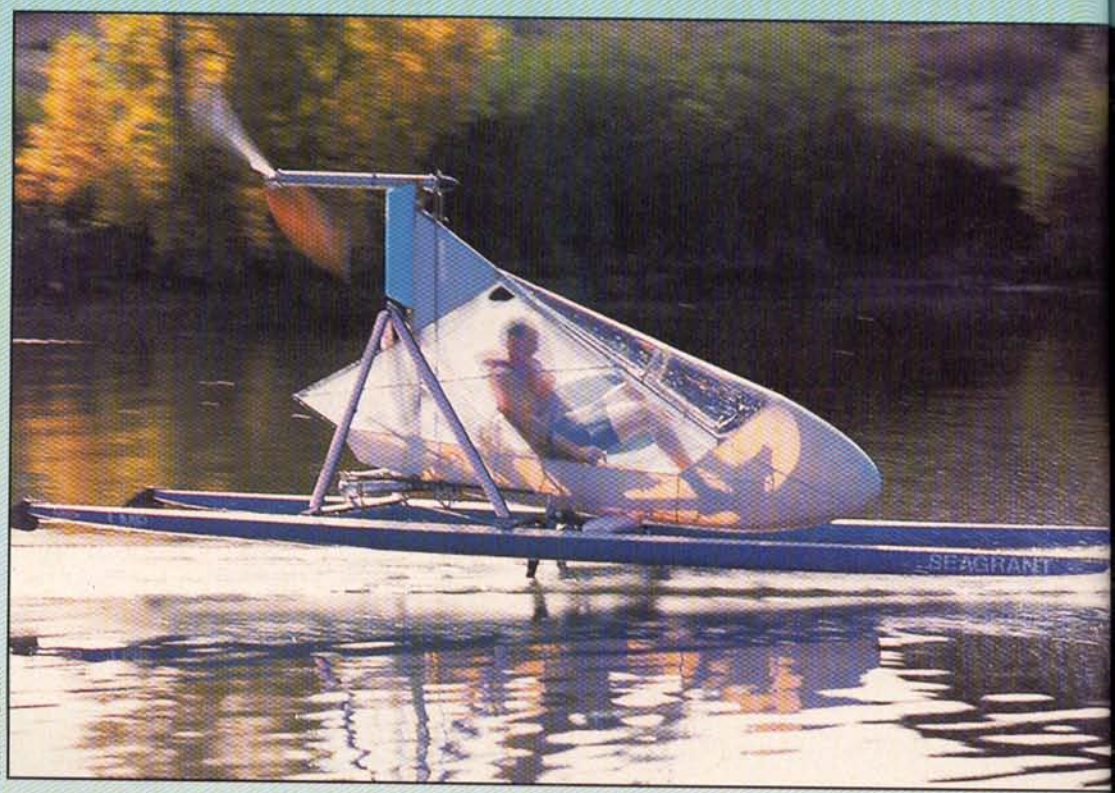
DECAVITATOR V



STUART F. BROWN

Decavitator skims across Puddingstone Reservoir in San Dimas, Calif. The 48-pound watercraft didn't manage to better its fastest run on this attempt.

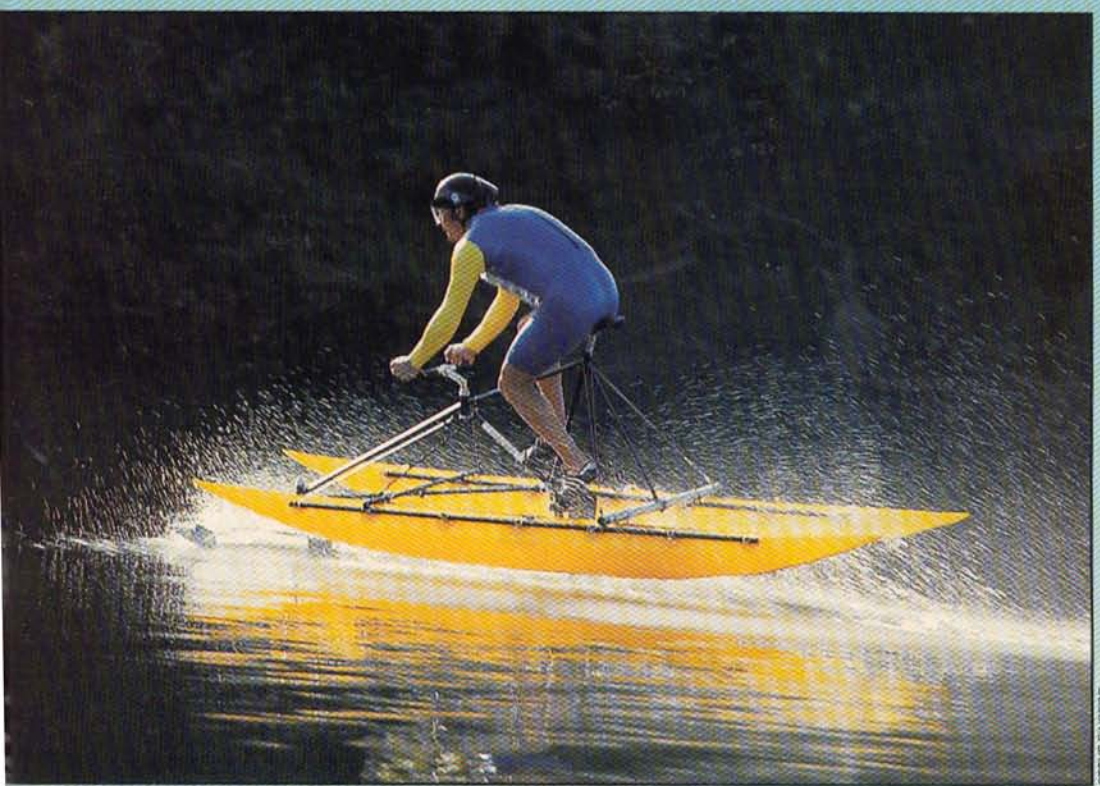
The race for the fastest human-powered watercraft has a winner.

BY STUART F. BROWN

How fast can a watercraft sprint for 100 meters with one person as its power source? Competitors refined their designs, ran through the timing clocks, tweaked and tried again, fiddled, then ran some more during the past three years in pursuit of the $25,000 Du Pont Speed Prize. The quest was hitting a brisk 20 knots (23 mph), a velocity calculated to be attainable—in theory, at least. But it was a stretch, and nobody was sure they could actually get there.

When the contest expired on the last day of 1992, a craft called *Decavitator* hadn't quite hit the magic number, but had posted the highest certified speed of 18.5 knots (21.28 mph), fast enough to claim the cash. Constructed by a team from the Massachusetts Institute of Technology (MIT) in Cambridge, *Decavitator* uses a slow-spinning air propeller

FLYING FISH



STEVE FINBERG

Looking like a bicycle atop slender bananalike pontoons, the 40-pound *Flying Fish 20* is up on its wings with a bicycle racer furnishing the propulsion.

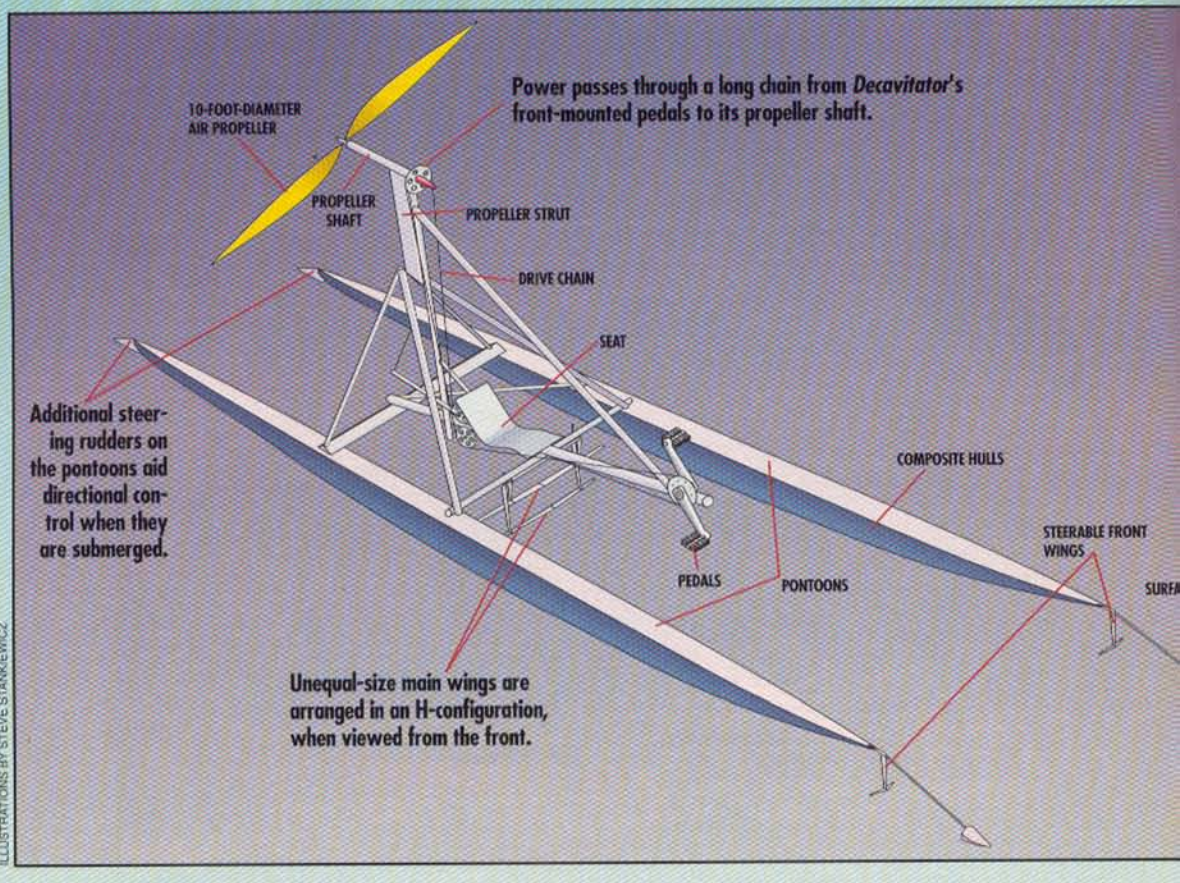
to push it through the water like an Everglades airboat. The boat's builders are led by Mark Drela, an MIT aeronautics and astronautics professor who was the aerodynamicist for the *Daedalus* human-powered aircraft flight from Crete to Greece ["88-Pound Pedal Plane," Feb. '87].

Since the prize competition was organized in 1989 by the Indianapolis-based International Human-Powered Vehicle Association (IHPVA), the MIT boat had dueled with *Flying Fish 20*, a quite-different-looking craft that reached a best official speed of 16.7 knots (19.21 mph) using a submerged propeller. *Flying Fish* is the creation of Alec Brooks and Allan Abbott. Brooks directs the electromechanical group at AeroVironment Inc. in Monrovia, Calif., where he was chief engineer on General Motors' solar-electric Sunraycer car and the prototype Impact electric passenger car. Abbott is a physician and professor at the University of Southern California who has set speed records in human-powered land vehicles.

A look at the two speedsters shows how different inventors can come up with widely varying solutions to the same challenge, though the craft share several features: Rotating pedals drive propellers through chains and sprockets. Twin floats provide buoyancy at low speeds, and hydrofoils—or underwater wings—lift the floats out of the water at higher speeds, slashing hydrodynamic drag by greatly reducing wetted area. But beyond this, differences in design philosophy abound.

Decavitator is built to keep itself almost entirely out of the water, which, at 850 times the density of air, imposes a vastly greater drag penalty. Thus the boat can be powered by a spindly 140-pound rider: Drela himself, who has been tagged with the water-flying handle "toothpick." The MIT craft uses smooth composite flotation hulls modeled after a racing kayak. A pair of unequally sized foils helps the boat accelerate and climb out of the water with moderate de-

A BIG PROPELLER IN THE AIR



ILLUSTRATIONS BY STEVE STANKIEWICZ

mands on the energy reserves of the rider, who pedals in a recumbent position.

From a standstill to a speed of about eight knots, *Decavitator* runs with its hulls submerged. At greater speeds, the boat begins to rise onto its foils. When the speed reaches about 14 knots, the rider pulls a lever to increase the foils' angle of attack. As the larger upper foil rises out of the water, it flips forward into a streamlined storage pod. The resulting reduction in water drag increases the boat's speed by approximately three knots with about the same amount of pedaling effort. Now the craft is supported by the small high-speed water wing, which carries it to its maximum speed.

Spinning at 250 rpm, the ten-foot-diameter propeller is designed for best efficiency at *Decavitator*'s intended top speed of 20 knots. At lower speeds, its efficiency drops off considerably. The MIT designers chose the fairly complex dual-foil system for its small, high-lift wing area and relatively low-power requirement at medium speeds. Sprinting to high speed takes much more rider effort, but brings the propeller closer to its design speed where drag losses are lowest.

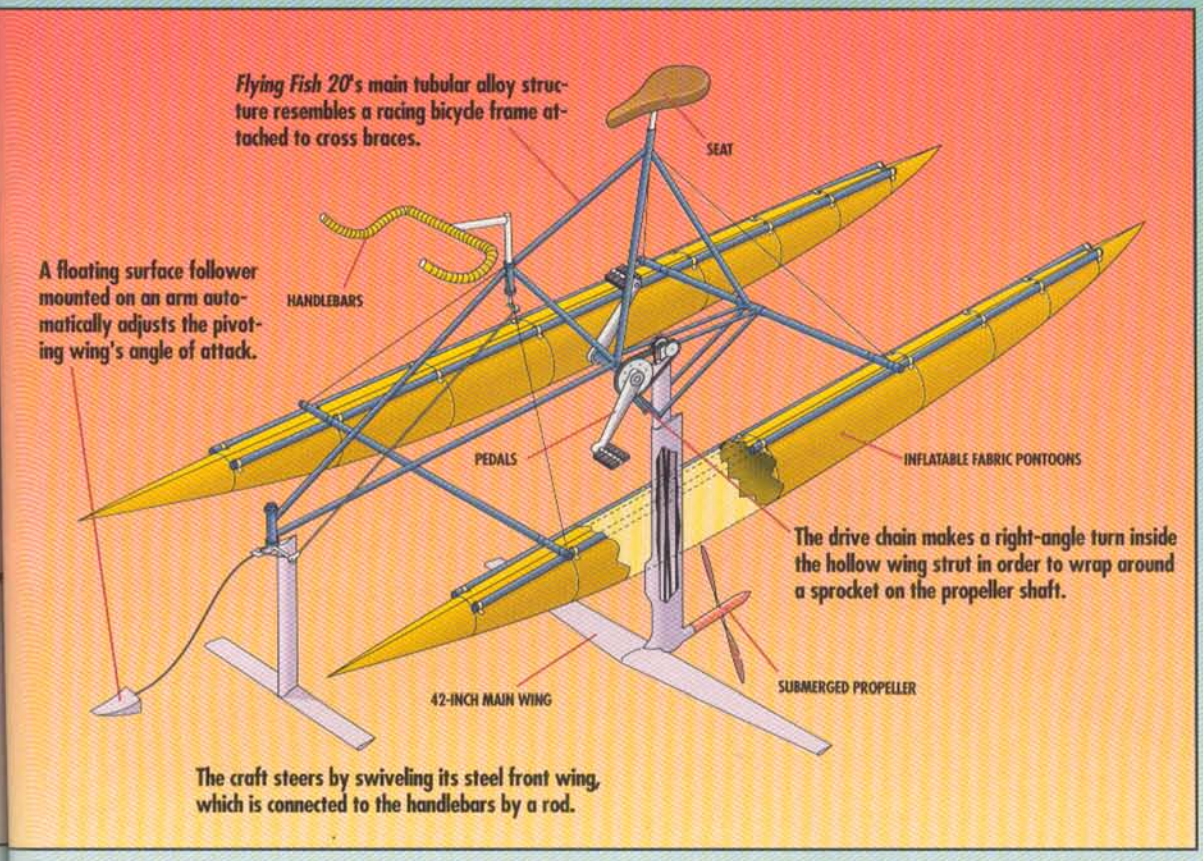
Perhaps most important, the big air propeller lets *Decavitator* capitalize on the 3.2-knot maximum tail wind that the IHPVA permits during official speed runs. The rules require only a one-way pass through the timing traps, so running in front of a legal breeze is the strategy of choice. It's possible that the official speeds of the two craft would have been closer if they had made all of their timed runs side-by-side under the same wind conditions, or running both with and against the wind, but that's not what the rule book stipulates.

Flying Fish 20 represents a contrasting idea about how to go fast on water. "We went for the brute-force, high-drag, high-horsepower approach," says Brooks, citing the advantages of mechanical simplicity. Using a conventional bicycle riding position with no controls except steering lets the team recruit powerful cycle racers who feel at ease aboard the watercraft after a little practice. Inflatable fabric pontoons support the *Fish* until it climbs onto its foils.

The designers' decision to use a single main foil dictated a compromise of shape with greater surface area than multiple wings would have. And the need to enclose the chain driving the small water propeller requires a large, submerged vertical strut. Together, these components account for most of the higher water drag in the *Flying Fish* layout.

Flying Fish 20 is the third incarnation of a 1984 craft that was originally designed to be catapulted from a floating ramp, thereby entering the water at takeoff speed without the need for pontoons. Olympic cyclist Steve Hegg pedaled *Flying Fish I* to a world's record 2,000-meter run this way,

A SMALL PROPELLER IN THE WATER



beating by ten seconds the time set by a single-rower racing shell. The *Flying Fish II* version, built in 1986, received a set of pontoons, equipping it for standing-start events.

The builders had to overcome several problems in sorting out *Flying Fish 20*—named after its hoped-for maximum speed—for the 100-meter Du Pont prize attempts. Persistent bending of the inverted T-shaped carbon-fiber main foil led to its replacement with one cast from hand-polished chrome-moly steel alloy. Reinforcing layers of carbon fiber were added to the supporting strut to cure a twisting movement that prevented the craft from climbing onto its wings. Finally, adding a small ledge to the strut's trailing edge solved an intermittent problem with air being drawn down from the water's surface, spoiling the propeller's thrust.

Decavitator and *Flying Fish 20* both borrow an idea for their small front foils from one of the grand old men of human-powered hydrofoil experimentation, engineer Sid Shutt of Brea, Calif., whose *Hydroped II* established a speed record of 13.8 knots in 1988. Shutt worked out the mechanics of running a spade-tipped surface-following arm in front of a pivoting foil. Roughness on the water's surface automatically adjusts the foil to an optimal angle of attack. Greg Ketterman, designer of Trifoiler ["World's Fastest Sailboat," Jan. '91], was also inspired by Shutt's simple and effective solution to the problem of pitch control. PS

HUMAN-POWERED SPEED PRIZES: SPARK PLUGS FOR INVENTION

By tantalizing potential innovators with a measure of money and glory, the two human-powered speed competitions funded by chemical maker Du Pont have inspired some of the finest high-efficiency engineering ever.

In 1986, Nathan Dean and Gardner Martin took home the first Du Pont human-powered speed prize of $18,000, which was offered to the builders of a bicycle or tricycle to reach 65 mph on level ground. Gold Rush, their streamlined two-wheeler, now resides in the Smithsonian Institution in Washington, D.C.

Admirers of the art of doing more with less can also look to *Decavitator* and *Flying Fish 20* for inspiration—even if neither made it all the way to 20 knots. Rules for the watercraft prize won by *Decavitator* were developed by a committee from the International Human-Powered Vehicle Association, the Indianapolis group that holds annual speed trials for land-, air-, and watercraft. Calculations showed that the right person in the right machine should be able to attain a 20-knot speed. Some human-power aficionados believe it still can be done. —*S. F. B.*