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Revision _____
Release Date DEC 5 1972

NASA CR-
140347

QUALIFICATION TEST REPORT
BUMP PROTECTION HAT
(SUBASSEMBLY OF
T020/M509 HEAD PROTECTIVE ASSEMBLY)

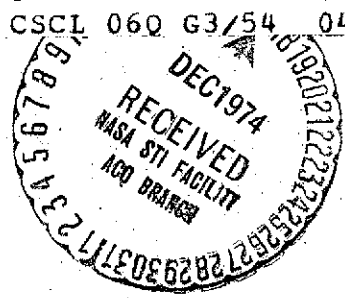
CONTRACT NAS 9-11905

TYPE II DOCUMENT

DRL T-706, LINE ITEM 61

(NASA-CR-140347) QUALIFICATION TEST REPORT BUMP PROTECTION HAT (SUBASSEMBLY OF T020/M509 HEAD PROTECTIVE ASSEMBLY) (General Electric Co.) 39 p HC \$3.75
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04254

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D. B. Willis
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APPROVED BY: G. E. Wood 12/1/72
G. E. Wood
Project Manager



GENERAL ELECTRIC
APOLLO AND GROUND SYSTEMS
HOUSTON PROGRAMS
Houston, Texas

ABSTRACT

The BPH (Bump Protection Hat), P/N 793-102, S/N 1001, was subjected to impact testing in accordance with QTP-72-1037, Qualification Test Procedure, and GE-TPS-C-010. The BPH underwent three impacts at 35 foot-pounds of energy. The impacts generated stress cracks, but no penetration. All impacts resulted in deflections of less than one-half inch.

The BPH successfully passed the testing and is considered to be qualified for Skylab and the Rescue Vehicle.

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1.0 INTRODUCTION

In accordance with QTP-72-1026, Qualification Test Plan for Skylab T020/M509 Head Protective Assembly, the only test required to qualify the assembly is to perform impact testing on the BPH (Bump Protection Hat). This report documents the performance of the required impact test.

Testing was performed in accordance with QTP-72-1037, Impact Test Qualification Test Procedure for the BPH (see Appendix A). Testing was performed on GE-TPS-C-010 (Appendix B). One deviation was made to the test procedure. Figure 3 of the test procedure called for impacts to be performed on one side, the front, and the back of the helmet. The actual impacts were performed on one side, the front, and the top of the helmet. The top was impacted instead of the back for two reasons: (1) It was felt that a top impact would be more realistic than a back impact. (2) The test facility would have to be modified to perform a back impact.

Testing was performed on the side and top of the helmet on October 30, 1972. The pendulum then had to be modified in order to perform the front impact. Front impact was performed November 16, 1972.

2.0 TEST APPARATUS

The test equipment is shown in Figures 1 and 2 of the test procedure (Appendix A). Photographs number 1, 4, and 8 of Appendix C show the test setup for the three impacts performed. The stop watch used during testing was not calibrated, as indicated on the Test Summary Sheet (Attachment A of QTP-72-1037).

3.0 PROCEDURE

Test procedures were according to QTP-72-1037 (Appendix A) and GE-TPS-C-010 (Appendix B).

4.0 RESULTS

All three impacts caused stress cracks on the outside of the BPH. The side impact also caused stress cracks on the inside of the BPH. There were no stress cracks on the inside of the BPH for the top and front impacts. Analysis of the side impact cracks showed that the outside stress cracks were not the same as the inside cracks, hence, there was no penetration of the helmet. All cracks were acceptable according to the pass-fail criteria of QTP-72-1026.

4.0 RESULTS (Continued)

Analysis of the high-speed film for shell deflection showed the following results for the three impacts:

- a. Side Impact - Less than $3/8$ " deflection, though the exact amount could not be determined.
- b. Top Impact - Approximately $3/8$ " deflection.
- c. Front Impact - Less than $1/2$ " deflection, though the exact amount could not be determined because the impact was a glancing blow.

Maximum allowable deflection was $1/2$ ". All three deflections were within the allowable amount.

One DR was generated at post-test on the stress cracks (Appendix B). No FIAR's were generated. The DR is closed.

5.0 CONCLUSIONS

All three impacts successfully passed the test from the standpoint of both cracks and deflection.

It was agreed by the Test Conductor, Technical Monitor, and NASA Quality Control that the stop watch not being calibrated was no problem. Stop watches are normally not calibrated for such tests. Human reflex error is a much more significant factor in timing the period of oscillation.

The top of the helmet being impacted instead of the back is considered valid for the following reasons:

1. A top impact is much more likely than a back impact.
2. It was originally not required to impact the top. It was agreed by the test parties that a top impact is desirable.
3. The back area of the helmet is similar to the front area, which was impacted.
4. Side impact is the most severe since there is no liner in the impacted area to absorb part of the energy.

The BPH successfully completed qualification testing for Skylab and Rescue Vehicle.

APPENDIX A

TEST PROCEDURE
TEST SUMMARY SHEET
TEST DATA SHEETS

IMPACT TEST
QUALIFICATION TEST PROCEDURE
FOR SKYLAB
BUMP PROTECTION HAT
P/N 793-102

CONTRACT NAS 9-11905

Type I Document

DRL T-706, Line Item 63

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PREPARED BY: D. B. Willis 10/19/72
D. B. Willis
Product Engineer

APPROVED: Ralph J. ... 10/19/72
Technical Monitor

APPROVED: G. E. Wood 10/19/72
G. E. Wood
Project Manager

APPROVED: Medwin E. Lawrence 10-19-72
Branch Chief

APPROVED: Larry E. Bell 10/19/72
Chief, Crew Systems Division

APPROVED: 105/... 10/19/72
Quality Engineering

GENERAL ELECTRIC
APOLLO & GROUND SYSTEMS
HOUSTON PROGRAMS
Houston, Texas

DOCUMENT CHANGE/REVISION LOG

OCT 19 1977
Date

Chg No	Change Authority	Pages Affected	Change Description	CEI S/N

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Document No. QTP-72-1037
Revision _____
Date OCT 10 1977
Page 2 of 8

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1.0 INTRODUCTION

This document details the procedure for subjecting the BPH (Bump Protection Hat) to impact testing according to QTP-72-1026, Qualification Test Plan for Skylab TO20/M509 Head Protective Assembly.

2.0 PURPOSE

The purpose of the test is to determine the shock absorbing characteristics of the BPH when impacted with a fixed hemispherically shaped anvil. The impact shall be at 12 ft./sec. with a mass of 0.48 slugs, according to QTP-72-1026, or an equivalent energy of 35 foot pounds. High speed photography shall be used to determine the shell deflection during impact.

3.0 APPLICATION

Any discrepancies, difficulties, replacement of components, deviations from procedures, etc., experienced during the test shall be documented on the Test Summary Sheet (Attachment A). The Test Conductor and the MSC Inspector shall sign the Test Summary Sheet. Any DR's or FIAR's generated shall be written in accordance with paragraph 5.6.2 of QTP-72-1026. Deviations from procedure shall be indicated on the Test Data Sheet (Attachment B).

4.0 REQUIREMENTS AND TEST PREPARATIONS

4.1 TEST EQUIPMENT AND FACILITY REQUIREMENTS

The test will be conducted by the special projects laboratory of the Crew Systems Division's Material Development Section. The test apparatus shall be a pendulum and wooden mannequin head assembly as shown in photograph 1.

The test article shall be one Bump Protection Hat, P/N 793-102, S/N 1001.

Support equipment shall include the following:

<u>Item</u>	<u>Part No.</u>	<u>Specification</u>
Communications Carrier	16536G-03 or -04	Class III
Camera	--	400 frames/sec.
Stop Watch	--	Calibrated
Grid	--	$\frac{1}{8}$ " squares or less

4.2 TEST EQUIPMENT VALIDATION

Prior to start of the test, a receiving inspection shall be performed on the BPH to assure no damage. The camera and stop watch shall be verified to be calibrated and functioning properly.

4.3 SAFETY PRECAUTIONS AND SPECIAL HANDLING

There are no special safety precautions involved in this test. Caution should be exercised while handling the BPH, camera, and stop watch to prevent damage to the hardware.

4.4 TEST SETUP

The test equipment shall be set up as shown in Figures 1 and 2. The Communications Carrier shall be placed on the mannequin head and the BPH strapped over the Communications Carrier.

NOTE: Adjust the BPH suspension system to the mannequin head size.

4.5 TEST SETUP VALIDATION

The MSC Inspector shall verify proper test setup and stamp the Test Data Sheet accordingly, prior to commencing test.

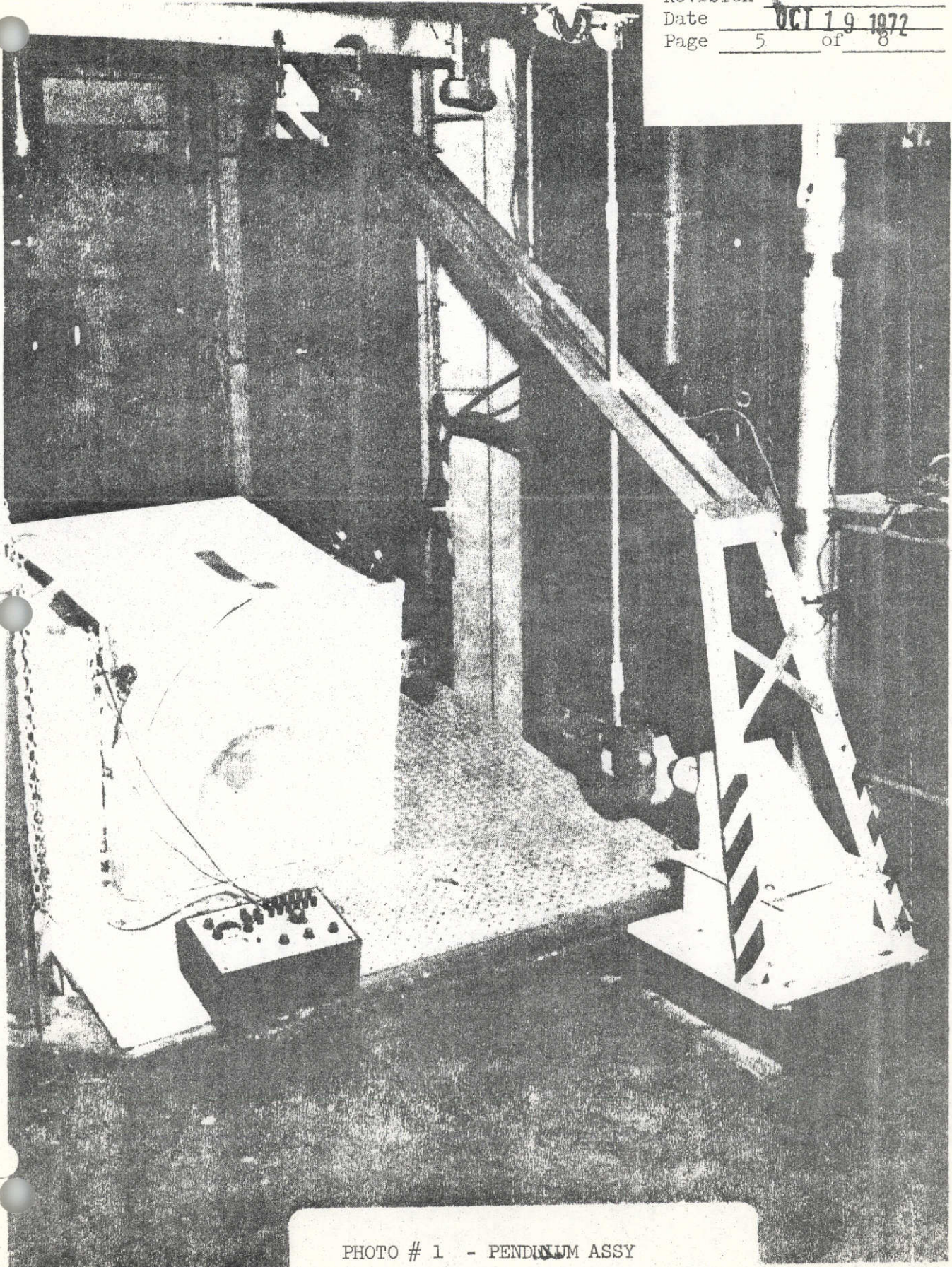
5.0 TEST PROCEDURE

5.1 Prepare pendulum and wooden head assembly per Figures 1 and 2.

5.2 Suspend the impact head with the BPH and Communications Carrier mounted as a pendulum, and determine the period of oscillation. Determine period by swinging the pendulum through an arc of $< 6^\circ$ and timing the period through 10 oscillations, using the stop watch to time.

5.3 Calculate the center of percussion of the impact assembly by the following formula: $L = gt^2 / (2\pi)^2$ where L is the length from the pivot point to center of percussion, g is acceleration due to gravity, and t is the period of oscillation of the pendulum. (See Figure 1.)

- 5.4 Weigh and record weight of the impact assembly with the BPH and Communications Carrier mounted on the head.
Weight _____
- 5.5 Calculate the release angle required for a 35 foot-pound impact by the following formulas:
- $E = mgh$ where m is the mass of the impact assembly, g is the acceleration due to gravity, and h is the vertical height when the center of percussion is raised.
 - $\theta = \cos^{-1} \left(\frac{L-h}{L} \right)$ where L and h are defined in 5.3 and 5.5 respectively.
- 5.6 Orient the impact assembly such that region 1 of Figure 3 will be impacted.
- 5.7 Pull impact assembly back to the desired release angle as calculated in step 5.5.
- 5.8 Begin countdown of 5-4-3-2-1 - Release. Turn camera on at count of 2.
- 5.9 Impact helmet. Do not let helmet strike the anvil more than once. Stop camera.
- 5.10 Orient the impact assembly such that region 2 of Figure 3 will be impacted.
- 5.11 Repeat steps 5.7 through 5.9.
- 5.12 Orient the impact assembly such that region 3 of Figure 3 will be impacted.
- 5.13 Repeat steps 5.7 through 5.9.
- 5.14 Remove the BPH and inspect for damage. Pass-fail criteria for the BPH is defined in paragraph 6.3.2.2.3 of QTP-72-1026.



NSA
FORM-17-72

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PHOTO # 1 - PENDULUM ASSY

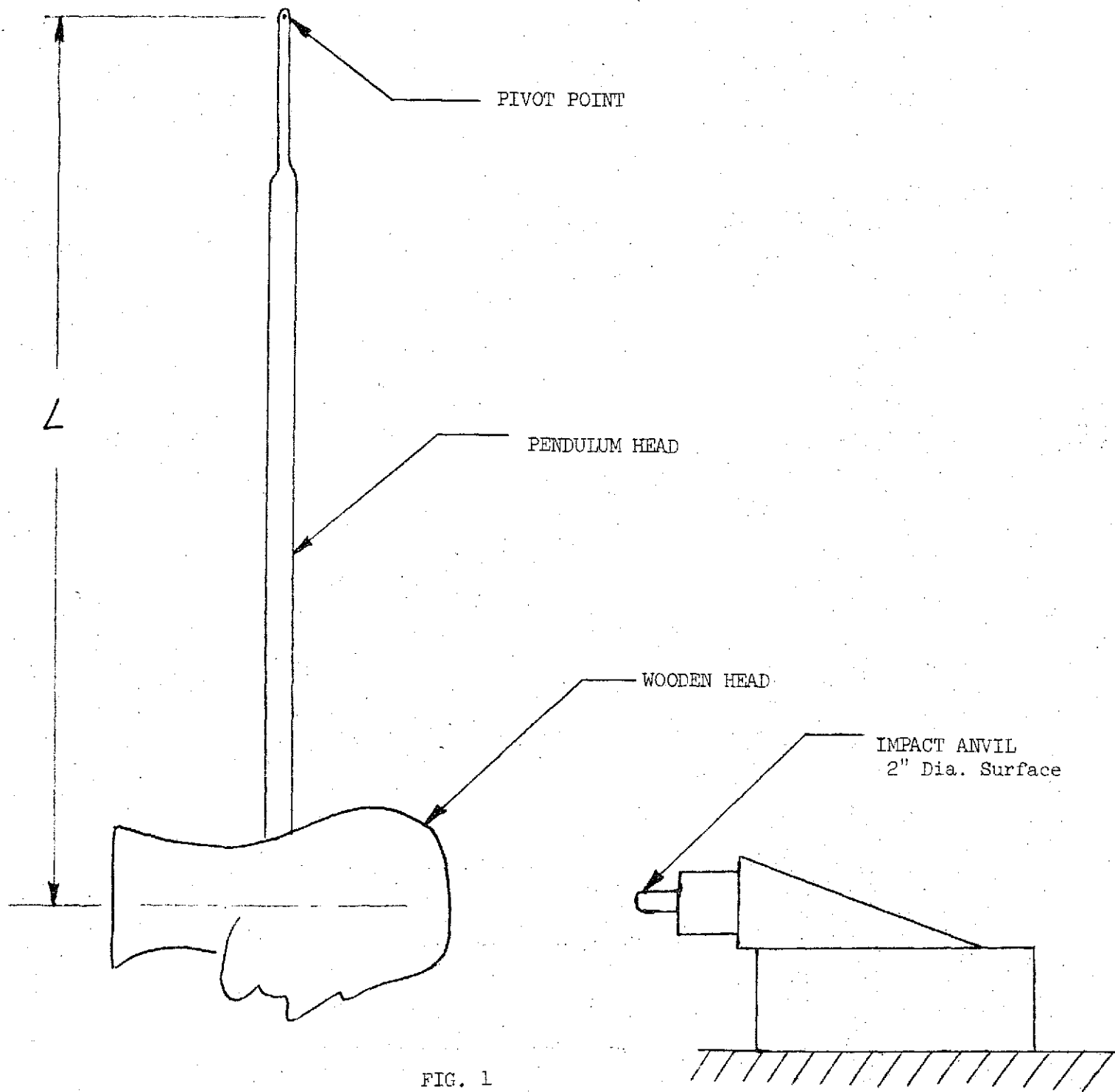
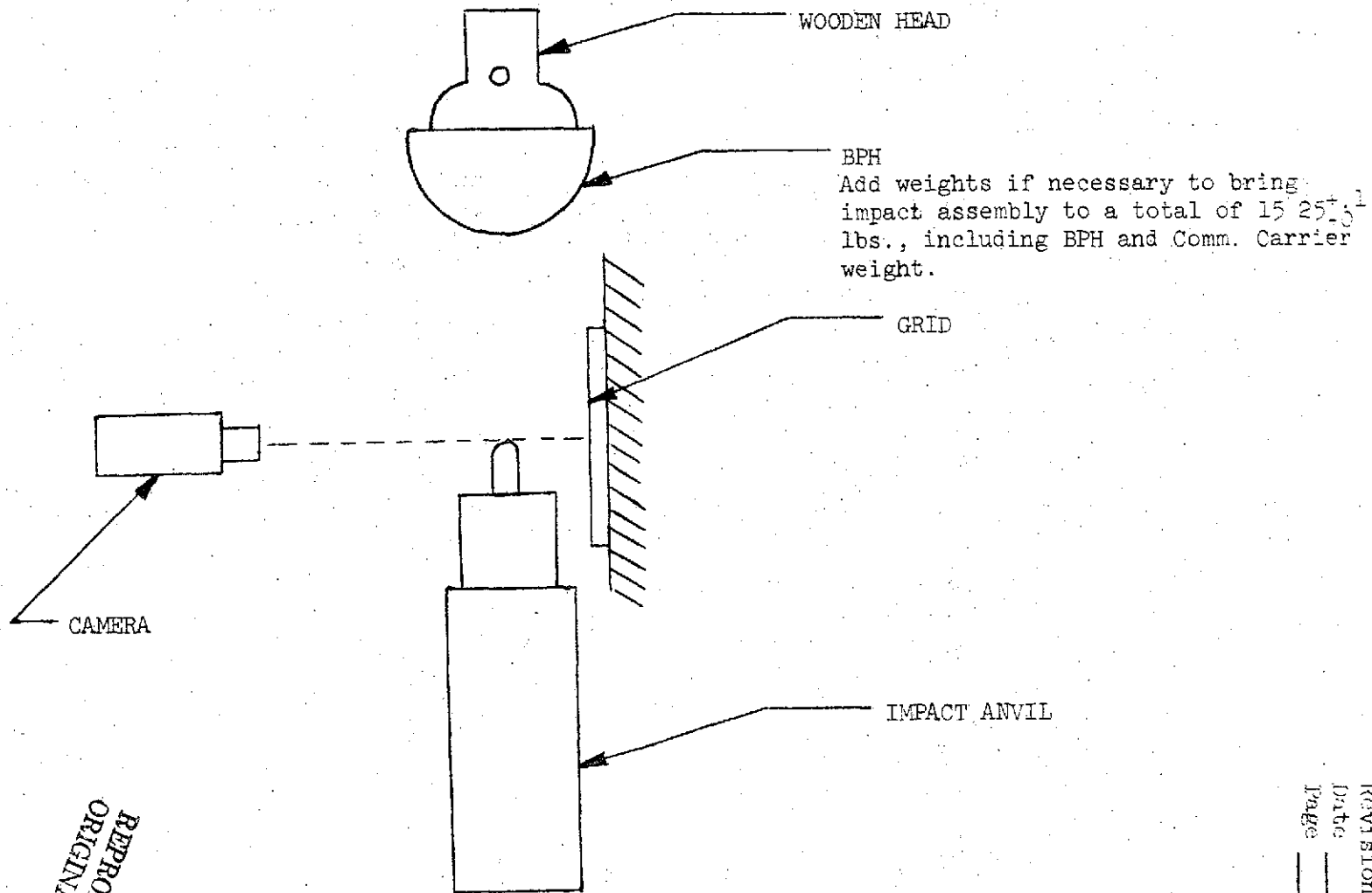


FIG. 1



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FIG. 2

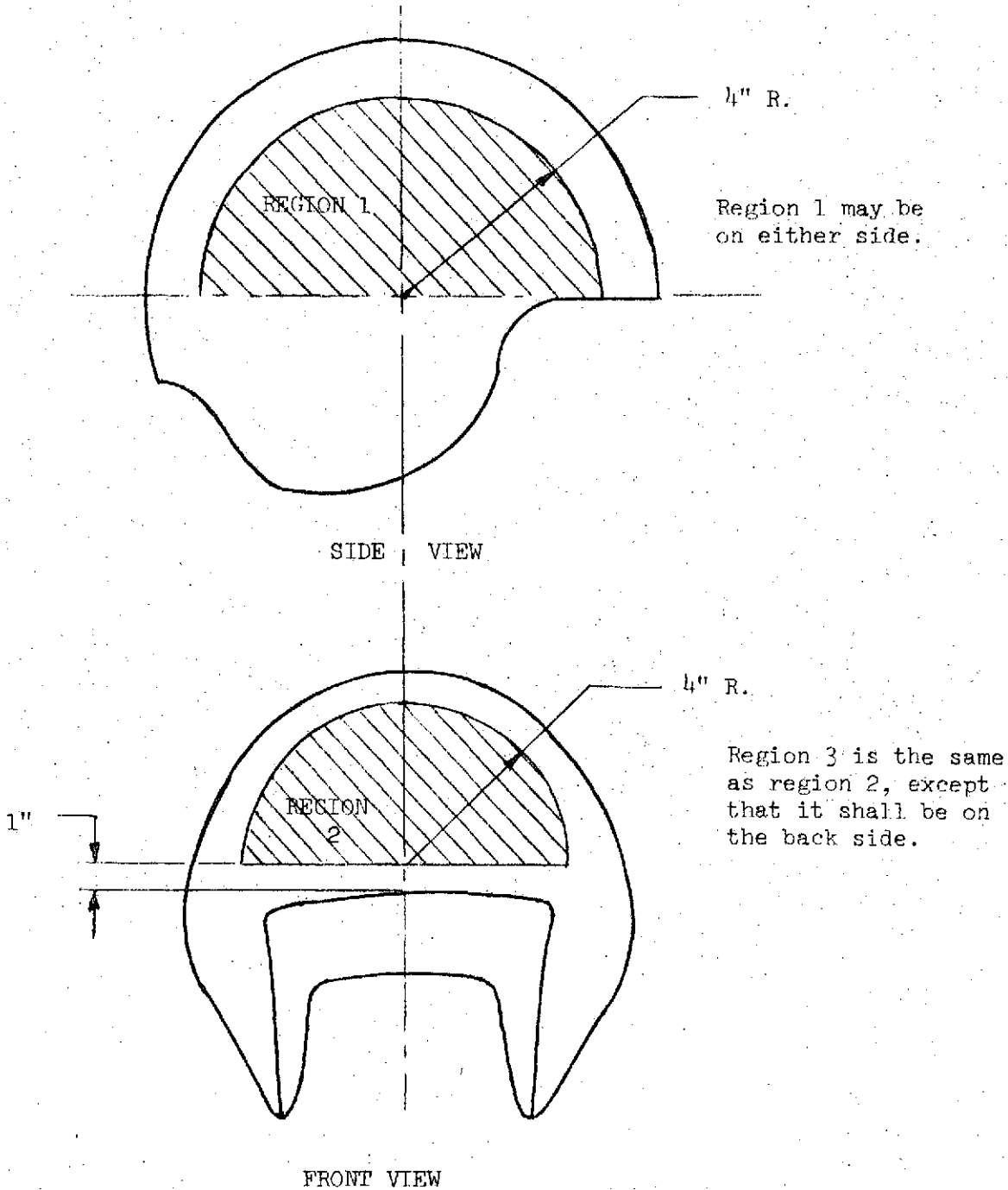


Figure 3

TEST SUMMARY SHEET
FOR
IMPACT TEST OF BUMP PROTECTION HAT

1. Test Hardware P/N 793-102
Test Hardware S/N 1001
Date Test Performed 10/30/72



2. Indicate Test Procedure deviations below:

- a. Stop watch not calibrated.
- b. Region three on Fig 3 replaced by a top of helmet impact (see TPS 6E-TPS-C-010)



3. Indicate DR's generated during test below:

NASA-060 11/16/72



4. Indicate FIAR's generated during test below:

None



5. Additional test data information:

None



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6. With the exceptions noted above, the test was successfully performed according to the procedures of QTP-72-1037, Impact Test Qualification Test Procedure for Skylab Bump Protection Hat.

D. B. Willis 11/27/72
Test Conductor

Adm for L. Dotson
MSC Quality Inspector

TEST DATA SHEET

Attachment B

TITLE Qual Test Procedure	END ITEM NOMENCLATURE Bump Protection Hat	DATE 10/30/72
DOCUMENT NUMBER QTP-72-1037	PART NO 793-102	REV —
	SERIAL NO 1001	Page 1 of 1 Pages

PARA	PROCEDURE	TECH	INSP	NASA
------	-----------	------	------	------

4.2 Receiving Inspection performed on BPH.
Condition satisfactory.

BPH P/N 793-102
BPH S/N 1001

4.2 Support equipment calibrated and functioning properly.

4.5 Test setup verified proper.

5.2 Period of oscillation determined. Period is 2.48 seconds.

5.3 Center of percussion determined. L is 5.01 ft.

5.4 Weight of impact assembly is 15.25 lbs. including BPH, Communication Carrier.

5.5 Release Angle = 57 degrees.

5.6 BPH oriented for region 1.

5.9 BPH impacted for region 1.

5.10 BPH oriented for region 2. (As specified on)

5.11 BPH impacted for region 2. (GE-TPS-C-010) Saw

5.12 BPH oriented for region 3.

5.13 BPH impacted region 3.

5.14 BPH inspected for damage. Record any DR's generated at Post-Test here.

DR# NASA-060 11/16/72

Record any FIAR's generated at Post-Test here.

NONE

TEST DATA SHEET

Attachment B

TITLE Qual Test Procedure		END ITEM NOMENCLATURE Bump Protection Hat		DATE 11/16/72	
		PART NO 793-102		REV	
DOCUMENT NUMBER QTP-72-1037		SERIAL NO 1001		Page 1 of 1 Pages	
PARA	PROCEDURE	TECH	INSP	NASA	
4.2	Receiving Inspection performed on BPH. Condition satisfactory. BPH P/N <u>793-102</u> BPH S/N <u>1001</u>			11/16/72	
4.2	Support equipment calibrated and functioning properly.			11/16/72	
4.5	Test setup verified proper.			11/16/72	
5.2	Period of oscillation determined. Period is <u>2.46</u> seconds.			11/16/72	
5.3	Center of percussion determined. L is <u>4.95</u> ft.			11/16/72	
5.4	Weight of impact assembly is <u>15.25</u> lbs. including BPH, Communication Carrier.			11/16/72	
5.5	Release Angle = <u>58</u> degrees.			11/16/72	
5.6	BPH oriented for region 1.			11/16/72	
5.9	BPH impacted for region 1.			11/16/72	
5.10	BPH oriented for region 2.			11/16/72	
5.11	BPH impacted for region 2.			11/16/72	
5.12	BPH oriented for region 3. (Region 2 of Fig. 3) <i>ABW</i>			11/16/72	
5.13	BPH impacted region 3.			11/16/72	
5.14	BPH inspected for damage. Record any DR's generated at Post-Test here. <u>DR # NASA-060 11/16/72</u> <u>NONE</u>			11/29/72	
	Record any FIAR's generated at Post-Test here. <u>None</u>			11/29/72	

APPENDIX B

TPS'S
DR'S

I T Y P E	A	Configuration Change	X	11/15/72	TEST PREPARATION SHEET NASA - MANNED SPACECRAFT CENTER	2. TPS No.	GE-TPS-C-010	
	B	Non-Configuration Change	X			3. S/C	Cat.	No.
4. Mod. Sheet Number						5. Page 1 of 3		
6. S/C No./Model No.			7. Date	8. Time	9. Need Date			
10. Drawings, Documents, Ocp's, & Part Number(s)			10/27/72		10/30/72			
13. System			16536G-03		11. Contract Number			
15. TPS Short Title			Skylab Bump Protection Hat		NASA-11905			
17. Reason for Work:			Perform Impact Qual Test		12. Serial Number			
To perform the impact qual test required for the Bump Hat for Skylab					See TPS			
18. DESCRIPTION (Print or Type)					14. Ref. E. O. Number			
1. Contact AC for MIP's					16. Wt. Req.			
2. Release one Bump Protection Hat, P/N 793-102, S/N 1001 from GE Banded Stoves.			10/27/72		21. Insp. Tech. 22. [Stamp]			
3. Transfer the Bump Prot Hat S/N 1001 and one class III Comm Carrier, P/N 16536G-03, S/N 10P to Bldg. 7 Bay Area for impact test.			10/30/72		[Stamp]			
4. Perform the procedures indicated in Document QTP-72-1037, dated Oct 19, 1972, with the following exceptions:					[Stamp]			
a. Region 2 of Fig. 3 of QTP-72-1037 shall be replaced by a region consisting of a 4" radius circular area originating from the top center					[Stamp]			
19. Prepared By			Q. B. Willis		20. Final Acceptance Date			
REFER TO PROCEDURES FOR REQUIRED SIGNATURES			11-29-72		[Stamp]			
Contractor			Date		Date			
[Signature]			10/27/72		[Signature]			
[Signature]			10/27/72		[Signature]			

TEST PREPARATION SHEET

CONTINUATION SHEET

NASA - MANNED SPACECRAFT CENTER

TPS No. **6E-TPS-C-010**
 S/C - Cat. - No. -
 Page **2** of **3**

	DESCRIPTION (Print or Type)	Tech.	Insp.	
			Cont.	NASA
4a.	(Continued) Point of the Bump Hat			
4b.	Delete the region 3 impact (A total of two impacts shall be performed instead of the original three per QTP-72-1037).			MIP
5	At the completion of testing, return the Bump Hat and the Comm Carrier to GE Receiving	see MIP		
6.	Bump Hat S/N 1001 and Comm Carrier S/N 108 received at GE receiving.			MIP
			11/15/72	
7.	Release Bump Hat S/N 1001, P/N 793-102, and Comm Carrier S/N 108, P/N 16536G-03 from GE receiving.			MIP
8.	Transfer Bump Hat S/N 1001 and Comm Carrier S/N 108 to Bldg 7 Bay Area for impact tests		NOV 16 '72	MIP
9.	Bump Hat S/N 1001 and Comm Carrier S/N 108 received at Bldg 7 Bay Area		NOV 18 '72	MIP
10.	Perform the procedures indicated in Document QTP-72-1037, dated Oct. 19, 1972, with the following exception: Perform <u>one</u> impact only, being region 2 of Fig 3 of QTP-72-1037.			MIP

TEST PREPARATION SHEET

CONTINUATION SHEET

NASA - MANNED SPACECRAFT CENTER

TPS No.

GE-TPS-C-018

S/C

Cat.

No.

Page

3

of

3

DESCRIPTION (Print or Type)

Tech.

Insp.

Cont.

NASA

11. At the completion of testing, remove the floral liner as required from the Bump Hat to inspect the impacted areas from the inside. Record any applicable DR's or FIAR's generated as a result of inspection, by entering the numbers in the applicable area of the Test Data Sheet of ATP-72-1037.

MIP
11/16/72
DR# NASA-060

12. Transfer the Bump Hat S/N 1001 and Comm Carrier S/N 108 to GE Receiving.

11/16/72

13. Bump Hat S/N 1001 and Comm Carrier S/N 108 received at GE Receiving.

11/16/72

14. Downgrade Bump Hat S/N 2001 to Class III and place in GE Class III stores.

11/29/72

1. TYPE	A	Configuration Change	X	TEST PREPARATION SHEET NASA - MANNED SPACECRAFT CENTER		2. TPS No.	GE-TPS-C-010(m)	
	B	Non-Configuration Change				3. S/C	Cat.	No.
4. Mod. Sheet Number				5. Page		1 of 1		
6. S/C No./Model No.				7. Date	8. Time	9. Need Date		
				10/30/72	11:00 A.M.	10/30/72		
10. Drawings, Documents, Ocp's. & Part Number(s)						11. Contract Number		
						NAS9-11905		
						12. Serial Number		
						1001		
13. System						14. Ref. E. O. Number		
Skylab Bump Protection Hat						-		
15. TPS Short Title							16. Wt. Req.	
Impact Qual Test							-	
17. Reason for Work:								

18. DESCRIPTION (Print or Type)	21. Insp.		
	Tech.	22. CONT.	23. NAA
1. Contact GC for MIP's	10/30/72		
2. Delete step 4b of original TPS.	10/30/72		
3. Revise step 5 of original TPS to read as follows: At the completion of testing for regimes 1 and 2, return the Bump Hat and the Comm Carrier to GE Receiving and hold until test facility is modified to perform regime 3 test			 11/15/72

19. Prepared By		20. Final Acceptance Date	
D. B. Willis		11-15-72	
REFER TO PROCEDURES FOR REQUIRED SIGNATURES		REFER TO PROCEDURES FOR REQUIRED SIGNATURES	
Contractor	Date	NASA	Date
			10/30/72

1. Category GE		DISCREPANCY REPORT/MATERIAL REVIEW RECORD NASA - MANNED SPACECRAFT CENTER					PAGE 1 OF 1	
2. Article Name Bump Protection Hat		3. Drawing Number 793-102		4. Serial/Lot Number 1001		5. RECORD NUMBER		
6. Contractor's Name GENERAL ELECTRIC		7. Contractor's Drawing Number		8. Contractor's Serial Number		IDR		
9. Supplier's Name SIERRA ENG. Co.		10. Supplier's Drawing Number		11. Supplier's Serial No.		DR/MRR NASA-060		
13. REF. Document No. GE-TPS-C-010		14. Spacecraft N/A	15. Fault N/A	16. Funct. N/A	17. Cause/Origin N/A	18. System N/A	19. Disposition NEED PROTECTION KIT	

DISCREPANCY

REFERENCE STEP # 11 OF GE-TPS-C-010, INSPECTION AFTER IMPACT REVEALED STRESS CRACKS AT ALL THREE IMPACT LOCATIONS.

20. Initiator's Signature Coy A. Martin		21. Stamp Number 126 M	22. Organization and Location of Initiator NASA Q.A./GE-745		23. Date 11/16/72	
---	--	----------------------------------	---	--	-----------------------------	--

DISPOSITION

24. MR Action Required? <input checked="" type="checkbox"/> YES <input type="checkbox"/> No	25. Replacement Part Number	26. Retest Required <input type="checkbox"/> Yes <input type="checkbox"/> No	27. Retest Accept Date	28. FIAR Number	
--	-----------------------------	---	------------------------	-----------------	--

29. MRB Decision <input type="checkbox"/> USE "AS IS" <input type="checkbox"/> REPAIR <input type="checkbox"/> REWORK <input type="checkbox"/> SCRAP	INSTRUCTIONS					QC STAMP CONT. NASA	
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1. Pass-fail criteria in the Qual Test Plan, QTP-72-1026, para. 6.3.2.2.3, states that stress cracks are acceptable, but penetration cracks are not. None of the cracks penetrated the helmet. Hence the cracks are acceptable for passing qual. Qualification testing is complete. Downgrade the Bump Hat to class III per TPS GE-TPS-C-010.

QBW.

30. DATE 11/29/72	FINAL ACCEPTANCE
--------------------------	-------------------------

MRB APPROVAL SIGNATURES

31. System Engineer (Contractor) D. S. Willes	DATE 11/29/72	32. System Engineer (NASA) <i>Per Delcom</i> Ralph M. ...	DATE 11/29/72
33. Quality Control Rep. (Contractor) J. H. ...	DATE 11/29/72	34. Quality Control Rep. (NASA) Coy A. Martin	DATE 11/29/72
35. Program Office Rep. (Office Code)	DATE	36. Quality Engineer (NASA) <i>Per Delcom</i> Don Rathburn	DATE 11/29/72

APPENDIX C

PHOTOGRAPHS

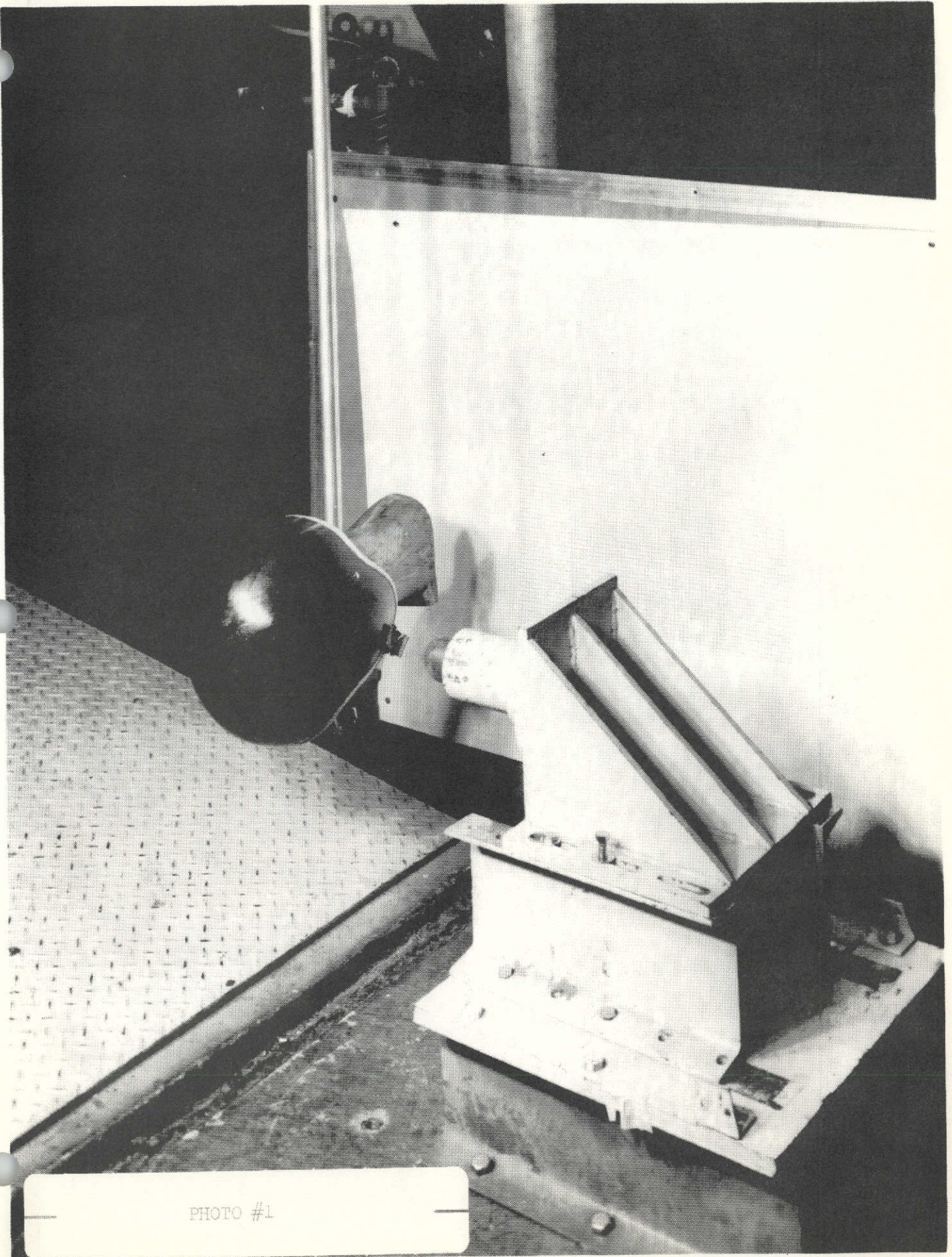
PHOTOGRAPH DESCRIPTIONS BY NUMBER

1. Test Setup for Side Impact
2. Side Impact Viewed from outside helmet
3. Side impact viewed from inside helmet
4. Test setup for top impact
5. Top of helmet viewed prior to impact
6. Top of helmet after impact (magnified 3 times)
7. Top inside of helmet after impact
8. Test setup for front impact
9. Front of helmet viewed prior to impact
10. Front of helmet after impact
11. Front inside of helmet after impact

NOTE: All high-speed film taken to determine deflection is in file at General Electric.

NASA
S-72-51945

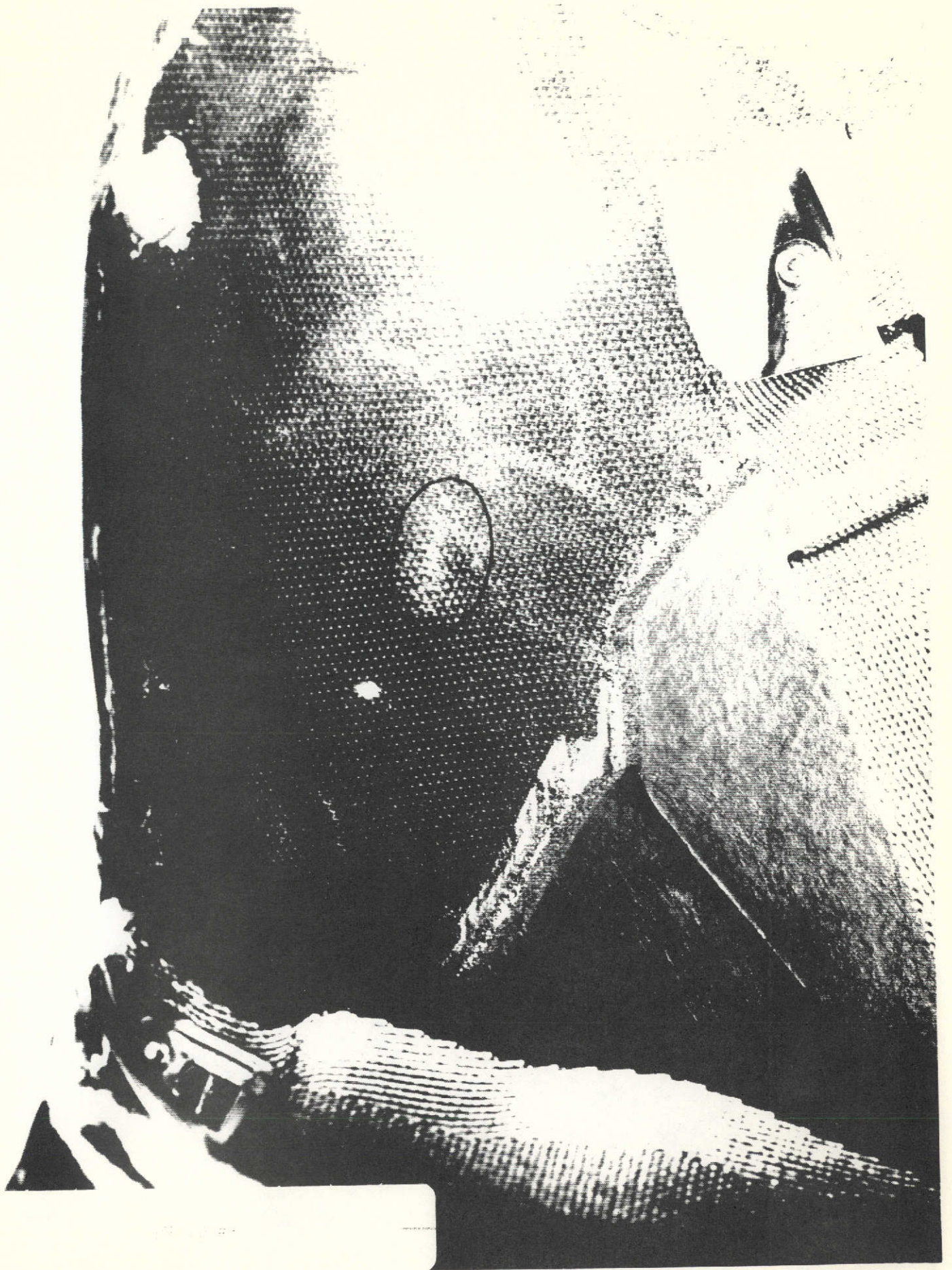
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NASA
S-72-51949



NASA
S-72-51947



NASA
S-72-51948

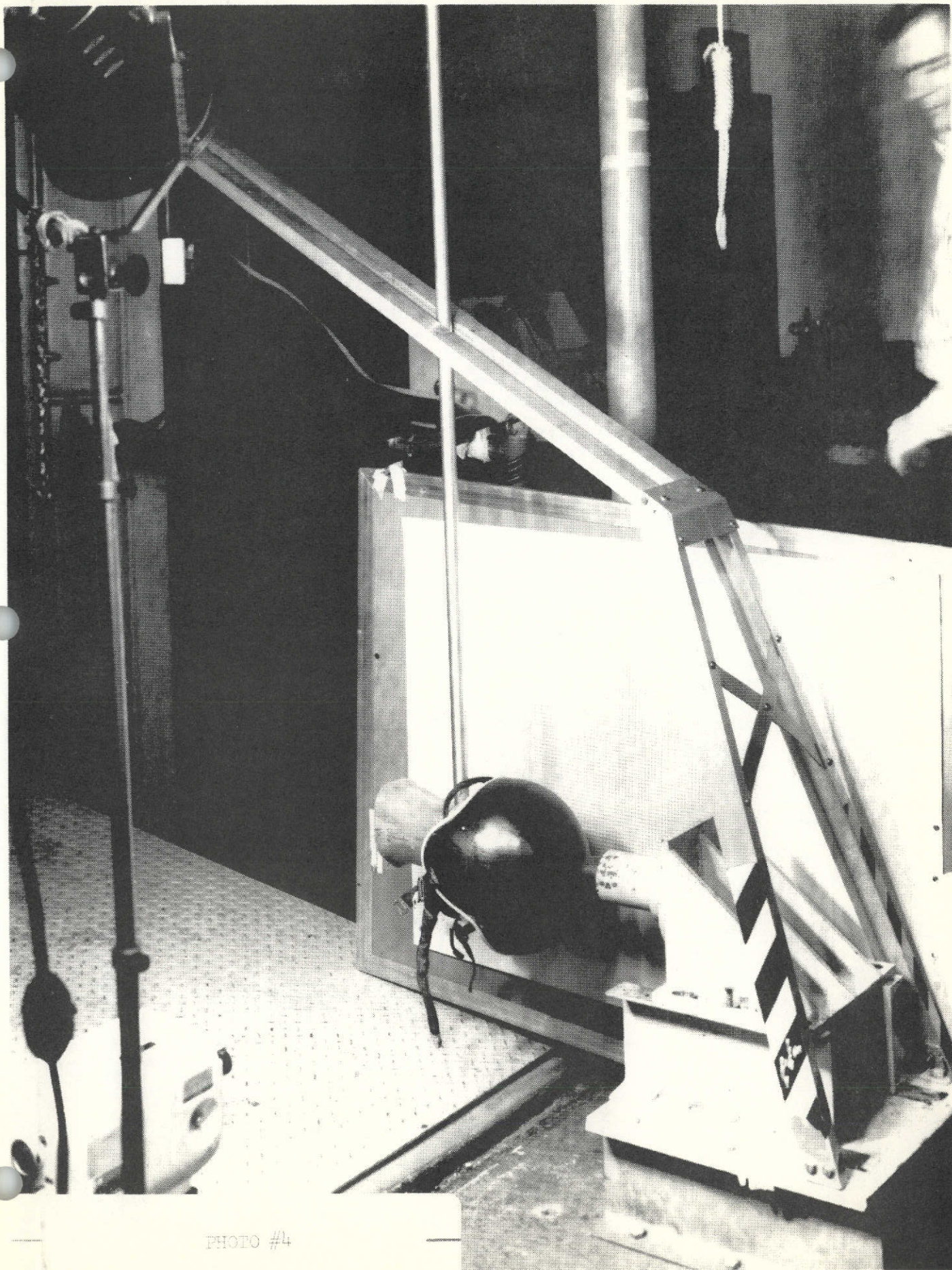


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S-72-51950

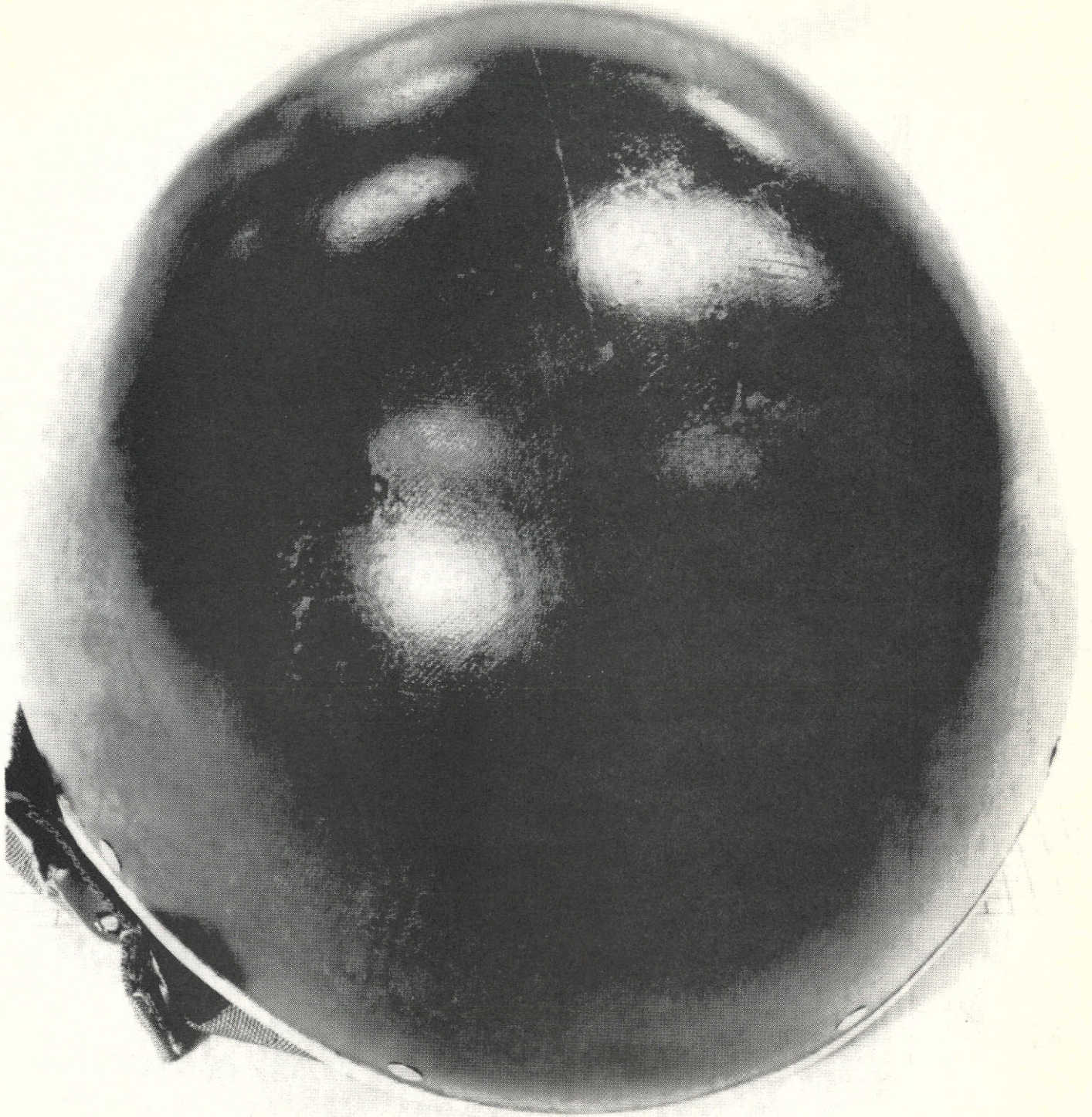


PHOTO #5

NASA
S-72-51946

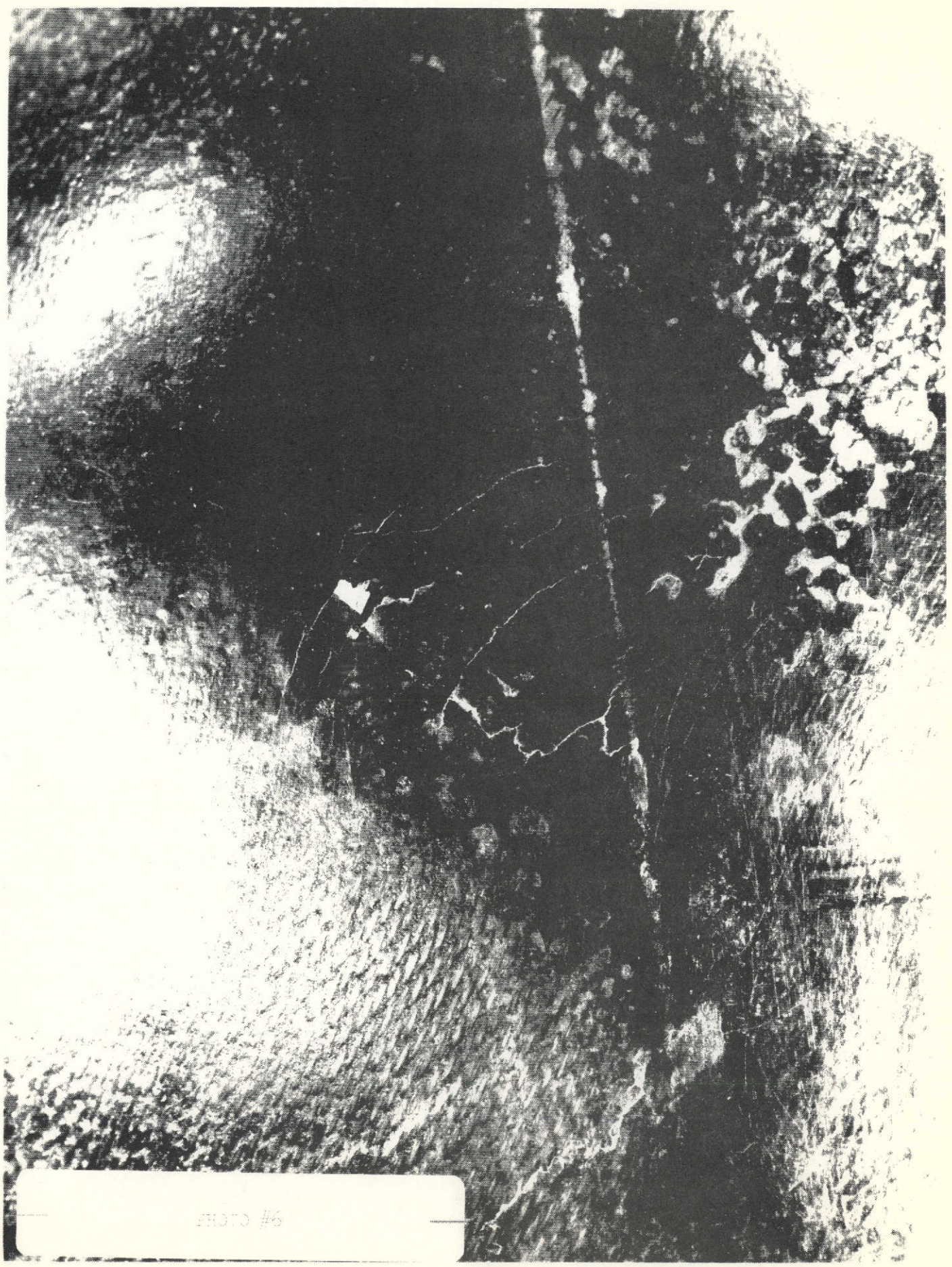


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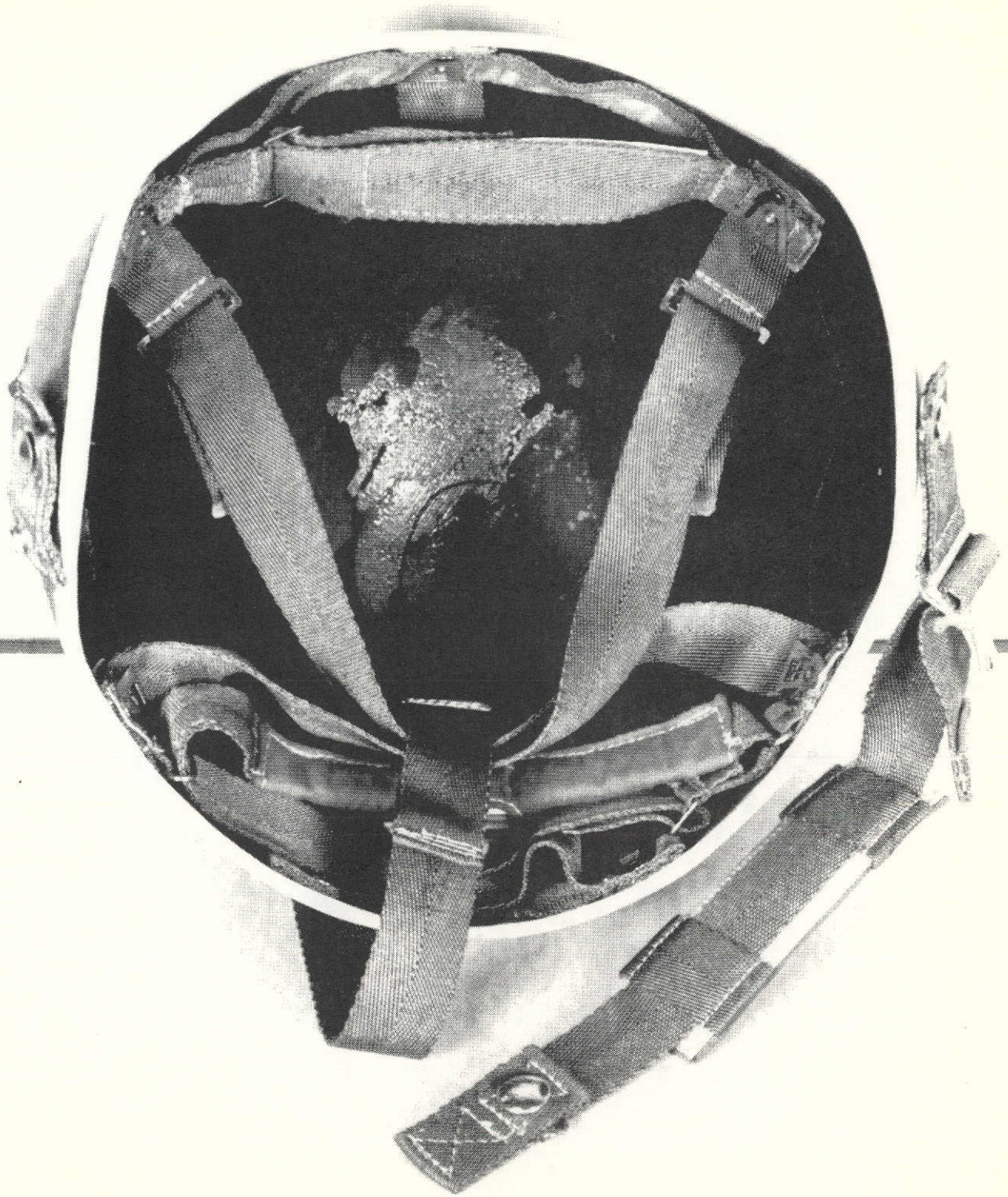


PHOTO #7

NASA
S-72-53318

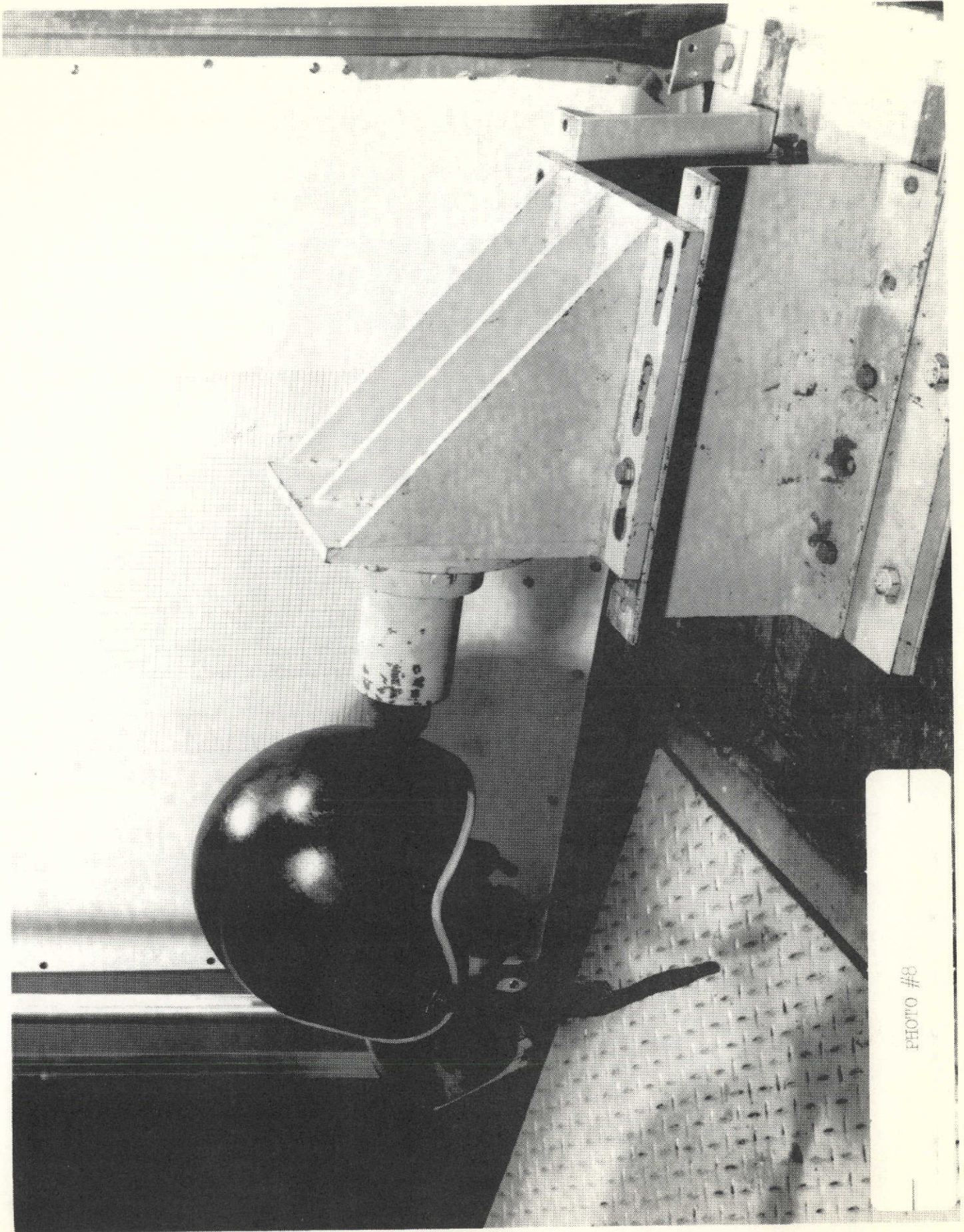


PHOTO #8

NASA
S-72-53317

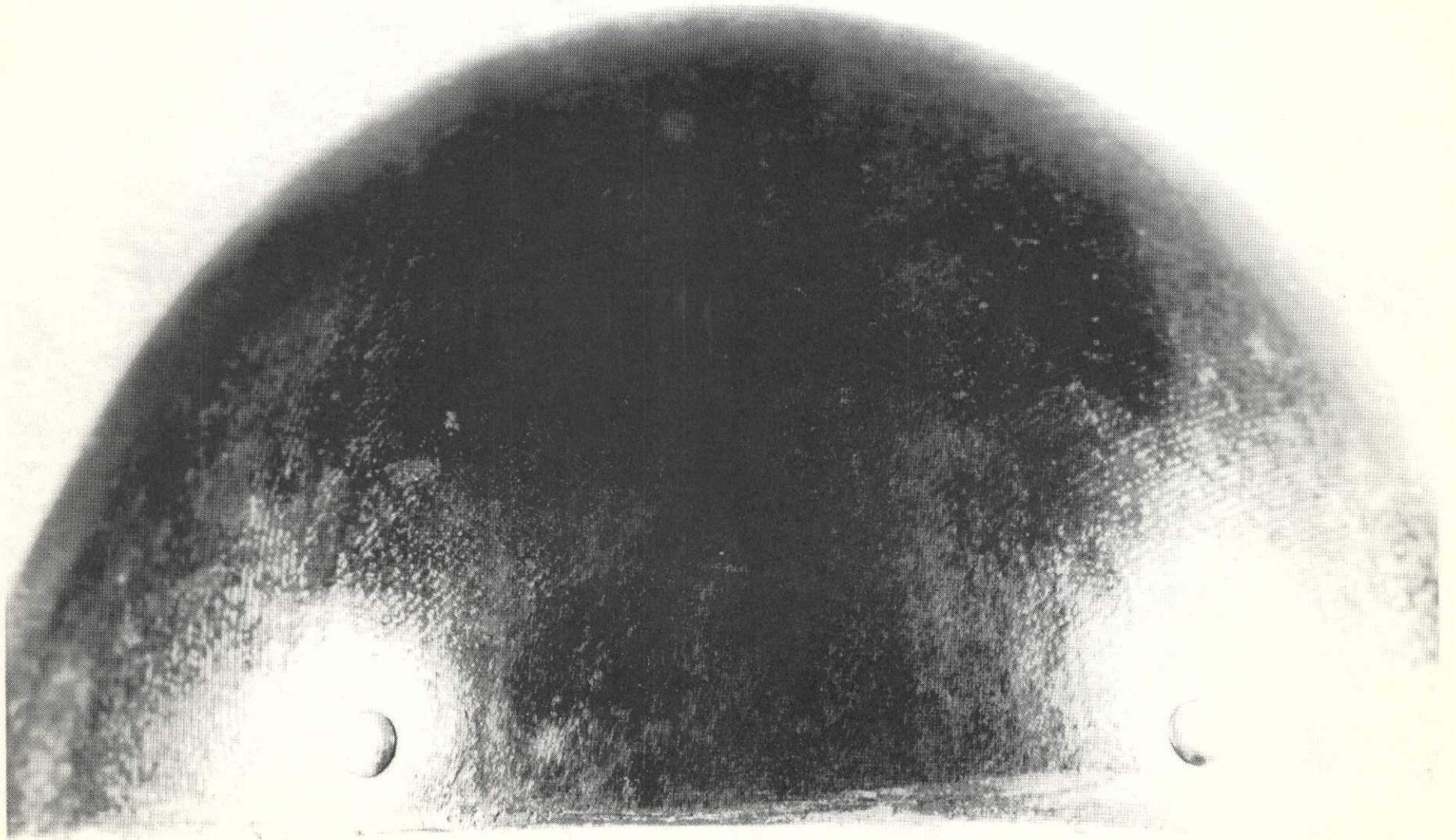


PHOTO #9

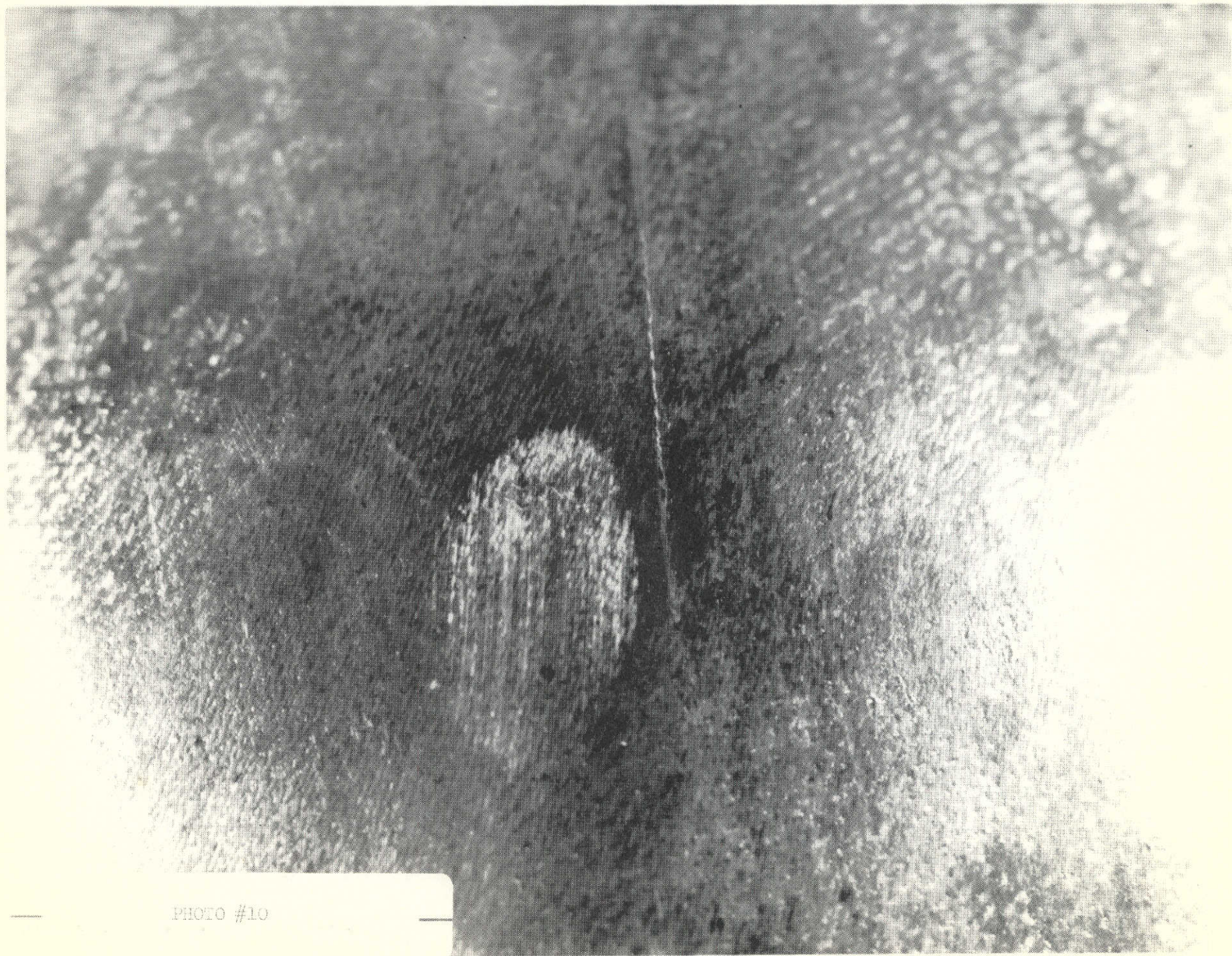


PHOTO #10



— PHOTO #11 —