Bendix Aerospace Systems Division

LSG BOYD BOLT RELEASE TEST REPORT

This ATM documents the System Safety Analysis performed on the LSG Boyd Bolt Interface.

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1.0 INTRODUCTION AND SUMMARY

1.1 Purpose

The purpose of this ATM is to perform a "worst case" analysis of LSG/Boyd Bolt interface using the data recorded at the tests performed at Arthur D. Little Incorporated on 15 July through 21 July 1971 to determine the inherent safety of the design.

1.2 Background and Summary

In ATM 1017, Gross Hazard Analysis - LSG, published 11 June 1971, the LSG Subpack No. 1 interface was identified as having a potentially catastrophic safety hazard. It was theorized that release of boyd bolts or boyd bolt failure on the LSG Experiment could cause possible damage to equipment or personnel since release of the bolts also releases the energy stored in the sunshield. The sunshield on the LSG has a tensile preload of 1200 to 2000 lbs. divided equally among the four bolts. See Figure 1.

This analysis was performed in accordance with ATM-935, "System Safety Program Plan for ALSEP Flight Array E". The results of this analysis and the test show that the normal release of the boyd bolt does not present a safety hazard.

However, under a highly unlikely situation of a boyd bolt failure and using "worst case" assumptions, it can be assumed that a failed bolt can strike an astronaut EMU. The effect of a failed bolt upon the integrity of an EMU cannot be determined sufficiently at this time to classify the hazard as Safety Negligible.

2.0 GENERAL DESCRIPTION OF TESTS

Two sets of tests were performed at A. D. Little, Incorporated. Both sets of tests were made using the LSG structural model.

The first tests were performed to determine the deflections within the LSG Experiment under various preloads, to ascertain whether permanent distortion occurs within the instrument and to determine the axial loads on the bolts after release of each bolt for the three possible release sequences. A vernier height gauge was used to determine deflections and load cells were used in measuring the tension in the bolts. The preloading was accomplished using 1/4 - 20 stainless steel bolts.

The second set of tests were performed to determine the axial load imparted to the Universal Handling Tool (UHT) and the torque required on the UHT to release the bolt. Serialized boyd bolts were used for the release. Data obtained from the first set of tests was utilized in setting the preload on the LSG Experiment for the second series of tests. After the preload was set, releases were performed using a UHT simulator. In the final test at 2000 lbs. the bolts were removed using a crew training model UHT.

Releases were recorded with two cameras. Camera No. 1 used a normal lens and recorded pictures at 64 fps. The viewing angle permitted recording a view of the total experiment during releases. Camera No. 2 used a telephoto lens and focused on the vibration fixture, boss, boyd bolt guide cup, and UHT simulator head. Film speed was 45 to 50 fps.

A third camera was used during significant releases when the LSG was preloaded to the 2044 lb. and 2000 lb. level. This camera recorded the same view as camera one. The frame rate was approximately 500 frames per second. The camera recorded timing marks every .01 second for exact timing calculations. This camera was used to record the total time it took for the sunshade to rise.

In addition to the film the comments of the crew engineering representative who performed the releases was also recorded.

Releases were performed at the following LSG preloads:

1) 110 lbs.
2) 286 lbs.
3) 385 lbs.
4) 638 lbs.
5) 946 lbs.
6) 1364 lbs.
7) 1600 lbs.
8) 2044 lbs.
9) 2000 lbs.

A more detailed description of the tests and the recorded data is given in Appendix A, "Boyd Bolt Tests", Arthur D. Little, Incorporated.

3.0 ANALYSIS

The energy which is capable of propelling boyd bolts is stored in the LSG by means of deflection of the LSG Experiment. The deflection is divided among the following assemblies.

a. Axial deflection within the instrument (insulating cones and bending of the instrument housing cover)
b. Bending of top shade beam
c. Bending of shade hinges
d. Elongation of upper shade
e. Bending of "T-beam" at lower end of upper shade

After release of the four bolts holding down the instrument, all components of the preloading system return to their normal unloaded position. No permanent deformation of parts occurs. This is shown by the no load boss to fixture clearance with the boyd bolts finger tight. The clearance varied from .093 inch to .096 inch and averaged .095 inch over the period of the testing. This variation is insignificant with regard to the total deflections of the LSG. Since deformation did not occur the LSG deflection can be regarded as pure spring deflection, that is, the energy stored is identical to that stored in a spring.

There are three methods that can be postulated in which the energy stored in the LSG Experiment may be hazardous to personnel or equipment. They are as follows:

1. During release of the boyd bolt on the LSG enough energy is imparted to the astronaut to throw him off balance.
2. Since the UHT does not have the capability of removing boyd bolts and the sunshade is a relatively stiff mechanism, after the first bolt is released, release of the second bolt on the same side of the sunshade may allow the sunshade to rise further and propel the bolt that is not being restrained by the UHT and astronaut force. See figure 2.
3. Failure of the bolt while the LSG is preloaded may cause the LSG to propel the bolt with sufficient energy to damage equipment or injure personnel.

3.1 Analysis of Problem No. 1 - Normal Boyd Bolt Release

The LSG Experiment can be regarded as a spring restrained by four bolts. The total energy stored in the spring is defined by the following equation.

$$E_p = 1/2\ KX^2$$

where K is the force constant of the spring and X is the distance that the spring is displaced.

K can be calculated using the following relationship:

$$F = KX$$

F is the spring force and X is the distance the spring is displaced.

At 2000 lbs., as shown in the last release test, the total displacement averaged .081 inch.

$$F = KX$$
$$2000\ \text{lbs.} = (K)(.081\ \text{in})$$
$$24,700\ \text{lbs/in} = K$$

The total energy stored in the LSG deflection under a 2000 lb. preload is:

$$E = 1/2\ KX^2$$
$$E = 1/2\ (24,700\ ^{\text{lbs}}/\text{in})\ (.081\ \text{in})^2$$
$$E = 81.0\ \text{in. lbs.}$$
$$E = 6.75\ \text{ft-lbs.}$$

This is a worst-case calculation since the preload is at the maximum specification limit.

The energy is not released with the release of a single bolt, and depending on the sequence the amount of energy released varies. There are basically three possible release sequences in which the amount of energy varies.

The release sequences are:

1. Bolt 1, 3, 2 and 4
2. Bolt 1, 2, 3 and 4
3. Bolt 1, 4, 2 and 3

See Figure 3.

Using the data from the load versus shade deflection tests performed on 15 July and 16 July, the total energy released can be calculated by determining the total energy remaining in the sunshield. The energy released with the release of each bolt is given below as a percentage of the total energy stored in the LSG.

Release Seq. No. 1	Release Seq. No. 2	Release Seq. No. 3
Bolt No. 1 - 45%	Bolt No. 1 - 45%	Bolt No. 1 - 45%
Bolt No. 3 - 36%	Bolt No. 2 - 53%	Bolt No. 4 - 41%
Bolt No. 2 - 17%	Bolt No. 3 - 2%	Bolt No. 2 - 14%
Bolt No. 4 2%	Bolt No. 4 - 0%	Bolt No. 3 - 0%

From this it can be seen that the maximum stored energy that can be released from the release of a boyd bolt is 53% of 6.75 ft-lbs. or 3.58 ft-lbs.

3.2 Analysis of Problem No. 2 - Throwing of a Previously Released Boyd Bolt

In the release tests performed at Arthur D. Little Corporation, the released boyd bolts were not removed from the sunshade in order that this possibility could be investigated. The cameras were arranged so that the rear bolt could be viewed if it were thrown into the air. In the last release test, using release Seq. No. 2 at a 2000 lb initial preload, upon release of bolt No. 2, Bolt No. 1 was thrown approximately 1/2 inch into the air. In lunar gravity this would be approximately 3 inches and using a 100% safety margin about 6 inches.

3.3 Analysis of Problem No. 3 - Boyd Bolt Failure

From the analysis performed for boyd bolt release it can be seen that failure of a bolt will release forty-five percent of the energy stored in deflection of the LSG. The total energy stored can be as much as 6.75 ft. lbs. This means that 3.04 ft-lbs. of energy are released upon failure of a bolt. The weight of a 2363296-214 boyd bolt with nut, spring, and guide cup attached is less than .01 lb. on the Lunar Surface. If all the stored energy is released into the boyd bolt, it can be thrown several hundred feet.

4.0 CONCLUSIONS

4.1 Normal Boyd Bolt Release

During normal boyd bolt release, no more than 3.6 ft.-lbs. of potential energy are released from the LSG Experiment. It is within the capability of an astronaut to absorb this much energy while deploying the LSG Experiment. The Interface Control Specification for Astronaut/ALSEP E, IC 314134, states that the astronaut can provide steady state forces as high as 20 lbs. and dynamic forces as high as 60 lbs. A 20 lb. force would permit the boyd bolt to rise .18 ft. This is not sufficient to constitute an astronaut hazard.

4.2 Throwing of a Previously Released Boyd Bolt

From the high speed film taken of LSG boyd bolt releases it has been determined using a 100% safety margin that a previously released boyd bolt cannot be thrown more than 6 inches on the lunar surface. This does not present a safety hazard.

4.3 Boyd Bolt Failure

Theoretically, on the lunar surface, if all the potential energy released upon failure of a bolt is transferred into the bolt, then it can be thrown several hundred feet. This distance may be calculated using the following equation.

$$E = Wd$$

E = energy in ft-lbs
W = weight in lbs
d = distance in feet

$$3.04 = (.01)(d)$$
$$304 \text{ ft} = d$$

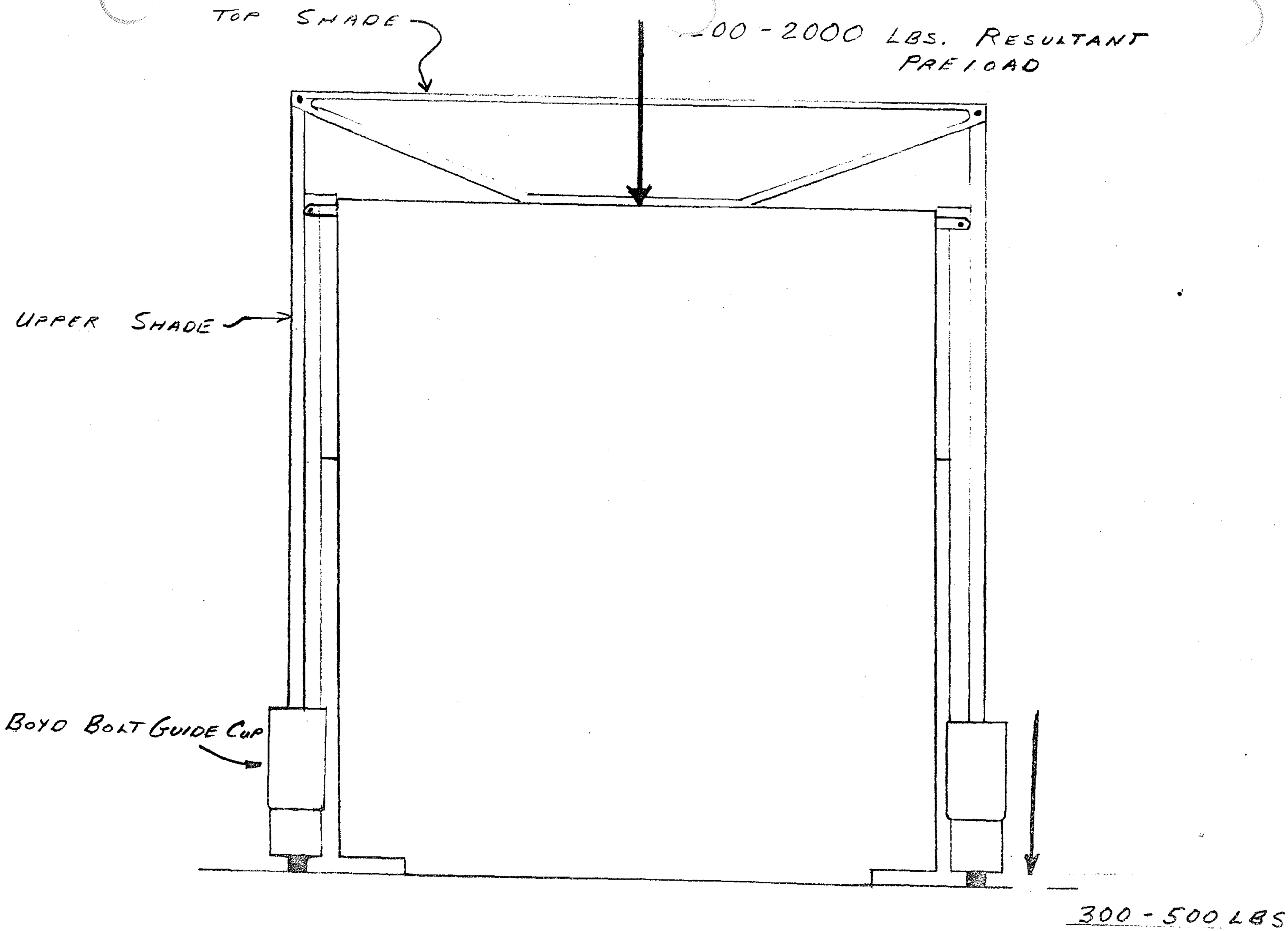
However, all the potential energy stored in the LSG cannot be released into the bolt upon failure. A fast release does not translate all potential energy into kinetic energy and much of the energy would be consumed in twisting of the sunshade and shearing of the bolt, but these values cannot readily be determined analytically. It can, though, be reasonably assumed that the bolt can fly at least several feet upward upon failure.

The failed bolt may strike an astronaut EMU. It is by this means that it may create a potential hazard. Although the impact would be at a low energy level, it is not known whether the EMU has the capability of withstanding the impact that would result from failure of a bolt.

It may be noted that failure of boyd bolts used in the LSG installation is a highly improbable situation. Nominal preload is 400 lbs. per bolt. Maximum preload is 500 lbs. per bolt. Tests conducted in 1968 and documented in ATM 807 indicate that normal installation (torquing the ESNA nut to 44 in-lbs) produces axial loads of 500 lbs. Destructive testing of bolts, also documented in the same ATM shows that boyd bolts fail with axial loads of greater than 1000 lbs. This presents a 2.0 safety factor at maximum preload. It should also be noted that boyd bolts have never failed in this manner when properly installed and it must be remembered that in order for the boyd bolt to possibly present an astronaut hazard, it must fail in the specific interval of time that the astronaut would be in the proximity of Subpackage No. 1.

In summary the effect of a failed bolt upon the integrity of an EMU cannot be determined sufficiently to permit classifying the hazard as safety negligible. Based on the fact that boyd bolts will withstand twice the axial loads required in LSG installation and the failed boyd bolt would be a low energy projectile with no sharp edges, it appears that the potential hazard is an acceptable risk for an astronaut to take.

It is recommended that the potential hazard be reported to the MSC System Safety Office as a residual hazard with a recommendation that the capability of the EMU to sustain the impact of a low energy projectile be determined.



LSG PRE LOADING

FIGURE 1

LSG PROPELLING PREVIOUSLY RELEASED BOYD BOLTS

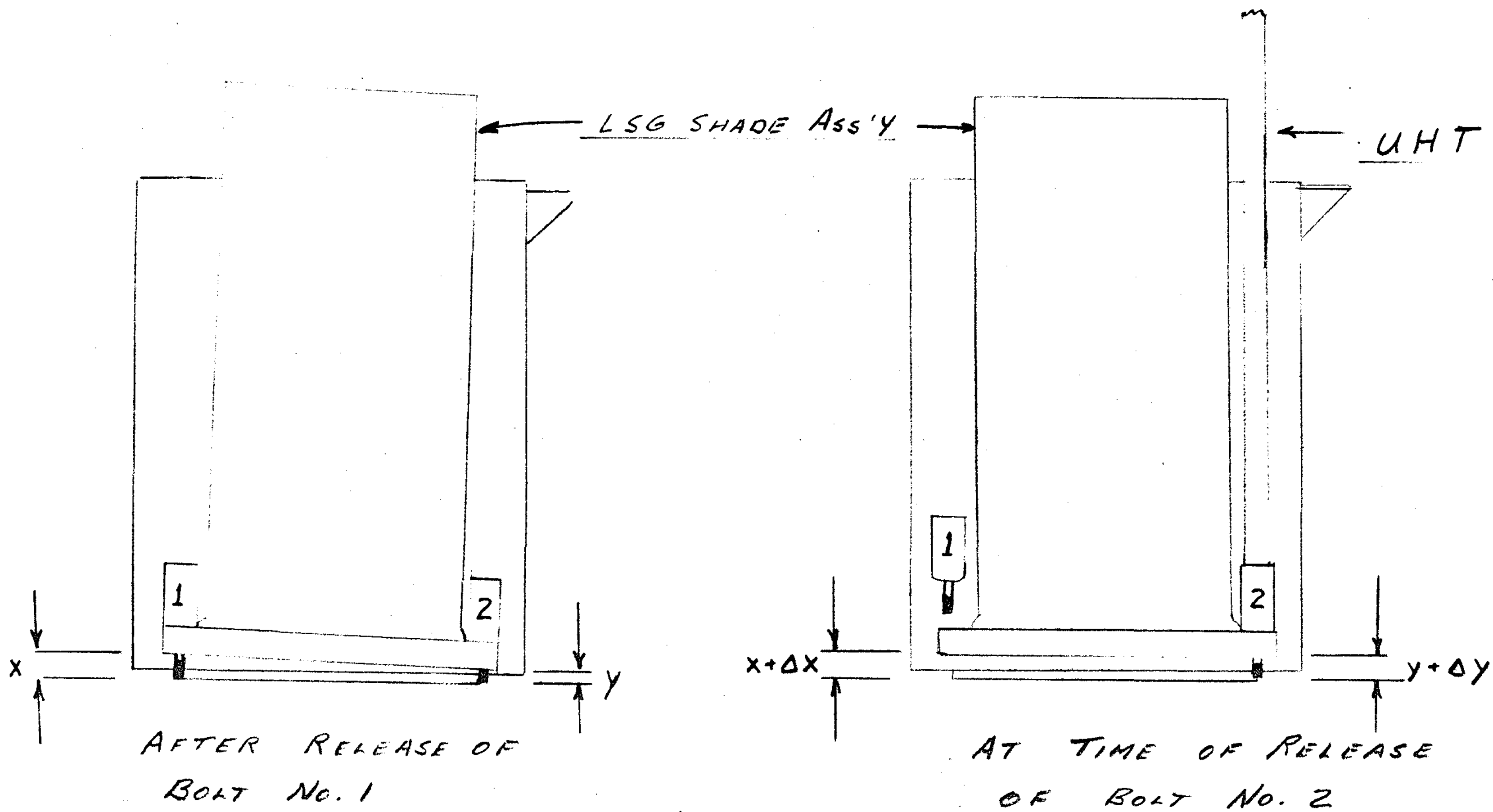


FIGURE 2

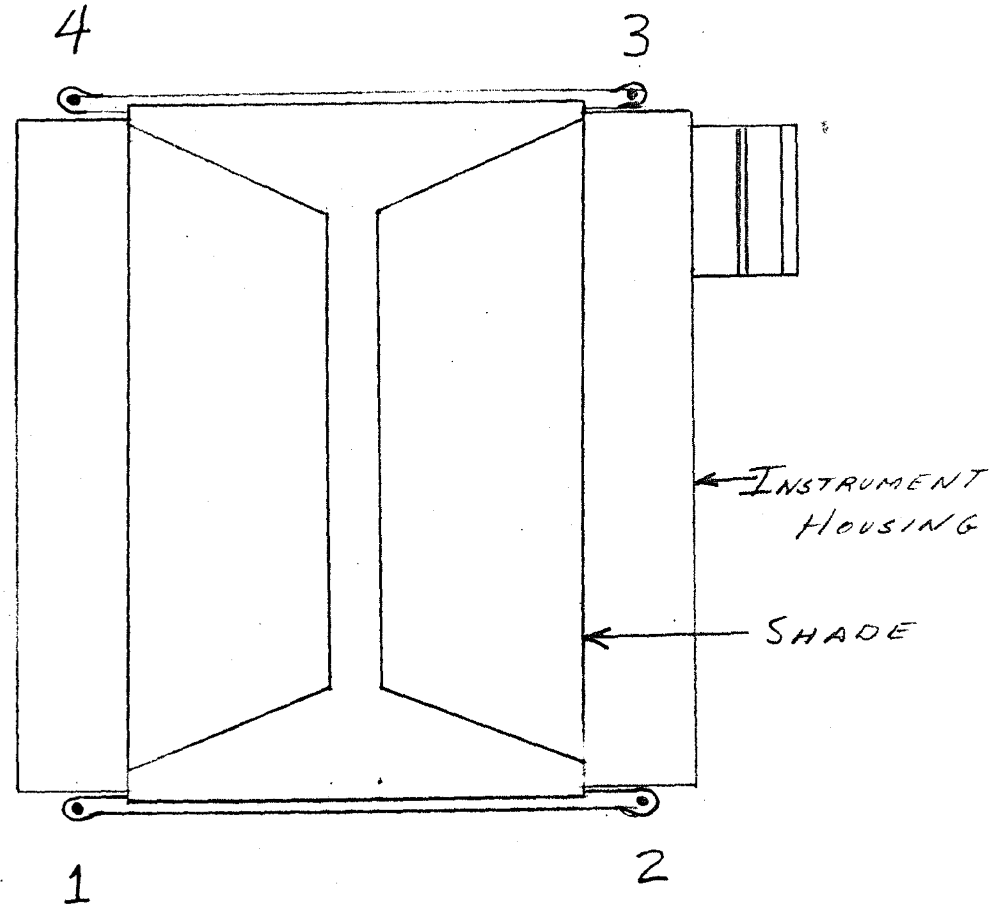
APPENDIX A

LUNAR SURFACE GRAVIMETER

Bendix Subcontract SC-850
C-73007

AUGUST 10, 1971

BOYD BOLT TESTS



TOP VIEW OF LSG

SHOWING BOLT ARRANGEMENT

FIGURE 3

MEMORANDUM

To: G. Parish

Case: 73007-15 Date: 6 August 1971

Subject: Boyd Bolt Tests

I. INTRODUCTION

Under Change Order No. 10 (Bendix TWX No. S-1370) dated 8 July 1971, Arthur D. Little, Inc. was directed to perform the tasks described in the test outline of BXA TWX S-1354 dated 6 July 1971. The purposes of the tasks were to obtain deflections of the gravimeter shades under various conditions of bolt loads and, under the direction of Bendix, the human factors assessment of the effects of Boyd Bolt release. These tasks were completed in the month of July 1971.

II. TASK DESCRIPTION

There were two series of tests and/or measurements performed. These were defined in Bendix TWX S-1354 and this telegram is repeated here.

SERIES I TESTS

This series of tests is to be conducted using the structural model and conventional high strength bolts. Instrumentation to determine load in each bolt and deflection of the sun shade at various locations is required.

A. Determine deflections vs gimbal preload at the following locations for a gimbal preload range of 1200 to 2000 pounds:
   1. Across top shade
   2. Across top shade hinges
   3. Across lower T-beam of the upper shades
   4. Elongation of upper shade
   5. Total gap between upper shade and bolt receptacle.

B. Determine repeatability of item A-5 above

C. Determine method of preloading sun shade to obtain gap compatible with Boyd Bolt length before Bolt installation if such preloading is required.

From R. M. Lucas Bldg./Room 20/505 Ext. 886

(Upon completion of Items A and B, Bendix will advise ADL whether or not Boyd Bolt installation is feasible without a preload on the sun shade.)

D. Determine load in each bolt after installation per determined procedure and after release of each bolt for the following sequences of release:

1. Diagonal 1-3, diagonal 2-4
2. Short side 1-2, short side 3-4
3. Long side 1-4, long side 2-3

E. Determine changes in deflections listed in Item A at release of each bolt per sequences listed in Item D.

SERIES II TESTS

These test are to be conducted using the structural model, Boyd Bolts, and UHT to determine astronaut interface loads. The following measurements are to be made when releasing the bolts in the sequences listed in Items D-1, D-2, and D-3 above.

A. Axial load imparted to Universal Handling Tool (UHT)

B. Torque required on UHT to release bolt

- -

ADL was not required to reduce the test data. It is to be noted that in Series I, A, 4, elongation is a derived quantity and not a direct measurement.

III. INSTRUMENTATION AND ACCURACY

SERIES I

The attached ADL photographs 11379-1,2,3 and 4 show the instrumentation used for the Series I tests. Photograph 1 shows how one strain indicator was used with a bridge switching and balancing network to read the strain (load) in the four bolt load cells. Photograph 2 is a view of the +Y side of the gravimeter with the load cells installed and photograph 3 includes the vernier height gage in combination with a dial indicator for the deflection measurements. A close-up view of the installed load cell is shown in photograph 4.

The structural model was used for all Series I and II tests. The model consisted of all shades without cable restraints and with the detent mechanism made inoperable. The gimbal housing, instrument housing and cover were assembled according to the latest drawings. However, the instrument housing was empty of parts and open to the atmosphere. Also included were the inner and outer container completely assembled. The insulating cones were installed according to the latest configuration including the dusting of the cone surfaces. There was no other insulation. In summary, all of those elements that are in the load path were included in the assembly. The gravimeter was mounted to the vibration fixture (Drawing 4009-009, Rev. A) which was three-point supported on an inspection surface plate. The vernier height gage was also on this surface plate so all dimensional data was referenced to the same flat surface. Gross fixture distortion was calculated at a conservative 0.002 inches (at 2000 pounds) from the center to edge of the fixture and the 3-point support was located to minimize this effect.

The vernier height gage was checked (re-zeroed) before and after any one set of readings (one load condition) by re-measuring the height of an arbitrary reference block which also rested on the surface plate. The vernier height measurements were read and recorded to the nearest 0.001 inch and the accuracy of the system was ± 0.0005. All readings were made by two individuals.

The load cells were 1.5 inch long, 6061-T6 aluminum tubes, 3/8 OD with a wall thickness of 0.049 inches. Each tube was instrumented with a 4 arm Wheatstone bridge using foil strain gages to achieve independence of torsion, bending and temperature effects. The cells were cycled in compression and calibrated (traceable to NBS) to 1000 pounds each or a material stress of 20,000 psi. The individual load cell sensitivity was 5.18 micro-inches per pound and readings were made and recorded to the nearest micro-inch or 0.2 pounds. From the beginning to end of the Series I test (two days) there was a net drift (or zero shift) of the load cells of an average + 10 micro-inches or + 2 pounds. The recorded total load in the data sheets was accurate to $\pm$ 1/2 percent and at the same time individual bolt loads were within the desired load by $\pm$ 2 pounds at a total load of 1200 pounds and $\pm$ 5 pounds at the maximum total load of 2,000 pounds.

MEMORANDUM

To: G. Parish

Case: 73007-15 Date: 6 August 1971 Page: 4

Subject: Boyd Bolt Tests

Bolt threads, nuts and washers were coated with MoS_2 to reduce friction for smooth load changes. The bolts were 1/4-20, 303 stainless steel mated with conventional steel nuts.

It is of interest to note that the load indicator beam in the top shade was accurately indicating the total load. This feature was used in the Series II tests to verify total load (in addition to measured deflections).

SERIES II

The basic instrumentation for the Series II test were 16mm motion picture cameras with color film. The background contained a 2 inch square grid and at the bolt location was included a inch scale and a 1/2 second division stopwatch. One battery operated camera, with a telephoto lens operated at 45 to 50 frames a second and recorded a close-up of the bolt location including reference marks on the UHT. A second spring would camera with a normal lens recorded the entire assembly, but not including the operator's hand, at 64 frames per second. Part way through the tests, a Fastax camera was employed. This camera, also with a telephoto lens, operated at about 500 frames per second and timing marks at 1 millisecond intervals were included along the edge of this film. The purpose of this camera was to define the deflection vs time data of the UHT in order to deduce the force pulse to the operators hand. A direct measurement of this force was considered ambiguous. Viewing all of the film will make the above description obvious. All cameras were maintained in a fixed position and the gravimeter was turned to position the bolt of interest in the field of view. The telephoto lens and normal lens cameras were mounted on their tripods in an inverted position to maintain a horizontal field of view. The Fastax camera was in a normal upright position.

One torque measurement of Boyd Bolt release was made using a Bendix torque wrench and is so reported in the data.

The basic approach to installing the Boyd Bolts with known axial loads (any reasonable instrumented load cell would be impossible to use with these bolts) was as follows:

The assembly was bolted down with four conventional bolts to a predetermined shade-to-fixture clearance. From the Series I tests and other tests these clearances were directly related to known bolt loads. Then, one at a time, the conventional bolts and nuts were replaced with Boyd Bolt assemblies to achieve the same clearances. In effect, the gravimeter was preloaded (or predeflected) by this method. In other instances, the Boyd Bolts themselves were used to produce the desired deflections. In no case were the load cells used with conventional bolts in this process because there was no assurance that a load was maintained after Boyd Bolt substitution. Deflection (or clearance) measurements were just as accurate and considerably more convenient. The examination of the Series I tests and experience showed that although individual bolt loads could be made to be different by a considerable amount, the total desired load could be achieved quite accurately. Furthermore, as individual bolt loads were controlled as desired, deflections and clearances were fairly reproducible.

As the tests progressed to higher total loads, the shade-to-fixture clearance method of determining individual bolt load was augmented by the total load indicator pin measurement which had been shown to be accurate and very reproducible.

IV. TEST RESULTS

The test results of both series of tests are included with this report in raw form as the data was recorded. Series I test results are presented in the first 19 sheets. Series II test results are presented in the last 6 sheets and describes the development of the loads, the photographic notation on the 16mm film, and the operators Boyd Bolt release comments.

Also included as data with this report is one copy each of the 8 reels of unedited 16mm film obtained during the Series II tests.

APPROVED........DATE.......... CAMBRIDGE MASS. SKETCH NO.........

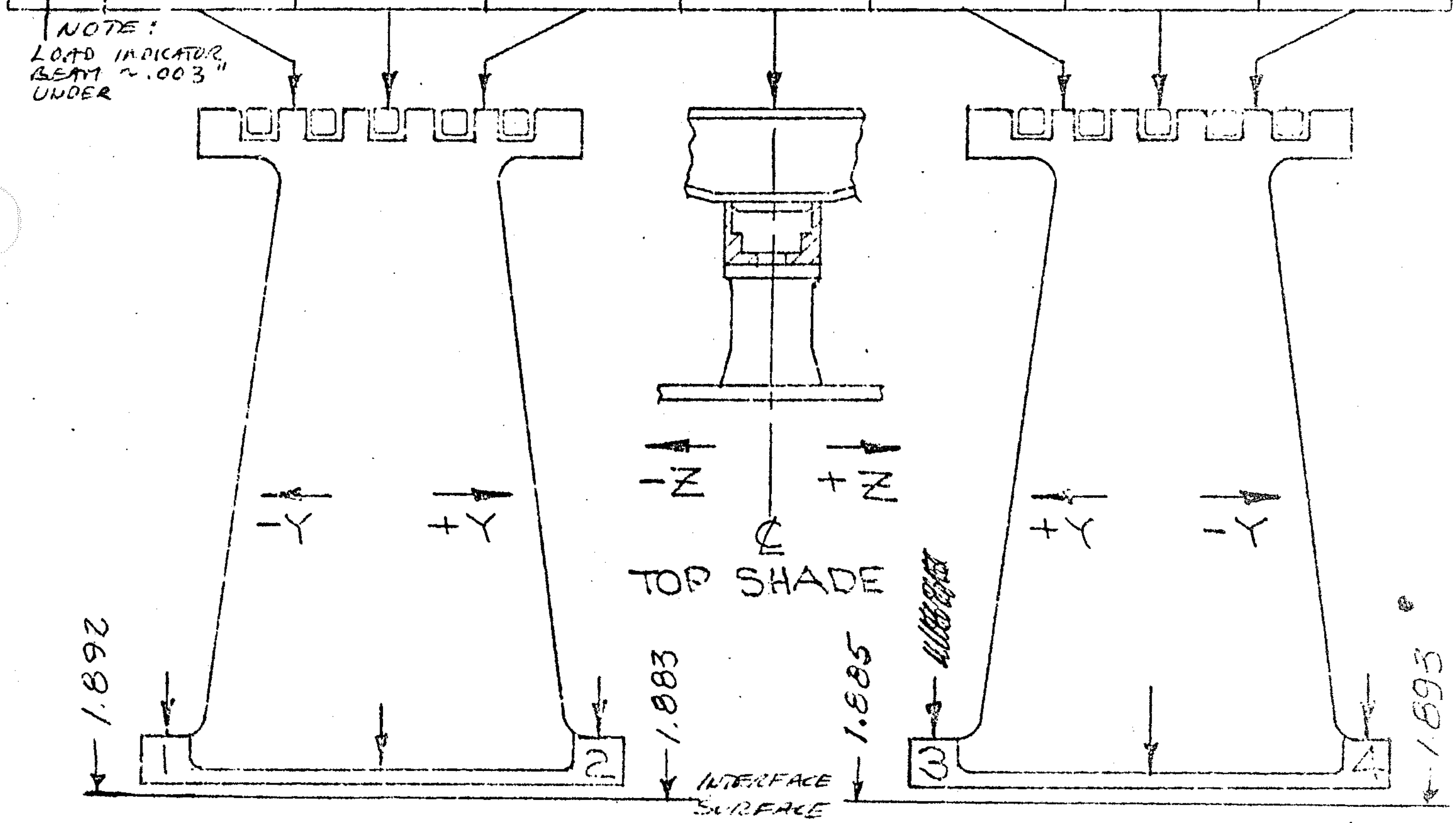
CLIENT BxA - LOAD VS SHADE DEFLECTION TEST CASE NO. 73007-15

TEST NO: I-A

CONDITION: STRUCTURAL MODEL; LUNAR SURFACE GRAVIMETER
RE-ZERO BLOCK = 3.500
INCREASING LOAD INCREMENTS

TOTAL LOAD POUNDS — DIMENSIONS IN INCHES FROM ARROW LOCATIONS TO SURFACE PLATE

0	15.323	15.350	15.320	15.353	15.320	15.352	13.325
800	15.284	15.312	15.279	15.326	15.275	15.310	15.283
1200	15.269	15.299	15.264	15.322	15.266	15.302	15.273
1600	15.257	15.287	15.251	15.316	15.254	15.293	15.262
2000	15.246	15.277	15.241	15.312	15.243	15.282	15.251



0	2.609	2.122	2.600	2.604	2.125	2.601
800	2.568	2.081	2.553	2.549	2.081	2.566
1200	2.552	2.067	2.537	2.537	2.070	2.553
1600	2.538	2.053	2.520	2.523	2.057	2.538
2000	2.526	2.043	2.507	2.561	2.049	2.527
~~1200~~						~~2.548~~

ADL-98-358

SERIES I-A INCREASING

LOAD APPLICATION

518/400

518/400

13540
11,000
2000259

1.295

1.295
4 | 5.18

5.18 MIN/LB

1295
4
0

1036

1	2	3	4	1	2	3	4
~~200~~	~~240~~	~~250~~	~~240~~	970	990	950	990

360	170	260	320	2036	2030	2010	2090
							20
270	290	280	340	0	-86	-2	-11
				0	-1+	-1/2	-2
580	560	520	690	-1	-12	-2	[illegible]
940	910	900	930			3 1/2	
						800	

12-0036

800 LB

CLIENT BYA | ACCOUNT NO. 73007-15 | PAGE 1C OF 14

SERIES I-A INCREASING | NAME Paul | DATE 15 July

LOAD APPLICATION

1	2	3	4		1	2	3	4	
260	170	210	290		1200	1380	1230	1350	
370	310	340	380		1392	1392	1375	1398	
470	400	440	460		1555	1490	1498	1540	12-1590
510	480	500	510		1593	1557	1580	1587	
550	533	524	547	1200 LB	1590	1585	1591	1599	
557	548	540	558	12=	1586	1578	1580	1574	2000 LB
558	547	553	550	0554	-4	-7	-11	-25	
	$\Delta_M = 11 \approx 2^{\#}$				1586	1578	1580	1574	
980	870	790	990		0554	0560	0558	0553	
1[illegible]	998	960	1010		2	6	7	11	
1048	1022	1020	1034						
1072	1060	1053	1080	1600					
1074	1058	1076	1072						
1072	1070	1070	1076	12-1072					
	$\Delta_M = 6$	~ 1+ LB							
		AFTER MEAS							
72	72	72							
1063	1053	1060	1084						
-9	-19	-12	+12						
	-5 LB	$\frac{5}{1600}$							

APPROVED........DATE........ CAMBRIDGE, MASS. SKETCH NO.................

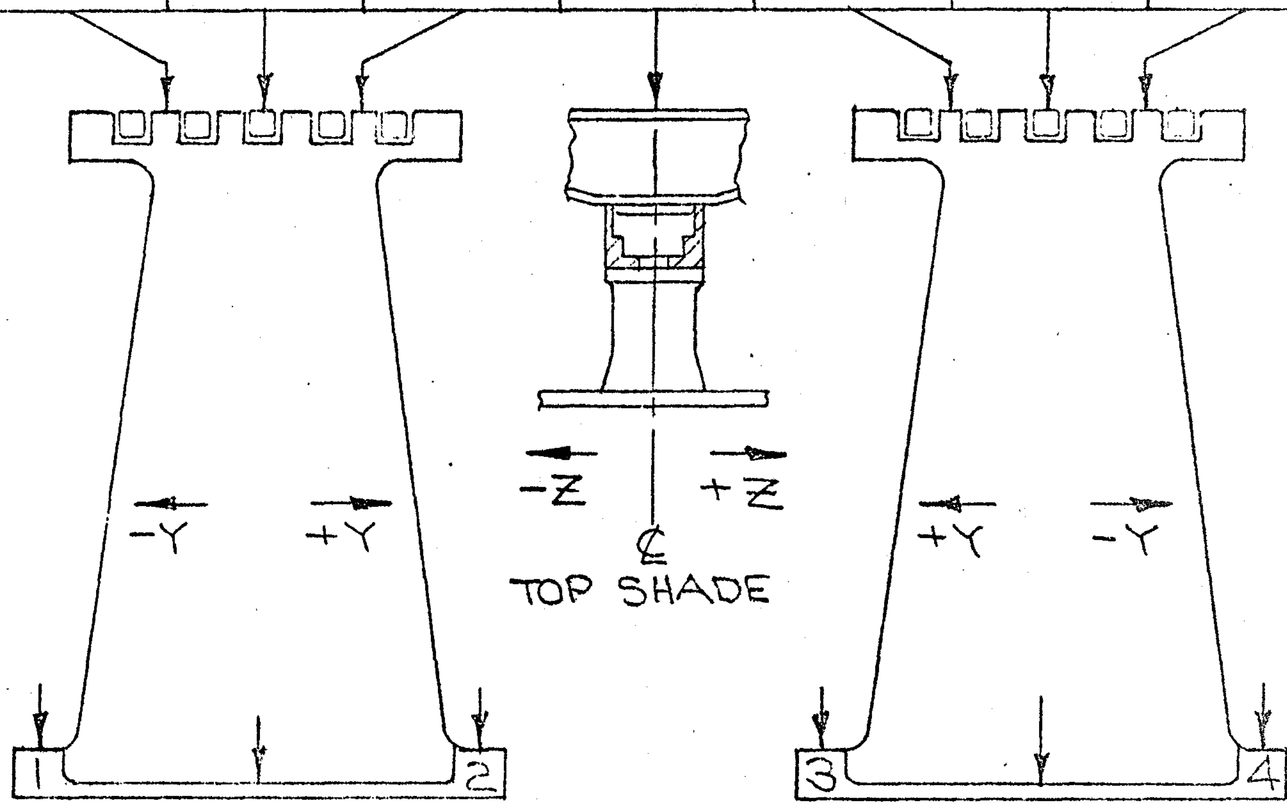
CLIENT BxA - LOAD VS SHADE DEFLECTION TEST CASE NO. 73007-15

TEST NO: I-A

CONDITION: STRUCTURAL MODEL; LUNAR SURFACE GRAVIMETER
DECREASING LOAD INCREMENTS
RE-~~ZERO~~ BLOCK 3.500

TOTAL LOAD POUNDS — DIMENSIONS IN INCHES FROM ARROW LOCATIONS TO SURFACE PLATE

0	15.317	15.346	15.314	15.350	15.321	15.352	15.323
800							
1200	15.269	15.299	15.264	15.319	15.262	15.299	15.269
1600							
2000	15.246	15.277	15.241	15.312	15.243	15.282	15.251



0	2.604	2.117	2.593	2.605	2.124	2.607
800						
1200	2.550	2.065	2.537	2.534	2.066	2.548
1600						
2000	2.526	2.043	2.507	2.511	2.049	2.527

ADL-98-868

SP 10.8114

CLIENT BxA- LOAD VS SHADE DEFLECTION TEST CASE NO. 73007-15

TEST NO: I-B

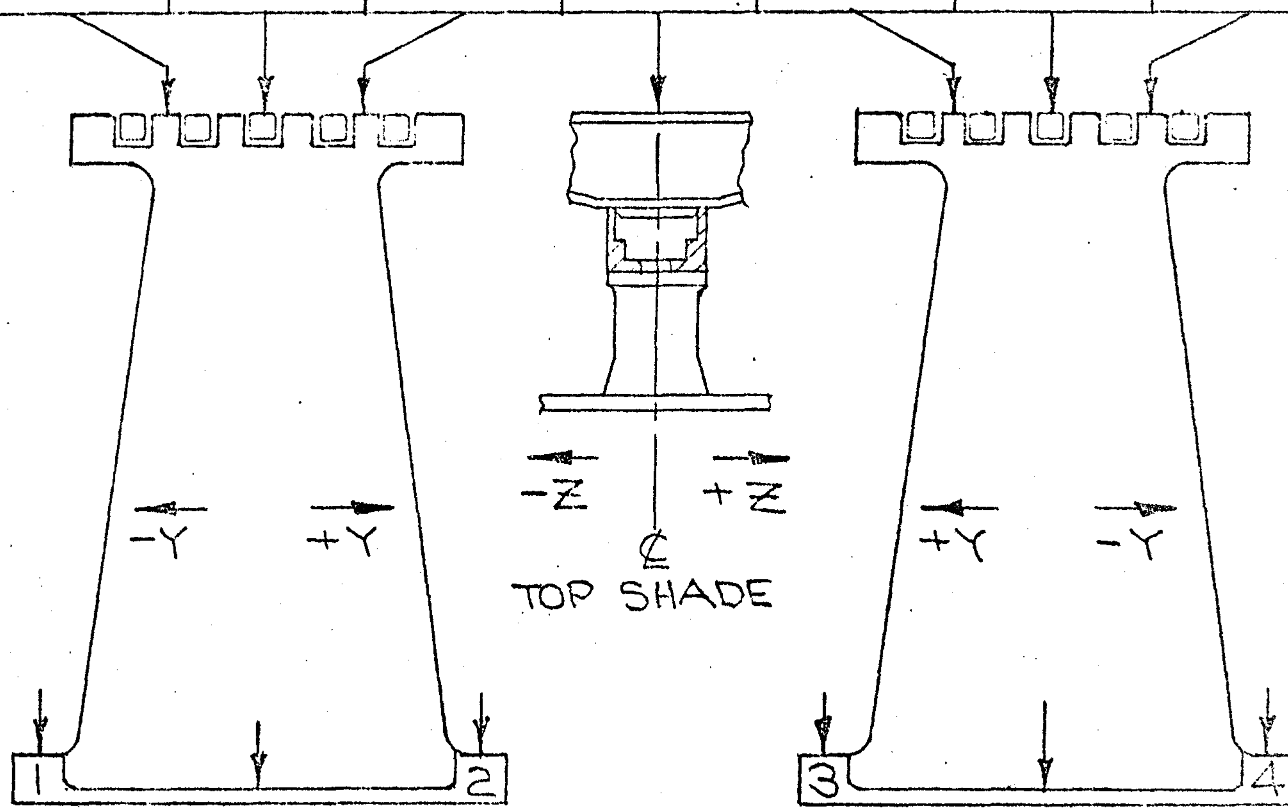
CONDITION: STRUCTURAL MODEL; LUNAR SURFACE GRAVIMETER

REPEATABILITY

RE-ZERO BLOCK = 3.500

TOTAL LOAD POUNDS — DIMENSIONS IN INCHES FROM ARROW LOCATIONS TO SURFACE PLATE

0	15.317	15.346	15.314	15.350	15.321	15352	15.323
2000	—	—	—	—	—	—	—
[redacted]	—	—	—	—	—	—	—
[redacted]	—	—	—	—	—	—	—
[redacted]	—	—	—	—	—	—	—
[redacted]	—	—	—	—	—	—	—



	0	2.604	2.117	2.593	2.605	2.124	2.607
930PM 15 JULY	2000	2.518	—	2.495	2.520	—	2.530
9:30AM 16J	2000	2.518	—	2.495	2.520	—	2.530
	0	2.601	—	2.584	2.605	—	2.612
	2000	2.515	—	2.500	2.516	—	2.520
	0	2.600	—	2.591	2.608	—	2.606

ADL-98-868

CLIENT BXA

ACCOUNT NO. 73007-15 | PAGE 38 OF 14

NAME BCP | DATE 7-15-71

REPEATABILITY

1	2	3	4		1	2	3	4	
1853	1605	1680	10 1775	½ Turn					Turns
1765	1835	1950	1785	1/8 T (on 2 & 3)	1460	1380	1280	1360	½
1910	1800	1920	1880	1/16 T (1 & 4)	1950	0060	0130	0050	½
0310	0240	0520	12 0250	¼ T	0570	0430	0440	0510	¼
0580	0610	0730	0740	¼ T	0720	1040	0760	1120	¼
1120	0940	1190	1100	¼ T	1130	930	960	1050	1/8 (1,3)
1040	1140	1200	1120	1/16 T (2)	1270	1290	1190	1310	~1/8
1250	1040	1230	1140	1/16 T (1)	1450	1520	1450	1470	~1/8
1594	1592	1585	1586	—	1580	1540	1540	1550	
— PM	THURS,	7-15	—	—	1570	1600	1580	1580	
	FRI,	7-16			1600	1596	1580	1580	LOAD INDICATOR BEAM OVER BY .001/.002
Load drop,	micro-inches.								
-20	-10	-28	-40		1592	1600	1582	1583	
1568	12- 1577	12- 1560	12- 1552						
1165	1590	1975	12 0610	RELEASE #4 BY ½T	600	1890	1560	1210	½ OFF (1)
-403	—	+415	-942	Δ μIN					
-80	—	+80	-200	Δ~LBS					
420	500	580	300	ACTUAL LBS					
0480	0820	0520	0540	1,2,3 REL BY ½T					
2 LBS	2 LBS	2 LBS	2 LBS	ALL LOOSE					
RESIDUAL	LOAD								

BXA

ACCOUNT NO. 73007-15 | PAGE 3C OF 14

NAME Rul | DATE 16 July 71

ZERO LOAD: SUMMARY OF REPEATABILITY I-B

BOLT NUMBER:	1		2		3		4	
I-A START	2.609		2.600		2.604		2.611	
		-5		-7		+1		-4
	2.604		2.593		2.605		2.607	
		-3		-9		0		+5
	2.601		2.584		2.605		2.612	
		-1		+7		+3		-6
	2.600		2.591		2.608		2.606	
Σ	$(\times 10^{-3})$	-9		-9		+4		-5

CLIENT BXA

ACCOUNT NO. 73007-15 PAGE 3D OF 14

NAME Rul. DATE 16 July 71

2000 LB LOAD : SUMMARY OF REPEATABILITY I-B

BOLT NUMBER:	1		2		3		4	
I-A INITIAL	2.526		2.507		2.511		2.527	
		−8		−12		+9		+3
12 HOUR HOLD	2.518		2.495		2.520		2.530	
		0		0		0		0
	2.518		2.495		2.520		2.530	
		−3		+5		−4		−10
	2.515		2.500		2.516		2.520	
$\Sigma (x10^{-3})$		−11		−7		+5		−7

APPROVED ______ DATE ______ CAMBRIDGE, MASS. SKETCH NO. ______

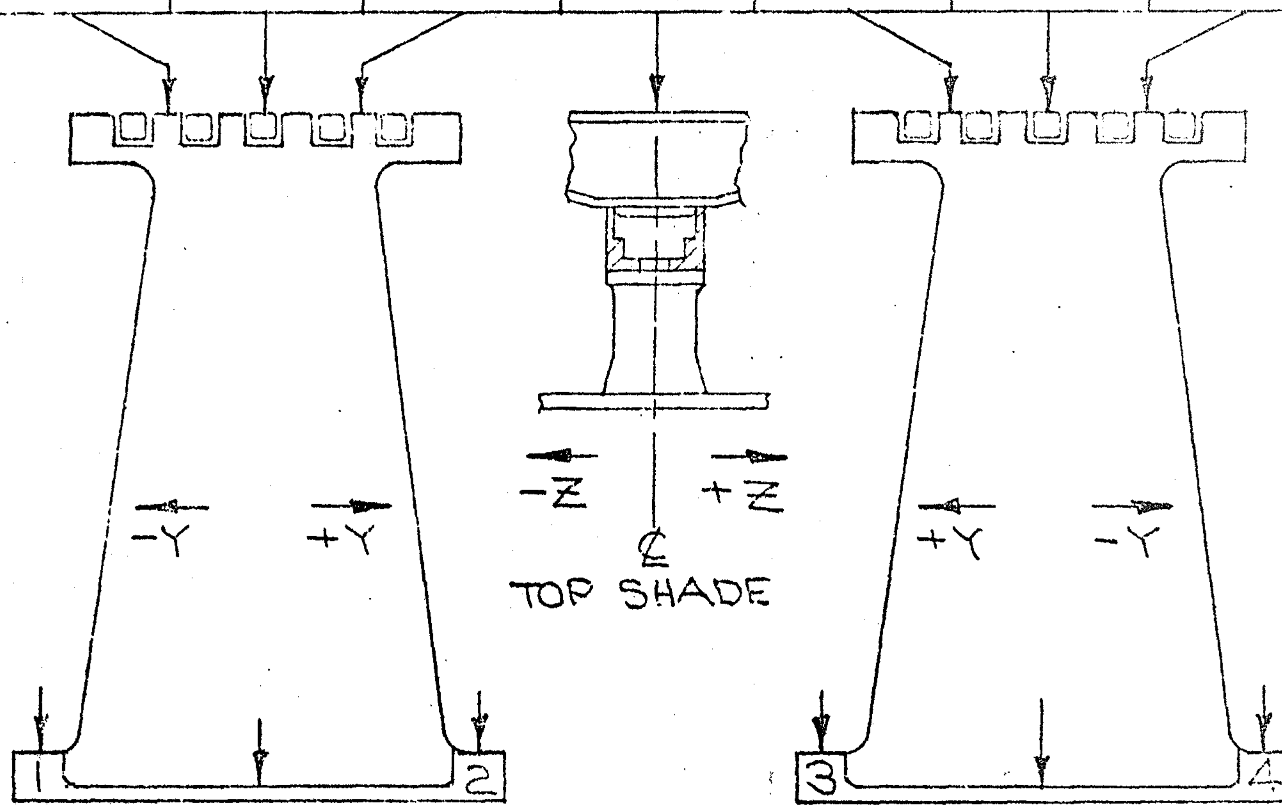
CLIENT BxA - LOAD VS SHADE DEFLECTION TEST CASE NO. 73007-15

TEST NO: I - E, D, 1

CONDITION: STRUCTURAL MODEL; LUNAR SURFACE GRAVIMETER
PRE RELEASE MEASUREMENTS

TOTAL LOAD POUNDS — DIMENSIONS IN INCHES FROM ARROW LOCATIONS TO SURFACE PLATE

0							
~~[illegible]~~							
~~[illegible]~~							
1600	15.247	15.278	15.242	15.314	15.259	15.294	15.261
~~[illegible]~~							



0						
~~[illegible]~~						
~~[illegible]~~						
1600	2.527	2.042	2.508	2.531	2.060	2.535
~~[illegible]~~						

ADL-98-868

CLIENT BXA- LOAD VS SHADE DEFLECTION TEST CASE NO. 73007-15

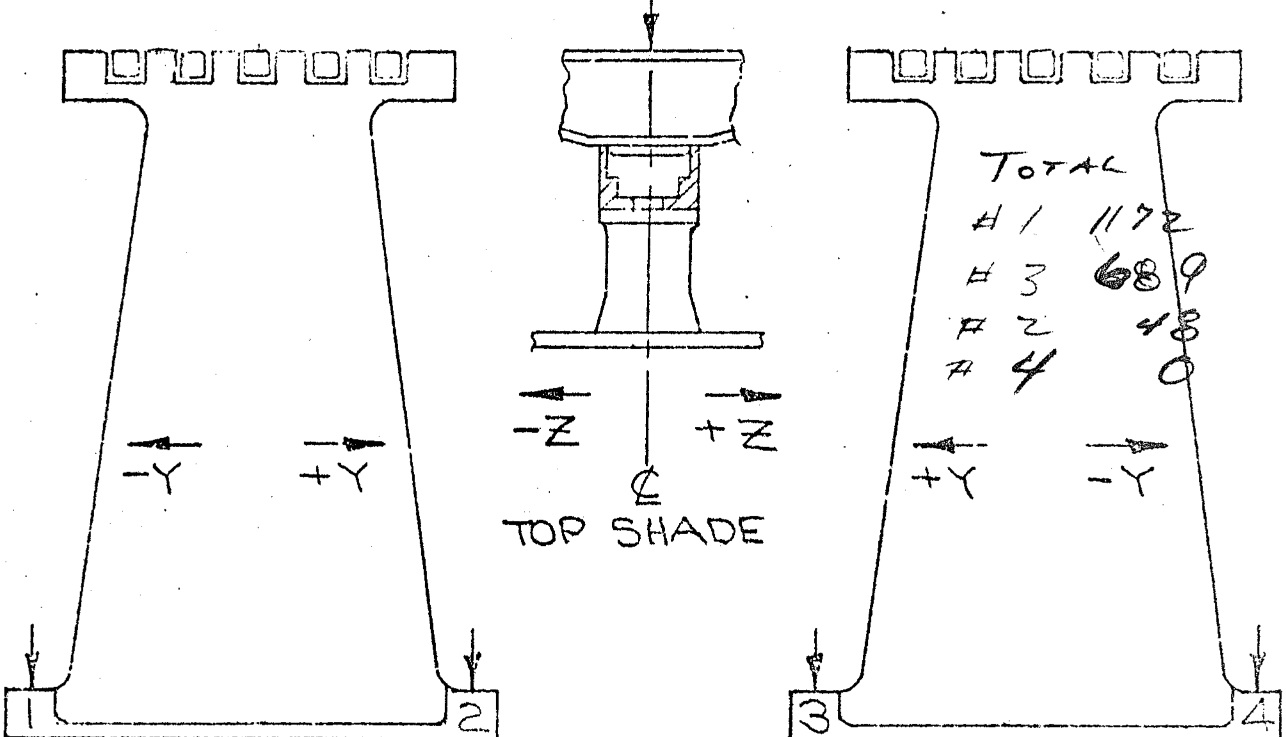
TEST NO: I-E, D, 1

CONDITION: STRUCTURAL MODEL; LUNAR SURFACE GRAVIMETER

5.18 μ in PER POUND

INITIAL TOTAL LOAD, 1600 LBS

	BOLT NO. 1			BOLT NO. 2			
RELEASE	STRAIN IND. READING	μ IN.	LOAD, LB.	STRAIN IND. READING	μ IN.	LOAD, LB.	
#1	10-1000	0	0	12-1722	2722	525	
#3	10-1000	0	0	12-0804	1804	349	
#2	10-1000	0	0	10-1000	0	0	0
#4	10-1000	0	0	10-1000	0	0	0
#7 BY .025 (1/2 TURN)	12-0300	[illegible]		12-1390	2390		



	BOLT NO. 3			BOLT NO. 4		
RELEASE	STRAIN IND. READING	μ IN.	LOAD, LB.	STRAIN IND. READING	μ IN.	LOAD, LB.
#1	12-1113	2113	408	12-0289	1289	249
#3	10-1000	0	0	12-0630	1630	340
#2	10-1000	0	0	★10-1250 (2 NO LOAD BOLT IN HOLE) 10-1060 (2 BOLT REMOVED)	250 60	48
#4	10-1000	0	0	10-1000	0	0
#7 BY .025 (1/2 TURN)	12-1140	91[illegible]		12-0700	17[illegible]	

★ REMOVING BOLT FROM HOLE, SHADE 1-2 SWINGS OUT BY 2 1/8" AT BOSS.

ADL-98-868

SP 10,671A

CLIENT: BxA - LOAD VS SHADE DEFLECTION TEST   CASE NO. 73007-15

TEST NO: I - E, D, 1

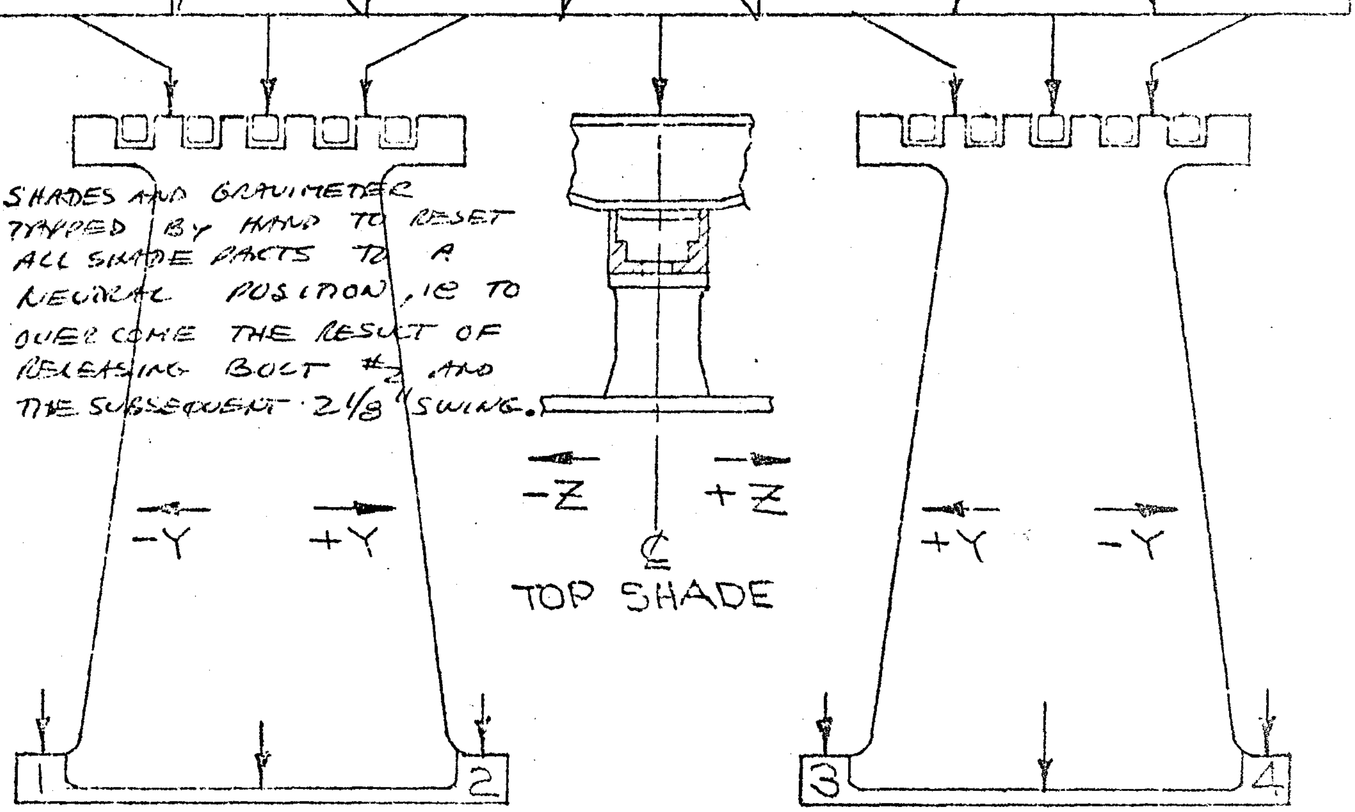
CONDITION: STRUCTURAL MODEL; LUNAR SURFACE GRAVIMETER
RE-ZERO BLOCK = 3.500"

INITIAL TOTAL LOAD POUNDS: 1600 LBS

DIMENSIONS IN INCHES FROM ARROW LOCATIONS TO SURFACE PLATE

RELEASE	LOAD							
#1	0	15.287		15.259		15.256		15.258
#3		15.287		15.256		15.298		15.275
#2	800	15.397		15.396		15.265		15.256
#4	1200	——— ★		——— ★		——— ★		——— ★
	1600	15.319 ★★		15.316 ★★		15.322 ★★		15.323 ★★
	2000							

★★ SHADES AND GRAVIMETER TAPPED BY HAND TO RESET ALL SHADE PARTS TO A NEUTRAL POSITION, IE TO OVERCOME THE RESULT OF RELEASING BOLT #2 AND THE SUBSEQUENT 2 1/8" SWING.



ADL-98-868

RELEASE

RELEASE	LOAD						
#1	0	2.593		2.510	2.531		2.534
#3		2.595		2.509	2.599		2.533
#2	800	OUT OF POSITION		OUT OF POSITION	2.558		2.530
#4	1200	2.617 ★	★	2.596 ★	2.602 ★		2.604 ★
	1600	2.607 ★★		2.596 ★★	2.606 ★★		2.605 ★★
	2000						

★ REMOVING ALL BOLTS FROM HOLES SHADES SWING OUT BY 9/16" AT BOSSES. MEASUREMENTS MADE BY REINSERTING BOLTS WITH NO LOAD, BUT FOR ALIGNMENT

APPROVED........DATE..........   CAMBRIDGE, MASS.   SKETCH NO..................

CLIENT BxA - LOAD VS SHADE DEFLECTION TEST   CASE NO. 73007-15

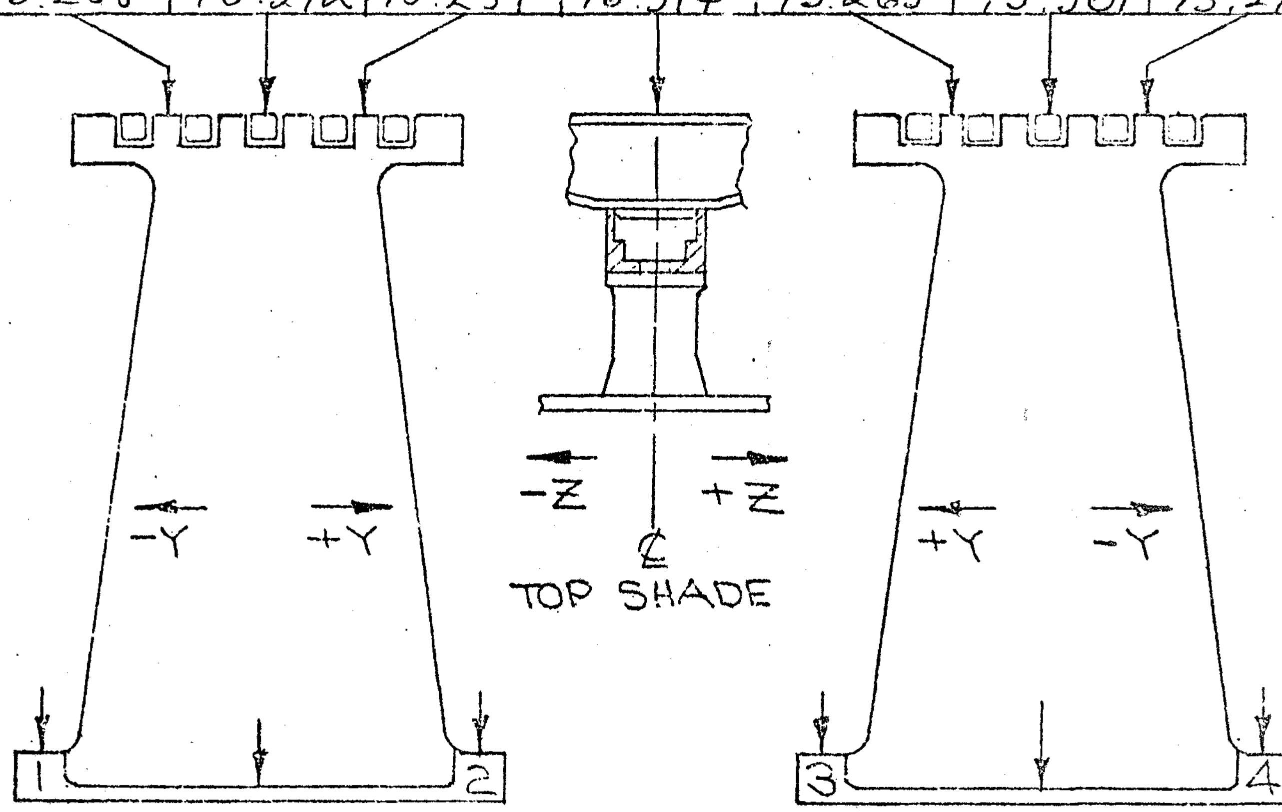
TEST NO: I-E, D, 2

CONDITION: STRUCTURAL MODEL; LUNAR SURFACE GRAVIMETER

PRE RELEASE MEASUREMENTS
LOAD CELLS RE-ZEROED TO 10-1000
WITH BRIDGE BALANCE

TOTAL LOAD POUNDS   DIMENSIONS IN INCHES FROM ARROW LOCATIONS TO SURFACE PLATE

0							
~~800~~							
~~1200~~							
* ~~1600~~	~~15.243~~	~~15.297~~	~~15.244~~	~~15.319~~	~~15.270~~	~~15.306~~	~~15.275~~
~~2000~~							
1600	15.238	15.272	15.239	15.314	15.265	15.301	15.270



0						
~~800~~						
~~1200~~						
* ~~1600~~	~~2.513~~	~~2.040~~	~~2.514~~	~~2.539~~	~~2.070~~	~~2.547~~
~~2000~~						2.
1600	2.510	2.037	2.511	2.537	2.069	2.546

* RE-ZERO READ 3.505

ADL-98-868

37 10,611A

CLIENT BxA - LOAD VS SHADE DEFLECTION TEST CASE NO. 73007-15

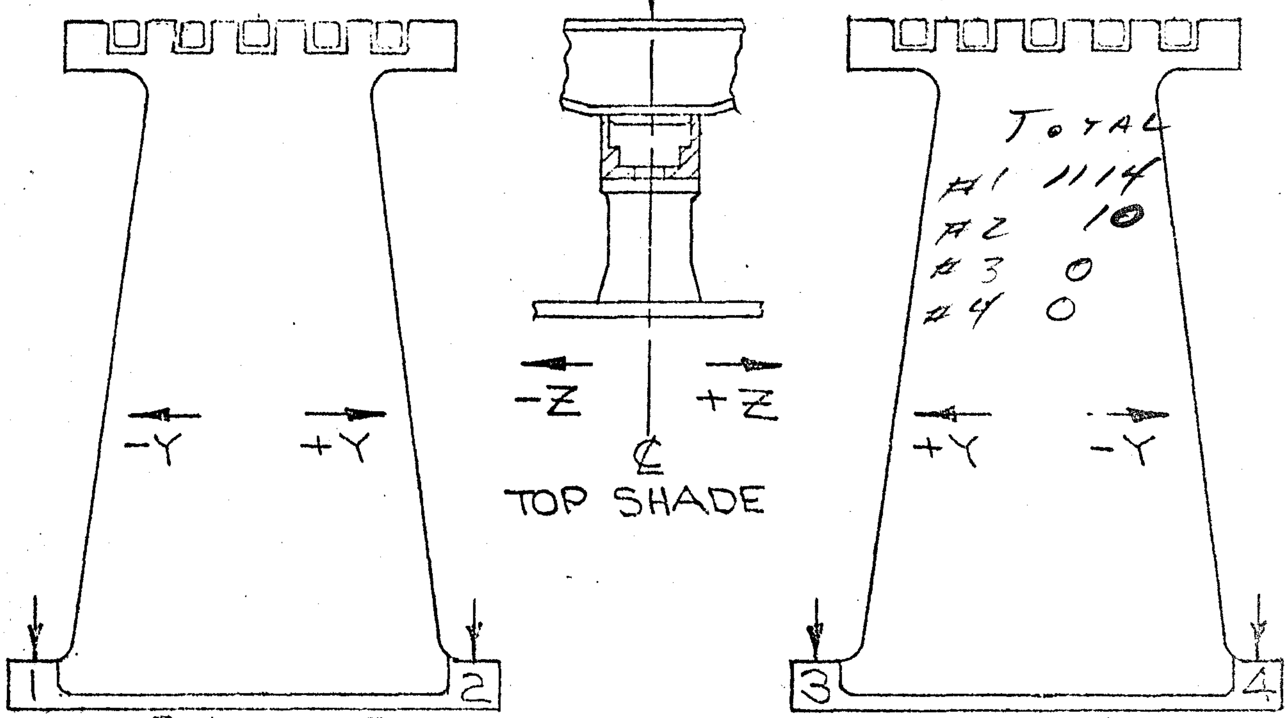
TEST NO: I - E, D, 2

CONDITION: STRUCTURAL MODEL; LUNAR SURFACE GRAVIMETER

5.18 µIN PER POUND

INITIAL TOTAL LOAD, 1600 LBS

RELEASE	BOLT NO. 1 STRAIN IND. READING	BOLT NO. 1 µ IN.	BOLT NO. 1 LOAD, LB.	BOLT NO. 2 STRAIN IND. READING	BOLT NO. 2 µ IN.	BOLT NO. 2 LOAD, LB.
#1	10-1000	0	0	12-1630	2630	508
#2	10-1000	0	0	10-1000	0	0
#3	10-1000	0	0	10-1000	0	0
#4	10-1000	0	0	10-1000	0	0
#1 BY .025 (1/2 TURN)	12-0240			12-1404		



RELEASE	BOLT NO. 3 STRAIN IND. READING	BOLT NO. 3 µ IN.	BOLT NO. 3 LOAD, LB.	BOLT NO. 4 STRAIN IND. READING	BOLT NO. 4 µ IN.	BOLT NO. 4 LOAD, LB.
#1	12-1226	[illegible]	430	10-1913	[illegible]	176
* #2	10-~~1~~050		10	10-1000	0	
#3	10-1000	0	0			
#4	10-1000	0	0	10-1000	0	0
#1 BY .025 (1/2 TURN)	12-1108			12-0753		

* ALL LOADS BASICALLY ZERO

ADL-98-868

SP 10,611A

APPROVED........DATE.......... CAMBRIDGE, MASS. SKETCH NO.................

CLIENT: BxA - LOAD VS SHADE DEFLECTION TEST CASE NO. 73007-15

TEST NO: I - E, D, Z

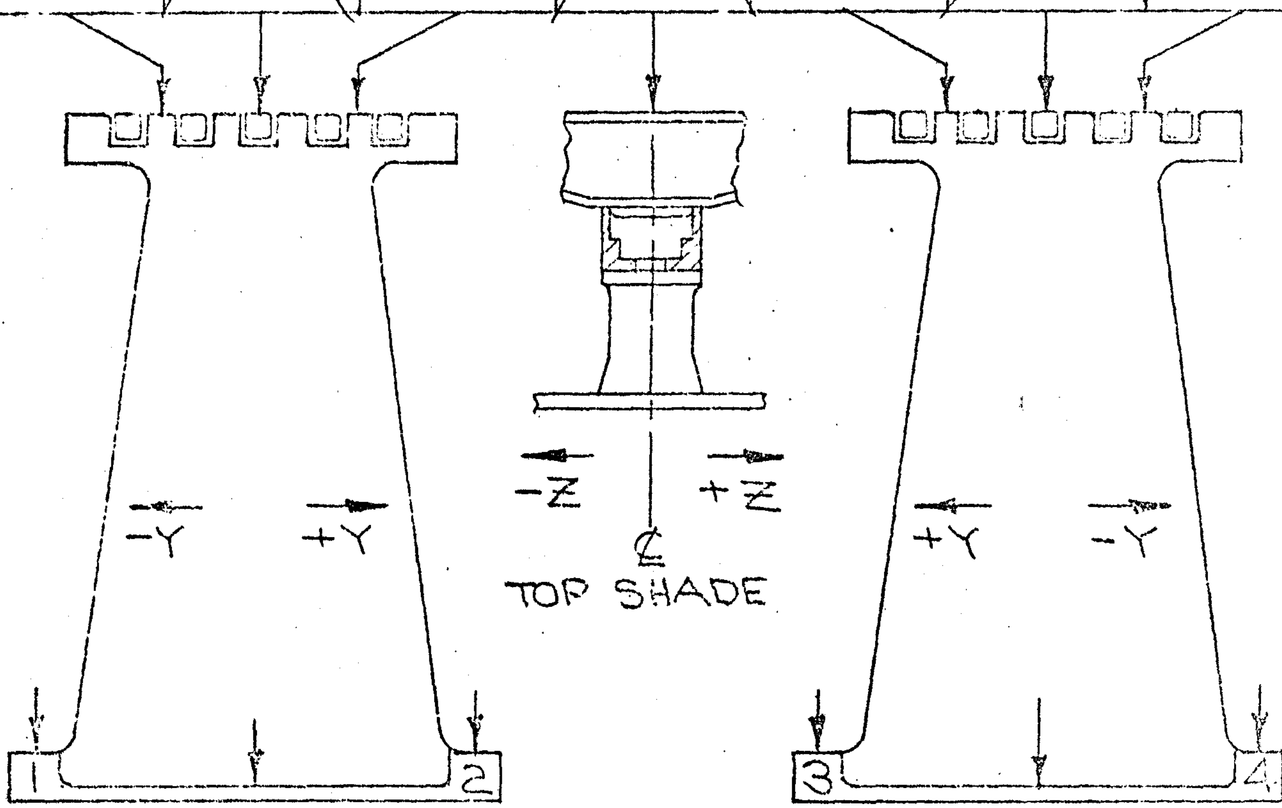
CONDITION: STRUCTURAL MODEL; LUNAR SURFACE GRAVIMETER
Re-Zero Block 3.520"

INITIAL TOTAL LOAD POUNDS 1600 LBS

DIMENSIONS IN INCHES FROM ARROW LOCATIONS TO SURFACE PLATE

DEFLECT.

#1	0	15.288		15.260		15.263		15.265
#2		OUT OF POSITION		OUT OF POSITION		——		——
#3	800							
#4	1200							
	1600							
	2000							



RELEASE

#1	0	2.593		2.513	2.537		2.544
#2		OUT OF POSITION		OUT OF POSITION	——		——
#3	800						
	1200						
	1600						
	2000						

REMOVING BOLT #2 SHADE 1-2 SWINGS OUT BY 2.5 INCHES AT THE BOSS.

ADL-98-868

APPROVED......DATE...... CAMBRIDGE, MASS. SKETCH NO..........

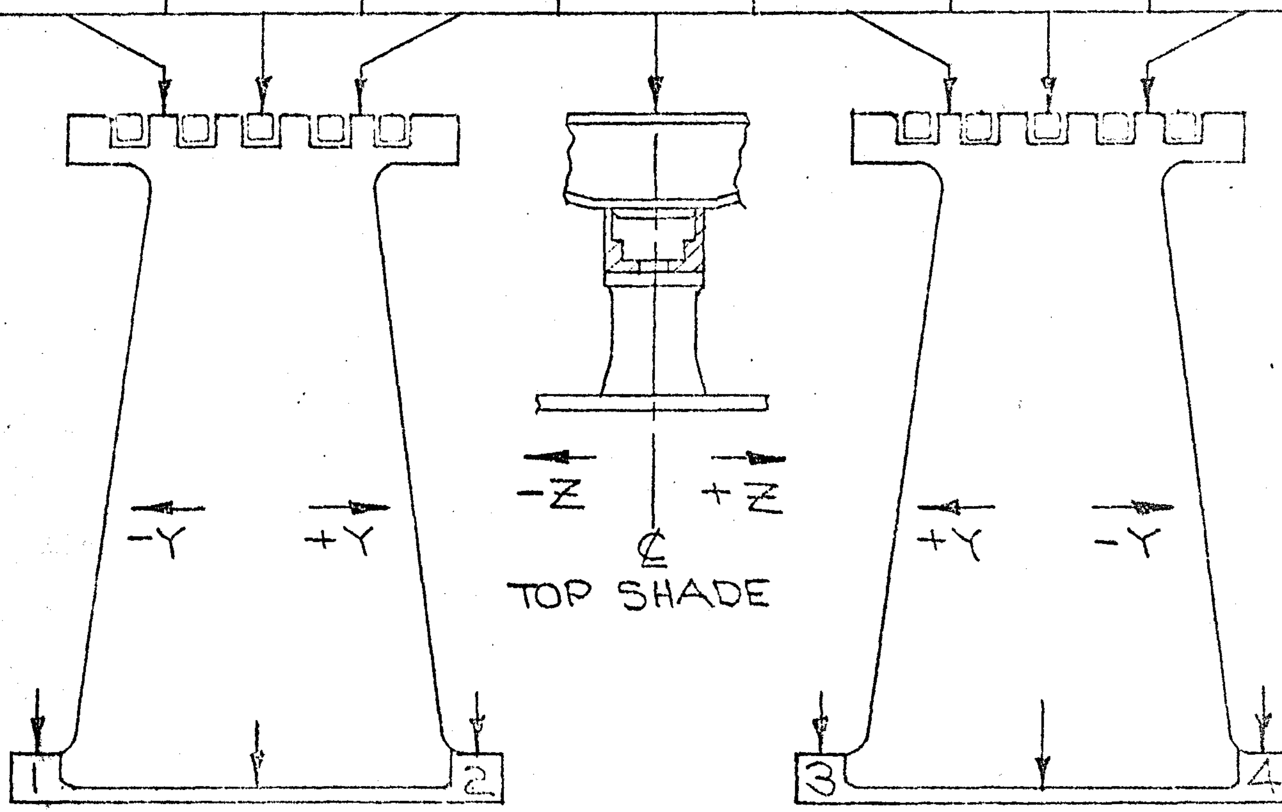
CLIENT: BXA - LOAD VS SHADE DEFLECTION TEST CASE NO. 73007-15

TEST NO: I - E, D, 3

CONDITION: STRUCTURAL MODEL; LUNAR SURFACE GRAVIMETER
PRE - RELEASE MEASUREMENTS

TOTAL LOAD POUNDS — DIMENSIONS IN INCHES FROM ARROW LOCATIONS TO SURFACE PLATE

0							
~~800~~							
~~1200~~							
1600	15.263	15.293	15.259	15.315	15.249	15.285	15.253
~~2000~~							



0						
~~800~~						
~~1200~~						
1600	2.543	2.060	2.529	2.520	2.050	2.526
~~2000~~						

ADL-98-868

SP 18,611A

CLIENT: BxA - LOAD VS SHADE DEFLECTION TEST CASE NO. 7300(-15

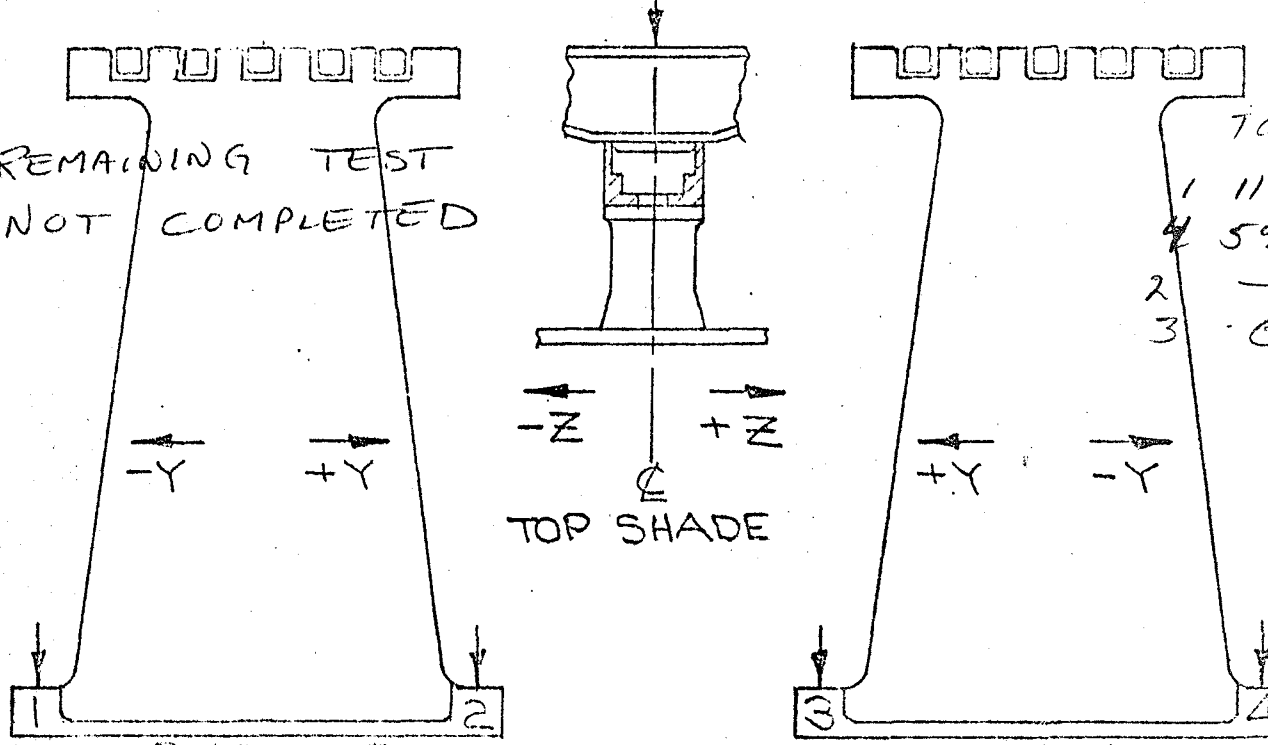
TEST NO: I - E, D, 3

CONDITION: STRUCTURAL MODEL; LUNAR SURFACE GRAVIMETER

5.18 μin PER POUND

INITIAL TOTAL LOAD, 1600 LBS

RELEASE	BOLT NO. 1 STRAIN IND. READING	μ IN.	LOAD, LB.	BOLT NO. 2 STRAIN IND. READING	μ IN.	LOAD, LB.	
#1	10-1000	0	0	12-1834	2834	547	
* #4	10-1000	0	0	12-0754	1754	338	
#2	10-1000	0	0	10-1000	0	0	
#3	10-1000	0	.0	10-1000	0	0	
#1 By .025 (1/2 TURN)	12-0226			12-1317			



** REMAINING TEST NOT COMPLETED

TOTAL
1 1182
4 596
2 —
3 0

RELEASE	BOLT NO. 3 STRAIN IND. READING	μ IN.	LOAD, LB.	BOLT NO. 4 STRAIN IND. READING	μ IN.	LOAD, LB.
#1	12-1089	2089	399	12-0220	1220	236
* #4	12-0336	1336	258	10-1000	0	0
#2	**			10-1000	0	0
#3	10-1000			10-1000	0	0
#1 By .025 (1/2 TURN)	12-1118			12-0650		

* EXPERIMENT HAS LIFTED ~5/16 INCH ON SIDE 1-4 LOADS WERE READ AT THIS POINT WITH BOLT #4 BOUND IN HOLE.

ADL-98-868

APPROVED .... DATE .... CAMBRIDGE, MASS. SKETCH NO. ....

CLIENT BxA - LOAD VS SHADE DEFLECTION TEST CASE NO. 73007-15

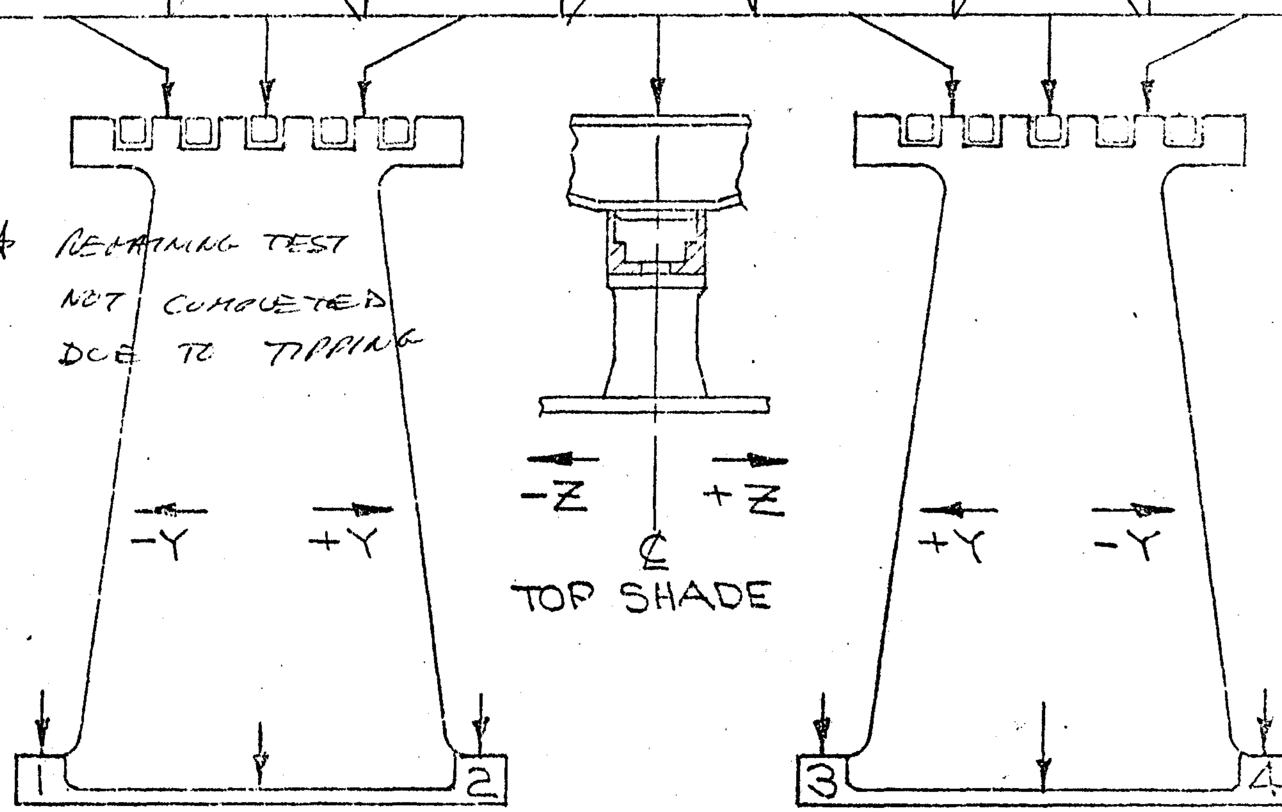
TEST NO: I - E,D, 3

CONDITION: STRUCTURAL MODEL; LUNAR SURFACE GRAVIMETER
RE ZERO BLOCK = 3.500

INITIAL TOTAL LOAD POUNDS 1600 LBS

DIMENSIONS IN INCHES FROM ARROW LOCATIONS TO SURFACE PLATE

RELEASE	LOAD POUNDS							
#1	0	15.302		15.275		15.246		15.248
#4		★★						
#2	800							
#3	1200							
	1600							
	2000							



★★ REMAINING TEST NOT COMPLETED DUE TO TIPPING

ADL-98-858

RELEASE	LOAD POUNDS						
#1	0	2.607		2.528	2.516		2.525
#4							
#2	800						
	1200						
	1600						
	2000						

ITEM: BxA | ACCOUNT NO. 73007-15 | PAGE 13 OF 14
NAME: Rvl | DATE 7-16-71

SERIES I-E-D1 LOAD APPLICATION

1	2	3	4	Turns
1280	1460	1370	1430	1/2
0160	1880	0130	0060	1/2
0370	0460	0480	0630	1/4
980	850	1040	910	1/4
1020	1030	1010	1090	~1/8
1072	1058	1060	1078	
1066	1068	1072	1082	

I-E-D2

1078	1066	1068	1077

I-E-D3

1060	1076	1078	0999
1067	1095	1020	1070
1070	1095	1022	1070
1166	1065	1009	1040
1056	1150	980	1020

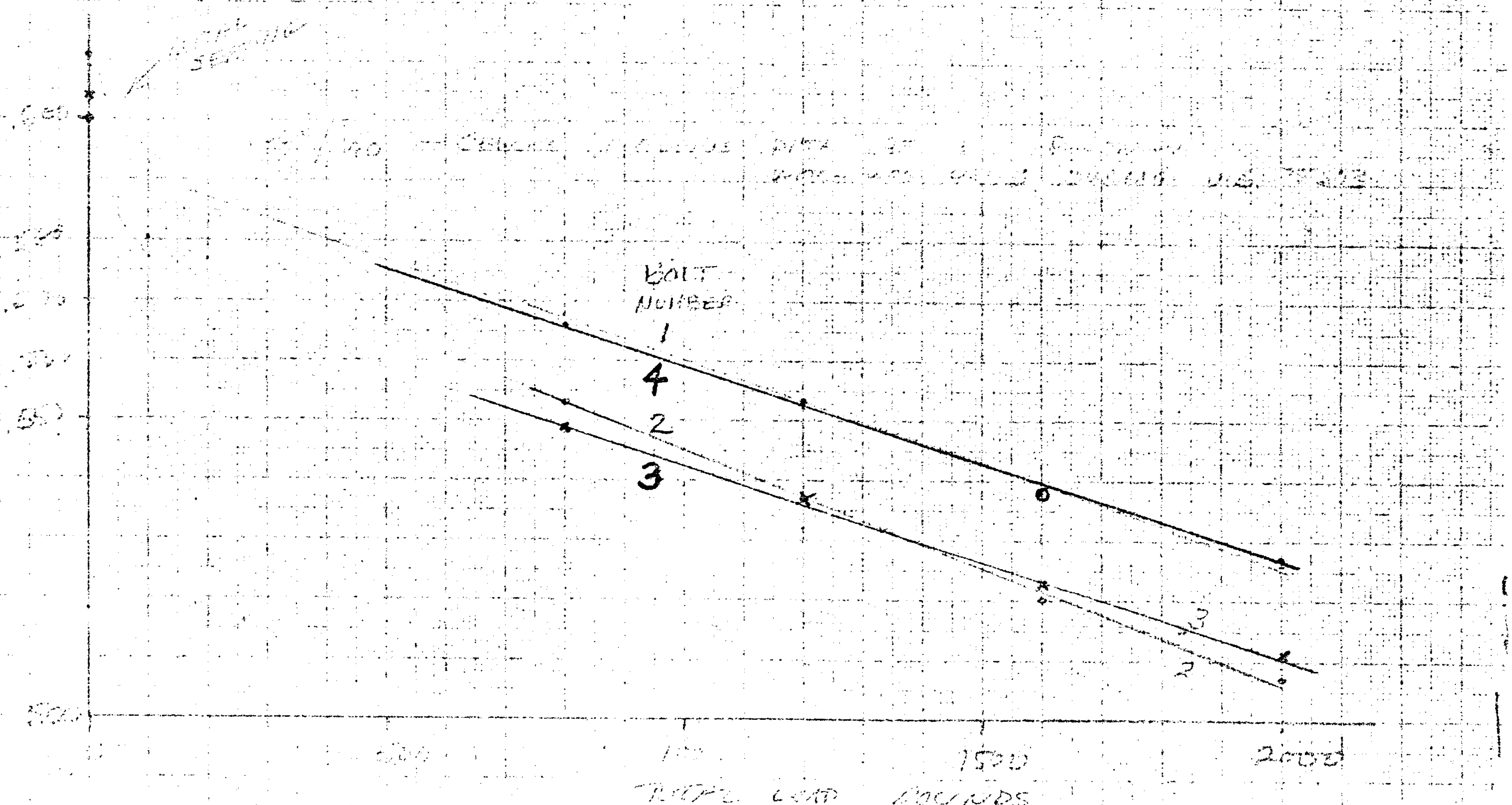
1070

1123	1065	968	100
1080	1078	1020	1099
1060	1037	1000	1020
1068	1090	1072	980
[illegible]	1068	1065	980
1077	1072	1050	1050
1052	1077	1053	1050
1060	1074	1055	1051

1	2	3	4	
1058	1073	1050	1067	
1070	1073	1050	1068	
1061	1072	1052	1063	
1079	1070	1052	1065	
1073	1070	1070	1057	
Δ Max = 3 LBS			1067	3 1/2
+1	-2	-2	15	≥18
1076	1071	1069	1057	
1076	1072	1074	1058	

PLOT CHECK OF LINEARITY OF DEFLECTIONS
AT BOSSES VS LOAD TO ASCERTAIN THE CHOICE
OF 1600 POUNDS FOR TESTS
I-E.D.

BAP + [illegible] 16 JULY 71



LSG BOYD BOLT ENGINEERING TEST

SERIES II TESTS - RUN # 1

ACCOUNT NO. 73007-15

PAGE 1 OF 6

NAME Drl

DATE 7/19/71

	BOLT NO			
	1	2	3	4

LOAD INDICATOR SET @ .010 DEFLECTION = 50 KG = 110 #

BOSS-TO-FIXTURE CLEARANCE = .079

BOYD BOLT INSTALLATION SEQUENCE - 1,3,4,2.

LOAD INDICATOR POSITION UNCHANGED AFTER BOYD BOLT INSTALLATION.

RELEASE SEQUENCE - 1,3 - COMMENT: "NO EXCESS FORCE ON ASTRONAUT". BOLTS 2 & 4 NOT RELEASED BECAUSE OF LOW FORCE FROM BOLTS 1 & 3

SERIES II TEST - RUN #2

LOAD INDICATOR SET @ .010 = 130 KG = 286 #

BOSS-TO-FIXTURE CLEARANCE = .074

BOYD BOLT INSTALLATION SEQUENCE - 3,1,2,4

LOAD INDICATION READ AFTER BOYD BOLT TIGHTENING

RELEASE SEQUENCE 1,3 COMMENT #1 "NO EXCESSIVE FORCE" #3 "MORE FORCE BUT NOT EXCESSIVE."

BOLTS 2 & 4 NOT RELEASED.

LOAD INDICATOR SET @ .022 DEFLECTION = 175 KG = 385#
BOSS-TO-FIXTURE CLEARANCE = .066
BOYD BOLT INSTALLATION SEQUENCE - 1,3,4,2
LOAD INDICATION READ AFTER BOYD BOLT TIGHTENING.
RELEASE SEQUENCE 1,3,4,2 COMMENT "APPROXIMATELY THE SAME AS #3 OF RUN 2 - NOT EXCESSIVE".
ALL BOLTS RELEASED.

SERIES II TEST - RUN # 4 7/20/71

BOSS-TO-FIXTURE CLEARANCE WITH B.B. SPRING LOAD ONLY = .095 AVERAGE.
~~ALL BOYD BOLTS REMOVED - 1/4-20 BOLTS USED TO ESTABLISH LOAD.~~
LOAD INDICATOR SET @ .036 DEFLECTION = 290 KG = 638#
BOSS-TO-FIXTURE CLEARANCE = .058
BOYD BOLT INSTALLATION SEQUENCE - 1,3,4,2
LOAD INDICATION READ AFTER BOYD BOLT TIGHTENING.
RELEASE SEQUENCE 1,3,2,4
PHOTOS IDENTIFIED AS - SERIES II D,1 RELEASED 1-3-2-4 - TOT. LOAD 638#
COMMENT #1 - "NO EXCESSIVE FORCE"
COMMENT #3 - SAME.
COMMENT #2 - SAME.
COMMENT #4 - SAME.

LSG. BOYD BOLT ENGINEERING TEST | ACCOUNT NO. 73007-15 | PAGE 3 OF 6

SERIES II TEST - RUN 5 | NAME [illegible] | DATE 7/20/71

BOSS-TO-FIXTURE CLEARANCE WITH B.B. SPRING LOAD ONLY = .093 AVERAGE.
LOAD INDICATOR SET @ .050 DEFLECTION = 430KG = 946#
BOSS-TO-FIXTURE CLEARANCE = .046
BOYD BOLT INSTALLATION SEQUENCE - 1,3,4,2
LOAD INDICATION READ AFTER BOYD BOLT TIGHTENING.
RELEASE SEQUENCE - 1,3,2,4
PHOTOS IDENTIFIED AS - SERIES II D1, RELEASD. 1-3-2-4 TOT. LOAD 946#
COMMENT: #1 - "NOTICABLE INCREASE IN FORCE BUT STILL ACCEPTABLE"
#3 - SAME.
#2 - SAME
#4 - "NEGLIGABLE FORCE."

SERIES II TEST - RUN 6
(LCS FELT SOME MOTION OF THE SHADE BEFORE RELEASE OF BOLT #1 !!!)
BOSS-TO-FIXTURE CLEARANCE WITH B.B. SPRING LOAD ONLY = .095 AVERAGE.
LOAD INDICATOR SET @ .070 DEFLECTION = 620 KG = 1364#
BOSS-TO-FIXTURE CLEARANCE = .036
BOYD BOLT INSTALLATION SEQUENCE - 1,3,4,2
LOAD INDICATION READ AFTER BOYD BOLT TIGHTENING.
RELEASE SEQUENCE 1,3,2,4
[illegible] PHOTOS IDENTIFIED AS - SERIES II D1, RELEASED 1,3,2,4 TOT. LOAD 1364#
COMMENT #1 - "STILL ACCEPTABLE"
#3 SAME
#2 SAME.
#4 "NEGLIGABLE FORCE"

TORQUE ON BOYD BOLTS #1 - 44 IN # , #3 - 45 IN # , #4 - 18 IN #
#2 [illegible]

LSG BOYD BOLT ENGINEERING TEST | ACCOUNT NO 73007-15 | PAGE 4 OF 6
SERIES II TEST - RUN 7 | NAME [signature] | DATE 7/20/71

BOSS-TO-FIXTURE CLEARANCE WITH B.B. SPRING LOAD ONLY = .096 AVERAGE

LOAD INDICATOR SET @ .081 DEFLECTION = 725 KG = 1600 #

BOSS-TO-FIXTURE CLEARANCE = .024

BOYDE BOLT INSTALLATION SEQUENCE 1,3,4,2

LOAD INDICATION READ AFTER BOYD BOLT TIGHTENING.

RELEASE SEQUENCE 1,3,2,4

TORQUE ON BOYD BOLTS #1 - 55 IN-# #2 - 55 IN-# #3 - 63 IN# #4 - 60 IN#

CAMERAS PHOTOS IDENTIFIED AS - SERIES II D 1, RELEASED 1,3,2,4 TOT. LOAD 1600 #

COMMENT #1 - "NOISY BUT STILL ACCEPTABLE"

#3 - SAME

#2 - SAME (WIDE ANGLE CAMERA NOT WOUND)

#4 - "NEGLIGABLE FORCE"

LSG BOYD BOLT ENGINEERING TEST | 73007-15 | 5 | 6
SERIES II. TEST - RUN 8 | [illegible] | DATE 7/21/71

ALL BOYD BOLTS & ~~RECEPTACLES~~ NUTS REPLACED WITH NEW ONES. BOLT INSTALLATION ACCOMPLISHED BY PRELOADING WITH 1/4-20 BOLTS IN PLACE OF BOYD BOLTS. 1/4-20 BOLTS REPLACED WITH BOYD BOLTS & BOYD BOLTS TIGHTENED TO REQUIRED LEVEL IN SINGLE STEP.

BOSS-TO-FIXTURE CLEARANCE: BOLTS FINGER TIGHT = .095 AVERAGE (.091-.100)

LOAD INDICATOR SET @ * DEFLECTION = 930 KG. = 2044 #

BOSS-TO-FIXTURE CLEARANCE = #1-.017, #2-.018, #3-~~.018~~ .008, #4-.015

BOYD BOLT INSTALLATION SEQUENCE 1,3,4,2

LOAD INDICATION READ AFTER BOYD BOLT TIGHTENING

TORQUE ON BOYD BOLTS #1 = 73 IN-LB, #2 = 70 IN-LB, #3 = 63 IN-LB, #4 = 75 IN-LB

RELEASE SEQUENCE - 1, 3, ~~4~~ 2, ~~2~~ 4

CAMERAS PHOTOS IDENTIFIED AS - SERIES II D, 1 RELEASED 1, 3, ~~4~~ 2, ~~2~~ 4 TOTAL LOAD 2044 #

COMMENTS #1 "SPECTACULAR BUT ACCEPTABLE" (CUP & WASHERS FLEW OFF WHEN TOOL WAS EXTRACTED)

#3 "ACCEPTABLE"

~~#2~~ #2 SAME (** BOLT #4: SIDE OF GRAVIMETER RAISED 1/8 INCH OFF BASE PLATE)

(2 CAMERAS) #~~2~~4 "NEGLIGABLE FORCE" (BOLT TURNED TOO FAR FIRST PASS - BOLT DID NOT RELEASE - RELEASE ACCOMPLISHED BY TURNING IN REVERSE DIRECTION.)

RELEASE TORQUE MEASURED WITH TORQUE WRENCH (0-75 IN-LB RANGE)

BOLT NO 1. = 6 IN LB FOR 15° THEN STARTED TO DECREASE.

BOLT #1 WAS PARTIALLY RELEASED TO CHECK RELEASE TORQUE.

FASTEX CAMERA TIMING MARKS 1 MILLISECOND APART.

* CLEARANCE BETWEEN PIN & GAGE SURFACE - .002 - CLEARANCE FOR 2000 LB LOAD = .003.

** REMOVING BOLTS 1 & 2 PERMITS SUN SHADE TO SWING OUT 2¼" AND GRAVIMETER RETURNS TO NORMAL POSITION.

D.H. Wilson 7/21/71

454 BOYD BOLT ENGINEERING TEST	ACCOUNT NO. 73007-15	PAGE 6	OF 6
SERIES II TEST - RUN 9 (ALTERNATE SEQUENCE)	NAME Dul	DATE 7/21/71	

ALL BOYD BOLTS REMOVED. & 1/4-20 BOLTS INSTALLED FOR PRELOAD.

BOSS-TO-FIXTURE CLEARANCE - BOLTS FINGER TIGHT = .096 (.090-.101)

LOAD INDICATOR SET @ HIGH LIMIT DEFLECTION = KG = 2000 #

BOSS-TO-FIXTURE CLEARANCE = #1=.015, #2=.015, #3=.015, #4=.015

BOYD BOLT INSTALLATION SEQUENCE 3,4,2 - 1/4-20 LEFT IN #1

1/4-20 REMOVED FROM POSITION #1 & REPLACED WITH LOOSE BOYD BOLT.

LOAD INDICATION READ AFTER BOYD BOLT INSTALLATION,

TORQUE ON BOYD BOLTS # 3= ? , #4= OVER 75 IN-LB, #2= ?

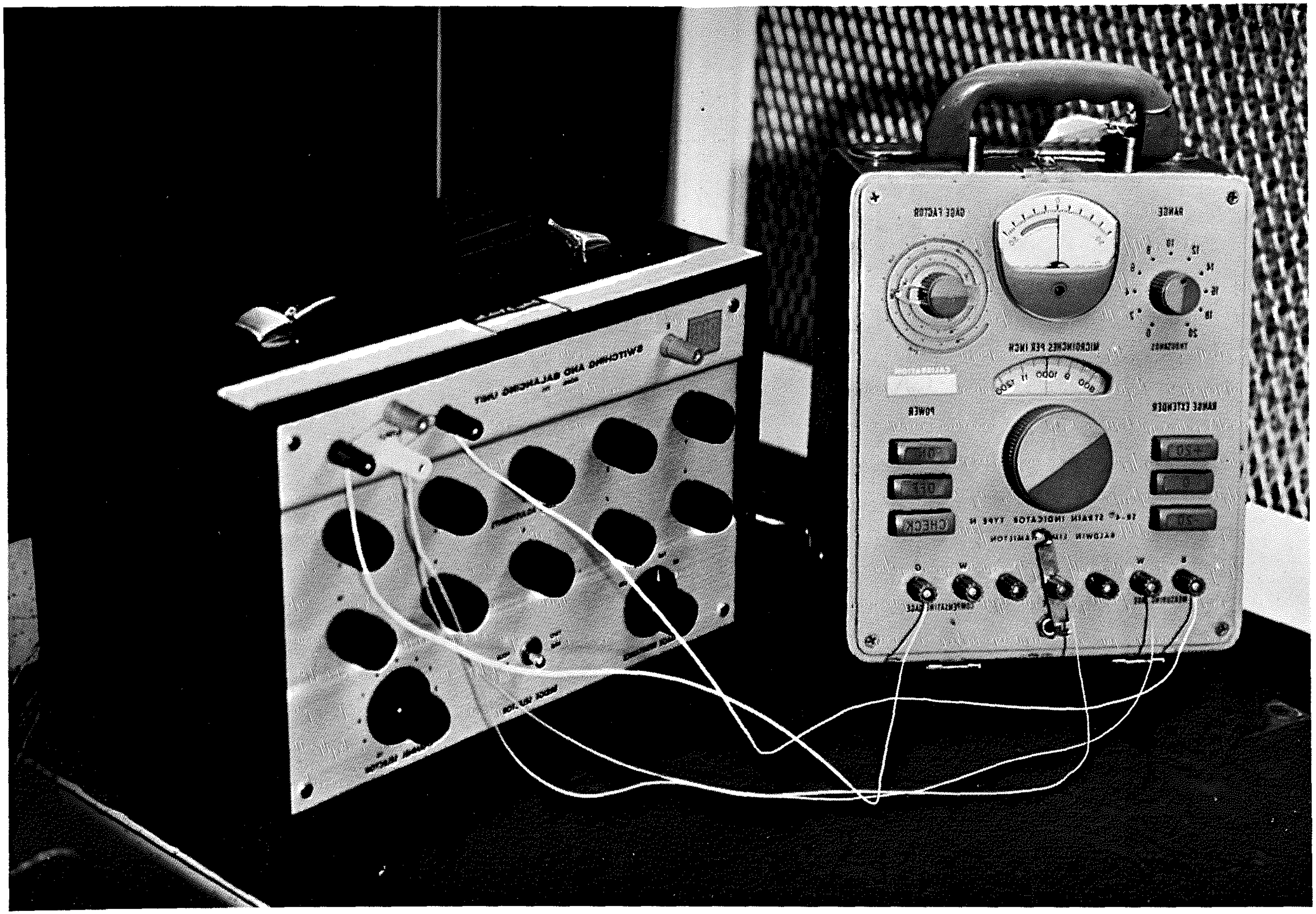
RELEASE SEQUENCE 2, 3, 4

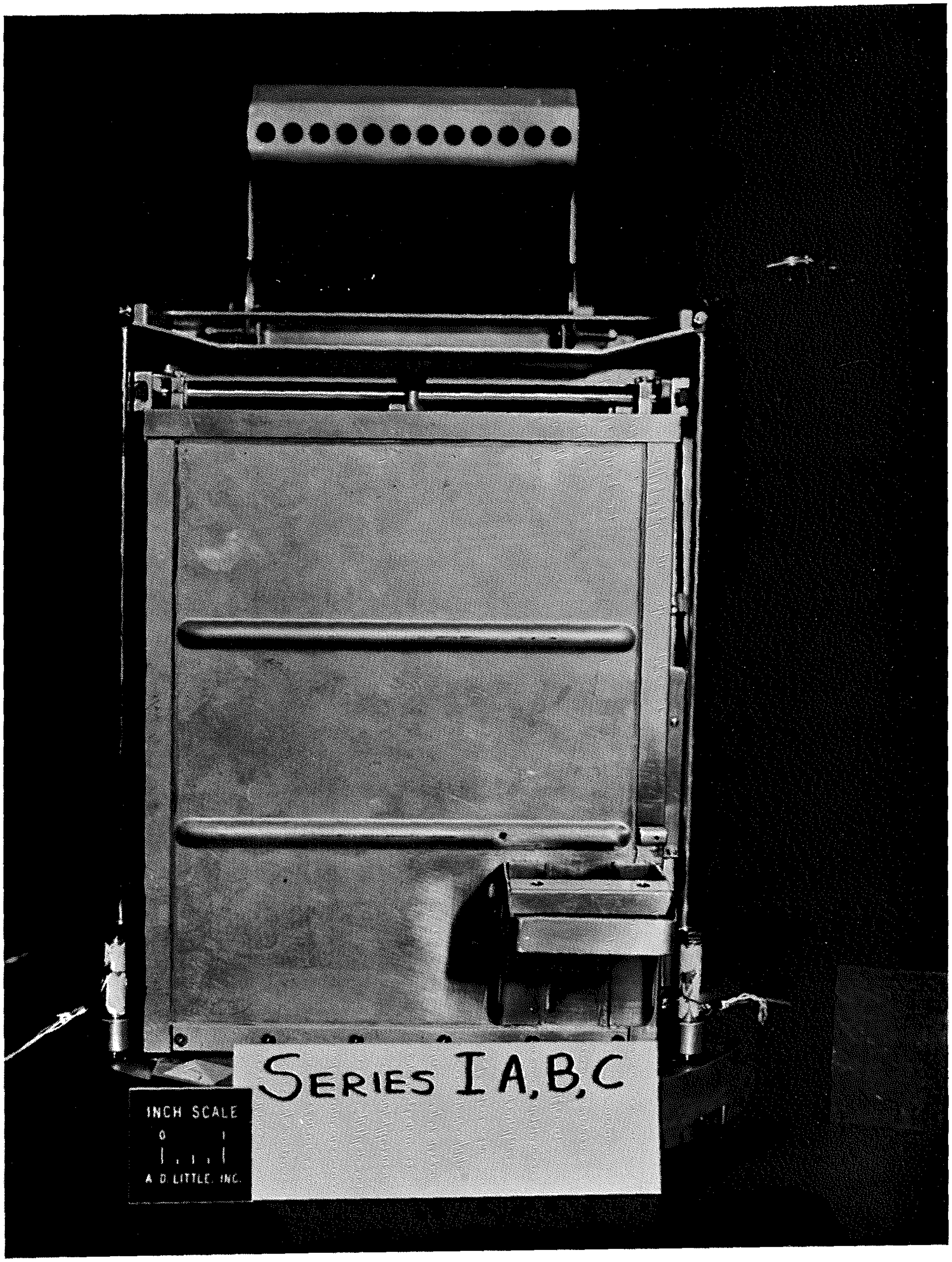
PHOTOS IDENTIFIED AS, SERIES II D, 2 - RELEASED 1,2,3,4 - TOTAL LOAD 2000#

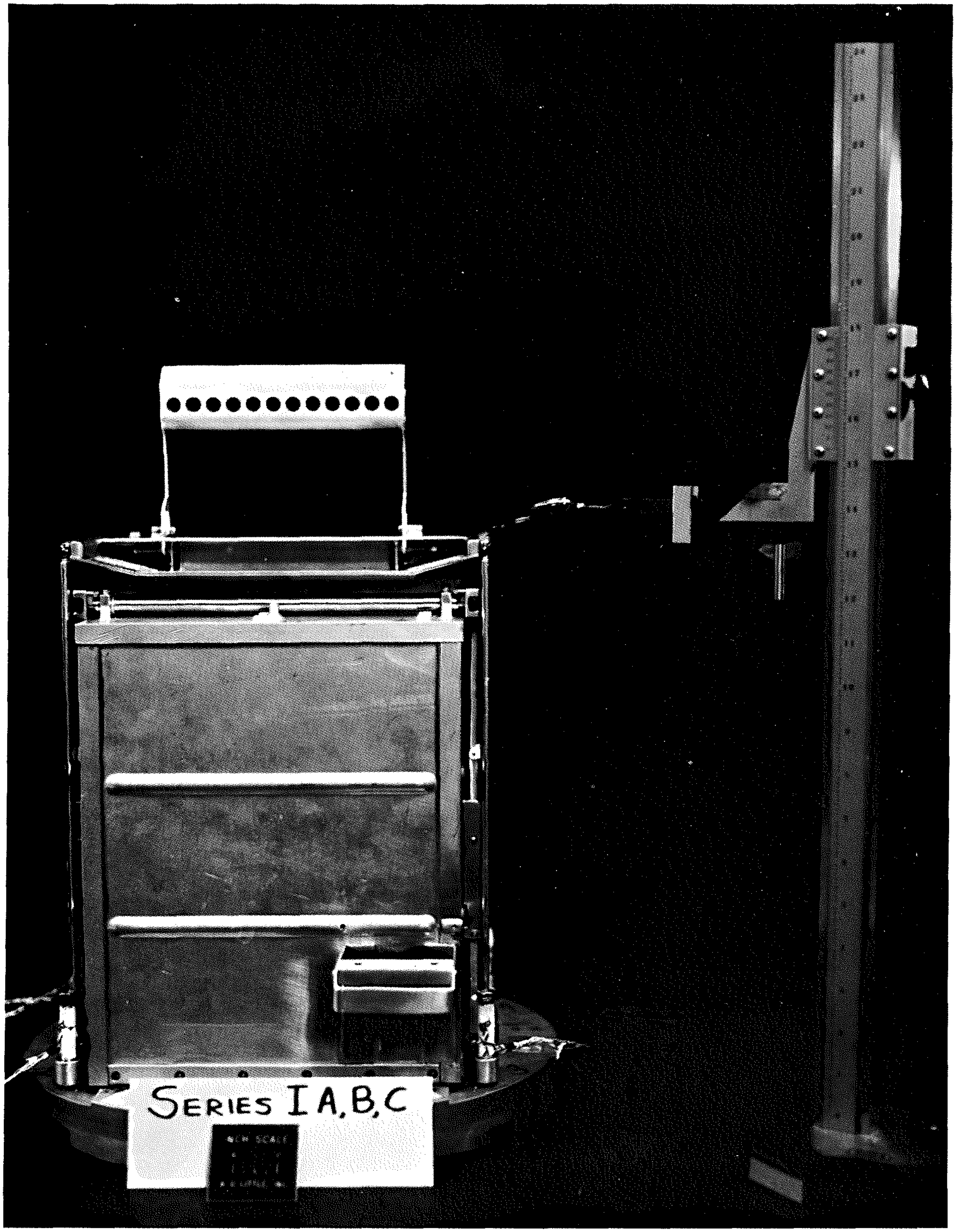
CAMERAS COMMENT #2 "ACCEPTABLE" (GRAVIMETER LIFTED, ON BOLT 1 & 2 SIDE, 3/16 INCH ABOVE BASE PLATE)

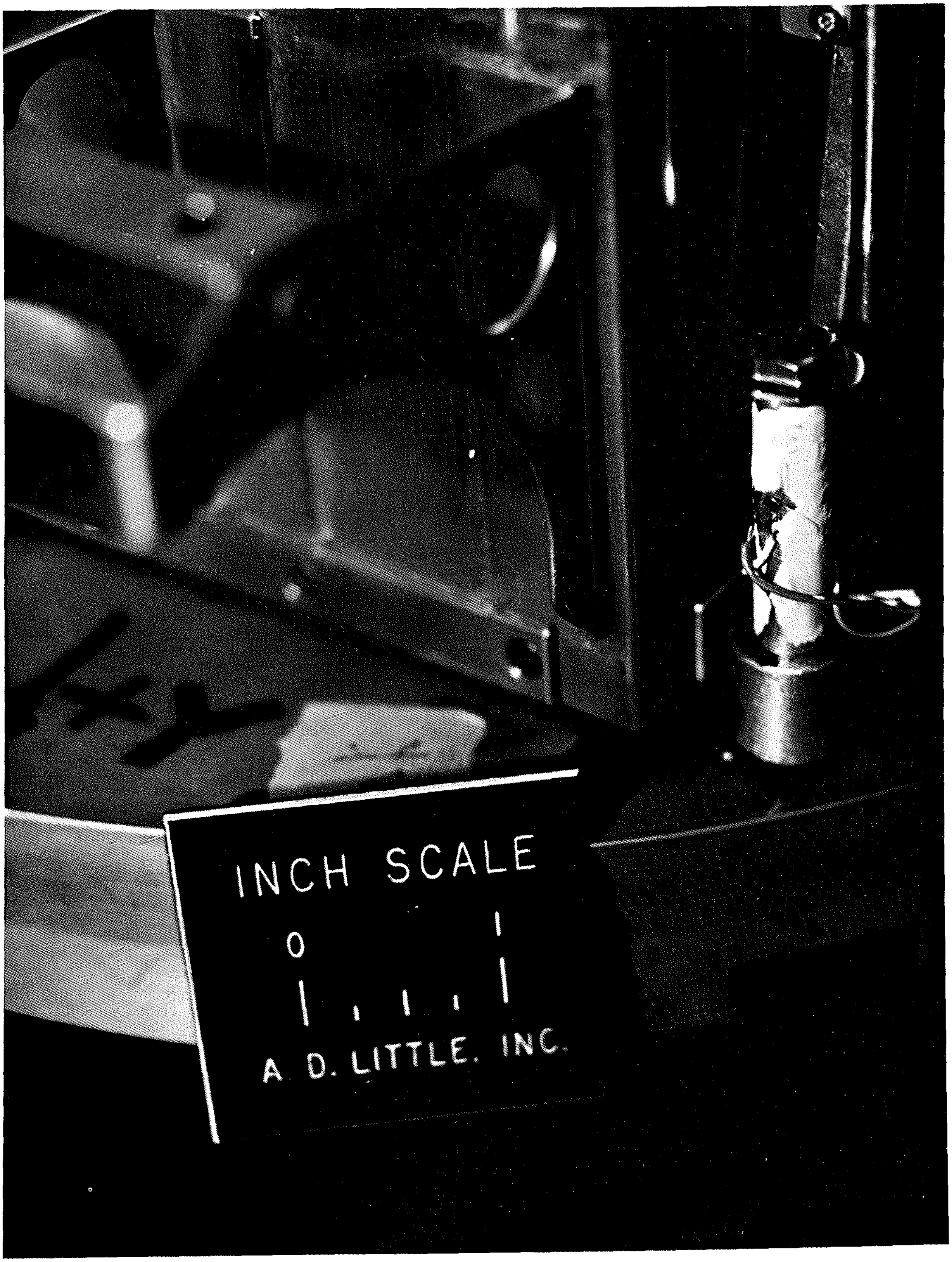
#3 NO SIGNIFICANT FORCE (GRAVIMETER LOWERED BY 1/32 TO 5/32 ABOVE BASE PLATE)

#4 NEGLIGABLE FORCE (GRAVIMETER RETURNED TO NORMAL POSITION)


SWITCHING AND BALANCING UNIT
GAGE FACTOR
RANGE
THOUSANDS
MICROINCHES PER INCH
POWER
RANGE EXTENDER
ON
OFF
CHECK
+20
0
-20
STRAIN INDICATOR TYPE N


SERIES I A,B,C
INCH SCALE
0 1
A D LITTLE, INC.


SERIES I A,B,C


INCH SCALE
0
1
A. D. LITTLE, INC.