TECHNICAL MEMORANDUM WHOI-5-72

Woods Hole
Oceanographic
Institution

DATA LIBRARY & ARCHIVES
Woods Hole Oceanographic Institution

TECHNICAL MEMORANDUM NO. 5-72

DSRV ALVIN WEIGHT REPORT, 1972

By
Arnold G. Sharp and Andrew H. Eliason

WHOI Tech.
Memo. 5-72
C.2

WOODS HOLE, MASSACHUSETTS 02543

WHOI-5-72

DSRV ALVIN WEIGHT REPORT, 1972

Prepared by

Arnold G. Sharp and Andrew H. Eliason

December 1972

DATA LIBRARY & ARCHIVES
Woods Hole Oceanographic Institution

TECHNICAL MEMORANDUM

*Prepared for the Office of Naval Research
under Contract No. N00014-71-C-0107; NR
265-107.*

ABSTRACT

Complete weight and stability computations are presented for the research submarine ALVIN for the year 1972. Longitudinal and vertical components of the BG distance are shown for the vehicle in its normal submerged condition, for the vehicle with the large rock drill attached and then released, and for a number of vehicle emergency conditions. Calculations for pounds per inch immersion and moment to trim one degree also are included. Results of the tethered trim dive are presented and discussed.

TABLE OF CONTENTS

- I. Introduction
- II. Weight and Stability Computations
 - A. Explanation of Procedure
 - B. Definition of Symbols
 - C. Outline of Computations
 - D. Computer Printout
 - E. Other Calculations
- III. Tethered Trim Dive
 - A. Description of Test
 - B. Preliminary Data
 - C. Test Results
- IV. Discussion
- V. References
- VI. Appendix - Computer Program

I. Introduction

The following pages contain the weight and stability report for the research submarine ALVIN for the year 1972. While the emphasis mainly is on the computed weight and stability figures, the report also contains an account of the tethered trim dive which was performed at dockside in Woods Hole.

The weight and stability calculations are in the usual form, showing a tabulation of weights, displacements, moment arm values (both longitudinal and vertical), and first moments. Weight, displacement, and moment summations yield values which locate the center of gravity G and the center of buoyancy B of the vehicle. Finally, longitudinal and vertical components of the BG distance are computed. The computer print-out sheets have been reproduced and are included in this report. The computations were performed using the W.H.O.I. Sigma-7 computer made by Xerox Data Systems, Inc.

The major change made to the submarine since the last operating season was the installation of the new sea-water variable ballast system which was developed at the Naval Ship Engineering Center in Annapolis, Maryland. This system replaced the original variable ballast system which used oil as its working medium. The new system is compact and has considerably less air weight than the old system. However, it is heavier in water than the old system, and this fact, together with some minor modifications to the vehicle, made necessary a reduction in payload of approximately 300 pounds.

The large bottom rock drill, being developed by the W.H.O.I. Department of Geology and Geophysics, was mounted on ALVIN during 1972 for test dives in Woods Hole Harbor, and also in deeper water. The weight and stability computations include two sections related to rock drill operations - one for ALVIN submerged with the drill attached, and a second one for the vehicle just after release of the drill on the ocean bottom.

II. Weight and Stability Computations

- A. Explanation of Procedure In computing the weight and stability of ALVIN, two separate force systems were considered. The weights, acting downward, were summed to find the total weight, which acts at the center of gravity G. Similarly, the buoyancy forces, which act upward, were summed to find the total buoyant force or displacement, which acts at the center of buoyancy B. The locations of G and B were determined by summing the moments of weights and displacements with respect to the forward perpendicular and the base plane. Points G and B are assumed to lie in a vertical plane which passes through the longitudinal centerline of the submarine.

For the computer run, data was obtained for the separate components (or packages) and a data card was punched for each. The items were broken down into sub-groups as follows (refer to computer printout sheets):

1. Pressure hull plus contents
2. Other forebody

3. Afterbody
4. Variable load
5. Entire vehicle
6. Rock drill
7. Released forebody
8. Emergency conditions

At the end of each sub-group the weight, displacement and moment summations were made, and the locations of G and B were determined. At the end of Section 4 (variable load) cumulative summations were made which yielded G and B values for the entire submarine in what is called the "normal submerged" condition. In this condition the main ballast tanks are flooded, the variable ballast tanks are 25 percent flooded, and the trim mercury is divided 50 percent forward and 50 percent aft.

Included in the computer program was a section which enabled the computer, using the longitudinal and vertical components of the BG distance, to plot a diagram of the static equilibrium position of the submarine in any given condition. These diagrams have been reproduced and are included following the summations for the entire vehicle, the released forebody, the rock drill conditions and the 8 emergency conditions.

B. Definition of Symbols The following symbols which appear on the computer printout sheets are defined here for convenience.

W - weight of item in air, lbs.

X - distance of center of gravity of item from forward perpendicular, feet (positive x means aft of F.P.; see figure 1.)

Y - distance of center of gravity of item above base plane,
feet (see Figure 1.)

MX - product of W times X, foot-lbs.

MY - product of W times Y, foot-lbs.

D - displacement of item, lbs. of seawater

XP - distance of center of buoyancy of item from forward
perpendicular, feet (positive XP means aft of F.P.)

YP - distance of center of buoyancy of item above base plane, feet

MXP - product of D times XP, foot-lbs.

MYP - product of D times YP, foot-lbs.

BG longitudinal - distance between center of buoyancy B and center
of gravity G, longitudinal component, feet (negative value
indicates tendency for bow-up angle of trim; see Figure 2.)

BG vertical - distance between center of buoyancy B and center of
gravity G, vertical component, feet (positive value indicates
vertical stability of submerged vehicle; see Figure 2.)

The following additional terms and symbols appear in various places
in this report:

Forward Perpendicular - vertical plane passing through foremost
edge of front window cone of ALVIN (see Figure 1.)

Base Plane - horizontal plane passing through bottom of skids
of ALVIN (see Figure 1.)

B' - new position of center of buoyancy B. Lateral shift occurs
due to change of underwater form when vehicle is inclined
on the surface (see Figure 3.)

Figure 1. Longitudinal Section of ALVIN Showing Sample of Data Used in Computations

Figure 2. Longitudinal Section of ALVIN Showing Components of BG Distance

Metacenter M - point found by extending line of action of vertical buoyancy force through B' to intersect with original vertical centerline of vehicle inclined on the surface (see Figure 3.)

GM - vertical distance from center of gravity G to metacenter M

(M above G indicates positive stability of surfaced vehicle;
(see Figure 3.)

C. Outline of Programmed Computations

1. Total weight = summation W
2. Total displacement = summation D
3. Distance to center of gravity, longitudinal
$$XW = (\text{summation } MX) / (\text{summation } W)$$
4. Distance to center of gravity, vertical
$$YW = (\text{summation } MY) / (\text{summation } W)$$
5. Distance to center of buoyancy, longitudinal
$$XPD = (\text{summation } MXP) / (\text{summation } D)$$
6. Distance to center of buoyancy, vertical
$$YPD = (\text{summation } MYP) / (\text{summation } D)$$
7. BG longitudinal = $XPD - XW$
8. BG vertical = $YPD - YW$

Figure 3. Transverse Section of ALVIN Showing Locations of Points K, G, B, B' and M

D. Computer Printout

RUN

ALVIN WEIGHT AND STABILITY COMPUTATIONS

SPHERE ONLY

IDENTIFICATION	W	X	Y	MX	MY	D	XP	YP	MPX	MYP
P. HULL MINUS INSTS	6152.35	4.97	4.89	30577.18	30084.99	10668.99	4.50	4.75	48010.45	50677.70
HULL INSERT-FWD	500.00	1.14	4.75	570.00	2375.00	16.79	1.14	4.75	19.14	79.75
HULL INSERT-BOTTOM	500.00	3.72	1.42	1860.00	710.00	16.79	3.72	1.42	62.46	23.84
HULL INSERTS-P AND S	1000.00	2.39	3.46	2390.00	3460.00	33.58	2.39	3.46	80.26	116.19
HATCH INSERT	266.00	4.50	8.11	1197.00	2157.26	12.92	4.50	8.11	58.14	104.78
WINDOW-FWD	9.81	1.14	4.75	11.18	46.60	.00	.00	.00	.00	.00
WINDOW-BOTTOM	9.81	3.72	1.44	36.49	14.13	.00	.00	.00	.00	.00
WINDOWS- P AND S	19.62	2.39	4.75	46.89	85.54	.00	.00	.00	.00	.00
WINDOWS RET. RING-FW	8.37	1.14	4.75	9.54	39.76	1.09	1.14	4.75	1.24	5.18
WINDOW RT RING BOT	8.69	3.72	1.30	32.33	11.30	1.14	3.72	1.30	4.24	1.48
WINDOW RT RINGS PAS	15.74	2.39	3.46	40.01	57.92	2.18	2.39	3.46	5.21	7.54
SPHERE REL.-UPPER	59.04	4.50	1.33	265.68	78.52	5.49	4.50	1.21	24.70	6.64
HATCH	220.00	4.50	8.11	990.00	1784.20	.00	.00	.00	.00	.00
HINGE ARMS	8.00	4.21	8.28	33.68	66.24	1.04	4.21	8.28	4.38	8.61
HINGE SHAFT	5.68	4.00	8.28	22.72	47.03	.74	4.00	8.28	2.96	6.13
INSIDE HANDLE	4.50	4.91	7.94	22.09	35.73	.00	.00	.00	.00	.00
OUTSIDE HANDLE	9.00	4.91	8.28	44.19	74.52	1.17	4.91	8.28	5.74	9.69
SPRING RETAINER	4.67	4.14	8.28	19.33	38.67	.61	4.14	8.28	2.53	5.05
INT-SWING CLAMP	2.66	4.60	7.94	12.24	21.12	.00	.00	.00	.00	.00
MISC	1.19	4.50	8.11	5.35	9.65	.00	.00	.00	.00	.00
HINGE SPRINGS	11.25	4.00	8.28	45.00	93.15	1.47	4.00	8.28	5.88	12.17
HATCH WINDOW	1.19	4.50	8.19	5.35	9.75	.00	.00	.00	.00	.00
HATCH WIND RET-RING	3.78	4.50	8.10	17.01	30.62	.49	4.50	8.10	2.20	3.97
HINGE BLOCKS	11.50	3.92	8.05	45.08	92.57	1.50	3.92	8.05	5.88	12.07
PENETRATORS(7) FWD	72.45	1.06	4.75	76.80	344.14	4.43	1.06	4.75	4.70	21.04
PENETRATORS(5)BOT	51.75	4.29	1.42	222.01	73.48	3.16	4.29	1.42	13.56	4.49
LIFT PADS	17.86	4.50	8.17	80.37	145.92	2.33	4.50	8.17	10.48	19.04
C8NA. HALVES-UPPER	35.00	4.50	1.09	157.50	38.15	3.02	4.50	1.09	13.59	3.29
MISC. OUTSIDE	10.00	4.50	8.10	45.00	81.00	1.30	4.50	8.10	5.85	10.53
STRAZA MBD 100	30.00	3.13	5.53	93.90	165.90	.00	.00	.00	.00	.00
STRAZA MBD 200	32.00	4.04	5.96	129.28	190.72	.00	.00	.00	.00	.00
STRAZA MBD 300	40.00	4.37	6.67	174.80	266.80	.00	.00	.00	.00	.00
UHER 4000	8.50	4.13	7.08	35.10	60.18	.00	.00	.00	.00	.00
C2 ANALYZER	3.50	5.38	6.70	18.83	23.45	.00	.00	.00	.00	.00
82 BOTTLE	33.00	6.71	3.79	221.43	125.07	.00	.00	.00	.00	.00
L10H CANISTERS (2)	20.00	6.29	5.71	125.80	114.20	.00	.00	.00	.00	.00
CABIN LIGHT	1.00	5.67	6.79	5.67	6.79	.00	.00	.00	.00	.00
RATIONS	2.00	4.29	7.17	8.58	14.34	.00	.00	.00	.00	.00
FACE MASKS,VEST	6.80	5.33	5.88	36.24	39.98	.00	.00	.00	.00	.00
PILOTS CHAIR	9.31	2.88	2.88	26.81	26.81	.00	.00	.00	.00	.00

ALVIN WEIGHT AND STABILITY COMPUTATIONS

SPHERE ONLY (CONTINUED)

IDENTIFICATION	W	X	Y	MX	MY	D	XP	YP	MXP	MYP
TRIM INDICATOR	.30	1.63	5.50	.49	1.65	.00	.00	.00	.00	.00
CABIN LIGHTS, P/S (2)	2.00	3.67	5.46	7.34	10.92	.00	.00	.00	.00	.00
MAP LIGHTS (4)	4.00	2.58	6.50	10.32	26.00	.00	.00	.00	.00	.00
FLIGHT BOARDS	3.00	4.58	2.12	36.64	16.96	.00	.00	.00	.00	.00
MISC WIRING, HDWR	10.00	4.55	4.75	45.50	47.50	.00	.00	.00	.00	.00
PENETRATOR LEADS	80.00	4.55	4.75	360.00	380.00	.00	.00	.00	.00	.00
URINALS (3)	3.00	5.50	2.50	16.50	7.50	.00	.00	.00	.00	.00
CAMERAS	6.00	5.80	5.20	34.80	31.20	.00	.00	.00	.00	.00
TOOL KIT	4.00	5.50	2.40	22.00	9.60	.00	.00	.00	.00	.00
SCUBA REGULATORS (3)	7.80	5.80	2.50	45.24	19.50	.00	.00	.00	.00	.00
FLASHLIGHTS (6)	4.80	5.50	2.40	26.40	11.52	.00	.00	.00	.00	.00
SOUND PHONES (2)	6.00	4.30	7.00	29.80	42.00	.00	.00	.00	.00	.00
CUSHIONS	4.00	4.60	2.20	18.40	8.80	.00	.00	.00	.00	.00
RELEASE T-BAR	4.00	5.60	2.40	22.40	9.60	.00	.00	.00	.00	.00
RACK ASSEMBLIES	35.00	4.60	5.00	161.00	175.00	.00	.00	.00	.00	.00
EMERG WATER	5.00	6.00	2.80	30.00	14.00	.00	.00	.00	.00	.00
DISTR PANEL	44.50	6.00	3.75	267.00	166.87	.00	.00	.00	.00	.00
PORT WING PANEL	12.50	2.90	6.25	36.25	78.12	.00	.00	.00	.00	.00
RADIO	11.25	4.52	5.96	51.52	67.05	.00	.00	.00	.00	.00
FATHOMETER	9.00	4.38	5.62	39.42	50.58	.00	.00	.00	.00	.00
U G C	31.00	4.29	6.75	132.99	209.25	.00	.00	.00	.00	.00
INSTR PANEL	17.00	1.75	6.25	29.75	106.25	.00	.00	.00	.00	.00
LOWER SHELVES (3)	12.50	2.90	5.50	36.25	68.75	.00	.00	.00	.00	.00
GYRO, CONTR UNIT	33.50	5.91	5.46	197.98	182.91	.00	.00	.00	.00	.00
POWER SUPPLY 6V	7.00	7.00	5.12	49.00	35.84	.00	.00	.00	.00	.00
STATIC INVERTER	39.00	6.67	3.54	260.13	138.06	.00	.00	.00	.00	.00
STBD WING PANEL	6.30	2.90	6.25	18.27	39.37	.00	.00	.00	.00	.00
SHELF UPPER STBD	2.00	4.35	6.75	8.70	23.50	.00	.00	.00	.00	.00
SHELF UPPER PORT	3.50	4.35	6.75	15.22	23.63	.00	.00	.00	.00	.00
SCUBA BOTTLE BRKT	10.00	5.92	3.54	59.20	35.40	.00	.00	.00	.00	.00
SHELF OVER IND PANEL	1.50	1.70	6.60	2.55	9.30	.00	.00	.00	.00	.00
SHELF OVER LEAK DET.	2.00	2.83	7.04	5.76	14.08	.00	.00	.00	.00	.00
FATHOMETER SCOPE	7.00	3.83	6.29	26.81	44.03	.00	.00	.00	.00	.00
FATHOMETER XMTR	17.00	4.38	5.62	74.46	95.54	.00	.00	.00	.00	.00
SCUBA BOTTLES (3)	54.50	6.62	3.63	360.79	197.83	.00	.00	.00	.00	.00
O2 BOTT BRKT	2.00	6.71	3.79	13.42	7.58	.00	.00	.00	.00	.00
AIR REGEN UNIT	13.50	6.38	4.50	86.13	60.75	.00	.00	.00	.00	.00
SPHERE STEP HDWR	6.00	5.00	6.50	30.00	39.00	.00	.00	.00	.00	.00
BATTERY SHELF	3.00	5.63	7.33	16.89	21.99	.00	.00	.00	.00	.00
FIRE EXTING	10.50	5.57	4.50	58.48	47.25	.00	.00	.00	.00	.00

ALVIN WEIGHT AND STABILITY COMPUTATIONS

SPHERE ONLY (CONTINUED)

IDENTIFICATION	W	X	Y	MX	MY	D	XP	YP	MXP	MYP
EMERG LIGHT BATT	5.00	6.50	4.50	32.50	22.50	.00	.00	.00	.00	.00
MISC SHEET METAL	5.00	4.50	4.50	22.50	22.50	.00	.00	.00	.00	.00
GYRO REPEATER	2.00	1.54	4.83	3.08	9.66	.00	.00	.00	.00	.00
FLARE BOX FLARES	6.00	5.38	5.87	32.28	35.22	.00	.00	.00	.00	.00
PILOTS CONTR BOX	7.00	2.00	7.00	14.00	49.00	.00	.00	.00	.00	.00
CLINOMETERS(2)	1.00	3.50	6.25	3.50	6.25	.00	.00	.00	.00	.00
FIRST AID KIT	1.00	6.20	2.79	6.20	2.79	.00	.00	.00	.00	.00
EMERG BATTERIES(2)	18.00	5.50	2.34	99.00	42.12	.00	.00	.00	.00	.00
PINGER BATTERIES(2)	12.00	5.50	2.34	66.00	28.08	.00	.00	.00	.00	.00

SPHERE ONLY

SUMMARY	NB. ITEMS	SUM W	S MXW	S MYW	SUM MX	SUM MY	SUM D	S MXP	S MYP	SUM MXP	SUM MYP
89		9803.97	4.36	4.68	42775.37	45924.62	10780.23	4.48	4.74	48343.60	51139.19

BG LONGITUDINAL

.12

BG VERTICAL

.06

ALVIN WEIGHT AND STABILITY COMPUTATIONS

OTHER FOREBODY

IDENTIFICATION	W	X	Y	MX	MY	D	XP	YP	MXP	MYP
SAIL, ETC	1323.35	4.64	7.02	6140.34	9289.92	1714.00	4.34	6.65	7438.76	11398.10
BBW BUOYANCY, NEW	863.00	.38	7.00	327.94	6041.00	1505.00	.38	7.00	571.90	10535.00
LG BUOYANCY RING	1135.00	4.42	3.43	5016.70	3893.05	1570.00	4.42	3.43	6939.40	5385.10
FRONT WINDOW COBE	102.00	.75	4.75	76.50	484.50	154.00	.75	4.75	115.50	731.50
MAIN BALLAST WATER	1493.76	4.50	6.00	6721.92	8962.56	1493.76	4.50	6.00	6721.92	8962.56
FIBERGLASS CLAMP	4.00	2.39	3.46	9.56	13.84	2.22	2.39	3.46	5.31	7.68
SONAR UNIT	92.00	.50	8.00	46.00	736.00	30.00	.50	8.00	15.00	240.00
MAIN BALLAST CONTROL	65.00	7.93	7.43	515.45	482.95	42.00	7.93	7.43	333.06	312.06
NDT PLUGS (8)	6.40	4.50	1.33	28.80	8.51	.83	4.50	1.33	3.73	1.10
MAGNETIC COMPASS	9.07	7.00	10.13	63.49	91.88	8.33	7.00	10.13	58.31	84.38
EXTERIOR LIGHTS	24.00	2.50	5.40	60.00	129.60	8.00	2.50	5.40	20.00	43.20
SEVENIUS ROTOR	8.00	3.50	13.20	28.00	105.60	2.00	3.50	13.20	7.00	26.40
PRECISION DEPTH TRAN	14.00	6.50	7.30	91.00	102.20	5.00	6.50	7.30	32.50	36.50
UCC XDUCER	27.00	6.50	12.50	175.50	337.50	4.00	6.50	12.50	26.00	50.00
PINGER	40.00	5.67	9.87	226.80	394.80	30.00	5.67	9.87	170.10	298.10
6V STRIBE	37.00	1.58	4.62	58.46	170.94	15.00	1.58	4.62	23.70	69.30
EGG CAMERAS (2)	50.00	.00	7.06	.00	353.00	30.00	.00	7.06	.00	211.80
FWD STRIBE	54.00	.00	6.50	.00	351.00	16.00	.00	6.50	.00	104.00

OTHER FOREBODY

SUMMARY	NB. ITEMS	SUM W	S MXW	S MYW	SUM MX	SUM MY	SUM D	S MXP	S MYP	SUM MXP	SUM MYP
	18	5347.58	3.66	5.97	19586.46	31948.85	6630.14	3.39	5.81	22482.19	38494.79

BG LONGITUDINAL --27

BG VERTICAL --17

ALVIN WEIGHT AND STABILITY COMPUTATIONS

AFTERBODY

IDENTIFICATION	W	X	Y	MX	MY	D	XP	YP	MXP	MYP
FRAME	47.50	9.18	2.77	4108.05	1239.57	169.00	9.18	2.77	1551.42	468.13
LG BUOYANCY PKG	2475.00	14.42	5.25	35689.50	12993.75	4120.00	14.42	5.25	59410.40	21630.00
SM BUOYANCY PK CTR	516.00	10.25	6.33	5285.00	3266.28	946.00	10.25	6.33	9696.50	5988.18
SIDE BUOYANCY PK(2)	410.00	10.40	6.75	4264.00	2767.50	656.00	10.40	6.75	6822.40	4489.80
V/BPKG UPPER PBT	748.30	10.18	5.70	7617.69	4265.31	1314.00	10.18	5.70	13376.52	7489.80
V/B PKG UPPER STRD	748.30	10.18	5.70	7617.69	4265.31	1314.00	10.18	5.70	13376.52	7489.80
V/B SPHERE LOWER PBR	237.00	6.78	1.42	1606.86	336.54	265.00	6.78	1.42	1796.70	376.30
V/B SPHERE LOWER STB	237.00	6.78	1.42	1606.86	336.54	265.00	6.78	1.42	1796.70	376.30
V/B SPHERES PLUMBING	25.00	9.16	4.31	229.00	107.75	3.24	9.16	4.31	29.68	13.96
V/B PLMP	86.00	5.15	1.00	442.90	86.00	14.72	5.15	1.00	75.81	14.72
V/B PLMP M8TR	150.00	5.15	1.00	772.50	150.00	88.96	5.15	1.00	458.14	88.96
SHUT-OFF VALVE	11.70	5.15	1.00	60.25	11.70	2.18	5.15	1.00	11.23	2.18
FLGAT SWITCH	13.00	5.15	1.00	92.70	18.00	1.92	5.15	1.00	9.89	1.92
TANK RELIEF VALVE	1.50	5.15	1.00	7.72	1.50	.00	.00	.00	.00	.00
VALVE FRAME, PIPING	20.00	9.83	3.38	196.60	67.60	.00	.00	.00	.00	.00
4-WAY VALVE	5.00	11.33	4.42	56.65	22.10	.00	.00	.00	.00	.00
BY-PASS VALVE	11.70	10.17	3.04	118.99	35.57	2.18	10.17	3.04	22.17	6.63
PB VALVE	5.40	10.13	4.46	54.70	24.08	.00	10.13	4.46	.00	.00
FLW METER	21.00	10.96	2.88	230.16	60.48	2.96	10.96	2.88	32.44	8.52
PUMP RELIEF VALVE	1.50	10.25	3.96	15.37	5.94	.00	.00	.00	.00	.00
CHECK VALVE	1.90	10.53	4.44	20.10	8.44	.00	.00	.00	.00	.00
HYDR CONTROL B8X	195.00	9.04	4.52	1762.80	881.40	142.22	9.04	4.52	1285.67	642.83
M8TR PUMP FRAME	15.00	5.15	1.00	77.25	15.00	.00	.00	.00	.00	.00
V/B BAG B8X SYNT P	211.60	10.10	3.67	2137.16	776.57	338.56	10.10	3.67	3419.46	1242.52
V/B BAG B8X COVER	36.40	10.10	3.67	367.64	133.59	17.92	10.10	3.67	180.99	65.77
HG SPHERES FWD (2)	24.00	1.79	1.90	42.96	45.60	41.70	1.79	1.90	74.64	79.23
HG FRAME FWD	12.00	1.79	1.90	21.48	22.80	4.54	1.79	1.90	8.13	8.63
HG FRAME SYNT FWD	5.00	1.79	1.90	8.95	9.50	8.00	1.79	1.90	14.32	15.20
HG SPHERES AFT (2)	24.00	17.50	3.92	420.00	94.08	41.70	17.50	3.92	729.75	163.46
HG FRAME AFT	10.00	17.50	3.92	175.00	39.20	3.78	17.50	3.92	66.15	14.82
HG FWD	245.25	17.50	3.92	439.00	465.97	.00	17.50	3.92	.00	.00
HG AFT	245.25	17.50	3.92	4291.87	961.38	.00	17.50	3.92	.00	.00
HG SYSTEM PLUMBING	25.00	11.00	2.00	275.00	50.00	5.00	11.00	2.00	55.00	10.00
SKIDS & B8LTS(2 STS)	46.50	8.67	.25	403.15	11.62	17.60	8.67	.25	152.59	4.40
CONTROL CENTER	293.00	10.21	4.63	2991.53	1356.59	209.00	10.21	4.63	2133.89	967.67
SPHERE REL. GUIDES(2)	19.00	4.50	1.20	85.50	22.80	2.50	4.50	1.20	11.25	3.00
SPHERES REL D8GS, ET	33.00	4.50	1.20	148.50	39.60	4.36	4.50	1.20	19.62	5.23
SPHERE RELEASE S-IMS	13.50	4.50	2.00	60.75	27.00	5.10	4.50	2.00	22.95	10.20
SPHERE RELEASE S-IMS	2.50	4.50	.50	11.25	1.25	.95	4.50	.50	4.27	.47
PROPULSION B8X & BIL	849.00	13.50	2.30	11461.50	1952.70	510.00	13.50	2.30	6885.00	1173.00

ALVIN WEIGHT AND STABILITY COMPUTATIONS

(CONTINUED)

AFTERBODY

IDENTIFICATION	W	X	Y	MX	MY	D	XP	YP	MP	MP
PROP BXX SUPPORTS	8.00	13.50	2.30	108.00	18.40	2.00	13.50	2.30	27.00	4.60
PROP BXX FRAME SUPP	3.00	13.50	2.30	40.50	6.90	1.00	13.50	2.30	13.50	2.30
FRAME REAR SPT STS	35.50	15.75	2.42	559.13	85.91	12.00	15.75	2.42	189.00	29.04
CONN HALVES LOWER	35.00	4.50	2.00	157.50	70.00	14.22	4.50	2.00	63.99	28.44
LIFT PRBF UNITS(2)	272.00	8.40	7.72	2284.80	2099.84	112.00	8.40	7.72	940.80	864.64
STERN PRBF ASSEMBLY	950.00	20.20	4.63	19190.00	4398.50	458.00	20.20	4.63	9251.60	2120.54
LIFT PRBF BIL	225.00	8.40	7.72	1890.00	1737.00	.00	8.40	7.72	.00	77.00
LIFT PRBF B6X	55.00	10.25	7.72	563.75	424.60	10.00	10.25	7.72	102.50	.00
STERN PRBF OIL	82.68	20.20	4.63	1670.14	382.81	.00	20.20	4.63	.00	.00
BATTERY & BXX FWD	1495.00	8.68	2.80	12976.60	4186.00	929.00	8.68	2.80	8063.72	2601.20
BATTERY & BXX MID	1495.00	10.00	2.80	14950.00	4186.00	929.00	10.00	2.80	9290.00	2601.20
BATTERY & BXX AFT	1495.00	11.40	2.80	17043.00	4186.00	929.00	11.40	2.80	10590.60	2601.20
BATTERY CUTOUT COVER	44.50	10.21	.90	454.34	40.05	24.70	10.21	.90	252.19	22.23
BATTERY DROPS(2)FWD	56.00	10.00	3.03	486.08	169.68	7.15	10.00	3.25	62.06	23.24
BATTERY DROPS(2)MID	56.00	10.00	3.03	560.00	169.68	7.15	10.00	3.25	71.50	23.24
BATTERY DROPS(2)AFT	56.00	11.40	3.03	638.40	169.68	7.15	11.40	3.25	81.51	23.24
BATTERY SYNTACTIC FW	57.50	8.68	1.10	499.10	63.25	92.00	8.68	1.10	798.56	101.20
BATTERY SYNTACTIC MI	57.50	10.00	1.10	575.00	63.25	92.00	10.00	1.10	920.00	101.20
BATTERY SYNTACTIC AF	57.50	11.40	1.10	655.50	63.25	92.00	11.40	1.10	1048.80	101.20
SPHERE SUP SYNTACTIC(2)	3.00	4.30	2.00	12.90	6.00	4.80	4.30	2.00	20.64	9.60
FRAME SYNTACTIC(9)	17.00	9.00	3.50	153.00	59.50	27.20	9.00	3.50	244.80	95.20
FRAME BBT SYNT STR 4	52.25	8.50	.30	444.13	15.67	83.60	8.50	.30	710.60	25.08
V/B BXX BRKT	1.50	17.50	5.00	26.25	7.50	.56	17.50	5.00	9.80	2.80
LWR BASKET HINGE (2)	4.50	4.00	.30	18.00	1.35	1.70	4.00	.30	6.80	.51
WT & BSKT REL BRKT 3	2.00	4.62	2.75	9.24	5.50	.76	4.62	2.75	3.51	2.09
V/B SPHERE BRAC (2)	2.00	6.73	1.42	13.56	2.84	.76	6.73	1.42	5.15	1.08
CTR V/B PKG BRAC 2	4.00	10.50	5.00	42.00	20.00	1.52	10.50	5.00	15.96	5.65
BXXY PKG HALLDOWN 6	3.00	15.00	5.00	45.00	15.00	1.13	15.00	5.00	16.95	5.65
H0ISTING PIN	2.50	12.50	7.44	31.25	18.60	.95	12.50	7.44	11.87	7.07
FWD FRAME SIDE BDS(2)	22.50	7.00	1.50	157.50	33.75	11.90	7.00	1.50	83.30	17.85
FRAME SIDE BD SKIN(2)	11.50	7.00	1.50	80.50	17.25	6.10	7.00	1.50	42.70	9.15
TIE DOWNS (4)	20.00	13.50	4.67	270.00	93.40	7.40	13.50	4.67	99.90	34.56
HANDLING PADS(6)	15.00	8.00	6.50	120.00	97.50	1.98	8.00	6.50	15.84	12.87
BATTERY CHG CABLE TR	10.00	10.70	7.83	107.00	78.30	3.70	10.70	7.83	39.59	28.97
BATTERY CHG CABLES	14.50	10.70	7.87	155.15	111.21	7.25	10.70	7.87	55.61	28.97
MARSH MARINE CABLES	62.50	9.35	4.67	584.37	291.87	31.25	9.35	4.67	292.19	145.94
INSTRUMENT CASE	17.00	6.30	.83	107.10	14.11	3.34	6.30	.83	21.04	2.77
BOTTOM WINDOW CANE	12.50	3.50	1.00	43.75	12.50	6.95	3.50	1.00	24.32	6.95
WEIGHT DR0PPERS(3)	30.00	4.62	2.75	138.60	82.50	7.50	4.62	2.75	34.65	20.62
BATTERY RESERV0IR 80	182.00	7.00	1.40	1274.00	254.80	215.10	7.00	1.40	1505.70	301.14

ALVIN WEIGHT AND STABILITY COMPUTATIONS

VARIABLE LOAD(NORMAL)

IDENTIFICATION	W	X	Y	MX	MY	D	XP	YP	MXP	MYP
MECHANICAL ARM	438.55	-0.30	2.70	-131.56	1184.08	143.00	.00	2.70	.00	386.10
MECH ARM REL	96.50	.80	3.00	77.20	289.50	30.50	.80	3.00	24.40	91.50
MECH ARM CONTR B9X	3.00	1.00	7.00	3.00	21.00	.00	.00	.00	.00	.00
ARM OFFSET BRKTS	13.00	1.00	3.00	13.00	39.00	3.00	.00	3.00	3.00	9.00
SAMPLE TRAY, TB8LS	135.00	-2.50	1.40	-337.50	189.00	45.00	1.00	1.40	-112.50	63.00
PERSONNEL (3)	500.00	5.86	4.13	2930.00	2065.00	.00	.00	.00	.00	.00
ASCENT WEIGHT	100.00	.39	2.75	39.00	275.00	9.00	.39	2.75	3.51	24.75
OTHER PAYLOAD	315.00	5.86	4.13	1845.90	1300.95	.00	.00	.00	.00	.00

VARIABLE LOAD(NORMAL)

SUMMARY	NO. ITEMS	SUM W	S MXW	S MYW	SUM MX	SUM MY	SUM D	S MXP	S MYP	SUM MXP	SUM MYP
8		1601.05	2.77	3.35	4439.03	5363.53	230.50	.35	2.49	-81.59	574.35
BG LONGITUDINAL		-3.13			BG VERTICAL	-0.86					

ALVIN WEIGHT AND STABILITY COMPUTATIONS

ENTIRE VEHICLE(NORMAL)

IDENTIFICATION	W	X	Y	MX	MY	D	XP	YP	MXP	MYP
SPHERE ONLY	9803.97	4.36	4.68	42745.31	45882.58	10780.23	4.48	4.74	48295.43	51098.29
OTHER FOREBODY	5347.58	3.66	5.97	19572.14	31925.05	6630.14	3.39	5.81	22476.17	38521.11
AFTERBODY	15575.63	11.23	3.91	174914.32	60900.71	14691.55	11.49	4.42	168805.91	64936.65
VARIABLE LOAD	1601.05	2.77	3.35	4434.91	5363.52	230.50	-1.35	2.49	-80.67	573.94

ENTIRE VEHICLE(NORMAL)

SUMMARY	NB. ITEMS	SUM W	S	MXW	S	MYW	S	MX	SUM MX	SUM MY	SUM D	S	MXPD	S	MYPD	SUM MXP	SUM MYP
	4	32328.23		7.48		4.46		241666.69		144071.86	32332.42		7.41		4.80	239496.84	155130.00
BG LONGITUDINAL		-0.07						BG VERTICAL		0.34

ENTIRE VEHICLE (NORMAL)

ALVIN WEIGHT AND STABILITY COMPUTATIONS

ROCK DRILL ABOARD

IDENTIFICATION	W	X	Y	MX	MY	D	XP	YP	MXP	MYP
IN NORMAL CONDITION	32328.23	7.47	4.45	241491.88	143860.62	32332.42	7.40	4.79	239259.91	154872.29
REMOVE ARM	-438.55	-0.30	2.70	131.56	-1184.08	-143.00	.00	2.70	.00	-386.10
REMOVE ARM RELEASE	-96.50	.80	3.00	77.20	-289.50	-30.50	.80	3.00	-24.40	-91.50
REMOVE ARM BRKTS	-13.00	1.00	3.00	-13.00	-39.00	-3.00	1.00	3.00	-3.00	-9.00
REMOVE ARM CONTR BOX	-3.00	1.00	7.00	-3.00	-21.00	.00	.00	.00	.00	.00
REMOVE SAMP TRAY ETC	-135.00	-2.50	1.40	337.50	-189.00	-45.00	-2.50	1.40	112.50	-63.00
REMOVE ONE PERSON	-167.00	5.86	4.13	-978.62	-689.71	.00	.00	.00	.00	.00
ADD ROCK DRILL PCWR	1639.00	-1.29	2.04	-2114.31	3343.56	922.60	-1.29	2.04	-1190.15	1882.10
ADD LEAD FWD	200.00	-1.02	5.50	-216.00	1100.00	20.00	-1.08	5.50	-21.60	110.00
PUMP V/B LIGHT	-265.00	10.12	5.70	-2697.70	-1510.50	.00	.00	.00	.00	.00
REMOVE HG FWD	-125.00	1.79	1.90	-223.75	-237.50	.00	.00	.00	.00	.00
ADD HG AFT	125.00	17.50	3.92	2187.50	490.00	.00	.00	.00	.00	.00

ROCK DRILL ABOARD

SUMMARY	NB. ITEMS	SUM W	S MXW	S MYW	SUM MX	SUM MY	SUM D	S MXP	S MYPD	SUM MXP	SUM MYP
12		33049.18	7.20	4.38	237824.86	144633.89	33053.52	7.20	4.73	238133.25	156314.80
BG LONGITUDINAL		.01			BG VERTICAL		.35

ROCK DRILL ABOARD

ALVIN WEIGHT AND STABILITY COMPUTATIONS

ROCK DRILL DEPLOYED

IDENTIFICATION	W	X	Y	MX	MY	D	XP	YP	MXP	MYP
ALVIN AND ROCK DRILL	33049.18	7.19	4.37	237623.60	144424.92	33053.52	7.20	4.73	237985.34	156343.15
REMOVE HG AFT	-370.25	17.50	3.92	-6479.37	-1451.38	.00	.00	.00	.00	.00
ADD HG FWD	370.25	1.79	1.90	662.75	703.47	.00	.00	.00	.00	.00
PUMP V/B HEAVY	590.00	10.18	5.70	6006.20	3363.00	.00	.00	.00	.00	.00
RELEASE ROCK DRILL	-1466.00	-1.29	2.04	1891.14	-2990.64	-880.00	-1.29	2.04	1135.20	-1795.20

ROCK DRILL DEPLOYED

SUMMARY	N6. ITEMS	SUM W	S	MXW	S	MYW	S	MX	SUM MY	SUM D	S	MXPD	S	MYPD	SUM MXP	SUM MYP	
5		32173.18		7.45		4.48		239704.32	144049.37	32173.52		7.43		4.80	239120.54	154547.95	
BG LONGITUDINAL		-0.02						BG VERTICAL								.33

ROCK DRILL DEPLOYED

RELEASED FOREBODY

ALVIN WEIGHT AND STABILITY COMPUTATIONS

EMERGENCY CONDITIONS (1)

IDENTIFICATION	W	X	Y	MX	MY	D	XP	YP	MXP	MYP
IN NORMAL CONDITION	32328.23	7.47	4.45	241491.88	143860.62	32332.42	7.40	4.79	239259.91	154872.29
BLOW MAIN BALLAST	-1493.76	4.50	6.00	-6721.92	-8962.56	.00	.00	.00	.00	.00

EMERGENCY CONDITIONS (1)

SUMMARY	NB. ITEMS	SUM W	S MXW	S MYW	SUM MX	SUM MY	SUM D	S MXP	S MYP	SUM MXP	SUM MYP
	2	30834.47	7.61	4.37	234769.96	134898.06	32332.42	7.40	4.79	239259.91	154872.29

BG LONGITUDINAL

-.21

BG VERTICAL

.42

EMERGENCY CONDITIONS (1)

ALVIN WEIGHT AND STABILITY COMPUTATIONS

EMERGENCY CONDITIONS (2)

IDENTIFICATION	W	X	Y	MX	MY	D	XP	YP	MXP	MYP
IN NORMAL CONDITION	32328.23	7.47	4.45	241491.88	143860.62	32332.42	7.40	4.79	239259.91	154872.29
DROP HG FWD	-245.25	1.79	1.90	-439.00	-465.97	.00	.00	.00	.00	.00
DROP HG AFT	-245.25	17.50	3.92	-4291.87	-961.38	.00	.00	.00	.00	.00

EMERGENCY CONDITIONS (2)

SUMMARY	NO. ITEMS	SUM W	S	MXW	S	MYW	S	SUM MX	SUM MY	SUM D	S	MXPD	S	MYPD	SUM MXP	SUM MYP
3	31837.73	7.44	4.47	236761.01	142433.27	32332.42	7.40	4.79	239259.91	154872.29						
BG LONGITUDINAL		-0.04						BG VERTICAL	.32

EMERGENCY CONDITIONS (2)

ALVIN WEIGHT AND STABILITY COMPUTATIONS

EMERGENCY CONDITIONS (3)

IDENTIFICATION	W	X	Y	MX	MY	D	XP	YP	MXP	MYP
IN NORMAL CONDITION	32328.23	7.47	4.45	241491.88	143860.62	32332.42	7.40	4.79	239259.91	154872.29
DROP MID BATTERY	-1435.00	10.00	2.80	-14950.00	-4186.00	-929.00	10.00	2.80	-9290.00	-2601.20

EMERGENCY CONDITIONS (3)

SUMMARY	N6. ITEMS	SUM W	S MXW	S MYW	SUM MX	SUM MY	SUM D	S MXPD	S MYPD	SUM MXP	SUM MYP
	2	30833.23	7.35	4.53	226541.88	139674.62	31403.42	7.32	4.85	229969.91	152271.09
EG LONGITUDINAL		••02			BG VERTICAL	•32

EMERGENCY CONDITIONS (3)

ALVIN WEIGHT AND STABILITY COMPUTATIONS

EMERGENCY CONDITIONS (4)

IDENTIFICATION	W	X	Y	MX	MY	D	XP	YP	1 MXP	MYP
IN NORMAL CONDITION	3232.23	7.47	4.45	241491.88	143860.62	32332.42	7.40	4.79	239259.91	154872.29
DROP FWD BATTERY	-1495.00	8.68	2.80	-12976.60	-4186.00	-929.00	8.68	2.80	-8063.72	-2601.20
DROP AFT BATTERY	-1495.00	11.4C	2.80	-17043.00	-4186.00	-929.00	11.40	2.80	-10590.60	-2601.20

EMERGENCY CONDITIONS (4)

SUMMARY	NO. ITEMS	SUM W	S	MXW	S	MYW	SUM MX	SUM MY	SUM D	S	MXPD	S	MYPD	SUM MXP	SUM MYP
	3	29338.23		7.21		4.62	211472.28	135488.62	30474.42		7.24		4.91	220605.59	149669.89
BG LONGITUDINAL										.03		BG VERTICAL		.29

EMERGENCY CONDITIONS (4)

ALVIN WEIGHT AND STABILITY COMPUTATIONS

EMERGENCY CONDITIONS (5)

IDENTIFICATION	W	X	Y	MX	MY	D	XP	YP	MXP	MYP
IN NORMAL CONDITION	32328.23	7.47	4.45	241491.88	143860.62	32332.42	7.40	4.79	239259.91	154872.29
DROP FWD BATTERY	-1495.00	8.68	2.80	-12976.60	-4186.00	-929.00	8.68	2.80	-8063.72	-2601.20
DROP MID BATTERY	-1495.00	10.00	2.80	-14950.00	-4186.00	-929.00	10.00	2.80	-9290.00	-2601.20
DROP AFT BATTERY	-1495.00	11.40	2.80	-17043.00	-4186.00	-929.00	11.40	2.80	-10590.60	-2601.20

EMERGENCY CONDITIONS (5)

SUMMARY	NB. ITEMS	SUM W	S	MXW	S	MYW	S	MX	SUM MX	SUM MY	SUM D	S	MXPD	S	MYPD	SUM MXP	SUM MYP
4		27843.23		7.06		4.72		196522.28	131302.62	29545.42	7.15	4.98	211315.59	147068.69			
BG LONGITUDINAL				.09				BG VERTICAL								.26

EMERGENCY CONDITIONS (5)

ALVIN WEIGHT AND STABILITY COMPUTATIONS

EMERGENCY CONDITIONS (6)

IDENTIFICATION	W	X	Y	MX	MY	D	XP	YP	MXP	MYP
IN NORMAL CONDITION	32328.23	7.47	4.45	241491.88	143860.62	32332.42	7.40	4.79	239259.91	154872.29
DR0P HG FWD	-245.25	1.79	1.90	-439.00	-465.97	.00	.00	.00	.00	.00
DR0P HG AFT	-245.25	17.50	3.92	-4291.87	-961.38	.00	.00	.00	.00	.00
DR0P FWD BATTERY	-1495.00	8.68	2.80	-12976.60	-4186.00	-929.00	8.68	2.80	-8063.72	-2601.20
DR0P MID BATTERY	-1495.00	10.00	2.80	-14950.00	-4186.00	-929.00	10.00	2.80	-9290.00	-2601.20
DR0P AFT BATTERY	-1495.00	11.40	2.80	-17043.00	-4186.00	-929.00	11.40	2.80	-10590.60	-2601.20

EMERGENCY CONDITIONS (6)

SUMMARY	N6. ITEMS	SUM W	S MXW	S MYW	SUM MX	SUM MY	SUM D	S MXP	S MYP	SUM MXP	SUM MYP
6		27352.73	7.01	4.75	191791.41	129875.27	29545.42	7.15	4.98	211315.59	147068.69
BG LONGITUDINAL		.14			BG VERTICAL	.23

EMERGENCY CONDITIONS (6)

ALVIN WEIGHT AND STABILITY COMPUTATIONS

EMERGENCY CONDITIONS (7)

IDENTIFICATION	W	X	Y	MX	MY	D	XP	YP	MXP	MYP
IN NORMAL CONDITION	32323.23	7.47	4.45	241491.88	143860.62	32332.42	7.40	4.79	239259.91	154872.29
DRBP HG FWD	-245.25	1.79	1.90	-439.00	-465.97	.00	.00	.00	.00	.00
DRBP HG AFT	-245.25	17.50	3.92	-4291.87	-961.38	.00	.00	.00	.00	.00
DRBP FWD BATTERY	-1495.00	8.68	2.80	-12976.60	-4186.00	-929.00	8.68	2.80	-8063.72	-2601.20
DRBP MID BATTERY	-1495.00	10.00	2.80	-14950.00	-4186.00	-929.00	10.00	2.80	-9290.00	-2601.20
DRBP AFT BATTERY	-1495.00	11.40	2.80	-17043.00	-4186.00	-929.00	11.40	2.80	-10590.60	-2601.20
DRBP ARM	-438.55	-0.30	2.70	131.56	-1184.08	-143.00	.00	2.70	.00	-386.10

EMERGENCY CONDITIONS (7)

SUMMARY	NO. ITEMS	SUM W	S	MXW	S	MYW	SUM MX	SUM MY	SUM D	S	MXPD	S	MYPD	SUM MXP	SUM MYP
7		26914.18		7.13		4.78	191922.97	128691.18	29402.42		7.19		4.99	211315.59	146682.59
BG LONGITUDINAL			.06				BG VERTICAL	.21

EMERGENCY CONDITIONS (7)

ALVIN WEIGHT AND STABILITY COMPUTATIONS

EMERGENCY CONDITIONS (8)

IDENTIFICATION	W	X	Y	MX	MY	D	XP	YP	MXP	MYP
IN NORMAL CONDITION	32328.23	7.47	4.45	241491.88	143860.62	32332.42	7.40	4.79	239259.91	154872.29
FL88D V/R SPHERES	1062.00	9.05	4.27	9611.10	4534.74	.00	.00	.00	.00	.00
DR8P LG FWD	-245.25	1.79	1.90	-439.00	-465.97	.00	.00	.00	.00	.00
DR8P HG AFT	-245.25	17.50	3.92	-4291.87	-961.38	.00	.00	.00	.00	.00
DR8P FWD BATTERY	-1455.00	8.68	2.80	-12976.60	-4186.00	-929.00	8.68	2.80	-8063.72	-2601.20
DR8P MID BATTERY	-1495.00	10.00	2.80	-14950.00	-4186.00	-929.00	10.00	2.80	-9290.00	-2601.20
DR8P AFT BATTERY	-1495.00	11.40	2.80	-17043.00	-4186.00	-929.00	11.40	2.80	-10590.60	-2601.20
DR8P ARM	-438.55	-0.30	2.70	131.56	-1184.08	-143.00	.00	2.70	.00	-386.10

EMERGENCY CONDITIONS (8)

SUMMARY	NB. ITEMS	SUM W	S	MXW	S	MYW	S	MX	SUM MX	SUM MY	SUM D	S	MXPD	S	MYPD	SUM MXP	SUM MYP
	8	27976.18		7.20		4.76		201534.07	133225.92	29402.42		7.19		4.99		211315.59	146682.59

BG LONGITUDINAL -0.02

BG VERTICAL .23

EMERGENCY CONDITIONS (8)

E. Other Calculations

1. Pounds per Inch Immersion - This is the weight of a layer of water one inch thick at the waterplane and is used to obtain the change in draft for a given change in weight. The increase or decrease in draft is equal to the vehicle weight change divided by the pounds per inch immersion.

Thus, the pounds per inch immersion

$$\begin{aligned} \text{PPI} &= A_{wp} \times \frac{1}{12} \times 64 \\ &= 79.5 \times \frac{1}{12} \times 64 \\ &= 424 \text{ lbs. per inch} \end{aligned}$$

2. Moment to Trim One Degree - This is the moment required to produce an inclination of 1 degree in the longitudinal direction. It is found for the submerged vehicle by

$$\begin{aligned} \text{MTD} &= W(\text{BG}) \sin 1^\circ \\ &= 32328 (.34) (.0175) \\ &= 192 \text{ ft.-lbs.} \end{aligned}$$

III. Tethered Trim Dive

A. Description of Test The tethered trim dive was conducted at the dock of the Woods Hole Oceanographic Institution on May 5, 1972. The purpose of this test was to determine the so-called "load to submerge." This is essentially the weight which must be added to the normal surfaced submarine (including solid ballast) to cause it to be neutrally buoyant when submerged. This added weight, in the case of large combat submarines, includes normal fuel oil, variable ballast, residual water, fuel ballast, and main ballast. For the research submarine ALVIN the applicable items are variable ballast and main ballast; hence the load to submerge is the sum of the weights of main ballast water and that portion of variable ballast water which must be flooded to achieve submerged equilibrium. In the test, the vehicle was made heavy by a known amount using external lead weights. After the main ballast tanks had been fully flooded, the variable ballast tanks were partially flooded until the vehicle's weight in water was equal to the water weight of the additional external lead. This condition was read directly from a sensitive dynamometer bridled above the submerged submarine. The following sections contain a digest of the data and results obtained during the test.

B. Preliminary Data

1. Two persons aboard; 150 pounds of lead in sphere in place of third man.
2. Arm compensator weight: 260 pounds of lead (water weight).

3. Lead weights on sponsons: 160 pounds (water weight)
4. Dynamometer: Dillon, range 0-250 pounds
5. Tare weight on scale due to bridle: 5 pounds
6. Scale error: reads 10 percent low; therefore increase scale reading by 10 percent.
7. Vehicle draft: 7'3" average, with main ballast blown.
8. Vehicle displacement: 29,572 pounds, normal surfaced vehicle minus sample tray and science payload.
9. Water Sample: temperature 48.5° F
density 63.93 lbs. per cu. ft.

C. Test Results

The test was performed as follows:

1. Main ballast tanks were flooded (1494 pounds)
2. Variable ballast tanks were flooded until dynamometer reading was equal to weight of lead added to sponsons (corrected reading 149 pounds).
3. Variable ballast meter inside sphere was monitored. It was determined that 812 pounds of sea water were added to the V/B tanks in order to reach neutral equilibrium.

The load to submerge is then

$$1494 + 812 = 2306 \text{ pounds}$$

4. The V/B tanks were further flooded to produce the conditions of 25, 50, 75, and 100 pounds heavy. V/B meter readings were compared with the dynamometer readings and good agreement was noted.

5. A weight balance for the vehicle at the time of the trim

dive is as follows:

Surface condition minus sample tray and science payload	29572
Sample tray	135
Science payload	315
Load to submerge	<u>2306</u>
Normal submerged condition	32328 pounds

IV. Discussion

Vertical stability of the normal submerged ALVIN is indicated by the vertical BG distance of 0.34 ft., which is the same as the value obtained in the 1971 computations. The present longitudinal BG value is - 0.07 ft., slightly less than the 1971 value of - 0.08 ft. Both values indicate a slight nose-up angle, which can be easily corrected by use of the mercury trim system. BG values, both longitudinal and vertical, for the vehicle in the various modified or emergency conditions, can be seen to be the same as, or very close to, the 1971 values.

Significant changes to the submarine between the 1971 and 1972 operating seasons were the following:

- a. Removal of the oil variable ballast system and installation of the new sea-water system (net buoyancy loss: 310.56 lbs.).
- b. Installation of syntactic foam buoyancy material in port compartment formerly occupied by V/B system rubber bag (net buoyancy gain: 108.48 lbs.).
- c. Installation of a new heavier sample tray with a rotating basket (net buoyancy loss: 90 lbs.).

The above items, plus a few minor changes to the vehicle, necessitated a reduction in payload from 630 lbs. (the 1971 value) to 315 lbs.

The rock drill computations show that the submarine can be adjusted to very nearly zero trim both with the drill aboard, and with the drill deployed on the bottom. However in the latter case a severe nose-up condition is avoided only by the addition of 200 pounds of lead located

forward, as well as the transfer of the full amount of mercury to the to the forward tanks. The use of extra lead on the already heavily loaded vehicle is not desirable from the weight point of view but is necessary for trim purposes, since even a slight up-angle would make the final pickup of the drill more difficult. An added complication arises from the fact that, upon release of the rock drill, the variable ballast tanks must be partially flooded to compensate for the weight loss. The location of these tanks is such that the flooding itself tends to produce a nose-up condition, cancelling some of the advantage gained by the forward lead. In summary, the use of the rock drill with ALVIN requires the full use of the mercury trim system (plus additional forward lead), and nearly the full capability of the variable ballast system.

Since the surface and submerged inclining experiments were not performed in 1972 there are no new values of GM or experimentally determined BG to report. The weight report for 1971 (Ref. 2) contains the most recently obtained values. However, since the present calculated values agree so closely with those for 1971, it is felt that the GM value cannot have changed significantly.

V. References

1. "Weight, Buoyancy and Stability of DSRV ALVIN, 1967," by Arnold G. Sharp and Clifford L. Winget, WHOI Technical Memorandum DS-26, January, 1968.
2. "DSRV ALVIN Weight Report," by Arnold G. Sharp, Clifford L. Winget, and Andrew H. Eliason, WHOI Technical Memorandum No. 6-71, August, 1971.

VI. Appendix

Computer Program

Name: ALVINSTA

Type Main Program

Purpose: To compute total weight and total displacement of the DSV ALVIN in its normal and various emergency conditions; weight and displacement of various subassemblies (sphere, forebody, etc.); location of center of gravity and center of buoyancy for the vehicle and for subassemblies; BG distance for the vehicle and for subassemblies expressed in longitudinal and vertical components. The program has an optional plot tape output to give graphic representation of submersibles attitude under the various conditions.

MACHINE: XDS Sigma 7

SOURCE LANGUAGE: XDS Fortran IV

PROGRAM CATEGORY: Data Processing

DESCRIPTION:

A full description and an example of the input/output data may be found in W.H.O.I. Technical Memorandum DS-26, WEIGHT, BUOYANCY AND STABILITY OF DSRV ALVIN, 1967, Arnold G. Sharp, January 1968.

INPUT: Punched cards. For each section of data there is one set of data cards of the following form:

Card 1 28 character alphanumeric title

Succeeding Data cards of the following format:
cards (up
to 500) Columns

1-20	20	Char. Alphanumeric Identifier
22-29	W	Item air weight
31-35	X	CG X Distance
37-41	Y	CG Y Distance
43-50	D	Displacement of Item
52-56	XP	B X Distance
58-62	YP	B Y Distance
64	C	Control Integer

Last Card !EOD (After each data section)

OUTPUT: On the line printer. Please see Technical Memorandum DS-26 for format and example program output. On calcomp plotter. Graphic representation of ALVIN in the attitude calculated by the program for a given data section.

USAGE: The deck is set up

```
!JOB ---, ---
!MESSAGE PLOT TAPE (if needed)
!ASSIGN F:PLOT, (DEVICE, 7T), (BIN), (OUTSN,
      PLTL), (OUT), (UNPACK)
!FORTRAN LS, GO,X*
      (Fortran deck of ALVINSTA)
! DATA
!      (Permanent data deck)
      (Data cards as described above)
      *Use "X" option only if plot is desired
```

RESTRICTIONS:

1. Column 64 contains 0 (zero) on all but the last data card in each section (before !EOD card)
2. A (2) in column 64 of the last data card causes plot output for that section.
3. A (3) in column 64 of the last data card indicates last section and terminates program. Plot will be output for last section unless "X" option was not specified on !FORTRAN card.

STORAGE REQUIREMENTS: About 5000₁₀ words

SUBPROGRAMS REQUIRED: AXDRAW, PLOT, SYMBOL

OPERATIONAL ENVIRONMENT:

<u>Device</u>	<u>Function</u>	<u>Special requirements</u>
card reader	input	F:105 DCB
line printer	output	F:108 DCB
7 track tape	output	F:PLOT DCB

OPERATIONAL CHARACTERISTICS:

Reads a data section then prints and writes tape (if called for).

TIMING: About 2 1/2 min. for typical large job w/plot

PROGRAMMER: Andy Eliason

ORIGINATOR: Arnold Sharp

DATE July, 1971

REFERENCE: Technical Memorandum DS-26


```

1.  C    ALVIN WEIGHT AND STABILITY PROGRAM
2.  C
3.  C    JUNE 1971
4.  C    PROGRAMMER: ANDREW H. ELIASON
5.  C    USE X OPTION FOR CALCULATION WITH PLOT
6.  C
7.  C    IMPLICIT DOUBLE PRECISION (A-H,O-Z)
8.  C    REAL X2,Y2
9.  X    COMMON  IBUF(1000)
10. C    COMMON  ARRAY1(500)
11. C    COMMON  ARRAY2(500)
12. X    COMMON  ARRAY3(500)
13. X    COMMON  ARRAY4(500)
14. X    SCALE= 500.0
15. C    COMMON  IDEN(300,5),ID(7)
16. C    DIMENSION X(300),Y(300),W(300),D(300),XP(300),YP(300),C(300)
17. 100  FORMAT(5A4,1X,F8.2,2(1X,F5.2),1X,F8.2,2(1X,F5.2),1X,I1)
18. 200  FORMAT(46X,'ALVIN WEIGHT AND STABILITY COMPUTATIONS',35X,'PAGE ',I
19.      11/)
20. 250  FORMAT(46X,7A4/)
21. 260  FORMAT (46X,7A4,' (CONTINUED)',/)
22. 300  FORMAT(3X,'IDENTIFICATION',11X,'W',9X,'X',8X,'Y',9X,'MX',10X,'MY',
23.      11X,'D',9X,'XP',7X,'YP',8X,'MXP',9X,'MYP',/)
24. 400  FORMAT(1X,5A4,4X,F8.2,2(4X,F5.2),3(3X,F9.2),2(4X,F5.2),2(3X,F9.2))
25. 500  FORMAT(/// SUMMARY      N0. ITEMS',6X,'SUM W',4X,'S MXW',4X,'S MYW',
26.      16X,'SUM MX',6X,'SUM MY',7X,'SUM D',5X,'S MXP',3X,'S MYP',4X,'SUM
27.      1 MXP',5X,'SUM MYP')
28. 600  FORMAT(14X,I3,8X,F8.2,2(4X,F5.2),3(3X,F9.2),2(4X,F5.2),2(3X,F9.2))
29. 700  FORMAT(/,10X,'BG LONGITUDINAL',5X,F5.2,20X,'BG VERTICAL',5X,F5.2)
30. 800  FORMAT('1')
31. 900  FORMAT(7A4)
32. 950  FORMAT(//1X,7A4)
33. X    CALL PLOTS(IBUF,-1000)
34. C*****
35. C    READ ALVIN PICTURE DATA
36. C    M=1
37. 15  M1=M+3
38. READ(105,105,END=55)(ARRAY1(I),ARRAY2(I),I=M,M1)
39. 105  FORMAT (4(5X,I6,2X,I6,1X))
40. C    M=M+4
41. GO TO 15
42. 55  CONTINUE
43. C    M=M+4
44. C*****
45. C    READ SECTION TITLE AND DATA
46. C    IPAGE = 1
47. 5  N=1
48. READ(105,900)ID
49. 10  READ(105,100,END=20)(IDEN(N,J),J=1,5),W(N),X(N),Y(N),D(N),XP(N),
50. 1YP(N),C(N)
51. N=N+1
52. GO TO 10

```

```

53.      20 N=N+1;WRITE(108,200)IPAGE;WRITE(108,250)ID;WRITE(108,300)
54.      ITEM = 1
55.      SW=0.0;SRXW=0.0;SRYW=0.0;SRX=0.0;SRY=0.0;SD=0.0;SRXPD=0.0;SRYPD=0.0
56.      SRXP=0.0;SRYP=0.0
57.      C      CALCULATE RESULTS
58.      DO 30 I=1,N
59.      RX=W(I)*X(I);RY=W(I)*Y(I)
60.      RXP=D(I)*XP(I);RYP=D(I)*YP(I)
61.      SW=W(I)+SW;SD=D(I)+SD
62.      SRX=SRX+RX;SRY=SRY+RY;SRXP=SRXP+RXP;SRYP=SRYP+RYP
63.      SRXW=SRX/SW;SRYW=SRY/SW
64.      SRXPD=SRXP/SD;SRYPD=SRYP/SD
65.      BGL=SRXPD-SRXW;BGV=SRYPD-SRYW
66.      WRITE(108,400)(IDEN(I,J),J=1,5),W(I),X(I),Y(I),RX,RY,D(I),XP(I),
67.      1 YP(I),RXP,RYP
68.      IF(ITEM.EQ.40.0R.ITEM.EQ.80.0R.ITEM.EQ.120)IPAGE=IPAGE+1;WRITE(108
69.      1,800);WRITE(108,200)IPAGE;WRITE(108,260)ID;WRITE(108,300)
70.      ITEM=ITEM+1
71.      30 CONTINUE
72.      C      PRINT RESULTS
73.      WRITE(108,950)ID
74.      WRITE(108,500)
75.      WRITE(108,600)N,SW,SRXW,SRYW,SRX,SRY,SD,SRXPD,SRYPD,SRXP,
76.      1SRYPD;WRITE(108,700)BGL,BGV;WRITE(108,800);IPAGE=IPAGE+1
77.      C*****
78.      C      CALCULATE PICTURE ROTATION DATA
79.      X      IF(C(N).LT.2) GO TO 80
80.      X      THETA =DATAN2(SRXPD-SRXW,SRYPD-SRYW)
81.      X      DO 25 I=1,M
82.      X      IF(ARRAY2(I).GT.3000) ARRAY4(I)= 10500; GO TO 25
83.      X      X1= ARRAY1(I)
84.      X      Y1= ARRAY2(I)
85.      X      GAMMA=DATAN2(Y1,X1)
86.      X      R =DSQRT(X1**2+Y1**2)
87.      X      A = GAMMA + THETA
88.      X      X1= R*DCOS(A)
89.      X      Y1= R*DSIN(A)
90.      X      ARRAY3(I)=X1
91.      X      ARRAY4(I)=Y1
92.      X      25 CONTINUE
93.      C*****
94.      C      PLBT ALVIN PICTURE
95.      X      CALL PLBT(10.0,10.0,-3)
96.      X      CALL AXDRAW(-6.0,0.0,'X',1,16.0,0.0,-6.0,1.0,1.0,-1)
97.      X      CALL AXDRAW(0.0,-4.0,'Y',1,10.0,90.0,-4.0,1.0,1.0,-1)
98.      X      CALL SYMBOL (-7.0,-9.0,21,ID,0.0,28)
99.      X      DO 75 I=1,M
100.     X      IPEN=2
101.     X      IF(I.EQ.1.0R.IFLAG.EQ.1) IPEN=3;GO TO 65
102.     X      IF(ARRAY4(I).GT.10000)IFLAG=1;GO TO 75
103.     X      65 X2= ARRAY3(I)/SCALE
104.     X      Y2= ARRAY4(I)/SCALE
105.     X      CALL PLBT(X2,Y2,IPEN)
106.     X      IFLAG=0
107.     X      75 CONTINUE
108.     X      CALL PLBT (20.0,-10.0,999)
109.     C*****
110.     80 CONTINUE
111.     C      CHECK FOR LAST CARD
112.     IF(C(N).EQ.3)GO TO 40
113.     GO TO 5
114.     40 CALL EXIT
115.     END

```