spring. "If the car were black, it would be a cockroach!" is what the amused driver of a van shouted down to us, referring to the Miata's minuscule dimensions. Its size is only part of its charm, while handling, performance and ergonomics are the biggest joys, even in the not-quite-perfect prototype that we drove.

Right about now, with



Top is electrically operated on the 3-liter, 16-valve Porsche 944 S2 Cabriolet, due here as a '90 model.

June busting out all over (this issue of PM reaches subscribers and newsstand buyers by June 15), some lucky people are taking delivery of their MX-5s. That's because they committed a deposit of about \$1500 last winter, before even seeing the car in the metal. It's likely many were PM readers who saw first photos of the Miata in our March issue ("The Rites Of Spring," page 61). The line has been out the door ever since—and if you're on it, we can tell you that the Miata will be well worth the wait.

While Mazda has a lock on the affordable sports car, the automakers near Stuttgart have their own ideas about what a luxury roadster should be. If you want to go

out and play on the autobahn, you've got to have a lot of car at your command.

### Porsche 944 S2 Cabriolet

The 208 hp that moves this 944 is cranked out of the same 3.0-liter, 16-valve Four found in the S2 Coupe. While we wait to drive the Cabrio, we already know that it will do everything it's supposed to from the test drive Assistant Auto Editor Mike Allen made last year during the S2 Coupe's introduction in Europe. Flat out is indeed 149 mph, just as the Porsche's performance specs say. And it's rock steady at that speed as Mike discovered while flashing a clear path down the autobahn between Stuttgart and the Swiss border.

As you'd expect in this potent Porsche, the top is power operated. And the price tops out the 944 lineup: Unless suggested list is adjusted up or down after this writing, it will be \$52,650. Sticker shock for Porsche buffs was softened recently, when 944s were reduced about \$3000 across the board. The 944 starts at \$33,245, the S2 Coupe at \$41,900 and the Turbo at \$44,900.

Except for the \$10,000 premium to have no roof over your head, the S2 Cabriolet and Coupe are mechanically identical and share specs—like 0-60 mph in 7 seconds. If you reverse that, and do 60-0 mph in less than a second, there are (to supplement the 3-point belts) air bags for driver and passenger.

### Mercedes-Benz 500 SL

The special day is almost here—when Mercedes-Benz hands PM the key to its all-new 500 SL for a first test drive. The last SL intro was 18 years ago. Summer '71. Hockenheim road circuit, Germany. The 350 SL was replacing the 280. Priced at what was then a tough-nut \$10,000, the U.S. version had a sohc, 4.5-liter, 230-hp V8. On the straight at Hockenheim, we consistently saw 124 mph. After many laps, we noted (in "Car Without Compromise," page 58, Oct. '71) that the SL has "an extraordinary balance of performance, style and safety." As of now, we've only seen the 500 SL—at Geneva, where it intrigued our eye and intellect. We'll have to wait to see if it astounds our senses when we discover its performance firsthand. That report is coming soon. **PM**



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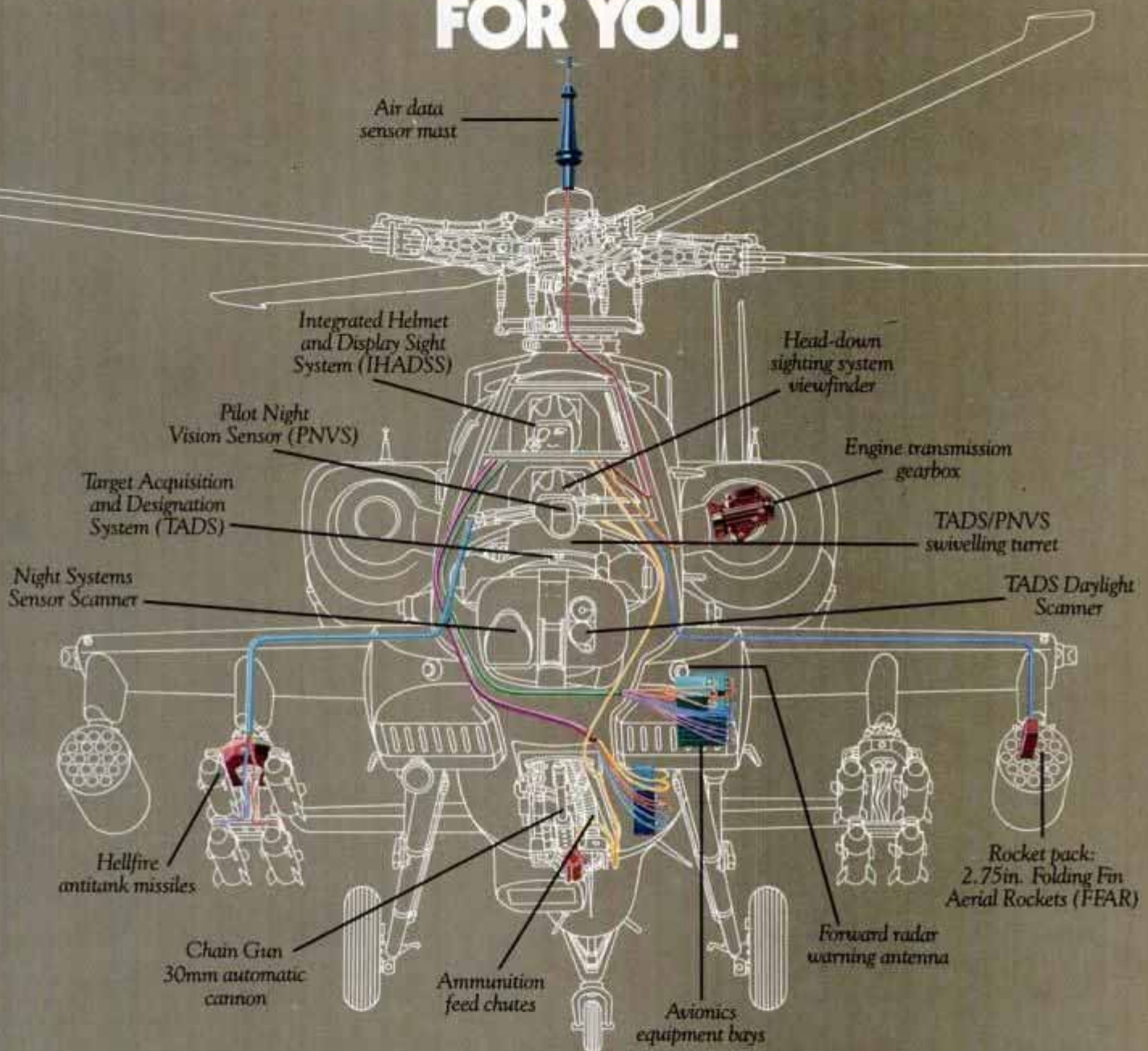


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## Where Were You In '69?

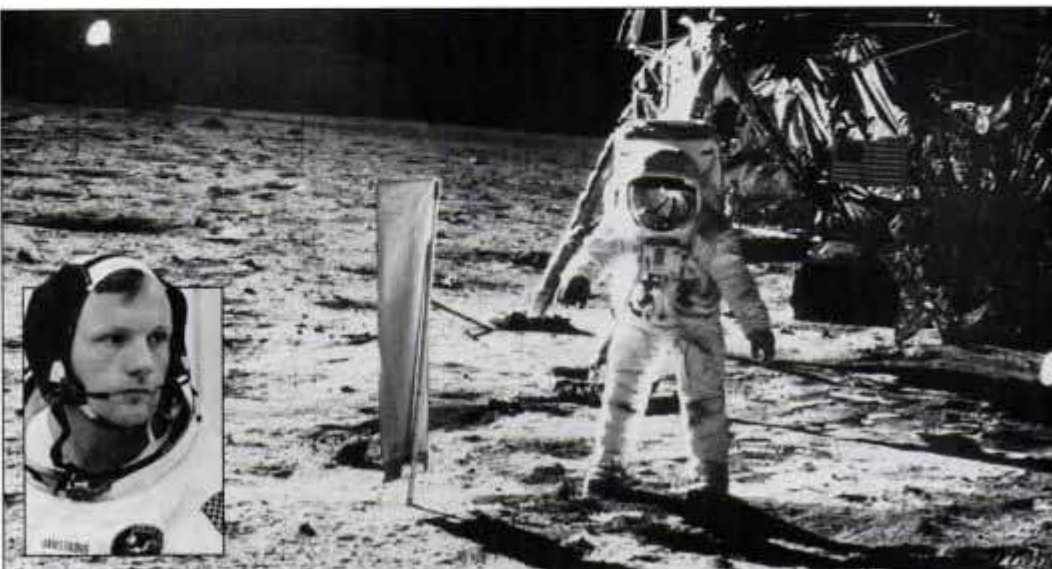
**I** WAS CAMPED with 5000 other Boy Scouts at a national jamboree in Coeur d'Alene, Idaho. One of the scoutmasters cranked up a portable generator. Another brought out a dilapidated black-and-white TV, and 150 of us jammed a mess tent to watch Neil Armstrong take a giant leap for mankind.

The last 20 years since the achievement of *Apollo 11* haven't been as ambitious. Funding cuts in the Nixon Administration severely stunted later *Apollo* flights to the Moon. The industrial tooling for the mighty *Saturn 5* rocket—capable of lofting a record 270,000 pounds that stands to this day—has all been lost. In fact, some say NASA can't duplicate this heavy-lift capability because they can't even find the plans.

The Space Shuttle has been underfunded since its inception, sowing the seeds, it's been alleged, for the *Challenger* disaster, an event that very nearly signaled the end of America's manned exploration of the final frontier. *Spacelab*—a space station every bit as capable as the Soviet *Mir*—was allowed to degrade in orbit and eventually burn up over Australia. Brilliant planetary explorations using *Pioneer*, *Mariner*, *Viking* and now *Voyager 2* have kept America's reputation as a space-faring nation afloat.

### Now what?

I recently attended a meeting at Princeton University sponsored by the Space Studies Institute. The assembled panelists tried to predict the next 20 years of America's space effort. They included Harrison H. Schmitt, the lunar module pilot on *Apollo 17*; Freeman



*Apollo* pioneer Neil Armstrong (inset) and Buzz Aldrin on the lunar surface with LEM Eagle.

Dyson, a faculty member of Princeton's Institute for Advanced Study; and Alan Ludwig of NASA's Office of Exploration. Their conclusions? The Ride Report and other NASA position papers give coherent direction to the next two decades of space exploration. Budget hurdles—not necessarily technical ones—and our national will may determine whether or not we take the next leap.

Consider the possibilities: In a building block manner, the assembly of Space Station *Freedom* in low-Earth orbit will permit a base from which permanent installations on the Moon can be established to extract its considerable resources. A voyage to Mars remains the high ground. Satellite arrays will reveal critical information about the environmental health of our home planet and about our life-giving Sun. Semiautonomous probes like *Magellan*, *Galileo*, *Cassini* and *CRAF* will build on knowledge already gained by the indefatigable *Voyager 2*, scheduled for a Neptune fly-by next month. The Great Observatories—including

the visible light Hubble Space Telescope scheduled for Shuttle deployment this year—will gather other light frequencies to help us further define our universe.

That's all been in the news for the past couple of years. But Schmitt and Representative George Brown (D-Cal.), who was on hand to present a succinct and sobering status of the space budget, had the most to add, lending a keen perspective on our space goals.

Schmitt says the next 20 years will bring not just missions of space exploration, but missions of global survival. "The Millennium Project will be a threefold, integrated mission to Earth, Moon and Mars," he asserts.

The first two parts—missions to Earth and the Moon—are easy to fathom. We must learn more about Earth's beleaguered biosphere if we're to wriggle our way out of man-induced environmental crises. But, Schmitt argues, the mission to the Moon will play a significant role in the continuation of Earth and all its diverse species.

### Lunar tunes

The light at the end of Earth's environmental tunnel may be the untapped, virtually unlimited resources of the Moon in the form of fusible helium 3, oxygen for fuel and lunar regolith suitable for space construction.

Returning to the Moon to extract these resources, and then returning the materials safely to Earth orbit, could supply us with space-based solar power arrays, and sufficient construction material to build micro-gravity manufacturing colonies in space.

As Schmitt sees it, studying Earth and establishing a permanent outpost on the Moon may no longer be a matter of exploration, but a matter of urgent environmental necessity.

So what about Mars? Schmitt's perspective is grounded in the altogether human instinct—and therefore the human need—to settle and civilize the world and now the universe. He sees an important link between our physical needs and our psychological needs in this respect. He wonders, as I do,



what will become of us if we choose not to meet the hard physical and intellectual challenge of peopling another planet.

### Budget priorities

Congressman Brown, a self-described space nut, lauded the vision shared by Schmitt and other panelists. But he also described a dark and forbidding world—namely the U.S. Congress—that still needs exploration and understanding.

“Pending before Congress is an Administration request for a 22-percent increase in the NASA budget for FY 1990. In the same light, Congress and the Administration will have to find \$41 billion (or nearly four times NASA's current budget) in real reduction in current federal spending to meet the funding targets of the Gramm-Rudman deficit reduction law. No matter how you look at it, the NASA budget is an easy target for Congressional budget cutters looking for places to trim.”

Brown foresees numerous attempts to place the burden of federal budget deficit reduction efforts on NASA's shoulders. He also sees immense harm to the future of America's space efforts if current cutbacks are approved.

In the end, Brown and Schmitt argue, the American public will have to make the difficult choice of whether this country's destiny lies in great leaps through space—or whether America will become a space also-ran.

### Cold-Fusion Debunked?

The possibilities are mesmerizing. Power derived from the amount of deuterium in a gallon of sea water—roughly  $\frac{1}{250}$ th of an ounce—assumes the rough equivalence of 300 gallons of gasoline. Looking at it another way, the top 10 ft. of Lake Michigan supplies the energy needs of the entire United States for the next 15,000 years.

Such speculations are the result of the feverish effort to duplicate the cold-fusion reaction reported by B. Stanley Pons of the University of Utah and Martin Fleischmann of the University of Southampton on March 23.

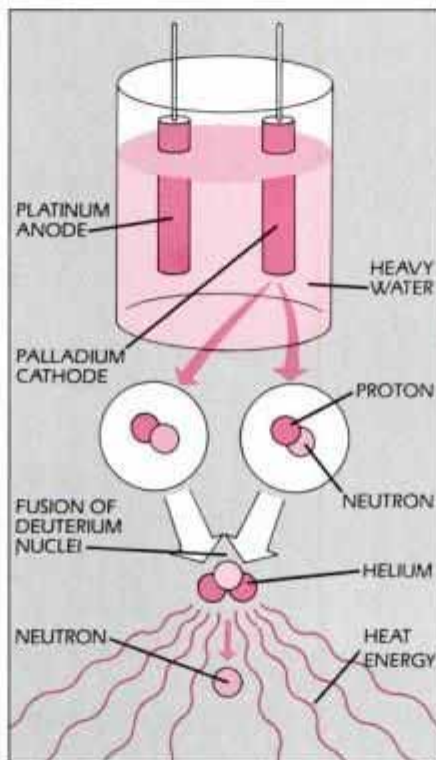
Fueling arguments as this was written in mid-May were sketchy reports from such diverse quarters as Italy, the Soviet Union and Texas A & M that key elements of the Pons-Fleischmann experiment (diagram) had been successfully duplicated—a crucial process in separating science fantasy from fact.

There were also numerous calls—particularly from America's physics community—that cold fusion has not been properly developed. Scientists from MIT cite crucial errors in the Pons-Fleischmann methodology and equipment. Still, something's happening in the world of electrochemistry. But is it fusion? You can sort out the claims as

they unfold in the daily newspaper by watching for mention of a detectable neutron emission, a key indicator of a nuclear fusion reaction.

### More questions

Skeptics report that the Pons-Fleischmann cell falls far short of generating the quantity of neutrons that would be present with a legitimate fusion event. Teams attempting to duplicate the experiment—particularly at Texas A & M and Stanford—report extremely high heat, but very little detectable neutron emission of the type that would accompany fusion. Pons insists, however, that the palladium electrode yield of 20 watts per cubic centimeter is higher than any known chemical reaction can produce. So, the Pons-Fleischmann theory goes,



The Pons-Fleischmann experiment consists of a simple electrolytic cell using a palladium cathode and platinum anode in a heavy-water solution. Energy input produces thermal output, helium 3 and, presumably, a healthy dose of neutrons.

it must be fusion. In fact, it may be a completely new type of fusion reaction similar to the unique fusion reaction produced by Steven Jones of Brigham Young University, as reported recently in *New Scientist* magazine. Jones is experimenting with a cold-fusion technique that uses subatomic particles called muons as a reaction catalyst—much like lasers and ion cyclotrons are used in more traditional fusion settings.

So watch this space. Whether or not PM ever presents instructions on how to build a fusion reactor in your backyard is highly questionable. But cold fusion, at the very least, gives us insight into the ways of the scientific world. **PM**

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# OUTDOORS

BY JOE SKORUPA

## Showboating In Biscayne Bay

**T**HE plan was to enter the Miami International Boat Show by boat, the only appropriate entrance for someone in my field. The boat was a Boston Whaler with a confidence-inspiring name—*Defiance*.

The *Defiance* is an interesting departure for Whaler. It's longer (36 ft.) than anything the company's ever built and it's made of aluminum. Boaters can expect to see these seamlessly welded vessels as patrol boats in the next couple of years.

Keeping pace with the *Defiance* on the ride down from Ft. Lauderdale was another new Whaler, a 25-ft. walk-around. It was interesting to watch its hull from my bow-on view. As it crashed through a wave, water rushed up to the reverse chine, which on a Whaler is deeply cut around the bow. When the water struck the chine, it abruptly changed course and was deflected away from the boat.

In addition to cockpit dryness, the boat maintained impressive stability in rollers and tracked beautifully while surfing down waves in a following sea.

Over the next couple of days I tested a number of new products, but the most interesting news was a rumor that OMC was ready to introduce a new propulsion system intended to become its stern-drive engine of the 1990s. This turned out to be true and I soon received an invitation to give the new unit a test drive.

What distinguishes the new OMC engines and vertical drives from earlier units is a synthesis of high-tech and user-friendly design elements brought together in a beefed-up package.

The name OMC King Cobra has been given to the new



Donzi Black Widow, which gave us a 70-mph ride, struts its stuff at the Miami boat show.

units, which have the following components: 1. *Spitfire ignition system*, which automatically adjusts timing to eliminate knock, 2. *Cone clutch*, which reduces slippage and increases torque transmission, 3. *Electrical connection center* with circuit breakers and a single wiring harness for all leads, 4. *Diagnostic plug-in receptacle* enabling service shops to use diagnostic computers.

Other friendly design elements include: a shift system center, which puts the standard-drive/counter-rotation adjustment on the engine,

Holley carburetor and high-mounted oil and fuel filters.

I tested a new 454-cu.-in. King Cobra in a slick Donzi Z25. A flip of a switch shifted fuel delivery from high-octane to low-octane gasoline, and, true to its billing, the King Cobra refused to knock. The OMC King Cobra package is available with 7.4-liter and 5.7-liter Chevrolet blocks and 7.5-liter Ford block.

The Miami boat show is a boat tester's bonanza, so here are a few impressions from the best of the test:

*Donzi Black Widow*—This

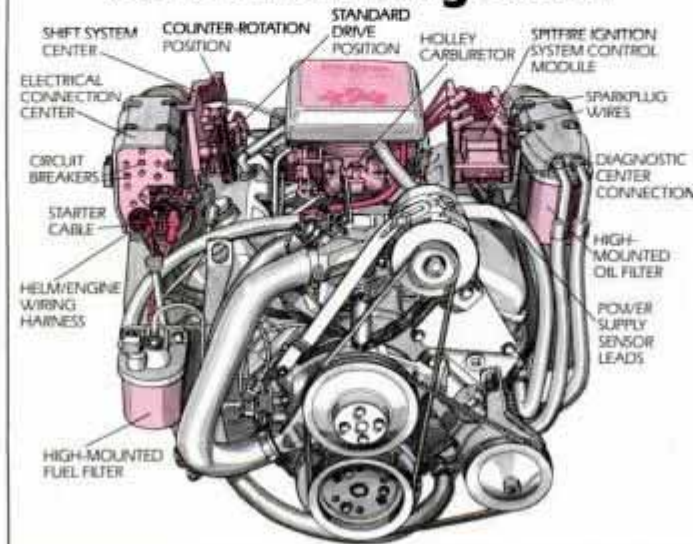
is the first of a new line of muscle boats from Donzi. It measured just under 30 ft. in length and was equipped with twin 340-hp OMC Cobra engines. The black hull scorched the water at 70 mph and turned heads with its stiletto nose, sleek stylings and roomy, luxurious cabin.

*Monterey 80 Sportfisherman*—I was lucky enough to get a high-speed run on the world's fastest sportfisherman, the 80-ft., \$5.25 million *Renegade*. The 65-ton battlewagon, which is equipped with twin MTU diesel engines producing 7000 hp, is capable of 55-mph top speed and definitely snaps your head back when the throttles are punched open.

*Cobalt Condurre 263*—The Cobalt name has been added to a 26-ft. cruiser and the result is an exercise in excellence. The new Condurre has rich styling, ample accommodations and a smooth-handling deep-V hull. The boat I ran was equipped with twin T-271 Volvo Duoprops—an ideal match for a boat reminiscent of a European luxury sedan.

I tested more boats, water toys and marine gear at the Miami show than I can fit in this space. But, hey, somebody had to do it. **FM**

### OMC's New King Cobra





**NOW! Training includes XT-compatible computer plus NRI's remarkable Robotic Discovery Kits!**

# Get training for industry's hottest new jobs as you build and program complete robotic control systems

Now you can get the skills in demand for the new jobs in industry today. With NRI's new at-home training in Robotics Technology, you actually build a fully IBM XT-compatible computer, then use it to program and control working robotic systems . . . each one engineered to recreate the exact operations performed by the robotic equipment found in today's industrial workplace.

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**Robotics comes to life as you see real-world industrial control principles in action**

Your NRI Robotic Discovery Kits come complete with everything you need to create working, moving robotic systems. You get structural members, motors, gear drives, sensors, scanners, potentiometers, plus a special Robotics Interface that links the robots you build to your computer.

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knowledge of electronic circuits and components as you experiment with your NRI Discovery Lab® and professional digital multimeter.

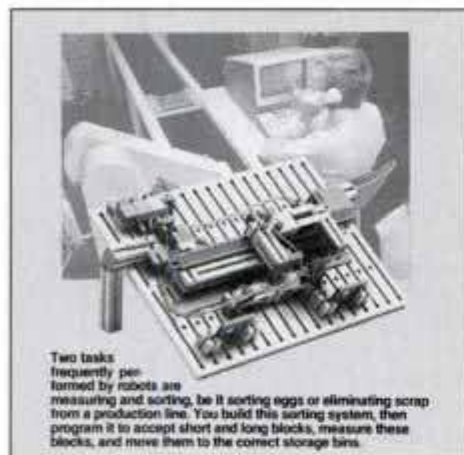
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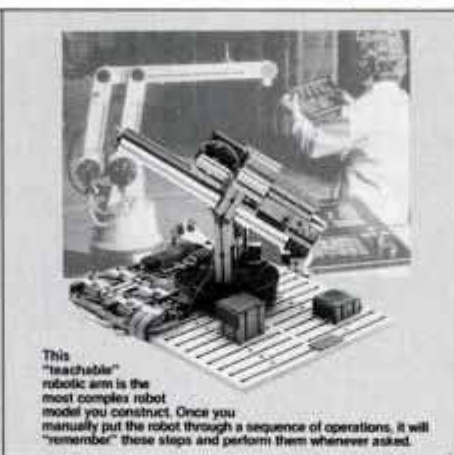
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If the coupon is missing, write to: NRI School of Electronics, McGraw-Hill Continuing Education Center, 4401 Connecticut Avenue Washington, D.C. 20008



Two tasks frequently performed by robots are measuring and sorting, as in sorting eggs or eliminating scrap from a production line. You build this sorting system, then program it to accept short and long blocks, measure these blocks, and move them to the correct storage bins.



This "teachable" robotic arm is the most complex robot model you construct. Once you manually put the robot through a sequence of operations, it will "remember" these steps and perform them whenever asked.

the job or start a new career as a robotics and industrial control technician.

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automation systems, programmed by you to do the types of operations and tasks performed in today's industrial environments. Tasks such as plotting polar coordinates to create graphic displays of numeric data . . . sorting different size objects and routing these objects to separate containers . . . even performing a preprogrammed sequence of operations again and again just as robots now do on manufacturing lines.

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# CAR CLINIC

BY MIKE ALLEN

## They Call It The Wanderer

**T**HE FRONT tires on my new Buick Regal aren't wearing uniformly, and the car wanders somewhat as it drives down the road. Three different alignment shops have told me that I need to have the rear end aligned as well. They say that 99 percent of new cars are like this. I never heard of this before.

What gives? Fact or fraud on the part of the alignment shops? Bad manufacturing/assembly?

A.A. PETILLI  
PARMA, OH

*It's not fraud or bad manufacturing. Back when the rear suspension of cars was based on a solid rear axle that weighed 200-plus pounds, and was as strong as a bridge truss, rear-wheel alignment*

*was rare, but even then not unheard of. The only adjustment possible was to be sure the thing pointed straight-ahead.*

*Modern cars, with front-wheel drive, have rear suspensions that are much lighter, often independent, and adjustable individually for toe-in and sometimes also for camber. They aren't necessarily more prone to damage, but they should be checked periodically. Be sure the alignment shop has a proper 4-wheel alignment rack, so all four corners are checked together.*

### Oil Dilemma

My '88 Suburban only gets about 1500 miles to a quart of oil, which I find most distressing. My last GM car, a '79 Caprice, would go the en-

tire distance between oil changes without using any oil at all, but this thing needs 4 quarts between the 7500-mile intervals. I expected the oil consumption to improve after the break-in, but by 15,000 miles, it seems that this is what I'm going to get. The dealer says this is normal, and GMC won't warrant any repairs.

LEROY THIBODOUX  
SIOUX CITY, IOWA

*All engines use some oil—if they don't, the oil isn't getting to places where it needs to be, like upper cylinder walls and valve guides. Fifteen hundred miles/quart is a little high, but not excessive, and I agree that it's not likely to change any—up or down.*

*If oil consumption on your other car was truly nonexistent, I'd be concerned about fuel dilution. Oil analysis would probably show the presence of unburned gasoline, which would increase the volume of oil in the crankcase, fooling you into thinking there wasn't any consumption.*

*If your Suburban has an otherwise clean bill of health, doesn't leak any oil (which the dealer should fix), then don't worry. And if you change oil at 3000-mile intervals as we've been stressing in PM for years, you'll only have to add 1 or 2 quarts between changes instead of four or five.*

### Play Misty For Me

My 1988 Mazda 626's air conditioner blows some sort of mist out of the dash vents on humid days. This happens whether the air recirculation lever is in the outside air or recirculate position. The dealer says this is normal. Please advise.

LOUISJ. CORRADO  
FARMINGDALE, NY

*Car owners seem to be automatically suspicious of anything unusual that the dealer describes as normal, but in this case the dealer is correct. Any vehicle will blow water vapor out of the a/c vents under the right conditions. Air can't hold as much moisture when it's cooler—that's why there's a tray to collect moisture dripping off the condenser fins, and a hose to dump the runoff outside the car. That's the water you see puddling underneath idling vehicles on hot days.*

*If you set the vent to recirculate, in a few minutes the air inside the car should dry out some, and the vapor will stop.*

### War Whoop

The radiator fan on my new Cheyenne pickup makes an annoying roaring sound every time it's revved up. The dealer replaced the fan clutch under warranty, but if anything, the roaring noise is louder than before. The service manager says that it's characteristic of that model. Mike, is there anything I can do, even at my own expense?

JOSEPH DANTINO  
WATERBURY, CT

*Fans (and cooling systems in general) have to be sized for the worst-case conditions, and that means using enough blade pitch to move a lot of air at idle—which causes a roaring sound at higher revs.*

*The fan clutch is supposed to keep the fan turning at close to engine speed at idle or at low speeds, but let it lag when the truck is moving. Are you complaining about noise at freeway speeds (which would be abnormal), or just in the driveway (which is normal, even if it is annoying)?*

*You might try replacing the entire fan and clutch assembly with an aftermarket*  
*(Please turn to page 38)*

### A Simple Extraction

We're seeing a lot of engines with aluminum heads, and increased intervals between tuneups. Both of those phenomena make for difficult extraction of plugs—at least without bringing the threads out of the heads along with the plug. Then you've got big problems. Two things: First, let the head cool off, and shrink down before you remove or install plugs—putting nice new (and cold) plugs into a hot head will make it tough to pull them later when they're both the same temperature.



Second, use some antiseize compound, like Never-Seez or Loc-Tite Anti-Seize on the threads. Use sparingly and well away from the electrodes, as this stuff is electrically conductive. And use a torque wrench to tighten the plug.





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You'll get astonishingly fast starts on cold mornings with both diesels and gas engines. The Canadian government tested TUFOIL at it's cold regions lab. They showed faster cranking and significant fuel savings with TUFOIL.

I keep getting telephone calls from owners of very expensive German diesels wanting to buy stock in our company. They say their diesels are accelerating like nothing they've ever seen before. One said he doesn't have to down shift any more on an annoying hill in his area.

Your car can have more power like that too.

What about additives that claim to be one time treatments that will last the life of an engine? Well, I've been following the scientific literature on lubrication for a very long time. As far as I know, there isn't a shred of scientific evidence for such a claim. So don't believe it!



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Engines last longer with TUFOIL. Our 1976- 476 T-Bird is now at 190,000 miles and purring.

A bunch of customers' cars have now passed 250,000 miles.

Several months ago, a nice man I'd never seen before walked into my office, big smile on his face, sat down and said, "Would you believe 340,000 miles on a Tufoil engine?" He went on to rave about how well his engine has been running all these years. I couldn't get a word in edgewise.

It made me very proud.

Recently, a truck driver called in with over 1,000,000 miles on a diesel using TUFOIL - Wow!

A customer from Vermont added 10% TUFOIL to his sticky mechanical transmission, called in and said he couldn't believe it... "Shifting is like slicing butter now!", he said.

SAAB owners are writing letters praising TUFOIL in their "NINES" magazine. They report spectacular improvements in their engines and transmissions!

Don't forget! TUFOIL is the result of over 15 years of research and development. The U.S. government has awarded us 6 patents so far...so have Germany, England, France and Canada.

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See NASA Tech Briefs for technical details, 1986, 1987 and 1988.

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electrical fan. Thermostatically controlled, this fan will only run when the coolant is hot enough. It will make a certain amount of noise then, but certainly less than your present fan.

There's even some pleasant fallout—when I tried this on my own pickup a couple of years ago, my fuel mileage, even while towing a 6000-pound trailer, increased almost 10 percent. The electric fan rarely runs when the truck is moving, as enough air moves through the radiator from the truck's forward motion.

### Secret Codes

I recently had a problem with ping on my 1985 Ford Van—the dealer did a considerable amount of work, including replacing the computer. The processor codes indicated that it was defective, but the new computer shows different codes. I became friendly with the mechanic, and he showed me how to read the codes with a voltmeter.

I have no way of knowing what the codes stand for, since my friend won't show me the shop manual. Are they some kind of secret?

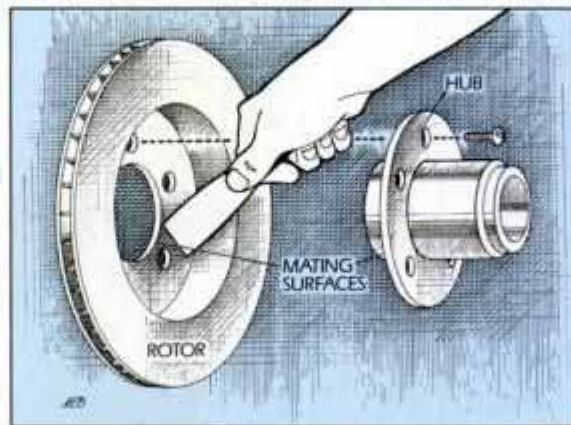
GERALD WOJCIK  
PHILADELPHIA, PA

Ford's EEC-IV engine management computer, like most other microproces-

### All Run Out

Replacing a brake drum or disc is a pretty straightforward operation—but whether you're replacing a remachined piece or just putting on a new one, there's one vital step.

Be sure the mating faces of the hub and drum/rotor are clean. Corrosion or brake dust trapped between



the hub and its mating surface will cause wobble ("runout" is the term you'll see in the manual). It may take some serious scraping and sandpapering to be sure you've got it all. Try smearing on a thin layer of antiseize compound to prevent a recurrence.

By the way, the same goes for the mating face between the rotor and the wheel, to prevent runout of the rim relative to the axle.

sor-based automotive systems, has a self-diagnostic capability. Whenever it sees a problem, it does two things—goes into a limp-home mode of reduced engine performance, and stores a trouble code in its internal memory, so a mechanic can look for the problem without

having to check out every sensor and actuator in the engine compartment. It even knows when it has an internal problem, and calls for its own replacement—which is what happened to your van.

The trouble codes aren't a secret. You can find them in the Ford Emissions

# TO PROVE HOW LONG RAIN



Diagnosis, Engine/Electronics manual, Volume H, which will set you back about \$60, and is available from Ford.

## Spreading Water On Troubled Oil

I have a 1977 Chevrolet Concours with 6-cylinder engine, and an interior coolant leak. There's a yellowish fluid with a slight gasoline smell in the PCV hose. It also collects in the aircleaner, and around the PCV valve.

My father thinks it could be either a head gasket or a cracked block. Is all of this connected? Is my father right in his prediction?

CHAD STRUNK  
MAPLE GROVE, MN

*I think you may not have a leak at all. The paraffinic fractions in motor oil tend to collect in the cooler parts of the system, like inside the PCV line, particularly during the cooler months. These waxy substances are yellowish in color, and depending on the temperature, about the consistency of thin mayonnaise. I've noticed that some brands of oil are more prone to this waxy buildup than others.*

*Coolant leaking into the crankcase tends to make all the oil look like mayonnaise. Oil analysis can tell you if there's even a trace of any coolant in the oil.*

## Breakdown Shakedown

I'm buying a new car in the next few months, and I had one question for "Car Clinic". Is there a break-in procedure for new cars?

OSCAR PETERSON  
MOLINE, KS

*Newer cars, whether domestic or foreign, are manufactured to much narrower tolerances than your father's Olds ever was. And the quasireligious rite of running-in a new vehicle at sharply reduced speeds and loads is a thing of the past. The car manufacturers recommend only that vehicles be run in a normal manner for the first few thousand miles.*

*Having said that, I'll add my 2 cents. I agree. I wouldn't ask my new car or truck to do sustained high speeds, tow a heavy trailer or idle for extended periods until it has several thousand miles clocked. I'd also change the oil and filter within the first thousand or so to remove any wear-in particles of metal. After that, there's no real reason to "baby" your baby. **PM***

## DO YOU HAVE A CAR PROBLEM?

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

## SERVICE TIPS

- Abnormal front brake wear on '86 and '87 Taurus and Sable may be caused by an improperly adjusted proportioning valve. TSB 87-2-9 details how to properly adjust the valve.
- Toyota TSB Vol.VII INFO-040 describes procedures for repositioning the water valve cable clamp on any vehicle where warm air is discharged into the interior even when the temp lever is in the maximum cool position.
- Adding a child seat tether to your Chrysler? You can order kits at a Chrysler dealer. TSB 23-22-88 details correct installation procedures.
- 1986 Mazdas 323 and 626 models may experience starting difficulty after being shut off for 30 to 60 minutes in cold weather. Frost apparently forms on the No. 1 and No. 2 main relay contacts. TSB 038-87-15 suggests replacing the relay with one with weatherproofing, and shows how to position and clamp the harness to keep moisture from entering.
- Owners of Mitsubishi 4wd vehicles whose 4wd indicator light stays on in 2wd during cold weather should either shift into 2wd before leaving the vehicle to cool or try backing up 5 to 10 ft. in 2wd. TSB 87-03-002.

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# INSIDE DETROIT

BY JIM DUNNE

## Retooling The Toronado

**L**IKE ITS GM personal luxury stablemates Cadillac Eldorado and Buick Riviera, the Oldsmobile Toronado is getting a thorough facelift for 1990, in an effort to restore dismal sales.

GM's approach here is the same as it was with the Eldo and the Riv—a substantial stretch at the rear of the car, plus reworked front sheetmetal.

However, with more lead time than the other two prestige divisions, Oldsmobile has been able to make far more extensive changes.

Aside from the hood and windshield structure, the prototype shown above shares almost no panels with



Toronado is set for fall introduction with virtually all-new sheetmetal from stem to stern.

### An All-New Escort

Ford is close to finalizing its replacement for the best-selling car in its lineup. For the first time since its intro-

duction at GM for some time now, Chevy's Cavalier shows no signs of dropping by the wayside.

Chevy will drop the eggcrate grille for its Z24 Cavaliers next year in a move that imitates the Pontiac Sunbird styling. In place of the grille, Chevy will have a solid plastic panel set between the headlights.

As is increasingly common today, the new Cavalier will be a bottom breather. Air intake will depend solely on the scoop set below the bumper.

The new design will give Z24 an exclusive front-end appearance, and add to the overall smoothness of the body shape.

### T-Bird 5 Liter

Yes, Ford will have a V8 for the Thunderbird next year, but it will not be the new 4.6-liter V8 reported earlier. In-

stead, Ford will install its proven 5-liter V8 in the 1990 model.

This decision marks the end of a number of turn-arounds at Ford over T-Bird power. The V8 was dropped from the current Thunderbird—and Cougar—because the hoodline was too low to clear the top of the engine.

"If we raised the hoodline, it would have ruined the strongest part of the T-Bird's styling," explained Jack Telnack, Ford's styling ace. "So that's why the V6 is used in the 1989 models."

But Ford planned to drop in the new V8, with its lower profile, in 1990, thus returning V8 power to the T-Bird, and at the same time saving the low-hood profile.

However, Ford recently decided that the new high-tech engine should be a Lin-

*(Please turn to page 42)*



Mazda 323-based Ford Escort is due for 1991 model year.

the current Toronado. The front-end cap has more detailing, the C-pillar has been altered and the stretched rear deck has been sculpted to add a little excitement to the going-away view.

Although the surface changes are extensive, GM has no plans for anything startling below the skin, save for suspension tuning. Power will again be supplied by General Motor's 3.8-liter 3800 V6, pulling the Toronado through a 4-speed automatic transaxle.

duction in 1981, the Escort will be an all-new car, based on Mazda 323 mechanicals.

The new car has a strong family resemblance, with sloping aero nose, rounded end cap and no grillework, à la Taurus. It will be offered in 2- and 4-door versions when it debuts in 1990, and is expected to be a little larger than the current Escort.

### No-Grille Cavalier

Although the J-bodies have been an endangered species



Chevy's Cavalier Z24 will get new front end for 1990.



The challenge was to create a car worthy of wearing the Thunderbird wings. The result is the most aerodynamic Thunderbird ever. And a car with performance to match its looks.

A responsive 3.8 liter V-6 engine with sequential electronic fuel-injection is standard. So is an independent rear suspension. And there's even the option of four-wheel-disc anti-lock brakes.

Inside, Thunderbird achieves a new level of comfort and convenience with increased room for five adults and a long list of standard features, including air conditioning, power windows and an electronic AM/FM stereo.

It all adds up to an automobile that's impressive even by Thunderbird standards. The 1989 Ford Thunderbird.

### **Transferable 6-Year/60,000-Mile Powertrain Warranty**

Covers you and future owners, with no transfer cost, on major powertrain components for 6 years/60,000 miles. Restrictions and deductible apply. Ask to see this limited warranty at your Ford Dealer.

## **Ford Thunderbird**

**There's never been a car like Thunderbird.  
And there's never been a Thunderbird like this.**



Buckle up—together we can save lives.

Have you driven a Ford...lately?





## INSIDE DETROIT

(Continued from page 40)

coln exclusive for at least a year. So the 5 liter was resurrected for the 1990 model.

Yes, the hoodline will be changed to accommodate the 5 liter. Prototypes for 1990 V8 models have a 3/4-in. rise in the center of the hood that clears the top of the engine and still keeps the hoodline relatively low.

### Reatta Disappointment

Reatta is one of the best of the affordable 2-seat cars you'll find on today's market. But the Buick standout has not been the market success GM envisioned—even though forecasts were relatively modest.

Expecting up to 20,000 sales per year when the car was introduced early last year, GM officials have seen the Reatta fall far short of that goal. Earlier this year it was selling at an annual rate of just under 6700, with a 140-days' supply (inventory) in dealers' lots.

Latest word is that Buick has shut down the Reatta assembly center for a week's "vacation" and to tool up for production of a convertible model.

What happened? More competitors, is one explanation. And in Reatta's price range—\$25,000 to \$30,000—the buyer bank is limited for 2-seaters.

Still, Reatta is not the sales disaster

Cadillac Division is experiencing with the Allanté. The Cadillac superluxury convertible is selling at a rate just under half that of the Reatta, also far below GM's sales projections.

### Diamond-Plated Cars?

Diamonds are forever, or so the advertisement claims. And that's why GM is taking a close look at the possibility of using diamonds, or more precisely diamond coatings, in its cars and machines of the future.

GM researchers are trying to develop a process of diamond coating aimed at making wear surfaces last longer—perhaps forever, at least in terms of a machine life. They are starting with the discovery in recent years that diamond film can be grown in the laboratory without the high pressures found in natural diamond development.

The trick now is to grow diamonds that will stick to a metal substructure. If successful, diamonds can replace some heat treating in high-wear parts like camshafts and bearing surfaces.

### Soviet Progress

Soviet car development has come a long way in recent years. One example is the new look in car warranties.

"Fifteen years ago," reports one So-

viet official, "we delivered our new cars with a small tool kit and a selection of replacement parts."

That was the warranty. The owner was on his own. Now, however, the warranty is closer to measuring up to world standards. It covers six years for body corrosion and two years for mechanicals and chassis defects.

One reason for the changes: The Soviets are selling more cars to the West, and hope to open U.S. dealerships soon.

### Camaro/Firebird Delay

GM appears in no hurry to get its next-generation Camaros and Firebirds in production. Once scheduled for introduction in 1992, the exotic new models will be delayed until the 1993 model year.

Changes in body materials—from all plastic to part steel—and slow engine development are the reasons for the delay. This is the second setback for the midprice sporty models. Three years ago a plastic-bodied, front-wheel-drive design was scrapped. At that time it was conceded that, in sporty cars, rear drive was the best way to proceed. If the front-drive plan was still in effect, the new Camaro and Firebird would be ready for introduction later this year. **FM**



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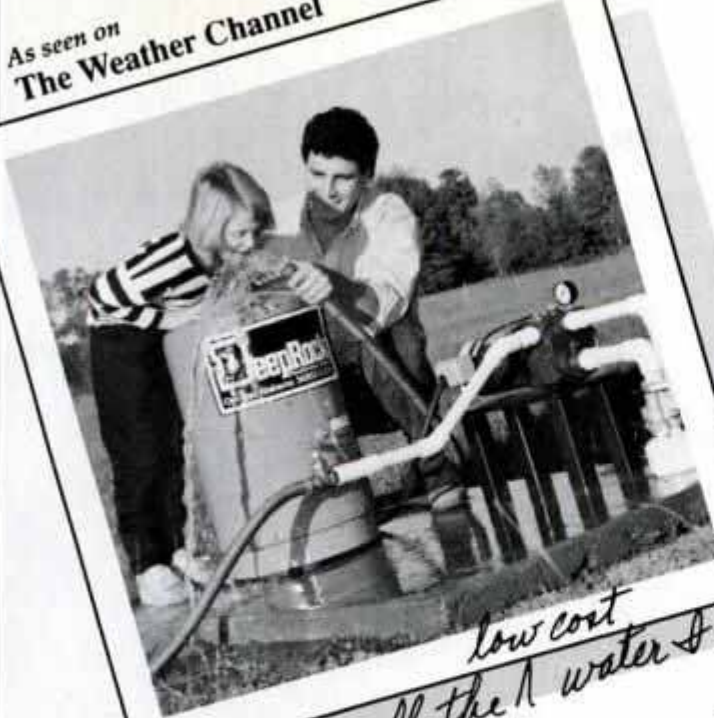
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# OLD HOUSE RESTORATION

BY BOB VILA

## Outdoor Living Space

**C**REATING an outdoor entertainment area is one of today's most popular home improvement projects. Often called outdoor living rooms, these spaces provide a place for family entertaining or just plain relaxing.

Although decks are a common item today, they are also a relatively modern structure and, in most cases, aren't appropriate on a restored period home. For many of these old houses, adding a patio or a gazebo may be the most authentic way to go.

Several factors must be carefully considered when adding either of these outdoor living spaces to a period home. These include the physical qualities and characteristics of the space and place, as well as the kind of entertaining you plan to do there. In addition, you'll be better off working within the confines of the land and existing landscape.

### The importance of proportion

When studying the proportions of a building, the relationship between the amount of solid wall space and openings or voids (like doors and windows) on its face is taken into account. The construction materials used, as well as colors, textures, size and scale of all facades and decorative elements, are also considered.

The key is to keep any added structures in proportion and scale with what already exists. For example, if your house has a porch and you want to build a gazebo nearby, the elements and proportional composition of the

*Contributing Editor Bob Vila is host of public television's "This Old House."*



Adding outdoor structures to your old house is a great way to increase your living space. Some of these structures are even available in easy-to-build kits like this Victorian gazebo.

porch are important. How tall and long is it? What types of railings, if any, are used? What's the spacing like between the porch columns? Are they fancy or plain? All these things should be considered when choosing or designing the gazebo so that it complements the house.

Obviously, a professional is trained to pick up these types of things quickly. But the average layperson, if he or she has some examples to follow and has a good eye for design and detail, can usually tell what goes and what doesn't.

You want to avoid, at all costs, adding a structure that's out of proportion with what's already there. It'll show up right away, spoiling the visual composition of your property.

The type of use this outdoor area is geared for is also important. Will it be used for active or passive activity? By this, I mean do you want a place to sit and sun yourself in the backyard and play cards or board games or do you want a space suitable for parties and dancing?

All this should come into play when designing your

outdoor space—if you plan to use it for more formal functions you don't want a lot of informal features.

### Patio pointers

Since most folks in the 18th century didn't have the leisure time that we do now, adding an outdoor patio area to homes built in this era is a 20th-century concession to modern living. (Back then, most planned outdoor spaces were usually considered domestic workyards.) So, even though it won't be an authentic re-creation, adding a patio

*(Please turn to page 46)*



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## Years of Testing and Use Have Proved it True!

Slick 50 has been thoroughly tested in independent laboratories and out on the road:

The March/April 1982, p. 35 issue of "Consumer Digest" magazine stated, "Slick 50 does reduce engine heat and ordinary wear, and our informal tests indicate that it will improve gas mileage by about 2 or 3 miles per gallon."

One of the country's most respected research institutes reported applying a powerful ultrasonic cleaning process to a Slick 50 treated engine and were surprised at its permanence. "We actually expected the Petrolon Slick 50 TFE Resin coating to also be removed, but later found it was still there."

TUV, a German testing laboratory with credentials every bit as prestigious as our Underwriters Laboratories, tested Slick 50 in 1986. They found substantial increases in both gas mileage and horsepower. Their tests showed that these gains were due to a reduction in friction.

The Federal Aviation Administration has fully accepted a similar product for aircraft—Slick 50 Aircraft Piston Engine Treatment (F.A.R. #33.49). This FAA endurance test simulated 1400 hours of engine use.

The power technology laboratory at a leading southwestern university stated, "Slick 50 does increase horsepower and decrease fuel consumption in tests done at the university."

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

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



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

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

## 4 Ways Slick 50 Saves You Money

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

1. Increase mileage
2. Increase horsepower (small economy cars and large RV's really need this)
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Up to 90% of the engine wear on a car can be caused by lubrication starvation cars experience when first started before the oil begins to circulate. Slick 50 can eliminate this problem for less than the cost of two tanks of gas.

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## OLD HOUSE RESTORATION (Continued from page 44)

can be done tastefully to keep within the flavor of the era.

Keeping in mind that any added space should follow the scale and design of the structure, it stands to reason that outdoor areas on very old homes should be plainer than those surrounding later, more ornate Victorian houses. A patio should reflect the simple composition, straight lines and rectilinear organization of these early buildings. Using native stone or rocks, like bluestone, fieldstone, shale and slate, keep the shape simple and in line with the structure of the house itself. Design the patio so it follows the outline of the house on one side and the natural contours of the land on the other.

Like everything else, patio design became more fanciful and elaborate in the Victorian era. Homes of wealthy owners may have used imported stones and more geometric, fanciful patio designs. The landscaping itself became more ornate, with ponds, fountains, walkways and garden walls. The more traditional or common Victorian homes used simpler materials and layouts, again keeping things in line and proportion with the design of the house itself.

### Gazebos today

Gazebos became popular in this era and were often found in Victorian gardens. Again, the structure must be kept in proportion with the scale and composition of the house to be a successful addition. Fortunately for owners of old Victorian houses, gazebos are making a comeback. There are prefabricated, easy-to-assemble gazebo kits available today, like the one shown on page 22, made by Vixen Hill, Main St., Elverson, PA 19520. All the materials needed for the gazebo's construction are shipped to your site and simply bolted together. If you can't find exactly what you want from a manufacturer, you can always choose a fairly simple design and have a local carpenter customize it with Victorian-style millwork and lattice panels.

Another alternative is to build the floor (and sometimes even the roof) yourself then order the other modules, like the posts, banisters and fretwork. This will be cheaper than going the complete prefab route and having all the materials shipped to you. There are design books available, too, that feature several different gazebo styles. Using one of these plans, you can also opt to build it yourself or hire someone to do all or part of this work for you. What you decide to do depends on your level of carpentry expertise and your budget. Of course, the cost of this project is dependent on the type of wood you use.

### Working with the landscape

One of the biggest mistakes I see old-house owners make, when trying to tackle a project like this, is not realizing what an important part the composition and color of the surrounding landscape has on the success or failure of your completed project. So before you decide to add a patio or gazebo to your property, there are some important points to consider.

One of the main things you must be aware of is the topography of your land. Flat ground is relatively easy. But if you've got some slopes and changes of elevation across the yard, you must be careful, especially when laying a patio, that you don't disturb the natural drainage of the land. You don't want to create hazards, like forcing rainwater to run toward the house. Another thing to keep in mind is the importance of the plant material you've already got back there and work with it, not against it. For example, if you've got some nice flowering shrubs or specimen trees, make sure your patio or gazebo is constructed in such a way that it highlights, rather than detracts, from these.

Color, too, plays an important part in all this. If you're adding a gazebo and have lots of flowering trees and shrubs, choose one made of cedar or redwood that can be stained a neutral color. But if your landscape is mostly evergreens and nonflowering shrubs, it may be better to finish the gazebo with a color in the same family as the house. Each situation must be evaluated and judged visually to discern what works best.

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# FREEWHEELING

BY TONY SWAN

## Barnstorming With Buick

**A**S WE'VE been hearing for a couple of years now, Buick has rededicated itself to the building—and, hopefully, selling of—“Premium American Motorcars.”

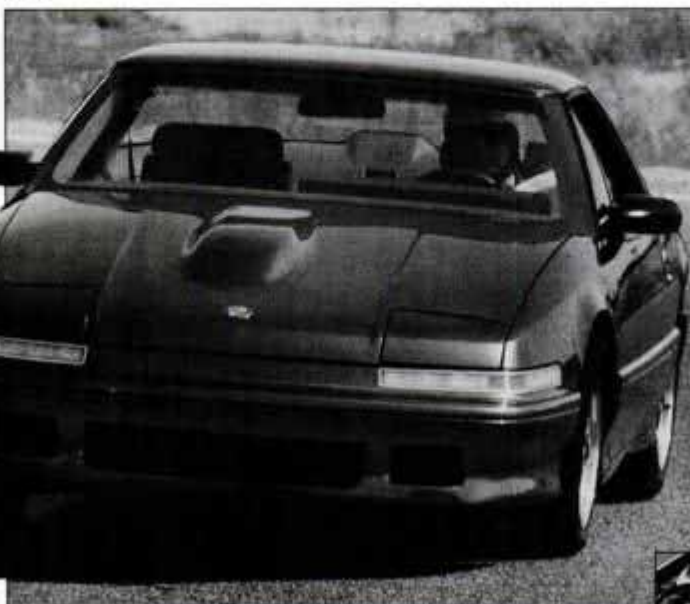
As a general mission statement, that's hard to argue with—very lofty, without being pompous. Unfortunately, when it comes to interpreting “Premium American Motorcars” in cold steel, Buick hasn't been quite as successful. Without putting too fine a point on it, sales over the past few years can be characterized as disappointing, and a lot of clever guys have been wandering around up in Flint trying to figure out just what a Buick ought to be.

However, while there's still some uncertainty on this particular question, we have a couple of reasons for believing that Buick is about to turn the corner on the image issue. We've seen some of the thoroughly appealing Buicks that the division will be bringing to market a couple years down the pike. And more recently, we had an opportunity to play with some of the powertrains Buick may be planning to offer even sooner.

### Firebird follies

To sample its future powertrain dimensions, Buick invited us out to Firebird International Raceway, in Phoenix, for a day of tire-smokin' and general evaluation of some rather interesting variations on current themes.

The roster ran from mild to wild, with a low-boost turbocharged Reatta, a high-boost turbo Reatta, a rear-drive



Experimental rear-drive Reatta is powered by Buick's potent 245-hp Regal Grand National 3.8-liter turbo V6 (right).

turbo Reatta, a supercharged Regal, a rear-drive turbo Regal and even a turbocharged Electra Estate Wagon.

That may sound like a pretty mixed bag, but we quickly found a significant commonality once the hoods were popped open. Every one of these concept hot rods is powered by GM's corporate 3800 3.8-liter V6 engine, all equipped with some sort of force-feeding apparatus.

### Critic's choice

Although we consider it an unlikely bet for production, since the basic car is very low volume to begin with, our favorite in this entertaining lineup was the rear-drive Reatta turbo. Not only does this setup improve the car's

handling, which is quite good even in standard-issue front-drive trim, it also gives it a distinctly meaner appearance, replete with fancy extensions to the rocker panels and air-dam, plus a power bulge in the hood.

The bulge does in fact cover a substantial output—245 hp at 4400 rpm, 355 lb.-ft. of torque at 2800. A stock 3800 V6, by way of contrast, makes 165 hp at 4800 rpm, and 210 lb.-ft. at 2000.

That's a healthy bump in propulsive potency, and as you'd expect, it gets the Reatta down the straights in a hurry. Getting to 60 mph takes 7 seconds, which is about 2 seconds quicker than the standard Reatta, and

the quarter-mile comes up in 14.5, almost 2.5 seconds better than the garden-variety edition. The rear-drive turbo version is also capable of 140 mph flat out, 15 mph better than the stocker.

These numbers are even more impressive when you realize that the cobbled-together rear-drive Reatta outweighs the production version by over 500 pounds, tipping the scales at a ponderous 3900 pounds.

### The plausible

Much as we liked the rear-drive Reatta turbo, we view



the front-drive versions as more production likely, and of the two of them, the mild version is much the more plausible.

With boost dialed back, the 3800 V6 makes 230 hp at 5100 rpm and 260 lb.-ft. of torque, enough to hustle the surrounding sheetmetal to 60 mph in 8 seconds and through the quarter-mile in 15 flat.

There is some torque-steer penalty for all this muscle, but it's not nearly so pro-



Regal rear-drive was another concept car that got the G.N. engine treatment. Buick also showed a supercharged front-drive model.



nounced as it is in the higher output version.

With boost running as high as 16 psi, this one matches the hp of the Reatta rear-drive, although torque has been held back to 300 lb.-ft. because the automatic transaxle simply can't handle any more than that.

Straightahead performance is similar to the rear-drive version, but straight-ahead is something that requires real concentration to achieve when the throttle is cracked open. Getting all that power onto the ground and maintaining decent driveability still seems to be beyond current front-drive technology.

## Regal concepts

Like the low-boost front-drive Reatta, the supercharged front-drive Regal struck us as falling into the realm of the distinctly possible.

Output here is pretty much identical to the mild Reatta turbo, falling short by 20 lb.-ft. in the torque department, which makes everything about even since the Regal is 200 pounds lighter.

The supercharger is by Eaton, and Buick had to fabricate a new intake manifold to accommodate it. The only other modification required was new pistons, yielding a compression ratio of 8.0:1, which was the c.r. for the entire test fleet.

At this level of output, the supercharged Regal did 0-60 in 8 seconds and the quarter-mile in 16. This may not flatten your nose, but it dusts the stock Regal by about 2 seconds in each category. More important, the supercharged 3.8 is smooth and quicker in response than any of the turbocars.

The rear-drive Regal turbo would have been called a Grand National just one model generation ago, and the inter-cooled turbomotor propelling it bears strong similarities to the old Grand National powerplant. What that means is gobs of output—245 hp at 4400 rpm and 355 lb.-ft. of torque at 2800, the same as the rear-drive Reatta turbo.

Since the rear-drive Regal is 500 pounds lighter than the Reatta, it's a half-second quicker to 60 mph, though quarter-mile times are identical.

When it came to challenging Firebird's rather peculiar collection of twists and turns—this is a difficult road course to love—the Regal didn't fare quite as well as we'd expected, which may be due to insufficient development time on the chassis. In particular, the rear suspension seemed to want a bit more work, although we have to think the potential is there, since it was adapted from the Corvette.

It was also interesting to note that for all its production improbability, the Regal rear-drive was the only other car in this group to get significant exterior

cosmetic attention. In this case, the hood received a slightly raised center section, with small louvers at the rear, a modification that lends a distinctive look to the car's profile.

## Behemoth with boost

How do you make over two tons of steel and woodgrain move from 0-60 mph in just over 5 seconds? Of course. Just add horsepower.

Buick's Advanced Concepts Group, which handled all these cars, simply pulled the Estate Wagon's stock 5.0-liter V8 and stuffed in yet another of its 3.8 V6 turbos, this one in GNX tune. With turbo and intercooler, this engine makes a whopping 328 hp at 4400 rpm, with 410 lb.-ft. of torque.

Substitute a 3.37:1 final drive for the stock 2.93, and you've got a rig that'll give Mom and the kids the hole shot at every stoplight from here to Woodward Avenue, wire wheels and automatic transmission notwithstanding.

Chassis modifications include heavier front and rear antiroll bars, stiffer shocks and quicker steering, and the wire wheels wear very serious tires: 255/60VR-16 Goodyear Gatorbacks.

It all adds up to much more fun-to-drive than you'd ever expect in an ultra-traditional 4300-pound American station wagon. But it's hard to take this fleet-footed mastodon seriously, because of all these concept cars, this one is least likely to see a showroom.

## Portents

Which brings us to the question of what will make it into future Buick showrooms. Although it would be a mistake to rule rear-drive out entirely, it's unlikely that we're going to see this for either the Reatta or the Regal.

While it would probably be easier—and hence cheaper—to tool up for rear-drive Reatta production, owing to the flexibility of the Reatta manufacturing techniques, the car's low sales volume wouldn't seem to justify such a move.

The Regal, on the other hand, has the sales volume but not the manufacturing flexibility. Which means the investment would be difficult to justify here, too.

However, there is certainly a message in these hotted-up V6 engines. Buick is casting about for ways to bolster a rather anemic image, and one of the traditional ways of doing this in autodom is by finding more hp.

Both Reatta and Regal have been criticized for languid performance, and a little dose of turbo wouldn't hurt either of them.

If we were gambling men, we'd be willing to bet that turbocharged versions of both these cars will show up in your Buick store. And soon. **PM**

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# Fingertip Control

BY FRANK VIZARD, Contributing Editor

**E**RGONOMICS is a big word that isn't in a lot of dictionaries. But if you're an electronics designer, then ergonomics is a word that you can spell backward and forward.

Ergonomics determines where and how the controls are placed on a piece of equipment. Equipment designers have to ask themselves questions such as:

- Are related controls grouped nearby one another so that they will be easy to operate?
- Are the buttons sized so an average man can get his finger on them?



The Eclipse autosound system uses touch-sensitive controls.

- Do people prefer pushbutton or rotary-dial volume and tuning controls?
- Are multiple-function buttons too confusing?

Nowhere is good ergonomic design more important than in a car audio system. This is because you are supposed to be able to operate the controls of the hi-fi gear

without taking your eyes off the road. The control panels of cassette receivers and CD players are the electronic equivalent of Braille texts. For safety's sake, they have to be read with your fingers.

For the most part, equipment designers have treated the issue with good intentions and varying degrees of

effectiveness. Generally, though, we're asked to commit to memory the layout of a control panel—as if we don't have anything else to think about. You might get tactile notification that your fingers have found a

button, but you really must rely on your memory to recall its function. That's okay if you're an ex-Green Beret, and can assemble a rifle blindfolded. Civilians generally haven't had that kind of training. This means most of us are taking our eyes off the road somewhere along the line.

Groping for buttons might be something people can do while parked, but it's definitely not a good idea while the car is in motion. One alternative to button-groping under consideration by several manufacturers is the touch-sensitive screen.

Alpine, for example, recently exhibited a concept car utilizing this technology. A complete audio/video entertainment system, a CD-ROM based navigation system, and a rear-view monitor as well as all other electronic functions of the car are accessed via a touch-sensitive screen. Interestingly, installation of the gear is actually made simpler—despite the fact that a CD player, DAT player, cellular phone, security system, AM/FM tuner, Super VHS-C video cassette recorder, and a color television are in-

(Please turn to page 54)

## Indoor Antennas: AM Gets A Helping Hand

Our most recent piece on antennas ("Audio," page 68, April '89) pulled in a lot of requests for information on AM radio antennas. Now, AM radio fans looking to pull in distant broadcasts can get some technical assistance courtesy of two unique indoor antennas.

The newer of the two is the ARC (Amplified Receiving Component) from Parsec. The ARC (\$130) is designed to boost both FM and AM reception, but it is the unit's AM capability that makes it novel. Parsec claims the ARC will provide clear reception of AM signals from more than 125 miles away.

The ARC measures 3.75 x 17 x 10 in., runs on AC power, and con-

nnects to your receiver's 75- or 300-ohm antenna input. It has four controls. One is a tuning knob that operates just like a radio dial. An AM Angle control allows you to rotate the antenna for the best orientation. The antenna's bandwidth can also be adjusted between narrow and wide. Lastly, the gain control helps regulate static levels. The circuitry is designed by Larry Schotz, an engineer noted for his innovations in radio reception. Call Parsec at (302) 651-9189 for the lo-

cation of the nearest dealer.

Less expensive at \$44, the Omnipotent antenna for AM traces its origin to Alaska's North Slope, where oil-field workers hungered for contact with the Lower 48.

The Omnipotent, a tire-shaped object 11 in. in diameter, is simply placed next to your radio and tuned to the desired frequency. No connections are required: By working on the principle of mutual inductive coupling, the Omnipotent boosts AM reception by a factor of 75 times.

The Omnipotent is available through the Herrington catalog, telephone (603) 437-4939. Herrington offers a 60-day trial period for the product.



Parsec's ARC antenna boosts AM as well as FM.



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cluded in the car. All of the components are linked to the central control unit by a standard connecting cable.

The Alpine concept car represents the type of system the company intends to sell in the next decade. In many ways, the Alpine car is reminiscent of the approach adopted in the Buick Riviera. On a smaller scale, though, touch-sensitive screens already are being used by Eclipse and Technics.

These two car stereo companies utilize touch-sensitive screens in different ways. In the Technics CQ-R9550 (\$700), the touch-sensitive screen solves a clutter problem because it can control a tuner, cassette player or an optional CD changer. As you switch among the different modes, only the appropriate control designations appear on the screen. Some universal controls—volume, tape eject, power, loudness, clock, dimmer—appear as buttons, and are not part of the screen display.

Commendably, the touch-sensitive screen of the CQ-R9550 allows controls for each of three different modes to be grouped cleanly and clearly together. Unfortunately, the number of controls in each mode is too numerous for simple operation.

In the tape mode, for example, 11 possible functions are arrayed on the

screen. With no tactile differentiation between each function, it becomes very difficult to operate the CQ-R9550 without looking at it.

A more interesting approach to the use of touch-sensitive screens is evident in the Eclipse EQZ-200. The EQZ-200 actually utilizes two separate touch-sensitive screens. The larger one to the far right of the faceplate changes, at the touch of a finger, to give you a video-game-like display of either a graphic equalizer, a spectrum analyzer, the current radio station, or tape indicators. Touching the upper right portion of this screen illuminates a digital clock.

To the left of the faceplate, underneath the cassette door, is the second, smaller touch-sensitive screen. Mostly, this screen serves as a handy volume control. All you do is slide your finger back and forth across the width of the screen to regulate volume. A function button in the lower left-hand corner of the faceplate changes the screen into either a balance or a fader control.

Like the Technics CQ-R9550, the larger of the two touch-sensitive screens solves a clutter problem in that each of the multiple elements of the unit can be adequately displayed. The smaller screen is more viable as a blind man's control, since you can hear whatever al-

terations you make. The EQZ-200 does have its share of buttons but they are easily found by tracing your finger around the unit's perimeter.

At a list price of \$1350, the EQZ-200 should have a fine ergonomic design. The EQZ-200 also has a lot of other features, and superior performance, that help justify the price tag. Ergonomics alone shouldn't bust your bank account.

## **Audi Audio**

Bose has teamed with Audi to produce the first acoustically designed, factory-installed car audio system ever to be offered as standard equipment in a German automobile. Based on a test drive, it's a wonder the German carmakers haven't caught onto the pleasures of autosound before this.

Available with the Audi 200 series, the system uses the by-now familiar Bose amplified speaker modules in combination with a modified Blaupunkt cassette receiver. While Bose is reluctant to put a power rating on any of its systems, this one is about the equivalent of 200 watts through four channels. Interestingly, with the introduction of the Audi system, Bose has become more forthcoming about particulars.

Bose amplifiers, for instance, differ from most in that a patented 2-state am-





plifier design is used instead of the more conventional Class B design. In a Class B design, transistors control the power flow on a continuous basis. By contrast, the Bose amplifier operates by rapidly switching on and off. This switching takes place at a faster rate than any changes in the audio signal, so the music is not adversely affected. The 2-state amplification doesn't generate as much heat as Class B amplifiers do. So the large heat sinks characteristic of Class B amplifiers are not necessary. This means the amplifiers can be much smaller than normal.

Packaged with each amplifier is a full-range loudspeaker. Two 6 x 9-in. models are installed in the rear deck. Two 4½-in. speakers are housed in a ported enclosure and installed in the lower part of the front doors. The front speakers are enclosed to enhance bass output. In the rear, the trunk acts as a speaker enclosure. Unenclosed speakers generally lack deep bass.

While the Bose speaker/amplifier modules are the voice of the system, the Blaupunkt cassette receiver is noteworthy because of its ergonomics. Controls are grouped in related clusters around individual raised mounds. For example, the four radio presets are grouped together on one mound. Your finger can

then slide off the mound in any of four directions for the appropriate preset. Other functions are similarly grouped, making the unit fairly easy to operate by touch alone.

Although Bose might go about things somewhat differently than most, its techniques yield nothing but positive results in the Audi 200 we evaluated. Sound quality was generally excellent although we did encounter some rare instances of muddiness in the bass response—a small complaint that would be praise for many other factory systems. Bose and Audi seemed well teamed. The Bose system is also available as an option in the Audi 100 series.

Meanwhile, more hi-fi companies continue to develop alliances with car companies. The latest are Nakamichi and Pioneer, who will be supplying components for the Toyota Lexus. A Nakamichi system will appear in the more expensive LS400, while a Pioneer system will appear in the ES250. Compact disc players are optional in both cars.

### Toys Of Summer

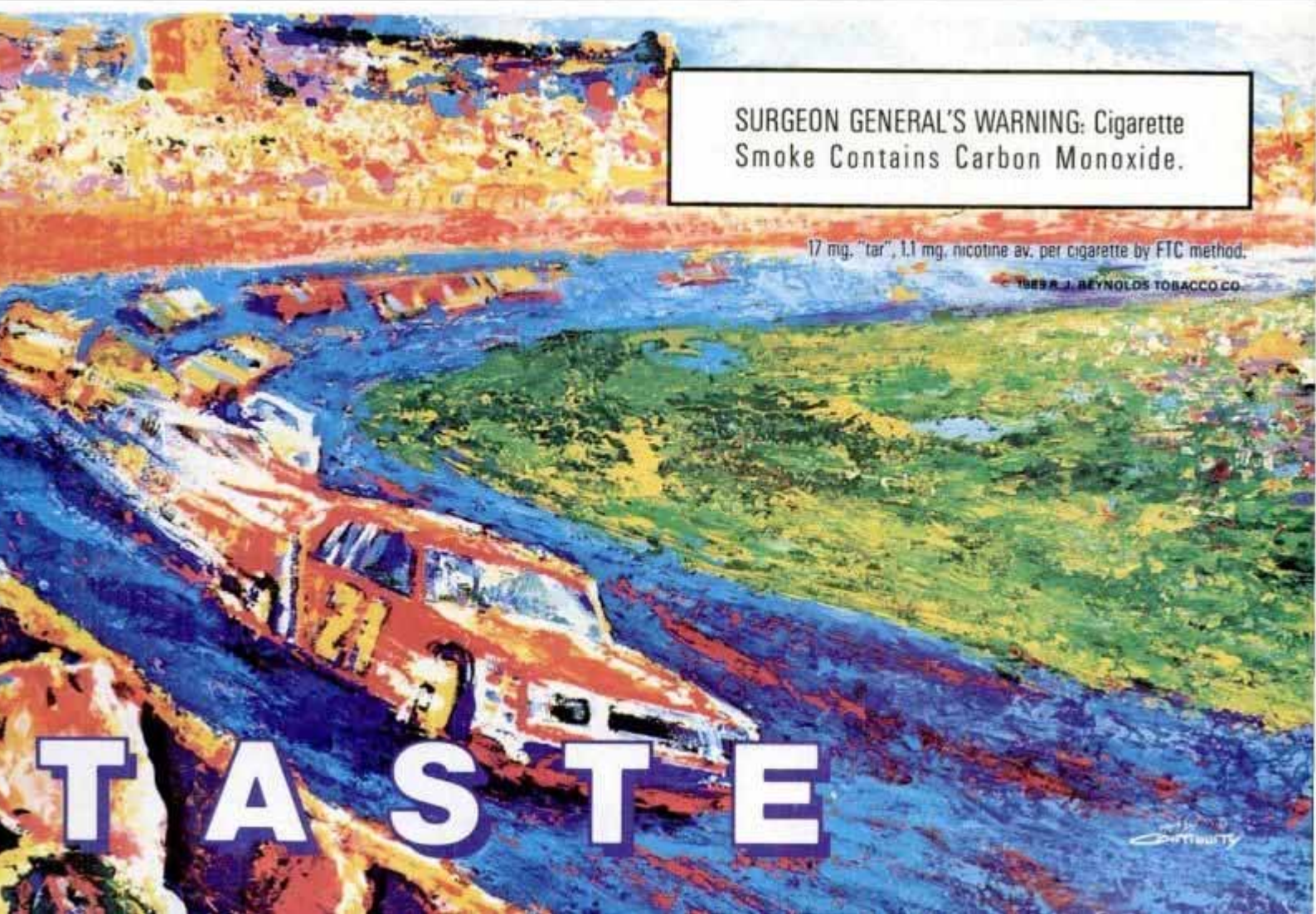
When the weather is warm you're more inclined to bring music outdoors, whether it be a personal stereo clipped to your belt or a larger, portable system for parties at the beach. But away from

an AC outlet, you'd better be conscious of how good your batteries are.

The first step toward getting the most out of batteries is to make sure they are fresh when you buy them. Late last year, Duracell became the first battery manufacturer to put an expiration date on its most popular alkaline batteries, a policy that is fast becoming an industry standard.

Duracell recently passed on some tips on how to keep batteries lasting longer. For example, lowering the volume on music systems can double battery life, since amplifiers are among the biggest power eaters in audio. Motors also eat a lot of power—but there's no benefit to slowing down a tape transport. However, Duracell notes that newer personal and portable audio systems function with greater efficiency than older models, due to improved electronic designs. Studies show that 90 percent of audio devices now operate with only a medium drain of 100 to 300 milliamps of current on the power source.

Duracell also recommends that you clean battery contact surfaces, and remove batteries when not in use. Finally, don't carry batteries loosely in a purse or pocket, as batteries can be shorted through contact with coins, metallic objects or each other. **FM**



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# LICENSE TO FLY

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PHOTO BY MARTIN GODDARD. INSET PHOTO BY TIM COLE

Part boat, part bird, this new ground-effect vehicle will speed you over the water. And you don't need certification to operate it.

BY TIM COLE, Science/Technology/Aerospace Editor

**L**OCAL guides call it The Back Country, maybe the "nether-est" of fishing's nether regions. But this clutch of islets and outcroppings scattered at random throughout the Bay of Florida is also where the fish are. Snappers. Jacks. Bonefish. Tarpon. They congregate at the end of a punishing 3-hour journey by center-console boat, through infrequently traveled, dangerously shallow waters. Just getting to the fish, let alone getting the lines wet, is an all-day affair.

But on this particular day in the summer of 1990, we're compressing the time and distance between fishing hole and frying pan with a flying fish of our own—an airfoil boat designed to traverse great expanses of water with unheard of speed, range, carry-

ing capacity and comfort. We're at the controls of a flarecraft, a new kind of flying machine that bridges the existing technologies for traveling over the water and through the air.

A revolutionary ground-effect vehicle built in West Germany and scheduled to enter the U.S. market next summer, the flarecraft flies on a dynamic air cushion just off the surface of the water, like a swan or a pelican. Hovercraft, also relying on the ground-effect phenomenon, have lift engines that furnish a static air cushion. Flarecraft fly much faster and more efficiently using far simpler construction and propulsion. The pressure created by the flarecraft's patented wing shape captures and compresses air against the water (or

The prototype flarecraft skims a German Lake. Its single-place cockpit (above) will have room for two in a future version.



mud bank, or shoal, or coral reef), which, augmented by the natural forces of aerodynamic lift, levitates the craft in a highly stable, usually swift sea-skimming flight. But you can't really call it flying, because the wing remains in a semistalled condition: Hence the term flarecraft, a word that developers hope will join the lexicon of transport along with trains, planes and automobiles.

In truth, according to aerodynamic designer John Roncz—creator of the airfoils for Burt Rutan's world-girdling *Voyager* and Beechcraft *Starship I*—a flarecraft is a technology that borrows from boats in slow-speed displacement mode, and aircraft, when it flies over the wavetops.



## LICENSE TO FLY

PHOTO BY MARTIN GOODARD



**AIRFISH II**

Airfish II reveals reverse-delta, reverse-dihedral planform and large tail structure.

"Airplanes are getting too expensive when you consider costs of operation, let alone the costs to certify. Boats are heavy, uncomfortable in a seaway, and hardly fuel efficient. Ground-effect technology in these so-called flarecraft has so many advantages over all prior methods of moving across water."

Like many other visionaries, Roncz foresees a time when flarecraft will economically replace the kind of large-scale hovercraft that link England and Europe.

"I can see huge flarecraft carrying cargo across the Earth's oceans. Right now, there are no real obstacles," says Roncz.

### The drawing board

Although Roncz's vision need not await enabling technologies, organizations with the required funding and

drive to harness the ground-effect phenomenon haven't materialized—until now.

Entrepreneur Bill Russell of Westport, Connecticut, recently founded Flarecraft Corp. to exploit ground-effect technologies. The company has entered into an agreement to market a 2-place recreational flarecraft, which will be produced by Messerschmitt subsidiary Rhein-Flugzeugbau (RFB) outside Düsseldorf. RFB's technical director, Hanno Fischer, is currently evaluating power and control issues aboard a prototype called Airfish II, the engineering test bed for the 2-place production machine that the team has tentatively dubbed Airfish III. His test tank: the sylvan waters of Lake Baldeney, home of the Krupp family dynasty.

"Ground-effect craft are a whole new transportation system," Russell

confidently asserts. "We're just seeing the beginning of it now, but the advantages in terms of payload, fuel efficiency, range and comfort are clearly there."

Best of all, Russell says, flarecraft are not considered aircraft. According to a recent FAA ruling, the craft is incapable of free flight in federally controlled air space. It depends on the ground to achieve the ground-effect pressure necessary to create the dynamic air cushion. Indeed, according to Roncz, the ground-effect craft's induced drag increases with altitude, making sustained high-level flight impossible.

"The environment in which it would operate would be more similar to that of a surface vessel," according to the FAA's Boston-based John Markunas.

Russell is banking on that ruling to introduce the freedom of flight to po-

\$1612.25 Double Spread

FIGURE ONTAL STABILIZER  
RUDDER (2)  
TWIN VERTICAL STABILIZERS

## Two Decades Of Ground-Effect R&D



**X-113**



**X-114**



**AIRFISH I**



**FUTURE COMMUTER**

The West German government subsidized X-113 and X-114 to test the military applications of ground effect. The X-113 was a center-fuselage trimaran design. The catamaran X-114 suffered a reduced payload. Designers reverted to the trimaran design for

the ultralight Airfish I. The end result may be a flarecraft commuter version. The future commuter, envisioned by Flarecraft Corp. and Germany's RFB concern, would be an 8-passenger design with enough room for cargo, too.

FLARECRAFT CORP. PHOTOS

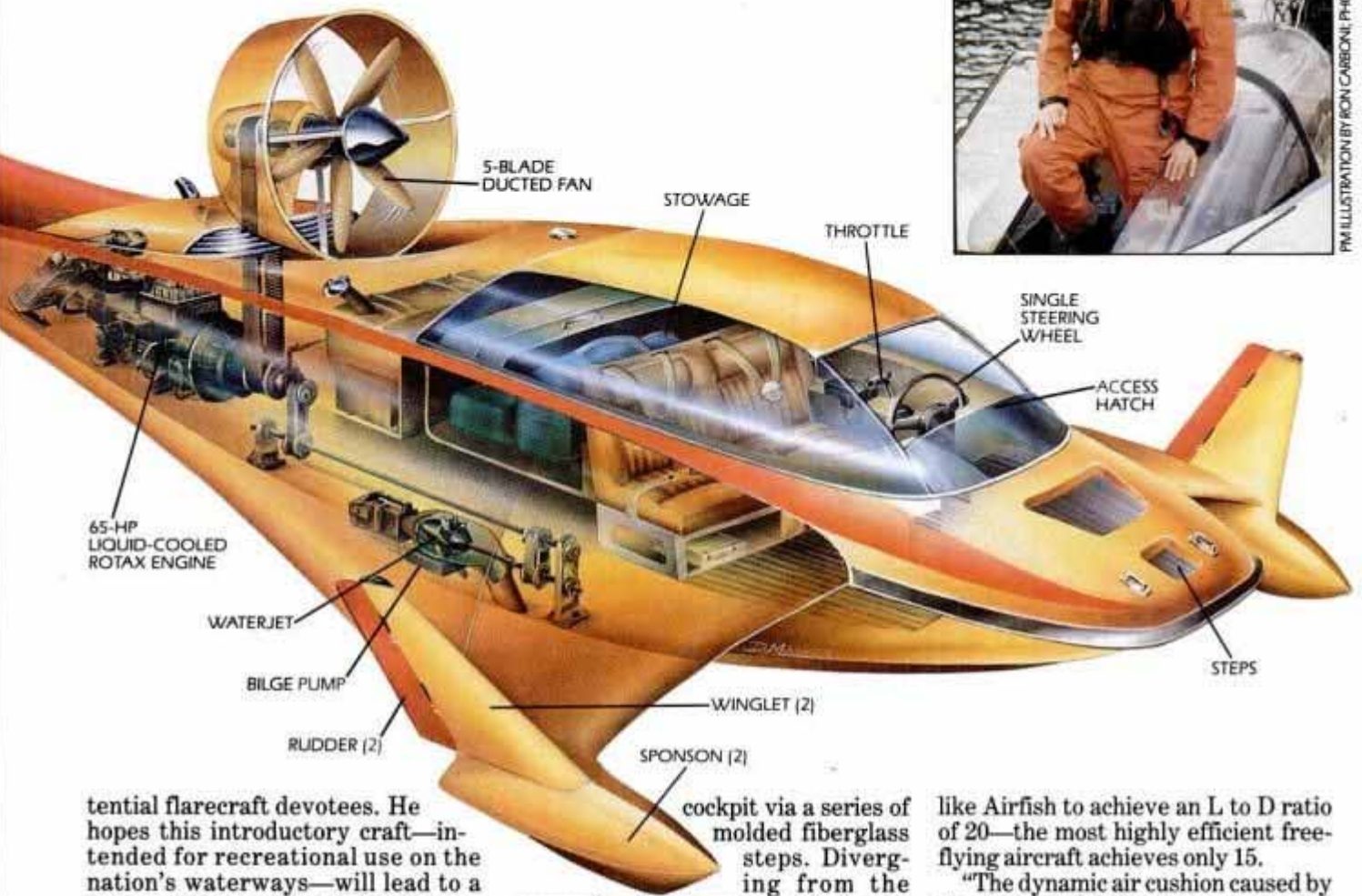


# TOMORROW'S FLARECRAFT

The 2-seat flarecraft, scheduled for introduction in the summer of 1990, will incorporate the Lippisch flarecraft design refined by designer Hanno Fischer (right) of Rhein-Flugzeugbau. A 65-hp liquid-cooled Rotax will power the vehicle, which also incorporates a small jet drive for slow-speed maneuverability.



PHOTO BY TIM COLE



tential flarecraft devotees. He hopes this introductory craft—intended for recreational use on the nation's waterways—will lead to a series of larger flarecraft for commuting, general transport and commercial cargo hauling.

As currently planned, the production 2-place flarecraft will be 34 ft. 6 in. from nose to tail and have a wingspan of 20 ft. Folding winglets will reduce the beam while the vehicle is moored. The main wings are removable for trailering.

Fischer is currently experimenting with a 90-hp horizontally opposed 4-cylinder Hirth engine aboard Airfish II. Airfish III will likely carry a 65-hp liquid-cooled Rotax that will be clutched to a small jet drive for slow-speed maneuverability in congested harbors. A maximum payload of 550 pounds is envisioned, which would be comprised of two passengers, their baggage, instrumentation and fuel. The sport flarecraft will be capable of a 300-mile range at a cruising speed of 72 mph.

Four-point harnesses will restrain the vehicle's dual occupants, who will enter the craft over the bow through a windscreen hatch and descend to the

cockpit via a series of molded fiberglass steps. Diverging from the conventional, the ground-effect craft will have no stick and no rudder pedals. A single steering wheel will link Airfish III's control surfaces—twin rudders on the twin vertical stabilizers aft, and twin rudders on the craft's pontoon-mounted winglets port and starboard. A single throttle positioned boating-style on the crash pad to the left of the operator will power the flarecraft onto a plane. Once a certain airspeed is achieved, Airfish III will go airborne without any deflection from the controls. Once in ground effect, the flarecraft can be banked into tight turns, and throttled back to cruising speed.

"We can fly five times faster than a ship at half the power," Fischer proclaims. "Airfish I, our previous test bed, achieved 100 km/hr. after we throttled back to an effective shaft output of only 15 hp."

## New efficiencies

The real advantage is in the traditional aerodynamic value of lift to drag. It's not uncommon for an airfoil boat

like Airfish to achieve an L to D ratio of 20—the most highly efficient free-flying aircraft achieves only 15.

"The dynamic air cushion caused by the flarecraft flying over the water also gives automatic stability," Fischer says. "The closer you come to the ground, the more dense the air cushion becomes. The vehicle consequently develops more air loads on the wing surfaces and more height-sustaining pressure. You achieve a kind of equilibrium status and you can fly hands off close to the ground with peak efficiency."

For all its futuristic implications, Airfish III's roots go back to the early '30s, when a Finnish innovator employed ground effect to move a heavy sledge across a series of frozen lakes. A tractor-mounted propeller engine supplied the motive force, augmenting the air cushion beneath the craft. Soon, the rudimentary vehicle manifested a destabilizing pitch-up at high speeds—exhibiting a pesky glitch that would plague future ground-effect efforts. The Finnish solution: Trail a ski to counteract this rather unhealthy tendency.

German aerodynamicist Dr. Alex-  
(Please turn to page 124)



# BEST SELLERS

\$1256.00 Double Spread

A 13-car pitched battle for small sedan supremacy.



DODGE SPIRIT ES

BY RICH TAYLOR, Contributing Editor; PM Photos by John Lamm

**T**HESE are America's best-selling bread-and-butter cars, midsize workhorses that take the kids to school, Mom to the store, Dad to work—and the whole family to Disneyland. The things that are really important are everyday things: Will all the grocery bags fit in the trunk? Does it have the ruggedness to rack up 20,000 miles a year as a busy family's only car?

But there's more to life behind the wheel than day-to-day scurrying. And while these sedans aren't intended to be high-performance machines, the best of them are surprisingly fun to drive. Even after commuting to

work all week, they're still good enough to lure you out on a Sunday morning drive, just for the fun of it.

We spent a full day driving back-to-back loops over a driving-for-fun road near Los Olivos, California. We spent more time on freeways from Los Angeles to Santa Barbara, and split another day between Willow Springs International Raceway and Los Angeles County Raceway performing our standard track tests.

We packed in four adults and a trunk full of camera gear and luggage for short trips, and even brought along a 2-year-old to try out the baby-seat convenience of the back seats.

We made sure that one-third of our test crew were women, because women are primary drivers of the family car. In other words, we've lived with these sedans just about the way the average American family would.

## Toyota Camry Deluxe V6

Unanimously, the nine men, four women and baby girl of our test crew prefer Toyota's Camry V6. The Camry isn't the prettiest nor the most stimulating to drive. But beneath the Camry's innocuous bodywork is a very competent, comfortable, high-quality automobile.

Like every car in this group, the Camry is front-wheel drive, in this case with independent struts front and rear. Under the hood, the Camry has a terrific 4-valves-per-cylinder 2.5-liter V6.

Toyota is famous for quality, and there's nary a ripple, gapped seam or misplaced thread. The interior is sedate, but seems like the interior from a more expensive luxury sedan, with high-quality materials, excellent color coordination, and chair-height Mercedes-like bucket seats. There's plenty of room in the back seat for a 6-footer.

The ergonomics are excellent, with controls that are both easy to figure



TOYOTA CAMRY DELUXE V6





**HONDA ACCORD LXI**



**HYUNDAI SONATA GLS**

out and easy to use, four big white-on-black analog gauges and an excellent driving position. Driving the Camry is a delight. The V6 revs to a giddy 7000-rpm redline, and is capable of hauling this car to surprisingly high speeds.

There's virtually nothing we'd change about the Camry, although our test crew wasn't exactly seduced by its conservative styling. Even at the racetrack it's responsive and predictable, fast and fun. And in everyday driving, it's superb.

Almost unbelievably, half the cars in this test cost more than the Camry V6's \$15,762. For our money, there's no better buy in a small family sedan.

### **Honda Accord LXI**

However, there are certainly other cars that could be called just as good, and the Honda Accord is clearly one of them. The Accord has been the standard of excellence since Honda invented this class in 1976. Today, it's been massaged to the point where it's one of the most sophisticated small sedans ever built. For example, by using a double A-arm suspension front and rear, stylists could draw the hood line almost down to the tires, to improve visibility and aerodynamics.

The Accord interior is significantly larger than the Camry's in cubic feet.



**PEUGEOT 405 S**



**SUBARU LEGACY L**



## BEST SELLERS

But it feels smaller. Indeed, the Accord feels like a much smaller, sportier, more "tossable" car.

Like the Camry, the Accord posted midpack performance at the race-track. Obviously, the feel of a family sedan is more important than absolute track numbers. And the Accord feels terrific. The steering is firm and positive, the handling is neutral, and the little 2.0-liter Four revs easily. Unfortunately, you'll find yourself shifting down a gear on hills the Camry conquers in high gear.

Our test car was upholstered in a tasteful checked cloth that gives it a very upscale, ritzy feeling. Even the trunk is well finished off. The driver's ergonomics are excellent, with controls and gauges that put you at ease immediately. The seats have good side and lumbar support for spirited driving and the 5-speed gearbox is easy to shift.

If the Accord is so good, why didn't it win this test? Well, the Camry feels more solid and substantial to us, more comfortable and, well, effortless.

\$1347.00 Double Spread



**CHEVROLET  
CORSICA LTZ**

Realistically, though, many people may prefer driving the Accord to the Camry. There's more interaction between driver and machine, so it's more fun. That illustrates the differing corporate philosophies of Toyota and Honda. Toyota builds competence—Honda creates fun.

### Mitsubishi Galant GS

However, if driving fun is a priority, you won't want to miss a test drive in a Galant. This is a real sports sedan, with a staggering list of high-tech features. The GS version we tested uses

a microprocessor and sensors to tune the air-spring suspension and variable shock absorbers. It's not a true "active" suspension, but certainly one of the most high-tech suspension designs of any sedan currently in production.

The Galant shines at the track. Its 68.5-mph slalom speed is the highest we've seen in our testing of small passenger cars. The slalom is designed to test suspension control in transient handling, empirical evidence that the high-tech chassis really works.

The engine is a 2.0-liter Four with



**MITSUBISHI GALANT GS**



**MAZDA  
626 LX**

## SPECIFICATIONS AND DIMENSIONS

MANUFACTURER/ MODEL	PRICE: LIST/ AS TESTED	ENGINE/ DISPLACEMENT (ci/cc)	ENGINE HP, NET/ TORQUE (lb.-ft.)	ENGINE/ DRIVE LAYOUT	TRANS- MISSION TYPE	WHEEL- BASE (in./mm)	LENGTH OVERALL (in./mm)	WIDTH OVERALL (in./mm)	TRACK FRONT/REAR (in./mm)
<b>Chevrolet Corsica LTZ</b>	\$12,825/ \$13,726	L4 OHV 173.1/2837	130 @ 4700 rpm/ 160 @ 3600 rpm	front/ front	3-speed auto	103.4/ 2625	183.4/ 4656	68.2/ 1731	F:55.8/1416 R:55.3/1404
<b>Dodge Spirit ES</b>	\$12,495/ \$14,438	L4 SOHC Turbo 152.5/2508	150 @ 4800 rpm/ 180 @ 2000 rpm	front/ front	5-speed manual	103.3/ 2622	181.2/ 4600	68.1/ 1729	F:57.5/1459 R:57.2/1452
<b>Ford Tempo GLS</b>	\$10,273/ \$12,145	L4 OHV 140.3/2307	100 @ 4400 rpm/ 130 @ 2200 rpm	front/ front	5-speed manual	99.9/ 2536	177.0/ 4494	68.3/ 1734	F:54.9/1393 R:57.6/1462
<b>Honda Accord LXi</b>	\$15,920/ \$16,165	L4 SOHC 12V 118.9/1955	120 @ 5800 rpm/ 122 @ 4000 rpm	front/ front	5-speed manual	102.4/ 2599	179.7/ 4562	67.4/ 1711	F:58.3/1480 R:58.1/1475
<b>Hyundai Sonata GLS</b>	\$9695/ \$13,700	L4 SOHC 143.1/2351	110 @ 4500 rpm/ 138 @ 3500 rpm	front/ front	4-speed auto	104.3/ 2648	184.3/ 4679	68.9/ 1749	F:57.3/1454 R:56.7/1439
<b>Mazda 626 LX</b>	\$13,199/ \$15,447	L4 SOHC 133.2/2184	110 @ 4700 rpm/ 130 @ 3000 rpm	front/ front	4-speed auto	101.4/ 2574	179.3/ 4552	66.5/ 1688	F:57.3/1454 R:57.7/1465
<b>Mitsubishi Galant GS</b>	\$15,269/ \$16,678	L4 DOHC 16V 121.8/1997	135 @ 6000 rpm/ 125 @ 5000 rpm	front/ front	5-speed manual	102.4/ 2599	183.9/ 4669	66.7/ 1693	F:57.5/1459 R:57.5/1459
<b>Nissan Stanza QXE</b>	\$12,199/ \$16,738	L4 SOHC 120.4/1974	94 @ 5200 rpm/ 114 @ 2800 rpm	front/ front	4-speed auto	100.4/ 2549	177.8/ 4514	66.5/ 1688	F:57.5/1459 R:57.5/1459
<b>Oldsmobile Cutlass Calais SL</b>	\$11,995/ \$15,693	L4 DOHC 16V 140.3/2300	150 @ 5200 rpm/ 160 @ 4000 rpm	front/ front	3-speed auto	103.4/ 2625	178.8/ 4539	66.7/ 1693	F:55.8/1411 R:55.2/1401
<b>Peugeot 405 S</b>	\$17,700/ \$18,145	L4 SOHC 115.9/1905	110 @ 5200 rpm/ 120 @ 4250 rpm	front/ front	5-speed manual	105.1/ 2668	177.7/ 4511	67.6/ 1716	F:56.7/1439 R:56.4/1431
<b>Subaru Legacy L</b>	\$12,000*/ \$15,500*	Flat-4 SOHC 16V 134.2/2200	160 @ 4500 rpm/ 161 @ 5900 rpm	front/ front	5-speed manual	102.0/ 2589	178.0/ 4519	67.0/ 1701	F:56.1/1424 R:56.1/1424
<b>Toyota Camry Deluxe V6</b>	\$14,108/ \$15,762	V6 DOHC 24V 152.9/2507	153 @ 5600 rpm/ 155 @ 4400 rpm	front/ front	5-speed manual	102.5/ 2602	182.1/ 4623	67.3/ 1708	F:58.3/1480 R:57.1/1449
<b>Volkswagen Jetta Carat</b>	\$15,140/ \$15,535	L4 DOHC 108.5/1780	105 @ 5400 rpm/ 110 @ 3400 rpm	front/ front	5-speed manual	97.3/ 2470	171.7/ 4359	66.1/ 1678	F:56.3/1429 R:56.0/1421

\*Estimated

1. Best speed achieved while weaving through seven cones placed in-line, 100 ft. apart; speeds provide index of transient response.



**NISSAN STANZA GXE**



**VOLKSWAGEN JETTA CARAT**

dual counterrotating balance shafts, double-overhead cams and four valves per cylinder. It's neither as powerful nor as smooth as Toyota's V6, but its nervous energy and raspy exhaust note are perfectly in keeping with the Galant's spirited and sporty personality.

Computers are used to control not only the suspension, but the variable-assist steering. We couldn't tell much difference between Normal and Sport suspension settings, but these high-tech details typify virtually every aspect of the Galant, from 4-wheel disc

brakes—ABS optional—to high-zoot sound system.

The Galant stylists have carved a lot of visual interest into the body and interior. It's more dramatic than the Camry, though perhaps not as sophisticated as the Accord. The driver's ergonomics are particularly well thought out, with a nice fat steering wheel, big gauges and logical placement of controls.

Bottom line, the Galant is a 4-door sports car that's always ready for action. It's all a matter of personality. Compared to the conservative perfec-

tion of the Camry and developmental polish of the Accord, the Galant GS is high-tech brash and sassy.

### Mazda 626 LX

Mazda's 626 is the most popular Japanese car in Germany. It's easy to see why. From the outside, it has the same rounded shape as a 3-series BMW or Scorpio, sort of a prettier, more delicate version of the same visual themes used on the slightly larger Toyota Camry.

Inside, the 626 has a dash with a

*(Please turn to page 120)*



**FORD TEMPO GLS**



**OLDSMOBILE CUTLASS CALAIS SL**

## TEST RESULTS

CURB WEIGHT (lbs.)	STEERING TYPE/TURNS LOCK-TO-LOCK	BRAKE SYSTEM FRONT REAR	FUEL ECONOMY (EPA city/PM test)		ACCELERATION 0-60 MPH (sec.) 1/4-MILE (sec. @ mph)		BRAKING 60-0 MPH (ft.)	700-FT. <sup>1</sup> SLALOM (mph)	SKIDPAD <sup>2</sup> 200-FT. CIRCLE (G)	EPA CARGO VOLUME (cu. ft.)	EPA PASSENGER VOLUME (cu. ft.)
			18/17.61	12.87/17.79 @ 76.92							
2750	Power R&P/ 2.9	F:9.7-in. vented disc/ R:7.8-in. drum	18/17.61	12.87/17.79 @ 76.92	123	66.51	.82	13.5	108.6		
2850	Power R&P/ 2.5	F:10.0-in. vented disc/ R:8.6-in. drum	18/17.16	11.11/16.66 @ 82.19	144	66.21	.82	14.4	111.0		
2650	Power R&P/ 3.0	F:9.2-in. vented disc/ R:8.0-in. drum	19/22.28	13.64/18.19 @ 74.68	132	65.56	.77	12.9	102.0		
2700	Power R&P/ 3.1	F:10.2-in. vented disc/ R:7.8-in. drum	22/21.14	12.97/17.77 @ 76.33	131	67.07	.80	13.7	104.3		
2700	Power R&P/ 3.0	F:10.1-in. vented disc/ R:9.0-in. drum	21/19.58	14.60/18.87 @ 72.58	167	63.10	.80	13.4	113.8		
2850	Power R&P/ 2.9	F:10.4-in. vented disc/ R:10.5-in. drum	19/22.04	14.38/18.80 @ 73.34	131	60.85	.76	15.9	100.0		
2800	Power R&P/ 3.1	F:10.4-in. vented disc/ R:10.4-in. drum	21/17.47	12.46/17.47 @ 77.85	159	68.57	.82	10.5	105.4		
2900	Power R&P/ 3.2	F:9.7-in. vented disc/ R:8.9-in. drum	21/19.88	16.35/19.78 @ 68.44	139	62.75	.73	12.0	89.0		
2800	Power R&P/ 2.9	F:9.7-in. vented disc/ R:7.8-in. drum	20/20.60	12.64/17.82 @ 78.39	162	67.43	.82	13.2	103.6		
2700	Power R&P/ 3.1	F:10.5-in. vented disc/ R:9.8-in. drum	20/21.05	13.24/17.98 @ 75.75	126	64.72	.84	13.7	104.7		
2700	Power R&P/ 3.2	F:10.2-in. vented disc/ R:10.5-in. drum	20/20.43	12.01/17.39 @ 80.21	140	63.53	.81	14.5	100.0*		
2900	Power R&P/ 3.8	F:10.0-in. vented disc/ R:10.6-in. drum	19/17.24	12.15/17.49 @ 79.85	159	63.15	.81	14.6	89.0		
2450	Power R&P/ 3.8	F:9.4-in. vented disc/ R:7.1-in. drum	22/25.27	12.57/17.53 @ 77.51	130	61.51	.83	16.6	86.9		

2. G-force generated during steady-state travel around a 200-ft.-dia. circle. Chart number is an average of best cw and ccw.



COLLECTIBLES

# RECAPITULATING The Classics

\$1768.00 Double Spread



Old-bike buffs restore the gleam to snazzy 2-wheelers and recapture a streamlined piece of their lost youth.

BY NORMAN S. MAYERSOHN,  
Contributing Editor

**T**HESE DAYS, you'd be an exception to the rule if there wasn't a long list of personal childhood artifacts that you wish were never discarded. Electric trains, comic books, baseball cards, maybe even your first car—all have become so precious that in most cases we can hardly afford to replace them just to satisfy a nostalgic longing.

Of course, back when we were growing up there was never time to look any direction but straight ahead. It only seemed natural that when something as important as a new bicycle was acquired, the old one had to go. Fortunately, the bike you grew up with may be one of the youthful necessities that you can still get back. In fact, 1940s' and 1950s' era bicycles



Schwinn curator James Hurd with the all-fiberglass Bowden Spacelander of 1960.

have become one of the hottest categories of collectibles in recent years.

Reliving those carefree days of school's summer vacation and the independence our bicycles allowed would be cause enough to search out the Schwinn or Columbia of the day, but the significance is even more deeply rooted to many PM readers. After all, that bike probably represented our first exposure to mechanical possessions, a device that needed regular maintenance, occasional repairs and hopefully survived well-intentioned modifications. From that point on, we were hooked.

Even if you weren't necessarily of knee-skinning age during the decades surrounding World War II, it's easy to recognize the bicycles of that era as classics of style and design. Their most prominent feature, and the one





Every colorful detail, even nameplates, are available to restorers at collector meets.

which distinguishes these two wheelers from all that came before, are the wide balloon tires.

The tube design of those balloon tires made punctures easy to repair, but they were not popular in America because of their higher cost. The Chicago-based Arnold, Schwinn & Co. saw them as a strong selling point, though. The company's engineers duplicated the wheel tooling and tire molds from European designs and introduced the low-pressure balloon tires here in 1933.

What really makes the bicycles on these pages so desirable, though, are the vivid memories brought to life by the flowing lines and stylized metalwork. With considerable accuracy, each one reflects the prevailing trends of contemporary industrial design. Like so many consumer products of the period, they take on Art Deco streamlining or pop culture characterizations. And many of the classic designs were available as ladies' models, too, so no member of the family had to be left out.

### Aerodynamic designs

In their earliest forms, balloon-tire bikes imitated motorcycle lines, adopting a mock gas tank between the top frame tubes. At first this was a storage compartment for headlight batteries, then a housing for an electric horn or portable radio. Schwinn brought out its Aerocycle in 1934 to capitalize on the streamline movement then sweeping automotive design, and before long this look was the standard of the industry. Columbia, Huffman, Shelby and Cleveland Welding all responded with sleek models that borrowed heavily from the airplane shape.

The romance of these special bikes was not restricted to special high-priced models. Retail chain stores had their own lines, and often they were among the most desirable. Montgomery Ward had the Hawthorne brand, Sears sold the Elgin models and later J.C. Higgins. The 1935 Elgin Bluebird is a standout among classics, featuring a headlight built into the steering head, an illuminated speedometer incorporated into the horn tank, and a leather saddle supported by leaf springs. All the gimmickry taxed young legs mightily, though—the Bluebird's shipping weight was a hefty 77 pounds. Sears's easy payment financing introduced youthful buyers to adult responsibilities, too, offering a plan of \$5 down and \$5 per month until the \$49.45 total was paid. Cash price was \$44.95.

Technical innovations flourished during the balloon-tire era as well. The Monark Silver Kings of the mid-1930s offered aluminum alloy frames long before they regained popularity



Shelby's Donald Duck-Bike is vintage 1949 (above). Sears/Elgin Bluebird (top right) dates from 1935, and elegant ladies' Skylark (right) from 1937.





## RECYCLING THE CLASSICS

in the 1980s. A flex-spring frame promised a smooth ride, and one year's free insurance against fire and theft was included with the purchase. Knee-action spring forks softened the jolts of neighborhood streets in the late 1930s.

At the farthest reach of forward-looking design was the Bowden Spacelander, conceived for a British technology fair in 1946. Except for the front fork, its framework was entirely built of bonded fiberglass. Production didn't begin until 1960, though, and by that time the slim racer-style bike was what the public craved. Spacelanders are a genuine rarity today, and priced accordingly.

One of the more popular, and certainly most memorable, balloon-tire model was the Schwinn Phantom series, produced from 1949 to 1959. As you see from our opening photo, its aeroshaped headlight on the front fender, pinstriped horn tank, whitewall tires and sleek styling mark it as a true classic. The Smithsonian Institution has recognized its status as a vintage piece of Americana by including a

1955 Black Phantom (ladies' model) in its transportation collection.

### Discovering a classic

Fortunately for those who would like to once again ride off on a Phantom or other balloon-tire bike, the classic 2-wheelers have not suffered the same

assures that they haven't yet become so precious that they must be kept under glass in climate-controlled conditions.

It's fitting that the most reliable method of acquiring a balloon-tire classic at a reasonable price is the all-American garage sale. Flea markets are next best, and then collector swap meets, which provide an education as well as a purchase opportunity. Don't forget the local bike shop or neighborhood repairman. If you put the word out, someone else's unwanted cast-off could become your pride and joy.

It's worthwhile to check the used-merchandise tabloids and consider placing a want ad for old bikes, too. The specialized magazines of antique dealers and old-car enthusiasts can be of great help. Even in bicycle collector publications complete, highly prized classics are available for a few hundred dollars. When you consider how much less space the bikes take up and the relatively low cost to restore, you'll understand why there are so many former car collec-

*(Please turn to page 123)*



Self-styled innovation continues for some balloon-tire enthusiasts.

price escalation seen in old toys and cars. A large number of balloon-tire bikes are still to be found in the dark recesses of basements and the rafters of neighbor's garages.

While they're unmistakably collectibles, enormous production numbers (some 38 million according to Schwinn History Center Curator Jim Hurd)

## This Phantom Rides Again

**J**UST because a bike is still in the hands of the original owner doesn't mean it's been well-cared for. The 1953 Schwinn Black Phantom in these photos and on the opening page was a basket case. The owner chopped the front fender, stripped the bike of many

original pieces and then, a generation later, the bike had been completely disassembled by his son. Still, the nostalgic attachment was strong enough to make a restoration desirable.

First, all the parts were thoroughly cleaned so that we could take stock

and determine what we'd have to acquire. I sent the frame out to an auto body shop for repainting and gave the painter an original Black Phantom color sales brochure to use as a guide. I also sent out many small parts for rechroming. The original spoke wheels were too far gone, so we found good used ones at an old bike flea market.

I did much of the repainting of smaller items myself. The rear carrier and light, front light housing, chain guard and the horn tank were all sandblasted, then carefully repainted. The Schwinn medallion mounted at the front of the frame was a particular nightmare.

The original saddle was sent to a specialist. He used leather that is almost identical to the original pattern and grain. He also reproduces metal side tabs. This type of detailing is revered by old-bike buffs.

A set of reproduction decals was easy to locate. One disappointment was that I could not locate a set of new old stock tires. We settled for whitewalls that are close to original in most details but not in tread pattern.

When the process was over, we were happy and the owner was happy.

—Frank Coggins



Though this Schwinn Black Phantom was a one-owner model, it suffered from youthful enthusiasm 35 years ago. Painstaking paint detailing, replacement decals and a reproduction seat covering restored it to as-good-as-new condition for original owner.

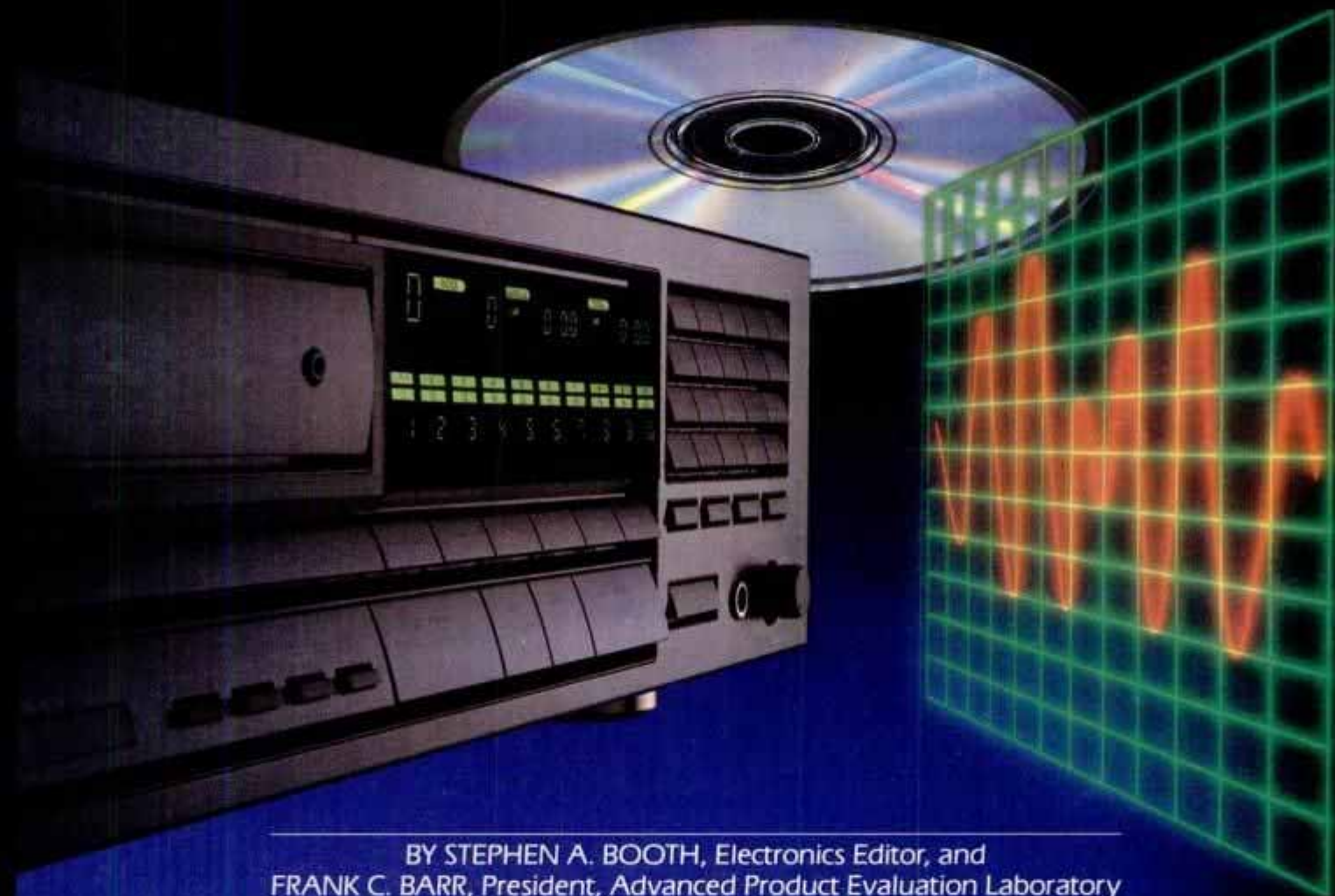


COMPACT

\$1376.00

# CD PLAYER SOUND OFF

Paying for more bits doesn't necessarily mean you're going to get better sound from a compact disc player.



BY STEPHEN A. BOOTH, Electronics Editor, and  
FRANK C. BARR, President, Advanced Product Evaluation Laboratory

**J**UST SIX YEARS have passed since the very first digital audio compact disc players made their debut in the United States. Amidst the hoopla and hyperbole of the product launch, one manufacturer enthusiastically proclaimed that CD represented "pure, perfect sound—forever." Yet ever since that time, the advertising for each new generation of CD players suggests

that perfection itself is capable of improvement.

Over the years, **POPULAR MECHANICS** has reported each of CD's steps up the evolutionary ladder. While all of these improvements have been real, they have not always been audible. This is to say, the enhancements in circuitry and internal components often improve the player's overall operation, accuracy and reliability—and some-

times even can be measured with lab equipment. But the improvements don't necessarily deliver any sonic difference that is evident to normal human hearing.

This, once again, appears to be the case with CD's latest incarnation: Players whose digital-to-analog converter (DAC) circuits use 20 bits or 18 bits instead of the usual 16.

Based on our tests at the Advanced



# CD PLAYER SOUND OFF

\$1206.50 Double Spread



Product Evaluation Laboratory (APEL) in Bethel, Connecticut, we have determined that the "extra" bits in a CD player's DACs do not contribute any audible improvement to the music you hear. Moreover, APEL's tests show that DACs with extra bits are not inherently superior to well-designed 16-bit DACs. Against a player with hand-picked 16-bit DACs—and even a rock-bottom-priced machine with 16-bit DACs—the models with more sophisticated DACs registered no audible improvement in the area of low-level (low volume) distortion, where the extra bits are supposed to help. Although APEL was able to measure the differences among the DACs, you can't hear them.

Even before our APEL tests, we suspected this would be the case. But in the absence of data from a lab, it is possible that the role of the bits will be overstated by advertising hype and well-meaning, but ill-informed, word of mouth.

Undoubtedly, extra-bit machines will be touted as achieving more accurate reproduction or better resolution than 16-bit models—with the implication that they sound superior. The re-

**YAMAHA CDX-1110U**  
Serial No. MO52038SU  
PRICE: \$1199  
OVERSAMPLING RATE: 8X  
This unit scores at or near the top for flat frequency response, low distortion/noise, tracking dropouts.  
\* Bit-shifting, 16-bit DACs.

sults of this test should keep the record straight, and stall the spread of a hi-fi half-truth akin to the common misconception that higher-octane fuel can make an econobox perform like a superstock drag racer.

### The equipment

POPULAR MECHANICS selected top-of-the-line CD players from four highly re-

### 18-BITS

#### ONKYO DX-7500

Serial No. 8807000702

PRICE: \$700

OVERSAMPLING RATE: 8X

In linearity, the DX-7500 is second only to the Philips CD-880. Other numbers aren't as impressive as those of the three other top-shelf players, but the differences are rarely audible.

garded audio manufacturers. Each of these machines represents a different philosophy and approach to building DACs.

■ Denon's DCD-3520 (\$1500) employs hand-trimmed, 20-bit DACs

ampling of the digital incoming off the CD.

■ Onkyo's DX-7500 (\$700) incorporates true 18-bit DACs, and performs 8X oversampling of the CD.

■ Philips, in its CD-880 (\$749), contends that well-constructed 16-bit DACs will perform as well as DACs with extra bits. The Philips-made DACs are hand-selected from the production run for their accuracy, as are the 4X oversampling digital filters.

■ Yamaha's CDX-1110U (\$1199) uses the company's Hi-bit or floating-bit technology. In an arrangement called bit-shifting, conventional 16-bit DACs act as 18-bit devices when needed. Specifically, when a low-level signal needs to be resolved, unused bits are shifted from the top end of the



DAC's scales to provide extra computing power at the bottom. The CDX-1110U uses 8X oversampling.

As a control for our experiment, APEL also measured a CD player that is more typical of the vast majority on the market in that it uses conventional, mass-produced 16-bit DACs, performs 4X oversampling and carries a suggested retail price below \$300. This became our reference player, to form a basis of compar-

## LAB TESTS\*

	DENON DCD-3520	ONKYO DX-7500	PHILIPS CD-880	YAMAHA CDX-1110U	REFERENCE PLAYER
1. Bits Per DAC/Oversampling Rate	20/8	18/8	16 <sup>1</sup> /4	18 <sup>2</sup> /8	16/4
2. Output Voltage <sup>3</sup> (Left/Right Channel)	2.15/2.15	2.02/2.08	1.97/1.95	2.14/2.24	2.16/2.10
3. Output Difference Between Channels	0.00 dB	0.25 dB	0.09 dB	0.40 dB	0.25 dB
4. Linearity Error, Worst Case (@ -90 dB)	+1.39 dB	-0.63 dB <sup>4</sup>	-0.30 dB	+1.20 dB	+2.71 dB
5. Linearity With Dither (@ -80 dB)	+0.52 dB	+0.17 dB	-0.16 dB	+0.40 dB	+0.52 dB
6. Frequency Response <sup>5</sup> (+dB/-dB)	+0.00/-0.28	+0.00/-0.22	+0.04/-0.13	+0.00/-0.16	+0.04/-0.29
7. Signal/Noise Ratio <sup>6</sup> (Left Channel)	117.1 dB	106.1 dB	113.9 dB	111.5 dB	100.5 dB
8. THD <sup>7</sup> + Noise, @ 0.0 dB for					
31 Hz	0.006%	0.005%	<b>0.004%</b>	0.006%	0.007%
1 kHz	<b>0.006%</b>	<b>0.006%</b>	<b>0.006%</b>	<b>0.006%</b>	0.007%
10 kHz	0.008%	0.009%	0.007%	0.006%	0.017%
16 kHz	0.017%	0.012%	<b>0.006%</b>	0.007%	0.022%
@ -30 dB for 1 kHz	0.013%	<b>0.007%</b>	0.040%	<b>0.007%</b>	<b>0.007%</b>
@ -50 dB for 1 kHz	0.200%	0.400%	<b>0.080%</b>	0.216%	0.165%
9. Dropouts <sup>8</sup> (1 per track, 0.05-4.0mm)	1.25mm	1.25mm	1.50mm	<b>2.00mm</b>	<b>2.00mm</b>
10. Dropouts <sup>8</sup> (2 per track, 0.05-4.0mm)	1.00mm	1.50mm	<b>2.20mm</b>	<b>2.20mm</b>	<b>2.20mm</b>

1. Hand-selected DACs. 2. Bit-shifting 16-bit DACs. 3. Measured at 1 kHz. Becomes 0 dB reference point for other measurements. 4. Worst case occurred at -80 dB. 5. Measured from 17 Hz to 20 kHz. 6. Measured at left channel, per EIA standard. 7. Total Harmonic Distortion. 8. At normal track pitch, using a 500 Hz tone. \*Boldface type indicates best measurement in each test category. Test discs: CBS CD1, 2nd Edition (Electronics Industries Assn. Proposed Standard); Pierre Verany PV-788032 (tracking tests.)



ison with the newer models. Like the others, it uses separate DACs for the left and right stereo channels.

### DACs and oversampling

For the record, the number of DACs and the degree of oversampling do have an audible effect on performance. At CD's introduction, single-DAC units with little or no oversampling were commonplace. But at this stage in the format's development, any player should have at least dual DACs and 4X oversampling.

Still, some less-capable, inexpensive CD players use a single DAC. This causes a slight delay in the arrival of musical information at your ears, as the left and right channels must be processed one after the other. What you hear is out of phase from the standpoint of time, and therefore slightly distorted.

Cheaper players might also use only 2X oversampling—or none at all. For CD recording, a musical signal is sampled 44,100 times per second (44.1 kHz). Each sample receives a 16-bit or 16-digit code of zeros and ones that represents its frequency (tone) and amplitude (volume level). In all, there are 65,536 codes for sound in the audible range, from 20 Hz to 20 kHz.

Contrary to popular myth, oversampling the information on the CD does not reconstruct a more accurate replica of the original musical waveform. Remember, the CD was recorded with 44.1 kHz samples. More frequent or closely spaced samples cannot be created on playback, because they do not exist on the original.

What oversampling does is eliminate sound-distorting noise actually created by the player's digital components. When the signal is oversampled, the noise is shifted to higher frequencies beyond the audible range (88.2 kHz, 176.4 kHz, 352.8 kHz for 2X, 4X and 8X oversampling, respectively), then filtered away. The farther the sampling is from the last audible frequency (20 kHz), the easier it is to filter without removing some of the audible high frequencies as well.

### Test criteria

Just as oversampling a CD cannot create musical samples that do not exist, adding more bits to the player's DACs cannot increase the amount of musical information in a CD's individual 16-bit codes. The additional bits are intended only to help the DACs translate the CD's 16-bit codes more accurately



### 20-BITS

#### DENON DCD-3520

Serial No. 630921005

PRICE: \$1500

OVERSAMPLING RATE: 8X

Denon introduced the first machine with 20-bit DACs.

Though its linearity with dither is the same as the reference player's, leads the pack in signal-to-noise, output-level matching.

than 16-bit DACs might.

The APEL tests are intended to check this contention—and also to measure whether any improvement attributable to the extra bits is audible. We should emphasize that the APEL tests do not make judgments regarding how well a player sounds. Subjective considerations aside, there are many other factors that affect a player's sound quality. These include even nondigital components, such as the number and makeup of the power supplies, the quality of the analog circuits, internal noise-isolation and construction of the chassis itself. Accordingly, the key test categories on the accompanying comparison chart are those that measure LINEARITY ERROR and LINEARITY WITH DITHER. These results present the worst-case inaccuracy of an individual machine's DACs.

Of course, APEL had to test every aspect of a machine's operation in order to isolate any factor that might affect the overall results negatively—for example, laser mistracking. The results of many of these tests are also presented on the chart. You'll find them useful for making comparisons when shopping for a CD player. Before describing how to interpret them, let's look at DAC linearity.

### 16-BITS

#### PHILIPS CD-880

Serial No. 012759

PRICE: \$749

OVERSAMPLING RATE: 4X

The CD-880 is proof that

16-bit DACs can perform as well or better than those with more bits.



### The role of bits

Let's assume that the frequency and level (amplitude) of a musical signal has been recorded correctly as a 16-bit code on a CD. It is now the job of the digital-to-analog converter to translate the code, bit by bit, back to the original analog waveform.

DACs, owing to internal causes and external ones (such as heat) sometimes measure the incoming code incorrectly. When a decoding error occurs in a loud passage of music, it

might be masked by other sounds. But if it occurs during a quieter passage, the error might be audible.

In the literature of digital audio, DACs have been cleverly compared to rulers. Although the entire length of the ruler might be correct, nonlinearities or incorrect spacings between its fractional markings might cause minute but possibly critical errors if measurements were being made in those areas.

The way a digital code is written, the leftmost or first digit is called the Most Significant Bit (MSB). It signifies the most basic character of the sound. Each subsequent bit to the right defines the sound more and more precisely. To prevent gross errors, builders concentrate on a DAC's accuracy or linearity at the MSB.

One method of doing this is to use individually selected and tested 16-bit DACs. This is the Philips approach. Another way is to make more precise measurements in the critical area by adding more fractional markings. This is what extra-bit DACs do. Each additional bit doubles the ruler markings within the same space. So, whereas a 16-bit DAC has 65,536 markings, an 18-bit DAC has 262,144, and a 20-bit DAC has 1,048,576. Of course, these extra-bit DACs might have nonlinearities between their minute markings, but an error of  $\frac{1}{262,144}$ th is much less significant than

being off by  $\frac{1}{65,536}$ th.

### Can you hear it?

The two APEL linearity tests show that the machines whose DACs have extra bits measure better than the reference player with mass-produced 16-bit DACs, although not as well as the Philips model with hand-selected 16-bit DACs. But in audible, real-

(Please turn to page 126)



## AVIATION

\$2695.00 Double Spread  
From Jan. 1989



# BIRD O

Swift. Agile. Deadly. The F-16 Fighting Falcon has already earned a place in the fighter hall of fame, and will continue to defend our skies well into the 21st century.

BY TIM COLE, Science/Technology/Aerospace Editor

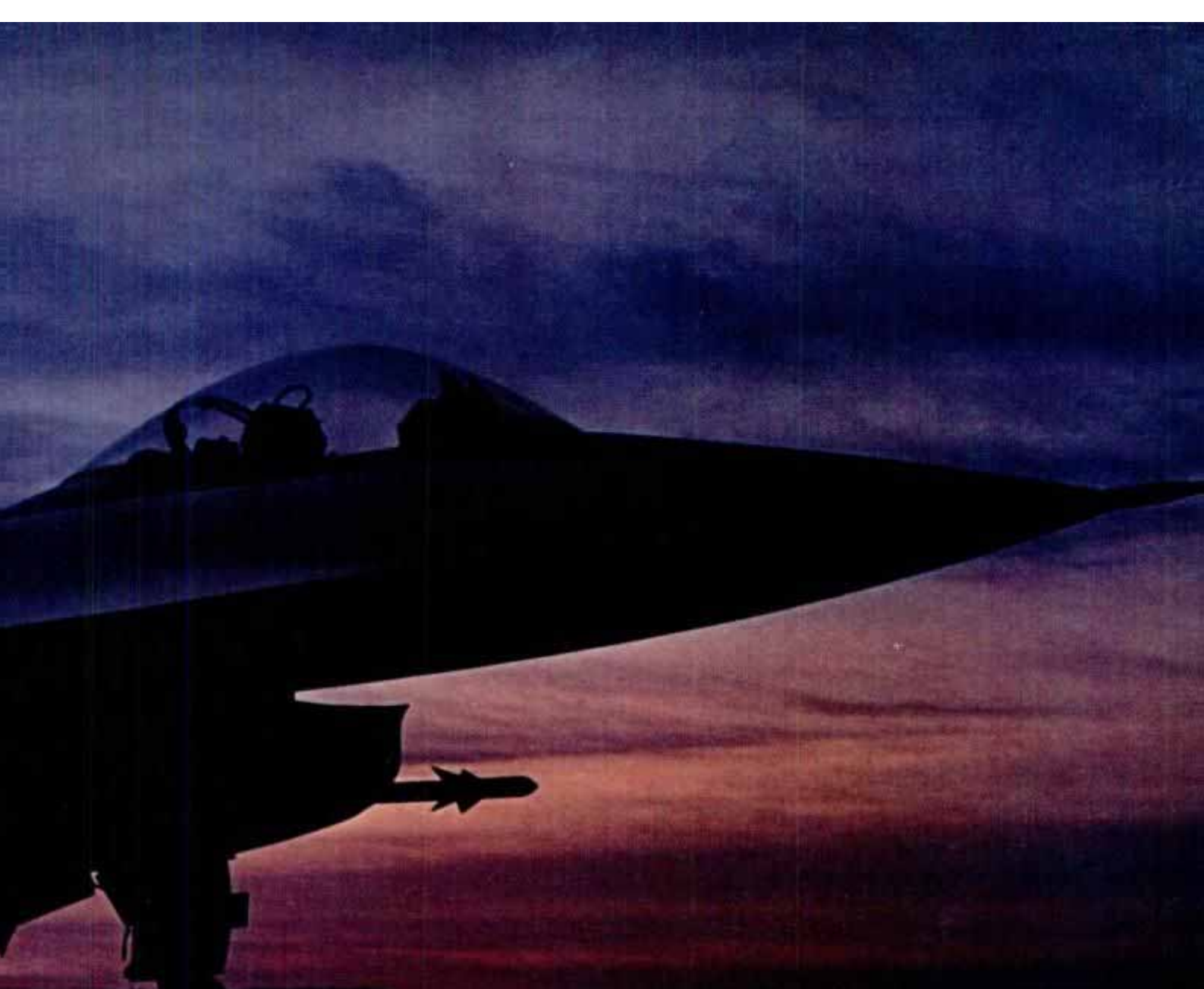
**Y**OU HAVE THE AIRCRAFT," said F-16 jockey Doug Dean over the interphone, yielding control of this \$20 million piece of sculpted high-grade aluminum traveling at 500 knots.

Nestled comfortably in my rear ejection seat, I grasped the fighter's side-stick controller and followed the luminescent railroad track advancing toward the electronic horizon on my heads-up display. Flying along this artificial flight path would keep us in general proximity to the ground track plugged into the inertial navigation system.

All at once the neurons firing in my brain made the inextricable link with the 16's fly-by-wire control surfaces, and the thirsty Pratt & Whitney F100 powerplant roaring just inches away.

Slight pressure from the tips of my Nomex-covered fingers redirected or rolled this charging mass of aeronautical wizardry, rudder angle bleeding in with tiny inputs from the palm of my hand. Man and machine finally merged as we punched a smoky hole in the clouds, the senses exploding as the F-16 popped at 10,000 ft.





# F16 PREY

into the crystal clarity of a Florida afternoon.

I skimmed the aircraft inches off the cloud deck, slamming around the haystacks and plumes, blasting through the larger agglomerations of stratocumulus.

"I try to explain to people what this is like," said Capt. Dean, enjoying the ride from his polycarbonate-enclosed perch up forward. "It's just so amazing."

He's right. It's hard to couch this one in the standard superlatives.

## Lean and mean

But for Dean, this is also a business trip. He and 7000 other pilots in the 25 wings of the United States Tactical Air Command fly to fight—one of the most demanding occupations in the world, a game of ultimates where

mistakes don't buy time in the penalty box or a stint on the bench.

Dean's instrument of war is the General Dynamics F-16 Fighting Falcon, a hybrid ground attack/air-to-air fighter that can engage enemy aircraft, go deep to strike an enemy's second-echelon supply lines and reserve troops, or give our own troops close air support at the forward edge of battle. The 2-seat training F-16B we were flying this day is a crucial element in TAC's mission to support the United States Central Command, our rapid deployment forces.

The F-16 has also entered the august ranks of the classic fighters—aircraft that have changed the world by the way they've altered aerial combat.

After a decade of service all over the world, the F-16



## BIRD OF PREY

— \$1474.00 From Feb. 1989  
\$500.00 Revised for July

joins those time-ly and yet timeless warriors like the World War I Spad, the Spit, the Me-109, the P-51, the F-100-series of supersonics, and Vietnam's workaday F-4 Phantom. With avionics and armament upgrades—like the LANTIRN all-weather, night-fighting laser-targeting device, and the advanced medium range air-to-air missile (AMRAAM)—the F-16 will be a potent force well into the next century.

### Hitching a ride

What better way to salute this modern classic than to don our G-suit and go on a typical F-16 training mission? Capt. Doug Dean, an F-16 instructor, and Air Force personnel of the 62nd Tactical Fighter Training Wing at MacDill AFB were glad to oblige.

A heightened reality pervaded the cockpit of our Fighting Falcon as the canopy thunked shut on this December afternoon. With the sky painted in a broken overcast, I was about to learn that flying to fight is tough men-

tal and physical work, mixing the brute power of a lineman with the reaction time of a linebacker with the intellectual acuity of a quarterback.

### The electric jet

At the F-16 pilot's disposal is one of the most advanced tactical avionics systems made today. The aircraft's look-down APG-66 radar (the newer C and D versions have the improved APG-68 model) is sensitive enough to find enemy aircraft in ground clutter. Later F-16s are equipped with LANTIRN pods, and the optional ALQ-131 strap-on pod, which jams enemy radio signals. The HUD integrates fire control, target acquisition and tracking, navigation, terrain avoid-

An oval underfuselage intake and polycarbonate bubble canopy characterize the lean, blended form of the General Dynamics F-16. Note the maneuverability-enhancing control surfaces on the underside of the aircraft.

ance and other aspects of fighter flight, allowing the pilot to find and shoot at heretofore impossible angles.

"You move the aircraft through all dimensions, presenting ground defenders with as much of a problem as you can," said Dean. "The 16's instruments and avionics help make it simple. With our heads-up system, you put the green dot on the white track—that's the axis you're traveling on—and push the red button."

These simple movements allow the pilot to take the airplane into, and away from, a distinctly hostile situation. Using radar-guided air-to-air missiles (AIM-7), infrared-guided air-to-air missiles (AIM-9), or the new AMRAAM, which will strike air threats beyond visual range, Dean and his colleagues will be able to use the F-16 more effectively against a constantly evolving threat. Increasingly, those threats—like the highly capable MiG-29—can strike first, or survive to strike back.

Training makes the difference, said Dean as we lined up on the tarmac next to our wingman for the afternoon, Capt. John Morrison. "I'll try to show you what I mean."

### Pulling Gs

Inspectors on the ground pulled the safety pins on our practice bombs and gave us a visual once-over. On the go-ahead from ground-control approach, we taxied to the head of MacDill's 11,450-ft. strip. The next sensation is well-known to Big Daddy Don Garlits—a pin-your-lips-back takeoff roll that launched us down the runway, the fuel-flow meter spinning in a kind of supernatural frenzy. The F-16 sprinted into the air, eager to "slip the surly bonds."

We were on a full training flight this afternoon, a bombing profile that would take us out over the Gulf of Mexico at an altitude of 1000 ft., then inland to the Air Force tactical training range at Avon Park. Ground scorers would use television cameras to

*(Please turn to page 118)*



The F-16's front office includes wide-view heads-up display and multiple CRT screens that offer the pilot instant updates on navigation, engine performance or weapons status. The F-16's bubble canopy (left) affords almost 360° sightlines.



PHOTO BY GEORGE HALL



## COMPARISON TEST

\$2061.00 incl. pg. 84

ALUMACRAFT  
PHANTOM V170

# BASS

# BLITZERS

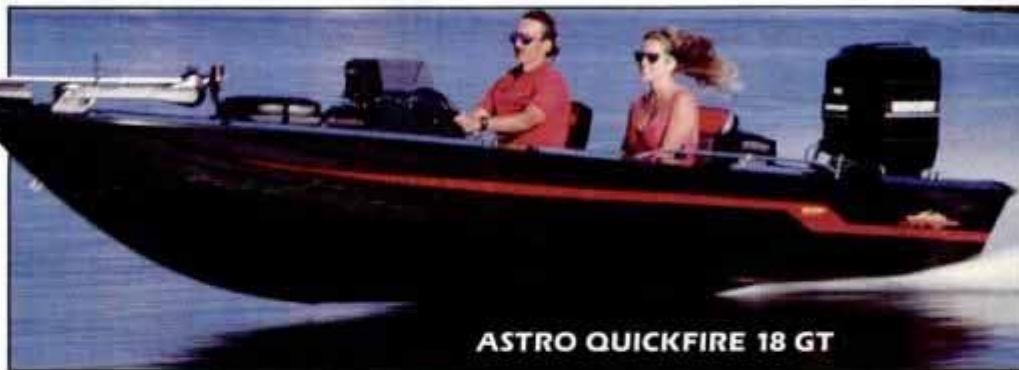
Good looks, sport-tech design and affordability converge in a 4-way aluminum bass boat shootout.

BY JOE SKORUPA,  
Boating/Outdoors Editor  
PM photos by Skip Gandy

**B**ASS boats are the assault weapons of fishing. Lean and mean. High powered and high speed. Designed with one mission in mind—to swiftly strike targeted territory and aggressively engage the adversary. But unlike other fighting machines, these battlewagons *do* take prisoners—a 2-man team's daily limit fits snugly into the aerated livewells.

A number of bass fishermen, no doubt, view themselves in less macho terms. Bassing, after all, is a recreational sport. On the other hand, it's no accident that the modern bass boat is a marvel of highly specialized offensive equipment.

Bass fanatics know what they want—a single starboard console that leaves space for a rod locker to port, shallow-draft hull for skirmishing in



ASTRO QUICKFIRE 18 GT

skinny water, raised bow and aft casting decks with pedestal seats, aerated livewells to keep bass healthy on the ride home, fore and aft mounting surfaces for instruments and equipment and, finally, a powerful engine to scream from spot to spot.

This basic configuration is so well suited to its purpose that boat builders stray from it at their peril. Demanding bassers, however, *do* have some options, most notably in hull material, and aluminum has recently

come on strong. Bassing was originally dominated by aluminum boats, but as the sport grew in popularity it progressed beyond simple, riveted tool boxes. The move was made partly because competitive fishermen wanted weight-bearing rigs to handle large engines and a sizable load of gear, and partly because the big-money pros became media stars and everyone wanted to emulate their flashy, hot-rod fiberglass rigs.

But, today, aluminum is back.



\$3754.00 Double Spread

Fleet of econocommandos ready to kick bass (left to right): Astro Quickfire 18 GT, Alumacraft Phantom V170, Crestliner Maverick V170 and Sylvan Bass Hawk 17.

Thanks to rivet-free construction and expensive shaping techniques, modern aluminum boats are contoured, stylish, loaded with fish-fighting features, and capable of handling high-horsepower engines.

The PM test team brought together four of these rigs for a head-to-head comparison test. We assembled the fleet in Sanford, Florida, where the pristine St. Johns River offers some of the best cypress-shaded bass fishing in the country.

All boats were equipped with the new 115-hp Mercury outboard, which features a number of high-tech bells and whistles. (More on this later.) Each engine was tuned and propped by a team of Merc technicians from

the company's Mercabo Test Base. Here are the test results.

## Astro Quickfire 18 GT

In the closest comparison test in recent memory, the Astro Quickfire 18 GT emerged victorious as the test team's top aluminum bass boat. The boat's greatest strength is consistency—solid scores across the board without any real weaknesses.

In theory, this is what you'd expect from a factory-integrated rig and the Quickfire 18 GT is, indeed, a package boat, put together by Mercury Powerboats. If it looks somewhat familiar, that's because it's based on the breakthrough Grey Thunder bass boat by Fisher Marine, which was acquired

by Merc last year. In addition to new graphics and stylings, the Quickfire 18 GT creates a unique formula for success by including all the features a bass fisherman demands as standard equipment—fore and aft aerated livewells, Lowrance fish/depthfinder, Thruster foot-control positioning motor, stainless-steel prop and three batteries (two deep cycle and one cranking).

Importantly for serious bassers, the Astro was the fleet leader in three crucial areas: 1. Top-end speed (48.5 mph), 2. Usable deck area (116.91 sq. ft.), and 3. Fishability (tied for first), a combination of functional layout, weight sensitivity at rest, and overall design excellence.

### TEST PARAMETERS

Each boat was propped and tuned by technicians from Mercury Marine. Speed and timing data were collected on Lake Monroe and are result of averaging four test runs for each boat with two adults aboard and matched fuel loads. Quarter-mile performance course began from dead stop and included two short sprints and full-speed right, left and 180° turns.



OVERALL RANKING/MAKE/MODEL	1. ASTRO QUICKFIRE 18 GT	2. ALUMACRAFT PHANTOM V170
LOA/Beam/Weight/Fuel Capacity	17'10"/82"/715 lb./22 gal.	17'2"/80"/925 lb./24 gal.
Top End (mph)/Ranking	48.5/1, speed champ by a hair	48.44/2, blisters the water
Acceleration 0-40 mph (sec.)/Ranking	9.16/2, leaps up on plane	9.02/1, a jackrabbit at touch of throttle
Performance Course (sec.)/Ranking	26.73/3, flat hull slides somewhat in turns	25.36/1, blew away the competition
Usable Deck Space (sq. ft.)/Ranking	116.91/1, longest hull affords most space	103.29/2, plenty of room to maneuver
Stowage Space (cu. ft.)/Ranking	21.74/3, adequate but more would be appreciated	21.29/4, opportunities missed
Fishability/Ranking	Superb layout, stability, functional design/1 (tied)	Largest livewells, functional layout/1 (tied)
Fit And Finish/Ranking	Voted best dressed, look of fiberglass/1	Lots of rivets, but fine detailing/2 (tied)
Price As Tested*	\$11,999 (boat-motor-trailer price)	\$5856
Address	Mercury Powerboats, P.O. Box 720, Murfreesboro, TN 37130, (800) BOATS-90	Alumacraft Boat Co., 315 W. St., Julien, St. Peter, MN 56082, (507) 931-1050

### WHAT'S A BASS BOAT?

The PM test team defined a bass boat as follows: slight-V hull, single starboard console, fore and aft raised casting platforms with pedestal seat mounts, aerated livewells, foredeck for mounting positioning motor, space for mounting fish/depthfinder and ability to handle high-horsepower engines.

Slight sightline obscuring of gauges. Tinted windshield makes fish/depthfinder difficult to read in certain light.



The only plastiformed console in fleet. Also handy in-dash flasher, but sightlines to gauges are obstructed.



\* All prices are for boat and accessories only, except for the Astro Quickfire 18 GT, a package boat.



The Astro was also voted best dressed in the fleet and finished on top in fit and finish. This was evident in its rounded corners, rivet-free visible exterior, built-in pedestal stowage compartment, fuel-fill mounted near driver, snazzy seats and styling, stout hardware, passenger courtesy handles and overall detailing.

Other strong showings were a second in acceleration (0-40 mph) and a close third in performance-course time (a high-speed quarter-mile run with hard left, hard right and full 180° turns). The only back-of-fleet ranking (distant third) occurred in stowage, where shortage of space is the result of a weight-balanced centerline layout (others opt for the freedom of an asymmetrical pattern).

Nits to pick are minor. In addition to lack of stowage space, the fixed seats (three across) were low to the deck and felt like sitting on a floor, tinted windscreen made fish/depth indicator hard to read in certain light and, more importantly, the flat hull (described as a mod-V, but more in bow than stern) displayed a tendency to slide through turns and wander somewhat at high speeds, especially in a chop. This last characteristic was most evident on the performance course where the Astro finished third despite blazing top-end marks and a second-place in hole-shot times.



Good looks of Astro Quickfire 18 GT are result of move from riveter's gun to welder's torch.

Overall, the Astro Quickfire 18 GT is a superbly built bass boat and a top-notch performer that demonstrates just how far aluminum boats have come in the past few years.

### Phantom V170

In second place by only the slimmest of margins, the Alumacraft Phantom V170 is the undisputed performance champ. It blew away the competition on the performance course, finishing a full second faster than the second-place boat. It was also first out of the hole. Only a fraction of a mph kept it from being top-end champ.

Other strong areas are fishability (tied for first, due in part to fleet's largest livewell space), usable deck

space (second), and fit and finish (tied for second). The only fourth-place ranking came in total stowage area, where it finished in a virtual tie with our test winner.

Several characteristics reveal the Phantom V170 to be a new-breed aluminum bass boat. These include how assuredly it handled the high-powered Merc outboard and tracked firmly under high-speed, wheel-lock turns. Other modern touches include aft platforms on either side of the engine, stout hardware, passenger courtesy handle, stainless-steel engine vents, molded plastic console, in-dash flasher, tinted windscreen, cassette/radio and tilt-and-trim switch in bow.



<b>3. CRESTLINER MAVERICK V170</b>
17'3"/81"/1165 lb./22 gal.
47.75/4, fast in a fast fleet
10.20/4, a bit sluggish getting on plane
26.38/2, beat faster boats by holding corners
101.81/3, more than sufficient
27.82/2, substantial with twin insert coolers
20" inner depth departs from classic bass design/2
Superb rivet-free hull, baked-enamel paint/2 (tied)
<b>\$6220</b>
Crestliner, 609 13th Ave. NE, Little Falls, MN 56345, (612) 632-6686

<b>4. SYLVAN BASS HAWK</b>
17'/79"/920 lb./23 gal.
48.13/3, within a fraction of the leaders
9.61/3, speedy and responsive
26.98/4, high-speed handling feels ragged
101.68/4, no substantial difference from leaders
32.22/1, most copious by far
No side decks and forward aerated livewell/3
Lean-and-mean economy approach/3
<b>\$5200</b>
Sylvan Marine, P.O. Box 65, New Paris, IN 46553, (219) 831-2950



### THE BRAINY OUTBOARD

High-tech features usually found on bigger engines come together on the new Mercury 115 to make it one of the new generation of "smart" outboards. Just introduced this year, the 115-hp, V4 Merc is equipped with Concept 2+2 carburetion, which restricts fuel flow to only two cylinders at low rpm. The result is fuel savings at trolling speed and a reduction of fumes. The 340-lb. engine also has an oil-injection system, loop charging and a through-cowl oil level gauge. Suggested retail price is about \$7000.

Adjustable wheel maximizes comfort and gauge sightlines. Electronics fit easily in front of windscreen.



Windscreen is an option that should be included. Good visibility, overall, of important gauges.





## BASS BLITZERS

At first glance, however, the Phantom still has the unpainted, riveted exterior reminiscent of the old tool-box days, although it sports a modern contoured shape. Other minor shortcomings are significant sightline obstruction of gauges on the dash panel and flimsy stowage latches (one pulled free).

Nevertheless, fishermen who seek a well-designed, affordable boat that's tops in performance will find the Alumacraft Phantom V170 a choice second to none.

### Maverick V170

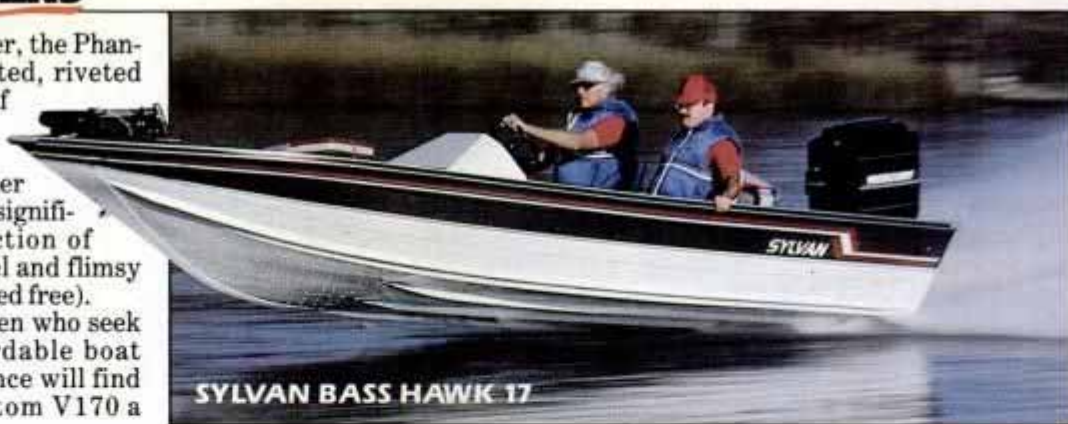
The smooth-handling Crestliner Maverick V170 demonstrates what new-wave aluminum boat building is all about, perhaps even more so than our test winner. The Maverick is the only boat in the fleet with a totally rivet-free hull and it sports a 20-year, transferable warranty.

On the performance course, the boat held corners hard enough to pin us against the gunwales, which enabled it to finish in second place despite back-of-pack rankings in hole shot and top-end speed (47.75 mph).

Solid second-place finishes in stowage space, fishability and fit and finish, plus a close third in deck space, round out the Maverick's rankings.

A few noticeable problems marred the Maverick's otherwise superb attention to detail. A misplaced and abandoned drill hole appeared on the windscreen mounting and two cracks were visible on the console (one in the windscreen and one in the aluminum console itself, which appeared to be the result of overtightening screws).

On the other hand, many outstanding features on the Maverick were found on no other boat, including full-seat and butt-seat pedestals, two Tempres built-in coolers, teak strips for entry/egress, and 3-position steering wheel. Other features of note are



SYLVAN BASS HAWK 17

courtesy handles for passenger and driver, sturdy hardware and the second largest livewell space.

### Sylvan Bass Hawk 17

The Bass Hawk 17 demonstrates a more lean-and-mean design philosophy than the other boats in the fleet. It has no side decks, for example, or aerated livewell in the bow. Nevertheless, it handles the big Merc outboard better than most lightweight aluminum boats of four or five years ago and comes with a low price tag.

Aside from affordability, the Bass Hawk's biggest strength is copious stowage space. It's an article of faith among fishermen that the more stowage space the better, and in this regard the Bass Hawk is the fleet leader. Despite back-of-pack rankings in top-end, hole shot, performance course and deck space, all Bass Hawk figures were competitive and don't reflect significant differences from other boats in the fleet.

However, lack of side decks and aerated livewell in the bow worked against the Bass Hawk in the category of fishability. And weakly supported rod box cover, misaligned deck cuts in the bow casting platform, full-rivet construction and absence of aft cleats and courtesy handles held back the boat's fit-and-finish ranking.

Features of note include good sight-

line of gauges, courtesy footlight on console, and comfortable seat height with plenty of legroom. The Bass Hawk 17 is a true econocommando and on its own terms, affordability, it catches bass with the best of them.

### Final impressions

In addition to the boats, the test team was anxious to get hands-on experience with Merc's new 115-hp outboard, which is new to the line and billed as a smart engine. What makes the powerplant so smart is its Concept 2+2 carburetion system, which restricts fuel flow to only two cylinders at slow speeds for improved economy and control of fumes. Other high-tech bells and whistles are oil injection and loop charging (computer-designed channeling of air-fuel mixture in cylinder for better firing).

At low rpm the 115 is noticeably quieter and less smoky than many outboards, which indicates that only two cylinders are firing. As you increase rpm, the boat picks up speed slowly until the trigger level is reached, around 1800 rpm. At this point the remaining two cylinders smoothly surge in.

As for hulls, should they be fiberglass or aluminum? A few years ago aluminum was an attractive alternative because it was durable (with long warranties), nearly maintenance free and affordable. The drawbacks were boxy shape, rivets, noisy ride, stripped-down approach to features, and inability to handle high-horsepower engines.

Today, the shortcomings have been addressed and the original strengths remain. The test team still believes heavier fiberglass rigs give a less ragged ride at wide-open throttle in choppy conditions, but the solution is simple—throttle back.

New rivet-free construction, full stringer systems, flotation, plastic consoles, contoured shapes, durable exterior paints and upgraded interiors make aluminum hulls a genuine alternative to fiberglass and the new wave in bass boats.

PM



CRESTLINER MAVERICK V170





## TOOL TECHNIQUES

# SANDER SECRETS

Smoothing rough spots with four portable power sanders.

TEXT AND PHOTOS BY  
ROSARIO CAPOTOSTO,  
Contributing Editor

**T**HERE ARE many aspects of woodworking that are enjoyable, satisfying, even fun. Sanding wood, however, isn't one of them. Unfortunately, sanding is a necessary and important part of the building process.

Presented here are shop-tested techniques for using four popular power sanders—belt sander,  $\frac{1}{4}$ -sheet palm sander,  $\frac{1}{2}$ -sheet finishing sander and disc sander. These techniques are designed to make smoothing wood less work, provide better results and help you get the most from each tool. Note that besides smoothing wood, we also show how to remove rust from

metal and polish finished surfaces.

Belt sanders are the most popular way to remove stock and smooth surfaces. They're designated by the size sanding belt they use and we show techniques for three popular versions:  $2\frac{1}{2} \times 16$  in.,  $3 \times 21$  in. and  $3 \times 24$  in. (The smaller number represents the width of the belt. The larger equals the belt's circumference.)

The palm sander and finishing sander are both orbital sanders. These tools are extremely safe and easy to use. The disc sander, on the other hand, is very aggressive and caution must be exercised to prevent removing too much stock.



## BELT SANDER

**T**HE BELT sander is an excellent all-purpose workshop sander. When fitted with a coarse-grit abrasive belt, it's an aggressive tool that shapes and removes stock quickly. Use a medium-grit belt to smooth rough surfaces and remove minor surface scratches and irregularities. For final smoothing, use a fine-grit belt. Abrasive belts are commonly available ranging from 50 grit to 180 grit. The lower the number, the coarser the grit. Most well-stocked hardware stores and home centers carry abrasive belts, but it's more economical to purchase belts by the dozen from a mail-order woodworking supply firm.

Belt sanders are rated by amperage and belt speed. The amperage rating is an indicator of power. Generally, the higher the amps, the more power. Amperage ranges from about 3 amps to 10 amps depending on the sander. Belt speed is measured in surface feet per minute (sfpm). Again, this varies from sander to sander, but it typically ranges from about 600 sfpm to 1600

sfpm. New to the scene are variable-speed belt sanders. In fact, the 3 × 21-in. Ryobi sander shown features variable speed. Rotate the thumbwheel on the front handle to increase belt speed from 775 sfpm to 1148 sfpm. Rotating the thumbwheel allows you to match the belt speed to the material being sanded. However, nearly all wood-sanding jobs are done at full speed.

Other features worth looking for include an extra-long power cord, belt-release lever and, most importantly, a dust collection bag. Belt sanders create an incredible amount of dust and capturing a majority of it is a real plus. **Caution:** Regardless of whether your

sander has a dust collection bag, always wear a dust mask or respirator to prevent the inhalation of fine wood dust.

Belt sanders are not particularly difficult to operate, but they do take some practice before you become comfortable with the weight and balance of your particular tool. One of the most common mistakes is pressing down too hard during sanding. This will only clog the belt, reduce the tool's effectiveness, and

put undue strain on the motor. Allow the weight of the sander to provide downward pressure. Use both hands to guide the tool in straight, overlapping passes in the direction of the wood's grain to prevent cross-grain scratches. The sander can be moved side to side across the width of the board, as long as the belt remains parallel with the wood's grain. Also, keep moving at all times. Sanding in one spot for just a few seconds will quickly create a depression.

Be sure that the piece you're sanding is fastened securely with clamps or butted against a backstop which is simply a board that's nailed or clamped to the workbench.



Three popular belt sanders: Ryobi 3 × 21-in. (upper left), Porter-Cable 3 × 24-in. (right), and 2½ × 16-in. Skill Sandcat (lower left).



Most sanders have belt-tracking knob near the front roller. Turn the knob, while the sander is running, until the belt is centered.



Avoid this common mistake. Keep the sander flat on the work. Tilting sander, as shown, will round over the board's end.



Although sanding across the grain isn't recommended ordinarily, it is a good way to remove stock quickly from rough lumber.



Weighing 4½ pounds, Skill Sandcat is small enough to use with one hand. Light weight is important when shaping wood.



Extend life of abrasive belts by cleaning with a rubber cleaning stick. Hold stick against the running belt to remove wood dust.



Flat-top sander can be clamped to workbench for use as a stationary tool. Ryobi offers this attachment for sanding bevels.



## **PALM SANDER**

**U**NLIKE BELT sanders, orbital palm sanders are designed for smoothing the surface, not for heavy stock removal. These small, lightweight sanders are used for the final, supersmooth sanding prior to applying a finish. Also, for sanding lightly between finish coats and for the final smoothing after a belt sander has been used.

Palm sanders accept a ¼-sheet of standard 9 × 11-in. sandpaper. The paper is held to the sander's pad by paper clamps—usually a pair of spring-loaded metal jaws. Other options include peel-and-stick or Velcro-backed sandpaper. The actual orbital sanding motion is produced by the pad moving in tiny, high-speed circles, or orbits. Palm sanders are rated according to orbits per minute (opm) which typically range from 12,000 to 15,000 opm. (For an in-depth look at palm sanders, see "Smooth Operators," page 83, Aug. '88.)

A vast majority of palm sanding is done with fine and very fine sandpaper, usually between 120- and 220-grit papers. However, medium-grit paper, such as 80 grit, can be used to smooth semirough surfaces and remove shallow scratches. Then, follow



Orbital palm sanders accept a ¼-sheet of sandpaper and are designed for fine, finish sanding. Makita model (left) has dust bag. At right, is the popular Porter-Cable Speed-Bloc sander.

up with progressively finer sandpaper to achieve the desired level of smoothness. Another important step is to always brush off the sanding surface when switching to a finer-grit sandpaper. This will remove any of the loose abrasive grits of the previous, coarser sandpaper that could scratch the surface. Employ this sweep-clean technique for all types of sanding—power or hand.

When using a palm sander, don't push down too hard. This will put undue strain on the motor and cause deep circular scratches. If small scratches do appear, remove them by sanding lightly by hand—with the

direction of the wood's grain—using very fine sandpaper. Always moving a palm sander with the direction of the wood's grain isn't quite as important as with a belt sander. But, it will create a smoother surface than sanding across the grain.

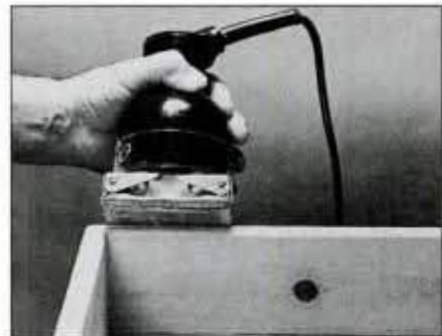
Even though palm sanders don't generate nearly as much dust as belt sanders, you may want to consider a dustless palm sander. A special spiked plate comes with the sander for punching holes in the sandpaper, as shown. During sanding, wood dust is sucked through the holes in the paper and the sander's pad and into a small collection bag.



Paper clamps differ from sander to sander. Clamp on Porter-Cable sander is lifted with a slotted screwdriver to accept sandpaper.



Dustless palm sander comes with spiked metal plate for punching holes in sandpaper. Wood dust is sucked through pad, into bag.



Besides smoothing flat surfaces, palm sanders are excellent for softening sharp edges and corners. Hold the sander at about 45°.



Advancing with the open side of sander can cause edge of abrasive paper to catch on splinters, as shown. Rotate sander 90°.



When fitted with an optional rubbing pad, palm sander can be used to polish a finished surface using rottenstone and water or oil.



To sand contoured, irregular-shaped surfaces, install a thick, sponge rubber pad on sander. Soft pad contours to shape of work.



## FINISHING SANDER

**T**HE ORBITAL finishing sander is similar to a palm sander except that it is more powerful and accepts a ½-sheet of standard 9 × 11-in. sandpaper. This provides twice as much sanding surface as a ¼-sheet palm sander.

Note that some tool manufacturers also offer a ⅓-sheet finishing sander that measures about 1 in. narrower and 2 in. shorter than a typical ½-sheet sander.

Finishing sanders, like palm sanders, are rated according to orbits per minute which typically range from about 10,000 to 12,000 opm. The exception is AEG which offers high-speed finishing sanders rated at 20,000 opm. Most power tool manufacturers also offer dustless finishing sanders that come with dust collection bags.

Unlike the one-handed palm sander, two hands should be used to control a finishing sander. Again, it's important not to push down too hard. Slight pressure is all that's needed to allow the sandpaper to do its job.

A ½-sheet finishing sander is particularly useful for smoothing large surfaces such as tabletops and ply-



Orbital finishing sander accepts ½-sheet of standard 9 × 11-in. sandpaper. Shown, is a standard model, but sanders that come with dust collection bags are available, too.

wood panels and cabinet doors. However, be careful when sanding near edges not to let the sander's pad tip over the edge. The semisoft pad has a tendency to round over edges and corners slightly. A finishing sander also provides a quick way to smooth joint compound and Spackle from wall-board repairs.

Other less-common uses for a finishing sander include rubbing paste wax to furniture with a soft cloth, and polishing metal surfaces with superfine 600-grit silicone-carbide abrasive paper, as shown.



Spring-loaded clamps hold the sandpaper. Be sure to pull the paper tight. Loose, floppy paper reduces the sander's effectiveness.



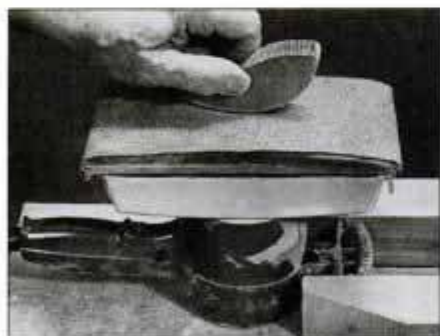
Gang sanding saves time when edge sanding. Two outside boards are scrap boards that prevent rounding inner workpieces.



Circular motion of orbital sander makes it ideal for sanding across right-angle joints. There's little chance of cross-grain scratches.



After switching to a finer-grit sandpaper, be sure to sweep the work surface clean. Abrasive-grit leftovers could scratch the surface.



To smooth small, odd-shaped pieces, clamp sander upside down to a bench. Use entire pad to prevent wearing a spot in sandpaper.



Cover sander's pad with a double layer of terry cloth and buff paste wax on furniture. Use a clean section of cloth for final buffing.



Polish metal with 600-grit silicone-carbide abrasive paper. To remove rust stains, apply mineral oil first, then polish the surface.



## DISC SANDER

**T**HIS versatile tool is actually two tools in one. It accepts abrasive discs for aggressive shaping and sanding of wood, or a lamb's wool bonnet for polishing finished wood and painted metal surfaces. In fact, disc sanders are commonly used in auto body repair shops and other commercial applications for grinding metal.

A disc sander consists of a powerful motor that spins a flexible rubber backing pad. The pad provides support for the sanding disc or polishing bonnet. Various diameter sanders are available, but the 7-in. model is the most common. Also, since sanding requires greater speed than polishing, look for a 2-speed tool to get the most for your money. For example, the 7-in. Ryobi disc sander, shown, operates at 1900 and 3400 rpm.

Make no mistake about it, this is a rough-sanding, no-nonsense tool. The rotary action of the disc results in semicircular, cross-grain scratches and it takes practice to be able to sand without gouging the surface. However, it is this raw power that makes the disc sander an excellent tool for rough work such as shaping wood, removing paint and cleaning rust from metal. When using the abrasive disc, apply enough pressure to flex about one-



Disc sander is fitted with a rubber backing pad for use with abrasive disc (bottom left) or polishing bonnet (right). Thick foam rubber abrasive pad (upper left) permits full-face sanding.

third of the disc flat on the surface. Hold the tool at a slight angle, as shown. Tilting up the handle too high will cause the disc to dig in and gouge the surface. And once the surface is gouged, it can be incredibly time-consuming to smooth out the damage.

When using a lamb's wool bonnet to polish finished wood, first apply paste wax to the surface with a damp cloth. Let the wax dry for 15 minutes and then buff it with the polisher set on low speed. Keep the bonnet moving at all times to prevent burning the wax. **PM**



For rough sanding, like removing paint, press down so one-third of disc makes contact. Keep handle low to avoid gouging.



Be careful when maneuvering the sander. The edge of the disc can easily slice into the work, as shown. Keep the sander moving.



Thick foam-backed abrasive pad allows fine sanding with 120-grit or finer sandpaper. Note that unlike a disc, pad is flat on surface.



To convert a disc sander to a stationary tool, first remove side handle and install a short block of 2x4. Secure block with a long bolt.



Clamp 2x4 block in a vise to hold sander upright. Use a foam-backed abrasive pad to provide a flat sanding surface.



A disc sander is a quick and easy way to remove rust from metal surfaces. Always wear eye protection when using a disc sander.



A lamb's wool bonnet is used for polishing jobs. Apply paste wax with a damp cloth, let dry and then buff with sander at low speed.



\$1465.00 Double Spread



**PLUMBING BASICS**

**SINGLE-HANDLE FAUCET REPAIR**

TEXT AND PHOTOS BY MERLE HENKENIUS

**S**TYLISTIC preferences aside, the main advantage in owning a single-lever faucet is its simplicity. Because these faucets contain few parts, a do-it-yourself repair can be done quickly and is a real money saver.

Most single-lever faucets operate by the principle of rotating or sliding ports. When the handle is rotated or raised, it moves a control mechanism inside the faucet. This mechanism has ports that match the inlet ports in the faucet body. When these ports are aligned, hot and cold water is then allowed into the spout. When rotated or lowered to the off position, the ports are moved out of alignment and the water flow is cut off.

Of all the single-lever faucets in use today, the vast majority were made by the Moen and Delta companies, or their corporate cousins, Aqualine and

Peerless. We'll concentrate on the repair of these two, with the knowledge that other makes can be accessed in a similar fashion.

**Moen faucet**

A Moen faucet needs repair when it drips through its spout or becomes stiff in its operation. Both symptoms are easily corrected with a replacement cartridge (around \$14), which is available at hardware and plumbing supply stores. As with all faucet repairs, the water will need to be shut off in advance.

If you own a Chateau Series Moen, begin by lifting the decorative cap from the handle. If you own a Model 7300, pry the index cap off to reveal the handle screw. In either case, loosen the screw and tip the handle back to remove it. Use pliers to loosen and



To remove a Moen faucet lever, loosen the screw on top of the handle and tip the lever back and up. Then pull off the lever.



To free the fixture's cartridge, you must first loosen the pivot nut by turning it counter-clockwise with a pair of pliers.



A brass retaining clip holds the cartridge secure inside the faucet body. Pull this clip out horizontally, using needle-nose pliers.



remove this nut underneath. With the pivot nut removed, you'll see a brass, U-shaped clip, positioned horizontally. Pull it straight out with small needle-nose pliers and set it aside. Then, use larger pliers to pull the cartridge up and out of the faucet body.

As the old cartridge will not look substantially different from the new one, discard it to avoid confusion. Then press the new cartridge into the faucet body until it seats itself.



Once the clip is removed, pull the cartridge up and out of the faucet body. If the cartridge is stuck, wiggle it slightly.

With the cartridge seated, slide the retaining clip back in place and replace the pivot nut and the handle body. To properly engage the lever under the rim of the pivot nut, tip it back, then down. Finally, replace the handle screw and cap.

### Repairing collar leaks

A collar leak will manifest itself in a puddle of water at the base of the faucet. The leak will occur only when the



To remove a faucet spout collar, lift and twist until it comes free. It may require gentle prying with a flat blade screwdriver to loosen it.

faucet is turned on. The problem is corrected by replacing the O-rings between the spout collar and the faucet body.

With the faucet lever and pivot nut removed, grasp the spout near its collar and twist and pull up at the same time. Cut away the old O-rings and roll exact replacements over the body until they seat in their slots. Coat the new O-rings with heat-proof grease and reinstall the spout.



After replacing spout O-rings, lubricate them with heat-proof grease and press the collar over the O-rings and faucet body.

### Repairing a single-handle Delta

Delta faucets have a few more components but are just as easy to repair. (Repair kits including new seats, springs and cam assembly—but without a new ball assembly—will cost around \$5.) Start tipping the handle back and loosening the set screw on its underside using an Allen wrench. With the handle off, you'll see a cap-assembly nut with a knurled edge. Use pliers padded with cloth, or the wrench supplied with the kit, to loosen and remove the cap.

Underneath is a nylon and neoprene cam assembly resting on top of a steel ball. Lift off the cam assembly and pull the ball from the faucet body. This will reveal two spring-loaded seats in the faucet ports. Use the kit wrench to lift out the seats and springs.

Discard both springs and seats.



Lift the cam and ball assemblies out of the faucet body to reveal the seats and springs located underneath the ball.

Then, slide the new seats and springs onto the wrench and guide them into their ports. Follow by pressing the ball into the body so that the peg inside the body aligns with the slot in the ball. Slide a new cam assembly over the ball, so that its tab fits the side-slot of the body, and screw the cap assembly onto the body. Finally,



To remove the handle on a Delta single-lever faucet, tip the lever back and remove the Allen screw located on underside of arm.



Remove the seats and springs using the Allen wrench that comes with each replacement kit. The new springs go into the ports first.

replace the handle and test your work. If a leak persists, tighten the cap assembly a little more.

If tightening won't stop the leak, then you'll have to replace the ball assembly. Delta offers both plastic and stainless-steel replacements. The stainless version will usually stand up better to wear. **PM**



Loosen the threaded cap assembly with pliers and lift it off to reveal the cam and ball assemblies underneath.



With the springs, seats and ball assembly in place, install a new cam assembly and replace the cap and lever handle.



**NEW PRODUCTS**

**GARDEN GEAR**



**Battery-Pack Power**

Sears recently introduced a line of cordless lawn and garden tools that are powered by a 12-volt battery. This system provides freedom from an extension cord without the weight and noise of a gas-powered unit. The 7-pound battery (\$60) comes with a strap to fit comfortably around your waist or shoulder. A plug-in charging stand (included) recharges the battery in 16 hours.

The tools shown include a Bushwacker hedge clipper and Weedwacker string trimmer. Each tool draws power from the battery pack via a coiled cable similar to those used on telephones. The hedge clipper (\$55) features a 16-in., double-edge cutting bar and a 5-amp motor that delivers 2600 strokes per minute. It cuts in both directions and will trim branches up to 3/4 in. dia. The clipper will run 45 minutes on a single battery charge.

The Weedwacker string trimmer (\$55)

runs about 30 minutes on a full charge and cuts a 9-in.-wide swath. It comes complete with 30 ft. of nylon trimming line. For details, contact Sears, Sears Tower, Dept. 703-PM, Chicago, IL 60684.



**Powerhead Plus**

If you're about to invest in several lawn and garden power tools, then check out Green Machine's Expand-It system. The Homeowner series (model No. 1900) consists of a single powerhead that accepts any of six individual tools: power blower, snow thrower, curved-shaft string trimmer, straight-shaft string trimmer, lawn edger and weeder/cultivator.

The powerhead is a 1.85-hp, 2-stroke, gas-powered engine. Each of the tools slide on and off the powerhead quickly by simply loosening a wingnut. No tools are needed when changing attachments.

The basic starter system includes the powerhead and a curved shaft, 18-in. string trimmer for about \$230. Additional tools cost about \$120 each. The Homeowner series is designed for small- to medium-sized yards. A larger, straight shaft version called the Estate 2800 is also available, with trimmer, for \$310. For more information and details, contact HMC/Green Machine, 20710 S. Alameda St., Box 560, Long Beach, CA 90801.

**Rain Man**

Here's a way to water your lawn easily, effectively and, best of all, without wasting water. The Rain King traveling sprinkler (\$80) can water a patch of lawn measuring up to 50 ft. wide x 100 ft. long. Simply pull out the desired length of steel tape from the sprinkler and push the metal stake into the ground. Then, adjust the width of the spray from 5 ft. to 50 ft. Water pressure in the hose powers the sprinkler along the steel tape, spraying water across your lawn as it moves. When it reaches the end of the tape, the sprinkler shuts off automatically. For more information and details, contact Aircap Industries, Box 2120, Tupelo, MS 38803. Or, you can call toll-free (800) 231-2285.







### Water Meter

Conserving water has become a major concern and the simple device shown here can help prevent wasteful water practices. Called the Time-A-Matic water timer (\$14), it's used with a sprinkler to deliver an exact amount of water and then shut off automatically. Attach the timer to either an outdoor faucet (sillcock) or directly to the sprinkler. Then, set the timer either to the number of gallons delivered—up to 1600 gallons—or length of time—up to 4½ hours. For details, contact Melnor Industries, 1 Carol Pl., Moonachie, NJ 07074.



### Husky Mower

Husqvarna has a tight-turning riding lawn-mower that boasts a minuscule 3½-in. turning radius. The Swedish-made mower features rear-wheel steering and front-mounted, 34-in.-wide mowing deck. The 3-blade mowing deck is equipped with guide rollers that help prevent scalping when mowing uneven terrain.

It's powered by a 12-hp Briggs and Strat-

ton engine and has five forward gears and one reverse gear. Top-end speed is nearly 6 mph.

Other features include electric start, kill-switch driver's seat and 6-position cutting height that's adjustable from 1 in. to 3½ in.

The mower (model No. 850-12) costs about \$2495. For more information and details, contact Husqvarna, 907 W. Irving Park Rd., Itasca, IL 60143. Or, call toll-free (800) 438-7297.

### Home Irrigation Kit

If you're serious about landscaping or vegetable gardening, then you should know about True Temper's Slo-Flo landscape watering system—a complete, do-it-yourself irrigation system.

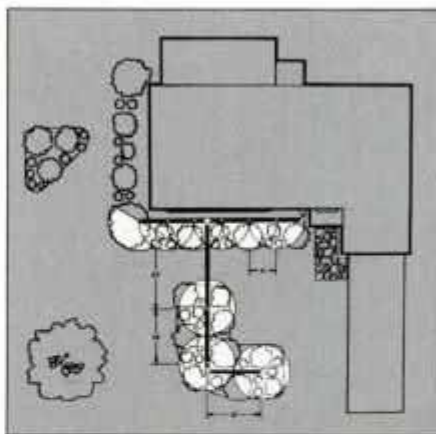
This easy-to-install kit comes with everything you need to irrigate up to 500 sq. ft. of landscaping. Simply run the flexible tubing from an outdoor faucet to the shrubs and plants (see illustration at right). Cut and join the flexible, ultraviolet light resistant tubing with push-in, barbed connectors (below left). From the tubing, insert risers (below right) that are then fitted with spray heads (below center).

The kit (\$41) includes a hose connector

with filter screen, flow regulator, 80 ft. of ½-in.-dia. flexible tubing, two L-shaped connectors, two T-shaped connectors, 20 risers, 12 half-circle spray heads, 12 full-circle spray heads, and two hose closures. A vegetable garden watering kit is also available. It can cover 500 sq. ft. as well, or be designed to handle six 25-foot planting beds spaced 3 ft. apart.

Each kit also contains what the manufacturer calls *goof plugs*. These simple devices act as couplings. So, if you make a mistake cutting the tubing or if you want to change your layout in the future, you can join two cut lengths of tubing wherever you want.

For more information and details, contact True Temper, Box 3500, Shiremans-town, PA 17011. **PM**





NEW TOOLS

THREE'S  
COMPANY

BY JOSEPH TRUINI,  
Shop And Tools Editor

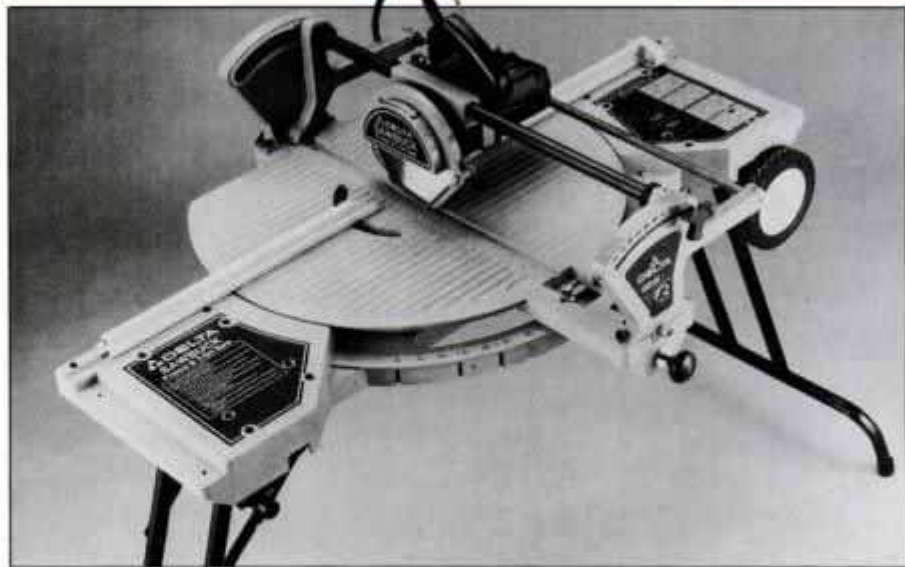
**T**HERE are few tool manufacturers that enjoy the fine reputation earned by Delta International. For more than 70 years, Delta has been making quality power tools for professionals and serious do-it-yourselfers. (You may recall that between 1945 and 1984, Delta tools were manufactured by and sold under the name Rockwell.) Therefore, whenever Delta announces the introduction of new tools, builders and homeowners alike are anxious for details.

Shown here are three of the latest additions to the Delta line of power tools. The first tool, the Deluxe Sawbuck frame and trim saw, is an updated and improved version of the original Sawbuck. The new Sawbuck is a versatile lumber cutter that's a cross between a radial-arm saw and power miter saw. With it, you can crosscut, miter, bevel and cut compound angles in stock up to, and including, 2x12s. The only cut the Sawbuck won't perform is a rip cut.

Powered by a 15-amp, 5500-rpm gear-driven motor, the Sawbuck accepts an 8-in.-dia. blade. The 28½-in.-wide × 52-in.-long saw table is made of a glass-reinforced polyester resin compound, known as SMC, that according to the manufacturer won't warp, dent or rust. Other features include an easy-to-use tilting bevel scale, rotating miter table, electric blade brake, built-in arbor lock (for quick blade changes) and positive mi-



Versatile sanding machine is a two-tools-in-one benchtop unit. It features a 1-in.-wide sanding belt and an 8-in.-dia. abrasive disc.



The Delta Sawbuck frame and trim saw has an 8-in.-dia. blade and functions as a cross between a radial-arm saw and a power miter saw. Leg stand and wheels are optional.

ter angle stops at zero, 22½° and 45° left and right. There are also positive stops at 31.62° miter and 33.85° bevel used for making compound angle cuts in standard crown moldings.

The cutting capacity at 90° (cross-cut) is 2¾ in. thick × 16 in. Miter-cut capacity is 1¾ in. thick × 12 in. Sawbuck will also accept a stacking-type dado blade for cutting dadoes up to 1⅜ in. wide. It weighs 78 pounds and Delta offers an optional folding leg stand with wheels for about \$65. The Deluxe Sawbuck (model No. 33-050) costs about \$740.

**Belt/disc sander**

This versatile belt/disc sander is the latest addition to Delta's line of benchtop power tools. A handy machine for any workshop, it features a 1-in.-wide × 42-in. sanding belt and an 8-in.-dia. abrasive disc. The belt and disc are driven simultaneously by a ½-hp motor. The belt runs at 3000 surface ft. per minute and the disc at 1725 rpm.

Use the two abrasive surfaces for sanding and grinding various materials including wood, plywood, plastics, steel, iron and aluminum. It can also be used for tool sharpening. Replace the sanding belt with an optional felt-covered belt to buff, polish and clean fine metals and jewelry.

Both the belt and disc have an adjustable worktable that tilts up to 45°. Remove the upper wheel guard to expose the idler pulley for sanding contours. Constructed of heavy-duty cast iron, the 62-pound tool comes with a miter gauge, 100-grit sanding belt and 60-grit abrasive disc. Delta offers a wide range of belts and discs

separately. The sander (model No. 31-340) costs about \$225.

**Bench saw**

Here's a benchtop table saw that's a valuable tool for the job site or workshop. The 8¼-in. saw features a 20 × 26-in. saw table made of the same polyester resin that's used in the Sawbuck. This keeps weight down—the table saw weighs only 40 pounds—while adding structural stability. The table won't dent or rust.

Powered by a 13-amp, 4500-rpm motor, the saw comes with a carbide-tipped blade, miter gauge, self-aligning rip fence and see-through blade guard with antikickback pawls. Maximum depth of cut at 90° is 2¼ in. At 45°, it's 1¾ in. The widest rip cut possible is 12 in. Optional table extensions increase the rip capacity to 24 in. The saw (model No. 34-330) costs \$320. For details on all these tools, contact Delta International, 246 Alpha Dr., Pittsburgh, PA 15238. **FM**



Benchtop table saw is sized for remodeling and woodworking projects. Table is made of glass-reinforced polyester resin.



# Who needs a Campbell Hausfeld® Air Compressor? Let's have a show of hands.



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# How To Repair HOLES IN DRYWALL

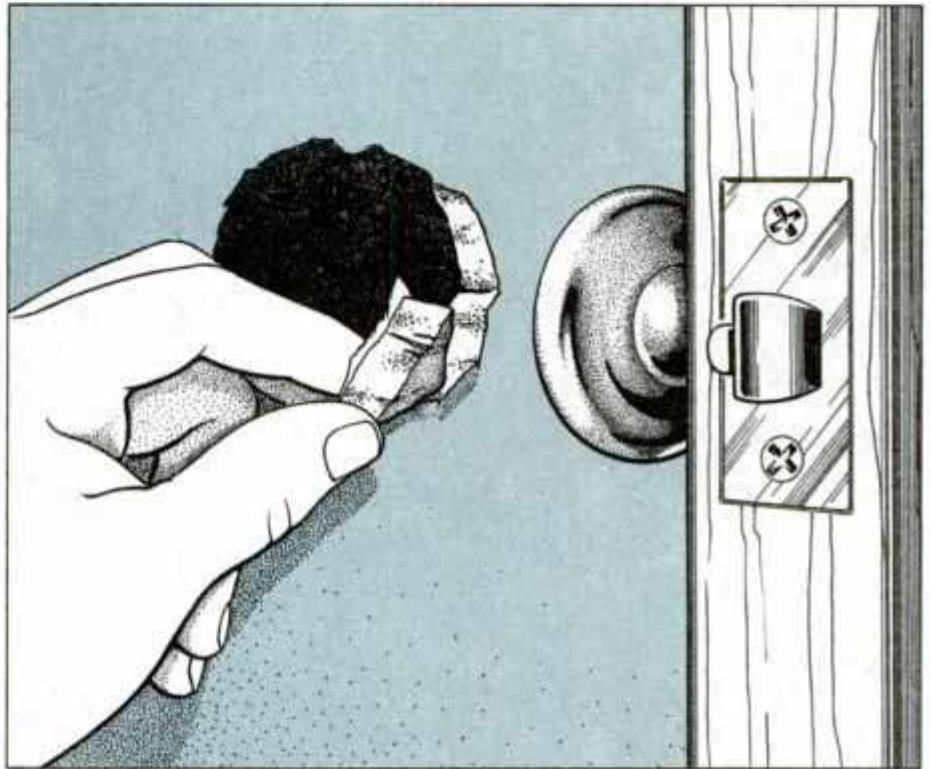
BY ROSARIO CAPOTOSTO, Contributing Editor, PM Illustrations by George Retseck

**T**HE MATERIAL most widely used on interior house walls is gypsum wallboard, also known as plasterboard or drywall. This product consists of a core of gypsum faced on both sides with tough paper. Although it serves its purpose well, it is relatively brittle and can puncture when struck by a sharp blow. But patching a hole is not a difficult task and you'll obtain a neat, sound repair by using one of two basic methods. Both make use of ready-mixed joint compound which is available in hardware stores and lumberyards.

## Small holes

Holes up to about 4 in. in diameter are patched with the wire mesh backup procedure. Begin by cutting a piece of ordinary wire screening slightly larger than the hole to be repaired. Thread a length of string through the center of the screen.

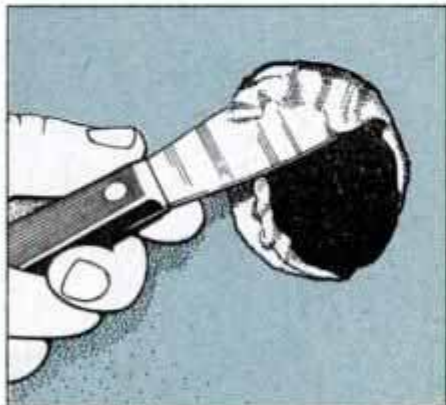
Next, moisten the edge of the hole and the perimeter of the back side of the opening. Then, using a narrow putty knife, apply compound to the edge and around the back of the opening. While holding onto the string, curl the screen and fit it through the hole in the wall. Then, pull on the string to draw the screen up against the back of the wallboard. Tie the string around a pencil or a length of dowel that spans the opening.



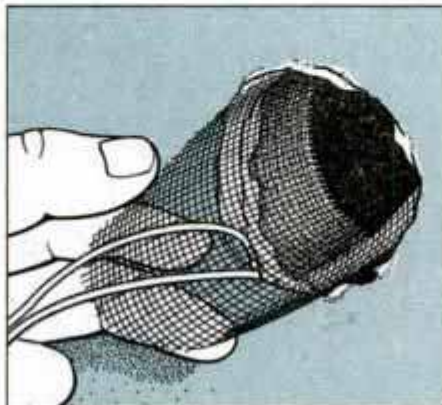
**1** Begin by removing all loose and broken gypsum from the damaged hole and strip off any torn and frayed paper. Also, vacuum away all dust, then dampen the edges.

Apply a layer of compound to the screen but not flush to the surface of the wall. When the screen has been coated overall, twist the pencil slightly to increase the tension on the screen. Allow this first layer to set,

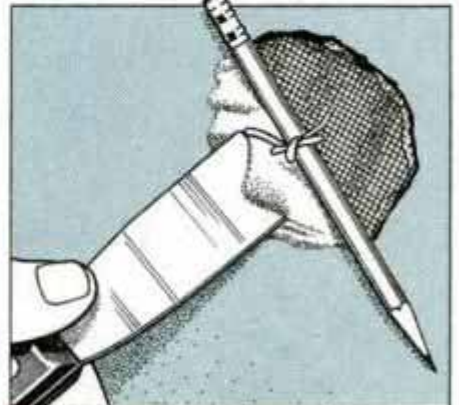
then cut the string to remove the pencil. Apply a second layer of compound so the patch will be flush to the surface of the wall. When this flush coat has set, apply a final thin coating of compound over the patch and slightly onto



**2** Use narrow putty knife to apply ready-mix joint compound to the edge of the hole and back surface of damaged panel.



**3** Thread a strong string through a piece of wire mesh screening, then curl the mesh and pass it through the opening.



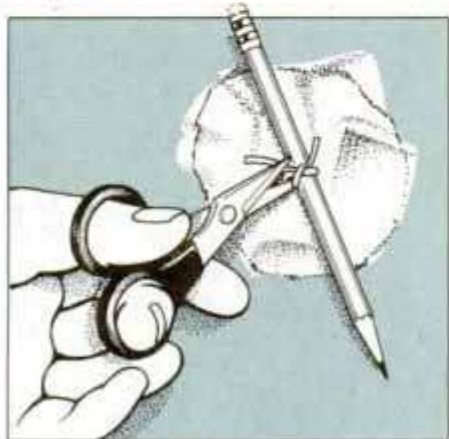
**4** Pull the mesh against the back of the wall, tie the string to a pencil, then apply a layer of compound over the mesh.



the surrounding wallboard. When dry, sand the patch with 220-grit abrasive paper.

## Large holes

Holes larger than 4 or 5 in. are best repaired with a plug cut from a scrap of wallboard. First, trim the hole square then cut a piece of board about 2 in. longer on each side than the hole size.



**5** When the first layer of joint compound has dried thoroughly, cut the string close to the mesh, and remove the pencil.

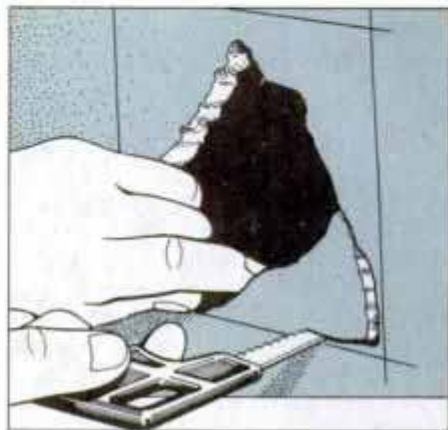
Mark off a centered area on the back of the patch,  $\frac{1}{4}$  in. smaller on each side than the hole in the wall. Cut through the paper surface and slightly into the core. Snap the board on each score line and carefully peel away the core material so that only a paper flap remains. Use 120-grit paper to sand the outer edges of the flap until they taper to a point. Dampen all



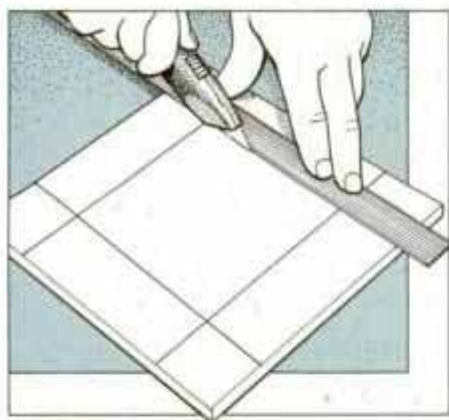
**6** After the second layer of compound has set, apply a thin final layer, feathered to slightly overlap the surrounding surface.

surfaces that will be bonded. Then, apply joint compound to the back of the patch flap, and edges of the hole.

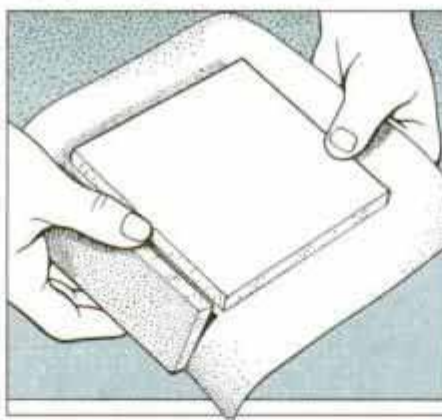
Press the patch into place and use a wide-blade knife to work the flap flush to the wall and to squeeze out excess compound. Allow to dry and then apply a thin coat of compound, extending about 1 or 2 in. beyond the patch area. When this is dry, sand smooth.



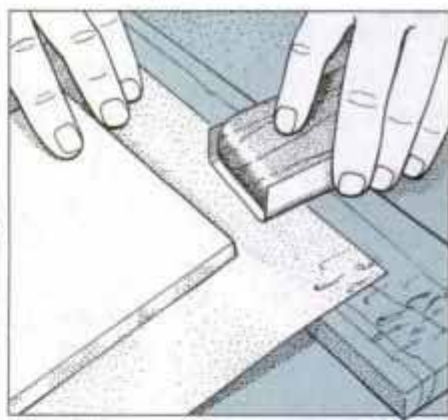
**7** To repair a larger hole, first square off the hole with a keyhole saw. Be sure to avoid wires or pipes with the saw.



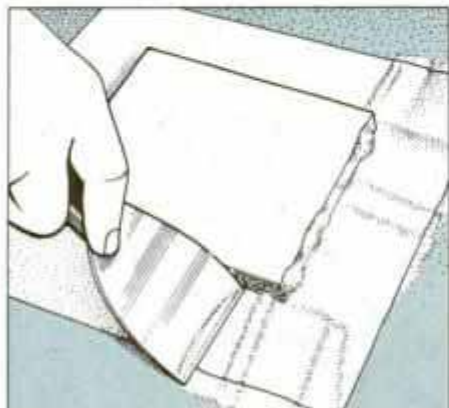
**8** Cut the wallboard plug to size and mark the back. Then cut through the paper facing and partly into the gypsum core.



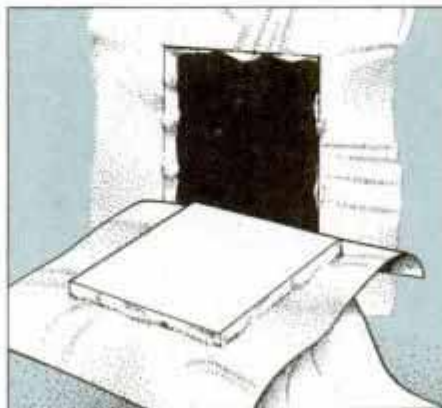
**9** Snap and peel back the waste segments leaving the center and the overhanging front facing paper intact.



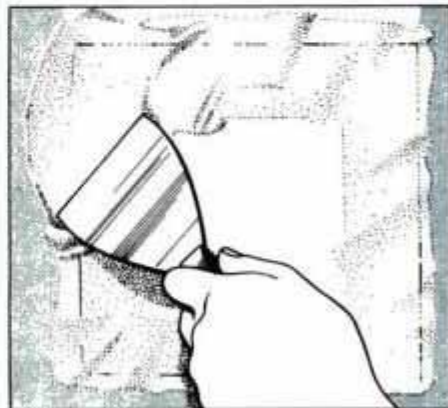
**10** Sand the edges of the flap to a taper at the outside edge. This feathering makes the patched surface less noticeable.



**11** Dampen the wall surfaces that will receive compound then spread it on the flap. Apply extra compound in the corners.



**12** Apply a thin layer of compound on the wall surface and hole edges, then slide the plug patch into the opening.



**13** Use a wide-blade knife to press flap against wall. Force out excess compound, then cover entire patch.



# Appliance Clinic

BY STEVE TOTH, Contributing Editor

## Whistles While It Works

I have a Whirlpool refrigerator freezer model No. EVD19PRO, serial No. E03796274. When the freezer is running, a whistle occasionally develops and continues until the unit shuts off. Slamming the doors stops the whistle. What's wrong?

JOSEPH CSULIK  
CENTER VALLEY, PA

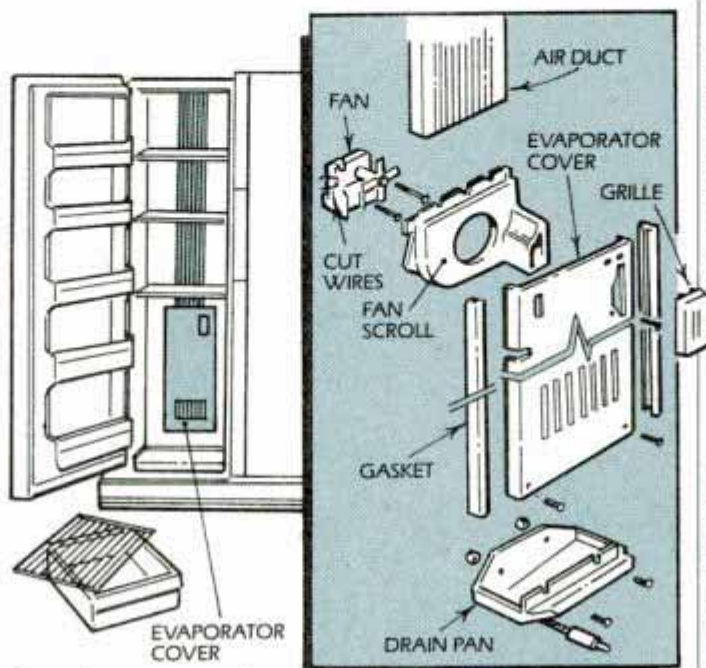
*The sound may be coming from the evaporator fan of your 19-year-old refrigerator. Due to the low temperature at which the fan operates, the lubrication in the motor can, over a period of time, dry out. When this happens, the bearing will wear and can make the noise you describe. By slamming the door, you change the position of the motor shaft in the bearing and the noise temporarily stops. It may take weeks or years, but the bearing will wear out to the point where the motor stops.*

*The solution is to install an evaporator fan motor kit available from your local Whirlpool parts distributor. The kit is part No. 482469 and costs about \$30.*

*To install the kit, first unplug the refrigerator and remove the food, shelves and basket from the freezer. Snap off the small plastic grille on the evaporator cover and remove the Phillips-head screws that hold the cover in place. If the gaskets on the sides of the evaporator cover come loose as you remove the cover, resecure them with masking tape before reassembling.*

*Behind the cover, you'll find the evaporator fan and motor. Remove the two screws that hold the motor in place and pull the fan and motor through the fan scroll that surrounds it. Cut the two wires going to the motor and remove the unit.*

*Follow the instructions that come with the new evaporator fan motor kit. Then, reassemble the refrigerator in the reverse order. This should eliminate the whistle.*



To replace evaporator fan, unplug fridge and take out shelves and drawers. Then, remove grille and evaporator cover. Disconnect fan, replace with new unit and reassemble.

## Projector Repair

I am trying to find the film-drive cog wheel for my 15-year-old Sears model No. 9205, Dual 8 Projector. Sears told me that they no longer have a listing for this part. Any assistance would be greatly appreciated.

DESMOND MURPHY  
SUNRISE, FL

*I believe that the correct model number for your projector is 584-9205. The first three numbers indicate that the unit was manufactured for Sears by the Bell & Howell Co. Although Sears is no longer able to help you, many functional parts can still be found by contacting your nearest Bell & Howell service company. Supply the service agent with the Sears model number of the projector and describe the part that you need. It sounds like you're looking for a feed roller, No. 450625.*

*You can get this part for about \$5 from one of the following companies: Island Camera Repair, 228 Rt. 109, Farmingdale, NY 11735, (516) 293-8910; UT Photo Service, 3088 Clybourn Ave., Burbank, CA 91505, (213) 245-6631 or International Camera Corp., 231 S. Jefferson St., Chicago, IL 60606, (312) 876-1530.*

## Circuit Board Trouble

My G.E. gas dryer model No. 1DG-4820E5H, serial No. ZD217863 has two automatic cycles that don't function. However, manual operation works fine. I checked the moisture sensor and all the wiring. The problem seems to be in the circuit board. Do you have any suggestions?

ARNOLD A. KATZ  
TORRANCE, CA

*I found that while the moisture sensor for your machine is still available, the circuit board is not. If you choose to keep your machine, your only option is to use it manually.*

*However, you might try calling the G.E. answer center at (800) 626-2000.*

*Ask for the phone number of the customer relations department in your area. Then, explain your problem to the customer relations department. They may have a policy regarding this situation and may be able to offer you an allowance on a new machine in light of the unavailability of the circuit board.*

## Needs Door

The door liner of my 11-year-old Frigidaire dishwasher has rusted and the surface is flaking. Since there is nothing else wrong with the machine, I'd like to replace the door. Where can I find this part?

CAROLYN DAMRON  
WAPPAPELLO, MI

*To locate an authorized Frigidaire service and parts center, call the Frigidaire action line at (800) 451-7007. If you have any further questions about part availability, product information or a complaint that your local dealer can't handle, call the customer relations department at (800) 327-2440.*

*If you have a problem with any appliance, send your question, along with the model and serial numbers, to Appliance Clinic, Popular Mechanics, 224 West 57th St., New York, NY 10019. Sorry, but letters cannot be answered individually. Problems of wide interest will be discussed in this column.*



# Homeowners' Clinic

BY NORMAN BECKER, P.E., Contributing Editor

## Sash Problem

My house has Andersen Thermopane double-hung windows. The windows have spring-loaded sash cords. Three of the top sashes jam and can't be released by pulling the cord back and forth. Also, when the sashes are pushed to the top and locked, they don't close tightly. What can be done about this?

E. SPENSER RYLAND  
LEBANON, PA

*There's a good chance that the window openings are not square. This condition can occur as the house settles, or be the result of improper installation. Also, when windows are installed, the voids between the jamb and framing should be filled with loose insulation. It's possible that an excessive amount of insulation was stuffed into the voids. This could push the jambs inward and reduce the clearance between the jambs and sashes.*

*First, try cleaning and lubricating the sash channels. You can lubricate them with furniture polish, paste wax or candle wax rubbed in with a rag. Do not use oil. You can use silicone, but it must be a dry silicone spray—not a lubricant like WD-40.*

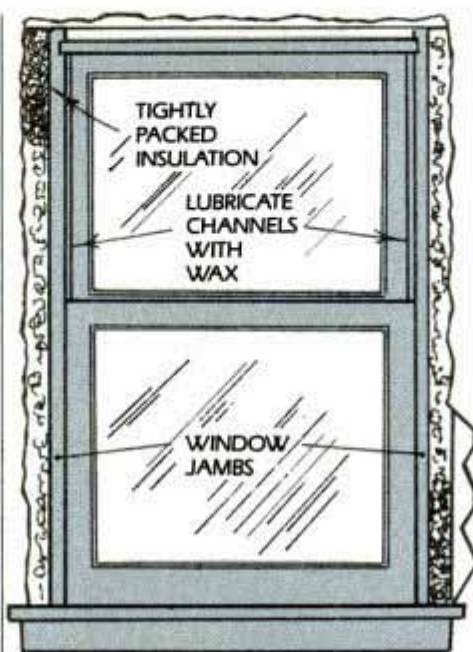
*If lubricating the channels doesn't correct the problem, then you'll have to remove the casing and resquare the window. This can usually be done from the inside.*

## Low Water Pressure

I have a house that is 60 years old. It has 1/2-in. galvanized iron pipes. The water pressure at the kitchen sink and upstairs bathroom has dropped to about half of what it should be. I had the incoming water checked by the city water department and the pressure was okay. Do I have to replace all the pipes or is there a simpler, less expensive solution?

JOHN W. HODGES  
ROANOKE, VA

*Although low water flow could be the result of low inlet water pressure, your water department has ruled this out as a possibility in your case. The first thing to check for would be partially clogged faucet aerators at the bathroom and kitchen sink. Unscrew*



*Stuck sashes can often be fixed by simply lubricating the channels. In other cases, insulation packed around the window pushes the jambs tight against the sashes.*

*the aerators from the faucets, inspect them and clean if necessary. If this doesn't help, then the low water flow is probably the result of a constriction in the distribution piping.*

*Over the years, mineral and corrosive deposits form on the inside of iron pipes. This reduces the effective opening which, in turn, reduces the flow at the faucets. If the rate of flow is unacceptable, the only solution is to replace the distribution piping and, in many cases, the inlet pipe.*

## Erratic Water Heater

In order to save on utility bills, I set my new electric water heater at the energy conserving range of about 120° F. Each morning, the temperature of the water might be anywhere from 90° F to 120° F. I've noticed that the temperature can drop to 85° F during the course of a 5-minute shower. What's wrong with the water heater?

GARY PETERSON  
CHAPEL HILL, NC

*You may have a defective water heater. It's possible that the thermostat is out of calibration and needs to be replaced. However, if your unit has two heating elements, first check their settings. If the elements are not set at*

*the same temperature, you can get variations similar to those you describe.*

*You didn't mention the capacity of the heater or its recovery rate. Electric heaters have a low recovery rate—especially in comparison to oil- and gas-fired units. If the tank has a low capacity, or hot water has been used prior to someone showering, then you may experience low hot-water temperatures.*

## Cellar Doors

I have an older home with an outside cellar entrance. Do you know who manufactures sloping metal doors used to cover the steps to the cellar?

FRANK WAMACK  
HONEA PATH, SC

*These doors are generally available in larger hardware, lumber or building supply centers and cost between \$244 and \$279 depending on size. One manufacturer of metal basement doors is the Bilco Co., Box 1203, New Haven, CT 06505. The phone number is (203) 934-6363. This company can send you information on both replacement doors (folder R-250) and units designed for a new installation (folder C-650).*

PM

## Service Tip

The Portland Cement Assn. has put together a handy book titled *The Homeowners Guide To Building With Concrete, Brick And Stone*. In addition to discussing the general characteristics of concrete and masonry building materials, it features photos, illustrations and step-by-step instructions for projects such as walks, driveways, steps and retaining walls. There is also a chapter on the repair and maintenance of concrete surfaces. The book is available from bookstores in both paperback (\$14.95) and hardcover (\$19.95) versions.

*Do you have a home-maintenance or repair problem? Send it to Homeowners' Clinic, Popular Mechanics, 224 West 57th St., New York, NY 10019. Letters cannot be answered individually, but problems of wide interest will be discussed in the column. For more home-repair and maintenance help, get PM's Home Care Guide, \$2.45 postpaid. Send your order(s) to Popular Mechanics, Box 1014, Radio City Station, New York, NY 10101.*





SPECIAL SECTION

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# HOW TO MAKE BETTER HOME VIDEOS

## ● CAMCORDER CINEMATOGRAPHY

Make attention-grabbing videos with the same moviemaking techniques the pros use. Planning a script. Shooting angles. Directing, lighting, titles and more.

## ● FINISHING TOUCHES

Tips on movie editing, special effects, soundtracks and other tricks that can turn your raw footage into a technical tour de force.

## ● TOOLS OF THE TRADE

Camcorder accessories that can give your videos an edge. Lights. Lenses. Filters. Batteries and more.





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# LIGHTS: CAMERA! ACTION!

Use the same cinematic techniques the pros use to make your home videos more interesting and exciting.

BY ARMAND ENSANIAN; PM Photos by Brian Kosoff



**T**HE remarkable advances in video camcorder technology have fulfilled most of the dreams of amateur moviemakers. The camcorder's compact size, and features such as autofocus, zoom, fades and noiseless scene transitions, make moviemaking easier than ever.

All of these conveniences, however, do not automatically make us great movie producers. The challenge of moviemaking is not in the acquisition of equipment, but in the telling of a delightful story.

Take a look at your home videos. Most likely you, as many of us, have dozens of tapes filled with random shots of gatherings, parties, friends and relatives. Most of these tapes become part of the family's dusty historical archives, waiting to be viewed by future generations. With a little planning, anyone familiar with the operation of the modern camcorder can produce attention-grabbing videos that will be viewed time after time.

## Preproduction planning

As with television and cinema, most of the work is done before shooting. It is important to think in terms of en-

tertaining your audience, and keeping its interest right from the beginning. A 10-minute video highlighting the key moments of a wedding will enjoy repeated showings much more than a dragged out, 3-hour knockdown bout.

The key is to keep it simple and include all the classic elements of film making. Identify *where* the action is happening, *who* is there, *what* is going on, *when* and *why* the event is occurring, and *how* it is all taking place. Keep individual shots short and simple—limiting them to 5 to 15 seconds. Actually count the seconds.

Start planning a few days before the event. Write down the itinerary as well as you can predict. This will provide an ideal foundation for a *script*. For example, the script for a family reunion picnic might involve the following: sending invitations, getting the house ready, preparing the food, picking up relatives at the airport, getting reacquainted with old friends and relatives, sitting down to the meal, reminiscing about the past, playing games, winding the day down, cleaning up, and a concluding moment of peace.

## The big picture

A properly scripted event can be shot with a single camera, requiring no editing whatsoever. More ambitious projects would require each scene to be shot more comprehensively, and edited later for transfer to a finished tape. In either case, don't limit yourself to trying to capture only candid action. Have your subjects act out a scene if it will help tell the story better. The beauty of video is that a bad scene may be erased and reshot.

Within each of the main scenarios listed above, your shooting script will need specific subscenes to help answer the where, who, what, when, why and how. The best way to do this is to think of your movie as a series of specific *still pictures*. The motion will be used only to enhance the *still*.

For example, subscenes under the heading Preparing The Food might include short 5- to 15-second vignettes of writing the shopping list, looking up recipes, calling an aunt for help, running to the store, cooking, digging out the grill, and so on.

It is much easier to visualize the



Don't chase subjects. To create the impression of dynamic motion, have your subjects move diagonally and toward the camcorder.



Use low shooting angles to emphasize speed and to make your subjects seem larger. Here's a good example of the "rule of thirds."

PM ILLUSTRATIONS BY BOB BERRAN



script outline by thinking in terms of these individual pictures. Professional moviemakers use *storyboards* to help organize their thoughts. These are a series of drawings that show specific shot-by-shot scenes as they will appear on film or tape.

### Anatomy of a scene

Each scene will tell its own part of the overall story. Just as the entire video has to have a beginning, middle and end, so do the individual scenes.

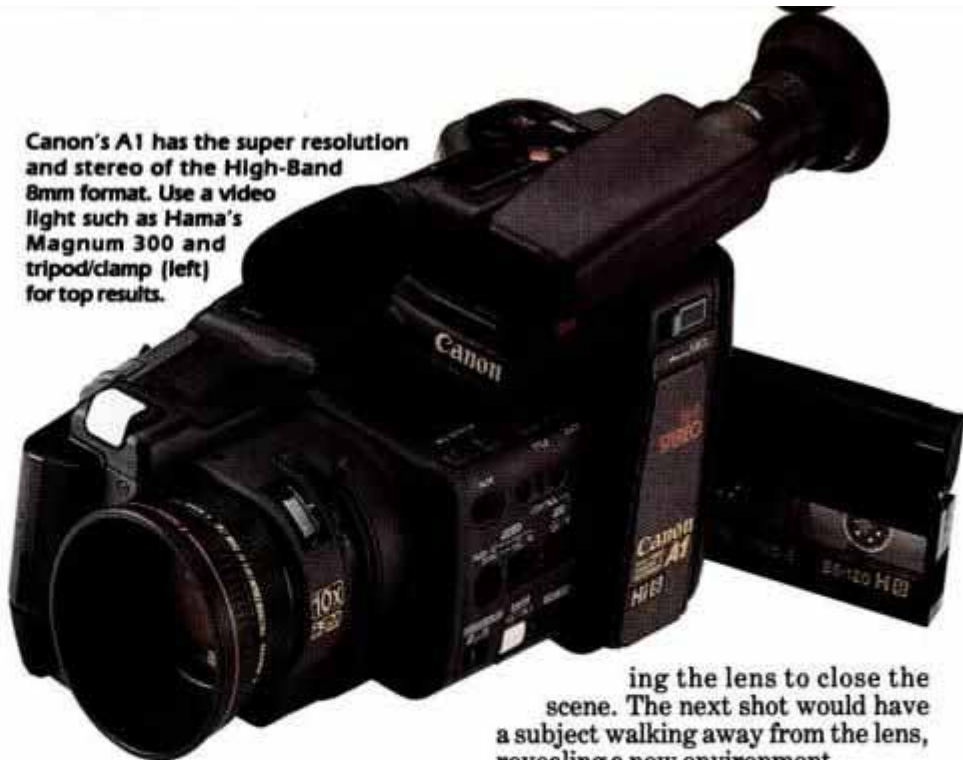
Scenes are made up of a series of shots relating to the same theme. To keep the viewer's interest, it is better to have a variety of different shots making up a scene rather than one long one. These should include a *long-distance* wide-angle shot showing where, a *medium-distance* shot to show detailed action and interaction, and *closeups* for highlighting specifics. Long shots, also known as *master-shots*, should include a reference to indicate size and distance. A shot of the Grand Canyon, for example, is more informative if there is a figure standing within the frame.

Keep your zooming to a minimum. It takes up too much time and can easily be overdone. Changing the camera angle, focal length and camera-to-subject distance between shots will have a lot more impact in maintaining viewer interest. Study television documentaries for reference.

### Set the mood

The pacing of shots is important in establishing mood. For example, we can imply chaos by keeping every shot in a scene down to only 2 seconds each. Imagine the trip to the airport: mother looking at clock, kids jumping into their clothes, chasing the dog inside, racing to the car, scrambling for the keys, detail shots of the speedometer, airport signs, running to terminal,

Canon's A1 has the super resolution and stereo of the High-Band 8mm format. Use a video light such as Hama's Magnum 300 and tripod/clamp (left) for top results.



ing the lens to close the scene. The next shot would have a subject walking away from the lens, revealing a new environment.

scanning the crowds. A long, concluding shot of hugging and kissing the found relatives will slow things back down again in preparation for the next scene.

Scene transitions are used to identify the beginning and end shots of a scene. Fade-ins and fade-outs are among the most popular methods. Many camcorders offer this feature. The same effect may be obtained by manually closing or opening the lens aperture if possible. Another technique is to slowly cover the lens with a piece of jagged cardboard.

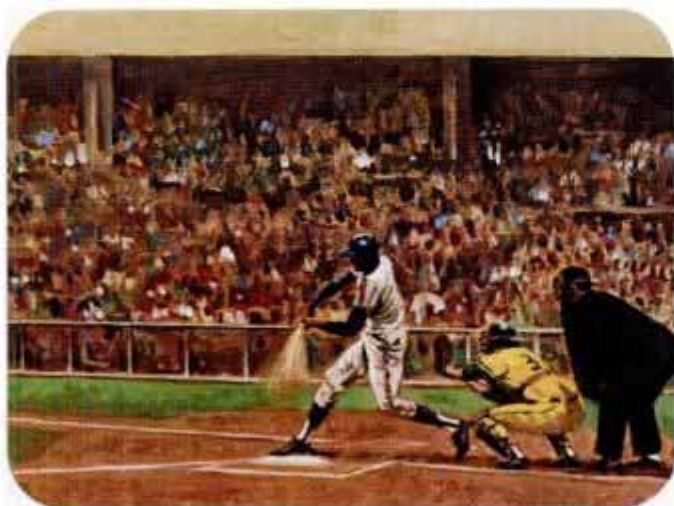
Focus-based scene transitions are good for showing the passage of time. For example, the concluding shot at the airport may slowly end by going completely out of focus. The opening shot of the reunion-picnic scene then starts out of focus and is brought quickly back in. Most camcorders allow manual focus override. The simplest transition has a subject walk toward the camera, completely cover-

### Camera techniques

Just as each scene is divided into specific shots, each shot may be individualized by various shooting techniques. Whatever the method, it is important to keep the camcorder steady. Tripods are ideal for stability, monopods for ease of handling.

Amateurs have a tendency to follow moving subjects. The results are often hard on the eyes. Take advantage of the moving picture capabilities of the video medium by having subjects move across *your* field of view instead of following them everywhere yourself. The most impressive motion effect is when the subject is moving diagonally across the frame and slightly toward the camcorder.

Good movie *walking* requires some exercise. Move your camcorder position to find those good points of view. For example, during the family reunion picnic, a baseball game is started. Shots of players running between



Lead the eye. Give your viewers a sense of movement and direction by leaving room in front of where the action is heading.



Convey drama by shooting from a low angle while tilting the camcorder on a downward angle in the direction your subject is moving.



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## LIGHTS! CAMERA! ACTION!

bases should have the base line cutting from one corner of the frame diagonally to the other—preferably with the action coming *toward* you. Low shooting angles emphasize speed and exaggerate subject size. Shoot with the camcorder at ground level, and set to telephoto, for slides into base. Don't shoot the entire game. Shoot many shorts from different views.

### Be a director

Video is a 2-dimensional medium. What appears to be close to our eyes will seem far apart on tape.

People in normal conversation hold a comfortable distance between themselves. In 2-D TV, this will seem like miles. Before shooting, direct your subjects to position themselves close to each other during conversation. Angle people toward each other, be they standing or sitting. This will require the least head movement when they talk among themselves and to the camcorder. Avoid firing-squad lineups. Show 5- to 10-second shots of lots of family members, varying positions and angles between shots.

Keep in mind that sound is part of the moviemaking process as well. Try to start at the beginning of sentences whenever shooting short vignettes. Tell your subjects what you want in advance, or ask specific questions. They too will appreciate looking and sounding more prepared. Always have them look directly into the lens whenever they are talking to you. By the way, one of the exceptions to keeping the camcorder steady is when eavesdropping on walking subjects. Follow them closely from behind. Keep your knees bent and slide your feet to absorb shock and minimize camcorder bounce.

Shooting angle greatly influences the viewer's interpretation of your attitude toward the subject. High angles imply dominance over the subject—so shoot children at their own level. Low angles make subjects look dominating—good for mother-in-law shots. Eye-level shooting shows a more personal interaction with the viewer. Off-level shooting from below, with the camera frame tilted slightly down on the side toward which your subject is moving, adds a sense of drama.

Indoor shooting will require some attention to lighting. Bounce-lighting is the easiest way to maintain control in normal rooms with 8- to 10-ft. ceilings. Two 250- or 500-watt lights may be placed in opposite corners of the room. Aim them at the ceiling. Hide the lamps behind existing furniture to

minimize annoying glare, both on tape and for the subjects. Brighter lighting will allow camcorders to use smaller aperture openings, thereby enhancing sharpness and depth of field.

### Composition

Good composition implies a proper balance of all of the visual elements within the picture. These include subject positioning, location of contrasting areas of light or color, and foreground/background interaction. It is often difficult to pay attention to rules of composition when shooting moving action. But some rules are simple enough to utilize.

One of the most important rules is the *rule of thirds*. Imagine drawing a tick-tack-toe board in your camcorder's viewfinder. Try placing important subjects, be they people or objects, at one of the points where two lines intersect. Larger elements influencing the picture should be placed one-third the distance from the top, bottom or sides—rarely directly in the center. For example, when shooting a medium shot of a pitcher, place him at one of the two lower intersections, leaving more room toward the direction of home base to

give a sense of forward motion. For landscapes or long shots, keep the horizon on either the upper or lower line. When shooting head-and-shoulder closeups, place the subject's eyes one-third down from the top of the screen, leaving a bit of room above the head. Tall subjects, such as lighthouses, are best placed along one of the two vertical lines. Centering a subject leaves little room for interaction with the environment.

Contrasting subject areas or colors must also be placed carefully. A small, bright area of light in an otherwise dim scene can easily dominate the viewer's eye. Colors work the same way. Complementary colors, such as green and red, or blue and yellow, contrast against each other the most.

Be conscious of distracting backgrounds when taping people. Try to move the shooting angle, or use a long focal-length to reduce the lens's depth of field and render the background out of focus. Also check to see if there are unwanted objects growing out of your subject's head.

One final note on composition: Whenever shooting people, avoid cutting them off at the joints, such as the hands, knees, elbows or ankles. Include feet in full-length shots, and the neck in tight closeups.

### The finishing touches

A bit of imagination can go a long way in making an attractive opening title scene, which must be shot beforehand. Graphics software run on a personal computer may be used to generate colorful title screens. Shoot them directly off the monitor if your PC doesn't have a video output jack.

Closeups of photographs, or projected slides, also make it easy to add sparkle to the opening sequence. Title lettering may be pasted directly onto a card or picture, using the many styles available from art stores.

The best lighting for copying pictures or title cards is found outdoors on cloudy days. Use a tripod to keep the camera absolutely still, unless you're panning across a large title picture. Don't discount the idea of adding a music soundtrack to the title.

If all this script writing and planning sounds like too much work, you'll be glad to hear about a do-it-yourself home movie kit called *Hollywood Make A Movie* (\$50). The kits are available in six categories, ranging from comedy to horror. They include scripts, scene-by-scene storyboards, props, sound effects tapes and title cards. All you have to do is choose the actors and follow the instructions. The kits make an ideal gift or video party game. Now, roll 'em! **PM**



Wobbly videos are uneasy to view. Tripods and monopods keep action steady.



HOME  
VIDEOS

# EDITING ROOM

\$1584.00

Editing gear and professional techniques give your videos a professional look.

BY FRANK VIZARD,  
Contributing Editor  
PM Photos by Spencer Jones

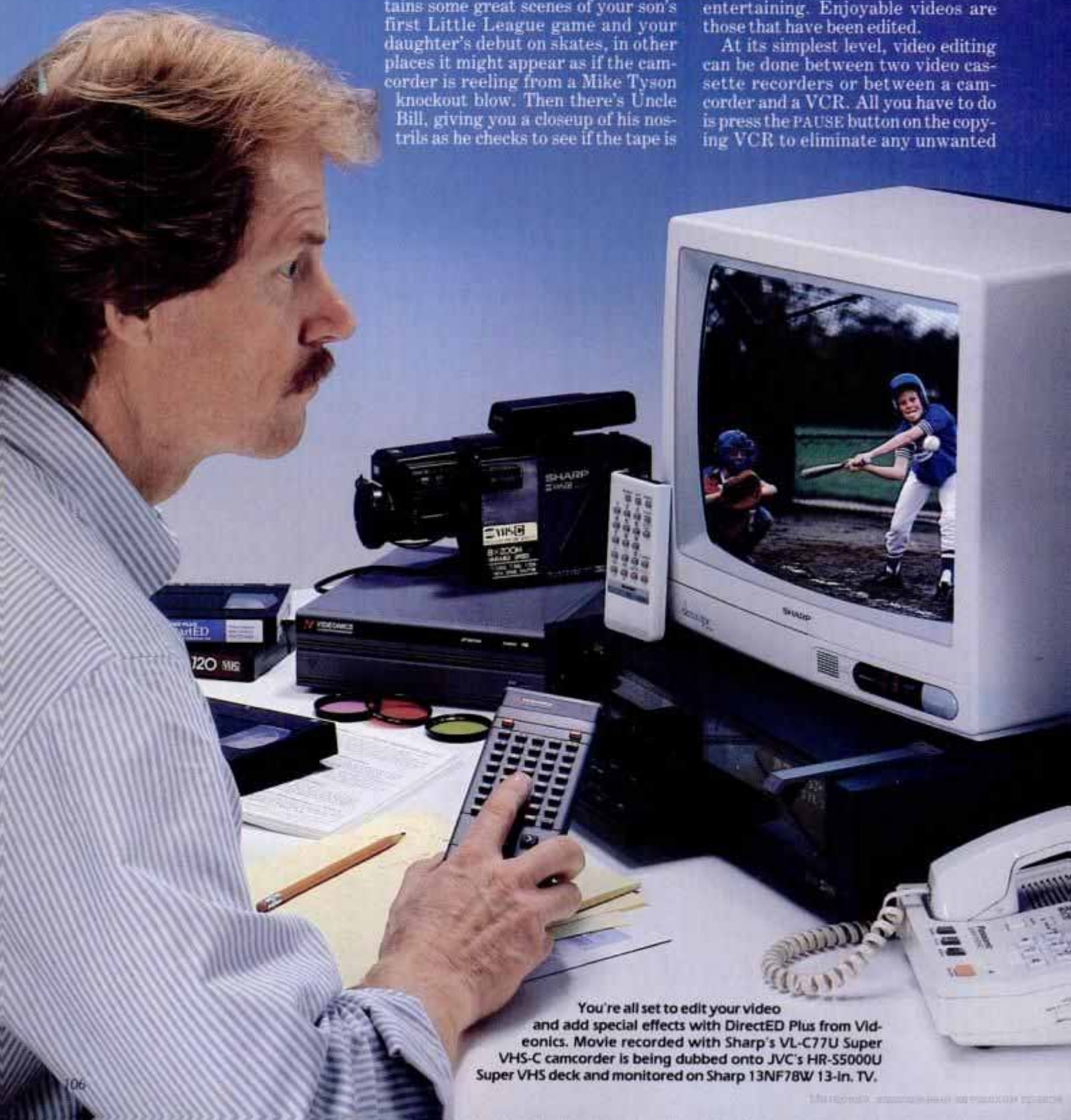
**V**IDEOS may be shot at a picnic or anywhere else a camcorder can be toted. Video movies, though, can only be made in the editing room. Until it is edited, everything you've recorded is simply raw footage.

While your videotape probably contains some great scenes of your son's first Little League game and your daughter's debut on skates, in other places it might appear as if the camcorder is reeling from a Mike Tyson knockout blow. Then there's Uncle Bill, giving you a closeup of his nostrils as he checks to see if the tape is

rolling. And those jitters—did you suddenly develop a bad case of the shakes?

Viewing raw footage might cause motion sickness. Invariably, it breeds boredom. Instead of punctuating your video with moments of interest, it's far better to make the whole video entertaining. Enjoyable videos are those that have been edited.

At its simplest level, video editing can be done between two video cassette recorders or between a camcorder and a VCR. All you have to do is press the PAUSE button on the copying VCR to eliminate any unwanted



You're all set to edit your video and add special effects with DirectED Plus from Videonics. Movie recorded with Sharp's VL-C77U Super VHS-C camcorder is being dubbed onto JVC's HR-S5000U Super VHS deck and monitored on Sharp 13NF78W 13-in. TV.



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## CUTTING ROOM

footage playing back from your camcorder recording.

Editing in this fashion is rather imprecise. Coordinating the two VCRs so that there is no distracting video noise between scenes can be difficult. Also, you're limited to one editing technique—the cut.

### Seamless editing

The *cut*, when one scene is instantly replaced by another, is the most common transitional device used in moviemaking. Flying erase heads, found in many camcorders, make the cuts between live shots practically seamless. But the transition might not be so smooth when dubbing various scenes from the camcorder to a VCR. And as common as cuts are, they are not always an appropriate transitional device.

You might, for example, want to indicate the passage of time or a change of location by using a *wipe*. A wipe is a line or other pattern that sweeps across an image, leaving a different image behind it. Wipes can be simple—a line moving left to right or top to bottom will do. They can also be more complex, opening and closing like a Venetian blind, for instance, from one scene to the next.

Another video editing technique involves the use of the *fade*. A fade occurs when an image slowly disappears, to be replaced by a solid graphic. Black is most commonly used, but any color in the rainbow is available. The length of the fade is also variable, as is the speed with which it occurs. If the fade occurs between two scenes—closing one and preceding the next—it's called a *dissolve*.

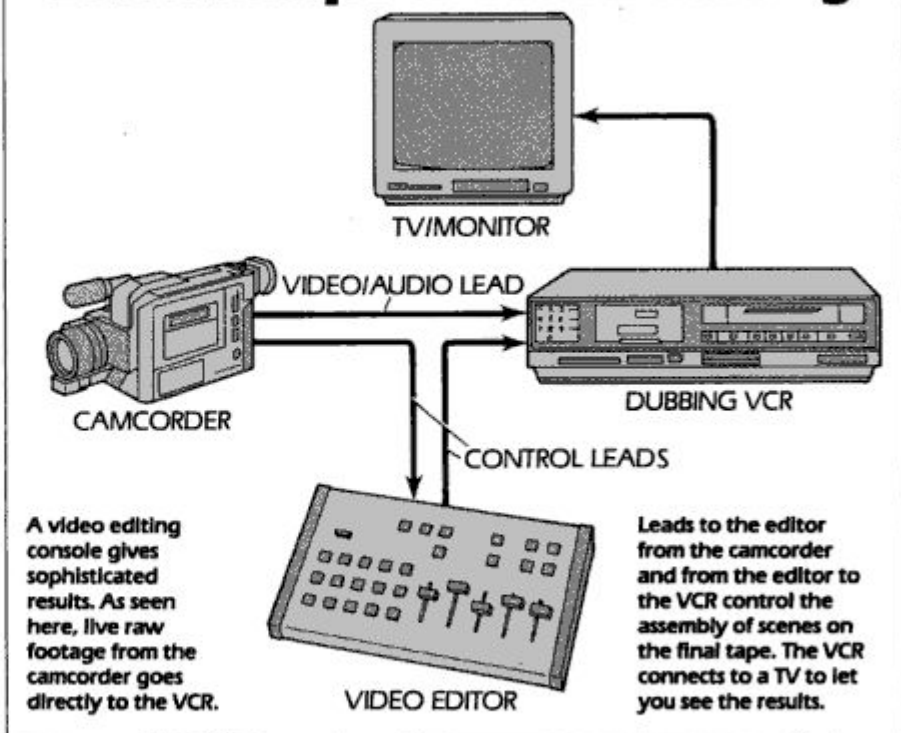
Video editing also includes the use of a wide variety of graphic elements. Titles, even one as simple as "Our Vacation," can be inserted using a variety of type styles against many different backgrounds. The titles, for example, could appear inside a computer-drawn birthday cake or keyhole. Type size varies too, so that you can present the opening titles very large and then use a smaller type size for captions or to credit the cast and crew at the end.

### Do your homework

Character generators, and a variety of fades and wipes, are included in many camcorders as standard or optional features. But whether they're part of the camcorder or features of stand-alone accessories, the effective use of video editing aids requires a good deal of planning.

Video editing, in fact, starts before the shooting begins. Master movie-

## Basic Setup For Video Editing



makers use storyboards to sketch each scene before shooting. Videomakers who use the same technique—think of it as a frame-by-frame illustration similar to a newspaper comic strip—will save themselves a lot of time in the cutting room later.

How much time a video editing job might take can be roughly determined by the number of wipes, fades and dissolves you want to create, multiplied by the length of the video. Six wipes and fades, for example, inserted into a 15 minute movie translates into about 90 minutes of work.

As carefully as you might plan, you still might have to do some work in the editing room. The video editing equipment available varies in complexity and price, reflecting the various levels of professionalism you might want to attain.

### Entry-level editing

Unfortunately, memorable moments do not always occur under the most ideal photographic conditions. Happily, you can clean up your videos after they've been recorded.

One handy device comes from Vidicraft of Portland, Oregon, a maker of video editing equipment. Vidicraft's Video Color Processor, the VCP-100 (\$200), allows you to restore some of the visual quality lost to low-light conditions. By using the VCP-100 correctly, you can brighten a dark video or enhance the colors. The VCP-100 is portable enough to be used while you're shooting on location.

The simplest editing package available is called DirectED Plus (\$550), from Videonics of Campbell, California. The machine combines the functions of a video editor, character generator and graphics special-effects generator in one box that connects between two VCRs or between a camcorder and a VCR. All the operating controls are contained in an easy to use, handheld remote control. On-screen menus provide easy-to-follow directions.

DirectED Plus lets you mark the beginning and end of a desired scene for inclusion in the final production. Any number of scenes can be included and arranged in any order. Potential users should note that the tape upon which the final production is being copied will rewind and play forward to the point where a new scene is to be added. This time-consuming process is repeated for every wipe or fade in the movie.

Videonics' machine is not precise enough to allow frame-by-frame editing, so leave yourself a little room before and after the footage you want to include in the final production. With practice, you'll need less and less elbow room in your editing.

The DirectED Plus works with any video format. By contrast, the Video Cut 10 (about \$1295) from Hama, a West German photographic supplier, works only with a select number of 8mm camcorders. Editing is more precise, to within six frames, and you can scroll horizontally or vertically across the screen to duplicate the title



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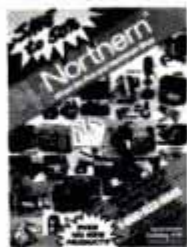
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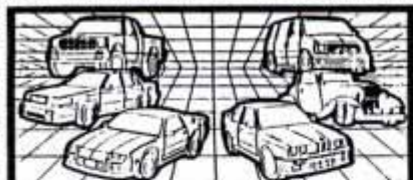
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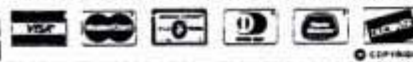
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## CUTTING ROOM

opening to "Star Wars."

For example, "In a galaxy far, far away Mom met Luke Skywalker—my Dad."

Hama's Video Cut 10 editing machine has a control panel slightly larger than the Videonics remote. The controller fits comfortably atop any table and its LCD screen can be tilted upward for easy viewing. The Video Cut 10, however, can only interact with an 8mm camcorder's tape counter system through a CONTROL-L output. The tape counter information is transmitted to the Hama video editor as pulses, permitting swift identification of any tape segment.

The Videonics and Hama video editing machines offer the convenience and small size of an all-in-one design. But if you truly want to be known as *F/X*—movieland's destination of special effects—you can adopt a component approach to editing your video production.

### Stepping up

A machine such as Showtime's VSEC-1 (about \$550) special-effects generator has 30 different patterns that can be used for wipes in any direction. These patterns can be given a soft edge to produce a dreamy or romantic sequence. The picture also can be made to fade to black & white. A *posterization* feature allows you to manipulate the gray tones of the b&w image. Lastly, the *polarization* function removes the edges of an image leaving only the color behind. The VSEC-1 and machines like it also offer the flexibility of multiple video inputs, so that you can assemble a movie from multiple video sources.

Special effects also can include audio-only sources. Background music can be supplied by tape decks, compact disc players and even turntables, although the latter's platter startup time often needlessly complicates the process. Sound-effects recordings such as city traffic, airports, chirping



RCA's character generator connects to your camcorder to add titles to your video.

birds, ocean surf and other ambient noises can lend atmosphere to your video movie.

### Sound investments

If you intend to narrate your video, a mixing microphone will add your voice to the soundtrack without eliminating the background music or original audio.

A wise procedure to follow is to write a script for the narration, record it on an audio cassette, time it while watching the video so that it fits within the desired video segment, then finally dub it onto the videotape. The same process should be followed if you intend to change the background music during the course of the video.

Another approach is to copy the entire audio portion of the raw video footage onto an audio cassette and work on it separately. You can then replace portions of the raw soundtrack with new material while retaining parts of the original audio, such as conversations. Careful cueing should return the reworked audio to its rightful position in the video—but beware of closeups.

Keep in mind that you'll need two tape decks for the job, or, what is called an "editing" cassette deck with two tape transports. Should you decide to record directly onto your VCR from a pair of cassette decks (or other combination of audio gear), an audio mixer works best to feed signals from the two sources to the single audio input of your VCR. But you can economize by wiring the dual audio sources to the VCR using Y-connectors, if necessary.

### Dubbing tips

Your final video production is basically a reorganized copy of your original footage. Because it is a copy, some degradation of the picture quality will occur. You can minimize this deterioration by using the best grades of blank videotape in both your camcorder and copying VCR. Some VCRs and camcorders help, too, by including an EDIT switch designed to



Hama's Video Cut 10 is a compact editing device for use with 8mm format camcorders.



minimize the loss of picture definition during dubbing. If you make multiple copies of your final production for distribution to friends and relatives, always make the dubs from your master copy—not a copy of the master.

Adopting the component approach to video editing allows you to plug in additional equipment to restore colors and details weakened during dubbing. Showtime, for example, offers a variety of machines that connect with its VSEC-1 special-effects generator to create a full-fledged studio. A complete package costs about \$2600.

Another major manufacturer of such products, Vidicraft, makes a special-effects generator similar to Showtime's in function and price. The company's other major products include the Audio/Video Processor (about \$460) and the Detailer IV (about \$420) that can perform such tasks as brightening dimly lit camcorder footage and reducing audio and video noise, among other improvements. With this versatile unit, you can also compare any adjustments you make against the original by using its split-screen feature.

### Looking ahead

As sophisticated as these devices are, they don't quite put you on par with studio professionals. The best special effects—such as pure dissolves (in which one video image merges into another), the superimposing of one video image atop another, and pinpoint titling—require that the multiple video sources be synchronous. But multiple video sources are by nature



Vidicraft's Detailer enhances sharpness and detail in subpar videos and dubs.

nonsynchronous. Camcorders and VCRs can be made synchronous provided there are *genlock* inputs for an external sync-generator.

Genlock inputs, though, and other black-magic such as time-base correction, remain pretty much limited to professional-class equipment. While you might not be able to duplicate all the video editing techniques used by the pros, keep in mind that much of what you can do at home today was possible only in the studio a few years ago. In the future, increasingly sophisticated video editing features are likely to be incorporated into home camcorders and VCRs. But that's another movie. Let's fade to black and roll the credits. **FM**

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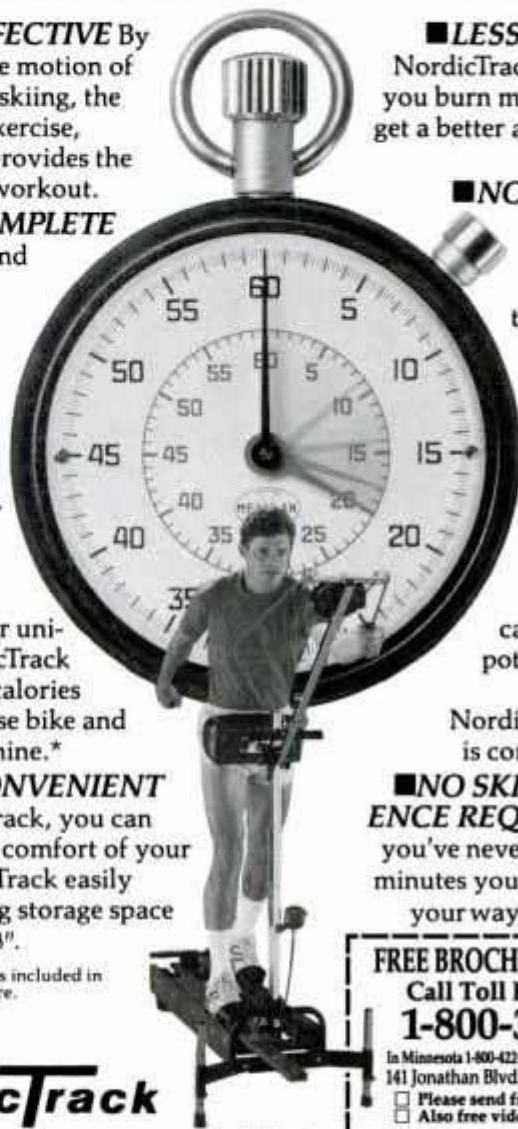
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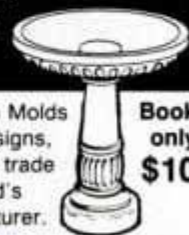
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HOME  
VIDEOS

# BEST BOYS, GRIPS AND GAFFERS

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Accessories are the stagehands you need for sharp moviemaking and slick editing.

BY FRANK VIZARD, Contributing Editor; PM Photo by Alex Laymen

**P**RODUCING a professional-looking video might require the help of lights, filters, special lenses, microphones and other gear that fits onto the camcorder.

As you shoot more and better videos, you'll discover the need for extra lighting. Although today's camcorders are designed to operate in low-light conditions, the resulting images often appear grainy and devoid of color.

One method of illumination is called the *fill light*. Usually mounted directly on top of the camcorder, the fill light eliminates any shadows caused by the position of the subject relative to other light sources. Even when

working alone, the fill light will help brighten colors and sharpen details. A fill light such as the Packtronics LT-3 (\$80), distributed by PSI, sports a 50-watt lamp. Optional rotating flaps called *barn doors* allow the light to be

Akron's Stay-Cool video light (1) fits neatly atop Ricoh's 8mm R630-Super camcorder (2). Other accessories include (3) Hama Shoulder Brace, (4) neutral-density and polarizer filters, (5) BASF 8mm and VHS-C cassettes, (6) 8mm headcleaning cassette, (7) Canon mixing microphone, (8) Arkon telephoto and wide-angle lenses, (9) Minolta accessory base with 35mm slide-to-video converter, (10) TDK full-size VHS cassette, (11) Hoftronic auxiliary power pack.





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HOME VIDEOS

## BEST BOYS, GRIPS AND GAFFERS

angled very precisely. Power comes from either a battery pack or AC adapter.

Just as for film cameras, there is a wide variety of special lenses available for camcorders. These include:

■ **Telephoto lenses** that increase the range of the camcorder's zoom lens.

■ **Wide-angle lenses** that broaden the field of vision are especially useful for shooting a lot of people in a small room.



Packtronics LT-3 video light gives 50 watts of fill, and can be mounted on a camcorder.

■ **Macro lenses** that let you shoot objects as close as 1 in. away. Many newer camcorders offer this built-in.

■ **Fish-eye lenses** that broaden the perspective to 180° with a slight bit of distortion around the edges.

■ **Hemispheric lenses** that create a distortion-free picture area three times broader than normal wide-angle capability.

Lens attachments often require manual focusing, but newer lenses are able to work in conjunction with the camcorder's auto-focus function.

Filters can improve the quality of your videos—and also add special effects. Some filters eliminate unwanted light. Key among these is a **neutral density** filter, which helps prevent overexposure caused by the reflected light from snow, sand and other overly brilliant environments. A **polarizer** filter also helps reduce glare and reflections, while enriching blue-sky backgrounds.

Most suppliers package filters in kits, particularly those designed for special effects. These include a **center focus** filter that sharply focuses the center of the picture while softening the edges, a **rainbow** filter that creates a multicolored halo around a bright spot in the picture, and a **starburst** filter that adds bursts of light to

bright spots.

Other filters include the **multi-imager**, which creates a number of identical images in the same picture, and color filters with clear centers for highlighting objects.

Every camcorder comes with its own built-in microphone, and these are generally satisfactory when the subject is close by. The solution to recording audio at a distance lies with **directional** and **remote** microphones.

Directional microphones reject nearby noise in favor of more distant audio sources. A directional microphone acts much like the zoom lens of the camcorder, in that it brings you closer to the subject.

Remote microphones use FM radio waves to transmit the audio signal wirelessly, up to 100 ft. A lightweight receiver attaches to the camcorder, and there's generally an earphone jack for monitoring the audio. Both clip-on and handheld microphones are usually included.

There also are microphones available for specific purposes. A **mixing** microphone, for example, allows you to record ambient sounds and dialogue while simultaneously adding music to the soundtrack from a personal stereo.

Whatever their power rating, standard camcorder batteries last only 20 to 90 minutes (depending on their size) before they must be re-



Ambico's V-0850 One-Gun Powerlite supplies 30 watts from its built-in battery.

charged. Portable lights also need their own power supply.

One alternative is to use auxiliary power packs. These vary in size, weight and output duration, depending on their composition. A 3-pound pack with nickel cadmium (NiCd) batteries might power a camcorder for up to 6 hours, or a 100-watt light for up to 35 minutes. Power packs are often worn on a belt around the waist for easy portability.

While the light weight of camcorders makes them easy to carry, their very lightness sometimes makes it difficult to shoot a steady picture.

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Tripods and one-legged *monopods* can anchor a camcorder for steady recording over a long period. Monopods are generally quicker to set up and are good for shooting in tight quarters. Gun grips and chest braces for camcorders are a safe investment if you're planning to shoot a remake of "Downhill Racer."

Most camcorders have a shoe mount that will hold only one accessory. Companies such as Sima make inexpensive accessory mounts capable of holding both a microphone and a light, for example. Sima also makes an accessory shoe for camcorders not equipped with one. Special mounts



Double pleasure? Ambico's Acrobat lens reverses for telephoto or wide-angle use.

also are available to raise microphones above the level of the camcorder—to avoid picking up noise from the tape transport and autofocus lens motors.

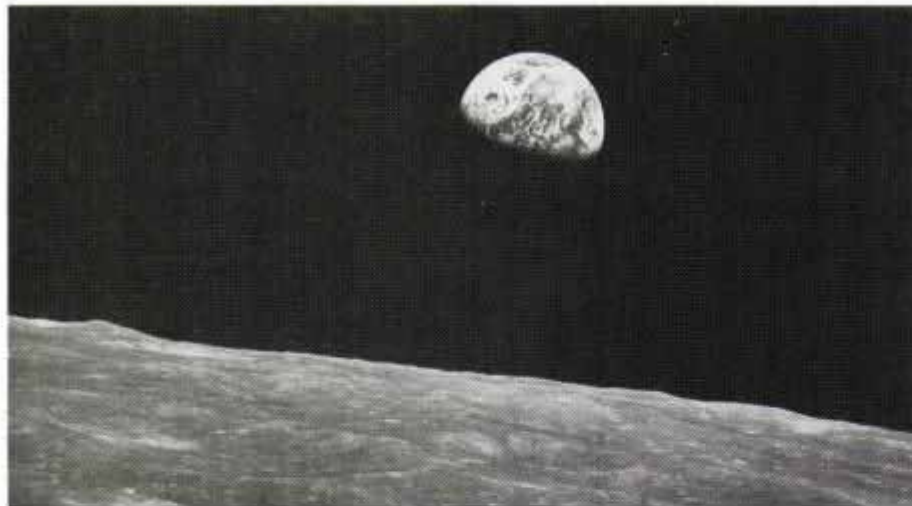
### Cases & Cleaners

Special carrying cases have been designed to pack your camcorder and accessories in a secure fashion. Suppliers include Coast, Packtronics, Ambico and others, including virtually every camcorder maker. Prices vary according to size and quality.

Shooting underwater requires a waterproof enclosure for the camcorder. These special enclosures and bags are sometimes available from the camcorder supplier, and are also made by specialty companies such as Hypertech and EWA-Marine. Prices vary according to the depth rating of the enclosure and the size of the camcorder.

Protecting the camcorder's internal video heads is as important as protecting it from hard knocks. Head cleaners to remove the debris that collects on video recording heads are available from many manufacturers, for every video format. To keep that debris to a bare minimum, use the highest grade of tape you can find. Quality-brand tape is the best overall investment you can make in your camcorder and videos.

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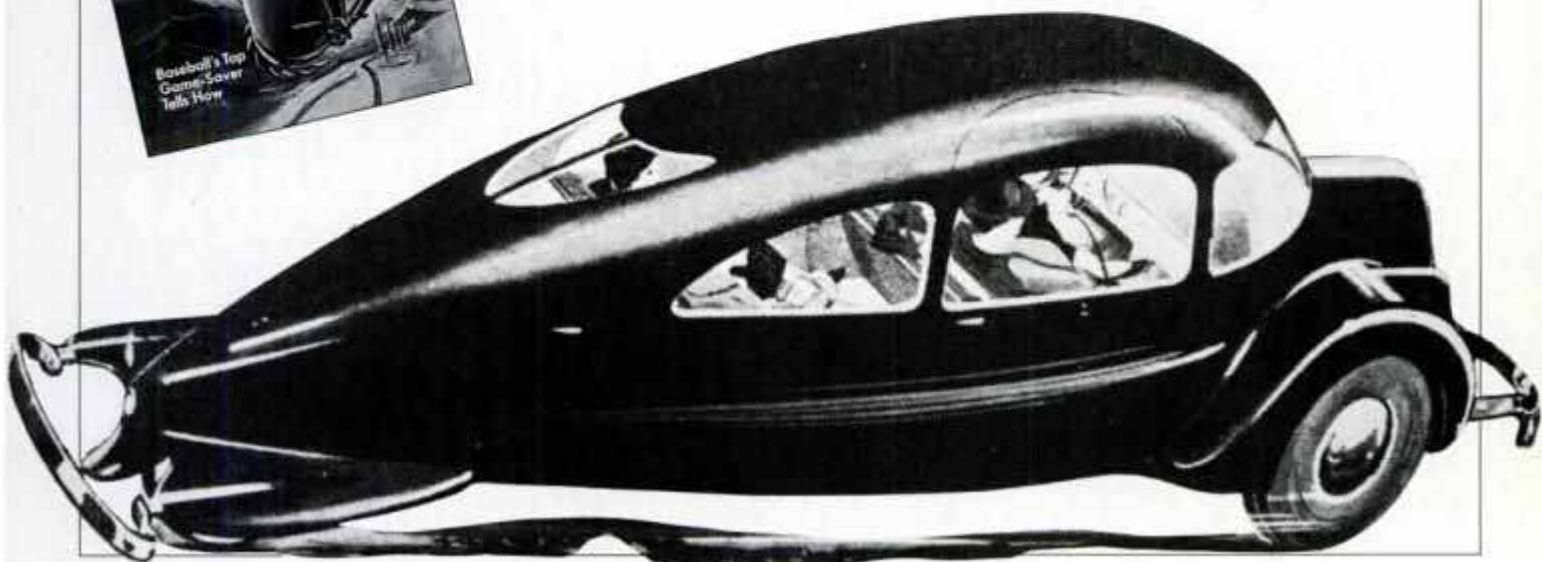
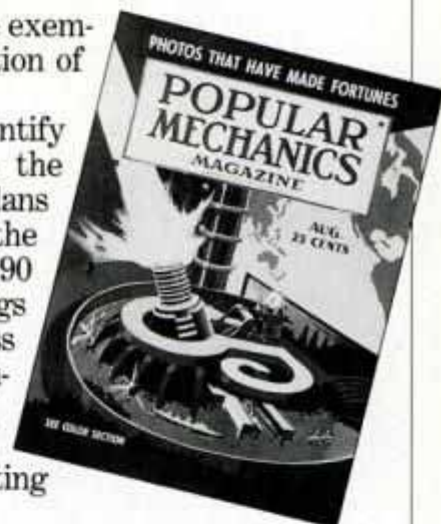
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The Henry Ford Museum & Greenfield Village and POPULAR MECHANICS need your help. To commemorate the 90th anniversary of the magazine, Henry Ford Museum and POPULAR MECHANICS are planning to collaborate on an exhibit on the history of the popular culture of American ingenuity and mechanical knowledge, as reflected in POPULAR MECHANICS.

Because of its important role in popularizing innovation and spreading mechanical know-how throughout the 20th century, the history of our magazine exemplifies the deep and lasting American tradition of ingenuity and problem-solving.

We need the help of all you readers to identify and locate examples of the inventions, the projects, the models, the cover art and the plans for the countless features that have filled the pages of POPULAR MECHANICS for the past 90 years. We are interested in both those things that predicted a future that never came to pass and those things that were so successful in becoming a part of daily life that we no longer even think about them. Please help us locate this material so we can create a timely and exciting historical exhibit.

Please send any information you think would be helpful to POPULAR MECHANICS Exhibit, 224 West 57 Street, New York, NY 10019.





judge our effectiveness in strafing, or dropping our smoke-emitting load of practice bombs. The Air Force has gouged what appears to be a runway in the central Florida outback—just a dirt and sand facsimile—along with look-alike East Bloc surface-to-air missiles sites. Truck bodies lined up on a dirt road approximate the appearance of a convoy.

Our objective today was to fly a pre-designated ground track to an initial point near Lake Kissimee, then descend to perform attack variations on the Avon Park targets. Dean and Morrison flew in tight military formation. When we crossed back over land, Doug and I descended to 1000 ft. while John covered us at 1500 ft.

**Bombs away**

Doug took a low pass over the Avon Park facility to show me the setup. Then we switched into fighting mode. The F-16 delivers bomb loads by diving at the target, the technique changing with the capabilities of the ordnance or the intensity of the ground fire. After the radar transfers target acquisition information to the heads-up display, sensors judge speed, distance and attack angle, telling the pilot when to consent to the release of the computer-delivered ordnance. After the pilot executes an evasive pop-up, gravity bombs release from the aircraft and arc into the target along the prescribed axis.

Our first pass at a convoy was a disappointment. We started an attack on a parked truck from an altitude of 500 ft., popped up to a 30° nose-high angle and snapped hard to the left, putting

us in position to make a 20° dive on the target. Some cockpit chatter proved distracting and we missed, although the videotape later revealed that we were well within the kill zone. Negative Gs at the top of the run—which levitated us out of our seats—were replaced in an instant at the bottom of the dive. The sensation, if you can imagine, was not unlike being sat on by an elephant as we pulled away from the target and made a sharp rolling turn to port. “We can do better,” said Doug. And we did, the next run producing a direct hit on the truck’s bullet-riddled flanks.

Doug then demonstrated a series of rapid pop-up attacks designed to show different tactics for different objectives. A 50° bomb delivery—for cracking runways—requires a pop-up of 45°. “You can change the tactic based on the kind of destruction you’re after.”

**Dogfighter**

Doug and John also demonstrated an air-to-air intercept, with Doug executing the classic ploy of hiding in the sun to descend on an unwary foe. During recent practice fighter weapons engagements, Dean showed sufficient perspicacity to wax four F-15 Eagles in simulated combat in 20 seconds, an unusual case of besting the Air Force’s air superiority platform using his wingman as a decoy. (“I got lucky.”) Increased use of long-range AMRAAMs will enhance the F-16’s potential as a long-range dogfighter.

What’s over the horizon for this modern classic? The Air Force is currently working on a program called

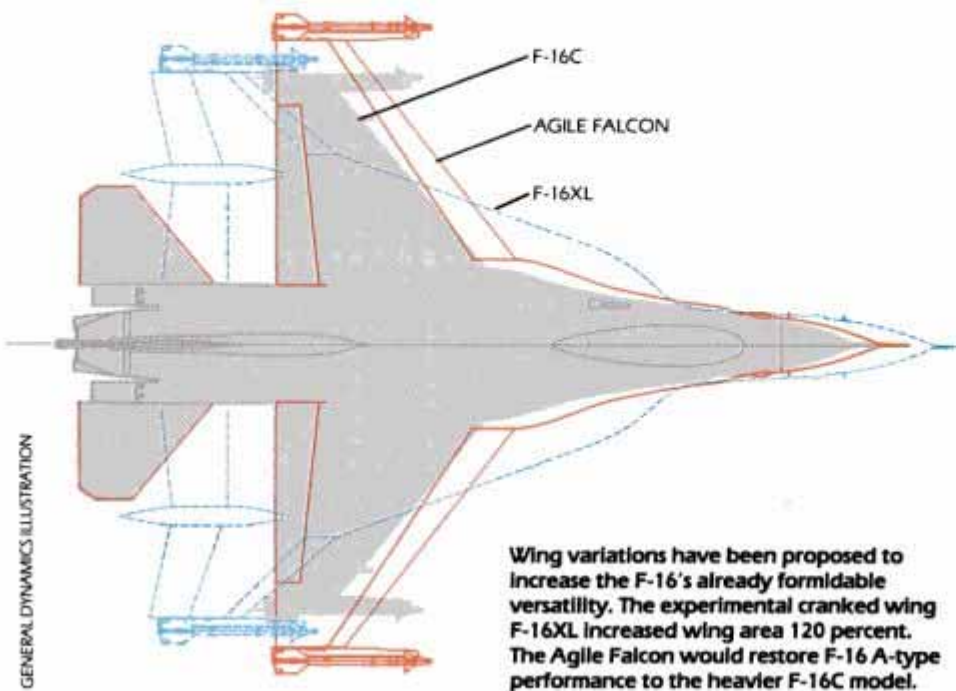
Advanced Fighter Technology Integration, a weapons targeting system that will allow the F-16 to make a low-level, high-G maneuvering pass against a ground target without pilot intervention. The AFTI prototype is also exploring ways for an F-16 pilot to perform all-angle gunnery during aerial encounters. Key to the system is a forward-looking infrared radar and a laser-targeting device. The FLIR finds the target, the laser measures distance and attack angle, passing the data to a fire control computer that directs the auto pilot and triggers ordnance release. The system will allow the pilot to control the plane, navigate, manage multiple threats, engage them—and escape.

**Fighters of tomorrow**

The Air Force and General Dynamics are testing the F-16’s suitability as a close-air-support platform. Designated A-16, the aircraft would use Falcon Eye, a FLIR-based helmet-mounted sight—along with terrain-following radar and a laser targeting system—to attack enemy armor and gun emplacements in forward battle areas. A follow-on called Agile Falcon will increase the F-16’s wing area, enhancing performance.

Beyond the F-16, fighters of tomorrow—indeed the classic fighters 100 years from now—will embody the stealth and highly automated characteristics currently being tested and evaluated at places like Wright-Patterson AFB. Blended composite shapes will absorb and deflect radar emissions, reducing—or eliminating—radar cross-sections. Structures made of carbon-fiber and carbon-carbon matrices will permit ultrahigh strength and low weight for thrust-to-weight ratios approaching 20:1. Vectored thrust high-performance powerplants with shielded exhaust to reduce infrared signature will permit supermaneuverability at sustained supersonic speeds. Supercockpits will incorporate pilot associates like AFTI that will help pilots manage complex battle scenarios.

Research continues on ways to make the pilots of the future less susceptible to G-induced loss of consciousness in airplanes that will far exceed the limits of human physiology. But for now, we’ve got a highly capable team in the F-16 and aviators like TAC’s Doug Dean. As we reentered the MacDill pattern after a pleasing romp through the Florida countryside, Doug hit the nail on the head. “They’re going to look back at the F-16 50 years from now and say, ‘Damn, what a sweet airplane.’” **PM**



Wing variations have been proposed to increase the F-16’s already formidable versatility. The experimental cranked wing F-16XL increased wing area 120 percent. The Agile Falcon would restore F-16 A-type performance to the heavier F-16C model.

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## BEST SELLERS (Continued from page 63)

sweeping parabolic curve that holds the white-on-black analog instruments. The seats could be a bit larger and wider for American-size people, but they have great lumbar support and plenty of adjustments.

Most controls are logically placed, and, typically Mazda, the 626 seems very well put together using premium materials. It's very functional and surprisingly Teutonic in feeling for a car built in Hiroshima. It's also fun to drive in a pleasant, undemanding way, and returned the third-best fuel economy in our group.

At the track, the 626 was something of a disappointment. Perhaps the fault lies with its slippery Yokohama 382 tires, but the 626 was near the bottom of the pack in everything but braking. It requires full attention to drive near the limit.

This is one of the most competitive market segments in the world. The Camry, Accord and Galant are pretty much equals, each with a different point of view. There's a gap between those top three and the 626.

## Volkswagen Jetta Carat

It's amazing. The Jetta is essentially a VW Golf with a trunk, but that simple addition makes it seem like a whole different class of car, though the interior room and performance obviously stay about the same. Like the Golf, the Jetta comes with three different versions of the same 1.8-liter engine, rated at 100 hp, 105 hp or 123 hp. Our test car was VW's luxury Jetta with 105 hp, 4-wheel disc brakes and Pirelli P600 tires on alloy rims.

There's nothing tricky about the Jetta at all. It's as straightforward as only a Volkswagen can be. In our testing, it returned significantly better gas mileage than the other contestants, was third in braking, near the top on the skidpad and midpack in acceleration. Only in our slalom test was the Jetta at the back of the pack. And—surprise—that add-on trunk is the largest in this group, which sets a premium on cargo capacity.

Perhaps because of its European origins, the Jetta is very different from the Japanese sedans which dominate this class. The interior is very functional, almost austere, very much in keeping with the boxy body. You sit high behind the steering wheel, in a very comfortable chair-like seat. German designers virtually invented the science of ergonomics, and the Jetta benefits from oversize, logically located controls.

The shifter is surprisingly notchy, the engine is a bit buzzy and there's a fair amount of road noise transmitted

through the chassis from the front suspension.

All our testers applaud the Jetta's sportiness, even in luxury Carat trim. It ranks close to the Galant in the fun-to-drive index. But the Golf/Jetta is getting rather dated, and ready for some refinement in the chassis and engine departments.

In this market segment, no company can afford to keep the same car in production for even five years without change. Which is another way of saying, nice as it is, as much fun as it is, the Volkswagen Jetta has stood still while the Japanese have gone roaring by.

## Dodge Spirit ES

What a nice surprise. The new Spirit—also sold by Plymouth dealers as the Acclaim—is probably the best sedan Chrysler has ever built, a comparative bargain and in our minds the best American car in this class.

The turbocharged Spirit is also hot. It zoomed through the quarter-mile eight-tenths of a second quicker than the next quickest car in this test, which is a significant difference. It was near the top in every other track test, too, and even has one of the largest interiors in the class.

The squared-up, very traditional appearance of the Spirit comes across as formal, rather than just plain boxy. It's certainly not an innovative look, but it's functional, and translates into generous interior volume.

Our test car had the tried-and-true turbo version of Chrysler's 2.5-liter Four. We found only a couple of problems with the Spirit. Dumping all that turbo power into Chrysler's front transaxle creates an unacceptable level of torque steer. On a winding road, the combination of torque steer, overly sensitive steering and pitch and yaw from the over-sprung, under-damped suspension makes even a professional driver back off a notch or two.

Otherwise, we found the Spirit lively and roomy, zippy yet formal. The huge interior holds surprisingly good seats and controls, with a full set of six easy-to-read analog instruments. If Chrysler would just do a little work on the steering and suspension, this would be an outstanding car, capable of going head to head with world-class sedans like the Camry, Accord and Galant. The Spirit is already 90 percent there.

## Oldsmobile Cutlass Calais

General Motors sells the same basic N-body platform as the Olds Cutlass Calais, Pontiac Grand Am and Buick

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Skylark. The Skylark is meant to be a compact luxury sedan, while the Grand Am is a hot sports sedan. The Oldsmobile version seems to straddle both camps, so we picked it to represent all three divisions.

We chose a 150-hp Quad 4 for our test car as probably the best balance between power, economy and reliability.

At the track, the Calais was mid-pack in every way, though it attacked the slalom with unexpected ferocity, thanks to its wide Eagle GT-4 tires. Our testers were quite taken with the Calais, and thought it pretty much the equal of the Dodge Spirit. With just a few changes, it could be as good as any sedan in this class.

Everyone liked the Calais styling—the lines are very simple and clean. The grilleless nose is especially nice and even the bolt-upright rear window seems perfectly appropriate on this classic, rather formal 4-door.

The inside of the Calais is very fancy, more like an expensive American luxury sedan than a car that costs only \$15,000. Like the other American cars in our test, the Calais's front seats are sized for large American bodies, and the ergonomics are much better than GM cars have been in the recent past. Even the six white-on-black analog gauges are clear and convenient.

Over-the-road handling is favorably comparable with most of the cars in this group. We saw 110 mph and the Calais felt solid as a rock. But mated to an automatic transmission, the Quad 4 isn't as quick as we expected.

### Chevrolet Corsica LTZ

Our test car came with the popular 2.8-liter V6 that's available in almost every Chevy product, from the Cavalier to the S-10 pickup. It's a sturdy, well-developed engine that ought to be dead reliable for family car use.

The V6 Corsica has almost identical performance to the Quad 4 Calais. Where the Corsica shines is in its external appearance. The pointy nose, wedge shape and handsome roofline are as modern and lithe as any small sedan in production. Unfortunately, the Corsica interior doesn't measure up to its exterior. The gauges are hard to see, the 2-spoke steering wheel is uncomfortable, with offbeat styling, and the pushbutton controls are hard to use.

Driving the Corsica is fine at normal speeds on the highway, but the handling deteriorates dramatically as speeds rise or the road turns bumpy. At high speeds, the car seems wobbly and under-damped, with a lot of pitch-and-yaw motion.

Overall, we'd say the Corsica is an

excellent, attractive platform from which Chevrolet could build a great family sedan. All it needs is a nicer interior, better suspension tuning and perhaps just a bit more horsepower. In all fairness, the top-line LTZ Corsica we tested costs about \$2000 less than our favorite Camry.

### Hyundai Sonata GLS

Korean Hyundai has come a long way in a short time. Three years ago, Hyundai entered the U.S. market with the Excel, essentially a Mitsubishi Mirage built under license, and promptly became the most successful new import company in history. Now Hyundai has added an all-new family sedan that's certainly competitive in this market and could easily be refined into one of the best cars in this group.

The Sonata chassis looks very much like the front-wheel-drive chassis of the previous Mitsubishi Galant, complete with 110-hp 2.4-liter engine and patented counterrotating balance shafts.

The styling is obviously up to the minute and contemporary, and the roomy interior borrows many of the same Mercedes 300 E styling cues used on Mazda's 626. The dash in particular is very European, as are the scooped-out door panels to leave more elbow room.

The seats don't look very special, but they are particularly comfortable. And while the Sonata is the same size as its competitors on the outside, the interior is 25 cu. ft. larger than that in the Camry.

Over the road, the Sonata's ride and handling are better than average, which is to say surprisingly good. The Sonata was mid-pack or better at the track, and all it really needs is more horsepower to move to the top of the charts. The styling, interior room and ergonomic design are already top-drawer.

### Peugeot 405 S

Designed by Pininfarina, the 405 was our consensus styling winner, and one of the prettiest small sedans to come our way in awhile.

Inside, excellence gives way to mere adequacy. The sleek roofline restricts headroom, with the wheel raked well away from vertical, like that in a van. The white-on-black gauges, however, are easy to read and most of the controls are logically placed. The heater controls are especially well handled. The shift lever in our test car promptly came off in our hand—Peugeot still has some old-fashioned quality control problems to

(Please turn to page 122)

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**BEST SELLERS** (Continued from page 121)

deal with in this brand-new car.  
Compared to even the Accord and Camry, the Peugeot has superior handling, steering and balance. It won on the skidpad and ranked near the top in transient handling and braking.  
For all its charms, the 405 found its way into the bottom half of this group—even though no one in our varied test group knew that the \$18,145 Peugeot is also \$2500 more than the Camry.

**Subaru Legacy L**

Legacy is a brand-new car that will be Subaru's flagship for the foreseeable future. It's about 5 in. longer and 400 pounds heavier than the familiar, old (now called) Loyale—and has a new 2.2-liter flat Four instead of the smaller cars 1.8-liter, plus bland but contemporary new bodywork. As one disappointed tester described it, "The Legacy is a missed opportunity to do something special."

Inside, the Legacy shares the new Japanese taste for Mercedes styling cues, with white-on-black gauges and a padded bolster that visually carries the line of the dashboard into the top of the doors, creating a cockpit effect. The seats are comfortable, though the interior feels a trifle cramped for four adults.

Driving the Legacy is more fun than looking at it. At the dragstrip, it was second only to the turbocharged Dodge Spirit, and it ranked near the top in most other performance tests. The 5-speed shifter is slick, the steering perfect and the handling excellent. The torquey engine pulls willingly, and there is absolutely no torque steer.

We like the flat Four power, the performance, the handling. The Legacy will no doubt be as reliable and trouble-free as any Subaru, and of course, it is also available with 4-wheel drive. Even the price is competitive. But the Legacy's anonymity and ordinary interior appointments dilute its newness.

**Ford Tempo GLS**

Backbone of rental car fleets from coast to coast, the Tempo—and identical twin Mercury Topaz—are like family sedans from another era. The 100-hp 2.3-liter Four is almost the only engine in this class—Chevy's V6 is the other—that doesn't have at least one overhead cam, although the Tempo did just fine in most of our standardized tests. It's just that the Tempo feels so mediocre, so humorless as it goes about its business.

Sitting in the driver's seat, your vista is pure rent-a-car. The dashboard is nicely styled, but you can't

see the gauges with the steering wheel in a normal position. The gearshift is a notchy cable shifter, the engine is noisy and there's a lot of wind buffeting around the windshield.

The seats offer only limited lumbar and lateral support. On the other hand, there is lots of headroom.

One look at the data panel tells you a basic strength of this car. The Tempo sells on price. At just \$12,145, our top-line GLS is a smart \$3500 less than the Camry.

**Nissan Stanza GXE**

No doubt a new, aerodynamic Stanza will be along in another year, as Nissan marches through its redesign of the entire product line. It's certain to be better than today's Stanza, which is slow, noisy and limited in the handling department.

Part of the blame for the Stanza's handling must go to its Yokohama 382 tires. These are the same tires we disliked on the Mazda 626. They seem to offer limited adhesion, and let go without much warning at the limit.

The Stanza is essentially the old Maxima fitted with the engine from the old 200SX. This little 2.0-liter Four is overwhelmed by a chassis designed for a 3.0-liter V6.

The boxy old body has been perked up with a rounded nose that makes it quite contemporary. Except for cramped headroom, it's also quite cozy. The seats are nicely upholstered in tweed, very comfortable with good lateral and lumbar support. The ergonomics are equally good, with logical controls and visible gauges.

Unfortunately, bringing the Maxima down-range with a smaller engine and cheaper appointments to create the Stanza has made it not only a poorer car, but also overpriced compared to other small cars engineered from the ground up. Our Stanza costs \$1100 more than a Toyota Camry with V6.

**Varied equality**

In addition to the cars we tested, add in four identical twins—Plymouth Acclaim, Buick Skylark, Pontiac Grand Am, Mercury Topaz—and you have 17 family sedans in this class. Anytime you have so many consumer products in competition, all sized and priced similarly, all capable of performance that's at least comparable, you have a very competitive market.

What this means to you is that there are no bad cars in this sedan group. Anybody trying to sell such a car would soon be forced out of business. To paraphrase George Orwell, these family sedans are essentially equal. But some are more equal than others.



## CLASSICS

(Continued from page 66)

tors now on two wheelers.

Even if you'd rather find a diamond in the rough and restore it on your own, the process of gathering information will link you to a network of replacement part suppliers. Used components, NOS (new old stock) and even reproduction pieces are available for a great many models, so it's smart to make contact with hobbyists who have done the research before.

By all means, the smartest buy is always a complete bike needing only cosmetic attention. Some soft items, like tires, seat covering and hand-grips are bound to be damaged, but these are fairly easy to replace. Missing fenders, horn tanks and chain guards are much tougher to find, and often costly to get.

When you have the bike actually in your possession, resist the temptation to disassemble it to the last part. Take a long, hard look at what you've got and decide on a long-term course of action. A slightly faded, but otherwise original model may be best left alone, with just a thorough cleanup to remove the evidence of many years' neglect. Not only will this get you on the road quicker, it will enable you to enjoy riding and lending it to others without fretting over every tiny stone chip or scratch. If the bike is in an advanced state of decay, you might consider just holding onto it for spare parts and searching for a better candidate for restoration.

The crucial rule of restoration is never go backward. Be extremely careful not to destroy anything presently in good condition. If you want to use whitewall cleaner on the tires, make sure to take them off the rims, because the cleaner might remove the paint along with the dirt. Don't dare take steel wool to a rust spot if you risk damaging an original decal.

It would be hard to imagine any item of nostalgia which could bring as much enjoyment to the owner as a classic balloon-tire bike. Everywhere it's ridden it will attract the attention of others, both those of an age to remember them as new models and youngsters who revel in the retro movement. Thankfully, here's one case of a classic machine that hasn't gotten away from us entirely. **PM**

### Source List

- **Antique/Classic Bicycle News**, P.O. Box 1049, Ann Arbor, MI 48106. Collector's information and want ads, current issues \$2. Also, distributes **Guide To Collecting The Classics**, \$8.95 plus \$2 for postage.
- **Hemmings Motor News**, Box 9510, Bennington, VT 05201. Collector want ads.
- **Schwinn History Center**, James L. Hurd, Curator, 217 N. Jefferson St., Chicago, IL 60606, (312) 454-7471. Schwinn product history source.

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## LICENSE TO FLY (Continued from page 59)

ander Lippisch—father of the delta wing and creator of Germany's Me-163 rocket plane during World War II—learned of the Finnish experience and developed two critical solutions to the pitch-up dilemma. The first: A reverse-delta, reverse-dihedral lifting surface that would furnish the desired aerodynamic lift and the required air compression. Lippisch addressed the pitch-up problem by grafting an enormous tail on the craft—in effect creating a load-bearing surface that flies out of ground effect, while the reverse delta main wing flies in ground effect. The load-bearing tail beat the pitch-up habit on X-112, Lippisch's 1963 proof-of-concept vehicle, and the basic ground-effect platform was set.

### Strength of composites

While Lippisch's rather crude balsa X-112 proved the basic concept, it still suffered several drawbacks. Wood fatigued quickly with each landing and absorbed water. The X-112 thus gained weight and wooden construction meant optimum aerodynamic shapes could not be achieved. Composites were the answer, so Lippisch turned to RFB, a leader in composite aircraft construction since the early '50s and also a pioneer in the use of ducted-fan propellers.

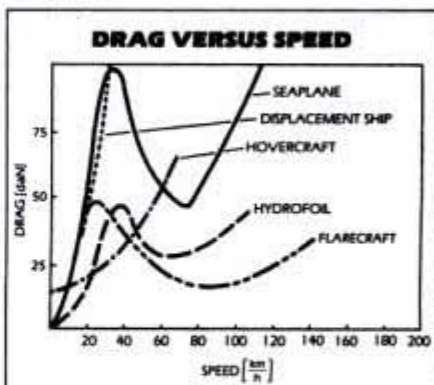
"We had to find an arrangement that was strong enough to withstand impact loads on the water, and yet light enough to fly," Fischer recalls. Composites also permitted contoured panel shapes that contributed to aerodynamic efficiency. The next prototype—the X-113—was fashioned by RFB under German government contract to investigate ground-effect technology for a military role.

"The vehicle flies in radar clutter. You just can't see it coming," Fischer says. "It's also so quiet it flies over acoustic sensors without raising alarms. It's composite so it has a low magnetic signature. The engine is throttled back to cruise so it has a low infrared signature. And it's fast. The military advantages are obvious."

The X-113, designed and flown between 1969 and 1972, marked a period of optimization for the RFB airfoil boat. Fischer and his colleagues fitted the machine with thrust measurement devices, so that output from the 40-hp powerplant could be assessed through the rpm range, determining thrust requirements for any desired altitude.

All aircraft designed to take off from water must fly through what's known as the hump curve (see accompanying graph). Hydrodynamic drag increases at slower speeds while the

craft is in displacement mode, then drops off abruptly when the aircraft goes on plane and ultimately flies. The X-113 showed that an airfoil boat could fly faster with less drag than a seaplane.



Flarecraft's superior performance: It takes off sooner and flies faster than most modes of waterborne aircraft.

The next flying article, the X-114, was also created at RFB on contract from the West German government. Statistics showed that the Baltic kicks up a 1.5-meter sea state 90 percent of the year. Service altitude in a ground-effect craft is customarily one-half the wingspan (although X-114, like its cousin Airfish II, could dodge over some significant obstacles) so the X-114 was designed to fly comfortably at that height while assessing its potential as a sub catcher.

The X-114 is also where the serious pursuit of large-scale ground-effect technology ended—until now. A landing accident—caused when the X-114's pilot forced X-114's pontoons into the water at the wrong angle of attack—soured interest.

### Fish stories

Fischer's fascination with ground-effect tech didn't end there. He and friend Klaus Matjasic developed an ultralight version called Airfish I in their spare time. Strapped for research and development cash, Fischer and Matjasic tested their preliminary airfoils by lashing the device to the roof of a sports car belonging to Fischer's wife. Instead of a wind tunnel, they made midnight runs down the autobahn at 80 knots, Fischer at the controls calling out flight data while Klaus drove with one hand and took notes with the other. Somehow Airfish I got built, its wide wingspan covered by sailcloth.

But Fischer already had Airfish II in mind, a ground-effect vehicle with thicker, more compact wings that permitted tighter cornering and easier trailering with the wings stowed.



Bill Russell—always a believer in the potential of ground effect—found Hanno Fischer two years ago and they've been working to create the production 2-seater ever since.

"RFB has built five craft to develop the technology," Russell says, "so now Flarecraft Corp. and RFB are getting ready for production."

But Russell isn't stopping there. Flarecraft Corp. and RFB are negotiating with a German manufacturer to design and test an 8-passenger commuter flarecraft. In effect, the commuter version will close a circle Russell began forming years ago.

"I started investigating ground-effect craft one day when I got frustrated trying to get from my house in Westport to La Guardia airport. We could have beaten the traffic easily by flaring down Long Island Sound, a perfect water highway. Well, this country has a lot of perfect water highways. And we have to come up with ways to move people and cargo in a faster, safer, more environmentally benign way. Ground effect is simple technology. It exists. It can do it."

The Soviets and the Chinese recognize the potential of ground effect. The Soviets have small, Lippisch-inspired 2-place designs for river patrol, and the U.S. Department of Defense has learned that the Soviets are developing a larger, UTKA-class ground-effect vehicle that will carry antiship missiles, troops and matériel for amphibious assault. The Chinese have also borrowed heavily from published drawings of Lippisch-derived ground-effect craft.

In this country, Russell has had discussions with Dr. Bill Bertelsen—early developer of the hovercraft—and now a member of Flarecraft Corp.'s technical advisory board along with John Roncz—to create a hybrid ground-effect skimmer like Airfish III that deploys a hovercraft skirt for beach landings. The key, according to Bertelsen, is a gimbaled-fan engine he has created that would provide a thrust mode for high-speed ground-effect flight, and a lift mode for moving over land.

"The gimbaled fan gives hovercraft the kind of precise control it's never known before. It could work for flarecraft, too," Bertelsen says.

The notion comes at an exciting time in the small but growing community of ground-effect aficionados. It's fertile ground for contemplation. Commuter vehicles. Large-scale transports. Polar voyagers. Swamp buggies. High-speed law-enforcement cruisers. Stealthy military platforms. Even fishing boats. **PM**

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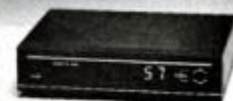
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### CD PLAYER SOUNDOFF

(Continued from page 69)

world terms, this is not significant.

As you can see, the differences among the players are marginal—within 3 dB (decibels) on the LINEARITY ERROR test. Keep in mind that 1 dB is the smallest change in level discernible to the ear. Moreover, these are worst-case linearity errors, and they occur at *minus 90 dB* (-80 dB in Onkyo's case). These volume levels are so low as to be inaudible. The sound output from the CD player would be mere microvolts.

To reproduce such low signals, an amplifier would have to be cranked to full throttle—and odds are that inherent noise in the hi-fi system would mask them. The LINEARITY WITH DITHER test measures the audibility of linearity errors over the inherent noise level of a hi-fi system in a typical home-listening environment. At worst case, it's about half a decibel.

### Interpreting test results

As more CD players with extra-bit DACs appear on the market, spec sheets and test tables will no doubt include measurements for linearity. Be sure to read them in conjunction with other measurements. Here's how to interpret the measurements presented in APEL's comparison chart.

■ Output voltage (item 2) for a typical CD player should be about 2 volts.

■ Output difference between channels (item 3) should be less than 1 dB—the lower the better.

■ The less fluctuation from 0 dB (positive or negative) the better, for items 4, 5, 6.

■ In decibels, the higher the better for item 7.

■ Total Harmonic Distortion plus noise (item 8) is represented as a percentage. The lower, the better—but THD below 3 percent is not audible. It's measured at full output voltage (0 dB) for four critical frequency bands (from 31 Hz to 16 kHz), and for 1 kHz at the lower output levels of -30 dB and a virtually inaudible -60 dB.

■ Dropouts (items 9, 10) on a CD can cause an audible pop, click or muting of sound. They're caused by manufacturing defects, or foreign substances on the CD's surface, that prevent the laser from reading the digital codes. This is more difficult when there are successive dropouts in a single track. Disc manufacturers keep defects to within 0.2mm, but the larger a dropout the laser can track, the better.

An understanding of these critical aspects of CD performance should help you compare not only the samples tested here, but any of many makes and models on the market. **PM**



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(Continued from preceding page)

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