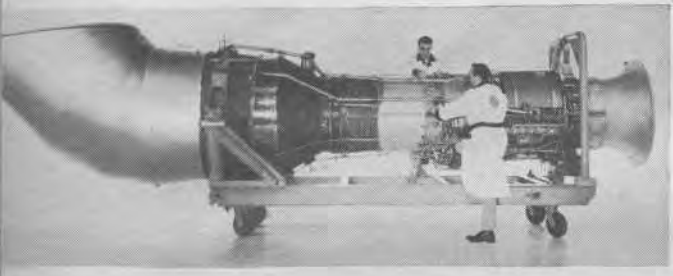
Seagoing Hydrofoils Fly Over Waves at 60 Knots

HS DENISON, 80-ton hydrofoil test ship, will skim ocean this summer at 60 knots. If fitted as passenger vessel, for coming trial in commercial service, she can carry 80 in airplane-type seats as in cutaway drawing at right.



The U. S. is launching

MIGHTY ENGINE of Denison, this 20,000-hp. gas turbine just completed for her by General Electric packs tremendous power in compact and lightweight 6,600-pound machine. Drive shaft will pierce big exhaust duct at left, as in drawing of ship.

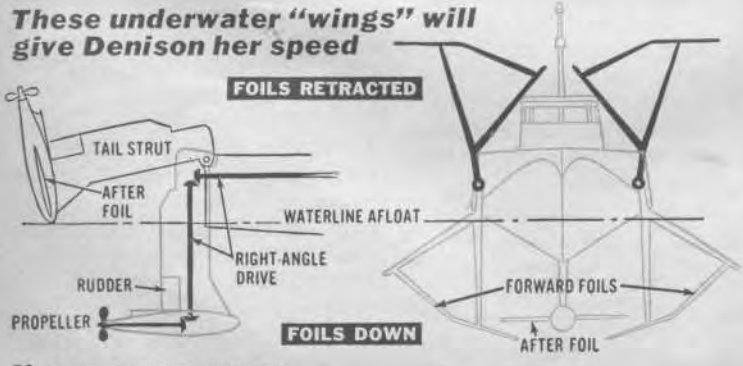
By Alden P. Armagnac

TWO new U. S. vessels with underwater wings may mark the greatest advance in marine design since steam replaced sail. The world's first hydrofoil ships designed for the high seas, they will inaugurate ocean travel at speeds up to 60 knots, or 70 m.p.h.

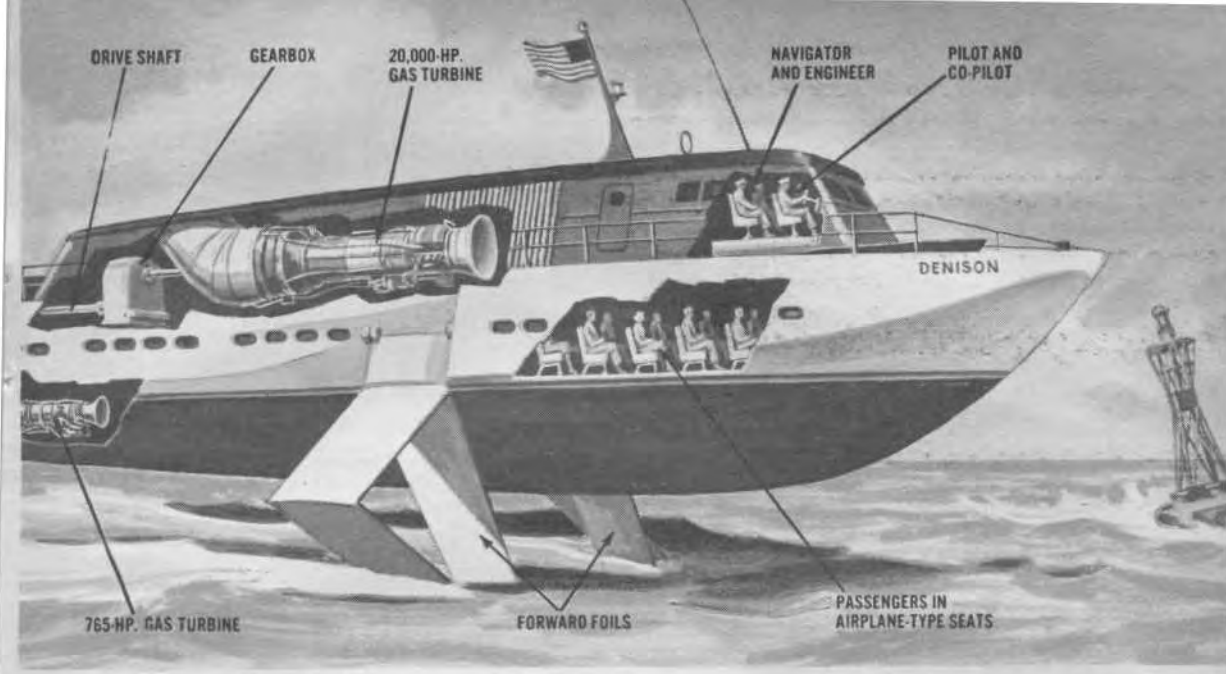
This summer will see the completion of the HS (Hydrofoil Ship) Denison for the Maritime Administration at an Oyster Bay, N. Y., shipyard. Its 80-ton size ties the record for foilborne vessels, and it will be the first ocean-going one. And the keel has been laid for the biggest hydrofoil ever built—the seagoing 110-ton subchaser PC(H)-1, due to join the Navy next year.

Hydrofoil craft like these will bridge

These underwater "wings" will give Denison her speed



SHIP "FLIES" five feet above water on surface-piercing foils forward (left), and submerged foil aft (far left) attached to pod that also carries propeller. Automatic controls operate trailing flaps on forward foils, and vary inclination of tail foil, to check heaving, pitching, and rolling in heavy sea. For docking, retractable foils are raised from water, as shown.



the world's first ocean vessels to speed on underwater wings

NAVY'S PC(H)-1, 110-ton subchaser due for completion next year, will be its first hydrofoil fighting ship. Combat-ready craft will be armed with torpedo tubes and machine guns, and will have latest in sub-detecting sonar gear. At foil-borne speed of 40 to 50 knots, it will dash to location of a detected enemy submarine, and launch homing torpedoes for the kill.

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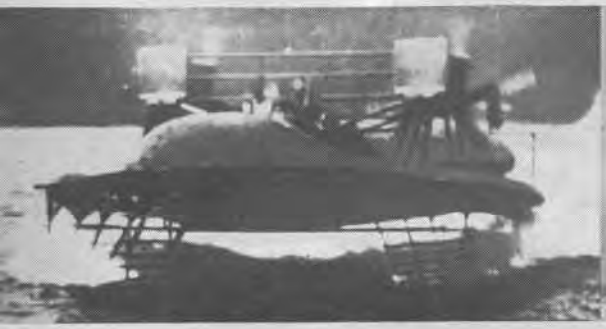
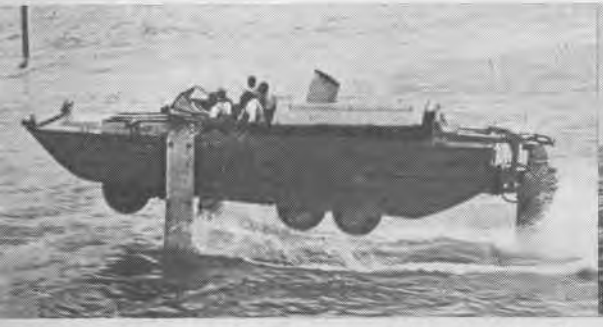
Early and modern hydrofoils in American waters



ONE OF FIRST successful hydrofoils, built by Alexander Graham Bell, had tryout above in 1919. It bettered 70 m.p.h. and set a world speed record for all watercraft of its day.

TEARDROP-SHAPED Lantern, Dr. Vannevar Bush's submerged-foil craft of early Fifties, showed stability as passenger rode standing. Foil-control system was ahead of its time.



FLYING DUCK, foilborne amphibian vehicle with wheels, was tried out last year by U. S. Army. The 13-ton craft, with submerged foils and gas turbine, skims the water at 35 m.p.h.

FIRST PASSENGER HYDROFOIL in U. S., beginning operation this summer between Bellingham, Wash., and Victoria, B. C., is foreign-built Flying Fish—a 60-passenger, 27-ton vessel.

the gap between the speeds of today's ships and planes.

Slashing through the water, winglike foils beneath their hulls exert lift, as a plane's wings do in air—and raise the hull clear of the surface. So foilborne vessels, freed of most of the wave-making and frictional drag that limits ordinary ships' speed, can go twice as fast or more.

That speed can carry voyagers faster than by conventional ships, more economically than by plane. It can bring perishable cargoes, like bananas from Central America, so quickly that costly refrigerating plants won't be needed. In warfare it can effect a swift amphibious landing, and can counter fast new submarines with still faster subkillers.

Abroad, hydrofoil boats ranging up to more than 50-ton size have carried hundreds of thousands of passengers over inland waters. America awaited its first hydrofoil service until only a few weeks ago—when a foreign-built vessel, the 27-

U. S. NAVY'S postwar hydrofoil program has produced series of novel craft. Largest so far, 15-ton Halobates, tested long-armed "feelers" at bow to control its submerged foils.

FASTEST HYDROFOIL of all, Navy's ladder-foiled XCH-4, hit 78 knots (90 m.p.h.). Two aircraft piston

ton, 60-passenger Flying Fish, was scheduled to begin 40-knot ferry runs between Bellingham, Wash., and Victoria, B. C. But now the U. S., which never built any large hydrofoil vessels before, has suddenly leapfrogged into world leadership in their development.

Recent American breakthroughs are responsible: new-shaped propellers for high speed, tremendously powerful and lightweight gas turbines to whirl them, electronic foil-control systems to defy ocean waves. Our big new foilborne ships will be showcases of these advances.

A gleaming white ship, blue-striped along her water line, the Denison will "fly" five feet above the sea. Well within her range of 855 nautical miles at top 60-knot speed, a New York-Bermuda run is expected to be one of her first trials.

Built by Grumman Aircraft Engineering Corp. and its affiliate, Dynamic Developments, Inc., the $5,000,000 Denison will serve the Maritime Administration as a test ship—a working model to try out plans for projected hydrofoil ocean liners of 500 to 1,000 tons.

For practical trials, MarAd will put the Denison in actual commercial service early next year. If used as a passenger ship, she will accommodate about 80 in airplane-type seats below deck.

By far the world's most powerful hydrofoil vessel, the funnel-less Denison will be driven by a gas turbine rated at up to 20,000 hp.—more than propels a conventional Mariner-type merchantman of 22,600 tons. Through an over-the-stern drive, the mighty engine spins a 36-inch propeller developing 25,000 pounds of thrust, virtually as much as a satellite-launching rocket.

The Denison flies on three foils—two forward ones, piercing the surface, and a submerged foil aft.

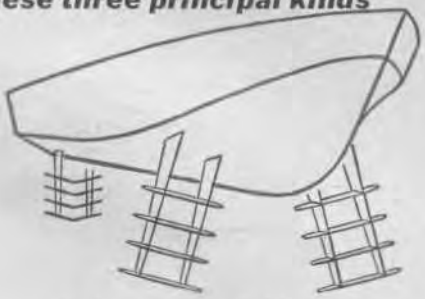
Secret of her seagoing ability is a newly developed foil-control system, perfected in sea trials of a 17-foot model of the Denison. For near-level flight over waves, the automatic controls actuate lift-regulating flaps on the forward foils to check heaving or rolling. They vary the inclination of the after foil to counteract pitching.

Flaps hinged to each side of the tail strut form the Denison's novel rudder. Opening either flap steers her that way. She turns in 1,000-foot radius.

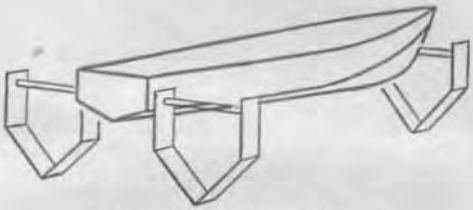
In port she lifts her retractable foils above the surface—and propels herself

[*Continued on page 187*]

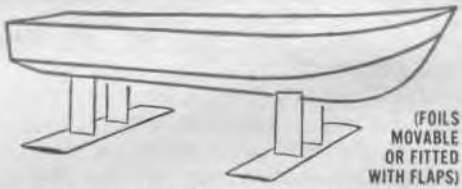
Hydrofoil craft "fly" on foils of these three principal kinds



Surface-piercing: ladder type



Surface-piercing: V or U type



Submerged (with movable elements)

engines, totaling 1,260 hp., drove air propellers of this 8-ton, 54-foot craft designed by William Carl.

MOST ADVANCED despite small size, Navy's gas-turbine-driven XCH-6 has propeller and foils of new "supercavitating" design—a recent breakthrough in research toward higher speed.

Hydrofoils Speed Over Waves

[Continued from page 59]

at eight m.p.h. with jets of water. An auxiliary gas turbine drives pumps that eject twin streams astern, from submerged nozzles. Vanes deflect the jets for steering and backing.

Except for alloy-steel foils and struts, the Denison is an all-aluminum ship. Hydrofoils are nearly as weight-conscious as airplanes, and so it takes airplane-style construction to give the Denison her 10-ton payload capacity.

Acting as pilot and co-pilot, her captain and first officer will sit side by side at steering wheels in the pilot house, with navigator and engineer behind them. An observer and a test engineer will complete her six-man crew for test runs.

Largest of hydrofoils, the Navy's subchaser PC(H)-1 will be a fully operational warship. Manned by an officer and 12 crewmen, it will be armed with torpedo tubes and machine guns, and will have the latest in sonar listening gear. Upon its completion by the Boeing Co. in 1962, it will introduce new tactics in antisubmarine warfare.

Playing a dual hunter-killer role, it will stalk subs by sitting quietly in the water and lowering its listening gear. On detecting an enemy sub it will leap into action. With twin gas turbines roaring, it will rise on its foils and dash in pursuit of the hostile craft, firing homing torpedoes for the kill.

Its 40-to-50-knot speed on foils will enable it to apply this "grasshopper" technique, alternately alighting and flying, and still keep up with an average ship formation. Designed to operate up to 250 miles offshore, it will have a range of 700 miles on foils—or 2,000 miles hullborne, using a diesel engine and extra propeller. It has an aluminum hull and stainless-steel foils of an advanced new "submerged" type.

The $2,000,000 PC(H)-1 is only a start. By 1965 you'll see the first of a fleet of U. S. hydrofoil destroyers, predicts Capt. Bruce G. Kroger, a prominent and successful Navy campaigner for large hydrofoil fighting ships. The Navy has budgeted about $17,000,000 to build a 300-ton experimental hydrofoil, for which it may award a contract this summer. Next it plans a 500-ton warship.

America's exciting new ships stem from

CONTINUED

a little-known Navy hydrofoil program that began in 1947. While hydrofoils were far from new at that time—Alexander Graham Bell had built a notably successful one nearly 30 years earlier—hardly any practical use had been made of them. The principal exception was a German blockade runner that had carried supplies between Sicily and Africa in World War II—an 80-ton, 105-foot, 43-knot diesel craft of 3,600 hp. designed by Baron Hans von Schertel.

At war's end, Russian forces overran the shipyard where von Schertel's craft was built, and got his plans; since then, sizable hydrofoils ply Russian rivers. In Switzerland, von Schertel himself organized the Supramar hydrofoil firm and designed a series of highly successful diesel-powered commercial hydrofoils, of which dozens have been built since 1953; the Flying Fish is one of them.

Meanwhile the U. S. Navy, starting with paper studies, progressed in the Fifties to testing radical new foilborne craft.

Driven by air propellers, the eight-ton XCH-4 raced over the sea at 78 knots, or 90 m.p.h. It set a speed record for hydrofoils that still stands.

Largest U. S.-built hydrofoil to date was the 15-ton landing craft Halobates, whimsically named after a water-walking bug. Two long float-tipped arms projected from its prow like feelers, which is exactly what they were. Sensing the boat's height above the water, they controlled its submerged foils accordingly.

How to do without feelers was shown by another submerged-foil craft, Dr. Vannevar Bush's teardrop-shaped Lantern. The Navy's 1957-built Sea Legs followed his scheme. An electric height-measuring probe, and a "black box" acting like an airplane autopilot, controlled its foils. The sensation was startling—even in rough water, the ride was so smooth as to give no feeling of speed.

These boats' all-underwater foils were new and revolutionary. The simple, fixed surface-piercing foils in common use were ideal for smooth water. But such a craft undulated up and down over waves—making the ride jolting, even dangerous, with high speed or high waves.

Submerged foils ignore waves. Suitably controlled, by varying their angle or operating trailing flaps, they fly a rough-water craft level and true.

That is the Navy's plan for a seagoing hydrofoil. Sea Legs' successful submerged-foil system will be the model for the one built into the PC(H)-1. MarAd's Denison will test a later, rival solution—equipping surface-piercing foils themselves with control flaps.

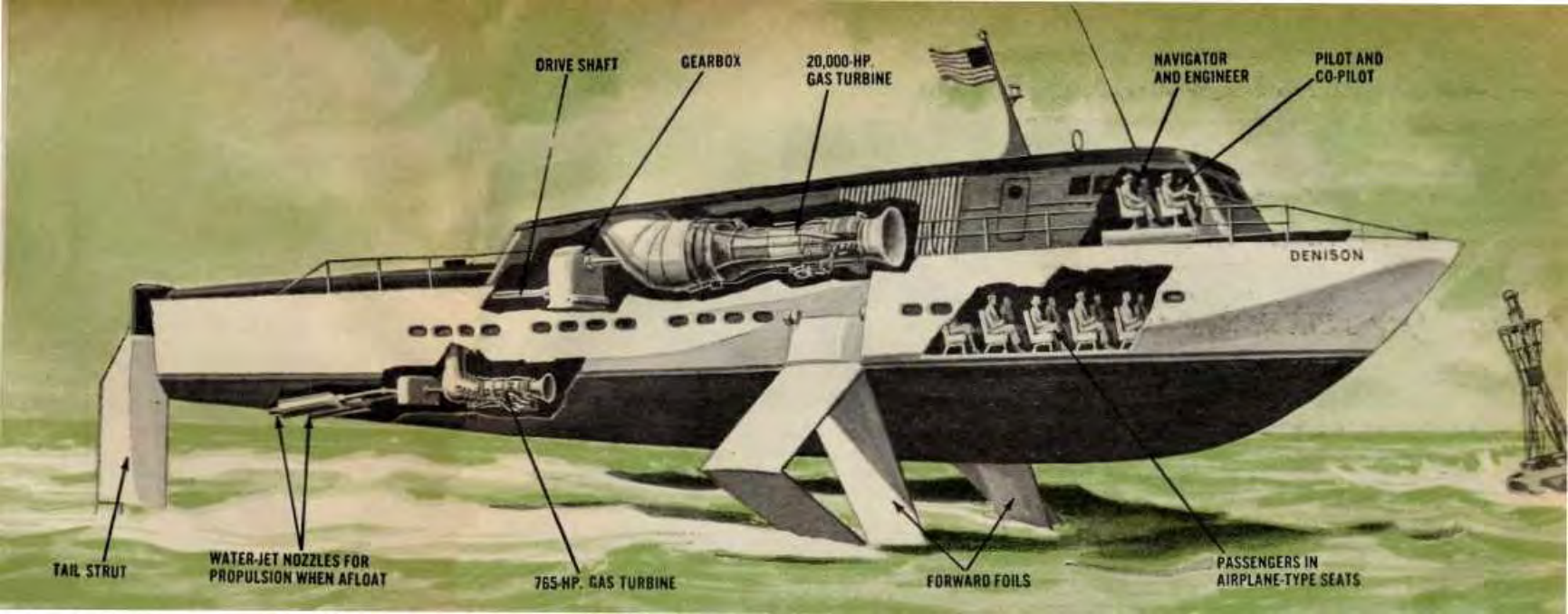
Interested by the Navy's successes, the Maritime Administration—responsible for developing promising new kinds of merchant ships—came into the hydrofoil picture in the mid-Fifties. In close cooperation with the Navy, it launched its own commercial-hydrofoil program. In 1958 its research head, the late Col. Charles R. Denison, sponsored a $75,000 study by Grumman to see if hydrofoil liners were feasible. They were, Grumman found. It recommended building a trial ship. The result was the Denison, named for the man who had started the project, and jointly financed by Government and industry. (MarAd will get her for a bargain $1,500,000; Grumman and other firms are picking up the tab for the rest of her $5,000,000 cost.)

Another breakthrough was introduced in the Navy's most recent experimental hydrofoil—the 23-foot, gas-turbined XCH-6, completed in 1959 by Dynamic Developments. It has propeller and foils of an advanced "supercavitating" profile, just discovered by Navy researchers.

Shaped like an axe with the sharp edge leading, these new propeller blades and foils promise unheard-of speeds. They work best above 65 or 70 knots.

Both the Denison and the PC(H)-1 have the new propellers. The Denison's three-bladed screw will be able to whirl at a fantastic 2,670 r.p.m., its blade tips traveling 400 m.p.h. The high-speed propellers and high-speed gas turbines make ideal mates for propelling a hydrofoil.

With the new foils still in an early stage of development, the Denison and PC(H)-1 will have foils of standard profile, like an airplane wing. But MarAd has commissioned Grumman-Dynamic to develop a set of the new supercavitating foils, which may go on the Denison later. Then she would hit an unprecedented 80 knots. In anticipation, her hull has been designed with the extra strength needed for this record speed. ■ ■


DRIVE SHAFT
GEARBOX
20,000-HP. GAS TURBINE
NAVIGATOR AND ENGINEER
PILOT AND CO-PILOT
DENISON
TAIL STRUT
WATER-JET NOZZLES FOR PROPULSION WHEN AFLOAT
765-HP. GAS TURBINE
FORWARD FOILS
PASSENGERS IN AIRPLANE-TYPE SEATS