WHOI-70-60
c.1

WOODS HOLE OCEANOGRAPHIC INSTITUTION

DATA LIBRARY
WOODS HOLE OCEANOGRAPHIC INSTN

REFERENCE NO. 70-60

TORQUE TESTS OF A FULL SIZE MODEL OF THE ALVIN/AUTEC EMERGENCY SPHERE RELEASE

Arnold G. Sharp and James R. Sullivan

This document has been approved for public release and sale; its distribution is unlimited.

WOODS HOLE, MASSACHUSETTS

WOODS HOLE OCEANOGRAPHIC INSTIUTITON
Woods Hole, Massachusetts

REFERENCE NO. 70-60

TORQUE TESTS OF A FULL SIZE MODEL OF THE ALVIN AUTEC EMERGENCY SPHERE RELEASE

DATA LIBRARY
WOODS HOLE OCEANOGRAPHIC INSTITUTION

by

Arnold G. Sharp and James R. Sullivan

November 1970

TECHNICAL REPORT

Submitted to the Office of Naval Research under contract Nonr-3484(00); NR 260-107.

Reproduction in whole or in part is permitted for any purpose of the United States Government. In citing this report in a bibliography, the reference should be followed by the phrase: UNPUBLISHED MANUSCRIPT.

This document has been approved for public release and sale; its distribution is unlimited.

Approved for Distribution

Scott C. Daubin, Chairman
Department of Ocean Engineering

ABSTRACT

Laboratory torque tests were performed using an actual emergency sphere release shaft of the type used in the research submarines ALVIN, SEA CLIFF and TURTLE. A test fixture was constructed which permitted laboratory simulation of the side (squeezing) forces applied to the release shaft cam as a result of forebody buoyancy. Estimated full-scale side forces were applied to the cam by a laboratory compression testing machine, and the torque required to rotate the shaft was measured. Tests were run with contacting surfaces (a) clean and dry, (b) greased, and (c) immersed in sea water. From the test results, values of release torque were calculated for the submarines in question. Coefficient of friction values for the contacting materials (Monel K-500 on phosphor bronze) also are reported.

TABLE OF CONTENTS

I INTRODUCTION

In 1965 the original emergency forebody release device of the research submarine ALVIN was replaced with one of improved design (Ref. 1). Subsequently, two new submarines, SEA CLIFF and TURTLE, have been built, and both vehicles use a release device patterned after the improved ALVIN release. The titanium pressure hull now being built by the U.S. Navy under Project Titanes is to be used interchangeably with the existing pressure hulls of the three aforementioned submarines, and it therefore will require release device components compatible with those vehicles.

In the event that use of the emergency sphere release ever should be necessary, it would be required that the release shaft be rotated manually one-quarter turn from within the sphere. The torque or turning effort needed to accomplish this rotation would depend on three major factors:

a. Possible squeeze of the contracted spherical hull wall around shaft bushing and shaft (a function of depth).

b. Axial thrust of release shaft cam against its thrust washer, caused by external hydrostatic pressure (a function of depth).

c. Frictional drag on release shaft cam due to side forces applied by release dogs (a function of forebody net buoyancy).

In addition to the foregoing factors, resistance to turning motion of the shaft could be caused by frictional drag of O-rings or other seals, possible misalignment of parts during assembly, and possible galling of contacting metal surfaces. These latter points are considered minor in the light of accumulated experience with the submarine ALVIN. Of the three major factors listed above, the effect of factor (a) should be negligible with a properly designed through-hull shaft bushing. Factors (b) and (c) will be present as factors inherent in the basic design of the release. It is therefore considered important to evaluate these effects as fully as possible for all anticipated operating conditions.

Full scale in-service tests of the release devices installed in their respective submarines, have proven to be less than completely satisfactory. Certain in-air tests have been performed but these have served primarily as a check on assembly procedures. The resisting torque would not have been comparable to that encountered in a submerged vehicle. Pressure vessel tests of the release shaft mounted in the sphere alone, such as those performed with the SEA CLIFF and TURTLE spheres at Naval Ship Research and Development Center (Ref. 2 and 3) yielded only partial information. Since the release dogs (part of the vehicle afterbody) were not present in these tests, the resisting torque on the release shaft due to the buoyancy of the forebody was missing. Only the axial thrust effect could be determined. Open water tests involving the complete submarine are difficult, expensive, and hazardous. Only in water of depth comparable to the operating depth of the submarine, would such a test provide full information. The shallow water tests which have been performed on a number of occasions have been until now the best source of information on the performance of the release. In these tests, however, the full effect of axial thrust due to hydrostatic pressure is absent.

Because of these difficulties in obtaining complete data in the field, the attempt has been made to provide full information by means of carefully controlled laboratory tests.

Pressure vessel tests of the newly designed ALVIN release shaft and bushing were performed at Woods Hole in April 1965. While these tests were primarily for the purpose of checking the effectiveness of the O-ring seals and gaskets, torque measurements were taken at that time also. Since the shaft and bushing alone were tested, measured torque was that due to axial thrust only. The test results were reported briefly at that time (Ref. 1).

In an earlier phase of the work reported herein, an accurately machined laboratory model of the release device was assembled and instrumented with electric resistance strain gages. Tests performed with this equipment led to the determination of forces on sphere release components under various conditions of loading. The results of these tests were reported in 1969 (Ref. 4).

The work outlined in this report was primarily concerned with applying the results of the 1969 model tests (Ref. 4) in an effort to predict release torques for ALVIN and the AUTEC vehicles. A test fixture was constructed which permitted laboratory simulation of the side (squeezing) forces applied to the release shaft cam by the release dogs. Estimated full-scale side forces (for ALVIN) were applied to the cam portion of the shaft using a laboratory compression testing machine, and the torque required to rotate the shaft was measured. Tests were run with the contacting surfaces (a) clean and dry, (b) greased, and (c) immersed in sea water.

From the results obtained, values of the coefficient of friction were calculated for the contacting materials (Monel K-500 on phosphor bronze) under the given test conditions.

It is felt that if the pressure vessel test results of 1965 and the results of the present investigation are superposed, a reasonably accurate prediction of release operating torques is possible. This has been done for ALVIN and the two AUTEC vehicles SEA CLIFF and TURTLE, and the results are presented in this report.

As the Project Titanes pressure hull nears completion and its weight and displacement figures become established, torque predictions can be made for it by extrapolation of the present results.

II DESCRIPTION OF TESTS

Equipment

The torque test fixture was designed around an actual sphere release shaft obtained from Electric Boat Division of General Dynamics Corporation during the construction of the submarines SEA CLIFF and TURTLE. This shaft was mounted in self aligning ball bearings which were fastened to a length of steel channel (Fig. 1). A steel base plate was attached at right angles to the channel and shaft, and served to support the load rod guide cylinders. During testing, the base plate was held in a vertical position so that the load rods were aligned with the axis of the compression testing machine. The load push rods were cylindrical, but were keyed to prevent their rotation during testing. At the inner end of each push rod a small bronze insert was fastened which had the same face dimensions and thickness as the bronze inserts on the ALVIN release dogs (Ref. 1). Material was Grade A phosphor bronze (copper alloy No. 510) and pieces for these tests were made from a bar of the material remaining after the manufacture of the ALVIN release in 1965. The bronze inserts of the fixture were designed to contact the cam surface in the same way that the release dog inserts contact the cam in the actual release device. The test fixture was fitted with 3 levelling screws so that it could be adjusted to its correct position in the testing machine. After a small initial load had been set on the testing machine the levelling screws could be backed off so that the compressive load would be taken entirely by the push rods.

For the in-salt water tests a watertight sheet metal box was constructed (Fig. 3). This box was open at the top so that the test model could be placed in the box, and the assembly mounted in the testing machine as a unit. The box was filled with salt water to a level where the friction surfaces were submerged. A watertight rotating seal was built into one side of the box so that the release shaft could extend through the wall, and the torque wrench could be used outside the box.

Compressive loads were applied to the test fixture using a Baldwin 60,000 pound capacity universal testing machine.

Torque measurements were made using a dial indicator type torque wrench made by Snap-On Tools Corp. of Kenosha, Wisconsin. This wrench was 12 in. long and had a range of 0-150 ft. lbs. (see Fig. 1).

Test Procedure

The first series of tests was performed with the contacting surfaces nominally clean and dry. Surfaces were prepared by first washing with liberal amounts of a degreasing compound called Megasol, and further, by wiping with a gauze pad soaked in trichloroethylene.

In the second test series the friction surfaces were coated with Lubriplate No. 130AA. This is a thin, light colored lubricating grease which has been used extensively by the operators of the submarine ALVIN in applications where both lubrication and corrosion protection have been required.

Finally a series of tests was run in which the contacting surfaces were immersed in sea water. The metal tank contained approximately 10 gallons of salt water taken from Woods Hole Harbor. The test fixture was placed in this box and the entire assembly mounted in the testing machine. The friction surfaces were cleaned, as in the first test series, so that they would be free of grease or oil before the sea water was added to the tank.

Test loads were applied in 100 or 200 pound increments over the range of the approximate full scale cam loading for the submarine ALVIN. Compressive loads were taken up to at least 1200 pounds, although higher loads were applied in some of the tests. At each value of load, the torque wrench was rotated through a small angle, first clockwise, then counterclockwise, and readings taken for both directions. The torque required to rotate the shaft was taken to be the torque wrench reading at the onset of shaft rotation.

The torque wrench was calibrated using dead weights. The head of the wrench was clamped firmly in a vise with the handle in a horizontal position, and a weight pan was suspended from the midpoint of the handgrip. Laboratory weights were added to the pan in 10 pound increments up to 60 pounds, and the wrench dial was read at each increment. Readings were found to be approximately 7 percent high (Fig. 7) and the torque values obtained during the tests were corrected accordingly.

III RESULTS

Based on the data obtained in these tests, the coefficient of friction for the two mating materials was calculated for each of the test conditions imposed. These values are shown in Table 1. By using these results, and combining the results of the model tests (Ref. 4) and the pressure-torque tests done in April, 1965 (see Table A-1), predicted torque values required to release the forebody were determined as shown in Table 2. For the submarine inclined at 30 degrees, the torque was computed on the basis of a transverse cam force equal to 0.7 times the forebody net buoyancy, as determined in the model tests (Ref. 4). Torque values for the level vehicle are based on a calculated cam force of 0.43 times net buoyancy. An experimentally determined value of this force was found to be somewhat less than the calculated value, and so the more conservative figure was used for the present report. All of the torque values reported include the effect of axial thrust due to hydrostatic pressure at operating depth.

The forebody net buoyancy values used in the calculations are 1844 pounds for ALVIN (Ref. 5), and 3120 pounds for the AUTEC vehicles (Ref. 6).

TABLE 1

Coefficient of Static Friction
Monel K-500 on Phosphor Bronze

Surfaces	μ
Dry	0.24
Greased	0.12
In Sea Water	0.15

TABLE 2

Approximate Torque to Release Forebody - Ft.-Lbs.
Vehicle in Sea Water at Operating Depth

	Level	30° List
ALVIN	42	60
SEA CLIFF/TURTLE	63	95

IV DISCUSSION

From a practical viewpoint the "clean and dry" test condition is the least interesting one since it is unlikely that the release device would be operated that way. If the device is actuated in air (for example, in a pre-dive test) this condition might be encountered, but there is a good chance that the surfaces would contain some quantity of oil or grease, either intentionally or otherwise. The operators of ALVIN follow a practice of applying a thin coating of grease to mechanical components such as those of the release mechanism, at the time of assembly.

With the submarine in sea water, any grease previously applied to the contact surfaces probably would be washed away in a short time. However, the test results show that sea water itself provides a fair degree of lubrication. In practice, it is possible that a thin film of grease might remain on the components in spite of the presence of sea water. If this should happen, torque values might be somewhat less than those reported here.

The axial thrust effect, i.e., the resisting torque attributable to external hydrostatic pressure forcing the release shaft cam against its thrust washer, appears to be difficult to predict accurately. The Woods Hole tests for this effect (Table A-1), indicated a torque of 12 foot-pounds at the 6000 foot depth, while the AUTEC tests at 7150 feet gave 9.2 foot-pounds for the SEA CLIFF hull (Ref. 2), and 3.3 foot-pounds for the TURTLE hull (Ref. 3). This discrepancy could be the result of slight differences in the O-ring seal arrangement in the two hull designs, or possibly because of the presence in one or more of the tests of a lubricant other than sea water. The pressure proof test of the AUTEC 2 (TURTLE) hull was done in two parts: a test in oil in which viewport deflections were measured, and a test in salt water, during which the hull release shaft was torque-tested (Ref. 3). It is possible that the low torque reading in that test was the result of a quantity of oil remaining on the release shaft after the completion of the first part of the test. The SEA CLIFF hull tests were done in salt water only, as were the Woods Hole tests of the ALVIN shaft-bushing assembly.

V CONCLUSIONS

Torque tests were performed with a full size laboratory odel of the ALVIN/AUTEC sphere release, using estimated full cale frictional drag forces. The results were combined with est data, previously obtained, of torque as a function of xternal hydrostatic pressure. The combined results led to he calculation of predicted torque required to actuate the elease device. Torque values are shown in Table 2 of this eport. The maximum torque of 95 foot-pounds is that for the UTEC vehicles, at operating depth, and having a 30 degree list.

VI REFERENCES

1. "Design and Manufacture of New Emergency Hull Release for ALVIN," by James W. Mavor and Arnold G. Sharp, W.H.O.I. Technical Memorandum No. DS-20, August, 1965.

2. "Hydrostatic Proof Test of AUTEC 1 (SEA CLIFF) Personnel Sphere," by Albert E. Dadley, Naval Ship Research and Development Center Report No. TR 720-7, June, 1967.

3. "Hydrostatic Proof Test of AUTEC 2 (TURTLE) Personnel Sphere," by Albert E. Dadley, Naval Ship Research and Development Center Report No. 720-9, March, 1968.

4. "Experimental Stress Analysis of Model of Emergency Forebody Release Device Used in Deep Diving Research Submarines ALVIN, SEA CLIFF, and TURTLE," by Arnold G. Sharp and James R. Sullivan, W.H.O.I. Reference No. 69-68, August, 1969.

5. "Weight, Buoyancy and Stability of DSRV ALVIN, 1967," by Arnold G. Sharp and Clifford L. Winget, W.H.O.I. Technical Memorandum No. DS-26, January, 1968.

6. Final Weight Report, AUTEC I and AUTEC II, NOBS 75 A General Dynamics Corporation, Electric Boat Division, Groton, Connecticut, October 16, 1970.

VII APPENDIX

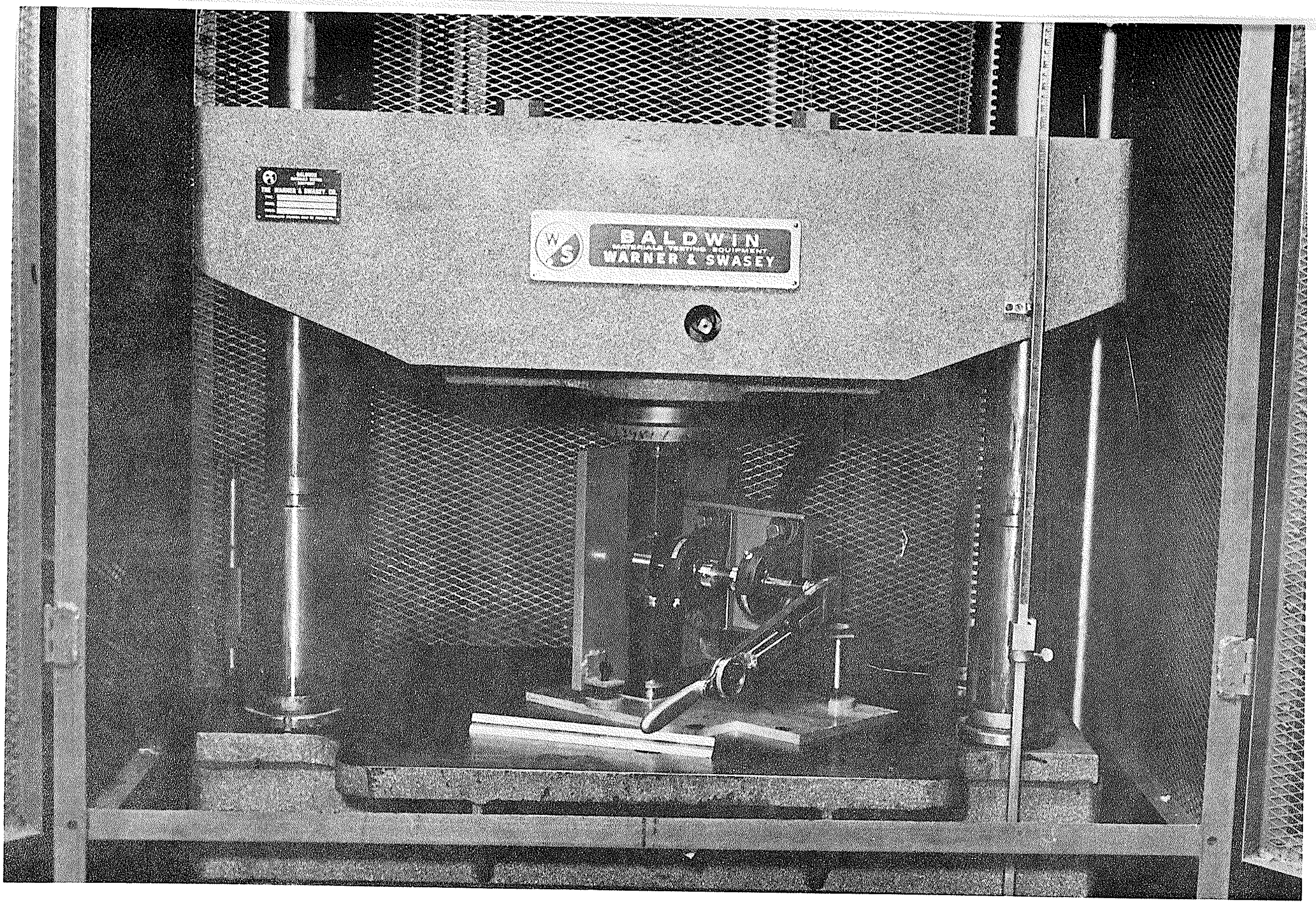

Figure 1. Release Model in Testing Machine

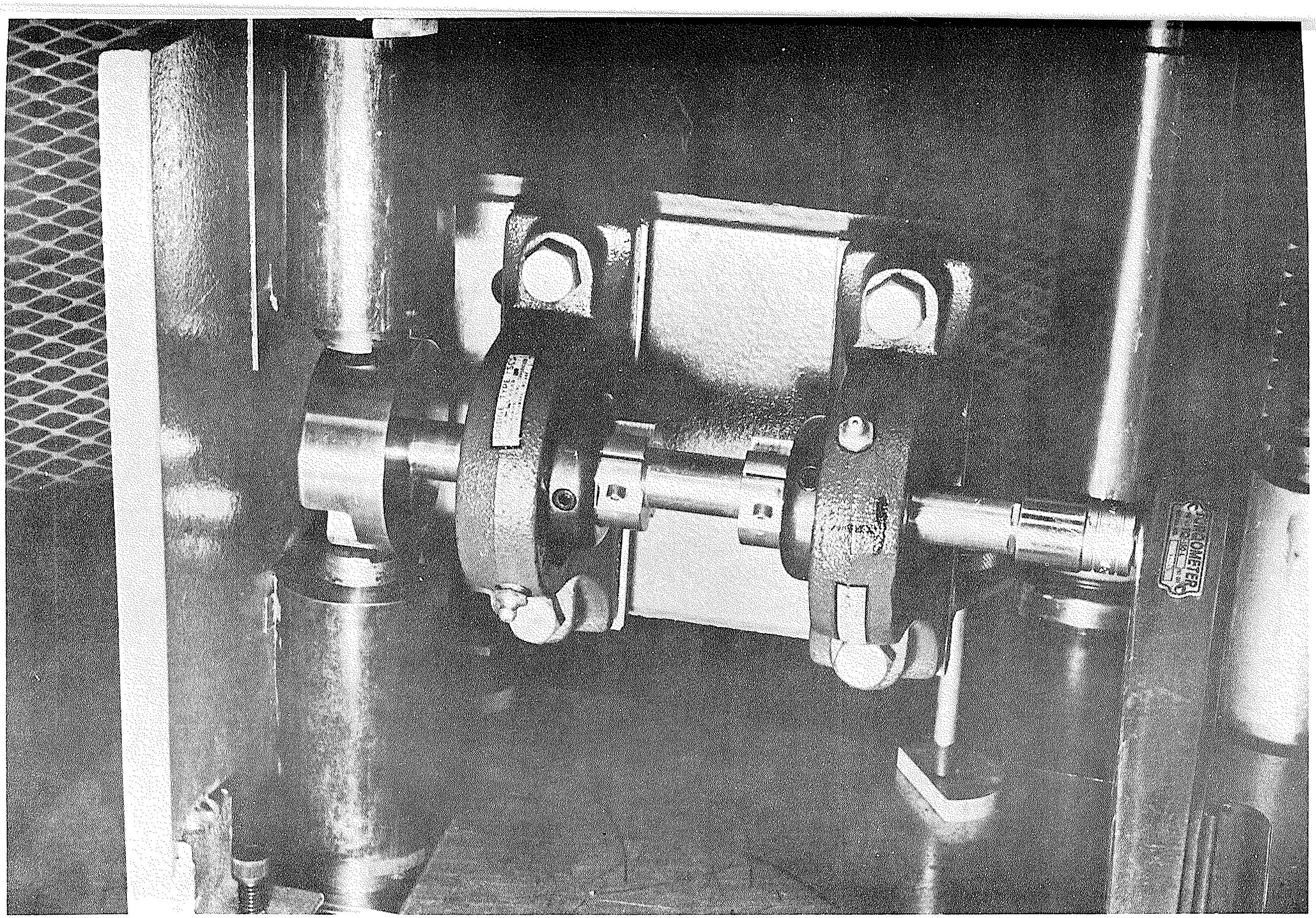

Figure 2. Close-up View of Test Model

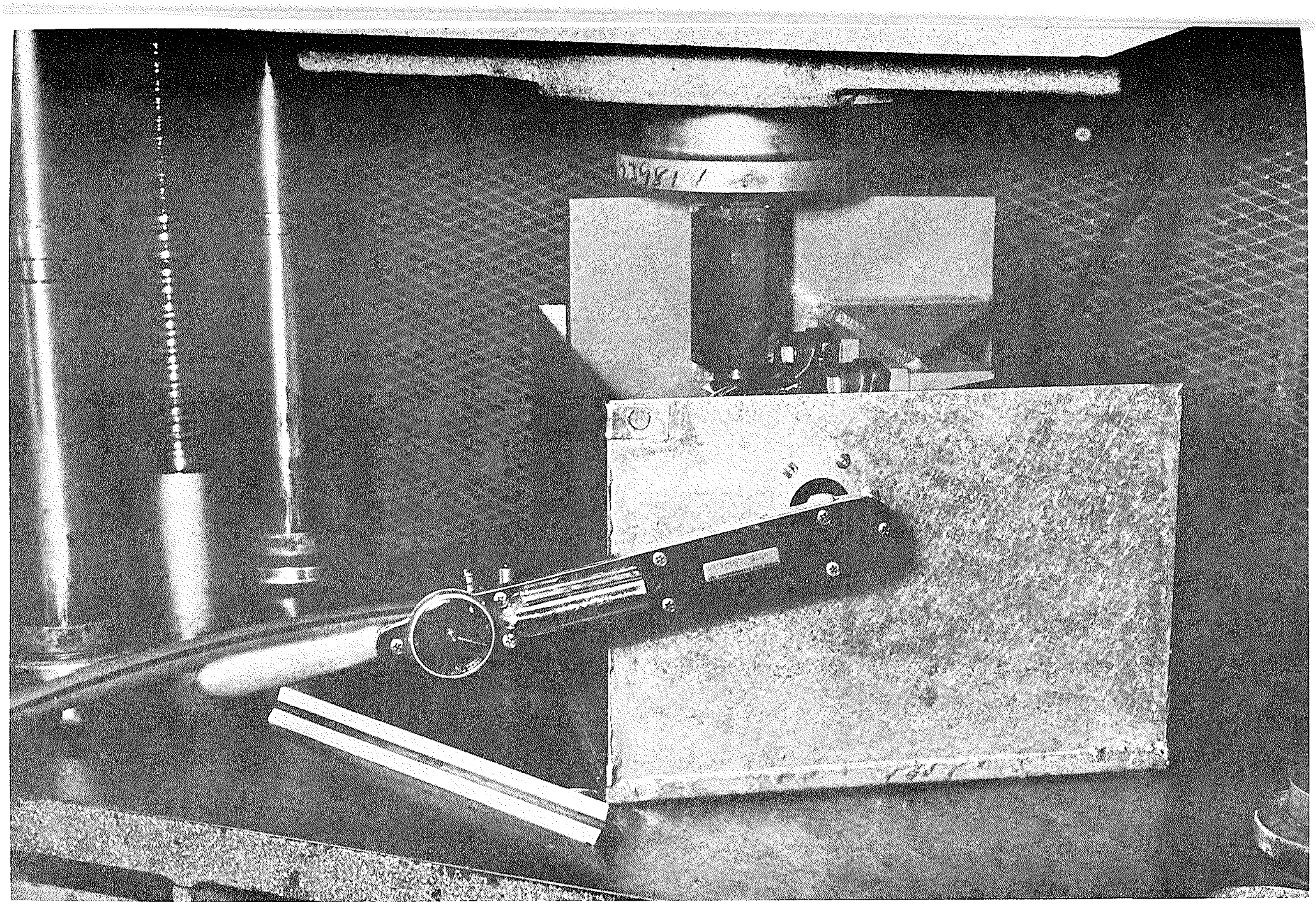

Figure 3. Test Model in Tank for Sea Water Tests

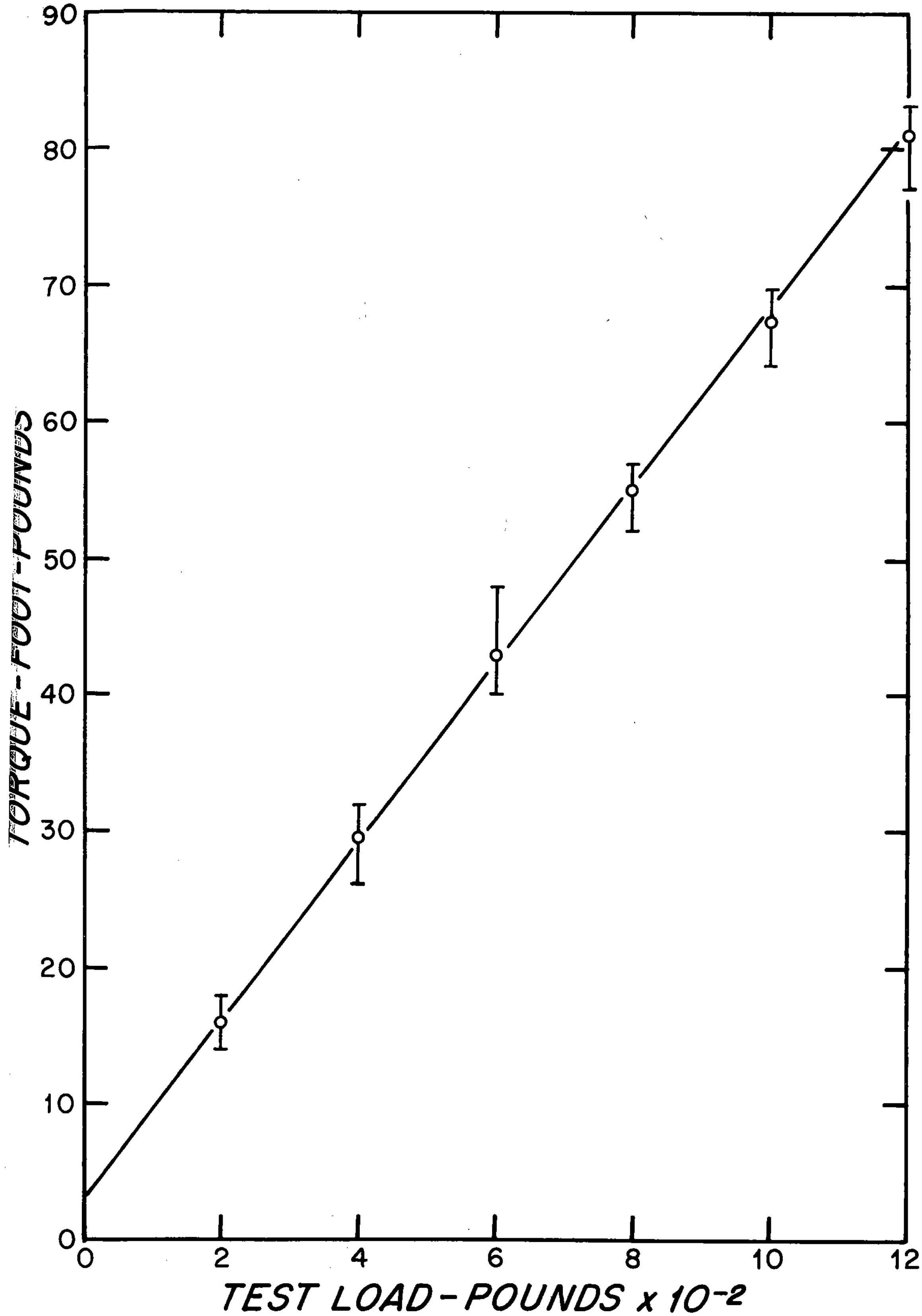

Figure 4. Test Data - Surfaces Clean and Dry

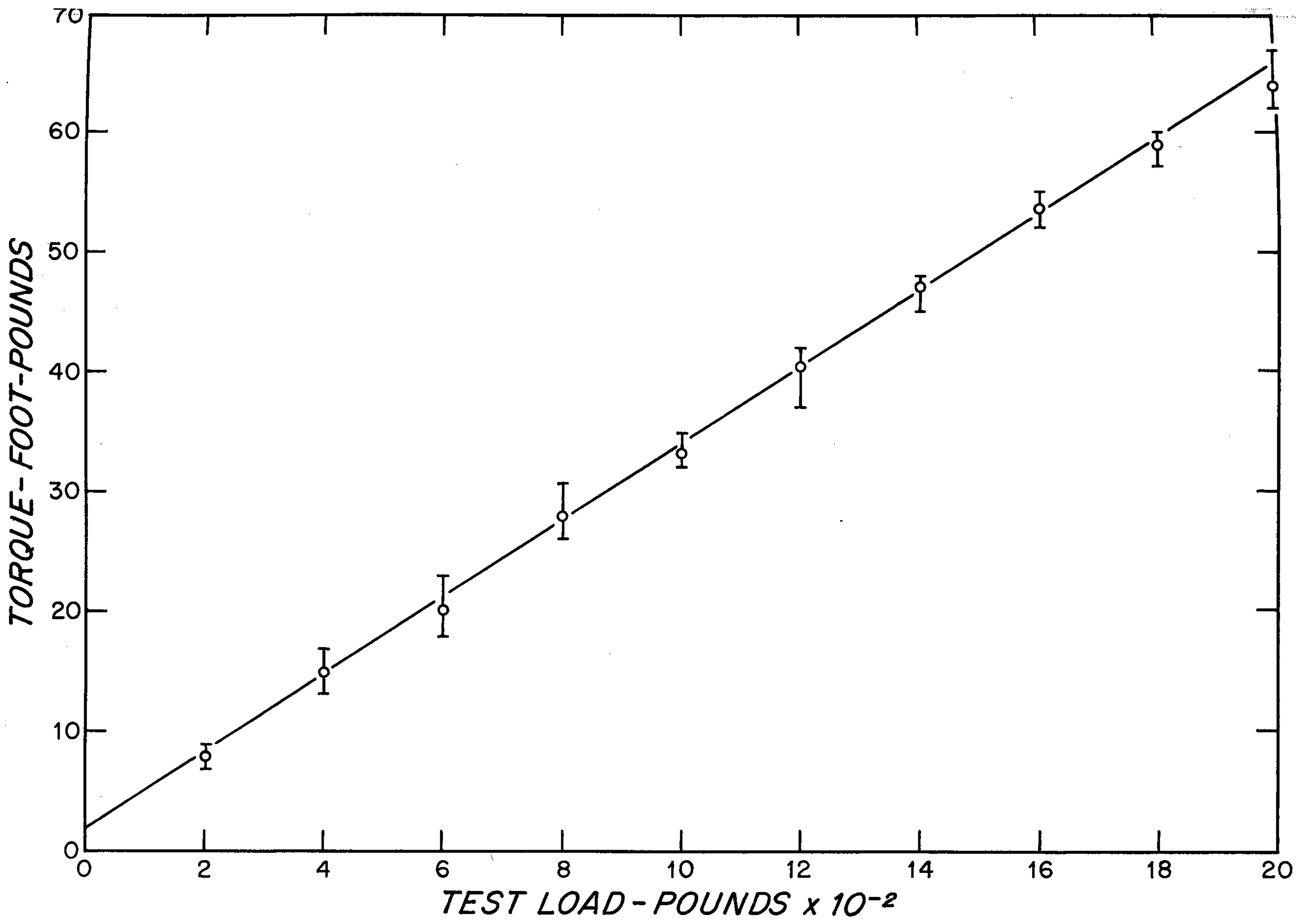

Figure 5. Test Data - Surfaces Greased

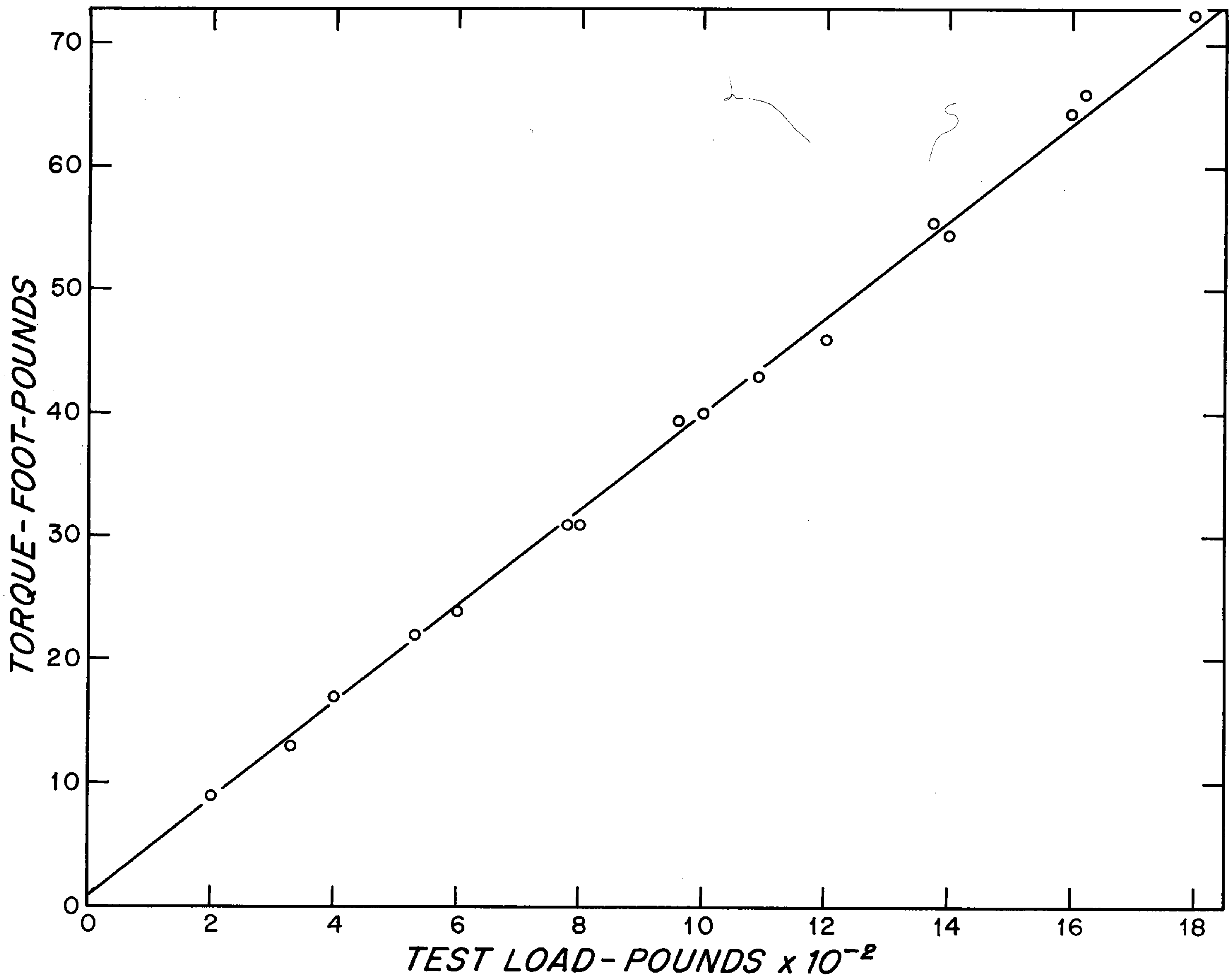

Figure 6. Test Data - Surfaces in Sea Water

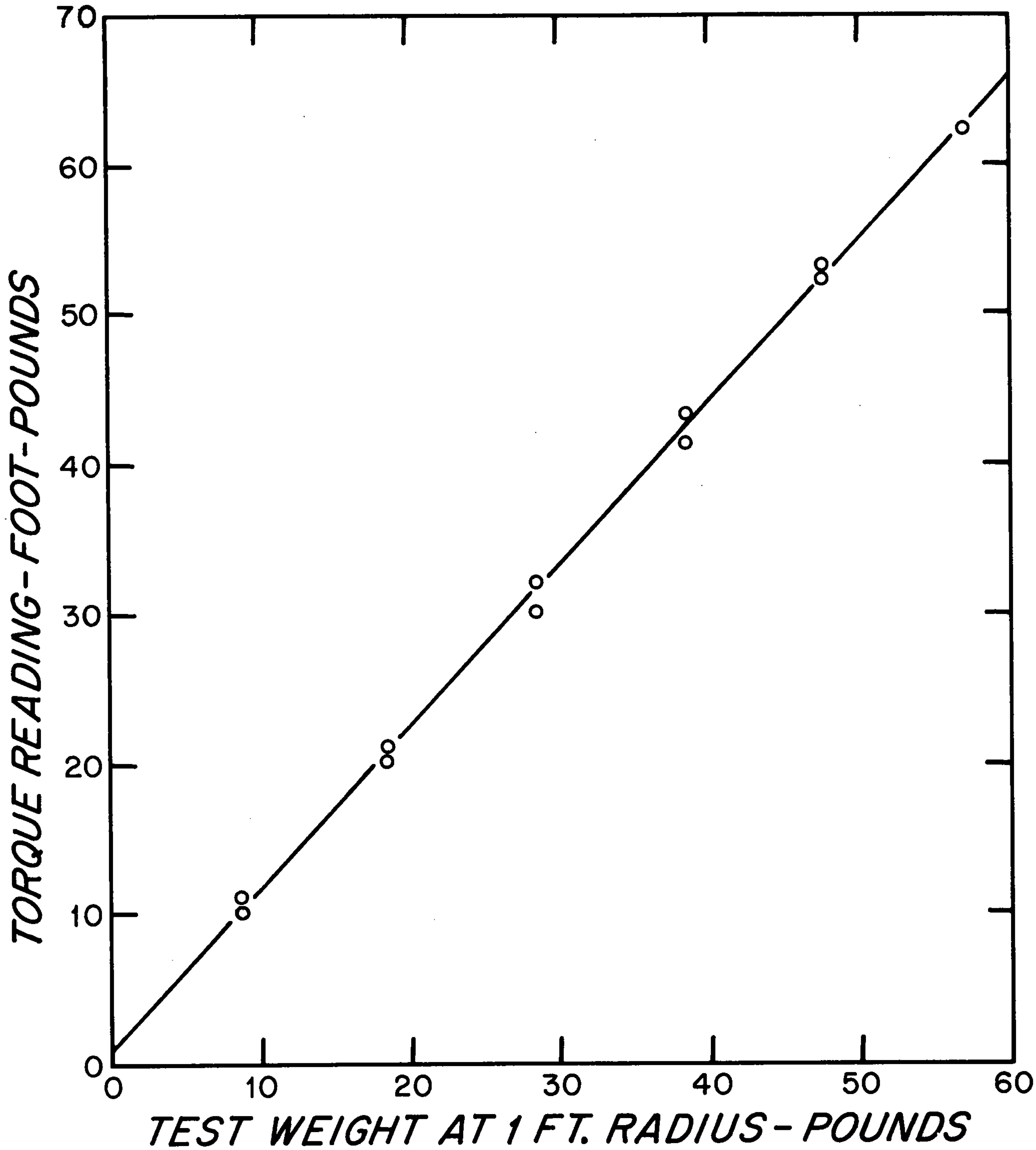

Figure 7. Torque Wrench Calibration

TABLE A-1

Pressure-Torque Test of ALVIN Sphere Release

Pressure (psi)	Torque (inch-lbs.)
1150	60
2000	120
2700	150
3850	210
4750	264
4300	216
3650	192
5000	264
1200	125
5000	300

The above data were taken on April 22, 1965 during a test of the newly designed ALVIN sphere release shaft and bushing. The test was designed to detect possible leakage past the O-ring seals, and to measure rotational torque due to axial thrust of the shaft. See W.H.O.I. Technical Memorandum No. DS-20, "Design and Manufacture of New Emergency Hull Release for ALVIN" by James W. Mavor and Arnold G. Sharp, August, 1965.

Revised October 1970

DISTRIBUTION LIST

Office of Naval Research	
Department of the Navy	
Attn: Code 466	1
480	1
Arlington, Virginia 22217	
Director	
Office of Naval Research	
Branch Office	
495 Summer Street	
Boston, Massachusetts 02210	1
Chief of Naval Operations	
Department of the Navy	
Attn: Op 03u	1
71	1
95	1
Washington, D. C. 20350	
Commander	
Naval Ship Systems Command	
Department of the Navy	
Attn: SHIPS 03	1
00V1	1
0342	1
205	1
00C	1
PMS 381	1
Washington, D. C. 20360	
Commander	
Naval Ship Research & Development Center	
Attn: Code 731	2
Washington, D. C. 20007	
Environmental Science Department	1
U. S. Naval Academy	
Annapolis, Maryland 21402	
Director	
Naval Research Laboratory	1
Attn: Code 2029 and 2040	6
Technical Information Division	6
Washington, D. C. 20390	
Commander	
U.S. Naval Oceanographic Office	
Washington, D. C. 20390	
Attn: Code 037-B	1
Code 1640	1
Commander	
Naval Electronics Lab. Center	
Attn: Code 2400	2
3119	1
4320	1
San Diego, California 92152	
Naval Post Graduate School	
Attn: Librarian	1
Dept. of Meteorology & Oceanography	2
Monterey, California 93940	
Commanding Officer & Director	
Naval Underwater Systems Center	
New London Laboratory	1
New London, Connecticut 93940	
Commander	
Submarine Forces Atlantic Fleet	
Norfolk, Virginia 23511	2
Commander	
Submarine Forces Pacific Fleet	
Fleet Post Office	
San Francisco, California 96601	2
Commander	
Submarine Development Group ONE	
Fleet Post Office	
San Francisco, California 96601	2
O-I-C. TURTLE	1
Commander	
Submarine Development Group TWO	
Fleet Post Office	
New York, New York 09501	1
C.O. NR-1	1
C. O. DOLPHIN (AGSS555)	1
Defense Documentation Center	
Cameron Station	
Alexandria, Virginia 22314	20
Commanding Officer	
Naval Ship Research & Development Laboratory	2
Annapolis, Maryland 21402	
Director, Hawaii Laboratory	1
Code 653	
Naval Undersea Research and Development Center	
P.O. Box 997	
Kailua, Hawaii 96734	
Director, Coast & Geodetic Survey	
U.S. Department of Commerce	
Office of Oceanography	
Washington, D.C. 20230	1

Project Manager
Deep Submergence Systems
Project PM-11
6900 Wisconsin Avenue, N.W.
Chevy Chase, Maryland 20015 — 1

Marine Science Affairs Staff
Building 159-E 4th Floor
Navy Yard Annex
Washington, D. C. 20390

Director
National Oceanographic
Data Center
Washington, D.C. 20390 — 1

Naval Training Devices Center — 1
Orlando, Florida 32813

Bureau of Commercial Fisheries
Department of the Interior
Washington, D.C. 20240 — 2

National Academy of Sciences
National Research Council
2101 Constitution Avenue, N.W.
Attn: Committee on Undersea Warfare — 1
Committee on Oceanography — 1
Mine Advisory Committee — 1
Material Advisory Board — 1
Washington, D. C. 20418

Commanding Officer
AUTEC Headquarters
West Palm Beach, Florida 33406 — 1

Commanding Officer
Code L31
Naval Civil Engineering Laboratory — 1
Port Hueneme, California 93041

Department of Naval Architecture
and Marine Engineering
Massachusetts Institute of
Technology
Cambridge, Massachusetts 02139 — 1

Director
Defense Research Laboratory
University of Texas
Austin, Texas 78712 — 1

Director
Marine Physical Laboratory
Scripps Institution of Oceanography
San Diego, California 92152 — 1

Director
Marine Laboratory
University of Miami
1 Rickenbacker Causeway
Virginia Key
Miami, Florida 33146 — 1

Director
Lamont-Doherty Geological Observatory
Torrey Cliff — 1
Palisades, New York 78228

Director
Southwest Research Institute
San Antonio, Texas 78228 — 2

Professor T.P. Torda
Department of Mechanical Engineering
Illinois Institute of Technology
Chicago, Illinois 60616 — 1

Director
Applied Physics Laboratory
University of Washington
Seattle, Washington 98105 — 2

Mr. J.G. Wenzel
Lockheed Missile & Space
Agency
Sunnyvale, California 94086 — 1

Grumman Aircraft Engineering
Corporation
Engineering Library Plant #25
Bethpage, Long Island
New York 11714 — 1

President
Bell Telephone Laboratories
Whippany, New Jersey 07981 — 1

Electric Boat Division
General Dynamics Corporation
Groton, Connecticut 06340 — 2

ALUMINAUT Project Coordinator
Reynolds Metals Company
Reynolds Metals Building
Richmond, Virginia 23218 — 1

Chesapeake Bay Institute
The John Hopkins University
Macaulay Hall
Baltimore, Maryland 21218 — 1

Mr. Eugene Clay
Hahn & Clay Machine & Boiler Works
5100 Clinton Drive
Houston, Texas 77020 — 2

Mr. H.W. Volberg
Straza Industries
790 Greenfield Drive
El Cajon, California 92021 — 1

Dr. Harold Edgerton
Edgerton, Germeshausen & Grier
160 Brookline Avenue
Boston, Massachusetts 02215 — 1

Mr. Samuel Raymond
Benthos Company
Old Main Street
N. Falmouth, Massachusetts 02556 — 1

Mr. George Hatchette
Oceanographic Engineering Corp.
P.O. Box 1560
La Jolla, California 92038 — 1

Mr. Herbert Fields
294 Washington Street
Boston, Massachusetts 02108 — 1

Director
Narragansett Marine Laboratory
University of Rhode Island
Kingston, Rhode Island 02881 — 1

President
U.S. Naval War College
Newport, Rhode Island 02840

Captain Ballinger, USN Retired
Sun Shipbuilding Corp.
Chester, Pennsylvania 19013 — 1

Lukens Steel Company
Coatesville, Pennsylvania 19320 — 1

Mr. A. Tuthill
International Nickel Company
67 Wall Street
New York, New York 10005 — 1

Capt. C.B. Momsen, USN Retired
AC Electronics/Defense Research Lab.
6767 Hollister Avenue
Goleta, California 93017 — 1

Westinghouse Electric Corp.
DEEPSTAR Project
Underseas Division
Washington Boulevard
Baltimore, Maryland 21230 — 2

Programmed & Remote Systems Corp.
899 West Highway 96
St. Paul, Minnesota 55112 — 1

Mr. H. E. Froehlich
3016 Armour Terrace
Minneapolis, Minneasota 55418 — 1

Reynolds Submarine Service Corp.
615 South West Second Avenue
Miami, Florida 33130 — 1

Autonetics
Division of North America Aviation
Ocean Systems Operation
3370 Mira Loma Avenue
Anaheim, California 92085 — 1

Hawaii Technological Information Center
P.O. Box 2359
Honolulu, Hawaii 92085 — 1

Lehigh University
Bethlehem, Pennsylvania 18015
Attn: Dr. Adrian F. Richards

Oceanographer of the Navy
Code ON 41
732 N. Washington St.
Alexandria, Virginia 22314 — 2

J. Seward Johnson
501 George Street
New Brunswick, N. J. 08903 — 1

Edwin Link
10 Avon Road
Binghamton, New York 13905 — 1

Taylor A. Pryor
Makapuu Oceanic Center
Makapuu Point, Waimanalo
Hawaii 96795 — 1

Tom Phalen
Northeastern University
360 Huntington Avenue
Boston, Massachusetts 02115 1

John Perry
2751 South Dixie Highway
West Palm Beach, Florida 2

Commander
Coast Guard Group Woods Hole 1
Woods Hole, Massachusetts 02543

Director
Bureau of Commercial Fisheries 1
Woods Hole, Massachusetts 02543

Prof. W. Heronemus
University of Massachusetts
Amherst, Massachusetts 01002 2

Director
Ocean Systems
Grumman Aerospace Corp.
Bethpage, Long Island, New York
11714 1

Operations Manager
Grumman Aerospace Corp.
Port of West Palm Beach
West Palm Beach, Florida

Chairman
Department of Ocean Engineering
University of Hawaii
Honolulu, Hawaii 96822 1

Director
Marine Biology Laboratory
Woods Hole, Massachusetts 02543 1

Director
Engineering Design and Analysis Lab.
University of New Hampshire
Durham, New Hampshire 03824 1

Head, Code 485
Ocean Technology
Office of Naval Research
4555 Overlook S.W.
Washington, D. C. 20390 1

Department of Geology
Duke University
Box 6665
College Station
Durham, N. C. 27708 1

Marine Institute
University of Georgia
Sapelo Island, Georgia 1
31327

Institute of Oceanography
Old Dominion University
P.O. Box 6173
Norfolk, Virginia 23508 1

Gulf Universities Research
Corp.
227 System Building
College Station, Texas 77843 1

Battelle Memorial Institute
505 King Avenue
Columbus, Ohio 43201 1

University of Southeastern
Massachusetts
North Dartmouth, Massachusetts 02747
Attn: Reference Room 1

Massachusetts Institute
Of Technology
Department of Naval
Architecture and Marine
Engineering Rm. 5-226 1
Cambridge, Massachusetts 02139

Massachusetts Institute of
Technology
Instrumentation Lab.
Cambridge, Massachusetts 02139 1

Scripps Institution of
Oceanography
La Jolla, California 92037 1

University of Washington
Department of Oceanography
Seattle, Washington 98105 1

Florida Atlantic University
Department of Ocean Engineering
Boca Raton, Florida 33432 1

Naval Postgraduate School
Department of Oceanography
Monterey, California 93940 1

United States Coast Guard
Academy
New London, Connecticut 06320 1

University of Rhode Island
Ocean Engineering Department
College of Engineering
Kingston, Rhode Island 02881 1

International Hydrodynamics
145 Riverside Drive
N. Vancouver 2, B.C. 1

Office of the Commandant
United State Coast Guard Building
1300 E. Street, N.W.
Washington, D. C. 20591 1

United States Coast Guard Building
Office of Engineering
Rm 5202
1300 E. Street, N.W.
Washington, D. C. 20591 1

Commander
Portsmouth Naval Ship Yard
Portsmouth, N.H. 1

Supervisor of Shipbuilding
Conversion and Repair, USN
Groton, Connecticut 20360 1

Naval Ship Engineering Center
Center Building
Prince Georges Center
Hyattsville, Maryland 20782 1

Woods Hole Oceanographic Institution
Reference No. 70-60

TORQUE TESTS OF A FULL SIZE MODEL OF THE ALVIN/AUTEC EMERGENCY SPHERE RELEASE by Arnold G. Sharp and James R. Sullivan. November 1970. 12 pages, 1 table, 7 figures, 6 references. Contract Nonr-3484(00); NR 260-107.

Laboratory torque tests were performed using an actual emergency sphere release shaft of the type used in the research submarines ALVIN, SEA CLIFF and TURTLE. A test fixture was constructed which permitted laboratory simulation of the side (squeezing) forces applied to the release shaft cam as a result of forebody buoyancy. Estimated full-scale side forces were applied to the cam by a laboratory compression testing machine, and the torque required to rotate the shaft was measured. Tests were run with contacting surfaces (a) clean and dry, (b) greased, and (c) immersed in sea water. From the test results, values of release torque were calculated for the submarines in question. Coefficient of friction values of the contacting materials (Monel K-500 on phosphor bronze) also are reported.

1. Torque Test
2. Emergency sphere release
3. Research submarine

I. Sharp, Arnold G.
II. Sullivan, James R.
III. Nonr-2484(00); NR 260-107

This card is unclassified.

Woods Hole Oceanographic Institution
Reference No. 70-60

TORQUE TESTS OF A FULL SIZE MODEL OF THE ALVIN/AUTEC EMERGENCY SPHERE RELEASE by Arnold G. Sharp and James R. Sullivan. November 1970. 12 pages, 1 table, 7 figures, 6 references. Contract Nonr-3484(00); NR 260-107.

Laboratory torque tests were performed using an actual emergency sphere release shaft of the type used in the research submarines ALVIN, SEA CLIFF and TURTLE. A test fixture was constructed which permitted laboratory simulation of the side (squeezing) forces applied to the release shaft cam as a result of forebody buoyancy. Estimated full-scale side forces were applied to the cam by a laboratory compression testing machine, and the torque required to rotate the shaft was measured. Tests were run with contacting surfaces (a) clean and dry, (b) greased, and (c) immersed in sea water. From the test results, values of release torque were calculated for the submarines in question. Coefficient of friction values of the contacting materials (Monel K-500 on phosphor bronze) also are reported.

1. Torque Test
2. Emergency sphere release
3. Research submarine

I. Sharp, Arnold G.
II. Sullivan, James R.
III. Nonr-2484(00); NR 260-107

This card is unclassified.

Woods Hole Oceanographic Institution
Reference No. 70-60

TORQUE TESTS OF A FULL SIZE MODEL OF THE ALVIN/AUTEC EMERGENCY SPHERE RELEASE by Arnold G. Sharp and James R. Sullivan. November 1970. 12 pages, 1 table, 7 figures, 6 references. Contract Nonr-3484(00); NR 260-107.

Laboratory torque tests were performed using an actual emergency sphere release shaft of the type used in the research submarines ALVIN, SEA CLIFF and TURTLE. A test fixture was constructed which permitted laboratory simulation of the side (squeezing) forces applied to the release shaft cam as a result of forebody buoyancy. Estimated full-scale side forces were applied to the cam by a laboratory compression testing machine, and the torque required to rotate the shaft was measured. Tests were run with contacting surfaces (a) clean and dry, (b) greased, and (c) immersed in sea water. From the test results, values of release torque were calculated for the submarines in question. Coefficient of friction values of the contacting materials (Monel K-500 on phosphor bronze) also are reported.

1. Torque Test
2. Emergency sphere release
3. Research submarine

I. Sharp, Arnold G.
II. Sullivan, James R.
III. Nonr-2484(00); NR 260-107

This card is unclassified.

Woods Hole Oceanographic Institution
Reference No. 70-60

TORQUE TESTS OF A FULL SIZE MODEL OF THE ALVIN/AUTEC EMERGENCY SPHERE RELEASE by Arnold G. Sharp and James R. Sullivan. November 1970. 12 pages, 1 table, 7 figures, 6 references. Contract Nonr-3484(00); NR 260-107.

Laboratory torque tests were performed using an actual emergency sphere release shaft of the type used in the research submarines ALVIN, SEA CLIFF and TURTLE. A test fixture was constructed which permitted laboratory simulation of the side (squeezing) forces applied to the release shaft cam as a result of forebody buoyancy. Estimated full-scale side forces were applied to the cam by a laboratory compression testing machine, and the torque required to rotate the shaft was measured. Tests were run with contacting surfaces (a) clean and dry, (b) greased, and (c) immersed in sea water. From the test results, values of release torque were calculated for the submarines in question. Coefficient of friction values of the contacting materials (Monel K-500 on phosphor bronze) also are reported.

1. Torque Test
2. Emergency sphere release
3. Research submarine

I. Sharp, Arnold G.
II. Sullivan, James R.
III. Nonr-2484(00); NR 260-107

This card is unclassified.

Unclassified

Security Classification

DOCUMENT CONTROL DATA - R&D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) Woods Hole Oceanographic Institution Woods Hole, Massachusetts 02543	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

TORQUE TESTS OF A FULL SIZE MODEL OF THE ALVIN/AUTEC EMERGENCY SPHERE RELEASE

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Technical

5. AUTHOR(S) (Last name, first name, initial)

Sharp, Arnold G. and Sullivan, James R.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
November 1970	12	6

8a. CONTRACT OR GRANT NO. Nonr 3484(00); NR 083-004 b. PROJECT NO. c. d.	9a. ORIGINATOR'S REPORT NUMBER(S) WHOI REF. NO. 70-60 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)

10. AVAILABILITY/LIMITATION NOTICES

This document has been approved for public release and sale; its distribution is unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY Office of Naval Research Ocean Science & Technology Division Arlington, Virginia 22217

13. ABSTRACT

Laboratory torque tests were performed using an actual emergency sphere release shaft of the type used in the research submarines ALVIN, SEA CLIFF and TURTLE. A test fixture was constructed which permitted laboratory simulation of the side (squeezing) forces applied to the release shaft cam as a result of forebody buoyancy. Estimated full-scale side forces were applied to the cam by a laboratory compression testing machine, and the torque required to rotate the shaft was measured. Tests were run with contacting surfaces (a) clean and dry, (b) greased, and (c) immersed in sea water. From the test results, values of release torque were calculated for the submarines in question. Coefficient of friction values of the contrating materials (Monel K-500 on phosphor bronze) also are reported.

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
1. Torque Test						
2. Emergency sphere release						
3. Research submarine						

INSTRUCTIONS

1. ORIGINATING ACTIVITY: Enter the name and address of the contractor, subcontractor, grantee, Department of Defense activity or other organization *(corporate author)* issuing the report.

2*a*. REPORT SECURITY CLASSIFICATION: Enter the overall security classification of the report. Indicate whether "Restricted Data" is included. Marking is to be in accordance with appropriate security regulations.

2*b*. GROUP: Automatic downgrading is specified in DoD Directive 5200.10 and Armed Forces Industrial Manual. Enter the group number. Also, when applicable, show that optional markings have been used for Group 3 and Group 4 as authorized.

3. REPORT TITLE: Enter the complete report title in all capital letters. Titles in all cases should be unclassified. If a meaningful title cannot be selected without classification, show title classification in all capitals in parenthesis immediately following the title.

4. DESCRIPTIVE NOTES: If appropriate, enter the type of report, e.g., interim, progress, summary, annual, or final. Give the inclusive dates when a specific reporting period is covered.

5. AUTHOR(S): Enter the name(s) of author(s) as shown on or in the report. Enter last name, first name, middle initial. If military, show rank and branch of service. The name of the principal author is an absolute minimum requirement.

6. REPORT DATE: Enter the date of the report as day, month, year; or month, year. If more than one date appears on the report, use date of publication.

7*a*. TOTAL NUMBER OF PAGES: The total page count should follow normal pagination procedures, i.e., enter the number of pages containing information.

7*b*. NUMBER OF REFERENCES: Enter the total number of references cited in the report.

8*a*. CONTRACT OR GRANT NUMBER: If appropriate, enter the applicable number of the contract or grant under which the report was written.

8*b*, 8*c*, & 8*d*. PROJECT NUMBER: Enter the appropriate military department identification, such as project number, subproject number, system numbers, task number, etc.

9*a*. ORIGINATOR'S REPORT NUMBER(S): Enter the official report number by which the document will be identified and controlled by the originating activity. This number must be unique to this report.

9*b*. OTHER REPORT NUMBER(S): If the report has been assigned any other report numbers *(either by the originator or by the sponsor)*, also enter this number(s).

10. AVAILABILITY/LIMITATION NOTICES: Enter any limitations on further dissemination of the report, other than those imposed by security classification, using standard statements such as:

(1) "Qualified requesters may obtain copies of this report from DDC."

(2) "Foreign announcement and dissemination of this report by DDC is not authorized."

(3) "U. S. Government agencies may obtain copies of this report directly from DDC. Other qualified DDC users shall request through
_______________."

(4) "U. S. military agencies may obtain copies of this report directly from DDC. Other qualified users shall request through
_______________."

(5) "All distribution of this report is controlled. Qualified DDC users shall request through
_______________."

If the report has been furnished to the Office of Technical Services, Department of Commerce, for sale to the public, indicate this fact and enter the price, if known.

11. SUPPLEMENTARY NOTES: Use for additional explanatory notes.

12. SPONSORING MILITARY ACTIVITY: Enter the name of the departmental project office or laboratory sponsoring *(paying for)* the research and development. Include address.

13. ABSTRACT: Enter an abstract giving a brief and factual summary of the document indicative of the report, even though it may also appear elsewhere in the body of the technical report. If additional space is required, a continuation sheet shall be attached.

It is highly desirable that the abstract of classified reports be unclassified. Each paragraph of the abstract shall end with an indication of the military security classification of the information in the paragraph, represented as *(TS)*, *(S)*, *(C)*, or *(U)*.

There is no limitation on the length of the abstract. However, the suggested length is from 150 to 225 words.

14. KEY WORDS: Key words are technically meaningful terms or short phrases that characterize a report and may be used as index entries for cataloging the report. Key words must be selected so that no security classification is required. Identifiers, such as equipment model designation, trade name, military project code name, geographic location, may be used as key words but will be followed by an indication of technical context. The assignment of links, roles, and weights is optional.