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CONSTRUCTION PROGRESSES ON PX-15 SUBMERSIBLE

NEWS ORGAN TO DESCRIBE GRUMMAN OCEAN ACTIVITIES

Early in October, 1966, the decision to build a new submersible vehicle was taken by the president and Executive Committee of Grumman Aircraft Engineering Corporation. The vehicle, known only as the PX-15, was to be based on the design of Dr. Jacques Piccard of Switzerland, who earlier in that same year became an exclusive consultant to Grumman.

Today the construction of the PX-15 is well advanced. The hull plates have been rolled and the steel hemispheres that form the ends of the pressure cylinder have been forged. Detailed engineering and design are also proceeding apace, and the original goal of completion of construction by year's end will be met.

To inform and keep apprised those in the ever-increasing oceanographic community of the PX-15 development and other activities of Grumman, we are introducing this newsletter. Its intent is not a detailed compendium of this unique and pioneering project. Its aim is to present a running commentary on the problems and solutions, the innovations and engineering approaches, the progress and the evolution of the arts and sciences which go into a project of such scope.



A technician at Stevens Institute of Technology in Hoboken, N.J., checks the hydrodynamic characteristics of a scale model of the Grumman-Piccard PX-15, prior to the start of actual construction.

GRUMMAN, DR. PICCARD TEAM TO BUILD NEW UNDERSEA VEHICLE

The Grumman-Piccard PX-15 is being built in the unlikely Alpine village of Monthey, Switzerland, some 250 miles from the nearest open water. At the foundry of Giovanola, S.A., the steel submersible is taking shape.

The choice of Switzerland and Giovanola to help build the first Grumman submersible was dictated by a number of circumstances. First, because the PX-15 is the basic design of Dr. Jacques Piccard, who makes his office and laboratory in Lausanne, it assured his continued presence and supervisory control during the construction period. Giovanola, long a major fabricator of conduits for high pressure hydroelectric systems, has had extensive experience in the welding techniques associated with high strength steel. And also, it was at Giovanola that Dr. Piccard built the "Auguste Piccard", the 98-foot tourist submarine operated at the 1964 Swiss National Fair. That 40-passenger vehicle has since carried more than 30,000 tourists on over 1100 dives in Lake Geneva. Because of the experience gained with the "Auguste



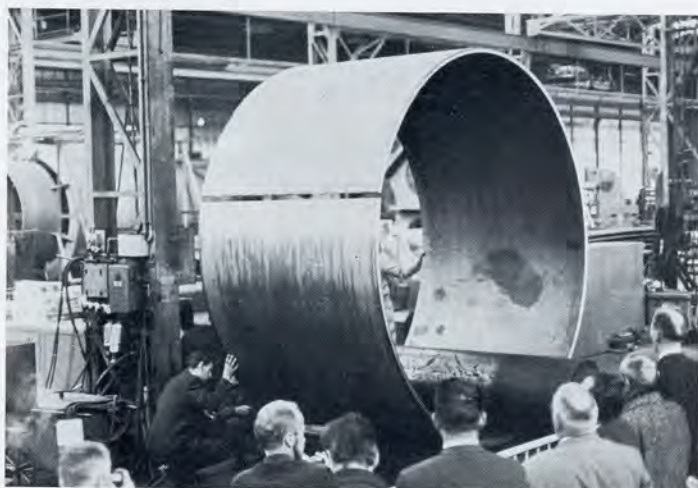
Artist's concept of the PX-15 shows how the new submersible can be used as a stable platform for marine biological, acoustic and other observations at depths to 2,000 feet beneath the surface.

Piccard", the opportunity to utilize many of the dies, tools and facilities (e.g. the huge heat treating ovens built especially for the submersibles) prepared for the earlier submarine, it was decided to construct the PX-15 in Monthey also. After final assembly, the vehicle will be

carried overland to a European Atlantic Coast port for shipment to the new Grumman marine facilities at West Palm Beach.

The general structural arrangement of the hull consists of a ring-stiffened cylinder with hemispherical end closures. The hull is fabricated of 1-3/8-inch thick steel plate having a yield strength of 80,000 psi. Structural rings spaced uniformly along and inside the hull provide sufficient support to the shell to permit safe operational depth to 2000 feet while maintaining a margin of safety of 2 on hull collapse. This combination of hull plating and reinforcement also provides a hull bulk modulus in excess of 400,000 psi.

In order to permit relatively easy modification of the hull for future missions, the initial design makes use of a hull mechanical joint located near the center of the hull and employs integral hull flanges which are bolted together. Low pressure sealing is provided by a conventional "O" ring seal while high pressure sealing is provided by metal-to-metal contact of the machines' mating surfaces. This separation joint will permit future hull modifications for more advanced vehicle uses which will be discussed subsequently.



A steel plate, which previously had stretched some 30 feet, begins to take shape as a cylindrical portion of the PX-15 pressure hull at Monthey, Switzerland. Seven sections of the 38mm-thick steel and twin hemispheres go to make up the basic pressure hull.

Two "soft" main ballast tanks are mechanically attached to the hull, one on each side, and provide additional buoyancy to the vehicle when it is surfaced. This additional buoyancy provides adequate freeboard to permit ingress-egress through either of the vehicle's two hatches. These main ballast tank assemblies are normally completely flooded during submerged operations. Diving from the surface is accomplished by permitting water to enter these tanks from the bottom, while air is vented



One of the steel stiffening rings used to reinforce the PX-15 pressure hull gets a critical look from David Bannerman, center, of the American Bureau of Shipping, at the Monthey construction site. The PX-15 is the first submersible to be certified by ABS.

PX-15 SPECIFICATIONS

Weight	130 tons
Length	48'
Beam	13'-4" without motors; 18'-6" with motors
Height	20'
Max. Operational Depth	2000 ft.
Collapse Depth	4000 ft.
Battery Capacity	750 kwh (1000 hr. rate)
Propulsion	Four 25-HP, three-phase, variable-frequency electric motors
Power Conversion	Two variable-frequency solid-state inverters powering the main propulsion motors Two fixed-frequency, solid-state inverters powering the propulsor pod rotational motors One fixed-frequency, solid-state inverter powering various on-board equipment
Visibility	29 viewports (placed to permit all around visibility)
Payload	5 tons minimum
Life Support	6 Men for 4 weeks plus 2 weeks emergency reserve
Emergency Droppable Ballast	5 tons
Max. Submerged Speed	Approximately 5 knots

off at the top. After surfacing, stored compressed air, carried in high-pressure tanks located in faired compartments above the main ballast tanks, is valved into the main ballast tanks at the top, blowing out the entrained water at the bottom.

Variable buoyancy control is provided by two pressure-resistant ("hard") tanks located beneath the hull in the lower keel section. The vehicle is neutrally buoyant near the surface when these tanks are half full of water. Allowing water to enter, or blowing water out by compressed air, provides vertical maneuvering capability for the vehicle within its operational depth limit.

Electrical power is supplied by lead-acid batteries housed in the free-flooded keel section. These batteries are pressure-compensated to sea ambient, and consist of up to 378 individual cells connected in series-parallel. They provide 168 VDC to two fixed frequency inverters which power the propulsor positioning motors and 336 VDC to two variable frequency inverters which power the main propulsion motors. In addition, the battery provides 112 VDC for exterior lighting and 28 VDC for on-board equipment. It is interesting to note that the weight of batteries carried is roughly 25% of the vehicle gross weight.

Propulsion for the PX-15 is provided by four 25-hp, AC electric motors powered from two variable-frequency, solid-state inverters. This configuration provides speed control of the vehicle and sufficient power to propel the submerged PX-15 to speeds in excess of 4 knots. In addition, the propulsion motors can be fully reversed and rotated in the vertical plane thus providing up, down and reverse thrust capability. By applying forward thrust with the motors on one side of the vehicle and reverse thrust with the motors on the other side of the vehicle, the PX-15 can make stillwater turns within its own length.

PICK PALM BEACH PORT AS HOME BASE FOR PX-15 OPERATIONS

West Palm Beach has been selected as the test port for the PX-15 and its operational base following its delivery to the United States early next year.

Under the terms of agreement with the Port of Palm Beach, Grumman will occupy a new building of approximately 9,600 square feet in Riviera Beach, with an adjoining slip measuring 50 feet by 150 feet. Dockside storage space totaling some 9,450 square feet is also provided for in the agreement.

The Florida site will serve dual purposes, since it will also be the test port for the Grumman hydrofoil gunboat "Flagstaff", being built in Stuart, Fla. Present plans call for the Flagstaff to be launched on or about November 15, and to be berthed at the Port of Palm Beach during the rigorous sea trials that must be completed prior to formal acceptance by the U.S. Navy.

SIX-WEEK SUBMERGED MISSION IN GULF STREAM PROPOSED FOR PX-15 IN SUMMER OF 1968

One anticipated use of the PX-15 would be to perform a submerged drift in the Gulf Stream from West Palm Beach, Florida, to a point off Halifax, Nova Scotia, a distance of approximately 1450 n mi. This mission was conceived by Dr. Piccard to permit a team of scientists to remain in the depths of the Gulf Stream continuously for several weeks and achieve a comprehensive survey of day-to-day phenomenon. In addition to the scientific value of such a venture, it would derive a considerable amount of useful experience in the operational problems associated with a large submersible. The lessons learned during this mission could assist Grumman in determining what design changes, if any, will be required for later missions.

Preliminary studies have indicated that the most suitable depth to be explored during the first drift is about 200 meters. However, from this depth it is expected that periodic excursions could be made up to 100 meters and down to 400 meters. At 200 meters depth, the temperature in the middle of the stream is between 15° and 17°C. As the temperature of the stream increases toward the east, the drift can be controlled by monitoring the temperature changes and periodically propelling the submersible back to the desired isotherm. The anticipated mission duration is between four and six weeks.

Since the PX-15 would remain continuously submerged throughout the mission, it would not be able to determine its position accurately in latitude and longi-



Brief formal ceremonies marked the announcement of West Palm Beach as the home port for the PX-15. Here, left to right, are Grumman representatives W.M. "Bill" Rand, operations manager, and Walter H. Scott, director of Grumman Ocean Systems, together with Port Commissioner C.M. Langham and Dr. Piccard.

tude. It is essential that all data recorded during the drift be correlational with respect to depth, latitude, longitude and time. For this reason, a surface support vessel must be used to track the course of the submersible throughout its drift. The support vessel would be equipped with suitable communications and navigational equipment to permit position fixing with respect to shore installations while establishing the position of the submersible with the aid of sonic detection gear.



The approximate course of the Gulf Stream Drift Mission parallels the west wall of the northward-bound stream. The PX-15 can hover in mid-water at depths ranging from 300 feet to 2000 feet.

MOTORS, INVERTERS PROVE OUT IN TESTS AT HAMBURG MANUFACTURING FACILITY

Crucial tests mating the AC electrical motors with the solid-state static inverters for the PX-15 were successfully completed in July in a special tank at the Hamburg facilities of Pleuger Unterwasserpumpen GmbH.

The tests, lasting several weeks, were aimed at evaluating the motors, the inverters and the mechanism which rotates the motors to drive the submarine downward or toward the surface.

The free-flooding motors are designed for operation at depths in excess of 2000 feet, and are streamlined, including stabilizing vanes and Kort-type nozzles to maximize thrust efficiency and to protect the propellers. They operate on 220 volt current, and deliver approximately 720 rpm at full load speed. The motors feature a four-bladed propeller (truncated scimitar-type) and positioning systems to permit rotation of more than 350 degrees about a horizontal axis perpendicular to the



Two of the 25-horsepower AC motors that will be used to propel the PX-15 undergo extensive tests in Hamburg, prior to their shipment to Monthey. Four electrical motors will provide propulsion.

thrust axis. Each motor can be mounted either on the starboard or port side of the pressure hull.

SUGGESTIONS FOR EXPERIMENTS SOUGHT

Ocean scientists in the United States and throughout the world are being invited to suggest experiments for the Gulf Stream Drift Mission.

Research projects involving acoustic signalling, the Deep Scattering Layer, light stimulation, physical and chemical measurement; magnetic gradient studies; internal wave determinations and collection and classification of micro-organisms are some of the possible areas of inquiry laid open by the PX-15's unique underwater capabilities and the duration and extent of the Gulf Stream Drift.

For the experiments there will be 112 VAC, 112 VDC and 28 VDC power available. There are 29 viewing ports planned for the vehicle, with outside lighting provided by 70 incandescent lights. A special hatch for releasing samples and other small objects to the surface, as well as a device for "capturing" small marine life under ambient pressure for microscopic examination, are being designed into the 50-foot, 130-ton vehicle.

