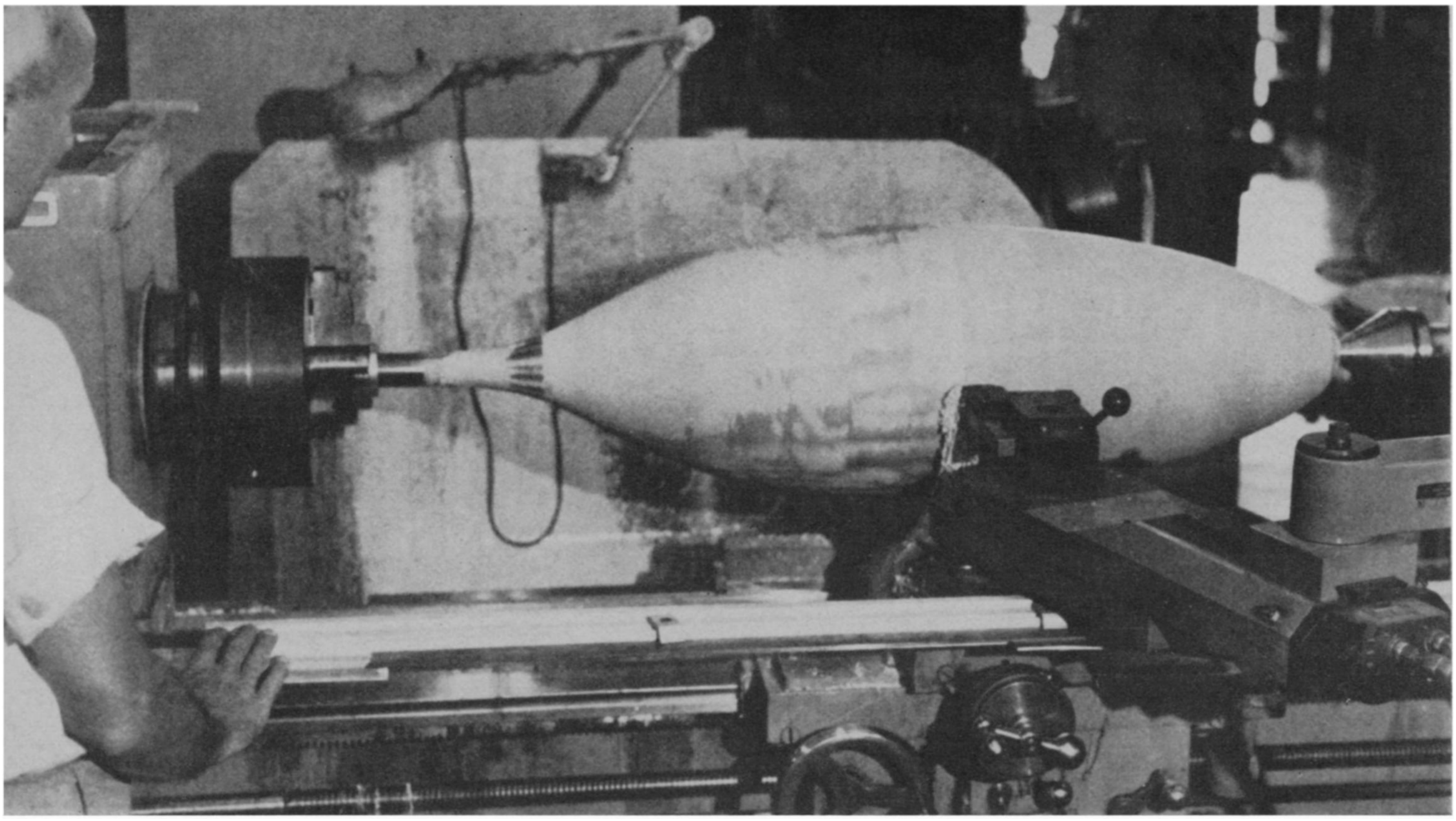


North American Aviation

A solid lead drop test body takes its carefully calculated shape on template-controlled lathe.

MARINE ENGINEERING

Undersea Hot Rods

Test shapes have reached 100 miles per hour underwater. Aerospace engineers say 200 mph and more may be possible.

by John Ludwigson

The ocean has always forced a relatively stately pace on those who navigate it. Except for hydrofoils and air-cushion vehicles which ride largely above the surface, today's merchant ships—at around 15 miles per hour—reach no more than a few times the speeds of Roman triremes.

A bomb-shaped chunk of lead tested for the Navy at speeds over 100 miles per hour may change all that.

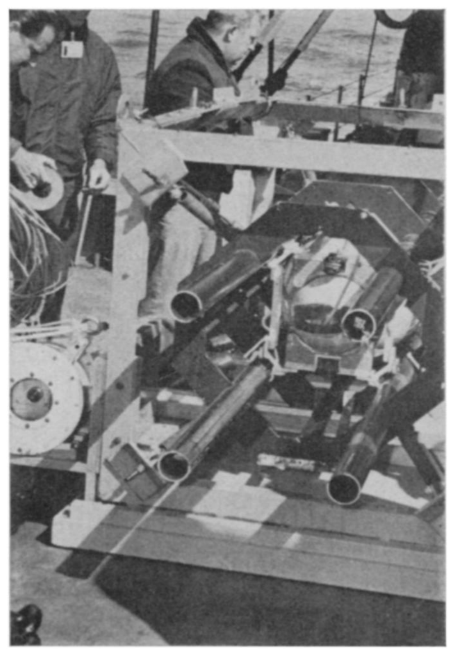
Engineers looking into the problems of making cargo ships go faster find that as their speed increases, the power needed to add each subsequent mile per hour goes up rapidly.

Underwater, without waves and wind to fight, marine engineers find the going easier. Nuclear submarines reach sustained speeds of 30 miles an hour and more—but at the cost of carrying large, expensive propulsion systems.

For both merchantmen and subs the name of the problem is the same: turbulence. Water sliding smoothly over a hull offers little resistance; water burbling past in swirls and eddies, especially around projections such as stabilizers, sonar domes and rudders, produces tremendous slowing forces.

While a certain amount of turbulence is inevitable, it can be kept to a minimum by careful design. Thus, sonar domes are made smooth and rounded or set flush into a hull, submarines have lost the decks and guns they once carried and hull shapes are now painstakingly worked out by computers fed with the latest information from hydrodynamic research. But it's still not enough.

Perhaps the ultimate so far in streamlined, fast-moving underwater vehicles is being produced in a program at North American Aviation's Ocean Systems Operations at Compton, Calif. There, bomb-shaped lead bodies have already been tracked at over 115 miles



North American Aviation

Test vehicle in launcher awaits run.

an hour as they dropped through the water.

North American engineers have followed up that initial speed trial with tests of larger, powered vehicles that run horizontally beneath the surface at less than half the speed. After a look at these, they now believe it possible to build vehicles capable of going as fast as propeller-driven airplanes—more than 200 miles an hour.

Since some of the work was done under a contract with the U. S. Navy's Bureau of Weapons, exact speeds and depths reached have been kept secret. The NAA program apparently is the only study of this kind that has been made of the possibilities of underwater travel at such high speeds.

The secret of achieving high speeds underwater, according to NAA's project engineer, David E. McNay, is in controlling the flow of water over the hull. Ideally, the entire hull would be bathed in laminar flow— smooth layers of flowing water that do not mix.

Laminar flow was thought to be impossible to maintain on a high speed body underwater before the NAA study. Tests in wind tunnels—the shapes perform much the same in air as in water—had shown this to be true. But NAA engineers, suspecting that turbulence in the tunnels was disturbing the flow around the test shapes, took their tests to sea and learned that they were right.

The trick, they learned, was that air flow in the wind tunnels had not been anything like as smooth as the vast currents in the ocean. Mild turbulence in the air in the tunnels had been upsetting the laminar flow around models hung within them.

Out in the sea—a medium 800 times as dense as the air—they tried first running a test vehicle fitted with a special turbulence sensor. In 13 runs of this vehicle, they learned that the ocean, lacking turbulence, was a much more suitable place for laminar flow tests and promptly moved their experiments.

Besides the drop tests with solid lead bodies, NAA engineers tried letting a larger, buoyant body bob to the surface from 600 to 1,000 feet down. This vessel carried instruments that measured the extent of laminar flow over it. Its ascent speed was clocked as it passed hydrophones suspended on a cable nearby; it was reportedly impressive, but is also not being discussed publicly.

With the possibility of laminar flow proved, the aerospace engineers turned to learning something about how to make the most use of it.

In practice, McNay observes, the best that can be done is to achieve laminar flow along about 60 percent of a hull's length. Beyond that, turbulent flow returns, but can be kept fairly gentle if the rear of the hull is correctly shaped.

The experimental vehicle eventually worked out at NAA looks something like a six-foot-long football with a tail. Its forward end is gently tapered at an angle calculated to part the water no faster than it can be smoothly moved aside. Its after end, where turbulence occurs, tapers faster, but still smoothly, ending in a long rat tail that supports four fins and counter-rotating propellers.

The secret of maintaining laminar flow, according to McNay, is to keep the vehicle's nose expanding as far back as possible. In other words, a 100 percent laminar flow vehicle would taper evenly from its broad rear all the way to its nose. Such a shape, however, would lose all the advantage gained by laminar flow in the extreme turbulence that would be generated behind it.

North American engineers combined the best of both worlds and made their shapes expand as far as they could, then tapered the after sections as rapidly as possible. Too rapid a taper would have induced cavitation, in which the water passing by the tail would have actually separated from the craft, forming an empty space that would exert tremendous drag.

With just the right taper on both ends, the engineers reaped the benefits of low-drag laminar flow while losing no more performance to turbulence than any normal, non-laminar vehicle would.

They even equipped their tiny craft with counter-rotating propellers especially designed to operate in exactly the turbulence conditions they predicted would be found at the vehicle's long tail end.

The resulting shape might easily find application in compact, high speed torpedoes; Navy officials say they're not interested in moving submarines at these speeds.

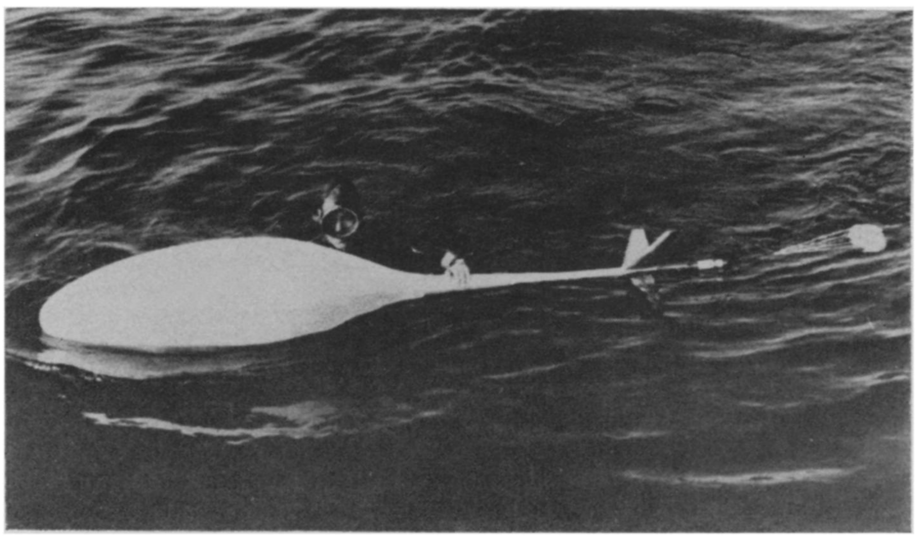
NAA's success, McNay insists, is based on simple, out-of-the-textbook engineering. Such shapes not only are the key to high speeds, he points out, but greatly increase the efficiency of a hull at low speeds.

NAA's success, however, does not mean that 200-mph submarines are on the way, he cautions. Large submarines benefit less from laminar flow than the small, torpedo-sized vehicles tested, McNay says, because the all-important laminar flow covers proportionately less of their hull surface area. The military might buy the technique, if it had a need, but even with a big boost from laminar flow, high speeds underwater require large amounts of power—more than would probably be economical for a commercial vessel.

The most likely applications to ship design for such knowledge are reduction of noise in military submarines and increasing the capabilities of small research submarines. NAA engineers, in reporting on their test vehicle, noted that the large area covered by laminar flow was a perfect location for a sonar array that could utilize sound frequencies normally impossible because of water noises created by turbulent flow around conventional sonar domes.

They also speculated on attaining speeds up to the speed of sound in water—3,400 miles an hour. "That's something like achieving orbital speed in the atmosphere," McNay observes.

While he refuses to rule it out as impossible, the aerospace engineer is making no predictions. ". . . admittedly it's not a need of the moment," he says.



North American Aviation

With its drogue chute trailing behind, a buoyant test vehicle ends its run.