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Woods Hole
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TECHNICAL MEMORANDUM NO. 4-78

WEIGHT AND STABILITY OF DSRV ALVIN, 1978

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October 1978

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prepared by

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ABSTRACT

The ALVIN weight and stability report for 1978 contains the usual programmed computations covering the normal submerged and normal surfaced vehicle configurations as well as a number of emergency conditions. Weight and stability figures also are reported for major vehicle subassemblies. Because of important structural modifications to ALVIN during the 1977-78 overhaul period the surface and submerged inclining experiments were conducted at the end of that period. The usual tethered trim dive also was performed and the results of these experiments are reported.

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I. Introduction

Following Dive No. 795 on October 3, 1977 ALVIN was brought into the high crane bay of the Iselin Facility for disassembly. This was the beginning of a major submersible overhaul that required about six months for completion. During the course of reassembly a number of new features were added to the vehicle, and improvements were made to certain existing systems. Some of the more important additions and changes are described below.

The aluminum alloy frame that has been in use in ALVIN since 1971 has during that time demonstrated poor resistance to corrosion and reduced strength at and near welded joints. Despite careful repair-welding of damaged areas and the addition of reinforcing members wherever possible, new cracks have appeared in the frame during each operating season. A new frame made of unalloyed titanium, ASTM Grade 2, has been installed to replace the aluminum structure. The new material is stronger than the old, is extremely resistant to corrosion in sea water, and it can be welded to produce joints with properties very close to those of the parent metal. ALVIN group engineers designed the new frame and the contract for its construction was awarded to Titanium Fabrication Corporation of Fairfield, New Jersey. The completed structure

was delivered to Woods Hole on December 13, 1977. The new frame weighs 635 pounds, about 200-pounds more than the old aluminum alloy frame.

Following the 1977 operating season, ALVIN's stern propeller shroud assembly and the associated steering mechanism enclosure were found to be damaged and corroded. These aluminum alloy parts were replaced by titanium welded assemblies of similar design. The electrical control center box formerly of welded aluminum, also has been rebuilt of titanium.

The new frame was designed to be approximately two feet longer than the original, making the overall length of the submersible about 24 feet. The added length was inserted just aft of the forebody section and it provides a space for one additional battery. The new battery has not yet been installed, but work is proceeding on the required battery box and support frame. The new space also can be used for extra syntactic foam buoyancy material if the submersible is required to lift a heavy object from the bottom.

Above the new battery space a new fiberglass main ballast tank has been installed. This tank, normally flooded during a dive, can be emptied as ALVIN approaches the surface. The added buoyancy from this tank has increased the freeboard of the surfaced vehicle by about six inches.

The variable ballast pump/motor assembly has been mounted on tracks for easy removal for maintenance. The heavy propulsion box has been mounted on a hinge so that it can be lowered conveniently for servicing. A new forward weight dropper/basket release device has been incorporated into the new frame.

Because of the shortened 1977 operating season occasioned by the major overhaul period of 1977-78, and because only minor changes to ALVIN had occurred between the 1976 and 1977 seasons, a formal weight report was not issued in 1977. The 1976 report (Ref. 1) may be considered to describe adequately the weight and stability condition of ALVIN until the beginning of the 1977-78 overhaul. The most recent inclining experiments prior to those conducted this year were those detailed in the weight report of 1975 (Ref. 2). As a rule, inclining experiments are done only when repairs or modifications to ALVIN are of a kind that might alter surface or submerged stability characteristics. Since the changes to the submersible during the most recent overhaul were relatively large in scope, the inclining experiments and other related tests were considered necessary. These tests were performed on May 2, 1978 and the results are included in this report.

II. Weight and Stability Computations

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

1. Sphere only (pressure hull plus contents)
2. Other forebody
3. Afterbody
4. Variable load
5. Released forebody
6. Entire vehicle

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

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

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

7. Surface condition

8. Emergency conditions

At the end of each subgroup the weight, displacement and moment summations were made, and the locations of G and B were determined. At the end of Section 5 (released forebody) 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 about one-third flooded, and the trim mercury is divided 50 percent forward and 50 percent aft.

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.)

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 sur-
face (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.)

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

ALVIN HEIGHT AND STABILITY COMPUTATIONS

SPHERE ONLY

IDENTIFICATION	W	X	Y	MX	MY	D	XP	YP	MXP	MYP
P HULL MINUS INSERTS	5081.54	4.97	4.89	25255.25	24848.73	10604.08	4.50	4.75	47718.36	50359.38
HULL INSERT FWD	383.78	1.14	4.75	437.51	1822.95	14.77	1.14	4.75	16.84	70.15
HULL INSERT BOT	386.28	3.72	1.42	1436.96	548.52	14.77	3.72	1.42	54.94	20.97
HULL INSERT PORT	387.29	2.39	3.46	925.62	1340.02	14.77	2.39	3.46	35.30	51.10
HULL INSERT STBD	385.54	2.39	3.46	921.44	1333.97	14.77	2.39	3.46	35.30	51.10
HATCH INSERT	261.53	4.50	8.11	1176.88	2121.01	9.28	4.50	8.11	41.76	75.25
WINDOW FWD	9.02	1.14	4.75	10.28	42.84	3.48	1.14	4.75	3.97	16.53
WINDOW BOT	9.02	3.72	1.44	33.55	12.99	3.48	3.72	1.44	12.95	5.01
WINDOWS P'S	18.04	2.39	3.46	43.12	62.42	6.96	2.39	3.46	16.63	24.08
WINDOW RET RING FWD	4.80	1.14	4.75	5.47	22.80	1.09	1.14	4.75	1.24	5.13
WINDOW RET RING BOT	4.80	3.72	1.30	17.86	6.24	1.09	3.72	1.30	4.05	1.42
WIND RET RINGS P'S	9.60	2.39	3.46	22.94	33.22	2.18	2.39	3.46	5.21	7.54
SPHERE REL UPPER	48.50	4.50	1.33	218.25	64.50	5.49	4.50	1.21	24.70	6.64
HATCH ARMS	199.34	4.50	8.11	897.03	1616.65	11.37	4.50	8.11	51.16	92.21
HINGE SHAFT	4.57	4.21	8.28	19.24	37.84	1.05	4.21	8.28	4.42	8.69
INSIDE HANDLE	3.25	4.00	8.28	13.00	26.91	.75	4.00	8.28	3.00	6.21
OUTSIDE HANDLE	2.57	4.91	7.94	12.62	20.41	.00	.00	.00	.00	.00
SPRING RETAINER	5.14	4.91	8.28	25.24	42.56	1.18	4.91	8.28	5.79	9.77
INT SWING CLAMP	2.67	4.14	8.28	11.05	22.11	.61	4.14	8.28	2.53	5.05
HINGE SPRINGS	1.52	4.60	7.94	6.99	12.07	.00	.00	.00	.00	.00
HATCH WINDOW	12.05	4.00	8.28	48.20	99.77	1.45	4.00	8.28	5.80	12.01
HATCH WIND RET RING	2.02	4.50	8.19	9.09	16.54	.94	4.50	8.19	4.23	7.70
HINGE BLOCKS	2.16	4.50	8.10	9.72	17.50	.50	4.50	8.10	2.25	4.05
PENETRATORS (7) FWD	6.58	3.92	8.05	25.79	52.97	1.51	3.92	8.05	5.92	12.15
PENETRATORS (5) BOT	36.68	1.06	4.75	38.88	174.23	4.48	1.06	4.75	4.75	21.28
PENETRATORS (2) P	26.20	4.29	1.42	112.40	37.20	3.20	4.29	1.42	13.73	4.54
PENETRATORS (2) S	10.48	2.75	4.25	28.82	44.54	1.28	2.75	4.25	3.32	5.44
CABLE 24 COND 220 FT	10.48	2.21	3.52	23.16	36.89	1.28	2.21	3.52	2.83	4.51
BLANKING PLUGS (3) P	85.80	2.50	2.70	214.50	231.66	4.24	2.50	2.70	105.60	114.05
BLANKING PLUGS (4) S	18.00	2.97	3.26	53.46	58.68	1.23	2.97	3.26	3.65	4.01
LIFT PADS	24.00	3.04	3.52	72.96	84.48	1.64	3.04	3.52	4.99	5.77
CONN HALVES UPPER	10.20	4.50	8.17	45.90	83.33	2.35	4.50	8.17	10.37	19.20
MISC OUTSIDE	52.50	4.50	1.09	236.25	57.22	5.25	4.50	1.09	23.63	5.72
STRAZA M80 100	10.00	4.50	8.10	45.00	81.00	2.30	4.50	8.10	10.35	18.63
STRAZA M80 200	30.00	3.13	5.93	93.90	165.90	.00	.00	.00	.00	.00
STRAZA M80 300	32.00	4.04	5.96	129.28	190.72	.00	.00	.00	.00	.00
TAPE RECORDER	40.00	4.37	6.67	174.80	266.80	.00	.00	.00	.00	.00
O2 ANALYZER	2.00	4.13	4.50	8.26	9.00	.00	.00	.00	.00	.00
O2 BOTTLES (3)	3.50	5.38	6.70	18.83	23.45	.00	.00	.00	.00	.00
	105.00	6.71	3.79	704.55	397.95	.00	.00	.00	.00	.00

ALVIN WEIGHT AND STABILITY COMPUTATIONS

(CONTINUED)

SPHERE ONLY

IDENTIFICATION	W	X	Y	MX	MY	D	XP	YP	WXP	WYP
LIGH CANISTERS (3)	24.00	6.29	5.00	150.96	120.00	.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
EMERG BREATH APPAR 3	45.00	5.33	5.88	239.85	264.60	.00	.00	.00	.00	.00
VESTS (3)	6.00	5.33	5.88	31.98	35.28	.00	.00	.00	.00	.00
PILOTS CHAIR	9.31	2.88	2.88	26.81	26.81	.00	.00	.00	.00	.00
TRIM INDICATOR	.30	1.63	5.50	7.34	1.65	.00	.00	.00	.00	.00
CABIN LIGHTS P.S.(2)	2.00	3.67	5.46	10.32	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
FL98R BBARDS	8.00	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	4.50	4.75	360.00	380.00	.00	.00	.00	.00	.00
URINALS (3)	1.00	5.50	2.50	5.50	2.50	.00	.00	.00	.00	.00
CAMERAS	6.00	5.80	5.20	34.80	31.20	.00	.00	.00	.00	.00
T89L KIT	4.00	5.50	2.40	22.00	9.60	.00	.00	.00	.00	.00
FLASHLIGHTS(6)	4.80	5.50	2.40	26.40	11.52	.00	.00	.00	.00	.00
RADAR REFLECTOR	.50	5.50	2.50	2.75	1.25	.00	.00	.00	.00	.00
SOUND PHONES(2)	6.00	4.30	7.00	25.80	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
STBD DISTR PANEL	42.00	2.90	6.25	121.80	262.50	.00	2.90	6.25	.00	.00
PORT WING PANEL	12.50	2.90	6.25	36.25	78.13	.00	.00	.00	.00	.00
RADIO	11.25	4.58	5.96	51.52	67.05	.00	.00	.00	.00	.00
U Q 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 COMP	17.00	3.50	5.75	59.50	97.75	.00	.00	.00	.00	.00
POWER SUPPLY 6V.	7.00	7.00	5.12	49.00	35.84	.00	.00	.00	.00	.00
INVERTER	27.00	7.67	6.54	207.09	176.58	.00	.00	.00	.00	.00
POWER PANEL	20.00	6.00	3.75	120.00	75.00	.00	6.00	3.75	.00	.00
SHELF UPPER STBD	2.00	4.35	6.75	8.70	13.50	.00	.00	.00	.00	.00
SHELF UPPER PORT	3.50	4.35	6.75	15.22	23.63	.00	.00	.00	.00	.00
SHELF OVER IND PANEL	1.50	1.70	6.60	2.55	9.90	.00	.00	.00	.00	.00
SHELF OVER LEAK DET.	2.00	2.88	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 (2)	14.00	3.00	5.50	42.00	77.00	.00	.00	.00	.00	.00
ALTIMETER	5.00	2.25	7.00	11.25	35.00	.00	.00	.00	.00	.00
62 BATTLE BRK (3)	8.00	6.71	3.79	53.68	30.32	.00	.00	.00	.00	.00

ALVIN WEIGHT AND STABILITY COMPUTATIONS

(CONTINUED)

SPHERE ONLY

IDENTIFICATION	W	X	Y	MX	MY	D	XP	YP	MXP	MYP
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
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 (3)	27.00	4.50	6.00	121.50	162.00	.00	.00	.00	.00	.00
ALNAV CLOCK	14.00	5.75	5.50	80.50	77.00	.00	.00	.00	.00	.00

SPHERE ONLY

SUMMARY	NO. ITEMS	SUM W	S MXW	S MYW	SUM MX	SUM MY	SUM D	S MXPD	S MYPD	SUM MXP	SUM MYP
93		8331.61	4.37	4.73	36374.96	39405.38	10780.82	4.47	4.74	48239.98	51055.38

BG LONGITUDINAL .11

BG VERTICAL .01

ALVIN WEIGHT AND STABILITY COMPUTATIONS

OTHER FOREBODY

IDENTIFICATION	W	X	Y	MX	MY	D	XP	YP	XP	YYP
SAIL/ETC	221.85	4.64	7.02	1029.38	1557.39	135.00	4.64	7.02	626.40	947.70
SPLASH GUARD	20.00	4.50	8.50	90.00	170.00	12.06	4.50	8.50	54.27	122.51
LITTON UP FBDY SYNT	1904.50	4.64	7.00	8836.88	13331.50	2201.65	4.64	7.00	10215.66	15411.55
3M UPPER FOREBODY	863.00	.38	7.00	327.94	6041.00	1434.60	.38	7.00	555.15	10042.20
LWR SYNT RING	1041.00	4.42	3.43	4601.22	3570.63	1147.00	4.42	3.43	5069.74	3934.21
FRT WINDOW CANE	36.00	.75	4.75	27.00	171.00	21.70	.75	4.75	16.27	123.07
MAIN BALLAST WATER	1346.00	4.50	6.00	6057.00	8076.00	1346.00	4.50	6.00	6057.00	8076.00
MAIN BALLAST TANKS	178.00	4.50	6.00	801.00	1068.00	107.50	4.50	6.00	483.75	645.00
VELOCIMETER	20.00	2.20	9.50	44.00	190.00	10.00	2.20	9.50	22.00	35.00
SAIL CONTROL BAY	30.00	3.40	12.00	102.00	360.00	20.00	3.40	12.00	68.00	240.00
SAIL J BOX	107.00	7.00	9.00	749.00	963.00	72.00	7.00	9.00	504.00	648.00
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
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
CURRENT METER/ETC	18.08	3.50	13.20	63.28	238.66	4.00	3.50	13.20	14.00	52.80
EGG CAMERAS (2)	104.00	.00	7.06	.00	734.24	30.00	.00	7.06	.00	211.80
STROBE PWR UNITS	48.00	7.50	7.25	360.00	348.00	32.00	7.50	7.25	240.00	232.00
FWD STROBE	54.00	.00	6.50	.00	351.00	16.00	.00	6.50	.00	104.00
BAR RADIO TRANS	1.70	7.50	12.00	12.75	20.40	.84	7.50	12.00	6.30	10.08
BAR FLASH LIGHT	1.70	7.50	12.00	12.75	20.40	.84	7.50	12.00	6.30	10.08
TV CAMERA	30.00	1.50	7.75	45.00	232.50	6.40	1.50	7.75	9.60	49.60
OUTSIDE DEPTH GAGE	5.00	.50	3.25	2.50	16.25	1.30	.50	3.25	.65	4.22
RESCUE SLING, SHCKLS	33.00	4.50	9.00	148.50	297.00	4.20	4.50	9.00	18.90	37.80
SIDE HOOK RCPTLS	20.66	7.62	4.62	157.43	95.45	4.69	7.62	4.62	35.74	21.67

OTHER FOREBODY

SUMMARY	NO. ITEMS	SUM W	S MXW	S MYW	SUM MX	SUM MY	SUM D	S MYPD	S MYP
	25	6212.56	3.79	6.25	23551.68	38823.73	6656.33	6.21	41354.55
BG LONGITUDINAL		.17			BG VERTICAL		.04		

AFTERBODY

IDENTIFICATION	W	X	Y	MX	MY	D	XP	YP	MP
FRAME	635.00	10.18	2.77	6464.30	1758.95	143.41	10.18	2.77	397.25
RUBBER SPH SEAT	20.79	4.50	2.73	93.55	56.76	17.06	4.50	2.73	46.57
ARM BRKTS NEW (2)	49.22	1.50	3.00	73.83	147.66	22.36	1.50	3.00	67.08
LG BUBY PKG AFT	2310.00	16.16	5.05	37329.60	11665.50	4082.56	16.16	5.05	20616.93
PINGER	87.00	16.00	6.75	1392.00	587.25	55.00	16.00	6.75	371.25
SIDE BUBY PKG (2)	433.00	10.40	6.75	4503.20	2922.75	692.00	10.40	6.75	4671.00
CTR BUBY PKG	113.00	12.15	5.83	1433.70	687.94	210.71	12.15	5.83	1228.44
TI BUBY SPH UP CTR	224.00	12.15	6.33	2721.60	1417.92	525.93	12.15	6.33	3329.14
MB TANK UP AFTBDY	55.50	12.15	6.83	674.32	379.06	34.81	12.15	6.83	237.75
MB WATER UP AFTBDY	300.00	12.15	6.83	3645.00	2049.00	300.00	12.15	6.83	2049.00
NEW MB TANK UP	138.00	9.10	6.00	1255.80	828.00	74.10	9.10	6.00	444.60
NEW MB TANK SS FRAME	28.12	9.10	7.21	255.89	202.75	3.72	9.10	7.21	26.82
NEW MB TANK SYNT	187.50	9.10	5.04	1706.25	945.00	333.30	9.10	5.04	1679.83
NEW MB WATER	1561.00	9.10	6.00	14205.10	9366.00	1561.00	9.10	6.00	9366.00
VB SPH LWR P	262.00	7.63	1.42	1999.06	372.04	265.00	7.63	1.42	376.30
VB SPH LWR S	26.20	7.63	1.42	1999.06	372.04	265.00	7.63	1.42	376.30
LWR VB SPH BRKT	7.57	6.88	.58	52.08	4.39	1.72	6.88	.58	1.00
LWR VB SPH UP BRKTC	2.18	8.04	2.50	17.53	5.45	.49	8.04	2.50	1.22
VB BUBY PKG UP P	253.00	12.08	6.20	3056.24	1568.60	449.78	12.08	6.20	2788.64
VB BUBY PKG LWR P	208.00	12.08	5.20	2512.64	1081.60	369.70	12.08	5.20	1922.44
VB SPHERES UP P	224.00	12.29	5.75	2752.96	1288.00	525.93	12.29	5.75	3024.10
VB BUBY PKG UP S	250.00	12.08	6.20	3020.00	1550.00	444.44	12.08	6.20	2755.53
VB BUBY PKG LWR S	204.00	12.08	5.20	2464.32	1060.80	362.67	12.08	5.20	1885.88
VB SPHERES UP S	224.00	12.29	5.75	2752.96	1288.00	525.93	12.29	5.75	3024.10
V/B SPHERES PLUMBING	25.00	9.16	4.31	229.00	107.75	3.24	9.16	4.31	13.96
VB PUMP	86.00	5.95	1.04	511.70	89.44	14.72	5.95	1.04	15.31
VB PUMP METER	150.00	5.75	1.04	862.50	156.00	88.96	5.75	1.04	92.52
VB PUMP MTG BRKT	17.89	5.83	1.04	104.30	18.61	4.11	5.83	1.04	4.27
VB PUMP MTG RAILS	13.69	5.83	.54	79.81	7.39	3.15	5.83	.54	1.70
VB SYST TI MTG RAILS	16.04	12.35	2.44	198.09	39.14	3.64	12.35	2.44	8.88
MISC FBGLS ANGLE	4.66	12.35	2.44	57.55	11.37	2.50	12.35	2.44	6.10
VALVE 3 WAY PILOT	15.00	13.84	1.96	207.60	29.40	1.96	13.84	1.96	3.84
VALVE/METERING	22.00	12.71	1.71	279.62	37.62	2.87	12.71	1.71	4.51
FLOWMETER	9.00	13.83	3.21	124.47	28.89	1.18	13.83	3.21	3.79
FILTER	6.00	13.12	4.46	78.72	26.76	.78	13.12	4.46	3.48
VALVE/AUTOCLAVE (2)	28.00	11.62	1.92	325.36	53.76	3.66	11.62	1.92	7.03
VB HYDR PUMP, METER	80.00	13.46	3.92	1076.80	313.60	10.45	13.46	3.92	40.95
VB HYDR CNTR B8X	171.88	11.67	3.50	2005.84	601.58	88.32	11.67	3.50	309.12
MISC VB PLUMBING	20.00	12.67	2.00	253.40	40.00	4.00	12.67	2.00	8.00
HQ SPHERES FWD (2)	26.00	1.79	1.90	46.54	49.40	41.70	1.79	1.90	79.23

ALVIN WEIGHT AND STABILITY COMPUTATIONS

(CONTINUED)

AFTERBODY

IDENTIFICATION	W	X	Y	MX	MY	D	XP	YP	MP	MY
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 SPH AFT (2)	26.00	19.50	3.92	507.00	101.92	41.70	19.50	3.92	813.15	153.46
HG FRAME AFT	10.00	19.50	3.92	195.00	39.20	3.78	19.50	3.92	73.71	14.82
HG FWD	245.25	1.79	1.90	439.00	465.97	.00	1.79	1.90	.00	.00
HG AFT	245.25	19.50	3.92	4782.38	961.38	.00	.00	.00	.00	.00
HG PLUMBING	25.00	12.00	2.00	300.00	50.00	5.00	12.00	2.00	60.00	10.00
SKID SHOES	40.06	8.90	.05	356.53	2.00	9.10	8.90	.05	80.99	.45
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 DOGS, FT	33.00	4.50	1.20	148.50	39.60	4.36	4.50	1.20	19.62	5.23
SPHERE RELEASE SWMS	2.50	4.50	.95	1.25	1.25	.95	4.50	.50	4.27	.47
PROP BOX & OIL	849.00	15.50	2.30	13159.50	1952.70	310.00	15.50	2.30	7905.00	1173.00
PROP BOX PIG MOD	12.00	15.50	2.30	186.00	27.60	.00	.00	.00	.00	.00
PROP BOX HINGE ,ETC	12.98	14.75	1.33	191.45	17.26	2.95	14.75	1.33	43.51	3.92
PR BOX HINGE BLOCKS	1.39	14.75	1.12	20.50	1.56	.32	14.75	1.12	4.72	.36
PROP BOX HANGERS	3.60	17.17	3.62	61.81	13.03	.82	17.17	3.62	14.08	2.97
PROP BOX STRUTS	4.88	18.67	3.33	91.11	16.25	1.11	18.67	3.33	20.72	3.70
CONN HALVES LOWER	35.00	4.50	2.00	157.50	70.00	14.22	4.50	2.00	63.99	28.44
LIFT PROP UNITS,BOX	382.00	9.00	7.75	3438.00	2960.50	232.00	9.00	7.75	2088.00	1798.00
LIFT PROP BOX OIL	127.00	9.00	7.75	1143.00	984.25	.00	.00	.00	.00	.00
STERN PROP ASSBL	950.00	22.12	4.65	21014.00	4417.50	458.00	22.12	4.65	10130.96	2129.70
STERN PROP OIL	82.68	22.12	4.65	1828.88	384.46	.00	.00	.00	.00	.00
BATT NO 2	1353.25	10.83	2.80	14655.70	3789.10	746.74	10.83	2.80	8087.19	2090.87
BATT NO 3	1353.25	12.30	2.80	16644.97	3789.10	746.74	12.30	2.80	9184.90	2090.87
AFT BATT	1353.25	13.77	2.80	18634.25	3789.10	746.74	13.77	2.80	10282.61	2090.87
BATT DROPS NO 2 (2)	56.00	10.67	3.03	597.52	169.68	7.15	10.67	3.25	76.29	23.24
BATT DROPS NO 3 (2)	56.00	12.04	3.03	674.24	169.68	7.15	12.04	3.25	86.09	23.24
BATT DROPS AFT (2)	56.00	13.62	3.03	751.52	169.68	7.15	13.62	3.25	99.95	23.24
BATTERY COMPENSATOR	86.92	16.66	1.62	1448.09	140.81	84.71	16.66	1.62	1411.27	137.23
PRESS COMPENS FWD 2	29.18	3.76	1.08	109.72	31.51	23.60	3.76	1.08	88.74	25.91
BATT CHG CABLE TRAY	13.25	12.31	4.62	163.11	61.21	3.01	12.31	4.62	37.05	13.91
BATT CHG CABLES	14.50	12.70	7.67	184.15	111.21	7.25	12.70	7.67	92.07	35.61
SPHERE SUP SYNTAC(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
V/B BOX BRKT	1.50	19.50	5.00	29.25	7.50	.56	19.50	5.00	10.92	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
CTR BUOY PKG BRKT 2	6.14	12.29	5.08	75.46	31.19	1.39	12.29	5.08	17.08	7.06
BUOY PKG HOLDOWN(6)	3.00	17.00	5.00	51.00	15.00	1.13	17.00	5.00	19.21	5.65
HOIST PIN	6.65	14.50	7.44	96.42	49.48	.95	14.50	7.44	13.77	7.07

ALVIN WEIGHT AND STABILITY COMPUTATIONS

(CONTINUED)

AFTERBODY

IDENTIFICATION	W	X	Y	MX	MY	D	XP	YP	MXP	MP
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 (2)	10.00	10.25	4.67	102.50	46.70	3.70	10.25	4.67	37.92	17.29
HANDLING PADS (6)	15.00	9.00	6.50	135.00	97.50	1.98	9.00	6.50	17.82	12.87
MARSH MARINE CABLES	62.50	11.35	4.67	709.37	291.87	31.25	11.35	4.67	354.69	143.94
INSTRUMENT CASE	17.00	6.30	.83	107.10	14.11	3.34	6.30	.83	21.04	2.77
BOTTOM WINDOW CONE	12.50	3.50	1.00	43.75	12.50	6.95	3.50	1.00	24.32	6.95
FWD WT DROP,SBL	10.50	.25	3.00	-2.63	31.50	3.50	.25	3.00	.38	10.50
PORT WT DROP,SBL FWD	10.10	4.50	3.00	45.45	30.30	3.40	4.50	3.00	15.30	10.20
STBD WT DROP,SBL FWD	10.10	4.50	3.00	45.45	30.30	3.40	4.50	3.00	15.30	10.20
PORT WT DROP,SBL AFT	10.10	6.00	3.00	60.60	30.30	3.40	6.00	3.00	27.40	10.20
STBD WT DROP,SBL AFT	10.10	6.00	3.00	60.60	30.30	3.40	6.00	3.00	27.40	10.20
RUBBER GASKETS(3)	10.00	4.50	2.60	45.00	26.00	8.33	4.50	2.60	37.48	21.66
MISC PLUMBING	24.00	12.10	3.67	290.40	88.08	3.14	12.10	3.67	37.99	11.52
ED8 FATIHM XDCR	31.50	2.00	1.65	63.00	51.97	15.50	2.00	1.65	31.00	25.57
UGC XDCR	27.00	2.07	1.94	55.89	52.38	4.00	2.07	1.94	8.28	7.76
BENTHOS ALTIM XDCR	3.50	2.27	1.62	7.94	5.67	1.25	2.27	1.62	2.84	2.02
SYNT FWD SKIDS	22.00	6.50	.25	143.00	5.50	39.00	6.50	.25	253.50	9.75
CONTR CTR BOX	94.71	11.87	3.33	1124.21	315.38	370.00	11.87	3.33	4391.90	1232.10
CONTR CTR COVER	17.29	12.25	3.48	211.80	60.17	9.37	12.25	3.48	114.78	32.61
CONTR CTR INT PANELS	82.00	12.25	3.48	1004.50	285.36	.00	.00	.00	.00	.00
CONTR CTR OIL	260.00	11.87	3.33	3086.20	865.80	.00	.00	.00	.00	.00
CONTR CTR MISC FIT	25.00	12.25	3.48	306.25	87.00	.00	.00	.00	.00	.00
SM BUBY PKGS AFT	103.00	19.28	5.38	1985.84	554.14	183.11	19.28	5.38	3530.36	985.13
SYNT AFT SKIDS	21.93	12.50	.25	274.12	5.48	38.98	12.50	.25	487.25	9.74
AMF XPDR CASE	80.00	11.83	4.12	946.40	329.60	45.00	11.83	4.12	532.35	185.40
AMF XPDR HEAD	8.00	19.12	5.12	152.96	40.96	5.82	19.12	5.12	111.28	29.80
AUX BATT BOX BRKT	23.50	17.87	1.96	419.94	46.06	8.88	17.87	1.96	158.69	17.40
SS INSERTS & BBLTS	4.00	18.03	3.17	72.12	12.68	.50	18.03	3.17	9.01	1.58
BASKET ELECT DISC	15.00	.67	2.00	10.05	30.00	4.87	.67	2.00	3.26	9.74
MIDSHIP BUBY P FWD	25.75	11.11	4.62	286.08	118.96	48.00	11.11	4.62	533.28	221.76
MIDSHIP BUBY S FWD	30.00	11.11	4.62	333.30	138.60	56.45	11.11	4.62	627.16	260.80
MIDSHIP BUBY P AFT	30.00	13.22	4.62	396.60	138.60	56.45	13.22	4.62	746.27	260.80
MIDSHIP BUBY S AFT	29.00	13.19	4.62	382.51	133.98	54.59	13.19	4.62	720.04	252.21
FWD SKIN SUPPRTS	13.25	2.00	1.50	26.50	19.88	8.80	2.00	1.50	17.60	13.20
NEW SYNT AFT 4 CF	144.00	17.50	3.50	2520.00	504.00	256.00	17.50	3.50	4480.00	896.00
NEW SYNT AFT	102.00	15.75	.75	1606.50	76.50	181.33	15.75	.75	2855.95	136.00
NEW SYNT AFT	34.00	18.33	1.75	623.22	59.50	60.44	18.33	1.75	1107.87	125.77
NEW SYNT AFT	22.50	17.75	3.66	399.38	82.35	40.00	17.75	3.66	710.00	146.40
FBGLS ANGLES AFT	25.52	20.41	2.50	520.86	63.80	13.70	20.41	2.50	279.62	34.23

ALVIN WEIGHT AND STABILITY COMPUTATIONS

AFTERBODY (CONTINUED)

IDENTIFICATION	W	X	Y	MX	MY	D	XP	YP	MXP	MP
AFTBDY SIDE H86KS	23.18	8.33	4.62	234.74	130.19	6.40	8.33	4.62	53.31	29.57
ANGLE BRKT FWD WT DR	4.45	.79	2.75	3.52	12.24	1.02	.79	2.75	.81	2.80
SLED RUNNERS	21.12	2.25	.33	47.52	6.97	4.80	2.25	.33	10.80	1.58

AFTERBODY

SUMMARY	NO. ITEMS	SUM W	S	MXW	S	MYW	S	MX	SUM MX	SUM MY	SUM D	S	MXPD	S	MYPD	SUM MXP	SUM MP
123		17838.12		12.58		4.10		224403.76	73188.51	16867.99			12.99		4.66	213038.48	78553.22
BG LONGITUDINAL		.41						BG VERTICAL	.55								

ALVIN WEIGHT AND STABILITY COMPUTATIONS

VARIABLE LOAD(NORMAL)

IDENTIFICATION	W	X	Y	MX	MY	D	XP	YP	MP	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 BOX	10.00	1.00	7.00	10.00	70.00	.00	1.00	7.00	.00	.00
ARM OFFSET BRKTS	13.00	1.00	3.00	13.00	39.00	3.00	1.00	3.00	3.00	9.00
SAMPLE TRAY, T88LS	150.00	-2.50	1.40	-375.00	210.00	45.00	-2.50	1.40	-112.50	53.00
PERSONNEL (3)	500.00	5.86	4.13	2930.00	2065.00	.00	.00	.00	.00	.00
ASCENT WEIGHT	500.00	4.50	2.60	2250.00	1300.00	45.00	4.50	2.60	202.50	117.00
ADDTL PAYLOAD	300.00	-2.50	1.40	-750.00	420.00	.00	.00	.00	.00	.00
ADDTL WT, FWD WT DRAP	200.00	-2.00	2.81	-400.00	562.00	26.17	-2.00	2.81	-52.34	73.54

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
	9	2208.05	1.64	2.78	3623.63	6139.58	292.67	.22	2.53	65.06	740.14

BG LONGITUDINAL -1.42

BG VERTICAL

-.25

ALVIN WEIGHT AND STABILITY COMPUTATIONS

RELEASED FOREBODY

IDENTIFICATION	W	X	Y	MX	MY	D	XP	YP	MXP	MYP
SPHERE ONLY	8331.61	4.37	4.73	36374.96	39405.38	10780.82	4.47	4.74	48239.38	51055.38
OTHER FOREBODY	6212.56	3.79	6.25	23551.68	38823.73	6656.33	3.62	6.21	24071.34	41334.55
PERSONNEL (3)	500.00	5.86	4.13	2930.00	2065.00	.00	.00	.00	.00	.00
MECH ARM CONTR BOX	10.00	1.00	7.00	10.00	70.00	.00	.00	.00	.00	.00

RELEASED FOREBODY

SUMMARY	NO.	ITEMS	SUM W	S	MXW	S	MYW	SUM MX	SUM MY	SJM D	S	MXPD	S	MYPD	SUM MXP	SUM MYP
	4		15054.17		4.13		5.34	62866.64	80364.11	17437.15		4.15		5.30	72311.82	92419.94

BG LONGITUDINAL .03

BG VERTICAL .04

ALVIN WEIGHT AND STABILITY COMPUTATIONS

ENTIRE VEHICLE(NORMAL)

IDENTIFICATION	W	X	Y	MX	MY	D	XP	YP	MP	MP
SPHERE ONLY	8331.61	4.37	4.73	36374.96	39405.38	10780.82	4.47	4.74	48239.98	51055.38
OTHER FOREBODY	6212.56	3.79	6.25	23551.68	38823.73	6656.33	3.62	6.21	24071.84	41354.56
AFTERBODY	17838.12	12.58	4.10	22403.76	73188.51	16867.99	12.99	4.66	219038.48	78553.22
VARIABLE LOAD(NORMAL)	2208.05	1.64	2.78	3623.63	6139.58	292.67	.22	2.53	65.06	740.14

ENTIRE VEHICLE(NORMAL)

SUMMARY	NO. ITEMS	SUM W	S MXW	S MYW	SUM MX	SUM MY	SUM D	S MXP	S MYP	SUM MXP	SUM MYP
4		34590.34	8.32	4.55	287954.03	157557.21	34597.81	8.62	4.96	231415.36	171723.30

BG LONGITUDINAL .10

BG VERTICAL .41

ALVIN WEIGHT AND STABILITY COMPUTATIONS

SURFACE CONDITION

IDENTIFICATION	W	X	Y	MX	MY	D	XP	YP	MXP	MYP
IN NORMAL CONDITION	34590.34	8.32	4.55	287958.03	157557.21	34597.81	8.42	4.96	231415.36	171723.30
DROP ASCENT WT	-500.00	4.50	2.60	-2250.00	-1300.00	-45.00	4.50	2.60	-202.50	-117.00
BLOW M/B FB DY	-1346.00	4.50	6.00	-6057.00	-8076.00	.00	.00	.00	.00	.00
BLOW M/B AFTBDY	-300.00	12.25	6.83	-3675.00	-2049.00	.00	.00	.00	.00	.00
BLOW NEW MB AFTBDY	-1561.00	9.10	6.00	-14205.10	-2366.00	.00	.00	.00	.00	.00

SURFACE CONDITION

SUMMARY	NO. ITEMS	SUM W	S	MXW	S	MYW	S	MXM	SUM MX	SUM MY	SJM D	S	MXPD	S	MYPD	SUM MXP	SUM MYP
5		30883.34		8.48		4.43		261766.93		136766.21	34552.81		8.43		4.97	231212.86	171606.30

BG LONGITUDINAL .005

BG VERTICAL

.54

ALVIN WEIGHT AND STABILITY COMPUTATIONS

EMERGENCY CONDITIONS (1)

IDENTIFICATION	W	X	Y	MX	MY	D	XP	YP	MXP	MYP
IN NORMAL CONDITION	34590.34	8.32	4.55	287954.03	157557.21	34597.81	8.42	4.96	291415.36	171723.30
DRSP NO 2 BATT	-1353.25	10.83	2.80	-14655.70	-3789.10	-746.74	10.83	2.80	-8087.19	-2090.87

EMERGENCY CONDITIONS (1)

SUMMARY	NO. ITEMS	SUM W	S MXW	S MYW	SUM MX	SUM MY	SUM D	S MXP	S MYP	SUM MXP	SUM MYP
	2	33237.09	8.22	4.63	273298.34	153768.11	33851.07	8.37	5.01	283328.17	169632.43

BG LONGITUDINAL .15

BG VERTICAL .38

ALVIN WEIGHT AND STABILITY COMPUTATIONS

EMERGENCY CONDITIONS (2)

IDENTIFICATION	W	X	Y	MX	MY	D	XP	YP	MXP	MYP
IN NORMAL CONDITION	34590.34	8.32	4.55	287954.03	157557.27	34597.81	8.42	4.96	291419.36	171723.30
DRBP NO 2 BATT	-1353.25	10.83	2.80	-14655.70	-3789.10	-746.74	10.83	2.80	-8087.19	-2090.87
DRBP NO 3 BATT	-1353.25	12.30	2.80	-16644.97	-3789.10	-746.74	12.30	2.80	-9184.90	-2090.87

EMERGENCY CONDITIONS (2)

SUMMARY	NO. ITEMS	SUM W	S MXW	S MYW	SUM MX	SUM MY	SJM D	S MXP	S MYP	SUM MXP	SUM MYP
3		31883.84	8.05	4.70	256653.36	149979.01	33104.33	8.28	5.06	274143.27	167541.55
BG LONGITUDINAL		.23			BG VERTICAL	.36					

ALVIN WEIGHT AND STABILITY COMPUTATIONS

EMERGENCY CONDITIONS (3)

IDENTIFICATION	W	X	Y	MX	MY	D	XP	YP	MP	MYP
IN NORMAL CONDITION	34590.34	8.32	4.55	287954.03	157557.21	34597.81	8.42	4.96	231415.36	171723.30
DROP N9 2 BATT	-1353.25	10.83	2.80	-14655.70	-3789.10	-746.74	10.83	2.80	-8087.19	-2090.87
DROP N9 3 BATT	-1353.25	12.30	2.80	-16644.97	-3789.10	-746.74	12.30	2.80	-9184.90	-2090.87
DROP AFT BATT	-1353.25	13.77	2.80	-18634.25	-3789.10	-746.74	13.77	2.80	-10282.61	-2090.87

EMERGENCY CONDITIONS (3)

SUMMARY	NO. ITEMS	SUM W	S MXW	S MYW	SUM MX	SUM MY	SUM D	S MPD	S MYPD	SUM MYP
4		30530.59	7.80	4.79	238019.11	146189.91	32357.59	8.15	5.11	165450.68
BG LONGITUDINAL		.36			BG VERTICAL	.32				

ALVIN WEIGHT AND STABILITY COMPUTATIONS

EMERGENCY CONDITIONS (4)

IDENTIFICATION	W	X	Y	MX	MY	D	XP	YP	MXP	MYP
IN NORMAL CONDITION	34590.34	8.32	4.55	287954.03	157557.21	34597.81	8.42	4.96	291415.36	171723.30
DRBP NO 2 BATT	-1353.25	10.83	2.80	-14655.70	-3789.10	-746.74	10.83	2.80	-8087.19	-2090.87
DRBP NO 3 BATT	-1353.25	12.30	2.80	-16644.97	-3789.10	-746.74	12.30	2.80	-9184.90	-2090.87
DRBP APT BATT	-1353.25	13.77	2.80	-18634.25	-3789.10	-746.74	13.77	2.80	-10282.61	-2090.87
DRBP ARM	-438.55	-0.30	2.70	131.56	-1184.08	-143.00	.00	2.70	.00	-386.10

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
5		30092.04		7.91		4.82	238150.67	145005.83	32214.59		8.19		5.12	263860.66	165094.58
BG LONGITUDINAL		.28					BG VERTICAL	.31							

EMERGENCY CONDITIONS (5)

SUMMARY

STOP 0 BG LONGITUDINAL .24

III. Tethered Trim Dive

The tethered trim dive is conducted for the purpose of determining experimentally the load to submerge, which is the total weight that must be added to the submersible in the normal surface condition to achieve neutral buoyancy. Just prior to the tethered trim dive of May 2, 1975 the following weights were added to the basic unloaded submersible:

Variable load

5 weights @ 240 lb.	1200 lb.
Inclinometer	28
Base board	3
2 persons	333

Ballast

Main ballast, forebody	1346
Main ballast, upper aft	300
Main ballast, new aft	<u>1561</u>
TOTAL	4771 lb.

The submersible was found to be neutrally buoyant after adding these weights. The variable ballast system was not used during the test. Weights only were used to produce neutral buoyancy. In practise a combination of solid ballast and sea water ballast will be used.

The submersible in the normal surface condition is the basic unloaded vehicle plus the following items of variable load:

Mechanical arm	438.55 lb.
Arm release	96.50
Control box	10.00
Arm brackets	13.00
Sample tray	150.00
Personnel	<u>500.00</u>
	1208.05 lb.

The load to submerge is then

$$L_s = 4771 - 1208$$

$$= 3563 \text{ lb.}$$

The total main ballast water is 3207 lb.

The solid ballast or variable ballast required would be

$$3563 - 3207 = 356 \text{ lb.}$$

Calculation of Water Density

Tethered Trim Dive, May 2, 1978

Water Temperature: 47.0 deg. F.

Salinity: 35 parts per thousand

Temperature in deg. C.:

$$C = 5/9 (F-32)$$

$$= 5/9 (47-32)$$

$$= 8.33$$

Using Sigma-T Tables (Ref. 3):

$$\sigma_T = 27.248$$

$$\text{Density} = 1.0272 \text{ grams/cm}^3$$

$$\text{or } 64.12 \text{ lb./ft.}^3$$

IV. Inclining Experiments and Induced Rolling Test

The surface and submerged inclining experiments were conducted at the W.H.O.I. dock on May 2, 1978. Six steel plates, each weighing about 31 pounds in air, were used as inclining weights. A pendulum-type inclinometer was set up in an athwartships direction inside the personnel sphere. The weights were placed on ALVIN's sponson 3.5 feet out from the longitudinal centerline plane, and moved, one weight at a time, to the corresponding point on the opposite sponson. Inclining moments were calculated and inclinometer readings were taken each time a weight was moved. Tests were done for the submarine in both the surface and submerged conditions. For the submerged test the vehicle was made nearly neutrally buoyant and was kept about six feet below the surface by line handlers. Inclining weights were moved by swimmers. To ensure accuracy the handling lines were slacked just before each inclinometer reading was taken.

The approximate surface and submerged displacement values at the time of these tests have been calculated using the computed value of displacement of the normal submerged vehicle as a reference. These calculations are not exact since additional assembly work continued on ALVIN after the completion of the tests. The error involved is

considered to be small and not enough to adversely affect test results. Test data and the plot of tangents for each inclining experiment are included in this section.

The induced rolling (sallying) test of the submersible was accomplished by generating a series of forced oscillations about the boat's longitudinal axis. A line was attached to the sail and several men alternately pulled and released the line causing the vehicle to roll at its natural frequency. The roll period was determined as the average of four successive cycles of roll. The results of this test also are presented.

Computation of Total Displacement for
Surface and Submerged Inclining Experiments

1. Normal submerged condition 34,590 lb.

2. For the surface inclining experiment subtract
the following:

One person	167	
Sample tray	150	
Ascent weight	500	
Add'l payload	300	
Add'l weight	200	
Mech. arm	558	
VB water	300	
MB water fwd	1346	
MB water mid	300	
MB water new	<u>1561</u>	
Total	5382	<u>5,382</u>
		29,208

and add the following:

Weight droppers,		
wts.	1200	
Inclinometer	28	
Base board	3	
Inclining wts.	<u>183</u>	
Total	1414	<u>1,414</u>
Surface Condition, May 2, 1978		30,622 lb.

3. For the submerged inclining experiment,
add the following to the above surface
condition:

MB water fwd	1346	
MB water mid	300	
MB water new	<u>1561</u>	
Total	3207	<u>3,207</u>
Submerged condition, May 2, 1978		33,829 lb.

Surface Inclining Experiment

Data Form

1. Data Recorded: Variable load, inclining weights, moment arms, drafts, inclinometer angles, water temperature and density, roll periods.
2. When Recorded: Variable load - prior to launch (in weight log)

Inclining weights - when placed on sponsons and when moved.

Moment arms - when weights are placed.

Drafts - after adjusting to 0° trim

Inclinometer angles - as weights are added or changed.

Roll period - while sallying ship

Water temperature and density - at end of experiment.
3. By Whom Recorded: Trials engineer or recorder
4. Data:
 - a. Draft (after adjusting to 0° trim)
Port 6'11" Stbd 6'10" Time 1700
 - b. Moment arms (ft. - in. by steel tape)
To C.G. of weights port sponson 3'6"
To C.G. of weights stbd sponson 3'6"

c. Weights and angles

<u>Movement</u>	<u>Wt.-lbs. net</u>	<u>Moment-ft.-lbs.</u>	<u>Tan θ</u>
All Wt P	<u>-183.6</u>	<u>-642.6</u>	<u>.065</u>
1 Wt P-S	<u>-122.4</u>	<u>-428.4</u>	<u>.055</u>
1 Wt P-S	<u>-61.2</u>	<u>-214.2</u>	<u>.045</u>
1 Wt P-S	<u>0</u>	<u>0</u>	<u>.035</u>
1 Wt P-S	<u>+61.2</u>	<u>214.2</u>	<u>.028</u>
1 Wt P-S	<u>+122.4</u>	<u>428.4</u>	<u>.022</u>
1 Wt P-S	<u>+183.6</u>	<u>642.6</u>	<u>.012</u>

d. Roll period

	<u>Period-Sec. (T)</u>
1st roll	<u> </u>
2nd roll	<u> </u>
3rd roll	<u> </u>
4th roll	<u> </u>
Total	<u>17</u>
Average T	<u>4.25 T² 18.06</u>

e. Water temperature 47 °F

f. Hg distribution

Height of Hg in fwd tanks in. ;
lbs. of Hg

Height of Hg in aft tanks in. ;
lbs. of Hg

5. Remarks:

6. Date May 2, 1978 Location WHOI Dock

Recorder

Arnold G. Sharp
Trial Engineer

ALVIN SURFACE INCLINING EXPERIMENT

MAY 2, 1978

Figure 4. Plot of Tangents for Surface Inclining Experiment

Submerged Inclining Experiment
Data Form

1. Data recorded on this form are specifically for the submerged portion of the inclining trials; the previous form contains all other data.

a. Weights and angles

<u>Movement</u>	<u>Weight</u> <u>Lbs. Net</u>	<u>Moment</u> <u>Ft. Lbs.</u>	<u>Tan θ</u>
All Wt. S	+159.5	+558.2	.027
1 Wt S-P	+106.4	+372.4	.033
1 Wt S-P	+ 53.2	+186.2	.047
1 Wt S-P	0	0	.061
1 Wt S-P	- 53.2	-186.2	.073
1 Wt S-P	-106.4	-372.4	.085
1 Wt S-P	-159.5	-558.2	.070 ?

b. Roll period

	<u>Period-Sec. (T)</u>	
1st roll	_____	
2nd roll	_____	
3rd roll	_____	
4th roll	_____	
Total	_____	
Average T	_____	T ² _____

2. Remarks:

3. Date May 2, 1978

Location W.H.O.I. Dock

Recorder

Arnold G. Sharp

Arnold G. Sharp
Trials Engineer

ALVIN SUBMERGED INCLINING EXPERIMENT

MAY 2, 1978

Figure 5. Plot of Tangents for Submerged Inclining Experiment

Induced Rolling (Sallying)
Surface Condition

Time for four (4) cycles of roll 17 Sec.

Roll period $T = 4.25$ Sec.

$$T^2 = 18.06$$

Using the equation

$$GM = \frac{1.23 K^2}{T^2}$$

and rearranging

$$\begin{aligned} K^2 &= \frac{(GM) T^2}{1.23} \\ &= \frac{0.85 (18.06)}{1.23} \\ &= 12.48 \end{aligned}$$

$$\begin{aligned} \text{The radius of gyration } K &= \sqrt{12.48} \\ &= 3.53 \text{ ft.} \end{aligned}$$

V. Discussion of Results

The principal results obtained from the weight and stability computations, and from the various dockside tests, are shown below in Table 1. The total submerged displacement, 34,590 pounds, is about 2200 pounds greater than the corresponding value in 1976, the date of the last weight report. Of this amount about 1650 pounds is contributed by the newly installed main ballast tank and its water, so that the dry weight of the present submersible is about 600 pounds greater than that of ALVIN in 1976. This difference can be accounted for by the new frame, stern propulsion assembly, control center box and miscellaneous small parts, all rebuilt of titanium and heavier than their aluminum counterparts.

The computed value of BG vertical has increased from 0.38 ft., the 1976 value, to 0.41 ft., or about eight percent. The value obtained in the submerged inclining experiment was 0.45 ft., which represents a 25 percent increase over the corresponding 1975 value.

The GM distance, determined in the surface inclining experiment, shows the greatest increase over previous values. The newest value, 0.85 ft., is 44 percent greater than the

Table 1

	Normal Submerged Condition	Normal Surface Condition
BG longitudinal, ft. (computed)	0.10	
BG vertical, ft. (computed)	0.41	
BG vertical, ft. (inclining)	0.45	
GM vertical, ft. (inclining)		0.85
Radius of gyration K, ft.		3.53
Load to submerge, lb. (trim dive)		3563
Total displacement lb. (computed)	34,590	30,883

value obtained in 1975. The new main ballast tank, with a capacity of over 1500 pounds of sea water, can be credited for this marked increase in surface stability. Also related to this new tank is a six inch increase in freeboard of the surfaced vehicle.

The results of the surface induced rolling test led to the calculation of the transverse radius of gyration of the submersible, a value of 3.53 ft. Assuming only minor changes to the submarine, the induced rolling test could be used for future approximate determinations of GM without the need for the more elaborate inclining experiment.

VI. References

1. DSRV ALVIN Weight Report, 1976, by Arnold G. Sharp, W.H.O.I. Technical Memorandum No. 4-76, December 1976.
2. DSRV ALVIN Weight Report, 1975 by Arnold G. Sharp, W.H.O.I. Technical Memorandum No. 5-75, October 1975.
3. Processing Oceanographic Data, by E. C. LaFond, U.S. Navy Hydrographic Office Publication No. 614, Washington, D.C., 1951.

VII. Appendix - Computer Program

 ALVIN WEIGHT AND STABILITY PROGRAM
 JUNE 1971
 PROGRAMMER: ANDREW H. ELIASON
 MODIFIED BY W FREUND
 AUGUST 1975
 TO ELIMINATE THE NEED FOR MULTIPLE RUNS.
 PROGRAM CHANGED SO THAT OUTPUT VALUES FROM SOME SECTIONS ARE
 STORED INTERNALLY FOR USE AS INPUT TO LATER SECTIONS.

 USE X OPTION FOR CALCULATION WITH PLOT

NOTE: THE PROGRAM EXPECTS INPUT AS FOLLOWS:
 1 SET OF ALVIN PICTURE DATA FOLLOWED BY AN EOD CARD (OR EOD ALONE)
 5 SETS OF DATA EACH PRECEDED BY A SECTION ID CARD AND
 FOLLOWED BY AN EOD CARD.

1 SECTION ID CARD (ENTIRE VEHICLE=NORMAL) FOLLOWED BY AN EOD CARD.
 1 TO N SETS OF EMERGENCY CONDITION DATA EACH PRECEDED BY A
 SECTION ID CARD AND FOLLOWED BY AN EOD CARD.
 THE PROGRAM MAY BE HALTED AFTER ANY SECTION BY PUNCHING A 3 IN
 COLUMN 64 OF THE LAST DATA CARD OF THE LAST SECTION WANTED.
 EXCEPT THAT - SINCE THERE IS NO CARD DATA FOR THE
 ENTIRE VEHICLE=NORMAL SECTION, THE 3 SHOULD BE PUNCHED IN
 COLUMN 64 OF THE SECTION ID CARD IF THE ENTIRE VEHICLE SECTION
 IS THE LAST ONE WANTED.
 THE PLOT OPTION (2 IN COL. 64) FOLLOWS THE SAME RULE.

PROGRAM PERFORMS WEIGHT AND STABILITY CALCULATIONS FOR
 ALVIN AND ITS PARTS.
 OUTPUT IS IN SECTIONS. DATA IS READ IN FOR ONE SECTION.
 CALCULATIONS ARE MADE AND RESULTS PRINTED. THEN THE NEXT SECTION
 DATA IS READ, ETC.

EACH SECTION PRODUCES DETAIL AND SUMMARY RESULTS.
 FOR EACH SECTION OF THE OUTPUT THE OUTPUT PAGE NUMBER IS SET = 1
 AND THE SECTION ID IS READ IN FROM A CARD.
 SECTIONS ARE INDEPENDENT OF ONE ANOTHER EXCEPT THAT
 OUTPUT FROM SOME IS INPUT TO OTHERS.

THE FIRST 4 SECTIONS ARE TITLED:

1. SPHERE ONLY
2. OTHER FOREBODY
3. AFTERBODY
4. VARIABLE LOAD

SIX OF THE SUMMARY VALUES FROM EACH OF THE FIRST FOUR SECTIONS
 ARE STORED IN ARRAY STORE(6,4) FOR USE BY LATER SECTIONS.

SECTION 5 IS TITLED RELEASED FOREBODY. INPUT TO THIS SECTION
 IS SUMMARY VALUES FROM SPHERE ONLY AND FOREBODY PLUS
 NEW INPUT READ JUST BEFORE PROCESSING THIS SECTION.
 OUTPUT FROM THIS SECTION IS NOT SAVED.

SECTION 6 IS TITLED ENTIRE VEHICLE(NORMAL). INPUT TO THIS SECTION
 IS THE SUMMARY VALUES OF THE FIRST 4 SECTIONS. NO ADDITIONAL
 DATA IS READ IN FOR THIS SECTION.
 OUTPUT FROM THIS SECTION IS SAVED FOR INPUT TO THE FOLLOWING
 SECTIONS.

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60. C THE SECTIONS FOLLOWING ARE TITLED EMERGENCY CONDITIONS.
61. C THERE IS NO LIMIT TO THE NUMBER OF THESE SECTIONS.
62. C FOR EACH SECTION INPUT CONSISTS OF THE SUMMARY VALUES FROM
63. C SECTION 6 (ENTIRE VEHICLE) PLUS NEW INPUT RECORDS READ
64. C JUST BEFORE PROCESSING EACH SECTION.
65. C
66. C *****
67. C
68. C IMPLICIT DOUBLE PRECISION (A-H,O-Z)
69. C REAL X2,Y2
70. C
71. C
72. C X      IBUF(1000)
73. C      CMM6N  ARRAY1(500)
74. C      CMM6N  ARRAY2(500)
75. C      CMM6N  ARRAY3(500)
76. C      CMM6N  ARRAY4(500)
77. C      SCALE= 500.0
78. C
79. C      CMM6N  IDEN(300,5),ID(7)
80. C      DIMENSION X(300),Y(300),W(300),D(300),XP(300),YP(300),C(300)
81. C
82. C      CALL PLOTS(IBUF,,1000)
83. C *****
84. C      READ ALVIN PICTURE DATA *****
85. C *****
86. C *****
87. C
88. C      M1=1
89. C      15 M1=N+3
90. C      READ(105,105,END=55)(ARRAY1(I),ARRAY2(I),I=M,M1)
91. C      105 FORMAT (4(5X,16,2X,16,1X))
92. C      M1=M+4
93. C      GO TO 15
94. C      55 CONTINUE
95. C      M1=M+4
96. C *****
97. C
98. C      INTEGER NEED, START, SMRY
99. C      INTEGER JSECT, J, L, N
100. C      INTEGER NUMBER
101. C *****
102. C      OUTPUT SECTIONS 1 = 4
103. C      SPHERE ONLY = OTHER FOREBODY = AFTERBODY = VARIABLE LOAD
104. C      ALL DATA FOR THESE SECTIONS IS READ IN SO WE START READING
105. C      INTO FIRST ELEMENTS OF INPUT ARRAYS.
106. C      SUMMARY VALUES ARE SAVED FOR USE BY LATER SECTIONS.
107. C      THE SECTION ID'S ARE SAVED. THEY ARE USED FOR DETAIL LINE ID'S
108. C      BY LATER SECTIONS.
109. C *****
110. C
111. C      REPEAT 5, FOR JSECT = (1,4)
112. C      IPAGE = 1
113. C      READ(105,900) ID
114. C      CALL RDATA(1)
115. C      CALL CALCPRI
116. C      CALL SAVE(JSECT)
117. C      CALL PICTURE
118. C      IF(C(N).EQ.3) STOP
119. C

```

```

*****  

C  

C *****  

C OUTPUT SECTION 5 = RELEASED FOREBODY.  

C WE GET FIRST 2 RECORDS FROM CORE THEN START READING INTO  

C ELEMENT 3 OF INPUT ARRAYS.  

C *****  

C  

C IPAGE = 1  

C READ(105,900) ID  

C CALL COREID(2)  

C CALL CORDATA(2)  

C CALL RDATA(3)  

C CALL CALCPRI  

C IF(C(N).EQ.3) STOP  

X  

C *****  

C OUTPUT SECTION 6 = ENTIRE VEHICLE NORMAL.  

C ALL 4 RECORDS FOR THIS SECTION COME FROM CORE.  

C SINCE NO DATA IS READ HERE WE GET PICTURE/STOP CODE FROM ID CARD.  

C SAVE SUMMARY DATA FROM THIS SECTION.  

C *****  

C  

C IPAGE = 1  

C N = 4  

C READ(105,901) ID,C(N)  

C CONTINUE  

C CALL COREID(4)  

C CALL CORDATA(4)  

C N = 4  

C CALL CALCPRI  

C CALL SAVE(I)  

C CALL PICTURE  

C IF(C(N).EQ.3) STOP  

X  

C *****  

C OUTPUT SECTIONS 7 TO N = EMERGENCY CONDITIONS.  

C THERE IS NO LIMIT TO THE NUMBER OF THESE SECTIONS.  

C END RUN WITH 3 IN COL. 64.  

C WE GET FIRST INPUT RECORD FROM CORE. THEN WE READ.  

C START READING INTO ELEMENT 2 OF INPUT ARRAYS.  

C *****  

C  

C ID OF FIRST DETAIL LINE IS THE SAME FOR ALL OF THESE.  

C INTEGER EMLINE(5)/IN NORMAL CONDITION '/',  

C REPEAT 7, FOR J = (1,5)  

C   IDENT(J,J) = EMLINE(J)  

C CONTINUE  

7  

C  

C INTEGER GO/O/  

C RPPEAT 10, WHILE GO.EQ.O  

C   IPAGE = 1  

C   READ(105,900) ID  

C   CALL CORDATA(1)  

C   CALL RDATA(2)  

C   CALL CALCPRI  

C   CALL PICTURE  

X  


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180. IF(C(N).EQ.3) STOP
    C CONTINUE
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      10 CONTINUE
      900 FORMAT(7A4)
      901 FORMAT(7A4, T64, I1)
      SUBROUTINE RDATA(START)
      REPEAT 5, FOR N = (START, 300)
        READ(105,100,END=7)
        X(IDEN(N),J), J=1,5)
        X W(N), X(N), Y(N), D(N), XP(N), YP(N), C(N)
        CONTINUE
      5 CONTINUE
      7 CONTINUE
      N = N + 1
      RETURN
      100 FORMAT(5A4,1X,F8.2,2(1X,F5.2),1X,F8.2,2(1X,F5.2),1X,I1)
      SUBROUTINE SAVE(SMRY)
      DOUBLE PRECISION STORE(6,4)
      INTEGER IDSTORE(4,5)
      REPEAT 5, FOR L = (1,5)
        IDSTORE(SMRY,L) = ID(L)
        CONTINUE
      5 CONTINUE
      STORE(1,SMRY) = SW
      STORE(2,SMRY) = SRXW
      STORE(3,SMRY) = SRYW
      STORE(4,SMRY) = SD
      STORE(5,SMRY) = SRXPD
      STORE(6,SMRY) = SRYPD
      RETURN
      SUBROUTINE COREID(NUMBER)
      REPEAT 5, FOR N = (1,NUMBER)
        REPEAT 3, FOR L = (1,5)
          IDEN(N,L) = IDSTORE(N,L)
          CONTINUE
        3 CONTINUE
        5 CONTINUE
        RETURN
      SUBROUTINE COREDATA(NEEDED)
      REPEAT 5, FOR N = (1, NEEDED)

```

```

240. W(N) = STORE(1,N)
241. X(N) = STORE(2,N)
242. Y(N) = STORE(3,N)
243. D(N) = STORE(4,N)
244. XP(N) = STORE(5,N)
245. YP(N) = STORE(6,N)
246.
247. C
248. 5 CONTINUE
249. RETURN
250. C
251. *****
252. SUBROUTINE CALCPRI
253. *****
254. WRITE(108,200)IPAGE,WRITE(108,250)ID,WRITE(108,300)
255.
256. ITEM = 1
257. SW=0.0;SRXW=0.0;SRYW=0.0;SRX=0.0;SRY=0.0;SD=0.0;SRXPD=0.0;SRYPD=0.0
258. SRXP=0.0;SRYP=0.0
259. C
260. CALCULATE RESULTS
261. DO 30 I=1,N
262. RX=W(I)*X(I);RY=W(I)*Y(I)
263. RXP=ID(I)*XP(I);RYP=D(I)*YP(I)
264. SW=W(I)+SW;SD=D(I)+SD
265. SRX=SRX+RX;SRY=SRY+RY;SRXP=SRXP+RXP;SRYP=SRYP+RYP
266. SRXW=SRX/SW;SRYW=SRY/SW
267. SRXPD= SRXP/SD;SRYPD=SRYP/SD
268. BGL=SRXPD-SRXW;BGV=SRYPD-SRYW
269.
270. WRITE(108,400)((IDEN(I,J),J=1,5),W(I),X(I),Y(I),RX,RY,D(I),XP(I),
271. 1 YP(I),RXP,RYP
272. C
273. IF(ITEM.EQ.40.8R,ITEM.EQ.80.8R,ITEM.EQ.120)IPAGE=IPAGE+1
274. 1 WRITE(108,200)IPAGE,WRITE(108,260)ID,WRITE(108,300)
275. C
276. ITEM=ITEM+1
277. 30 CONTINUE
278. C
279. PRINT RESULTS
280. WRITE(108,950)ID
281. WRITE(108,500)
282. 1SRYP,WRITE(108,700)BGL,BGV,
283. C
284. RETURN
285. C
286. 200 FORMAT(1H1,
287. X 46X, 'ALVIN WEIGHT AND STABILITY COMPUTATIONS',
288. X 35X, 'PAGE ', I1/)
289. C
290. 250 FORMAT(46X,7A4/)
291. C
292. 260 FORMAT (46X,7A4, ' (CONTINUED)',/)
293. C
294. 300 FORMAT(3X, 'IDENTIFICATION',11X, 'W',9X, 'X',8X, 'Y',9X, '4X',10X, 'MY',
295. 11X, 'D',9X, 'XP',7X, 'YP',8X, 'MXP',9X, 'MYP',/)
296. C
297. 400 FORMAT(1X,5A4,4X,F8.2,2(4X,F5.2),3(3X,F9.2),2(4X,F5.2),2(3X,F9.2))
298. C
299. 500 FORMAT(// ' SUMMARY N0. ITEMS',6X, 'SUM W',4X, 'S MXW',4X, 'S MYW',

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300. 16X,'SUM MX',6X,'SUM MY',7X,'SUM D',5X,'S MYPD',3X,'S MYPD',4X,'SUM
301. 1 MXP',5X,'SUM MYP')
302.
303.
304. 600 FORMAT(14X,13.8X,F8.2,2(4X,F5.2),3(3X,F9.2),2(4X,F5.2),2(3X,F9.2))
305. 700 FORMAT(/,10X,'BG LONGITUDINAL',5X,F5.2,20X,'BG VERTICAL',5X,F5.2)
306.
307. 800 FORMAT('1')
308.
309. 950 FORMAT(/,1X,7A4)
310.
311. C*****
312. X SUBROUTINE PICTURE *****
313. C*****
314. C CALCULATE PICTURE ROTATION DATA *****
315. X IF(C(N).LT.2) GO TO 80 *****
316. X THETA =DATAN2(SRXPD-SRXW,SRYPD-SRYW) *****
317. X DO 25 I=1,M *****
318. X IF(ARRAY2(I).GT.3000) ARRAY4(I)= 10500; GO TO 25 *****
319. X X1= ARRAY1(I) *****
320. X Y1= ARRAY2(I) *****
321. X GAMMA=DATAN2(Y1,X1) *****
322. X R =DSQRT(X1**2+Y1**2) *****
323. X A = GAMMA + THETA *****
324. X X1= R*DCOS(A) *****
325. X Y1= R*DSIN(A) *****
326. X ARRAY3(I)=X1 *****
327. X ARRAY4(I)=Y1 *****
328. X 25 CONTINUE *****
329. C*****
330. C PLOT ALVIN PICTURE *****
331. X CALL PLOT(10.0,10.0,=3) *****
332. X CALL AXDRAW(=6.0,0.0,'X',1,16.0,0.0,=6.0,1.0,1.0,=1) *****
333. X CALL AXDRAW(0.0,=4.0,'Y',=1,10.0,90.0,=4.0,1.0,1.0,=1) *****
334. X CALL SYMBOL (=7.,=9.,=21,10.0,=28) *****
335. X DO 75 I=1,M *****
336. X IPEN=2 *****
337. X IF(1.EQ.1.0R,IFLAG.EQ.1) IPEN=3;GO TO 65 *****
338. X IF(ARRAY4(I).GT.10000)IFLAG=1;GO TO 75 *****
339. X 65 X2= ARRAY3(I)/SCALE *****
340. X Y2= ARRAY4(I)/SCALE *****
341. X CALL PLOT(X2,Y2,IPEN) *****
342. X IFLAG=0 *****
343. X 75 CONTINUE *****
344. X CALL PLOT (0.0,0.0,999) *****
345. X 80 CONTINUE *****
346. X RETURN *****
347. C *****
348. END *****

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