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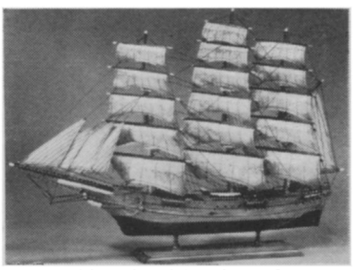

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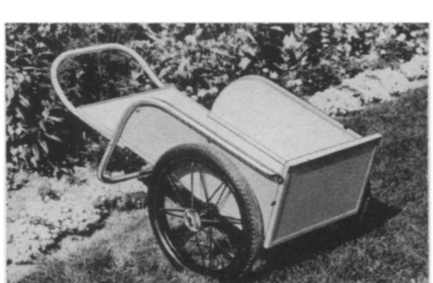

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Navy

Dr. McLean (right) tries out a plastic sphere in a swimming pool.

Down in the Sea in a Bubble

Navy engineers are making steady progress on glass submarines.

by John Ludwigson

Traditionally, deep-diving oceanographers have looked out at their wet, wet world through thick glass peepholes set in the walls of massive steel pressure-proof spheres.

But something better is on the way. The wrap-around, 360-degree panoramic picture window is in the submariners' future. If engineers can find a way to predict their reliability, future research submarines may all be made of glass for visibility and safety.

The idea is to use a bubble or sphere of glass as the pressure hull for the passengers and locate everything else—ballast, motors, batteries—outside in their own containers.

A glass hull, perhaps about 56 inches in diameter and one and a half inches thick, would have the important advantage of being positively buoyant—if things went awry, it would simply bob up from the depths with its human cargo. Steel hulls such as presently in use have all the buoyant characteristics of anchors . . . and they are far more expensive than glass.

A typical glass submarine, as conceived by engineers at the Naval Ordnance Test Station (NOTS), China Lake, Calif., might consist of twin pontoon hulls with the bubble nestled snugly between them—a sort of catamaran arrangement. An early test model of one of these, known as Hikino—Hawaiian for "can do"—has already been built. It lacks only one important ingredient—the 56-inch diameter glass sphere.

It's not that such large spheres haven't been built. The Corning Glass Works has a whole yard full at their Corning, N.Y., plant. The problem lies in making one good enough to take men safely to the bottom of the sea, according to the man who suggested the idea to the Navy. And the central question, notes Henry A. Perry, a research materials engineer at the Naval Ordnance Laboratory, White Oak, Md., is how to make a hatch in the sphere that will not weaken it.

For Hikino his solution is to make two large hemispheres and hinge them in the middle, much like a giant clam shell. Metal rings are to be mounted on the edges of the hemispheres to make the joints and protect the glass.

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Perry prepares a sphere test.

The problem so far has been that the glass splits at the edges, inside the metal rings, in unmanned pressure tests. If the tests are not stopped at that point, Perry explains, the sphere soon implodes—collapses—with great violence.

"Now we're on the frontier of ignorance," he says. "We've come to the conclusion that glass only fails in tension, never in compression . . . so we think we're getting tension in the edges (of the hemispheres) . . ."

Perhaps, he speculates, some minor irregularities in the edges of the hemispheres or a slight rubbing motion of the glass on the metal rings may cause the splitting—a sort of spalling off of chips from the rim. This may be fixed by arranging the metal rings so they compress the glass edges or possibly by tempering the glass.

"It's too soon to say whether we will solve these problems or not," Perry observes. "We're right up to where we don't know either."

He has, for example, on his office shelf a 10-inch hemisphere mounted in a metal ring that has undergone 8,426 pressure cycles simulating dives to 20,000 feet in the ocean. It is in perfect shape, but the several identical hemispheres tested with it have all failed because of edge splitting.

Splitting is not the only problem, Perry points out, but it is the major immediate difficulty preventing delivery of a usable sphere to the NOTS engineers in California. Once it is solved, the key words will be "fracture safety."

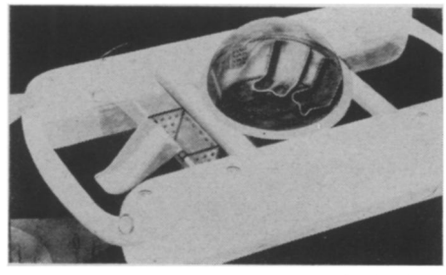
Most metal hulls are tough enough to retain their shape and integrity even if punctured or otherwise damaged. Glass is more likely to shatter or crumble when broken, unless it is somehow held together like the plastic-laminated glass in an automobile windshield.

Deep under the ocean, a glass pressure hull—sphere—would be tightly compressed by the water around it and very difficult indeed to crack, Perry says. Near the surface, however, it would be more vulnerable if, for example, it should bang against the hull of the ship tending it.

Two ways of protecting the sphere seem likely, probably for use together as a double shield. They are chemical or physical tempering of the glass and covering it inside and out with thick, resilient plastic blankets.

Glass failures usually start at a flaw in the face of the glass, but almost never in the interior. To combat this, Perry suggests, ". . . the thing to do is put the surface into compression and leave it there."

That, he explains, would hold the edges of any flaws together with an internal force in the glass that would have to be overcome before it could begin to fail. One such process is already in wide use on plate glass windows and doors.



Corning Glass

A Hikino-style glass sub concept.

That way, says Perry "you get glass that doesn't act like glass." He keeps a couple of examples in his office, which has become a miniature museum of glass technology. His samples of tempered glass are smallish, curved plates that look perfectly ordinary until he proves—by smashing one on the table with his fist—that they can be bent flat and will just snap back like metal springs. Dropped on a concrete floor they bounce.

A combination of tempering and the plastic overlays, Perry predicts, ". . . may offer an approach to a fracture-safe design equal to or better than metals for the same depth."

He is hoping that the same tempering process will offer a solution to the edge splitting problem. If it does, the NOTS people will probably get their glass sphere sometime this year. . . . about a year later than expected.

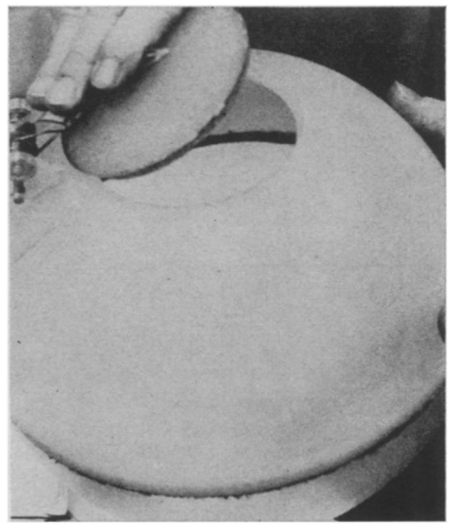
Perry had wanted to build an experimental glass submarine himself. He introduced the idea of building one to the Navy at a conference in Washington in 1962. He was allowed to go ahead on research on the glass, but the idea of building a complete vehicle at NOL was turned down. The lab simply had too much other work to do.

In 1965, Dr. William B. McLean, technical director at NOTS, suggested that his laboratory might take on the task of engineering a boat and it was approved. "So we have a cooperative effort," Perry explains, "where NOTS builds the boat and we give them every bit of design data we can."

The result, initially, will be three boats; the Hikino, a similar craft Dr. McLean is building at his home, and China Lake's Deepview, a cigar-shaped little sub with a 44-inch hemisphere in its nose.

Eventually, however, Perry is hoping to turn his spheres into a variety of useful shapes. They might be joined, according to rough sketches he drew for his own reference, into roughly square undersea stations, three-lobed hulls or, arranged in sections like an armored caterpillar, into a traditional elongated submarine shape.

The key to all of it, he emphasizes, is learning how to join the sections. Once that is licked, oceanographers will be going down into the sea in the safest, cheapest submarines ever made . . . a sort of inside-out aquarium arrangement in which they, not the fishes, will be under glass.



Glued sphere with hatch is next.