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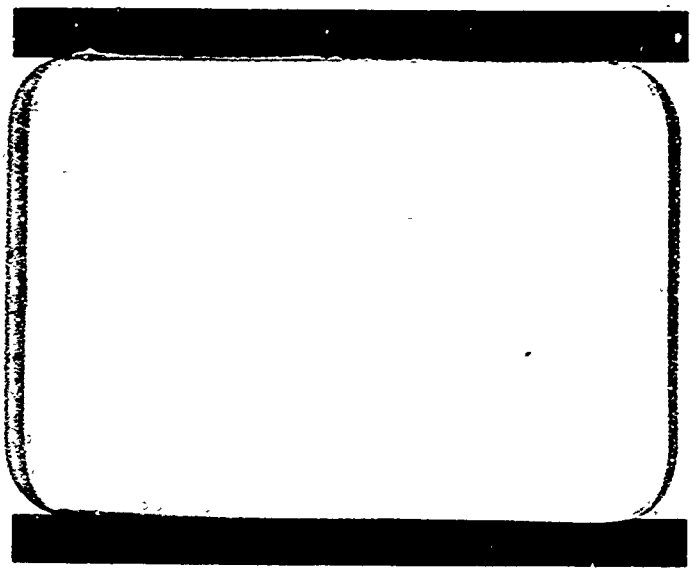

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MISSILE 1F

INVESTIGATION REPORT

Run S1-613-14-01

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FORWARD

This report presents the findings of the Accident Investigation Board investigating the explosion of Missile 1F during static firing S1-613-14-01 at Sycamore Canyon Test Site S1. This report includes all pertinent information available to date, and will be appended as additional information becomes available.

The Board and Committee personnel assignments are presented in Section 6.9 of this report.

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LIST OF ABBREVIATIONS

Adj.	-	Adjust
AMR	-	Atlantic Missile Range
A/P	-	Autopilot
Assy.	-	Assembly
B-1	-	Booster number 1
B-2	-	Booster number 2
BEA	-	Base Emergency Authorization
BOI	-	Break of Inspection
Bstr.	-	Booster
Cal.	-	Calibrate/Calibration
CEC	-	Consolidated Electronics Corporation
CIC	-	Change Identification and Control Number
Ckt.	-	Circuit
C/O	-	Checkout
cps	-	Cycles per second
Defl.	-	Deflector.
dgf	-	Degrees Fahrenheit
DP	-	Delta Pressure
DPC	-	Delta Pressure Cutoff
EA	-	Easterline Angus
ECP	-	Engineering Change Proposal
Eng.	-	Engine
EO	-	Engineering Order
FAT	-	Firing Acceptance Test
F/D	-	Fill and drain
Flt.	-	Flight
FM	-	Frequency modulation
GD/A	-	General Dynamics/Astronautics
GG	-	Gas Generator
GMA	-	Government Material Authorization
GN2	-	Gaseous nitrogen
HCU	-	Helium Charge Unit
H.S.	-	Head suppression
Hyd.	-	hydraulic
Instl/Inst	-	Installation/install
Inst/n	-	Instrumentation
IR	-	Inspectors Report
IRL	-	Instrumentation Requirements List
LN2	-	Liquid nitrogen
LSR	-	Logic Signal Responder
Mod.	-	Modification
mm	-	Millimeter
NAA	-	North American Aviation
Nac.	-	Nacelle
NAS	-	Naval Air Station
NRD	-	Non-routine Discrepancy
NV	-	Non-voting
OSH	-	Off Scale High

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LIST OF ABBREVIATIONS (Continued)

P.A.	-	Public address
PCU	-	Pneumatic control unit
Pneu.	-	Pneumatic
Prop.	-	Propulsion
PS	-	Pressure switch
psi	-	Pounds per square inch
psig	-	Pounds per inch gage
PU	-	Propellant utilization
Quad.	-	Quadrant
RCC	-	Rough Combustion Cutoff
R & D	-	Research and Development
Reg.	-	Regulator
RP-1	-	Rocket Propellant number 1
rpm	-	Revolutions per minute
R/V	-	Re-entry vehicle
SN	-	Serial number
SPGG	-	Solid propellant gas generator
Sply	-	Supply
Sust.	-	Sustainer
STL	-	Space Technology Laboratories
Syc.	-	Sycamore
Syst.	-	System
TGSE	-	Test Ground Support Equipment
TO	-	Technical order
TRIC	-	Trichlorethyene
TVA	-	Temporary Varience Authorization
V1	-	Vernier engine number 1
V2	-	Vernier engine number 2
Vern.	-	Vernier
Vlv.	-	Valve
VPM	-	Vendor Part Modification
VN	-	Vendor number
Xducer.	-	Transducer
Xfer.	-	Transfer
X-Y Axis	-	Axis through verniers
Y-Y Axis	-	Axis through boosters
Z-Z Axis	-	Longitudinal axis

1.0 INTRODUCTION

Run S1-613-14-01 of Atlas Missile 1F was conducted at 1347 hours, 13 May 1962, at Sycamore Test Stand S1. The run was prematurely terminated after 1.77 seconds of engine operation by the automatic cutoff circuit monitoring redline recorder P1325T, the Engine Compartment Ambient Temperature, when the indicated temperature exceeded the upper redline limit of 250 dgf. Visual evidence of fire in the vicinity of the missile thrust section was observed at this time and all emergency water systems were immediately activated in an effort to minimize additional damage. The flames, which had rapidly enveloped the missile lower tank section, continued to burn at a generally constant rate until, at 5.4 seconds, a high order explosion was apparent in the area of the thrust section. A final explosion, occurring at 6.4 seconds, completely destroyed the missile and missile service tower. The blast and subsequent fire severely damaged or destroyed the majority of equipment in the surrounding area, including the Atlas Utility Building. The blast also severely damaged Centaur vehicle C-3 and imparted minor damage to the Centaur Test Stand (S4) and the Centaur Utility Building. No personnel were injured as a result of the explosion of subsequent fire.

An Accident Investigation Board was formed, as a result of the explosion, to conduct a detailed examination and analysis of all data and recovered hardware. It is the intent of this report to document all pertinent findings of the Board, and to present those recommendations the Board considers necessary to prevent a possible recurrence of this nature.

2.0 SUMMARY

Missile 1F, at Sycamore Static Test Stand S1, was destroyed by explosion during firing Run S1-613-14-01, conducted on 13 May 1962. This was the second firing of the Block III test program and the ninth static firing of Missile 1F since erection on 7 March 1961. A previous attempt to conduct this test, on 12 May, was aborted 319.8 seconds after start countdown due to problems in the Rough Combustion Cutoff circuitry. These problems were unrelated to the events culminating in missile destruction.

Scheduled engine durations for this test were 40 seconds boosters, 60 seconds sustainer, and 65 seconds verniers. Actual durations were 1.77 seconds of booster 1 operation and 1.23 seconds of sustainer operation. Vernier engine ignition was not obtained. The booster 2 engine, due to loss of electrical control to the main lox valve solenoid, continued to operate until the first major explosion at 5.4 seconds. Bootstrap of the sustainer engine was not achieved due to abnormal engine head suppression valve operation.

This run included a scheduled 60 minute hold at Ready for Commit to demonstrate the capability of entering the commit sequence after a prolonged hold period with lox aboard. Actual hold duration was 64.79 minutes.

Missile 1F was an R & D missile functionally comparable to production F series missiles. Certain modifications were installed, however, including butterfly shutoff valves in the lox and fuel staging disconnects, R & D thrust section lift-off cameras, staging camera bracketry on the missile fuel tank, and a rotated sustainer lox regulator discharge elbow and vernier lox supply flex hose modification.

The investigation of the explosion was conducted under the direction of the Accident Investigation Board. The following sections present the conclusions arrived at by the Board, and a detailed discussion of the examinations and analyses of the various Board Working Committees. The results of special investigations being conducted by North American Aviation's Rocketdyne Division and General Dynamics Astronautics were not complete at the time of publication of this report and will be issued, with comments from the Investigating Board, as a supplement at a future date.

3.0 CONCLUSIONS

Analysis of all recorded data and recovered sustainer engine hardware indicates that missile destruction was the culmination of a sequence of events initiated by improper operation of the sustainer engine main lox valve (head suppression valve). The improper operation consisted of an approximate 350 millisecond delay in valve opening. Although laboratory tests have failed to exactly duplicate the problem, the most probable cause of valve opening delay (hesitation at the four degree open position) was shaft seizure resulting from the freezing of moisture and rust in the valve idler shaft bearing housing on the opposite end of the shaft from the valve actuator mechanism. When the valve began its opening movement, the sustainer pump was at its maximum spin charge speed. The abnormal loads thereby imposed on the pump shaft produced sufficient shaft deflection to allow the rotating impeller to contact the pump case wear ring. This rubbing generated a fire within the pump case, in the vicinity of the impeller upstream face, which created sufficient internal pressure to fracture the pump volute at its parting line and rapidly expel the forward portion from the main case. The resulting damage to the propellant and hydraulic ducting created an uncontrollable thrust section fire and subsequent explosion of the Missile.

4.0 RECOMMENDATIONS

The following recommendations were established by the Accident Investigation Board as a result of the Missile 1F explosion:

1. Action be taken to determine a method for indicating or precluding the presence of moisture in the HS valve idler shaft bearing housing. Possible methods are:

   a) Use of improved lip seal.
   b) Use of a dessicant plug to absorb whatever moisture is ingested into the housing.
   c) Procedure changes to preclude introduction of moisture into the HS valve bearing housing.

2. A study be conducted to determine whether increased ground hydraulic system pressure is advisable.

3. Further studies should be conducted on an urgent basis to determine the feasibility of precluding interference between the rotating and stationary elements in the lox pump. Some possible fixes that should be considered are:

   a) A non-combustible liner such as teflon or Kel-F in the wear ring and inlet assembly which would not cause failure should rubbing occur.
   b) Increased clearances to permit additional shaft deflections.

4. A method of accurate time correlation be provided on all motion picture data. (Accomplished for all future Sycamore Testing).

5. Conduct a detailed study of time and data correlation between all instrumentation recording channels and motion picture data.

5.0 DETAILED EXAMINATION

5.1 DATA EXAMINATION

The first indication of abnormal sustainer engine operation was noted at 0.680 seconds, following booster engine ignition, when the H.S. valve began its opening movement. The valve position data indicated movement from closed to the 5 degree open position by 0.68 seconds. The trace remained at this level until 1.03 seconds at which time the trace indicated valve opening movement at a normal rate. The valve reached the 38 deg open position at 1.37 seconds. After this time the valve position data indicated closing movement until 1.62 seconds, at which time the trace reached the approximate closed position where it remained until loss of data. As a consequence of the late opening movement of the H.S. valve, the P.U. valve did not begin its opening movement until 1.16 seconds. The valve opening rate was normal and the valve reached the full open position at 1.87 seconds. It remained full open until 1.97 seconds, at which time it began moving closed and reached an approximate 7 degree open position at 2.59 seconds.

Sustainer lox pump inlet pressure data indicated an increasing trend beginning at 1.29 seconds, reaching the off scale high (OSH) limit at 1.32 seconds. After this time, data was not recovered from this measurement. This lox system pressure surge was also observed in both booster lox pump inlet pressure traces, which reached the OSH limit at 1.33 seconds. Both of these measurements, however, re-entered the information band at 1.36 seconds and continued to record valid data until loss of the missile. Reflections of a lox system pressure surge were observed in the sustainer thrust chamber lox injection manifold pressure measurement at 1.34 seconds and in the sustainer gas generator lox regulater discharge pressure measurement at 1.35 seconds.

At 0.75 seconds the measurement sensing the sustainer gas generator lox injection pressure indicated a rise in pressure, reaching 60 psig by 1.40 seconds. It remained at this approximate level until 1.91 seconds, at which time it returned to approximately 0 psig.

At 1.65 seconds the sustainer gas generator blade valve closed micro switch deactivated and reactivated at 1.89 seconds. In the interval that the closed micro switch was deactivated there was no indication of activation of the valve open microswitch.

The sustainer lox pump seal cavity pressure measurement indicated abnormal data during the sustainer start sequence. The pressure increased from 0 psig at 0.6 seconds and reached 4.56 psig by 0.9 seconds. The pressure then decreased to 3.62 psig by 1.1 seconds and spiked to 12.8 psig at 1.6 seconds. The pressure had decayed to 0.8 psig by 1.95 seconds. Pressure increases of the magnitudes indicated were not observed on previous firings of this missile.

The initial peak of the sustainer pump speed during solid propellant gas generator operation was approximately 1500 RPM higher than on past tests of this missile. Following 1.34 seconds, the speed data indicated an increase from 8,745 RPM to 10,125 RPM by approximately 1.85 seconds. The increasing speed trend over this time interval was not the result of bootstrap of the engine.

For this test three accelerometers had been installed on the sustainer lox pump inlet flange to measure flange vibration along the missile X, Y, and Z axis. No data was recovered from the acceleleremeter sensing vibration in the X axis. Low amplitude, high frequency vibration data appeared on both the Y and Z axis accelerometer at 0.56 seconds. A sharp increase in vibration intensity occurred at 0.68 seconds concurrent with the initial indicated opening movement of the H.S. valve. Between 0.68 and 0.77 seconds, maximum vibration levels were 45 g peak to peak at a predominant frequency between 675 and 725 cps. An unrealistic shock load was indicated on these measurements at 0.87 seconds. Average maximum vibration levels from .90 to 1.34 seconds varied between 20 and 80 g peak to peak. Since this was the first time these measurements were installed on Missile 1-F, comparison data is not available. Shock impulses and simultaneous loss of data occurred between 1.34 and 1.35 seconds on both flange measurements.

Thrust section ambient temperature data appeared normal until approximately 1.4 seconds, at which time the four ambient temperatures began increasing toward OSH. A cutoff signal was generated automatically by P1325T, the engine compartment ambient temperature, at 1.77 seconds when this measurement passed the upper redline limit of 250 dgf.

Data recorded by the four dual element (high and low temperature) thermisters during the firing was also normal until approximately 1.34 seconds. The four thermister temperature measurements (low temperature sensing elements) installed in the thrust section indicated a drop in engine compartment ambient temperature starting at approximately T-18 seconds. This is coincident with the initiation of the 10 second engine compartment CO_2 purge.

The engine compartment ambient thermocouples verified the steady state levels of the thermister data. The thermocouples had too wide a range and too slow a response time to show the transients reflected by the thermister.

Measurement A1353T (Engine environment A-frame) showed a temperature drop from 33.5 dgf to 19.5 dgf at T-18 seconds. The temperature rose slowly to 21 dgf by T-10 seconds when a sudden increase to 27 dgf occurred. This temperature was maintained until ignition. This thermister was located on the staging rail support (A-frame) in Quad II at Station 1221. The A-frame was approximately 35 dgf from the missile Y-Y axis and the transducer for A1353T was 13.7 inches inboard of the point where the A-frame joined the rail.

Measurement A1361T showed a temperature decrease from 34.5 dgf to 27.5 dgf at T-18 seconds. This temperature was maintained until T-11 seconds when a sudden rise to 33.5 dgf was indicated. The temperature then decayed slowly to 31 dgf at ignition. The transducer for A1361T (Engine environment- Quad II rail) was located on the inboard side of the staging rail in Quad II at Station 1188. The rail was approximately 35 dgf from the Y-Y axis. Thermisters A1353T and A1361T were displaced from each other approximately 13 inches horizontally and 33 inches vertically.

At T-19 seconds thermister A1350T (Engine environment sustainer hydraulic panel) began a slow decline from 28.5 dgf reaching 23.5 dgf by T-11 seconds. The temperature increased to 24 dgf by ignition. This thermister was located on the staging rail A-frame in Quad IV, near Station 1221. The thermister installation was approximately 35 dgf from the Y-Y axis and 12 to 14 inches inboard from the point where the A-frame joined the staging rail.

Thermister A1363T (Engine environment-sustainer lube tank) indicated a rise from 18 dgf to 21 dgf between T-20 and T-17 seconds. The temperature then fell erratically to a minimum of 9 dgf at T-5 seconds when a slow rise began, reaching 15.5 dgf at ignition. The thermister for A1363T was attached to the sustainer lube oil tank at Station 1240 in Quad I.

The behavior of the four thermister temperature measurements beginning at T-18 seconds is believed to result from the engine compartment CO_2 purge. This purge was initiated at T-18 seconds and lasted for 10 seconds. It's purpose was to insure an inert atmosphere inside the thrust section during the captive firing. The CO_2 was introduced through two nozzles which extended through the fire shield (Station 1269). These nozzles were on the Y-Y axis, with one on each side of the sustainer engine. Both nozzles were fed by a common CO_2 supply and line. The line was "teed" at the fireshield to flow into the nozzles.

Thermister data recorded during the Firing Acceptance Test (FAT) tanking were very similar in time and temperature to the firing test data. The thrust CO_2 purge was also activated at the same time and duration as used during the FAT tanking.

An attempt has been made to correlate the 1-F and 11-F thermister data. During the 11-F flight countdown the thermister equivalent to A1353T indicated a sharp drop and recovery. The magnitude of this drop was 27 dgf below the steady-state level of 88 dgf and it occurred at lox slug stop. There was no similar indication during the 1-F test at rapid topping complete.

The sustainer/vernier hydraulic system pressure data indicated a lower pressure drop than normal at the time the H.S. valve data indicated initial opening movement at 0.68 seconds. Normally this pressure will decrease 150 to 200 psig at this time. On this test the pressure decreased only 20 psig. The bootstrap trend of this measurement was normal until 1.24 seconds, after which time the measurement hesitated and then began an abnormal decay, reaching 0 psig by 2.1 seconds.

Abnormal data was observed in autopilot system performance at 1.15 seconds. At this time the yaw displacement gyro (YDG) output signal showed evidence of a disturbance which induced a 0.48 cps sinusoidal output (0.21 degrees peak-to-peak) on the YDG. At this approximete time, the booster engines were in the transition to mainstage operation. Investigations of displacement gyro data on previous firings of missile 1-F did not show this YDG disturbance. Normal data was recorded on remaining autopilot measurements until the 1.35 second time period.

The cutoff signal generated by the engine compartment ambient thermocouple (P1325T) at 1.77 seconds resulted in a normal shutdown of the B-1 engine. The cutoff signal had no effect on the B-2 engine nor did the activation of the automatic cutoff backup signal at 2.30 seconds. The B-2 engine continued to operate at a near full thrust level until at least 5.4 seconds, approximately one second prior to loss of the missile. The majority of B-2 engine prarmeters were lost at 5.4 seconds. Final explosion of the missile did not occur until approximately 6.4 seconds, at which time all remaining instrumentation was lost.

5.2 HARDWARE EXAMINATION

A thorough search of the area surrounding the test stand was initiated the day following the explosion in an effort to locate and identify all possible missile components. Recovery of hardware from the collapsed tower structure was delayed until the tower remains had been sufficiently shored to provide for the necessary personnel safety. All recovered fragments were tagged as to identity, their location noted on a dispersion chart, and then collected by missile system to facilitate examination and analysis of the hardware for the purpose of ascertaining the agent of missile destruction. Considerable emphasis was placed on obtaining comprehensive documentation of all fragments with regards to heat and smoke damage and nature of failure. Photographs of the collected hardware were also obtained to provide a permanent documentation.

Presented in this section are the condition of recovered hardware, significant hardware items that were not recovered or identified, and special items of interest with respect to hardware condition. Results and conclusions of the hardware analyses are presented in Sections 5.5.

5.2.1 PROPULSION SYSTEM HARDWARE

This section presents pertinent information concerning the condition of recovered propulsion system components. For clarity, the propulsion system is discussed by major sub-assembly with emphasis on sustainer engine components.

A. Sustainer Engine

1. Chamber - The lox dome, injector, combustor section, and hydraulic manifold were found as one unit in the skim pond. The exhaust-erator and lower expansion section were separated from the main chamber below the throat area and also found in the skim pond. There was no evidence of chamber internal overpressurization.

2. Head Suppression and Ignitor Fuel Valves - The HS valve was found attached to the lox dome inlet, although all mounting bolts were either stretched or missing. The ignitor fuel valve was separated from its linkage housing to the HS valve, with the ignitor valve cam follower locked in the full open position by deformation of the cam follower supports. These were pinched together by the deformation of the HS valve actuator linkage housing.

3. Propellant Utilization Valve - The complete PU valve with majority of plumbing attached was intact on the sustainer combustion chamber.

5.2.1 (continued)

4. Hydraulic Package - The hydraulic control manifold including the FU and HS servo valves and majority of plumbing were intact on the main chamber. Several manifold tubes were severed at the lox pump support bracket.

5. Hypergol Ignitor Chamber - Found attached to the main chamber with the retaining pin retracted from case.

6. Oxidizer Regulator - Found intact although mounts were broken from pump attachment.

7. Power Package - The lox pump, fuel pump, and gearcase were found as a unit. The lox pump case was split at its maximum periphery over the entire circumference. The inlet side of the pump case was found separate from the power package east of the flame deflector spillway approximately 300 feet from the test stand with the inlet adapter, "Y" duct attaching flange, Rayco seal, and internal spring intact. The lox pump impeller and inducer remained attached to the pump but showed considerable evidence of heat. The impeller was burned and eroded both internally and externally with an erosion pattern indicating the heating occurred while the impeller was rotating. Both the lox pump wear ring and diverter lip were also extremely eroded. The hydraulic pump was broken from the gearcase at its weakest section.

B. Booster Engine #1 - The majority of B1 engine components were dispersed east of the test stand or in the skim pond. The thrust chamber skirt section was separated from the injector and found with the dome/injector assembly in the skim pond. The main lox valve, lube oil tank, power package, and gas generator and turbine assembly were all located east of the tower. All B1 components showed external evidence of impact and fire damage.

C. Booster Engine #2 - B2 engine components were dispersed over a wide area west of the test stand or in the skim pond. All recovered hardware indicated extreme damage, due mainly to failure of B2 engine to shut down prior to missile destruction. The following major components were never located or identified: turbine exhaust heat exchanger, surge chamber, lox and fuel bootstrap lines, lox purge check valve, main lox valve, directional control valve, and ignitor fuel valve. The gimbal block, lube oil tank, main fuel valve, power package, and gas generator control assembly were all shattered into several pieces.

D. Vernier Engines - The majority of vernier feed plumbing was not found. Both chambers showed impact damage and were separated from the propellant valve assemblies. Both solo tanks were found in pieces, due

5.2.1 (Continued)

apparently to impact and not overpressurization. The lox and fuel flex lines were both attached to sustainer engine hardware.

E. Lox Topping System - Both topping check valve bodies were found intact although attached plumbing was severely damaged. Remainder of topping lines and hardware were found in several pieces and indicated impact and fire damage.

F. Sustainer Low Pressure Ducting - The flex joint immediately upstream of the lox pump inlet flange was found severely damaged with several bellows sections flattened. All remaining portions of the lox and fuel ducting which were identified indicated severe tearing and burning.

G. Booster Low Pressure Ducting - Most recovered ducting showed extreme impact and fire damage. The major pieces of all staging shutoff valves were recovered in various states of damage. Most duct flanges were broken or twisted indicating severe impact damage. The airborne portion of the lox fill and drain valve was almost completely destroyed although the 8" flex joint remained attached to the valve flange. The fuel fill and drain valve suffered a broken housing plus other impact and fire damage. All valve ducting was torn from the mounting flanges.

5.2.2 PNEUMATIC SYSTEM

A. Area of Dispersion of Recovered Hardware - Components of the airborne pneumatics system recovered were found over a widely dispersed area. Nearly fifty per cent of the recovered components were in the remains of the test stand structure and one of the shrouded helium spheres was over 1000 feet from the stand. The location of the components recovered is essentially radially from their position on the missile. The boiloff valve was found in the remains of the tower structure.

B. Condition of Recovered Hardware - Three of the helium spheres were intact, two of them having most of the shrouding attached. These had sustained minor apparent structural damage but the other shrouded spheres were fragmented into numerous pieces. The ambient helium sphere was ruptured into essentially two large pieces which evidenced fire damage as well as other visual structural damage. The boiloff valve was relatively undamaged. The flanges, bolts and casing were intact and appeared sound. A portion of the liquid oxygen tank forward bulkhead was still attached to the valve. Both high pressure helium check valves were recovered intact. The tubing had been extruded from the "B" nuts except for one short segment at the inlet of one valve. There was no evidence of fire on the valves themselves but the piece of tubing was covered with carbon. One of the valves was marred

5.2.2 (Continued)

and gouged. The airborne pressurization regulators were damaged structurally but only the fuel regulator showed carbon deposits. The ducting had been torn from the components as was the tubing of the lox regulator. The fuel regulator still had a short length of tubing attached. The flange and bolts of the hardware joining the relief valves to the regulators were intact on both regulators and most of the casting itself was still attached to the fuel relief valve. One stop valve cap had been sheared from each regulator as evidenced by the sheared retaining bolts. The main body was undamaged and the nameplates were readily discernible. The sensing controllers and other attached hardware were also torn from the main body. The relief valves were damaged more severely than the regulators. The fuel relief valve was heavily coated with carbon and the body was mashed on one side. The flange and bolts on the mounting bracket side were attached and undamaged. The ducting and tubing had been extruded from the nuts or sheared off at the valve. The nameplates were legible. The changeover valve was damaged structurally to a considerable extent but was relatively intact. The motor housing was bent, marred and gouged and three screws had been sheared from one of the valve side covers. The tubing had been extruded from the "B" nuts. Inspection at the side plate revealed that the valve was partly open. The oxidizer pressurization duct diffuser was clean and only slightly dented. The duct to and including the upper flange and bolts of the manual shutoff valve were attached. One of the valves with a small portion of housing was recovered as was a very small portion of the other housing with the nameplate attached. The bolts on the pieces of housings found were intact. Only miscellaneous pieces of tubing, LN2 shrouds and fill ducts were recovered. Those pieces found were twisted and mangled severely. The helium distribution manifold, located in Quad III was intact, burned and had only two short sections of line attached. The manifold was attached to a small portion of bulkhead. The Quadrant II staging disconnect was relatively intact, the Quadrant IV staging and III - IV riseoff disconnects, delta pressure switch and transducers were damaged and showed signs of fire damage.

5.2.3 HYDRAULIC SYSTEM

There appeared to be no damage to missile hydraulic components from sources other than external explosions.

The dispersion pattern of the recovered hardware locates them on radial lines outward from the Z axis of the missile, in line with their respective locations on the missile. Several parts were found in the spill pond, and appear to have been washed down the spillway and into the pond by the main flame deflector water flow. Evidence of scratch marks on these parts indicates they slid over the concrete spillway.

5.2.3. (Continued)

The customer disconnect bracket with adjoining tubing and flex lines were damaged due to being torn away by the explosion. The only fire damage to these parts was a small burn hole 1/2" X 3/16" on the return line from the sustainer hydraulic pump to the customer disconnect bracket. The casing of the sustainer hydraulic pump was found in two pieces. The upper flanged section was still attached to the sustainer engine, and the lower body section appeared to have been sheared off, possibly while being washed down to the spill pond. These parts were sheared at the narrow neck between the flange and body section. The hydraulic manifold that is located at the apex had all tubing sheared off. None of these preceding parts appeared to have suffered fire damage. All above hardware was located in the spill pond.

Five identifiable parts were found from the two airborne hydraulic reservoirs. The top of the B1 hydraulic reservoir with the hydraulic piston in the up position appeared to have been separated from the remaining part of the reservoir by external blast. No visible fire damage was evident, and all tubing was sheared off. The top of the sustainer hydraulic reservoir had all tubing sheared and evidence of fire damage, probably as a result of being in the test stand area after the explosion. A piece of the sustainer hydraulic reservoir was found with a piece of shrapnel imbedded in the tank section. There was no visible fire damage. The hydraulic piston was in the down position. The bottom section of the booster hydraulic reservoir shows no fire damage.

The sustainer system 27-08650-5 check valve was found with all tubing sheared off, with no evidence of fire damage.

The V-1 pitch and yaw actuators were found near the spillway, and the V-2 pitch and yaw actuators were in the area of the lox farm. The servo valves were missing from all actuators except the V-2 pitch actuator. None of the actuators appeared to have suffered fire damage.

The four booster and two sustainer engine actuators were found at varying locations around the test stand area. Two booster and both sustainer actuators appeared to have suffered fire damage, while the other two booster actuators showed no similar evidence. Both sustainer actuators had part of the brackets that connect to the cylinder end of the actuator still attached to the actuator although the brackets were sheared off as were the piston end of the actuators. A servo valve was missing from one of the actuators. The two booster actuators, with no evidence of fire, had the piston end broken off. One servo valve was missing. Part of the bracket from the missile structure had been sheared off and was still attached to the cylinder end of these actuators. The two booster actuators that suffered fire damage had the cylinder end bent violently, although no part of the bracket was attached to the actuators. The piston end of one

5.2.3 (Continued)

of the actuators was sheared off, the other was intact.

The sustainer and both booster accumulators were damaged by external forces, either by flying pieces or by hitting something while being propelled away by the force of the explosion. One booster accumulator and the sustainer accumulator was sheared off.

The sustainer system Sterer valve appears to have suffered damage by external explosion. All tubing was sheared off although there was no evidence of fire damage. The booster system Sterer valve was found in a badly mutilated condition. Again no fire damage was evident.

Several parts of the B-1 hydraulic pump were found, and all parts appear to have suffered external blast damage with no evidence of fire damage. The pump attachment flange was still attached to the necessary drive pad, but the remaining parts of the pump were sheared or blasted off. Several of the parts have not been found or identified. The hydraulic piston assembly and the adjoining cylinder assembly were found separated from each other. Six of the nine pistons were damaged or sheared off, again probably due to the explosion.

Minor pieces of tubing, tube connections, and check valves were found, most of which was damaged beyond recognition.

5.2.4 AIRFRAME

The lox tank nose adapter 27-75005, while relatively undamaged, was separated from both the lox tank, and the nose handling adapter. Approximately 1/3 of the upper bulkhead was retained with the adapter, while the entire lox boil-off valve mating ring was torn out. The Calmec boil-off valve with the tank mating ring was apparently undamaged. There were slight carbon deposits on the adapter, but no evidence of heat damage.

The lox tank pressurization duct and diffuser installation 27-73127, complete with elbow and doublers on tank skin was intact although torn from the tank skin. There was no evidence of heat damage to this item.

Large portions of the lox tank remained in the tower after the incident. The largest section, from Station 664 forward about 7 feet, was complete, though buckled through Quad II - III area and carboned in the upper areas. A large section from Station 693 forward about 3 feet showed heat discoloration and another large section at Station 896 centered on the Y axis in Quad IV - I area showed heat discoloration and carbon deposits.

A 2 foot by 5 foot section from the lox tank in the area of the Quad IV lox elbow shows evidence of heat discoloration. The lox elbow and bellows show heat distortion and discoloration. A pod fairing bracket adjacent to

5.2.4 (Continued)

the elbow has aluminium alloy slag in the hinge. A smaller portion of the lox tank with the lox elbow from Quad III showed no evidence of fire damage.

There are no identifiable portions of the missile fuel tank available, nor are there any fragments of the pod fairings or doors. Two small fragments (about 2 square feet) of intermediate bulkhead showed considerable heat discoloration.

A small fragment (18" X 24"), of what apparently is the anti-slosh baffle, was found and showed no heat discoloration.

The tank section Station 1133 mating ring was found in three sections, all considerably twisted and deformed. A strip of tank skin, welded to the ring, was intact throughout the ring's length, as failure was in the skin above and below the ring. The largest ring section, about 10 feet long, had been straightened and showed evidence of heat damage. As this section was found in the rear of the fire gutted Utility Building, heat damage may have occurred at this time. There were no attaching bolts remaining for the tank to thrust section rings, and all the holes had been elongated in a direction parallel to the tank surface. Only one or two small (3" or 4") sections of the booster 1133 ring were found.

A portion of the fuel tank apex, with the fuel staging disconnect flange was found. Failure was in the tank skin around the largest doubler, and it was noted that the flange had collapsed into itself, concertina fashion.

Several small portions of the externally reinforced section of the fuel tank apex, adjacent to the sustainer cone attachment flange were found.

Several pieces of thrust section longerons up to 30" long were found. One large piece of the Quad IV longeron indicates a web torn and displaced in a direction towards Quad III. All pieces were heavily carboned.

A 2 foot portion of the thrust section jettison track was found, and showed fire damage.

One section 20" long of the Station 1206 frame was found.

The thrust section nacelles and firewall were completely shattered, with no large sections found.

The thrust barrel was completely shattered, with the largest piece approximately 12" X 36" from the Quad III area above the fireshield.

5.2.4 (Continued)

A portion of the partial frame between the upper and lower He bottles in Quad III - IV, reveals a burnt and molten area, where the lox topping line passes through the frame.

5.2.5 A/B ELECTRICAL HARDWARE

The missile inverter was found approximately 40 feet from northeast corner of stand. All plug receptacles had been ripped away including internal wiring receptable to component. Internal condition, as viewed through the receptacle holes, seemed to be in fair condition although distorted from original configuration. The outer casing was blackened by fire and was ruptured at one point near the top center. The rupture appeared to have been caused by internal components pushing outward. Rupture was approximately 4 inches long and .1 inch wide at maximum point with slight bulging outward. One inspection plate on connector end was torn loose leaving broken mounting stud on the casing. It should be noted that the location of the inverter was 180 deg from the majority of other pod 2 components. The mounting legs and bolts held. Pieces of mounting rails were found still connected to the inverter mounts.

The Acoustica Propellant Utilization Computer casing was blown apart in numerous fragments. The canister and internal parts were burned, blackened and strewn out in a long line to the west of the stand or almost directly outward from Pod 2 where the canister was mounted. The majority of larger recognizable parts were found on the S-4 access road. There was no ground fire where majority of parts were found.

The only recognizable part of the engine relay box that was found was the canister cover. The cover was burned and blackened. All electrical receptacles were torn from the cover leaving only distorted mounted holes. The cover was found in Area 32 (#283) fuel farm, which is 180 deg out from where the engine relay box normal mounting is located (Pod 2).

The only recognizable part located of the battery simulator box was a Cannon plug with bits of wire attached. The plug was burned and physically damaged. It was found approximately 500 feet from missile on the S-4 access road. It is assumed that all other parts of the simulator box were destroyed beyond recognition or have not been found.

At this writing it is assumed that the power changeover switch was either destroyed beyond recognition or has not been found. Search parties have made special trips to locate the switch but so far have been unsuccessful.

The umbilical jacks suffered severe damage. The recognizable parts were located and the areas are recorded on the fragmentation survey charts. Three umbilical adapters were found approximately 500 feet west of the stand on the S-4 access road. The booster umbilical was found in front

5.2.5 (Continued)

of the stand near the LN2 storage tank revetment. Indications are that the adapters were ripped away from the missile jacks. The adapters suffered extreme physical damage by the explosion and contact with the structure and ground at point of impact. The metal casing of one adapter was melted by the fire which prevailed after the initial explosion.

The airborne harnesses were destroyed beyond repair. The harnesses, including the plugs, were fragmented and burned. Identification of individual harnesses was impossible in 95% of the cases where harness pieces were found. The distribution was wide spread from the stand to the surrounding area.

5.2.6 FLIGHT CONTROL SYSTEM

Major damage or destruction was suffered by the majority of Flight Control system hardware. The servo amplifier canister was shattered and indication of severe burning were noticeable on the recovered fragments. The displacement gyro canister was also shattered althcugh all four gyros were located intact in their cases. Three were located in the tower structure and one in the canyon south of the tower. The flight programmer canister suffered severe tearing and burning as did the 600P1 flight control umbilical. Relatively minor damage, consisting mainly of smoke deposits, was incurred by the booster gimbal blocks and the remote rate gyro package. Both gimbal blocks were still workable.

5.3 ENGINEERING FILM EXAMINATION

The detailed review of the five available items of film coverage has been completed. The 200 frame per second camera, located at the east spillway ledge, fell over prior to, or as the result of, the first major explosion and consequently the final explosion was not recorded on this camera. Steam and smoke from the flame bucket obscured the view of the stand and missile prior to the time the camera began falling so it cannot be determined exactly if it was the first major explosion shock which caused the camera to topple.

Three of the remaining four items of film coverage were compared by utilizing the final explosion (indicated by recorded data at approximately 6.4 seconds) as a base point after counting frames from the first indication of ignition seen on each camera to this common point. Satisfactory correlation of the first major explosion and the first appearances of abnormalities about the thrust section was obtained from these three items. The three items, a 128 frame/second camera to the west of the test stand in the canyon, and one each 24 frame/second cameras at both the north and south observer tanks, established the first indication of abnormal performance subsequent to 1.3 seconds after ignition start. This compared with the recorded test data.

The final item of film coverage, a 24 frame/second camera also located in the vicinity of the north observer tank, did not correlate with the three previously mentioned. This camera did not record the final explosion but did record the first major explosion. This time was compared to the three other items of coverage and by so doing the first indication of abnormal performance was indicated as occurring prior to 1.3 seconds after ignition start. A re-calibration of camera frame speed revealed that the camera was not running at 24 frames/second but was in fact operating at an average frame speed of approximately 27 frames/second. This was established by photographic department personnel. When the 27 frame/second rate was used to time the intervals between the recorded incidents the first indication of abnormal performance was established to be subsequent to 1.3 second after ignition start and in close agreement with the other three film items. The film became over exposed immediately after the occurrence of the first major explosion indicated by recorded data to have occurred at approximately 5.4 seconds.

5.4 DATA ANALYSIS

A review of the data recorded during the test revealed that the head suppression valve (main lox valve of the sustainer engine) did not open in a manner consistant with its opening on the eight previous firings of Missile 1F, as indicated by the valve position measurement P1529D. Prior to the occurrence of the indicated abnormal behavior of this valve, there is no valid indication of abnormalities elsewhere in recorded data.

The H.S. valve position data indicates that the valve began a movement toward open at a time that was consistant with its initial opening movement on the eight previous firings. However, on this firing the valve paused at the indicated 5 degree open position for approximately 350 milliseconds before continuing movement toward open. H.S. valve action of this nature was experienced once previously by GD/A during testing of Missile 2E at Sycamore Test Stand S2. On Test S2-505-A2-02, the H.S. valve paused at the 5 degree open position for approximately 840 milliseconds. The H.S. valve on that test then moved open normally and the test was terminated safely by observer cutoff when it became apparent that the sustainer engine was not operating. Following the Missile 2E test, the H.S. valve, the hydraulic control manifold, and the ignitor fuel valve were replaced and sent to Rocketdyne for failure analysis. During cold testing of the H.S. valve by Rocketdyne, the "hang up" of the valve was repeated. Disassembly of the valve revealed moisture in the shaft bearing cavity on the opposite end of the shaft from the valve actuator mechanism. The ignitor fuel valve and hydraulic control package were functionally tested satisfactorily. The failure of the head suppression valve to function properly on that test was attributed to shaft seizure resulting from moisture freezing in the shaft bearing cavity. The major difference between the test of Missile 2E and this test of Missile 1F, regarding H.S. valve motion, was the length of time the valves "hung up" at the 5 degree open position.

A comparison of pump speed versus H.S. valve position between the two tests does not indicate any significant differences after the time on each test at which the H.S. valve began its major opening movement. On the Missile 1F test the pump speed began increasing from 8250 rpm after the time that the H.S. valve reached the 33 degree open position. The pump speed on the test of Missile 2E, at the time the valve reached the 33 degree open position, was 8700 rpm.

On the Missile 1F test, the pump speed was 8850 rpm at the time that the H.S. valve reached its indicated maximum open position of 38 degrees (at 1.37 seconds). Hardware analysis indicates the valve actually opened to 45 $\pm$ 1 deg. On the Missile 2E test, the pump speed was 8050 rpm when the valve was at the 38 degree open position.

5.4 DATA ANALYSIS (Continued)

The indicated closing movement of the H.S. valve, after 1.37 seconds, is not believed to be valid data. If the valve were, in fact, closed after this time, and were the lox system intact, a pressure increase would have been indicated on the sustainer lox regulator discharge pressure, which appears to be recording valid data after 1.37 seconds. Since the pump speed is increasing at this time and both the lox regulator discharge pressure and thrust chamber lox manifold pressure are decreasing, it appears that the integrity of the lox system was lost prior to 1.37 seconds. The sustainer lox pump inlet pressure strain gage transducer measurement indicated OSH at 1.32 seconds and it is therefore concluded that the integrity of the lox system was lost within the time interval between 1.32 sec and 1.37 seconds due to an abnormal pressure surge within the lox system.

The P.U. valve data does not react normally to the indicated closing movement of the H.S. valve, subsequent to 1.38 seconds. Opening of this valve requires igniter fuel system pressure within the hydraulic manifold and since the igniter fuel valve is cam operated by the H.S. valve, the P.U. valve should have begun a closing movement prior to 1.65 seconds when the H.S. valve reached the approximate closed position. Since the P.U. valve did not begin to move toward closed until 1.97 seconds, it appears that the indicated closing movement of the H.S. valve is invalid data.

The pressure surge indicated by the sustainer lox pump inlet pressure data and substantiated by the booster lox pump inlet pressures, supports a sustainer lox system detonation between the time interval of 1.32 and 1.37 seconds, with a resultant loss of lox system integrity.

The behavior of the sustainer gas generator lox injection pressure measurement remains unexplained. The trace should maintain a zero psig level until bootstrap of the engine, after which time this measurement will reflect lox pressure to the gas generator combustor. Premature pressure rise data have been occasionally recorded on this measurement at other test sites. However, these rises have been related to hot gas leakage past the GG lox poppet at ignition start and in none of the instances noted was unsatisfactory engine performance experienced. The data from this measurement during this test appears additionally unrealistic at the time that the "gas generator blade valve closed" microswitch deactivates at 1.65 seconds, in that there is no response on the trace. If the lox system was no longer intact at 1.65 seconds, the indicated trapped pressure between the poppet and the blade valve should have vented upstream thru the blade valve. Also if the lox system were intact at 1.65 seconds, some reaction from the trace would be expected when the blade valve opened.

5.4 DATA ANALYSIS (Continued)

The indicated deactivation and reactivation of the "sustainer gas generator blade valve closed" microswitch between 1.65 seconds and 1.89 seconds appears to be normal under the circumstances. In order to open the blade valve, the fuel manifold pressure sensed at the hydraulic manifold must be approximately 450 psig, to shuttle the blade valve control valve in the hydraulic manifold. After 1.38 seconds a speed increase of the sustainer pump occurred which continued until burn out of the SPGG at 1.78 seconds. It appears that with the fuel jacket of the thrust chamber being primed since 1.16 seconds, when the PU valve started open, and the overspeed trend of the pump following loss of lox system integrity of 1.38 seconds, sufficient manifold pressure was created in the fuel manifold to cause the blade valve to start open. Burn out of the SPGG at 1.78 seconds and consequent deacceleration of the pump resulted in loss of fuel pressure and prevented the blade valve from reaching the open position.

Investigation of the lox pump seal cavity pressure anomalies on this test revealed that a similar anomaly occurred on the test of Missile 2E, in which the H.S. valve also hung up. It appears that the cavity pressure increase is a result of the delay in opening of the H.S. valve.

The increase in sustainer pump speed which occurred starting in the vicinity of 1.34 seconds also supports the loss of integrity of the sustainer lox system. Such a speed trend would be expected in the event that the lox pump became unloaded. The continued integrity by the fuel side of the sustainer system was indicated by the fuel pump inlet pressure measurement. This data reacted in a normal manner to the closing of the P.U. valve and continued to record data until approximately 5.37 seconds. The "gas generater blade valve closed" microswitch activations, the gas generator lox injection pressure measurement, and the gas generator fuel injection pressure measurement did not indicate boostrap of the engine at the time the speed increase began.

Tests have been conducted in an effort to explain the apparent shock load on the sustainer lox pump inlet at 0.87 seconds. These tests consisted of bench tests utilizing a Gulton Accelerometer System. Vibration inputs were at frequencies below 20 cps. The results indicated that there is no apparent magnification of the input signal at this frequency range. The following conditions were found to simulate an output similar to that recorded on 1F.

a. A slightly loose connection between the cable and the transducer. (highly improbable)

b. A faulty or noisy cable as a result of a breakdown in its inner insulation. The output was simulated by slightly moving or whipping the cable.

5.4 DATA ANALYSIS (Continued)

c. The grounding of the transducer against a body containing a static charge, such as a piece of missile hardware. The piece of hardware would have to stay in contact with the transducer in order to simulate the output.

It is concluded that the outputs recorded on 1F do not represent quantitative valid data.

5.5 HARDWARE ANALYSIS

Analysis of recovered missile hardware verified the origin of explosion to be the sustainer engine lox pump. All damage incurred by hardware other than the sustainer was the results of heat and/or impact resulting from the subsequent fire and explosion.

Detailed teardown of the sustainer engine components was performed at Rocketdyne Canoga Park to derive maximum advantage from the available facilities. Teardown and inspection was performed by Rocketdyne personnel with the concurrance of hardware specialists from the Air Force Inspector General Office. Special tests were accomplished, as necessary, to provide additional background information or to attempt duplication of various hardware anomalies.

To eliminate unnecessary duplication in recording the results of hardware analysis, the reader is referred to the Hardware Investigation Tesm Report which is presented in full in the following pages.

HARDWARE INVESTIGATION TEAM REPORT (U)

SM-65F MISSILE TEST ACCIDENT

ATLAS 1F, AFSN 60-5524

STAND S-1 SYCAMORE STATIC TEST SITE

GENERAL DYNAMICS/ASTRONAUTICS

SAN DIEGO, CALIFORNIA

13 MAY 1962

The hardware investigation of this missile test accident was conducted and this report is submitted by:

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A. SEQUENCE OF EVENTS

Atlas missile 1F, SN 60-5524, was destroyed by fire and explosion at stand S-1, Sycamore Static Test Facility, San Diego, Calif., 13 May 1962. Personnel injury and private property damage were not involved in this mishap. The accident occurred during static firing run number S1-613-14-01, the second static firing of Block III testing and the ninth static firing since the erection of this missile in stand S-1 on 7 March 1961. This firing was conducted to support missile and instrumentation changes planned for Pacific Missile Range flights. One of the test objectives was to evaluate LOX loading and launch control logic circuitry operation under a one hour hold condition at "Ready for Commit". Planned engine run times were 40 seconds for the booster engines, 60 seconds for the sustainer engine, and 65 seconds for the vernier engines.

Countdown was started at approximately 1235 PDT, 13 May 1962, with a planned one hour hold with propellants loaded. The commit sequence was completed (T-0) at 1345 PDT. Sustainer engine ignition start signal occurred 0.54 seconds after booster engine ignition.* At 0.67 seconds, the head suppression valve data indicated that the valve started to open and then hesitated between 4 and 6 degrees open for 350 milliseconds. At 1.01 seconds, the valve started opening and reached 38 degrees open at 1.38 seconds. The valve data showed that the valve started closing at approximately 1.38 seconds. Pressure surges were observed in the sustainer LOX pump inlet pressure, booster LOX pump inlet pressure, sustainer thrust chamber LOX manifold pressure, and the sustainer LOX regulator discharge pressure; peaking at approximately 1.34 to 1.35 seconds. The three sustainer engine pressure measurements indicated loss of sustainer LOX system integrity between 1.34 and 1.38 seconds.

* Note that all times in this report are based on "quick look" data and subject to possible changes when instrumentation delay characteristics are taken into account.

Loss of the missile sustainer hydraulic system coincided closely with the loss of sustainer engine LOX system integrity. The missile, missile service tower, and utility building were destroyed. Aerospace Ground Equipment and facility equipment around the service tower sustained major damage (Figs 1 and 2). Note that the skim pond where the sustainer was found had not been drained at the time the photographs were taken. Figure 3 shows the skim pond after draining.

B. TYPE OF ACCIDENT - DESTRUCTION OF MISSILE AND SUPPORT EQUIPMENT BY FIRE AND EXPLOSION.

C. INVESTIGATION AND ANALYSIS

1. General

Analysis of instrumentation data and films indicated that the initial abnormalities occurred in the LOX system of the sustainer engine. Therefore, the investigation was concentrated on recovered portions of the sustainer engine including the LOX turbopump, the head suppression valve, associated plumbing, and hydraulic control components.** Extensive damage and separation of portions of these subassemblies occurred during the explosion and subsequent ejection from the stand.

The sustainer thrust chamber was found with the head suppression (HS) valve body attached by the turnbuckles. The turbopump was torn from the pump mounts and the thrust chamber was separated at a plane just downstream of the throat (Figs 4 and 5). The sustainer engine turbopump assembly was recovered in several pieces. The turbine, gear case, RP-1 pump, approximately half of the LOX pump volute, impeller, inducer, and pump shaft were still joined as an assembly. A portion of the LOX pump volute, wear ring, inlet housing, RACO seal and the mating GD/A LOX duct

** Parts nomenclature used in this report conform to T.O. 2K-LR105-14, "Illustrated Parts Breakdown".

flange (with a small piece of the bellows) were found as a unit (Figs 6 and 7). Two additional pieces of the pump volute were recovered separately (Fig 8). A portion of the LOX pump volute was not recovered.

2. LOX Pump Volute

The fractured surfaces of the LOX pump volute exhibited a characteristic herringbone pattern showing that the volute had separated circumferentially approximately at the casting parting line, with both halves being propelled apart axially by a rapid onset of extreme over-pressure. Shearing of the LOX pump discharge flange attachment bolts at the mating surface between the flange and the head suppression valve housing, and brinelling of the bolt holes in the flange halves and valve housing confirmed the fore and aft axial movement of the two halves of the LOX pump volute (Fig 9). The energy level required to separate the volute with sufficient force to cause the resulting fractures of surrounding hardware, exceed that which could have been developed hydraulically, and could only have resulted from an explosion within the pump.

3. Head Suppression Valve Assembly

The HS valve actuator was separated from the valve by the forward movement of the front half of the LOX pump volute (Fig 10). The aft side of the actuator housing was deformed inward by the LOX pump discharge flange striking it as evidenced by matching brinelling on the edge of the flange and the deformed portion of the housing. Deformation inward of the actuator housing resulted in the brinelling of the interior of the housing against the fuel igniter valve cam attachment bolt (Fig 11). Comparison of the location of this brinell mark with layout drawings showed that the head suppression valve was 45 ± 1 degrees open when the actuator housing was deformed during the LOX pump explosion.

At that time, it should have been fully open (90°). Separation of the actuator assembly from the valve housing, resulted in a bending fracture of the head suppression valve gate drive shaft at the mating surface between the actuator housing and the valve housing. The actuator housing cover plate, switch box and position potentiometer, and the fuel igniter valve were separated from the head suppression valve actuator housing during its deformation. The 45 degree valve position was also established by a brinell mark on the fuel igniter valve cam made by the cam follower.

The fuel igniter valve cam working face exhibited signs of what appeared to be abnormal wearing. There were numerous shallow crater-like depressions in the area over which the cam follower roller travels. The shape of the deformations did not conform to a typical corrosion pattern and there were no signs of oxidation residue. The deformations did not have the appearance of galling. Discussions with personnel who were familiar with this assembly indicated that similar wear patterns have been observed on cams that have been in service for extended time periods. Damage sustained by the sustainer engine fuel igniter valve housing and cam follower during deformation of the HS valve actuator housing, showed that the fuel igniter valve was open at the time of the LOX pump explosion.

The HS valve actuator cylinder was dented on the forward side resulting in a shallow inward deformation of the cylinder wall. The anodized surface of the cylinder bore and a small metal chip was machined off the dented area by the outboard land of the actuator piston while it was moving in the closed direction. A portion of the chip was found between the teflon retainer outboard of the rubber O-ring packing and the inside face of the outboard piston land. The location of the brinell marks on the

actuator piston and the sliced off portion of the dent in the cylinder wall indicated that if the actuator and head suppression valve gate were connected at the time of cylinder deformation, the gate would have been open approximately 54 degrees. This obviously occurred after the pump explosion, but the sequence of events is subject to speculation. A valve closing command was generated at ignition plus 1.73 seconds which was adequate time for the HS valve to reach the full open position. Assuming that the hydraulic lines were intact, and that the actuating cylinder was struck sometime after 1.73 seconds with the piston groove aligned with the area dented, the observed chip removal could be explained.

The head suppression valve drive shaft, idler shaft, and gate were disassembled. The bearing assemblies were free on the shaft and withdrew easily. The mylar lip seals used for excluding moisture from the valve drive shaft bearings were partially split in the seal radii. The idler shaft outboard seal was split in the same manner, while the inboard seal was intact at disassembly. It should be noted that the most likely point of moisture entry during a normal test run is through the seal that remained intact. Moisture was observed inside the seal retainer and vent valve assembly which is installed in the idler shaft housing. The idler shaft needle bearing assembly contained water and scaly rust deposits on the needle bearing tapered ends and outer bearing race. Several of the needles were galled on the inboard end (Fig 12). The polished surface of the idler shaft exhibited several types of deformation (Fig 13). Brinelling imprints of the needle bearings occurred on opposing sides of the idler shaft. Build up of metal in the brinelled areas of the idler shaft showed valve gate motion toward the closed position. Marks were also observed on the surface of the idler shaft which showed compression of a hard gritty substance between the needle bearings and the shaft surface. Pile up of material around these depressions

indicated shaft movement in both directions. One distinctive mark deeper than the other was observed with metal build up occurring in the direction of gate closing motion. The mating surfaces between the idler shaft square drive and the anodized valve gate exhibited a heavy coating of newly developed, finely textured ferrous oxide, probably the result of the assembly being submerged in the skim pond.

Although both of the mylar lip seals on the valve drive shaft were split, no evidence of moisture or oxidation was found in the drive shaft needle bearings. Heavy brinelling of the polished bearing surface of the drive shaft was evident on opposing sides of the shaft which coincided with the drive shaft needle bearings. This brinelling occurred during the bending fracture of the drive shaft initiated by the separation of the actuator assembly from the valve housing. Brinell marks resulted from instantaneous impact, hence showed no direction of rotation. A series of lightly brinelled lines corresponding to needle valve spacing was observed outboard of the bearing wear area extending under the outboard mylar lip seal. These marks were made on the shaft prior to final assembly since similar damage was not reflected in the mylar lip seal. They could have resulted from an attempt to fit an undersized or defective bearing on the drive shaft during assembly.

A section of the head suppression valve seal lip was broken away from the seal. Evidence of tension and compression stresses in the failed area showed that the missing portion of the seal had failed in bending toward the LOX dome which was opposite to the direction of loading had moisture frozen this portion of the seal to the gate. Tests conducted at Rocketdyne indicated that a lip seal frozen to the gate would break free when approximately 400 psi hydraulic pressure was applied to the opening side of the actuator piston. Furthermore, the test seal suffered no deformation.

The head suppression valve gate was deformed on the middle of the upstream edge. Pile up of metal in the deformed area indicated that the impact drove the gate toward the closed position and that the damage occurred after separation of the head suppression actuator assembly.

4. Head Suppression Valve Delay

It has been postulated that the missile 1F HS valve hang up was due to freezing of moisture in the idler shaft bearing. The potentiometer mounted on the end of the drive shaft indicated a 4 to 6 degree opening. Since the measurement of deflection was made at the driven end, the apparent movement of the valve was attributed to torsional deflection of the drive shaft and gate linkage, primarily in the aluminum gate valve. One test run on Sycamore missile 2E exhibited a similar HS valve hangup for approximately 800 milliseconds. Prior to disassembly of the 2E valve, Rocketdyne laboratory tests confirmed freezing of the idler shaft and bearing assembly. Laboratory tests following the 1F incident showed that the gate valve could have hung up due to a combination of factors such as lip seal friction (1100 to 1200 psi actuating pressure), ice on the lip seal (up to 400 psi), and dirt and ice in the idler bearing (up to 800 psi). At the time of HS valve opening, the missile was operating on ground hydraulic supply (2000 psi). Recent Rocketdyne tests do not fully duplicate the 2E/1F valve behavior in that the maximum delay induced was not over 60 milliseconds. Rocketdyne tests are continuing and will be reported separately.

If the HS valve idler shaft froze and broke loose, one would expect to see a spike on the valve position trace as the shaft torque was released. Apparently, the reason why the HS valve position trace does not jump at the start of opening is due to the restricter orifice in the hydraulic return line and to lip seal friction.

Other possible causes of the 1F HS valve behavior investigated were air in the system, contamination in the hydraulic package, and water in the HS valve actuating cylinder.

Rocketdyne tests (14 November 1960 memo) proved that the engine hydraulic system would bleed itself in one-half an hour under 2000 psi inlet pressure without actuation of the hydraulic system. The 1F hydraulic system was in operation more than one hour prior to engine start.

An HS valve actuating cylinder was deliberately contaminated with water to see what would happen if the piston bleed orifice froze. In the final test, water was used without oil and did not freeze under the simulated hold conditions; i.e., 2000 psi and chilled with LN_2.

The tear down inspection of the hydraulic control package showed adequate clearances and free movement of the servo valves. A microscopic examination of the "B" valve showed no sign of foreign object damage. The inlet filter was relatively clean. There was little contamination on the upstream side, no contamination on the downstream side, and no holes in the filter element.

5. Internal Burning

The inside of the sustainer LOX pump exhibited metallic erosion, metallic deposits, and carbon deposits. The nature of the deposits indicated burning before and after the explosion. There was no visual physical evidence of rubbing; however, the surfaces were so badly damaged in the pertinent areas that rub marks would have been obliterated. The most severe burning occurred on the wear ring diverter lip and the matching impeller surface. The diverter lip was burned completely away for approximately 180° of the circumference. Steps on the wear ring labyrinth seal were also burned

but less severely than the diverter lip. Burn patterns on the impeller are fairly uniform around the circumference of the shroud in the labyrinth seal area. Passages inside the impeller were severely burned, with three places on the impeller shroud burned away 1/2 to one inch back from the outside periphery. Flow patterns in this area conform to the direction of flow inside the impeller. There was no burning or rubbing on the back face (balance rib area) of the impeller. The inducer exhibited a limited amount of burning. Large pieces of the inducer blades were broken off on one side. Examination showed that these were cold breaks. Direction of motion during failure was upstream indicating separation after the initial explosion. There was deep erosion in the inlet assembly progressing in the upstream direction. Fire developed in the gaseous boundary layer between the LOX and the inlet assembly interior face, and progressed from areas of higher to lower pressures (upstream). See Appendix B.

The RACO seal was intact but the steel expander was buckled inward in one place (Fig. 14). Molten metal had flowed across the inlet housing and piled up on the downstream edge of the expander (Fig. 15). Heating of the steel expander, insulated from the inlet housing by the teflon portion of the seal, caused it to expand and buckle in compression pushing the aluminum slag built up on the ring away from the inlet housing. One side of the inner edge of the steel expander ring showed several hairline radial cracks in the buckled area. It was noted that although the steel and aluminum surrounding the teflon portion of the seal was severely burned and eroded adjacent to the teflon, the teflon seal material did not show any significant evidence of erosion (Fig. 16).

The bellows in the GD/A Y-duct was torn off the flange and badly mangled indicated mechanical damage rather than failure due to internal pressure (Fig. 17).

The above observations indicate that burning originated at the leading edge of the impeller shroud, probably due to rubbing against the diverter lip.

6. Pump Clearances

The major portion of the turbopump assembly from the inducer, impeller, and aft portion of the LOX pump volute aft through the RP-1 pump, gearcase, and turbine was disassembled and checked against the last known build for proper shims and measurement of clearances. The assembly conformed to the last build, which showed a diverter lip to impeller clearance of 0.041 inch. Running clearance depending upon static and external effects, and dynamic effects without shaft bending could have resulted in a net diverter lip clearance of 0.032 to 0.017 inch. Calculated effects of pump operation against a closed or partially closed HS valve indicated a shaft deflection of 0.020 inch could be experienced due to unbalanced pressures in the volute. Tests conducted at Santa Susana on one pump with various delays in HS valve opening times, showed that in actual operation, larger shaft deflections than those calculated would be experienced, and would have resulted in severe rubbing. With the HS valve opening late, the area of minimum clearance was in a position which would have produced the wear ring damage observed on 1F. It is interesting to note that the area of maximum wear ring damage on 1F was approximately 180° from that experienced on 11F.

7. Gas Generator

The gas generator (GG) was separated from the turbine. The turbine inlet duct was broken just downstream of the flange, leaving the flange attached to the GG. The GG support brace was broken in compression, but remained attached to the GG. The GG dual gate valve and GG injector were found together but sheared off the combustor body. The propellant inlet adapters were broken off the valve. The GG valve actuator was broken off the valve and

found dangling from the engine by the closing hydraulic line. The solid propellant gas generator (SPGG) with its heater were bolted to the GG flange but were separated at the weld to the GG outlet duct (Fig 18). This weld failed as a result of post accident damage, however, it was noted that the weld was sub-standard. There was no evidence of hot gas leaks prior to the fracture.

8. Material in the LOX Dome

An NAS 1144 bolt head, two pieces of the HS valve lip seal, and one piece of Cannon connector were found in the sustainer LOX dome together with dirt, fibrous material, and sand. This foreign material evidently entered the LOX dome after the explosion. The top of the bolt head had been subjected to heat, but the underside was still shiny. An examination of the bolt head showed that it failed due to bending during missile disintegration rather than from over torquing. The piece of Cannon connector showed signs of burning. The piece of lip seal was discolored and one edge showed some evidence of heating. The fibrous material was heavily sooted and burned. Similar fibrous material was found in the skim pond.

D. CONCLUSIONS

1. Conditions conducive to seizure existed within the head suppression valve idler shaft and bearing.

2. Late opening of the head suppression valve caused unbalanced dynamic loads on the LOX pump impeller resulting in excessive deflection of the pump shaft.

3. Rubbing occurred between the impeller and diverter lip as evidenced by excessive burning and erosion in that area.

4. Impeller and diverter lip rubbing resulted in an uncontrolled LOX/aluminum alloy fire severely eroding the wear ring, impeller, and inlet assembly.

5. An explosion occurred in the LOX pump volute shortly after ignition of the LOX/aluminum alloy fire.

6. The head suppression valve was open 45° ± 1° at the time of LOX pump explosion.

7. The weld attaching the SPGG to the GG hot gas duct did not contribute to the accident.

8. The foreign material found in the LOX dome entered after the explosion.

E. CAUSE

The most probable cause of this accident was freezing of the head suppression valve idler shaft and needle bearing assembly.

F. RECOMMENDATIONS

It is recommended that:

1. A study be conducted to determine a method for precluding the presence of moisture in the HS valve idler shaft bearing housing. Possible methods are:

   a) Use of improved lip seal.

   b) Use of a dessicant plug to absorb whatever moisture is ingested into the housing.

2. A study be conducted to determine whether increased ground hydraulic system pressure is advisable.

3. Further studies should be conducted to determine the feasibility of precluding interference between the rotating and stationary elements in the LOX pump. Some possible fixes which should be considered are:

   a) A non-combustible liner such as teflon or Kel-F in the wear ring and inlet assembly which would not cause failure should rubbing occur.

   b) Increased clearances to permit additional shaft deflections.

G. ACTION TAKEN

1. Rocketdyne ECP MA3-186R1 was submitted for improved head suppression valve bearing lip seals and dessicant plugs for the head suppression valve idler shaft bearing housing.

2. Rocketdyne is conducting further studies for the above recommendation of developing a non-combustible liner for the LOX pump wear ring and inlet assembly.

APPENDIX A

APPENDIX B

FROM: K. Rothe, Supervisor, Hydrodynamics Unit

SUBJECT: LOX Pump Explosion - Mk 4; Atlas 1-F Failure at Site S-1; Sycamore Canyon Static Test Site, San Diego, 13 May 1962

Per request of Major Flanders and Mr. S. Berman, a brief inspection of the Mk 4 hardware was made with the special purpose to explain the flame propagation traces found in the pump passages. The inspection of the hardware showed the following:

1) No severe burning of the inducer.

2) No severe burning of the impeller leading edges and impeller hub at the inlet.

3) No burning in the scroll passage with the exception of one spot approximately 40° to 90° downstream of volute tongue.

4) No burning or rubbing in balance rib area of impeller.

5) Severe burning in impeller wear ring area and in two passages of the impeller. In the impeller blade passage the fire progressed from impeller discharge towards the impeller inlet.

6) Severe burning of the housing surrounding the inducer. Here, also, the fire progressed upstream, showing most damage close to the impeller front wear ring and less damage at inducer inlet.

The fire pattern which can be detected from the burned hardware shows that the flames progressed in some areas upstream against the pumped LOX. This is true for the casing surrounding the inducer and for the traces found inside the impeller passages on the impeller back shroud.

Most likely the fire started in the impeller front shroud wear ring and diverter lip area (the area which experienced the most damage) due to rubbing. Wherever it started in this area, the fire proceeded towards the pump inlet and

impeller tip, the only direction in which the fire finds both oxygen and aluminum. Reaching the casting which surrounds the inducer, the fire will travel upstream in the direction of decreasing pressure along the boundary layer of the inducer tip area. It is that area where the inducer tip vortex already generates gaseous oxygen necessary to maintain the fire.

The second major damage occurred at several spots at the shroud of the impeller tip diameter. Here the shroud was locally completely destroyed. After destruction of the shroud, the fire reached the back shroud of the impeller. The developed heat gasefied the LOX and the fire proceeded along the boundary layer of the impeller back shroud in the direction of decreasing pressure and incoming LOX.

The traces left by the fire in the inlet duct, at the impeller inlet, at the inducer blades, and in the impeller front wear ring area only show the motion of the boundary layer in a pump under normal operation. They were formed during the time the fire developed. As soon as the fire was fully developed, normal pump operation was interrupted and no firm prediction can be made as to the direction in which the fire might proceed. In the discussed case it is felt that the rupture of the scroll due to increasing pressure interrupted the burning process as soon as the fire was fully developed.

The total time elapse from fire start to fully developed fire is estimated to be a few milliseconds, say $^{10}/_{1000}$ to $^{20}/_{1000}$.

Summarizing, it can be stated that the fire will always follow the boundary layer flow because

1) the boundary layer flow velocity is low;
2) the direction of the boundary layer flow is always from high pressures to low pressures in stationary parts;
3) in rotating parts the statement under 2) is only true for gaseous boundary layer. In other words, the boundary layer starts to flow in the direction of lower pressure as soon as it has been gasefied.
4) Due to low flow velocities the LOX can be gasefied in the boundary layer without being carried away if enough heat input is provided.

FIGURE 1 VIEW OF TEST SITE

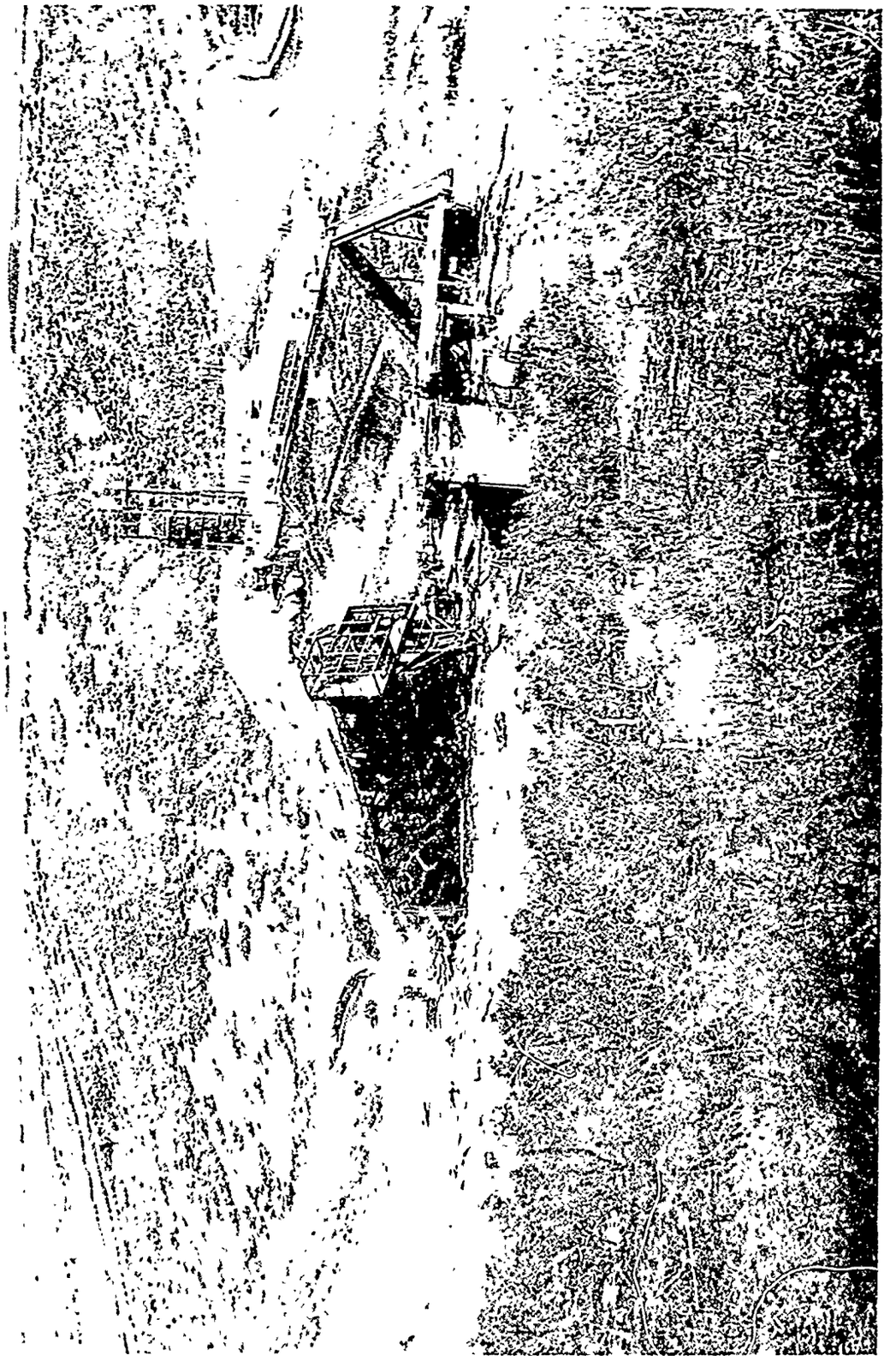

FIGURE 2 SERVICE TOWER

FIGURE 3 SKIM POND DEBRIS

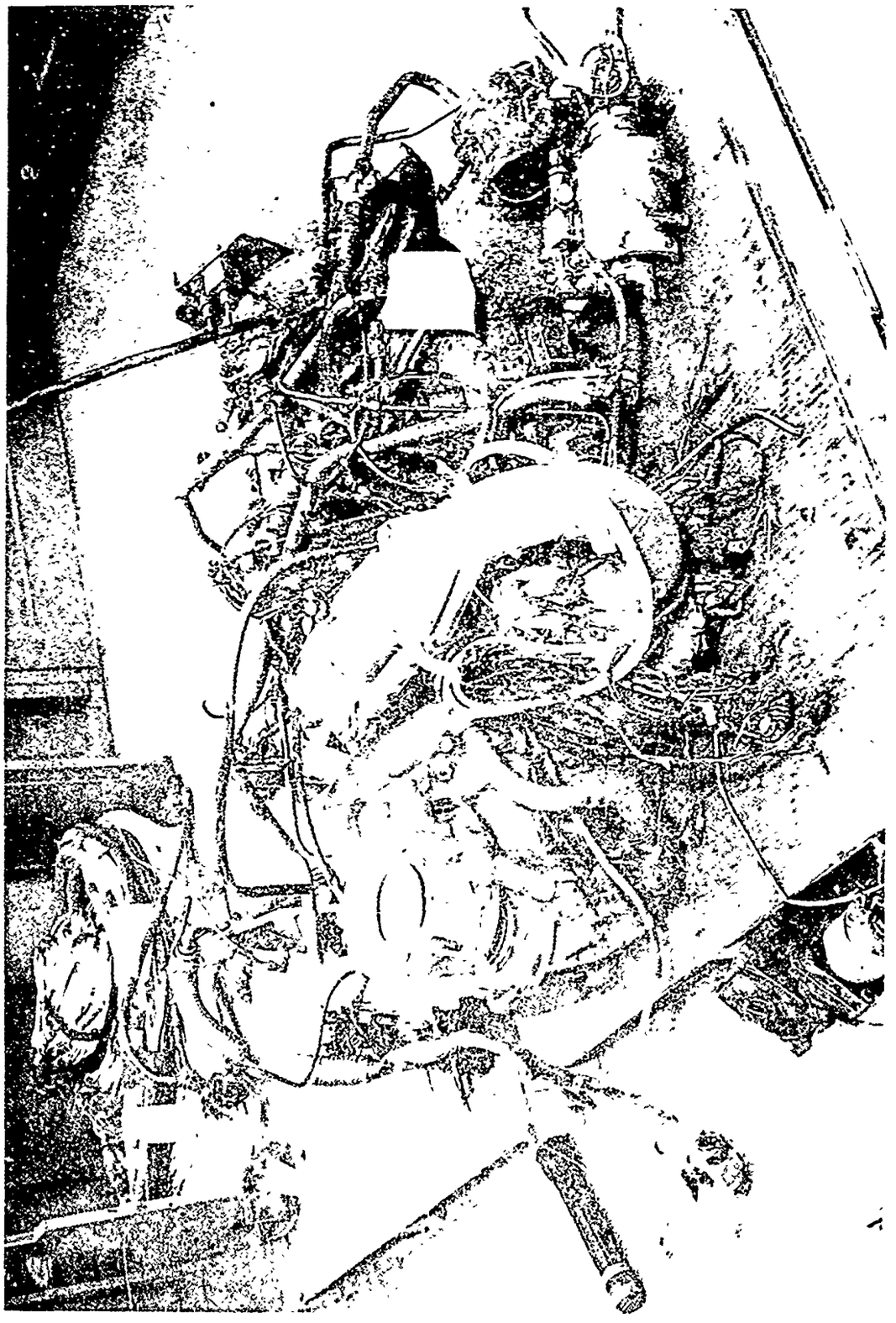

FIGURE 4 FRONT THREE-QUARTER VIEW OF SUSTAINER

FIGURE 5 AFT THREE-QUARTER VIEW OF SUSTAINER

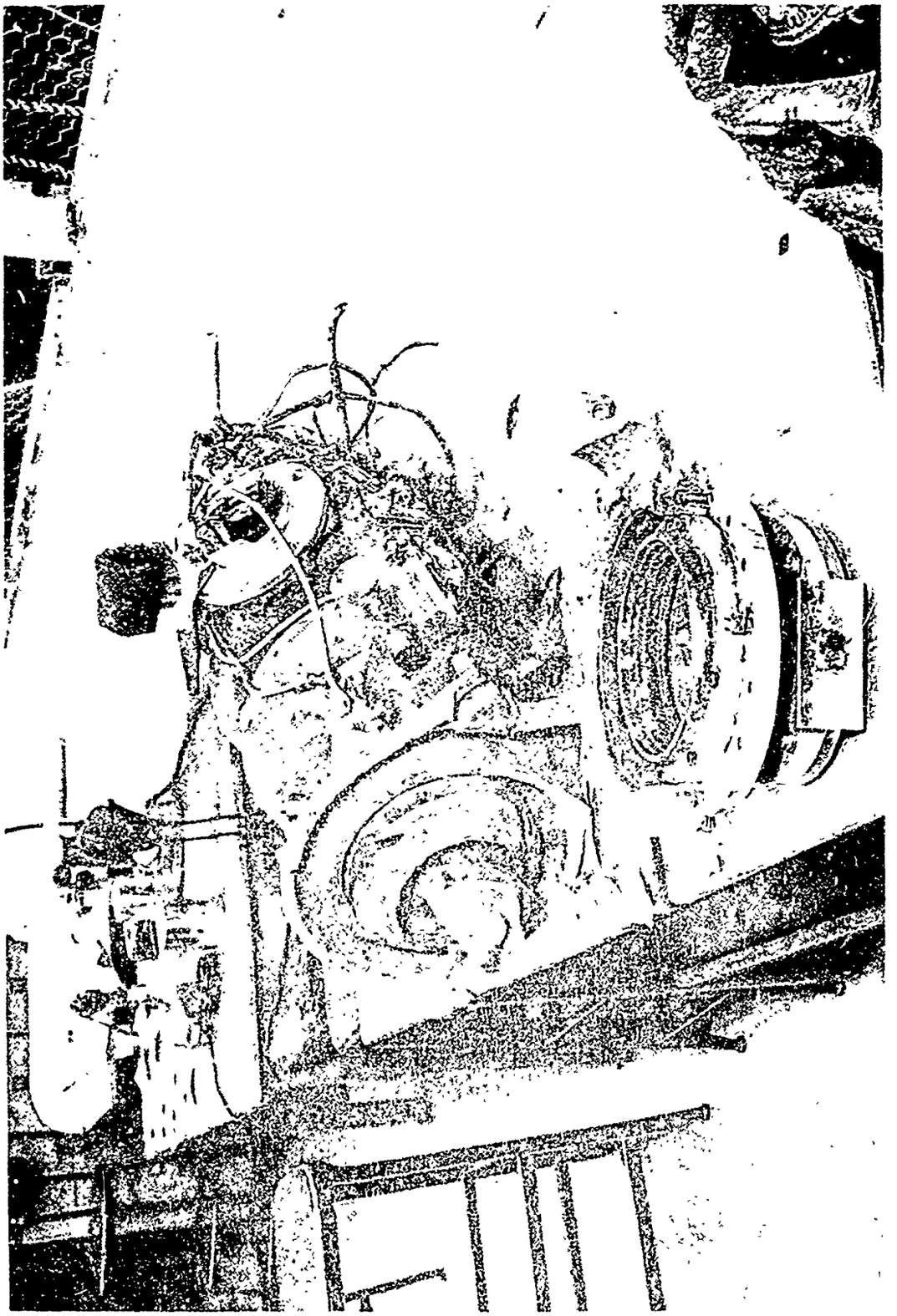

FIGURE 6 TURBOPUMP, INLET END

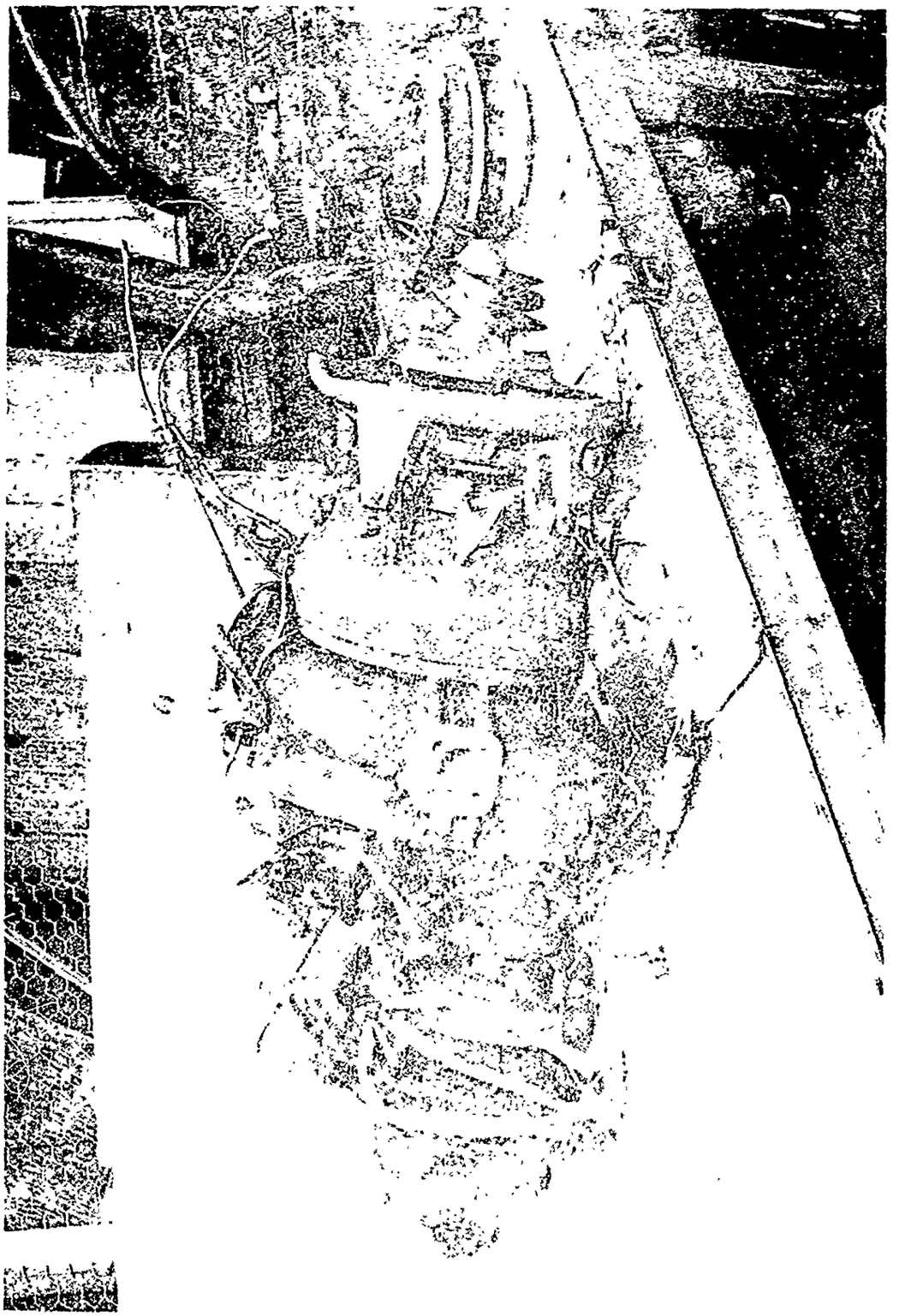

FIGURE 7 TURBOPUMP, RIGHT SIDE

FIGURE 8 RECOVERED PARTS OF PUMP VOLUTE

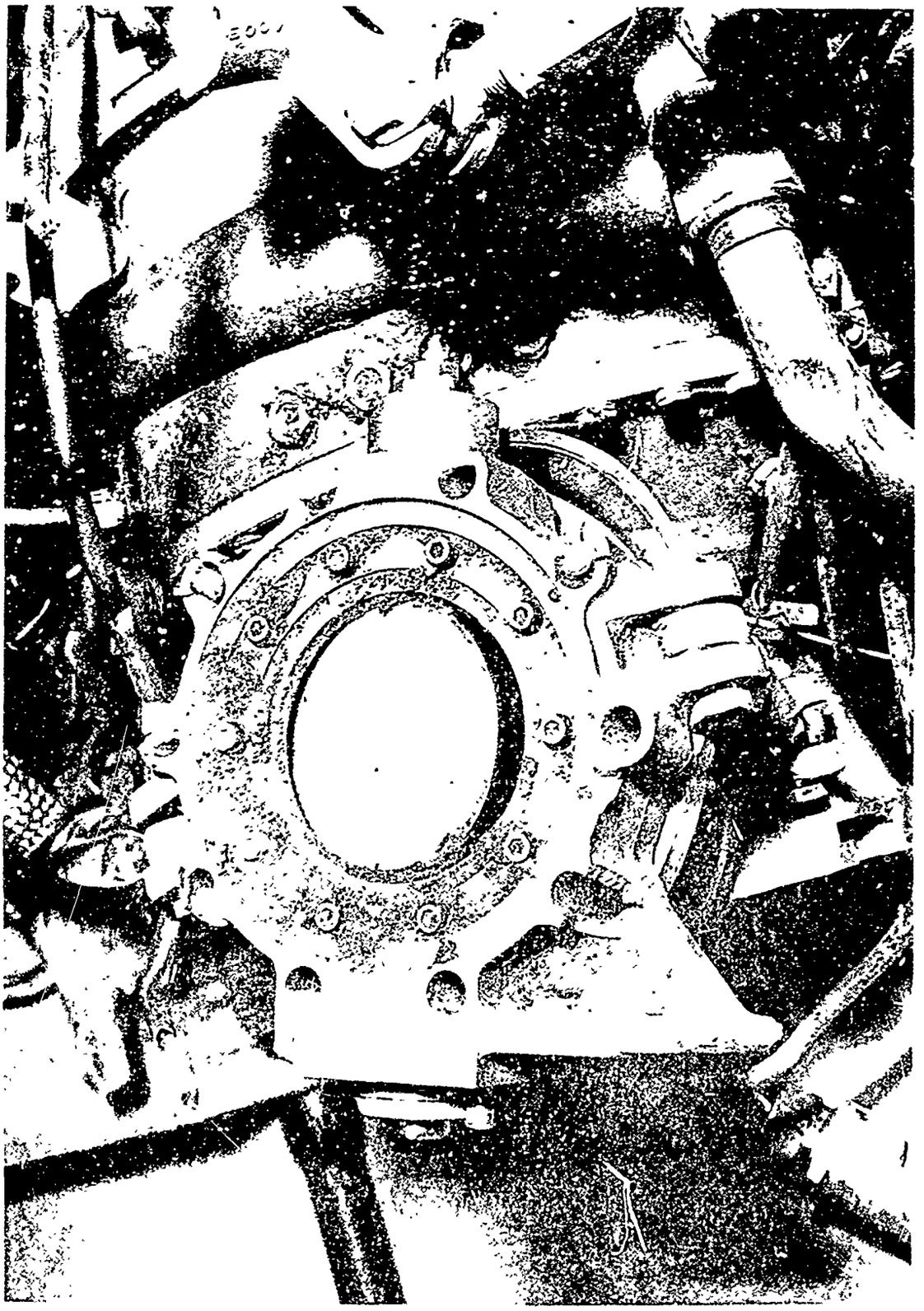

FIGURE 9 INLET SIDE OF HS VALVE

FIGURE 10 RECONSTRUCTION OF HS VALVE DAMAGE

5.5-31

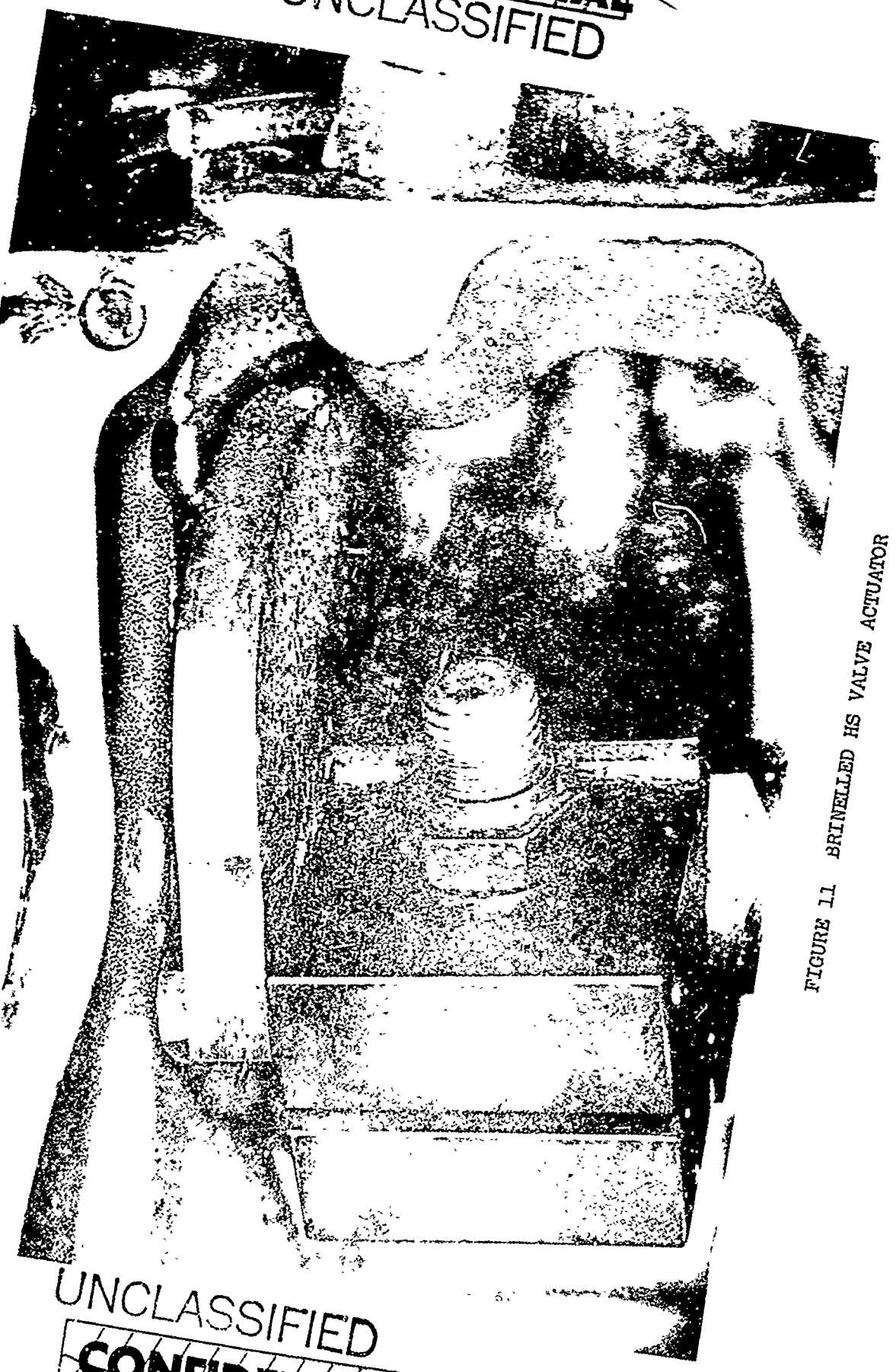

FIGURE 11 BRINELLED HS VALVE ACTUATOR

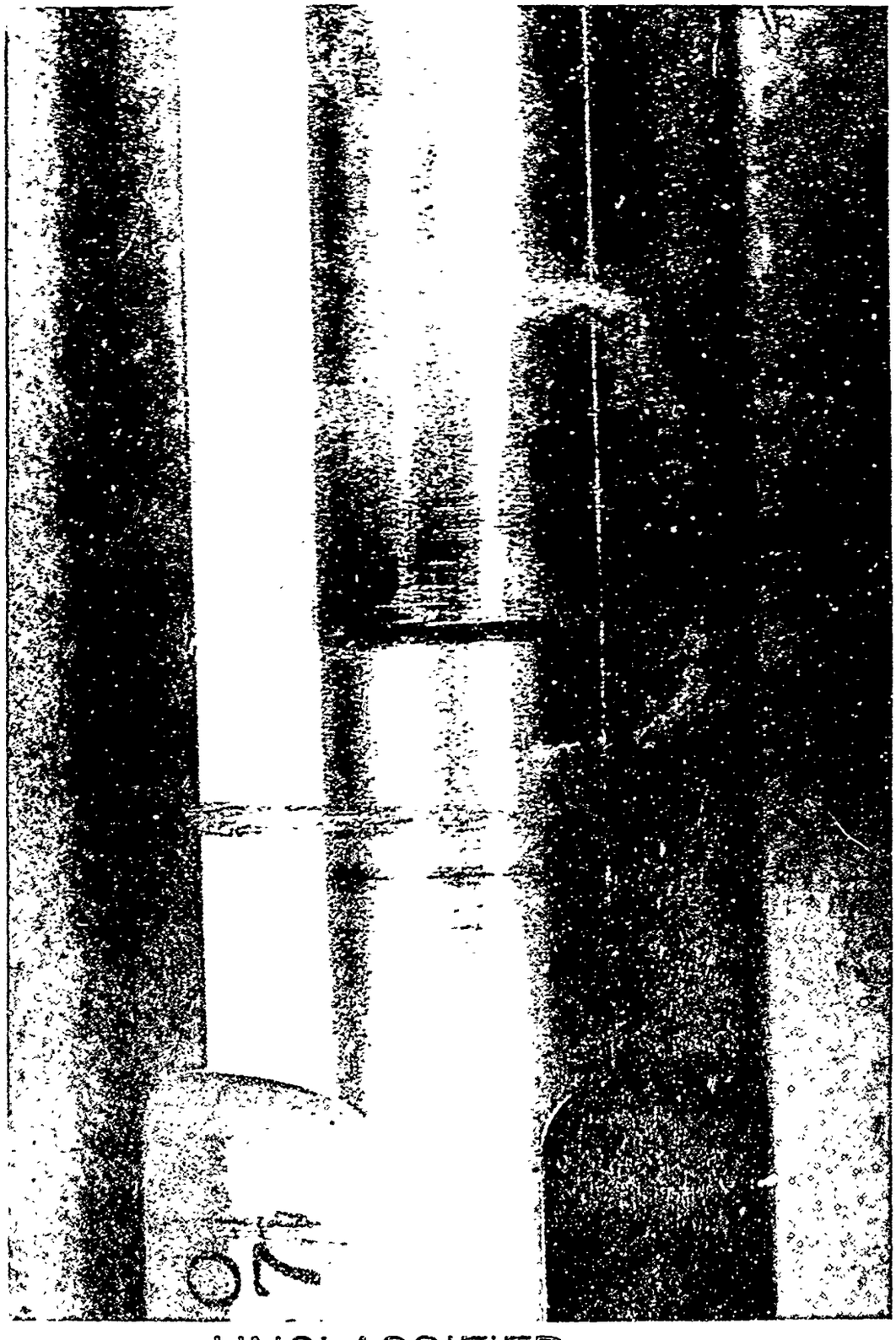

FIGURE 12 HS VALVE IDLER SHAFT

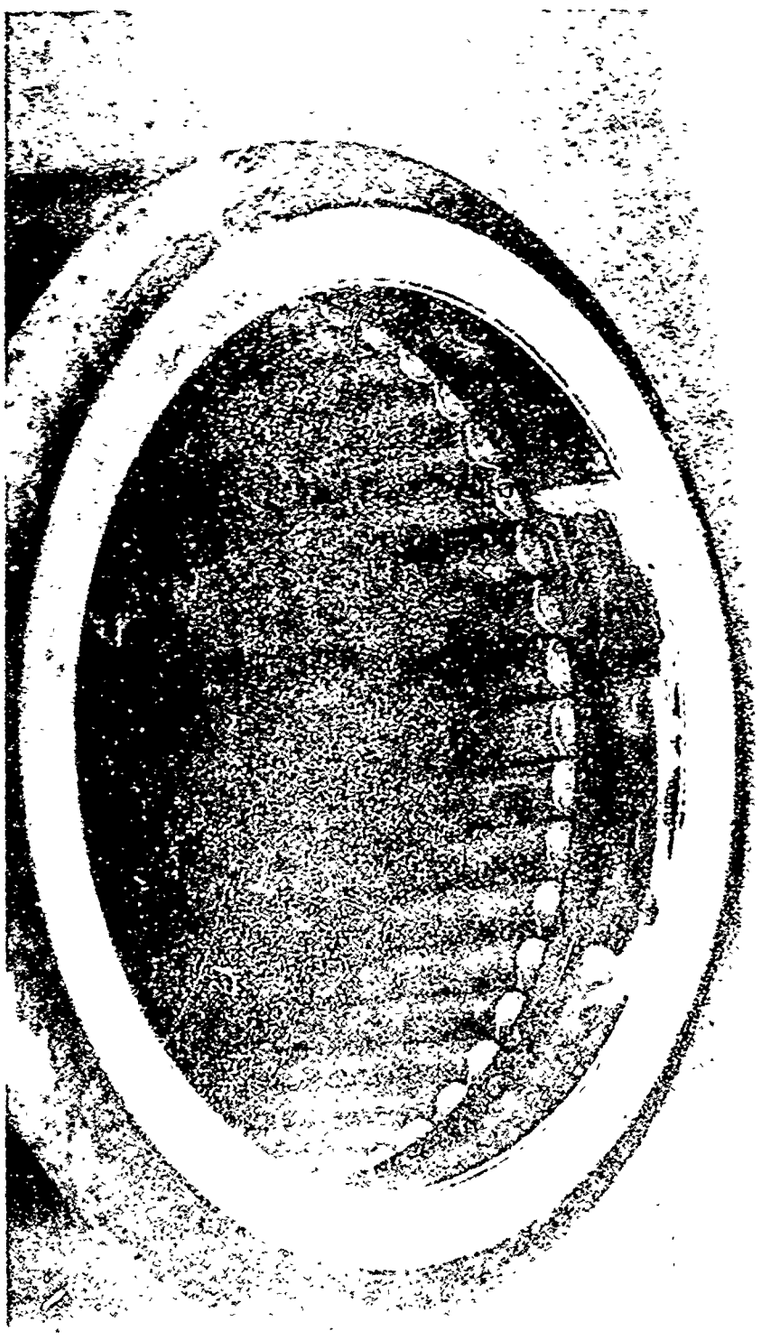

FIGURE 13 HS VALVE IDLER SHAFT BEARING

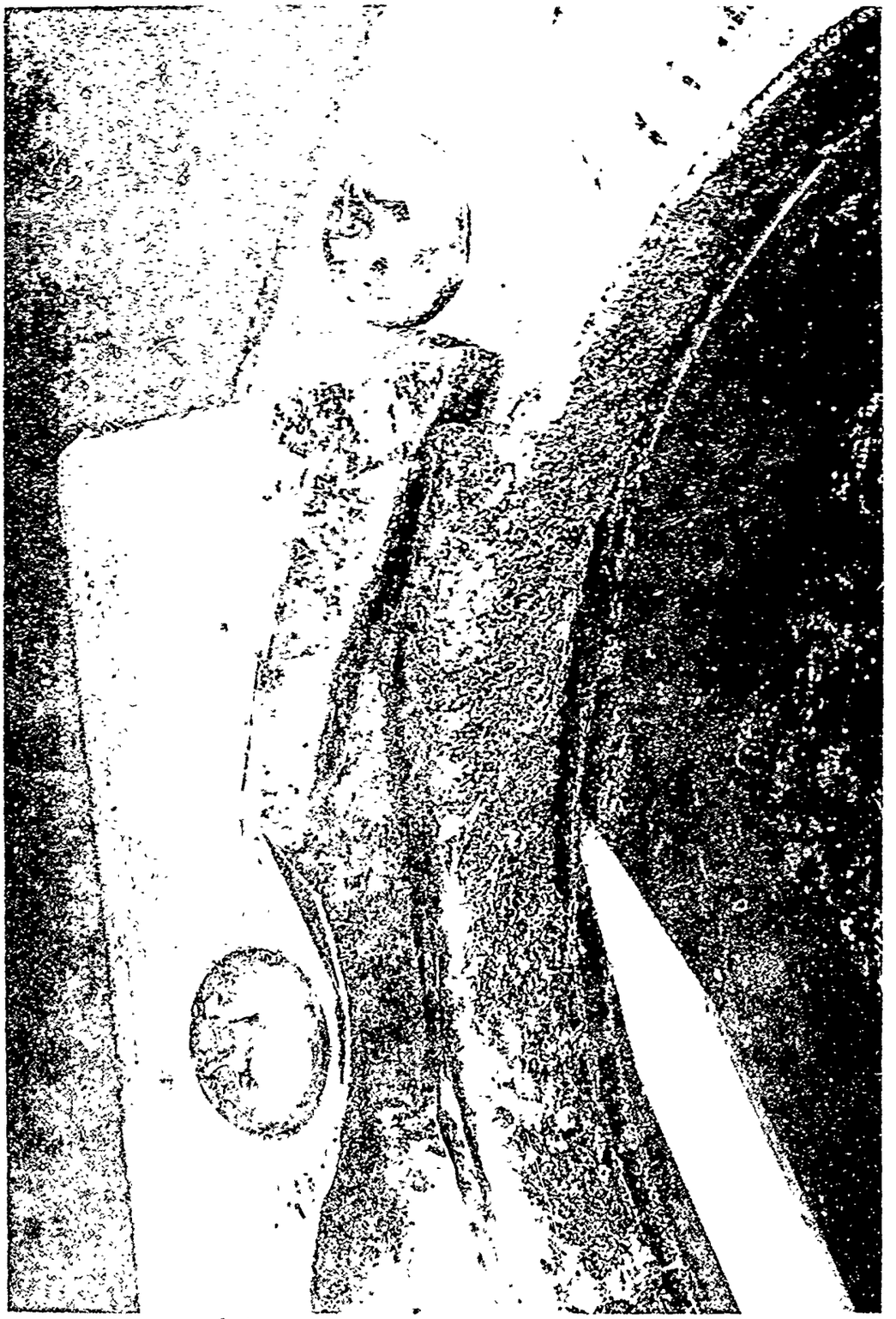

FIGURE 14 DEFORMED INLET SEAL EXPANDER

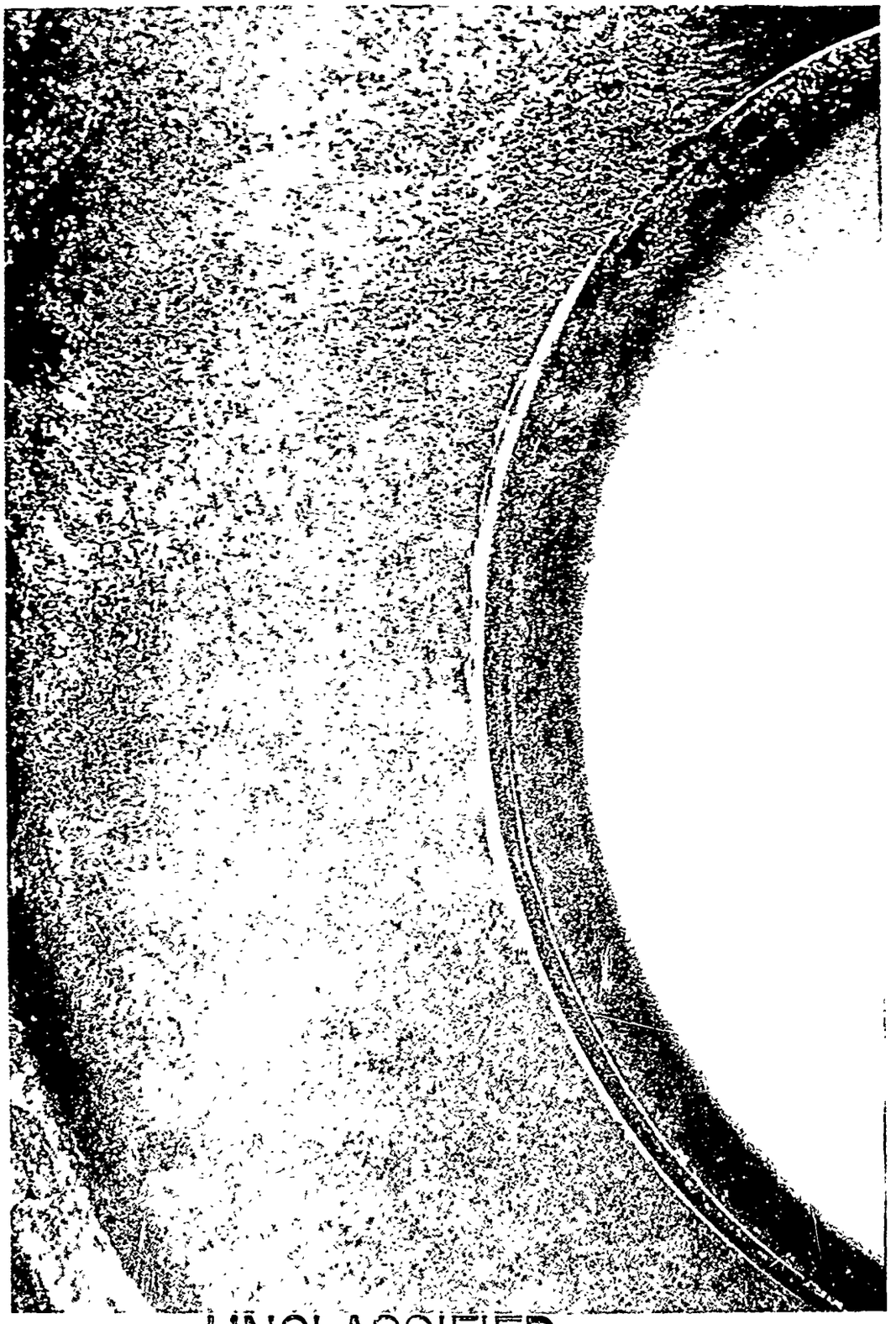

FIGURE 15 DEPOSITS ON INLET SEAL

5.5-36

FIGURE 16 METALLIC EROSION ADJACENT TO INLET SEAL

FIGURE 17 Y-DUCT BELLOWS

5.5-38

FIGURE 18 GG AND SPGG WELD

6.0 ENCLOSURES

6.1 COMMAND NET VOICE TAPE

The following tabulation presents a running account of voice communications during Run 613-14, as recorded from the Command Net. The tabulation starts at X-12 minutes and includes the one hour hold period.

TIME	NAME	CONVERSATION
12/28/21	P.A.:	Mark X minus 12 minutes.
	P.A.:	Set condition red.
	P.A.:	Time is 12:29 PDST
	P.A.:	Start of countdown.
	P.A.:	All personnel remain in assigned blockhouse positions. Transfer room personnel clear the transfer room and report. Test Conductor?
	J. Stewart:	Go ahead.
	R. MaGuire:	Transfer room is cleared.
	J. Stewart:	Thank you.
	P.A.:	X minus 11 minutes 30 seconds, mark!
	T. Cross:	Airborne fill and drain valve in silo position.
	P.A.:	X minus 11 minutes 20 seconds, mark!
	D. Burgess:	Instrumentation on slow.
	P.A.:	X minus 11 minutes, mark!
	P.A.:	X minus 10 minutes 50 seconds, mark!
	N. Skow:	Acoustica ready.
	P.A.:	X minus 10 minutes 40 seconds, mark!
	D. Burgess:	Instrumentation ready.
	T. Cross:	Ground fill and drain valve open.

COMMAND NET VOICE TAPE (Continued)

TIME	NAME	CONVERSATION
12/28/21 (Cont'd)		
	P.A.:	X minus 10 minutes 25 seconds, mark!
	R. Bray:	Pre-start ready.
	P.A.:	X minus 10 minutes 20 seconds, mark!
	D. Burgess:	There will be no standardization of Brown recorders.
	R. Bray:	Shutdown power on.
	P.A.:	T minus 10 minutes 10 seconds, mark!
12/30/04	R. Bray:	Silo operation.
	P.A.:	T minus 10 minutes 5 seconds, mark!
	P.A.:	T minus 10 minutes, mark!
	R. Maguire:	Instrumentation on.
12/30/23	P.A.	T minus 9 minutes 52 seconds, mark!
12/30/23	V. Speer:	Start countdown.
	P.A.:	Minus 9:50...mark. Minus 9:49. Minus 9:47.
	J. Casto:	Hydraulic pressure ok.
	P.A.:	Minus 9:42.
	-----	Fox 1145 normal.
12/30/49	V. Speer:	Start lox chilldown.
	-----	HCU bottle pressure normal.
	-----	Start 2 storage tank ullage normal.
	P.A.:	T minus 9 minutes 17 seconds.

COMMAND NET VOICE TAPE (Continued)

TIME	NAME	CONVERSATION
12/30/49 (Cont'd)		
	-----	Vent 2 pressure complete.
	-----	Pump inlet normal.
	T. Cross:	Lox prefill switch on.
	P.A.:	T minus 9 minutes 12 seconds
		T minus 9 minutes 7 seconds
	J. Stewart:	Report any system No Go.
	P.A.:	T minus 9 minutes, mark!
	Inst:	Indication on Uncle 1080 Peter.
12/31/27	R. Bray:	Start rapid load.
		Garbled - (Two voices at same time)
	P.A.:	T minus 8 minutes 37 seconds, mark!
	-----	Lox storage tank ullage normal.
	P.A.:	T minus 8 minutes 25 seconds, mark!
	R. Bray:	Engine timers ready.
	-----	Mark 10 per cent.
	P.A.:	T minus 8 minutes, mark!
	-----	Mark 20 per cent.
	P.A.:	T minus 7 minutes 52 seconds, mark!
	V. Speer:	Engine and missile power ready.
	-----	Camera power on.
	R. Killian:	Does that look good, Tim?

COMMAND NET VOICE TAPE (Continued)

TIME	NAME	CONVERSATION
12/31/27 (Cont'd)		
	T. Cross:	It looks pretty fast for the first part.
	-----	Mark 30 per cent.
	-----	Mark 40 per cent.
	P.A.:	T minus 7 minutes, mark!
	-----	Mark 50 per cent.
	P.A.:	T minus 6 minutes 52 seconds, mark!
	-----	Mark 60 per cent.
	J. Stewart:	Slowing down.
	-----	Mark 70 per cent.
	P.A.:	T minus 6 minutes, mark!
		T minus 5 minutes 52 seconds, mark!
	-----	Mark 80 per cent.
	P.A.:	T minus 5 minutes 32 seconds, mark!
	-----	Mark 90 per cent.
	P.A.:	T minus 5 min. 22 seconds, mark!
	-----	Nancy 1519 Peter 3 pounds.
	P.A.:	T minus 5 min. 12 seconds, mark!
12/34/59	-----	95 per cent
		Garbled - (Indication on ------)
		L2 closed.
		Nancy 1519 Peter, 2 pounds.

COMMAND NET VOICE TAPE (Continued)

TIME	NAME	CONVERSATION
12/34/59 (Cont'd)		
	P.A.:	T minus 5 minutes, mark!
	T. Cross:	Low topping.
	———	Engine amiss, oops!
12/35/24	T. Cross:	High topping.
	P.A.:	T minus 4 minutes 37 seconds, mark!
	C. Clayborne:	RCC active.
	P.A.:	T minus 4 minutes 22 seconds, mark!
	C. Hyde:	Test readiness measurements satisfactory.
	V. Speer:	Flight control and R/V ready.
	-----	Fox 1952 Peter 120 pounds.
	P.A.:	T minus 4 minutes 7 seconds, mark!
	-----	Nancy 1530 Peter 9.4.
12/36/15	P.A.:	T minus 3 minutes 57 seconds, mark and holding.
	J. Stewart:	Instrumentation prepare for test objective PF30 and PF38. Ready for commit.
	J. Stewart:	Start the 1 hour hold and call out every 10 minutes.
	T. Cross:	Peter 1682 Peter, what do you read?
	-----	1682 Peter is reading 1.4 psid.
	T. Cross:	Roger.

COMMAND NET VOICE TAPE (Continued)

TIME	NAME	CONVERSATION
12/36/15 (Cont'd)		
	-----	.....and going up a little.
	-----	Fox 1952 Peter is slowly decreasing and it's now 105 pounds.
	T. Cross:	Roger.
	T. Cross:	Nancy 1519 Peter, what do you read?
	-----	1.8 pounds.
	T. Cross:	Roger.
	J. Stewart:	Observers can we have a report on the condition of the stand and the missile?
	G. Grande:	Everything normal at the South Tank.
	-----	Everything appears normal at the Blockhouse.
	R. Smay:	North tank reports normal.
	J. Stewart:	Roger, thank you.
	-----	Fox 1952 Peter is rapidly decreasing. It's now 60 pounds.
	T. Cross:	Roger.
	R. Killian:	Gentlemen, we would like to restrict the lunch eating to either the back bay areas or else the basement.
	R. Killian:	No, you're not. When Herb comes back, he will take over these two, ok. And when Rich

COMMAND NET VOICE TAPE (Continued)

TIME	NAME	CONVERSATION
12/36/15	R. Killian: (Cont'd)	
		comes back he'll take this one; and when Miller comes back he'll take this one.
	T. Cross:	Test Conductor ?
	R. Killian:	Go ahead.
	T. Cross:	We just got our first topping cycle at 6 minutes.
	R. Killian:	Roger, good enough.
	T. Cross:	Nancy 1524 Peter, what do you read?
	----	25 pounds.
	T. Cross:	Roger.
	C. Hyde:	Tim, and 1501 is holding very steady at 149.
	T. Cross:	Roger, thank you.
	R. Killian:	Does that 1054 look OK?
	R. Killian:	1054 look OK during tanking?
	T. Cross:	Peter 1682 Peter, what do you read?
	----	Peter 1682 Peter is reading 1.38.
	T. Cross:	Roger.
	T. Cross:	1682 what do you read now?
	-----	1682 Peter is reading 1.4 psig.
	T. Cross:	Roger, let me know at any time if it goes above 1.42.
	-----	Will do.

COMMAND NET VOICE TAPE (Continued)

TIME	NAME	CONVERSATION
12/36/15 (Cont'd)		
	P.A.:	Stand by for hold plus 10 minutes.
	P.A.:	Mark! Hold plus 10 minutes.
	T. Cross:	Nancy 1530 Peter, what do you read?
	T. Cross:	Nancy 1530 Peter, what do you read!
	-----	Coming up.
	-----	Nancy 1530 Peter reads 9 pounds.
	T. Cross:	Roger
	P.A.:	Stand by for hold plus 20 minutes.
	P.A.:	Mark! Hold plus 20 minutes.
	T. Cross:	Nancy 1530 Peter, what do you read?
	-----	8 point.....8.....(Comm trouble).
		I'll try to get it for you in a minute here.
	T. Cross:	Roger.
	-----	8.18.
	T. Cross:	Roger.
	P.A.:	Standby for hold plus 30 minutes.
	P.A.:	Mark! Hold plus 30 minutes.
	T. Cross:	Nancy 1530 Peter, what do you read?
	-----	7.25.
	T. Cross:	Roger.
	T. Cross:	1682, what do you read?
	-----	1.35

COMMAND NET VOICE TAPE (Continued)

TIME	NAME	CONVERSATION
12/36/15 (Cont'd)		
	T. Cross:	Roger.
	T. Cross:	82, what do you read?
	-----	1.35.
	T. Cross:	Roger.
	P.A.:	Standby for hold plus 40 minutes.
	T. Cross:	1682, what do you read?
	-----	1.35.
	T. Cross:	Roger. Did you notice any fluctuation at all?
	P.A.:	Mark! Hold plus 40 minutes.
	-----	It's fluctuating slightly between 1.35, sometimes as high as 1.4.
	T. Cross:	Roger - Good!
	T. Cross:	Nancy 1530 Peter, what do you read?
	-----	6.5.
	T. Cross:	Roger.
	T. Cross:	Nancy 1524 Peter, what do you read?
	-----	Zero or very close to maybe a half a pound.
	T. Cross:	Roger.
	-----	Nancy 1524 Peter is increased to about 4 pounds.
	T. Cross:	Roger. Will you let me know when it hits ten pounds?

COMMAND NET VOICE TAPE (Continued)

TIME	NAME	CONVERSATION
12/36/15 (Cont'd)		
	-----	Affirmative.
	-----	Nancy 1524 Peter indicating 10 pounds.
	T. Cross:	Roger, thank you.
	-----	Nancy 1524 vented down to about 1 pound.
	T. Cross:	Roger.
	T. Cross:	Nancy 1501 Peter, what do you read?
	P.A.:	Standby for hold plus 50 minutes.
	-----	Nancy 1501 Peter reads 155 pounds.
	T. Cross:	Roger.
	P.A.:	Mark! Hold plus 50 minutes.
	R. Killian:	Oh, North Tank?
	R. Smay:	North Tank.
	R. Killian:	How's everything look?
	R. Smay:	Everything's normal.
	R. Killian:	South Tank?
	G. Grande:	Everything's normal.
	R. Killian:	Blockhouse?
	-----	Appears normal from here.
	R. Killian:	Roger. Periscope?
	-----	Normal from here.
	R. Killian:	OK.

COMMAND NET VOICE TAPE (Continued)

TIME	NAME	CONVERSATION
12/36/15 (Cont'd)		
	R. Killian:	We would like everyone to within the next 5 minutes close out their lunch period and resume their countdown stations.
	R. Killian:	Would like hold time called out at hold plus 55 minutes, Murphy, and hold plus one hour.
	-----	Nancy 1524 Peter indicates 10 pounds.
	T. Cross:	Roger.
	R. Killian:	At hold plus 55 minutes, I expect everyone to be on their countdown stations, on the job. I expect them to review all their console status as well as measurement status. Report anything which is of a questionable nature, so that at hold plus one hour we can pick up a systems readiness check.
	P.A.:	Mark! Hold plus 55 minutes.
	J. Stewart:	Instrumentation, did you get your FM tapes changed all right?
	-----	All tapes changed. Instrumentation ready.
	T. Cross:	Nancy 1530 Peter, What do you read?
	----	5.4
	T. Cross:	Roger. Nancy 1501 Peter, what do you read?

COMMAND NET VOICE TAPE (Continued)

TIME	NAME	CONVERSATION
12/36/15 (Cont'd)		
	-----	155 psi.
	T. Cross:	Roger.
	-----	152, correction.
	T. Cross:	Roger. Nancy 1530 Peter, what do you read?
	-----	5.4 on Nancy 1530 Peter.
	T. Cross:	Roger.
	T. Cross:	Fox 1952 Peter, what do you read?
	-----	2 pounds.
	T. Cross:	Roger.
	R. Killian:	South Tank, do you have LN2 vapors going back up into the bucket?
	G. Grande:	No, we don't Roy.
	R. Killian:	North tank, do you have any evidence of vapors coming out from underneath the thrust section?
	R. Smay:	I see vapors around the LN2 overboard duct and just about in the center between Quads I and II.
	R. Killian:	OK. Those are probably coming from the engine control bottle.
	R. Smay:	Right.
	T. Cross:	Test Conductor?
	J. Stewart:	Go ahead.

COMMAND NET VOICE TAPE (Continued)

TIME	NAME	CONVERSATION
12/36/15 (Cont'd)		
	T. Cross:	Lox system is satisfactory.
	R. Killian:	What does 1290 Tare read?
	J. Stewart:	Thank you.
	-----	Plus 50, Roy.
	R. Killian:	Plus what?
	-----	Plus 50 degrees.
	R. Killian:	Roger.
	R. Killian:	OK. We are getting kind of low on engine control supply pressure, I mean supply temperature.
	J. Stewart:	Roger. Place the Step three permit over-ride switch on.
	H. Lipp:	Step three over-ride switch on.
	R. Killian:	We should be watching or paying particular attention to 1474 Peter.
	-----	Test readiness measurement satisfactory.
	R. Killian:	With this cold temperature, particularly at the vernier tanks pressurized.
	J. Stewart:	Could I have a report on the Nancy 1530 Peter?
	-----	Nancy 1530 Peter 5.25.
	J. Stewart:	Thank you.
	J. Stewart:	Report system readiness when called out.

COMMAND NET VOICE TAPE (Continued)

TIME	NAME	CONVERSATION
12/36/15 (Cont'd)		
	J. Stewart:	Facility Power?
	H. Taylor:	Go!
	J. Stewart:	Missile Power?
	H. Taylor:	Go!
	J. Stewart:	Flame Deflector?
	G. Richardson:	Go!
	J. Stewart:	Firex?
	G. Richardson:	Go!
	J. Stewart:	Pneumatic?
	R. Masters:	Go!
	J. Stewart:	Lox?
	T. Cross:	Go!
	J. Stewart:	Fuel?
	T. Cross:	Go!
	J. Stewart:	Purge?
	E. Miller:	Go!
	J. Stewart:	Autopilot?
	J. Casto:	Go!
	J. Stewart:	Hydraulic?
	J. Casto:	Go!
	J. Stewart:	Engine Test?
	H. Lipp:	Go!

COMMAND NET VOICE TAPE (Continued)

TIME	NAME	CONVERSATION
12/36/15 (Cont'd)		
	J. Stewart:	Auxiliary Control?
	H. Lipp:	Go!
	J. Stewart:	Test Conductor Console?
	R. Bray:	Go!
	J. Stewart:	Launch Officer Console?
	V. Speer:	Go!
	J. Stewart:	Instrumentation?
	R. MaGuire:	Go!
	J. Stewart:	RCC?
	C. Clayborne:	Go!
	J. Stewart:	Acoustica?
	N. Skow:	Go!
	N. Skow:	Acoustica dialed in sensor Station 2.
	J. Stewart:	Well, I didn't request it yet.
	N. Skow:	Are you going to request it?
	G. Grande:	Test Conductor?
	J. Stewart:	Go ahead.
	G. Grande:	We have an indication of heavy frost around the inside of the thrust section around the lower edge in Quad IV.
	J. Stewart:	Around the fireshield?
	G. Grande:	Roger.

COMMAND NET VOICE TAPE (Continued)

TIME	NAME	CONVERSATION
12/36/15 (Cont'd)		
	R. Killian:	Around the fireshield, George?
	G. Grande:	Yes, Roy.
	P.A.:	Standby for hold plus one hour.
	R. Killian:	OK, can you tell what the status of the vernier lox vent bleed is?
	G. Grande:	Seem to be getting.....
	P.A.:	Mark! Hold plus one hour.
	G. Grande:	We seem to be getting some liquid out of it.
	R. Killian:	Okay.
	R. Killian:	Do you see any ....is it external on the thrust section in that area, George?
	G. Grande:	Well, it's hard to tell from here, Roy. It shows a heavy frost on the outside.
	R. Killian:	Well, what I'm trying to find out, is it right on the X-X axis in the area where the topping fill line goes in, or is it over in the Quad IV area between the sustainer and the booster where the vernier lox vent line comes out?
	G. Grande:	Seems to run from Quad III all the way over to Quad IV, Roy.

COMMAND NET VOICE TAPE (Continued)

TIME	NAME	CONVERSATION
12/36/15 (Cont'd)		
	R. Killian:	All the way from Quad III to Quad IV. Where does it start in Quad III?
	G. Grande:	Approximately the lower camera area.
	R. Killian:	Lower camera area and how far over into Quad IV?
	G. Grande:	All the way over to the nacelle.
	R. Killian:	All the way over to the nacelle?
	J. Stewart:	Can we have the camera operator pan that camera over?
	R. Killian:	Well, it's been some time since we held for an hour, George. Do you have any.....were you on any of the operations where we held for an hour?
	G. Grande:	Yes, I was, Roy. I never noticed this before.
	J. Stewart:	You'll have to pan it up there.
	R. Killian:	No, I'd be particularly not, since we have held for an hour recently, George, but sometimes in the past whenever we had thrust section ambient in and we held for an hour, the Quad IV area always had a considerable habit of being extremely low. We have been

COMMAND NET VOICE TAPE (Continued)

TIME	NAME	CONVERSATION
12/36/15 (Cont'd)		
	R. Killian: (Cont'd)	
		filling the LN2 shouds for sometime and topping all this time.
	G. Grande:	Roger.
	R. Killian:	Plus the fact we have excellent observation conditions today.
	R. Killian:	How does the thrust section ambient look?
	-----	Normal.
	R. Killian:	All normal?
	-----	All normal.
	R. Killian:	Nothing at all that's lower than normal? Or unusual on a short hold?
	-----	Nope, they are all normal.
	R. Killian:	Dave, do we still have the instrumentation in for the Support Rod in Quad IV that we used on the Soak Evaluations?
	D. Burgess:	Negative, I don't think we do.
	R. Killian:	There are an awfully lot of ambients hangling around up there, and I would like to know what the status is of the circuitry. Far as I know none of it has been pulled out.

COMMAND NET VOICE TAPE (Continued)

TIME	NAME	CONVERSATION
12/36/15 (Cont'd)		
	W. Melendez:	This is correct, Roy, but they are still in for print, but not connected electrically on the 1800 series.
	R. Killian:	How far does it come to?
	R. Killian:	Is it disconnected the in J Box?
	W. Melendez:	It's disconnected electrically, right.
	R. Killian:	No, he can do it.
	R. Killian:	George, how far up on the barrel section does the frost go?
	G. Grande:	Approximately 18 inches, Roy.
	R. Killian:	OK.
	R. Killian:	Is it fairly heavy?
	G. Grande:	Not particularly heavy, just shows an indication of being white and frosted up.
	R. Killian:	OK.
	R. Killian:	You can't see any part of the fire shield underneath, can you?
	G. Grande:	No, I can't Roy.
	R. Killian:	How about the disconnect there? Is it heavily frosted? Should be.
	G. Grande:	Yes, there is quite a bit of frost there.
	R. Killian:	OK.

COMMAND NET VOICE TAPE (Continued)

TIME	NAME	CONVERSATION
12/36/15 (Cont'd)		
	R. Killian:	OK, Jim, let's pick it up.
	J. Stewart:	OK, Tim, how's the lox level?
	T. Cross:	Nancy 1530 Peter?
	-----	4.75
	T. Cross:	Roger, lox level satisfactory.
	J. Stewart:	Roger.
	J. Stewart:	Acoustica, dial in sensor station #2 and report.
	N. Skow:	Sensor station #2 has been dialed in.
	J. Stewart:	Roger.
	J. Stewart:	Switch all instrumentation to fast and report.
	R. MaGuire:	All instrumentation on fast.
13/40/51	J. Stewart:	Press start commit.
	V. Speer:	Start commit power internal amber.
	V. Speer:	Power internal green.
	P.A.:	Mark T minus 3 minutes 43 seconds.
	R. Masters:	Step III Light.
	R. Masters:	Boiloff valve closed light.
	P.A.:	T minus 3 minutes 27 seconds, mark!
		T minus 3 minutes 24 seconds, mark!

COMMAND NET VOICE TAPE (Continued)

TIME	NAME	CONVERSATION
13/42/14	R. Masters J. Casto	Internal..... Oil evacuation..... (simultaneously)
	P.A.:	Minus 3 minutes 20 seconds, mark!
	H. Taylor:	Inverter on.
	T. Cross:	Hi Topping.
	P.A.:	T minus 3 minutes 12 seconds, mark!
	-----	1582 reading 135 at high topping.
	P.A.:	T minus 3 minutes, mark!
	P.A.:	T minus 2 minutes 43 seconds, mark!
	P.A.:	T minus 2 minutes 35 seconds, mark!
	T. Cross:	100%
	P.A.:	T minus 2 minutes 33 seconds, mark!
	-----	Missile lift up and locked in amber.
	----	T minus 2 minutes 30 seconds.
	R. MaGuire:	T 3 on.
	R. Killian:	Lock Topping tank is vented, Tim.
	T. Cross:	Roger.
	P.A.:	T minus 2 minutes 23 seconds, mark!
		Vapors to LN2 vent duct.
	P.A.:	T minus 2 minutes, mark!
	R. Killian:	Say it again, Smitty.
		Vapors to LN2 vent duct is venting the tank.

COMMAND NET VOICE TAPE (Continued)

TIME	NAME	CONVERSATION
13/42/14 (Cont'd)		
	R. Killian:	Roger.
	P.A.:	T minus 1 minute 50 seconds, mark!
	G. Richardson:	Start main deflector water.
	P.A.:	T minus 1 minute 42 seconds, mark!
	R. Killian:	Will that thing run on local? Will that recorder run on local? If it will put it on local and let's have local control.
	P.A.:	T minus 1 minute 25 seconds, mark!
	-----	Won't run anyway.
	P.A.:	T minus 1 minute 18 seconds, mark!
	P.A.:	T minus 60 seconds, mark!
	G. Richardson:	Launcher coolant on. Start vernier flame deflector.
	R. Killian:	Remember, gentlemen, ignition start may occur before the time count runs out or slightly after. Do not panic.
	P.A.:	Minus 50 seconds.
	R. Smay:	North tank water ready.
	P.A.:	Minus 40 seconds.
	P.A.:	Minus 30 seconds.
	J. Stewart:	South tank, report water system.
	G. Grande:	Water OK.

COMMAND NET VOICE TAPE (Continued)

TIME	NAME	CONVERSATION
13/42/14 (Cont'd)		
	P.A.:	Minus 20 seconds.
	P.A.:	Minus 18 seconds.
	G. Richardson:	Engine CO2 on.
	R. Killian:	Hey George, you'll have to speak up; we can barely hear you.
	P.A.:	Minus 15 sec.
	R. MaGuire:	T 2 on.
	P.A.:	Minus 10 seconds.
	P.A.:	Nine.
	P.A.:	Eight.
	P.A.:	Seven.
	P.A.:	Six.
	P.A.:	Five.
	R. MaGuire:	Run camera's on.
	P.A.:	Four.
	P.A.:	Three.
	P.A.:	Two.
	P.A.:	One.
	P.A.:	Zero.
13/45/38	R. Killian:	Ignition Start.
	P.A.:	One.

COMMAND NET VOICE TAPE (Continued)

TIME	NAME	CONVERSATION
13/45/38 (Cont'd)		
	P.A.:	Two.
	-----	Horn.
	R. Killian:	Cutoff and all water on!
		All water on!!
		All water on!!
		All water on!!
		All water on!!
		All water on!!
13/45/50 (Approximately)		
		From this point on, many bits of conversation are on tape but quite unintelligible due to lack of volume and noise interference.
	R. Killian:	Ready to explode!!!!!!!
	(Unintelligible talking and noise)	
	-----	Lost everything, we lost everything, tower and all.
	R. Killian:	OK. Gil, will you call out the Fire Dept., please?
	H. Gillespie:	Affirmative.
	R. Killian:	Turn off tower fog.

COMMAND NET VOICE TAPE (Continued)

TIME	NAME	CONVERSATION
13/45/50 Approximately (Cont'd)		
	R. Killian:	Cutoff the topping tank.
	R. Killian:	Excuse me.
	R. Killian:	Leave the topping tank on.
	(Unintelligible conversation)	
	R. Killian:	No need to go to the Annex, just hold everything down, till Security's in the area.
	R. Killian:	Security - Security - Security Control!
	-----	Will someone see if we have any telephone communications and get in contact with Security Control, please?
	H. Gillespie:	This is Security Control - Go ahead.
	-----	Missile tank pressure has dropped off.... hit cutoff button.....
	-----	Missile lox tank pressure has dropped off.... all water.....
	J. Stewart:	Instrumentation on slow.
	R. MaGuire:	Instrumentation on slow.
	T. Sickich:	Testing one, two, three, four.
	T. Sickich:	Testing one, two, three, four.
	-----	59 huh?

COMMAND NET VOICE TAPE (Continued)

TIME	NAME	CONVERSATION
13/45/38	Approximately (Cont'd)	
	T. Sickich:	Let's see, John, help me get all these stand lines will ya? Get everything from 60 down except don't touch 85; well, let's see--85's out there.
	----	Did you get Security yet?

6.2 OFFICIAL OBSERVERS REPORTS

Presented in this section are the official observer, console operator, recorder monitor, and countdown caller reports as presented to the test conductor subsequent to termination of the run. The reports have been transcribed from the command net voice tape and edited so as to include only pertinent conversation.

SOUTH TANK

Jim Stewart:	OK. South Tank would like to review once more what you observed.
George Grande:	At the time of ignition start, I observed fire which was a larger than usual fire; it seemed to be all about.. ...oops! think we're losing communication again. It seemed to be all about the bottom of the missile, lower edge of it, Jim, and it spread quite rapidly. As soon as I seen this I was sure I knew what was gonna happen so I ducked into the tank at the time I seen the fire and reported FIRE, and I no sooner got into the tank when it did explode and I yelled out EXPLOSION.
Stewart:	OK. Did you cut or press your cut-off button?
Grande:	No, Jim. As soon as I seen the fire I knew it was gonna happen so I ducked in. I didn't have time to even think about touching the button.
Stewart:	OK. And the condition of the silo topping tank?
Grande:	At the time?
Stewart:	No, after the explosion.
Grande:	After the explosion it seemed to be all right. There's a...like I say...part of the stand was down over the top of the area there but it seems to be OK.

6.2 OFFICIAL OBSERVERS REPORTS (Continued)

Stewart: And the condition of the rapid load tank?

Grande: There is part of the, oh, stand and debris on top of the area but the tank itself seemed to be OK.

Stewart: And the condition of the GN2 pre-fab?

Grande: The GN2 pre-fab is in fairly good condition other than debris around it.

Stewart: And the GN2 storage vessels?

Grande: The GN2 storage vessels themselves are intact; the H---compressor has the...lids and stuff blown off of it.

Stewart: The fuel transfer unit.

Grande: It is OK. There's debris around the area, but other than that it seems to be OK.

NORTH TANK

Stewart: OK. North tank. You want to review your observations.

Reginal Smay: At the time of ignition start; right at ignition start it seemed like a normal ignition but this kept; this got larger until the flames billowed out under the thrust section and on the outside of the thrust section; at this time I realized it was an explosion, and I hollered EXPLOSION and reached for my cut-off button And at the same time, I dropped down into the tank and it exploded before I could actually push the cut-off button. In the explosion we had debris, we had one helium ball light on the hill up here and roll down next just on the other side of the escape road. It's laying down here in the canyon now. It seemed to be aflame as it rolled down. And I don't know how much other debris was in the air at the time.

6.2 OFFICIAL OBSERVERS REPORTS (Continued)

Stewart: You didn't observe the verniers lighting off?

Smay: I saw no sign of vernier ignition. I believe the explosion was before time for vernier ignition.

Stewart: And the concentration of the explosion was at the bottom of the missile?

Smay: At the bottom of the missile. In fact I saw no.....

Stewart: ....initial explosion?

Smay: ...initial explosion from this side, it just looked like big flames had billowed out almost simultaneously with ignition; with ignition start.

Stewart: In your direction, right?

Smay: From this direction.

Stewart: OK. South tank?

Grande: Go ahead, Jim.

Stewart: Did you see flames from your direction or towards your direction:

Grande: You mean, at the explosion or the .....

Stewart: When you first noticed the flames and the fire.

Grande: No, Jim. They just seemed to spread rapidly, very rapidly out of the area from underneath the bottom part of the missile.

Stewart: Roger. Thank you.

TEST CONDUCTOR CONSOLE OPERATOR

Royce Bray: Observations from commit phase and start. Everything was normal up until ignition start. I was watching for the R&D operation light.

6.2 OFFICIAL OBSERVERS REPORTS (Continued)

Royce Bray: (Continued) Before the R&D operation light came on there was delta p and the explosion. I reached for the stop button, it was already red, it was already cut off. The light had not come on when I heard either the DP or the explosion. No, I don't know which I heard first. It probablycame on with the cutoff.

Roy Killian: Jim, do you have any comments?

Stewart: The only thing is I did observe the R&D light on after the explosion.

Killian: Which one?

Stewart: The one on the Test Conductor's Console.

Killian: I mean which explosion?

Stewart: The second.

Killian: This before the shock wave?

Stewart: I can't recall.

Killian: I will add something to that.

LAUNCH OFFICERS CONSOLE OPERATOR

Verle Speers: All indications on the LCC was normal up until the time of the DPC sounded.

Killian: Do you have any recollection when the DP sounded, because I don't remember it sounding, but that's beside the point.

Speers: All I know, I got my engine start light normal and just hard to pin point any time.

Killian: Had you heard any buzzer yet to signify that we had gone back to R&D?

Speers: No.

6.2 OFFICIAL OBSERVERS REPORTS (Continued)

COUNTDOWN CALLER

Killian: Do you have anything as far as observations are concerned?

Charles Murphy: I did hear the buzzer on the LOC when it came on the delta p. I believe that was shortly after ignition, it sounded just prior to autopilot beginning to call run time.

MISSILE POWER FACILITY POWER MONITOR

Harley Taylor: Everything over here looked normal until explosion.

PNEUMATICS

Roy Masters: Everything on the pneumatics panel looked normal. I was watching the tank pressures up to the apparent explosion. At the same time I observed emergency buttons.

Killian: Were you looking at your tank pressure meters at all?

Masters: Yes, I was and the tank pressures, the helium and delta p monitor all were normal.

LOX TANKING

Tim Cross: Everything was normal. We seemed to have a normal rate decrease in lox. The explosion happened about lox topping drop out. We set up for a drain immediately after DP went off.

FUEL TANKING AND PURGE

Edward Miller: On the fuel tanking, everything was normal. On the purge, I had a switch to turn on at three seconds and it seemed that at the time I reached for it everything happened.

HYDRAULICS AND AUTOPILOT

James Casto: Hydraulics was normal. I remember that we did

6.2 OFFICIAL OBSERVERS REPORTS (Continued)

HYDRAULICS AND AUTOPILOT (Continued)

James Casto: (Continued) drop back to R&D control...it sounded like a normal start and except for that slight delay from zero time and then immediately after the explosion they dropped out missile AC and DC and we indicated a load on the panel by dim lights so we killed panel power at this time.

Killian: Jim, did you call any time second count at all?

Casto: Yes, it seems like I called up to about one or two numbers and that's when the explosion occurred. 1 or 2 seconds, I don't recall.

Bill Middendorf: Autopilot seemed to be normal up until the time of ignition. Booster start transients appeared to be okay, but sustainer start transients went immediately off scale until the explosion and we lost everything. The time indicator on the test programmer is stopped at 2.3 seconds which may be an indication of the time the explosion actually occurred.

ENGINE TEST PANEL AND OBSERVER CONTROL - FACILITY POWER

Herbert Lipp: On the auxiliary control we got a cutoff right after engine start and I hollered CUTOFF, and then the explosion, maybe about the same time.

INSTRUMENTATION CONTROL

Dave Burgess: It just so happened, Roy, I was watching the TV screen at the time. Normally I don't, but I was at this time, and it appeared that there was just too much fire. Normally you can sense that the amount of fire is correct. But there was just too much fire and it was apparent that there was evidently a lox rich atmosphere or something that was causing extra flames.

6.2 OFFICIAL OBSERVERS REPORTS (Continued)

INSTRUMENTATION CONTROL (Continued)

Killian: I'd like to go around the thrust section ambients.

Bill Melendez: Red Lines - P1677 was normal throughout until the blast when it pegged up positive. 1712 was riding normal at all times until the blast. 1325 was riding normal at all times. On 1710 it was riding normal and before, oh, at ccmmit start, ignition, it gave a very slight pip, oh, about one increment. Wasn't anything great, but that is the only thing I ever saw on it.

Killian: Did you ever have any response on any of them as far as fire?

Melendez: No, nothing. Oh, after the blast everything went up.

Killian: That's what I'm saying, but before that nothing. What do you have on 1711 and 1290 and indications?

Ray Neises: No, 1711 was okay, of course, until after, and 1290 also normal.

Killian: Okay. Do you have anything as far as 1474, 1027, 1030?

Edward Leonard: No, I watched 74 right up to ignition start, and it was normal and at ignition start I shifted over to these two red lines. They seemed to be working normal and then it happened so quick that they just went right down again.

Killian: How about the PU valve - Do you have anything as to how it responded.

Leonard: Yes, it started up, I don't think it went up as high as it usually does and then it started down into the red line lower reading line, but this time we had cutoffs etc.

6.2 OFFICIAL OBSERVERS REPORTS (Continued)

ON SUSTAINER TEMP AND SUSTAINER LUBE OIL

Tony Tangorra:	On sustainer temp, it went up banged out normal and all the way to the end and then it went right down.
Killian:	About the lube oil.
Tangorra:	The lube I had got a good look at that because I was watching the two second ones first.
Killian:	You didn't see anything at all?
Tangorra:	No.
Killian:	How about B-1 combustion temp and lube oil?
Joe Semancsin:	B-1 and P1713T came up within two seconds and then somebody was hollering to put the water on - it dropped down, dropping down, and P1714T came up too within time, but didn't go down right away.
Killian:	Okay. Did both of them appear normal at start for SPGG's, Joe?
Semancsin:	Well, I believe this one could have been a little bit sluggish, but they both came up.
Killian:	Okay. Had they come out of the red lines and started back in?
Semancsin:	They didn't go all the way to the 1300 dgf. They came up to about 1200 dgf and dropped a little bit.
Killian:	Started back to normal?
Semancsin:	That's right.
Killian:	Good. Lube oils.
Arthur MacGregor:	P1473, P1272P both started to rise, but we were only about 2 ½ seconds, and we got an explosion, and they dropped right back.

6.2 OFFICIAL OBSERVERS REPORTS (Continued)

HYRDRAULIC RETURN PRESSURE

Paul Battenberg: At your command of "all water on" sustainer hydraulic pressure spiked to the right.

Killian: What happened at start, Paul, as far as the two hydraulic pressures. I mean the two hydraulic pressures?

Battenberg: They were normal and about your command at "all water on" the sustainer spiked and that caught my attention and I didn't get the booster.

Killian: Okay. How about the booster and sustainer hydraulic supply pressures?

Lee Smith: They were normal up until start. Apparently at the same time you yelled, "water on" I caught a flash in my eyes and at this time before I could even turn to the window looking, one time the booster had started up and then down the other was spiking erratic, but it had not spiked erratic until your command of "all water on".

Killian: Okay. Any other recorder monitors have anything to report?

Don Hart: On the pump speeds, I was watching B1 and B2 and both of these came up and I think that B2 dropped out and B1 was still up.

Killian: Records will verify. This is only for backup information - not for the purpose of determining whether anybody missed anything on their observation etc. just to see if there is anything that people can add that will further add to the data.

Killian: Do you have anything to report Charlie Oliver?

Charles Oliver: Really not much in addition to what's been said. I was watching measurements generally not any in particular.

Killian: How about the pump inlet temps?

Oliver: Pump inlet temps - they were good at start - and they were well within. Generally start transients looked normal and that is about as far as they went.

6.2 OFFICIAL OBSERVERS REPORTS (Continued)

HYDRAULIC RETURN PRESSURE

Charles Hyde: I was observing F1001 and 1003 at start. I saw what I feel to be a normal transient. It seemed that start occurred approximately two seconds after the countdown caller had called zero time. I then observed the ambients after the explosion and all the ambients that I could see were pegged positive.

Killian: Is there anyone in the back-bay Brown CEC or FM and Sanborn that has anything to report? - with regards to the pump inlet pressures, PCU pressures, temps, etc.?

Jay Barham: The lox pump inlet pressure seemed kind of sluggish, they came up and then they started back down. There was an engineer in here.

Killian: We can get that from Bill Sweitzer. How about any of the other temps or valve positions etc.?

Barham: Only at time of explosion did the new P1098D pegged negative.

Sam Bradsher: Lox pressure reg inlet temp seemed to be functioning normally until the time of the explosion.

Killian: F1115T.

Bradsher: It is clear.

Killian: Do you have ideas as to what it was reading?

Bradsher: Approximately 200 to 225 dgf.

Killian: Negative 200 to 225 dgf or positive?

Bradsher: Positive.

Don Hass: Sanborn measurements all seemed to go up to the time of firing and then after that we did get some vibrations.

6.2 OFFICIAL OBSERVERS REPORTS (Continued)

COMMUNICATIONS

Tom Sickish:	Everything was normal with me, until the vibration rather.
Killian:	Okay, I just wondered if you heard anything.
Sickish:	No, the boiloff valve was normal and everything else.
Clarence Cleyborne:	This RCC - everything seemed normal at the initiation ignition and then about two seconds later all of the channels started counting and the only one that actually showed a cutoff light was B1 able. The one that was nervous yesterday.
Killian:	Okay. Acoustica?
N. M. Skow:	Acoustica was normal right up to the explosion and then we lost power.
Killian:	Okay. The only thing I have to add is what I think - - - - nothing - - I think the performance was excellent, people.

6.3 PHOTOGRAPHS

Presentsd in the following section are pertinent photographs of Sycamore Site 1 damage.

Figure 6.3-1 Test stand area from pipeline trestle.
Figure 6.3-2 View of service tower from parking lot behind lox storage area.
Figure 6.3-3 Test stand area from fuel farm looking toward blockhouse.
Figure 6.3-4 View of the service tower and facility equipment.
Figure 6.3-5 Site 1 Blockhouse Annex interior.
Figure 6.3-6 Site 1 Utility Building.
Figure 6.3-7 Sustainer combustion chamber as recovered from skim pond.
Figure 6.3-8 Sustainer combustion chamber after partial clean-up.
Figure 6.3-9 Sustainer lox duct adapter and part of broken lox pump volute.
Figure 6.3-10 Portions of the sustainer low pressure ducting.
Figure 6.3-11 Sustainer turbopump.
Figure 6.3-12 Sustainer turbopump.
Figure 6.3-13 Head suppression valve actuator housing.
Figure 6.3-14 Head suppression valve actuator shown in position on the thrust chamber.
Figure 6.3-15 Booster injector plate and fuel staging disconnect - forward half.
Figure 6.3-16 B1 turbopump assembly found wedged into tower structure.
Figure 6.3-17 Damaged booster turbine assembly.
Figure 6.3-18 Parts of B2 turbopump.
Figure 6.3-19 B2 turbopump components
Figure 6.3-20 Damaged propulsion system hardware - primarily B2 components.
Figure 6.3-21 Airborne pneumatics hardware.

~~CONFIDENTIAL~~
UNCLASSIFIED

FIGURE 6.3-1

TEST STAND AREA FROM PIPELINE TRESTLE
(Neg. No. 87765A)

UNCLASSIFIED
~~CONFIDENTIAL~~

FIGURE 6.3-2

VIEW OF SERVICE TOWER FROM PARKING LOT BEHIND LOX STORAGE AREA
(Neg. No. 877794)

FIGURE 6.3-3

TEST STAND AREA FROM FUEL FARM LOOKING TOWARD BLOCKHOUSE. LOX CONTROL PREFAB VISIBLE NEAR SERVICE TOWER.
(Neg. No. 87833A)

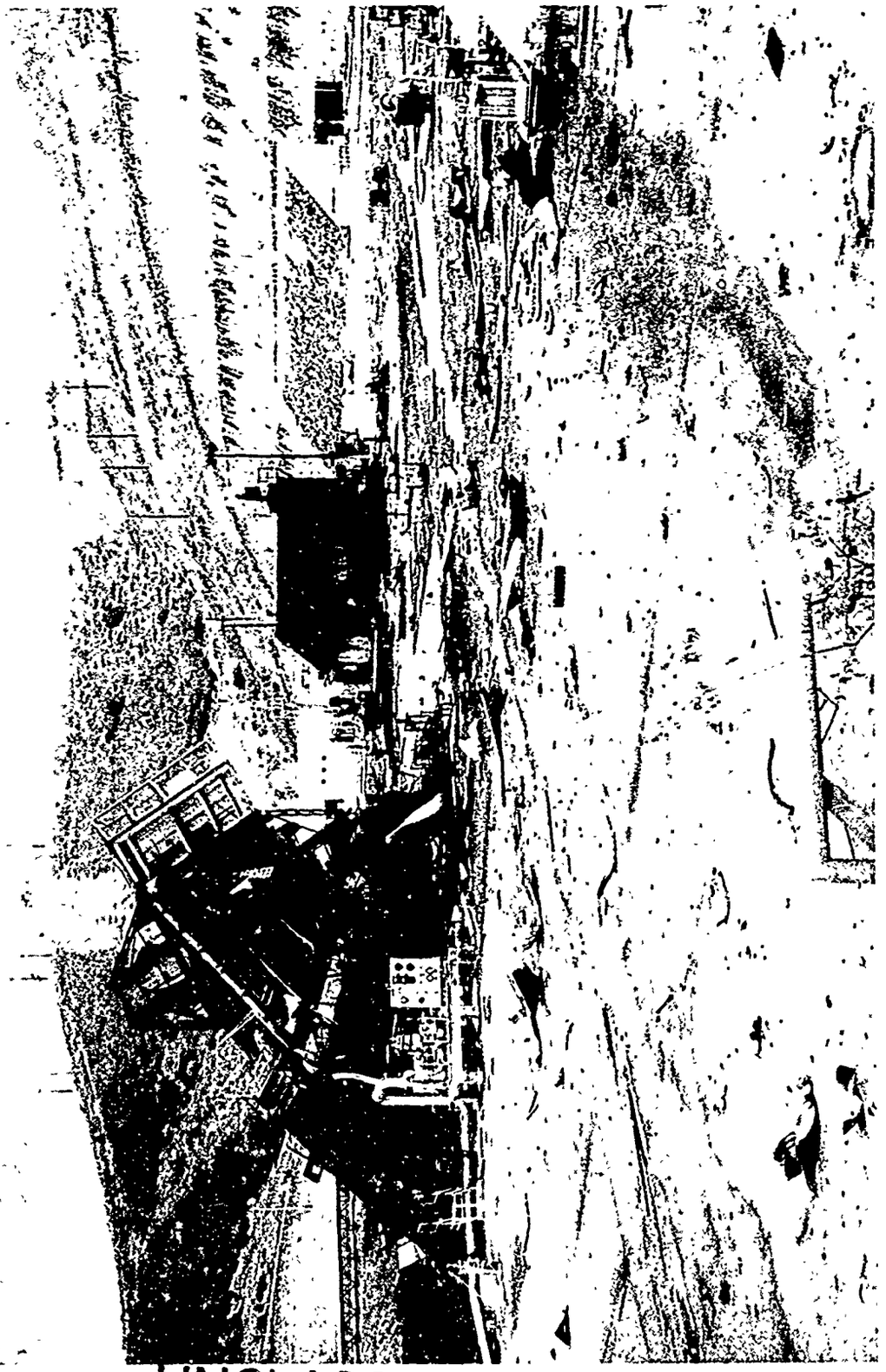

FIGURE 6.3-4

VIEW OF THE SERVICE TOWER AND FACILITY EQUIPMENT (Neg. No. 87773A)

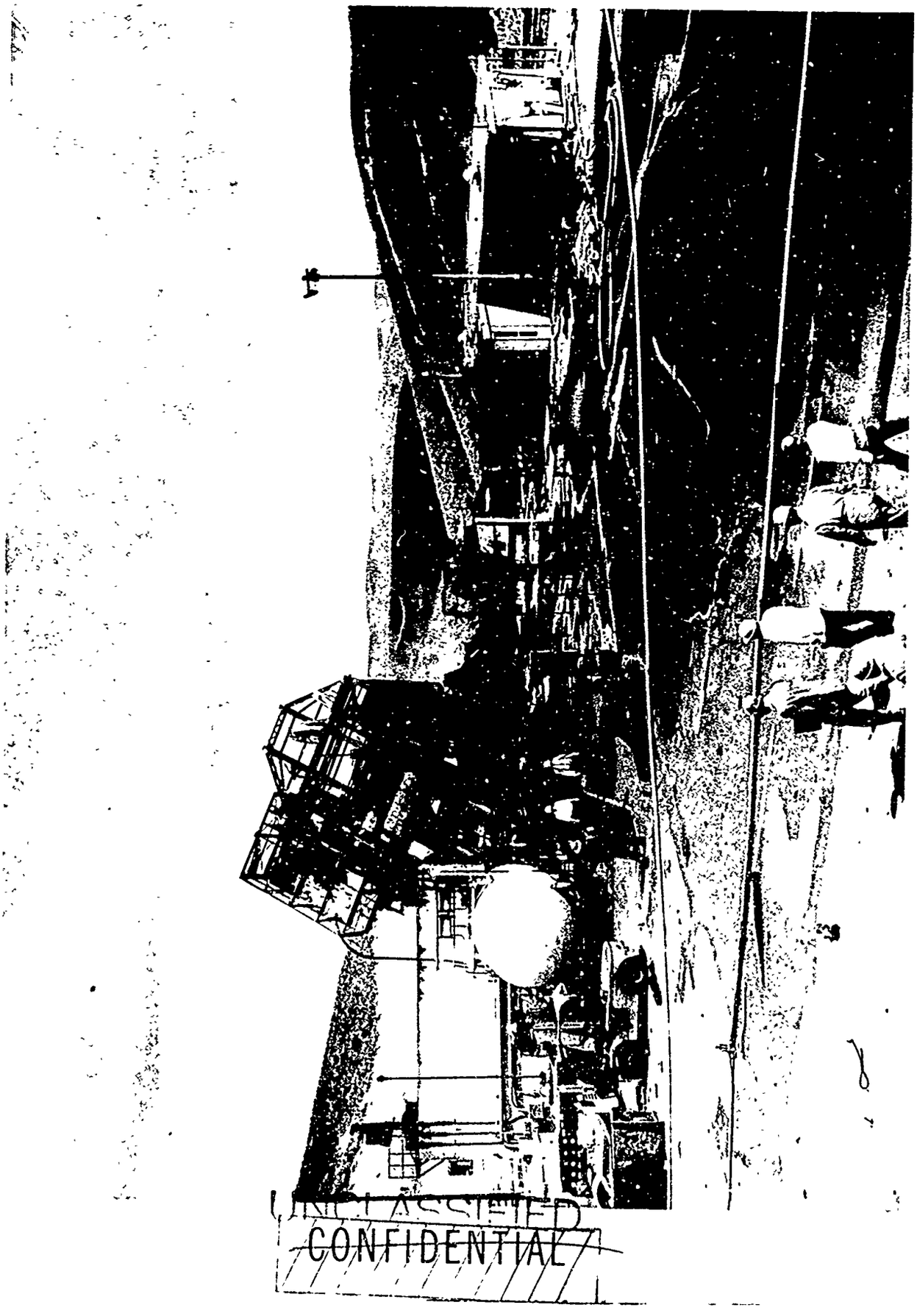

FIGURE 6.3-5

S1 BLOCKHOUSE ANNEX INTERIOR
(Neg. No. 87642A)

FIGURE 6.3-6

S4 UTILITY BUILDING
(Neg. No. 87635A)

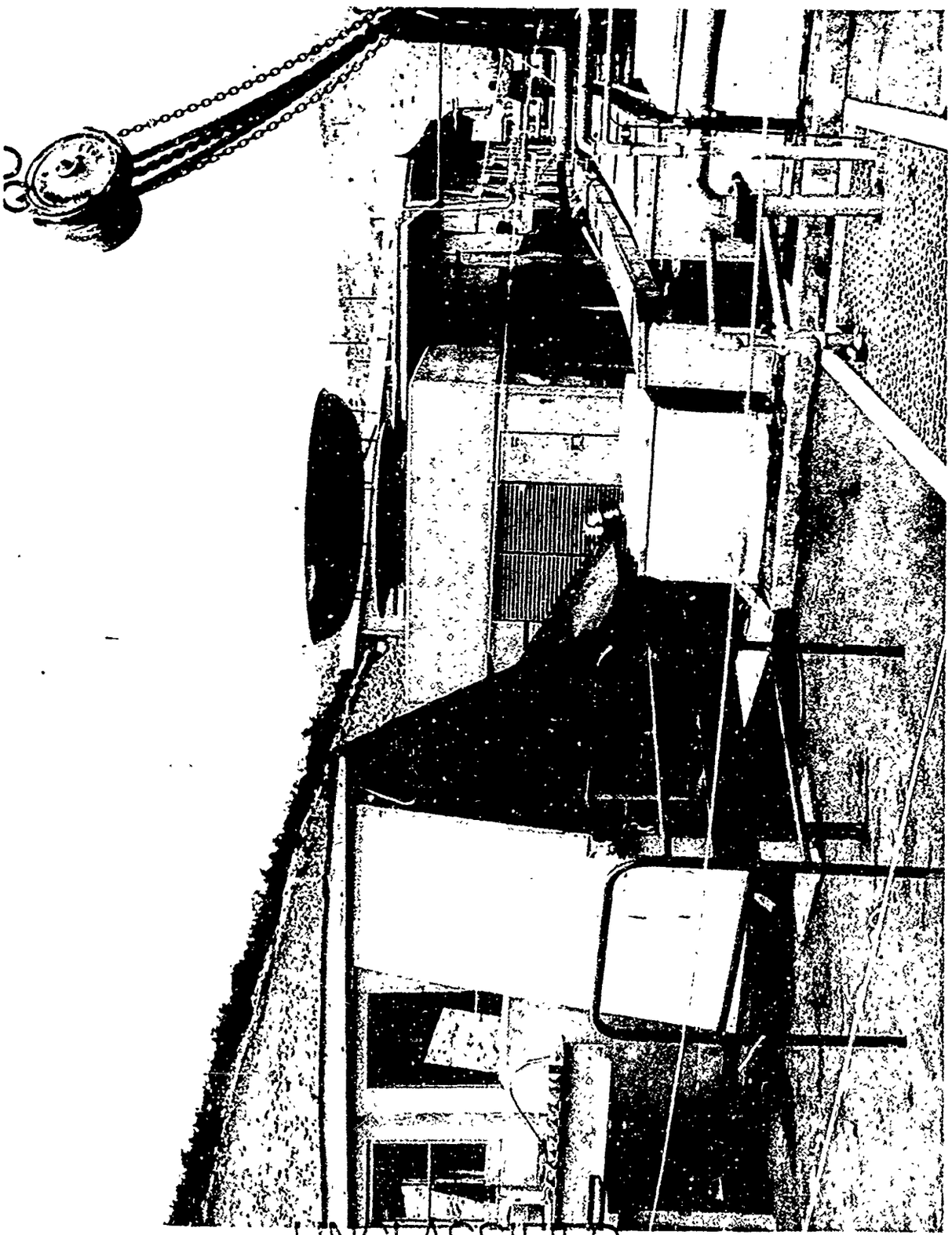

FIGURE 6.3-7

SUSTAINER COMBUSTION CHAMBER
AS RECOVERED FROM SKIM POND
(Neg. No. 87862A)

FIGURE 6.3-8

SUSTAINER COMBUSTION CHAMBER
AFTER PARTIAL CLEAN-UP
(Neg. No. 87864A)

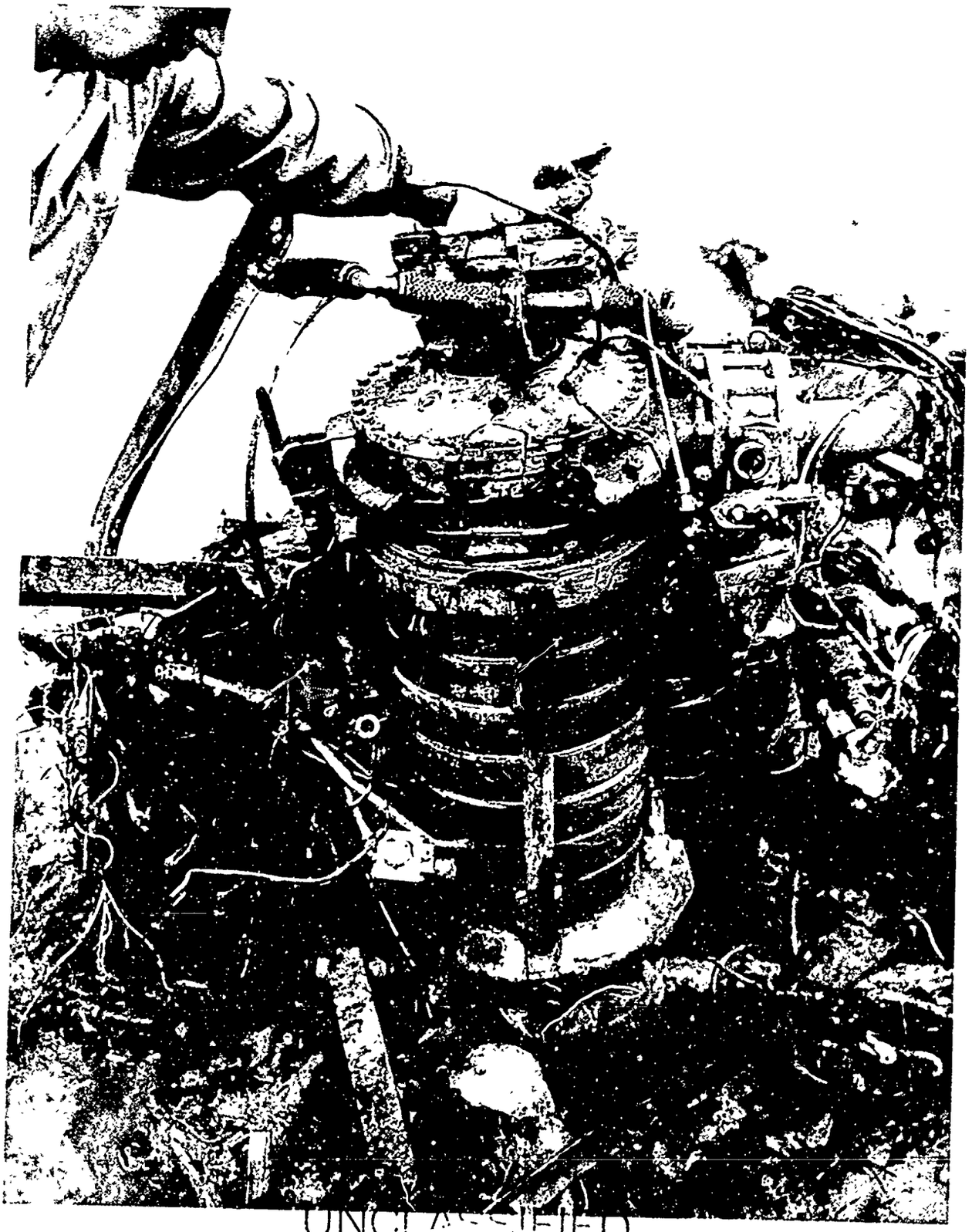

FIGURE 6.3-9

SUSTAINER LOX DUCT ADAPTER AND PART OF BROKEN LOX PUMP VOLUTE (Neg. No. 87912A)

FIGURE 6.3-10

PORTIONS OF THE SUSTAINER LOW PRESSURE LOX DUCTING (Neg. No. 88024A)

FIGURE 6.3-11

SUSTAINER TURBOPUMP
(Neg. No. 88029A)

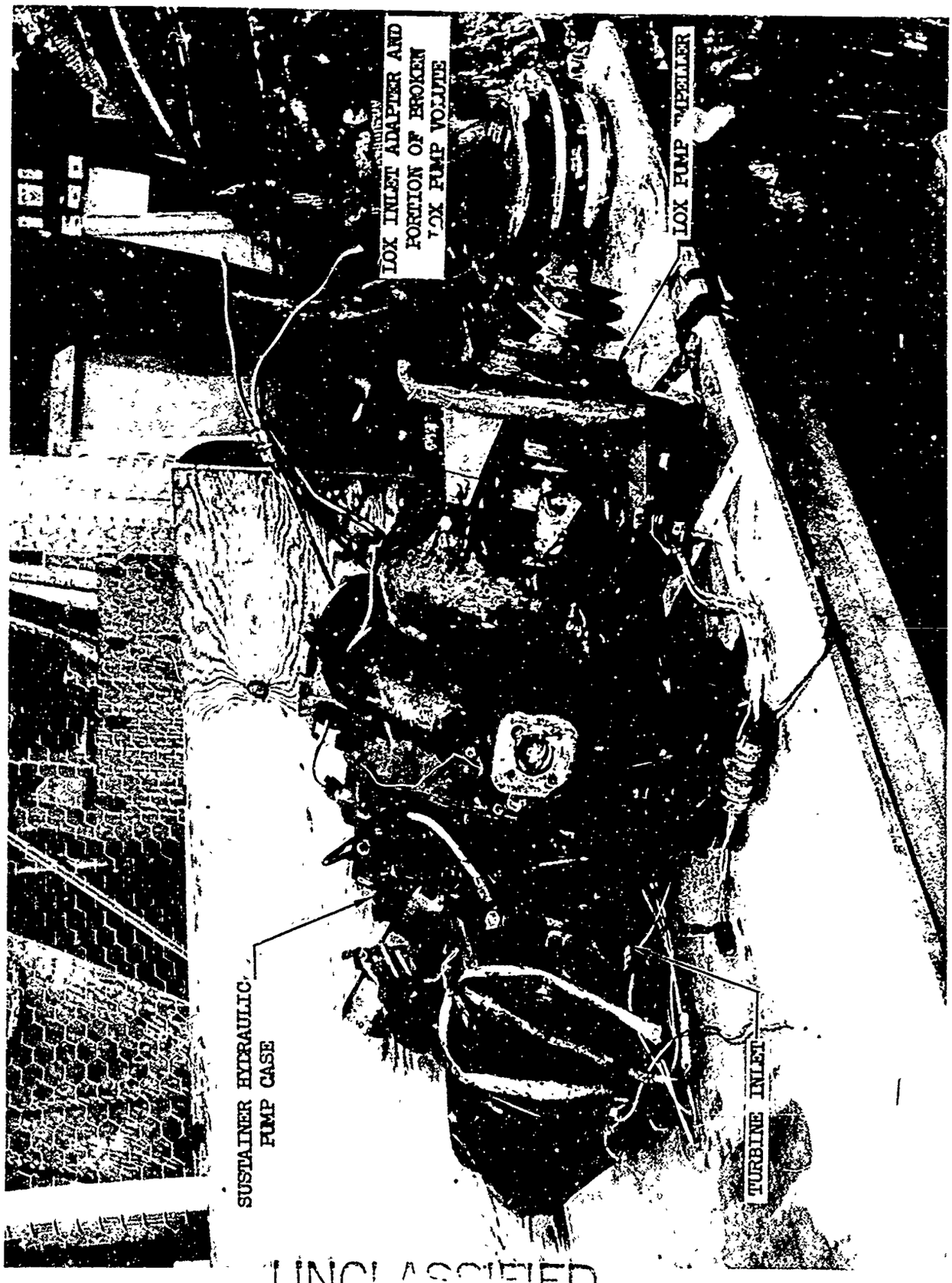

FIGURE 6.3-12

SUSTAINER TURBOPUMP
(Neg. No. 88028A)

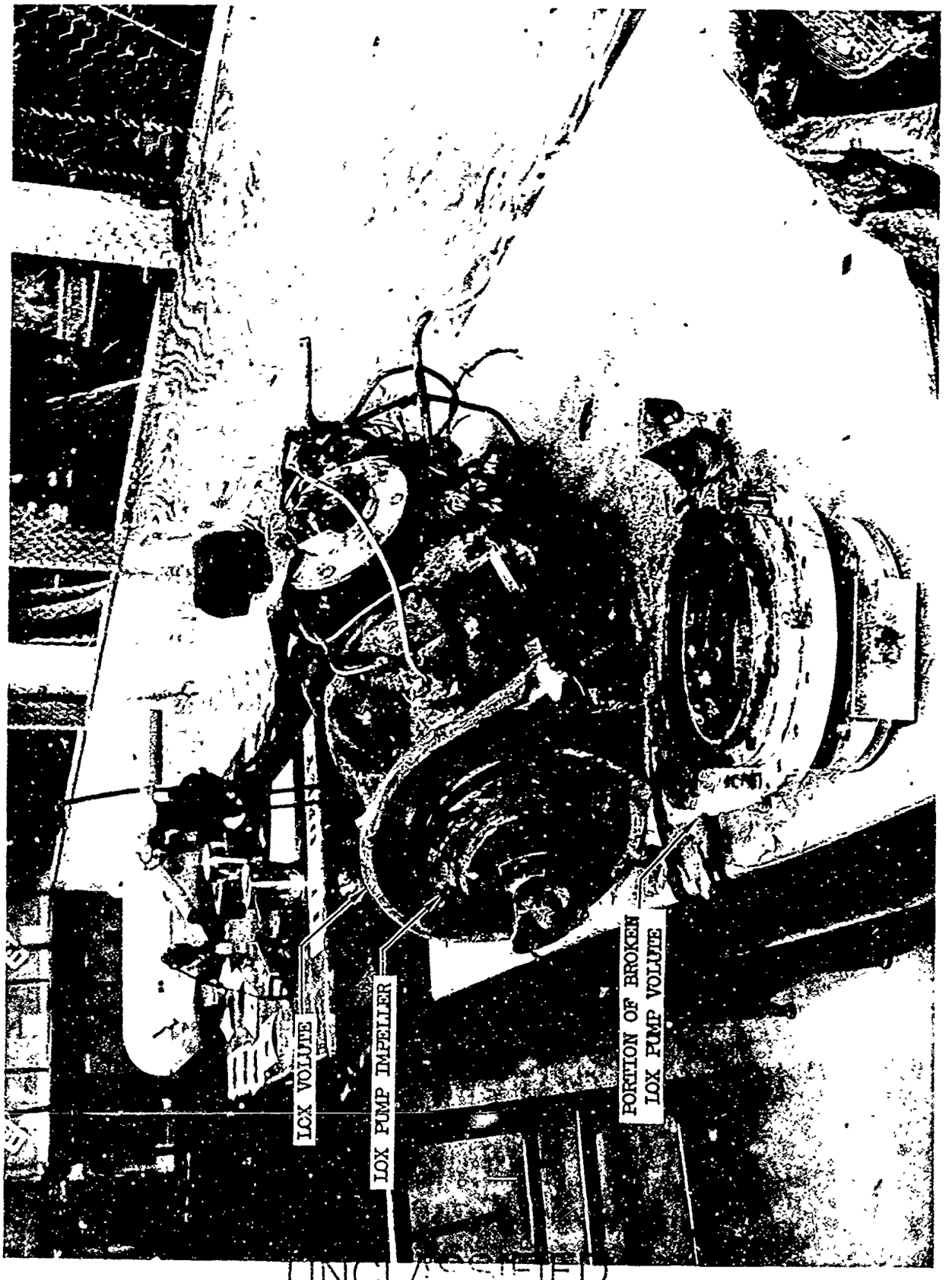

FIGURE 6.3-13

HEAD SUPPRESSION VALVE
ACTUATOR HOUSING
(Neg. No. 88022A)

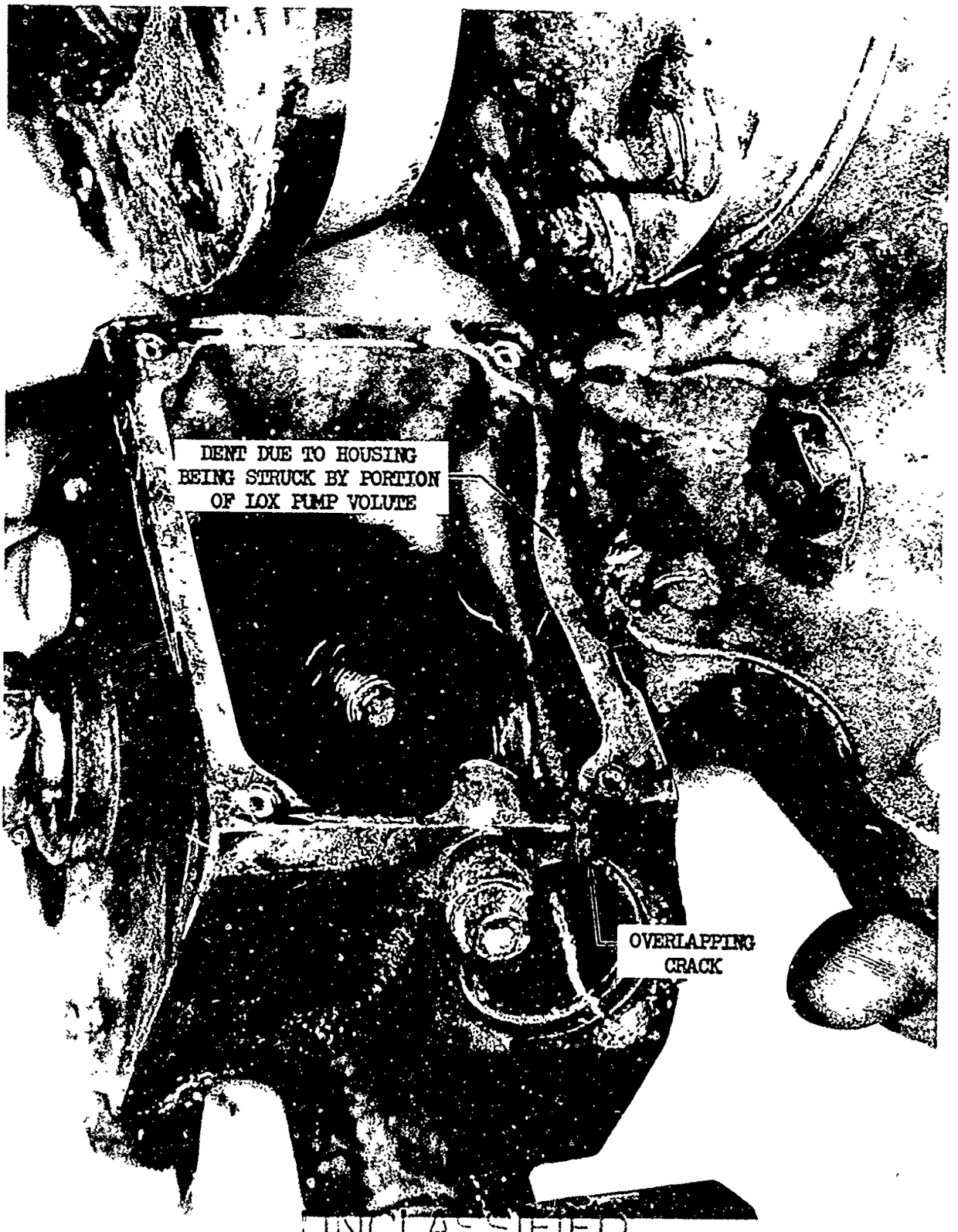

FIGURE 6.3-14

HEAD SUPPRESSION VALVE ACTUATOR SHOWN IN POSITION ON THE THRUST CHAMBER
(Neg. No. 88021A)

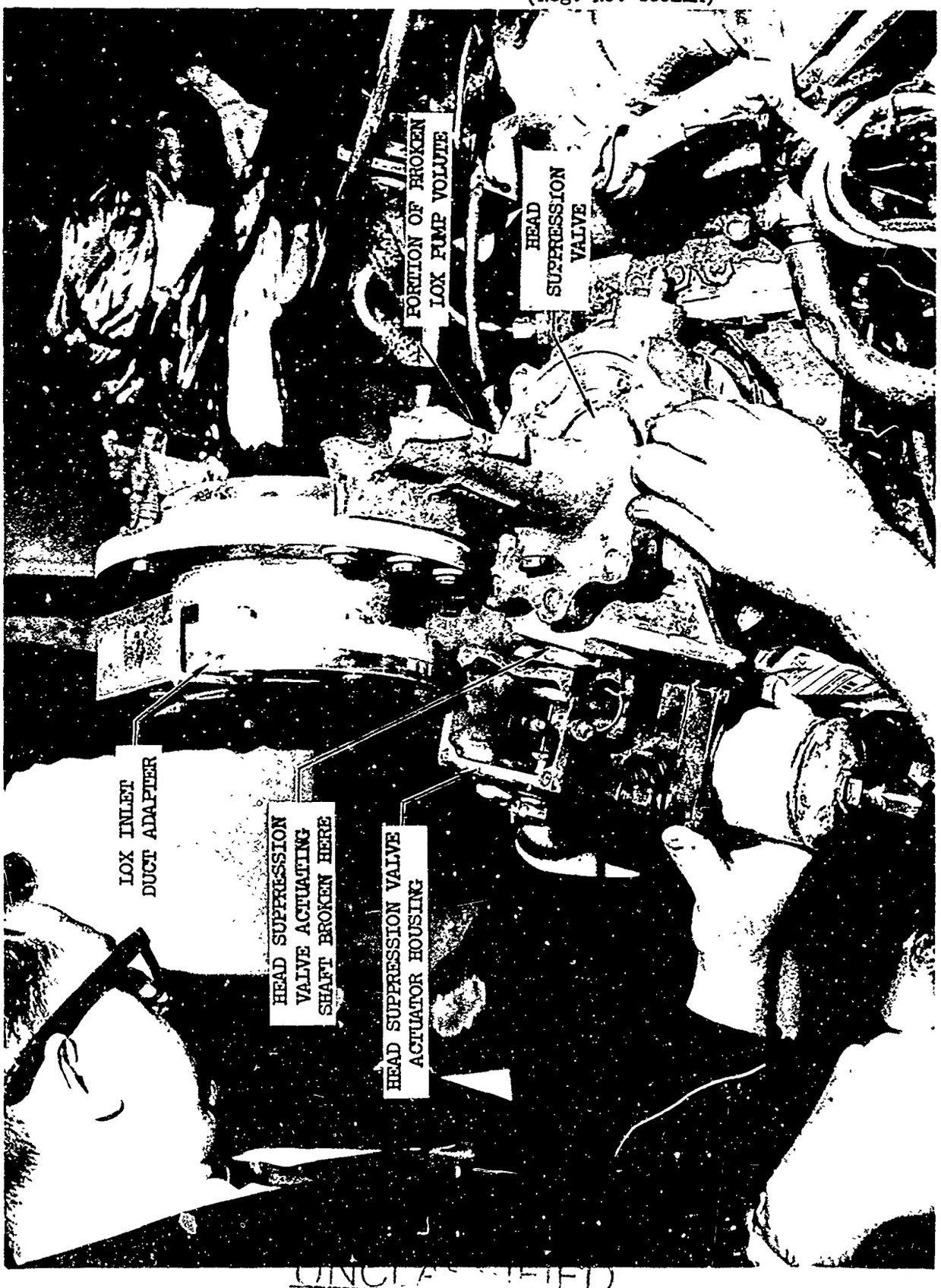

FIGURE 6.3-15

BOOSTER INJECTOR PLATE AND FUEL STAGING DISCONNECT--FORWARD HALF
(Neg. No. 87915A)

FIGURE 6.3-16

B1 TURBOPUMP ASSEMBLY FOUND WEDGED INTO TOWER STRUCTURE (Neg. No. 87918A)

FIGURE 6.3-17

DAMAGED BOOSTER TURBINE ASSEMBLY
(Neg. No. 87921A)

FIGURE 6.3-18

PARTS OF B2 TURBOPUMP
(Neg. No. 87920A)

FIGURE 6.3-19

B2 TURBOPUMP COMPONENTS
(Neg. No. 88557A)

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FIGURE 6.3-20

DAMAGED PROPULSION SYSTEM HARDWARE
--PRIMARILY B2 COMPONENTS
(Neg. No. 88315A)

UNCLASSIFIED
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~~CONFIDENTIAL~~
UNCLASSIFIED

FIGURE 6.3-21

AIRBORNE PNEUMATICS HARDWARE
(Neg. No. 88554A)

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FIGURE 6.4-1

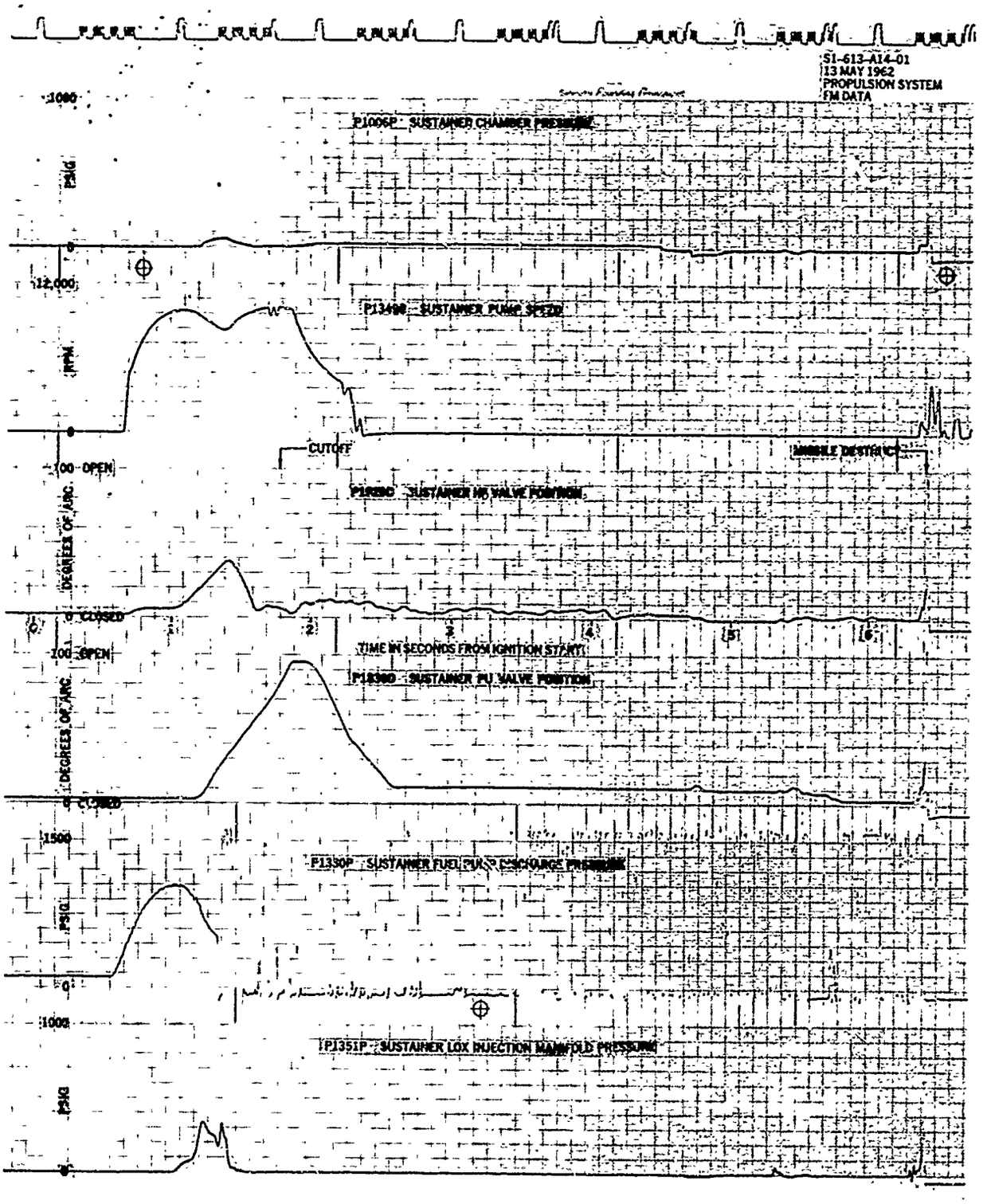

FIGURE 6.4-2

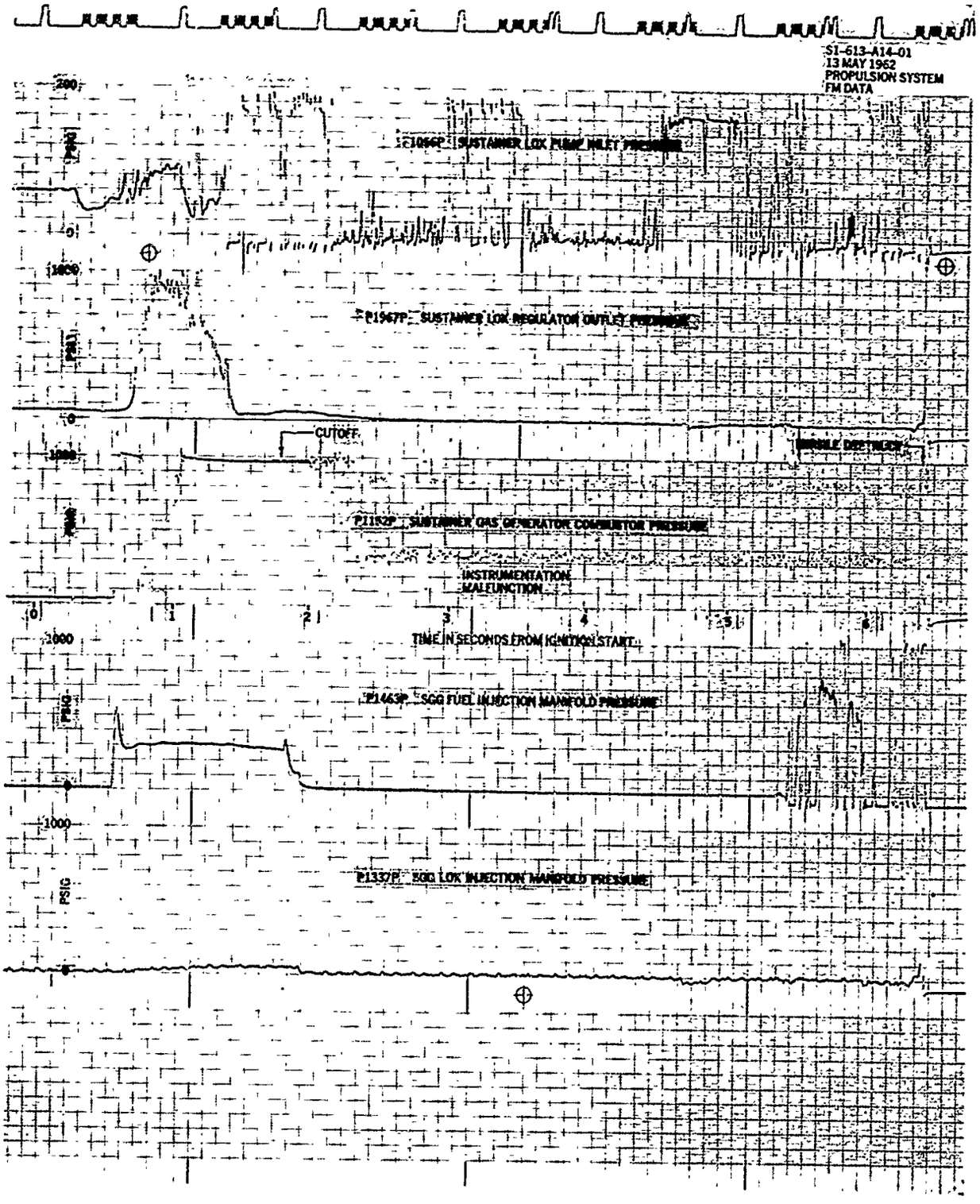

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FIGURE 6.4-3

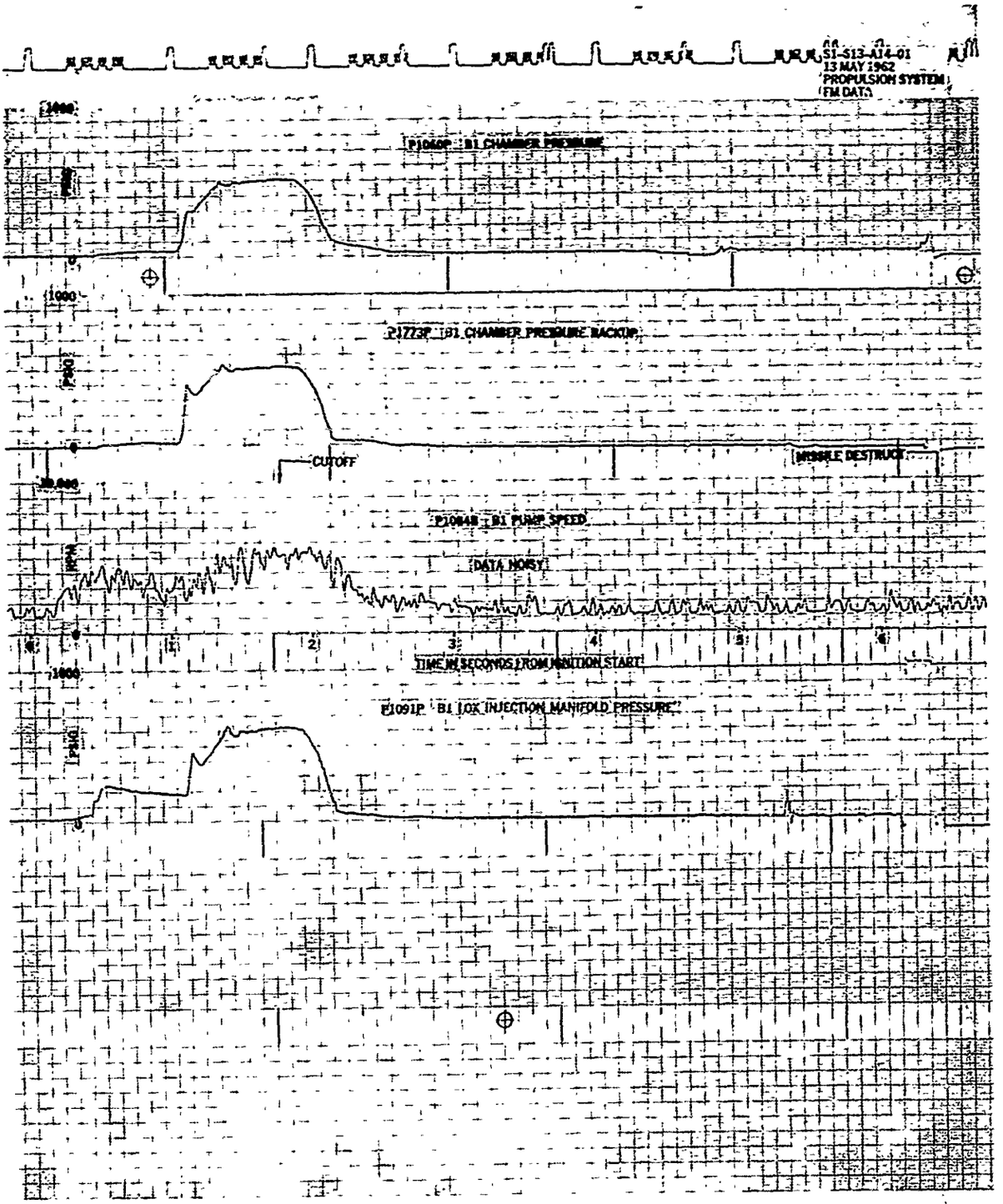

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FIGURE 6.4-4

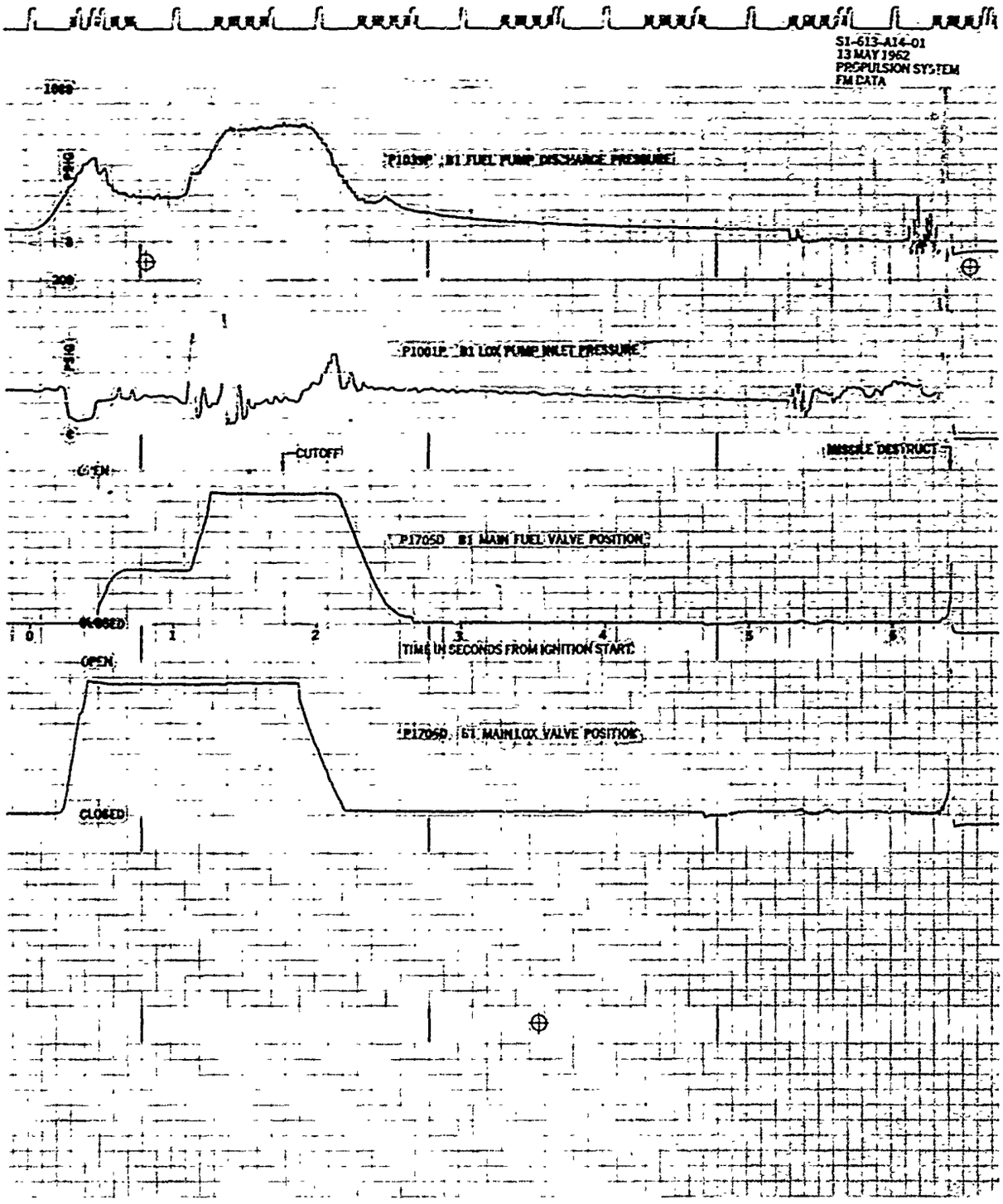

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FIGURE 6.4-5

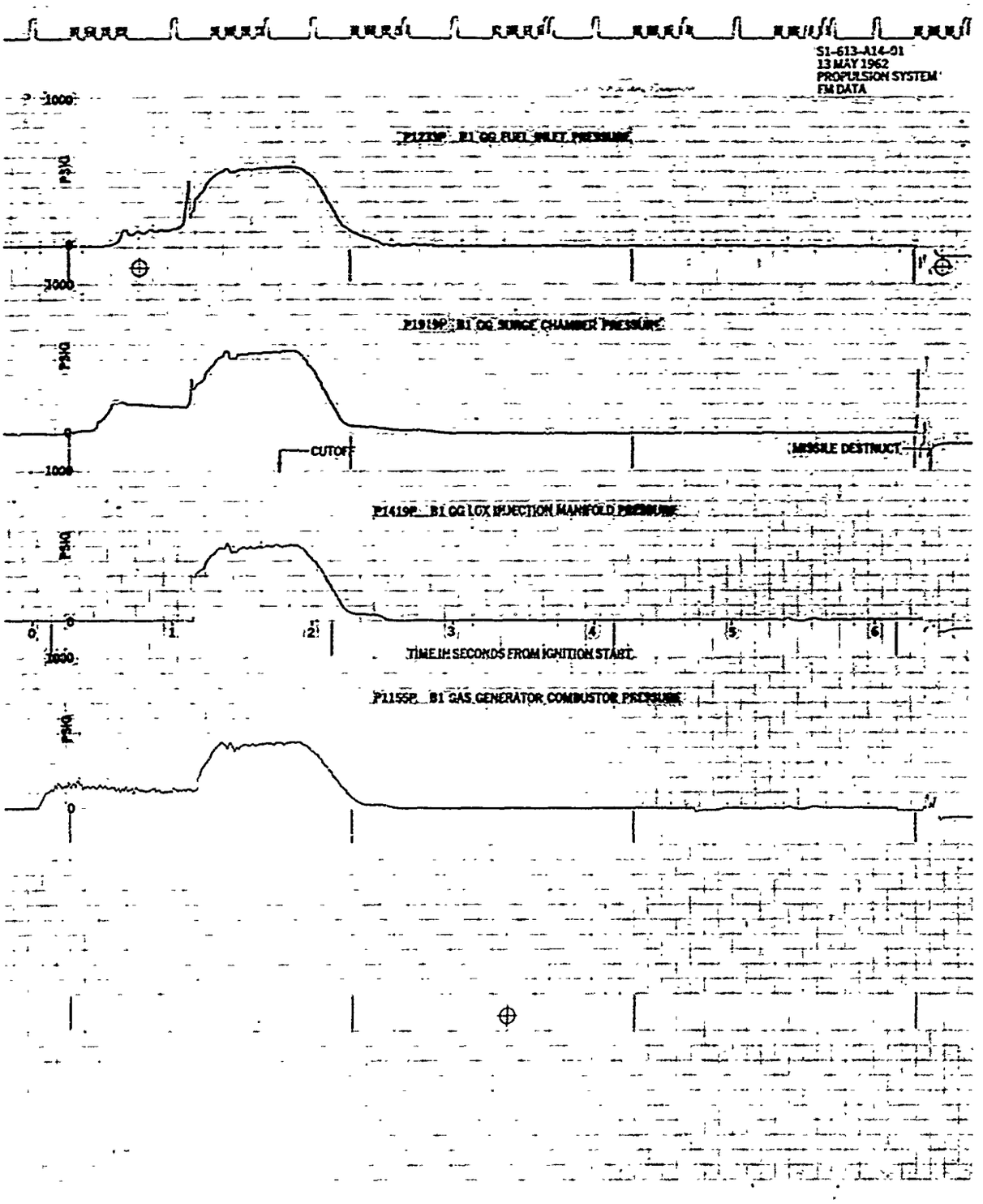

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FIGURE 6.4-6

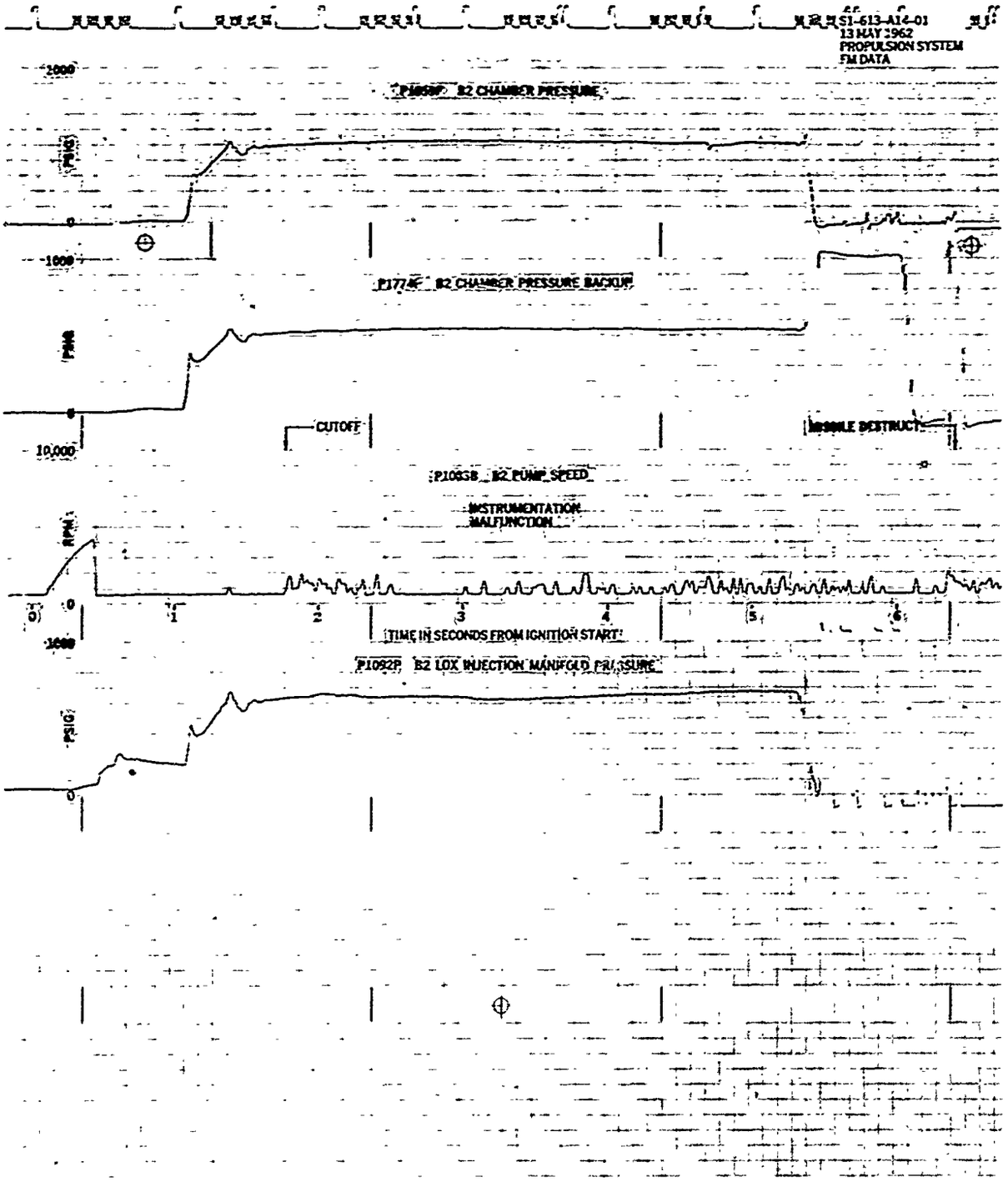

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FIGURE 6.4-7

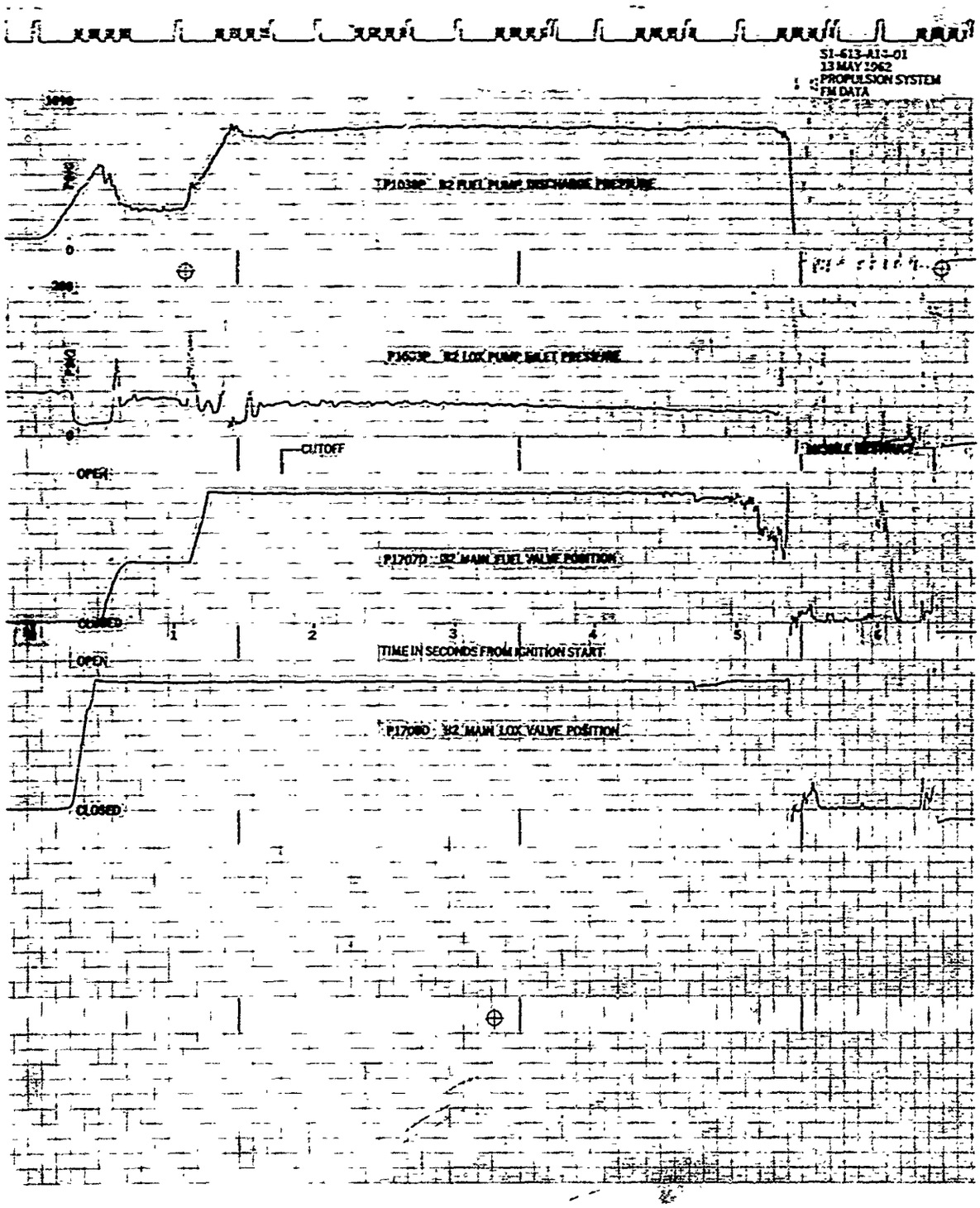

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FIGURE 6.4-8

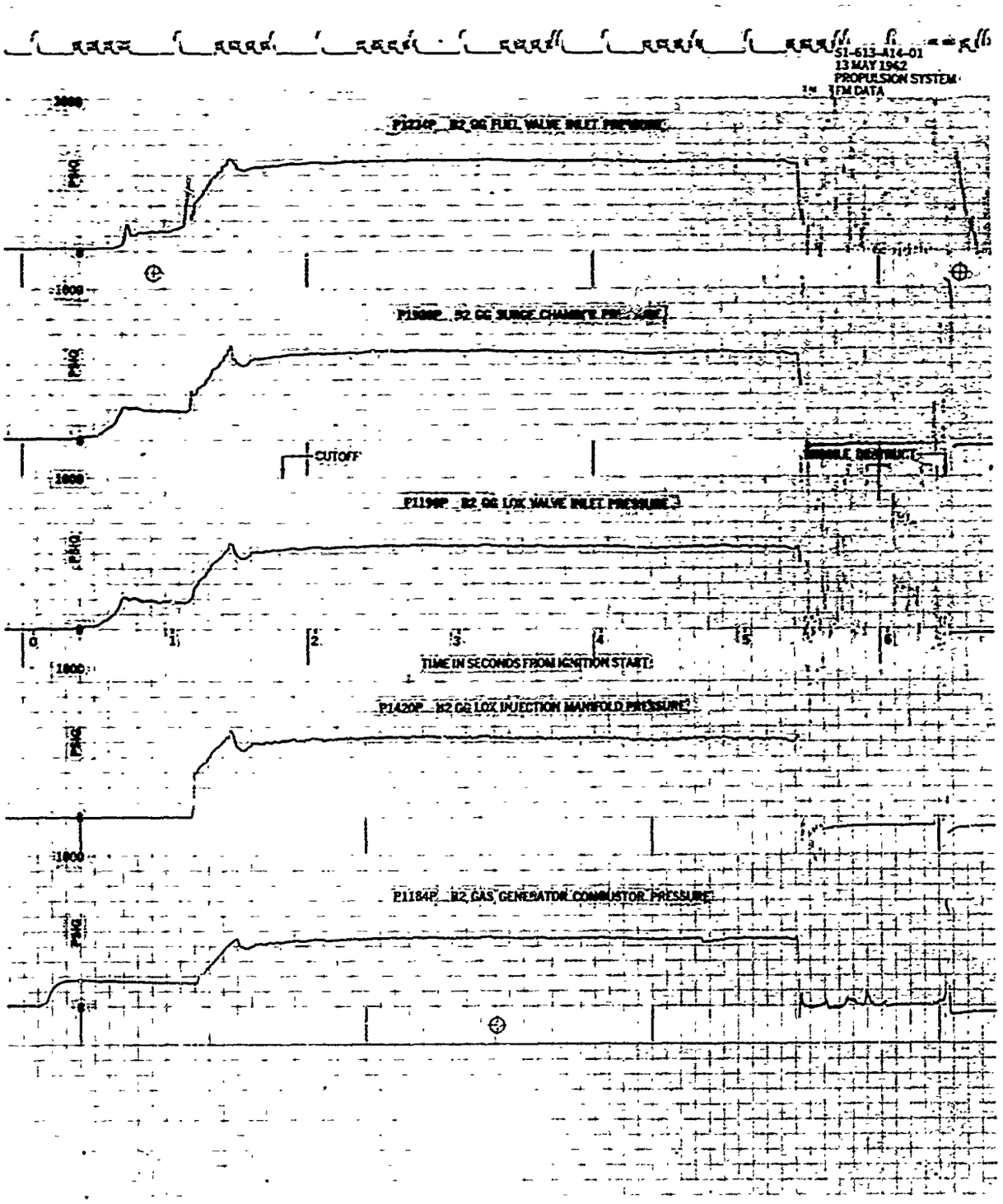

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FIGURE 6.4-9

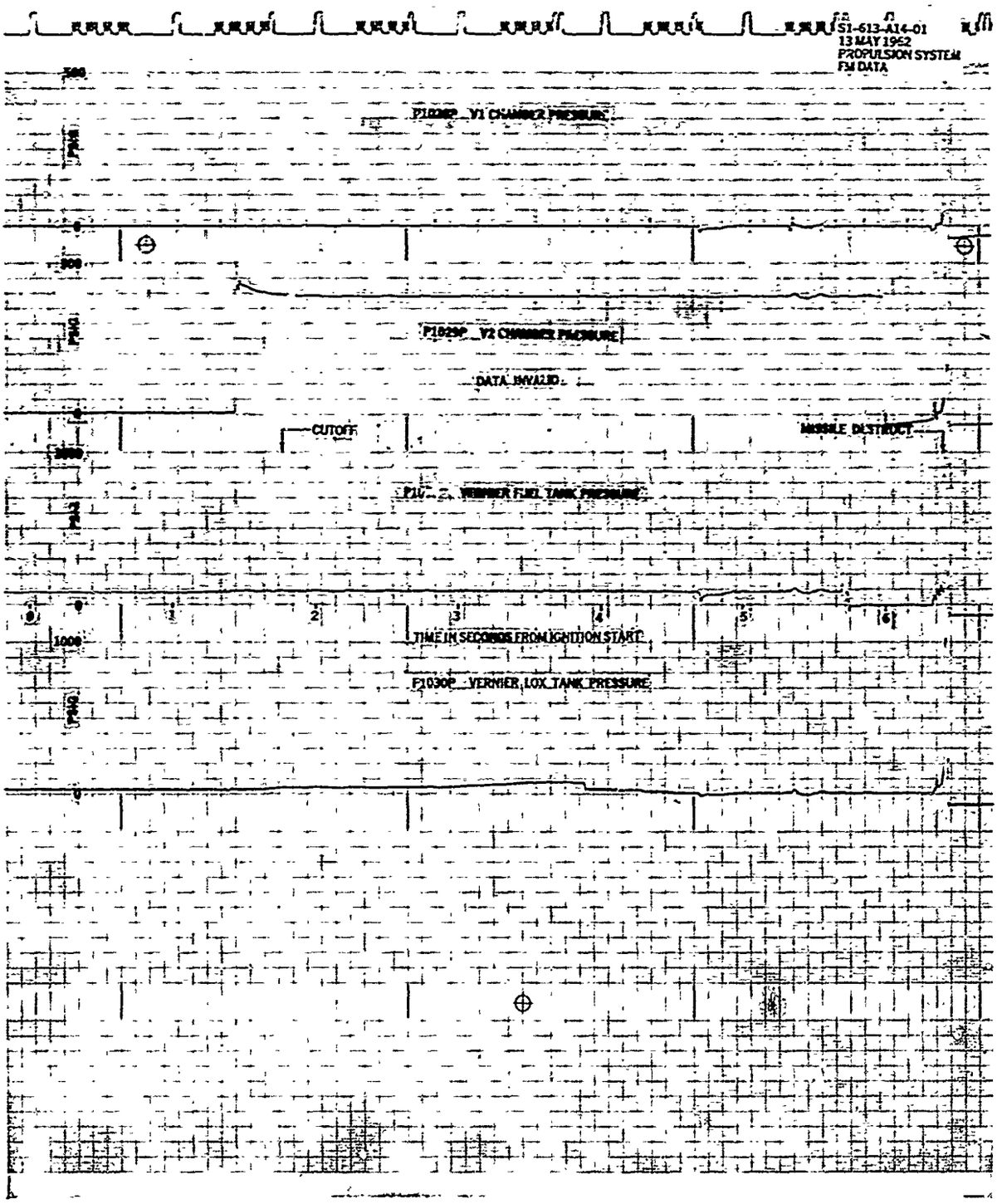

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FIGURE 6.4-10

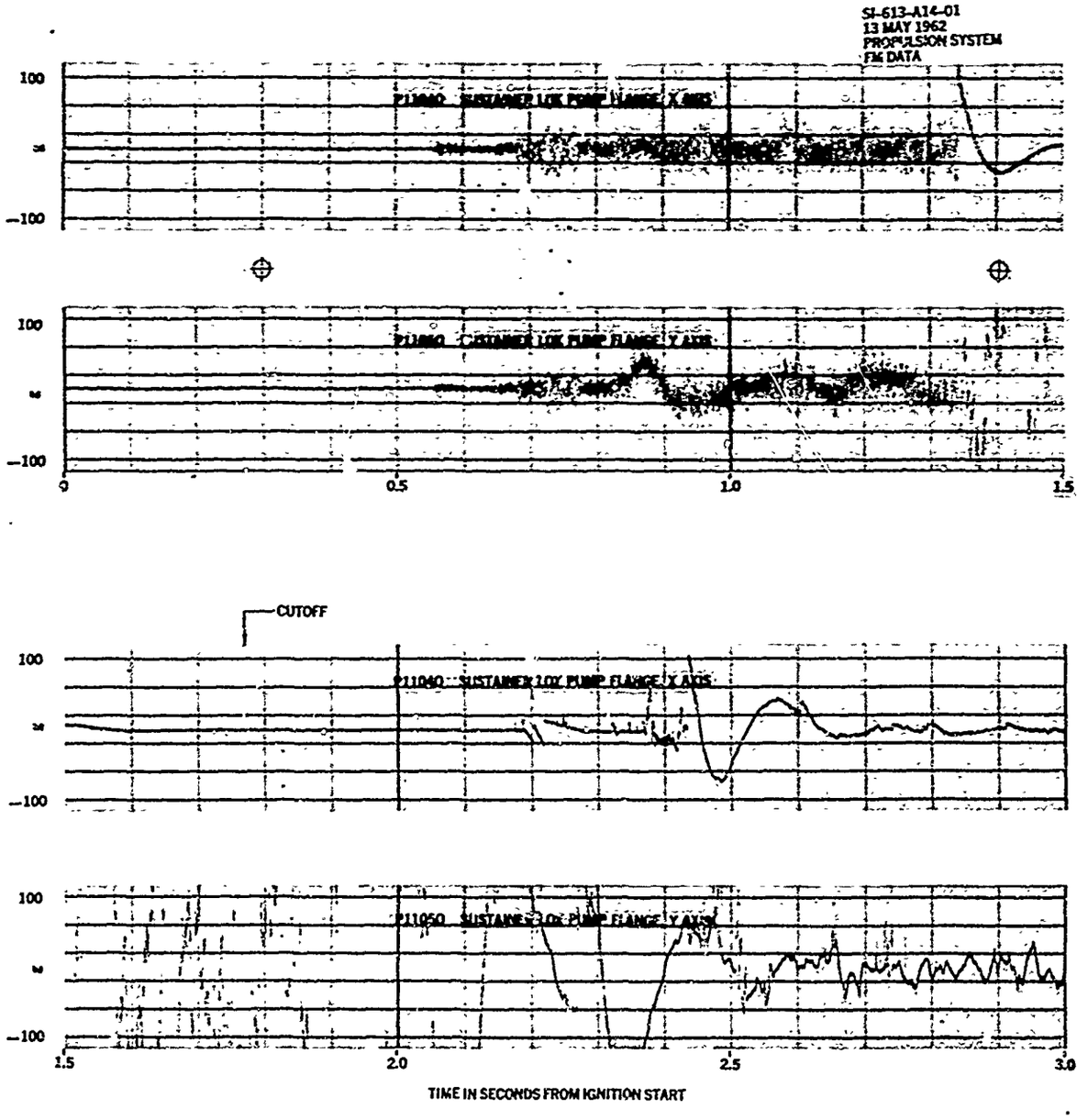

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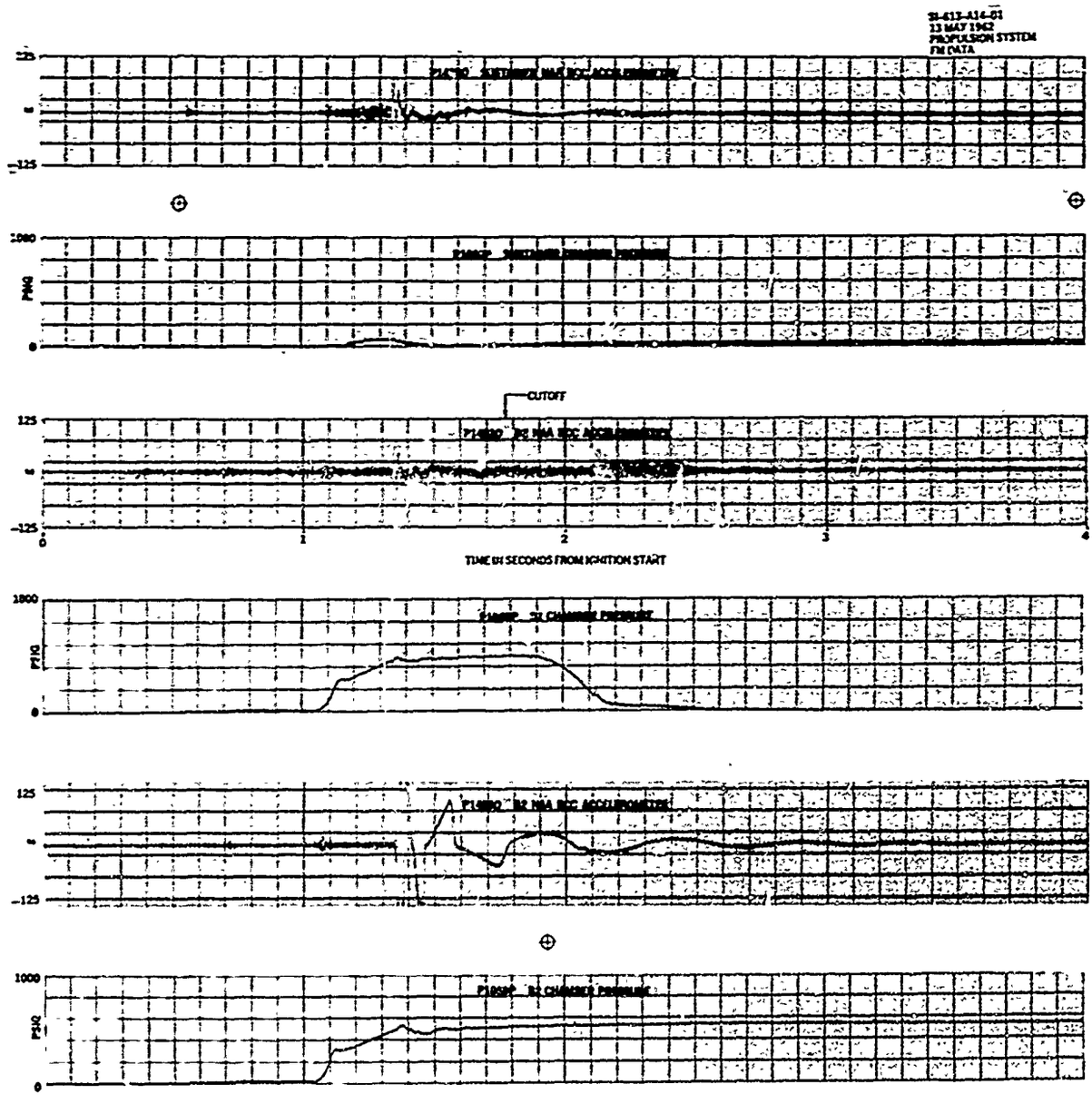
FIGURE 6.4-11



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6.5 FRAGMENTATION SURVEY

Presented in the following is a tabulation, by system, of hardware dispersion. Included are three dispersion maps, indicating the location of recovered hardware relative to the test stand. Items recovered in the immediate area of the test stand have location designations by Quad number and are shown on Figure 6.5-1.

6.5.1 PROPULSION

Item No.	Item Description	Item Location Sector
0012	Booster Turbopump	Quad I
0013	B-2 Fuel Duct & Prevalve	Quad I
0014	Booster LOX Valve Actuator	Quad I
238	Gimbal Block #201674-D401543	5 T
260	Booster Boot	3 P
271	Booster SPGG	3 Q
298	Part of Pump Housing	3 H
459	Ignitor Fuel Valve	1 G
478	Tachometer #7740256	1 G
529	Low Press Gimbal Ring	9 M
531	LOX Pump Piece	2 U
536	Gimbal Block	2 U
654	Kohler Valve #K 1247-10	4 I
676	V-1 Engine & Gimbal Mount	4 X
739	Tachometer P/N 562-815	4 T
875	Part of Booster #45582841	4 U
902	Turbine Assy S/N 248R	2 S
929	Pump Casing Part	1 S
1062	Fuel Pump Housing	1 S
1231	Heat Exchanger Part	2 D
1232	Turbopump Support	2 H
1250	Gimbal Block	2 U
1263	Gimbal Casting	1 X
1286	Hypergol Container	1 B
1287	Gear Drive & Shaft	1 B
1288	Pump Case & Gear With Shaft	1 T
1401	Sustainer LOX Pump Inlet Adapter	4 L
1403	Sustainer LOX "Y" Duct Flange	5 L
1405	Sustainer Skirt & Exhausterator	7 M
1407	Booster Thrust Chamber	7 M
1408	Part of Sustainer Engine	7 M
1409	Gas Generator	1 U
1420	Engine & Support Parts	7 L
1422	Booster Fuel Duct	1 W
1510	Booster Exit Skirt	7 L
1519	Booster Main Fuel Actuator	7 M
5001	Booster Pump	1 F

6.5.1 (Continued)

Item No.	Item Description	Item Location Sector
5007	Turbine & GG Assy	Quad I
5011	Vernier Fuel Manifold	1 F
5012	Fuel Prevalve	1 F
5013	Hypergol Container	1 G
5014	LOX Discharge Manifold	1 G
5015	Turbopump Heater	1 F
5016	Hi Press Fuel Duct	1 F
5017	Fuel Stage & Shutoff Valve	1 G
5019	Booster Lox Dome Assy	1 T
5021	Lube Oil Pump	
5022	LOX Inlet Elbow Piece	
5023	Booster Turbopumps	1 T
5028	Vernier Check Valve	1 V
6000	Sustainer LOX Regulator	7 M
6002	Sustainer SPGG	7 M
6004	Sustainer Combustion Chamber	7 M
6005	Sustainer GG Blade Vlv & Injector Head	7 M
6007	Vernier Pneu Ctl Manifold	7 M
6008	V-1 Thrust Chamber	7 M
6009	Vernier LOX Solo Bottle	7 M
6011	Sustainer Engine Gimbal	7 L
6013	Sustainer Power Package	7 L
6014	Ignitor Fuel Valve	7 L
6015	Sustainer GG Body	7 L
6016	Booster Dome & Injector	7 L
10010	Part of Pump Housing	4 Q
10011	SPGG Gasket	4 Q
12707	Booster Turbopump Support	Quad II
12708	Pump Gear Reduction	Quad II
12710	Booster GG	Quad III
12715	Propellant Control Valve	Quad III
12716	Booster Pump Inducer Shaft	Quad III
12726	Accessory Drive Pad (Hyd)	Quad I
12728	Booster Oil Pump	Quad I
12737	Booster Engine Fuel S/O Vlv	Quad IV
12738	Booster Lox Dome Inlet Valve	Quad IV
12741	Sustainer Gimbal Block	Quad IV
12744	Turbine Overspeed Assy	Quad IV
12746	Gimbal Block Assy	Quad IV
12748	Gimbal Block Assy	Quad IV
12751	Booster Hyd Pump Drive Shaft	Quad IV
12752	Booster Hyd Pump Drive Shaft	Quad IV
12798	Sustainer Hi Press Duct Flange	Quad III
12851	P1420P B-2GG Lox Injection Man	Quad III
12853	Booster Tach & Drive	Quad II
12849	Bal Turbine Exhaust	Quad I

6.5.1 (Continued)

Item No.	Item Description	Item Location Sector
14114	Piece of Engine	7 L
14126	Fuel Valve	1 V
14129	Sustainer Turbine Part	2 B
14137	Booster Reduction	3 A
20002	LOX Topping Check Vlv. to Hi Press Line-Elbow	7 L
60004	Booster Tachometer	2 C

6.5.2 HYDRAULIC

Item No.	Item Description	Item Location Sector
0010	Part of Booster Actuator	4 K
323	B-1 Hydraulic Panel	3 X
512	V-1 Pitch Actuator	4 X
606	Hydraulic Actuated Lock	4 G
679	V-2 Pitch Actuator	4 W
960	V-2 Yaw Actuator	2 U
962	Booster Hydraulic Reservoir Part	1 A
1348	V-1 Yaw Actuator	4 L
1424	Booster Hydraulic Reservoir Part	2 G
5025	Booster Hydraulic Actuator	1 T
6006	Sustainer Hydraulic Pump	7 L
6028	Sustainer Hydraulic Actuator	7 L
12730	Booster Hydraulic Pump Cylinder	Quad IV
12742	Booster Hydraulic Pump Cylinder	Quad IV
12735	B-1 Hydraulic Accumulator	Quad IV
12751	Booster Hydraulic Pump Drive Shaft	Quad IV
12752	Booster Hydraulic Pump Drive Shaft	Quad IV
12758	Sustainer Hydraulic Accum. Part	Quad IV
12776	Booster Hydraulic Pump Casting	Quad IV
12781	B-2 Hydraulic Accum.	Quad III
60007	Top of Booster Hydraulic Tank	Quad IV

6.5.3 PNEUMATIC

Item No.	Item Description	Item Location Sector
0004	Lox Airborne Reg.	2 F
158	Helium Bottle	4 A
160	Helium Bottle	4 A
178	Helium Bottle	6 U
315	Fuel Airborne Regulator	3 W
320	Regulator Piece	4 X
530	Helium Bottle	1 T
684	Control Valve	6 W
780	Changeover Valve	2 M

6.5.3 (Continued)

Item No.	Item Description	Item Location Sector
782	Helium Manifold	2 M
789	Launcher Helium Heat Exchanger	7 N
912	Butterfly Valve	2 D
1002	Fuel Control Solendid Valve	1 1
1220	Helium Check Valve	2 V
1231	Heat Exchanger	2 F
1243	Helium Bottle Part	1 W
1331	Helium Bottle Part	3 L
1334	Bellows, Helium Shroud	3 L
1336	Helium Bottle Part	2 L
1385	Helium Bottle Part	2 L
1406	Helium Bottle	7 M
1413	LOX Pneu. Vlv.	7 M
1416	Pneu. Actuator	7 M
1419	Duct With Flange	7 M
1471	Regulator Diaphragm	2 W
1520	Vernier Helium Bottle	7 M
6007	Vernier Pneu Ctl. Man.	7 L
6022	LX 6 Actuator	7 L
10039	Helium Ball Half	4 O
12703	Helium Bottle Part	Quad I
12704	LN_2 Shroud Dump	Quad I
12725	Lox Tank Relief Valve	Quad I
12739	Pneu. Check Valve	Quad IV
12792	Airborne Regulator Block	Quad IV
12816	Helium Bottle Pieces	Quad IV
12825	Helium Bottle Part	Quad III
12833	Airborne Regulator Block	Quad IV
12834	Airborne Regulator Block	Quad IV
12856	Lox Control Valve	Quad II
14112	Helium Bottle	8 L
14126	Fuel Relief Valve	Quad I
14138	LN_2 Shroud	2 X
14139	Helium Bottle Part	3 X
14140	Helium Bottle Part	2 A
14154	Helium Bottle Part	2 A
14155	Helium Bottle Part	2 A
20003	Relief Valve	7 L

6.5.4 ELECTRICAL

Item No.	Item Description	Item Location Sector
203	Cannon Plug & Harness #27-11665-805	8 W
204	Electrical Actuator Pin	6 X
254A	Acoustica Control Unit Assy	2 P

6.5.4 (Continued)

Item No.	Item Description	Item Location Sector
279	Part of Umbilical	3 H
282	Umbilical Adapter	3 H
377-382	Stillwell Sections	2 T
385	Stillwell Sections	2 T
388-390	Stillwell Sections	2 T
403	Umbilical POD 2	5 T
404	Umbilical POD 2	5 T
451	Inverter Cannister	1 X
458	Part of Umbilical	1 G
763	Cannister Assy.	5 R
765	Cannister Printed Circuit Board	5 R
1020	Part of Umbilical	1 H
1110	Umbilical	1 W
1473	Stillwell Section	2 W
5030	Umbilical	1 W
6003	Auto Pilot Box	7 M
10002	Piece of Cannister	3 S
12702	Auto Pilot Cannister	Quad I
12706	D.C. Power Plug POD 2	QUAD I
12868	Stillwell Sect. Attached to B.O. Vlv.	Quad I
12871	Cannister Assy.	Quad III
14111	27-41470-801 Printed Circuit	7 M
14158	Stillwell Section	2 X

6.5.5 STRUCTURE

Item No.	Item Description	Item Location Sector
0016	LOX Topping Flex Line #27-23562-7	Quad I
102	Small Piece of Skin	8 T
128	Small Piece of Skin	9 U
151	Small Piece of Skin	11 V
155	Missile Pin 27-72231-25-B101	5 X
161	Inside of Missile Tank	3 B
183	Small Piece of Skin	6 U
206	Piece of Heavy Alum with Hinge Pin	7 X
214	PT40 PSI TVA #688 7-76840-7-0	5 X
265	Pieces of Tank & Booster	2 Q
602	Large Piece of Msl. Skin #N27-72003-185	4 G
683	Stainless Mtg. Bkt. #27-85321-807-01	3 W
685	Piece of Tank With IR #601766	3 X
729	Chunk of Casting #U27-41414-7	6 R
770	Missile Tank Skin	5 S
802	Portion of Mating Ring	6 A
804	Parts of Pod Access Doors	5 A
808	Skirt Section #27-45404-9	4 6
851	Part of Jettison Rail	4 T

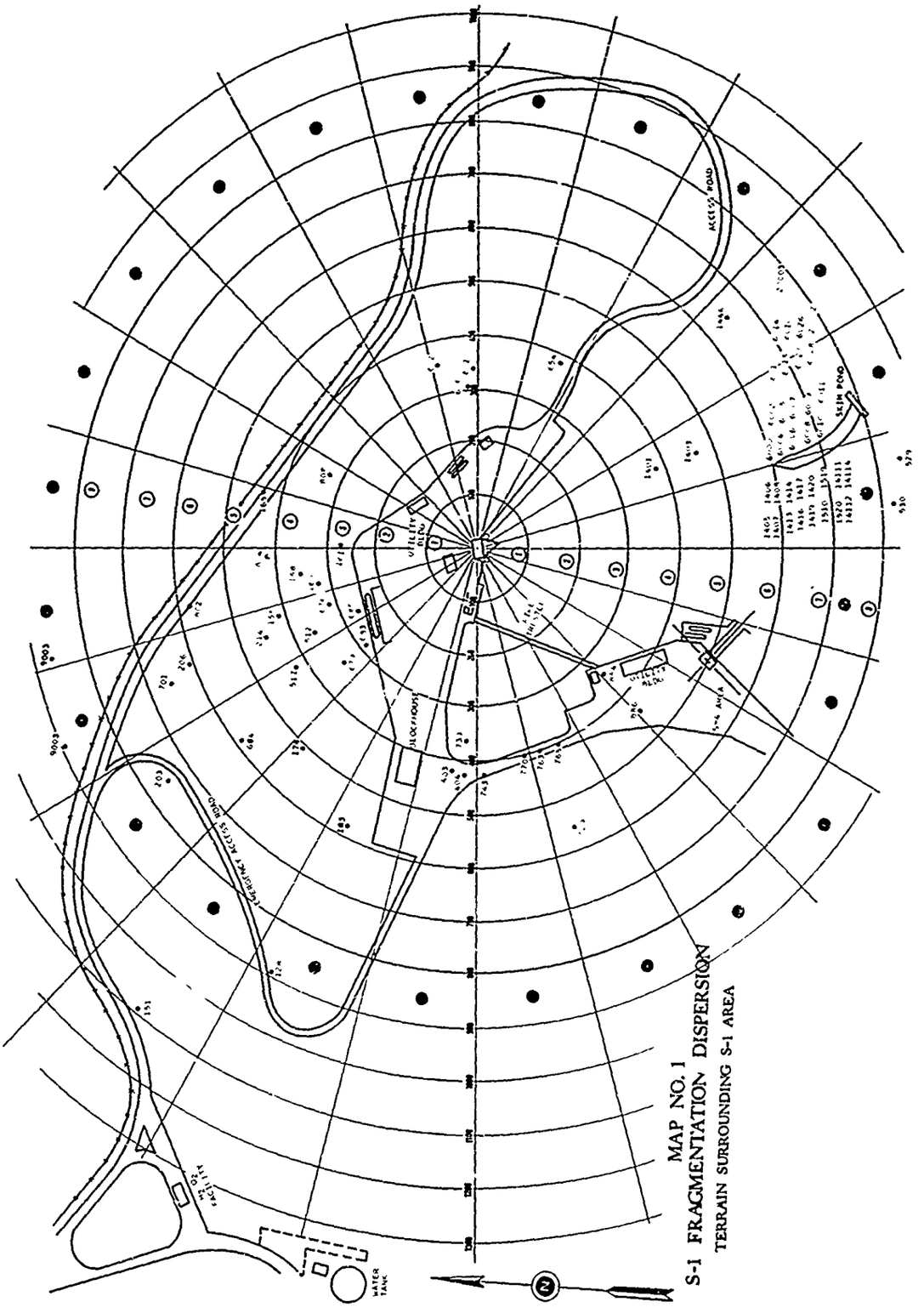
6.5.5 (Continued)

Item No.	Item Description	Item Location Sector
886	Butterfly Assy. for Valve	5 P
903	Part of Nose Adapter	2 S
1104	Fill & Drain Valve	1 C 100'
1256	6" Alum. Casting - Part of Msl. Tiedown	3 U
1285	27-72227-1 A/B LO_2 Duct W/Large Sect. Skin	1 B
1330	Booster SPGG Access Door	2 L
1382	Part of Thrust Barrel Ring	3 L
1386	Piece of Thrust Sect. & Flooring	3 L
9003	Msl. Skin with Brace #7-73412-116/C1	9 A
9008	Missile Skin with Duct	9 X
10033	Large Piece of Missile Structure	3 N 270'
10038	Bulkhead Camera Mount Fitting & Sect.	3 O
12867	Boiloff Valve	Quad I 25'
12881	LO_2 Tank Duct Diffuser	Quad I
12882	Msl. Nose Cone Adapter	Quad III 70'
12883	Msl. Tank Skin	Quad III
13556	Piece of Ducting	4 M
13566	Piece of Ducting	4 M
14183	Part of Missile Apex	3 A

6.5.6 TOWER

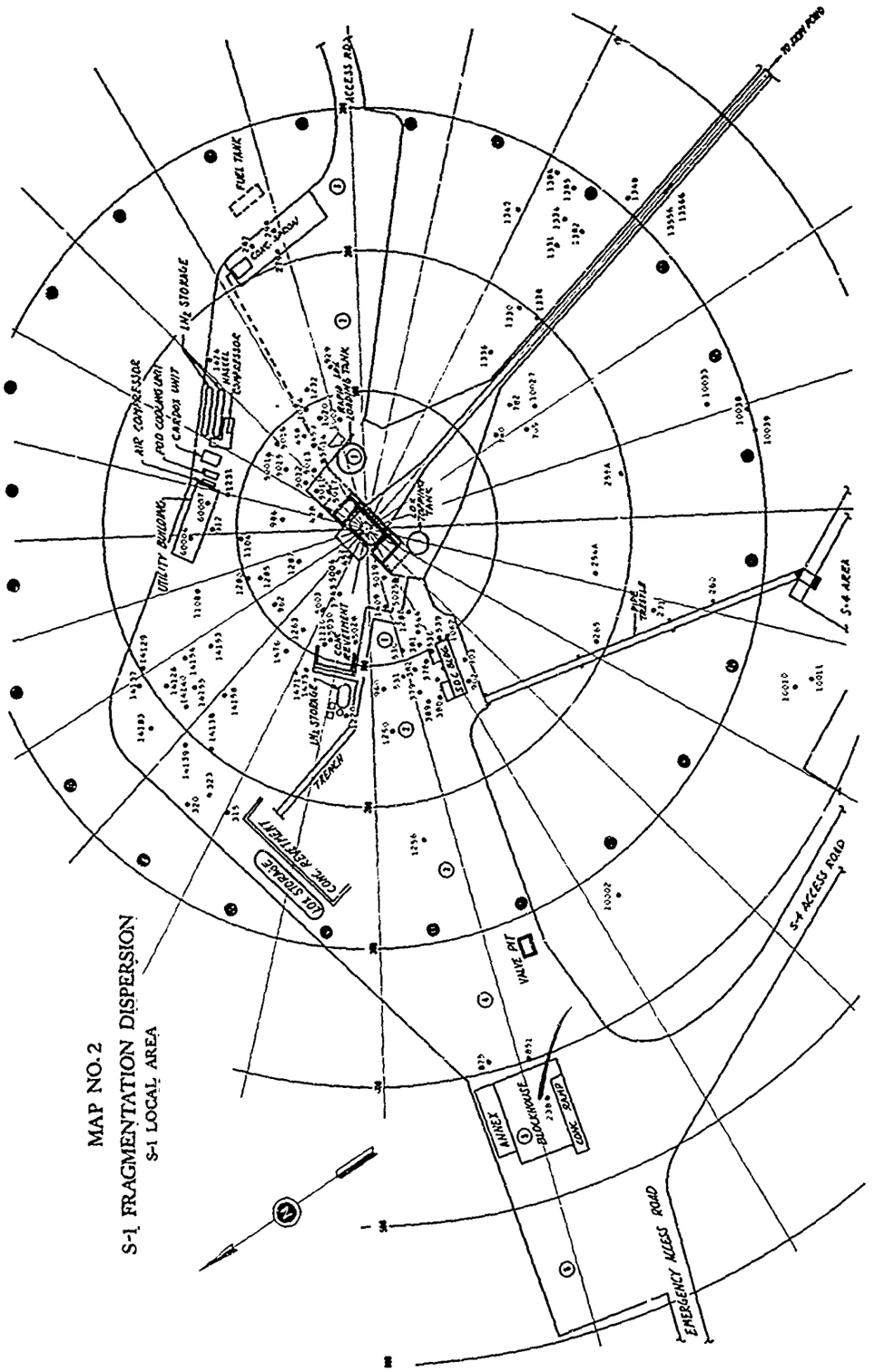
Item No.	Item Description	Item Location Sector
165	Part of Vernier Flame Bucket	5 B
255A	Half Level & Electrical "J" Box	2 O
517	Large Piece of Vernier Flame Bucket	5 W
601	Elevator Door	4 G
701	3 Ft. Sq. Deck Plate	7 X
986	Stand Deck	1 D
1338	Topping Control Unit Cover	2 L
1343	Junction Box	3 K
1446	Part of Vernier Flame Bucket	7 K
1476	V-2 Work Stand	2 X
5003	Vernier Deck Plate	1 X
5004	Stand Deck	1 X
6010	Vernier Flame Bucket	7 M

Figure 6.5-1



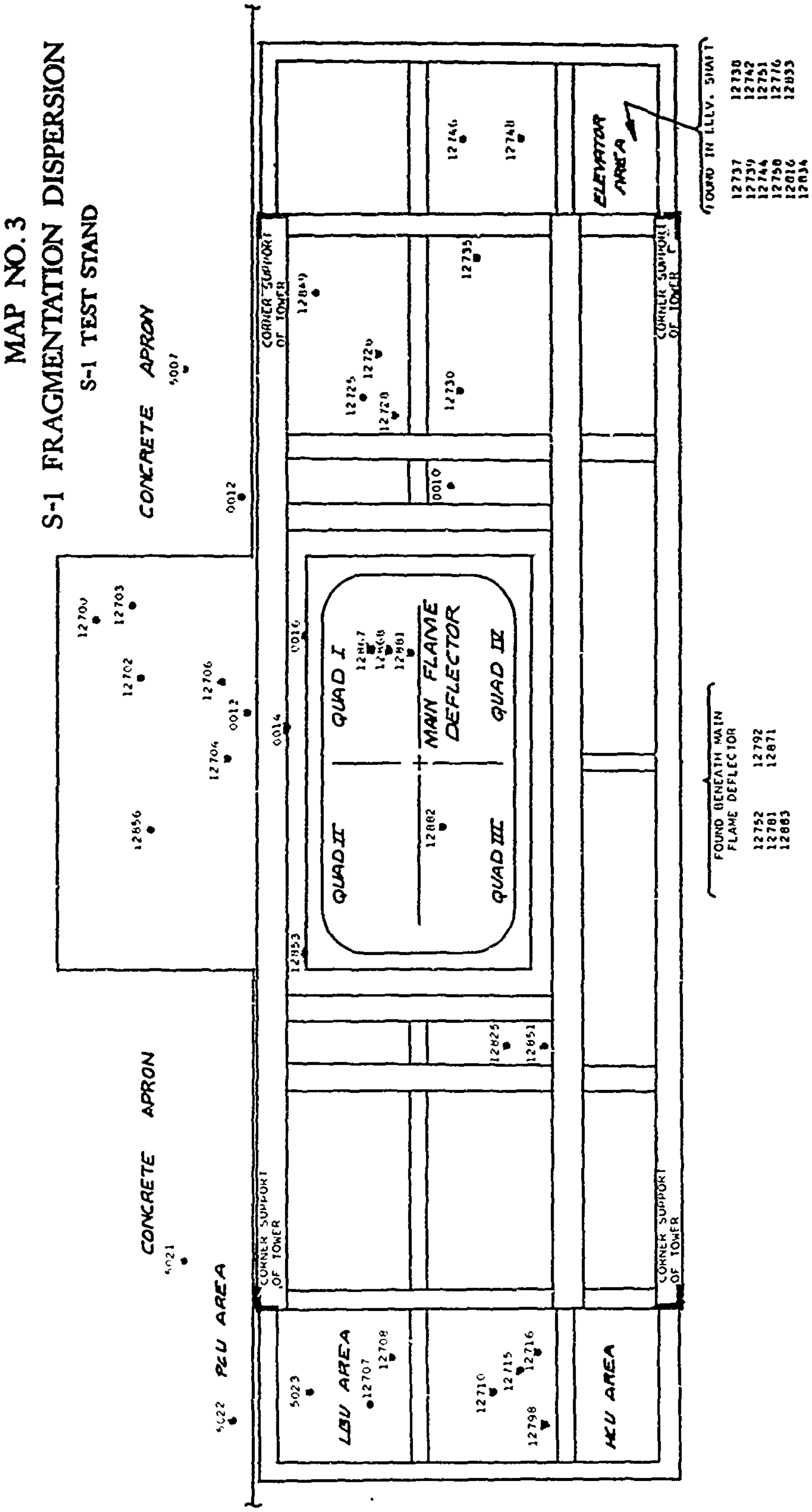
MAP NO. 1
S-1 FRAGMENTATION DISPERSION
TERRAIN SURROUNDING S-1 AREA

Figure 6.5-2



MAP NO. 2
S-1 FRAGMENTATION DISPERSION
S-1 LOCAL AREA

Figure 6.5-3



6.6 S1 AND AMR TOWER WATER SURVEY

Four separate water supplies are activated at Sycamore stand S1 during each tanking or firing test. These consist of LN2 flushing water (activated at X-25 minutes), main flame deflector water (activated at X-1 minute 50 seconds), launcher coolant water, and vernier flame deflector water. The latter two supplies are activated at X-60 seconds. Water is not applied inside the thrust barrel during a normal operation. A thrust section firex water system is available for use during an emergency condition, however, this system has not been activated since Run S1-609-10-01 on 15 November 1961. Two successful firings (S1-610-10-01 on 28 November 1961 and S1-611-12-01 on 23 March 1962), have been accomplished since that date.

LN2 flushing water is manually activated by the last person to leave the stand area prior to condition red. This water is intended to protect the flame deflector and stand structure from the effects of cryogenic temperatures resulting from LN2 and Lox drain or cryogenic leaks from supply ducting. Prior to installation of engine blowoff covers as standard equipment (25 September 1961), the main chambers were repeatedly subjected to spray from the LN2 flushing water nozzles. Since blowoff cover installation, however, entrance of water into the chambers was possible only when the covers inadvertently separated from the chambers during a tanking test. This has occurred on occassion, apparently due to water seeping past the covers in sufficient quantity to force the covers from the chambers. Under these circumstances, the possibility of water entering the injector did exist, although the probability of water passing upstream of this point was slight. To prevent further occurrences of this nature, the LN2 flushing water nozzles were repositioned to avoid excessive water spray contacting the chambers in the area of the blowoff covers. This modification was accomplished prior to the final firing of Missile 1F. There was no evidence of premature blowoff cover separation during this test.

AMR Complex 11 water supplies are activated at T-80 minutes (LN2 flushing water) and at T-1 minute 50 seconds (main flame deflector water). The LN2 flushing water nozzles are mounted below the main chambers on the launcher pedestal interface and are directed towards the flame bucket. Water, therefore, is not deliberately impinged on the main chambers, although minor amount of spray could be deflected upwards, particularly when the wind is blowing into the flame deflector mouth. To date, engine blowoff covers have not been installed on any "F" Series missile launch from Complex 11.

6.7 PERTINENT CORRESPONDENCE

6.7.1 YIELD AND EXPLOSIVE FORCES

The following is a report by the Explosive Forces Investigating Team.

Film analysis of the missile 1-F explosion revealed that three explosions had occurred. Table I gives the times of these explosions along with other events, time zero being taken at the first explosion. The first minor explosion occurred at approximately 0.23 seconds after start of sustainer hypergol ignition. Following the first explosion was 4 seconds of burning in the propulsion area. The fuel for this burning more than likely came from the main sustainer fuel line which passes within 8 inches of the sustainer lox pump. The second explosion, occurring 4 seconds after the first, was an explosion of considerably greater strength than the first but of lesser strength than the third explosion.

Film analysis revealed no structure damage to buildings at sites S-1 and S-4 as a result of the second explosion. The third and last explosion was the major explosion which caused the damage to sites S-1 and S-4. The third explosion occurred at approximately 5 seconds after the first explosion.

The major (third) explosion which occurred in missile 1-F is estimated to be of very low yield. Although visual observation of the destroyed S-1 test stand may lead one to expect a large yeild, the surrounding structures at sites S-1 and S-4 do not show the expected damage that would result from a large yield. Until otherwise proven, it appears that the greatest damage which occurred at site S-1 resulted mostly from heat damage due to the fire that lasted 5 seconds before and a long duration after the major explosion. The damaged structures at sites S-1 and S-4, which were not exposed to fire damage, were damaged by the weak shock wave* initiated by the major explosion.

There was no pressure instrumentation at either site S-1 or S-4, therefore, other means had to be used to estimate the resulting overpressures and ultimately the yield of the major explosion. The methods used to estimate the overpressures at various distances were:

1. Visual damage assessment of surrounding structures at sites S-1 and S-4
2. Calculated shock velocity from film analysis

By employing the years of experience at hand, the available data on blast effects to structures, it was possible to estimate approxi-

* Film analysis reveal a shock velocity which was a little greater than Mach 1.

6.7.1 YIELD AND EXPLOSIVE FORCES (Continued)

mately by visual observation the overpressure required to cause a given amount of damage to a structure. Also, knowing the shock velocity at various distances, one may calculate overpressures at those distances from well-known relationships between pressure, velocity, and distance. Table II gives the estimated overpressures required to cause the damage inflicted upon the various structures at sites S-1 and S-4. Table II also includes calculated minimum pressures required to start deformation in the various structures.

The weight of TNT explosive required to give the estimated overpressures (based on shock velocity) at the distances recorded in Table II is 2150 pounds. Assuming an equivalence of 1 pound of lox-RP-1 mixture to 1 pound of TNT, this would give a yield of 2150 pounds of lox-RP-1 mixture or 0.86 per cent of the 250,000 pounds of propellant aboard missile 1-F. Caution must be used in assuming a one-for-one equivalence between TNT and lox-RP-1 because the explosive potential of the lox-RP-1 mixture is a function of the unknown amount of mixing, etc.

TABLE I

SEQUENCE OF EVENTS AS RECORDED ON FILM

Event	Camera I Frame Number	Camera I Time Seconds	Camera II Frame Number	Camera II Time* Seconds	Camera III Frame Number	Camera III Time Seconds	Camera IV Frame Number	Camera IV Time Seconds	Camera V Frame Number	Camera V Time Seconds
Start Sustainer Hypergol	643	-0.225	1704	-0.208 (-0.185)	3267	-0.175	5227	-0.227	6128	-0.25
End Sustainer Hypergol	655	-0.165			3269	-0.167	5235	-0.164		
First Explosion	688	0	1709	0	3273	0	5256	0	6134	0
Second Explosion			1817	4.5 (4.0)	3369	4.0	5754	3.89	6228	3.917
Start Missile 1-F Settling			1832	5.125 (4.56)						
Third Explosion			1845	5.67 (5.04)	3394	5.042	5883	4.898		
Elevator House Hit By Shock Wave			1847	5.75 (5.11)	3396	5.125				
S-4 Utility Bldg, Hit By Shock Wave					3401	5.333				

* Times in parenthesis are calculated by using 27 frames per second.
Camera I - 200 Frames/sec. - Southeast flame bucket
Camera II - 24 Frames/sec. - Northwest above block house
Camera III - 24 Frames/sec. - S-4 South tank
Camera IV - 128 Frames/sec. - S-4 Sewer area
Camera V - 24 Frames/sec. - North on hill

TABLE II

ESTIMATED OVERPRESSURES
(Estimated Yield 2150 lb. TNT)

Structure	Distance, ft.	Minimum Pressure, psi*	Estimated Overpressure, psi From Damage Assessment	Estimated Overpressure, psi From Estimated Shock Velocity.
S-4 Utility Building	330	0.6	1.25-1.75	2.0
	420	0.6	1.25-1.75	1.5
S-4 Steel Transfer Doors	400	0.5	1.5-2.0	1.6
S-4 Guard House	450		0.5-1.0	1.3
S-4 Guard House	475		0.5-1.0	1.2
S-4 Centaur Tank	500		1.0	1.1
S-1 Block House Annex Door	410		1.25-1.75	1.52
S-1 S.D.C. Building	100	0.8	4-5	15.5**
	140	0.8	3-4	9.0**

* These are minimum pressures required to start deformation as calculated by the stress group

** These pressures are too high as witnessed by S.D.C. Building. The shock wave may be in a transient phase at this short distance which would not lend itself to the analysis.

Date: 21 May 1962

6.7.2 To: Captain L. F. Gifford,
United States Air Force

From: S. R. Simpson,
Acting Site Manager

Subject: Damage to Missile 1-F Acoustica Equipment, in Compliance with Requests from Airborne and Facilities Hardware Committees

1.0 Examination of landline data and physical appearance of parts, indicate that the Acoustica computer and stillwells were blown from Missile 1-F about six (6) seconds after booster ignition. The following Acoustica equipment, in support of Missile 1-F, has been damaged beyond repair:

Computer Assembly, CA-109, P/N 101720-1, S/N 0069
Lox Stillwell, SL-192A, P/N 101350-1, S/N 0252
Fuel Stillwell, SF-191, P/N 101340, S/N 0150
Signal Conversion Unit, SC-102, P/N 50007507, S/N 002
Fuel Alternate String Cable, P/N 50021146-5
LOX Alternate String Cable, P/N 50021146-6

1.1 Numerous pieces of the Acoustica Computer assembly were found between 200 and 400 feet southwest of the service tower. All sections of the computer assembly were badly burned.

1.2 All fourteen (14) sensors of the lox stillwell were located between twenty (20) and fifty (50) feet directly north of the service tower. The sensor backshells were found to be in tact and the secondary stillwells were still connected, but sections of the stillwell, which had fallen close to the tower, were badly burned.

1.3 Only three (3) sensor stations of the fuel stillwell have been located. They were found approximately fifty (50) feet north of the service tower and were not badly burned.

1.4 The signal conversion unit, containing twelve (12) sensor controls, was found approximately 100 feet southwest of the service tower, in a badly mangled and burned condition. This unit, which weighted about forty (40) pounds, had originally been mounted to the north side of the service tower.

1.5 Neither the fuel nor lox alternate string cables have been located and are assumed to have been consumed by the fire.

2.0 It is requested by Acoustica Associates, Inc. that all available sections of the lox stillwell and the fuel stillwell be forwarded to Acoustica Associates, Inglewood, California for quality and strength evaluation.

3.0 The Blockhouse Monitor, MO-200 MD-1, P/N 101394, S/N 006 and the Signal Output Panel, SP-102, P/N 5007508, S/N 002, were located in the blockhouse at the time Missile 1-F exploded, and thereby, escaped any apparent damage.

/S/ S. R. Simpson
S. R. Simpson, Acting Site Manager
A/A - Sycamore Static Test Site

6.8 MISSILE HISTORY

Presented in the following section is a chronological listing, by planning department completion dates, of BOI's, EO's, ClC's, Planning Cards and Procedures that were accomplished in the time interval between the completion of Test 12 and hot firing S1-613-14-01. Also included are inspection IR's and NRD's, by initiation date, that were written against missile hardware and installations, and a listing of items that were officially planned by the Sycamore planning group but were not indicated as completed in the planning records.

Of possible interest are items relating to inspection and special testing of the sustainer "Y" duct. All work was accomplished by site BOI between 1 and 8 May 1962. The testing included replacing the lox pump inlet Rayco seal, visually inspecting the impeller and wear ring for indications of rubbing (there was no such indication), and conducting gimbal tests to measure restraints imparted to the pump by the lox and fuel low pressure ducting. The above testing was accomplished in support of the Missile 11F investigation and was performed under the supervision of Rocketdyne Canoga Park personnel.

23 March 1962

				Date Planned	Date Complete
27	93936	BK 1C	HYPERGOLIC SLUG INSTL	20 March 62	23 March 62
BOI	1		FLAME DEFL PRESSURE METER	22 March 62	23 March 62
BOI	1		XDCR FAILURE	23 March 62	23 March 62
BOI	2		REMOVE NAC COVER TRIC CLEAN	22 March 62	23 March 62
BOI	2		C/O INVERTER VOLTAGE	23 March 62	23 March 62
BOI	3		FUEL SPLY IGNITOR FUEL VLV C/O	22 March 62	23 March 62
BOI	3		C/O PROPELLANT LEVEL XFER ROOM	23 March 62	23 March 62
BOI	4		SUST ENG HYD LEAK CHECK	22 March 62	23 March 62
BOI	5		LEAK CHECK F/D VLV INTERNAL LEAKAGE	22 March 62	23 March 62
BOI	8		C/O EVACUATION CHAMBER	23 March 62	23 March 62
BOI	9		C/O EVACUATION CHAMBER	23 March 62	23 March 62

F & CD/IR: #711545 Date 3-23-62
P/N: 555022 - Vlv Assy Volute Bleed.
Next Assy: 401501
Problem: Flow rate reduced after hot firing.
Disposition: Repaired and reinstalled.

F & CD/IR: #711551 Date 3-23-62
P/N: 555022 - Valve Assy.
Next Assy: 401501
Problem: Volute Vlv. flow rate reduced after hot firing.
Disposition: Repaired and reinstalled.

F & CD/IR: #711591 Date 3-23-62
Class Failure: Minor
P/N: 27-77014-1 - Radiation Boot Assy.
Next Assy: 27-77015
Problem: Sust. boot torn on seam of zipper flap
Disposition: Replaced

24 March 1962

27	06191	3 A	REMOVE GROUND STRAP FM-28V	27 Feb. 62	24 March 62
27	06191	5 A	POWER SUPPLY	22 Feb. 62	24 March 62
C1C	98295		27-06191-5A VPM 2	22 Feb. 62	24 March 62

26 March 1962

27	93701	BK 1B	LN2 SHROUDS LEAK CHECK W/GN2	26 March 62	26 March 62
27	93857	BK 1A	LOX TOPPING PRESSURIZATION SYSTEM	26 March 62	26 March 62
27	93951	BK 2E	BSTR & SUST TURBO PUMPS	26 March 62	26 March 62
BOI	2		PLAYBACK FM FROM BACKUP	26 March 62	26 March 62

26 March 1962 (Continued)			Date Planned	Date Complete
BOI	3	SUPPORT C/O XDCR	26 March 62	26 March 62
BOI	4	POST CAL P1039P	26 March 62	26 March 62
BOI	5	CONDUCT DROP LEVEL TEST	26 March 62	26 March 62
BOI	5	FACILITY GAGE CAL	6 March 62	26 March 62
BOI	6	C/O HCU PRESSURE SWITCH	26 March 62	26 March 62
BOI	9	REPAIR VENT LINE	26 March 62	26 March 62
BOI	10	VERIFY WIRING SYST TO INST/N	26 March 62	26 March 62
BOI	10	REMOVE FISHER CONTROLLER	26 March 62	26 March 62
BOI	11	C/O VERN PNEU REG	26 March 62	26 March 62
BOI	12	C/O VERN ENG MOUNTING BOLTS	26 March 62	25 March 62

F & CD/IR: #711548 Date: 3-26-62
Class Failure: Non-significant
P/N: 6141-1 - Fuel Transfer Pump
Next Assy: Fuel transfer unit
Problem: Leaks
Disposition: Design Review

F & CD/IR: #711546 Date: 3-26-62
Class Failure: Major
P/N: 27-08554-3 - Accumulator (Booster B-1)
Next Assy: 27-85042-1
Problem: Leaking "O" ring - case pressure
Disposition: Replaced

F & CD/IR: #711547 Date: 3-26-62
Class Failure: Major
P/N: 27-08554-3F - Accumulator (Booster B-2)
Next Assy: 27-85052-1
Problem: Leaking "O" ring - case pressure
Disposition: Replaced

27 March 1962

27	90583	BK 2A	SILO LOX STORAGE TANK	26 March 62	27 March 62
BOI	5		POST CAL FUNCTIONAL RECORDERS	27 March 62	27 March 62
BOI	8		REPLACE FUEL GROUND F/D VLV	26 March 62	27 March 62
BOI	9		REPLACE B1 & B2 HYD ACCUMULATORS	26 March 62	27 March 62
BOI	13		INSTALL PCU SUPPLY RELIEF VLV	27 March 62	27 March 62
BOI	14		C/O FUEL LEAKAGE	27 March 62	27 March 62
BOI	15		VOLUTE BLEED VLV FLOW TEST	27 March 62	27 March 62
BOI	16		FLOW TEST IR'D VOLUTE BLEED VLV	27 March 62	27 March 62

28 March 1962

				Date Planned	Date Complete
7	18318	500 1A	WIRE TAB J BOX A109	22 March 62	28 March 62
27	81002	801 B	LOX TANK DUCT C/O	28 March 62	28 March 62
BOI	3		RAPID LOAD GN2 DOME LEAK	21 March 62	28 March 62
BOI	4		PREPARE LOGIC UNIT	23 March 62	28 March 62
BOI	6		C/O TIMER SETTING	24 March 62	28 March 62
BOI	6		C/O XDCRS P1092P & P1232P	28 March 62	28 March 62
BOI	8		ADJ & REPROGRAM AMPLIFIERS	26 March 62	28 March 62
BOI	10		TOWER LOC NOZZLE SAFETY HAZARD	28 March 62	28 March 62
BOI	17		REMOVE REG GN602	28 March 62	28 March 62
BOI	19		C/O PS 324	28 March 62	28 March 62
BOI	25		GROUND SPRAGUE RID UNIT C/O	2 March 62	28 March 62
BOI	44		PCU PS 51 LOCKOUT C/O	15 March 62	28 March 62
BOI	94		TVA FOR LOX 2 PRESSURE VENT	21 March 62	28 March 62
BOI	96		INST TVA 2ND STORAGE REG	22 March 62	28 March 62
GMA	12565		RCC SYSTEM KIT	2 Feb. 62	28 March 62
GMA	12565	A	MULTI-CHAMBER RCC C/O	26 March 62	28 March 62
C1C	13494	27-81002-801	CHG B E.O.W.	22 March 62	28 March 62
C1C	16270	27-87041	E.O. 212498	27 March 62	28 March 62
C1C	38370	7-18318-500	1A D/C B	20 March 62	28 March 62

F & CD/IR: #711436 Date: 3-28-62
Class Failure: Minor
P/N: 44-1505 - Valve
Next Assy: Pneu Inst.
Problem: Excessive Pressure
Disposition: Design Review

F & CD/IR: #711550 Date 3-28-62
Class Failure: Minor
P/N: GBX205-K2 - Regulator
Next Assy: Tank Pressure Line Instl.
Problem: Leaks
Disposition: Adjusted

F & CD/IR: #711554 Date: 3-28-62
Class Failure: Non-significant
P/N: GBX205-K2 - Regulator
Next Assy: Tank Pressure Line Instl.
Problem: Leaks
Disposition: Design Review

29 March 1962

				Date Planned	Date Complete
7	18695	500 1A	TAB LIST WIRING	22 March 62	29 March 62
27	27090	1 1F	LOX XFER LINES C/O	9 March 62	29 March 62
27	27092	1 1A	LOX F/D VLV C/O	9 March 62	29 March 62
BOI	13		PROVIDE MATERIAL FOR REWORK	28 March 62	29 March 62
BOI	17		VERIFY CONTINUITY	29 March 62	29 March 62
BOI	18		SETUP SYST REMOVAL CN602	28 March 62	29 March 62
BOI	20		C/O DIODE CONTINUITY	29 March 62	29 March 62
BOI	21		EXAMINE SUST BYPASS VLV	29 March 62	29 March 62
C1C	14212	7-00008-501 D	GMA 12565	23 Feb. 62	29 March 62
C1C	28713	7-18695-500 1A	O/D	20 March 62	29 March 62

F & CD/IR: #711438 Date: 3-29-62
Class Failure: Non-significant
P/N: 7-01720-1 - Transducer
Next Assy: 27-11651
Problem: Did not operate on proper curve - recheck ok.
Disposition: Adjust.

F & CD/IR: #711557 Date: 3-29-62
Class Failure: Minor
P/N: 6146-1
Problem: Supercedes 711548

30 March 1962

27	69029	809 1A	PANEL ASSY AUXILIARY PNEU	28 March 62	30 March 62
BOI	7		REPLACE IR'D XDCR	29 March 62	30 March 62
BOI	14		REMOVAL OF LV A34	28 March 62	30 March 62
BOI	22		LEAK C/O OF LOX CONTROL VLVS	29 March 62	30 March 62
BOI	22		PROPULSION ELECTRICAL INITIATOR C/O	29 March 62	30 March 62
BOI	23		C/O VERN PNEU REG & XDCR	30 March 62	30 March 62
BOI	24		VLV N-50 RELAY C/O	30 March 62	30 March 62
C1C	14185	27-27092-1 1A	E0212362	9 March 62	30 March 62

F & CD/IR: #711559 Date: 3-30-62
Class Failure: Non-significant
P/N: 555022 - Valve Assy.
Next Assy: 401501
Problem: Vlv assy dropped - damaged fitting.
Disposition: Repaired and reinstalled.

31 March 1962

			Date Planned	Date Complete
BOI	27	RECONNECT INLET VLV L-60	31 March 62	31 March 62

1 April 1962

F & CD/IR: 588086 Date: 4-1-62
Class Failure: Non-significant
P/N: 0-20T0100 - Gauge
Next Assy: Pod cool syst.
Problem: Threads stripped
Disposition: Design Review

2 April 1962

BOI	20	CLEAN VOLUTE BLEED VLV	28 March 62	2 April 62
BOI	26	C/O VERN PNEU REG	30 March 62	2 April 62
BOI	28	REPAIR FLOWMETER LEAK	2 April 62	2 April 62
BOI	29	SUPPORT PROPULSION SYST C/O	2 April 62	2 April 62

F & CD/IR: #711443 Date: 4-2-62
Class Failure: Major
P/N: 27-45045-5 - 2 rate gyro
Next Assy: 27-62031
Problem: Schrader fitting loosened - No pressure in canister.
Disposition: Failure Analysis

F & CD/IR: #711444 Date: 4-2-62
Class Failure: Non-significant
P/N: 650982-21 - Gas Generator Assy.
Next Assy: 650040
Problem: Booster S.P.G.G. - Stud & finger loose
Disposition: Held for repair

F & CD/IR: #711445 Date: 4-2-62
Class Failure: Non-significant
P/N: 650988-21 - Gas Generator Assy.
Next Assy: 650040
Problem: Sust S.P.G.G. - Outward dents in heater blanket corner
Disposition: Replaced

2 April 1962 (Continued)

F & CD/IR: #711446 Date: 4-2-62
Class Failure: Non-significant
P/N: 650988-21 - GG Assy.
Next Assy: 650040
Problem: Sust SPGG - Outward dents in heater blanket corner
Disposition: Replaced

F & CD/IR: #711447 Date: 4-2-62
Class Failure - Non-significant
P/N: 650982-21 - GG Assy.
Next Assy: 650040
Problem: Booster SPGG - Deep ding in heater blanket corner.
Disposition: Replaced

F & CD/IR: #711448 Date: 4-2-62
Class Failure: Minor
P/N: 7-320 - Galvanometer
Next Assy: Bay Recorder
Problem: Erratic
Disposition: Design Review

F & CD/IR: #711560 Date: 4-2-62
Class Failure: Non-significant
P/N: A67-09217 - 3/4" tube assy
Next Assy: Compressor
Problem: Dented
Disposition: Condemned

F & CD/IR: 711561 Date: 4-2-62
Class Failure: Minor
P/N: L0900A14X2 - Thermostat
Next Assy: Air Cooling Unit
Problem: Erratic
Disposition: Design Review

F & CD/IR: #711562 Date: 4-2-62
Class Failure: Non-significant
P/N: POR-372-1-A - Filter
Next Assy: Fuel System
Problem: Quarterly Cleaning Due
Disposition: Held for Repair

F & CD/IR: #711589 Date: 4-2-62
P/N: 27-29082-801 - Valve Instl (Lox)
Next Assy: Propellant Line Instl
Problem: Leaks
Disposition: Replaced

2 April 1962 (Continued)

F & CD/IR: #711590 Date: 4-2-62
P/N: 402238 - Clip
Next Assy: 400120
Problem: Broken
Disposition: Replaced

3 April 1962

				Date Planned	Date Complete
7	19662	500 C	XDCR INSTL LINES LN2	3 April 62	3 April 62
27	24009	801 J	HOSE AND MANIFOLD INSTL	28 March 62	3 April 62
27	27090	1 1F	LOX XFER LINES C/O	3 April 62	3 April 62
27	68854	500 1A	RELAY PANEL LOX R & D	3 April 62	3 April 62
27	93951	BK 2E	BSTR & SUST TURBOPUMPS BEA	4 April 62	3 April 62
27	94476	1	INSPECT ELECTRICAL CHECKLIST	2 April 62	3 April 62
EO	212560		LOX TOPPING C/O	2 April 62	3 April 62
EO	212600		CORRECT SILO R & D BUS	3 April 62	3 April 62
BOI	1		C/O P1506D FOR OPEN WIPER	3 April 62	3 April 62
BOI	7		ACCELEROMETER CALIBRATION	26 March 62	3 April 62
BOI	9		TIEBACK WIRE	29 March 62	3 April 62
BOI	10		P1003P PRESSURE C/O	30 March 62	3 April 62
BOI	11		REWORK DIESEL GENERATOR UNIT	29 March 62	3 April 62
BOI	14		REPAIR PUMP LEAK	2 April 62	3 April 62
BOI	15		REMOVE TUBING	2 April 62	3 April 62
BOI	19		ACCOMPLISH PRE-RELEASE EO	29 March 62	3 April 62
BOI	30		DETERMINE LEAKAGE RATE AT V2	2 April 62	3 April 62
BOI	31		REPLACE IR'D VLV	3 April 62	3 April 62
BOI	33		LEAK CHECK SUST LOX BELLOW	3 April 62	3 April 62
BOI	69		FABRICATE ORIFICE	20 March 62	3 April 62
BOI	90		INSTALL ORIFICE OVERBOARD BLEED	21 March 62	3 April 62
BOI	145		REMOVE F1105R FLOWMETER	23 Jan. 62	3 April 62
C1C	16518		27-29043 EO 212560	30 March 62	3 April 62
C1C	16559		27-68854-500 1A EO 219699	2 April 62	3 April 62
C1C	16701		27-61933 EO 212600	2 April 62	3 April 62
C1C	99418		27-24009-801 F EO S	15 Feb. 62	3 April 62

F & CD/IR: #711449 Date: 4-3-62
Class Failure: Minor
P/N: 7-01414-1 - Transducer
Next Assy: 27-17016
Problem: Output Signal Intermittant - Stable Input
Disposition: Depot Repaired

3 April 1962 (Continued)

F & CD/IR: #711451 Date: 4-3-62
Class Failure: Non-significant.
P/N: 27-62731-895 - Umbilical Harness
Next Assy: 27-60026
Problem: Insulation skinned for several wires
Disposition: Not Indicated

F & CD/IR: #711562 Date: 4-3-62
Class Failure: Non-significant
P/N: 27-79081-151 - Door Assy
Next Assy: 27-79081
Problem: B-1 nacelle door broken
Disposition: Repaired in place

F & CD/IR: #711564 Date: 4-3-62
Class Failure: Minor
P/N: 27-85107-493 - Tube Assy
Next Assy: 27-85107
Problem: Cracked "B" nut
Disposition: Replaced

F & CD/IR: #711565 Date: 4-3-62
P/N: 202766-21 - Thrust chamber assy
Next Assy: 100116
Problem: Broken eyelet - Sust eng. chamber exit.
Disposition: Repaired in place

4 April 1962

				Date Planned	Date Complete
27	24009	805 C	VERNIER SYST HOSE INSTL	4 April 62	4 April 62
27	93702	BK 2C	RCC SYST C/O	26 March 62	4 April 62
27	93951	BK 2E	BSTR & SUST TURBOPUMP C/O	29 March 62	4 April 62
EO	212531		DIAGRAM CKT PNEU CONTROL BOI 44	26 March 62	4 April 62
EO	212532		AUXILLARY CONTROL PANEL BOI 44	26 March 62	4 April 62
EO	212546		PCU PS-51 C/O	3 April 62	4 April 62
EO	212547		PCU PS-51 C/O	3 April 62	4 April 62
EO	212548		PCU PS-51 C/O	3 April 62	4 April 62
EO	212549		PCU PS-51 C/O	3 April 62	4 April 62
EO	212558		PCU PS-51 C/O	3 April 62	4 April 62
EO	212574		PANEL ASSY ENG UNIT 1	4 April 62	4 April 62
EO	212577		SWITCH BACK TO R & D	4 April 62	4 April 62
EO	219698		WIRING REVISION BOI 51	30 March 62	4 April 62
BOI	2		PCU PS-51 C/O	19 March 62	4 April 62
BOI	2		A/P GIMBALING TAPE	15 Feb. 62	4 April 62
BOI	11		INSTL FUSE BOX	28 March 62	4 April 62
BOI	12		REPAIR & CAL P1175T XDCR	4 April 62	4 April 62

4 April 1962 (Continued)

				Date Planned	Date Complete
BOI	12		PREVENT SWITCHING TO R&D CONTROL	28 March 62	4 April 62
BOI	13		REMOVE THERMOSTAT	2 April 62	4 April 62
BOI	15		TIME LOX DELIVERY VALVE	28 March 62	4 April 62
BOI	30		REMOVE GYRO COVER	4 April 62	4 April 62
BOI	31		DELETE P1231X	4 April 62	4 April 62
BOI	32		REPLACE SEAL	3 April 62	4 April 62
BOI	32		REPAIR HARNESS	4 April 62	4 April 62
BOI	35		SECURE PROPULSION SYST	3 April 62	4 April 62
BOI	37		C/O BSTR MAIN FUEL VLV	4 April 62	4 April 62
BOI	39		REPLACE WIRING SUPPORT BRACKET	4 April 62	4 April 62
BOI	40		REPLACE GASKET FOR LEAK CHECK	4 April 62	4 April 62
C1C	16417		27-60491 EO 212531	4 April 62	4 April 62
C1C	16417		27-62669 EO 212532	4 April 62	4 April 62
C1C	16417		27-61944 EO 212545	3 April 62	4 April 62
C1C	16417		27-16924 EO 212547	3 April 62	4 April 62
C1C	16417		27-61915 EO 212549	3 April 62	4 April 62
C1C	16417		27-61927 EO 212546	3 April 62	4 April 62
C1C	16417		27-60491 EO 212548	3 April 62	4 April 62
C1C	16559		27-68853 EO 219698	2 April 62	4 April 62
C1C	16661		27-61929 EO 212574	3 April 62	4 April 62

F & CD/IR: #711567 Date: 4-4-62
Class Failure: Non-significant
P/N: 27-29098-31 - Gasket
Next Assy: 27-29082
Problem: Gasket deformed
Disposition: Condemned

F & CD/IR: #711588 Date: 4-4-62
Class Failure: Non-significant
P/N: 83-67900-065 - Gasket
Next Assy: 27-24009
Problem: One time use item
Disposition: Condemned

5 April 1962

				Date Planned	Date Complete
27	90390	BK 2A	FLUID SAMPLING PROCEDURE	4 April 62	5 April 62
27	90574	BK 1C	HYD SYST FILL AND BLEED	4 April 62	4 April 62
BOI	36		REPLACE IR'D TUBE	4 April 62	5 April 62
BOI	38		REMOVE VERN LOX REG	4 April 62	5 April 62
BOI	41		OVERNIGHT SECURE MISSILE		5 April 62
GMA	12972		SUST ENG INSTL C1C 12972	22 March 62	5 April 62
TVA	A16747	E	CANCEL	5 April 62	5 April 62

5 April 1962 (Continued)

F & CD/IR: #711452 Date: 4-5-62
Class Failure: Minor
P/N: 395220-4 - Patch Cord
Next Assy: Access Recorder
Problem: Open
Disposition: Condemned

F & CD/IR: #711568 Date: 4-5-62
Class Failure: Non-significant
P/N: X021-B - Flex Hose
Next Assy: Line Instl.
Problem: Ruptured
Disposition: Condemned

F & CD/IR: #711569 Date: 4-5-62
Class Failure: Minor
P/N: 27-24046-7 - Distribution Manifold
Next Assy: Purge Instl.
Problem: Cracked
Disposition: Condemned

F & CD/IR: #711587 Date: 4-5-62
Class Failure: Non-significant
P/N: MS28741-8-1800 - Pneu. Hose Assy.
Next Assy: Lox Pressurization
Problem: "B"-nut cracked
Disposition: Replaced

6 April 1962

				Date Planned	Date Complete
27	90583	BK 2A	LOX STORAGE TANK	5 April 62	6 April 62
BOI	7		REMOVE VERN CLAM SHELLS	26 March 62	6 April 62
BOI	21		REMOVE FLEX HOSE		6 April 62
BOI	43		FLEX LINE REPAIR		6 April 62
C1C	16417		27-62042 EO 212558	3 April 62	6 April 62

F & CD/IR: #711570 Date: 4-6-62
P/N: 553500 - Regulator
Next Assy: 551722
Problem: Unstable reg. - 566 psig to 590 psig.
Disposition: Replaced

9 April 1962

			Date Planned	Date Complete
BOI	2	INSPECTION OF BOOSTER	6 April 62	9 April 62
BOI	4	REPAIR INSTL P1478T	9 April 62	9 April 62
BOI	4	REPLACE VERN PNEU CONTROL	6 April 62	9 April 62
BOI	4	C/O LOX SENSOR STATION	9 April 62	9 April 62
BOI	4	CAL GAGES MWO 137649	15 Feb. 62	9 April 62
BOI	5	REPLACE LOX DOME MANIFOLD	6 April 62	9 April 62
BOI	6	PRESSURIZE MISSILE LOX TANK	6 April 62	9 April 62
BOI	11	REMOVE SHAVINGS LOX FILTER	9 April 62	9 April 62
BOI	12	CHECK STORAGE TANK BLANKET PRESSURE	9 April 62	9 April 62

F & CD/IR: #711572 Date: 4-9-62
Class Failure: Non-significant
P/N: 27-02528-1 - Filter
Next Assy: Line Instl.
Problem: Metal Shavings
Disposition: Repaired and reinstalled

F & CD/IR: #711571 Date: 4-9-62
Class Failure: Non-significant
P/N: 27-08089-18 - Vent Duct and Relief Valve
Next Assy: 27-81009
Problem: Misalignment - vent duct and relief vlv.
Disposition: Replaced

F & CD/IR: #711573 Date: 4-9-62
Class Failure: Minor
P/N: 27-85107-311 - Tube assy. sust. hyd. ground pressure.
Next Assy: 27-85107
Problem: Cracked "B" nut
Disposition: Replaced

F & CD/IR: #711586 Date: 4-9-62
Class Failure: Non-significant
P/N: 27-02528-1 - Filter
Next Assy: Fuel line instl.
Problem: Threads damaged
Disposition: Repair reinstalled

10 April 1962

27	68746	867 A	SEQUENCE & RESPONDER GROUP	2 April 62	10 April 62
27	90534	BK 1A	SILO LOX TOPPING TANK	10 April 62	10 April 62
EO	212590		RELOCATE F1354T	9 April 62	10 April 62
BOI	3		OPEN PODS AND NACELLES	6 April 62	10 April 62
BOI	5		UPDATE LOGIC UNIT	24 March 62	10 April 62

10 April 1962 (Continued)

			Date Planned	Date Complete
BOI	6	C/O RCC AMPLIFIER GAIN	9 April 62	10 April 62
BOI	7	C/O SUST. PITCH ACTUATOR LEAKAGE	9 April 62	10 April 62
BOI	7	ADD TV COVERAGE	9 April 62	10 April 62
BOI	8	SET SPARE SUST PITCH ACTUATOR	9 April 62	10 April 62
BOI	9	PURGE TOPPING LINE	9 April 62	10 April 62
BOI	10	REMOVE BROKEN FILTER PURGE PORT	9 April 62	10 April 62
BOI	13	REPLACE IR'D TUBE	9 April 62	10 April 62
BOI	14	CORRECT MISALIGNED CONDUIT	9 April 62	10 April 62
BOI	15	SECURE MISSILE OVERNIGHT	9 April 62	10 April 62
BOI	16	TACK WELD SUST DRAIN	9 April 62	10 April 62
BOI	28	COMMUNICATIONS	31 Jan. 62	10 April 62
BOI	33	REPAIR KELLOG PHONES	6 April 62	10 April 62
C1C	13494	7-19634 EO 212590	9 April 62	10 April 62
C1C	13883	27-61639-3 CHG 1A EO 213319-1	5 April 62	10 April 62

F & CD/IR: #711585 Date: 4-10-62
P/N: 651133 - Igniter assy.
Next Assy: 650040
Problem: Tube not crimped to body
Disposition: Replaced

11 April 1962

7	18691	500 1A	VERIFY A103 TAB	22 March 62	11 April 62
27	93858	BK 1A	LEAK CHECK LOX TOPPING LOW PRESSURE	10 April 62	11 April 62
BOI	1		C/O MISSILE LIFT TIMER	9 April 62	11 April 62
BOI	8		ADJUST A/P AMPLIFIER	11 April 62	11 April 62
BOI	8		CAL GAGES	16 March 62	11 April 62
BOI	9		C/O LOX STATION 5 SENSOR	11 April 62	11 April 62
BOI	18		REPLACE LOX TOPPING GASKET	10 April 62	11 April 62
BOI	19		REMOVE NACELLE COVER	11 April 62	11 April 62
BOI	21		CHECK BOILOFF VLV LEAKAGE	11 April 62	11 April 62
BOI	22		CHECK ICE ON LOX TANK	11 April 62	11 April 62
BOI	32		REPAIR 25 HEADSETS S1	21 March 62	11 April 62
C1C	01795		27-68746-867 CHG A EO BB	2 April 62	11 April 62
C1C	01805		27-68764-869 CHG A EO BD	9 April 62	11 April 62

F & CD/IR: #711456 Date: 4-11-62
Class Failure: Minor
P/N: 55-01142-1 -Transducer-skin temperature
Next Assy: TVA A21231
Problem: Transducer open
Disposition: Condemned

11 April 1962 (Continued)

F & CD/IR: #711575 Date: 4-11-62
Class Failure: Critical failure
P/N: 27-02020 (P10) - Filter element
Next Assy: lox pre-fab
Problem: Contaminated (PFAR S-290)
Disposition: Failure Analysis

12 April 1962				Date Planned	Date Complete
27	60425	1	1B DIAGRAM CIRCUIT	10 April 62	12 April 62
27	61656	3	1E LAUNCH CONTROL REQUIREMENTS	10 April 62	12 April 62
27	68746	869	A REWORK LSR	9 April 62	12 April 62
BOI	1		PLAYBACK DATA	6 April 62	12 April 62
BOI	1		INSPECT FILTER L-15 (LOX)	10 April 62	12 April 62
BOI	4		REPROGRAM NACELLE DOOR WORK	12 April 62	12 April 62
BOI	5		OBTAIN LOX SAMPLE	12 April 62	12 April 62
BOI	23		INVESTIGATE LOX F/D VLV	11 April 62	12 April 62
BOI	24		PROVIDE AMBIENT LOX TO TANKING	11 April 62	12 April 62
BOI	25		RESET SILO AC VOLTAGE	11 April 62	12 April 62
BOI	26		SECURE MISSILE OVERNIGHT	11 April 62	12 April 62

F & CD/IR: #711459 Date: 4-12-62
P/N: 101350 - Stillwell assy.
Next Assy: 27-72253-809
Problem: Open circuit
Disposition: Repaired in place

F & CD/IR: #711577 Date: 4-12-62
Class Failure: Non-significant
P/N: 27-77014-1 -Radiation boot-sust.
Next Assy: 27-77015-1
Problem: Damaged
Disposition: Replaced

13 April 1962				Date Planned	Date Complete
27	60179	1	1C DIAGRAM CIRCUIT	22 March 62	13 April 62
27	70468	500	1A C/O PYROTECHNIC CABLE	12 April 62	13 April 62
27	90452	BK	1B C/O GG IGNITOR	9 April 62	13 April 62
27	90534	BK	1A SILO LOX TOPPING TANK C/O	9 April 62	13 April 62
27	90579	BK	1C C/O SILO & R&D CONTINUITY	29 March 62	13 April 62
27	90597	BK	1 C/O RAPID LOAD PREFABS	27 March 62	13 April 62

13 April 1962 (Continued)

				Date Planned	Date Complete
27	93612	BK 1C	ACOUSTICA CLOSED LOOP C/O	26 March 62	13 April 62
27	93857	BK 1A	LOX TOPPING TANK PRESSURIZATION C/O	20 March 62	13 April 62
27	93857	BK 1A	LOX TOPPING TANK PRESSURIZING SYSTEM C/O	27 March 62	13 April 62
27	93910	BK 2B	GROUND & A/B PNEU SYST C/O	26 March 62	13 April 62
27	93917	BK 2E	PROPULSION MATED LEAK & FUNCTIONAL	26 March 62	13 April 62
27	94476	BK 1B	INSPECTION CHECK LIST	13 March 62	13 April 62
BOI	1		PREPARE CABLE FOR TANK OBSERVER	11 April 62	13 April 62
BOI	2		NULL AUTOPILOT	13 April 62	13 April 62
BOI	3		DRAIN LOX STORAGE TANK	12 April 62	13 April 62
BOI	4		CHECK LOX FILTER L-15	12 April 62	13 April 62
BOI	10		FLUSH LOX STORAGE TANK	13 April 62	13 April 62
BOI	11		HYD SYST FILL & BLEED	13 April 62	13 April 62
BOI	22		HELIUM SYST XDCR C/O	1 March 62	13 April 62

F & CD/IR: #711576 Date: 4-13-62
Class Failure: Minor
P/N: RV061503A - Hyd. Relief Valve
Next Assy: Compressor
Problem: Cracked
Disposition: Condemned

14 April 1962

27	90534	BK 1A	LOX TOPPING	5 April 62	14 April 62
27	90534	BK 1B	SILO LOX TOPPING TANK	16 April 62	14 April 62
27	90574	BK 1C	FILL AND BLEED	26 March 62	14 April 62
27	93951	BK 2E	BSTR & SUST TURBOPUMP	11 April 62	14 April 62
BOI	2		ACCOMPLISH HYD TEST OBJECTIVE	12 April 62	14 April 62
BOI	7		PURGE LOX TANK	13 April 62	14 April 62
BOI	8		REPLACE DIRTY LOX FILTERS	13 April 62	14 April 62

16 April 1962

BOI	4		C/O XDCR	16 April 62	16 April 62
BOI	4		C/O LOX LOADING HIGH PRESSURE BOTTLE	12 April 62	16 April 62
BOI	5		REMOVE XDCR	13 April 62	16 April 62
BOI	5		CHECK PROPELLANT SENSOR	16 April 62	16 April 62
BOI	6		REPAIR & C/O P1177T	13 April 62	16 April 62
BOI	6		SUPPORT HYD TEST	12 April 62	16 April 62
BOI	7		ANALYZE RAYCO SEAL	12 April 62	16 April 62
BOI	8		REMOVE BOILOFF VLV	12 April 62	16 April 62
BOI	13		C/O LOX STORAGE TANK	13 April 62	16 April 62

16 April 1962 (Continued)

			Date Planned	Date Complete
BOI	14	REDUCE BOTTLE PRESSURE	13 April 62	16 April 62
BOI	17	ENTER MISSILE LOX TANK	14 April 62	16 April 62
BOI	18	HYD FILL & BLEED	16 April 62	16 April 62
BOI	20	C/O BOILOFF VALVE	16 April 62	16 April 62

F & CD/IR: #711581 Date: 4-16-62
Class Failure: Non-significant
P/N: 27-29098-45 - Gasket
Next Assy: Lox Line Inst.
Problem: Distorted, Contaminated (Human)
Disposition: Condemned

F & CD/IR: #711578 Date: 4-16-62
Class Failure: Minor
P/N: 27-23571-839 - Seal
Next Assy: 27-21004
Problem: Seal leaking
Disposition: Condemned

F & CD/IR: #711579 Date: 4-16-62
Class Failure: Non-significant
P/N: 27-85322-9 - Fairing, V-2
Next Assy: 27-85017-7
Problem: End Damaged
Disposition: Replaced

F & CD/IR: #711580 Date: 4-16-62
P/N: 204300 - Thrust chamber B-1
Next Assy: 100651
Problem: Ding in exterior of B-1 thrust chamber
Disposition: Adjusted

17 April 1962

27	11651	807	1A	PANEL INSTL	22 Feb. 62	17 April 62
27	61182	1	1C	C/O AUXILIARY SDC PANEL	22 March 62	17 April 62
27	94476	BK	1B	ELECTRICAL CHECK LIST	16 April 62	17 April 62
EO	212533			YDCR PANEL INSTL	13 April 62	17 April 62
EO	289011	1		XDCR TRACK SUPPORT	16 March 62	17 April 62
BOI	1			COMPLETE HYD LEAK TEST	12 April 62	17 April 62
BOI	2			C/O POD COOLING SYST	12 April 62	17 April 62
BOI	3			PURGE LOX TANK	12 April 62	17 April 62
BOI	4			REPAIR NACELLE DOOR	12 April 62	17 April 62

17 April 1962 (Continued)

			Date Planned	Date Complete
BOI	5	CALIBRATE GAGES	22 Feb. 62	17 April 62
BOI	7	CHECK DEW POINT	14 April 62	17 April 62
BOI	42	SUPPORT PROPULSION C/O		17 April 62
BOI	44	TRIC FLUSH		17 April 62
BOI	76	SET UP FM FOR FUEL DETANKING	17 March 62	17 April 62
BOI	20	DAMAGED HOSE		17 April 62
BOI	7	ELIMINATE MOISTURE IN LOX TANK	17 April 62	17 April 62
BOI	9	UPDATE LSR	26 March 62	17 April 62
BOI	9	DRY LOX STORAGE TANK	13 April 62	17 April 62
BOI	12	C/O SUST LOX "Y" DUCT	13 April 62	17 April 62
BOI	12	PURGE LOX TANK	13 April 62	17 April 62
BOI	13	PREVENT ICE BUILDUP ON DUCT	16 April 62	17 April 62
BOI	14	CORRECT VACUUM PUMP LEAK	16 April 62	17 April 62
BOI	21	RESET LOX LOADING CONFIGURATION	16 April 62	17 April 62
BOI	68	CALIBRATE GAGES	15 March 62	17 April 62

F & CD/IR: #484003 Date: 4-17-62
Class Failure: Non-significant
P/N: 1908 - Filter assy.
Next Assy: Lox System
Problem: Contaminated
Disposition: Depot repaired

F & CD/IR: #711473 Date: 4-17-62
Class Failure: Minor
P/N: 100937 - Mixer Amplifier
Next Assy: Dac Bay
Problem: No output
Disposition: Design Review

F & CD/IR: #711474 Date: 4-17-62
Class Failure: Minor
P/N: 100973 - Mixer Amplifier
Next Assy: Dac Bay
Problem: No output
Disposition: Design Review

F & CD/IR: #484004 Date: 4-17-62
Class Failure: Non-significant
P/N: 27-79081-173 - Seal
Next Assy: 27-79081
Problem: Seal torn
Disposition: Condemned

17 April 1962 (Continued)

F & CD/IR: #484005 Date: 4-17-62
Class Failure: Non-significant
P/N: 27-79081-173 - Seal
Next Assy: 27-79081
Problem: Seal torn
Disposition: Condemned

F & CD/IR: #484006 Date: 4-17-62
Class Failure: Non-significant
P/N: 27-23571-839 - Seal
Next Assy: 27-21004
Problem: Seal distorted
Disposition: Condemned

F & CD/IR: #484007 Date: 4-17-62
Class Failure: Non-significant
P/N: 27-23571-839 - Seal
Next Assy: 27-21004
Problem: Seal distorted
Disposition: Condemned

F & CD/IR: #484008 Date: 4-17-62
Class Failure: Non-significant
P/N: 27-23571-839 - Seal
Next Assy: 27-21004
Problem: Spacer replaced per engineering directive
Disposition: Repaired

18 April 1962

				Date Planned	Date Complete
27	27089	1 1D	PREFAB INSTL	15 Feb. 62	18 April 62
BOI	1		TAKE SAMPLES	12 April 62	18 April 62
BOI	3		MODIFY ACOUSTICA LOX	14 April 62	18 April 62
BOI	3		C/O PNEU CONSOLE DP METER	2 April 62	18 April 62
BOI	8		A/P AMPLIFIER SPARES	18 April 62	18 April 62
BOI	9		PREVIOUS MISSILE DAMAGE	12 April 62	18 April 62
BOI	9		C/O AUDIO WARNING AMPLIFIER GAINS	18 April 62	18 April 62
BOI	10		LOX LOADING FLANGES C/O	13 April 62	18 April 62
BOI	11		RETURN LOX LOADING TO B/P	13 April 62	18 April 62
BOI	16		CORRECT ECP 1805	29 March 62	18 April 62
BOI	16		VENT LOX STORAGE VACUUM	13 April 62	18 April 62
BOI	17		REPAIR SURGE CHAMBER LEAK	18 April 62	18 April 62
BOI	21		ECN 28555 TO FOLLOW	13 April 62	18 April 62
BOI	22		REPLACE DAMAGED HOSE		18 April 62

18 April 1962 (Continued)

			Date Planned	Date Complete
BOI	22	PURGE LOX TANK	17 April 62	18 April 62
BOI	23	INST HALLAMORE MOD KIT	30 March 62	18 April 62
BOI	23	FILL TOPPING TANK	18 April 62	18 April 62
BOI	24	MONITOR STORAGE TANK	18 April 62	18 April 62
BOI	25	RAISE CHILLDOWN PRESSURE	18 April 62	18 April 62
BOI	26	DEW POINT READING C/O	18 April 62	18 April 62
BOI	27	INVESTIGATE PLAY IN SUST	18 April 62	18 April 62
BOI	77	ECN 28554 TO FOLLOW	5 April 62	18 April 62
BOI	79	EWR 33243 TO FOLLOW	18 April 62	18 April 62
ECN	28554	LINE INSTL TANK PRESSURE	17 April 62	18 April 62
ECN	28555	LINE INSTL LOX XFER	17 April 62	18 April 62
CIC	14185	27-27089-1 1D EO 213603	18 April 62	18 April 62

F & CD/IR: #484002 Date: 4-18-62
Class Failure: Non-significant
P/N: 202842 - Dome
Next Assy: 100651
Problem: Two holes tapped wrong size
Disposition: Repaired

F & CD/IR: #711477 Date: 4-18-62
Class Failure: Minor
P/N: 27-12782-1 - Temperature Thermometer
Next Assy: 27-12753
Problem: Open element
Disposition: Depot Repair

19 April 1962

27	90452	BK 1B	GG & SPGG IGNITOR C/O	17 April 62	19 April 62
27	90583	BK 2A	SILO FILL PROCEDURE	19 April 62	19 April 62
BOI	1		CAL PC1 AND N2	19 April 62	19 April 62
BOI	1		DRAIN LOW PRESSURE FUEL DUCT	19 April 62	19 April 62
BOI	4		CHECK FOR H_2O IN SUST ENGINE	19 April 62	19 April 62
BOI	5		SECURE PCU	19 April 62	19 April 62
BOI	16		INST DP GAGE	17 April 62	19 April 62

F & CD/IR: #484009 Date: 4-19-62
Class Failure: Non-significant
P/N: 27-85314-11 - Tube Assy
Next Assy: 27-85314
Problem: Gauges and surface scratches
Disposition: Condemned

20 April 1962

			Date Planned	Date Complete
BOI	1	XDCR IR'D A1361T	19 April 62	20 April 62

F & CD/IR: #484011 Date: 4-20-62
Class Failure: Major
P/N: 27-85314-817 - Sust Servo Cylinder
Next Assy: 27-85010-813
Problem: Static leak @ 100 psi - 50 drops per 24 hrs.
Disposition: Replaced

F & CD/IR: #484012 Date: 4-20-62
Class Failure: Major
P/N: 27-85311-807 - Sust Servo Cylinder
Next Assy: 27-85011-803
Problem: Static leak @ 100 psi - 50 drops per 24 hrs.
Disposition: Replaced

21 April 1962

BOI	1	LOX PURGE PARTS	13 April 62	21 April 62
BOI	2	INST/N ACTIVATOR CHANGE	20 April 62	21 April 62
BOI	7	IRL REQUIREMENTS		21 April 62
BOI	8	IRL REQUIREMENTS	6 April 62	21 April 62
BOI	12	DRAIN TOPPING TANK	20 April 62	21 April 62
C1C	13494	27-17016-801 CHG 1B ECN-28559	19 April 62	21 April 62
C1C	13494	27-11691-831 CHG 1A ECN 28541	19 April 62	21 April 62

F & CD/IR: #484014 Date: 4-21-62
Class Failure: Non-significant
P/N: 1940-6 - Retainer ring
Next Assy: 27-79082
Problem: 4 retainers missing
Disposition: Replaced

F & CD/IR: #484015 Date: 4-21-62
Class Failure: Minor
P/N: 1911-6-4 - Sleeve bolt
Next Assy: 27-79082
Problem: 4 bolts worn and distorted
Disposition: Replaced

23 April 1962

				Date Planned	Date Complete
27	11691	831 1A	XDCR INSTL	20 April 62	23 April 62
BOI	8		DETERMINE AMOUNT OF LEAK	23 April 62	23 April 62
27	17016	801 1B	GENERAL ARRANGEMENT INSTL	20 April 62	23 April 62
BOI	1		LEAK CHECK LOX LOADING SYST	23 April 62	23 April 62

F & CD/IR: #711481 Date: 4-23-62
Class Failure: Non-significant
P/N: 55-01142-1 - Transducer skin temperature
Next Assy: 27-17016
Problem: Broken lead from heat sensing element
Disposition: Condemned

F & CD/IR: #484016 Date: 4-23-62
Class Failure: Major
P/N: 59083 - Seal Lox
Next Assy: 27-27867
Problem: Blowing leak (PFAR S-293)
Disposition: Failure Analysis

24 April 1962

27	90534	BK 1B	LOX TOPPING LINE PROCEDURE	21 April 62	24 April 62
27	90574	BK 1C	HYD FILL AND BLEED	20 April 62	24 April 62
27	93951	BK 2E	BSTR & SUST TURBOPUMP	20 April 62	24 April 62
BOI	1		PC-3 ADJUSTMENT	21 April 62	24 April 62
BOI	2		REMOVE BSTR NAC COVER	19 April 62	24 April 62
BOI	3		REMOVE SUST BOOT	19 April 62	24 April 62
BOI	5		DUMP LN2	23 April 62	24 April 62
BOI	6		INSPECT Y DUCT	19 April 62	24 April 62
BOI	7		PURGE ENGINES	23 April 62	24 April 62
BOI	8		REPLACE IR'D HYD LINES	20 April 62	24 April 62
BOI	9		IR SUST PITCH ACTUATOR	20 April 62	24 April 62
BOI	10		IR V2 PITCH ACTUATOR	20 April 62	24 April 62
BOI	13		PC-3 ADJUSTMENT	21 April 62	24 April 62
BOI	14		TAKE LN2 SAMPLES	21 April 62	24 April 62
BOI	15		TAKE DEW POINT READING	23 April 62	24 April 62
BOI	62		MODIFY B1 LOX DOME	15 March 62	24 April 62
GMA	8216		INST BSTR ENGINE	23 April 62	24 April 62

F & CD/IR: #484018 Date: 4-25-62
P/N: 242001-855-120 - Pneu Hose Assy
Next Assy: Pneu test cart
Problem: Ruptured
Disposition: Condemned

25 April 1962

				Date Planned	Date Complete
7	08620	819 1A	DRAIN POD COOLING UNIT	21 March 62	25 April 62
BOI	1		PERMIT MISSILE WORK	25 April 62	25 April 62
BOI	1		RECORD SILO TANK	24 April 62	25 April 62
BOI	1		REPAIR WATER LEAK	25 April 62	25 April 62
BOI	2		DUMP LN2 FROM LOX TANK	24 April 62	25 April 62
BOI	2		MAKE & INST CAMERA BRACKET	24 April 62	25 April 62
BOI	3		ADJUST CHILLDOWN PRESSURE	24 April 62	25 April 62
BOI	3		REPLACE SEAL AND BOLT	24 April 62	25 April 62
BOI	3		CHECK INVERTER INSTL	24 April 62	25 April 62
BOI	4		REPLACE SEAL ASSY	24 April 62	25 April 62
BOI	75		ACCOMPLISH MWO 138200	2 April 62	25 April 62

26 April 1962

27	90583	BK 2A	C/O STORAGE TANK-LOX	25 April 62	26 April 62
27	90583	BK 2A	FILL LOX TANK	26 April 62	26 April 62
BOI	1		CAL N1530P	25 April 62	26 April 62
BOI	1		C/O P1177T	23 April 62	26 April 62
BOI	1		FABRICATE CAMERA HOUSING	23 April 62	26 April 62
BOI	1		REMOVE ENG CONTROL PLUG	18 April 62	26 April 62
BOI	2		TORQUE RAPID LOAD BOLTS	25 April 62	26 April 62
BOI	3		C/O N1527T	26 April 62	26 April 62
BOI	5		C/O CAMERA ELECTRICAL	26 April 62	26 April 62
BOI	6		ACCOMPLISH NOISE CHECK	26 April 62	26 April 62
BOI	12		REPLACE CHECK VALVES	26 April 62	26 April 62
BOI	13		C/O VOLUTE VALVES	26 April 62	26 April 62
BOI	14		C/O BSTR TORQUE	26 April 62	26 April 62
EWR	33240		IDENTIFICATION PLATES	18 April 62	26 April 62
CIC	15016		7-08620-819 1A EO D	20 March 62	26 April 62

F & CD/IR: #484020 Date: 4-26-62
Class Failure: Non-significant
P/N: 400964-7 - Body hypergol-sust.
Next Assy: 400120
Problem: 3/8" outlet tube fitting torqued 300 in/lbs should be 180 in/lbs.
Disposition: Adjusted

F & CD/IR: #711485 Date: 4-26-62
Class Failure: Minor
P/N: 55-01112-3 - Temperature transducer
Next Assy: Transducer installation
Problem: Open
Disposition: Design Review

26 April 1962 (Continued)

F & CD/IR: #711486 Date: 4-26-62
Class Failure: Minor
P/N: 4221 - Cable
Next Assy: Headset Assy.
Problem: Cords open
Disposition: Condemned

27 April 1962

				Date Planned	Date Complete
27	90534	BK 1B	LOX TOPPING TANK FILL	23 April 62	27 April 62
27	90534	BK 1B	TOPPING TANK C/O	25 April 62	27 April 62
27	93936	BK	HYPERGOL INSTL	26 April 62	27 April 62
BOI	4		RE-INSTL P1773P	27 April 62	27 April 62
BOI	8		INSTRUMENT STAGING VLVS	29 April 62	27 April 62
BOI	12		INSTALL XDCR	27 April 62	27 April 62
BOI	17		C/O VERN VALVES	27 April 62	27 April 62
BOI	19		REMOVE VERN HYPERGOLS	27 April 62	27 April 62
BOI	20		REMOVE BSTR HYPERGOLS	27 April 62	27 April 62
ECN	28601		INSTL LUBE TEMPERATURE	26 April 62	27 April 62
ECN	28602		INSTL THERMISTOR	26 April 62	27 April 62
ECN	28603		INSTL THERMISTOR	26 April 62	27 April 62
C1C	90297		27-12751 ECN 28601	25 April 62	27 April 62
C1C	90297		27-12748 ECN 28602	25 April 62	27 April 62
C1C	90297		27-12753 ECN 28603	25 April 62	27 April 62

F & CD/IR: #484023 Date: 4-27-62
Class Failure: Major
P/N: 27-02405-1 - Valve Assy - check
Next Assy: 27-24009
Problem: Leak-body & flange - 300 psig-two 1/4" bubbles per/sec.
Disposition: Replaced

F & CD/IR: #484024 Date: 4-27-62
P/N: 553700 - Regulator
Next Assy: 554128
Problem: 300 psig input-erratic output - 150 psig low
Disposition: Replaced

F & CD/IR: #484025 Date: 4-27-62
P/N: 305341 - Lox relief valve
Next Assy: 650040
Problem: Relief vlv. sticks in open pos.-Lox solo bottle.

30 April 1962

			Date Planned	Date Complete
BOI	12	C/O P1774P	30 April 62	30 April 62
BOI	13	CHECK WIRE TAB LIST	30 April 62	30 April 62
BOI	18	LEAK CHECK VERN VLVS	27 April 62	30 April 62
BOI	24	REPLACE IR'D VLV	27 April 62	30 April 62
BOI	29	REWORK DAMPENER ASSY	30 April 62	30 April 62
ClC	3494	27-11690 ECN 28535	27 April 62	30 April 62

F & CD/IR: #565359 Date: 4-30-62
Class Failure: Non-significant
P/N: 27-02405-1 - Vlv. Check
Next Assy: 27-24009
Problem: Contaminated, received improperly packaged (No replacement)
Disposition: Depot Repair

1 May 1962

BOI	1	C/O SENSOR STATION 6	1 May 62	1 May 62
BOI	2	SIGNAL POWER SUPPLY	1 May 62	1 May 62
BOI	4	A/P SERVO HEATER	27 April 62	1 May 62
BOI	6	MISSILE LIFT TIMER	17 April 62	1 May 62
BOI	6	TEST OBJECTIVE PF102	30 April 62	1 May 62
BOI	7	IR RELIEF VLV	30 April 62	1 May 62
BOI	8	INST XDCR	17 April 62	1 May 62
BOI	8	LEAK CHECK VERN LOX VLV	30 April 62	1 May 62
BOI	9	REPLACE VERN PNEU REG	30 April 62	1 May 62
BOI	12	HPU PRESSURE	1 May 62	1 May 62
BOI	18	REPLACE VERN SEAL	1 May 62	1 May 62
BOI	24	INST BRACKETS	30 March 62	1 May 62
BOI	25	INST THRUST SECTION INST/N	30 March 62	1 May 62
BOI	71	FABRICATE BRACKETS	30 March 62	1 May 62
BOI	73	FABRICATE 4 CLAMPS	30 March 62	1 May 62
BOI	78	FABRICATE NUTS	11 April 62	1 May 62
ECN	28535	INST XDCR	30 April 62	1 May 62

F & CD/IR: #484026 - Date: 5-1-62
Class Failure: Non-significant
P/N: 27-85107-821 - Tubing Instl. Hyd.
Next Assy: 27-85100
Problem: MS 24393 Bulkhead unions (3) instld. wrong
Disposition: Adjusted

F & CD/IR: #711498 Date: 5-1-62
Class Failure: Non-significant
P/N: 55-01142-1 - Transducer skin temperature
Next Assy: 27-17016
Problem: Lead broken during installation
Disposition: Condemned

1 May 1962 (Continued)

F & CD/IR: #484030 Date: 5-1-62
Class Failure: Minor
P/N: 242001-855-120 - Pneu. Hose Assy.
Next Assy: Pneu Test Cart
Problem: Ruptured
Disposition: Condemned

F & CD/IR: #484027 Date: 5-1-62
Class Failure: non-significant
P/N: 27-23571-839 - Seal
Next Assy: 27-21004
Problem: One time use item
Disposition: Condemned

F & CD/IR: #484028 Date: 5-1-62
Class Failure: Non-significant
P/N: 27-23571-843 - Seal
Next Assy: 2721004
Problem: One time use item
Disposition: Condemned

F & CD/IR: #484029 Date: 5-1-62
Class Failure: Non-significant
P/N: 27-23571-841 - Seal
Next Assy: 27-21004
Problem: One time use item
Disposition: Condemned

2 May 1962

			Date Planned	Date Complete
BOI	19	LEAK CHECK VERN LOX HOSE	1 May 62	2 May 62
C1C	16240	TVA-A22888 A 7-65412	12 April 62	2 May 62
C1C	16240	TVA-A23505 A 7-65412	12 April 62	2 May 62
C1C	16240	TVA-A23578 A 27-61180	12 April 62	2 May 62
C1C	16899	27-60177-1 1B ECN 28573	19 April 62	2 May 62

F & CD/IR: #711500 Date: 5-2-62
Class Failure: Minor
P/N: HR-16 - Solenoid Switch
Next Assy: Launcher Boost Unit
Problem: Intermittent
Disposition: Condemned

F & CD/IR: #484031 Date: 5-2-62
Class Failure: Non-significant
P/N: 83-67900-099 - Gasket
Next Assy: 27-24009
Problem: Distorted
Disposition: Condemned

3 May 1962

				Date Planned	Date Complete
27	90534	BK 1B	FILL LOX TANK	26 April 62	3 May 62
BOI	5		REMOVE SUSTAINER BOOT	27 April 62	3 May 62
BOI	5		RAPID LOX LOADING	21 April 62	3 May 62
BOI	24		HYD FILL AND BLEED	2 May 62	3 May 62
BOI	26		LOX REG ELBOW	2 May 62	3 May 62
BOI	29		ADJUST LOX DUCT STRUT	3 May 62	3 May 62
C1C	16240		27-60498-300 1B EO 213672	12 April 62	3 May 62

F & CD/IR: #484055 Date: 5-3-62
Class Failure: Minor
P/N: 27-06220-1
Part Name: Diff Press Indicator
Next Assy: Pneu System
Problem: Can't adjust to full scale
Disposition: Design Review

4 May 1962

7	19634	1 1A	INST XDCR	4 May 62	4 May 62
27	27090	1 1F	LOX XFER LINES	9 March 62	4 May 62
BOI	1		Y DUCT GIMBAL CHECK	1 May 62	4 May 62
BOI	6		REMOVE XDCR	23 Feb. 62	4 May 62
BOI	13		C/O PC-3	4 May 62	4 May 62
BOI	28		REMOVE FUEL VALVE	3 May 62	4 May 62
BOI	32		GIMBAL TEST PREPARATION	3 May 62	4 May 62
BOI	33		SUST PUMP ADAPTER	3 May 62	4 May 62
BOI	34		SUST LOX PUMP ADAPTER	3 May 62	4 May 62
BOI	37		FUEL PUMP INLET DUCT	3 May 62	4 May 62
BOI	39		HPU HYD FILL AND BLEED	3 May 62	4 May 62
TVA	A22888	A	SITE POWER SYSTEM	12 April 62	4 May 62
TVA	A23505	A	SITE POWER SYSTEM	12 April 62	4 May 62
TVA	A23578	A	CANCEL	12 April 62	4 May 62

F & CD/IR: #484055 Date: 5-4-62
Class Failure: Minor
P/N: 3L2104 - Belt
Next Assy: 7-18137-1
Problem: Belt deteriorated
Disposition: Condemned

F & CD/IR: #484032 Date: 5-4-62
Class Failure: Non-significant
P/N: 27-23571-843 - Seal
Next Assy: 27-21004
Problem: Gasket distorted
Disposition: Condemned

5 May 1962

				Date Planned	Date Complete
7	17053	508 03	INSTRUMENTATION	4 May 62	5 May 62
7	17053	508 04	INSTRUMENTATION	4 May 62	5 May 62
7	17053	500 02	INSTRUMENTATION	4 May 62	5 May 62
27	60498	500 1B	FIREX SYSTEM	13 April 62	5 May 62
BOI	3		SUPPORT GIMBAL TEST	1 May 62	5 May 62
BOI	3		REPLACE CHECK VALVES	26 April 62	5 May 62
BOI	4		VERIFY INTEGRITY	25 April 62	5 May 62
BOI	4		REMOVE HARNESS LACING	5 May 62	5 May 62
BOI	5		REPLACE DEFECTIVE WIRE	5 May 62	5 May 62
BOI	6		VEN" 33052 TEST CART	1 May 62	5 May 62
BOI	7		PREPARE FOR GIMBAL TEST	1 May 62	5 May 62
BOI	7		REPAIR DOOR ON LAUNCHER BOOST UNIT	2 May 62	5 May 62
BOI	9		RELOCATE P1504D	4 May 62	5 May 62
BOI	9		PREPARE FOR GIMBAL TEST	2 May 62	5 May 62
BOI	10		GIMBAL TEST CHECK	3 May 62	5 May 62
BOI	10		LEAK CHECK BONNET GASKET	2 May 62	5 May 62
BOI	13		BLEED STIC GN2 SUPPLY	1 May 62	5 May 62
BOI	14		SUPPORT INSTRUMENTATION	1 May 62	5 May 62
BOI	14		DRAIN FUEL	4 May 62	5 May 62
BOI	15		SUPPORT A/P	1 May 62	5 May 62
BOI	19		SUPPORT 27-21003-502 ADJUSTMENT	5 May 62	5 May 62
BOI	21		C/O LAUNCHER BOOSTER UNIT	2 May 62	5 May 62
BOI	22		SUPPORT 27-21001-501	5 May 62	5 May 62
BOI	31		CLEAN SUST DUCT FLANGE	3 May 62	5 May 62
BOI	36		BLANK FLANGE FUEL DUCT	3 May 62	5 May 62
BOI	38		SUST TAMPER ASSY	3 May 62	5 May 62
BOI	76		VERIFY CIRCLE READINGS	15 Jan. 62	5 May 62
BOI	80		FABRICATE CAMERA BOXES	20 April 62	5 May 62
BOI	82		FABRICATE BLANK FLANGE	2 May 62	5 May 62
BOI	83		CAMERAS	3 May 62	5 May 62
BOI	84		CAMERAS	3 May 62	5 May 62
BOI	85		FABRICATE BRACKETS	3 May 62	5 May 62
BOI	89		FUEL STAGING VLV	3 May 62	5 May 62
C1C	16876		27-21003-501 CHG. AH ECN 25431	2 May 62	5 May 62
C1C	26876		27-21003-502 CHG. AJ ECN 25431	2 May 62	5 May 62

F & CD/IR: #484033 Date: 5-5-62
Class Failure: Minor
P/N: 27-23545-801 - Dampener Assy
Next Assy: 27-21004-51
Problem: Inconsistant static friction of 50 ± 5 lbs
Disposition: Replaced

5 May 1962 (Continued)

F & CD/IR: #484056 Date: 5-5-62
Class Failure: Non-significant
P/N: 7-69507 - Electrical Harness
Next Assy: Test Roll/Pitch Program
Problem: Human error - Put 110 VAC on wire
Disposition: Replaced

6 May 1962

				Date Planned	Date Complete
27	21003	502 AF	B1 FUEL STAGING SHUTOFF VLV	2 May 62	6 May 62
27	21003	501 AF	B2 FUEL STAGING SHUTOFF VLV	2 May 62	6 May 62
BOI	1		Y DUCT GIMBAL CHECK	4 May 62	6 May 62
BOI	3		REINFORCE ACCELEROMETER BRACKETS	5 May 62	6 May 62
BOI	6		REPLACE WIRE	5 May 62	6 May 62
BOI	7		REPLACE WIRE AND COMPONENTS	5 May 62	6 May 62
BOI	8		REPAIR HARNESS	5 May 62	6 May 62
BOI	9		REPLACE STATION 7 SELECTOR SWITCH	6 May 62	6 May 62
BOI	18		SUPPORT 27-21003-501	5 May 62	6 May 62

F & CD/IR: #484034 Date: 5-6-62
Class Failure: Minor
P/N: 27-23545-801 - Dampener Assy
Next Assy: 27-21004-5
Problem: Erratic static friction of 35 to 60 lbs.
Disposition: Not indicated

F & CD/IR: #484035 Date: 5-6-62
Class Failure: Minor
P/N: TJL 1400 HG - Thermovalve
Nexy Assy: Air cool system
Problem: Can't adjust to full scale
Disposition: Design Review

7 May 1962

7	17053	508 05	INSTRUMENTATION	7 May 62	7 May 62
7	17053	508 2	INSTRUMENTATION	3 May 62	7 May 62
27	21001	501 B1	REMOVE LOX DUCT INSTL	2 May 62	7 May 62
27	94476	BK 1B	PRECOUNT OPERATIONS	4 May 62	7 May 62
BOI	5		INSTL OF P--OS ON LOX DUCT	7 May 62	7 May 62
BOI	10		LAUNCHER BOOSTER UNIT SELECTOR SWITCH	7 May 62	7 May 62
BOI	11		C/O VLV P-10	7 May 62	7 May 62
BOI	12		BSTR GG LOX CHECK VLV	4 May 62	7 May 62
BOI	13		LOX SYSTEM REWORK	22 Feb 62	7 May 62
BOI	13		C/O POD COOLER THERMO VLVS	7 May 62	7 May 62
BOI	14		REMOVE 27-27090-87	26 Feb 62	7 May 62
BOI	15		VENT MISSILE TANK PRESSURES	5 May 62	7 May 62

7 May 1962 (Continued)

			Date Planned	Date Complete
BOI	22	REMOVE AND REPLACE 27-23545-801	5 May 62	7 May 62
BOI	25	REPRESSURIZE MISSILE TANKS	5 May 62	7 May 62
BOI	30	VENT SUST LOX DUCT	3 May 62	7 May 62
BOI	34	SCRIBE REPP FUEL VLVS	7 May 62	7 May 62

F & CD/IR. #[illegible] Date. 5-7-62
Class Failure: Non-significant
P/N.. 27-[illegible] - tube assy
Next Assy: 27-[illegible]
Problem: Bleed tube [illegible]
Disposition: Replaced

F & CD/IR: #[illegible] Date. 5-7-62
Class Failure: Non-significant
P/N: 27-[illegible] - Valve assy.
Next Assy: 27-[illegible]
Problem: Butterfly vlv. binding in assy.
Disposition. Replaced - reinstalled

F & CD/IR. [illegible] Date. 5-7-62
Class Fail[illegible] Non-significant.
P/N: 27-[illegible]-1 - Rod assy.
Next /ssy. 27-[illegible]
Problem. [illegible] in/lbs 3 threads damaged
Disposition. Repaired in place

F & CD/IR. [illegible]-34057 Date: 5-7-62
Class Failure. Non-significant
P/N: R13[illegible]-1 - 4PDT Relay
Next /ssy: A/P Relay Compartment Assy.
Problem: Damaged by 110 VAC on wire
Disposition: Condemned

8 May 1962

7	19657	500 LA	OBSERVER CUTOFF SYSTEM	9 March 62	8 May 62
27	21001	500 BN	REPLACE B1 STAGING SHUTOFF VLV.	2 May 62	8 May 62
27	21003	503 B	STAGING SHUTOFF VLV ACTUATOR	2 May 62	8 May 62
27	21004	501 A	STAGING SHUTOFF VLV ACTUATOR LUG	2 May 62	8 May 62
BOI	11		C/C XDCR P117I	27 April 62	8 May 62
BOI	21		SUPPORT 27-21003-504	5 May 62	8 May 62
BOI	23		SUPPORT 27-21001-502	5 May 62	8 May 62
BOI	27		INST CAMERA SUPPORTS	6 May 62	8 May 62
BOI	30		SUST BLEED PORT LEAK CHECK	7 May 62	8 May 62
BOI	32		LEAK CHECK MISSILE TANKS	7 May 62	8 May 62
BOI	35		CUSTAINER TURBOPUMPS	3 May 62	8 May 62

8 May 1962 (Continued)			Date Planned	Date Complete
BOI	35	SUPPORT B2 STAGING VALVE	7 May 62	8 May 62
BOI	36	REPLACE TUBE	7 May 62	8 May 62
BOI	37	MODIFY ACCELEROMETER	7 May 62	8 May 62
BOI	38	MODIFY FUEL STAGING VALVE	7 May 62	8 May 62
BOI	39	VENT MISSILE TANK	8 May 62	8 May 62
BOI	41	B2 LOX STAGING VALVE	8 May 62	8 May 62
BOI	77	REMOVE N1527T	27 April 62	8 May 62
BOI	78	PROVIDE 8 VOLT EXCITATION	4 May 62	8 May 62
BOI	91	LOX STAGING VALVE	8 May 62	8 May 62
CIC	16876	27-21003-504 ECN 25431	2 May 62	8 May 62

F & CD/IR: #484042 Dates: 5-8-62
Class Failure: Non-significant
P/N: 27-22006-1 - Viv. Assy.
Next Assy: 27-21004
Problem: Leakage around flange and flange bolts
Disposition: Fixed in place

9 May 1962

7	17053	508 06	INSTRUMENTATION	9 May 62	9 May 62
BOI	2		REMOVE FORWARD NACELLES	1 May 62	9 May 62
BOI	5		FABRICATE HOUSING	30 April 62	9 May 62
BOI	6		CAL GAGES	6 March 62	9 May 62
BOI	7		REMOVE LOX TANK WIRES	3 May 62	9 May 62
BOI	8		REMOVE XDCR	4 May 62	9 May 62
BOI	8		PRESSURIZE LOX STORAGE TANK	2 May 62	9 May 62
BOI	9		LOX STAGING VALVE	8 May 62	9 May 62
BOI	10		REWIRE P1395S	4 May 62	9 May 62
BOI	12		CAMERA SUPPORT BRACKET	6 May 62	9 May 62
BOI	14		ASSIST STAGING VALVE REMOVAL	7 May 62	9 May 62
BOI	14		WELD CAMERA BOX	8 May 62	9 May 62
BOI	15		WELD MISSILE LN2 INLET	8 May 62	9 May 62
BOI	45		REPLACE SPGG	8 May 62	9 May 62
CIC	16495		27-27094-1 1A EO 212528	12 April 62	9 May 62

F & CD/IR: #484044 Date: 5-9-62
Class Failure: Non-significant
P/N: 27-81059-801 - Bottle shroud assy
Next Assy: 27-81031
Problem: Cracked Weld.
Disposition: Repaired in place

F & CD/IR: #484045 Date: 5-9-62
Class Failure: Major
P/N: 27-02102-23 - Valve assy - Lox F/D
Next Assy: 27-21001
Problem: (2) cracks from bottom weld section
Disposition: Failure Anaysis

9 May 1962 (Continued)

F & CD/IR: #484064 Date: 5-9-62
Class Failure: Non-significant
P/N: 27-0212-23 - valve assy - Lox F/D
Next Assy: 27-21001-819
Problem: Pin F of J1 Receptacle
Disposition: a.f.o.

F & CD/IR: #484067 Date: 5-9-62
Class Failure: Non-significant
P/N: 27-80249-7 - Gasket
Next Assy: 27-81031
Problem: 4 gaskets cut
Disposition: Condemned

F & CD/IR: #484062 Date: 5-9-62
Class Failure: Non-significant
P/N: KC3-21-30PN - Electric Connector
Next Assy: A/P Monitor
Problem: Wire broken
Disposition: Repaired

10 May 1962				Date Planned	Date Complete
27	90390	BK 2A	FLUID SAMPLING PROCEDURE	3 May 62	10 May 62
27	93701	BK 1P	LEAK CHECK LN2 SHROUDS	4 May 62	10 May 62
BOI	4		CAMERA BRACKETRY	25 April 62	10 May 62
BOI	4		ADJUST CAMERA BRACKETRY	27 April 62	10 May 62
BOI	10		INSTALL CAMERA BOX	24 April 62	10 May 62
BOI	12		REPLACE XDCR	10 May 62	10 May 62
BOI	13		INSTALL SANBORN	10 May 62	10 May 62
BOI	39		SCRIBE VALVE	7 May 62	10 May 62
BOI	44		REPLACE SHAFT	8 May 62	10 May 62
BOI	47		LEAK CHECK BOI 46	9 May 62	10 May 62
BOI	48		PERMIT FUEL TANKING	9 May 62	10 May 62
BOI	49		LEAKING F/D VALVE	10 May 62	10 May 62
BOI	51		VENT LOX STORAGE TANK	10 May 62	10 May 62

F & CD/IR: #484049 Date: 5-10-62
Class Failure: Major
P/N: 27-02102-23 - Vlv assy - Lox F/D
Next Assy: 27-21001
Problem: Internal leakage when closed
Disposition: Failure Analysis

10 May 1962 (Continued)

F & CD/IR: #489197 Date: 5-10-62
Class Failure: Non-significant
P/N: 27-23552-7 - Rod End
Next Assy: 27-23556
Problem: Rod end bent
Disposition: Condemned

11 May 1962				Date Planned	Date Complete
27	90574	BK 1C	GROUND & AIRBORNE FILL & BLEED	3 May 62	11 May 62
27	93917	BK 2E	PROPULSION MATED LEAK TEST	27 April 62	11 May 62
NRD 1			LN2 Flush nozzle, between the sustainer and booster 1 engines in Quad I, issues a solid stream of water when the water is turned on.	11 May 62	11 May 62

12 May 1962				
BOI	4	CHANGE CAMERA LIGHT	12 May 62	12 May 62
BOI	5	REPAIR HYD LINE	12 May 62	12 May 62
BOI	19	REPAIR ELECTRICAL HARNESS	12 May 62	12 May 62
BOI	46	B2 NACELLE	12 May 62	12 May 62
BOI	47	INSPECTOR AID TO ENGINEERING	12 May 62	12 May 62
BOI	48	C/O N1528T	12 May 62	12 May 62
BOI	49	C/O AIRBORNE LOX REGULATOR	12 May 62	12 May 62

IR 565380 - The R/D 1C116 sustainer engine (S/N 222722) was damaged due to explosion of missile. No replacement was needed.

15 May 1962				
BOI	76	MEASURE FLANGE	5 April 62	15 May 62

F & CD/IR: #484017 Date: Not given
Class Failure: Non-significant
P/N: 56873 - Filter
Next Assy: 901202
Problem: MWO change
Disposition: Condemned

Presented in the following is a chronological listing of items planned, but have no indicated completion date.

			JOB TITLE	DATE PLANNED
TVA	A21283		REPLACE VALVE L-50	3-26-62
BOI	3		UPDATE RESPONDER UNIT	4- 4-62
27	18527	1 A	INSTALL XDCR	4- 6-62
27	27096	1 1D	TANK PRESSURE LINE INSTL	4-26-62
27	27096	1 1A	AUXILIARY LINE INSTL	4-26-62
ECN	28605		MISSILE LIFT PANEL ASSY	4-30-62
ECN	28611		INSTALL LOX CONTROLLER	4-30-62
27	49502	5 B	STRUCTURAL AND MECHANICAL	5- 1-62
BOI	1		REWORK 28 V RELAY	5- 1-62
27	93952	BK 2E	BOOSTER AND SUSTAINER	5- 3-62
BOI	12		XFER ROOM STEP 2 OUTPUT	5- 4-62
BOI	11		FUEL SHUTOFF VALVE	5- 4-62
BOI	16		SUPPORT 27-21004-801 A	5- 5-62
BOI	17		MOUNT CAMERA	5- 5-62
BOI	24		RELOCATE CAMERA MOUNTING PLATE	5- 5-62
BOI	86		FABRICATE COVER PLATE	5- 5-62
BOI	26		MOUNT CAMERA	5- 6-62
BOI	23		INSTALL CAMERA BRACKET	5- 6-62
BOI	6		RELOCATE P1479T	5- 7-62
BOI	29		SUSTAINER DUCT FLANGE	5- 7-62
BOI	31		HOLE IN CAMERA BOX	5- 7-62
BOI	85		FABRICATE ACCELEROMETER BRACKET	5- 7-62
BOI	7		INSTALL ACCELEROMETER	5- 8-62
BOI	10		FUEL STAGING VALVE	5- 8-62
BOI	42		LOX STAGING VALVE	5- 8-62
BOI	43		FUEL STAGING VALVES	5- 8-62
BOI	92		FABRICATE PLATES	5- 8-62
BOI	94		FABRICATE BRACKETS AND PLATES	5- 8-62
BOI	95		FABRICATE BRACKETS AND PLATES	5- 8-62
BOI	96		FABRICATE BRACKET AND PLATES	5- 8-62
BOI	93		LOX STAGING VALVE	5- 9-62
27	90534	BK 2B	LOX TOPPING TANK	5-11-62
BOI	9		LOX STAGING VALVE	5-11-62
TVA	21269	A	CABLE UNAVAILABLE	5-11-62
TVA	21270	A	CABLE NOT AVAILABLE	5-11-62
27	93910	BK 2B	GROUND A/B PNEUMATIC SYSTEM 1922	5-12-62
BOI	90			5-17-62
ECN	28609		TRANS INSTALLATION BOI 11, 19, 45	5-24-62
ECN	26560		TRANS INSTALLATION BOI 12	5-24-62

6.9 INVESTIGATION BOARD AND COMMITTEE ASSIGNMENTS

At the request of Col. H. E. Moose, President of the Accident Investigation Board, formal working committees were formed in the following areas. Airborne Hardware, Documentation, Explosive Forces and Yield, TGSE and Facilities Hardware, and Data Investigation. Compiled in this section are a listing of the delegated committee members and their functions.

ACCIDENT INVESTIGATION BOARD

Col H. E. Moose, RWRU, President

Lt Col G. W. Johnson, RWRUE, Member

Maj F. A. Silvasy, RWRUE, Investigation Officer

2 Lt L. R. White, RWRU-1, Recorder

Maj C. W. Flanders, AFIMS, Member (NV)

Mr. E. R. Roth, AFIMS, Member (NV)

Mr. F. T. Gardner, GD/A, Member

Mr. S. Zeenkov, GD/A, Member

Mr. D. M. McGray, STL, Member

Mr. A. Chase, Rocketdyne, Member

Mr. S. Simpson, Accoustica, Member

AIRBORNE HARDWARE COMMITTEE

R. G. Killian - GD/A Chairman

Capt. L. F. Gifford - USAF - Co-Chairman

C. H. Oliver - GD/A Propulsion

R. E. Masters - GD/A Pneumatics

P. R. Battenberg - GD/A Hydraulics Airframe

J. R. Rose - GD/A Electrical

D. W. Burright - GD/A Operations Support

L. P. Birse - GD/A Inspection

T. J. Collins - STL

J. Ruppert - NAA/Rocketdyne

G. Oetken - AFQC

S. Simpson - Acoustica Associates

C. O. Bennett - GD/A Design Designee Mechanical

D. I. Goetting - GD/A Design Designee Electrical

R. F. Sprague - GD/A Designee Flight Control

K. King - GD/A Prop. Design

D. Howard - GD/A Pneumatic Design

R. Stocklosa - GD/A Hydraulic Design

A. Morse - GD/A Flt Control Design

Dave Bradley - GD/A

Hoyt Graham - STL

Joe Green - STL

Sidney Berman - AFIFS

Don Eddy - Rocketdyne

DOCUMENTATION COMMITTEE

W. W. Johnston - GD/A - Chairman

Capt. L. F. Gifford - USAF - Co-Chairman

W. J. Sweitzer - GD/A

INVESTIGATION TEAM - EXPLOSIVE FORCES AND YIELD

A. N. Hatch - GD/A 595-1 Aerothermo Dynamics

L. V. Feigenbutz - GD/A 595-1 Aerothermo Dynamics

W. M. Smalley - Aero Space Corp.

W. Pfanner - GD/A Structional Analysis

E. D. Frost - GD/A

Don Endsley - AFIGS

Gus S. Economy - DIG/Safety AFIMS

TGSE AND FACILITIES HARDWARE COMMITTEE

F. J. Stewart - GD/A Chairman

J. M. MacDonald - GD/A Co-Chairman

R. Richards - GD/A Material

C. L. Gould - GD/A Electrical - TGSE

D. W. McCallum - GD/A Mechanical - TGSE

M. X. Dougherty - GD/A Design Electrical

F. A. Derango - GD/A Design Mechanical

E. A. Zdvorak - GD/A Mechanical - Facilities

K. Cannestra - GD/A Electrical-Facilities

G. Oetken - AFQC

J. H. Ruppert - NAA/Rocketdyne

S. Simpson - Acoustica Associates

T. J. Collins - STL

J. W. Taylor/L. Birse - GD/A Inspection

S. Chavez - GD/A Plant Engineering

D. Morgan - GD/A Safety

C. Frasher - GD/A S-4 Centaur

DATA COMMITTEE

H. L. Obertreis - GD/A Test Evaluation - Chairman

A. Chase - NAA/Rocketdyne - Co-Chairman

G. G. Christ - GD/A Instrumentation

I. F. Littman - STL

D. M. McCray -STL

D. W. Healy - GD/A Test Evaluation

S. Simpson - Acoustica Associates

G. Oetken - AFQC

W. J. Sweitzer - GD/A (Syc.) Propulsion

R. Stocklosa - GD/A Hydraulic Design

C. L. Hyde - GD/A (Syc.) Pneumatics

E. J. Dubatowski - GD/A (Syc.) Hydraulics-Airframe

C. D. Westfall - GD/A (Syc.) Flight Control

V. C. Knarreborg - GD/A (Syc.) Operations Support - Instrumentation

Lt. L. B. Haws - AFPRO

K. King - GD/A Prop. Design

D. Howard - GD/A Pneumatics Design

A. Morse - GD/A Flt Control Design

6.10 WITNESS INTERROGATION

This section is a documentation of the pertinent comments presented, by the witnesses of the Missile 1F mishap, during a post run interrogation.

I was positioned directly behind the Launch Officer's Console with a view of the lower portion of the missile available to me through the blockhouse windows. LOC indicators appeared normal throughout "commit start" countdown until after the "T-0" callout. My attention shifted to the windows before ignition. Immediately after ignition, a billowing fire appeared on the left side of the booster section (as viewed from the blockhouse), cutoff and water were called for and the explosion(s) occurred. The subsequent shock-wave was prominent in the blockhouse.

Signed - Seymour Zeenkov Asst. Proj. Engineer 5/13/62

1. In Electronics Room
2. Acoustica Console
3. Everything normal, and on control
4. Explosion

Signed - W. M. Skov, Clock No. 83993 5/13/62

My Station - Esterline Angus Recorders in DO-34, 1 to 4, DO-35, 1 to 4. Eight (8) of the above recorders operated well throughout the run. From Commit Start to the time of the explosions, I was watching the recorders one (1) through four (4) in DO-34. I did not observe any cutoffs during this time. The records on EA's may not bear this out. The people in the back bay Browns were calm and stayed on their recorders until they were secured.

Signed - G. A. Theobald, Clock No. 89727 5/13/62

I was operating the communication console on this date, as marked above. Standing near the console, as I have in the past runs, everything seemed normal up to the time of the explosion, then I felt the concussion and it seemed to shake me up a little. Also, I heard the Transfer Room door shake, as I am located near the tunnel that runs to the Transfer Room. Then I heard the Kellogg selectors clicking quite fast. I reached over and switched the power off on our Kellogg power supply, switched off all the communications lines running to the stand and area. After removing the shorts from the outside area, I managed to get communications established between Security & Blockhouse area. I removed PA from S1 area and switched in S4 after checking it out for operation. After communications were established I ran the remaining tape from the boiloff valve test tape and put on a new

roll after completing the rest of the Reel #1 Side 2. I also installed a 28 volt power supply to operate the console, after main 28 volt power went off, with the permission of my supervisor.

Signed - T. A. Sickich, Clock No. 83340 5/13/62

Autopilot Control Console & Hydraulic Console Operator - All observations on above consoles were normal and per countdown. All call-out commands were normal and on time. Programmer run time meter started running at ignition start and I started call-out time. As I recall, immediately after the count of two seconds, there were several call-outs either in the blockhouse or on the command net. At this time, I ceased the time call out and heard the explosion. To the best of my knowledge hydraulics returned to R&D before loss of power. After explosion, Missile AC & DC was turned off on the Missile Power Control Panel. At this time I observed the indicator lights on the Autopilot Control Panel were dim and requested to secure panel power. It was granted and panel power was secured.

Signed - James A. Casto, Clock No. 22634 5/13/62

I was stationed at the Auxiliary Control Panel and everything was normal. Ignition was approximately two seconds past zero time. Approximately one second after ignition start we had the cutoff lights appear upon the Auxiliary Control Panel. Approximately a second later there was an explosion.

Signed - Herbert P. Lipp, Clock No. 57588 5/13/62

I was Firex and Flame Deflector operator at the time of explosion. Everything was normal, until after the explosion, on both panels. I was watching the water pressure meters and could see nothing. I heard the test conductor call "all water on" just prior to the explosion and started all water that I could before and after the explosion.

Signed - George L. Richardson, Clock No. 76858 5/13/62

My assignment was Brown recorders. Location: back bay. DO-31, DO-32, DO-33 Measurement numbers: P1212D, N1515P, P1213D, P1002P, P1001P, P1098D, P1004P, P1003P, F1365T.

All measurements looked normal. As countdown monitor said "0", the lox pump inlet pressure began to rise and oscillate and appeared to be sluggish. At ignition start they dipped low in pressure. I heard loud screaming on command net and then an explosion. This was from 3 to 5 seconds after ignition start. After explosion all measurements went out. The blockhouse

shook and the air conditioning vent fell to the floor.

Signed - J. W. Barham, Clock No. 13798 5/13/62

At commit start I was watching the 6 Brown recorders in DO-23 & DC-25. All looked normal. At engine start I was watching the 2 redline measurements P1473P, B1 Lo Pr Lube Oil and P1279P, B2 Lo Pr Lube Oil. Both measurements started up scale. The light from the fire attracted my attention to look out the glass port in the blockhouse just as I felt the shock wave. I did not press the cutoff button.

Signed - A. R. MacGregor, Clock No. 59299 5/13/62

Fuel Tanking Panel
Purge Panel

From commit start to ignition start everything was normal on both panels. At ignition start I was watching the TV monitor above the panel. I saw flames coming from the area around the engines and up the side of the booster section. I heard the call-outs for ignition start + 1 second, + 2 seconds. I had to turn the purge panel power ON at ignition start + 3 seconds. The explosion occurred just prior to this time. All panel lights went dim and the TV monitor went to just a raster.

Signed - Edward Miller, Clock No. 64649 5/13/62

RCC Operator - Everything was normal on RCC between commit start and ignition. Seconds after ignition start, all binary counters commenced counting. Cutoff was observed on Channel B1A only. In my mind, this appeared after the explosion.

Signed - Clarence S. Clayborne, Clock No. 24070 5/13/62

I was observing two redlines P1709T (S. GG Combustor) and P1465P (S. Lo Pr Lube Oil Manifold) prior to start commit. During 10 sec. of start commit and after 10 seconds of start commit, the recorder for P1709T was reading normal at ignition start. It went up fast and hit the positive end of the recorder and came out of red normally until cutoff and then went negative. It operated normal in its two second limits. I did not observe P1465P due to it having 7 seconds to get out of red. Other measurements that I was observing, P1682P, U1080P, U1081P and P1341P all appeared normal prior to start commit. Then I focused my attention on the two redlines mentioned above.

Signed - A. V. Tangorra, Clock No. 89076 5/13/62

I was assigned to be the roving instrumentation technician in the front bay Brown area. At commit start I was looking at recorders in the general area of bay DO-18, DO-19 and DO-20. All measurements appeared normal until the explosion.

Signed - E. J. Smith, Clock No. 84533 5/13/62

During the hot run firing S-1-613-14-01, I was operating the Instrumentation Console. All instrumentation was on fast. At T-158S, run cameras switch T-2 was activated, soon afterwards at T-8S ignition, stage cameras T-1 switch was activated. Also, at T-5S,T/S camera T-4 switch was activated. All instrumentation prior to ignition start was GO over the command net. To me, ignition start sounded good and as I raised my eyes from the console a couple of seconds later, all I saw was a yellow flash at the blockhouse windows.

Signed - Ronald J. Maguire, Clock No. 59567 5/13/62

Assignment: Brown Recorders
Location: D046, 47, 48, Back Bay Brown Area
Measurements: F1368T, P1951T, F1356, P1096D, N1790T, F1353T, F1285P, F1286P, F1355P
Up to commit start and after, all nine of these recorders were normal until the explosion, after which most went to zero. I observed nothing abnormal.

Signed - Fred Westfall, Clock No. 95902 5/13/62

From just before the countdown everything seemed normal. We went through commit start and the final countdown with no holds. We got to zero and went past zero, 1 or 2 seconds and had ignition start. Everything seemed to be running OK. There was a cutoff and then there was an explosion.

My assignment was watching the back up FM tape in D076 and D077 bays also to watch the Sanborn recorder in bay D078. There were a number of STL people observing the measurements on the Sanborn recorder in D078. I was looking at P1095D and P1097D. I noticed slight oscillation on P1095D but it was not close to being out of band and I believe P1097D also had some oscillation. Also, during the three seconds we fired, neither was close to being out of band. Of course at the explosion, then both pegged out. The FM back up tapes operated OK all the time until we had power failure throughout the blockhouse.

When I was down in the Transfer Room, I noticed that the back of the RCC amplifier cabinet was closed. Now this was not normally left closed, so I estimate it was an hour and a half before this Run I opened the back of the RCC cabinet. I always remember it being open before to give the equipment

ventilation and to let it run cooler. When I noticed it closed I opened the back door and I put my hand on one of the power chassis and it was hot. I could not leave my hand on it so I left the door open.

Signed - Bayard J. Rehkopf, Clock No. 76110 5/13/62

1. From commit start to zero time, the 1st and 2nd stage hydraulics measurements H1033P and H1140P were recording normal pressure of 2250 psig, well within design operating limits.
2. At zero time, I recall hearing the Autopilot Tape Reader function and perhaps 1 or 2 seconds later, simultaneous with the test conductor's command of "water on". A bright (whitish) light was perceived out of the corner of my eye.
3. At this moment H1140P became erratic spiking upscale and H1033P spiking downscale. I actuated my cutoff button.
4. The blast wave hit the blockhouse and shortly thereafter power was shut down.

Signed - L. B. Smith, Clock No. 84772 5/13/62

Subject: Observations of Brown Recorders during Run S1-613-14-01
Ref: Measurements P1232P, P1830D, P1529D, P1474P, P1027P & P1030P

During Run S1-613-14-01 I was observing the Brown recorders and the following is a statement of my observations:

All measurements were functioning normally from commit start until ignition start. From commit start until T-0, I was paying particular attention to P1474P (V control press regulator) to make sure it stayed within the limits of 555 to 625 psig. At T-0, I shifted my attention to my two redline cut-offs, P1232P and P1830D. At ignition start P1830D came off 0 deg and went up to approximately 75 deg, it then started on and then immediately after, the explosion took place.

Signed - E. A. Leonard, Clock No. 56761 5/13/62

1. I was assigned the following recorders for the subject run.
   F1011P Lox press discharge
   F1009P Fuel Press Disch
   N1530P Lox Topping Tank Level
   F1182P Lox Ullage Pressure
   CP1017P S4 lox Boost Pump In
   CP1019P S4 LH2 Boost Pump In
2. All measurements were normal until the explosion. Then, all lost indication except CP1017P and CP1019P, which still indicated normal tank pressure until bay power was secured.

Signed - R. C. Palmer, Clock No. 70889 5/13/62

Measurements involved:
P1677T Edison Loop - Normal (Redline)
P1325T Eng. Comp. Amb. - Normal (Redline)
P1712T B2 Nac. Amb. - Normal (Redline)
N1508T Low Top Tk. Ctl. Jt - Pegged Neg. (-325 deg)
All temps pegged positive at or about the same time of blast.

Signed - William Melendez, Clock No. 53745 5/13/62

From start commit to ignition start everything seemed normal in FM area. I do not have any visual measurement to look at except for all volume unit meters for signal level on all four FM tape recorders and like I stated before everything looked normal. After two or three seconds of ignition start the blast occurred and at the same time all levels at volume unit meter dropped down, losing all signals.

Signed - N. D. LaGiglia, Clock No. 55230 5/13/62

Immediately before ignition start, I checked all front bay Brown recorders and TV systems and was satisfied that all were running properly. I noticed on the TV monitor, looking at the front of the stand, flame which curled up and around the B-2 thrust chamber, which continued up to the explosion. Following the explosion I checked all TV systems to see if any could be used for surveillance of the area. All cameras were dead so I cut all power to the cameras and TV system.

Signed - John Jeffers, Jr., Clock No. 29513 5/13/62

From blockhouse observer's position, the test stand and missile appeared normal until the command of ignition start. There were some vapors appearing periodically from under the missile in Quad 1 and 2 areas, which were also being observed on the TV monitor. At the command of ignition start, flames seemed to burst out all around the V2 engine, and B2 engine nacelle. The B2 engine nacelle then seemed to erupt in flames and the entire test stand was then lost ot sight in flame and smoke. The V2 engine did not appear to have gained a started condition.

Signed - T. Jones, Blockhouse Observer 5/13/62

The missile and stand appeared normal in all respects through tanking and during the one hour hold before firing. At the time of engine start B-1 and B-2 apparently went into ignition start normally then billowed into flames which seemed to roll, in both directions from B-2 under the entire thrust section and up around the sides of B-2 nacelle and then B-1 nacelle. This action was extremely fast and appeared as though it was an explosive action. At this time I yelled "Explosion" in the phones, dropped down into the tank, attempting to reach and push the cutoff button at the same time. I did not push cutoff as the missile exploded before I could push the button. My view of the sustainer was hampered by the V-2 stand and fuel swivel. I did not discern any V-2 ignition.

Signed - R. E. Smay, North Tank Observer, Clock No. 84224 5/13/62

At time count zero, there appeared to be a delay of ignition for several seconds. The first appearance of fire appeared to be a lazy orange colored flame rolling from beneath the fire wall at B-2 engine. The fire appeared to grow in intensity for 2 - 3 seconds completely covering Quad 1 & 2 - boiling as high as V-2 engine. Then came explosion, and immediately all vision was obscured in the smoke and flame. Observance of the missile up until the first appearance of flame, indicated all conditions were normal as seen from the periscope.

Signed - R. L. Woods, Clock No. 98600 5/13/62

I was in the front part of the tank looking out. Everything was normal until ignition start. After ignition, black smoke rolled out, like the engine started. Within just a second a flash of fire, coming on both sides of the smoke, like both boosters had caught on fire, with an explosion following immediately. This fire on the boosters looked like it was on the south side of the stand in Quad 3 and 4. I did not see the verniers start.

Signed - Joe Estebo, North Tank Observer, Clock No. 33529 5/13/62

During the one hour hold, all indications on F1001P and F1003P were normal at step two pressures. The last 25 minutes of the one hour hold I was relieved for a lunch period. I returned to my blockhouse station about 5 minutes before the end of the one hour hold. The time count progressed and missile pressures were advanced to Step III pressures, normal. The time continued and missile pressures went to internal and still were normal. I heard ignition start and just a fraction of a second after, I heard cutoff and fire. Then I heard Roy Killian call for all water on. After that sentence, missile lox tank and fuel tank pressures started to drop at about the same time. When they got into the red zone, I hit the cutoff button. Until that time all indications were normal. After the one hour hold, the south tank reported frost at the missile around the Quad III and Quad IV area of

the outer thrust section of the missile, south side. It was reported that the frost was approximately 18" up the side of the thrust section. The test conductor said that we had this condition before. It was felt that this condition was OK, and the countdown was started again.

Signed - Frank T. Adorno, Jr., Recorder F1001P and F1003P, Clock No. 10420 5-13-62

It looked like a normal firing of the booster engine then fire exploded all around the test stand. The vernier engine did not fire. No one in the north tank could hit the button. The fire and explosion went about 300 feet in the air and about 200 feet across.

Signed - R. L. Robertson, Clock No. 77806 5-13-62

During the one hour hold with both tank banks of the missile loaded with propellants, and immediately after resuming the countdown, I reported to the test conductor that there was an indication of frosting on the lower edge of the missile approximately 18" in height, extending from the area of the lower mounted camera unit, to the Q4 section of the nacelle.

The test conductor asked me if I had noticed this condition on the previous tanking tests, to which I replied "Negative". The test conductor then asked for a read out on the thrust section ambient temperature measurement. The reply was, "Temperature Normal".

The test conductor then asked me if I could detect any liquid draining from the area, to which I replied "Negative". The test conductor again asked for a read out on the thrust section ambient temperature measurement, the reply was again "Temperature Normal".

The test conductor then asked me if I thought that this was not a normal frosting, due to the LN2 in the holding shrouds sitting for an hour in this state, and due to the weather condition on this day, at which time the count was again resumed. At the command of vernier and main flame deflector water on, I observed the water from the buckets, and reported same to the test conductor. Shortly after this, as the Command Ignition Start was given, I was observing the lower section of the missile and main flame deflector area through bird dams. I observed the engines fire off, and at the same instant, the combustible area around the lower section of the thrust section and launcher seemed to ignite.

Seeing that this was not a normal start, I instantly thought of what may take place next. I ducked down inside the tank and yelled "Fire", into my mouthpiece. I had hardly gotten down when I heard and felt a tremendous explosion, and immediately yelled "Explosion" into my mouthpiece. At that time, I looked through the observation window in the front of the tank and saw a huge ball of smoke and flame around the stand area, with debris flying

in all directions. I could see that the test stand had fallen over. I immediately reported into my mouthpiece, that we had lost the missile, test stand and everything. The time lapse between Ignition Start and the explosion was momentary.

Signed - George Grande, Clock No. 40161 5/13/62

7.0 LISTING OF DAMAGE INCURRED

The estimated requirements for the refurbishment of Sycamore S1 to a condition suitable for continuation of the static test program are presented below. This estimate was established for planning purposes only.

Design Manhours	5000 hours
Vendor and Subcontractor Costs	$1,282,500

Presented in this section is a complete listing of damaged TGSE and facility equipment including an estimation of the degree of damage incurred by each item.

MECHANICAL
TGSE

NAME	PART NO.	% DAMAGE
1. Rocketdyne Service Cart	G2000MD4X6	15
2. Rocketdyne Pneu Test Unit	G3004	100
3. Rocketdyne Pneu Test Console	9529-84180(G3052)	50
4. Safety Net (two)	27-09722	100
5. Flame Deflector Covers	27-09721	10
6. Main Flame Deflector	7-96015	5
7. Vernier Flame Deflectors	7-96078 7-96011	100 100
8. Vernier Flame Deflector Platform	27-96092	100
9. Service Tower	7-96109	100
10. Test Stand (Below Sta 17)	27-98959	25
11. Helium Charge Unit (Installation) Distribution	27-08014 27-86111	100 80
12. Hydraulic Pumping Unit (Installation) Distribution	27-08657 27-87041	50 100
13. Pressurization Control Unit (Installation)	7-08432	50
14. Launcher Booster Unit	7-08352	60
15. LN2 Heat Exchanger (Helium)	27-08612	5
16. Pod Cooling Unit (Duct Installation)	7-08620 27-80011	50 100
17. Ullage Tank System (Lox)	7-08115	100

MECHANICAL (Continued)

NAME		PART NO.	% DAMAGE
18.	Ullage Tank System (Fuel)	7-08116	100
19.	Launcher	27-49500	90
20.	Stret n Sling	7-91060	50
21.	Thrust Section Heater (Duct Instl)	7-86304 & 27-08138 27-80039	20 100
22.	Nose Handling Adapter	27-91049	10
23.	Nitrogen Charge Panel	7-08411	100
24.	Erection Mechanism	27-49519	100
25.	Canister Purge System	7-86105	5
26.	Fuel Transfer Unit	7-02221	5
27.	Lox Transfer Unit (R&D)	7-02222	1
28.	Gox-Lox Tank	7-21202	100
29.	Captive Firing Kit	27-24020	100
30.	Fuel Drain Kit	27-24508	100
31.	Erection Screw	27-95455	100
32.	Booster Turbine Exhaust	27-96101	30
33.	Silo Lox Topping Instl.	27-27038	65
34.	Silo Rapid Lox Loading Instl.	27-27084	40
35.	Fuel Distribution System	7-86147	15
36.	Mass Flowmeter Instl.	27-86146 EO 204374	5
37.	Haskell Compressor	6550	10
38.	Tower Pressurization System	27-89045 7-89342	100

MECHANICAL (Continued)

NAME		PART NO.	% DAMAGE
39.	Anti-Fire System	27-96108	70
40.	Booster Coolant System	27-96107	100
41.	Firex Instl (Silo Low Tank)	27-27083	30
42.	Firex Instl (Low Topping Tank)	27-90114	15
43.	Monitor Nozzle System	7-09311	60
44.	Perimeter Fire System	27-98971	80
45.	Skirt Firex System	27-80187	100
46.	Vernier Firex System	27-09137	100
47.	Tower Fog System	PE-55-409-M-7	100
48.	Missile Deluge System	PE-55-409-M-7	90
49.	GN2 Distribution System	7-00139	60

Facility

1.	CO2 Unit	10
	Distribution Lines	50
2.	Utility Bldg	85
3.	SDC Bldg	75
4.	Blockhouse Annex	10
5.	Helium Distribution System	5
6.	LN2 Distribution System	5
7.	GN2 Distribution System	5
8.	Facility Water System	10
9.	Access Structures	20

ELECTRICAL
TGSE

NAME		PART NO.	% DAMAGE
1.	AC 400 Cycle Generator	AFS 6125-724-8941	2
2.	Emergency Battery Instl	7-68259	50
3.	Acoustica Signal Conversion Unit	50007507	100
4.	Acoustica Alternate String Cable	50021146-5-6	100
5.	Umbilical Cables	27-69709	100
6.	Site Control Wiring and Cabling	27-01641 27-61184 27-09150	10 30 30
7.	Silo Logic Equip	27-68746	1
8.	R & D Consoles and Racks	27-69903	1
9.	Terminal Boxes (Test Stand) Umbilical Junction Boxes Area Interconnecting Boxes	27-69903	60
10.	Battery Tester	7-68374	50
11.	Stretch Control Box	7-68260	100
12.	Local Purge Control Assy	27-68923	50
13.	Battery Switch Box	7-68026	50
14.	Pneu Sequence Box	27-68973	15
15.	Missile Power Relay Box	27-69713	5
16.	Erection Control Assy	27-68660	100

Facility

1.	Lighting - Blockhouse Annex	80
2.	Lighting - Area	20
3.	60 Cycle Distribution System	15
4.	Regulated Power Distribution System	20

ELECTRICAL (Continued) NAME	PART NO.	% DAMAGE
5. Pod Air Cooling Ctls.		40
6. SDC 60 Cycle Supply System		100
7. Elevator and Hoist Control (SDC)		30
Instrumentation		
1. Umbilical Cables	7-19545	100
2. Instrumentation Cal Cart	7-18006	35
3. S-1 TV System	7-18008	40
4. Camera Pads Circuits	7-18008	60
5. Communications System (Test Stand Area Circuits)	7-15002	50
6. Area Instrumentation Circuits	7-17093	60
7. Wind Speed Indicator	7-18309	50
8. Terminal Boxes (Test Stand)	7-17090	95
MOTION PICTURE CAMERA AND EQUIPMENT		
A. Cameras (DBM - 4AM)		
1. 16 mm S/N 4339		20
2. 16 mm S/N 4338		100
3. 16 mm S/N 4432		40
4. 16 mm S/N 4445		60
5. 16 mm S/N 4447		100
6. 16 mm S/N 4431		100
B. Associated Equipment		
1. Magazine S/N 932		30
2. Carrying Case S/N 5034		100

MOTION PICTURE CAMERA AND EQUIPMENT (Continued)

NAME	PART NO.	% DAMAGE
B. Associated Equipment (Continued)		
3. Tripod (2) Two		100
4. Lens (8) Eight		100

SEVERABLE AND NON-CAPITAL EQUIPMENT

NAME	QUANTITY	% DAMAGE
I. Severable Equipment		
A. General Dynamics/Astronautics		
1. Furniture and Fixtures		
a. Chairs	12	100
b. Desks	6	100
c. Work Bench	1	100
d. File Cabinets	6	100
e. Table	1	100
f. Recording Time Clock	1	100
g. Oscillator Wide Range	1	100
h. Fire Extinguishers	21	100
i. "17" Drill Press	1	100
j. Bench Grinder	1	100
k. Hand Combinator	1	100
2. Portable Tools		
a. Grinder	4	100
b. Riveter	1	100
c. Hammer	1	100
d. Drill Motors	7	100
B. Government Equipment		
1. Furniture and Fixtures		
a. Work Benches	4	100 ✓
b. Desks	4	100 ✓
c. File Cabinet	1	100 ✓
d. Chairs	7	100 ✓
e. Storage Cabinets	2	100 ✓
f. Steel Lockers	12	100 ✓
g. Table	1	100 ✓

SEVERABLE AND NON-CAPITAL EQUIPMENT (Continued)

NAME	QUANTITY	% DAMAGE
I. Severable Equipment (Continued)		
B. Government Equipment (Continued)		
1. Furniture and Fixtures (Continued)		
h. Power Supply (M135)	1	100
i. Hand Cart	1	100
j. Video Amplifier	1	100
k. Scopemobile Cart	1	100
l. Water Cooler	1	100
m. Acetylene Welding Cart	1	100
n. Fire Extinguishers	7	100
o. Airco Welder	1	100
p. Schramm Compressor	1	100
2. Portable Tools		
a. Transit Stand	1	100
b. Grinder	3	100
c. Hammer Pneu	3	100
d. Skil Sander	1	100
e. Drill Motor	3	100
f. Jack Lift	2	100
g. Fork Lift	1	5
h. Tow Tractor	1	5
II. Non-Capital Equipment		
A. Plant Equipment (Perishable)		
1. Portable Wood Sheds	6	100
2. Desks	2	100
3. Specific Gravity Kit	1	100
4. Aldis Lamp	1	100
5. Black Lamps	2	100
6. Ohmeters	10	100
7. Airmask Unit	2	100
8. Fire Blankets	3	100

SEVERABLE AND NON-CAPITAL EQUIPMENT (Continued)

NAME	QUANTITY	% DAMAGE
II. Non-Capital Equipment (Continued)		
A. Plant Equipment (Perishable) (Continued)		
9. 50 lb. Recharge Power	1	100
10. Nozzles, Fire	8	100
11. Fire Hoses	2	100
B. Perishable Tools		
1. Torque Wrenches	10	100
2. Open End Breakaway Wrenches	10	100
3. "B" Nut Wrenches	21	100
4. Non-Sparking Pipe Wrenches	8	100
5. Non-Sparking Open End Wrenches	18	100
6. Non-Sparking Box End Wrenches	12	100
7. Non-Sparking 1/2" Drive Socket Set	1 Set	100
8. Non-Sparking 3/4" Drive Socket Set	1 Set	100
9. Crow Foot	8 Sets	100
10. Double End Flare "B" Nut	2 Sets	100
11. Short Handle Combination "B" Nut	2 Sets	100
12. Heavy Duty Ratchet	2 Sets	100
13. Striking Box Sockets	1 Set	100
14. Extra Heavy Drive Sockets	1 Set	100
15. Cresent Wrenches	9	100
16. Pipe Wrenches	7	100
17. Carpenters Hand Tools	31	100

SEVERABLE AND NON-CAPITAL EQUIPMENT (Continued)

NAME	QUANTITY	% DAMAGE
II. Non-Capital Equipment (Continued)		
B. Perishable Tools		
18. Sledge Hammers	6	100
19. Pliers	353	100
20. C-Clamps	156	100
21. Punches	30	100
22. Hacksaw Blades	144	100
23. Metal Hole Saw	2	100
24. Metal Letter Stamps	12 Sets	100
25. Vises	12	100
26. Steel Scales	7	100
27. Steel Tapes	4	100
28. Fishscales	2	100
29. Snakes	2	100
30. Plumb Bob	2	100
31. Torque Driver #1500 Handles	36	100
32. Torque Tips	500	100
33. Screw Drivers	4	100
34. Gauges	9	100
35. Tube Benders	6	100
36. Flaring Tools	12 Sets	100
37. Pre-Sets	4 Sets	100
38. Handles	28	100

SEVERABLE AND NON-CAPITAL EQUIPMENT (Continued)

NAME	QUANTITY	% DAMAGE
II. Non-Capital Equipment (Continued)		
B. Perishable Tools (Continued)		
39. Counter Bores	165	100
40. Counter Sinks	150	100
41. Drills Assorted	6500	100
42. Drill Attachments	24	100
43. Dies	5 Sets	100
44. Files-Hand	600	100
45. Reamers	5 Sets	100
46. Taps and Easy Cuts	110	100
47. Air Nozzles	15	100
48. Cutoff Blocks	6	100
49. Sliding Bar Extension	2	100
50. Embossing Tools	7	100
51. Flashlights	50	100
52. Prestolite Assorited Tips and Tank	2 Sets	100
53. Gasket Cutter	2 Sets	100
54. Spanner Wrenches	112	100
55. Wire Strippers	48	100
56. Calipers	14	100
57. Micrometers	6	100
58. Soldering Irons	90	100
59. Amp Tools	50	100
60. Stakon Tools	39	100

SEVERABLE AND NON-CAPITAL EQUIPMENT (Continued)

NAME	QUANTITY	% DAMAGE
III. Personal Tools		
A. Tool Kits	45	100

GENERAL S-4 AREA
TGSE

NAME	PART NO.	% DAMAGE
1. Load Cell Instl	55-99011	10
2. Hydraulic Supply Unit	55-87201	1
3. Brine Chiller	55-08002	4
4. Air Handling Unit	55-08122	5
5. Stretch Sling	55-90013	1
6. Helium Reg Controller	(55-92030) 4150R	100
7. Helium Supply Line (S-1 Area)	55-92030	10
8. GN2 Supply Line (S-1 Area)	55-83035)	8
9. Stored Regulators (Two)	VN-50-967 (55-83035)	100
10. TV Cameras	7-18992	15
11. Lox Transfer Line	55-92031	10
Facility		
1. Utility Bldg		70
2. Maintenance Bldg		20
3. Steam System		1
Missile (Centaur)	55-0501-3	Under Investigation