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Date 5-14-65
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INVESTIGATING COMMITTEE REPORT
TEST AND S2, RUN S2-212-B4-01

SYCAMORE TEST BASE

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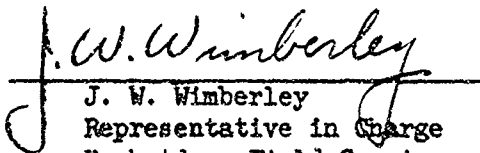
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FOREWORD

This document has been prepared under the direction of the Steering Committee for the Investigation of Test Stand S2, Run S2-212-B4-01, and represents the common agreement of the participating agencies.



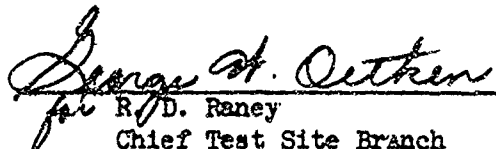
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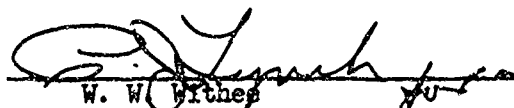
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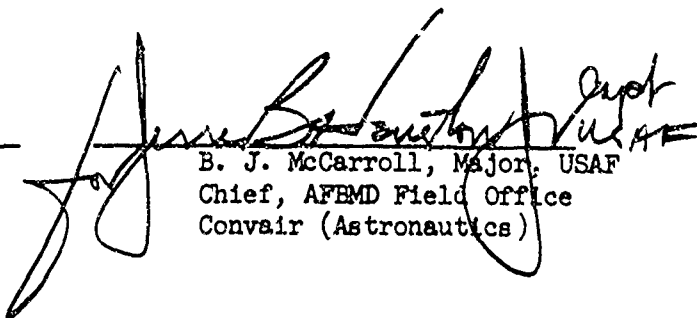
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FINAL ACCIDENT REPORT
RUN S2-212-B4-01

1.0 INTRODUCTION

1.1 An explosion occurred at Sycamore Test Stand S-2 on 18 June 1958. during static firing test S2-212-B4-01 (Run 212) on Missile 1B. No personnel were injured. Extensive hardware damage sustained by the following major components necessitated their removal and replacement: Booster Engine, Sustainer Engine, that portion of the Vernier engine contained within the thrust section. The jettisonable thrust section required repair. A preliminary investigation report was issued 20 June 1958.

1.2 In compliance with Convair DSP 1-29 an investigation was conducted to determine:

- 1) The cause of the explosion
- 2) A means to prevent recurrence
- 3) Extent of damage
- 4) A course of action which would provide the least interruption to the "B" series test program.

1.3 The cause of the explosion has been determined. To prevent recurrence, recommendations have been proposed and corrective action has been taken. The missile was removed from the stand and transported to San Diego Plant Number 1 on 27 June. Repairs and replacements were effected by Sycamore engineers and technicians under the provisions of Convair Cost Proposal 758-61, "Restoration of missile 1B and related TGSE at Sycamore Stand S-2 to Test Configuration," dated 9 July 1958. The missile was repaired and returned to Sycamore on 9 July.

1.4 The preceding page presents the membership of the Steering Committee, the Investigation Board and the Sub-Committees responsible for the compilation and documentation of this report.

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FINAL ACCIDENT REPORT
RUN S2-212-B4-01

2.0 TEST CONDITIONS

2.1 Run S2-212-B4-01 (Run 212) was the fourth attempt to accomplish the fourth scheduled test on Missile 1B. The three previous attempts were prematurely terminated as follows:

2.1.1 Run S2-209-B4-01 (Run 209) was terminated, after 1.18 seconds, by the Sustainer overspeed control circuit.

2.1.2 Run S2-210-B4-01 (Run 210) was terminated, after 3.4 seconds, by a manual cutoff when missile LO₂ tank pressure fell below Redline limits due to failure of a solenoid operated check valve in the Airborne He bottle charge line.

2.1.3 Run S2-211-B4-01 (Run 211) was terminated, after 1.1 seconds, by the Sustainer overspeed control circuit.

2.2 Runs S2-203-A2-01 and S2-205-A2-01 in the first block of the 1B test series were also prematurely terminated by the Sustainer overspeed control circuit. Since recorded engine parameters reflected no indication of turbine overspeed in any of the four instances of overspeed cutoff, it was resolved that these cutoffs were due to overspeed trip malfunction. In order to prevent a recurrence in Run 212, the overspeed control circuit was disconnected at the engine relay box. Turbine speed was monitored on a Brown recorder and the Sustainer LO₂ Reference Regulator setting was reduced to 785 PSIG from 810 PSIG in order to decrease the rate of thrust build-up in the event it became necessary to execute a manual cutoff.

2.3 Run 212 scheduled engine durations were Booster 100 seconds, Sustainer 194 seconds and Vernier 220.5 seconds.

2.4 The primary objectives of Run 212 were:

- (1) Analyze the performance of the MA-1 Propulsion System during a long duration three stage engine firing with programmed gimbal in each stage, (2) Analyze the operation of the Airborne Pneumatic system, (3) Develop Series "B" tanking and starting techniques and, (4) Develop procedures for systems checkouts and "B" series static firing in support of operations at AFMTC. For detailed description of test objectives see General Captive Test Plan No. ZB-7-036, Revision B.

2.5 Booster and Sustainer staging were to have been initiated by the Flight Programmer. Missile hydraulic requirements were to have been supplied by the Airborne System. Missile pneumatics were to have been supplied by the Airborne system with continuous replenishment from the facility helium system. However, switchover to Airborne engine control pneumatics did not occur due to premature cutoff. Missile electrical requirements were to have been supplied by the Airborne battery and inverter, however, they were supplied from the ground system because Airborne battery voltage was too high.

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- 2.6 Run 212 was performed in accordance with "Run 4 countdown 17 June 1958." This countdown deviated from the countdown signed off by the design groups on 3 June 1958 as follows:
- 2.6.1 The fuel tanking level of 10,761 gallons was changed to 10,766 gallons in order to comply with report AA-E-130, Propellant loading for the XSM-65-B3 Missile.
- 2.6.2 Due to failure of the PU manometers LO₂ was dumped to missile station 519, according to Vibrotron readings, instead of to a computer comparator null error indication.
- 2.6.3 Because the allowable temperature at the LO₂ breakaway valve (P1021T) was exceeded during Runs 209 and 210, the 60 second time count was eliminated. All the items in the 60 second count were re-sequenced to move the LO₂ dump to within 30 seconds of major command "Vernier Squibs Fire" (Time Zero). Commands were called out by the Test Conductor and a 15 second time count was called out between commands "Depress Start Switch" and "Vernier Squibs Fire."
- 2.6.4 Run 4 countdown dated 17 June 1958 is included in this report as Appendix A. The only deviation from this countdown during Run 212 was that missile power was supplied from external because the internal missile DC power system malfunctioned.

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FINAL ACCIDENT REPORT
RUN S2-212-B4-01

3.0 TEST PREPARATIONS

3.1 X-1 Day Preparations

X-1 day preparations began at 2400 17 June and were completed at approximately 1400 18 June. Fuel remained on board the missile from the previous day's run attempt and the missile was in a state of readiness which considerably reduced the preparations required.

0020 - The fuel tank was topped off to station 953 as indicated by the sight gage. The flow total registered 80 gallons of fuel tanked.

1200 - Booster and Sustainer engines were Trichlor flushed and the Boosters were filled with lithium chloride.

1300-1400 - Igniters installed.

3.2 Precount Operations

1408 - Precount operations started.

1451 - An official hold was called. Inspection of the thrust section revealed grease around B2 thrust chamber gimbal mount. The area was cleaned & operations resumed. Total hold time was 14 minutes.

1510-1525 - Precount operations were delayed to complete the installation of the flexible firewall.

1530 - Transfer of LN₂ to the missile shrouds started.

1556 - All shrouds were filled and the LN₂ flow control valves had cycled.

1556 - Precount operations were completed. Predicted duration for this section was 60 minutes; actual elapsed time was 108 minutes.

3.3 Countdown Operations

1600 - Countdown operations began and the area was placed in Condition Red.

1601 - Booster and Sustainer hydraulic systems set up started. The Sustainer missile return pressure was reported to be 7 psig. A hold was called at 1602 to send a mechanic to the area to check the return gage on the Sustainer hydraulic cart. It indicated 6-8 psig. By use of the hand pump in the cart, the pressure was increased to 33 psig. It then dropped slightly, stabilizing at about 28 psig. Countdown operations resumed at 1608 after a total hold of 7 minutes.

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3.3 (Cont'd)

- 1608 - Missile bottle pressurization commenced. Instrumentation reported a bottle pressure of 3000 psig at 1611.
- 1609 - Missile pressurization Sequence 2 was initiated.
- 1609 - LO₂ tank and facility chillover commenced.
- 1616 - Pumps 1A & 1B were started. LO₂ tanking was switched to a separate communications channel and LO₂ was tanked according to the support requirements of missile 3B.
- 1633 - Missile pressurization Sequence 3 was initiated.
- 1637 - Missile power was switched to internal. Upon switching DC, missile AC voltage and frequency increased rapidly out of limits and the DC internal voltage was reported to be approximately 34 volts. It was decided to continue the run on external power. Post run investigation of records revealed that the missile battery had not been pre-loaded by the factory.
- 1637 - At approximately X-57 seconds, LO₂ was dumped for 27 seconds to missile station 519.
- 1638 - Booster and Sustainer ignition was initiated. Immediately after ignition, cutoff occurred and fire was reported in the thrust section. All firex systems were turned on and the fire quickly extinguished. Booster Ground Bus Power and Booster Engine Control pressure was lost. All power to the missile was secured.
- 1642 - CO₂ system secured.
- 1642 - LO₂ detanking commenced.
- 1655 - Fire was reported again in the thrust section. The CO₂ system was turned on and the fire was quickly extinguished.
- 1657 - The CO₂ system was again secured.
- 1713 - LO₂ detanking was completed and the firex system was secured.
- 1715 - An attempt was made to detank fuel but the tank observers reported heavy leakage from the thrust section and it was decided to leave the fuel in the missile until an investigation could be made. Upon reporting to the area, the Stand Engineer reported heavy thrust section damage and fuel leaking downstream of the Sustainer pre-valve. After further investigation of damage to the missile, the Sustainer pre-valve was kept closed by removing the opening control pressure line, and the fuel was detanked.

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FINAL ACCIDENT REPORT
RUN S2-212-B4-01

3.3 (Cont'd)

1745 - All systems were secured. Predicted durations of this section was 80 minutes; actual elapsed time was 105 minutes.

3.4 Safety Precautions

Safety Engineer Report -- Sycamore Test Site

- 3.4.1 The X-1 day and precount preparations were accomplished with proper safety precautions. Supervision in all sections carried out their scheduled work assignments with proper safety equipment. Coordination between Stand area and Blockhouse key personnel was satisfactory in all phases of countdown.
- 3.4.2 During the attempted firing all personnel assigned to specified tasks were at their stations and in direct contact with the Test Conductor's area. They carried out these tasks in an orderly and well coordinated manner.
- 3.4.3 Immediately after the accident exceptional team effort was shown by all personnel. I believe it was this team coordinated effort that held the damage to this limited extent.

S/

R. H. Moore
Safety Engineer

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4.0 SUMMARY OF TEST OBSERVATIONS

4.1 The following is a summary of visual observations made before, during and after the explosion based on written testimony of Blockhouse and Tank Observers. Where these observations were not substantiated by test data a qualifying comment is added.

4.1.1 V2 Ignition appeared normal. V1 ignition appeared fuel rich and rough. However, test data does not substantiate a rough fuel rich V1 ignition.

4.1.2 Booster and Sustainer ignition appeared short. A puff of smoke was immediately noticed to come from the Sustainer engine and fire broke out, concentrated primarily in the region of the Sustainer and BL exhausts. A spreading fire was seen near the V1 flame deflector which became entrained in the flames bellowing up from the lower thrust section.

Review of photographic coverage and hardware investigation reveals no indication of fire in the region of the V1 thrust chambers.

4.1.3 Fire was reported by observers within 7 seconds of Vernier ignition and was also noted on the Blockhouse television display at this time. CO₂ firex and launcher coolant systems came on and the fire was promptly extinguished. CO₂ was turned off and the firex was left on.

4.1.4 A second flare up was observed and promptly extinguished by again turning on CO₂. Fire and launcher coolant systems remained on throughout the fire.

4.1.5 CO₂ was turned off and detanking of LO₂ was accomplished without incident. The stand engineer and a fireman were sent out to inspect the missile. Firex and launcher coolant systems were turned off.

4.1.6 When the fuel prevalves were actuated to detank fuel, considerable fuel appeared to be coming from the Sustainer Gas Generator exhaust. Detanking of fuel was delayed until the Sustainer fuel prevalve control could be disconnected.

4.1.7 Post run hardware examination revealed that the Sustainer Gas Generator Fuel blade valve remained closed throughout the run and that the fuel blade valve seals were intact. It was also determined that the fuel volute of the Sustainer turbopump contained a crack approximately 3/8" X 10". It is therefore believed that the fuel reported by the observer as leaking from the Gas Generator exhaust was actually coming from the cracks in the fuel turbopump volute.

4.1.8 Verbatim testimony of the observers is presented as Appendix B to this report.

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FINAL ACCIDENT REPORT
RUN S2-212-B4-01

5.0 TEST DATA

5.1 The following is a chronological presentation of significant Run 212 data analysis as pertains to the cause and history of the thrust section explosion which occurred during this run. The time at which each event occurred is stated in seconds with relation to Vernier Igniters Firing (Zero Time). Appendix C of this report gives a detailed presentation of the analysis of all data recorded during Run 212. Appendix D presents a detailed chronological history of significant data. (Appendices C and D follow Section 7 of this report).

5.2 Chronological History of Major Events:

(Zero time is Vernier Igniters firing)

TIME (SECONDS)

EVENT

-467	Sustainer Gas Generator discharge temperature indicates a decline from 117 Deg. F to negative peg. The time at which this decline took place is unknown as the recorder was not turned on until -467 seconds.
-299.83	Commenced pressurization Sequence III which indicates the LO ₂ tanking was completed.
-149.13 to -90	During this period, three unsuccessfull attempts were made to switch electrical power to internal and the run proceeded on external power.
-61	Indication of continuous LO ₂ flow of approximately 3 lbs/min to the Sustainer Gas Generator. The time the flow started is unknown as the CEC recorder No. 8146 was not turned on until this time.
-38.13	LO ₂ duct pressure activity indicating fill and drain valve closing at completion of LO ₂ dumping.
-13.24 to -1384	Vernier start sequence initiated and start tanks pressurized resulting in transient Vernier and Gas Generator propellant flows due to displacement of gas. Sustainer Gas Generator LO ₂ flow increases to .5 lbs/minute (See Graphs 6, 8 & 10)
0	Vernier igniter squibs signaled to fire.
-.64 to 0.83	Vernier propellant valves signaled to open, propellant and chamber pressures indicate combustion occurs (See Graphs 1, 2 & 6).
-0.84 to 0.89	Sustainer gas generator fuel flowmeter indicates low amplitude signal or noise which may indicate flow to gas generator or igniter fuel valve. (See Graph 9).

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5-2 (Cont'd)

<u>TIME</u>	<u>EVENT</u>
1.81 to 1.82	Booster and Sustainer LO ₂ and igniter fuel valves energized to open indicating main igniters have fired.
1.87 to 2.22	Booster and Sustainer main LO ₂ valves open; pressures and flows indicate igniter LO ₂ and fuel flow (See Appendix D). Sustainer gas generator fuel flow indication may be flow to gas generator. (See Graph 9).
2.30	Ignition complete indicates ignition detection signaled gas generator igniters to fire.
2.31 to 2.37	Many measurements indicate transients or loss of signal. (See Appendix E). Booster and Vernier sequence control power is lost indicating disruption of electrical circuits. Loss of ground automatically initiates cutoff. Load cells and launcher strains indicate shock of significant magnitude (See Graphs 3 & 5). Most accurate time correlation is by measurements recorded on oscillograph which indicate shock originated in Sustainer section. Sustainer fuel flow starts at 130 lbs/sec. indicating system ruptured. (See Graph 7).
2.38 to 2.47	Engine compartment temperature starts to increase though not abnormally (See Graph 11). Other measurements indicate transients and loss of signal.
2.48 to 2.53	Vernier pressures indicate propellant valves closed and combustion ceasing.
2.65	Sustainer HSV closed by microswitch indication but still partially open by angular position transducer.
2.74 to 3.01	Many measurements still erratic and losing signals.
3.27 to 3.31	Missile movement, Sustainer fuel duct pressure, activity and engine compartment temperature and launcher strains indicate another shock and probable start of major fire (See Graph 5).
3.42	Sustainer HSV confirmed to be closed by angular position, transducer. This indicates electrical control circuit disruption since the open signal and control hydraulic pressure were still present.
5.08 to 5.21	Engine electrical control circuits de-energized by cutoff; propellant start tanks vent.

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5.2 (Cont'd)

<u>TIME</u>	<u>EVENT</u>
7.87 to 7.97	Missile movement and pneumatic pressure transients indicate another shock or air-borne pressure supply transient.
13.36 to 17.87	Propellant pre-valves indicate closed and Sustainer fuel flow ceases (See Graph 7)
20.67 to 30	Thrust section temperatures reach maximum and begin to decrease towards ambient (See Graphs 11 & 14) indicating fire decreasing.
48.87	Fuel tank pressure indicates restep to Sequence II.
120	Thrust section temperatures at or near ambient indicating fire out. (See Graphs 11 & 14).

5.3 Analysis of Results

5.3.1 Propulsion System:

- 5.3.1.1 The Sustainer gas generator temperature (Graph 19) and lox flowmeter (Graph 8) indicate lox flowing into the combustor prior to start. Indicated fuel flow to the Sustainer gas generator (Graph 9) is suspected as signal noise because of the low amplitude, non-sinusoidal trace.
- 5.3.1.2 Vernier ignition and start tank fed operation were similar to previous runs. (Graphs 1, 2 & 6). Main engine ignition was completed but mainstage was not achieved due to lack of gas generator igniter links break signal. Without the GG igniter links break signal the gas generators propellant blade valves and main fuel valves were not signalled to open. Vernier propellant and main lox valve closed, apparently due to loss of electrical control power as opening signals were still transmitted until 2.78 sec. after ignition was completed. Cutoff vented the start tanks. Sustainer fuel flowed for 13 sec. from ignition complete until propellant pre-valves closed, indicating that the Sustainer fuel system was ruptured as there was no indication of fuel valves opening.
- 5.3.1.3 Analysis of records from the preceeding firing, Run 211, show a pronounced temperature surge in the Sustainer Gas Generator immediately after cutoff. (See Graph 20). Temperature rose from approximately 1000° at cutoff to 1800° 0.1 second later. The recorder pegged at 1820°F for 0.5 seconds, fell to 1450°F, spiked to 1680°F, and then declined normally. After the run the transducer was inspected and showed evidence of being burned and was replaced prior to Run S2-212. This measurement has not been reliable in the past, and the above temperatures can be considered approximate only, in view of the damage

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5.3.1.3 (Cont'd)

suffered by the transducer. However, it is reasonable to conclude that a large and relatively prolonged temperature surge occurred immediately after cutoff. This surge probably caused the failure of the Gas Generator LO₂ seals. It represents the only significant deviation from normal run conditions, disregarding Sustainer Overspeed Trip activation, which was observed in Run 211 data.

5.3.1.4 The Sustainer Gas Generator was disassembled at Sycamore. The blade valves were found in the closed position. The LO₂ seals were shattered. The fuel seals were intact (See photographs 17 through 28).

5.3.1.5 After examination of the Sustainer Gas Generator at Sycamore the unit was released to Rocketdyne for examination at Canoga Park. A detailed examination of individual components was conducted. It was discovered that the injector head was bulged slightly downward (.068 inches maximum). The LO₂ manifold was found to be slightly bulged upward and outward (.020 inches). (See Appendix F for Rocketdyne reports).

5.3.2 Electrical System:

After three attempts to switch to internal electrical power, the electrical power remained on external and was normal until 2.36 sec. when propulsion control power (E1027V) indication was lost; missile systems power remained normal for remainder of the test.

5.3.3 Pneumatic System

Propellant tank pressures were normal throughout the test. Fuel tank and lox regulator pressures reflect change to internal at approx. -31 sec, but temperatures do not reflect cold gas flow. Sustainer control pressure transient (@2.27 sec), indicates controls pressure switchover to internal .71 after this signal. Most measurements indicate signal loss or transients after ignition complete (2.30 sec.) as result of shock, fire, and disruption of instrument signal circuits. Indicated booster control pressure loss is a signal loss as LO₂ reference regulator still indicates pressure.

5.3.4 Hydraulic System

Ground supply maintained pressures satisfactorily.

5.3.5 Flight Control System

Engines were maintained in null position, autopilot program was not initiated as main engines complete signal was not transmitted.

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5.3.1.3 (Cont'd)

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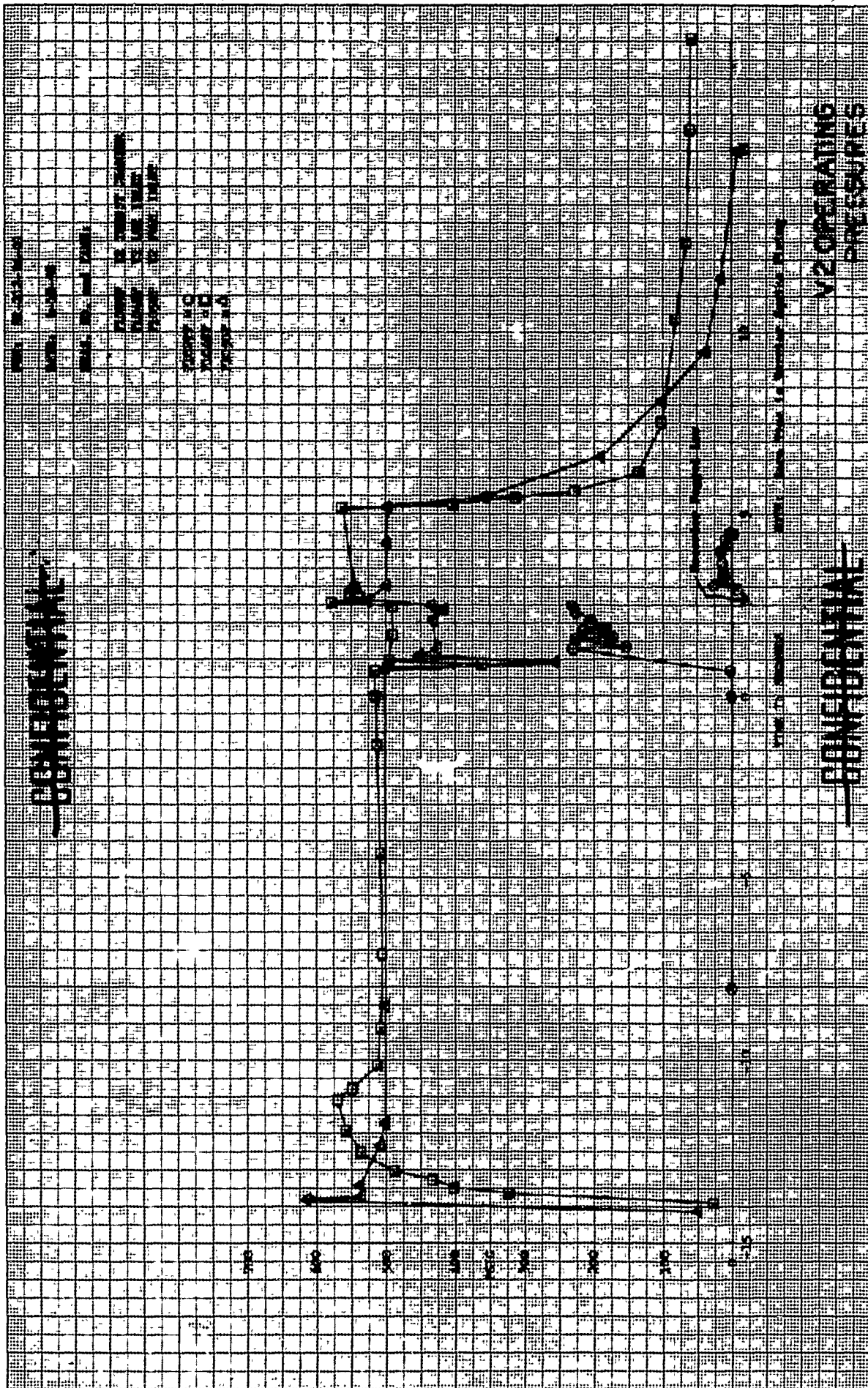
5.3.4 Hydraulic System

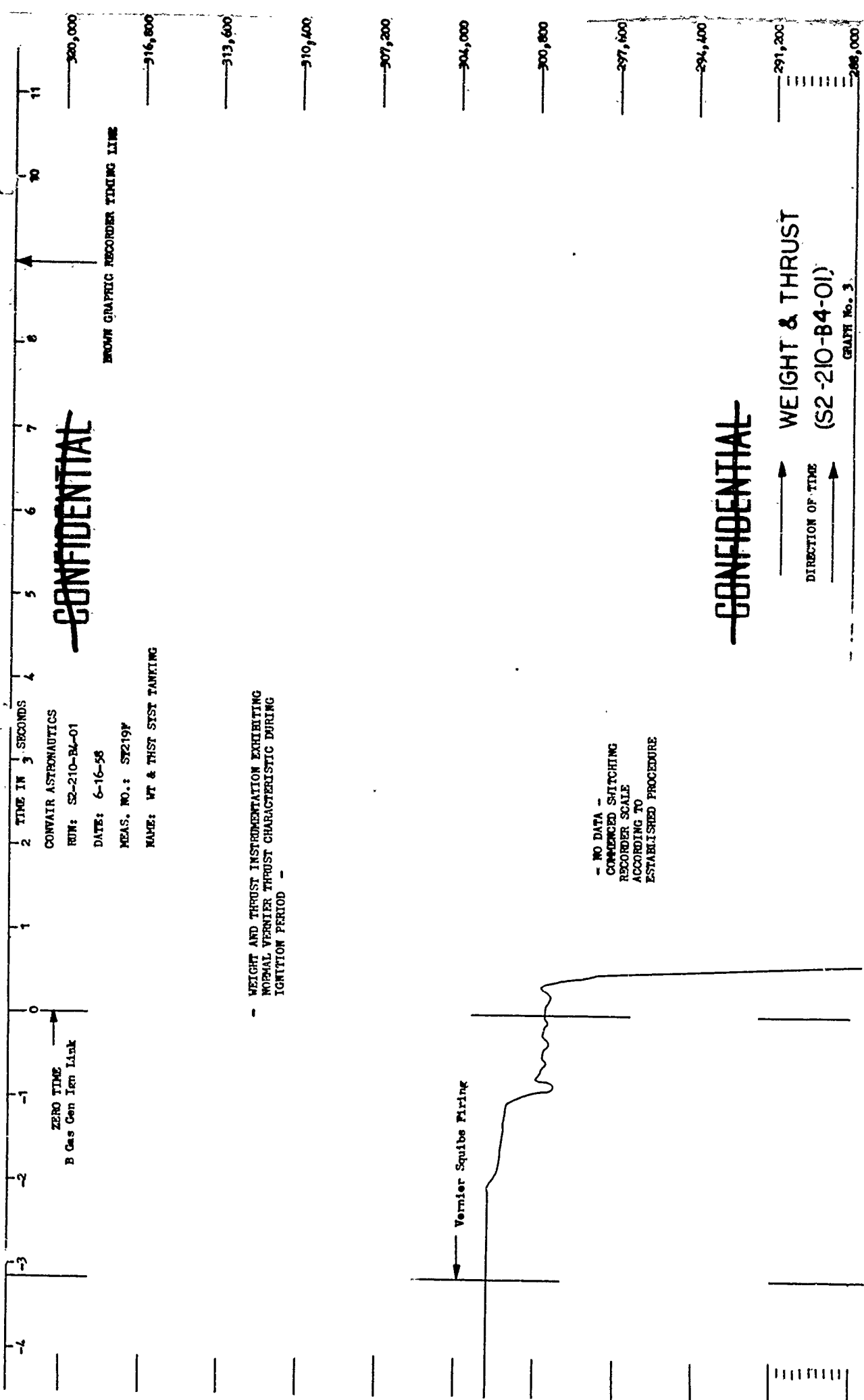
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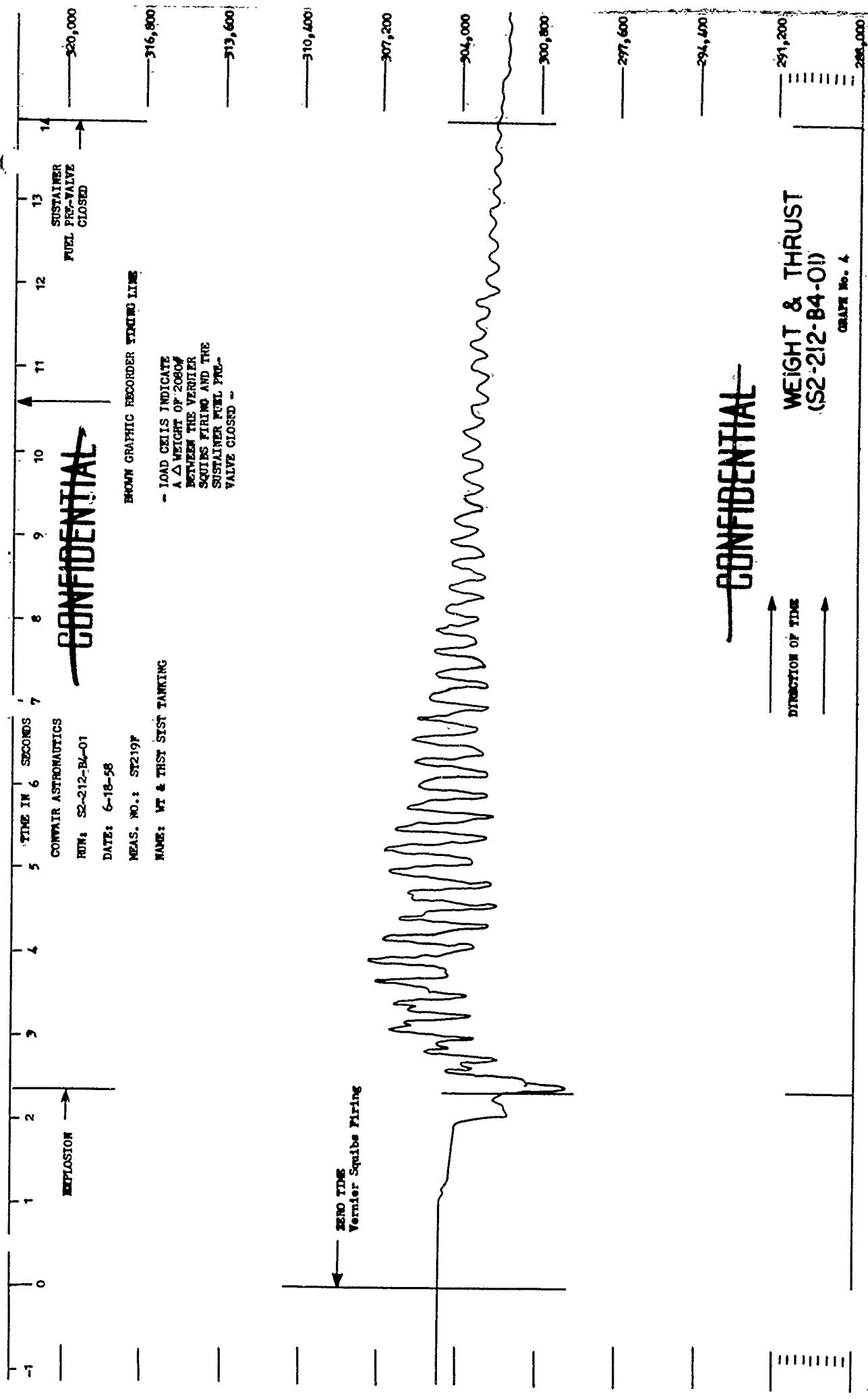
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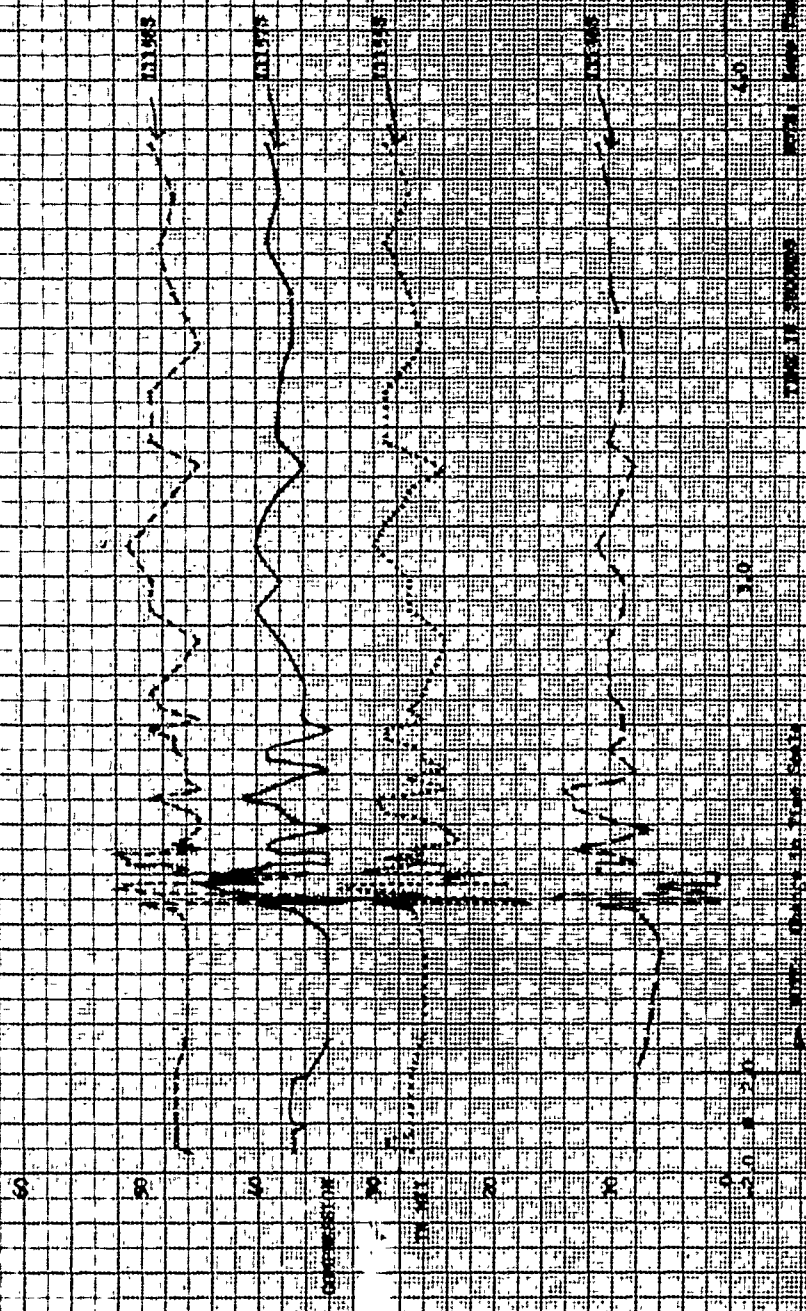






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DATE: 12-12-54-01
TIME: 6:15-20
NAME: W. H. HARRIS
TEST: 11555 100 AIT STRUT 1A
11556 100 AIT STRUT 1B
11557 100 AIT STRUT 2A
11558 100 AIT STRUT 2B



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LAUNCHER STRAINS

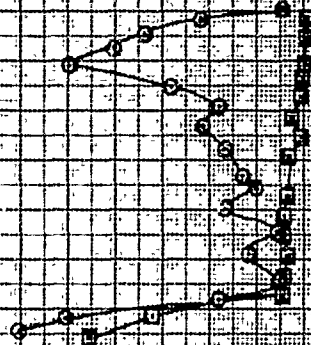
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NOTE: FIG. 22. Worn are 100 mic. View indicated
4 to 40.73 mic. Note Neckline between 40.73 Mic.
and 10.75 Mic. due to high frequency

NAME	DATE	TIME	LOCATION	REMARKS
John Doe	10/10/20	10:00	Room 101	Arrived
Jane Smith	10/10/20	10:05	Room 101	Arrived
Bob Johnson	10/10/20	10:10	Room 101	Arrived
Alice Brown	10/10/20	10:15	Room 101	Arrived
Charlie White	10/10/20	10:20	Room 101	Arrived
Diana Green	10/10/20	10:25	Room 101	Arrived
Frank Black	10/10/20	10:30	Room 101	Arrived
Grace King	10/10/20	10:35	Room 101	Arrived
Henry Lee	10/10/20	10:40	Room 101	Arrived
Ivy Scott	10/10/20	10:45	Room 101	Arrived
Jack Adams	10/10/20	10:50	Room 101	Arrived
Karen Hall	10/10/20	10:55	Room 101	Arrived
Leo Young	10/10/20	11:00	Room 101	Arrived
Mia Evans	10/10/20	11:05	Room 101	Arrived
Noah Hill	10/10/20	11:10	Room 101	Arrived
Olivia Green	10/10/20	11:15	Room 101	Arrived
Peter King	10/10/20	11:20	Room 101	Arrived
Quinn Lee	10/10/20	11:25	Room 101	Arrived
Rachel Scott	10/10/20	11:30	Room 101	Arrived
Samuel Adams	10/10/20	11:35	Room 101	Arrived
Tina Hall	10/10/20	11:40	Room 101	Arrived
Uma Young	10/10/20	11:45	Room 101	Arrived
Victor Evans	10/10/20	11:50	Room 101	Arrived
Wendy Hill	10/10/20	11:55	Room 101	Arrived
Xavier Green	10/10/20	12:00	Room 101	Arrived
Yara King	10/10/20	12:05	Room 101	Arrived
Zoe Lee	10/10/20	12:10	Room 101	Arrived

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THE UNIVERSITY OF CHICAGO

THE

VERNIER PROPELLANT FLOWS

2000

THE

FL007R	SUSTAINMR	2001	FL007R
FL008R	SUSTAINMR	2002	FL008R

PL0072 ① N
PL0082 ② N

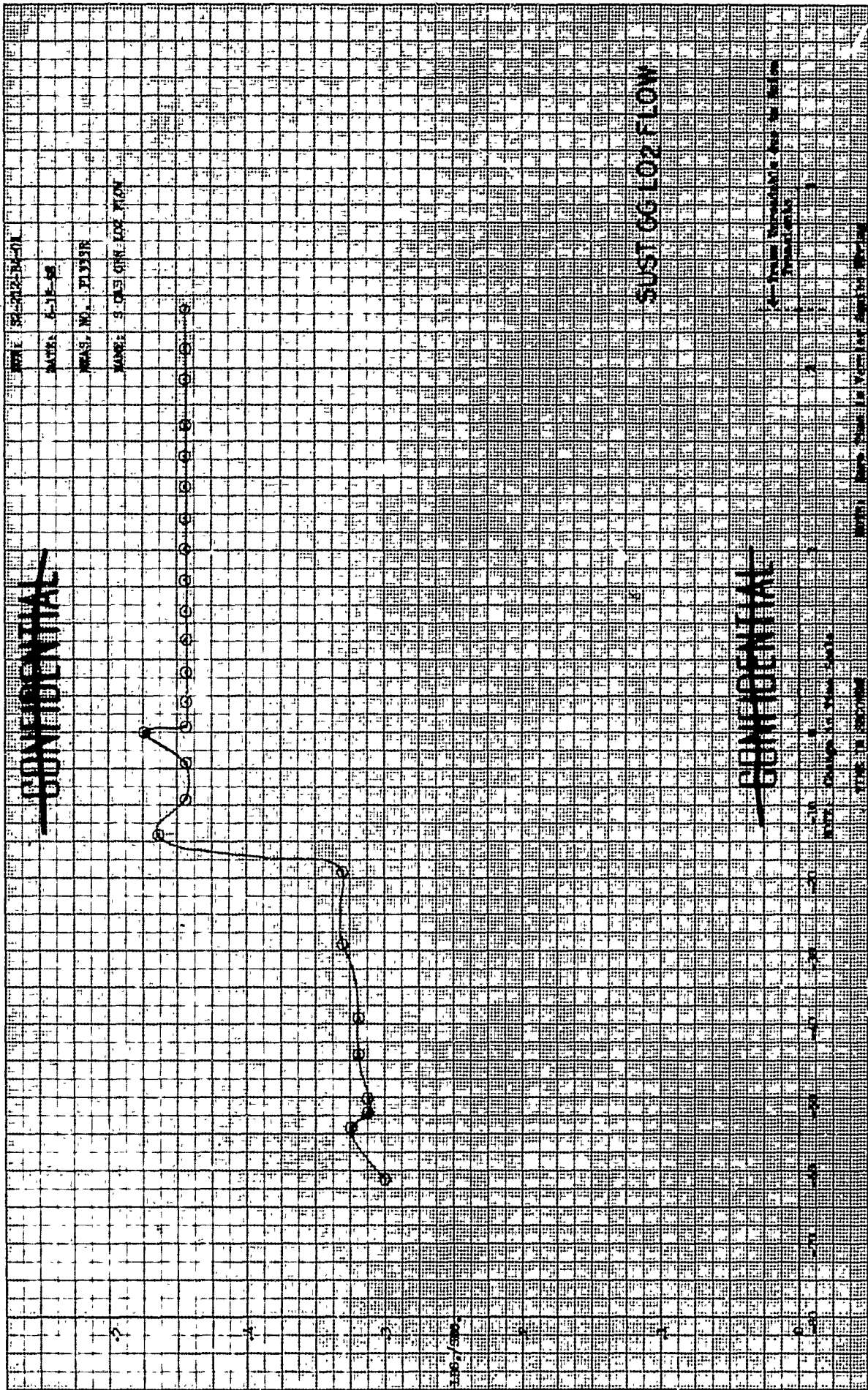
WILLIAMSON COUNTY, TENN.

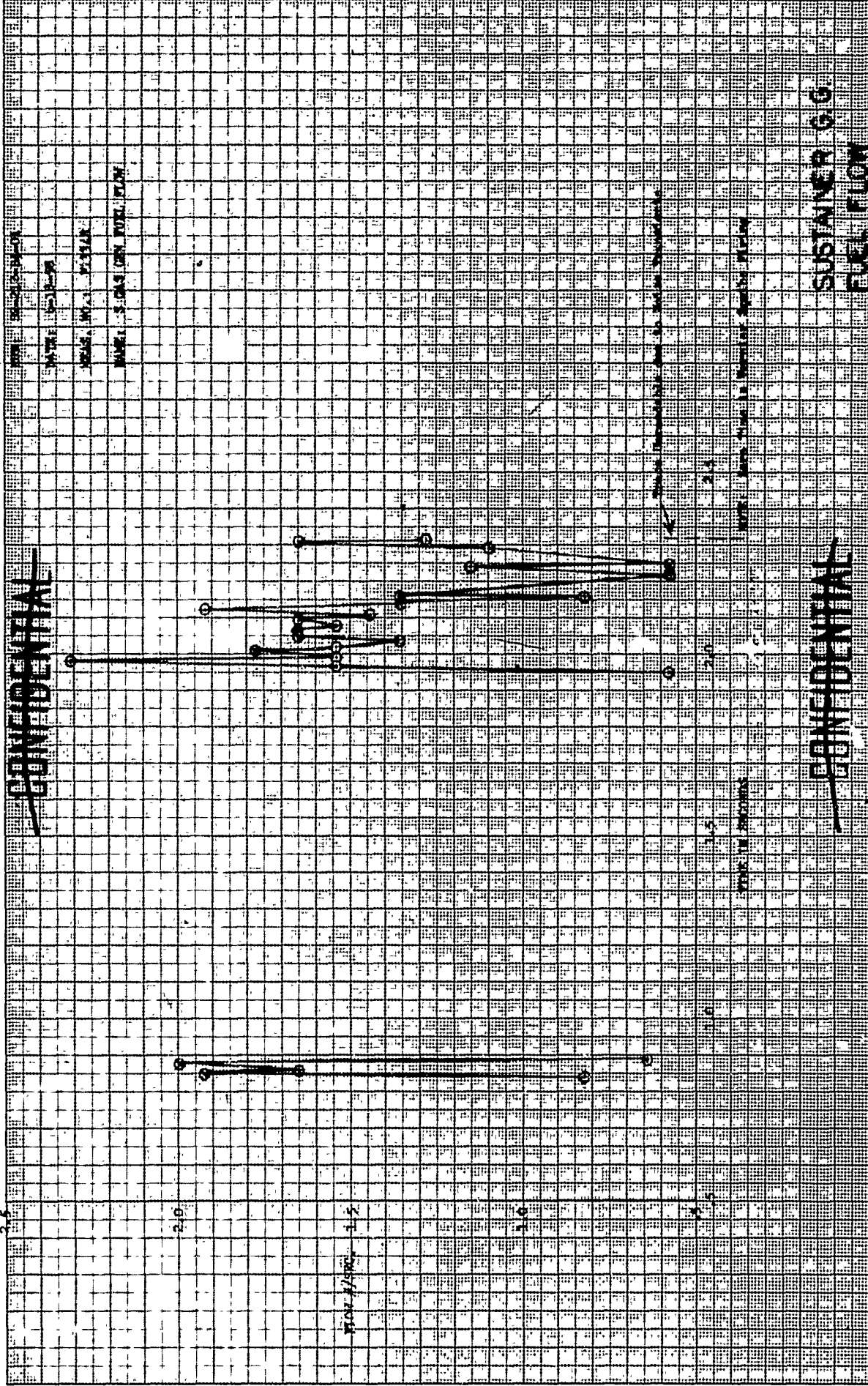
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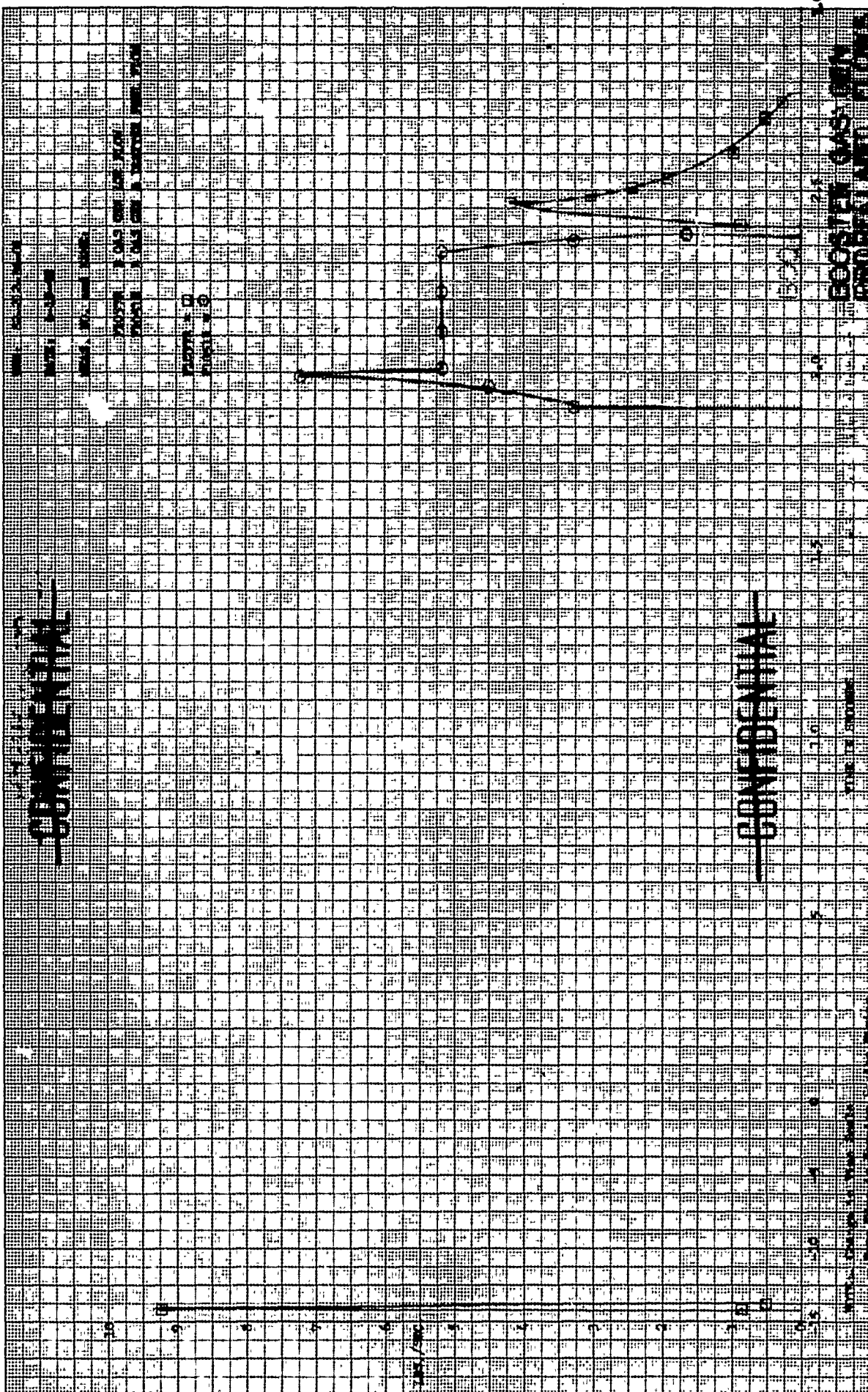
GRAPH No. 7

THE UNIVERSITY OF CHICAGO PRESS

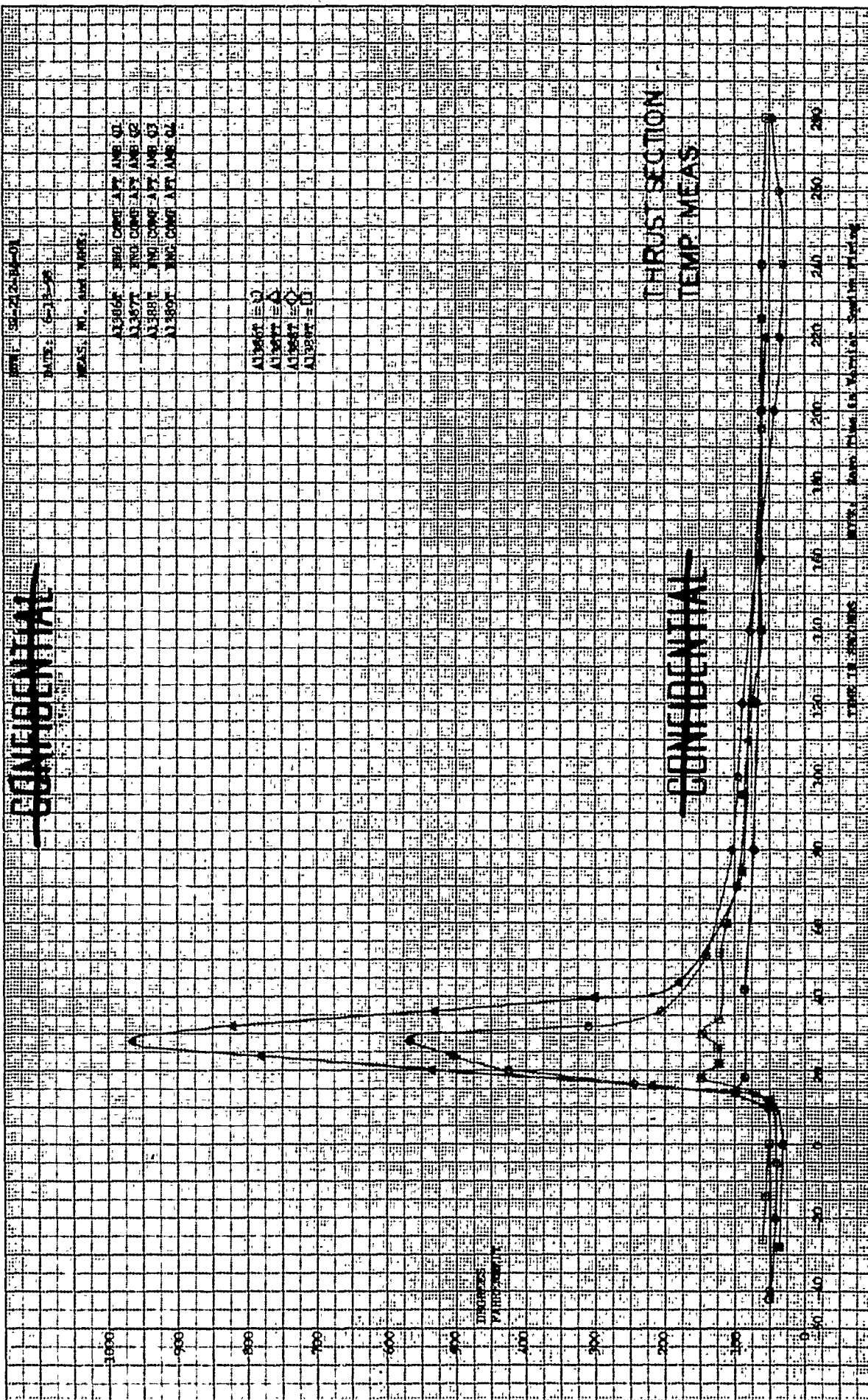


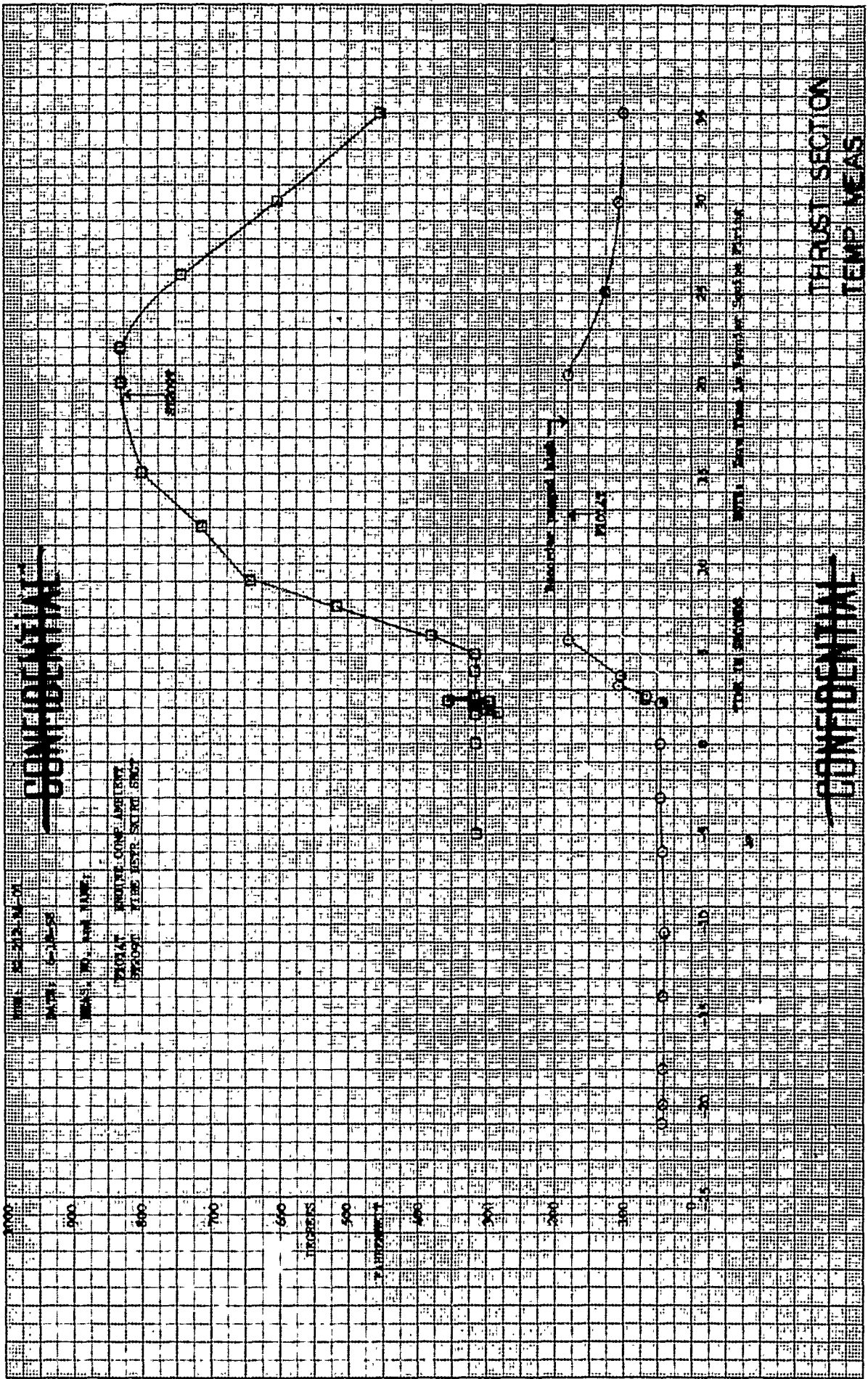


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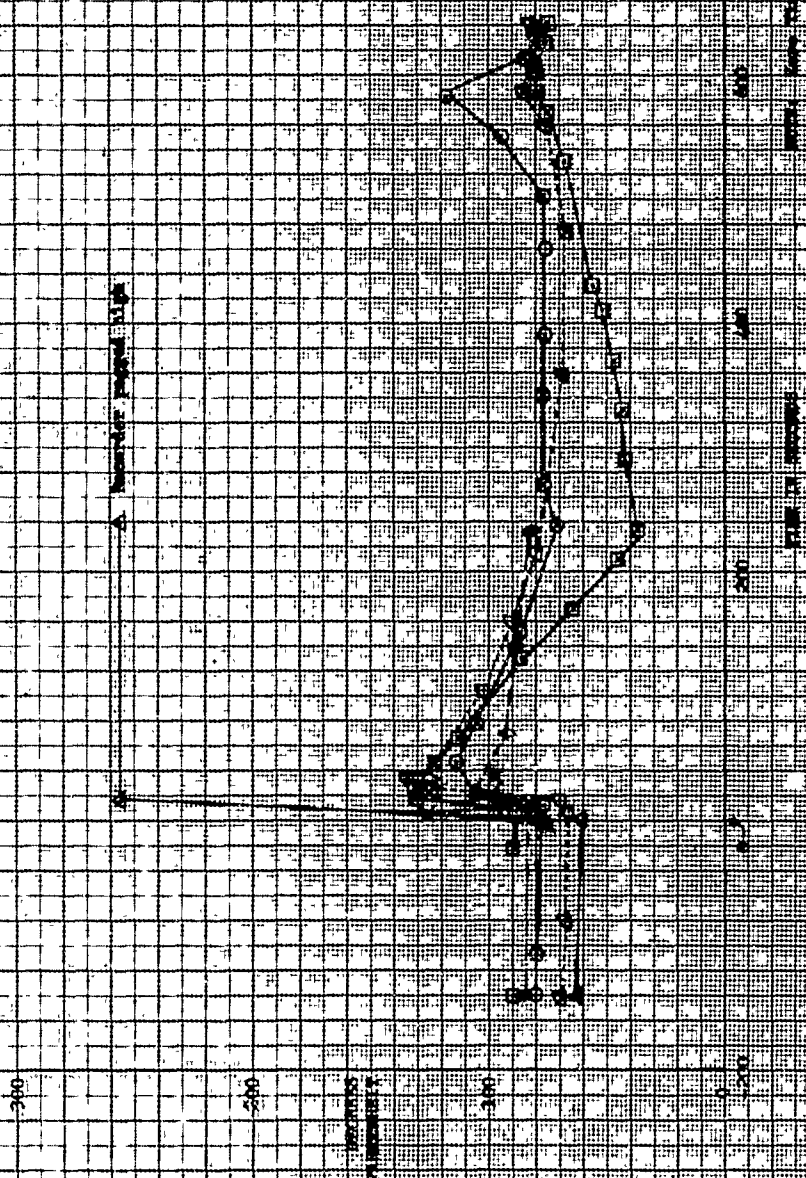


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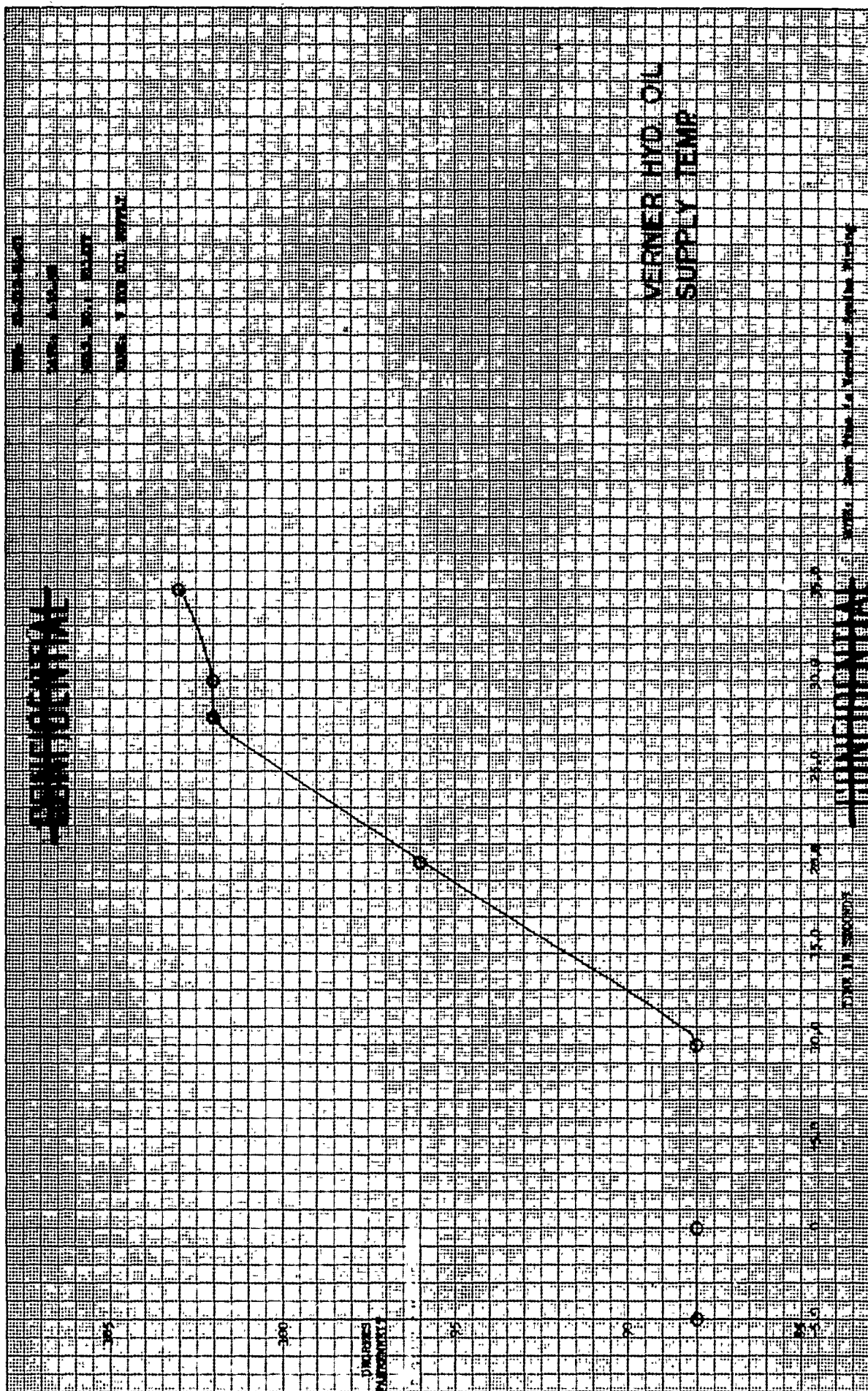


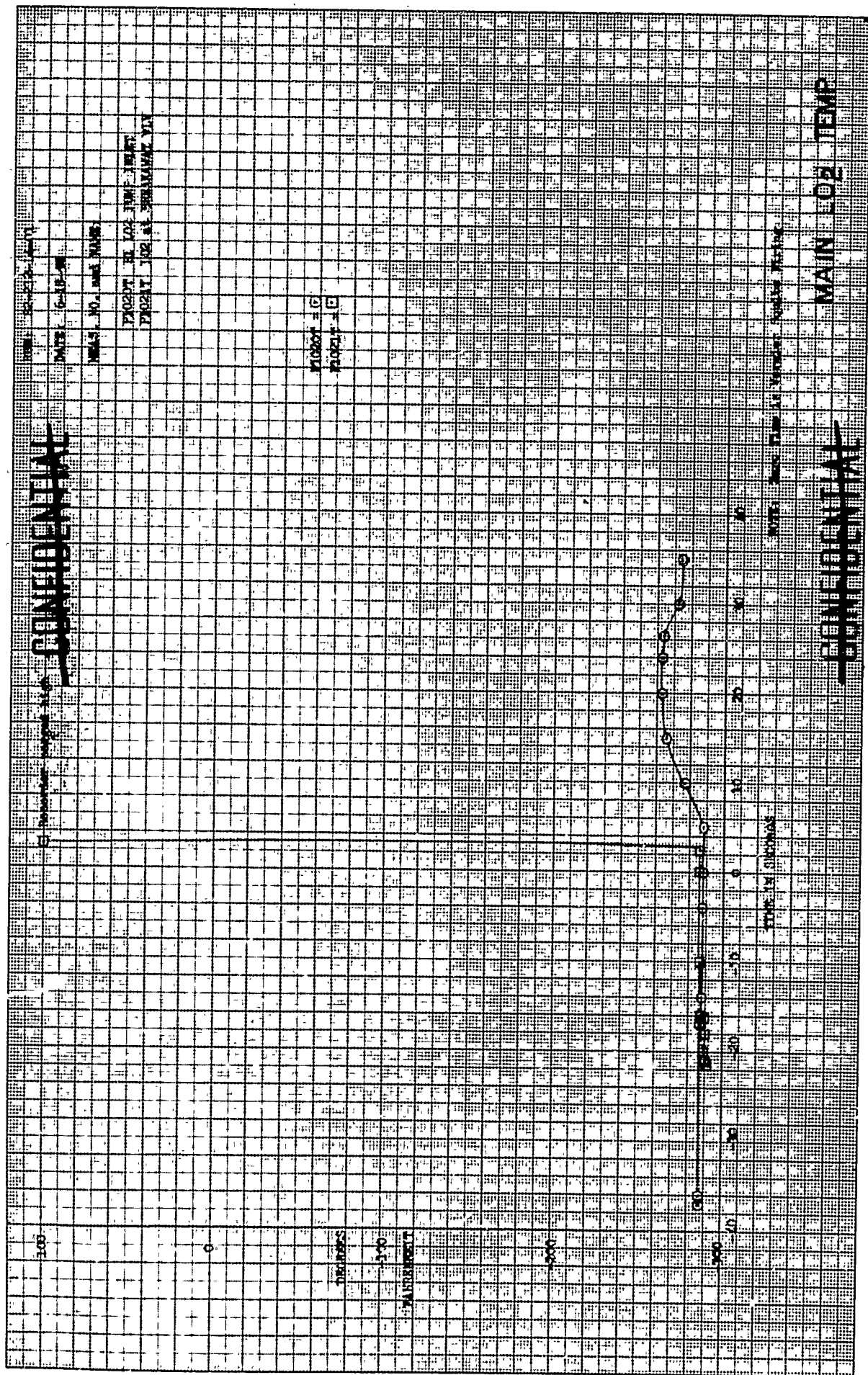
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BOTTLES DISCH. TEMP.





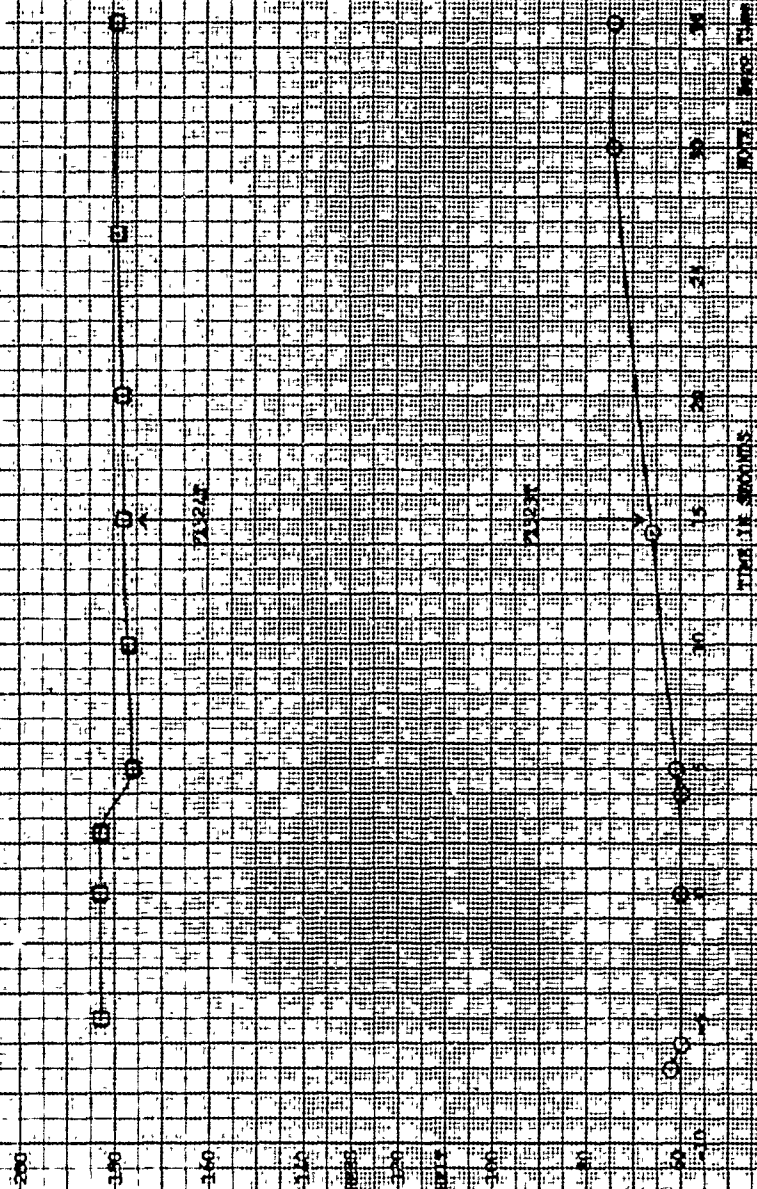
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FORM 8-50-12-100-1

DATE: 10-1-58

BY: J. H. JONES

ALERT: 3 THERMAL MEASUREMENTS
TYPICAL 3 POINT MEASUREMENTS - 100



TIME IN SECONDS

NOTE: MEASUREMENTS TAKEN AT 100% THRUST

SUSTAINER BEARING
TEMPERATURES

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FORM 12-115-12-11

DATE: 5-16-54

RE: STURGEON NO. 1, P-1067

NAME: B. BAS GEN. DISCH.

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TEMPERATURE

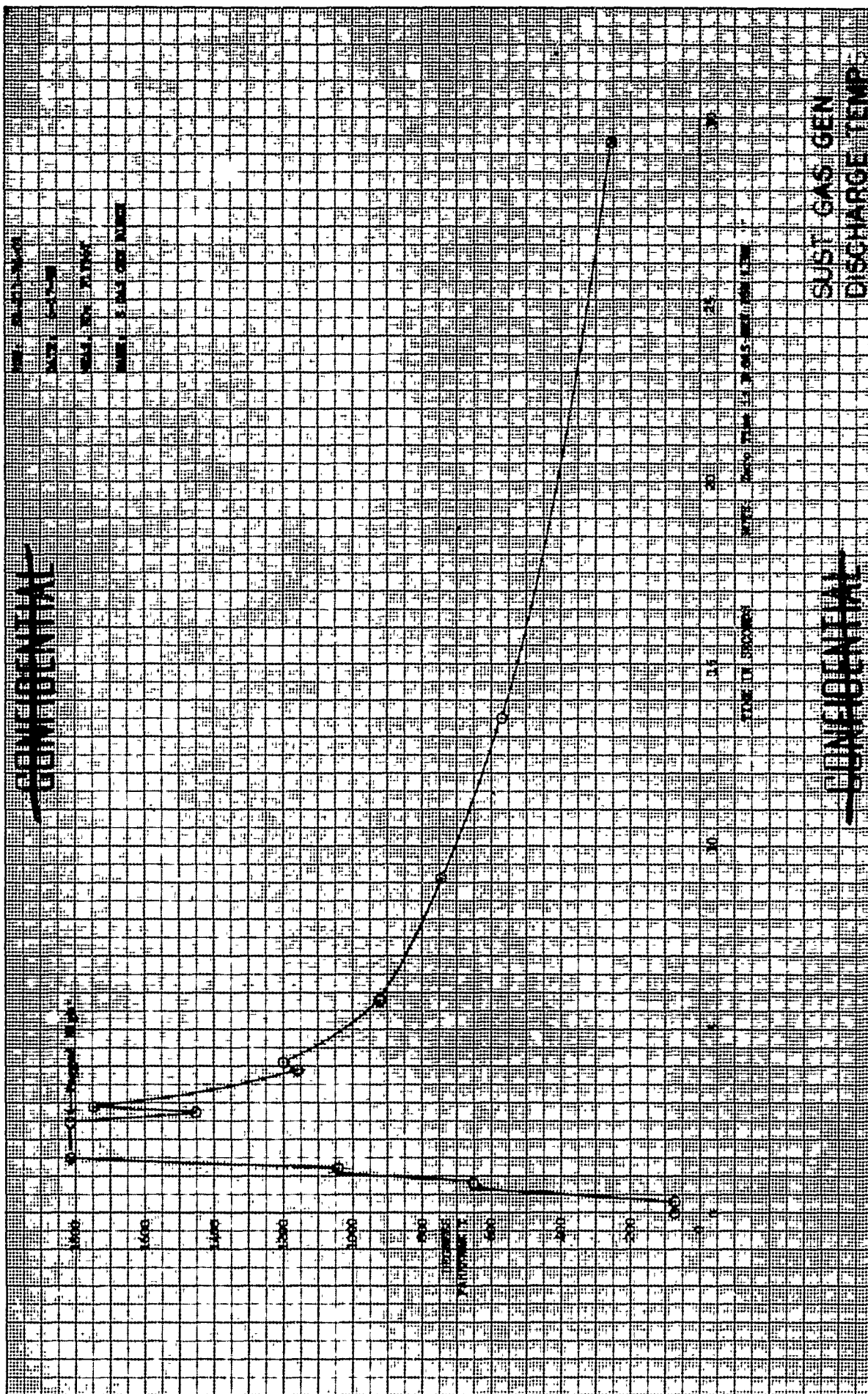
TIME IN SECONDS

SUST. GAS GEN. DISCHARGE TEMP.

FLUORENCE

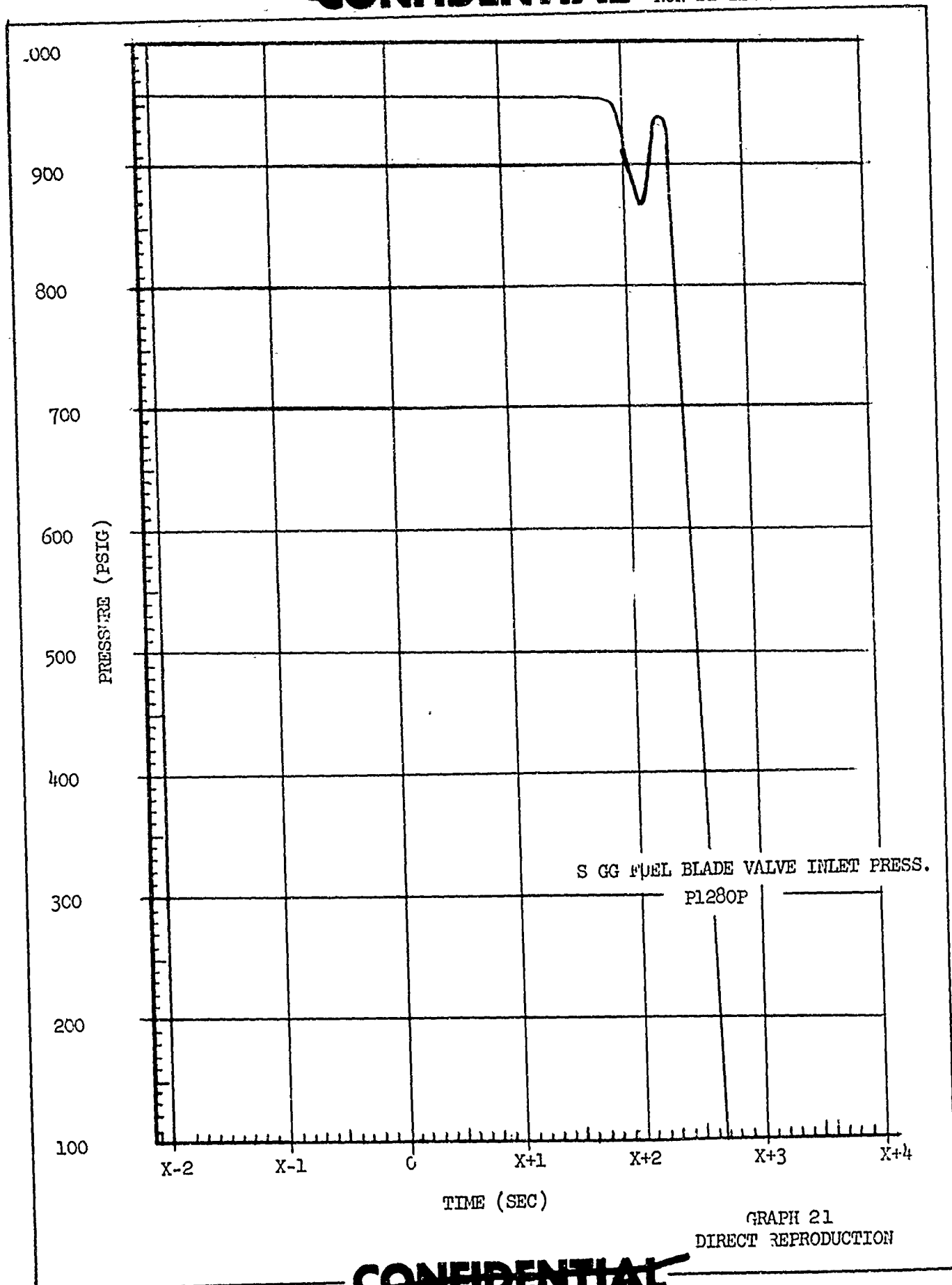
TIME IN SECONDS	SUST. GAS GEN. DISCHARGE TEMP.	FLUORENCE
0	350	0
25	350	350
50	350	380
75	350	390
100	350	400

GRAPH No. 19



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RUN S2-212-B4-01



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FINAL ACCIDENT REPORT
RUN S2-212-B4-01

6.0 HARDWARE DAMAGE

6.1 The following is a summary of the hardware damage sustained by Missile 1B as a result of the explosion in the Sustainer turbine system.

6.2 Sustainer Engine

- 1) Nozzle and second stage turbine wheel blown off (See Photo 6).
- 2) Fuel pump volute cracked completely around circumference. Also crack approximately 10 inches long and 3/8 inches wide near hub. (See Photo 5).
- 3) Turbo pump gear case separated. (See Photos 5 and 28).
- 4) Gas Generator exhaust shroud torn off and blown upward toward Quads I and II (See Photos 1 and 7).
- 5) Exhaust shroud straps torn off and hanging loose. (See Photo 1).
- 6) Thrust chamber torn and twisted, tubes sheared from throat section downward. Primary force was applied from Quad IV to Quad II with heaviest damage at fourth band down from throat. Chamber bands were "U" shaped and exterior of Quad IV was compressed to interior of Quad II. (See Photos 1 and 2).
- 7) Three cannon connectors were broken on Engine Relay box. Bottom of Relay box slightly bent around connector.
- 8) All drain lines were bent, twisted, and collapsed (See Photo 2).
- 9) Exhaust manifold blown out through flame bucket. One small section imbedded in skirt section at Quad IV. (See Photo 6).
- 10) Sustainer Gas Generator Number P086 (NAA 9512-44185-51) was removed and analyzed to determine the condition of the blade valves and combustion chamber. Results of the investigation disclosed the LO₂ downstream port seal was shattered and the upstream seal was cracked. (See Photos 17 through 28).

6.3 Booster Engine

6.3.1 B1 Thrust Chamber - Damaged beyond repair (See Photos 8 and 9).

- 1) Quad II damage consisted of an 8 inch cut 2 feet from the bottom, and a 1/4 inch hole 1 foot from the bottom of the thrust chamber.
- 2) Between Quads II and III damage consisted of a large 6 inch concave area with a 2 inch hole through the wall 3 feet from the bottom, eight smaller holes and concave areas, and a 1/2 inch hole through the wall.

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6.3.1 (Cont'd)

- 3) Damage in Quad III consisted of two 2 inch holes approximately 2 feet from bottom of chamber, a 2 inch cut and a small hole through the wall 3 feet from the bottom, a 1/2 inch hole and twelve collapsed tubes 1 foot from the bottom, a 1/2 inch hole 7 inches from the bottom, and three small dents 3 inches from the bottom.

6.3.2 BE Thrust chamber - Heavily damaged (See Photos 10 and 11).

- 1) Damage consisted of punctured tubes and 1/2 inch holes between second and third bands of chamber, a 6 by 14 inch concave area and collapsed tubes between third and fourth bands on side toward Sustainer. The area was dented diagonally for 3 inches. In addition, eight tubes were sheared off.

6.3.3 Booster Engine Components

- 1) Miscellaneous engine plumbing destroyed (See Photo 2).
- 2) Booster turbine exhaust duct below heat exchanger collapsed. (See Photos 3 and 7).
- 3) Lube oil tank punctured. (See Photo 4).
- 4) Pneumatic control system damaged extensively.
- 5) An estimated 90% of all engine control wiring destroyed.

6.4 Vernier Engine No. 1

6.4.1 Damage to the V-1 engine consisted of the following:

- 1) Pressure switch harness burned.
- 2) Pitch actuator harness burned.
- 3) Several wires in Plug P90208-7 were charred and potting compound around plug was melted.
- 4) Ground wire to Receptacle J90208-7, and several other wires were charred.

6.5 Thrust Section (See Photo 14)

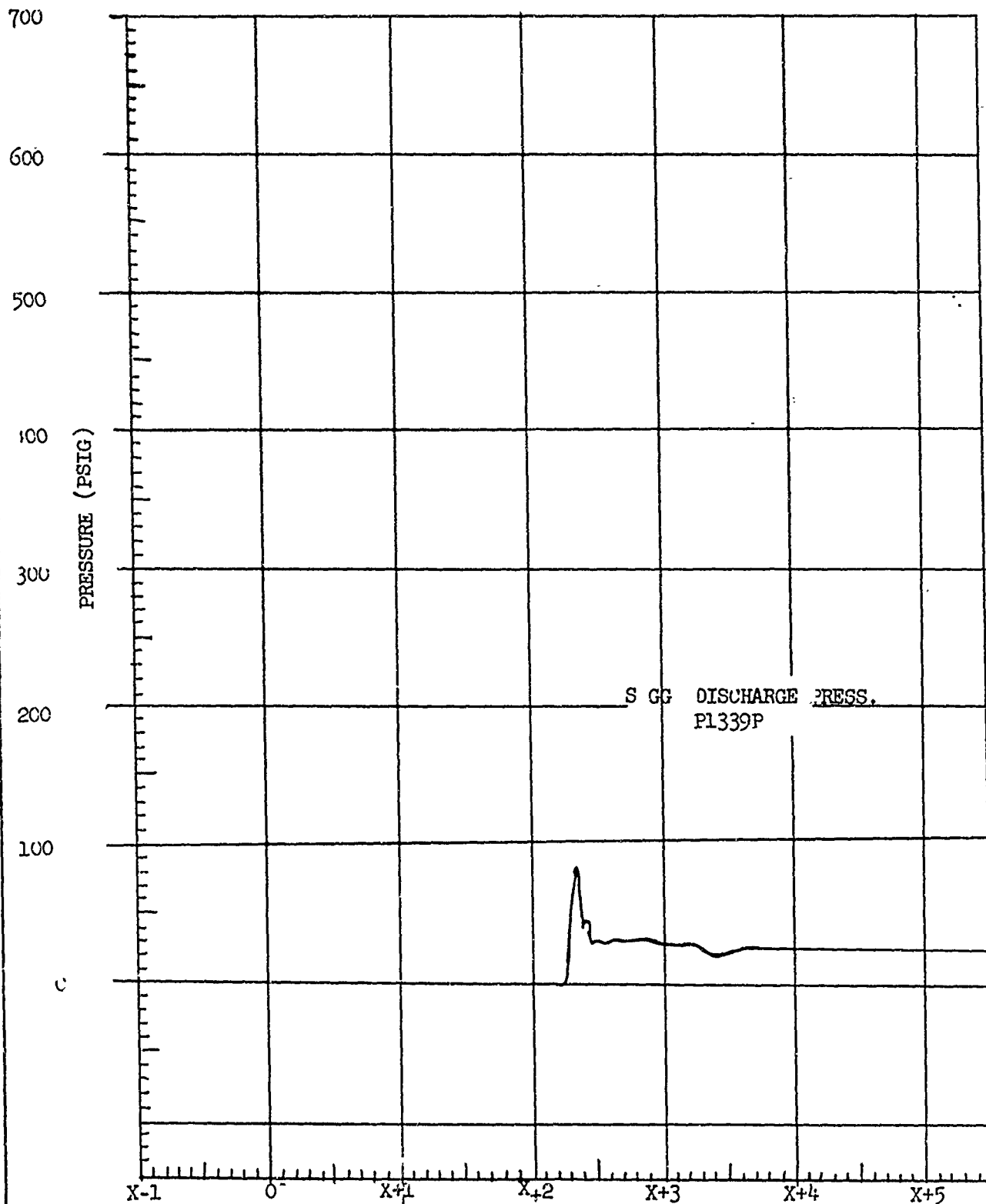
6.5.1 Damage in Quad I

- 1) Interskin and compression strut pulled loose at Sta 1248.
- 2) Interskin pulled loose 75 inches from Quad I between Sta 1248 and 1297.
- 3) Skirt section pulled loose from rivets in barrel section between Sta 1297 and Sta 1248.

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FINAL ACCIDENT REPORT
RUN S2-212-B4-01

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GRAPH 22
DIRECT REPRODUCTION

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RUN S2-212-B4-01

6.5.1 (Cont'd)

- 4) Horizontal strut and bulkhead at Sta 1268 pulled from rivets. Bulkhead rippled.
- 5) Strut between Sta 1297 and Sta 1268 pulled loose with some corrugation.
- 6) Bulkhead web at Sta 1248 pulled loose from rivets and bulkhead rippled.
- 7) Bulkhead web at Sta 1297 pulled loose at rivets.

6.5.2 Damage from Quad I to Quad II

- 1) Split along rivets in thrust barrel section at Sta 1268.
- 2) Dents (35) ranging from 9 to 15 inches from end of barrel between each corrugation.
- 3) Interskin pulled loose from rivets at Sta 1297 bulkhead.
- 4) Interskin pulled loose from rivets at Sta 1268.
- 5) Interskin on X-X axis pulled loose from Sta 1248 to Sta 1297.
- 6) Interskin pulled loose from rivets at Sta 1297 bulkhead.
- 7) LN₂ fill and drain line damaged by 2 inch hole at Sta 1248.

6.5.3 Damage in Quad II

- 1) Tubing badly burned.
- 2) Interskin pulled loose 15 inches from Quad II between Sta 1206 and Sta 1297.
- 3) Corrugation pulled loose from Sta 1297 bulkhead.

6.5.4 Damage from Quad III to Quad IV

- 1) Bulkhead web at Sta 1299 torn loose from rivets. Eight feet of Web torn in many places.
- 2) Innerskin riveted to corrugation from Sta 1268 to Sta 1299 torn loose. Multiple cracks in innerskin and rivets pulled out.
- 3) Innerskin riveted to corrugation from Sta 1268 torn loose. Rivets pulled out and stiffeners cracked.
- 4) Corrugation of Sta 1248, halfway between Quads, torn loose from rivets.

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6.5.4 (Cont'd)

- 5) Launcher purge and control panel between Quads at Sta 1300 demated and twisted. (See Photo 13).

6.5.5 Damage in Quad IV (See Photos 12, 15 and 16)

- 1) Compression struts torn loose from mounting brackets at Sta 1245 and Sta 1280.
- 2) Large diagonal hole, 12 by 4 inches, torn in corrugation of Booster pod extension at Sta 1287.
- 3) Diagonal hole in 6 inch section of bulkhead at Sta. 1299.
- 4) Disconnect panel (7-77260-1) at Sta 1268 disconnected and twisted.
- 5) Corrugation at Sta 1299 torn loose by piece of Sustainer exhaust shroud. Corrugation extended about 12 inches.
- 6) Bulkhead rivets at Sta 1299 pulled out. Web and angle web torn.
- 7) Rivets pulled loose from corrugation at Sta. 1268. Corrugation and webbing torn across width and corrugation extended about 12 inches.
- 8) Stiffener at Sta 1240 pulled out and a crack, about 10 inches, extends away from rivets.
- 9) Innerskin riveted on corrugation, behind jettison rail from Sta 1206 to 1248, torn and pulled from rivets.
- 10) Corrugation of Sta 1268 pulled from former bulkhead and extended from 1 to 12 inches away from center of thrust chamber.
- 11) Vertical tear in inner skin along rivets between Sta 1230 and 1240 extends about 30 inches from X-X axis.
- 12) Vertical tear in inner skin along rivets between Sta 1240 and Sta 1247 extends for about 15 inches from Y-Y axis.
- 13) Thrust barrel parted from bulkhead at Sta 1268 for about 4 feet starting at X-X axis.
- 14) Hole torn in thrust barrel structure on X-X axis.
- 15) Hole torn in thrust barrel structure about 12 inches from X-X axis.

6.6 Thrust Section Interior

6.6.1 General Damage

- 1) Heat exchanger dented for about 1/4 its circumference on side facing the Sustainer.

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FINAL ACCIDENT REPORT
RUN S2-212-B4-01

6.6.1 (Cont'd)

- 2) Lower compression strut mounting bracket broken and piece missing.
- 3) Gusset (7-77961-38) bent and torn with one rivet popped out.
- 4) Angle strut (7-77961-34) bent and torn.
- 5) Entire area below bulkhead at Sta 1268 heat blistered.
- 6) CO₂ and Firex pipe bent and twisted in Quads I and IV. Firex pipe smashed into Bl, causing severe damage. (See Photo 9) Braces for Firex pipe bent and twisted.
- 7) Compression struts in Quads I and IV torn loose from thrust section skirt (both upper and lower strut). In Quad II, only the upper strut is loose. In Quad III, only the lower strut is loose.
- 8) LN₂ supply line to pressurization bottle shroud caved-in directly below shroud in Quad I and II.
- 9) Bl engine relay box connectors burned and broken.
- 10) Split 3 inches long in bottom half of Booster lube oil tank on Quad IV side. (See Photo 4)
- 11) Lower Booster relay box bracket torn off.
- 12) Oval shaped crack about 12 by 8 inches in diameter in Sustainer turbopump gear case.
- 13) Crack in fuel volute of Sustainer turbopump. (See Photo 5).
- 14) Engine pneumatic manifold wiring charred and burned.
- 15) Booster exhaust duct caved-in below heat exchanger. Small dent in heat exchanger. (See Photo 7).
- 16) On lower Booster engine relay box, one cannon connector broken and 2 connectors burned and cracked. Cannon connector lines burned and cracked.
- 17) Asbestos on thrust section heating duct torn, twisted, and burned.

6.7 Missile Pods

6.7.1 Damage to equipment in Missile pods was as follows:

- 1) Ground wire for MSD plug and J1131 connector burned entire length (approx. 24 inches).
- 2) Taped end of ground cable at base of pod burned approximately 3 inches.

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6.7.1 (Cont'd)

- 3) Potting compound for MSD cable and connector (J1131) charred 6 inches from connector.
- 4) Pod doors paint blistered in area 6 inches wide over entire length of doors.

6.8 Facilities

6.8.1 Damage to facility equipment was as follows:

- 1) Rubber insulation from wire between Quads I and IV burned and melted along trunnion at level 17.
- 2) Rubber insulation on wire at level 17 between Quads III and IV melted and burned.
- 3) Leak in hydraulic flex line at rise-off fitting in Quad IV, level 17. (See Photo 13).
- 4) All rise-off panel hydraulic flex lines between Quads III and IV at level 17 are badly discolored from smoke and burning.
- 5) Flex heater duct across deck between Quads I and IV at level 17 burned for about 6 feet of its length.
- 6) Foil wrapping on Pod coolant flex line in Quad IV, level 17, blown and tattered. Little evidence of flex line burning.

6.9 Tower

6.9.1 Damage to tower components and equipment was as follows:

- 1) Curtain on south east side of tower at level 17 badly burned.
- 2) Pod cooling duct between levels 17 and 27 scorched and burned for about 6 to 7 feet. All of one "Y" duct scorched and burned.
- 3) Paint was badly scorched on southeast bottom side of tower level 35 platform.
- 4) Paint on south bottom sides of tower level 27 platforms badly scorched and damaged by water.
- 5) Thrust barrel heater ducting at level 17 badly scorched and burned in several places.
- 6) Fence, railing, and duckboards on level 17 badly corroded and damaged by fire and water.
- 7) CO₂ piping south side of level 17 badly corroded and damaged by fire and water.

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RUN S2-212-B4-01

6.10 Instrumentation

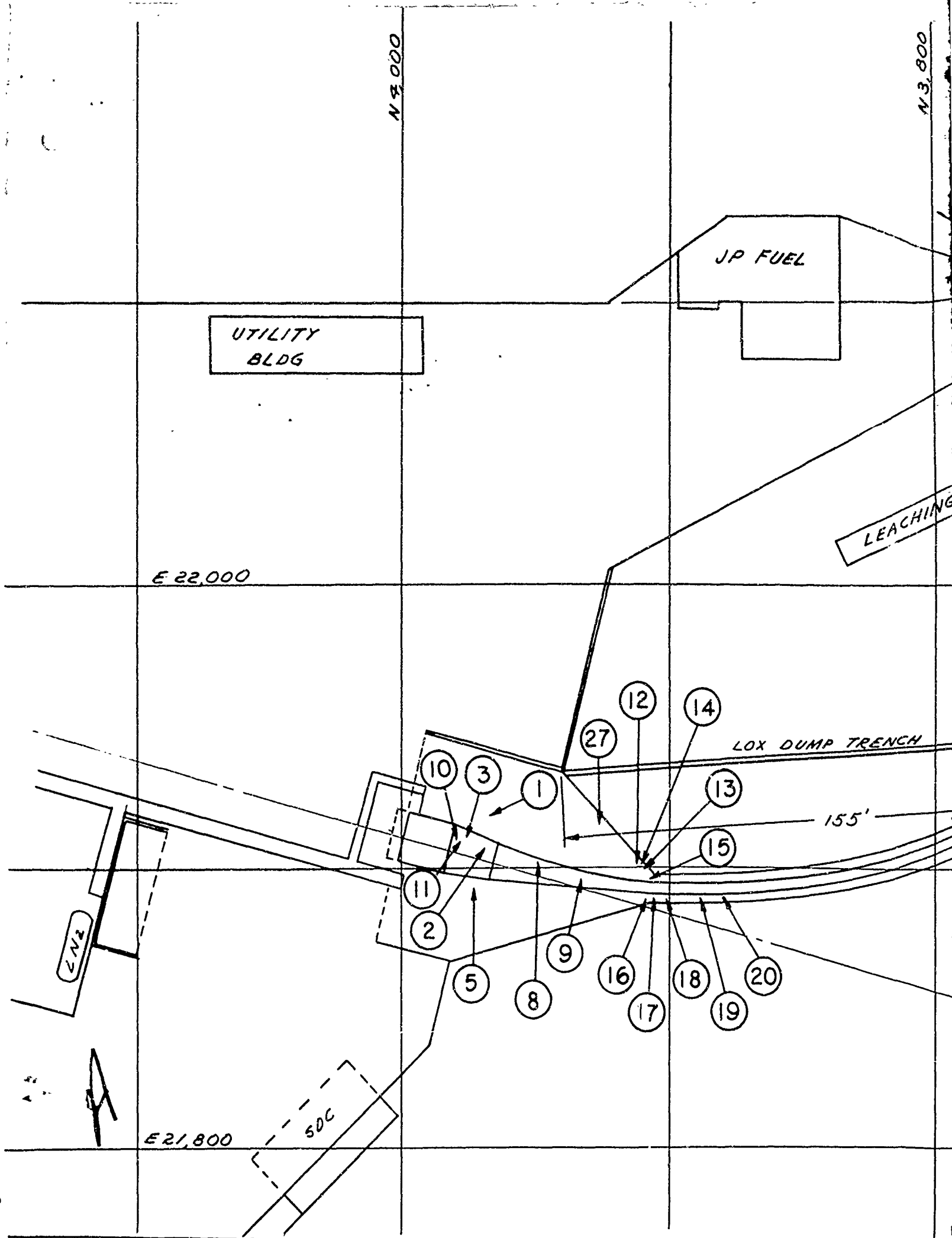
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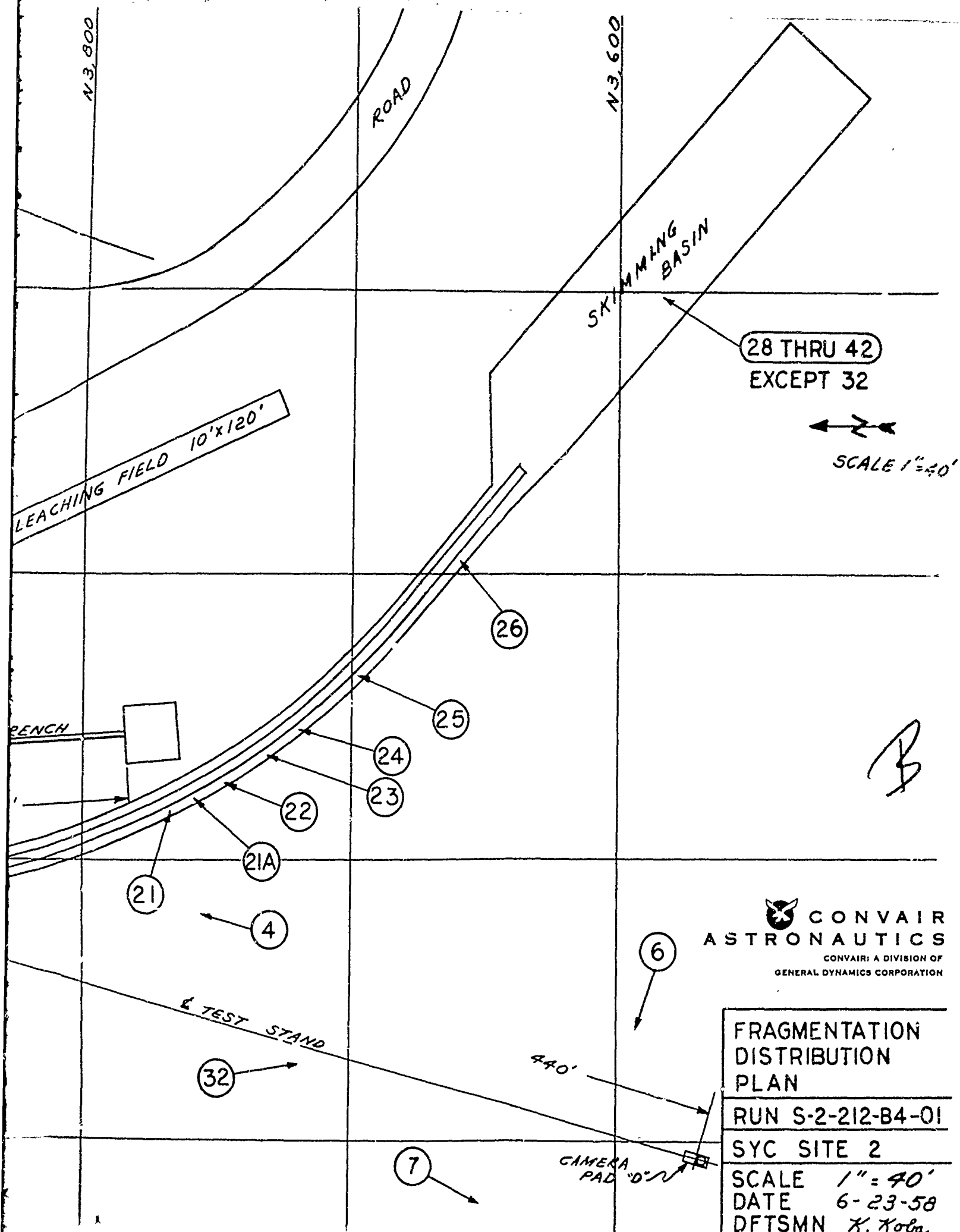
MEASUREMENT		TRANSDUCER	
NO.	NAME	PART NO.	SERIAL NO.
A95P	FAIRING DIFFERENTIAL	7-01225-805	7
A109P	FAIRING DIFFERENTIAL	7-01225-805	204
F1011P	LO ₂ PRESS REG DISCH	7-01225-803	57
F1114P	LO ₂ PRESS REG INLET	7-01226-801	148
F1124P	S TANK HE BTL DISCH	7-01226-801	267
H1033P	B1 HYD ACCUMULATOR	7-01226-801	246
H1052P	S HYD ACCUMULATOR	7-01226-5	13
H 1T	MSL HYD PUMP DISCH	7-01223-5	67
P1349B	S PUMP SPEED	7-01437-A1	NAA
P 2P	B1 FUEL PUMP INLET	7-01226-1	15
P1010P	B1 LUB OIL MAN	7-01226-3	136
P1027P	VERNIER FUEL TANK	7-01226-3	442
P1059P	B2 THRUST CHAMBER	7-01627-5	2297
P1091P	B1 LO ₂ INJ MAN	7-01627-801	2027
P1093P	B1 FUEL INJ MAN	7-01627-801	3534
P1094P	B2 FUEL INJ MAN	7-01627-801	1763
P1235P	VERN LO ₂ TK REG OUT	7-01226-3	46
P1280P	S GG FUEL VLV INLET	7-01226-3	65
P1330P	S FUEL PUMP DISCH	7-01226-801	50
P1332P	S LO ₂ PUMP DISCH	7-01226-801	5
P1489P	B GAS GEN LO ₂ VLV IN	7-01226-3	3
P1014T	ENG COMP AMBIENT	7-01223-1	52
P1017T	B2 TURBINE IN	7-01265-801	17
ST171P	BGG FUL ORFC BLK IN. P	7-01226-3	41

6.11 FRAGMENTATION SURVEY

- 6.11.1 As part of the activities of the hardware investigation committee a survey was conducted to locate and identify all fragments of the missile blown from the stand area during the explosion. The locations of all fragments discovered was recorded on a map of the area (reproduced on the following page) and each fragment was inspected and identified by Convair and Rocketdyne personnel.
- 6.11.2 The locations of the individual fragments is not considered significant. The majority of the fragments were recovered from the flame deflector wash and the fuel skimming pond after it was drained. The majority of the fragments were found where they were carried by flame deflector water.
- 6.11.3 Exceptions to this are fragments number 4, 6, 7 and 32 which were located where they fell.
- 6.11.4 A list identifying individual fragments shown on the distribution plan is reproduced on page 19.

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CONVAIR
ASTRONAUTICS
 CONVAIR: A DIVISION OF
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**FRAGMENTATION
 DISTRIBUTION
 PLAN**

RUN S-2-212-B4-01

SYC SITE 2

SCALE 1" = 40'
 DATE 6-23-58
 DFTSMN K. Koba

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FINAL ACCIDENT REPORT
RUN S2-212-B4-01

6.12 Individual Fragment Identification List

- 1) Instrumentation pickup.
- 2) 3 small steel fragments, heavily carboned on one side.
- 3) Fragment - marked 4-1102-75.
- 4) Second Stage Sustainer Turbine wheel
- 5) S cap fitting, marked with orange paint. Does not appear to have come from the explosion.
- 6) Aluminum fragment.
- 7) Strap for retaining boot.
- 8) Two inch piece of drain line
- 9) 3-4 inch fragment, probably from the Sustainer GG exhaust duct manifold.
- 9A) Similar to number 9. Located one foot to the south..
- 10) Cable assembly with a brass identification band stamped J-3067-2.
- 11) Two identification tags and a two inch piece of line marked as follows:

TAG NUMBER ONE: 4600 PSIG
TVA 71230-13

TAG NUMBER TWO: Set at 4600 psig
89-34906-002-13

TWO INCH PIECE: 7-17706-13 CVA - 01
325
- 12) Part of an Igniter cable
- 13) Another igniter cable.
- 14) A piece of cable with color coded wiring. Does not appear to have come from the explosion.
- 15) A group of parts found together including:
 - a) An igniter cable and a Vernier Igniter clamp marked 9512412-07
 - b) Six fittings for attaching the boots. These parts appear to have been brought together by flame deflector water action.
- 16) Two small metal fragments
- 17) One of the bolts which attaches the second stage turbine wheel to the turbine shaft.
- 18) Fragment

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6.12 (Cont'd)

- 19) Turbine wheel blade.
- 20) 2-3 inch fragment
- 21) 2-3 inch fragment
- 21A) Large twisted fragment. 20, 21 & 21A all appear to have come from the Sustainer GG exhaust system.
- 22) Two pieces of tubing, a fitting holding them together, and a small (separate) piece of aluminum. The tubing appears to be part of the Sustainer drain lines.
- 23) A piece of Sustainer "Broomstick" igniter which does not seem to have been exposed to weather and is probably from Run S2-212-B4-01.
- 24) A fragment and an identification tag marked 7-67742-801 ^{CVA}₁₄₈ -01
- 25) A one inch piece of tubing.
- 26) A piece of aluminum probably from one of the fittings used to attach the boots.
- 27) A turbine wheel blade.

All parts numbered 28 through 42 were found in the Skimming Pond with the exception of number 32.

- 28) A large piece of the Sustainer GG exhaust.
- 29) A large thicker fragment. Appears to be from the Sustainer GG exhaust manifold.
- 30) Two pieces of Sustainer Thrust Chamber re-inforcing bands.
- 31) Piece of tubing. Probably from one of the Sustainer drain lines.
- 32) Aluminum tag stamped number one.
- 33) Sustainer Turbine Second Stage Inlet Nozzles.
- 34) Eighteen inch section of the Sustainer GG exhaust duct.
- 35) Part of the Sustainer GG exhaust duct manifold.
- 36) The Sustainer Pneumatic Helium Heat Exchanger coils.
- 37) Four pieces of U channel considerably deformed. Probably Sustainer thrust chamber reinforcing bands.
- 38) Three pieces of strap.

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6-12 (Cont'd)

- 39) LN₂ shroud duct marked 7-87570-BN-01.
- 40) Two pieces of the Sustainer thrust chamber wall tubing.
- 41) A group of fragments from the Sustainer GG exhaust duct and exhaust duct manifold.
- 42) A piece of the fiberglass firewall.

Miscellaneous - A collection of small fragments, fittings, etc., placed in a box marked "Misc. parts Run S2-212-B4-01."

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FINAL ACCIDENT REPORT
RUN S2-212-B4-01

7.0

CONCLUSIONS

The explosion was caused by damaged seals in the Sustainer Gas Generator LO₂ blade valve. These seals were damaged at cutoff during Run 211. LO₂ was flowing past the Sustainer Gas Generator blade valve from a time early in Lox tanking. LO₂ saturated the residual material in the Sustainer Gas Generator, Sustainer Turbine and the Gas Generator exhaust duct and manifold. The resulting hydrocarbon gels were detonated by the Sustainer Gas Generator igniters firing. The explosion was centered in the Sustainer turbine probably at a point between the first stage turbine wheel and the second stage nozzles. Secondary explosions may have occurred in the exhaust duct and manifold. The cause of the LO₂ blade valve seal failure has not been positively determined. It is suspected that the seals were damaged by a minor explosion which occurred between the Sustainer gas generator injection head and the LO₂ manifold at cutoff on Run 211. A second and less probable theory is that the seals became misaligned and were damaged by the LO₂ blade valve closing.

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FINAL ACCIDENT REPORT
RUN S2-212-B4-01

8.0 RECOMMENDATIONS AND CORRECTIVE ACTION

- 8.1 It is recommended that Gas Generator purge procedures be reviewed and implemented to ensure adequate purge pressure and duration. During the next test firing of missile 1B it is planned to modify purge procedures. GG purges will be turned on five seconds prior to Vernier engine start and continued for ten minutes after cutoff. Purge source pressure will be increased to ensure adequate purge pressure.
- 8.2 Gas Generator propellant flows and temperature measurements should be checked during propellant tanking and after firing to aid in detecting leaks.
- 8.3 The S2 water and CO₂ fire fighting systems were demonstrated to be adequate in controlling a fire of this nature. It is recommended that these systems be mandatory for all static firings
- 8.4 Closing of pre-valves as a part of emergency fire procedures should be adopted as standard procedure for all static firings. Local controls for the Booster and Sustainer pre-valves should be provided.

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APPENDIX A

FINAL COUNTDOWN
RUN S2-212-B4-01

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14 JUL 68 Page 001

LOCATION
OR
-PANEL

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THE NEW YORK PUBLIC LIBRARY
ASTOR LENOX TILDEN FOUNDATION
500 5TH AVENUE
NEW YORK 17, N.Y.

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PAGE 003

7- CHECK 500 CUTOFF LOGOUT ON DEF
8- CHECK TEST SOURCE EXCITATION UNIT
9- CHECK POWER LINE

10- TEST SOURCE EXCITATION UNIT POWER
SUPPLY SW ON

-CHECK 500 VOLTAGE 15 1500

1-0.02 VAC

2-100 VDC

1- CHECK 500 TEST PROGRAM REPORT

2- CHECK TEST PROGRAM REPORT

3- CHECK TEST PROGRAM REPORT

4- A/P TEST PROGRAM REPORT

5- CHECK 500 TEST PROGRAM REPORT

6- CHECK 500 TEST PROGRAM REPORT

SUPPLY SW ON

-CHECK VOLTAGE

1-0.02 VAC

2-150 VDC

3-150 VDC

4-450 VDC

5- CHECK 500 TEST PROGRAM REPORT

-REFERENCE VOLTAGE

-TEST POSITION

-SENSITIVITY

A/P PG 6AS
TEU RACK

TEU RACK

TEU RACK

6.3 VAC

300 VDC

A/P TST PG

2A

A/P TST PG

PG AUX PH

A/P TEST

6.3 VAC

150 VDC

300 VDC

450 VDC

INST

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SYG 5-2 1-B RUN- 4 AS RUN COUNTDOWN

14 JUL 58 PAGE 006

C-RCC DEVICE POWER SW ON

W

RCC DEVICE

D-BINARY COUNTER TEST/RUN SW TO RUN

W

B1 COUNTER

E-BINARY COUNTER POWER SW ON

W

B1 COUNTER

F-STEPPING SW COUNTER POWER SW ON

W

RCC STEP

G-RCC TEST/RUN SW TO RUN

W

RCC DEVICE

H-RCC CONTROL SW TO INACTIVE

W

B1 COUNTER

2- ACTIVATE RCC CHANNEL 23 POWER- ALLOW

15 MIN WARMUP

ELCTRIC RM

A-TEST PANEL SIG INPUT SW TO RUN

TEST PNL

B-RCC MAIN POWER SW ON

W

RCC RM PWR

C-RCC DEVICE POWER SW ON

W

RCC DEVICE

D-BINARY COUNTER TEST/RUN SW TO RUN

W

B1 COUNTER

E-BINARY COUNTER POWER SW ON

W

B1 COUNTER

F-STEPPING SW COUNTER POWER SW ON

W

RCC STEP

G-RCC TEST/RUN SW TO RUN

W

RCC DEVICE

H-RCC CONTROL TO INACTIVE

W

B1 COUNTER

3- ACTIVATE RCC CHANNEL 24 POWER- ALLOW

15 MIN WARMUP

ELCTRIC RM

A-TEST PANEL SIG INPUT SW TO RUN

TEST PNL

B-RCC MAIN POWER SW ON

W

RCC RM PWR

C-RCC DEVICE POWER SW ON

W

RCC DEVICE

D-BINARY COUNTER TEST/RUN SW TO RUN

W

B1 COUNTER

E-BINARY COUNTER POWER SW ON

W

B1 COUNTER

F-STEPPING SW COUNTER POWER SW ON

W

RCC STEP

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SYC 5-2 1-3 RUN- 4 AS RUN COUNTDOWN

14 JUL 58

PAGE 007

G-RCC TEST/RUN SW TO RUN

RCC DEVICE

H-RCC CONTROL SW TO INACTIVE

81 COUNTER

4- CATHODE FOLLOWER POWER SUPPLY SW ON

TRANS RM

5- AUDIO WARNING CHANNEL 32 POWER SW ON

TRANS RM

A-CHECK GAIN SW SET AT 50

50

6- AUDIO WARNING CHANNEL 33 POWER SW ON

TRANS RM

A-CHECK GAIN SW SET AT 50

50

7- AUDIO WARNING CHANNEL 34 POWER SW ON

TRANS RM

A-CHECK GAIN SW SET AT 30

30

8- CHECK SENSITIVITIES SET AT RUN

ELECTRNC RM

VALUES/CHANNELS 32, 33 & 34

0013 * CALIBRATE INSTRUMENTATION & RECORD ANY

INST

VARIATION BETWEEN ICM STEPS & PRIOR CALIBRATION

X-1 DAY-

0016 * SET UP CAMERA CONTROLS & REPORT

INST

0017 * ACTIVATE EMERGENCY DIESEL GENERATOR & REPORT

17 MIN-

1- DEPRESS RESET BUTTON ON TRANSFER

BLKHS BSMT

PANEL BK22-19

2- START DIESEL GENERATOR

BLKHS REAR

3- AFTER 5 MIN WARMUP/CLOSE BREAKER ON

BLKHS REAR

GENERATOR PANEL

4- CHECK VOLTAGE AT 480 VAC

BLKHS REAR

5- CHECK FREQUENCY AT 60 CYCLES

BLKHS REAR

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SYC S-2 1-B RUN- 4 AS RUN COUNTDOWN

14 JUL 58 PAGE 006

6- SWITCH COMMUNICATIONS TO EMERGENCY

GLKHS BSHT

POWER

0018 * CHECK & ADJUST ENGINE REG SETTINGS TO RUN VALUES

13 MIN-

1- CHECK ENG CONTROL VLV ITEM 67 OPEN

PCU

2- CHECK ENG CONTROL SW ON

PNEUMATIC

3- BROWN RECORDERS ON SLOW/LOCALLY

INST CTRL

4- 6 ENGINE CONTROL REG 750 H/- 15 PSIG

750 H/-15

MISSILE

F1125P

BAY D111-1

INST

5- BOOSTER LO2 REF REG 525 H/- 10 PSIG

525 H/-10

MISSILE

P1026P

BAY D111-2

INST

ST1142P

BAY D108-1

INST

6- LO2 START TANK REG 450 H/- 20 PSIG

450 H/-20

MISSILE

P1177P

BAY D112-3

INST

7- SUS ENG CONTROL REG 750 H/- 15 PSIG

750 H/-15

MISSILE

F1142P

BAY D112-1

INST

8- SUS LO2 REF REG 810 H/- 10 PSIG

810 H/-10

MISSILE

P1344P

BAY D112-2

INST

9- VERMIER FUEL TANK REG 535 H/- 10 PSIG

535 H/-10

MISSILE

P1236P

BAY D110-2

INST

10-VERMIER LO2 TANK REG 520 H/- 10 PSIG

520 H/-10

MISSILE

P1235P

BAY D109-2

INST

11-FUEL START TANK REG 800 H/- 40 PSIG

800 H/-40

MISSILE

P1178P

BAY D111-3

INST

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SYC 0-2 1-B RUH- 4 AS RUN COUNTDOWN

14 JUL 66 PAGE 009

12-EXOM RECORDERS OFF/RETURN TO

A JUMP CIRCUITS

INST CNTRL

0019 * READY POD 1 FOR HOT TEST & REPORT

MISSILE

31 MIN-

1- OPEN P.U. PURGE VALVE

POD 1

2- CHECK A/P CARTRIDGE PREPARED FOR

POD 1

HOT FIRING

A-SUS 1, 7 & 8 ON

B-SUS 2, 3, 4, 5 & 6 OFF

3- INST-LL MAIN MISSILE BATTERY

POD 1

4- CLOSE & SECURE POD DOORS

POD 1

0020 * REMOVE MECHANICAL LOCKS FROM STRUT

TS-STAGE

SLING & REPORT

REMOVED X-1 DAY-

0021 * CHECK LAUNCHER STABILIZING SYSTEM PRESS ON & REPORT

2000 PSIG HYD PAD

1- CHECK BOOSTER UNIT OUTLET PRESS/

2000 PSIG MINIMUM

2150 PSIG-

2- CHECK PRESSURE LINES OUT

HD & R

0022 * CHECK WIND VELOCITY & REPORT-PAK 35 124

INST

6 TO 15 KNOTS-

0023 * CHECK ALL FIREX GAS OFF

FIREX

0024 * PREPARE FIREX SYSTEMS FOR TEST & REPORT

X-1 DAY-

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SYC 5-2 1-3 RUN 4 AS RUN COUNTDOWN

14 JUL 58 PAGE 010

1- OPEN SKIRT FOG MANUAL SHUTOFF VALVE VLV PIT #3

312W

2- SKIRT FOG MANUAL SELECTOR VALVE 323W

TO FAIL-WET

3

3- OPEN LAUNCHER COOLANT MANUAL SHUT-

OFF VALVE 201W

4- LAUNCHER COOLANT MANUAL SELECTOR VLV

212W TO FAIL-WET

6

5- OPEN TOWER WATER MANUAL SHUTOFF

VALVE 402W

6- LOWER MISSILE WATER MANUAL SELECTOR

VALVE 420W TO FAIL-WET

6

7- OPEN VERMIER DEFL MANUAL

SHUTOFF VALVE 101W

8- OPEN GAGE COCK 56W/CHECK VACUUM GAGE

FOR PROPER VALVE/41W 5.5 IN #3

9- CLOSE GAGE COCK 56W

0025 * CHECK NO PERSONNEL IN ELEVATOR

0026 * SECURE SERVICE TOWER & UTILITY PANEL 30C2

1- TURN OFF ELEVATOR POWER SW-13

HOLD 1451 TO 1502 - REMOVE GREASE FROM

AROUND 62 THRUST CHAMBER GENERAL MOUNT

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SYN 8-2 1-2 001- 4 AS 201 COUNTDOWN

14 JUL 58

PAGE 011

////////////////////

DELAY 1510-1520-SET UP FLEXIBLE FIREBALL

////////////////////

X-1/43H 0027 * PREPARE BOOSTER & SUS HYDRAULIC SYSTEMS FOR RUN

1- CHECK AUTOPILOT AC POWER SW ON

A

AUTOPILOT

A-CHECK PHASE ROTATION, CORRECT

G

PG AUX PN

LIGHT ON

B-CHECK OUTPUT SW IN CUTOFF

A/P TST PG

2- CHECK HEATER & REFRIGERATOR SW'S ON

HYD CARTS

3- CHECK LOCAL/REMOTE SW'S TO REMOTE

HYD CARTS

4- START BOOSTER GROUND PUMP

HYDRAULIC

5- CLOSE BOOSTER BYPASS VLV

HYDRAULIC

A-CK MSSL INLET PRESS/2000 PSIG

2000 PSIG

B-CK MSSL OUTLET PRESS/75 PSIG MAX

75 PSIG MAX

6- START SUS GROUND PUMP

HYDRAULIC

7- CLOSE SUS BYPASS VALVE

HYDRAULIC

A-CK MSSL INLET PRESS/2000 PSI

2000 PSIG

B-CK MSSL OUTLET PRESS/75 PSIG MAX

75 PSIG MAX

8- CHECK MSSL HYD RESERVOIR FLUID

MISSILE

LEVELS/ADJUST IF NECESSARY

9- OPEN BOOSTER BYPASS VALVE

HYDRAULIC

10-STOP BOOSTER GROUND PUMP

HYDRAULIC

11-OPEN SUS BYPASS VALVE

HYDRAULIC

12-STOP SUS GROUND PUMP

HYDRAULIC

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SVC S-2 1-B RUN- 4 AS RUN COUNTDOWN

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13-A/P AC POWER SW OFF

AUTOPILOT

0023 * CHECK FACILITY SYSTEMS SUPPLY PRESS/RECORD & REPORT

CHECKED X-1 DAY-

1- POD COOLER OPERATION/APPROX 45F

COOLER PAD

2- FUEL TRANSFER UNIT PRESS

110 PSI FUEL PAD

A-CHECK THE FUEL MANIFOLD VLVS OPEN

1-FILTER INLET VALVE 103NP

2-SUPPLY OUTLET VALVE 110RP

3-TRANSFER UNIT INLET VALVE 113 KP

3- PNEUMATIC BOOSTER SUPPLY PRESS

2200 PSIG TS-STAL17-R

4- LAUNCHER GN2 SUPPLY PRESS-

2200 PSI TS-STAL17

5- EMER LO2 PREVALVE CONTROL PRESS

TS-STAL43

A-SUPPLY MIN 1800 PSI-

B-REGULATED 1000 PSI-

6- PCU HELIUM SUPPLY PRESSURES

PRESS PAD

A-NORMAL- 2025 PSIG

B-EMERGENCY - 2025 PSIG

C-BANK - MIN 3500 PSI - 4600 PSIG

7- OPEN A/5 HE SUPPLY VALVE 213HE

PRESS PAD

8- LO2 TRANSFER UNIT PRESS

110 PSI

LO2 PAD

9- OPEN STORAGE TANK OUTLET VLV 101LX

LO2 PAD

10-GN2 BANK PRESSURE

2200 PSIG

LO2 PAD

11-CHECK PURGE MANIFOLD PRESS

1000 PSIG

PURGE BOX

1000 +/- 50 PSIG

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SYG 5-2 1-2 RUN- 4 AS RUN COUNTER

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1000 PSIG-

12-CHECK VALVE CONTROL PRESS

400 PSIG PURGE BOX

400 +/- 20 PSIG

400 PSIG-

13-CLOSE & SECURE PURGE BOX

PURGE BOX

14-REPORT ELEM GEN FALG & VOLT

ELMS REAR

15-DEACTIVATE STATION SLING

TOWER

1-1 DAY-

1- CHECK LITE OUT

PRESC

2- MONITOR ISSUED VERTICAL ALIGNMENT / MIN

15-0-15

LIMITS 15-0-15 MINUTES

3- MAKE VLV FL & DEFL COVERS & SAFETY OUT & REPORT

4- CHARGE CO2 FIREX SYSTEM

1- CHECK THAT POC 1, POC 2 & ENG CO2

FIXER

CONTROLS FUNCTION. & VLVs ACTUATE

2- CHECK THAT CO2 SYSTEM ELECTRIC ALARM

PILOT VLVs 100, 100 & 200 ARE CLOSED

PLUNGER DOWN & SOLENOID DE-ELECTRIC

3- CLEAR ALL PERSONNEL FROM TROUGH

TEST STAND

SECTION

4- SLOWLY OPEN CO2 STORAGE UNIT DIS-

CO2 STORAGE

CHARGE VLV V1 TILL SYS FULLY CHARGED

5- CHECK CO2 ROSE REEL INLET VLV OPEN

6- PRESSURIZE AIR FLASK TO 4000 PSIG & REPORT

7-5-17-17

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SYC 3-2 1-5 RUN- 4 AS RUN COUNTDOWN

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X-1 DAY-

1- CK 7000 PSIG HELIUM RECEIVER

PRESSURIZED

7000 PSIG

PNEU UNIT

2- CHECK HIGH PRESS SUPPLY VALVE 6000
CLOSED

CHARGE PNL

3- CHECK PRESS REG 6200 BACKED OFF

CHARGE PNL

4- CHECK PRESS REG 6200 VENT CLOSED

CHARGE PNL

5- CHECK VENT VALVE 7400, CLOSED

CHARGE PNL

6- CONNECT ACCUM PRE-CHARGE LINE DETAIL

AIR FLASK CHARGE P. DETAIL

MISSILE FITTING

7- OPEN FLASK PRESSURIZING VALVE 7000.

CHARGE PNL

8- CHECK 7000 PSIG NITROGEN VENT

PNEU UNIT

VALVE CLOSED

9- SLOWLY OPEN 7000 PSIG NITROGEN

PNEU UNIT

SHUTOFF VALVE

10-SLOWLY OPEN MI PRESS SUPPLY VLV 6000

CHARGE PNL

11-ADJUST PRESS REG 6200. TO PRESSURIZE

4000 PSI

CHARGE PNL

FLASK TO 4000 PSIG

NOTE-PRESSURE TO BE READ ON

PRE-CHARGE LINE PRESS GAG.

12-CLOSE HIGH PRESS SUPPLY VALVE 6000

CHARGE PNL

13-OPEN VENT VALVE 7400 TILL GAS FLOW

CHARGE PNL

CEASES/CLOSE

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SYN 3-2 1-2 RUN 4 AS RUN COUNTDOWN

14 JUL 58

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- 14-CLOSE PRESSURIZING VALVE 750P
- 15-DACKOFF PRESS 620P
- 16-CLOSE 7000 PSIG NITROGEN SHUTOFF VLV
- 17-OPEN 7000 PSIG NITROGEN VENT VLV

CHANGE PNL
CHANGE PNL
PREU UNIT
PREU UNIT

TILL GAS FLOW CEASES/CLOSE

-1/-CH 0024 * ACTIVATE THROAT SECTION HEATING UNIT & REPORT

*7 01. - UNIT NOT OPERATING PROPERLY
FOUND TO VOID OF OIL & FILLED & RESTARTED

- 1- CHECK HEATING UNIT CONTROL SW. TO
NEUTRAL

FACULTY PNL

- 2- CHECK DUCTING PROPERLY LEADING TO
UNIT & TO MISSILE SHUTOFF

HEAT UNIT

- 3- PULL BURNER FUEL VLV OP

HEAT UNIT

- 4- START HEATING UNIT

HEAT UNIT

- 5- HEAT UNIT CONTROL SW. ON

FACULTY PNL

- 6- DEPRESS BURNER START SW

HEAT UNIT

- 7- SET AIR VOLUME CONTROL TO FULL

HEAT UNIT

- 8- SET TEMP CONTROLLER TO MAX

HEAT UNIT

- 9- MONITOR OUTLET TEMP TO APPROX 300P

HEAT UNIT

N-05. 0030 * ACTIVATE HASKELL DIESEL COMPRESSOR & REPORT
NOT REQUIRED-

300P

NOTE-THIS OPERATION TO BE PERFORMED ONLY IF
FACILITY COOLANT IS LESS THAN 3500 PSIG

- 1- CYCLE SW TO NEUTRAL

PRESS PNL

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SYC 3-2 1-6 RUN- 4 AS RUN COUNTDOWN

14 JUL 58

PAGE 016

- 2- THROTTLE CONTROL TO START
 - 3- START SW TO ON
 - 4- THROTTLE CONTROL TO RUN
 - 5- HYDRAULIC VALVE SELECTOR TO OPERATE
 - 6- LOCAL/REMOTE S TO REMOTE
- 0026 * SECURE LAUNCHER '2 & REPORT

X-2/30H

0026 * SECURE LAUNCHER '2 & REPORT

8 MIN-

- 1- ENGINE AC BREAKER SWS ON -3
- 2- CHECK LO2 HEATER LITE ON
- 3- AREA CLEAR SW ON
- A-CHECK LITES ON

3W LCHR BOX 2
A LO2 CTRL
LCHR BOX 2
G ELG TEST
G PRESTART
TS-STAB-R

- 4- SECURE LAUNCHER BOX 2 & CLOSE ALL
VENT VALVES

- 0037 * SET UP MISSILE TERMINAL BOX PURGES & REPORT
- 1- OPEN ELECTRICAL BOX '2 PURGE
VALVE 1375H

X-1/20H

TS-STAB-R

- 2- CHECK PRESS REG 1360 SET FOR 3 LCH
WATER

TS-STAB-R

- 0025 * FILL LM2 SHROUD
16 MIN-

X-1/004

- 1- CHECK LM2 STORAGE TANK PRESS/VENT
SW TO VENT/HEAT EXCH CIRC
- 2- OPEN PRESS VALVE 3120H

PRESS PAD

PRESS PAD

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SYN 3-2 1-6 RJN- 4 AS RUN COUNTDOWN

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PAGE 016

- 2- THROTTLE CONTROL TO START
- 3- START SW TO ON
- 4- THROTTLE CONTROL TO RUN
- 5- HYDRAULIC VALVE SELECTOR TO OPERATE
- 6- LOCAL/REMOTE SW TO REMOTE

PRESS PAD
PRESS PAD
PRESS PAD
PRESS PAD
PRESS PAD
TS-STAB-R

0036 * SECURE LAUNCHER #2 & REPORT

3 MIN.

- 1- ENGINE AC BREAKER SMS ON -3
- 2- CHECK LO2 HEATER LITE ON
- 3- AREA CLEAR SW ON
- 4- CHECK LITES ON

LCHR BOX 2
LO2 CTRPL
LCHR BOX 2
ENG TEST
PRESTART
TS-STAB-R

- 4- SECURE LAUNCHER BOX 2 & CLOSE ALL
VENT VALVES

0037 * SET UP MISSILE TERMINAL BOX PURGES & REPORT

- 1- OPEN ELECTRICAL BOX #2 PURGE

VALVE 1375H

- 2- CHECK PRESS #26 1365.3 SET FOR 3 INCH

WATER

0038 * FILL L#2 SHROUD

16 MIN.

- 1- CHECK L#2 STORAGE TANK PRESS/VENT
SW TO VENT/HEAT EXCHANGER
- 2- OPEN PRESS VALVE 3125H

PRESS PAD
PRESS PAD

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SYC 3-2 1-1 RUN- AS RUN COUNTDOWN

14 JUL 58 PAGE 017

3- CLOSE 3 INCH THIN VENT VALVE 302LM
4- SET PRESS REG 30500 TO 40 PSI - 4 PSI
PRESS GAGE 310000

PRESS PAD
PRESS PAD

40 PSIG

5- OPER L-2 PUMP VALVE FOR 15 SEC-CLOSE

9-OUT PNEUMATIC

A-CHECK VALVE OPERATION/ 2 VALVLS

TEST STAND

6- OPEN L-2 FLUSHING WATER VALVE

STAND

7- DEPRESS L-2 PRECOOL SW-UNIT 10 MIN

PNEUMATIC

8- DEPRESS PRESSURIZE SW

PNEUMATIC

A-CHECK L-2 SUPPLY PRESS/20 PSIG

PNEUMATIC

0039 * CHECK PUMP PANEL POWER SW OFF

PURGE

0040 * PERFORM ENGINE CUTOFF CHECK

X-1/24H

1- OBSERVER DEPRESS 15 CUTOFF SW

A-CHECK CUTOFF LITES ON

ENG CNTRL

B-CHECK EA PER 153 FOR RESPONSE

LAST

P1223X DAY 0127

3R

2- ENGINE RESET TO RESET

ENG TEST

0041 * CHECK RCC SYSTEM FOR CONTINUITY

1- MISSILE INVERTER SW ON

MSGL POWER

2- AUDIOLY CHECK CHANNELS 32, 33 & 34

ELECTRIC RUN

FOR NOISE/EARPHONES

3- MISSILE INVERTER SW OFF

MSGL POWER

4- RESET RCC CHANNELS 32, 33 & 34

ELECTRIC RUN

5- INACTIVE/ACTIVE SW TO ACTIVE - 3

31 COUNTER

0042 * NOTIFY SECURITY - COUNTDOWN WILL START

X- 32 H

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SYN 072 1-5 RUN- 4 AS RUN COUNTDOWN

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IN APPROXIMATELY 15 MIN

0043 * CHECK TUNNEL ESCAPE HATCH CLOSED

TEST AREA

0044 * ALL PERSONNEL TO BLOCKHOUSE, INST PERSONNEL

CLEAR TRANSFER ROOM/SECURITY CHECK ALL PRESENT

THEN SECURE BLOCKHOUSE DOORS

7

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05-1204
15-1204
24-1204
1-1204
12-1204
20-1204

45
155
156
157
158

X-36	0045	X	PM ANNOUNCEMENT - START OF COUNTDOWN - TIME 10 X-30 (HR)
X-36	0046	X	SET ARE, IN CONDITION, REP
X-36	0047	X	REPORT IF SYSTEMS READY OR TUNING AS LISTED WHEN CALLED OUT

- 1- FACILITY POWER - READY
2- FLAME REFLECTOR - READY
3- MISSILE POWER - READY
4- ENGINE TEST - READY
5- LO2 SYSTEM - READY
6- FUEL SYSTEM - READY
7- PURGE - READY/PANEL POWER OFF
8- HOLD DOWN & RELEASE - READY
9- PRESSURIZATION - READY
10- PNEUMATIC - READY
11- HYDRAULIC - READY
12- AUTOPILOT - READY
13- INSTRUMENTATION - READY
14- RCC - READY
15- TEST CONDUCTOR CONSOLE - READY
16- OBSERVERS - READY
A- NORTH TANK
B- SOUTH TANK
C- CLOCKHOUSE

E-SOUTH TAXX

C-LOCKHOUSE

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SYN 3-2 1-2 2-2 3-2 4-2 5-2 6-2 7-2 8-2 9-2 10-2 11-2 12-2 13-2 14-2 15-2 16-2 17-2 18-2 19-2 20-2 21-2 22-2 23-2 24-2 25-2 26-2 27-2 28-2 29-2 30-2 31-2 32-2 33-2 34-2 35-2 36-2 37-2 38-2 39-2 40-2 41-2 42-2 43-2 44-2 45-2 46-2 47-2 48-2 49-2 50-2 51-2 52-2 53-2 54-2 55-2 56-2 57-2 58-2 59-2 60-2 61-2 62-2 63-2 64-2 65-2 66-2 67-2 68-2 69-2 70-2 71-2 72-2 73-2 74-2 75-2 76-2 77-2 78-2 79-2 80-2 81-2 82-2 83-2 84-2 85-2 86-2 87-2 88-2 89-2 90-2 91-2 92-2 93-2 94-2 95-2 96-2 97-2 98-2 99-2 100-2

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0048 * START BOOSTER & SUS HYD SYSTEMS

1- AUTOPILOT AC POWER ON	G	AUTOPILOT
2- BOOSTER GROUND PUMP ON	G	HYDRAULIC
3- CLOSE BOOSTER BYPASS VALVE	G	HYDRAULIC
A-CK MISSL INLET PRESS/2000 PSI		
B-CK MISSL OUTLET PRESS/75 PSI	75 PSI	INX
4- SUS GROUND PUMP ON	G	HYDRAULIC
5- CLOSE SUS BYPASS VALVE	G	HYDRAULIC
A-CK MISSL INLET PRESS/2000 PSI		
B-CK MISSL OUTLET PRESS/75 PSI	75 PSI	INX

HOLD 1602 TO 1608 - INCREASE SUS HYD RETURN

PRESS - WAS 7 PSIG - INCREASED TO 33 PSIG

0049 * FILL MISSILE HELIUM BOTTLES

1- CHECK & G GROUND LITES CYCLE	PNEUMATIC
2- BROW RECORDERS ON SLD	INST CNTRL
F1124P 04Y 0416-2	
F1145P 04Y 0416-1	
3- DEPRESS HELIUM STORAGE	G
4- REPORT PRESS AT 500 PSI INTERVALS	PNEUMATIC
5- REPORT WHEN PRESSURE REACHES 5000 PSI	INST
NOTE-IF BOTTLE PRESSURE OF 3000 PSIG CAN	INST

NOT BE ATTAINED FROM FACILITY SOURCE

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SYN 3-2 1-3 RUN-4 AS RUN COUNTDOWN

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A-COMPRESSOR CYCLE/READY SW TO CYCL

PNEUMATIC

0050 * DEPRESS PRESS SEQUENCE TO 2 SW

26

PRESS

1- MONITOR MISSILE FUEL TANK PRESS

PRESS

TO 30 PSI REPORT WHEN PRESS COMPLETE

0051 * SET UP LO2 PANEL FOR OPERATION

1- CHECK SW 2 TANK PRESS LITE ON

LO2 CNTRL

2- CHECK VLV CONTROL PRESS LITE ON

LO2 CNTRL

3- PANEL OPERATIONAL POWER SW ON

LO2 CNTRL

0052 * VIBRATON PAINTOUT SW TO OPERATE

INST

0053 * LO2 TANKING RECORDERS ON. SLOW/CIRCUIT

INST CNTRL

B JUMP POSITION

1- BROWNS

F1001P SAY D121-2 P1021T SAY D122-2

F1003P SAY D119-2 ST160T SAY D124-1

N1011F SAY D107-1 ST161T SAY D124-1

P1014T SAY D120-2 ST162T SAY D124-1

P1020T SAY D115-1 ST163T SAY D124-1

P1126T SAY D116-1 ST164T SAY D124-1

P1127T SAY D116-2 ST165T SAY D124-1

P1209T SAY D118-2 ST166T SAY D124-2

P1213T SAY D116-1 ST168T SAY D124-2

P1323T SAY D116-2 ST169T SAY D124-2

P1324T SAY D116-3 ST170T SAY D124-2

2- SAS- RECORDERS 3 & 4 SAY D127/LOCALLY

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CYC 5-2 1-5 RUN- 4 AS RUN COUNTDOWN

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X-25 0054 CHILDDOWN LO2 SYSTEM FOR TANKING

- 1- CLOSE RETURN VALVE " " LO2 CNTRL
- 2- OPEN PUMPS 4A & 4B OUTLET VLVS 2A " LO2 CNTRL
- 3- CHECK PUMP 4C THROTTLE VALVE FULL OPEN/PANEL METER A " LO2 CNTRL
- 4- LO2 TANK PRE-FILL SW ON A " LO2 CNTRL
- 5- OPEN LO2 PRE-VALVE G " PRESS
- 6- OPEN LO2 FILL & DRAIN V LVL G " LO2 CNTRL
- 7- OPEN PUMP OUTLET VALVE A " LO2 CNTRL
- 8- OPEN PUMP INLET VALVE A " LO2 CNTRL
- 9- CLOSE STORAGE TANK /EIT VLV " " LO2 CNTRL
- 10-OPEN STORAGE TANK PRESS VLV " " LO2 CNTRL
- A-MONITOR STORAGE TANK PRESS 25 PSIG " " LO2 CNTRL

TO APPROX 25 PSIG

11-MONITOR 45SL LO2 TANK PRESS / 10 PSI MAX PRESS

10 PSIG MAX

NOTE-IF LO2 TANK PRESSURE EXCEEDS 10 PSIG

OPEN EMERGENCY DUMP VALVE OR BLEED

VALVE & LOWER TANK PRESS/CLOSE

12-OPEN RETURN VALVE 10 SEC/CLOSE

13-DESERVES REPORT LO2 BUILD-OFF

VALVE OPERATION

14-REPORT WHEN LIQUID IS INDICATED

A TO W " " LO2 CNTRL

TANKS

INST

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SYC 3-2 1-2 RUN- 4 AS RUN COUNTDOWN

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AT P1021T BAY D125-2

15-RESET LO2 DIGITIZER

16-CLOSE PUMP LA & LB OUTLET VLVS

17-START PUMP LC

0055 * WHEN VIBRATION INDICATES LO2 IN MISSILE-

INCREASE FLOW

1- OPEN PUMP LA & LB OUTLET VLVS

2- START PUMPS LA & LB

A-CHECK PUMP LB ON, THEN PUMP LA

B-CHECK PUMP LC STOP/AUTO

3- OPEN PUMP LC BYPASS VALVE

4- REPORT TANK LEVEL - 20 IN INTERVALS/
VIBRATION

5- MONITOR NOZZLE LO2 TANK PRESS /

0056 * LO2 TANKING RECORDERS ON SLOW/CIRCUIT

0057 * ACTIVATE PU VALVE CONTROL PROGRAMMER & REPORT

1- HULL SW OFF

2- 400 CYCLE SW ON

3- 25 VDC SW ON

4- SIGNAL DC/400 CYCLE SW TO DC

5- STEP SW TO CYCLE START

6- CHECK STEPPING SW ROTOR SET AT START

OF PROGRAM

7- CONNECT THE BLACK & RED SIGNAL JACKS

LO2 CNTRL

2W

LO2 CNTRL

A

INST

LO2 CNTRL

A

LO2 CNTRL

2A

LO2 CNTRL

A

INST

10 PSI MAX PRESS

INST CNTRL

INST

INST

INST

INST

INST

INST

INST

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SYC 3-2 1-3 RUN- 4 AS RUN COUNTDOWN

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X-22 * 0058 * TO THE CORRESPONDING PLUGS ON PROGRAMMER
PERFORM ENGINE GIMBALING PROGRAM
6 MIN-

1- CHECK ARMED/SAFE SW TO SAFE
2- ENGINE CUTOFF LOCKOUT SW ON
3- GIMBAL THE BOOSTER SUS & VERNIER

A AUTOPILOT
A/P PG BAS

THRUST CHANGERS AT 1 DEG & 1/2 CPS FOR APPROX
5 MIN TO PREVENT SERVO VALVE MALFUNCTION

4- CHECK PRESSURIZING TIMER SET
FOR 87 SEC

AUTOPILOT

5- CHECK SUS CUTOFF TIMER SET FOR
7 SEC

AUTOPILOT

6- AFTER PROGRAMMER HAS RECYCLED, ENG
CUTOFF LOCKOUT SW OFF

A/P PG BAS

X-16 * 0059 * NOTIFY SECURITY-COUNTDOWN TIME IS NOW
APPROX 10 MIN

X-16 * 0060 * CHECK GIMBALING PROGRAM COMPLETE

X-16 * 0061 * CAMERA'S POWER SW ON/NOTION NIGHT DAY 0102

X-16 * 0062 * SANDOWN RECORDERS TO USE POSITION

X-16 * 0063 * CHECK ENG TIMERS READY

INST CTRL
INST
ENG TIMER

1- CHECK L ENG TIMER SET FOR 105 SEC

105 SEC

A-BOOSTER TIMER SET

2- CHECK SUS ENG TIMER SET FOR 199 SEC

199 SEC

A-SUS TIMER SW ON

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SYC 3-2 1-3 201- 4 AS RUN COUNTDOWN

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3- CHECK V ENG TIMER SET FOR 217.5 SEC

217.5 SEC

A-VERNIER TIMER SW ON

4- ENGINE TILER SW TO READY

G

ENG TIMER

0064 * TURN ON FF SYSTEMS & REPORT

MSL POWER

1- MZUSA ON

MSL POWER

2- COVAP ON

MSL POWER

3- GE SELECTOR SW TO ON

MSL POWER

A-CHECK FILAMENT LITE ON

A

B-AFTER 3 MIN ON FULL POWER LITE ON

G

C-CHECK FILAMENT LITE OFF

0065 * AC METER SELECTOR SW TO INT

MSL POWER

0066 * MISSILE INVERTER SW ON

W

MSL POWER

1- CHECK OUTPUT AT 115V AC & 400 CYCLES

115V AC

2- USING AC METER SELECTOR SW - ADJUST

MSL POWER

EXT VOLT & FREQ TO MATCH INVERTER OUTPUT

0067 * ALL CONTROLS SATISFACTORY CHECK-REPORT

1- FACILITY POWER

2- FLAME DEFLECTOR

3- MISSILE POWER

4- ENGINE TEST

5- LO2

6- FUEL

7- PURGE

8- HOLD DOWN & RELEASE

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SYC S-2 1-2 RUN- 4 AS RUN COUNTDOWN

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9- PRESSURIZATION
10-PNEUMATIC
11-HYDRAULIC
12-AUTOPILOT
13-INSTRUMENTATION
14-KCC
15-OBSERVERS
A-NORTH TANK
B-SOUTH TANK
C-BLOCKHOUSE

16-TEST CONDUCTOR

X-12

0066 * ALL BOMBS ON SLOW- THE FOLLOWING

MEASUREMENTS HAVE JUDGMENT REQUIRMENTS

MEAS NO	DESCRIPTION	DAY NO	LL	UL	UNITS
P1528D	SUS PU VLV POSITION	0108-2	26		DLG
P1020P	VERNIER LO2 TANK	0109-1	500	540	PIG
P1235P	VER LO2 TK REG OUT	0108-2	910	920	PIG
P1439P	2 GAS GEN LO2 VLV II	0109-3	430	470	PIG
P1027P	VERNIER FUEL TANK	0110-1	515	555	PIG
P1236P	VERNIER FUEL TANK REG OUT	0110-2	525	575	PIG
P1075P	1 FUEL START TANK	0110-3	750	790	PIG
P1026P	3 LO2 REG REFERENCE	0111-2	915	935	PIG
P1176P	3 FUEL START TANK REG	0111-3	760	790	PIG
P1244P	3 LO2 REG REFERENCE	0112-2	800	820	PIG

INST CTRL

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SYN 5-2 1-5 RUN 4 As RM. COND. DCS.

P1177P	B LO2 START TANK REG	D113-3	430	470	PIG
H1033P	B1 HYD ACCUMULATOR	D114-1	1500	4000	PIG
P1126T	B1 LO2 PUMP Q130 BRG	D116-1	-60	300	DGF
P1127T	B2 LO2 PUMP Q130 BRG	D116-2	-60	300	DGF
P1324T	S P.U.P BEARINGS-LO2	D116-2	-60	300	DGF
P1236T	S GAS GEN DISCHARGE	D117-2		1400	DGF
P1213T	B1 TURBINE BEARING	D118-1		750	DGF
P1209T	B2 TURBINE BEARING	D118-2		750	DGF
P1323T	S TURBINE BEARING	D118-3		750	DGF
A1338T	ENG COMP AFT A12 Q3	D125-1		300	DGF
P1339T	ENG COMP AFT A12 Q4	D125-1		300	DGF
A1052P	S HYD ACCUMULATOR	D214-1	1500	4000	PIG
A1337T	ENG COMP AFT A12 Q2	D125-1		300	DGF
A1336T	ENG COMP AFT A12 Q1	D125-2		300	DGF
E1026V	MSL SYSTEMS INPUT	D221-2	26	29	VDC
P1014T	ENGINE COMP AMBIENT	D220-2	45		DGF
THE FOLLOWING MEASUREMENTS HAVE REDLINE INDICATIONS					
A1264D	MSL TK MOVEMENT X AX	D107-2		2.25	IN
A1266D	MSL TK MOVEMENT Y AX	D107-3		2.25	IN
F1125P	B CTL PNEU REG	D111-1	735	765	PIG
F1142P	S CTL PNEU REG OUT	D113-1	735	765	PIG
F1003P	FUEL TANK HELIUM	D119-2	53	66	PIG
	AFTER BOOSTER STAGING		45		PIG
P1332P	S LO2 PUMP DISCH.	D119-3		1050	PIG

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F1001P	LO2 TANK HELIUM	D121-2 22	27	PIG
ST206P	S LUB PUMP SRS	D112-2 30		PIG
F1145P	S CTL HE STL DISCH	D210-1 1800	3500	PIG
F1124P	S TK HE STL DISCH	D216-2 400	3500	PIG
F1121P	S CTL HE STL DISCH	D217-1 500	3500	PIG
F1005P	S TK HE STL DISCH	D217-2 400	3500	PIG
P1010P	S1 LUB OIL TANK	D218-1 550		PIG
P1011P	S2 LUB OIL TANK	D218-2 550		PIG
P1341P	S LUB PUMP GEAR	D218-3 400		PIG
P1017T	S2 TURBINE IN	D220-3	1400	DGF
P1018T	S1 TURBINE IN	D221-3	1400	DGF
L1257T	FLAME DEFLECTOR	D223-1	1800	DGF
L1259T	FLAME DEFLECTOR	D223-2	1800	DGF
L1263T	FLAME DEFLECTOR	D223-3	1800	DGF

0069 * NOTIFY SECURITY THAT COUNTDOWN TIME IS

NOW APPROX 5 MIN

1070 * HELIUM PUMP METER READS 0.6 OR

ST219F-BAY 207-1 INDICATES 102,000 LB L02

1- STOP PUMPS LA & LB

2- START PUMP LC

3- CLOSE PUMP LC BYPASS VALVE

4- CLOSE PUMP LA & LB OUTLET VALVES

5- START RECORDING 11011F

1071 * HELIUM FULL TANK PUMP LITE COMES ON

INST	L02	CNTRL
	L02	CNTRL
	L02	CNTRL
	L02	CNTRL
	L02	CNTRL
INST		
	L02	PANEL

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SYC 1-2 1-2 RUN- 4 AS RUN COUNTDOWN

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1- STOP PUMP LC

L02 CNTRL

2- CLOSE FILL & DRAIN VALVE

W

L02 CNTRL

3- OPEN RETURN VALVE

A

L02 CNTRL

4- TANK FILLED SW ON

G

L02 CNTRL

G
PRESS

007. * SECURE L02 SYSTEM & REPORT

L02 CNTRL

1- CLOSE PUMP INLET VALVE

W

L02 CNTRL

2- OPEN EMERGENCY DUMP VALVE

R

L02 CNTRL

3- CLOSE STORAGE TANK PRESS VLV

L02 CNTRL

4- TEST POSITION KEY 01

L02 CNTRL

0072 * REPORT & SECURE MISSILE WEIGHT

INST

MI01LF DAY 0107-1

INST

1- REPORT VIOLATION READING

INST

0074 * CEC RECORDERS TO RE-DATE

PRESS

0075 * DEPTESS PRESS SEQUENCE TO 3 SW

25

0076 * START MAIN FLAME DEFL WATER FLOW & REPORT

FACILITY PMR

1- COOLANT VLV BREATHES SW ON/

OVERIDE PANEL

2- MAIN FLAME DEFL SW ON

G

FLAME DEFL

2- OPEN THROTTLE VALVE 100%

100%

FLAME DEFL

4- POSITION WATER FLOW

SOUTH TANK

5- UNIFORM MAIN DEFL PRESS/70-90 PSI

INST

L1161P DAY 0100-1

0077 * START VERIFIER FLAME DEFL WATER FLOW & REPORT

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BYC -2 1-3 RUN- 4 AS RUN COUNTDOWN

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1- VERNIER DEFL SM ON

G FLAME DEFL

2- MONITOR MANIFOLD PRESS/ IN 18 PSIG

18 PSIG

G FLAME DEFL

3- WATER SYSTEMS READY SM ON

G FLAME DEFL

0070 * VERNIER LO2 VENT SM TO VENT/INST

G PRESTART

MONITOR VERNIER BLEED

G ENG CNTRL

DAY 2101

INST

0075 * LO2 DUMP VLV SM TO OPEN/OBSERVERS REPORT

G PNEUMATIC

0080 * MISSILE POD COOLER SM OFF

G FACILITY PMR

0081 * THRUST SECTION HEATER SM OFF

G FACILITY PMR

0082 * LAUNCH COOLANT AUTO/OFF SM TO AUTO

G FIREX

0083 * 20 MIN CAUTIONS ON

G INST CNTRL

0084 * CHECK MISSILE BOTTLE PRESSURE- 3000 PSIG

G 3000 PSIG

3100 PSIG-

F1005P DAY D217-2

F1124P DAY D213-2

F1121P DAY D217-1

F1145P DAY D216-1

0085 * PREPARE AUTOPILOT TEST PROGRAMMEN FOR RUN & REPORT

1- CHECK ENGINE CUTOFF LOCKOUT SM OFF

A/P PG BAS

2- CHECK A/P ARMED/SAFE SM TO SAFE

A/PILOT

3- CHECK A/P DISCRETE SM TO AUTO

A/PILOT

4- CHECK TAPL POSITION. IF NEEDED

A/P TST PG

5- FLADDER SEL SM TO REMOTE

A/P TWT PG

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1-2 301-4 100 100 100 100

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6- CODE SELECTOR TO AUTO/FLY
7- MANUAL/AUTO SW TO AUTO
8- LADDER SW ON
9- OTOM SW ON
10- RECORDEDS 2-10 INDICATOR ON
11- 1/P READY SW ON

A/P TST PG
A/P TST PG
A/P TST PG
A/P TST PG
A/P AUX PH
AUTOPILOT
PRESTART
ENG CNTRL
ENG TEST
HDS R

ENGINE TEST/FLY SW TO - /CHECK

ENGINE 1-10 COMPLETE LIFE ON

REPORT 100000 VERTICAL ALIGNMENT/TIME

LI ITS 15-0-15 MINUTES

CHECK 1-10 HYDRAULIC PRESS

910280 100 1114-1

110220 100 1114-1

100000 100000 REPORT FUEL DEFLECTION AFTER

100000 100000 MISSILE AC POWER SOURCE SW TO INT

1- CHECK LIFE ON PRESTART PANEL

100000 100000 AUTOPILOT OUTPUT SW TO ON

100000 100000 CHECK ENGINES FOR ZERO POSITION

100000 100000 OBSERVERS REPORT L02 VAPORS FLOW

100000 100000 VALVE 1-10 DEFLECTION

100000 100000 OPER L02 FUEL 1-10 VALVE UNTIL FULL

100000 100000 METER READS-1.10/CLOSE - CHECK FULL

100000 100000 METER READS-1.40% AFTER VALVE IS CLOSED

2000 PSI HYDRAULIC

INST

SOUTH TANK

MISSILE POWER

PRESTART

A/P TST PG

A/P AUX PH

TANKS

L02 CNTRL

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P1027F DAY 0110-1
P1020P DAY 0109-1
P1073P DAY 0110-1
P1409P DAY 1209-1

PURGE
INST CTRL

0104 * ENGINE STARTED ON
0105 * FASTENING TRAILER
0106 * VEHICLE LEAVING FIVE

THE FOLLOWING STEPS TO LOG DETAILING

AND SCHEDULED ITEMS, BECAUSE OF THE
FIVE, A SCHEDULED PROCEDURE HAVE BEEN
TO EXTINGUISH THE FIRE & TO A-GREEN
THE HAZARDOUS CONDITION OF THE MISSILE.

REPORT MISSILE SUPPLY PRESSURE

PNEUMATIC
ENG CTRL
INST

20
6

0107 * FASTEN CAMERAS
0108 * BOOSTER STAGING/FLIGHT PROGRAMS
0109 * P.O. VLV PROGRAMMED START OF TO

INST CTRL
AUTOPILOT
ENG CTRL
ENG TEST
PURGE
PNEUMATIC

20
6
6
6
6
6

1- CHECK BOOSTER CUTOFF LITES ON
2- CHECK BOOSTER PURGES ON/AUTO
3- CHECK STAGING SIMULATION VLV OPEN

CYC 3-2 1-5 RUN-4 AS RUN COUNTDOWN

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4- CHECK LAUNCH COOLANT ON/AUTO

5- ENG CO2 SW ON/10 SEC/OFF

0112 4 LAUNCH COOLANT AUTO/OFF S. 10 OFF

0113 4 APP ARMED/SAFE SW TO AR EQ

0114 4 VERMILION TANKS RE-PRESSURIZED/AUTOPILOT TANK

01027P SWY 0110-1

01030P SWY 0109-1

0115 4 SUSTAINER ST-5116/AUTOPILOT TANK

1- CHECK SUC CUTOFF LITES ON

2- CHECK SUSTAINER PURGES ON/AUTO

3- CLOSE FUEL PRE-VALVE

4- CLOSE LO2 PRE-VALVE

5- OPEN LO2 FILL & DRAIN VLV

6- ENG CO2 SW ON/10 SEC/ OFF

0116 4 VERMILION CUTOFF/FLIGHT PURGES ON

1- CHECK VERMILION CUTOFF LITES ON

2- CHECK VERMILION PURGES ON/AUTO

3- REPORT ISSU SUPPLY PRESS CHANGE OVER

4- DEPRESSURIZE MISSILE TANKS TO

SEQUENCE 2/AIRPORT AND COMPLETE

AIRFIELD PRESS RESET SW UNTIL FUEL

TANK PRESS STARTS TO DECREASE

FIREX

FIREX

FIREX

AUTOPILOT

INST

AUTOPILOT

ENG CNTRL

ENG TEST

PURGE

FUEL TANKING

LO2 CNTL

LO2 CNTRL

FIREX

AUTOPILOT

ENG CNTRL

ENG TEST

PURGE

PNEUMATIC

PRESS

PRESS

CONFIDENTIAL

CONFIDENTIAL

CONFIDENTIAL

SYN 1-2 1-3 RUN- 4 AS RUN COUNTDOWN

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CUTOFF

5- IGNITION FUEL TRK PRESS TO 30 PSIG

30 PSIG PRESS

5- VERNIER FLAME DEFL SW OFF

A FLAME DEFL

6- START 1 SECOND TIME CALLOUT

0117 * ACC INACTIVE/ACTIVE SW TO INACTIVE

ELECTRNC RUN

0118 * MISSILE HE SW TO COMP/AERPORT WHEN 0 PSI

PNEUMATIC

0119 * MISSILE SUPPLY SW TO EXT

PNEUMATIC

0120 * ENGINE TIMER SW TO OFF/4 S'S

ENG TIMER

0121 * ENGINE TEST/ARM SW TO TEST

ENG CNTRL

0122 * ENGINE TEST SELECTOR TO COMPONENTS

ENG TEST

0123 * DC POWER SOURCE SW TO EXTERNAL

MISSILE POWER

0124 * AC POWER SOURCE SW TO EXTERNAL

MISSILE POWER

0125 * MISSILE INVERTER SW OFF

MISSILE POWER

0126 * SECURE INSTRUMENTATION

INST

1- ALL RECORDERS OFF

INST CNTRL

2- AM TAPES STOP SW ON

INST CNTRL

0127 * VERNIER LOX VENT SW TO CLOSE

ENG CNTRL

0128 * CHECK - G S HYDRAULIC PRESSURE

HYDRAULIC

0129 * TURB OFF RF SYSTEMS

2000 PSIG MISSILE POWER

1- AZUSA OFF

MISSILE POWER

2- LOVAP OFF

MISSILE POWER

3- G.E. SELECTOR SW TO OFF

MISSILE POWER

0130 * MISSILE POD COOL SW ON

FACILITY POWER

0131 * THRUST SECTION HEATER SW TO NEUTRAL

FACILITY POWER

0132 * WATER SYSTEMS READY SW OFF

FLAME DEFL

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~~CONFIDENTIAL~~

~~CONFIDENTIAL~~

CYC 3-2 1-4 101-4 NO FOR COUNTDOWN

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0100 SECURE A/P TEST PROGRAMMER'S REPORT

AUTOPILOT

1- A/P OUTPUT 5V TO CUTOFF

2- READER 5V OFF

3- MOTOR 5V OFF

4- READER SELECTOR 5V TO LOCAL

5- CODE SELECTOR 5V TO OFF

6- A/P ARMED/SAFE 5V TO SAFE

7- ENGINE CUTOFF LOCKOUT 5V ON

ENGINE RESET 5V TO RESET

0104 * OBSERVERS REPORT CONDITION OF JET AND MISSILE

ENG TEST

0105 * SECURE MAIN FLAME DEFL SYSTEM'S REPORT

1- 101 DEFL 5V OFF

FLAME DEFL

2- AFTER 30 SEC/CLOCKOUT VLV WEATHER 5V

FACILITY PWR

OFF/OVERRIDE PANEL

3- THROTTLE VLV 5V TO CLOSE/30 SEC/JTOP

FLAME DEFL

4- WATER SYSTEM'S REPORT 5V OFF

FLAME DEFL

5- PUMP 5V OFF

FLAME DEFL

0107 * DISARM 5V TO NO

PNEUMATIC

0108 * GATE 5V OFF

INST CTRL

0109 * CROWN RECORDER P10211 ON/OFF P123-2

INST

0110 * DRAIN MISSILE LOG TANK

1- CRP. PUMP INLET VALVE

LO2 CTRL

2- REPORT ON LIQUID INDICATED 5V

LO2 CTRL

3- EL FLG 5V

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0100 0101 0102 0103 0104 0105 0106 0107 0108 0109 0110 0111 0112 0113 0114 0115 0116 0117 0118 0119 0120 0121 0122 0123 0124 0125 0126 0127 0128 0129 0130 0131 0132 0133 0134 0135 0136 0137 0138 0139 0140 0141 0142 0143 0144 0145 0146 0147 0148 0149 0150 0151 0152 0153 0154 0155 0156 0157 0158 0159 0160 0161 0162 0163 0164 0165 0166 0167 0168 0169 0170 0171 0172 0173 0174 0175 0176 0177 0178 0179 0180 0181 0182 0183 0184 0185 0186 0187 0188 0189 0190 0191 0192 0193 0194 0195 0196 0197 0198 0199 0200

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0100 - TEST POSITION KEY TO PROVIDE
OPERATIONAL POWER UNTIL CHS HAS
SET UP FUEL PUMP FOR MISSILE DETACKING

0101 - TEST POSITION KEY ON
0102 - CLOSE PUMP OUTLET VALVE
0103 - OPEN PUMP INLET VALVE
0104 - OPEN RETURN VALVE
0105 - CLOSE PUMP FEED-THROTTLED FLOW VALVE
0106 - OPEN FUEL PRE-VALVES
0107 - DRAIN MISSILE FUEL TANK
0108 - FUEL LEAK-THROTTLED CHAMBER
0109 - MONITOR FUEL TANK PRESSURE
0110 - OPEN STORAGE TANK VENT VALVE
0111 - OPEN FILL & DRAIN VALVE
0112 - REPORT TANK LEVEL AT 20 IN INTERVALS
0113 - OPEN TANK LEVEL REACHES STA 1160/
TANK FILLED & OFF
0114 - OBSERVE REPORT CONDITION OF MISSILE - STAND
0115 - PA CALLOUT / AREA IN CONDITION - SER
0116 - STAND ENGINEER & FIRE LIGHT TO AREA/REPORT
GENERAL - MISSILE & TANK CONDITION
0117 - FIRE ALARM & TANK TANK ROOM LIGHT
0118 - BREATHING APPARATUS/CHECK & REPORT
0119 - TEST STAND SAFETY CHECK TO AREA / 4 TECHNICIAN & DIRECTOR

LO2 CTRL

FUEL TAKING
FUEL TAKING
FUEL TAKING
FUEL TAKING
FUEL TAKING
FUEL TAKING

PRESS

FUEL TAKING
FUEL TAKING

INST

INST

FUEL TAKING

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0156 1- INSTALL FLY & OFFL SAFETY LIT & COVERS/NEPROT
NOTE -IF RUN IS ABORTED, REMOVE ALL IGNITERS
BEFORE DRAINING PROPELLANTS FROM ENGINES

BLKRS 05HT

0157 1- SWITCH COMMUNICATIONS TO NORMAL POWER
0158 1- SECURE EMERGENCY DIESEL GENERATOR & REPORT
0159 1- DEPRESSURIZE MISSILE TANKS TO SEQUENCE 1-REPORT

1- DEPRESS PREOCCURIZATION TESTER SW
2- IGNITOR TANK PRESSURE
V-L02 2 PSIG
V-FUEL 5.5 PSIG
V-1
0160 1- PUT MISSILE INTO ORBIT
0161 1- BLEED OFF PRESSURE FROM CO2 SYSTEM & REPORT
1- CLOSE CO2 STORAGE UNIT DISCHARGE VLV
V-1

CO2 STORGE

TEST STAND

FUEL PAD
PRESS

1- CLOSE BOOSTER FUEL PRE-VALVE
2- CLOSE FILL & SHUT IN VALVE
3- CLOSE FILLAGE VALVE
4- OPEN STORAGE UNIT PRESS VLV CONTROL
V
W
5 PSIG

FUEL TAKING
FUEL TAKING
FUEL TAKING
FUEL TAKING

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THE UNIVERSITY OF CHICAGO

166. K. SUGI, M. YAMOTO, H. KUNITA and K. KIKUCHI

五ノ二

2. FUEL VIBRATOR. READOUT POSITION ON THE

3- LOZ VULNATECH; REMOUT 20,190, 50, 100, 150, 200, 250, 300, 350, 400, 450, 500, 550, 600, 650, 700, 750, 800, 850, 900, 950, 1000, 1050, 1100, 1150, 1200, 1250, 1300, 1350, 1400, 1450, 1500, 1550, 1600, 1650, 1700, 1750, 1800, 1850, 1900, 1950, 2000, 2050, 2100, 2150, 2200, 2250, 2300, 2350, 2400, 2450, 2500, 2550, 2600, 2650, 2700, 2750, 2800, 2850, 2900, 2950, 3000, 3050, 3100, 3150, 3200, 3250, 3300, 3350, 3400, 3450, 3500, 3550, 3600, 3650, 3700, 3750, 3800, 3850, 3900, 3950, 4000, 4050, 4100, 4150, 4200, 4250, 4300, 4350, 4400, 4450, 4500, 4550, 4600, 4650, 4700, 4750, 4800, 4850, 4900, 4950, 5000, 5050, 5100, 5150, 5200, 5250, 5300, 5350, 5400, 5450, 5500, 5550, 5600, 5650, 5700, 5750, 5800, 5850, 5900, 5950, 6000, 6050, 6100, 6150, 6200, 6250, 6300, 6350, 6400, 6450, 6500, 6550, 6600, 6650, 6700, 6750, 6800, 6850, 6900, 6950, 7000, 7050, 7100, 7150, 7200, 7250, 7300, 7350, 7400, 7450, 7500, 7550, 7600, 7650, 7700, 7750, 7800, 7850, 7900, 7950, 8000, 8050, 8100, 8150, 8200, 8250, 8300, 8350, 8400, 8450, 8500, 8550, 8600, 8650, 8700, 8750, 8800, 8850, 8900, 8950, 9000, 9050, 9100, 9150, 9200, 9250, 9300, 9350, 9400, 9450, 9500, 9550, 9600, 9650, 9700, 9750, 9800, 9850, 9900, 9950, 10000, 10050, 10100, 10150, 10200, 10250, 10300, 10350, 10400, 10450, 10500, 10550, 10600, 10650, 10700, 10750, 10800, 10850, 10900, 10950, 11000, 11050, 11100, 11150, 11200, 11250, 11300, 11350, 11400, 11450, 11500, 11550, 11600, 11650, 11700, 11750, 11800, 11850, 11900, 11950, 12000, 12050, 12100, 12150, 12200, 12250, 12300, 12350, 12400, 12450, 12500, 12550, 12600, 12650, 12700, 12750, 12800, 12850, 12900, 12950, 13000, 13050, 13100, 13150, 13200, 13250, 13300, 13350, 13400, 13450, 13500, 13550, 13600, 13650, 13700, 13750, 13800, 13850, 13900, 13950, 14000, 14050, 14100, 14150, 14200, 14250, 14300, 14350, 14400, 14450, 14500, 14550, 14600, 14650, 14700, 14750, 14800, 14850, 14900, 14950, 15000, 15050, 15100, 15150, 15200, 15250, 15300, 15350, 15400, 15450, 15500, 15550, 15600, 15650, 15700, 15750, 15800, 15850, 15900, 15950, 16000, 16050, 16100, 16150, 16200, 16250, 16300, 16350, 16400, 16450, 16500, 16550, 16600, 16650, 16700, 16750, 16800, 16850, 16900, 16950, 17000, 17050, 17100, 17150, 17200, 17250, 17300, 17350, 17400, 17450, 17500, 17550, 17600, 17650, 17700, 17750, 17800, 17850, 17900, 17950, 18000, 18050, 18100, 18150, 18200, 18250, 18300, 18350, 18400, 18450, 18500, 18550, 18600, 18650, 18700, 18750, 18800, 18850, 18900, 18950, 19000, 19050, 19100, 19150, 19200, 19250, 19300, 19350, 19400, 19450, 19500, 19550, 19600, 19650, 19700, 19750, 19800, 19850, 19900, 19950, 20000, 20050, 20100, 20150, 20200, 20250, 20300, 20350, 20400, 20450, 20500, 20550, 20600, 20650, 20700, 20750, 20800, 20850, 20900, 20950, 21000, 21050, 21100, 21150, 21200, 21250, 21300, 21350, 21400, 21450, 21500, 21550, 21600, 21650, 21700, 21750, 21800, 21850, 21900, 21950, 22000, 22050, 22100, 22150, 22200, 22250, 22300, 22350, 22400, 22450, 22500, 22550, 22600, 22650, 22700, 22750, 22800, 22850, 22900, 22950, 23000, 23050, 23100, 23150, 23200, 23250, 23300, 23350, 23400, 23450, 23500, 23550, 23600, 23650, 23700, 23750, 23800, 23850, 23900, 23950, 24000, 24050, 24100, 24150, 24200, 24250, 24300, 24350, 24400, 24450, 24500, 24550, 24600, 24650, 24700, 24750, 24800, 24850, 24900, 24950, 25000, 25050, 25100, 25150, 25200, 25250, 25300, 25350, 25400, 25450, 25500, 25550, 25600, 25650, 25700, 25750, 25800, 25850, 25900, 25950, 26000, 26050, 26100, 26150, 26200, 26250, 26300, 26350, 26400, 26450, 26500, 26550, 26600, 26650, 26700, 26750, 26800, 26850, 26900, 26950, 27000, 27050, 27100, 27150, 27200, 27250, 27300, 27350, 27400, 27450, 27500, 27550, 27600, 27650, 27700, 27750, 27800, 27850, 27900, 27950, 28000, 28050, 28100, 28150, 28200, 28250, 28300, 28350, 28400, 28450, 28500, 28550, 28600, 28650, 28700, 28750, 28800, 28850, 28900, 28950, 29000, 29050, 29100, 29150, 29200, 29250, 29300, 29350, 29400, 29450, 29500, 29550, 29600, 29650, 29700, 29750, 29800, 29850, 29900, 29950, 30000, 30050, 30100, 30150, 30200, 30250, 30300, 30350, 30400, 30450, 30500, 30550, 30600, 30650, 3

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5-10. OFF LINE POWER SUPPLY

U. S. DEPARTMENT OF AGRICULTURE

U.S. POWER SUPPLY

TO GET THE SYSTEM TO STAY

2- CLOSE LUG STORAGE TANK OUTLET VALVE

—J
C
C
C

22- L 2 SUPPLY TO CLOSURE

S - OPEN HEAT EXCHANGER L14 SPAIN VLV

4-- L:2 NOSE PURCH SW OI/HEAT EXCH/HEAT

5- CLOSE LN2 FLUSHING WATER VALVE

C164 * ACTIVE TURST SECTION, PLASTER

一、

2- START HEATING UNIT

HEAT UNIT CONTROL

一、二、三、四、五、六、七、八、九、十、十一、十二、十三、十四、十五、十六、十七、十八、十九、二十、二十一、二十二、二十三、二十四、二十五、二十六、二十七、二十八、二十九、三十、三十一、三十二、三十三、三十四、三十五、三十六、三十七、三十八、三十九、四十、四十一、四十二、四十三、四十四、四十五、四十六、四十七、四十八、四十九、五十、五十一、五十二、五十三、五十四、五十五、五十六、五十七、五十八、五十九、六十、六十一、六十二、六十三、六十四、六十五、六十六、六十七、六十八、六十九、七十、七十一、七十二、七十三、七十四、七十五、七十六、七十七、七十八、七十九、八十、八十一、八十二、八十三、八十四、八十五、八十六、八十七、八十八、八十九、九十、九十一、九十二、九十三、九十四、九十五、九十六、九十七、九十八、九十九、一百。

6- NO FUR OUTLET TEMP TO APPROX 500F

FUEL TANKING

FUEL TAKING

LIST

List

LIST

三

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0
0
9
3
2
0

PNEUMATIC

2000

CHAS. E. DAVIS

TEST STAND

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CLASS - PG CALLOUT-STAND IN LOCAL AREA - TEST AREA IN

CONDITION GREEN/ALL TECHS & TECHS TO TEST AREA

CLASS - REPORT FIRST STAGE SEPARATION TEST

DELETED-

1- CLEAR ALL PERSONNEL FROM STN 33

2- W/P AC POWER ON

3- ENGINE CUTOFF LOCKOUT ON

4- W/P ARMED/SAFE ON TO ARMED

5- NOTIFY TEST STAND THE FIRST STAGE

SEPARATION. CARTRIDGES WILL FIRE IN

SECTION 2 IN

6- START AUTOPILOT FLIGHT PROGRAMMER

7- CASSEVERE REPORT ACTIVATION OF SEPARATION SYSTEM

8- WHEN PROGRAMMER RECYCLED, ANNOUNCE AREA CLEAR

9- ENGINE CUTOFF LOCKOUT ON OFF

10- ARMED/SAFE ON TO SAFE

11- W/P AC POWER ON OFF

12- ELECTRICALLY DISCONNECT CARTRIDGES

13- REPORT CARTRIDGES NOT FIRED

14- REMOVE ALL CARTRIDGES

15- ALT FIREX SYSTEM TO FAIL ERY & REPORT

16- SHIFT FCC MANUAL SELECTOR VALVE 3230

TO FAIL-ONLY

2- LAUNCHED CUCUL T MANUAL SELECTOR V-V

TEST STAND

AUTOPILOT

W/P PG GAS

AUTOPILOT

AUTOPILOT

W/P PG GAS

AUTOPILOT

AUTOPILOT

MISSILE

TEST STAND

MISSILE

VLV PIT 33

FINEX

VLV PIT 33

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112 TO FAIL-DRY

1- LO 2 MISSILE DELOVE MANUAL SELECTION

ALVE 420 TO FAIL-DRY

113 * ACTIVATE SERVICE TO ER 3 UTILITY PANEL 2202

1- 101. ON ELEVATOR POWER 1-12

114 * SECURE MISSILE TERMINAL CON FUSES & REPORT

CUTION. DO NOT OPEN FUSES TIL PRESS RELIEVED

1- CLOSE ELECTRIC LOCK 3.2 POUND

SUPPLY VALVE 0.731

115 * SET UP LO2 TANKING UNIT FOR MAKEUP

1- CLOSE LO2 STORAGE TANK OUTLET VALVE

1 ILK

116 * OPEN PUMPING PETER VALVE

2- OPEN PUMP INLET VALVE

117 * SECURE FCC TRANSFER 500 EQUIPMENT & REPORT

1- GUNDOGE FOLLOWED POWER 21 OFF

2- RADIO WARNING CH 22 POWER 21 OFF

2- RADIO WARNING CH 23 POWER 21 OFF

4- RADIO WARNING CH 24 PC IN 21 OFF

118 * FIRE 21 START HOSE FLOOR INTO FLOOR DEFLECTOR

DELETE -

119 * ENGINE TEST START 21 ON

DELETE -

117 * AUTOPILOT - 0 POWER 0 01

FIRCH

TS-STAB17-R

FIREX

SOC 2106

TS-STAB3-R

LO2 PAD

LO2 CNTRL

LO2 CNTRL

ENG TEST

AUTOPILOT

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DELETED-

177 - 100 SEC/30 OFF

DELETED-

1- 100 SEC/30 OFF

2- 100 SEC/30 OFF

177 - 100 SEC/30 OFF

DELETED-

177 - 100 SEC/30 OFF

DELETED-

1- 100 SEC/30 OFF

2- 100 SEC/30 OFF

3- 100 SEC/30 OFF

4- 100 SEC/30 OFF

5- 100 SEC/30 OFF

6- 100 SEC/30 OFF

7- 100 SEC/30 OFF

8- 100 SEC/30 OFF

9- 100 SEC/30 OFF

10- 100 SEC/30 OFF

11- 100 SEC/30 OFF

12- 100 SEC/30 OFF

13- 100 SEC/30 OFF

14- 100 SEC/30 OFF

177 - 100 SEC/30 OFF

177 - 100 SEC/30 OFF

HYDRAULIC

HYDRAULIC

PURGE

PURGE

PURGE

PRESS

FUEL TAKING

ENG TEST

ENG TEST

FUEL TAKING

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APPENDIX B
OBSERVERS VERBATIM
TESTIMONY

RUN S2-212-B4-01

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FINAL ACCIDENT REPORT
RUN S2-212-B4-01

VISUAL OBSERVER: K. E. Newton, Chief Test Conductor

LOCATION: Right Blockhouse Periscope

LO₂ tanking, tank pressurization, vents and Vernier ignition appeared normal. Booster and Sustainer ignition appeared short. Observed a fire and smoke coming out of thrust section and enveloped the Bl area. Firex and CO₂ came on and fire was immediately extinguished.

S/ K. E. Newton
K. E. Newton

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VISUAL OBSERVER: R. R. MacDougal, S2 Stand Engineer

LOCATION: Middle Blockhouse Periscope

LO₂ tanking, tank pressurization, vents and ignition appeared normal. First noticed puff of fire and smoke apparently concentrated around Bl. The viewing angle could cause smoke around the Sustainer to appear concentrated around Bl.

S/ R. R. MacDougal
R. R. MacDougal

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FINAL ACCIDENT REPORT
RUN S2-212-B4-01

VISUAL OBSERVER: E. R. McFadden, Test Conductor

LOCATION: Left Blockhouse Periscope

During ignition stage attention was directed to Sustainer Tachometer speed recorder. An abrupt rise and drop of recorder was noted during ignition. Started for periscope; when fire warning came from tank observer, immediately called for cutoff, CO₂ and firex.

S/ E. R. McFadden
E. R. McFadden

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VISUAL OBSERVER: R. C. Lynch, Asst. Test Conductor

LOCATION: Blockhouse TV

Was watching test conductor's console and two channels of closed loop TV. Vernier ignition appeared reasonably normal as did early ignition stage on main chambers. Mainstage never developed either on TV or on test conductor's console. My first indication of a malfunction was at the end of ignition stage, or where ignition stage should have ended. Hear no explosion but suddenly saw what appeared to be burning fuel falling from the thrust section between the Sustainer engine and BI on the Quad I side of the missile. Light indications on test conductor's consoles were improper at this time, but I cannot recall to what extent they were wrong.

Depressed Vernier cutoff button at first indication of the malfunction and commenced the activation of fire fighting system.

S/ R. C. Lynch
R. C. Lynch

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FINAL ACCIDENT REPORT
RUN S2-212-B4-01

VISUAL OBSERVER: C. H. Oliver, Test Engineer

LOCATION: North Tank Observer

V2 ignition appeared normal. Booster and Sustainer ignition start appeared normal. Almost immediately after ignition start observed Vernier cutoff. Ignition stage suddenly appeared as a fire with flames billowing out around the thrust section. Fire seemed concentrated under BI and Sustainer engine. Called for cutoff. Firex and CO₂ came on and fire was promptly extinguished. CO₂ turned off. Shortly afterwards the fire flared up again. CO₂ was turned on and fire again extinguished. CO₂ was turned off and firex was left on. No further indication of fire. Detanking of LO₂ appeared normal. Fuel leak during attempt to detank fuel could not be seen from north tank due to firex water, LN₂ flush water and heavy vapor.

S/ C. H. Oliver
C. H. Oliver

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FINAL ACCIDENT REPORT
RUN 82-212-B4-01

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VISUAL OBSERVER: Frank DiPiazza, Test Engineer

LOCATION: South Tank Observer

First sighted a fuel rich abnormal Vernier engine ignition and then the appearance of mainstage and an immediate cutoff. Sound of cutoff was present. At that time, I noticed a spreading fire in the area of Vernier engine VI, and immediately I reported fire.

S/ F. DiPiazza
F. DiPiazza

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FINAL ACCIDENT REPORT
RUN S2-212-B4-01

VISUAL OBSERVER: Dane Allard, Photographer

LOCATION: Photo Tank Observer

As the main engines ignited I noticed a burst of flame and smoke which seemed to be concentrated under the Sustainer and Bl engines. The flames and smoke engulfed the lower section of the missile. After the fire was extinguished a second flare-up occurred which was also promptly extinguished.

S/ Dane Allard
Dane Allard

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APPENDIX C

SUMMARY OF DATA PRESENTATION
BY MEASUREMENT NUMBER

RUN S2-212-B4-01

NOTE: Appendix C lists all measurements recorded during Run 212 and describes the method employed in analyzing each record. The following abbreviations are used in column headings.

TAB: Tabulated
GRA: Graphical presentation
NOT SIG: Not significant
NOT REV: Not relevant

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APPENDIX -C-

SUMMARY OF DATA PRESENTATION

BY MEASUREMENT NUMBER

RUN S2-212-B4-01 18 JUNE 58

MEAS #	DESCRIPTION	REPORT TAB	NOT GRA	NOT SIG	COMMENT REV
A1264D	MSL TK MOVEMENT X AX	X			
A1266D	MSL TK MOVEMENT Y AX	X			
A1386T	ENG COMP AFT AMB Q1		X		
A1387T	ENG COMP AFT AMB Q2		X		
A1388T	ENG COMP AFT AMB Q3		X		
A1389T	ENG COMP AFT AMB Q4		X		
E1006V	INVERTER PHASE A		X		114 V
E1023V	EXT AC PHASE A		X		104.64 V
E1027V	PROP CONTROL INPUT			X	
E1028V	MSL SYSTEMS INPUT			X	
F1001P	LO2 TANK HELIUM			X	
F1003P	FUEL TANK HELIUM			X	
F1005P	B TK HE BTL DISCH			X	
F1011P	LO2 PRES REG DISCH			X	

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F1034P	FUEL PRES ORFC DP	X		
F1065P	L02 TK HE LN @ ORFC	X		
F1066P	G02 BO LN @ ELBOW		X	
F1067P	G02 BO ELBOW TAP DP		X	
F1114P	L02 PRES REG INLET	X		
F1121P	B CTL HE BRL DISCH	X		
F1124P	S TK HE BTL DISCH	X		
F1125P	B CTL PNEU REG	X		
F1142P	S CTL PNEU REG OUT	X		
F1145P	S CTL HE BTL DISCH	X		
F1147P	L02 PRES ORFC DP	X		
F1212P	FUEL PRES ORFC IN	X		INVALID DATA
F1017T	FUEL PRES ORFC IN		X	
F1064T	G02 BO LN @ ELBOW		X	
F1115T	L02 PRES REG IN	X		
F1122T	BCTL HE BTL DISCH	X		
F1123T	S TK HE BTL DISCH		X	
F1130T	B CTL HEAT XGR OUT	X		
F1144T	S CTL HE BTL DISCH		X	
F1146T	L02 PRES ORFC IN		X	
F1219T	AIRBORNE REGS SUP	X		
H1003P	MSL HYD PUMP DISCH		X	
H1033P	B1 HYD ACCUMULATOR		X	
H1052P	S HYD ACCUMULATOR	X		

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H1140P	V	HYD PUMP DISCH	X	
H1001T	MSL	HYD PUMP DISCH		X
H1131T	S	HYD PUMP DISCH	X	
H1141T	V	HYD OIL SUPPLY		X
L1161P	FL	DEFR WATER MAN		X
L1155S	TOT	AUX STRUT 1A	X	
L1156S	TOT	AUX STRUT 1B	X	
L1157S	TOT	AUX STRUT 2A	X	
L1158S	TOT	AUX STRUT 2B	X	
L1257T	FLAME	DEFLECTOR		X
L1259T	FLAME	DEFLECTOR		X
L1263T	FLAME	DEFLECTOR		X
N1011F	WT & THST	SYS-THRUST	SEE ST219F	
P1083B	B2	PUMP SPEED		X
P1084B	B1	PUMP SPEED		X
P1349B	S	PUMP SPEED		X
P1528D	S	MAIN FUEL VALVE		X
P1529D	S	MAIN LO2 VALVE	X	
P14390	S	NAA RCC ACCEL		X

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P14520	B1 NAA RCC ACCEL		X	
P14530	B2 NAA RCC ACCEL			X
P1001P	B1 LO2 PUMP IN /BROWN/	X		
P1001P	B1 LO2 PUMP IN /CEC/			X
P1003P	B2 LO2 PUMP INLET /BROWN/	X		
P1003P	B2 LO2 PUMP INLET /CEC/			X
P1004P	B2 FUEL PUMP INLET/BROWN/	X		
P1004P	B2 FUEL PUMP INLET /CEC/			X
P1006P	S THRUST CHAMBER /BROWN/	X		
P1006P	S THRUST CHAMBER		X	
P1010P	B1 LUB OIL MAN	X		
P1011P	B2 LUB OIL MAN	X		
P1026P	B LO2 REG REFERENCE	X		
P1027P	VERNIER FUEL TANK	X		
P1028P	V1 THRUST CHAMBER	X	X	
P1029P	V2 THRUST CHAMBER	X	X	
P1030P	VERNIER LO2 TANK	X		
P1047P	V1 LO2 INLET /BROWN/	X	X	
P1047P	V1 LO2 INLET /CEC/			X
P1048P	V2 LO2 INLET /BROWN/	X	X	
P1048P	V2 LO2 INLET /CEC/			X
P1049P	V1 FUEL INLET /BROWN/	X	X	
P1049P	V1 FUEL INLET /CEC/			X
P1050P	V2 FUEL INLET /BROWN/	X	X	
P1050P	V2 FUEL INLET /CEC/			X

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P1055P	S FUEL PUMP INLET	X	
P1056P	S L02 PUMP INLET /BROWN/	X	
P1056P	S L02 PUMP INLET /CEC/		X
P1059P	B2 THRUST CHAMBER /BROWN/	X	
P1059P	B2 THRUST CHAMBER /CEC/		X
P1060P	B1 THRUST CHAMBER /BROWN/	X	
P1060P	B1 THRUST CHAMBER /CEC/		X
P1075P	G FUEL START TANK	X	
P1091P	B1 L02 INJ MANIFOLD		X
P1092P	B2 L02 INJ MANIFOLD		X
P1093P	B1 FUEL INJ MANIFOLD		X
P1094P	B2 FUEL INJ MANIFOLD		X
P1100P	B GG COMBUSTION CHM	X	
P1177P	B L02 START TANK REG	X	
P1178P	G FUEL START TANK REG		X
P1181P	L02 DEL MSL FILL VLV		X
P1182P	FUEL DEL AT FILL VLV		X
P1235P	VERN L02 TK REG OUT	X	
P1236P	VERN FUEL TK REG OUT	X	
P1280P	SGG FUL VLV INLET	X	
P1330P	S FUL PUMP DISCH	X	
P1332P	S L02 PUMP DISCH	X	
P1337P	SGG L02 INJ MAN	X	
P1339P	S GAS GEN DISCH	X	
P1341P	S LUB PUMP GEAR	X	
P1344P	S L02 REG REFERENCE	X	

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P1350P	S FUEL INJ MANIFOLD	X	
P1351P	S LO2 INJ MANIFOLD	X	
P1489P	B GAS GEN LO2 VLV IN	X	
P1007R	SUSTAINER FUEL FLOW	X	
P1008R	SUSTAINER LO2 FLOW	X	
P1037R	B GAS GEN LO2 FLOW	X	
P1042R	VERNIERS LO2 FLOW	X	
P1043R	VERNIERS FUEL FLOW	X	
P1051R	B GAS GEN & IGN FUEL	X	
P1333R	S GAS GEN LO2 FLOW	X	
P1334R	S GAS GEN FUEL FLOW	X	
P1014T	ENGINE COMP AMBIENT	X	
P1017T	B2 TURBINE IN	X	75-100 DEG F
P1018T	B1 TURBINE IN	X	80-90 DEG F
P1020T	B1 LO2 PUMP INLET	X	
P1021T	LO2AT BREAKAWAY VLV	X	
P1126T	B1 LO2 PUMP OTBD BRG	X	138-145 DEG F
P1127T	B2 LO2 PUMP OTBD BRG	X	157 DEG F
P1209T	B2 TURBINE BEARING	X	74 DEG F
P1213T	B1 TURBINE BEARING	X	MINUS 30 DEG F
P1323T	S TURBINE BEARING	X	
P1324T	S PUMP BEARINGS-LO2	X	
P1336T	S GAS GEN DISCH	X	
P1437W	S RCC BINARY COUNTER	X	

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P1454W	B1 RCC BINARY COUNT	X
P1455W	B2 RCC BINARY COUNT	X
P1067X	B2 LO2 VLV CLSD MSW	X
P1068X	B1 LO2 VLV CLSD MSW	X
P1069X	B2 FUEL VLV CLSD MSW	X
P1070X	B1 FUEL VLV CLSD MSW	X
P1071X	B GG VLV CLSD MSW	X
P1072X	BOOSTER CUTOFF RELAY	X
P1078X	VERN LO2 TK PRES SOL	X
P1079X	VERN FUL TK PRES SOL	X
P1096X	VERN TKS PRES RELAY	X
P1135X	PROP ST PRES RELAY	X
P1136X	B IGN DETR DELAY COF	X
P1137X	ETP PREP COMPLETE LT	X
P1139X	B LO2 V OPEN CTL SOL	X
P1142X	TCC IGN COMPLETE LT	X
P1143X	B GAS GEN IGN LINK	X
P1145X	BGG VLV OPEN CTL SOL	X
P1146X	BGG VLV CLOS CTL SOL	X
P1147X	BGG VLV OPEN MSW	X
P1148X	B FUL V OPEN CTL SOL	X
P1149X	B1 VLV CLOS CTL	X
P1150X	B FUL V CLOS CTL SOL	X
P1154X	TCC MAIN ENG COF SW	X
P1155X	OBSERVER CUTOFF	X

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P1156X	B1 TBN OVRSPED TRIP	X
P1157X	B2 TBN OVRSPED TRIP	X
P1158X	PREP INCOMPLETE COF	X
P1164X	TCC VERN ENG COF SW	X
P1165X	VERN ENG LOKIN RELAY	X
P1166X	FUEL INJ PURGE SOL	X
P1167X	VM PROP OPEN CTL SOL	X
P1169X	B2 LO2 VLV OPEN MSW	X
P1170X	B1 LO2 VLV OPEN MSW	X
P1186X	TCC FUEL S T FULL LT	X
P1192X	B1 ROUGH COMB COF	X
P1193X	B2 ROUGH COMB COF	X
P1194X	B1 FUEL VLV OPEN MSW	X
P1195X	B2 FUEL VLV OPEN MSW	X
P1196X	S LO2 V OPEN CTL SOL	X
P1197X	S LO2 V VLOS CTL SOL	X
P1198X	S LO2 VLV OPEN MSW	X
P1199X	S LO2 VLV CLOSED MSW	X
P1200X	S FUL V OPEN CTL SOL	X
P1201X	S FUL V CLOS CTL SOL	X
P1202X	S FUEL VLV OPEN MSW	X
P1203X	S FUEL VLV CLSD MSW	X
P1219X	#1 OBSERVER CUTOFF	X
P1220X	#2 OBSERVER CUTOFF	X
P1221X	#3 OBSERVER CUTOFF	X
P1222X	#4 OBSERVER CUTOFF	X

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P1223X	#5 OBSERVER CUTOFF	X
P1224X	#6 OBSERVER CUTOFF	X
P1225X	#7 OBSERVER CUTOFF	X
P1226X	#8 OBSERVER CUTOFF	X
P1227X	#9 OBSERVER CUTOFF	X
P1228X	#10 OBSERVER CUTOFF	X
P1229X	#11 OBSERVER CUTOFF	X
P1230X	#12 OBSERVER CUTOFF	X
P1299X	B IGN DETR DELAY - PU	X
P1335X	S GG VALVE CLSD MSW	X
P1347X	S CUTOFF SIGNAL	X
P1427X	VERN LO2 VENT SW	X
P1429X	TCC RELEASE SWITCH	X
P1438X	ROUGH COMB COF S	X
P1441X	B IGN STAGE TIMER-DO	X
P1443X	LO2 PRE VALVE OPEN	X
P1444X	LO2 PRE VALVE CLOSED	X
P1445X	FUEL PRE VALVE OPEN	X
P1446X	FUEL PRE VALVE CLSD	X
P1499X	S GG VLV OPEN MSW	X
P1503X	B FUEL S T VENT CTL	X
P1510X	TCC VERN CMPLT LITE	X
P1512X	B2 LO2 V CLOS CTL	X
P1515X	VERN STRT DY COF	X
P1516X	VERN SQUIBS FIRING	X
P1519X	VERN STRT DY COF TMR	X

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P1561X	B LO2 REG REF VENT	X
P1566X	DC GRND PWR FAIL COF	X
P1568X	STRT TKS PRESS TIMER	X
P1575X	PRE START READY	X
P1580X	S FUEL PRE VLV CLSD	X
P1581X	S FUEL PRE VLV OPEN	X
P1582X	S LO2 REG VENT V CTL	X
P1583X	S FUEL VLV LOKUP CTL	X
P1586X	S IGN FUEL V OPEN CTL	X
P1587X	S GG VLV OPN CTL	X
P1588X	S TBN OVRSP TRIP	X
P1591X	S HYD PRES SW	X
P1592X	B ENG CUTOFF	X
P1593X	S ENG CUTOFF	X
P1594X	TCC SUSTAINER COF SW	X
P1595X	SGG VLV CLSG SOL	X
P1596X	HOLDON RELEASE REL	X
P1598X	V ENG CUTOFF	X

S1074C	B1 PITCH SA OUT	X
S1075C	B2 PITCH SA OUT	X
S1076C	V2 ROLL SA OUT	X
S1077C	V1 ROLL SA OUT	X
S1078C	B1 YAW SA OUT	X
S1079C	B2 YAW SA OUT	X
S1214C	S PITCH SA OUT	X

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S1236X	BOOSTER COF DISCRETE	X	
S1237X	BOOSTER COF PRGR OTP	X	
S1238X	JETTISON BOOSTER SIG	X	
S1239X	PRES VERN TKS DISC	X	
S1240X	PRES V TKS PRGR OTP	X	
S1241X	SUSTAINER COF DISC	X	
S1242X	SUS CUTOFF PRGR OTP	X	
S1243X	PRE-ARM DISCRETE	X	
S1244X	PRE-ARM PRGR OTP	X	
S1245X	VERNIER COF DISCRETE	X	
S1246X	VERNIER COF PRGR OTP	X	
S1247X	EJECT NOSECONE UMBIL	X	
S1248X	RELEASE NOSECONE	X	
S1249X	FIRE RETRO-ROCKETS	X	
ST219F	WT & THS SYS TANKING	X	
ST206P	S LUB PUMP BRG		X
ST001R	SUS HYD FLOW RATE		X
ST160T	S ENG CTL MAN	X	
ST161T	B ENG CTL MAN	X	
ST162T	V LO2 TK PRES SOL	X	
ST163T	V LO2 TK PRES VLV	X	MINUS 67 DEG F
ST164T	B1 HYD ACUM	X	

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ST165T	S HYD ACUM	X			
ST166T	S HYD RES	X			
ST168T	LO2 ST TK PRES SOL	X			
ST169T	B1 LO2 VLV CLOS CTL	X			
ST170T	B2 LO2 VLV CLOS CTL	X			
ST183T	B2 THS CHM Y AX INPD EXT	X	66-85 DEG F		
ST184T	B1 THS CHM Y AX INBD EXT	X	75-101 DEG F		
ST185T	B2 THS CHM Y D45 DEG EXT	X			
ST186T	B1 THS CHM Y D45 DEG EXT	X	75-113 DEG F		
ST209T	FIRE DETR SKIRT SECT	X			
ST214T	VIBRATRON CASE TEMP	X			
ST007V	ENG GND PWR BUS			X	
ST152V	A/P 400 CY REF PH A			X	
ST215X	VIBRATRON PRINT READOUT				X
U1107C	PU SV AMP OUT			X	
U1021P	LO2 TK HD VIBROTRON			X	
U1022P	FUEL TK HD VIBROTRON			X	
U1091V	ERROR RATIO DEMOD OP			X	
U1105V	PU SV COMMAND SIG			X	

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APPENDIX D

DETAILED CHRONOLOGICAL HISTORY
OF SIGNIFICANT DATA

RUN S2-212-B4-01

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APPENDIX -D-
DETAILED CHRONOLOGICAL HISTORY
OF SIGNIFICANT DATA
52-212-84-01 18 JUNE 58

TIME	REC	MEAS	DESCRIPTION	EVENT
-467.13	117-2	P1336T	S GAS GEN DISCH	DEC FROM 117 DEG F TO PEG NEG
-299.83	119-2	F1003P	FUEL TANK HELIUM	INC FROM SEG 11 TO 111 /53.3 PSIG/
-214.13	208-2	P1337P	SGG LO2 INJ MAN	INC FROM 1.26 PSIG TO 16.70 PSIG
-149.13	221-1	E1027V	PROP CONTROL INPUT	INC FROM 27.3 TO 33.6 VOLTS FOR 13 SEC
-149.13	221-1	E1027V	PROP CONTROL INPUT	ON INT SWOVER ATTEMPT
-149.13	221-2	E1028V	MSL SYSTEMS INPUT	INC FROM 27.7 TO 34V ON INT SWOVER ATMP
-149.12	221-2	E1028V	MSL SYSTEMS INPUT	BACK TO EXT AFTER 13 SEC
-129.13	221-1	E1027V	PROP CONTROL INPUT	INC FOR 7 SEC ON 2ND INT SWOVER ATTEMPT
-129.13	221-2	E1028V	MSL SYSTEM INPUT	2ND SWOVER ATTEMPT 34V FOR 7 SEC
-105.63	221-1	E1027V	PROP CONTROL INPUT	INC FOR 16 SEC ON 3RD INT SWOVER
-105.63	221-1	E1027V	PROP CONTROL INPUT	ATTEMPT
-38.13	122-1	P1003P	B2 LO2 PUMP IN	3RD SWOVER ATTEMPT 34V FOR 16 SEC
-38.03	123-1	P1001P	B1 LO2 PUMP IN	OSCILLATES @ 8 CPS FOR 3.5 SEC
-37.93	123-3	P1056P	S LO2 PUMP INLET	OSCILLATES FOR 1.5 SEC @ 4 CPS
-31.36	121-3	F1011P	LO2 PRES REG DISCH	OSCILLATES FOR 1 SEC @ 8 CPS
-30.89	119-2	F1003P	FUEL TANK HELIUM	INC FROM 25 TO 26.5 PSIG
-30.43	123-3	P1056P	S LO2 PUMP INLET	INC FROM 55.3 TO 57.8 PSIG IN 27.7 SEC
-25.00	121-2	F1001P	LO2 TANK HELIUM	OSCILLATES FOR .6 SEC @ 11 CPS
				PRE START STEADY 26.5 PSIG

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-25.00	217-2	F1005P	B TK HE BTL DISCH	STEADY 3130 PSIG
-25.00	217-1	F1121P	B CTL HE BTL DISCH	STEADY 3200 PSIG
-25.00	CEC	F1017T	FUEL PRES ORFC IN	STEADY 60 DEG F
-25.00	222-1	F1122T	B CTL HE BTL DISCH	STEADY MINUS 175 DEG F
-17.15	123-2	P1021T	LO2 AT BREAKWAY VLV	DEC FROM MINUS 285 TO MINUS 291 DEG F
-14.24	29	P1161X	TCC VERN ENG STR SW	ACTIVATE
-14.23	27	P1078X	VERN LO2 TK PRES SOL	ACTIVATE
-14.23	26	P1079X	VERN FUL TK PRES SOL	ACTIVATE
-14.23	25	P1096X	VERN TKS PRES RELAY	ACTIVATE
-14.23	23	P1135X	PROP S T PRES RELAY	ACTIVATE
-14.23	24	P1427X	VERN LO2 VENT CONT	DEACTIVATE
-14.22	113-3	P1117P	B LO2 START TANK REG	TRANSIENT 508 TO 498 TO 514 PSIG
-14.21	109-1	P1030P	VERNIER LO2 TANK	INC FROM AMB /MINUS 14/ TO 515 PSIG
-14.18	110-2	P1236P	VERN FUEL TANK REG OUT	DEC 533 PSIG TO 524 PSIG
-14.17	110-1	P1027P	VERNIER FUEL TANK	INC FROM AMB /MINUS 6 PSIG/ TO 527 PSIG
-14.17	109-2	P1235P	VERN LO2 TK REG OUT	TRANSIENT 523 TO 479 TO 525 PSIG
-14.19	209-3	P1049P	V1 FUEL INLET	INC FROM AMB /62 PSIG/ TO 524 PSIG
-14.13	210-1	P1050P	V2 FUEL INLET	INC FROM AMB/67 PSIG/TO 518 PSIG
-14.13	110-3	P1075P	G FUEL START TANK	TANK PRESSURIZES
-14.11	109-3	P1489P	B GAS GEN LO2 VLV IN	INC FROM AMB/48 PSIG/ TO 495 PSIG
-13.99	209-2	P1048P	V2 LO2 INLET	INC FROM AMB /32 PSIG/ TO 519 PSIG
-13.96	209-1	P1047P	V1 LO2 INLET	INC FROM AMB /32 PSIG/ TO 520 PSIG
-13.93	208-2	P1337P	SGG LO2 INJ MAN	INC FROM 16.70 PSIG TO 35.20 PSIG
-13.84	208-3	P1280P	SGG FUEL VLV INLET	INC FROM AMB /167 PSIG/ TO 956 PSIG
-12.18	30	P1568X	STRT TKS PRESS TIMER	ACTIVATE
.00	28	P1516X	VERN SQUIBS FIRING	ACTIVATE

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.59	113-1	F1142P	S CTL PNEU REG OUT	STEADY AT 737 PSIG
.63	31	P1165X	VERN ENG LOKIN RELAY	ACTIVATE
.64	32	P1167X	VERN PV OPEN CTL	ACTIVATE
.65	131	S1240X	PRES V TKS PRGR OTP	ACTIVATE
.71	209-2	P1048P	V2 LO2 INLET	TRANSIENT - 519 TO 366 TO 502 PSIG
.71	210-1	P1050P	V2 FUEL INLET	TRANSIENT 518 TO 271 TO 430 PSIG
.76	209-1	P1047P	V1 LO2 INLET	BEGAN OSCILLATION FOR .6 SEC
.79	109-1	P1030P	VERNIER LO2 TANK	DEC FROM 518 PSIG TO 510 PSIG
.83	109-2	P1235P	VERN LO2 TK REG OUT	TRANSIENT 525 TO 518 TO 528 PSIG
1.03	219-1	P1028P	V1 THRUST CHAMBER	INC FROM AMB /8 PSIG/ TO 188 PSIG
1.03	219-2	P1029P	V2 THRUST CHAMBER	INC FROM AMB /1 PSIG/ TO 213 PSIG
1.06	112-2	P1004P	B2 FUEL PUMP INLET	DEC FROM MINUS .8 PSIG TO PEG NEG
1.27	219-2	P1029P	V2 THRUST CHAMBER	OSCILLATES 4 CPS FOR .6 SEC
1.47	CEC-	F1034P	FUEL PRES ORFC DP	INC FROM 16.1 TO 17.0 PSIG
1.47	CEC-	F1147P	LO2 PRES ORFC DP	INC FROM 53.6 TO 54.4 PSIG
1.47	218-3	P1341P	S LUBE PUMP GEAR	INC FROM AMB /17 PSIG/ TO 32.2 PSIG
1.56	39	P1510X	TCC VERN COMPLETE LT	ACTIVATE
1.57	36	P1166X	B&S FUEL INJ PRG SOL	ACTIVATE
1.67	CEC-	F1065P	LO2 TK HE LN & ORFC	INC FROM 25 TO 28 PSIG
1.73	209-3	P1049P	V1 FUEL INLET	TRANSIENT 524 TO 290 TO 453 PSIG
1.81	113	P1149X	B1 LO2 V CLOS CTL	ACTIVATE
1.81	112	P1512X	B2 LO2 V CLOS CTL	ACTIVATE
1.82	45	P1139X	B LO2 V OPEN CTL SOL	ACTIVATE
1.82	67	P1196X	SUSTAINER HSV SOL B	ACTIVATE
1.82	74	P1197X	SUSTAINER HSV SOL A	ACTIVATE
1.82	66	P1586X	S IGN FUEL V OPEN CTL	ACTIVATE

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1.87	108-3	P15290	S MAIN LO2 VALVE	STARTED OPEN FROM 0 DEG
1.88	123-3	P1056P	S LO2 PUMP INLET	TRANSIENT 46 TO 39 TO 42 PSIG
1.89	221-1	E1027V	PROP CONTROL INPUT	DEC .5 V
1.89	68	P1199X	S LO2 HSV CLOSED MSW	DEACTIVATE
1.91	48	P1067X	B2 LO2 VLV CLSD MSW	DEACTIVATE
1.93	214-1	H1052P	S HYD ACCUMULATOR	DEC FROM 1840 TO 1590 PSIG
1.93	208-3	P1280P	SGG FUEL VLV INLET	TRANSIENT 956 TO 863 TO 941 PSIG
1.94	123-1	P1001P	B1 LO2 PUMP IN	TRANSIENT 51 TO 42 TO 49 PSIG
1.95	110-3	P1075P	G FUEL START TANK	DEC FROM 804 PSIG /IGN FLOW/
1.95	46	P1068X	B1 LO2 VLV CLSD MSW	DEACTIVATE
1.99	216-1	F1145P	S CTL HE BTL DISCH	STEADY AT 3116 PSIG
1.99	122-1	P1003P	B2 LO2 PUMP IN	TRANSIENT 54 TO 42 TO 52 PSIG
2.01	117-3	P1006P	S THRUST CHAMBER	INC FROM AMB
2.01	49	P1169X	B2 LO2 VLV OPEN MSW	ACTIVATE
2.12	110-3	P1075P	G FUEL START TANK	SURGE TO 941 PSIG
2.17	47	P1170X	B1 LO2 VLV OPEN MSW	ACTIVATE
2.22	69	P1198X	S LO2 HSV OPEN MSW	ACTIVATE
2.27	113-1	F1142P	S CTL PNEU REG OUT	TRANS 742 TO 640 TO 825 TO 633 TO 767
2.27	113-1	F1142P	S CTL PNEU REG OUT	TO 743 PSIG
2.30	119-2	P1339P	S GAS GEN DISCH	TRANSIENT 0 TO 87 TO 27 PSIG
2.30	50	P1142X	ICC IGN COMPLETE LT	ACTIVATE
2.31	216-2	F1124P	S TK HE BTL DISCH	STEADY AT 1630 PSIG
2.31	111-1	F1125P	B CTL PNEU REG	STEADY AT 743 PSIG
2.31	CEC	P1351P	S LO2 INJ MANIFOLD	BEGAN OSCILLATION FOR .07 SEC
2.31	109-3	P1489P	B GAS GEN LO2 VLV IN	INC FROM 493 PSIG TO 527 PSIG
2.32	CEC	P1055P	S FUEL PUMP INLET	DEC FROM 64.4 PSIG TO 27 PSIG

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2.32	208-2	P1337P	SGG LO2 INJ MAN	TRANSIENT 35.20 TO 130.00 TO 1.26 PSIG
2.33	CEC-	F1034P	FUEL PRES ORFC DP	TRACE BECOMES ERRATIC NOISE
2.33	CEC-	F1065P	LO2 TK HE LN @ ORFC	TRACE BECOMES ERRATIC NOISE
2.33	CEC-	F1147P	LO2 PRES ORFC DP	TRACE BECOMES ERRATIC NOISE
2.33	CEC	F1017T	FUEL PRES ORFC IN	INC FULL SCALE
2.33	109-1	P1030P	VERNIER LO2 TANK	DEC FROM 523 PSIG TO 410 PSIG
2.33	CEC	P1100P	BGG COMBUSTION CHM	TRANSIENT OFF SCALE
2.33	113-3	P1177P	B LO2 START TANK REG	DEC TO 0 PSIG
2.33	208-3	P1280P	SGG FUEL VLV INLET	DROP FROM 941 TO MINUS 24 PSIG
2.33	CEC	P1350P	S FUEL INJ MANIFOLD	TRANSIENT PEG TO PEG
2.33	CEC	P1351P	S LO2 INJ MANIFOLD	TRANSIENT PEG TO PEG
2.33	123-2	P1021T	LO2 AT BREAKWAY VLV	INC TO PEG POS FROM MINUS 287.5 DEG F
2.33	58	P1071X	BGG VLV CLSD MSW	DEACTIVATE
2.33	11	P1137X	ETP PREP COMPLETE LT	DEACTIVATE
2.34	217-2	F1005P	B TK HE BTL DISCH	DROP FROM 2800 TO 0 PSIG
2.34	222-1	F1122T	B CTL HE BTL DISCH	DEC FROM MINUS 175 TO MINUS 193 DEG F
2.34	114-2	F1219T	AIRBORNE REGS SUP	INC FROM 94 DEG F TO PEG POS
2.34	AM-5	P1439Q	S NAA RCC ACCEL	TRANSIENT TO APPROX 66.5 G
2.34	AM-8	P1452Q	B1 NAA RCC ACCEL	TRANSIENT TO APPROX 51 G
2.34	218-1	P1010P	B1 LUBE OIL MAN	TRANS AMB /5.4 PSIG/ TO MINUS 2.8 TO
2.34	218-1	P1010P	B1 LUBE OIL MAN	AMB
2.34	218-2	P1011P	B2 LUBE OIL MAN	8 PSIG TRANSIENT
2.34	123-3	P1056P	S LO2 PUMP INLET	OSCILLATES FOR 2.6 SEC @ 10 CPS
2.34	208-1	P1330P	S FUEL PUMP DISCH	TRANSIENT 93 TO MINUS 2 TO 104 PSIG
2.34	CEC	P1454W	B1 RCC BINARY COUNT	SPIKE 1.5 MS
2.34	55	P1069X	B2 FUEL VLV CLSD MSW	DEACTIVATE

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2.34	58	P1071X	BGG VLV CLOSED MSW	ACTIVATE
2.34	11	P1137X	ETP PREP COMPLETE LT	ACTIVATE
2.34	45	P1139X	B LO2 VLV OPEN CTL SOL	DEACTIVATE
2.34	51	P1143X	B GAS GEN IGN LINK	DEACTIVATE
2.34	22	P1503X	GFST VENT CTL	DEACTIVATE
2.34	112	P1512X	B2 LO2 V CLOS CTL	DEACTIVATE
2.34	30	P1568X	STRT TKS PRESS TIMER	DEACTIVATE
2.34	403-1	S1107V	B1 PCH ACTR FEEDBAK	TRANSIENT .5 DEG DN FOR .1 SEC
2.34	403-5	S1216V	S PCH ACTR FEEDBAK	TRANSIENT .25 DEG DN FOR .16 SEC
2.34	405-5	S1217V	S YAW ACTR FEEDBAK	TRANSIENT .5 DEG YAW RT FOR .03 SEC
2.35	121-2	F1001P	LO2 TANK HELIUM	OSCILLATES 23.1 TO 28.7 PSIG
2.35	119-2	F1003P	FUEL TANK HELIUM	OSC 48.2 TO 44.3 PSIG FOR 1.5 SEC
2.35	214-3	F1114P	LO2 PRES REG INLET	DEC FROM 3020 TO 0 PSIG
2.35	119-3	P1332P	S LO2 PUMP DISCH	TRANSIENT 44 TO MINUS 8 TO 67 PSIG
2.35	53	P1070X	B1 FUEL VLV CLSD MSW	DEACTIVATE
2.35	58	P1071X	BGG VLV CLOSED MSW	DEACTIVATE
2.35	113	P1149X	B1 LO2 V CLOS CTL	DEACTIVATE
2.35	49	P1169X	B2 LO2 VLV OPEN MSW	DEACTIVATE
2.35	22	P1503X	GFST VENT CTL	ACTIVATE
2.36	221-1	E1027V	PROP CONTROL INPUT	DEC TO PEG NEG
2.36	111-2	P1026P	B LO2 REG REF	DEC FROM STEADY 536.3 PSIG TO 530.4 PSI
2.36	115-3	P1060P	B1 THRUST CHAMBER	ANB TO 54 PSIG THEN PEGS MINUS
2.36	31	P1165X	VERN ENG LOKIN RELAY	DEACTIVATE
2.36	32	P1167X	VERN PV OPEN CTL	DEACTIVATE
2.36	47	P1170X	B1 LO2 VLV OPEN MSW	DEACTIVATE
2.37	221-2	E1028V	MSL SYSTEMS INPUT	TRANSIENT OF .6 V

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2.37	121-3	F1011P	LO2 PRES REG DISCH	OSCILLATES 15 PSIG
2.37	216-2	F1124P	S TK HE BTL DISCH	TRANS 3100 TO 2930 TO 3330 TO 2475 TO
2.37	216-2	F1124P	S TK HE BTL DISCH	2850 PSIG
2.37	108-3	P1529D	S MAIN LO2 VALVE	REACHED MAX POS 86.77 DEG
2.37	123-1	P1001P	B1 LO2 PUMP IN	OSCILLATES FOR 1.08 SEC @ 4.5 CPS
2.37	110-1	P1027P	VERNIER FUEL TANK	TRANSIENT 527 PSIG TO 507 PSIG
2.37	109-2	P1235P	VERN LO2 TK REG OUT	TRANSIENT 528 TO 429 TO 661 PSIG
2.37	109-3	P1489P	B GAS GEN LO2 VLV IN	DEC TO AMB /48 PSIG/
2.37	3	P1445X	B FUEL PRE VLV OPEN	DEACTIVATE
2.38	115-2	P1059P	B2 THRUST CHAMBER	DEC FROM AMB TO PEG MINUS
2.38	110-2	P1236P	VERN FUEL TANK REG OUT	TRANSIENT 523 TO 427 TO 554 TO 495 PSIG
2.38	220-2	P1014Y	ENGINE COMP AMB	TRANSIENT 45.5 TO 42.5 TO 69.0 DEG F
2.38	117-2	P1336T	S GAS GEN DISCH	TRANSIENT PEG NEG TO 390 TO 124 DEG F
2.38	131	S1240X	PRESS V TKS PRGR OIP	DEACTIVATE
2.39	69	P1198X	S LO2 HSV OPEN MSW	DEACTIVATE
2.40	222-1	F1122T	B CTL HE BTL DISCH	INC FROM MINUS 193 DEG F TO PEG POS
2.40	222-3	F1130T	B CTL HEAT XGR OUT	INC FROM 82 DEG F TO PEG POS
2.41	122-1	P1003P	B2 LO2 PUMP IN	OSCILLATES @ 5 CPS FOR 1.2 SEC
2.41	113-2	P1344P	S LO2 REG REF	OSC 165 FROM 789 PSIG FOR 1.7 SEC
2.41	116-3	P1324T	S PUMP BEARINGS-LO2	DEC FROM 182.5 TO 177 DEG F
2.43	217-1	F1121P	B CTL HE BTL DISCH	DEC FROM 3200 TO 0 PSIG
2.44	213-1	H1140P	V HYD PUMP DISCH	600 PSIG DIP TRANSIENT
2.47	115-2	P1059P	B2 THRUST CHAMBER	INC TO 32.80 PSIG
2.48	219-2	P1029P	V2 THRUST CHAMBER	DEC FROM 233 PSIG TO AMB /1 PSIG/
2.48	209-1	P1047P	V1 LO2 INLET	BEGAN OSCILLATION FOR .42 SEC
2.48	209-2	P1048P	V2 LO2 INLET	TRANSIENT ~ 496 TO 585 TO 546 PSIG

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2.50	109-1	P1030P	VERNIER LO2 TANK	INC FROM 410 PSIG TO 683 PSIG
2.51	219-1	P1028P	V1 THRUST CHAMBER	DEC FROM 220 PSIG TO AMB /8 PSIG/
2.52	210-1	P1050P	V2 FUEL INLET	TRANSIENT 450 TO 545 TO 514 PSIG
2.53	209-3	P1049P	V1 FUEL INLET	TRANSIENT 453 TO 560 TO 522 PSIG
2.57	122-2	P1004P	B2 FUEL PUMP INLET	TRANSIENT - PEGS POS TO NEG
2.63	220-2	P1014T	ENGINE COMP AMB	TRANSIENT 69.0 TO 64.5 TO 107.0 DEG F
2.65	107-2	A1264D	MSL TK MOVEMENT X AX	STEADY AT .025 INCHES
2.65	107-3	A1266D	MSL TK MOVEMENT Y AX	STEADY MINUS .08 INCHES
2.65	216-1	F1145P	S CTL HE BTL DISCH	TRANSIENT 3079 TO 2391 TO 3288 TO 2237
2.65	216-1	F1145P	S CTL HE BTL DISCH	TO 2655 PSIG
2.65	68	P1199X	S LO2 HSY CLOSED MSW	ACTIVATE
2.68	117-2	P1336T	S GAS GEN DISCH	TRANSIENT 124 TO 213 TO 140 DEG F
2.74	109-1	P1030P	VERNIER LO2 TANK	DEC FROM 683 PSIG TO 410 PSIG
2.77	109-2	P1235P	VERN LO2 TK REG OUT	TRANSIENT 661 TO 455 TO 509 PSIG
2.87	214-1	H1052P	S HYD ACCUMULATOR	INC TO 2210 PSIG
2.87	108-3	P1529D	S MAIN LO2 VALVE	CLOSING - 1.40 DEG
2.96	115-3	P1060P	B1 THRUST CHAMBER	DEC FROM 302.8 PSIG /MAX/ TO PEG MINUS
2.97	CEC	P1100P	BGG COMBUSTION CHM	TRACE RETURNS TO AMB
2.99	117-2	P1336T	S GAS GEN DISCH	DEC FROM 140 DEG F TO PEG NEG
3.01	115-2	P1059P	B2 THRUST CHAMBER	DEC FROM 176.0 PSIG TO PEG MINUS
3.27	107-2	A1264D	MSL TK MOVEMENT X AX	INC TO .125 INCHES
3.27	107-3	A1266D	MSL TK MOVEMENT Y AX	INC TO MINUS .025 INCHES
3.30	217-3	F1115T	LO2 PRES REG IN	INC FROM 80 DEG F TO PEG NEG
3.30	110-2	P1236P	VERN FUEL TANK REG OUT	TRANSIENT 519 TO 426 TO 474 PSIG
3.31	208-1	P1330P	S FUEL PUMP DISCH	TRANSIENT 95 PSIG TO 39 PSIG TO 46 PSIG
3.31	220-2	P1014T	ENGINE COMP AMB	TRANSIENT 107.0 TO 104.3 TO PLUS PEG

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3.37	42	P1299X	B IGN DETR DELAY-PU	ACTIVATE
3.40	117-3	P1006P	S THRUST CHAMBER	MAX DEFL - 6 PSIG
3.42	108-3	P1529D	S MAIN LO2 VALVE	FULL CLOSED
3.79	111-1	F1125P	B CTL PNEU REG	DEC TO .8 PSIG
3.87	221-2	E1028V	MSL SYSTEMS INPUT	STABLE AT 28.3 V
5.08	38	P1077X	VERN COF REL LOCKIN	ACTIVATE
5.08	93	P1566X	DC GND PWR FAIL COF	ACTIVATE
5.09	109-1	P1030P	VERNIER LO2 TANK	DEC FROM 536 PSIG TO AMB /MINUS 14 PSIG
5.09	80	P1347X	S COF RELAY LOCKIN	ACTIVATE
5.09	102	P1582X	S LO2 REG VENT V CTL	ACTIVATE
5.09	107	P1598X	VERNIER ENG COF	ACTIVATE
5.09	133	S1242X	SUS CUTOFF PRGR OTP	ACTIVATE
5.09	137	S1246X	VERNIER COF PRGR OTP	ACTIVATE
5.10	122-2	P1004P	B2 FUEL PUMP INLET	INC FROM REG NEG TO MINUS 3.5 PSIG
5.10	38	P1077X	VERN COF REL LOCKIN	DEACTIVATE
5.10	93	P1566X	DC GRND PWR FAIL COF	DEACTIVATE
5.10	102	P1582X	S LO2 REG VENT V CTL	DEACTIVATE
5.10	107	P1598X	VERNIER ENG COF	DEACTIVATE
5.10	126	S1237X	BOOSTER COF PRGR OTP	ACTIVATE
5.11	110-1	P1027P	VERNIER FUEL TANK	DEC FROM 475 TO AMB /MINUS 6 PSIG/
5.11	27	P1078X	VERN LO2 TK PRES SOL	DEACTIVATE
5.11	26	P1079X	VERN FUL TK PRES SOL	DEACTIVATE
5.11	23	P1135X	PROP S T PRES RELAY	DEACTIVATE
5.11	11	P1137X	ETP PREP COMPLETE LT	DEACTIVATE
5.11	50	P1142X	TCC IGN COMPLETE LT	DEACTIVATE
5.11	29	P1161X	TCC VERN ENG STR SW	DEACTIVATE

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5.11	36	P1166X	B6S FUEL INJ PRG SOL	DEACTIVATE
5.11	67	P1196X	SUSTAINER HSV SOL B	DEACTIVATE
5.11	74	P1197X	SUSTAINER HSV SOL A	DEACTIVATE
5.11	42	P1299X	B IGN DETR DELAY-PU	DEACTIVATE
5.11	80	P1347X	S COF RELAY LOCKIN	DEACTIVATE
5.11	24	P1427X	VERN LO2 VENT CONT	ACTIVATE
5.11	22	P1503X	GFST VENT CTL	DEACTIVATE
5.11	39	P1510X	TCC VERN COMPLETE LY	DEACTIVATE
5.11	28	P1516X	VERN SQUIBS FIRING	DEACTIVATE
5.11	66	P1586X	S IGN FUEL V OPN CTL	DEACTIVATE
5.11	133	S1242X	SUS CUTOFF PRGR OTP	DEACTIVATE
5.11	137	S1246X	VERNIER COF PRGR OTP	DEACTIVATE
5.12	25	P1096X	VERN TKS PRES RELAY	DEACTIVATE
5.13	109-2	P1235P	VERN LO2 TK REG OUT	TRANSIENT 488 TO 505 TO 483 PSIG
5.17	209-2	P1048P	V2 LO2 INLET	DEC FROM 568 TO AMB /32 PSIG/
5.17	210-1	P1050P	V2 FUEL INLET	DEC FROM 514 PSIG TO AMB /67 PSIG/
5.19	209-3	P1049P	V1 FUEL INLET	DEC FROM 522 PSIG TO AMB /82 PSIG/
5.20	209-1	P1047P	V1 LO2 INLET	DEC FROM 549 PSIG TO AMB /32 PSIG/
5.21	110-3	P1075P	G FUEL START TANK	TANK VENTS
7.87	107-3	A1266D	MSL TK MOVEMENT Y AX	INC TO MINUS .020 INCHES
7.87	216-2	F1124P	S TK HE BTL DISCH	TRANS 2750 TO 3000 TO 2640 TO 2800 PSIG
7.87	113-1	F1142P	S CTL PNEU REG OUT	TRANSIENT 737 TO 798 TO 697 TO 736 PSIG
7.87	216-1	F1145P	S CTL HE BTL DISCH	TRANSIENT 2473 TO 2770 TO 2343 TO 2484 PSIG
7.87	216-1	F1145P	S CTL HE BTL DISCH	
7.89	119-2	F1003P	FUEL TANK HELIUM	OSC 59.0 TO 52.5 PSIG FOR .5 SEC
7.92	109-2	P1235P	VERN LO2 TK REG OUT	TRANSIENT 483 TO 550 TO 453 TO 474 PSIG

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7.93	110-2	P1236P	VERN FUEL TANK REG OUT	TRANSIENT 485 TO 530 TO 495 PSIG
7.93	119-3	P1332P	S LO2 PUMP DISCH	TRANSIENT 67 TO 82 TO 63 PSIG
7.94	214-1	H1052P	S HYD ACCUMULATOR	200 PSIG TRANSIENT
7.95	121-2	F1001P	LO2 TANK HELIUM	OSCILLATES 25.4 TO 28.3 PSIG
7.95	121-3	F1011P	LO2 PRES REG DISCH	OSCILLATES 7 PSIG
7.97	113-2	P1344P	S LO2 REG REF	OSC 82.6 FROM 771 PSIG FOR 1.8 SEC
8.87	216-1	F1145P	S CTL HE BTL DISCH	STEADY AT 2465 PSIG
9.37	218-3	P1341P	S LUBE PUMP GEAR	DEC FROM 32.2 PSIG TO AMB /17 PSIG/
11.02	117-3	P1006P	S THRUST CHAMBER	DEC FROM MAX TO AMB
12.09	122-2	P1004P	B2 FUEL PUMP INLET	TRACE NOISY FOR 8.8 SEC @ MINUS 2.5 PSI
12.87	213-3	H1141T	V HYD OIL SUPPLY	TEMP INC
13.36	5	P1581X	S FUEL PRE VLV OPEN	DEACTIVATE
13.51	CEC	P1055P	S FUEL PUMP INLET	DEC FROM 28.5 PSIG TO 12.7 PSIG
14.02	7	P1443X	LO2 PRE VALVE OPEN	DEACTIVATE
15.10	4	P1580X	S FUEL PRE VLV CLSD	ACTIVATE
17.73	123-3	P1056P	S LO2 PUMP INLET	DEC FROM 45 PSIG TO 25 PSIG
17.87	122-1	P1003P	B2 LO2 PUMP IN	DEC FROM 34 PSIG TO 29 PSIG
17.87	6	P1444X	LO2 PRE VALVE CLOSED	ACTIVATE
17.97	123-1	P1001P	B1 LO2 PUMP IN	DEC FROM 52 PSIG TO 30 PSIG
20.67	220-2	P1014T	ENGINE COMP AMB	DEC FROM PLUS PEG TO 105.0 DEG F IN 10
20.67	220-2	P1014T	ENGINE COMP AMB	SEC
20.87	107-2	A1264D	MSL TK MOVEMENT X AX	DEC TO MINUS .270 INCHES
20.87	122-2	P1004P	B2 FUEL PUMP INLET	TRACE STABLE NEAR 0 PSIG
21.37	208-3	P1280P	SGG FUEL VLV INLET	BEGAN RANDOM NOISE
22.87	107-3	A1266D	MSL TK MOVEMENT Y AX	DEC TO MINUS .050 INCHES
24.38	86	P1588X	S TBN OVERSPEED TRIP	DEACTIVATE

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34.87	123-3	P1056P	S LO2 PUMP INLET	DEC FROM 27 PSIG TO 10 PSIG
35.87	213-1	H1140P	V HYD PUMP DISCH	INC FROM 1970 TO 3260 PSIG
35.87	123-1	P1001P	B1 LO2 PUMP IN	DEC FROM 30 PSIG TO 0 PSIG
35.87	122-1	P1003P	B2 LO2 PUMP IN	DEC FROM 28 PSIG TO 0 PSIG
40.87	117-2	P1336T	S GAS GEN DISCH	INC FROM PEG NEG TO 75 DEG F
47.87	107-3	A1266D	MSL TK MOVEMENT Y AX	INC TO MINUS .022 INCHES
47.87	113-1	F1142P	S CTL PNEU REG OUT	BEGAN OSCILLATION
47.87	123-3	P1056P	S LO2 PUMP INLET	BEGAN RANDOM OSCILLATIONS
47.87	115-3	P1060P	B1 THRUST CHAMBER	OSCILLATES PLUS THEN PEGS MINUS
48.87	119-2	F1003P	FUEL TANK HELIUM	DEC SEG 111 TO 11 / 22.9 PSIG/ IN 113 SE
48.87	115-2	P1059P	B2 THRUST CHAMBER	OSCILLATES PLUS THEN PEGS MINUS
48.87	113-2	P1344P	S LO2 REG REF	BEGAN RANDOM NOISE
49.87	111-2	P1026P	B LO2 REG REF	OSCILLATES PLUS THEN PEGS MINUS
51.87	113-3	P1177P	B LO2 START TANK REG	RANDOM OSCILLATIONS
52.87	216-2	F1124P	S TK HE BTL DISCH	BEGAN OSCILLATION
52.87	111-1	F1125P	B CTL PNEU REG	BEGAN OSCILLATION
52.87	216-1	F1145P	S CTL HE BTL DISCH	BEGAN OSCILLATION
52.87	212-3	H1131T	S HYD PUMP DISCH	INC 20 DEG F
53.37	109-2	P1235P	VERN LO2 TK REG OUT	BEGAN RANDOM TRANSIENTS
54.37	110-2	P1236P	VERN FUEL TANK REG OUT	BEGAN RANDOM OSCILLATIONS
72.87	107-3	A1266D	MSL TK MOVEMENT Y AX	DEC TO MINUS .090 INCHES
88.87	221-1	E1027V	PROP CONTROL INPUT	ERRATIC TRACE
556.37	220-2	P1014T	ENGINE COMP AMB	TRANSIENT 75.5 TO 97.6 TO 70.5 DEG F
	8		SPARE	DEACTIVATE
	9		SPARE	ACTIVATE
	33		SPARE	DEACTIVATE

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34	SPARE	DEACTIVATE
37	SPARE	DEACTIVATE
62	SPARE	DEACTIVATE
76	SPARE	DEACTIVATE
89	SPARE	DEACTIVATE
94	SPARE	DEACTIVATE
95	SPARE	DEACTIVATE
96	SPARE	DEACTIVATE
97	SPARE	DEACTIVATE
98	SPARE	DEACTIVATE
111	SPARE	DEACTIVATE
117	SPARE	DEACTIVATE
119	SPARE	DEACTIVATE
120	SPARE	DEACTIVATE
123	SPARE	DEACTIVATE
124	SPARE	DEACTIVATE
125	SPARE	DEACTIVATE
142	SPARE	DEACTIVATE
143	SPARE	DEACTIVATE
144	SPARE	DEACTIVATE
145	SPARE	DEACTIVATE
146	SPARE	DEACTIVATE
213-1	H1140P V HYD PUMP DISCH	PRE START STEADY 1900 PSIG
19	APS HYD UNDER PRESS	DEACTIVATE
60	B COF RELAY LOCKIN	DEACTIVATE
44	B LUBE TANK PRESO SW	DEACTIVATE

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90	P1136X	B IGN DETR DELAY COF	DEACTIVATE
43	P1144X	B LUBE TNK PRESS SOL	DEACTIVATE
57	P1145X	BGG VLV OPEN CTL SOL	DEACTIVATE
115	P1146X	BGG VLV CLOS CTL SOL	DEACTIVATE
59	P1147X	BGG VLV OPEN MSW	DEACTIVATE
52	P1148X	B FUEL VLV OPEN CTL SOL	DEACTIVATE
114	P1150X	B FUEL VLV CLOS CTL SOL	DEACTIVATE
108	P1154X	TCC B ENGINE COF SW	DEACTIVATE
91	P1155X	OBSERVER CUTOFF	DEACTIVATE
87	P1156X	B1 TBN OVRSPD TRIP	DEACTIVATE
88	P1157X	B2 TBN OVRSPD TRIP	DEACTIVATE
92	P1158X	PREP INCOMPLETE COF	DEACTIVATE
100	P1159X	B LUBE TK PRESS COF	DEACTIVATE
110	P1164X	TCC VERN ENG COF SW	DEACTIVATE
20	P1186X	TCC FUEL S T FULL LT	DEACTIVATE
83	P1192X	B1 ROUGH COMB COF	DEACTIVATE
84	P1193X	B2 ROUGH COMB COF	DEACTIVATE
54	P1194X	B1 FUEL VLV OPEN MSW	DEACTIVATE
56	P1195X	B2 FUEL VLV OPEN MSW	DEACTIVATE
71	P1200X	SUSTAINER PUV SOL F	DEACTIVATE
75	P1201X	SUSTAINER PUV SOL E	DEACTIVATE
73	P1202X	S FUEL PUV OPEN MSW	DEACTIVATE
72	P1203X	S FUEL PUV CLSD MSW	ACTIVATE
149	P1219X	#1 OBSERVER CUTOFF	DEACTIVATE
150	P1220X	#2 OBSERVER CUTOFF	DEACTIVATE
151	P1221X	#3 OBSERVER CUTOFF	DEACTIVATE

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152	P1222X	#4 OBSERVER CUTOFF	DEACTIVATE
153	P1223X	#5 OBSERVER CUTOFF	DEACTIVATE
154	P1224X	#6 OBSERVER CUTOFF	DEACTIVATE
155	P1225X	#7 OBSERVER CUTOFF	DEACTIVATE
156	P1226X	#8 OBSERVER CUTOFF	DEACTIVATE
157	P1227X	#9 OBSERVER CUTOFF	DEACTIVATE
158	P1228X	#10 OBSERVER CUTOFF	DEACTIVATE
159	P1229X	#11 OBSERVER CUTOFF	DEACTIVATE
160	P1230X	#12 OBSERVER CUTOFF	DEACTIVATE
147	P1231X	OBSERVER CUTOFF N TANK	DEACTIVATE
148	P1232X	OBSERVER CUTOFF S TANK	DEACTIVATE
78	P1335X	SGG VALVE CLSD MSW	ACTIVATE
10	P1379X	APS ARM	DEACTIVATE
13	P1381X	APS RUN	DEACTIVATE
14	P1382X	APS IGNITION	DEACTIVATE
15	P1383X	APS COMPOSIT VLV SOL	DEACTIVATE
16	P1386X	APS READY TO COMMIT	DEACTIVATE
17	P1388X	APS COMMIT	DEACTIVATE
18	P1390X	APS SPEED SHUTDOWN	DEACTIVATE
70	P1429X	TCC RELEASE SWITCH	DEACTIVATE
85	P1438X	ROUGH COMB COF S	DEACTIVATE
35	P1441X	B IGN STAGE TIMER-DO	DEACTIVATE
2	P1446X	B FUEL PRE VLV CLSD	DEACTIVATE
79	P1499X	SGG VLV OPEN MSW	DEACTIVATE
82	P1515X	VERN SRT DY COF	DEACTIVATE
40	P1519X	VERN SRT DY COF YMR	DEACTIVATE

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103	P1561X	o LO2 REF REG VENT	DEACTIVATE
12	P1575X	PRE START READY	DEACTIVATE
63	P1583X	S FUEL VLV LOKUP CTL	DEACTIVATE
64	P1584X	S FUEL TK PRESS SOL	DEACTIVATE
65	P1585X	S LUBE TNK PRESS SW	DEACTIVATE
77	P1587X	S GG VLV OPEN CTL	DEACTIVATE
104	P1591X	S HYD PRESS SW	ACTIVATE
105	P1592X	BOOSTER ENG CUTOFF	DEACTIVATE
106	P1593X	SUSTAINER ENG CUTOFF	DEACTIVATE
109	P1594X	TCC SUSTAINER COF SW	DEACTIVATE
116	P1595X	SGG VLV CLOSING SOL	DEACTIVATE
118	P1596X	HOLD DN PRE-LEASE	DEACTIVATE
99	P1597X	S LUBE TK PRESS COF	DEACTIVATE
126	S1235X	PROGRAMER RUN TIME	DEACTIVATE
127	S1236X	BOOSTER COF DISCRETE	DEACTIVATE
129	S1238X	JETTISON BOOSTER SIG	DEACTIVATE
130	S1239X	PRES VERN TKS DISC	DEACTIVATE
132	S1241X	SUSVAINER COF DISC	DEACTIVATE
134	S1243X	PRE-ARM DISCRETE	DEACTIVATE
135	S1244X	PRE-ARM PRGR OTP	DEACTIVATE
136	S1245X	VERNIER COF DISCRETE	DEACTIVATE
138	S1247X	RLS IN-FLIGHT DISCON	DEACTIVATE
139	S1248X	RELEASE NOSE CONE	DEACTIVATE
140	S1249X	FIRE RETRO-ROCKET	DEACTIVATE
122	ST215X	VIB PRINTER TIME	OPERATED EACH 1.5 SEC

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APPENDIX E
PHOTOGRAPHS OF DAMAGE
RUN S2-212-B4-01

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IMPRINT OF SUST.
TURBINE EXHAUST DUCT.



PHOTO No. 1
SUSTAINER THRUST CHAMBER

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SUST 1st STAGE
TURBINE WHEEL



PHOTO No. 2
VIEW BETWEEN BI& SUSTR. THRUST CHAMBERS

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BSTR LUBE-OIL TANK

BSTR TURBINE
EXHAUST DUCT
MANIFOLD



PHOTO No. 3
THRUST SECTION GUARDS III & IV

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PUNCTURE

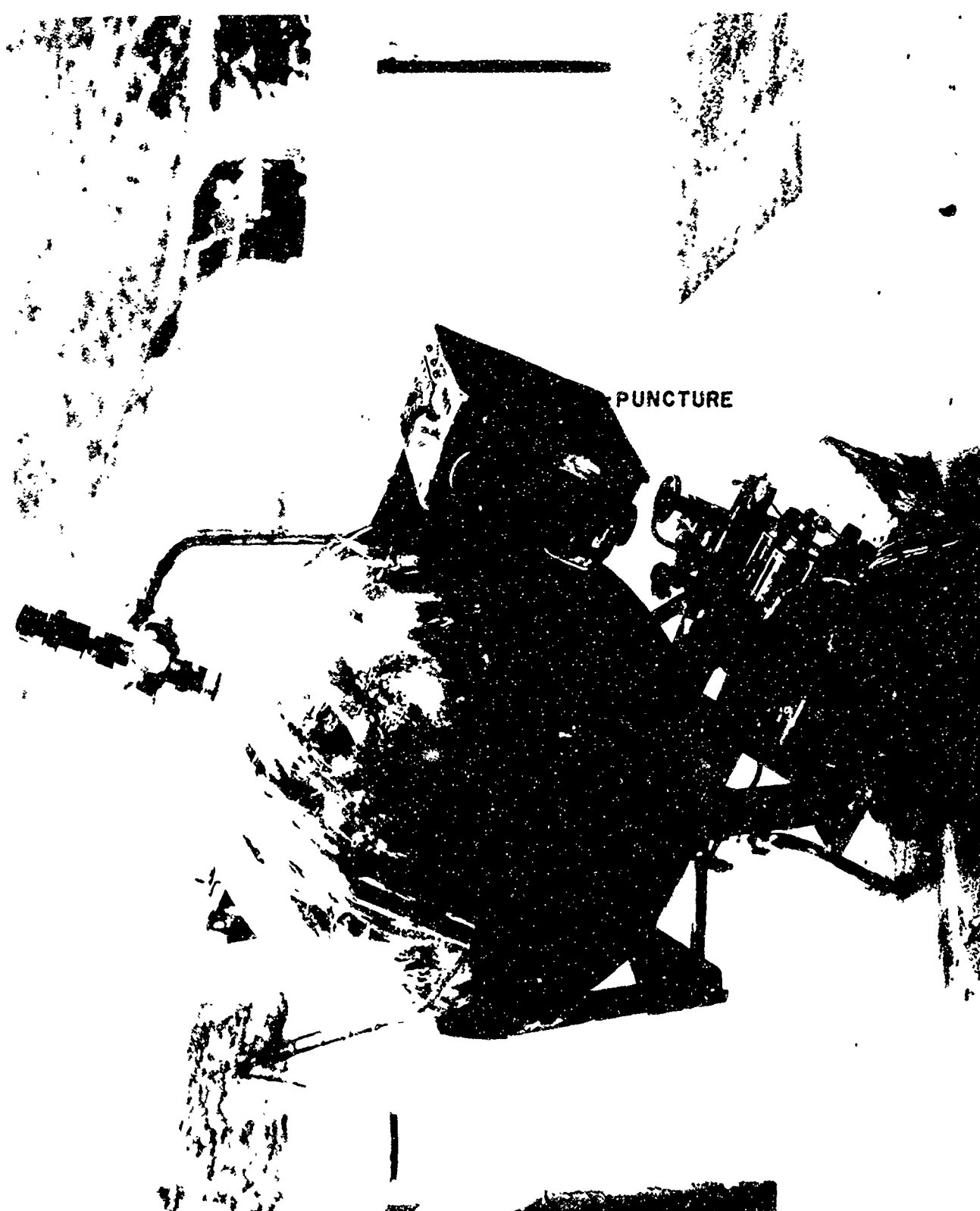


PHOTO No.4
BOOSTER LUBE OIL TANK

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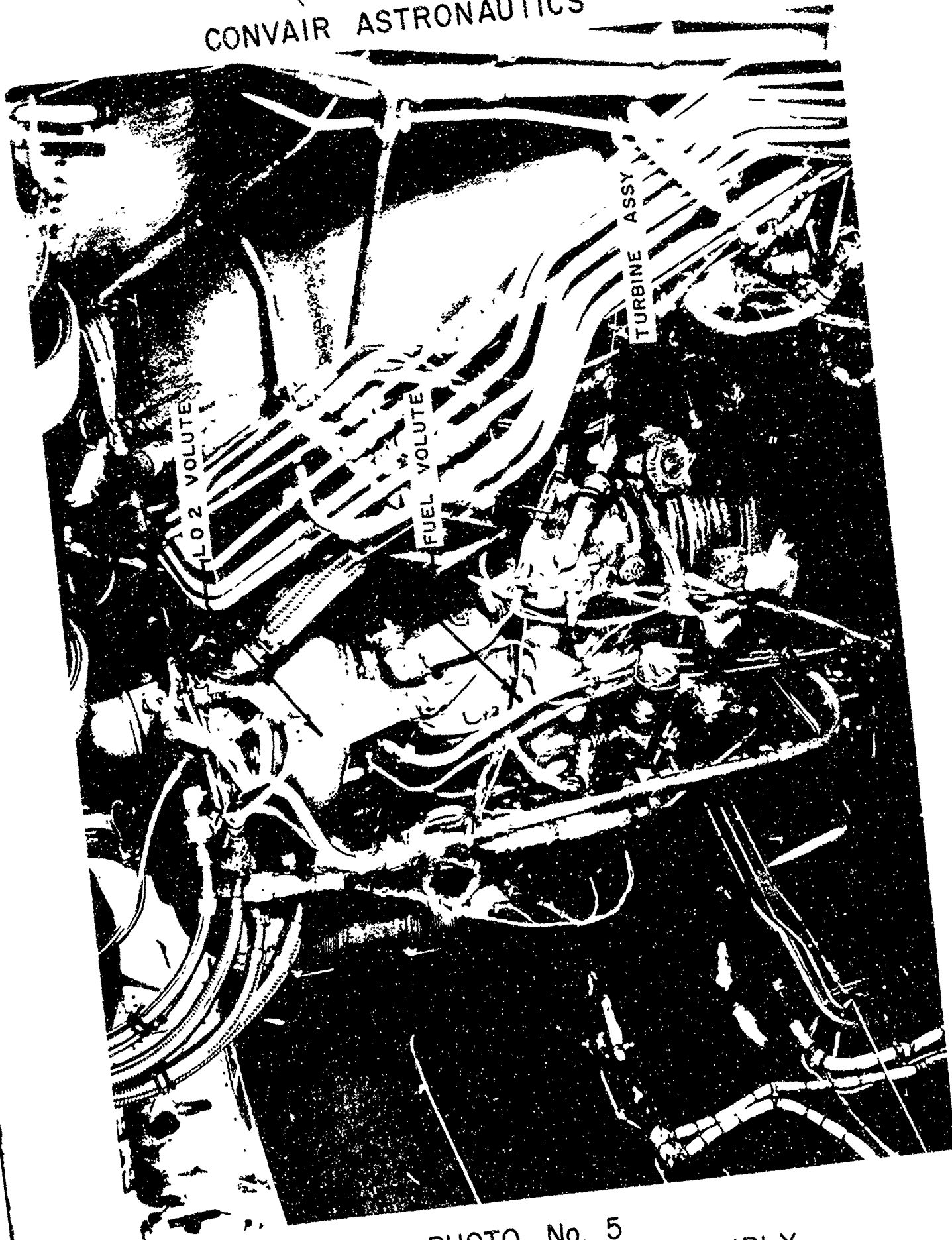


PHOTO No. 5
SUSTR. TURBO PUMP ASSEMBLY

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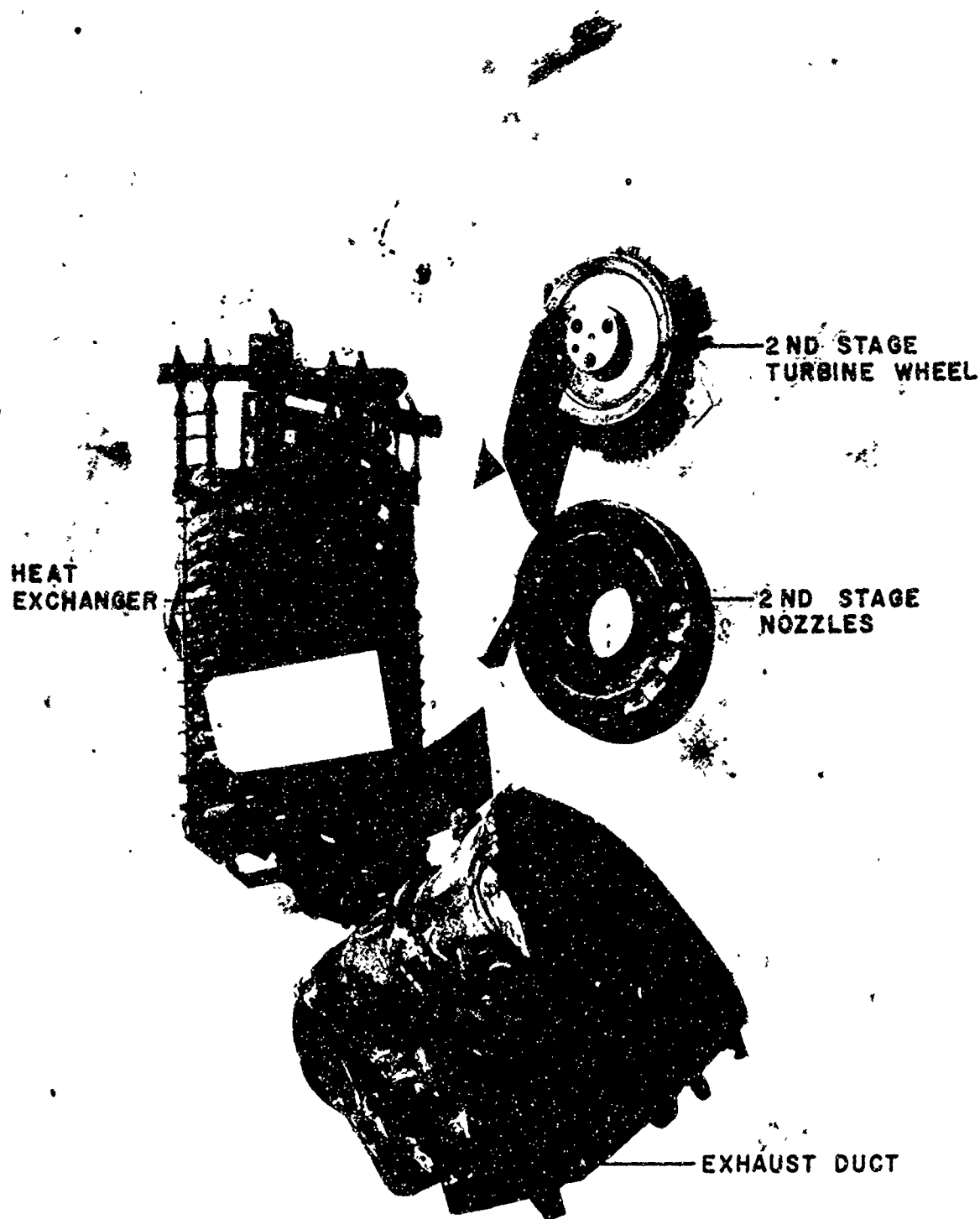


PHOTO No. 6
MAJOR SUSTAINER ENGINE PARTS
EJECTED BY THE EXPLOSION

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PHOTO No. 7
BOOSTER TURBINE EXHAUST &
SUSTAINER TURBINE EXHAUST MANIFOLD

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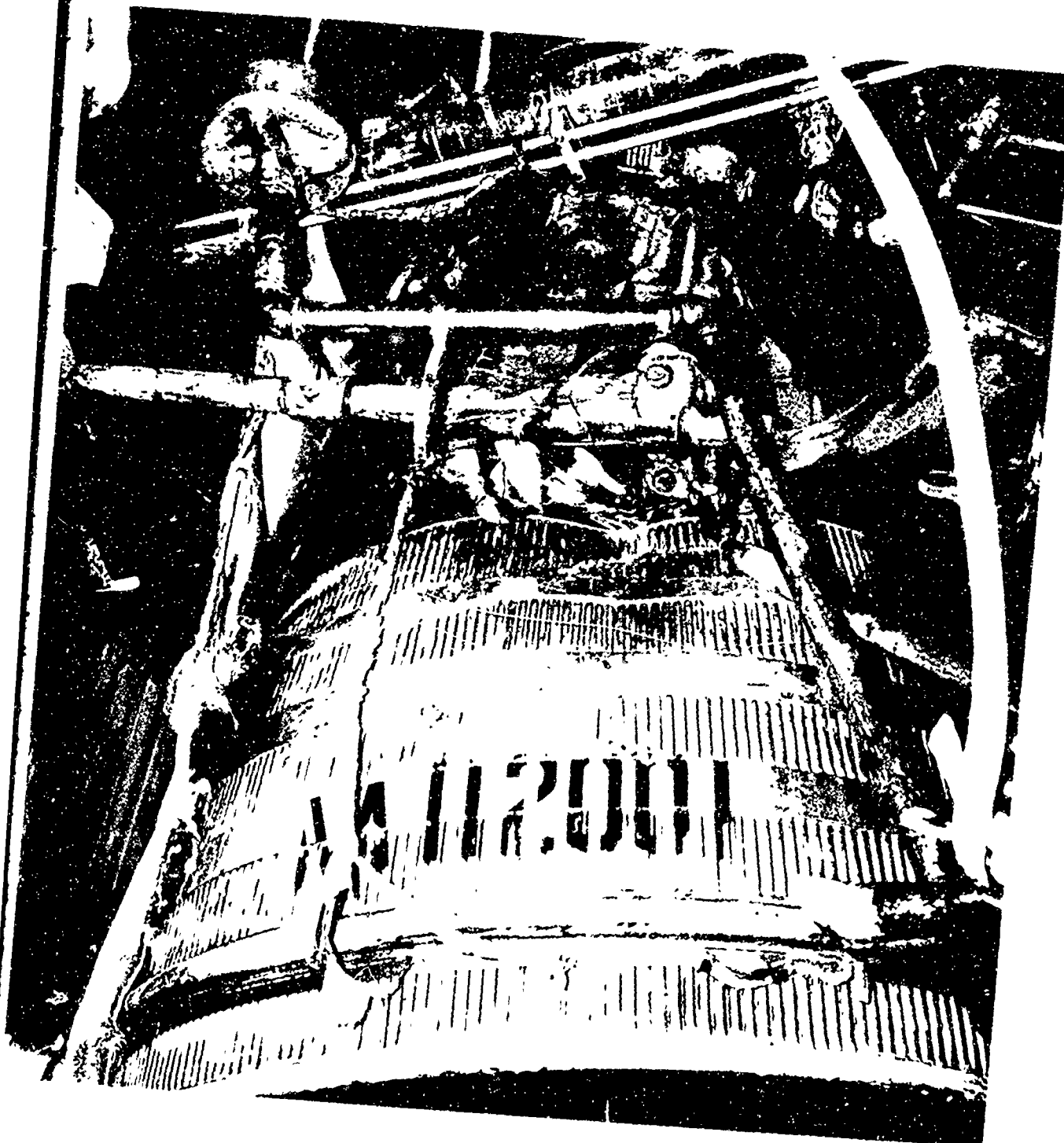


PHOTO No. 8
BI THRUST CHAMBER

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PHOTO No. 9
INTERIOR OF B1 CHAMBER

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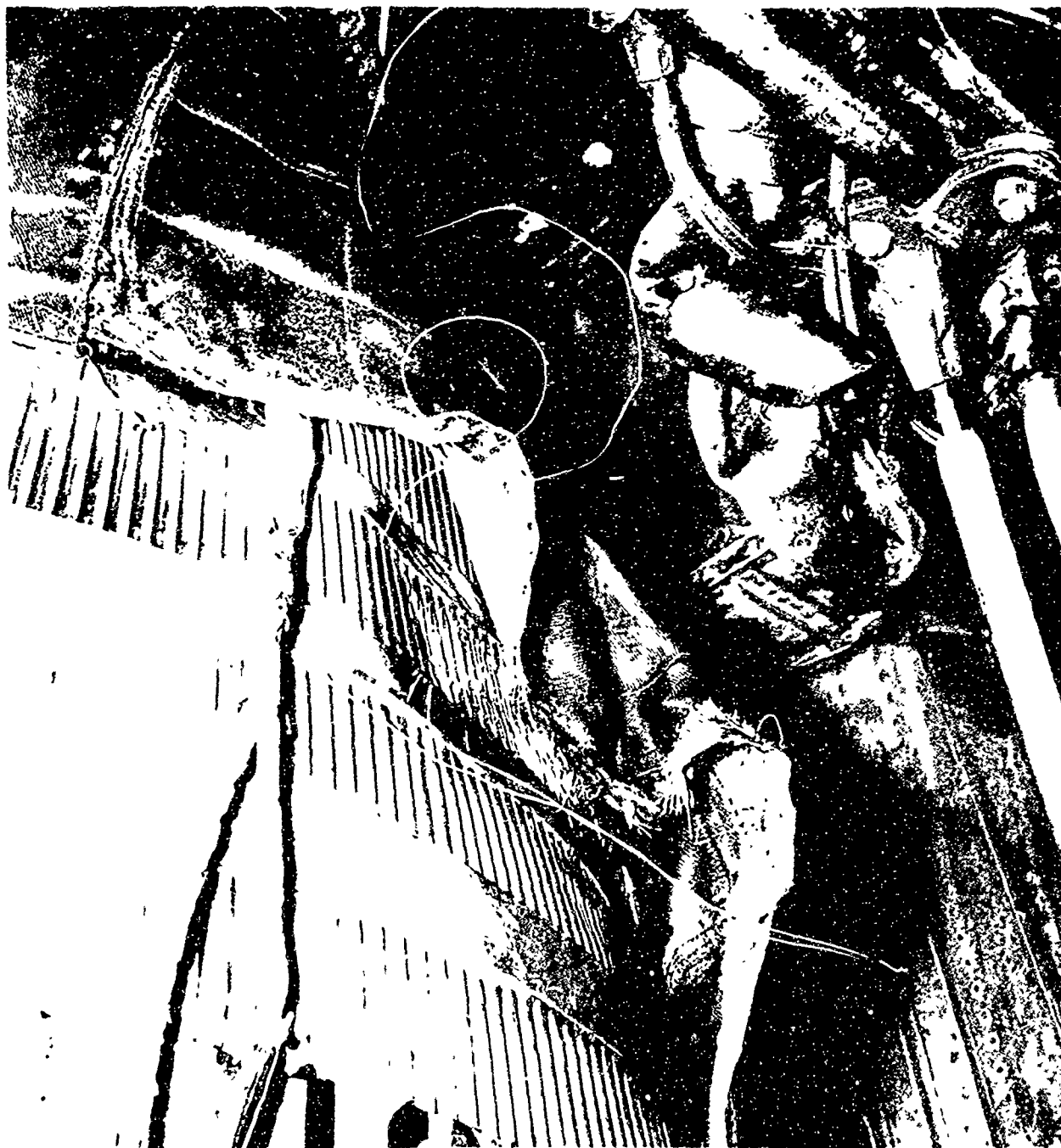


PHOTO No. 10
B2 THRUST CHAMBER

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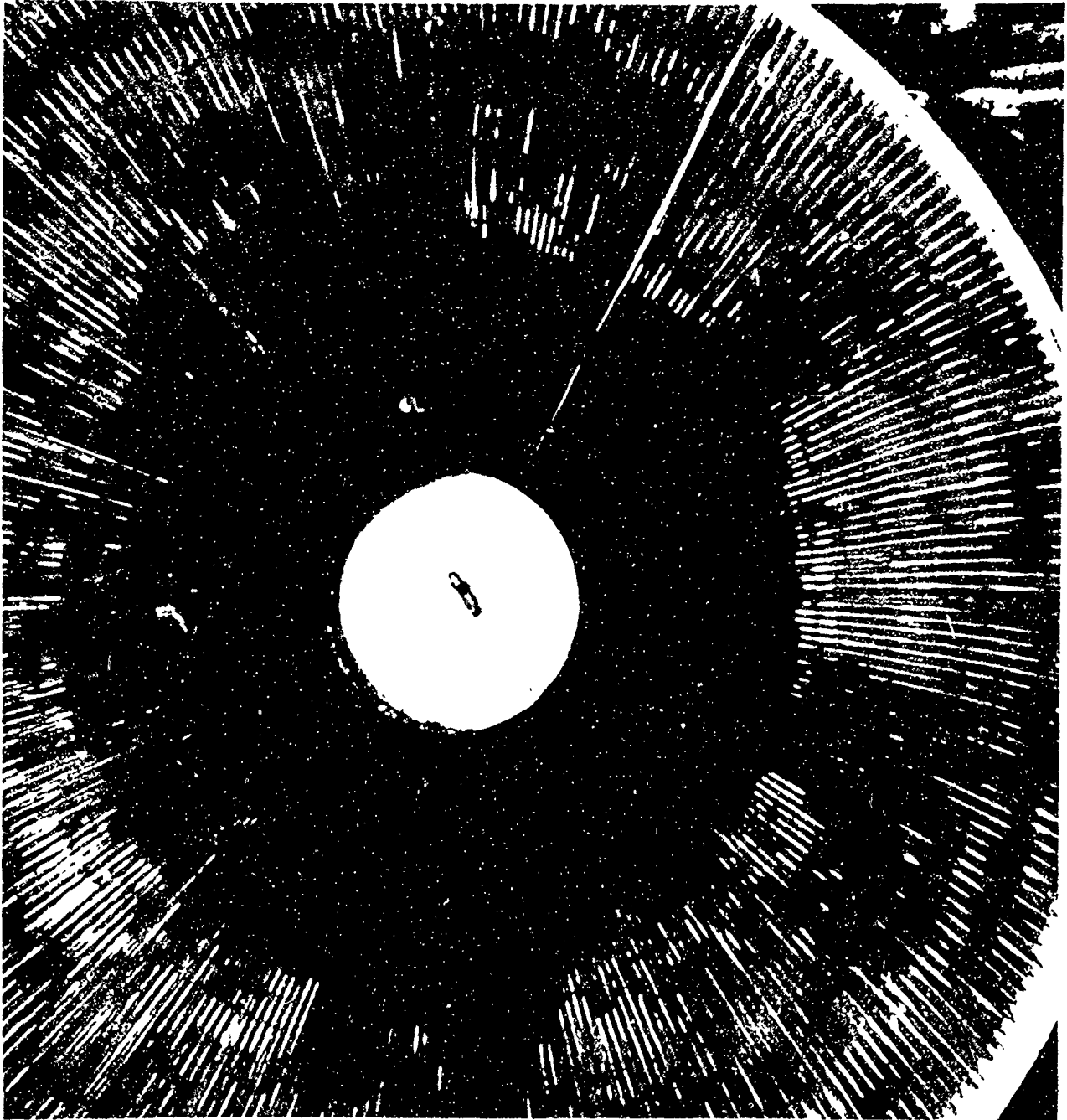


PHOTO No. 11
INTERIOR OF B2 CHAMBER

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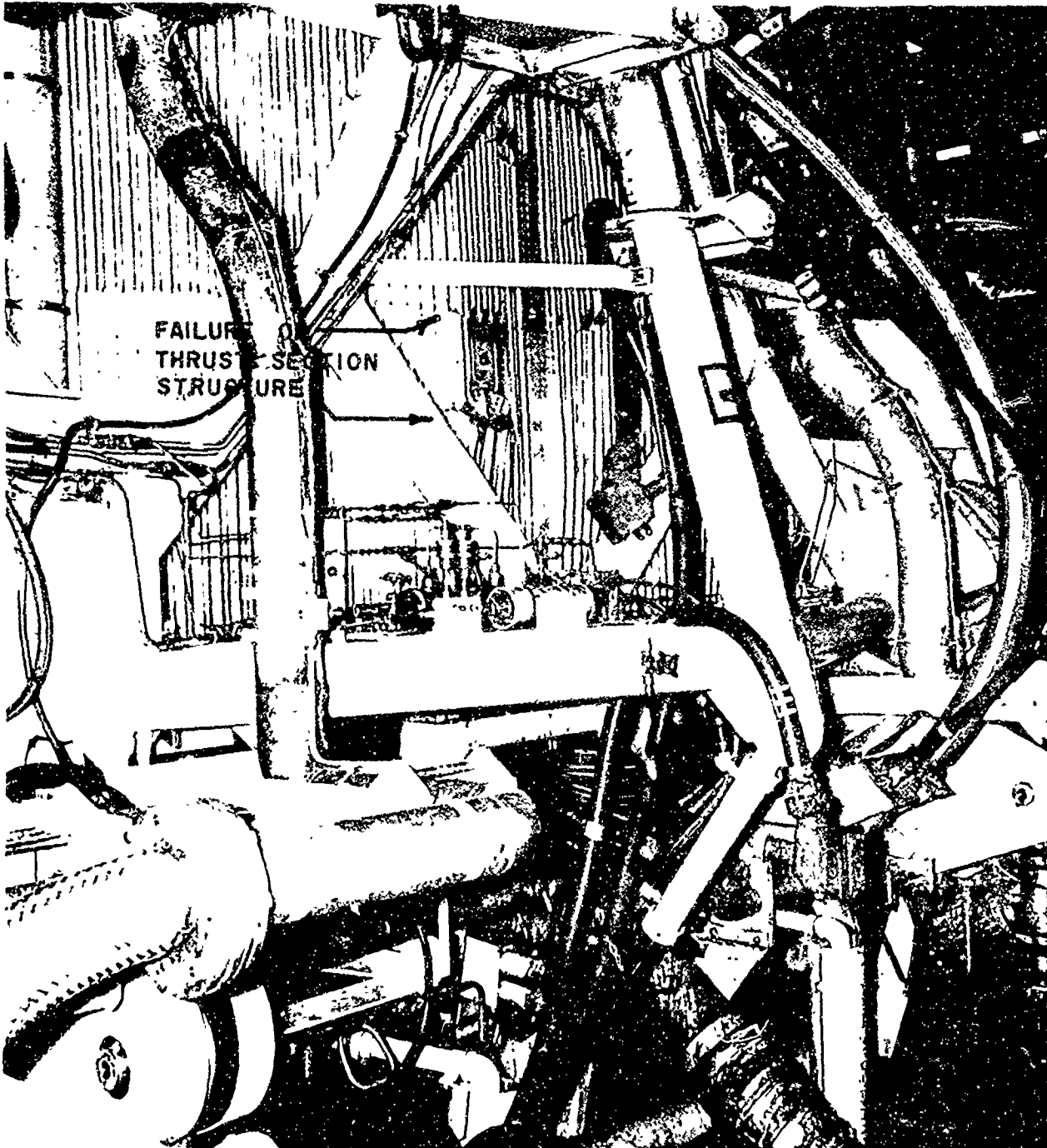


PHOTO No. 12
EXTERIOR SKIRT DAMAGE
QUAD IV AND EJECTED UMBILICALS

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PHOTO No. 13
PURGE RISE OFF PANEL

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PHOTO No. 14
FAIRING DAMAGE INTERIOR OF QUAD I

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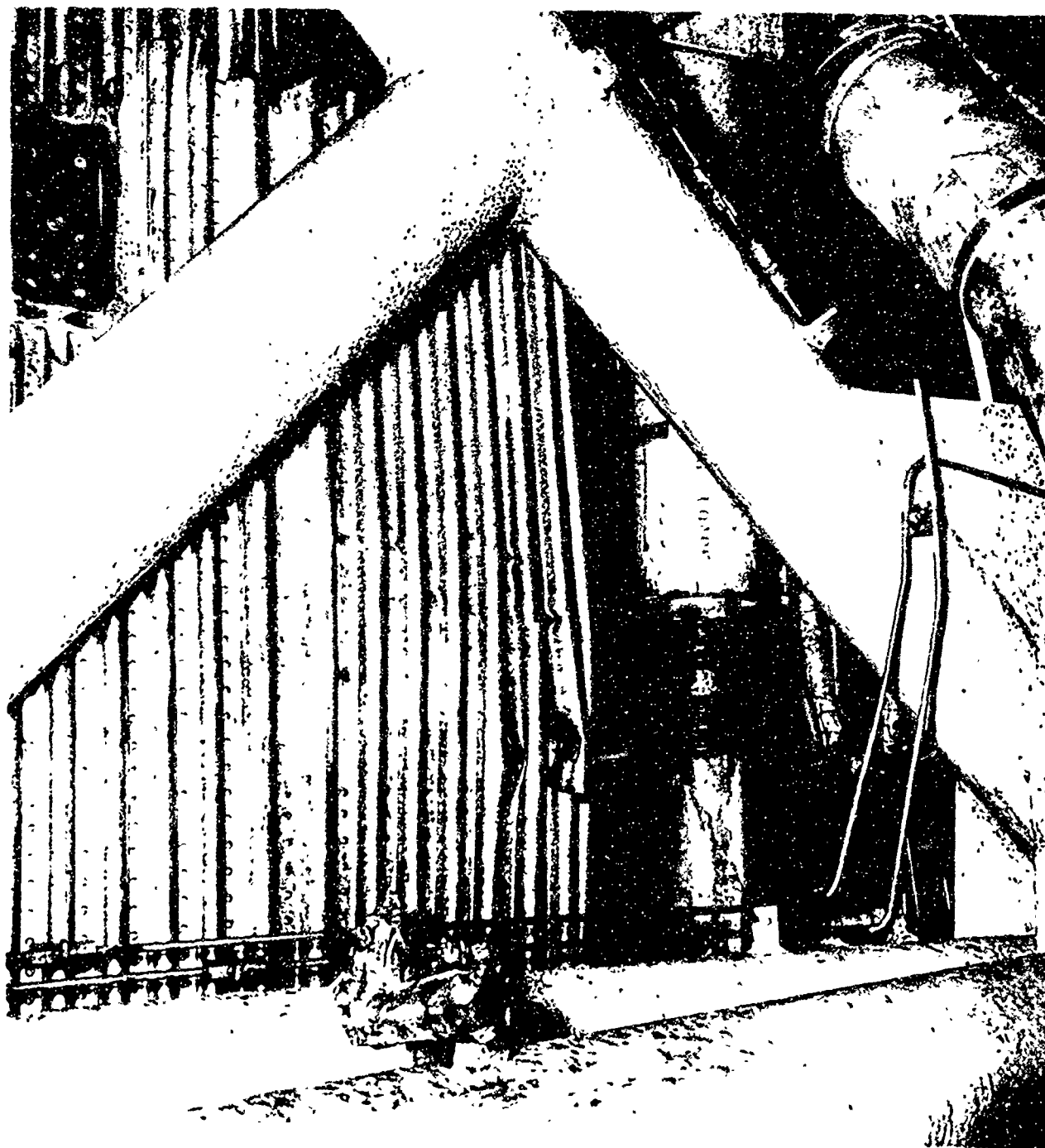


PHOTO No.15
FAIRING DAMAGE QUAD IV

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PHOTO No. 16
FAIRING DAMAGE QUAD IV

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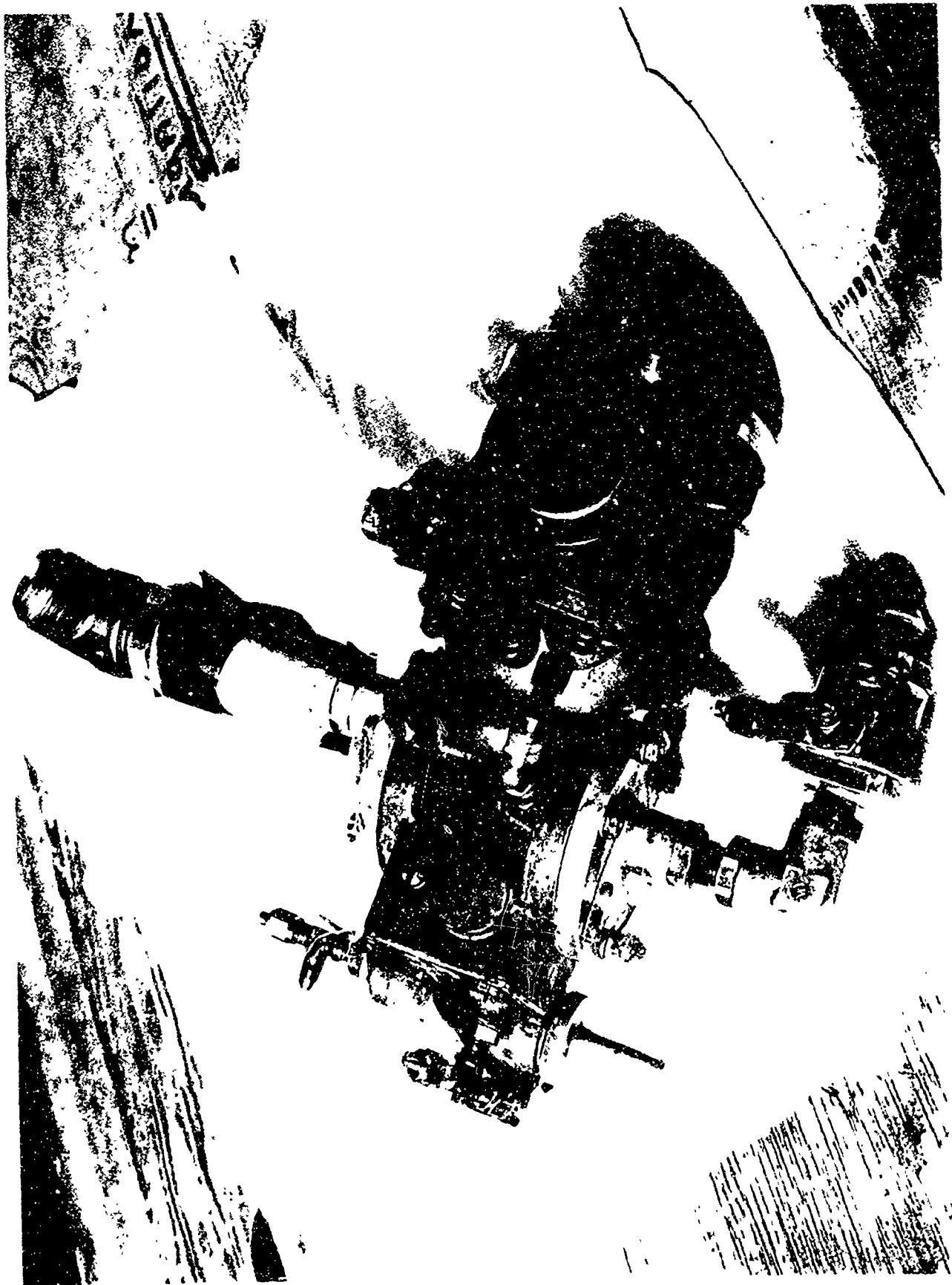


PHOTO No. 17
SUSTAINER GAS GENERATOR
AS REMOVED FROM MISSILE

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CONVAIR ASTRONAUTICS

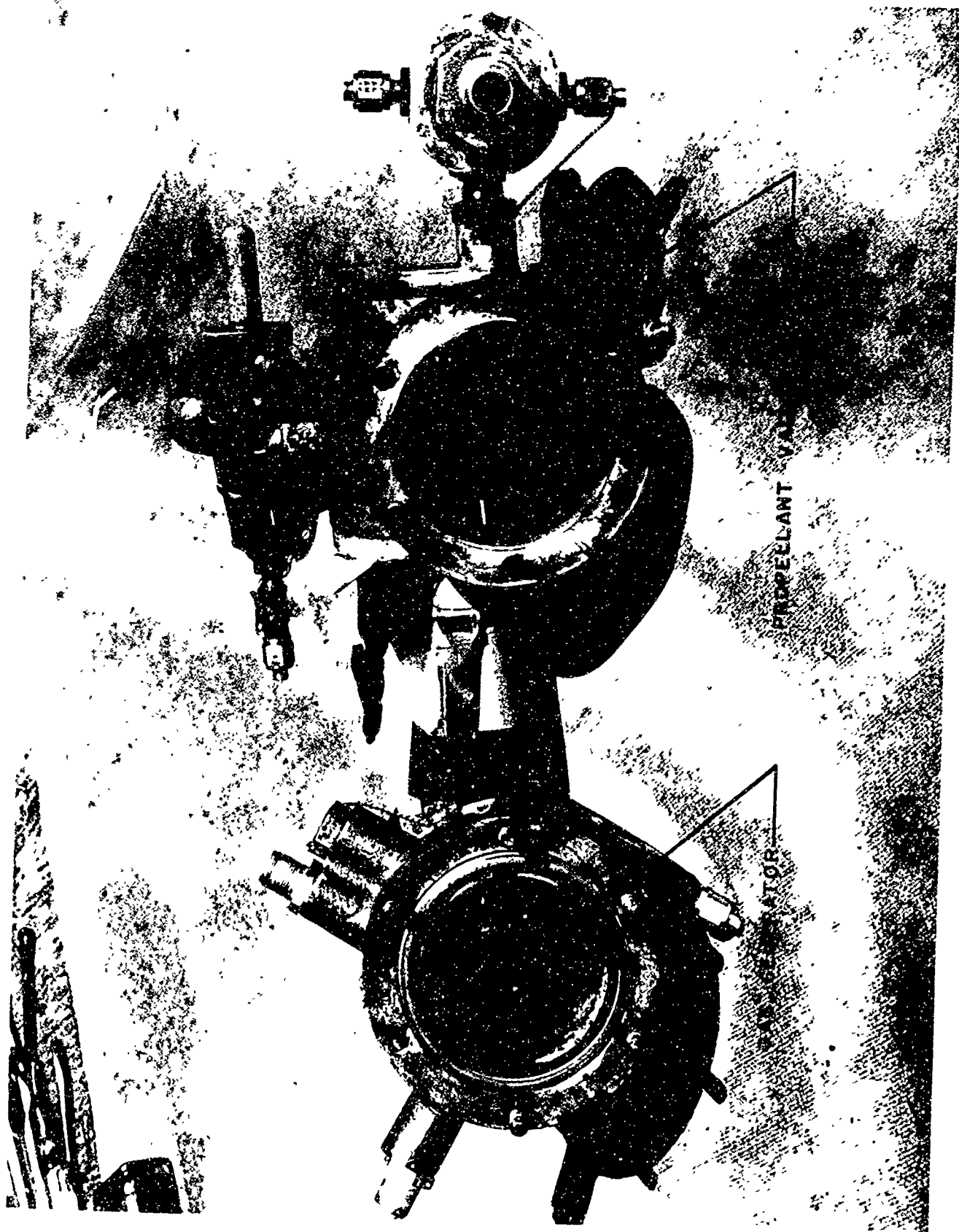


PHOTO No. 18
SUSTAINER PROPELLANT VALVE
ASSEMBLY REMOVED FROM GAS GENERATOR
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CONVAIR ASTRONAUTICS

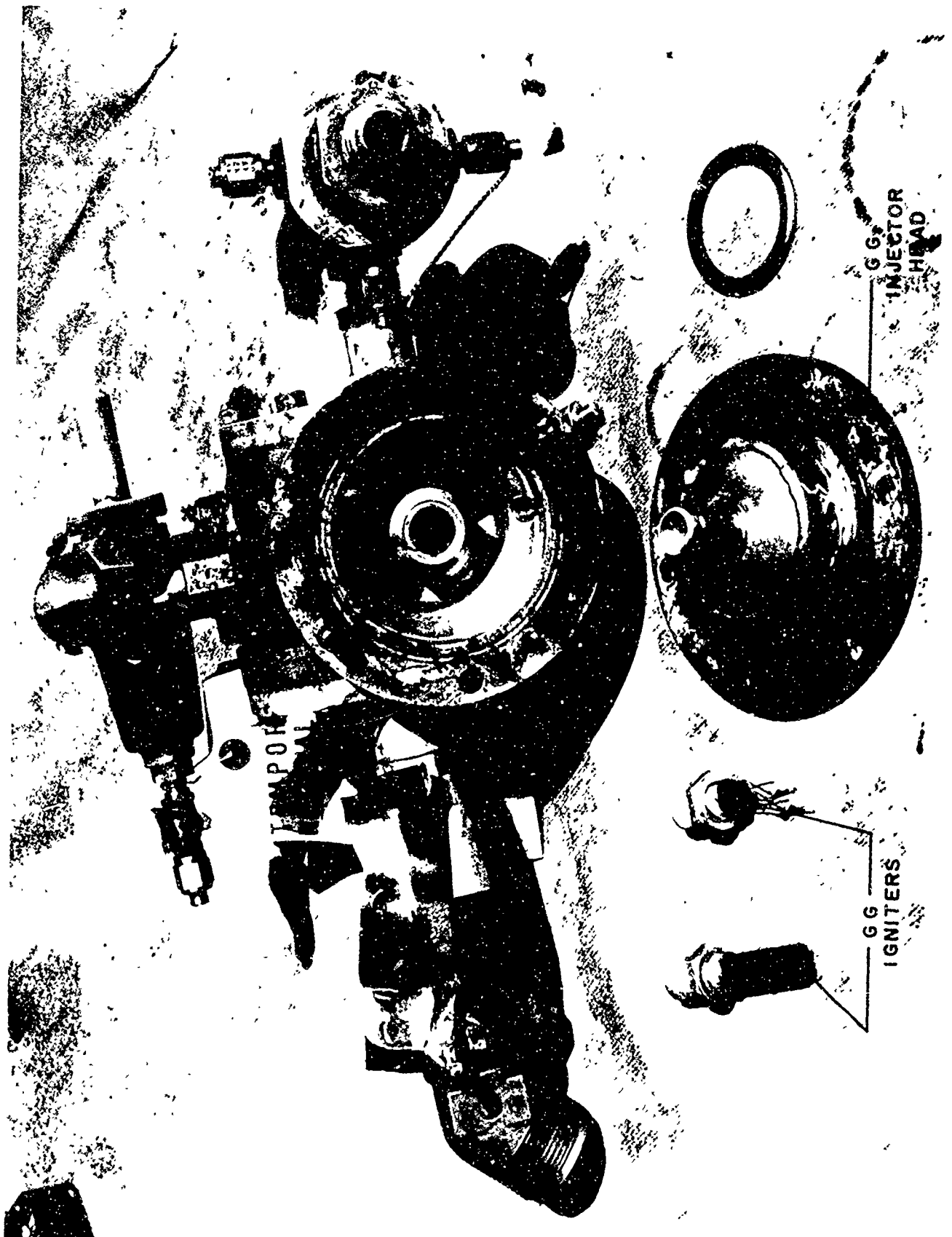


PHOTO No.19
PROPELLANT VALVE ASSEMBLY
WITH INJECTOR HEAD REMOVED

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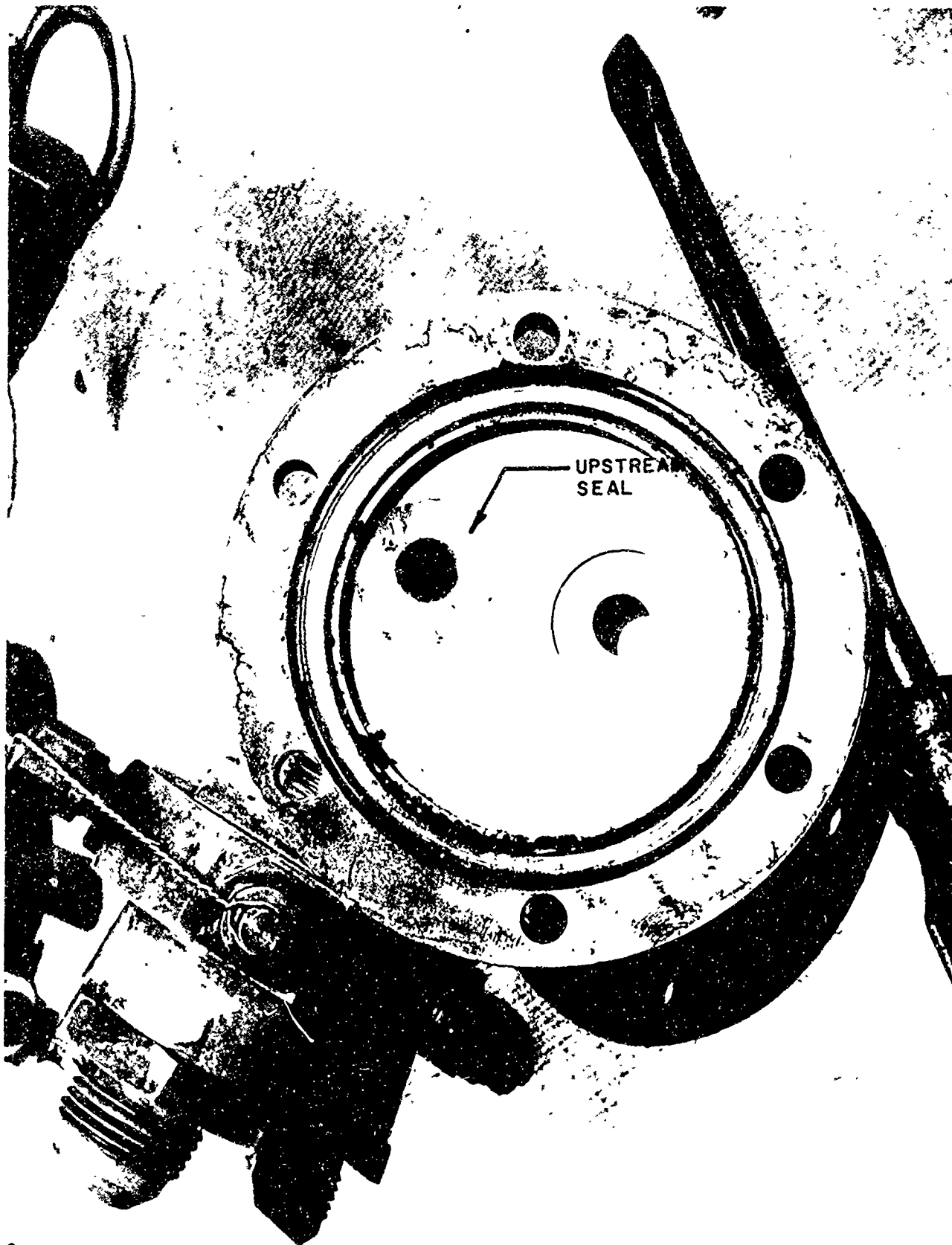


PHOTO No. 20
LO₂ BLADE VALVE COVER PLATE
SHOWING CRACKED UPSTREAM SEAL

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CONVAIR ASTRONAUTICS

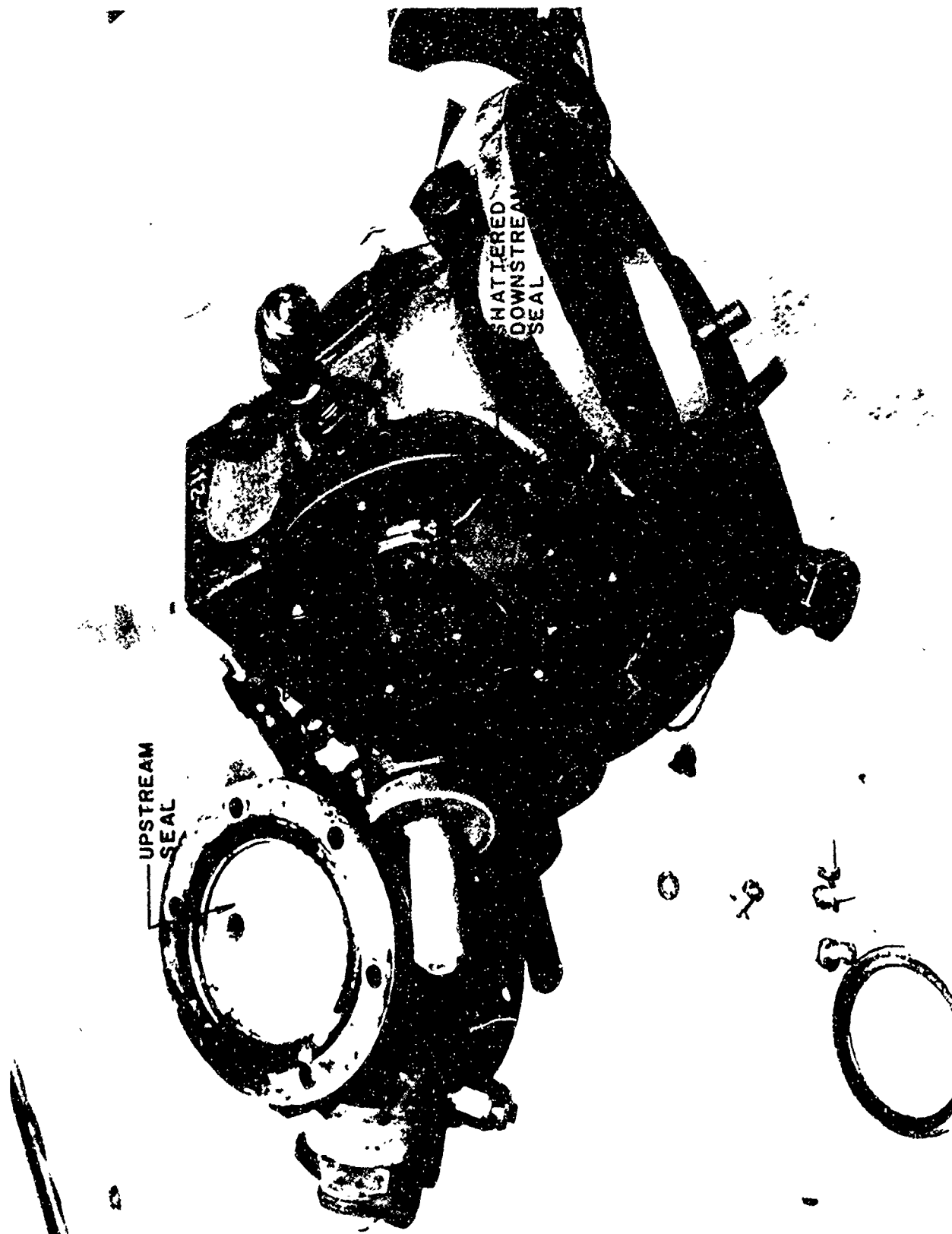


PHOTO No. 21
LO₂ BLADE VALVE SHOWING
SHATTERED DOWNSTREAM SEAL AND
POSITION OF VALVE WHEN DISASSEMBLED
VIEW I

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CONVAIR ASTRONAUTICS

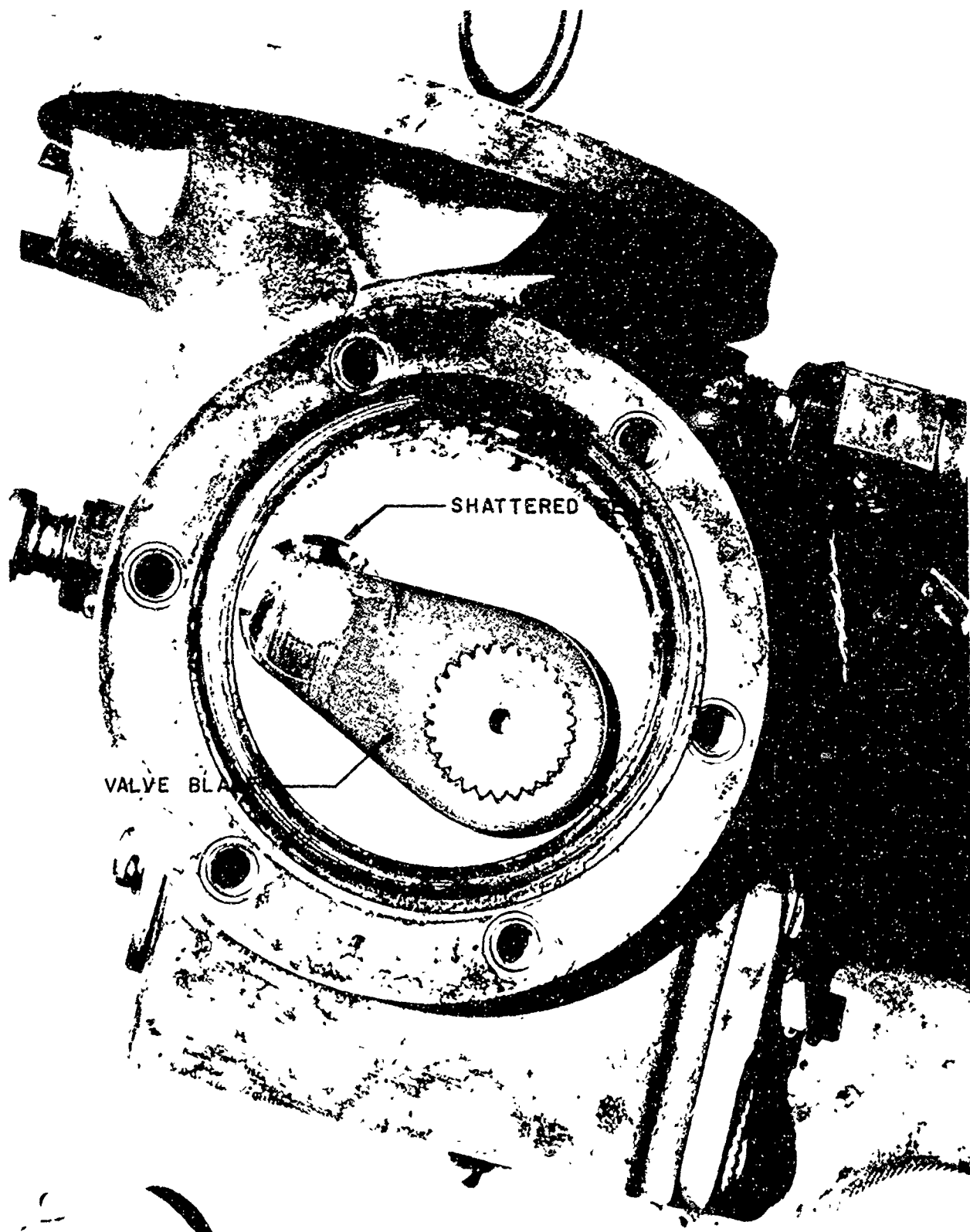


PHOTO No. 22
LO₂ BLADE VALVE SHOWING
SHATTERED DOWNSTREAM SEAL AND
POSITION OF VALVE WHEN DISASSEMBLED
VIEW 2

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CONVAIR ASTRONAUTICS

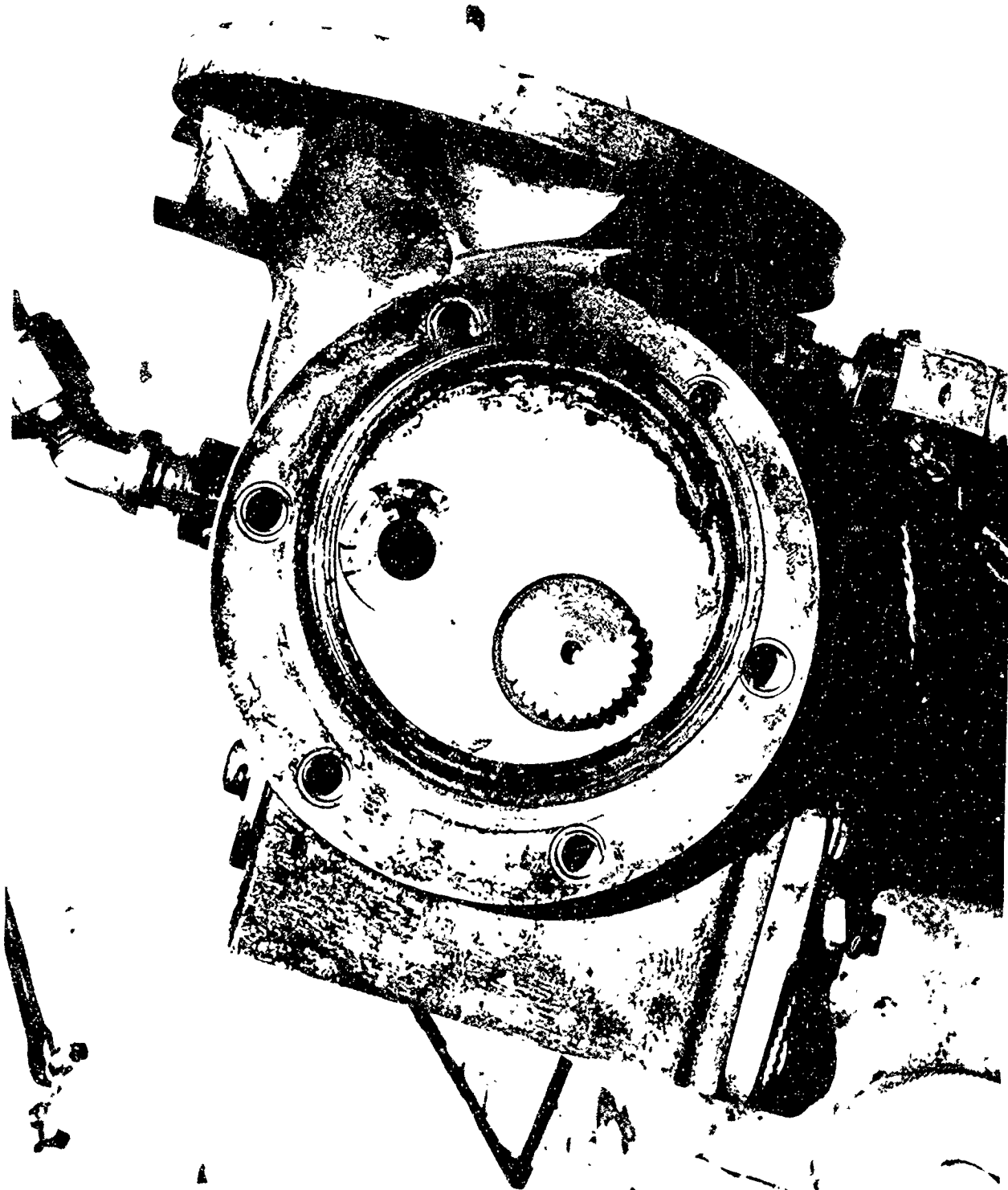


PHOTO No. 23
LO₂ BLADE VALVE DOWNSTREAM
SEAL WITH BLADE REMOVED

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PHOTO No. 24
LO₂ BLADE VALVE
DOWNSTREAM SEAL

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PHOTO No. 25
LO₂ BLADE VALVE
UPSTREAM SEAL

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CONVAIR ASTRONAUTICS

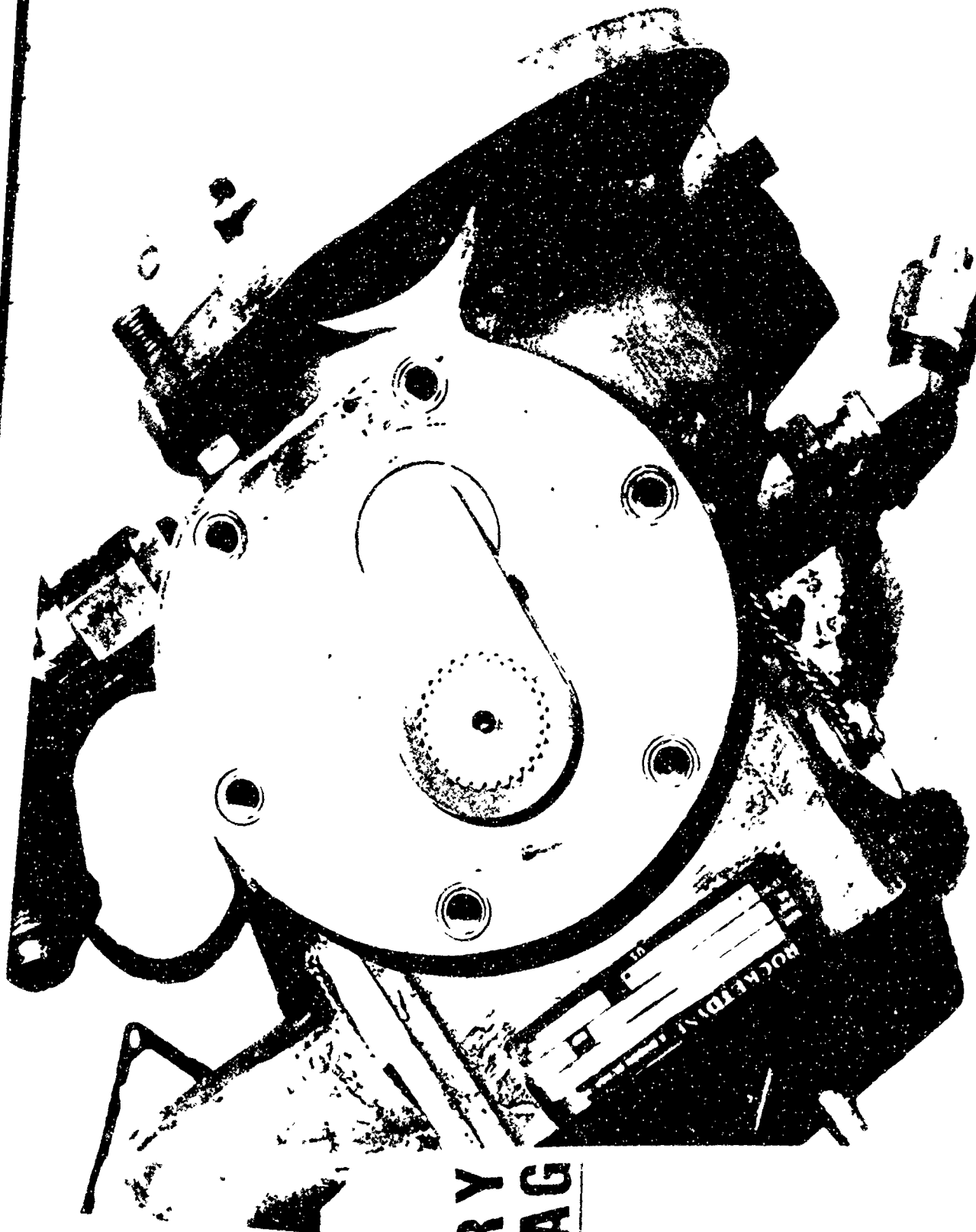


PHOTO No. 26
FUEL BLADE VALVE SHOWING
DOWNSTREAM SEAL INTACT

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NOTE. SPOT ON
VALVE BLADE IS
OIL & RESIDUE

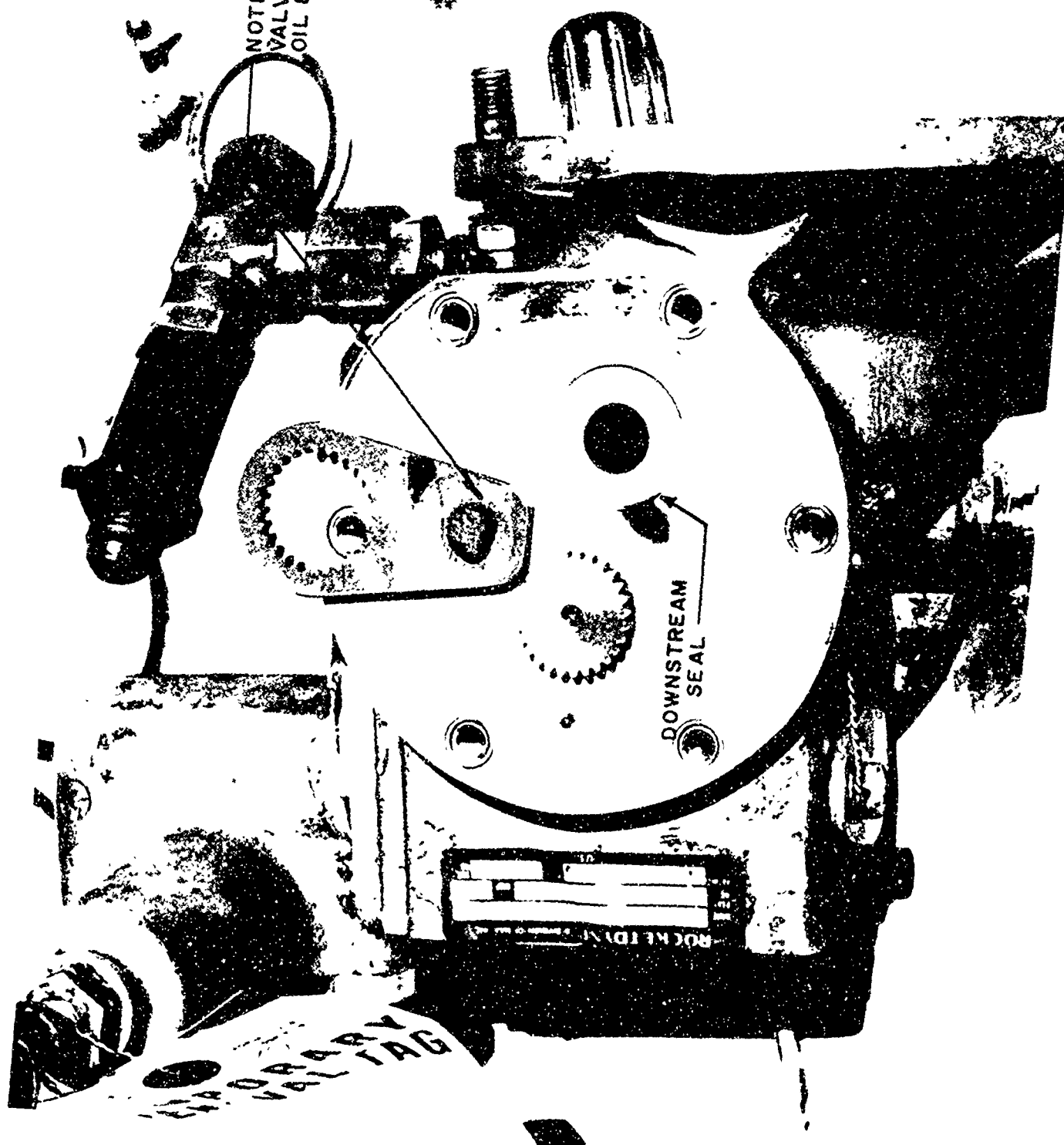


PHOTO No. 27
FUEL BLADE VALVE DOWNSTREAM SEAL
WITH BLADE REMOVED AND TURNED OVER

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CONVAIR ASTRONAUTICS

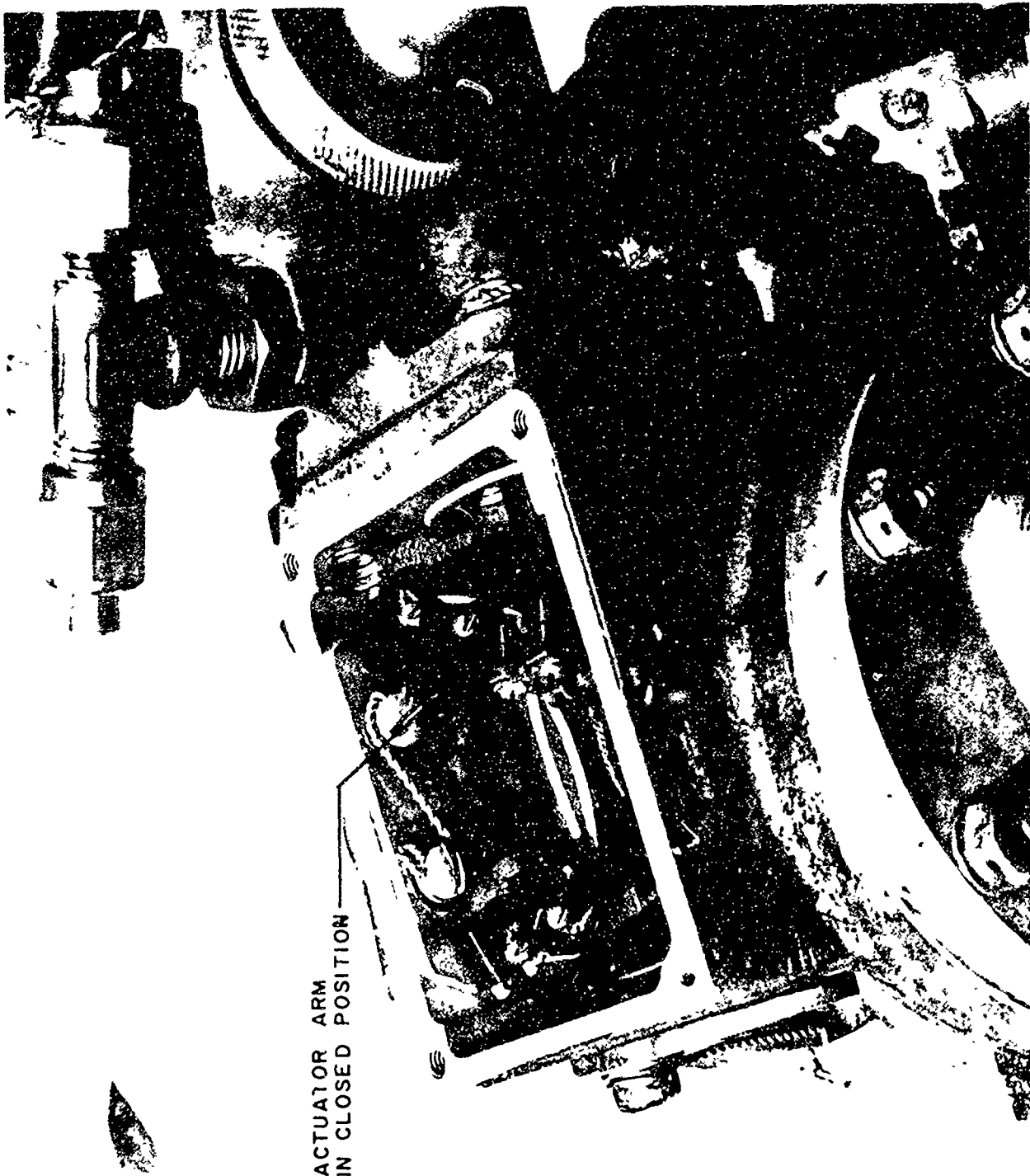


PHOTO No. 28
SUSTAINER GAS GENERATOR
PROPELLANT VALVE ASSEMBLY AS
DISASSEMBLED

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APPENDIX F

ROCKETDYNE INVESTIGATION REPORT

S2-212-B4-01

~~CONFIDENTIAL~~

~~CONFIDENTIAL~~ FINAL ACCIDENT REPORT
RUN S2-212-B4-01

LEM 844-1014

30 June 1958

TO: M. A. McClure, 596-42, Canoga

FROM: H. L. Conrad, 596-44, Canoga

SUBJECT: Accident Report Missile 1B (Engine S/N NA112001) at Sycamore Canyon Test Facility

At 16:38 hours on 18 June 1958, an explosion occurred in the turbine of the Sustainer engine (S/N NA222007) installed in Missile 1B as part of engine assembly S/N NA112001. This explosion caused considerable damage to the lower boattail structure, Booster chambers, Booster power package assembly, and the Sustainer engine assembly. Apparent cause of the explosion was failure of the Sustainer gas generator blade valve LO₂ seal at cutoff on the previous run.

The test in which the explosion occurred was the twelfth scheduled test on this missile and the fourth attempt to complete the first run of the Block II series of tests. The run was scheduled to be 100 seconds Booster, 194 seconds Sustainer, and 220.5 seconds of Vernier engine operation. Countdown and start appeared normal. Approximately 0.04 seconds after the gas generator igniters were signalled to fire, the explosion occurred. The ensuing fire was extinguished in approximately twelve (12) seconds by using water and CO₂.

Examination of Records

Examination of all records on this run and the previous run revealed the following:

1. Normal conditions prior to start and during the previous run.
2. On the previous run, the Sustainer gas generator probe had been burned off. Indications were that this had been caused by a cutoff temperature spike. (The chart was pegged at 1800°F). Momentary temperature spikes had occurred at cutoff on all previous runs. No pressure surge could be detected because the LO₂ injection manifold pressure and gas generator chamber pressure charts were inoperative. The gas generator system was examined externally for signs of high temperature prior to Run 12 and the results were negative.

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ITEM 11-1011

30 June 1950
Page 2

Examination of Records (Continued)

3. About 4 seconds after cutoff on the previous run (approximately five feet of oscillograph paper), the LO₂ flowmeter indicated intermittent flow until the recorder was turned off.
4. The oscillograph trace indicated LO₂ flow to the Sustainer gas generator on this run prior to start.
5. The Sustainer gas generator discharge temperature chart was pegged down scale prior to start of this run.

Examination of Hardware

Examination of the Sustainer gas generator after the explosion revealed a detonation or severe pressure surge had occurred in the LOX injector manifold. Further, the LO₂ seal was found to be shattered and the outline of the valve blade was impressed on the back-up plate for the seal.

Probable Cause

The probable cause and events leading up to the explosion is believed to be as follows:

1. The Sustainer gas generator LO₂ blade valve seal was shattered presumably at cutoff on the previous run by a sharp pressure surge or detonation in the LO₂ injector manifold of the gas generator as indicated by the following:
 - a) The gas generator injector was moved downward and the manifold was bowed upward.
 - b) The gas generator blade valve was in the closed position.
 - c) Temperature spike and possible pressure surge at cutoff on the previous run (no pressure information recorded to verify pressure surge).
 - d) LO₂ leakage indicated at cutoff of previous run and prior to start of this run.

The surge or detonation was probably caused by a malfunction of the gas generator LO₂ injector manifold at the cutoff point. This situation could have been caused by the fact that the missile was in the process of being fired at the time the injector manifold was cut-off and initiated.

2. The failed seal was shattered by the pressure surge at cutoff and caused a LO₂ leak into the gas generator manifold. The LO₂ leak caused the gas generator to detonate and fire.

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FINAL ACCIDENT REPORT
RUN S2-212-B4-01

LEM 844-1014
30 June 1958
Page 3

Action Taken

The following action has been taken to minimize the possibility of this type of accident happening in the future:

1. A Field Service Bulletin has been written to re-emphasize ROCKETDYNE's recommended purge pressures and sequencing.
2. Recommend that cutoff temperature spikes on future tests be carefully evaluated to insure that no contamination of the gas generator LO₂ injector manifold has occurred.
3. Gas generator flowmeter and discharge temperature records be checked before and after each run for signs of LO₂ leakage.
4. The gas generator exhaust systems should be checked after LO₂ tanking for signs of LO₂ vapors.

A complete and detailed accident report is being prepared as a joint effort of Convair, Air Force, Ramo-Wooldridge and ROCKETDYNE representatives at Sycamore Canyon test site.

S/ _____
H. L. Conrad,
Flight Support Unit
ATLAS Engines

APPROVED:

S/ _____
H. Diem, Supervisor
Flight Support Unit
ATLAS Engines

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ROCKETDYNE
A DIVISION OF NORTH AMERICAN AVIATION, INC.

FAILURE ANALYSIS REPORT

1. Report No. 177666	2. Date of Analysis 23 July 1958	3 Test No.	4A. Facility Rocketdyne	4B Location A8
5. Failed Item P/N 9512-44185-51	6. Failed Item S/N P-086	7. Failed Item Name Sus G.G. Assy	8. F/I Type or Model	

9. HISTORY OF TROUBLE (NOTED FROM ITEM 26.1 ON F.C.D.R): On 18 June 1958, captive firing test No. 11 (TE-11) was performed at the Sycamore Canyon installation. After 2.34 seconds of mainstage start, the Gas Generator squibbs fired, followed by an explosion in the Turbine and Turbine Exhaust system. This explosion resulted in almost complete destruction of the sustainer engine. Extensive damage was also inflicted on the booster engine. In reviewing the test records on the sustainer engine, it was disclosed that a steady oxidizer flow was evident in the Gas Generator for 80 seconds prior to firing the Vernier squibbs. Flow rates recorded were .3 lbs/sec under tank head pressure and .51 lbs/sec at pressurization. Thermo-couple readings at the hot gas duct had dropped 30° below ambient temperature.

10. ANALYSIS PROCEDURE AND RESULTS: Disassembly of the Gas Generator disclosed the G.G. blade valve to be in the correct closed position and the following damaged detail parts were noted:

1. Shattered Oxidizer port seal.
2. Radially cracked pressure pad.
3. Oxidizer inlet cover plate with gate impression at the edge of the pad cavity.
4. Dull (not abrasive) surface bearing the outline of the port seal bore on the Lox blade.
5. Partially burned silicone "O" ring.
6. Bits of grey ash and hard matter within the oxidizer cover cavity.
7. I.D. of the fuel seal locally burned in one area.

Further examination revealed that the injector plate yielded convexly on the normally flat surfaces. The injector face had bulged .063 inches at its maximum point. The flange surface took a permanent deflection of .020 inches. Spectro-analysis proved the grey ash and hard matter to be part of the burned silicone "O" ring. The oxidizer port seal was inspected under a magnifying instrument and no obvious wear or marks were evident.

11. CONCLUSIONS AS TO CAUSE OF FAILURE:

It is an established fact that the oxidizer seal in the G.G. blade valve was leaking prior to the major explosion of the engine. Conclusions that the seal was shattered by a detonation can only be derived from what evidence is presented in test records and past experience of similarly shattered oxidizer port seals. Test run prior to X day had shown intermittent G.G. oxidizer flow and a prolonged temperature spike after G.G. cutoff. Records, therefore, imply that the oxidizer port seal had failed in the previous firing after cutoff.

12. RECOMMENDATIONS FOR PREVENTING RECURRENCE AND ACTION TAKEN: R & D experience have had only 3 instances where oxidizer seals were shattered or cracked as a result of detonations internal to the G.G. Assy. or adjacent downstream hardware. Normal runs on this type G.G. have shown temperature spikes after cutoff (not to be common) except where purging is inadequate. Due to oxidizer seal leakage frequently being very low and seal cracking rare, no design change is contemplated in this area of the valve assembly. Malfunction studies will be extended should this frequency increase. A new purge procedure is under consideration.

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B.G. SCOTT J. HOGSTAD

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