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FIRST YEAR'S OPERATIONS OF THE DRV BEN FRANKLIN

THE AUTHOR

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IN AUGUST 1969 THE GRUMMAN AEROSPACE CORPORATION DEEP RESEARCH Vehicle *BEN FRANKLIN* completed a record breaking submerged drift in the Gulf Stream. This Gulf Stream Drift Mission was a joint Grumman/Piccard, NASA and NAVOCEANO project. It covered over 1444 miles in thirty days. The Vehicle remained submerged during this drifting period at an average depth of 650 feet making several excursions to 1800 feet. Getting the *BEN FRANKLIN* to this point covered a period of sixteen months of hard work. The twelve months preceeding the Drift Mission are discussed in this article. Forty dives were made during the period. Those dives, their lessons and frustrations make up the *BEN FRANKLIN's* first year at sea.

Arrival

In May 1968 the M/S *Anvers*, a ship of the Belgian Line, tied up to the pier at the Port of Palm Beach, Florida. Secured to her deck, looking for all the world like a large white boiler, was the pressure hull of the submersible PX-15. In the ship's hold were 97 wooden packing crates and pallets containing everything required to reassemble the mesoscaphe ("medium depth craft"). This cargo included major items such as ballast tanks, piping, the battery keel assembly, and over 400 battery cells. Smaller important parts were also here: bolts, washers, nuts, wire, and even recording paper for the boat's fathometer. Most of these parts had been assembled during the construction of the PX-15 in Switzerland,

then removed from the vehicle, packed, and transported by railroad through the mountain passes to Antwerp. Here they began the month-long trip which brought this Grumman project to the United States.

During the next three months the PX-15 was reassembled, tested, and improved in a large hangar alongside Slip 2, where she was housed at the Port of Palm Beach. By the end of July 1968, the PX-15 was rolled out. Major reassembly had been completed and the boat was now ready to get wet. The first year of operations at sea with the world's largest privately-owned deep research vehicle (DRV) was about to begin.

Some Background

A short digression is necessary here to give some background on the early steps which led up to this first operating period of the PX-15.

The original idea for the PX-15 was conceived by Dr. Jacques Piccard in 1965. Preliminary engineering studies were begun in Switzerland in 1967, after an agreement between Dr. Piccard and the Grumman Corporation, which was to finance the project and the boat's first mission, the Gulf Stream Drift.

The Gulf Stream Drift Mission was to serve two purposes. The primary mission was to be a scientific endeavor, the aim of which was to gather data about the stream and selected sections of the sea bed beneath it. Secondly, the mission would serve to demonstrate the ability of the PX-15 to do work while remaining submerged for extended periods of time, drifting silently at selected depths in the water column, giving the scientists aboard an unparalleled opportunity to study the undersea life of the Stream.

The mission plan called for the vehicle to submerge in the center of the Gulf Stream, or as close to the high velocity core as possible. The dive was to begin off Palm Beach, Florida, and end thirty days later in the Atlantic off Nova Scotia, a distance of 1500 miles.

The PX-15 was christened the *Ben Franklin* on August 21, 1968 at the Port of Palm Beach. The name had been selected as fitting for this vehicle, since it would explore the river-in-the-sea that Benjamin Franklin had studied so many years ago. Vehicle outfitting and dockside checkout of various systems were completed during the next several weeks. On 22 November 1968 the *Ben Franklin* made her first dive in shallow water. December saw the completion of a three-day closed boat test designed to prove and evaluate the ship's life support system. At Christmastime, 1968, towing tests were carried out at sea. With these tow test, shallow work was completed. There had been problems and a few mistakes were made by the project team. The problems which did occur were quickly rectified and the mistakes never repeated. The next dive would be the *Ben Franklin's* first for the year 1969, and her first in the open ocean.

First Year

The tasks to be accomplished during 1969 appeared to be quite formidable. A complete test and training program had been planned. The *Franklin* was a new boat, the concept novel, and the schedule short.

Dives had been planned which were to take the boat deeper and deeper, until her operating depth of 2,000 feet was reached and where sea pressure would reach over 900 psi on the 1 3/8″ thick steel pressure hull. Both American Bureau of Shipping (ABS) and U.S. Navy certification were desired. The vehicle had to be proven to these two demanding agencies as well as to a Committee on Safety which had been set up by Grumman. When the requirements of these three groups had been satisfied, the *Franklin* would be outfitted to get underway on the Gulf Stream Drift Mission. We had planned this submerged cruise well and were sure it would take place that year (1969). Once it was completed, the *Franklin* would return to Palm Beach for an overhaul period and complete inspection of all systems. Upon completion of the overhaul, the vehicle would be put to work.

Ocean Operations

The test plan for the first day at sea read in part:

Objectives

- To perform a dive in the Atlantic Ocean off Palm Beach in approximately 100 feet of water.
- To establish submerged handling characteristics in shallow depths (approximately 60 feet below the surface).

For this first ocean operation the weather was not good, although it was not as bad as operations personnel later grew used to working in. Weather later became an overriding problem. It did slow the test program and eventually delayed the start of the Drift Mission. The sea for this dive was choppy, with four-to-five foot waves riding on top of long, high swells. During this period of operations the crew had to ride the *Franklin* to the dive site in order to monitor on-board ship systems and to tend the tow cable. This practice was later modified as confidence in the boat and the towing technique grew. This first ride out was uncomfortable for all (Figure 1).

In the early afternoon of January 27th the *Ben Franklin* arrived at the selected dive site. Casting free of her tow, she dove for the first time in the open ocean. The boat was now in her element. The ride was smooth, with little sensation. For those who had been aboard submarines before, being able to watch through any one of the boats twenty-nine ports while the vehicle submerged and approached

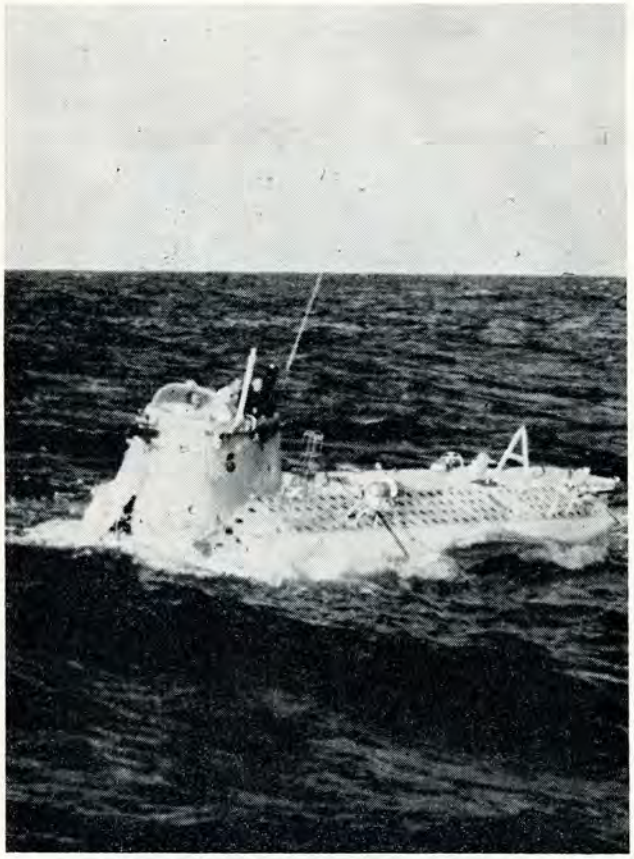

Figure 1. Franklin at sea.

the bottom was a new thrill. The dive report reads:

> The boat handled well. Observations were made through the ports. A landing site was selected and the boat put down in 78 feet of water at 1410. The landing was soft and the boat held the bottom, shifting slightly in the current and from the effects of the long deep rollers top-side.

Unfortunately, for those aboard, this dive had to be cut short. Humidity became a problem. The warm moist air in the vehicle condensed on the cold steel of the hull and the overhead piping. Large droplets began to fall and find their way along the bulkheads and into the equipment. The problem of high humidity in the boat was later solved by using a variety of techniques:

- When in port, a heavy duty industrial air-conditioning unit was run into the boat through removeable ducting.
- Installation of an on-board dehumidifier which was operated when the air-conditioning unit was removed.
- Use of bags of commercial dessicant while the boat was submerged.

A much more serious problem was presented in sub-to-surface communications. At this time *Franklin* was equipped with two underwater phones. Both were the same type. Because of electrical interference and grounding problems in the equipment, low power, and the location of hydrophones, communications with the surface ship became a problem. Communications became almost non-existent if either ship was out of position relative to the other. After remaining on the bottom for some time, *Franklin* requested permission to surface from the Dive Director aboard the support ship. Permission was given and the boat began to ascend. At about 40 feet from the surface it was almost impossible for either ship to get through to the other. *Franklin* was held at thirty feet while attempts were made to regain clear communications, but this proved to be a losing battle. *Franklin's* systems were secured and the crew listened for surface ship noise in the area. When none was heard, the boat surfaced. The support ship picked up the tow and *Franklin* returned to port.

During a later de-briefing, *Franklin's* crew learned of a potentially dangerous situation which had been narrowly averted. After the clear-to-surface signal had been given and the submersible had started up, a small freighter moved into the operating area to see what was going on. This in spite of the fact that the support ship was flying proper signals, indicating that she was operating with a submerged object. While attempting to contact the *Franklin*, the support ship had moved out of position in order to head off the unwelcome intruder. This incident highlighted our absolute need of more adequate underwater communications equipment. Steps were immediately taken to improve this situation. First, the equipment already installed aboard the boat was improved. Changes were incorporated in the basic system to make it more effective. Secondly, a better system was purchased and installed aboard the *Franklin* and the support ship, the yacht *Grifon*. Our solution of the communication problem, although operationally limiting until the new system was installed, proved adequate. In addition, a Continuous Track Frequency Modulated (CTFM) Sonar System was purchased and installed aboard the *Franklin*. During subsequent operations, both the CTFM and the higher quality communications system proved to be worth every dollar spent for them.

Three Dives

On February 5, 1969 the *Ben Franklin* made three dives, first to 98 feet, then to 493 feet, and finally to 540 feet, where the boat was bottomed. The crew spent the night observing the sea around them, alternately standing watch or sleeping.

The operation began with *Franklin* descending to 98 feet, where an attempt to hover was made. A minor electrical problem in the ship's motor controls forced her to surface. Repairs to several loose wires were made and *Franklin* dove again. At 493 feet some small leaks were found at a set of battery charging penetrators. The boat surfaced. It was found that improperly installed clamps holding an external rubber cap in place over the penetrator was

causing the problem. These caps and clamps were removed, cleaned, dried, and reinstalled. The third dive of the day began. The *Franklin* using her four 25 H.P. electrical motors moved into gradually deeper water. During the day the boat was taken to 540 feet. When basic equipment checks had been completed, the crew of six settled down to supper. Operations were discussed and plans for the next day's activities reviewed. Things had gone well. A few additional leaks had been found and stopped by tightening the hull penetrators inside the boat (Figure 2).

The test plan now called for the crew to rest for the night on the bottom and, in the early morning have *Franklin* move out, still submerged, to deeper water. After showering, four crew members retired to sleep or read. The other two men cleaned up the dishes and assumed the watch. A normal three section watch routine had been set up for the night. For those who remained up, the view outside was fascinating. Large numbers of small animals and zooplankton, consisting mostly of copepods, were attracted by the ship's lights. Like bugs in summer, they settled around the lighted ports. Outside, in the glare of *Franklin's* external lights, numerous crabs were seen. For one long period lasting several hours, thousands of squid were observed darting into and out of the lamp glow. During the night some of the external lights failed. Because of the large number of these lights aboard, we expected that some would fail. However, more than the expected number went out; as many as half had to be repaired later. There were several reasons for this:

- Poor external molded splice joints.
- Breakdown of insulation on some conductors which had received small amounts of wear.
- Failure of the lamp assembly itself because of air trapped in the reflector housings.

Many of these problems were isolated and remedied. New assembly techniques, better methods of installation, and (in some cases) a new type of lamp assembly all helped. However, the problem of lighting failure was never completely solved during the year. It still remains a basic equipment problem. In the *Franklin's* case, the large number and variety of external lights aboard did help. If one light failed, there was always another at a different port or one of greater wattage covering the same external area.

In the early morning hours of February 6, a leak was discovered at the termination point of an electrical conductor aboard the boat. The cable had holed during the long submerged period and seawater had found its way along this cable and into the equipment. Although the leak itself was just a "weep," there was no way to investigate the external side of the heavy power cable to determine what was wrong and how it was to be repaired while at sea. Discussions were held with support ship personnel; it was decided to terminate the dive and return to port for repairs. *Franklin* surfaced after having been submerged at 540 feet for over twelve hours. The first set of hull strain gage readings had been taken while the dive was in progress and they indicated that everything was well.

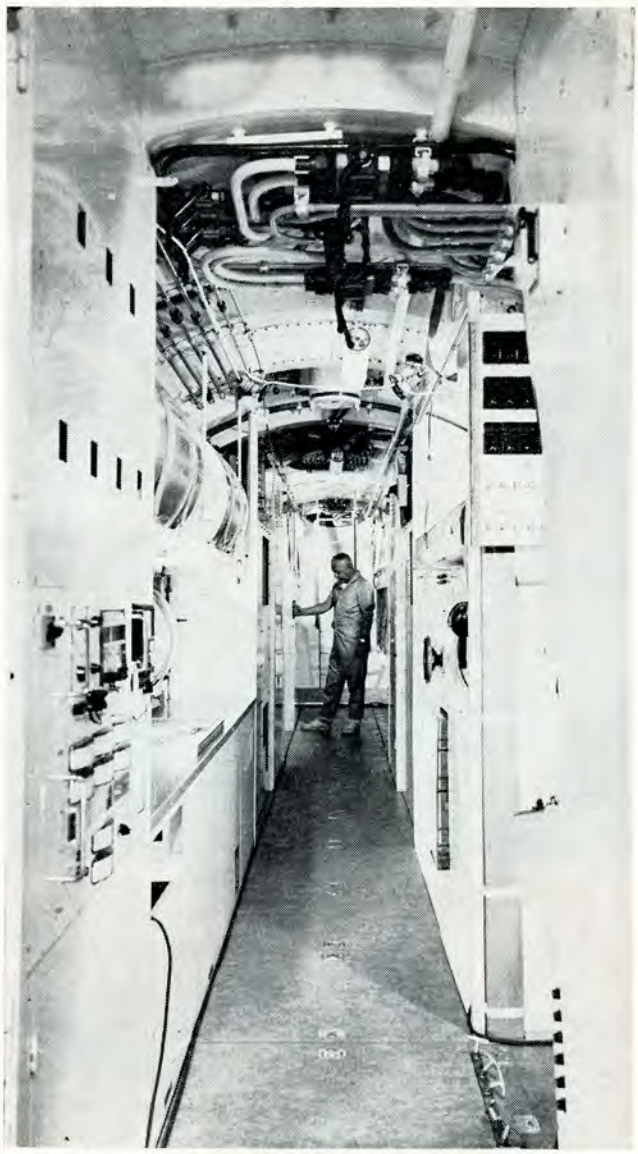

Figure 2. Franklin interior—Hull penetrators in overhead and below deck.

During the next week in port all *Franklin's* wiring, connectors, and splices were visually inspected and tested. The one conductor which had failed was found to have a defective molded splice joint.

This was cut out of the line and the joint repaired.

To 800 Feet

Franklin's next dive was overnight. The boat landed in 490 feet of water, where approximately eight hours were spent. The *Franklin* was raised off the bottom and was run submerged (for 10 hours) to an 800-foot depth, where she was again bottomed. Equipment was cycled and checked. Another set of hull strain gage readings were taken.

The hull was exhibiting excellent structural properties.

No attempt was made to move into deeper water because of sea conditions on the surface. Winds of 25 to 30 knots were blowing, making topside living uncomfortable and interfering with the surface crew's ability to track and communicate with the submersible. When one of the Grifon's tracking heads was lost, the dive program was called off until the weather improved. *Franklin* surfaced after 23½ hours below.

2,000 Foot Dive

Bad weather now held the *Franklin* and her support ship in port. High seas, rain, and blustery winds were not conducive to testing a new research submersible. However, the time lost by not going to sea was put to good use. Minor repairs, paint touch up, installation and inspection of new equipment

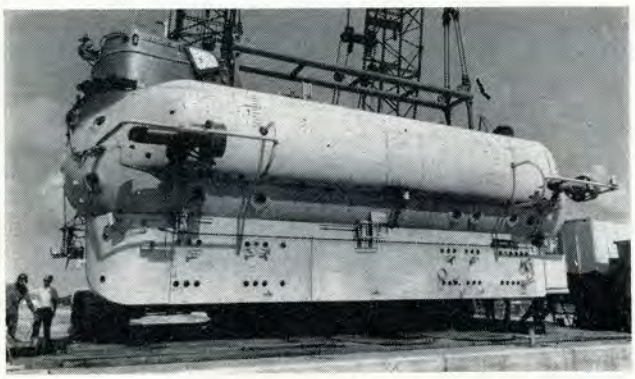

Figure 3. Ben Franklin—Ready for 2000 feet.

occupied everyone. At last, on 18 February, the *Franklin* again put to sea. The crew and the entire project team were eager to get to 2,000 feet. All felt the boat was ready (Figure 3).

The dive plan called for the first bottom stops to be close to the last maximum depth to confirm strain gage readings. The landing was made at 792 feet.

Topside the weather was again kicking up. Seas began to make tracking difficult. A slight "weep" was found in an instrument multi-conductor penetrator. The dive was not aborted at this point because the crew was sure the "weep" would stop as the boat went deeper. This capability of the basic penetrator design had been demonstrated in chamber tests. This proved true as the boat descended into the depths. The "weep" just about stopped as sea pressure forced a rubber gasket tighter into the penetrator housing. In later dives however, additional problems arose with these penetrators and many were removed and replaced with a new series of penetrator/connector which allowed much greater freedom in the ship's through-hull wiring and offered many advantages in replacement, circuit trouble-shooting, and installation of new equipment.

Upon completion of the first set of strain gage readings, *Franklin*, using her motors, lifted off the

Figure 4. Ben Franklin control station.

bottom. While maintaining an altitude of 100 feet, she moved toward deeper water. Using the current and four motors, *Franklin* was able to make a good two knots over the bottom. On this long transit the boat handled very well and all the crew soon became proficient in this operation (Figure 4). While moving at this altitude, only two crew members were required to handle the boat. The two watch members alternated during these periods; while one piloted the craft the other made a constant inspection of all penetrators and systems. He also monitored carbon dioxide and oxygen levels and operated the CTFM sonar. The other crew members were free to carry on their own scientific programs, to sleep, or to look out of the twenty-nine ports at the ever-present "snowstorm" of marine life outside.

Franklin's next stops put her at 1160 feet and then at 1555 feet. This was the deepest the boat had been to date. A more than thorough inspection of the whole boat was made at this point. Systems were checked electrically and operated. Then a complete set of strain gage readings were made and double-checked. These readings were compared to precalculated curves which had been made into charts. Plotting the actual readings against the curves told the structural test engineer, who was aboard, what the hull stresses were at any period of time. If any questions had been raised, he could have consulted with the stress analyst aboard the

support ship. Each stop for reading the gages, reducing the data, and checking results took two to three hours. There were over 200 gages located on those inside and outside surfaces of the boat which had been anticipated as areas of maximum stress. After a thorough review of all the data, the decision was made to go for 2,000 feet.

Communications with the support ship had again begun to deteriorate. Winds and high waves made the task of position-keeping on the surface difficult. The *Franklin* lifted off the bottom and moved out toward deeper water. The next stop was made at 1750 feet. The final leg out was run at 1500 feet. Two hours after the 1750 foot stop the *Franklin* began her descent to 2,000 feet. The ship's log for February 19th reads:

> 0446—Start descent to 2,000 feet
> 0455—Bottom—2011 feet to the keel bottom.
>
> The ocean bottom is flat; appears to consist of ooze and coral sand. Many small and large mounds and holes of various sizes are to be seen.

Franklin's three green-tinted thallium iodide lights cutting through the darkness at this depth, made visibility good but revealed a bleak, depressing landscape. No large life forms were observed, although the water was extremely clear. All the ship's external lighting was switched on and many photographs were made.

Communications with the support ship *Grifon* were lost at this point but were soon recovered. As part of standard operating procedure, if communication contact is lost for thirty minutes the boat is to surface. All of the crew wanted the dive to last as long as possible. Things however, worked out well and after several hours of picture-taking, observations, recording strain gage readings, inspecting all penetrators and windows, and making electrical checks, the crew started up. *Franklin* surfaced in very rough seas at 0730. The dive had covered a little over sixteen hours.

Additional Dives

Following the first successful dive to 2,000 feet (which proved hull integrity), a number of additional dives were made to shallow depths to check and test various operating parameters of the *Ben Franklin*. Surface and submerged running characteristics were investigated; bouyancy and stability measurements were made.

These dives were conducted during the months of March and April 1969, when weather prevented the *Franklin* from operating far from home.

One Year

A year had passed since *Franklin* had arrived in the United States. Several of the project milestones had been completed but a number remained undone. Weather had been the major enemy up to this point. On May 2, 1969 a series of shallow water dives were conducted to introduce the members of the press to the *Ben Franklin*. On two dives that day (each lasting roughly one hour), *Franklin* carried fourteen visitors and her crew of three to the bottom and up again. However, the first real day at sea during the spring of 1969 was to make a dive to 800 feet. Various newly installed equipments would be operated and tested and a number of photo and scientific programs were to be carried out.

The first experiment to be tested was one which would be aboard for the drift mission. It was to be undertaken to establish the existence of phytoplankton in the Gulf Stream, seeking to detect bioluminescence and yellow substance. This was to be accomplished using near-ultra-violet light mounted in a device outside the *Franklin's* pressure hull. Electronic equipment, filters, etc., were mounted inside the hull. The dive was made with readings being taken at discrete depths. At each depth where readings were taken a water sample was brought aboard the *Franklin*. This was done to allow laboratory analysis of the sample to be taken and measured against the results obtained with the electronic equipment.

The second experiment carried out during this period was designed to accumulate quantitative data in a program to help develop better oceanographic imagery from spacecraft or aircraft, using new film and camera techniques. Here the *Franklin* had to dive to a preselected depth and hold that depth as aircraft flew overhead, taking data and pictures. Ambient light at various depths was measured from aboard the boat.

A dive was made to allow photographs to be taken. *Franklin* dove in clear water and descended slowly. While it moved down, photographers swam along-side and around the boat. Lighting was excellent. Making a dive with conditions like this seemed to make all the work worthwhile. As the boat descended to 150 feet, the divers could be clearly seen against the ocean sky when viewed from the upper window ports. They slowly faded away as *Franklin* went deeper and drifted away from them.

Eight days later, the boat completed a seventeen-hour dive to 1800 feet, during which the batteries were run out to their maximum, battery data gathered, air consumption information taken, speed data obtained, and additional cine/still photographs made.

ABS Certification Dive

On 10 June 1969 *Franklin* was towed to sea by the M/V *Privateer*, where she remained for close to sixty hours. During this period, two dives were made which completed major milestones in the boat's schedule.

- A trial drift period of twenty-four hours, during which *Franklin* proved her capability to remain relatively stable at a predetermined depth for extended periods of time. This was

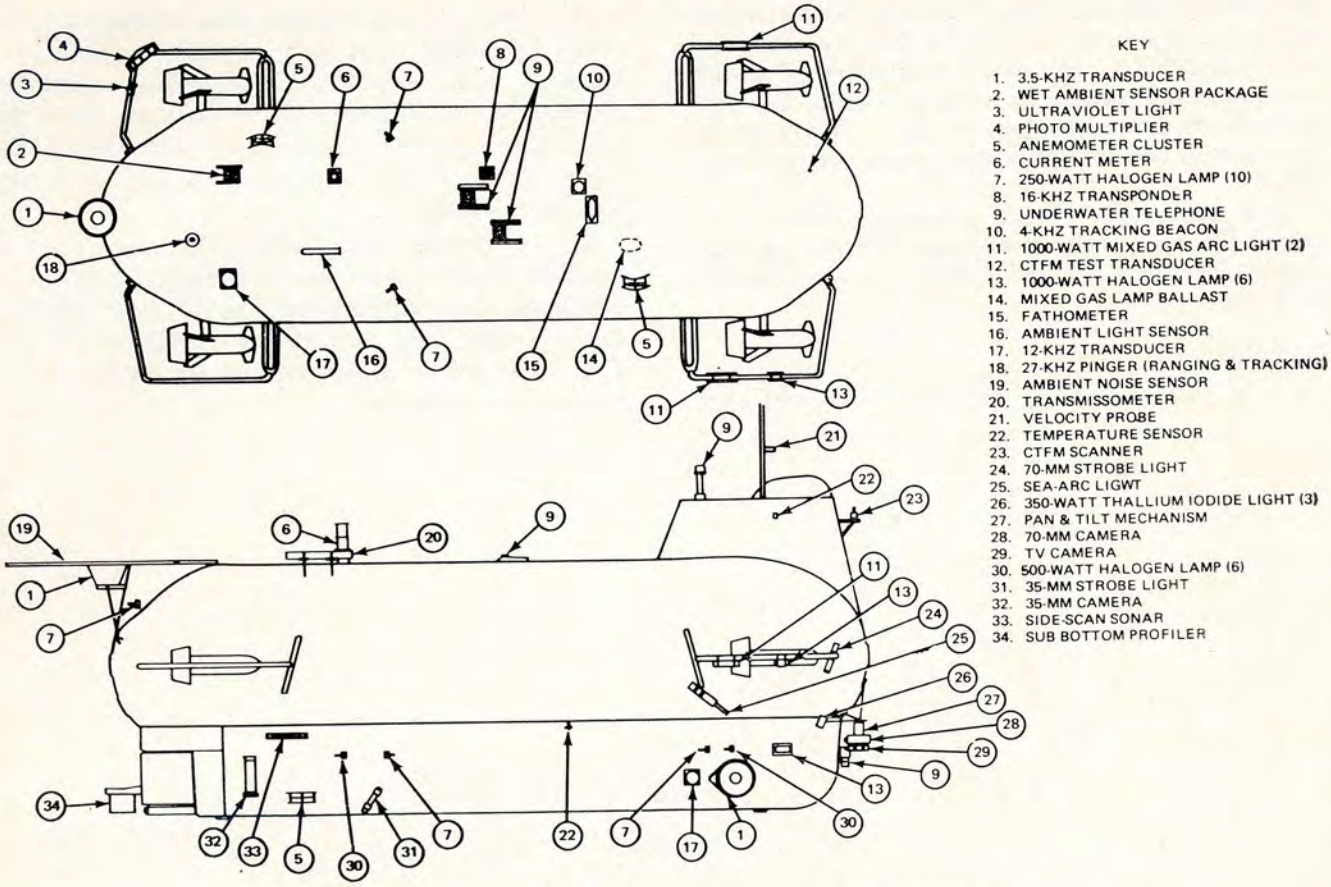

Figure 5. Gulfstream Drift Mission Oceanographic Instrumentation.

a prime requirement for the drift mission.

- A dive to 2,000 feet with the ABS surveyor aboard, completing the boat's requirements for certification by that agency.

For the first time, all of the boat's external lights were operated at depth. This was a bonus for the dive. The 250 watt, 500 watt, and 1,000 watt lamps brightly illuminated the bottom and the sea around the boat.

U.S. Navy Certification Dive

The first full year at sea was moving rapidly to its conclusion. Over four days (24 through 27 June) two dives were made. The first saw the completion of the Navy material certification dive. *Franklin* dove 1885 feet, where she bottomed for several hours while the Navy's representative made a thorough check of the major items involved in certification. With this milestone completed, *Franklin* surfaced and the Navy man was replaced by an additional crewmember. *Franklin* was dived again and stabilized at 540 feet. A drift commenced which lasted for 19 hours. Various depths were attained during

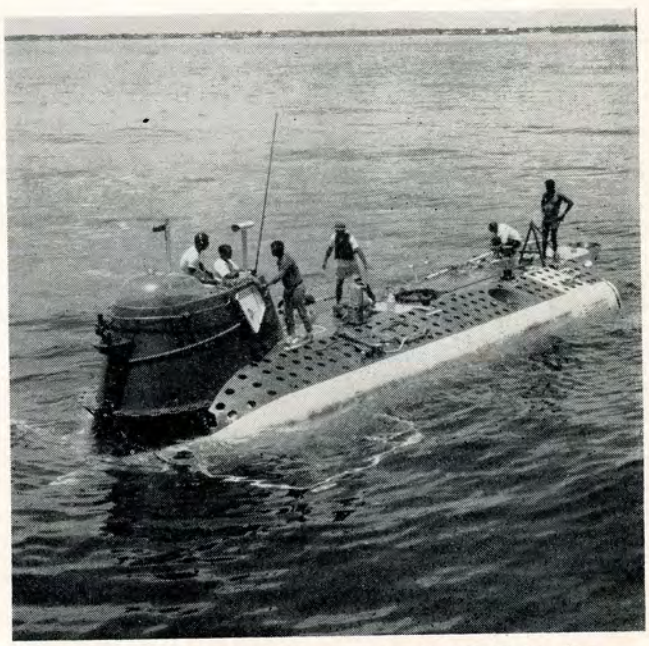

Figure 6. Ben Franklin ready for the Drift Mission.

the drift by using the boat's variable water ballast and shot ballast systems. When this operation had been completed to everyone's satisfaction, *Franklin* was run under maximum power to bring her batteries down. This was done to allow a good charge to be put in and to gather data on power consumption.

With these major events completed, *Franklin* returned to port. Thing now began to move rapidly. A new target date for the Drift Mission was selected, early July.

Final Dives

As the days moved on, two additional dives were made to test the now installed Naval Oceanographic Office equipment, thirty-four pieces of major oceanographic instrumentation and tracking equipment (Figure 5). During the first of these two dives the pilots for the Drift Mission were certified by the Navy. The final dive of the series was made on the July 4th weekend.

A year at sea had passed. The research submersible *Ben Franklin* was now ready for her most important dive. (Figure 6). On 14 July 1969 the *Ben Franklin* dove to start her second year at sea, a dive of thirty days—the history making Gulf Stream Drift Mission.