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WOODS HOLE OCEANOGRAPHIC INSTITUTION

Reference No. 65-11

DEEP SUBMERGENCE RESEARCH

conducted during the period
1 January through 31 December 1964

Prepared under Contract Nonr-3484(00)

WOODS HOLE, MASSACHUSETTS

Woods Hole Oceanographic Institution

Woods Hole, Massachusetts

Reference No.65-11

Deep Submergence Research

conducted during the period
1 January through 31 December 1964

Submitted to Undersea Programs
Office of Naval Research

Prepared under Contract Nonr- 3484(00)

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Abstract

Deep Submergence Research

1 January through 31 December 1964

During the above period the Deep Submergence Research Program at Woods Hole Oceanographic Institution moved steadily forward with the inspection of the final assembly and test of the 6,000 foot Deep Submergence Research Vehicle (DSRV) ALVIN. The vehicle was received in Woods Hole in May and was commissioned on June 5, 1964. Subsequently, a series of some 70 dives in shallow water were conducted for operator training and scientist orientation. A discussion of operations, use of instruments, construction of a catamaran for a support vessel, support equipment and miscellaneous testing programs is included. The submarine is presently undergoing an extensive inspection and refit period, the results of which are reported. Technical reports that include the details of some of the activity are referenced.

Reports

The following technical reports contain detailed information developed under this contract:

1. WHOI Reference 64-1 "Deep Submergence Research Conducted During the period 1 November 1962 - 31 December 1963" dated February 1964.
2. WHOI Technical Memorandum No. TM-DS-1 "Electrical and Pressure Tests of ALVIN's Electrical Through-hull Penetrators" by M.J. McCamis, et al, dated November 1964.
3. WHOI Technical Memorandum No. TM-DS-12 "Twenty-four (24) Man-Hour Test of ALVIN's Environmental System" by W.M. Marquet, et al, dated November 1964.
4. WHOI Technical Memorandum No. TM-DS-13 "Preliminary Memorandum on the Weight, Buoyancy and Stability, Speed, Power, Drag and Thrust of the Research Submarine ALVIN" by J.W. Mavor, Jr., dated November 11, 1964. (Final reports in preparation)
5. WHOI Technical Memorandum No. TM-DS-14 "Analysis of Proposed Titanium Buoyancy Spheres for ALVIN" by J.W. Mavor, Jr., Dated 18 December 1964.
6. Southwest Research Institute (S.W.R.I.) Project No. 03-1206, "ALVIN Hull Penetrator Test" by E.M. Briggs and R.C. DeHart dated February 1964.
7. S.W.R.I. Project No. 03-1206 "Experimental Stress Analysis for ALVIN Hull No. 1" by E.M. Briggs and R.C. DeHart dated May 1964.
8. S.W.R.I. Project No. 03-1206 "Experimental Stress Analysis for ALVIN Hull No. 2" by E.M. Briggs and R.C. DeHart Revision dated May 1964.
9. S.W.R.I. Project No. 03-1206 "Experimental Stress Analysis of ALVIN Buoyancy Spheres" by E.M. Briggs and R.C. DeHart dated October 1964.
10. S.W.R.I. Project No. 03-1206 "Stud Tension Tests of Twelve Interference Fitted Studs After Compressive Failure" by E.M. Briggs and R.C. DeHart dated December 28, 1964.

Reports (continued)

11. David Taylor Model Basin (DTMB) Report No. 1792 "Predictions of the Collapse Strength of Three HY 100 Steel Spherical Hulls Fabricated for the Oceanographic Research Vehicle ALVIN" by Thomas J. Kiernan dated March 1964.
12. Ocean Research Equipment, Inc. (ORE) Report No. 04641 "An Investigation of the Performance of Hollow Glass Spheres at Pressure" dated April 13, 1964.
13. Applied Science Division of Litton Systems, Inc. (ASD, Litton) Report "ALVIN High Pressure Test Report" dated July 24, 1964.
14. ASD, Litton Report "Quality Assurance Report for ALVIN Project 7178 Aluminum Spheres" dated June 9, 1964.
15. ASD, Litton Report "Quality Assurance Report for ALVIN Project 6061 Aluminum Spheres" dated June 9, 1964.
16. ASD, Litton Report "ALVIN Buoyancy Material Test Report" dated August 28, 1964 and supplement November 16, 1964.
17. ASD, Litton Report "Operator and Organizational Maintenance Instructions for ALVIN", Volumes I through IV, dated 6 November 1964.
18. Illinois Institute of Technology "Surface Stability and Underwater Drag Investigations on the ALVIN Oceanographic Submarine" by T. Paul Torda, August 12, 1964 (Second Preliminary Report).
19. Illinois Institute of Technology "Proposal for Experimental Program for Drag Reduction of the ALVIN Oceanographic Submarine" by T. Paul Torda, November 23, 1964.

Papers

1. "ALVIN - Ocean Research Submarine" by Joseph B. Walsh and William O. Rainnie, Jr., published in MECHANICAL ENGINEERING, Vol.86, August 1964 pp.22-26.

Introduction

The year 1964 saw a greatly expanded interest and activity in the field of manned deep submersibles, a part of which stemmed directly from the tragic loss of THRESHER the year previously. At least six (6) other deep diving submarines were to be launched or used for the first time in the United States -- ASHERAH, Electric Boat (E.B.) and the University of Pennsylvania; ALUMINAUT, E.B. and Reynolds; DENISE, Cousteau and Westinghouse; MORAY and DEEP JEEP, NOTS, China Lake. The Naval Electronics Laboratory (NEL) launched and used TRIESTE II for the first time at the THRESHER scene off Cape Cod. The Deep Submergence Systems Review Group (DSSRG) completed its study and reported on its recommendations. The Special Projects Office (SPO) was assigned the responsibility of carrying out the DSSRG's basic program in the field of salvage and rescue of disabled submarines. This past year may well mark the beginning of a new era in "inner space". Woods Hole Oceanographic Institution (WHOI), sponsored by the Office of Naval Research (ONR), continued its own pioneering accomplishments in this area, having received the Deep Submergence Research Vehicle (DSRV) ALVIN in May 1964 from the Applied Sciences Division (ASD) of Litton Industries.

General

The Deep Submergence Research Vehicle Group (DSRVG) at WHOI continued to monitor the design, construction, assembly and test of the vehicle as it neared completion in Minneapolis, Minnesota. All of the components began arriving at the ASD plant in early January and an extensive schedule of pressure and operating tests of components, including pressure tests of Hulls No. 1 and No. 2, was carried out prior to assembly.

A completion and shipping date of late May was set and a commissioning ceremony was held in Woods Hole on June 5, 1964. The vehicle was then launched and a series of shallow water trials, training and orientation dives for scientists were carried out during the period from June to October near Woods Hole. Upon completion of this successful series of some 77 dives, the vehicle was moved to an Otis Air Force Base hangar for a complete tear-down for inspection, alterations, and completion of the instrument suit prior to the deep dive testing program. ONR and the Bureau of Ships (BuShips) conducted a preliminary construction audit and design review which is continuing.

Major effort was expended in designing and constructing the 96 foot catamaran for a towed support vessel capable of lifting ALVIN in and out of the water. The battery and air charging van, as well as the machine shop and utility van, was indispensable in conducting operations both ashore and on a barge in Buzzards Bay. A 35 ton crane from Loranger Construction Company was used for lifting the submarine during this period without a hitch.

Additional personnel were employed and with those previously included in the group, became experienced and proficient at operating and servicing ALVIN. Tending craft consisted of the ATLANTIS II work boat or RISK, and the Boston Whaler. Mechanical difficulties were at a minimum once the craft became fully operational in late July.

The 16 mm camera was used to record the major steps in this process and of operations at sea. Many still pictures have also been taken for future reference. Presentations have been given to various interested groups and persons.

More detailed discussion of this activity follows. This is not a comprehensive report of all matters, but a summary of the more important ones. Extensive additional detail is contained in the various reports referenced herein.

Drawing Approval and Program Monitoring

The vehicle drawing review and approval continued, but at a reduced level since most of the design was completed, and hardware was being built and inspected during the early part of this period. The majority of the time of the operating personnel and the staff was spent at the Contractor's and sub-contractors' plants observing the testing program of components reported in Report No. 13 and final assembly and the installed testing. The final pressure testing of the pressure hulls was conducted at Southwest Research Institute (SWRI) in San Antonio, Texas. Fortunately, Hull No. 2 was tested to 3,300 psi before the collapse test of Hull No. 1 as during this event the tank ruptured at 4,300 psi. Strain data recorded was as expected.

The aluminum frame welding, buoyancy and variable ballast sphere machining and welding was completed, as well as the fiber-flas skin and casting of buoyancy material. The assembly of the main propulsion, mercury trim, variable ballast and main ballast systems was carefully observed. The pressure sphere was instrumented and wiring completed between it, the control centers and

the various boxes housing the motors, sensors and pumps.

The installed testing of the hydraulic and electrical systems went very well and the vehicle was ready for shipment on 20 May. A press conference was held in Minneapolis, including the Governor of the State and other dignitaries, and then the assembled submarine was loaded onto 1 specially suspended low bed trailer and the conning tower, batteries, buoyancy packages, and miscellaneous hardware was loaded aboard the second trailer for the straight-through run to Woods Hole on May 22nd, arriving on 26 May.

Instrument contract drawings were also reviewed and the assembly and testing programs monitored. The mechanical arm was built and final tests conducted at Litton. The scanning sonar testing and acceptance was completed by Straza at NEL, as was the U/W telephone. The U/W TV was revised to suit the voltage requirements and reshipped to WHOI. Lights and cameras, power inverters, the PGR, echo sounder, atmosphere monitoring devices, etc. were all tested for use.

Pressure Hulls

No. 1 and 2 pressure hulls, complete with all hardware including hatch, windows, electrical penetrators, hull release mechanism, etc., were pressure tested in the tank at SWRI after sonic inspection before and after test. Hull No. 2, with $\sim$ 150 strain gages attached was pressurized to 3,300 psi and strain data taken appeared to be normal. The known flaws in Hull No. 1 were sonically monitored during testing and showed no signs of propagating to pressures up to 3,300 psi. On the collapse test of Hull No. 1, the pressure tank ruptured near the top and blew the lid off at 4,300 psi, inflicting some damage on the hardware of the hull in the process, but there was no apparent damage to the hull itself. Strain data obtained at 4,000 psi prior to the casualty was considered normal. This halted further attempts at collapsing this hull temporarily, as well as testing Hull No. 3. Results of these tests are reported in Reports No. 7 and 8.

The hull release mechanisms in both hulls were operated during pressurization of the hulls and the increase in torque required to operate them with increase in pressure was observed to be nominal.

The electrical penetrators were tested before assembly in the hulls for continuity to 10,000 psi per the requirements of the specifications, the results of which are recorded in Reports No. 2 and 6.

Hull No. 1 is still awaiting facilities to complete the collapse test. Hull No. 2 was assembled in the vehicle as delivered. No leaks

in this hull have been experienced to date from any source. Service experience indicates that the hatch "O" ring should be replaced at frequent (quarterly) intervals.

Surface crazing of one window has occurred since delivery, the cause of which has not been determined. This window will be replaced and a separate test of at least one full scale window to collapse is in preparation and will be completed before deep dives are conducted.

Structural Analysis and Testing

The pressure hull analysis and testing program was the major structural activity during the report period. All of the data collected by the fabricator, Hahn and Clay, S.W.R.I., A.S.D. and WHOI was assembled and will be published in the near future. David Taylor Model Basin published an independent analysis, Report No. 11.

The history of these hulls from molten metal to pressure resistant structures is a lengthy and comprehensive one, but in view of the critical nature of this single component relative to personnel safety, the thoroughness seems justified.

It was gratifying to observe that the strain data taken at the test pressures used for Hulls 1 and 2 was very close to the predicted strains from previous analyses. In addition, as predicted, the lamination in Hull No. 1 that was monitored sonically during and after testing, did not propagate or appear to affect the strength of the hull at the test pressures which were well above the expected operating pressures. Moreover, the soundness of the design from a structural standpoint of the hatch, hatch and window insert, window, electrical penetrator and hull release was confirmed. Two other pressure resistant structures, the collapse of which could lead to serious difficulty, were carefully followed and prescribed measurements and tests were performed. These were the fixed buoyancy spheres (9 in vehicle) machined from 7178-T6 hemispherical aluminum forgings; and the variable ballast spheres (6 in vehicle) machined from 6061-T4 aluminum hemispherical forgings. The 7178 hemispheres were mechanically joined in matched pairs by evacuating the air inside and bonding the joint with epoxy overlaid with a rubber sealing strip. The 6061 hemispheres were TIG welded at the equator and holes drilled in each end for connection of the variable ballast system piping.

Two (2) of the poorest of each kind of these spheres were selected from the production lot and collapsed at SWRI. The collapse pressures of all spheres equalled or exceeded the contractual and predicted values.

The quality assurance procedures and production testing of these is shown in Reports No. 14 and 15. The collapse test data are recorded in Report No. 9. A summary report of all of the information is in preparation and will be available in the near future.

Another structural problem studied was the design and construction of two bridges for the joining of the catamaran hulls. Strain gages were installed in critical areas on a 1/12th scale model and later on the full scale catamaran as built. Both model and vessel were towed at sea in waves to record strains. A report of this testing is in process.

Hydrodynamic Analysis and Testing

The 1/4 scale model hydrodynamic study at Illinois Institute of Technology was continued during this period and the results are shown in Report No. 18. A correlation between the model data and the vehicle shallow water trial data is being studied and a report of this effort is in preparation.

Buoyancy Material

All of the buoyancy material for the ALVIN was prepared at the Contractor's plant and is made from epoxy and glass micro-balloons. The small test samples poured separately from each pour used in the vehicle were tested and found to be deficient in some respects to the strength and water absorption expected. Thus cores were taken from all pours as installed in the vehicle and separately tested and reported in Report No. 16. As a result of this testing program at A.S.D., the material appears adequate for the service intended but may require replacement sooner than desired because of longer term water absorption. Life tests on this material are planned to proceed concurrently with vehicle operations. In no case has catastrophic failure been exhibited by even the poorest material tested to 5,000 psi. It is therefore considered that safety of operations will not be materially affected by the use of this material.

WHOI is participating in discussions being held by Subcommittee XX on Cellular Plastics - Syntactic Foam Task Group, formed by the American Society for Testing and Materials (ASTM) to establish testing and acceptance standards for this relatively new material. It is expected that a great deal of useful engineering information will result from this effort.

Fabrication and Final Assembly

No. 2 sphere was shipped to Minneapolis after completion of testing to 3,300 psi, where it was fitted to the frame and the interior racks, wiring and instrument panels were installed. Concurrently, the system components were being tested (see Report No. 13) and assembled into the main ballast box, variable ballast box and main ballast box. The vehicle piping was completed, the control centers installed and the complete systems checked out. The batteries were charged and discharged 3 times and then assembled in their boxes.

Prior to installation, all parts were weighed. The major buoyancy packages, spheres, and battery boxes were also weighed in water. The weight and balance of the vehicle required a reduction in batteries and the addition of buoyancy material externally outboard of the main ballast tanks on the forebody and inside the fibre-glas skin above the batteries.

Commissioning

Upon arrival, the submarine was unloaded in the Laboratory of Oceanography parking lot and readied for the Commissioning Ceremony held on June 5th at this location. Approximately 500 WHOI employees and dignitaries assembled on a beautiful sunny day for this significant occasion and heard the Hon. James H. Wakelin, Jr., Assistant Secretary of the Navy for Research and Development, give the principal address. One of his forecasts was that increased interest and activity in the deep submergence field was emerging, and this has been borne out in the recent past.

Training and Shallow Water Testing

The training and shallow water testing phase began with the first dive, a tethered one, on June 26, conducted to establish the trim of the submarine. An inclining experiment dive was next conducted in Eel Pond to remove the sea swell variable and then a free dive was made on July 2. On this dive the variable ballast system failed to operate and leaks were discovered in the main ballast tanks. In addition, the variable ballast system was found to be very slow and modifications to this piping as well as correction of the electrical problems associated with the original failure and the correction of the main ballast tank leaks took up the month of July. However, on July 31 the first free dive in open water was conducted successfully and a period of successful operations was commenced that was concluded in October.

The current in Great Harbor introduced a variable that should be eliminated for shallow water testing so the operating scene was shifted to Buzzards Bay off "Stony Beach" by loading the submarine and all support equipment, including the crane, onto a barge on loan from Mr. Dan Clark. There the currents were negligible and speed trials were attempted. However, the shallow water and restricted visibility prevented the collection of satisfactory data and it was decided to conduct as many dives as practicable for training of the crew and particularly for the exposure of potential scientific users of the craft to its capabilities. This effort continued in Buzzards Bay and will be covered elsewhere, until on September 1st the submarine was moved back to the WHOI dock and operations in Great Harbor. Again, current was a factor, but one which the now more experienced pilots could handle, and the training and trials continued. Intermingled with "orientation dives" were others to measure the craft's maneuverability, maximum trim angle, static thrust submerged, compensation system, and release of the forebody. This latter test concluded the testing program for this period.

The result of this training and testing period was a vehicle that performed well with very minor difficulties after the initial problems were corrected; a crew that could operate, maintain and support the craft reasonably efficiently; and a craft that was useful in performing a few scientific tasks, even if elementary, during its early existence.

A summary of the dives is shown in Appendix "A".

Orientation Dives

When it was found that the shallow water conveniently available to Woods Hole was not especially susceptible to obtaining good data for acceptance of the vehicle, it was decided that the introduction of this new instrument to the scientist interested in its use was most desirable, and a series of dives for this purpose were commenced. These were conducted on a very flexible and informal basis so as to interfere the least with other programs. Sometimes on an hour or less notice, a particular individual was on the scene and ready to dive for as long as he wished or as long as the remaining commitments would permit. In addition, visitors from other activities such as laboratories, government agencies, and legitimately interested companies dived in ALVIN. Many direct observations of the environment were made by biologists, geologists, physical oceanographers, chemists and geophysicists, each interested mainly in what the ALVIN could do in their particular field.

There were a few observations made that were of immediate and direct interest to the individuals involved. One was the survey of Great Harbor by the group of geologists studying the Continental Shelf. This particular area was surveyed by some of the same persons using "SCUBA" gear prior to the ALVIN's dives and the methods were compared. In some respects ALVIN is superior since more comfort, less physiological danger and in some cases, better observation are possible. However, tactile response is lacking among other things. It remains to be seen whether this vehicle can provide as much information to the interested scientist as the more direct approach (SCUBA) in shallow water, but it most certainly can in waters beyond SCUBA depths.

Gravity measurements with the LaCoste Gravimeter were made in Buzzards Bay and in Great Harbor. These were made to prove the feasibility of doing it in ALVIN as well as providing data for those points involved. Currents prevented taking such data in Vineyard Sound at this time.

It was noted that use of the mechanical arm was practical, even by those initially unfamiliar with its operation. Also observed was the fact that fish fed in great numbers in the tracks made by the vehicle on the bottom. The scanning sonar provided "relative" navigation information that will be of interest to both the pilots and scientists. In short, the vehicle seems to hold promise in fulfilling its task of providing another useful tool for investigation of the phenomena of the oceans heretofore obscured from direct observation by the interested oceanographer.

Instrumentation

1. Vehicle Instruments

The instrumentation used during the operational period is of some importance to what ensued. The vehicle was furnished by the Contractor with the following instrumentation:

- 1) MK 22 Gyro Compass
- 2) Aircraft magnetic compass
- 3) Speed indicator
- 4) Trim and list indicators
- 5) Variable ballast capacity
- 6) Main ballast blow air pressure
- 7) Battery condition meters

An electrical shallow and deep depth gauge system were not operational.

The compasses performed as expected. The speed indicator, however, did not provide useful information and is now being checked. The trim and list indications were marginal in performance in list but satisfactory in trim (the most useful one). The variable ballast indication system was useable but not as sensitive in the low range as desired. The main ballast blow pressure functioned well, but the "battery condition" meters did not have enough range to be entirely satisfactory. The deficiencies in these instruments are being corrected during the present refit.

2. Navigation Instruments

The Straza Scanning Sonar was installed relatively early in the series of dives (No. 20). This proved to be a very useful instrument for locating oneself in the areas involved and avoiding obstacles such as rocks, etc. A set of pingers (37 kcs) and tri-planes were used for range and bearings. At times the submarine could operate independently of the surface units using these devices.

The doppler navigation system was installed but it was never "debugged" and therefore its usefulness was never fully evaluated.

Pingers were mounted on the submarine for tracking by surface units and these seemed to work well in the shallow water involved during this period.

3. Miscellaneous Instruments

The underwater TV and monitor was used at all times on the surface by the pilots as a "periscope" and it worked very well for this purpose. No tests were made to compare its performance to direct viewing through the windows for other tasks such as guiding the mechanical arm.

The mechanical arm was mounted later (Dive No. 37) for evaluation and proved to be a most useful device. Many observers unfamiliar with its operation at the beginning of a dive were able to pick up objects of interest on the first try. The extremely good maneuverability of the vehicle contributed to this ability. No mid-water tasks were attempted with the arm as the vehicle was always resting on the bottom. Core samples were taken with "jury-rigged" coring tubes.

During this period the echo-sounder -- Precision Graphic Recorder (PGR) and necessary power supply was shipped to the OCEAN PEARL in Florida to conduct several areal surveys in and around the

"Tongue of the Ocean" (TOTO) for information in planning the next series of dives including the deep dive testing. For this purpose the system worked well.

The rest of the instruments are presently being installed including the lights, cameras, etc.

Inspection and Refit

Early in October, operations were temporarily suspended and the ALVIN was taken to a hangar at Otis Air Force Base for an inspection refit prior to making any deep dives. The submarine was completely disassembled. Several unexpected problems were discovered during this process and are being, or have been corrected. The aluminum frame had two minor cracks from a blow of unknown origin. The member involved was replaced and all critical welds x-rayed and repaired. The aluminum variable ballast spheres were found to have corrosion where the paint had been damaged. These have been repaired and a more careful handling and protection program is being followed. The list control valves in the main ballast air system failed during operations so this system was sent back to Litton for repair and retesting as was the variable ballast system. The propulsion system and mercury trim system were inspected in place and some repairs were necessary in the latter. All of the buoyancy material in the submarine was selectively cored and the cores tested under pressure with satisfactory results. The fibreglas skin was repaired in many areas where separation had occurred. An additional bottle has been added to the main ballast system to give more tank blowing air capacity. The major changes were made in the electrical system and the following are some of the more important ones:

- 1) Addition of battery circuit breakers or disconnects to permit selective isolation of all of the batteries from the battery busses.
- 2) Isolation of the emergency circuits such as battery, mechanical arm and mercury dump from each other and from rest of the control circuits.
- 3) Several additional meters have been installed for more complete monitoring of the electrical circuits.
- 4) Relays for the underwater lights were installed in the control center.

- 5) The electrical circuits inside the sphere have been rewired and some of the vehicle controls and instruments have been moved to more convenient locations based upon experience gained with use.
- 6) The WHOI furnished instruments have been overhauled and checked and are being reinstalled, including some that were not used in the first series of dives.
- 7) A "leak detector" circuit has been added.
- 8) A set of electrical drawings of all of the changes have been made and the vehicle drawings are being brought up-to-date.

The sphere release shaft galled during the test of this device, and although a successful release was accomplished, a redesign to reduce or eliminate the difficulties encountered is proceeding and a retest will be made.

The interior arrangement of the sphere has been reviewed and some changes in seats, location of some of the equipment, and tie-downs for all loose gear have been added.

During the refit, another support van was added, bringing the total number to four, to house the instrument shop and associated spare parts. It was originally intended to use the utility van for this purpose, but experience has shown there to be too much interference from other activities in the utility van, as well as a severe shortage of spare parts and miscellaneous equipment stowage space. Provision has been made on the deck of the catamaran for this additional van.

Test discharges were run on the batteries furnished with ALVIN and the suspected low capacity was confirmed. Replacement and test of new batteries is being accomplished by Litton.

Support Vessel and Equipment

The two (2) 96' hulls acquired as Navy surplus equipment were towed to Woods Hole early in the year and bridges designed by Philip L. Rhodes Co. were constructed and welded to join these hulls into a catamaran type vessel. The design includes an electrically driven "elevator" for lifting ALVIN in and out of the water from between the hulls for washing down and servicing between dives.

It will also be a platform for the necessary support equipment such as the air and battery charging van, the machine shop van, an instrument van and a utility van which includes minimum provisions for feeding the crew. Provisional bunking arrangements are being provided also, but the final outfitting of this support craft is awaiting deep water and heavy weather testing.

A winch and long line are being provided for on the catamaran, designated Deep Submergency Research Vehicle Tender No. 1 (DSRVT-1), to permit deep unmanned dive testing to 7,500 feet. It will later provide a deep water mooring capability.

Four diesel driven "outboard" motors were acquired also as Navy surplus. One of these will be mounted to provide maneuvering capability and short range self-propulsion. Normally the catamaran will be towed and tended by a support ship.

A dummy ALVIN has been built to provide a means of training the crew in the handling capability of the catamaran as well as the unmanned deep dive procedure.

Aboard the catamaran are two 35 DW 480 V, 3 phase diesel generating sets to furnish power for the lifting and long line winches as well as hotel loads. Transformers are being installed to allow using either the generating van or the catamaran as sources of power for charging and lifting. The vans are powered by 208 V, 3 phase generators; this interchangeability had to be built in so that power is available for each, either together or separately.

A low bed trailer was procured for local transport of ALVIN around the Institution and a 16 ton "Holly Hoist", which has been tested to lift 25 tons, was acquired to move ALVIN and to provide the ability to disassemble the major parts of the submarine for inspection and maintenance, as well as the removal and replacement of battery boxes while aboard the catamaran.

Personnel

Positions within the DSRVG were filled to the extent believed necessary for the initial testing and operation of the submarine and the catamaran. As of 31 December 1964, the following persons are presently or have been employed on the project during this period:

Full Time

Engineering and Support

Earl E. Hays
James W. Mavor, Jr.
William O. Rainnie, Jr.

Henry M. Horn
William M. Marquet
Frank P. Omohundro
Mabel M. Reese

Operations

William O. Rainnie, Jr. - Pilot
Paul E. Hamman - Pilot
Marvin J. McCamis - Pilot

George D. Broderson
Richard A. Chandler
Allan R. Davison
Mark P. Fox
Russell G. Graham
David H. Mason
Chester R. Porembski
Clyde L. Tyndale
Valentine P. Wilson (Pilot-in-training)

The following resigned during this period:

Henry H. Learnard II
Karl R. Krueger
Orrin L. Swinhart

Part Time

John Duff
Charles Easterly
Henry Leonard
David M. Owen
Arnold G. Sharp
Jess H. Stanbrough
William S. Shultz
Allyn C. Vine
Joesph B. Walsh
Charlotte A. Muzzey

Summer

David Bedding
William Lane
Cary Rea
John Wilska
Kim Saunders

Visitors

Visits to personnel on this project continued at previous levels as more than 225 persons came to discuss submarines, instruments, equipments and tools. These are too numerous to mention by name, but included representatives from various private laboratories, government laboratories and Bureaus, foreign nations, industry and schools. In addition, several hundred casual visitors were shown the ALVIN while on the WHOI dock or at sea.

Future Program

It is intended to reassemble the submarine and conduct appropriate system tests and then ship it along with the support equipment and vans to a warm water port in Florida or other suitable location to complete the shallow water testing program. The deep diving tests will then be conducted, probably in Tongue of the Ocean, some time this spring, to include a tethered unmanned dive to test depth (7,500 ft.). While in this area, scientific dives may be conducted, if time permits, as well as inspection of certain underwater structures. Assuming a successful deep dive program is accomplished, an inspection of underwater structures will probably be conducted in the Bermuda area prior to return to Woods Hole this summer. The ALVIN will then be available for a full time scientific program as requested by WHOI and other interested scientists.

The catamaran will be tested at sea and the crew trained in the handling and support of the submarine from this platform. It will be towed to a suitable port to load ALVIN and the support equipment, and be towed to the Bahamas.

The Institution feels very fortunate to have been offered the services of Mr. Edwin Link and his ship SEA DIVER as the major support vessel for the shallow and deep water testing program. The OCEAN PEARL, owned by Mr. Seward Johnson, has also been offered as a support ship and survey vessel. Mr. Johnson has already performed initial surveys of the testing area that have been valuable in choosing sites.

Also under preparation are the contract plans and specifications for two additional deep diving submarines similar to ALVIN, one to be used as a sister-ship to ALVIN operated by WHOI, and one for the Navy's new Acoustic Underwater Test and Evaluation Center (AUTECH) in the Bahamas. It is hoped these two additional submarines will be contracted for in the near future.

Illustrations

- Figure 1 - Commissioning, June 5, 1964
 - Figure 2 - ALVIN Underway on the Surface
 - Figure 3 - ALVIN Being Hoisted onto the Dock at WHOI
 - Figure 4 - ALVIN, Hoisting Crane and Barge (Support Vans are shown on the right)
 - Figure 5 - Looking to Port--Observer's Side
 - Figure 6 - Looking to Starboard--Pilot's Side
 - Figure 7 - Looking Aft
 - Figure 8 - ALVIN Forebody Just Reaching Surface After Hull Release Test
 - Figure 9 - Mechanical Arm Mounted on ALVIN
 - Figure 10 - Mechanical Arm Jaws and Coring Tool
 - Figure 11 - DSRVT-1 Catamaran Tender
- } ALVIN Sphere Arrangement

Figure 1 - Commissioning, June 5, 1964

Figure 2 - ALVIN Underway on the Surface

Figure 3 - ALVIN Being Hoisted onto the Dock at WHOI
by Crane.

Figure 4 - ALVIN, Hoisting Crane and Barge (Support
Vans are shown on the right)

Figure 5 - Looking to Port--Observer's Side

Figure 6 - Looking to Starboard--Pilot's Side

Figure 7 - Looking Aft

ALVIN, Sphere Arrangement

Figure 8 - ALVIN Forebody Just Reaching Surface After
Hull Release Test

Figure 9 - Mechanical Arm Mounted on ALVIN

Figure 10 - Mechanical Arm Jaws and Coring Tool

Figure 11 - DSRVT-1 Catamaran Tender

Appendix A

Summary of Dives June-October 1964

<u>Dive No.</u>	<u>Date</u>	<u>Place</u>	<u>Pilots</u>	<u>Observers</u>	<u>Max. Depth (Ft.)</u>	<u>Dive Length (Hours)</u>	<u>Remarks</u>
1	6/26	Off WHOI Dock	Rainnie McCamis Learnard	None	27	1 1/4	1st Tethered Trim Dive
2	7/1	Eel Pond, Woods Hole	McCamis Rainnie	"	12	1	Submerged inclining experiment
3	7/2	Off WHOI Dock	Rainnie McCamis	"	25	2 1/2	1st Free Static Dive
4	7/31	"	McCamis Rainnie	"	25	3/4	System Check-out
5	8/4	Great Harbor, Woods Hole	McCamis Rainnie	"	38	1 1/4	1st Free Dive
6	8/5	"	"	"	70	1/2	Training Dive; M.B. Blow failed
7	8/7	"	"	"	40	2 1/4	Training Practice Salvage
8	8/7	"	"	H. Froehlich, ALVIN designer	32	1 1/4	Training; 1st Observer
9	8/12	Buzzards Bay off "Stony Beach"	"	None	45	1 1/4	Training
10	8/12	"	Rainnie McCamis	"	25	1/2	"
11	8/14	"	McCamis Rainnie	"	33	1 1/2	"
12	8/14	"	"	"	44	1	Speed Trials
13	8/17	"	"	"	35	1 1/4	" "
14	8/17	"	Rainnie McCamis	A. Vine	25	1	1st Scientific Observer

<u>Dive No.</u>	<u>Date</u>	<u>Place</u>	<u>Pilots</u>	<u>Observers</u>	<u>Max. Depth (Ft.)</u>	<u>Dive Length (Hours)</u>	<u>Remarks</u>
15	8/18	Buzzards Bay off "Stony Beach"	Rainnie Hamman	None	35	1	Training
16	8/18	"	Rainnie	Capt. C. Momsen	36	1	Orientation
17	8/14	"	McCamis	LCDR W.Lasley	36	3/4	"
18	8/19	"	McCamis Hamman	None	38	2	Training and Speed Trials
19	8/20	"	McCamis Rainnie	"	45	3/4	Speed Trials
20	8/20	"	Hamman Rainnie	W.Marquet	34	3/4	Instrument check; Scanning Sonar installed.
21	8/21	"	McCamis Rainnie	None	43	1 1/4	Speed Trials
22	8/24	"	Rainnie	R.Backus	36	1 1/2	Orientation
23	8/24	"	McCamis	W.Lane C.Rea	35	3/4	Training
24	8/24	"	Hamman McCamis	None	25	1	"
25	8/25	"	Rainnie	C.Bowin	42	1 3/4	Orientation--Gravity Measurements
26	8/25	"	Hamman Rainnie	A.Rechnitzer	33	3/4	Orientation
27	8/25	"	Hamman McCamis	W.Scheville	36	1 1/4	"
28	8/26	"	McCamis	G.Kelly J.Wilska	36	1	Training
29	8/26	"	Rainnie	P. Fye	41	1 1/4	Orientation
30	8/26	"	Hamman McCamis	J.Knaus	44	1	"

<u>Dive No.</u>	<u>Date</u>	<u>Place</u>	<u>Pilots</u>	<u>Observers</u>	<u>Max. Depth (Ft.)</u>	<u>Dive Length (Hours)</u>	<u>Remarks</u>
31	8/26	Buzzards Bay off "Stony" Beach	Hamman McCamis	R.Chase	34	3/4	Orientation
32	8/27	"	Hamman McCamis	W.Burt	30	1	"
33	8/27	"	Hamman Rainnie	J.Beckerle	40	1	"
34	8/27	"	Hamman McCamis	D.Bedding	35	3/4	Training
35	8/27	"	Hamman McCamis	L.Baxter	41	1 1/2	Orientation
36	8/27	"	Hamman McCamis	A. Vine	40	3/4	Orientation and Training
37	9/1	Great Harbor, Woods Hole	Hamman Rainnie	None	48	1	Pilot Qualification - Mechanical Arm Mounted
38	9/1	"	Rainnie	E.Link	28	1 1/4	Orientation
39	9/2	"	McCamis	S.Johnson	28	1	"
40	9/2	"	Hamman	E.Hays	25	3/4	"
41	9/3	"	Hamman	J.Stanbrough	25	3/4	"
42	9/3	"	McCamis	J.Hulsemann	33	2 1/4	Orientation and Geol. Observation
43	9/3	"	Rainnie	R.Pratt R.Cordry	25	1	" " " "
44	9/4	"	Hamman	D.Stanley D.Owen	44	1	" " " "
45	9/8	"	Hamman	H.Sanders R.Hessler	32	3/4	Orientation
46	9/8	"	McCamis	J.E.Burke	40	1	Photo Mission
47	9/8	"	Hamman	K.Emery	53	1 1/4	Orientation and Geol. Observation

<u>Dive No.</u>	<u>Date</u>	<u>Place</u>	<u>Pilots</u>	<u>Observers</u>	<u>Max. Depth (Ft.)</u>	<u>Dive Length (Hrs.)</u>	<u>Remarks</u>
48	9/9	Great Harbor, Woods Hole	Hamman	M. Fox R. Graham	31	1	Training
49	9/9	"	McCamis	D. Mason G. Broderson	40	1	"
50	9/9	"	Hamman	C. Tyndale C. Porembski	33	1	Instrument Check
51	9/10	"	Hamman	S. Mackay C. Menneken	34	3/4	Orientation
52	9/10	"	McCamis	A. Bennett D. Mintzer	30	3/4	"
53	9/15	"	Rainnie	L. Cather H. Bernstein	39	3/4	"
54	9/15	"	McCamis	D. Bumpus	30	2	Orientation and Current Measurement
55	9/15	"	Rainnie	R. Tagg	44	1	Orientation and Geol. Observation
56	9/16	Vineyard Sound	Hamman McCamis	None	50	1	Training in Current
57	9/21	Great Harbor, Woods Hole	McCamis	R. Dill A. Schlosser	40	1 1/4	Orientation
58	9/21	"	Hamman	A. Twitchell K. Mackenzie	30	1	"
59	9/22	"	Rainnie	J. Mavor	35	3/4	"
60	9/23	"	McCamis	J. Craven	34	1	"
61	9/23	"	Hamman	F. Weyl W. Whitmore	30	3/4	"
62	9/23	"	Rainnie	Capt. J. Heg Cdr. L. Jackson	40	1	"
63	9/23	"	McCamis	W. Avery D. Bleil	35	1/2	"

<u>Dive No.</u>	<u>Date</u>	<u>Place</u>	<u>Pilots</u>	<u>Observers</u>	<u>Max. Depth (Ft.)</u>	<u>Dive Length (Hrs.)</u>	<u>Remarks</u>
64	9/25	Great Harbor Woods Hole	Hamman	Capt. B Byrnside	34	1	Orientation
65	9/25	"	Rainnie	E. Bunce	45	1	"
66	9/25	"	McCamis	R. Meade F. Manheim	45	1 1/2	Orientation and Geol. Obs. - 1st Core Samples
67	9/28	Vineyard Sound	McCamis Hamman	None	17	1/4	Speed trials aborted because of current
68	9/28	Great Harbor Woods Hole	McCamis Hamman	None	62	1 1/2	Maneuvering submerged
69	9/29	"	McCamis Hamman	A. Vine	65	2 1/4	Speed Trials
70	9/30	"	Rainnie	Lcdr. L. Shumaker P. Ianuzzi	30	3/4	Observe operations
71	9/30	"	Hamman	A. Vine C. Porembski	28	2	Submerged maneuvering characteristics and instrument check
72	9/30	"	McCamis	C. Bowin	62	2	Geol. Obs. and gravity measurement
73	9/30	"	Rainnie Hamman	None	46	2	Tethered-To calibrate Var. Ball. Syst. Submerged
74	10/1	Off WHOI Dock	Hamman	H. Froehlich	20	1 1/4	Tethered-To measure max. trim angle and run machinery at max. angle
75	10/1	"	McCamis	W. Nesbitt	17	1 3/4	Tethered-Submerged Static Thrust Measurements
76	10/6	"	McCamis Hamman	None	23	3/4	Forebody release test aborted because of broken wrench.
77	10/6	"	Hamman McCamis	None	23	1/4	Forebody release test - successful.
10/6 -- Secured operations for inspection and refit.							

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