GULF STREAM
DRIFT MISSION

Press Book

CONTENTS

INDEX OF ILLUSTRATIONS*

*Half-tones are included in the Press Book for reference only. Glossy, black-and-white prints are available for all illustrative material included here and most other personnel, equipment or operating situations related to the vehicle and mission.

Color photographs, transparencies and film footage is also available, with specific requests for these and/or black-and-white photos directed to

Until 30 May	Jerry Kallman Kallman Associates 30 Journal Square, Jersey City, N.J. 201-653-3304
After 30 May	Grumman News Headquarters 747 National Press Building Washington, D. C. 202-393-2666

NOTE: Washington Mission News Headquarters will also be equipped with TELEX service to facilitate fast turn-around on individual requests for specific information, etc.

Hydrodynamic Testing

BEN FRANKLIN CHRONOLOGY

October 6, 1966	Contract is signed by Grumman and Dr. Piccard to build the PX-15.
March 16, 1967	Construction begins in Monthey, Switzerland, with rolling of first plates.
March 4, 1968	European construction phase ends.
May 3, 1968	PX-15 arrives in West Palm Beach.
July 26, 1968	PX-15 is launched.
August 21, 1968	PX-15 is christened the Ben Franklin.
November 22, 1968	Ben Franklin completes its first dive.
February 19, 1969	Ben Franklin dives to its operational depth limit of 2,000 feet.

BEN FRANKLIN CHARACTERISTICS

Gross Weight	147.35 tons
Net Weight	142.95 tons
Internal Volume	3769.7 cu. ft.
Length	48 ft.
O. D. of Pressure Hull	10.33 ft.
Beam (over ballast tanks)	13 ft. 4 in.
Beam (including motors)	18 ft. 6 in.
Beam (including motor guards)	20 ft.
Height	21 ft. (to top of sail)
Draft	14 ft.
Access	Two 30" hatches
Maximum Operational Depth	2000 ft.
Collapse Depth	4000 ft. +
Battery Power	750 KWH (10 hr. rate)
Propulsion	Four 25 h.p., 3 phase, variable frequency motors
Power Conversion	Two variable frequency (60 KVA) solid state inverters for propulsion Two fixed frequency (3 KVA) solid state inverters for rotating propulsion motors 360° Two 110 VAC solid state inverters for various on-board equipment
Visibility	29 viewports

Potable Water	188 gallons hot water 380 gallons cold water
Total Life Support	6 men for 4 weeks with a 2 week reserve
Emergency Ballast	6 tons of steel shot
Maximum Ascent Rate (Calculated)	One-shot ballast tank - 180 ft/min Two-shot ballast tanks - 257 ft/min With motors - 2 meters/sec
Normal Descent Rate	1.4 ft/sec (calculated)
Maximum Submerged Speed	4 knots
On Surface Time from Full Ahead to Stopped Using All Back Full	20 seconds
Endurance (calculated 8 hrs at hull speed	2 KTS 2 motors - 0.126 naut. mi/KWH 3 KTS 2 motors - 0.074 naut. mi/KWH
Thrust	1000 lbs per motor (nominal max)
Trim and List Angles (calculated)	Normal Trim $\pm 10^\circ$ - Emergency Trim $\pm 25^\circ$ Normal List 0° - Emergency max List $\pm 17.6^\circ$
Submerged BG	10.3 inches

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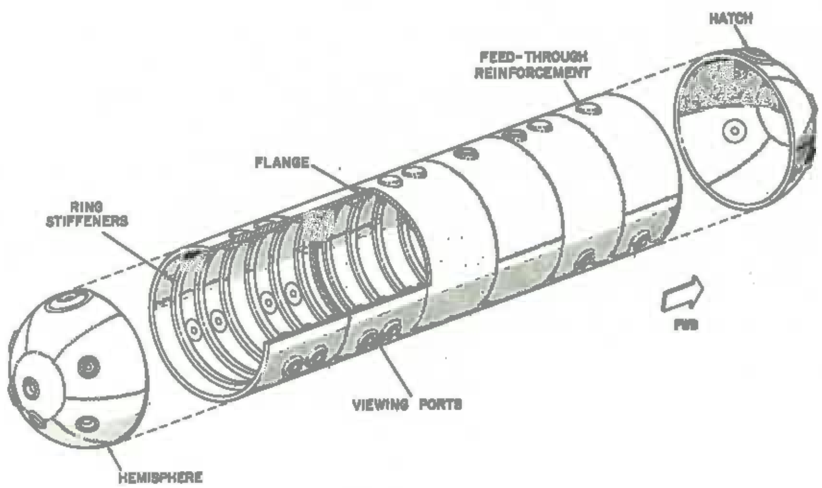


GRUMMAN / PICCARD PX-15
PRESSURE HULL

PRESSURE HULL

The pressure hull, 48 feet long by 10.33 feet in diameter, is cylindrical in shape with both ends capped by hemispheres. The empty hull has an inside capacity of 3769.7 cu. ft. The end hemispheres are made up of seven pieces, Welmonil steel plates, hot formed, sized and welded to a single shallow dished end cap. The Welmonil steel was manufactured by HOAG, Oberhausen, Germany. The complete cylindrical section is made in two sections, joined 29 feet from the extremity of the forward hemisphere at mating machined flanges. These cylindrical portions are made from Aldur steel, manufactured by Voest of Linz, Austria. The cylindrical sections use six sub-assemblies welded together. Four sub-assemblies comprise the forward section and two make up the cylinder aft of the joint. Both Aldur (77,800 psi yield) and Welmonil (71,500 psi yield) steels exhibit excellent mechanical qualities characterized by high resistance to cleavage fracture, high notch toughness, excellent weldability and high yield point. For welding, the hull sections were preheated to 150-degrees C. and maintained at that temperature until the weld on that section was completed. Welding of the hemispheres was all manual, while the cylinders were welded using automatic techniques.

The pressure hull itself is 1-3/8 inches thick, reinforced by hollow structural rings equally spaced at 27-1/2-inch intervals (center to center) along the inside of the cylinder. These structural rings are rectangular in cross section and have a web thickness of .790 inches with a cap of 1.25 inches. During assembly, the rings for each section were spaced exactly as required on a special tool. The rolled welded cylinder was heated and slipped over the rings. While temperature at each ring/cylinder joint was maintained and carefully monitored, the rings were welded in place. At the completion of fabrication at the Giovanola plant in Monthey, Switzerland, the entire hull was stress relieved in an oven.

ACCESS HATCHES, WINDOWS AND HULL PENETRATIONS

Access Hatches-

The hatch openings, one forward and one aft, are virtually 30-inch discs cut out of a reinforced section welded to the hull. The hatches are seated in a conical opening in order to seal when under pressure. Identical access hatches are located in the bow and stern hemispheres. Each hatch opens outward and is centered over the fore-and-aft line of the hull with five springs for counterbalancing. In the center, a conical plexiglass window (or viewport) is held in position by a retaining ring, bolted into the cast steel hatch. On the centerline, a steel eye-ring is welded to the hatch to provide a grip for opening from the outside.

The hatches are designed to close by their own weight and to be held firmly closed by external pressures. They can be opened in surface condition by normal manual pressure on the underside, counter-balanced by the five adjustable tension springs. For locking the hatch shut, two dogs are used. A simple lever-gear arrangement moves the dogs into place. When in the raised position, the forward hatch is held open by a latch connected to the sail by a stainless steel cable. The hatch can be held shut by a strongback, stowed in the sail.

Both hatches are fitted with a device to enable them to be opened from the outside. The device consists of an outer ring bolted to the hatch around the viewport. This outer ring overlaps an inner split ring that actually holds the viewport in place. The inner ring is slotted and the outer ring has ears extending upward to act as fulcrum points for a pry-bar. The pry-bar is slipped into one of the slots to remove the inner ring. Removal of the viewport is then completed by lifting it with a suction cup. The hatch mechanism can then be actuated by reaching it through the viewport. All emergency tools are stowed in the sail.

Windows-

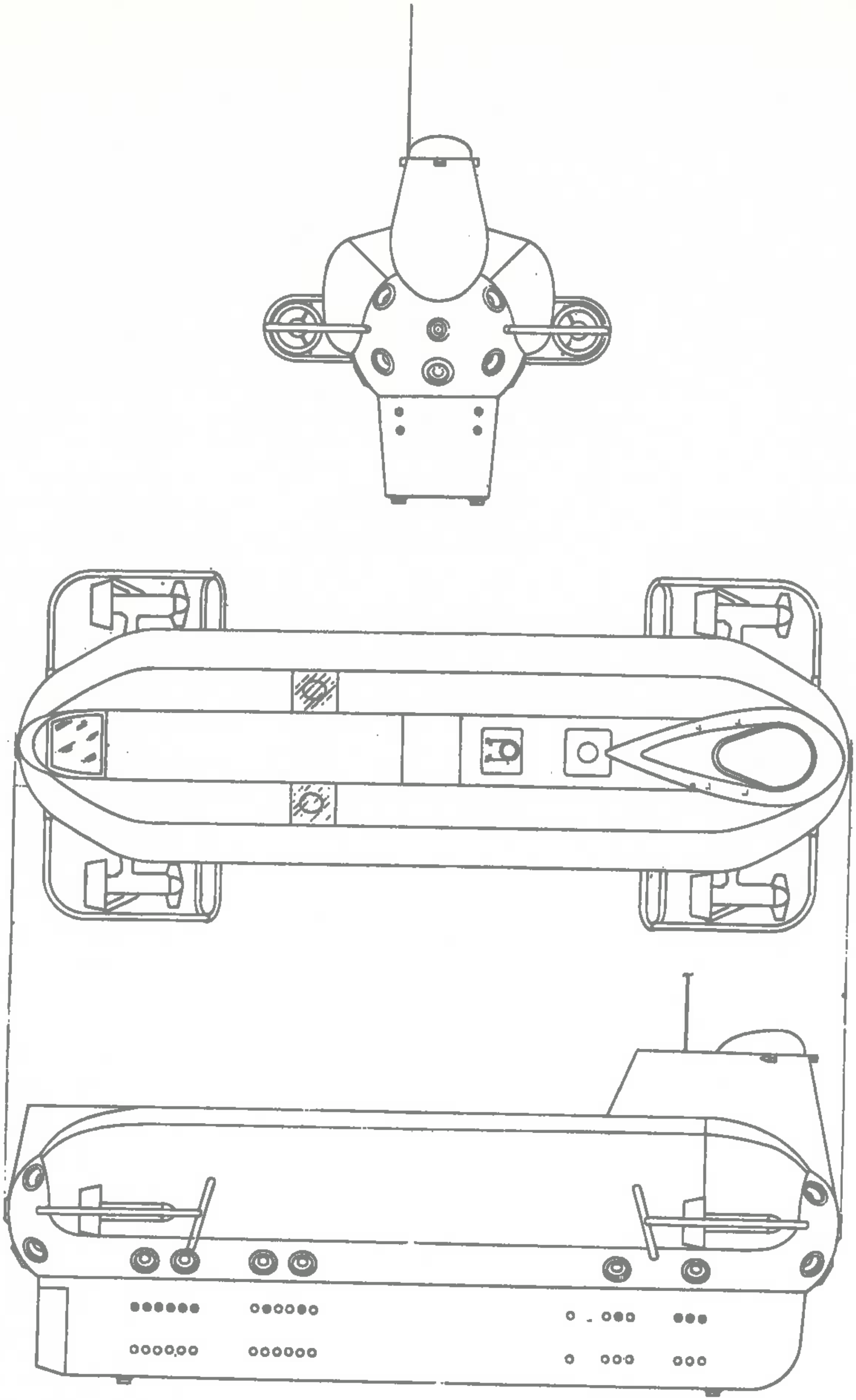
Plexiglass windows, manufactured by Isoplex, AG, Zurich, are used in 30 locations throughout the vessel. All are similar in construction except that the one in the SAS or sphere-release-hatch is smaller. The ports are conical in shape and fitted into machined surfaces cut in reinforced hull sections. The viewports, 3.5 inches thick, provide a 90-degree field of vision and are held in place by a steel retaining ring flush with the outer surface of the hull. To prevent corrosion of the machined hull surface seating the viewport, the surface was painted with Phos-Pho-Neal (a phosphoric acid coating) and Laminar X500 Green Primer (a zinc chromate). The surface was then covered with Lubriplate grease. To prevent moisture from reaching the machined surface from inside the boat a rubbery material---Pro-Seal 890---was applied where the hull contacts the plexiglass.

Hull Penetrations-

The hull penetrator castings for viewports and access hatches through which the hull penetrations for all pipes and cables pass were manufactured by Georges Fisher SA, Schaffhouse, Switzerland. The plan view of a typical reinforcement is lemon-shaped with a raised circular center about 5-1/2 inches (140 mm) thick. Castings for pipes and cables are bored with either 17 or 19 holes to allow various combinations of electrical, pneumatic and hydraulic system hull penetrators. Three sizes of hull penetrations have been drilled into the castings: 20mm, 24mm and 38mm diameters. All penetrators make use of two seals: a flat neoprene rubber gasket for low pressure seal and a conical plexiglass insert for high pressure.

There are two sizes of pipe penetrators: 26mm for approximately 3/8-inch pipe and 38mm for 3/4-inch pipe. Carbon steel is used for penetrators carrying sea water. Several penetrations in the casting are not in use and are filled with a steel plug. For battery cables, main water cables, battery charging and short power, a specially-designed penetrator is used. It is basically a 13mm diameter copper rod 215mm long with a bronze machined collar on the outboard end. The rod is inserted in a plexiglass sleeve and the rod and plexiglass are placed inside a steel penetrator insert.

For all circuits other than propulsion, battery cables, TV coaxial and strain gauges, a specially designed penetrator is used. This unit is basically a steel shell (or insert) that is designed to carry 19-1mm^2 wires arranged in two concentric circles. Inserted into the outer shell of the penetrator is a neoprene plug with holes to hold one half of standard Marsh and Marine connectors. The 1mm^2 wires are soldered to the connectors, knotted to prevent their flow into the hull and are fed through the penetrator which is then filled with epoxy.



General Arrangement -
Ben Franklin

HULL SUPERSTRUCTURE AND FITTINGS

To satisfy requirements for surface operations, maintenance and exterior equipment, a superstructure and special fittings have been installed. These components consist of: the Sail, Hull Pedestals, a Deck and Supports, Motor Guards, Lifting Points and Sling, and Battery Housing (keel).

A fiberglass sail (designed for 1000 psi) is mounted well forward on the hull. The sail has been designed to minimize exposure of crew members during surface operations. It is high enough to give full protection and good visibility through the use of a molded plexiglass dome mounted to the lip in the sail structure. It also protects the boat from flooding when the forward hatch is opened on the surface. Just aft of the bubble is a hatch that is normally shut during at sea operations. The sail also houses various subsystem components including the Magnetic Master Compass Transmitter, Temperature sensor, Obstacle avoidance sonar, Depth Sensor Oil reservoir (external pressure sensing), H. F. Radio Antenna, T. V. Periscope and Lighting mast (strobe, submarine identification, anchor, masthead lights - surface operations only).

When the boat dives or surfaces the sail is completely flooded or drained through a series of valves and one-way scuppers. Just prior to diving, two 3" dia. PVC ball valve flood ports are opened. This allows water to flood the sail from under the deck. A plexiglass vent in the sail bubble allows air to escape. Upon surfacing of the boat, drainage is accomplished through the use of two one-way scuppers located at the lowest area of the sail. These scuppers are simple hinged plates that shut with external water pressure.

Fabrication of the sail was done by Andre Perreten, Lausanne, Switzerland. It was molded in two halves of glass reinforced epoxy. Thickness of the skin varies from approximately 7/8 inch at the lower edge tapering upward to approximately 3/8 inch at the top. The structure was strengthened by the addition of a large number of fiberglass stiffeners. These stiffeners were bonded to the outer skin and the entire structure was further improved by the hand layup of several layers of glass cloth over the skin and onto the stiffeners.

Mounting of the sail to the hull is accomplished by bolting through the fiberglass structure into a series of mounting brackets that were welded to the hull prior to heat treatment. Sealing of the sail to the hull is accomplished by the use of a gasket like material called Coast Pro-Seal 890. This material was packed by hand along the area where the sail is bolted to the hull and also along the fiberglass protection around the after hatch.

Hull Pedestals - Fitted to the underside of the fore and aft hemisphere are four pedestals located in pairs filled with lead shot. These form an under-carriage so that BEN FRANKLIN can be supported while in dry dock without the use of special fixtures. The pedestals extend just below the forward fairing and battery housing. If a severe collision occurs, the pedestals were designed to fail at the point where they are bolted to the hull, thereby preventing rupture of the pressure hull. The entire assembly can be removed.

Deck and Supports - Running fore and aft along the top of the hull is a walking deck. The deck affords a working area along the length of the boat and also provides protection for piping, wiring and equipment located below it. A life line of stainless steel cable runs from the aft port of the sail to a steel tripod located just forward of the aft hatch.

The deck structure itself (designed for 1000 psi) was fabricated of welded carbon steel structural sections. The assembly was mounted by bolts onto upright brackets welded to the pressure hull. The deck structure contains several zinc plates for anodic protection.

The entire steel structure is covered by fiberglass panels bolted to the framework. A series of panels running fore-and-aft on both sides serve as fairings. These panels mount to steel angle plates welded to the deck structure itself and slant down to another angle mounted to the tops of the main ballast tanks.

Motor Guards - Allowing freedom of rotation but still offering protection against buffeting, a simple tubular welded frame protects the submerged motor casing from damage and from entanglement with underwater cables. The guards are constructed from seamless steel tubing that is bolted into sockets welded to the hull.

Lifting Points and Sling - For lifting during drydocking, shipment or any transportation, four heavy duty fittings are welded to the outside of the cylindrical section of hull over frames (3) and (14). These fittings are made from ALDUR 55-68 steel with an ultimate strength of 4-1/2 times the gross weight of the vehicle.

Battery Housing - (Keel) - The 376 batteries are housed in a keel structure that is attached to the bottom of the hull. Each battery is contained in its own compartment.

BALLAST AND TRIM TANKS

The ballast system aboard the BEN FRANKLIN can be divided into four main subsystems: Main ballast (162 cubic feet per tank) - 4 tanks; Variable ballast (12.3 cubic feet, 788 pounds salt water per tank) - 2 tanks; Shot ballast (3 tons of shot per tank) - 2 tanks; and Trim (49.5 cubic feet, 3,087 pounds of fresh water per tank) - 2 tanks. Other changes in ballast can be accomplished through the use of lead or syntactic foam.

Main Ballast Tanks - Adequate freeboard for surface maneuvering and the ingress and egress of personnel is provided by four main ballast tanks. These tanks, when dry, provide sufficient buoyant force to give the boat approximately 18 inches of surface freeboard under normal operating conditions (approximately 41,500 pounds of positive buoyancy). In order to dive the boat these tanks are flooded by venting the entrapped air from the tanks and allowing water to flow into them through open flood ports located at the bottom of each tank (six ports per tank, 4-1/2" in diameter). When the main ballast tanks are fully flooded, the boat should be in a state of approximate natural buoyancy at or very near the surface. At this point the addition of any more ballast will cause the boat to dive. The main ballast tanks are located in pairs on the port and starboard sides of the boat, tanks one and three to starboard and tanks two and four to port. They are constructed of laminated polyester and fiberglass approximately 1/4 to 3/8 inches thick. Additional strength is provided each tank by eleven fiberglass ribs spaced along the length of the tank and filled with syntactic foam. The fabrication of the tanks was done by Lunn Laminates, Inc., Wyandanch, New York.

Although the quantity of high pressure air carried aboard the boat is not enough to blow the tanks dry at 2000 feet, it is enough to blow to 50% of the tank capacity (for an emergency ascent only). As the vehicle ascends, the air in the tanks expands and forces additional water out the open flood ports. As mentioned before, each tank is free flooding, when vented, through six 4-1/2 inch diameter openings in its bottom. Flooding of a tank or tanks can be stopped by closing the solenoid operated vent valve located at the top of each one.

To flood the main ballast tanks, electrically operated vent valves located on the rear top of each main ballast tank are used. The operation of the valves is controlled from inside the boat using a switching mechanism to electrically operate a solenoid located in the valve. The valves are normally closed and must be energized to open, thereby providing fail safe operation. Hand installed plugs are placed over each vent when rigging for surface. Accidental flooding is prevented by an interlock system and a key operated switch.

To flood the MB tanks, a switch on the pilot's console activates the valve solenoid. The solenoid overcomes the pressure exerted by the spring holding the valve closed and the inside piston moves up off its seat allowing a free flow of air from the tank top. The tank rapidly floods through the open ports located in the tank bottom. When a tank is full, an indicator light goes on and the pilot releases the activate switch.

With the solenoid deenergized, a spring with 50 pounds of force, moves the piston back on its seat, closing the tank. With the valve shut, the MB tank is ready for blowing. Note - the valves will shut at any point during tank venting by the release of the switch on the pilot's console so that flooding can be stopped and the tanks blown dry.

Automatic blowing of the tanks is also accomplished by a safety device included in the penumatic system which actuates if the boat accidentally descends below 2200 feet.

Two electrically operated sensors monitor the water in each tank. The sensors are mounted in the center of each tank, one at the bottom and one at the top. They indicate when a tank is full, or nearly empty. When both lights are out the tank is dry.

Each tank also has an external blow connection on its rear top. This allows the tank to be blown on the surface or submerged, using an external source of air.

Variable Ballast Tanks - The two variable ballast tanks aboard the BEN FRANKLIN are externally mounted hard tanks. Each tank is mounted below the pressure hull and has a capacity of approximately 790 pounds of sea water. The tanks are fabricated from carbon steel heavy wall pipe and are considered to be "pressure vessels". They run the full length of the boat on port and starboard sides (37 feet long) and are mounted to the hull by a series of steel straps lined with neoprene, painted with a vinyl primer and topcoat. The sea connections for the Variable Ballast Tanks flood/drain lines are located under the pilot's viewport just above the upper row of batteries. Filters are located at each of the two flood/drain lines. Two filters, stainless steel tubes with holes covered with a plastic screen, prevent clogging of the vents. Each filter has two lines - one filter is for the two Variable Ballast Tanks outboard vents, and the other filter is for the hull vent, and for the SAS flood/drain line.

Shot Ballast System -

Shot Ballast Tanks - Separating the two main ballast tanks to port and starboard are the shot ballast tanks. They follow the same hull contours as the main ballast tanks. Each shot ballast tank is filled with steel shot up to a point about 4 inches below the water line. The tanks are free flooding and always open to the sea - to pressure compensate the tanks and to prevent rusting of the shot into an unmanageable agglomeration. When completely immersed in sea water, the corrosive action on the shot is minimized and the granules remain free. Shot used aboard the boat is Globe Steel S-780C. The tanks are constructed of sheet steel supported internally by steel truss frames. They were manufactured by Giovanola.

The shot ballast system has two functions - to adjust the buoyancy of the boat by metering out shot through a specially designed electromagnetic valve and to provide six tons of buoyancy (6,372 lbs. per tank) in an emergency by rapidly dropping all of the shot (release of hydraulic pressure on a piston opens a large door at the bottom of the shot ballast tank).

Metered Shot Drop System - This system is an electrically controlled means for dropping small quantities of shot for the purpose of reducing the weight of the boat. It consists of two electromagnetic valves - one for each shot tank. A specially constructed timer by Longines Watch Company, is installed in the pilot's console. This timer consists of two stop watches each connected to one of the shot ballast circuits. The timer automatically starts and stops as shot ballast is metered out of each hopper. The quantity of shot jettisoned is simply calculated by time units as 4.4 lbs. (2 kg) of shot falls through the valve per second. This operation is controlled by the pilot.

One push on the button on the pilot's console is approximately equivalent to one half second or 2.2 lbs. (1 kg) of iron shot.

Emergency Shot Ballast - This system was installed to provide a quick release of ballast in case of flooding or some other emergency requiring rapid surfacing or extra buoyancy.

Trim Tanks - During underwater operation, changes in pitch are necessary either to make closer inspection of terrain through fore and aft viewport, to compensate for movement of personnel or equipment, or to compensate for weight changes in water and waste tanks. To achieve or correst longitudinal stability, water is transferred between two trim tanks, One tank forward and one aft are located inside the bottom of the hemispheres at either end of the pressure hull. Each tank has a capacity of 50 cubic feet (3100 pounds of fresh water). Enough water to fill one tank completely is carried during missions. This is sufficient to produce approximately a 10^{o} angle, which is the equivalent of placing 5 men at one end of the vessel.

The forward trim tank has a filling hole in the top, closed by a threaded plug. Both tanks are linked by a polyethylene pipe running vertically and along the top of the hull interior forming an air venting system. The polyethylene pipe is joined to metal tubes located on the top of each trim tank. Each metal tube has a valve for air release.

When water is pumped from either tank it vents through the overhead pipe into the opposite tank. Trim water moves through two polyethylene pipes running fore and aft down the port side of the boat and connected to trim pumps, which are turned by electric motors and controlled at the pilot's station. Each pump operates in one direction only, and runs at 1750 rpm (2 hp) with a capacity of 84 gallons per minute.

Lead Ballast - In order to reach unladened diving trim, lead ballast has been added to the boat as follows:

Hull Pedestals

Forward Starboard	842 lbs. of shot
Forward Port	838 lbs. of shot

Aft Starboard	850 lbs. of shot
Aft Port	861 lbs. of shot

Trim Tanks (1-9/16 inch thick sections of lead)

Forward	4277 lbs.
Aft	3650 lbs.

PNEUMATIC SYSTEM

The Pneumatic System aboard the PX-15 can be divided into four circuits:

- o System high pressure air storage, fill, vent and distribution
- o Main Ballast Blow and Vent
- o Variable Ballast Blow and Vent
- o SAS Circuit

Air Storage - Compressed air is stored aboard in steel tanks. From these storage tanks, high pressure air enters the system through hull penetrators, quick acting hull valves, and piping which runs to a pressure reducer. Here the air pressure is reduced from 200 kg/cm^2 to 100 kg/cm^2 (2844 psi to 1422 psi) before it is distributed throughout the vehicle.

High Pressure Air Storage - High pressure air is stored in six air flasks. U. S. Steel compressed gas flasks designed for Class 3000 service (per specification MIL-F-22606B). Three size flasks are used, 7 cu. ft., 10 cu. ft. and 21 cu. ft., mounted port and starboard, in pairs, on the top of the boat below the sloping deck. The total capacity of the system when fully charged is 76 cu. ft. at 2500 psi. If all this air was bled into the hull, six atmospheres would be added to give a pressure of 105 psi. This figure assumes that the internal hull volume has been reduced by 30% due to installed equipment. Each flask is piped through its own hull valve, pressure gage and control valve all grouped near the pilot's station. The lines are manifolded together where they then feed through a single line to a pressure reducer. The tanks are mounted on brackets welded to the hull and held in place by neoprene lined steel straps. These straps are secured by a tightening nut and locknut arrangement fitted to the hull brackets. Stainless steel cables on each end of the flasks prevent fore and aft movement.

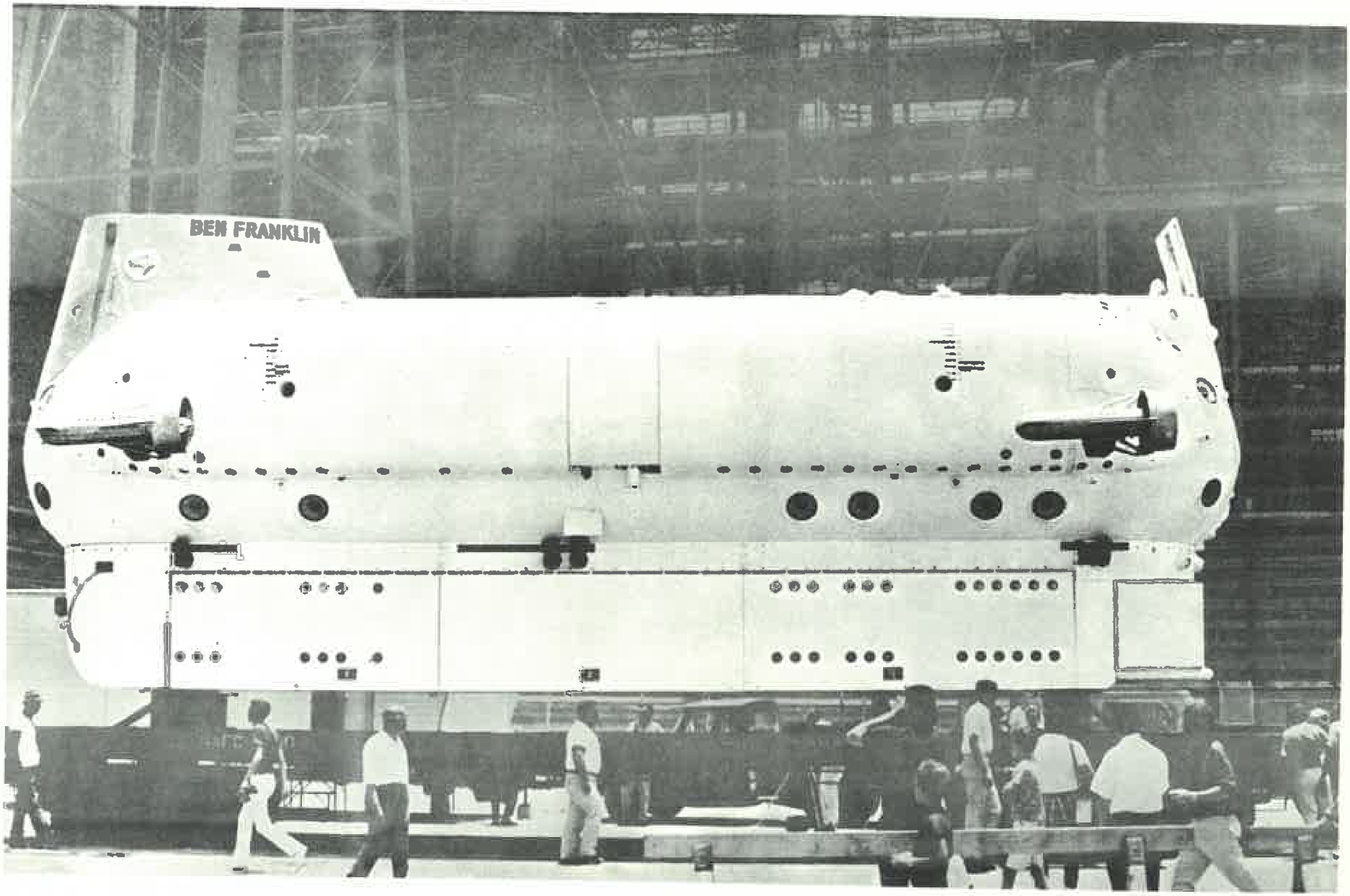
High Pressure Air Charging - The normal method of charging the high pressure air flasks is through an external filling connection located inside the sail. Here high pressure air from some external source (dockside compressors) passes through the filling system and into the tanks.

An additional connection is available inside the boat for charging the system should it be desired.

Main Ballast Blow and Vent - The main ballast circuit is tied into the pneumatic system at the pilot's station. Two lines each contain a simple control valve which supplies 100 kg/cm^2 air to a pair of main ballast tanks.

Variable Ballast Blow and Vent - The variable ballast circuit uses 100 kg/cm^2 supplied through the pneumatic distribution circuit. A "Tee" fitting breaks the variable distribution circuit into two halves. One half services the port variable ballast tank while the other half services the starboard variable ballast tank. Both sides are identical.

SAS Circuit - One line branches out of the main pneumatic distribution circuit and leads to the SAS. Blowing and flooding of the SAS is accomplished through a line which leads from the bottom of the chamber through a control valve, hull valve, penetrator and out to the sea through a screened fitting.


BEN FRANKLIN

HYDRAULIC SYSTEM

The PX-15 hydraulic system has two main functions: To open and shut the SAS chamber, to ensure that pressure is maintained in the shot ballast emergency drop system. All components in this system are manually controlled.

A hydraulic reservoir is located in the equipment cabinet across from the pilot's console. Oil is drawn from the reservoir by a lever-operated hand pump. From the hydraulic pump, fluid is sent to the circuit selector valve. In the line leading to this valve a "Tee"-coupling leads to the adjustable pressure control valve which ports oil back to the reservoir if the set pressure is exceeded

Hydraulic Pump - The pump in the system is a Greer Aircraft Emergency Hand Pump. It is fitted with a line filter at the pump outlet. The oil used in the system is Shell Tellus 927.

ELECTRICAL POWER AND DISTRIBUTION

Main Batteries - Batteries for BEN FRANKLIN were constructed by Electrona in Boudry, Switzerland. The cells are a lead acid type with cases made specially for the BEN FRANKLIN. Each cell, located in the keel area, is exposed to sea water and therefore compensated for sea pressure. The cells are mounted horizontally at an angle of 3^{o}. They are held in a keel pigeon hole with a stainless steel retainer which forces them against a rubber pad at the back of the pigeon hole. The electrical connections between the cells are made with 95 mm^2 flexible cable ending in plugs that are insulated from sea water. At the end of each cell is a reservoir which contains approximately 2 liters of acid and 8 deciliters of oil. The front of the reservoir is plexiglass, marked so that electrolyte levels can be checked. Since the oil is colored with a dye additive, the level of electrolyte can be read at the interface with the oil in the reservoir. The reservoir is also fitted with a connection to a common manifold for gas venting and compensation.

The batteries can be fully charged in 13 hours on land or while the boat is on the surface of water. When charging the batteries hydrogen gas is formed and about 53.5 cubic centimeters of distilled water are consumed. However, with a reserve of 2 liters of electrolyte, it is possible to charge about 30 times without adding water. Hydrogen gas is another problem.

Most of the generated hydrogen escapes; however 600-800 cm^3 of gas remains trapped in the cells six hours after charge. This quantity of gas affects the submerged stability of the boat since it is compressed upon submerging thereby causing the boat to become heavy. When ascending in the water, the gas expands causing the boat to become light - therefore the vehicle will tend to be unstable at depths down to about 100 meters and stable (the gas will be in solution) at depths greater than 100 meters. While on discharge, hydrogen is also formed and is freed from solution at .5 atmospheres.

Main Battery Characteristics

- 1000 AH at 10 hr. rate (100 amps)
- 750 AH at 3 hr. rate (250 amps)
- Total capacity 750 KWH

- 1.260 specific gravity when charged
- 1.120 specific gravity when discharged
- Low voltage 1.75 V at 10 hr. rate
- Low voltage 1.7 V at 3 hr. rate
- 2.8 liters (oil and electrolyte) in each reservoir
- Lifetime 650 cycles in 3 years
- 30 cycles between watering
- Battery jar hard rubber
- Battery weight approximately 160 lbs.
- Dimensions approx. 201 mm wide x 535 mm long x 231 mm high
- Maximum operating attitude 45°

In order to monitor the state of the battery, a recording ampere hour system is installed adjacent to the pilot station.

Emergency Batteries - In the event that main battery power is interrupted, 14 C & D Battery Co., DCUA, 13 calcium grid, lead acid batteries are provided. The cells are located in sealed compartments aft of the shower and toilet. The lead calcium type battery is particularly suitable for submarine use since the amount of hydrogen given off during discharge is too small to measure. Each cell provides 2.2 volts giving a total of 31 volts.

Emergency Battery Specifics

- 168 AH per cell x 30 V = 5 KWH
- Cell size 10-3/4" x 6-3/8" x 7-3/8"
- Weight 38 lbs each

- Cell voltage averages 1.75 to 2.20 volts over rated life (24.5 to 31 volts for 14 cell system)
- Operating temp. $0^{\circ}F$ to $140^{\circ}F$
- Fully charged specific gravity about 1.300
- 8 hrs. to 1.75 volts (168 AH)

Battery Chargers - The charging installation, located in the support van along with the air compressors, is composed of eight automatically controlled rectifiers divided in three groups:

Group 1 - 2 chargers for 84 cells each (168V)

Group 2 - 3 chargers for 56 cells each (112V)

Group 3 - 3 chargers for 14 cells each (28V)

Two charging programs can be set into the chargers - underwater charging (while boat is in the water) and service charging (while the boat is on land).

Underwater Charging - This program permits the full charge of the battery in a relatively short time (about 13 hours) producing a minimum of gas formation. More rapid charging may cause a carry-over of sulphuric acid.

Service Charging - This program differs from the underwater program by a smaller charging current of the second step. The program is somewhat longer since water pressure is not available to prevent acid carry-over. In addition to this, a lower charge current is necessary in order to prevent a temperature increase of over 95°.

In addition to the eight chargers already mentioned, a single cell charger is provided to charge from one to six cells simultaneously. Input power is 110 V AC.

Battery Venting and Compensation - Since all of the main batteries are located outside of the pressure hull, a method is provided to prevent them from being crushed by sea water pressure - a compensation system.

In addition to this, a means is also provided to allow for the escape of hydrogen gas produced in each cell. The gas venting and sea water compensation systems are joined together into one integrated system.

Briefly, each battery cell has a riser tube leading from its reservoir to a manifold located above the keel. The manifold is connected to a large fiberglass reservoir located forward of the keel. The reservoir is open to sea and therefore sea pressure is transmitted from the reservoir to the manifold to each cell. There are five manifolds (3 starboard and 2 port) and each one has two vent valves which allow for the escape of hydrogen gas.

Distribution System - Prior to entering the hull, current from the cells flows via molded neoprene connectors 95 mm^2 cable and then through Sawmut 400 amp fuses that are potted into the cable runs with a special epoxy system. The fuses are installed to protect the penetrators in case of a possible short. Tests show that they fail in 50 seconds with 1000 amps of current. From the fuses, the 38 lengths of 95 mm^2 cable pass into the hull via 38 penetrators and then into large fuse boxes under the walking deck near the penetrators. From the fuse boxes, the cables lead into a multi-circuit switch in the main distribution panel. The mode switch in turn feeds power to the propulsion system, 110 VDC bus, and 28 VDC bus.

External Wiring - The 95 mm^2 external wire (batteries to hull penetrators) is from R. E. Huber Co. (Swiss). It is stranded copper wire with a double insulation - butyl and hypalon. All connections are molded neoprene and specially designed. All other external wiring is 1 mm^2 Cossonay with a thermo-plastic insulator and "Gyrlon" jacket with a 3.0 mm outside diameter. This wire is gradually being replaced by a new wire with solid hypalon insulation.

110 Volt DC Bus

- 650 watt projectors
- Shot valve holding coil
- Trim system motors
- Air compressor
- Rudder limit switches

- o Hot plate
- o Hot water heaters
- o Convenience Outlets

28 Volt DC Bus

- o Rudder sensors
- o Salt water detector lights
- o MBT vent valves
- o Shot metering coil
- o Emergency lights (charging)
- o TOPAZ inverters (2)
- o Underwater telephone
- o Radio
- o Fathometer
- o TV (2)
- o Pinger
- o 150 watt projectors
- o Internal lighting
- o Navigation - compass, turn and bank, etc.
- o Hydraulic accumulator alarm
- o Shot dermagnetizing alarm
- o Electrical outlets

- Running lights
- Strobe light
- Submarine ident. light
- Temp. sensors (ext.)
- Pilot panel lights
- Horn
- Obstacle avoidance sonar (CTFM)
- Battery monitoring panel (inverter for ampere hour meter and digital voltmeter

110 Volt AC Bus

- Rudder indicator switch
- Convenience outlets
- Toilet - mascerator and blower
- Contaminant removal system
- Teledyne/solenoid for LOX tanks
- Salt water sensors (MBT levels and battery vent valves/reservoir)
- Thallium iodide lights
- Pan and tilt for TV
- Shot ballast level indicating system

PROPULSION AND STEERING

Pilot's Console (AEG) - This equipment contains all the necessary instruments and controls for operating the vessel.

Propulsion Panel - Built by AEG, Germany the panel is located directly in front of the pilot's seat.

The batteries normally provide 336 volts to two 60 KVA inverters for propulsion.

Each inverter powers one or two 25 hp propulsion motors with speed varied by changing the frequency and voltage. The batteries also supply two 3 KVA inverters which in turn provide power to index the orientation of the propulsion motors. The rotation motors (4) are .5 hp each.

Throttles - There are two "throttles" used to control the output of each 60 KVA inverter. Selection of throttle/motor combination is accomplished with the Propulation Inverter Selector. Normally, in one mode (turn mode) the starboard throttle controls the starboard motors and the port throttle controls the port motors. In a second mode (cruise mode) the starboard throttle controls the two aft motors and the port throttle controls the two forward motors. When the Propulsion Inverter Selector is shifted from vertical to the horizontal position, the port throttle controls the starboard or rear motors and the starboard throttle controls the port or forward motors (depending upon whether in cruise or turn mode). A detent is at the center throttle setting to indicate the stop position. Tachometers are provided for each motor and provide readings from 0 to maximum RPM (720).

Depress/Elevate Level - Two levers (joysticks) are used for motor positioning. The forward lever controls the forward motors and the rear lever controls the rear motors. Normally the forward joystick directs power from the forward 3 KVA inverter and the aft joystick the aft 3 KVA inverter. This can be reversed by shifting the Position Inverter Selector to the horizontal position. A dial is provided for each motor indicating its position.

SAME/OFF/OPPOSITE Switches - One of these switches is provided for each motor. In the "SAME" position, a motor operates as directed by the throttle. If the OPPOSITE position is selected, the motor will operate opposite to the throttle setting. In order to operate this switch, the throttle must first be at the OFF position and the propeller completely stopped. When in the OFF position the motor will not operate, One propulsion inverter may be used to operate one or two motors.

Other Dials - In addition to the motor position indicators and tachometers, the panel has an ammeter indicating current to each 60 KVA inverter and a voltmeter indicating voltage to each 60 KVA inverter. When battery voltage to an inverter drops to 300 volts, the throttle should not be operated beyond the 1/2 speed position. If battery voltage to an inverter drops below 260 volts, the inverter will automatically shut down.

Toggle Switches - At the top right hand corner of the panel are four toggle switches. These switches are used to energize the two propulsion and two motor positioning inverters.

Main Power Switch - This switch energizes the panel and can be operated only when the key (below the power switch) is in the ON position. The key prevents accidental operation of the propulsion system.

Emergency Shutdown Switch - In case of emergency, the panel and inverters (4) can be secured by pressing this switch. It is located above the main power switch.

Propulsion System Inverters - The BEN FRANKLIN propulsion system consists of four propulsion motor units, each consisting of a reversible 25 hp AC squirrel cage induction motor driving its own propeller and complete with an integral 0.5 hp reversible positioning motor used to rotate the propulsion motors up to 350°. The inverters for energizing the main propulsion motors are designed to supply continuously variable frequency and voltage for variable speed and reversing operation. The inverters for energizing the position motors operate at a constant frequency and voltage. Each inverter supplies one or two motors. The propulsion inverters are mounted either side of the passageway just aft of the main distribution panel. The port throttle controls the port inverter and the starboard throttle controls the starboard inverter.

General Description of Propulsion Motors - The propulsion plant of BEN FRANKLIN consists of 4 propulsion units, each of them composed of a Pleuger submersible propulsion motor, with a 4-bladed bronze propeller, a thrust nozzle and 2 stabilizing fins to compensate the hydraulic forces in case of diagonal flow. The motor is streamlined by fairings that are made of fiber glass reinforced resin. The motor is completely filled with a water antifreeze solution. The solution serves as cooling for the windings, lubrication for the soft rubber journal bearings and axial bearing, and pressure compensation underwater pressure which has access to the interior of the motor via a compensating diaphragm. The submersible propulsion motor is flanged to the hollow shaft of the training gear. The training gear is designed as a two-stage worm gear with a total transmission ratio of 1: 1200. The worms, the worm wheels, and the rotatable shaft move in roller bearings. Lubrication is secured by a high-efficiency lubricating oil with which the gear housing is completely filled. At the training gear, too, the underwater pressure is equalized by means of a compensating diaphragm. The training gear is driven by a Pleuger positioning motor. This motor is also filled with a water/antifreeze solution and pressure-compensated by a diaphragm.

Technical Data - Propulsion Motor, 25 HP -

Motor: Design: Submersible three phase A.C. motor, water-cooled, water-lubricated single cage rotor.

Nominal Characteristics:

Output	N	=	25	SHP
Speed	n	=	710	RPM
Frequency	f	=	50	c/s
Voltage	U_n	=	220	volts
Power Factor	cos	=	0.74	
Efficiency		=	80	%
Current	I_n	=	85	amps

Technical Data - Propeller -

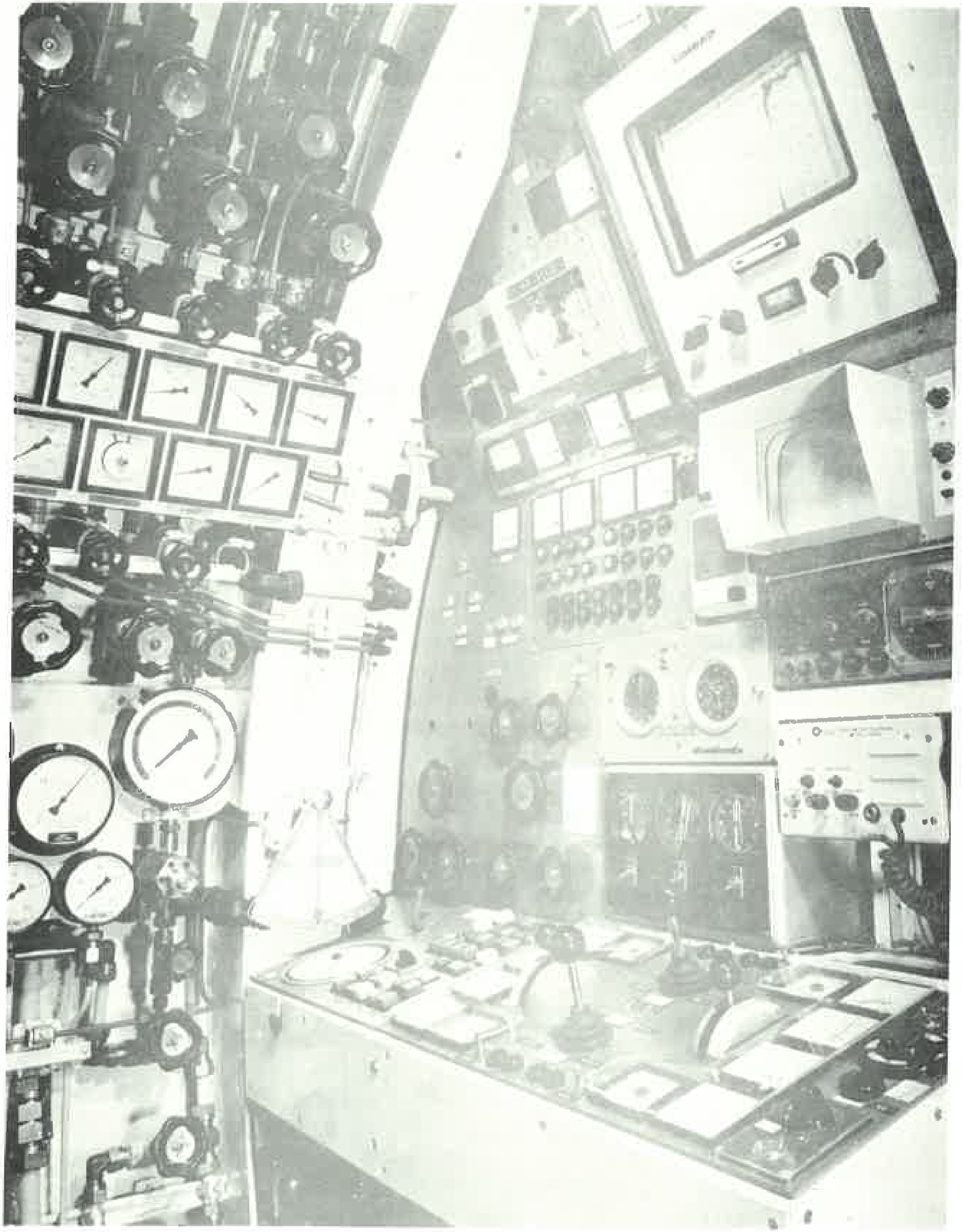
4 Blades	Shrouded
Diameter	720 mm (28.35 in.)

Blade thickness	11 mm (.44 in.)
Hub diameter	185 mm
Weight	40 Kg
Material	Bronze
Max. RPM	720
Tip clearance	5 mm

Steering - The steering system consists of two rudders acting together aft of the battery housing, an electric motor located between the rudders and a control switch at the pilot's console. The motor operates in each direction and moves the rudder from left 40° to right 40°. Magnetic sensor switches stop the motor at the full rudder position and indicate this with a light at the console. A third sensing switch indicates (at the console) when the rudder is in the amidships position. Normal steering is accomplished by differiential operation of the propulsion system.

Specifics on Rudder -

Number	2
Area	1521 sq. in. each
Total Effective Area	1521 sq. in.
Deflection	40° either side of amidships



Pilots Panel

INSTRUMENTATION & ELECTRONICS

The following equipments are part of the basic submersible system:

Sensor Circuits - This system consists of the salt water sensors, hydraulic pressure alarm and the demagnetizing current alarm.

Salt Water Sensors - These sensors are located as follows:

1) Main Ballast Tanks - There are two sensors in each tank upper and lower. The upper indicates when the tank is full and the lower indicates the tank is partially full. If both lights are off, the tank is empty.

2) Battery Manifold Reservoir - indicate salt water level at four points: Normal, 1/2 full, 3/4 full,

3) Battery Vent Valve - Each vent valve has an indicator that is energized when salt water has filled the vent valve reservoirs, line to the valve and bottom of the valve. The sensors are actually located in the bottom of the vent valve.

Hydraulic Pressure Alarm - The hydraulic pressure gage has a device set to indicate when pressure drops below a set value. The indicator is an audio alarm and light.

Shot Dribble System - When the shot ballast is being held by the 28V DC dribble system, a loss of 28V current to the coils will be indicated by an audio alarm and warning light.

Compass/Turn and Bank Indicator/Gyro - This equipment, standard aircraft gear, consists of three indicators - turn and bank, gyro compass, and remote reading magnetic compass. The system is designed to operate at voltages of 22.5 to 31.5 at 0° to 35°C at a saturated humidity level.

Magnetic Compass (magnesym) - Located in the sail, this equipment is supplied with 400 Hz, 26 volt, 3 phase power from a static inverter in the indicator panel at the pilot's console. The remote reading indicator at the pilot's console should not deviate more than 2 degrees from the master compass in the sail. A compensator is provided for the purpose of reducing compass deviations on north-south and east-west headings.

Directional Gyro - This component operates at 30V 800 cps 3 phase power. The gyro must be reset approximately every 15 minutes from the magnesym compass.

Turn and Bank Indicator - This aircraft indicator is used to provide roll and rate of turn information. It requires a 40 second warm-up.

Chronometer - A specially designed chronometer based on an electronic timepiece is installed directly above the propulsion panel. This battery operated clock/timer, supplied by Rolex of Geneva, was designed for an accuracy of 100th of a second per 24 hours.

Temperature Sensors - Two sensors are installed - one on the upper port side of the sail and one where the keel joins the hull - port side forward. An indicator on the pilot's console can be switched to read either sensor. The sensor consists of a fine wire of known resistance. Temperature causes the resistance to change and this is calibrated to read temperature.

Depth Sensors - Located under the TV periscope mast in the sail, a two liter reservoir provides an interface between sea water and hydraulic oil. Sea pressure is transmitted via hydraulic lines to three depth gauges - shallow, deep and recording. The system uses Humble's MARCOL 70 mineral oil.

Depth Recorder - A recording depth gauge is provided just behind the pilot's seat. The gauge operates between 0 and 800 meters and is powered by a wind-up motor 8-day clock. Two indicators are provided - an ink recorder (depth versus time) and a dial presenting actual depth. The equipment used aboard the BEN FRANKLIN is built by HAENNI S.A. of Jegenstorf, Switzerland.

Depth Gauges - Two depth gauges are provided in addition to the recording gauge - a shallow and a deep gauge. Both indicate sea pressure (depth) at the centerline of the hull.

Radio - A Simpson 150-A radio telephone is installed for use with a C/P Shakespeare 9-foot fiberglass whip antenna. A multi-wire type penetrator is used for this system.

Brief Description:

Channels	8 (crystal controlled)
Frequency Range	2 to 5 mc
Power Supply	28 V DC
Transmitter Power	150 Watts
Power Output	96 Watts
Current Drain	Receive: 2.5 amps Transmit: 30 amps
Weight	31 pounds

Intercom - A simple battery powered system is provided throughout the boat.

Unit Locations: Pilot's Console

Amidship

AFT

Sail - Pilot's Console Phone Circuit - Two sound powered telephone circuits are provided for communications between the sail (bridge) and pilot's console. Normally, handsets are connected to one circuit and full headsets to the other.

Underwater Telephone - One Straza unit is provided at the pilot's console. It can be switched to a vertical transducer located on deck amidships or a horizontal transducer just below the forward hemisphere. The Straza telephone is a single side band, suppressed carrier, underwater telephone which operates in a frequency range of from 8.3 to 10.7 KC. It is compatible with the Navy AN/UQ-1 and AN/PQC (diver held) underwater sound communication set and has a range of over 7500 yards. The unit is small and contains transistorized circuits mounted in plug in circuit boards.

Quick reference data:

Primary power - 24-28 VDC, 13 watts max (transmitting)

Power to transducer - 5 Watts

Carrier frequency - 8.087 KC (KHz)

Range - 7500 yds.

Horizontal directivity pattern - Omnidirectional

Vertical directivity pattern - 50° beam width

Fathometer - A SIMRAD (Oslo, Norway) fathometer is mounted on the pilot's console. Two transducers are located in the forward part of the battery housing (chin mount), one directed downward and one directed forward. The forward looking transducer provides an auxiliary obstacle avoidance capability.

CTFM Sonar - For obstacle avoidance, the BEN FRANKLIN has been provided with a Straza CTFM sonar. The equipment consists of a projector and hydrophone (both mounted on the forward upper part of the sail). The circuitry is completely transistorized and the equipment is designed to operate at unlimited depth by the use of oil filled pressure compensation techniques. The unit consists of a training mechanism projector, receiving hydrophone, Sonar unit, display unit, and analyzer.

The display unit (PPI unit) is monitored visually to detect and view returns from underwater objects lying in a volume $\pm$ 7.5 degrees vertically and $\pm$ 90 degrees horizontally about the longitudinal axis of the vehicle at ranges of 10 to 1500 yards. In addition, an aural signal is available to enable the operator to monitor the target return signals by means of a speaker or headset.

Pinger (Underwater Acoustic Tracking & Ranging System) - This system allows the support vessel to determine the direction and range to the BEN FRANKLIN. The equipment consists of a transponder-pinger, receiver antenna, and readout module. The transponder transducer is located on the main deck near the after hatch. The transponder, upon command of the support vessel, transmits an acoustic signal into the water through an omnidirectional transducer-preamplifier. The readout module is self-contained, battery operated, and has a meter readout for range.

Separate frequencies are used to separate the tracking pulse from the ranging pulse.

From inside the submarine, the transponder can be energized to send a continuous or momentary signal. The transponder however, would normally be set in the OFF position from which it can be energized upon command of the tracking station on the support vessel.

Topside TV - A Grundig-Electronic "Fernange" closed circuit television set is provided for use as a simple periscope system. The camera is located on top of a mast in the sail and the console is located at the pilot's console. A rotation motor is located in the base of the mast and is controlled from a switch at the console. The equipment is transistorized and operates with a power supply of 24 Volts DC. It will operate in a temperature range of -15°C to 40°C (5°F to 104°F) with a power consumption of 25VA.

Underwater TV - The Hydro Products "Hydro Eye II" television system, mounted just forward of the keel, is a complete self-contained camera, designed specifically for underwater applications. The system is composed of the camera, Thallium Iodide lights, Conrac monitor with power supply, remote focus control, and pan and tilt unit. The pan and tilt unit is a remote controlled manipulator operated from a joy stick aboard the submarine. It develops 18 foot pounds of torque to accommodate a heavy load in strong currents.

Battery Monitoring Panel - This compact system includes the necessary meters for monitoring the state of each battery string. (14 or 28 cells).

Ampere Hour Meters - There are 6 meters to read.

Voltmeter - In order to read the voltage of each battery string (14 or 28 cells) a digital voltmeter is included in the panel.

Ground Selection - Ground readings or all external equipments except the battery system is accomplished by using a megohm meter. The system for measuring grounds on the battery system uses a precision registor and digital volt meter to measure battery string voltage and voltages to ground.

LIFE SUPPORT

CO_2 Removal System - Carbon dioxide removal is accomplished passively by absorption on lithium hydroxide (LiOH) panels strategically located throughout the vehicle. Diffusive and natural convection currents circulate the atmosphere through the panels. (Three portable blowers are included as part of the system to be used to aid in circulation during those periods in which natural convection is not adequate.)

Each panel contains more than enough LiOH to remove the CO_2 generated by one man per day, however, because of panel surface limitations, (CO_2 removal rate per panel ($^{gm}CO_2$/hr) is roughly 1/3 the generation rate per man (^{gm} CO_2/hr) it is necessary to expose 3 panels per man. Thus for a six man crew it is necessary to expose 18 fresh panels, which will last approximately three days before needing replacement. The panels are located throughout the vehicle.

Once the vessel is sealed, CO_2 readings must be taken every four hours. Normal CO_2 buildup may reach the 1 - 1.5 per cent range. This level may vary reaching a maximum when crew activities are highest, and a miminum when activities are lowest.

CO_2 readings are to be made with the Dwyer Analyser. This instrument is checked daily with the Fyrite Analyzer and a CO_2 Drager tube.

When CO_2 levels reach 1.75 per cent and remain in this range for a minimum of four hours (2 readings) LiOH panels are changed. This represents an average panel exposure time of three days. Again, care in preventing panel dusting is exercised when removing the old panels and mounting new ones. Used panels are replaced in their original plastic bags.

Oxygen Supply & Regulation - Oxygen for the submersible is stored as a cryogenic liquid in two standard Linde cylinders each of which holds up to 250 pounds of O_2. Operation of the system requires that O_2 consumption be greater than normal O_2 boiloff to prevent a hazardous builup in O_2 partial pressure. Because normal boiloff is approximately 3.75 lb/tank/day, two tanks are used only when four or more crew members are on board. For less than a four man crew only one tank is used.

Temperature Control: (Gulf Stream Drift) - Because of moderate Gulfstream temperatures (average water temperature 15°C (59°F), temperature control for the vehicle's maiden mission is "passive". Using the sea as a heat sink, bare sections of the hull's interior surface will conduct heat out of the vessel. Internal temperatures have been estimated to range between 63°F and 83°F for corresponding sea water temperatures of 50°F and 70°F. The average vehicle temperature is anticipated to be 73°F. These numbers are based on a sedentary activity level for the crew and an average power drain of approximately 250 watts by the internal electrical equipment.

Humidity Control - Humidity control is accomplished passively by allowing moisture to condense on the bare sections of the hull interior. Thus relative humidity (RH) becomes a function of the temperature difference between the inner bull and the vehicle interior. A 10-degree difference yields a RH of approximately 70 per cent; 13 degrees - 65 per cent and 15 degrees - 60 per cent. As the moisture is condensed on the hull it runs into a catch trough that carries it into the waste water storage tank. A small dehumidifier is available on board for use as required. A back-up supply of desiccant (silica-gel) is also available to absorb moisture.

Atmospheric Pressure - The internal pressure of the Ben Franklin will be maintained at approximately sea level conditions (14. 7 psia). However under normal operating conditions, the internal pressure may vary from a low of 13. 5 psia to a high of 16 psia.

Contaminants Removal - Contaminant removal for the Ben Franklin is accomplished in the following manner:

- o Continuous passive removal of contaminants by LiOH and activated charcoal, both of which are provided in the CO_2 removal panels.
- o Intermittant active removal of contaminants by the odor removal (Purafil) cartridge in the toilet.
- o Periodic active removal by the portable contaminant removal system (operated as needed)

CO_2 Removal Panels

LiOH (lithium Hydroxide)

Activated Charcoal

Toilet Odor Removal Cartridge

Purafil

Portable Contaminant Removal System Cannisters

#18 Activated Charcoal

Kalite
Hopcalite
Acamite

#19 Activated Charcoal

Purafil

#20 Activated Charcoal

Hopcalite

Contaminants removed by each of the above are the following:

- LiOH in addition to its primary function of removing CO_2 will also remove acid gases such as HCl and H_2S.

- Activated Charcoal - A small quantity of activated charcoal is provided along with the LiOH in the CO_2 scrubbing panel and in each of the portable contaminant removal system cannisters. It absorbs organic vapors, odors and ammonia.

- Purafil - This material is pellitized activated alumina impregnated with potassium permanganate. It is found in the toilet odor removal cartridge and cannister #19.

  Purafil will remove odors, organic vapors, organic acids, phenols, sulphides, and oxides of nitrogen.

- Hopcalite - This substance is found in portable contami-removal cannisters #18 and #20. It is a catalyst and has a primary function of oxidizing CO to CO_2 (also handles aldehydes, alcohols, etc.)

- o Acamite - Found in portable contaminant removal cannister #18, absorbs alkaline gases (NH_3) and also acts as a drier.

- o Kalite - Found in portable contaminant removal cannister #18, absorbs acid gases (HCl, H_2S, etc.).

Waste Management System - The waste management system chemically treats and stores metabolic wastes onboard the vessel. Waste wash waters from the sink and shower are collected in a waste wash water storage tank from which flush water is drawn for the toilet. As the toilet is flushed, germicide is automatically metered into the exit stream. The wastes then enter a macerator where they are simultaneously pulverized and thoroughly mixed with the germicide. The treated wastes are held in the macerator between toilet uses. It is during this period that biological organisms are inactivated. Wastes are then pumped from the macerator into the waste storage tank where they remain until the tank is cleaned.

Toilet odors are handled by a blower which draws air through a cannister filled with Purafil. Storage tank odors are handled by a vent line that feeds into the odor removal cannister. Two waste tanks are installed - a "mini waste tank" and "waste storage" tank. The mini waste tank collects water from the three sinks and shower. This tank stows the water for use in flushing the toilet. The waste stowage tank is used to stow human waste received from the chlorinator.

The wash water storage tank is to be initially primed with 10-15 gallons of fresh water. At the conclusion of a mission, the tank is cleaned out.

Contaminant Detection - Trace contaminant detection on the Ben Franklin is accomplished with Drager-type gas detector tubes, a method requiring no power. Forty different tubes, many of which detect more than one contaminant, will be used. Measurements are made by breaking the tips off the tube and inserting them into a hand operated bellows pump.

Pumping a specific number of times for each contaminant, air is drawn through the chemical-filled calibrated tube. The chemical discolors lengthwise proportionally to the contaminants concentration in the atmosphere.

Gaseous contaminants certain to appear in the atmosphere of the Ben Franklin are those resulting from the crew's metabolic processes. In addition to the metabolic contaminants it is possible that other trace contaminants may be generated by on-board equipment, surface finishes, lubricants, etc.

Atmosphere Exchange System - The function of the atmosphere exchange system is to purge the vehicle atmosphere and replenish with fresh air. The system consists of a portable blower to which is attached approximately 30 feet of flexible ducting. The system is to be used when;

- o Smoke due to a fire or insulation breakdown has filled the vehicle.
- o The CO_2 level has reached 3.0 percent.
- o The 0_2 partial pressure has reached a hazardous level (Above 25 per cent).
- o A trace contaminant level has built up and cannot be removed by the contaminant removal system.

Potable Water System - The potable water supply consists of both hot and cold water. The cold water is stored in four saddle tanks each of which hold approximately 95 gallons and the hot water is stored in four super insulated tanks each of which hold 50 gallons. The tanks are initially filled with cold fresh water from dockside. Two inline filters remove gross particles and bacteria. A second bacterial filtering is performed as the water is drawn from the cold water tanks by another filter on the cold water discharge line. Hot water is prepared by using the electric immersion heaters in the insulated tanks.

EXTERIOR LIGHTING

Lighting outside the hull is arranged mainly for underwater observation and color photography. The light source consists of forty 650 watt floodlights, (110 Volt D.C.) and thirty-four 150 watt (28 Volt D.C.) floodlights located in the underside of the main ballast tanks, the battery housing under the hull, in the sail and in the faring between the superstructure deck, main ballast tanks and shot ballast tanks. Three thallium iodide lights are provided for the underwater TV.

Navigation Lights - The port and starboard running lights are located on the sail and the stern light is located on the main deck aft of the hatch. These three lights use the same pressure proof bulbs as the 28 Volt 150 watt projectors. All other navigation lights are not pressure proof and are located on a portable mast that fits on the starboard side of the sail just forward of the sail access hatch. This mast, normally stowed inside the boat, is in the shape of a cross and constructed of anodized aluminum. The following lights are affixed to the mast:

- Xenon Flasher light (an emergency light to be used if the submarine is lost.)
- a rotating amber beacon (submarine identification light)
- standard masthead light.
- standard anchor light.

Thallium Iodide Lights - Three of these Hydro Products lights are installed, two on the forward hemisphere for visual observation and one in the chin mount as part of the underwater TV system.

These 250 watt green lights are equivalent to 2000 watt incadescent projectors since green light penetrates sea water most efficiently. Operating depth maximum is 8000 feet and input power is 110V A.C. (60 cps). A warm-up time of 7 minutes is required and the operating life is in excess of 5000 hours.

SAS

The designation SAS has been adopted from the French word "le sas" currently used as an idiom for an air lock or vestibule in French-speaking countries.

This small lock is used to send spheres with biological or water samples, rolls of film, recorder paper rolls, written messages or other articles to the surface. The plastic spheres are approximately 5 inches in diameter and are made in two halves. A sphere is placed in a frame bolted to the SAS inboard hatch, the SAS flooded and the outside hull hatch opened by the hydraulic servo-motor. The sphere then rises to the surface, the outer hatch shut, and the chamber is blown dry with the air system.

The SAS is located at the top of the hull. Its hatch is a circular port - 310 mm outer face diameter - 150 mm inner, of cast steel and machined with conical edges to fit the conical opening of the hull casting. A small plexiglass view port is held into the hatch by a circular retaining steel ring. The inner diameter of the SAS hatch is 150 mm to allow for the passage of the spherical containers.

SAS Chamber - The chamber itself is a 244.5 mm x 20 mm wall pipe 110 mm long with flanges welded at top and bottom.

Inner SAS Hatch - The hatch in the bottom of the SAS chamber is a circular steel fitting 36 mm thick, 200 mm in diameter threaded on the outside of the circular center piece to form a tight screw fit. The center is machined out to take another plexiglass view port to permit checking on the inside of the chamber when flooded.

SAS Servo-Motor - Located outside the pressure hull above the SAS is a Hypramag HDK 100 servo-motor manufactured by Sudhydraulic, Marketoberdorf, W. Germany, which is used to open and shut the SAS outer hatch.

CRITICAL VALVES AND PIPING

From each pipe penetrator, a section of pipe runs to a hull valve, The pipe has welded to each end a flange fitting with an O-ring to prevent sea water from coming in contact with pipe threads. This pipe section is flange fitted to a penetrator and a hull valve. From the hull valve thru the remainder of a piping system, Ermeto fittings are used for all piping joints, Pipe sizes from penetrators to hull valve are approximately 3/4" and 3/8" nominal schedule 80 pipe.

Pipe Size and Material - There are three pipe materials used for major systems throughout the boat:

316L Stainless - Schedule 80 (heavy wall) used between penetrator and hull valve for all sea systems (pipe internally subject to sea water),

Size: 26,7 OD x 3,9 mm (3/4" nom, sch, 80 pipe)
17.1 OD x 3,0 mm (3/8" nom, sch, 80 pipe)

35.29 Carbon Steel - Schedule 80 equivalent used between penetrator and hull valve for air and hydraulic systems,

Size: 25,0 OD x 4,0 mm
16,0 OD x 3,0 mm

304 Stainless - Standard wall thickness pipe for sea systems, Used with Ermeto fittings,

Size: 25,0 OD x 2.5 mm
16,0 OD x 1.5 mm
8.0 OD x 1,0 mm

35.29 Carbon Steel - Standard wall thickness pipe for air and hydraulic systems. Used with Ermeto fittings.

Size: 25.0 OD x 3,0 mm
16.0 OD x 2,0 mm
12,0 OD x 1,5 mm
8.0 OD x 1,0 mm

Color Code - The following color code is used for piping systems throughout the boat:

2844# air - dark grey

1422# air - light grey

oxygen - green

hydraulics - yellow

salt water - blue

fresh water - cold water - clear
hot water - black

ARGUS Model BK Ball Hull Valves - Two type ball valves are used -- stainless for sea systems and standard for air and hydraulics. The valves are basically for 3/4" and 3/8" nominal pipe sizes and move from open to closed with 1/4 turn on the handle. Both types of valves were manufactured by Neve Argus Gesellschaft, Ettligen, Goethestrab 15, West Germany.

Stainless (316L) Valve - This hull valve was modified for use in sea water under high pressure. The valve body was enlarged slightly and constructed in a manner to prevent salt water from reaching threaded connections. An O-ring is used at each end where the valve is coupled to a pipe. This new valve is called type SBK. For 3/8" size, burst pressure is 800-900 kg/cm^2 (11,400-12,800 psi) and for 3/4" size, burst pressure is 700-800 kg/cm^2 (10,000-11,400 psi).

Standard Valve - This hull valve is made of carbon steel.

Body - 9S20K steel

Stem - MS58F44 steel

Ball - Chrome plated brass

Seat - Bronze

Globe Valves - All other valves used in sea, air, and hydraulic systems are globe valves manufactured by Voss GmbH, West Germany, and distributed by Hypramag, Zurich, Switzerland. They were modified by adding special inserts - an O-ring protected valve stem and teflon surface plug on the end of the stem Stainless steel valves are used for sea systems (models HVS 25 and HVS 16). Low grade stainless steel is used for air and hydraulic (models HVS 8, 12, 16, 25). The globe valves are designed to operate from 250 kg/cm^2 to 400 kg/cm^2 (3560 psi to 5700 psi) (depending on size) with a factor of safety of 4.

Flange Fittings - Each section of pipe between a penetrator and hull valve has flange fittings welded at each end. These fittings have an O-ring to prevent sea water from corroding pipe threads. They were manufactured by Giovanola Freres, S.A., Monthey, Switzerland.

Ermeto Fittings - Pipe systems downstream of the hull valves use Ermeto compression fittings. These fittings are designed for a maximum pressure of 400 kg/cm^2 (5700 psi) with a factor of safety of 4. For sea systems, stainless Ermeto fittings are used and for other (air, hydraulic), carbon steel is used.

DAMAGE CONTROL AND EMERGENCY EQUIPMENT

Fire Fighting - Dry powder fire extinguishers are located in the following positions:

(1) Forward hemisphere

(2) Aft hemisphere

(3) Amidships

Each extinguisher has five pounds of siliconized, non-toxic, dry powder. To operate, squeeze grip and direct spray at base of fire.

NOTE: Sheets, pillows, pillow cases, mattresses, bunk curtains and crew uniforms (coveralls), are made of non-flammable material.

Smoke Removal - For the purposes of removing smoke, the boat is equipped with a portable exhaust blower and flexible exhaust hose. To operate, place the blower as close to the main concentration of smoke as possible. Rig the exhaust hose to discharge smoke outside of the sail (via the upper hatch).

Specifics:

Blower - 500 c.f.m. capacity

G. E. Motor - 1/4 H.P.
24 Volt D.C.
10.6 Amps
1725 RPM

Portable Bilge Pump - This pump is a standard marine hand pump (plastic) that has a long enough discharge line to reach from any bilge area to the shower.

D.C. Bag (Damage Control) - This canvas bag contains:

o Fiberglass pipe patching kit

o Epoxy (general purpose)

o Pipe patching clamps

o Emergency flares and smokes

o Marlin line

o Duck-seel

Emergency Lights - These six lights are wired into the mode switch and light when 28 Volt D.C. power is lost. They can be removed from their holders for use as flashlights and are located throughout the boat in strategic areas. When in port with the mode switch on zero, the lights must be removed from the circuit or they will be on and operating off their 1.5 Volt NI-CAD batteries. A switch is provided for this purpose. When on the line, the lights will be constantly on Charge (power from 28 Volt D.C. bus). In addition to these, 3 scuba lanterns are provided for use during submerged escape.

Emergency Breathing - A set of six oxygen breathing apparatus are available as required. These are manufactured by chemox. In addition to this, a set of six Drager mixed gas (He/O_2) diving apparatus is provided for emergency use.

Emergency Tool Box - A tool box is provided to effect emergency repairs. The box contains an assortment of metric as well as standard tools.

Fuse Pullers - A set of fuse pullers compatible with all sizes of fuses used in the boat is provided.

PRINCIPAL U. S. SUBCONTRACTORS/SUPPLIERS

Oceanic Enterprises, San Diego, Calif.	Transponder (pinger)
Metric & Multistandard, Yonkers, N. Y.	Metric tools and hardware
Harvey Radio Co., Inc., Woodbury, N. Y.	Sony tape recording kits
Unico Environmental Inst. Co., Fall River, Mass.	Gas chromatograph
Teledyne, Pasadena, Calif.	Portable oxygen analyzer
U. S. Steel, New York City	Flasks & pressure vessels
Hydra Power, New Rochelle, N. Y.	Valves & solenoids
Bellanca A/C Engr. Inc., Wyandanch, N. Y.	Fairings
Tektronix Inc., Roslyn Heights, N. Y.	Oscilloscope
R.F.D. Inc., Richwood, W. Va.	Support boat
Humble Oil & Refining Co., Charlotte, N. Carolina	Marcol 70 oil
Chicago Float Works, Elk Grove, Village, Ill.	Float assemblies
Topaz Inc., San Diego, Calif.	Inverters
Parker Stearns, Brooklyn, N. Y.	Uncured neoprene
Gulfstream Steel Corp., Delray Beach, Fla.	Steel stock & plumbing supplies
Abrasives & Tools Inc., Riviera Beach, Fla.	Cutting tools and hardware
Graybar Electric Co., W. Palm Beach, Fla.	Electronic & electrical supplies
Harry Santos & Co., Fort Lauderdale, Fla.	Paints, chemicals, roping
Gulf Western Industries, Manchester, Conn.	Machining
Dexter Tool Co., W. Palm Beach, Fla.	Precision Parts
Bandy Steel Supply, Jensen Beach, Fla.	Cradle
Aircraft Porous Media, Glen Cover, N. Y.	Filters
Packaged Industrial Power Inc., Jersey City, N.J.	Batteries & battery charger
Hopkins Marine Hardware Co., W. Palm Beach, Fla.	Marine supplies
Powerdraulic-Nielsen Inc., Mount Vernon, N. Y.	Hydraulic fittings
Morris Abrams Inc., Plainview, N. Y.	Ball valves
Allmetal Screw Products Co., Garden City, N. Y.	Monel Hardware
Grimes Mfg. Co., Urbana, Ohio	Rotating beacon and emergency lights
Durham Aircraft Service, Woodside, N. Y.	Hardware
Electro Oceanics, Santa Monica, Calif	Cable Assemblies and Hot splicer with kits
BLH Electronics, Waltham, Mass.	Strain Gages
Mid-Island Electric, Plainview, N. Y.	Fuses
A&M Instruments Inc., Great Neck, N. Y.	Ammeters and shunts
Acromag, Inc., New York City	Counters
American Solenoid Co., Rahway, New Jersey	Switch
Electronic Research Assoc., Cedar Grove, N.J.	Inverters
Globe Steel Abrasive Co., Mansfield, Ohio	Iron shot
Thomas A. Edison Inc., Manchester, N. H.	Switches
Haydon Company, Waterbury, Conn.	Elapsed time indicators
Ebond Epoxies, Ft. Lauderdale, Fla.	Resin & potting compounds
Vaughn and Wright, W. Palm Beach, Fla.	Miscellaneous hardware
Cramer Electronics, Fort Lauderdale, Fla.	Electronic components

B.F. Gilmour Co., Inc., Brooklyn, N.Y.	Polyvinyl Chloride hardware
Southwest Products Co., Monrovia, Calif.	Dyflon bushings
Abscoa Industries, Hartsdale, N. Y.	AN hardware
B. F. Goodrich Co., Shelton, Conn.	Mattresses
Belmont Smelting & Refining, Brooklyn, N.Y.	Lead ballast
David Clark Co., Inc., Worchester, Mass.	Headsets
Kramer Associates, Howard Beach, N.Y.	Gas syringes
Hydro Products, San Diego, Calif.	Deep submergence transmitter & Iodide light and flasher assemblies
Boston Insulated Wire & Cable, Dorchester, Mass.	Hypalon cable
Viking Industries, Inc., Chatsworth, Calif.	Penetrator assemblies
Systems Components Corp., Cocoa Beach, Fla.	Valves & cartridges
Allen-Fry Steel Co., Los Angeles, Calif.	Stainless Steel rod
Tube Sales, Englewood, N. J.	Stainless Steel pipe
Superior Surgical Mfg. Co., Huntington, N. Y.	Bedding and clothing
Manhattan Marine, New York City	Portable marine blower
Stow-A-Way Products Co., Cohasset, Mass.	Food
Huck Mfg. Co., Detroit, Mich.	Monel rivets
Karl A. Neise Inc., Woodside, N. Y.	Belleville Springs
Reliance Steel & Aluminum Co., Santa Clara, Calif.	Aluminum plate
Adam Metal Supply Inc., Long Island City, N.Y.	Aluminum angles & tees
Ducommon Metals & Supply Co., Seattle, Wash.	Aluminum sheet
Joseph T. Ryerson, Jersey City, N.J.	Steel plate, rod and tubing
Scott Aviation, Lancaster, N. Y.	Air packs and chemicals
Straza, El Cajon, Calif.	Underwater telephone; Sonar (CTFM 500)
Van Dusan Aircraft Supply, Miami, Fla.	Circuit Breakers
Rayside Interiors, W. Palm Beach, Fla.	Bunk curtains
Warren E. Collins Inc., Braintree, Mass.	Respirometer
Medical Systems Corp., Great Neck, N. Y.	Pulsemeter
Military Packaging Co., Fort Lauderdale, Fla.	Desiccant
Avdel Inc., Ridgewood, N. J.	Quick Release pins
Richards Aircraft Supply Co., Fort Lauderdale, Fla.	Hardware
Fluid Scientific Inc., Merritt Island, Fla.	Hydraulic Valves
Reuter, Inc., Hopkins, Minn.	Cell jars
Jaco Electronics, Holbrook, N. Y.	Capacitors
Kistler Instr. Corp., Clarence, N. Y.	Depth rate indicator
General Radio Co., Ridgefield, N. J.	Sound level meter
Van Linda Iron Works, Lake Worth, Fla.	Machined parts
Kessler-Ellis Products, Atlantic Highlands, N.J.	Electric counters
Mine Safety Appliance Co., Pittsburgh, Pa.	Power cable cutter
Herbach and Rademan Inc., Phila., Pa.	Ribbon switches
Blake Equipment Corp., Englewood, N. J.	Differential pressure indicator
A. W. Sieloff, Palo Alto, Calif.	Diving masks
Bunting Magnetics Co., Franklin Park, Ill.	Ceramic magnets
Coastal Equipment, Ft. Lauderdale, Fla.	Personnel lockers and cabinets

PRINCIPAL EUROPEAN SUBCONTRACTORS/SUPPLIERS

Switzerland

Giovanola Freres, Monthey	Fabrication of the boat
Jallut, S.A., Bussigny	Paint (exterior)
Isoplex, AG, Zurich	Plexiglass windows
Andre Perreten, S.A., Lausanne	Fabrication of sail
Electrona S.A., Boudry	Batteries
Rolex, Geneva	Chronometers
Haenni, S.A., Jegenstorf	Depth recorder
Hypramag, Zurich	Valves
Atelier de Mechanique de Vevey, Vevey	Machining of hull flange
Georges Fisher, S.A., Schaffhausen	Hull penetrator castings
Longines Watch Co.	Timer

Germany

HOAG, Oberhausen	Steel for the hull
Pleuger Pumpen and Motoren, Hamburg	Electric motors
AEG, Hamburg and Berlin	Inverters and electrical system
Ardie-Werk, Nuremberg	Valves
Sudhydraulic, Marktoberdorf	Hydraulic components/motor
Ermeto Armaturen, Bielefeld	Piping and fixtures
Grundig, Munich	Television
Neve Argus, Ettligen	Valves
Draegerwerk, Lubeck	Artificial breathing apparatus

Austria

Voest, Linz	Steel for the hull

Norway

Simrad, Oslo	Fathometer

France

Olaer France, S.A., Colombes	Accumulator

DR. PICCARD

KAZIMIR

AEBERSOLD

BUSBY

HAIGH

MAY

Dr. Jacques Piccard, Scientific Leader of Mission

Dr. Jacques Piccard, born in Belgium in 1922, is a Swiss citizen and the son of the late Professor Auguste Piccard, who is best remembered for his exploits and explorations of the stratosphere in lighter-than-air-craft and of the ocean depths in vehicles of his own design.

The scientist was educated in Brussels and then in Switzerland, He received a degree from the University of Geneva in 1946, and a year later was awarded a diploma from the Graduate Institute of International Studies there. He was also an assistant professor at the University of Geneva prior to 1950. In June 1962, he was awarded a Doctor of Science degree from American International College in Springfield, Massachusetts,

Together with his father, Dr. Piccard participated in the design and operation of the first bathyscaph. This vehicle, like its successors, operated independently and was not attached in any way to a mother ship, as were earlier oceanographic vessels. The father-son team first constructed the FNRS-2 which was later turned over to the French Navy, and then the "Trieste", which ultimately was purchased by the U. S. Navy, Dr. Piccard piloted the "Trieste" on 65 successive dives. The last of these on January 23, 1960, was the record-breaking descent to 35,800 feet in the Marianas Trench off Guam in the Pacific Ocean.

In 1963-4, Dr. Piccard designed and constructed the world's first mesoscaph or middle-depth vehicle for the Swiss Exposition at Lausanne. This 98-foot submersible was put into service as a tourist submarine and carried more than 30,000 passengers on over 1,100 dives while in Lake Geneva.

Since 1966, he has been an exclusive consultant to Grumman Aircraft Engineering Corporation,

For his contributions to oceanographic science, he was awarded the Distinguished Public Service Award by President Eisenhower, the Theodore Roosevelt Distinguished Service Award and the Argosy Magazine Giant of Adventure Award.

In addition, he has received the Richard Hopper Day Memorial Award of the Academy of Natural Sciences of Philadelphia; honorary memberships in the "Institut Suisse Architects Navals" and "Societe

Helvetique des Sciences Naturelles." He is a life member of the National Geographic Society and holds the Drexel Institute Engineers' Day Award. Dr. Piccard is the author of several technical papers and a popularized account of the Trieste, entitled "Seven Miles Down", co-authored by Robert S. Dietz. The Swiss explorer speaks French, English, German and Italian. He makes his home in Lausanne, Switzerland with his wife and three children, Bertrand,12; Marie Laure, 5 and Thierry, 3.

Donald J. Kazimir, Captain

A native of Ossining, New York, Kazimir attended Wallkill (N. Y.) Central High School and Orange County Community College before receiving an undergraduate degree from Columbia College in 1956. A year later he was awarded a degree in Industrial Engineering from Columbia University School of Engineering. The Ben Franklin skipper also completed Basic Officers' Submarine School after two years of U. S. Navy duty aboard the destroyer USS Savage.

Kazimir, 35, was then assigned to the submarine USS Hardhead, where his posts included those of electronics, weapons, project, navigation and intelligence officer. From 1965-66 he was public affairs officer at the U. S. Naval Submarine Base in New London, Conn. Prior to joining Grumman Corporation in 1967, he was assigned to the submarine USS Tench, where he served as navigation and acting executive officer.

The captain is married to Leila Caliendo Kazimir and the couple make their home in Lake Park, Florida, with their two daughters. Kazimir's pastimes include Scuba diving and photography.

Erwin Aebersold, Chief Pilot

A long-time member of the Bureau Jacques Piccard staff, Aebersold received his engineering training at the Technical School, in Geneva and the University of Lausanne, in Switzerland. He has taught design and theory of plastics at the University of Lausanne, and was responsible for the basic design of the pilot's station for the earlier Piccard submersible, PX-8 (Auguste Piccard).

Aebersold served as chief engineer and shop master during the European construction phase of the Ben Franklin program (1967-8). He is a licensed airplane pilot and certified Scuba diver. His chief contributions to the Ben Franklin design have been associated with the vehicle's pneumatic, hydraulic, electrical, trim and ballast systems, as well as overall vehicle stability and SAS (lockout chamber) study.

The Swiss crewman makes his permanent home in Geneva with his wife, Simone. During the pre-Mission testing and assembly period, the couple have resided in Lake Park, Florida.

Roswell F. Busby, Scientist

Busby is a New York native, having been educated in Williamsport, Penna., before U. S. Army service and undergraduate studies at American University, where he earned a Bachelor of Science degree. He is also holder of a Masters degree in Oceanography from Texas A&M University, where he completed research in disposal of radio-active waste, and the geology of Campeche Bank and the sediment and reef corals of Cayo Arenas.

In 1960, he joined the U. S. Naval Oceanographic Office and Project AUTEC. Five years later he was named project leader for the program, which is concerned with determining the bottom environment of the Tongue of the Ocean, in the Bahamas. In 1966, he was named Branch Head, Deep Ocean Survey Vehicles Project, responsible for determining the design characteristics, oceanographic sensors and operational techniques for a 20,000 foot depth deep ocean survey vehicle. He has conducted operations with and dived in virtually every submersible currently operating in the United States, and currently holds qualifications as a Navy Scuba diver.

Busby is the author of several technical papers and reports, and is the inventor of "an undersea navigation device". He is a member of the Marine Technology Society and chairman of its Deep Vehicles Committee. The scientist is married and lives with his wife and two children in Fort Washington, Maryland.

Kenneth Haigh - Scientist

Kenneth Haigh, 45, was born in Goole, West Yorkshire, England. He received a diploma from Hull Technical College in electrical engineering and has passed qualifying examinations of the Institution of Electrical Engineers and the Institution of Mechanical Engineers. He is a Fellow of the latter group, and holds membership in the Institution of Radio and Electronics Engineers.

Following training by the British Broadcasting Company and three years in the Royal Navy, Haigh spent six years in private industry before returning to the Royal Navy Scientific Service in 1952. He has 17 years' experience in conventional submarines, and considers sonar and shipborne instrumentation his chief professional interests.

Haigh has prepared several technical papers and is the author of a book on submarine cables and cable ships. He has participated in a number of oceanographic research cruises, including a three week tour on a conventional British submarine. He joined the U. S. Naval Oceanographic Office as an exchange scientist in 1968.

The Drift Mission crewman makes his home in Washington, D. C. with his wife and daughter Rachel, 17. Another daughter, Mrs. Johanna Haigh Pavey, leves in Maidenhead, England. Daughter Rachel is an accomplished equestrienne, currently attending the Equestrian Riding Academy in Potomac, Maryland. Haigh counts among his chief pastimes fishing and writing.

Chester B. May, Scientist

Chester B. May is a pioneer in space system maintenance. He was the principal investigator for the space maintenance experiment on Gemini Spacecraft GT8 and GT11, and has written several papers on space vehicle simulators and maintenance.

The NASA researcher also holds a patent for a "space bonding attachment mechanism". Working at the NASA Marshall Space Flight Center in Huntsville, Alabama, May's activities have included space station subsystems maintainability, manned space operational experiment programs and extra-vehicular engineering, weightless and mission simulation.

May earned an engineering degree at Marshall University in West Virginia, and has completed courses in graduate studies at the University of Dayton. He is a native of Williamson, West Virginia, and now makes his home in Huntsville with his wife, Anita Horne May, and the couple's two children, Natalie Jill, 10, and Jesse Duane, 6. A former collegiate wrestling champion, May also performed in his high school band as a trombonist. Among his outside interests are cultivation and raising of orchids and other hothouse plants, and music. In 1966, May had the distinction of originating and chairing the First National Conference on Space Maintenance and Extra-Vehicular Activities, at Orlando, Florida.

MISSION SUPPORT PERSONNEL

Back Up Crew-

W. M. "Bill" Rand - Back Up for Donald J. Kazimir, captain

Rand, a U. S. Naval Academy graduate, is Mission Director, scheduled to head the day-to-day operations of the Ben Franklin and Drift Mission from the M/V Privateer. A veteran submarine expert, with more than seven years in the U. S. Navy's Submarine Service, Rand joined Grumman Corporation in 1967 and was formerly associated with the Fairchild Engine and Airplane Company, participating as project manager in that company's X-1 submarine program. A private pilot and Scuba diver, he is a native of Bangor, Maine. Rand is married to the former Evelyn Parker of Jacksonville, Florida. The couple have three sons, and make their home in Lake Park, Florida.

Harold G. Dorr - Back Up Pilot

Dorr joined Grumman Corporation in 1965 when he contributed to the company's aircraft, hydrofoil, spacecraft and submersible programs. He is a former U. S. Navy petty officer, having served as diesel engineer on the submarine USS Halfbeak. A New York native, Dorr completed courses in mechanical engineering at New York City Community College and holds a degree from Long Island University, C. W. Post College. He is married to the former Rita A. Mero and the couple have two children. They currently reside in Lake Park, but make their home in E. Northport, N. Y. Dorr is assigned to the M/V Privateer during the Mission.

J. Michael Costin - Navoceano Back Up

Costin, a native of Nebraska, is a graduate of the University of Nebraska, where he earned a degree in geology. His professional experience includes eight years at the Lamont Geological Observatory of Columbia University, where his chief interest was in physical oceanographic studies. Costin is scheduled to be aboard the M/V Privateer where his duties will include determining the position of the Ben Franklin within the Gulf Stream and conducting sunlight measurements which will be compared to similar measurements aboard the submersible. A bachelor, Costin makes his home in Arlington, Va.

Roger Merrifield - Navoceano Back Up

Merrifield, who has been with the Naval Oceanographic Office for eight years, is a graduate of Rensselaer Polytechnic Institute with a degree in geology. His duties have included conducting oceanographic studies from conventional (diesel) and nuclear submarines, including service aboard the USS SEADRAGON during its rendezvous with the USS SKATE at the North Pole. Merrifield has acted as party chief on oceanographic expeditions including the submersibles Alvin, Cubmarine, Aluminaut and Star III. During the Drift Mission he is party chief of the Navoceano personnel on the M/V Privateer, and responsible for tracking the Ben Franklin using newly designed tracking equipment. The oceanographer is married and has three children. The family makes its home at West Hempstead, New York.

Richard T. Heckman - NASA Back Up Crewman

Heckman, 35, is a native of Cleveland, Ohio. He was awarded an undergraduate degree in Industrial Engineering from John Hopkins University, and has completed graduate courses at the University of Alabama. He joined NASA in 1966, and is a flight system specialist in crew equipment simulation and testing, working at the Marshall Space Flight Center, in Huntsville. Heckman is a certified Scuba diving instructor and holds both instrument and glider pilot's ratings. Unmarried, the NASA backup man makes his home in Huntsville.

Surface Support Crewman - M/V Privateer

In addition to the back up crewmen assigned to the Privateer, that ship's complement also includes:

Robert A. Quick - Mission Control (back up to Mission Director)

Quick, who makes his home in Palm Beach Gardens with his wife and seven children, is a former U. S. Navy submarine maintenance and operational expert. During his 24 year tenure he was responsible for construction, repairs, overhaul and maintenance of all types of submarines, and was on the staff of the Atlantic Submarine Force, as repair supervisor for two squadrons of Polaris-class vessels. He was a program member of the original crew of the USS Nautilus, and a graduate of Navy nuclear power school. The Montana native joined Grumman in 1968.

Paul G. Campbell - Electronic Specialist

Campbell, a native of Ohio, has extensive experience in maintenance and operation of electronic instrumentation as a former U. S. Navy Electrician's mate. A Grumman employee for almost two years, he makes his home with his wife in North Palm Beach, Florida.

Bruce C. Sorensen - Mechanical Specialist

Sorensen's professional experience embraces more than 11 years' activity in rocket and life support systems, including two years on the NASA Lunar Module program. He can point to 12 years of commercial and sport Scuba diving and U. S. Navy duties as ship's engineer among his personal qualifications. A certified Grumman diver, he joined the company almost four years ago and now resides with his wife and three children in Palm Beach Gardens.

Raymond Gregory - Electronic Specialist

In addition to U. S. Navy service as an experimental swimmer for sea-air rescue procedures, Gregory includes in his experience work as an electronics installer and instrumentation test and evaluation duties. He joined Grumman in 1959, and contributed to the Hydrofoil Dennison program as a technician and diver. He was also involved in the Lunar Module and TFX programs, as well as the hydrofoil PGH-1 (Flagstaff) development. He makes his home with his wife Carrol, and the couple's three children in Centereach, Long Island, N. Y.

Joseph Pollio - Oceanographer (Navoceano)

Pollio, who makes his home in Clenton, Md. (cq) with his wife and nine children, holds a bachelors degree in Geodetic Science, and has completed graduate studies in geodesy and ocean engineering. He has been with the Naval Oceanographic Office for 12 years, during which he has served as a cartographer, instructor, and geodesist and oceanographer. His efforts have ranged from development of various underwater experiments and survey techniques (many of which will be employed during the Drift Mission) to direction of oceanographic expeditions aboard the Aluminaut and Star III. He has authored many professional papers on ocean bottom mapping, use of photography in oceanography and has lectured widely. Pollio will be responsible for geodetic positioning of the support ship and the Ben Franklin, tracking during the mission and for analysis and interpretation of photogrammetric and grammetric data.

Larry K. Hawkins - Oceanographer (Navoceano)

Before joining Navoceano three years ago, Hawkins was associated with the U. S. Geological Survey for five years, conducting studies pertaining to petrology and analysis of marine sediments and marine geology. Since assuming his current post, he has served as chief coordinator and chief scientist aboard AGOR (oceanographic survey) ships during field survey missions. He is presently project oceanographer with the Deep Submersible Vehicles branch, and a qualified Navy Scuba diver. He makes his home in Arlington, Va. with his wife and two children. On the M/V Privateer he is communications coordinator and will assist in the collection of oceanographic data and with tracking and navigation, as well as providing diver support to the Ben Franklin.

Martin Fogot - Electronics Engineer (Navoceano)

Holder of a B.S. in Electrical Engineering from New Mexico State University, Fogot will enter the University of Rhode Island in September to pursue a course of studies for an Ocean Engineering masters diploma. He is involved in instrumentation development engineering and is technical advisor to the Deep Ocean Vehicle group in that technical area. During the Drift Mission he is responsible for development and installation of Navoceano furnished instruments on the Ben Franklin and will operate a new tracking system of his own design. Fogot makes his home in Oxon Hill, Maryland with his wife Sharon.

Peter Bockman - Oceanographer (Navoceano)

A geology degree holder from American University, Bockman is concerned with selection, maintenance and calibration of instrument at Navoceano for deep vehicle operations. He has coordinated the installation and testing of scientific instrumentation on the Ben Franklin and is responsible for field training of survey personnel engaged in Navoceano studies. During the Drift Mission he will validate data and prepare log reports. He makes his home with his wife Barbara and their two sons in Fairfax, Va.

Leroy J. Freeman - Physical Science Technician (Navoceano)

Freeman, who resides in Fredericksburg, Va., with his wife and three children, includes among his duties readying survey equipment and assistance during oceanographic survey operations for Navoceano. His specific assignments during the Drift Mission include collection of oceanographic data in conjunction with the manned research vehicle, manitenance of project equipment and reduction of data obtained on board the support ship.

Surface Support Crewmen - USNS Kellar

Tentative Assignment of Personnel to the USNS Kellar includes:

Fred Dolan, Senior Grumman Representative, of Lloyd Harbor, New York, is concerned with monitoring of data obtained from Ben Franklin and coordinating engineering decisions from the Alert and Technical Alert facilities.

Dr. Raymond Davis, Grumman Human Factors Group, of Babylon, N. Y. is concerned with physiological, microbial and human factors aspects of the Ben Franklin crew and environment.

Robert Oser, Navoceano oceanographer, of Suitland, Md., is chief scientist aboard the USNS Kellar during the Gulf Stream Drift Mission.

Gerald A. Gotthardt, of Hyattsville, Md., Navoceano oceanographer, will study the effects of temperature and salinity on sound velocity in the Gulf Stream.

Wayne Werner, Navoceano electronics technician, will calibrate and maintain the Loran C. navigation system and provide navigational positioning control. He is a resident of Hillcrest Heights, Md.

Alfred G. Lewando, Jr., a Navoceano oceanographer, of Suitland, Md., will measure spacial and temporal variations of the Gulf Stream thermal structure to help develop synoptic sea-surface temperature prediction techniques.

Timothy W. Janaitis, Navoceano oceanographer, of New Carrollton, Md., will assist in biological and water sample collection and analysis as well as acoustic experiments.

Richard Young, Navoceano oceanographer of Forest Heights, Md., will assist in biological and water sample collection and analysis.

William Pugh, Navoceano oceanographer, of Olney, Md., will assist in collection and identification of biological specimens obtained in the Gulf Stream with midwater trawls.

Bernard J. Zahuranec, Navoceano oceanographer, of Oxen Hill, Md., will collect, identify and analyze biological specimens obtained in the Gulf Stream with midwater trawls.

James O. Tayler, Navoceano electronic development technician, of Woodbridge, Va., will calibrate and maintain the electronic equipment used with acoustic and biological data collection systems and assist in data analysis.

Paul Dunlap, Navoceano oceanographer, of Landover Hills, Md., will conduct bio-acoustic experiments of the Deep Scattering Layer within the Gulf Stream.

Roger L. Bach, Navoceano survey officer, of Alexandria, Va., will be responsible for overall survey efforts aboard the Kellar, including administration, logistics, and protocol.

Also on board the USNS Kellar will be a Medical Doctor and Public Information-Photography Representative (Grumman).

Grumman Alert Facility (Bethpage, N.Y.) Personnel

Walter K. Muench, Program Manager, Ben Franklin, of Hicksville, N.Y., will participate in the 'round-the-clock Alert Facility at Grumman-Bethpage, N.Y. A graduate of New York University, where he earned a bachelor's degree in mechanical engineering, he also holds a Masters in that field from Polytechnic Institute of Brooklyn, and is a licensed professional engineer for New York State. Muench, a ten-year employee of Grumman Corporation, includes in his professional experience key roles in the development of the Orbiting Astronomical Observatory (OAO) for NASA, and prior to joining Grumman, directorship of the Nuclear Components Section of the Foster Wheeler Corporation. The program manager has participated in a government-sponsored survey program for the State of Alaska and has wide experience in all aspects of oceanographic planning and survey work. Muench is married to the former Joan D. Schildwachter, and makes his home with his wife and four children in Juno Isles, Florida.

Walter H. Scott, Jr., Director, Grumman Ocean Systems, has headed that group since its inception in 1966. He is a graduate of Webb Institute in New York, where he earned a Bachelor of Science degree in Naval Architecture, and New York University where he was awarded a Masters Degree in Aeronautical Engineering. He joined the engineering staff of Grumman in 1941 and has participated in stress analysis, dynamic load calculation and structural flight test activities, before becoming assistant chief of preliminary design in 1953. In that post he was a participant in the development of several Grumman aircraft, including the WF-2, E-2A, A-6A, the Mohawk, the Gulfstream I, and more recently, the hydrofoil H. S. Denison. He served also as program manager for the Orbiting Astronomical Observatory (OAO) and as chairman of the Space Sciences Group and Advanced Programs Board. He is married to the former Frances Lynd, and makes his home with his wife in Centerport, New York. The couple have two grown sons.

Leo A. Geyer, Deputy Director, Grumman Ocean Systems, has been with the company over 26 years. He has contributed to projects involving aero-dynamics, hydrodynamic measurements, and missile design, as well as contributing efforts on the preliminary planning and design of aircraft and hydrofoil boats. He is a graduate of the University of Rochester where he earned a bachelors degree in Mechanical Engineering, and the Georgia School of Technology, where he was awarded a Master of Science degree in Aeronautical Engineering. Active in professional and engineering societies, he is married to the former Audrey Bulloch. The couple and their three children make their home in Huntington, N. Y.

Grumman Technical Alert Facility (Riviera Beach, Fla.)

Donald B. Terrana, project engineer, heads the Technical Alert Facility. He is a graduate of Polytechnic Institute of Brooklyn, and has attended Princeton University. A licensed pilot, Terrana has been with Grumman for more than 18 years, contributing recently to the F-111 program, prior to participation in the European construction phase of the Ben Franklin. An accomplished still and motion picture photographer, Terrana is married to the former Janice Smith. The couple and their three children currently reside in Riviera Beach, Florida. They make their permanent home in Oakdale, New York.

SURFACE SUPPORT

M/V PRIVATEER

Close-in escort ship for the Ben Franklin is the M/V PRIVATEER, an ex-U.S. Navy patrol craft (McMinnville- PCS- 1401), now operated by the Reynolds International, Inc., as a tender vessel for the deep submersible Aluminaut.

Privateer is a 250-gross ton wooden-hull ship capable of towing, tracking and tendering the submersible or conducting independent bathymetric surveys. It has adequate facilities for housing its operating crew, submersible support equipment, scientific and Ben Franklin operations personnel and ancillary laboratory or over-the-side equipment.

Principal Characteristics

Length Overall: 136 feet

Maximum Beam: 25 feet

Gross Tonnage: 250

Draft: 9 feet

Propulsion: Twin Screw/1,000 SHP

Cruising Speed: 10 knots

Fresh Water: 2,000 gallons

Towing Speed: 8.0 knots in Sea State 0 (Towing Screws Installed)

Crew: 12 maximum

Special Equipment

Navigation: Transistorized Loran D-X Navigator, allowing conservative ocean positioning within 0.2- 1.0 nautical miles at distances to 12,000 miles from baseline.

Communications:	Radar is 32-mile Raytheon Model 4000
	Radio transceivers and receivers include Raytheon Ray 75A-3C 2-5 mc, 10 crystal channel, 150W output plus receiver; Raytheon Model 1045, transistorized, battery-powered 1.8-3.8 mc, 6 crystal channel 45 W output plus receiver for .5-1.65 mc; two Hallicrafter all-band receivers, .5-30 mc; one air-to-ground receiver, 108-130 mc.
Depth Indicator:	Fathometer to 1,200 feet; Gift Precision Depth Recorder to 24,000 feet, with UQN transducer
Underwater Telephone:	AN/UQC-1B and equipment compatible with Ben Franklin equipment. A magnetic tape recorder is also installed for monitoring transmissions.

USNS KELLAR

Also furnishing surface support is the USNS John Gilbert KELLAR (T-AGS 25), a hydrographic survey vessel operated by the Military Sea Transportation Service, under the technical direction of the Commander, U. S. Naval Oceanographic Office. The 208-foot ship became operational this year, and is designed and equipped to collect depth soundings in coastal waters, and in its present role, to plot the course of the Gulf Stream and conduct synoptic measurements in conjunction with those taken by the crewmen aboard the Ben Franklin.

Principal Characteristics

Length, overall	208'4"
Length, waterline	196'
Beam, molded	39'5"
Draft, mean full load	13'11"
Shaft Horsepower	1000

RPM	200
Speed (sustained)	12 knots
Displacement, full load	1297 tons
Fuel Oil	300 tons
Potable Water	14 tons
Endurance	12,000 n.m. at 12 knots
Stores	60 days

Echo Sounding Equipment

Deep Water Broad Beam

Deep Water Narrow Beam

Long Range Scanning Sonar

Depth Recorder (19-inch)

Scanning Sonar (Portable)

Ship Positioning Equipment

EM Log

Gyro Compass

Loran-C Receivers

Satellite Receiver

Electronic Positioning, Range-Range

Electronic Positioning, Hyperbolic

Radar

Ben Franklin Launch

GULF STREAM DRIFT MISSION OPERATING PLAN

Mission Objectives - The primary objective of the Drift Mission is to permit the deep submersible Ben Franklin to drift with the Gulf Stream safely for 30 days, performing scientific oceanographic studies within the capabilities of the craft and support system.

Supplementary to this is the objective to travel the maximum distance along the track of the core of the Gulf Stream at varying depths; to investigate the analog between a submersible and a space station during a long-duration, closed-environment stressful voyage; and to demonstrate the engineering-operational concepts associated with long-duration submersible operation.

General Description - The Gulf Stream Drift Mission will last for thirty (30) days. The Ben Franklin will initially submerge in the Gulf Stream off the coast of Florida near West Palm Beach, carrying a crew of six and sufficient food, water, oxygen and life support equipment capable of supporting it for 42 days. The vehicle is to drift in a northerly direction, following the Gulf Stream. Oceanographic data of a geophysical-biological nature will be recorded during the Florida to Cape Hatteras portion of the drift. Five descents to the bottom are planned in this area, during which the Ben Franklin will drift along within 30 feet of the bottom for a 24-hour period.

From Cape Hatteras northward the oceanographic data taken will be primarily biological with fewer geophysical measurements being made. A continuous drift is planned in this region with no descents, since the bottom is beyond the 2,000-foot depth capability of the submersible.

Organization - The mission is organized to provide maximum safety while at the same time seeking to assure maximum opportunity for achievement of the mission objectives. Conduct of the mission is a Grumman Corporation function. The execution of this conduct rests with the mission director, on board the M/V Privateer. To support him, there is a Grumman Alert Facility at Bethpage, N. Y., and a Grumman Technical Alert Facility, at Riviera Beach, Florida. In addition, support is available from the Commander, Eastern Area, U. S. Coast Guard and the Chief of Naval Operations, which agencies will maintain mission monitoring.

Mission Control - The mission director will maintain mission control with a continuous tracking watch. With the exception of the safety of conduct of the assigned ships and their crews, the mission director will control all operations of the mission on the scene.

Mission Alert Facility - On the day of departure of the mission, a Mission Alert Facility will be established at Grumman-Bethpage. This facility will be maintained on an around the clock basis for both telephone and teletype communications and will be the central point for all Grumman shore-based activities during the Drift Mission. All Grumman communications from the mission director will be addressed to the Mission Alert Facility.

In the event of involvement of the U. S. Coast Guard Rescue Control Center, the Mission Alert Facility will provide a Grumman liaison representative on the scene at the Rescue Control Center, Governors Island. Responsible Grumman liaison representatives will limit their personal activities, when in an alert status, such that they can be at the Bethpage air facility within 30 minutes for a helicopter pick-up to Governors Island and the Rescue Control Center.

Mission Technical Alert Facility - Simultaneous with the establishment of the Mission Alert Facility, there will be established a Technical Alert Facility at Riviera Beach. The Technical Alert Facility will maintain an around the clock telephone watch. Personnel assigned to the Technical Alert Facility will be on call around the clock and will keep the Facility advised of their whereabouts on a one hour notice basis. This facility will have the responsibility for providing technical information relative to the Ben Franklin for abnormal or emergency reasons.

Mission News Headquarters - Grumman will maintain a Mission News Headquarters at Suite 747, National Press Building, Washington, D. C. All press releases relative to the mission will be cleared by this activity. Source data for this activity will be daily situation reports and other information originated by the mission director and passed to the Grumman Alert Facility. Upon occasions, the Grumman News Headquarters may request contact by Mission Control in which case communications will be established through the Grumman Alert Facility. News Headquarters telephone number is 202-393-2666.

Communications - Communications will be established to permit an orderly flow of information from Mission Control with emphasis on providing safe conduct data to those agencies having an emergency responsibility in response to any call for assistance.

Communications for non-critical information will be conducted on commercial radio-telephone networks utilizing marine operators and land lines to private telephones.

All communications relating to the Drift Mission and its conduct will be issued by the Mission Director. All other communications will be cleared through Mission Control prior to release.

Navigation - The M/V Privateer navigational position will be plotted continuously by Loran C. A navigational position will be passed to Ben Franklin each four hours commencing at midnight.

Tracking - Ben Franklin will be tracked by two parallel tracking systems installed on the submersible. The bearing pinger operates continuously at intervals of two pulses per second at 24 KHz. The range interrogator system operates at 27 KHz and may be manually controlled. In addition to the regularly installed redundant system, there is a battery powered 4 KHz pinger which emits a pulse every 2 seconds. This system also has a range transponding feature which may be controlled from Privateer.

Without prejudice to the intent of the provisions of these two sections, during the Gulf Stream Drift Mission, the Ben Franklin hatch should not be opened without due consideration of the impact of this act upon the primary objective of the mission.

Every attempt should be made to establish radio contact before committing to other means of contact which may require unsealing the craft.

Establishing radio contact will retain the option of discussing the underwater communication and tracking difficulties to make a realistic evaluation of further safe conduct of the mission utilizing abnormal tracking and communication.

A continuous watch will be maintained on Privateer. During the hours of 2:00 to 4:00 P.M. a split phone watch will be maintained in Miami for incoming commercial radio-telephone calls. As the mission develops, Mission Control will advise Grumman Alert of shifts to Jacksonville, Charleston, Norfolk, New York, and Boston.

In an emergency, outside split-phone watch hours, Mission Alert may request Rescue Control Center, Governors Island to relay message to M/V Privateer. Generally, Mission Control will respond on regular commercial radio nets.

Position Reports and Safety Status Reports - At 12:00 noon each day, Grumman Mission Control will contact U. S. Coast Guard Radio on single-side-band voice circuits to pass on a daily status report. The working station will pass this message via Telex to the U. S. Naval Oceanographic Office, Suitland, Maryland and Grumman Mission Alert, Bethpage, New York. In addition, the Coast Guard will pass this message to U. S. Coast Guard Commander Eastern Area and the U. S. Navy, Chief of Naval Operations.

The format of this message will be as follows:
GRUMMAN GRUMMAN GRUMMAN This is WV________ M/V Privateer, Ben Franklin Drift Mission Daily Number ________________.
    11:00 A.M. Position _______ ________ North Latitude
    _______ ________ West Longitude

Next interval estimated course ________________ SOA ____________ knots.
Conditions Normal (Except ______________)
    Abnormal (but acceptable)
    Contemplating Abort
    Aborted at __________ Q proceeding to ________
    ETA ___________ Q

In the event that the Coast Guard Rescue Control Center does not receive a Mission Daily by 2:00 P.M. on any given day, an automatic fixed-wing aircraft fly-over will be activated. If visual contact is not established within a reasonable time, the National Search and Rescue Plan will be activated.

Situation Reports (Sitreps) - At 2:00 P.M. each day, Grumman Mission Control will pass a SITREP via regular commercial radio-telephone facilities to the Grumman Alert Facility. The SITREP will include all information contained in the Mission Daily and will amplify any abnormalities. Personnel information and items of general interest will be included on an as occurring basis. The Grumman Alert Facility will distribute the SITREP via Telex to the U. S. Coast Guard Commander Eastern Area, the Chief of Naval Operations and the Grumman News Headquarters as well as other interested addressees.

Data transmissions will be released by Mission Control and passed on single side band frequencies directly to Suitland, Maryland on a pre-arranged basis not to interfere with Mission Dailies, SITREPS or regular primary guards. Navoceano will Telex received data to Grumman Mission Alert.

AMVER (Automated Merchant Vessel Report System) - Automated Merchant VEssel Report (AMVER) System, operated by the United States Coast Guard, is a maritime mutual assistance program which provides important aid to the development and coordination of search and rescue (SAR) efforts in many offshore areas of the world. Merchant vessels of all nations making offshore voyages are encouraged to voluntarily send movement (sailing) reports and periodic position reports to the AMVER Center located at Coast Guard New York, via selected coastal, extra continental, or Ocean Station Vessel radio stations. Information from these reports is entered into an electronic computer which generates and maintains dead reckoning positions for the vessels while they are within the plotting area. Characteristics of vessels which are valuable for determining SAR capability are also entered into the computer from available sources of information. Appropriate information concerning the predicted location and SAR characteristics of each vessel known to be within the area of interest, is made availalbe upon request to recognized SAR agencies of any nation, or person in distress, for use during an emergency. Predicted locations are only disclosed for reasons related to maritime safety.

This system will be used by the U. S. Coast Guard Commander Eastern Area to track mission progress. On the day of departure, Mission Control will originate an ANVER type I message to instigate the computer plotting system. Mission Dailies will automatically be used as an update when they are received by the U. S. Coast Guard Commander, Eastern Area. ANVER will be alerted by Mission Control upon arrival at the port of mission termination.

Weather - Mission Control will utilize regular Marine Weather Broadcasts as well as U. S. Navy Fleet Weather Center. Fleet Weather will be copied by Kellar and passed to Privateer by voice. Privateer will monitor regular Marine Weather Broadcasts.

Arrangements have been made for a land line patch to the U. S. Navy Fleet Weather Center (Norfolk) to permit Mission Control to consult directly with a forecaster if the situation warrants such a consultation.

Coast Guard Rescue Control Center (RCC) - RCC will normally receive data necessary for activating the National Search and Rescue (SAR) Plan through Mission Dailies received from the U. S. Coast Guard Commander, Eastern Area. In addition, the Grumman Mission Alert Facility will pass SITREPS directly to RCC by Telex. In the event of activation of the National SAR Plan, the RCC will pick up the Grumman Mission Alert Representative by helicopter at the Grumman, Bethpage Air Facility tower base for immediate transportation to RCC Governors Island. This pick up will be instituted by telephone from RCC to Grumman Alert Facility.

Premature Terminations And No Return Radials - Ports listed below are possible premature termination destinations. Depending upon the actual track location east or west of the West Palm Beach to Cape Hatteras route, some ports may or may not be real options because of the intersection of no return radials relatively distant to the west of the track. Two such ports are obviously not real options (Port Royal and Winyah) but are included for reference.

As the mission tracks east from Cape Henry, Norfolk, Virginia remains the option port until noon on day 22 at which time it shifts and becomes Boston, until the termination of the mission. New York is not an option in that it is more remote at the equal range positions from Norfolk and Boston. New York could only become an option if the actual track is somewhat north of the anticipated track.

Departure	Arrival
West Palm Beach	Fort Pierce
Fort Pierce	Port Canaveral
Port Canaveral	Jacksonville
Jacksonville	Fernandina
Fernandina	St. Simon
St. Simon	Savannah
Savannah	Port Royal
Savannah	Charleston
Charleston	Winyah
Charleston	Cape Fear
Cape Fear	Cape Lookout
#1 No Return	Cape Henry
#2 No Return	Norva

Support Van Movements - The Ben Franklin truck-mounted support van will move along the coast parallel to the path of the Drift Mission. As the mission proceeds across each no-return radial for optional ports, the support van will be requested to advance to the next optional port. Mission Control will request that Mission Alert contact the van crew by telephone to advise the move. Upon arrival at the new port, the van crew will advise Mission Alert by telephone on their arrival. Mission Alert in turn will advise Mission Control. The van crew will establish a 24 hour a day telephone watch for instructions from Mission Alert upon arrival of each station.

For planning, the best estimate of van movement is as follows:

Day 1	In West Palm Beach
Day 2	Depart for Fort Pierce
Day 3	Depart for Jacksonville
	Telephone check in at Melbourne with Mission Alert
Day 5	Depart for Charleston
	Telephone check in at Brunswich and Savannah
Day 8	Depart for Wilmington, N. C.
Day 14	Depart for Norfolk, Va.
Day 22	Depart for New London, Conn.

U. S. Coast Guard Search and Rescue and Rescue Control Center - In the event that assistance is required during the course of the mission, the call for assistance will be issued to the U. S. Coast Guard. This will be passed to the Coast Guard Rescue Control Center (RCC) Governors Island, New York. The RCC under the National Search and Rescue (SAR) plan will have the responsibility for mobilizing and directing the SAR effort. Upon request of the RCC or activation of SAR plan a Grumman representative from the Grumman Alert Facility will be helicopter transported from Bethpage to Governors Island for consulting assistance.

Under the terms of an inter-agency federal government agreement (National SAR Plan), the RCC has statutory authority to call upon the facilities of all agencies of the federal government to assist. In several possible cases the facilities of the U. S. Navy may be required.

Evacuation - In the event of a serious injury or illness on either the Privateer or Ben Franklin and the RCC determine that evacuation is risky or impracticable, the mission will be aborted.

Submerged Rescue - In the event that the need to conduct an underwater rescue becomes necessary, the RCC will request the assistance of the U. S. Navy Supervisor of Salvage (SUPSAL) from the Chief of the Naval Operations. The RCC will designate the senior representative of SUPSAL as in charge on the scene. The Grumman Mission Director will embark with the SUPSAL representative and act in a consulting capacity.

Without prejudice to such action as SUPSAL may deen appropriate, the following are guide lines for submerged rescue.

(1) Ben Franklin will have a minimum of two weeks of life support capability on the occasion of an incident.

(2) Ben Franklin personnel have the ability to evacuate the craft and proceed to a Personnel Transfer Capsule for transfer to the surface and decompression. The equipment used for this escape is the Drager FGG III which has a rated depth of 685 feet. These equipments are set on a mixture of 90% He, 10% 0_2 with a dosage of 50 liters per minute.

(3) Ben Franklin has two high salvage hull valves.

(4) Ben Franklin has a multiplicity of pad-eyes and hard points which may be used for cable attachments for pick up.

(5) Ben Franklin has a maximum operation depth of 2,000 feet with a designed collapse depth of 4,000 feet. Actual stress data in addition to calculations and analysis of model testing show that the hull may be expected to be intact at 5,000 feet. Ben Franklin carries two 34 KHz water activated pingers at internal high and low point locations to indicate the presence of water within the pressure hull.

(6) Every effort should be made to raise the Ben Franklin intact. To depths of 500 or 600 feet, hard hat divers may be utilized to attach a cable for lifting. Beyond this depth another submersible which is manipulator equipped may be utilized. Only as a last resort should an escape be attempted.

On June 1, 1969 SUPSAL will have the following equipment in the noted status:

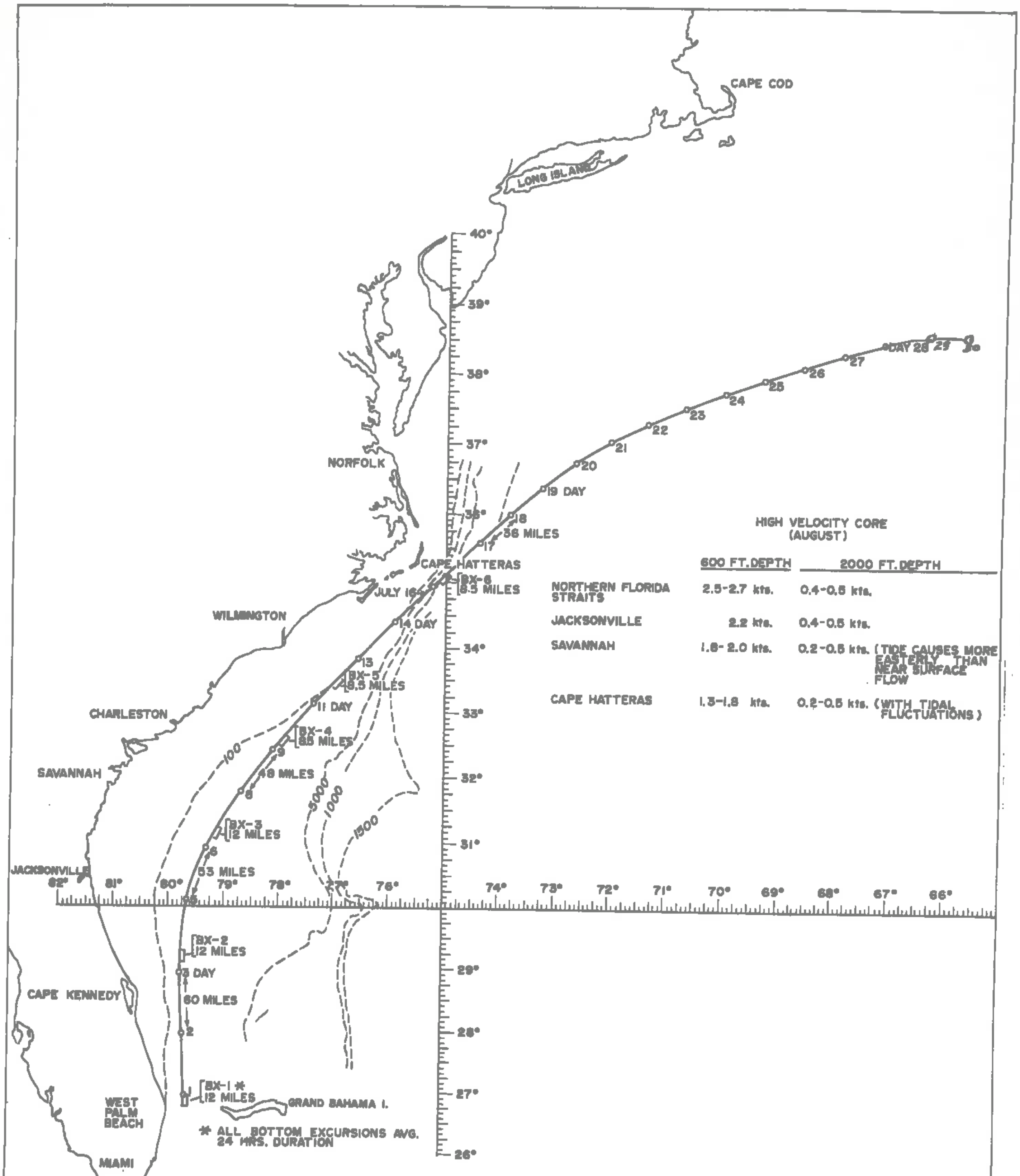
Location	Equipment	Status
Key West, Florida	ARS	Ready
Key West, Florida	YMLC**	Bare Boat
Miami, Florida	Aluminaut*	24 hr. standby
West Palm Beach	State Point	Ready
Fort Pierce	ADS IV ***	Ready
Mayport	ATF/ATA	Ready
Charleston	ARS	Ready
Norfolk	ASR/ARS/ATF	One or two ready
New York	ARS	Ready
New York	YMLC**	Bare Boat
New London	ASR	Ready
Subic Bay	ADS IV***	Ready
Santa Barbara	DOWB*	Under agreement with Sandia Corp.

There is an additional ADS IV system at the Union Carbide Plant in Tonawonda, New York which could be dispatched to the scene.

* Maximum operating depth in excess of 5,000 feet.

** Bow lifting capacity 300 tons.

*** ADS IV is a deep diving system utilizing a personnel transfer capsule (PTC), deck decompression chamber and crane handling equipment.



ANTICIPATED BEN FRANKLIN DRIFT

Pre-Mission Phase

During the pre-mission phase, Ben Franklin (including experiments), support ships and other support systems will be readied and checked out according to prelaunch procedures.

The submersible will be taken in tow by M/V Privateer with the crew aboard; the hatches will be closed at dockside. Upon arrival at the dive site it will be rigged for diving. The mission will start when the submersible is fully submerged.

The Mission Phase - The Gulf Stream Drift Mission has been divided into 9 blocks, which nominally cover approximately 1200 miles and 30 days. The first six blocks are each a fixed distance as determined by the pre-selected dive sites. The remaining 3 blocks are fixed time intervals due to the "pure" drifting character of the latter portion of the mission.

The duration of each of the first six blocks is based on the best prediction of stream velocities which will be encountered at the center of the Gulf Stream. As such, the times of these blocks may differ somewhat from the nominal due to variations in the stream speed and non-optimum location of the Ben Franklin in the stream.

The location relative to the stream will be transmitted to the submersible by M/V Privateer, and corrections will be made as required.

Block I - Block I starts at 26° 40' N. latitude and 70° 42' longitude, the point of first submergence off West Palm Beach. The Ben Franklin will submerge to the bottom for a two-hour instrumentation checkout. Following the checkout, the boat will ascend to the 600 ft. depth and drift along at this depth until the start of the first bottom survey, which is the beginning of Block II.

Block II - Block II starts nominally 56 hours into the mission at 29° 06' north latitude and 79° 47' longitude at the initiation of the first bottom survey dive from 600 ft. nominal cruise depth. This mission block lasts 73 hours and contains:

a) Dive to within 30 ft. of the bottom.

   1) Add approximately 100 lbs. of water in one VBT.

   2) Let boat stabilize at note depth and depth rate.

3) Add more water and note new trim point.

4) Repeat step 3 until trimmed at bottom guide rope.

5) Turn on thalium iodide light, CTFM and amp hour system, SS Sonar, sub bottom profiler, 35mm cameras and broad band hydrophones.

b) Drift along the bottom for approximately 24 hours taking pictures and geophysical measurements.

1) Personnel at stations

2) Conduct bottom experiments

3) Perform normal crew activities and take data as required.

4) Terrain follow using guide rope, air or power.

5) Rise preparations (ready equipment and crew).

6) Secure all above equipment including hydrophone receivers

c) Rise to 600 ft. depth.

1) Pressurize same VBT which was filled for dive. Blow empty.

2) Turn off CTFM, thalium iodide lights, etc.

3) Let boat stabilize and note depth. Stabilization depth should be close to original depth (600 ft.).

4) Final trim to desired depth.

d) 600 ft. drift (approximately 2.5 knots).

1) Personnel at stations.

2) Conduct drift experiments.

3) Perform crew activities. Turn on transducers and 70mm camera systems.

4) Take data.

5) Continue drift for approximately 47 hours (to next dive pt.).

6) Relocate boat relative to Gulf Stream core if required.

This sequence is generally repeated through Block VI, when the submersible passes Cape Hatteras and continues in the 600-foot depth drifting mode through Blocks VII, VIII and IX.

There are five planned excursions to the vicinity of the bottom for conducting of specified experiments, one each in the neighborhood of Cape Kennedy, Brunswick, Charleston, Cape Fear and Cape Hatteras.

Activities - In addition to piloting the boat and performing the experiments described briefly in Section 2.0 of this document the crew will be performing numerous everyday functions such as eating, sleeping, exercising, relaxing (recreation) and general observations. The performance of all of these activities are based on certain prescribed dictates such as:

a) A Pilot on duty at all times.

b) A minimum of two men awake at all times.

c) Performance of experiments at required frequency.

d) Easy transfer from a normal drift day to a bottom survey day leads to the construction of a specific crew timeline. Transfer from a normal drift day to a bottom survey day (Allowing D. Kazimir to be pilot during the initial phase of the bottom survey) is facilitated by having Kazimir use Piccard as a relief pilot thus allowing him to rest or make up sleep.

CREW ACTIVITIES

MEALS & SNACKS

ACTIVITY		TIME REQ'D MIN.
A.	Preparation	10
B.	Eat	20
C.	Clean up	5

Notes:

(1) Three 35 minute periods are allocated daily for Breakfast, lunch, and supper.

(2) Periods for snacks have also been identified. However, these may be taken whenever desired.

HYGIENE

ACTIVITY		TIME REQ'D MIN.
A.	Wash	5
B.	Dress, (undress)	5
C.	Misc.	5

Notes:

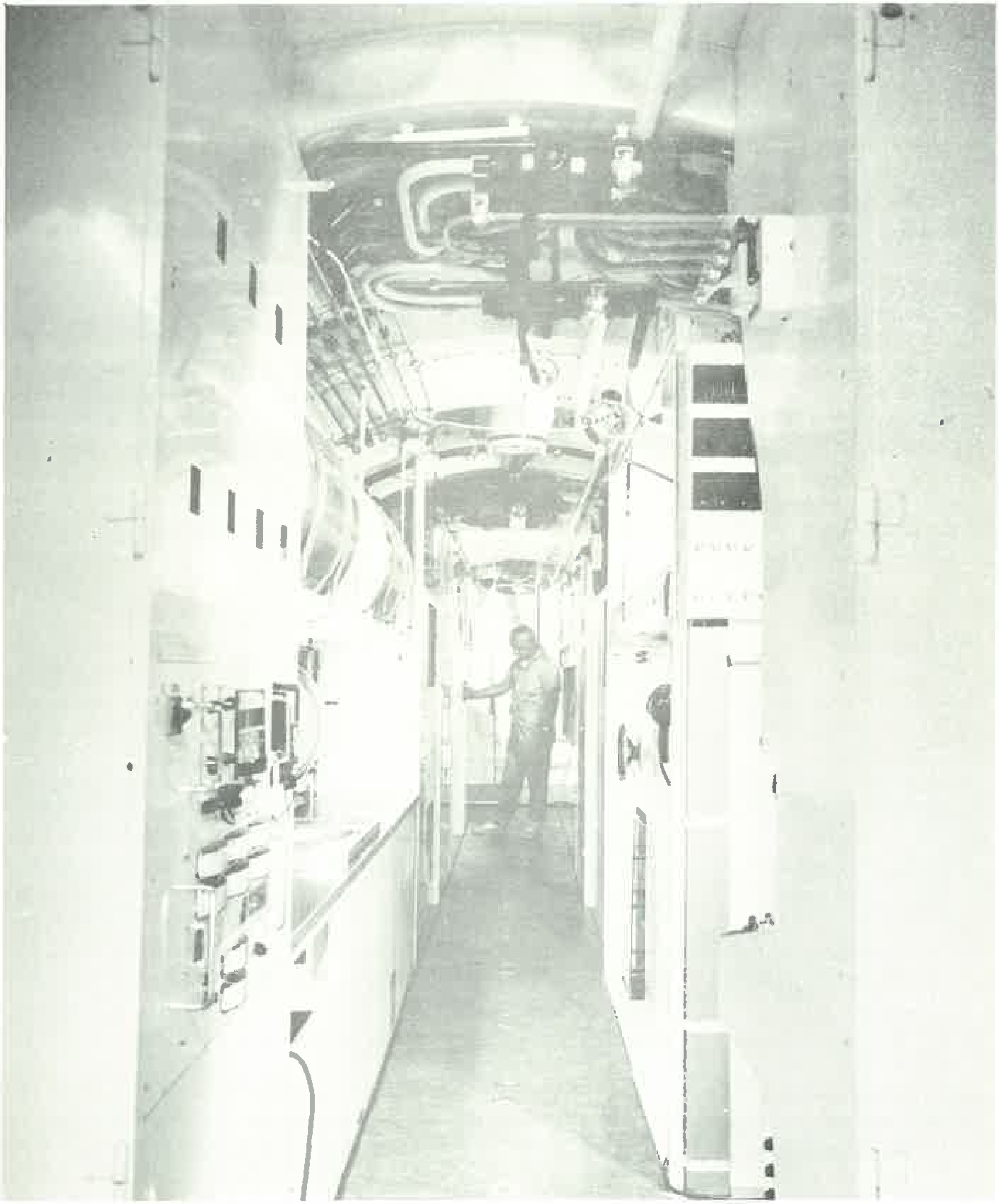
(1) Two 15 minute hygiene periods have been allocated daily.

(2) Miscellaneous items will include changing of linens, clothes, shower, etc.

SLEEP/NAP

SLEEP--A daily eight hour sleep period has been provided for each member of the crew. Fifteen minutes at both the beginning and end of this period have been allocated for hygiene.

NAP--A few hours rest period has been provided during which the crew may nap or participate in any form of recreation.



Interior View

FOOD, WATER, CLOTHING

Most of the food consumed during the Gulf Stream Drift Mission is freeze-dried or dehydrated. Thus by adding hot or cold water, the meals are prepared, normally in one or two-man portions.

The freeze-dried, dehydrated meals were chosen for several reasons: They can be reconstituted merely by the addition of water, eliminating the need for cooking and power consumption, or refrigeration; they can be prepared without cooking odors, smoke or a variety of utensils, and they can be easily portion-and calorie-controlled.

The menu below provides an average of 3158 calories per man per day. Meals are packed in two-man-day units, consisting of breakfast, lunch, dinner and a snack. The polyethylene bag containing these units is utilized as a refuse container at the conclusion of each meal.

Each crewman is assigned a set of teflon-coated eating utensils. After a meal the utensils are dipped in a sterilizing solution and wiped dry. The same procedure is followed with pots and mixing bowls used for preparation of the consumables. Refuse is sprayed with a sterilizing solution to prevent biological contamination, and stored in plastic bags.

The foods, prepared and packaged by Stow-A-Way Products Co., are packed in the following combinations:

BREAKFASTS

B-1
Orange Crystals
Familia/Milk/Sugar
Tea/Sugar
Coffee Mate
Nut Roll

B-2
Orange Crystals
Instant Scrambled Egg
Bacon Bar
Pecan Roll
Coffee/Sugar
Coffee Mate

B-3
Pineapple Crystals
Familia/Milk/Sugar
Fruitcake
Coffee/Sugar
Coffee Mate

B-4
Grapefruit Crystals
Frosted Flakes
Milk (non-fat)
Sugar Packs
Nut Roll
Coffee/Sugar
Coffee Mate

B-5
Pineapple Crystals
Instant Scrambled Egg
w/Bacon Bits
Nut Roll
Coffee/Sugar
Coffee Mate

LUNCHES

L-1
Deviled Ham
Crackers
Mustard
Pea Soup
Lemonade

L-2
Tuna Salad
Bread
Peach Slices
Grape Drink

L-3
Chicken Salad
Crackers
Chocolate Milk Shake
Cheese
Orange Drink

L-4
Egg Salad
Bread
Fruit Cocktail
Beef Soup
Lemonade

L-5
Chicken Soup
Peanut Butter
Jelly/Honey
Bread
Grape Drink

DINNERS

D-1
Beef Soup
Beef/Rice Dinner
or Beef Stew
Carrots
Crackers
Chocolate Pudding
Coffee/Sugar
Coffee/Mate
Salt/Pepper

D-2
Chicken Soup
Ham
Apple Sauce
Mashed Potato
Peas & Carrots
Coffee/Sugar
Coffee Mate
Salt/Pepper

D-3
Pea Soup
Beef Stew
Mashed Potato
Peas
Butterscotch Pudding
Coffee/Sugar
Coffee Mate
Salt/Pepper

D-4
Chicken Soup
Beef Patties
Mashed Potato
Peas
Nut Roll
Ketchup
Coffee/Sugar
Coffee Mate
Salt/Pepper

D-5
Potato Soup
Chicken Stew
Carrots
Crackers
Fruit Cocktail
Nut Roll
Coffee/Sugar
Coffee Mate
Salt/Pepper

SNACKS

S-1	S-2	S-3
Raisins (2)	Fig Bars	Mandarin Oranges
Chocolate Bars (2)	Cheese	Raisins
Nuts	Chocolate Bars	Nuts

S-4	S-5
Malted Milk Tablets	Nut Roll
Beef Jerky	Peaches
Chocolate Bars	Chocolate Bars

Like electrical power, water is a severely limited commodity aboard the Ben Franklin. It is allocated to food preparation, washing and showering, cleaning utensils and contingency requirements.

Hot water is assigned to food preparation (973 lbs. or about 118 gallons) and washing and showering (595 lbs. or about 72 gallons). The hot water is stored on board in four insulated tanks. Heated on at the beginning of the mission to 210-degrees F., the water will cool to 160-degrees at the conclusion of the mission... still hot enough to suitably prepare meals.

The cold water is used for food preparation, utensil washing and showering. A total of 3144 lbs. or about 379 gallons of cold water are allocated for these functions.

Daily requirements per man of hot and cold water include:

Hot Water		Cold Water	
Food	5.4 lb.	Food	3.75 lb.
Wash	1.7 lb.	Wash	5.3 lb.
Shower *	1.6 lb.	Shower *	5 lb.
		Utensils	1 lb.

* This represents the daily water allocation for showering. If a shower is taken every day, slightly less than a gallon is available. A shower every second day gives almost two gallons.

The crew consumes an average of 52 lbs. of hot water daily and 90 lbs. of cold water. A log of water usage will be kept and if water is consumed at a lesser rate than planned, the men will be able to shower more frequently, and vice versa.

Clothing

Each crewman is issued:

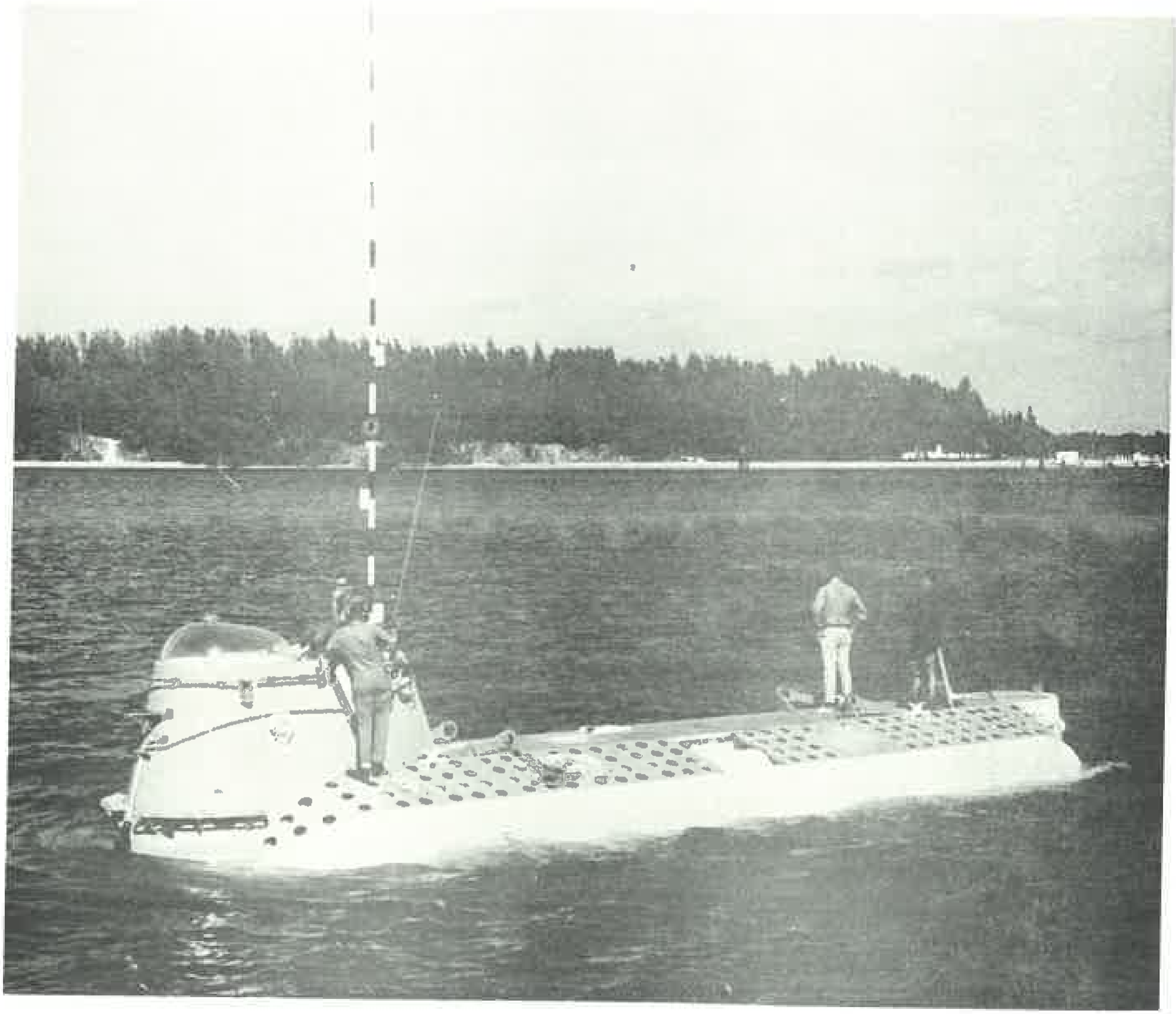
One dozen changes of underwear (T-shirts and boxer shorts)
One dozen changes of socks
Two pairs of deck shoes
Three pairs of walking shorts
Three pairs of coveralls (jump suit)
One sweater.

With the exception of the coveralls and deck shoes, all clothing is made of dacron/cotton. They are treated with an antimicrobial agent, permitting underwear and sox to be worn continuously for three days. Individual sets of underwear and socks are packaged in double sealed plastic bags which are used for storage after use.

The coveralls are made of "Nomex", fireproof fabric produced by DuPont. (The same garments are popular with racing car drivers.) The material is nylon, treated also with antimicrobial agents.

Mattresses are four inches thick and fire-retardant, produced by B.F. Goodrich Corp. They are said to be the first fire-retardant mattresses ever made.

Sheets and pillow cases are made of 80 per cent dacron and 20 per cent cotton fabric. This mixture presents good thermal characteristics, has excellent washing characteristics and is slightly water repellant. These items, too, are treated with antimicrobial agents to minimize bacterial growth while bedding is in use and during the time it is stored after use. Bedding will be changed once a week. Two sheets, a pillow case and cotton bath towel are packaged in a double sealed plastic bag that also serves as a storage bag for used bedding. Six sets of bedding are provided for each man. One lightweight dacron/cotton blanket is provided for each crewman as well.



On the Surface

GRUMMAN-PICCARD EXPERIMENT: OCEANOGRAPHIC OPTICS

Experimental Procedure - Measurements will be made of chlorophyll (Plankton), minerals (Fluorescent) and bio-luminescence.

The measurements of chlorophyll and minerals are to be made approximately every eight hours, preferably during the night, because residual light from the sun penetrating the sea causes an undesirably high background level that obscures precise measurement of the desired parameters.

The measurements of chlorophyll and minerals will also be made if any unusual phenomena such as change of sound velocity in sea or change in downwelling light and before and after any depth or position change of the Ben Franklin.

The measurements of bio-luminescence are to be made during forward propulsion maneuvers.

All measurements will be made, if possible, with external Ben Franklin lights out, and preferably with internal lights out, or at least blocking of internal light to the aft portholes so that the sensors have as low a light background as possible.

No measurements will be made during the day at depths less than 100 feet, because they will be generally worthless because of the high background light and the photomultiplier sensors may be damaged.

Date and time of all measurements are to be recorded.

NAVOCEANO SCIENTIFIC PROGRAM

The scientists of the Oceanographic Office are particularly interested in the Gulf Stream Drift Mission, one of the most extensive scientific operations ever to be conducted aboard a manned submersible, because it is expected to yield valuable data on the nature of the stream, the marine plants and animals associated with it and the sea floor topography it flows over. The mission also will provide the Oceanographic Office with valuable knowledge on the use of a deep-diving, manned submersible for ocean research and survey work.

Oceanographic Objectives -

Nature of Gulf Stream - One of the primary oceanographic objectives of the Gulf Stream Drift Mission will be to investigate the nature of the Gulf Stream. This objective will include studies of the stream's velocity (speed and direction), its turbulence and its physical and acoustic properties as they are associated with depth and time.

Current Study - Hoping to stay within the stream's high velocity jet (that portion of the Gulf Stream where the current is strongest and where both temperature and salinity can reach their extremes), the scientists want to drift 600 feet below the surface with the high velocity jet as it flows at speeds varying from 2.7 knots in the northern Florida Straits to 1.3 knots off Cape Hatteras, N. C.

Instruments - While drifting in the Gulf Stream at 600 feet, the scientists will use deck-mounted current and turbulence sensors to give them relative data on the stream's direction and speed. They will also be measuring its temperature, salinity, sound velocity and pressure using a water sensor pod developed specifically for submersibles. This pod continuously senses these characteristics and records its measurements on magnetic tape every two seconds.

To measure the relative transparency of water masses encountered by the submersible, the scientists will use a transmissometer, an instrument that records the amount of light absorbed by one meter of water.

The scientists will also use an ambient light photometer to measure the percentage of sunlight penetrating the water to the submersible's level of operations at 600 feet.

Acoustical Properties of Deep Scattering Layer - In addition to studying the nature of the Gulf Stream, the oceanographers aboard BEN FRANKLIN want to observe the Deep Scattering Layer (layers of migrating marine organisms which reflect sound as it ascends to the surface at sunset and descends to mid-depths at sunrise. Other than knowing the migration habit of the DSL, scientists have little knowledge either on what marine animals compose the layers or how they behave in the layers. Drifting at depths of 600 feet, the scientists hope to see the layer as it passes the submersible. As it does, they plan to transmit sound waves into it. They also want to transmit sound waves into the layer when it is below the submersible and when it is above the deep-diving vehicle. From this experiment, they will learn more about how the layer scatters sound and also how to discern the frequency of echoes bounded back by the layer. To record the acoustical properties of the DSL, the scientists will use an acoustic system, consisting of two transducers to transmit sound waves and a receiver to return the scattered echoes back to the scientists. The sound waves and echoes will be recorded on magnetic tape for later analysis. As the Deep Scattering Layer passes the submersible, the scientists hope to determine the types of marine animals or components comprising the layer by identifying them visually and photographically. While the layer passes the submersible, the researchers will sample the water around it to obtain an idea of the environmental conditions that sustain the marine animals in the layer.

Two 70mm cameras mounted on the bow of the submersible and 70mm and 16mm cameras will be operated by scientists watching the layer pass by two of the submersible's 29 viewports. The 70mm cameras mounted on the vehicle's bow will produce stereographic pictures, from which can be determined the actual size of the marine animals in the layer. For their lighting system, the scientists will use a Sea Arc light while the 70mm cameras mounted on the bow are in operation. This light projects a ray of almost constant intensity and diameter several feet into the water.

Sea Floor Geology - During the drift mission, the Navoceano scientists plan to make six excursions, each 24 hours long, to depths of 2,000 feet in an effort to delineate the sea floor over which the Gulf Stream flows. During all of the excursions, the scientists will inspect the sea floor's surface sediments to determine visually differences in sediment size and color, and natural characteristics. They also hope to observe sediment properties (such as ripple marks), plants growing on the sea floor, and inhabitants of the Plateau. These visual observations will help them to determine the relationship of one to another. The scientists will combine their visual observations with acoustic and photographic measurements.

To acoustically map the sea floor, the scientists will use a side-scan sonar system which is designed to record profiles of a sea floor area 200 feet wide on each side of the submersible hovering at 30 feet over the bottom.

The scientists will use two 35mm cameras and two 250-watt-second strobe lights to obtain 3,300 stereo-pair photographs of the sea floor. These cameras will provide pictures which the scientists can later use to determine the dimensions of objects photographed on the sea floor. They will also take pictures through the viewports with hand-held still and motion picture cameras.

Sub-bottom Geology - While hovering over the sea floor, the scientists also hope to obtain profiles showing the layering of sediments beneath the surface of the sea floor. The sub-bottom profiler to be used by the scientists aboard the BEN FRANKLIN is capable of generating 5.5 KH_2 frequency sound waves which penetrate the sea floor's sediment layering and are reflected off the bedrock back to hydrophones mounted on the submersible's hull.

Bottom Loss - At selected locations during the drift at 30 feet above the bottom, the scientists will measure acoustic reflectivity or "bottom loss". Often during sonar ranging operations, scientists and Naval personnel cannot account for the loss of sound pulses. They know that some of the sound pulse emitted into the water column spreads out into the water, some of it is absorbed by the water and some of it is lost when it hits a target. To measure this sound loss, the scientists will use a hydrophone designed to receive signals from noise produced by detonating explosives from a support ship.

Gravity, Magnetic Anomalies - During selected bottom excursions, the scientists will periodically measure both gravity and magnetic deviations called "anomalies". Gravity anomalies occur as differences between observed gravity and theoretical gravity, which is based on accepted figures for gravity as related to the size and shape of the earth. When gravity anomalies are found, geologists may be able to associate them with geological structures and may also be able to determine the elevation of the sea floor's surface. This can be done because the pull of gravity decreases as an object is further removed from the center of the earth. By taking gravity and magnetic measurements, the scientists aboard the BEN FRANKLIN not only may discover uncharted geological features, but also will obtain a general outline of the sea floor's geophysical characteristics. To measure the gravitational attraction, the scientists will use a La Coste-Rhomberg gravimeter geared with sensors designed to measure the pull of gravity. The gravimeter also has a recorder to store the measurements. To record the earth's magnetic field and any local deviations in the field's intensity and direction, the scientists will use a magnetometer.

THE SCOPE OF NASA'S PARTICIPATION IN THE MISSION

NASA's objectives for the next decade include developing systems to permit man to live and perform useful work in the space environment over long durations. To plan and design such systems, extensive knowledge is required of the inter-reaction of motivated groups of men performing useful operation tasks in a stressful, isolated and confined environment. To help gain the necessary knowledge, NASA is now pursuing a program which includes participation in earth-based simulators and undersea missions. These investigations include fixed undersea habitats and submersible vehicles for underwater research.

The Ben Franklin will be the first system designed with an isobaric environment (similar to space stations), with the capability of placing man in a highly stressful environment for long durations. This will be accomplished by diving to great depths into the ocean for the purpose of conducting a scientific oceanographic mission. The six man crew will be confined for a period of four weeks and will be concerned with operating the vehicle and carrying out a useful scientific experiment program. The crew will be learning new things about this new environment just as astronauts will be concerned with learning new things about the space environment.

NASA proposes to use the Ben Franklin during the Mission to evaluate the feasibility of using deep submersible vehicles as analogs for space stations. This will be accomplished by observing and describing the operational effectiveness and personnel interactions with the scientific mission.

The specific areas to be studied by NASA during the mission are:

1. - Maintainability: The characteristics of maintainability which will be studied on the Ben Franklin vehicle are: The time-history of scheduled maintenance tasks, and the effect of unscheduled maintenance tasks on crew performance and activities under actual operational conditions.

2. - Environmental Analysis: The internal atmosphere will be measured using a gas chromatograph. There will be a fixed time interval in which the following measurements will be performed:

1. Monitor for crew safety, oxygen, nitrogen, carbon dioxide.
2. Test for other constituents, e.g. carbon monoxide, hydrogen, hydrogen sulphide, methane, sulphur dioxide, and ammonia

In addition to the gas chromatograph measurement on board, syringe samples will be taken at regular intervals for detail analysis in the laboratory after the mission.

These measurements and how they change throughout the mission will provide useful data on a closed environment similar to that of a space station.

3. - Microbiology: This task is specifically concerned with collecting data in three areas; water potability, human flora, and environmental flora.

The water potability measurements will be taken each day and will be tested with endo media, total media, and yeastmold media. In the event contamination occurs during the mission, iodine will be added to the system.

Human flora measurements will be taken pre-mission, during the mission and post-mission. The measurements to be taken during the mission will use standard laboratory sampling techniques prepared beforehand and are to be stored on board for post-mission analysis.

The environmental flora will be sampled once every three days during the mission. An Anderson sampler will be used with previously prepared culture media. Bacteria colony count will be performed and recorded at 24, 48, and 72 hrs. after sample acquisition and then stored for post-mission analysis.

This data will provide a bacterial history of a closed biological environment which can be useful in the design of future space stations.

4. - Habitability: The measurements in this area are to be taken on a daily basis and will consist of: light level, noise level, vibration level, water consumption, food consumption, work/sleep cycle, traffic patterns, and personal hygiene management. The above measurements will be taken using mechanical counters, pressure sensors, meters and time-lapse photography.

The data in this area can be utilized in space station design for: work areas, recreation areas, food management area, and in the general layout of equipment to insure optimum personal interface. The proper design of these aspects of space stations is required for maximum efficiency and morale of the crew.

5. - Life Science: To insure proper data analysis and a correlation of events in the above areas the following physiological and behavioral measurements will be taken:

The physiological measurements will consist of Pre and Post Mission - metabolic, vital capacity, hand strength, sleep monitoring, performance (using Scows complex coordinator), and a standard physical. The measurements during the mission are: complex coordinator grip strength, and pulse (during exercise and recovery).

The behavorial measurements to be taken are:

Pre-mission: Rorschach, Edwards, NMRI Scales, ISQ, PAS, SSS, Firo B, Fitzgerald, personal diaries, and interviews.

Mission: NMRI Scales, Logs, mechanical counters (bunks, showers, head, aisle) time-sequence films, tape recorders.

Post-Mission: Edwards, NMRI Scale and crew interviews.

This data will be useful to the space program as an operational study accomplished in an environment similar to space stations. Other characteristics to be studied are: crew composition, real scientific mission, and relative long-duration, and closed environment. The data obtained on these aspects should prove valuable in the design of future space stations.

ROLES OF THE PRIVATEER, KELLAR AND ASWEPS AIRCRAFT IN THE MISSION

The primary function of the M/V Privateer will be to track the Ben Franklin by acoustic means.

The Kellar and ASWEPS (Anti-submarine Warfare Environmental Prediction Services) aircraft will research the Gulf Stream and provide supplemental information on position-fixing for the submersible.

ASWEPS aircraft will fly over the Privateer every third day. As the airplane flies over, the Privateer will sample the surface water, relaying its temperature to the aircraft. The ASWEPS plane will use this information to calibrate its airborne radiation thermometer and will then fly a grid pattern over the area determining the Gulf Stream's eastern and western limits. It will radio this information to the Privateer which will then calculate exactly where the Ben Franklin is located within the stream.

The Kellar will be performing experiments of its own and others in conjunction with the Privateer-Ben Franklin. It will also assist in helping the submersible find its exact location in the Gulf Stream. Every 12 hours, at noon and midnight, the Kellar will travel across the stream from border to border, approximately 40 miles, taking electronic bathythermograph readings. Each transit of the Gulf Stream will require about four hours, allowing Kellar eight hours out of every 12 for experimentation.

Among these experiments will be the use of Nansen casts to determine the physical characteristics of the Gulf Stream. (A Nansen bottle, usually made of metal, is lowered to a predetermined depth and then closed, capturing a water sample at that depth. Related instrumentation may also be used to determine temperature, currents and other data for that depth.) The salinity content of the samples will be determined on-board using the Kellar's own laboratories. Other water samples will be frozen and sent to shore laboratories for examination of their nutrient, phosphate, silicate, and nitrate contents. This latter information will have significant implications for analysis of the DSL, or Deep Scattering Layer.

The Kellar will also be equipped with a 70-foot long net (a Kidd Midwater Trawl). This net is in the general shape of a cone, with a collecting bottle where the pointed tip of a cone would be. Sensors located at the open end of the net will record water flow, temperature, pressure and light. The bottle at the narrow end of the net is equipped with an electronic lock, thus protecting the purity of samples collected at a particular depth. The net will be towed for 3 to 4 hour periods at a particular depth. (The depths will range from near-surface down to 1000 meters.) Samples from the Deep Scattering Layer

(DSL) will be of special interest.

In addition to the above activities, the Kellar will also conduct experiments in conjunction with the Ben Franklin. Upon request of the Franklin, relayed via the Privateer, the Kellar will detonate SUS (or Signal, Underwater Sound) charges. These miniature depth charges will detonate at a depth of 60 feet, sending sound waves to the sea bottom (as well as elsewhere). The Ben Franklin will receive these sound waves, and from them will determine the sea bottom's acoustic reflectivity (i.e. how well that portion of the sea bed reflects sound). Occasionally the Ben Franklin will remain under the Deep Scattering Layer and send sound waves upward through it. The Kellar will receive these signals and determine how they have been weakened in their passage through the layer. Conversely, the Kellar will also send signals down through the DSL to the Ben Franklin, which in turn will determine how much of the signal is lost when traveling through the layer. These activities are called attenuation experiments.

MR. BEN FRANKLIN AND THE GULF STREAM

An early scientific reference to the Gulf Stream occurred in a letter from Benjamin Franklin to the Secretary of the British Post Office. This letter, much of which is quoted below, was written in 1769, exactly 200 years ago.

Craven Street, October 29, 1769

Sir: Discoursing with Captain Folger...I received from him the following information, viz.:....that the whales are found generally near the edges of the Gulph Stream, a strong current so called, which comes out of the Gulph of Florida, passing north-easterly along the coast of America, and then turning off most easterly, running at the rate of 4, 3-1/2, 3 and 2-1/2 miles an hour; that (people concerned in the whale fishery)...cruise along the edges of the stream in quest of whales...; that they have opportunities of discovering the strength of it when their boats are out in pursuit of this fish, and happen to get into the stream while the ship is out of it, or out of the stream while the ship is in it, for then they are separated very fast, and would soon lose sight of each other if care were not taken; that ...they frequently...speak with ships bound from England to New York, Virginia, etc.,...and it is supposed that their fear of Cape Sable shoals, George's Banks, or Nantucket shoals, hath induced them to keep so far to the southward as unavoidably to engage them in the same Gulph Stream, which occasions the length of their voyages, since...the current being 60 or 70 miles a day, is so much subtracted from the way they make through the water.

At my request Captain Folger hath been so obliging as to mark for me on a chart the dimensions, course, and swiftness of the stream from its first coming out of the Gulph ...; and to give me withal some written directions whereby ships bound from the Banks of Newfoundland to New York may avoid the said stream, and yet be free of danger from the banks and shoals above mentioned...With much esteem, I am, etc...

Benjamin Franklin

E. Clinton Towl, Chairman of the Board - Grumman Corporation

E. Clinton Towl was one of the six original founders of the Grumman Aircraft Engineering Corporation in December, 1929. He served in a variety of capacities until 1937 when he was appointed Assistant Treasurer. Three years later he became Vice President and Assistant Corporate Secretary, Administrative Vice President in October, 1954, and in July, 1960, was appointed President. Towl was elected Chairman of the Board of Directors on May 16, 1966.

Towl provides leadership for Grumman's diversified aircraft and space programs, including the Lunar Module (LM), designed to land America's first astronauts on the surface of the moon. He is also responsible for Grumman's non-aerospace activities which he consolidated under a single corporate entity, Grumman Allied Industries, in February, 1963. Towl is Chairman of the Board of this subsidiary.

Towl has been, and continues to be, active in other business and civic capacities.

He is a Trustee of Adelphi University. He has been a member of the Board of Directors of the Bankers Trust Company since 1963 and the Long Island Lighting Company since 1965.

In 1966, Towl was the recipient of the Distinguished Citizen Award presented by Adelphi Suffolk College and the Annual Award from the Society for the Advancement of Management by Long Island University.

During 1965, he was a member of Governor Rockefeller's special committee for the Long Island Railroad and Chairman of the very successful United Fund of Long Island campaign. He is a member of the Nassau-Suffolk Economic Development Council. He was Leadership Gifts Chairman for the Nassau Council of Boy Scouts in 1964 and for three years served as Chairman of the Boy Scouts Century Club. In 1963, he was named "Man of the Year" by the Long Island Electronics Manufacturers Association. Towl is currently Chairman of the Board of Governors and a member of the Executive Committee of the Aerospace Industries Association.

Towl was born in Brooklyn, New York, October 26, 1905. He was educated at St. Paul's School, Garden City, New York, and at Cornell University. Towl resides in Syosset, New York with his wife, Christine, and has a son, F. Clinton, and a daughter, Mrs. Sandra Towl Corcoran.

BACKGROUND - U. S. NAVAL OCEANOGRAPHIC OFFICE

The mission of the U. S. Naval Oceanographic Office is to enhance the Navy's combat readiness by providing navigational and oceanographic data; carrying out related research, development, and support programs; and complying with other statutory requirements.

Traditionally, the Office has discharged this mission through the preparation and distribution of navigational charts and related publications. The first nautical chart was issued by Lieutenant Charles Wilkes in 1835. Lieutenant Matthew Fontaine Maury's "Wind and Current Chart of the North Atlantic", issued in 1847, was the predecessor of today's "Pilot Charts". As technology advanced, and as the nation's Naval and maritime activities expanded, the value of this data became ever more widely recognized. Today's charts are concerned not just with a limited number of shipping lanes but with the entire oceans of the earth. The tools of the trade have expanded from hastily-scratched log book entries and primitive sounding lines to embrace magnetic, geodetic, gravity, bathymetric, aeronautical, and satellite data, and even specially-designed and equipped vessels.

Oceanography is concerned not only with the topography of the ocean, with its winds and currents, but also with the nature of the ocean itself. It studies the flora and fauna of the sea, the salinity of its waters, and the complex relationships between the ocean and the atmosphere above. These studies are focused on acquiring knowledge of inner space and turning this knowledge to man's use. The Naval Oceanographic Office, while continuing to fulfill its invaluable mapping and charting function, is responding vigorously to these new programs.

The Office's contribution to fleet effectiveness, maritime safety, and scientific knowledge can be only as effective as its ability to disseminate its findings. The more-than 90,000 line items stocked in the Naval Oceanographic Distribution System include nautical, aeronautical, and topographic materials. One of the more important functions of the Distribution System is the correction of charts prior to issue. Continuing programs of automation, cost reduction, and orientation to user's needs are pursued. The Distribution System includes two major depots, located at Clearfield, Utah and at Philadelphia, Pennsylvania. In addition, six branch maritime offices, eight air navigation offices, and one hundred fifty authorized sales agents distribute maps, charts, and publications prepared by the Oceanographic Office and other cartographic producers.

Rear Admiral O. D. Waters, Oceanographer of the Navy

Rear Admiral O. D. Waters, Jr., U. S. Navy Oceanographer of the Navy, became the first head of the new Office of the Oceanographer following the establishment of the new command structure in 1966. Immediately prior to his present post, Admiral Waters was Oceanographer of the Navy in the Office of the Chief of Naval Operations and Commander of the U. S. Naval Oceanographic Office.

Before becoming the Navy's Oceanographer, he served in both wartime and peacetime billets during more than 30 years with the U. S. Navy.

He was (1964-5) Commander, Mine Force, Pacific Fleet with added duties as Commander, Naval Base, Los Angeles, Calif. He served (1962-4) as Inspector General and Assistant Chief of the Bureau of Weapons for Administration, Navy Department. Prior to that he was Commander, U. S. Naval Weapons Station (the former U. S. Naval Mine Depot) at Yorktown, Va. Soon after presidential approval of his rank of Rear Admiral in 1960, he was made Commander of Destroyer Flotilla ONE.

His list of firsts include establishment of the first U. S. Navy Mine Disposal School in 1941 and was officer in charge of that special school until January, 1943.

He also engaged in the design of atomic weapons at the Naval Ordnance Laboratory, in Washington, D. C. (1946), after taking part in Operation Crossroads, the atomic bomb tests at Bikini in the Pacific Ocean.

During the Suez Canal incident he assumed command (1956) of Destroyer Squadron TWO, operating in the Middle East area. He was concerned with strategic applications and policy on staff of the Supreme Allied Commander-Atlantic for three years prior to his Middle East shipboard service.

Included in his shipboard service are commands of the USS LAFFEY (1945-6); and USS GLYNN (1952-3) and officer duty aboard the USS MEMPHIS (1943) and the USS DOWNES (1936) and the USS AUGUSTA (1932-6).

Among his many shore stations was a tour as Assistant Naval Attache at the American Embassy in London.

Prior to his London post, he was a student in ordnance engineering at the Naval Post Graduate School, Anapolis, Md. (1938-40). His education also includes completing (1950) a course in the Armed Forces Staff College, Norfolk, Va. He graduated with distinction as an ensign in 1932 from the U. S. Naval Academy at Anapolis. Admiral Waters holds an honorary Doctor of Philosophy degree in Space Sciences from the Florida Institute of Technology (formerly Brevard Engineering College).

Admiral Waters is married to the former Lucile McGehee of Washington, D. C. The Virginia-born admiral and Mrs. Waters are the parents of four daughters: Martha Lane (now Mrs. George Philipps); Carol Weir (now Mrs. Robert Waldron); Lucile Dabney and Ann Elizabeth.

Captain T. K. Treadwell, Commander, U.S. Naval Oceanographic Office

A native of Ada, Oklahoma, Captain Treadwell assumed command of the U. S. Naval Oceanographic Office on July 1, 1968. He attended East Central State College in Ada, and received an undergraduate degree in geology from the University of Oklahoma. After a brief apprenticeship in petroleum geology and civil engineering, he entered the Navy in 1942.

During World War II, he served in the Atlantic and Pacific submarine forces. In 1946, he transferred to the Navy Hydrographic Office, renamed the Naval Oceanographic Office. He served aboard the Navy's survey and research ships in many areas of the world, particularly in the Caribbean, South American and Arctic areas.

He was a graduate student at Scripps Institution of Oceanography of the University of California in 1949-50 and was awarded a master's degree in geological oceanography. Captain Treadwell did further graduate work in Arctic studies at McGill University, Montreal, Canada, in 1954. Since that time, he has been closely associated with the Navy's program in oceanographic research and engineering. He has held numerous billets both at sea and in Washington and has planned and carried out many projects for the Oceanographer of the Navy. Much of his work has been in the field of military science with U. S. allies in NATO, SEATO, and other groups.

In a brief departure from his technical duties, Captain Treadwell was assigned as Chief of the Naval Mission to the Republic of Haiti from 1959 to 1961. While in Haiti, he supervised the training and operations of that nation's sea-going forces. On completion of the assignment, he returned to the Naval Oceanographic Office and became special assistant to the Oceanographer of the Navy and Deputy Commander of the U. S. Naval Oceanographic Office.

He has written numerous articles and books on mapping and oceanography and produced dozens of charts for Navy and merchant marine navigation. He is a director of the Marine Technology Society; president of the American Society of Oceanography; and a member of the American Geophysical Union, Explorers Club, the Arctic Institute, the Cosmos Club, and many other professional societies.

He is married to the former Nell McNeely and is the father of two sons.