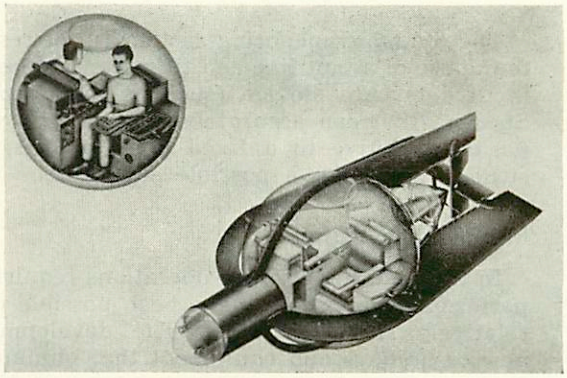
A TWO-MAN PLEXIGLASS SUBMARINE FOR OCEANIC RESEARCH



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THE NUMBER of undersea research programs has grown rapidly in recent years. Many of these programs have culminated in an urgent need for a variety of manned "inner space" vehicles. The desirable features of these vehicles vary greatly, depending upon their purpose. With this in mind, a set of specifications was developed for a small, but adaptable, research submarine called a "Utility Submarine." This set of specifications was certainly not the "best" or the "only" one; it merely reflected ideas of the authors based on inputs from a limited number of research workers. Using these specifications, a two-man plexiglass submarine was conceived and a preliminary design completed.

Presently, the durability and strength of plastic materials and model spheres are being tested. Construction of the sub will depend upon whether the outcome of this and other related studies are found compatible with current needs.

Description. The dry weight of the vehicle shown in the illustration is 6800 lb and the cost of the first prototype is estimated at less than $100,000. The vehicle consists of a manned pressure-resistant sphere and an external flooded structure designed to pivot in pitch about a horizontal axis of the sphere. The external structure resembles a balancing board with a free-flooding conning tower on one end and a motor, tailcone, propeller, and control vanes on the other. Aluminum fins structurally tie the external components together and also serve as the hydrodynamic flight surfaces.

The craft, as currently envisioned, will have two interchangeable 60-inch (inside-diameter) spheres: a clear Plexiglass sphere with a wall thickness of 4 inches for operation down to about 2,000 feet; and a thinner steel sphere for operation down to 10,000 feet. The steel sphere will have portholes for viewing.

The sphere is designed to house two men, their air-breathing equipment, nickel-cadmium batteries, and control and monitoring equipment required for submarine operation. The center of gravity of the loaded sphere is well below its center of buoyancy; since the sphere is free to rotate about an axis through the center of buoyancy, the sphere will always remain upright.

The horizontal pivot shafts on each side of the sphere will be rigidly attached to the sphere and all the cables, electrical and otherwise, will pass through these shafts. No rotating seals are required since the main bearings are outside the pivot shafts and are flooded.

The air-breathing equipment consists of water vapor and carbon dioxide scrubbers, a charcoal filter, and an oxygen supply. Sufficient breathing equipment for two men is available for a maximum submerged time of 52 hours.

Performance. The vehicle is equipped with an 11-HP motor which is submerged in a non-conductive oil; the top speed is estimated at 10 knots. The range is 28 miles when traveling at 5 knots for 5 hours. For a 20-hour mission, the range is 77 miles at 3 knots. This performance pertains when no lights are used and all the battery energy goes into propulsion. The vehicle is equipped with six 500-watt lights; the battery energy will operate all lights alone on a continuous basis for 2.3 hours.

Operation. The vehicle is designed to travel in the direction of the conning tower, and can travel at top speed at any pitch angle. The pitch of the outside structure is changed by deflecting the horizontal control vane. An auxiliary hand-operated winch rotates the outer structure in special situations. The amount of tilt of the men and their equipment will not be appreciable in the roll plane because the center of gravity is well below the center of buoyancy, providing a large moment to resist any tendency to roll.

The vehicle will be positively buoyant in the majority of operations. To hover at constant depth, the external structure will be pointed downward and the propeller speed adjusted until the downward thrust of the propeller counteracts the upward (positive) buoyancy force of the vehicle. The water flowing past the control vanes will provide continuous control during the hovering operation. During manipulation work near the bottom, the propeller will continuously pull water from along the ocean floor and pass it directly upward, thus clearing the area for better observation.

To make the submarine hover without power, neutral buoyancy is achieved by storing sea water in a special reservoir inside the sphere. Positive buoyancy can be resumed by either pumping out the reservoir or by dropping magnetically held weights. Additional droppable weights are included to insure recovery of positive buoyancy in an emergency.

When the craft is surfacing, the conning tower will be pointed upward. The vehicle is designed to float so that the sphere has 6 inches of freeboard, sufficient to drain the water from the free flooding conning tower. A water-filled hose then expands to seal the conning tower to the sphere and also to lock it and the outer structure to the sphere. The conning tower provides 4½ feet of freeboard and serves as a dry platform to permit entry and exit in high sea states.

The vehicle, although bulky looking has a relatively low drag. The conning tower and the tail cone serve to streamline the sphere, and the propeller prevents water separation by pulling water around the sphere and down the tail cone.

The vehicle design allows up to 170 lbs of oceanographic equipment to be carried in the conning tower. Special manipulators can be attached to the conning tower and operated in conjunction with the submarine for manipulation work at intermediate depths or at the bottom. To aid in manipulation, the submarine propellers will develop about 800 lbs of static thrust.

Uses. The Utility Submarine offers maneuverability, good speed, and excellent vision in the case of the Plexiglass sphere. The research capabilities of this unique vehicle include: bottom oceanography, photography, installation and removal of buoys, sea animal studies, plankton investigations, sonar studies, salinity and sound velocity measurements, and magnetic surveys.

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